

# **INITIAL ENVIRONMENTAL EXAMINATION REPORT**

## **Three Dimensional Seismic Survey for Oil Exploration in Block SL-2007-01-001 in Gulf of Mannar-Sri Lanka**

**CAIRN LANKA PVT. LIMITED  
October 2009**



Report prepared by:  
**National Aquatic Resources Research and Development Agency**  
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**PROJECT TITLE:** Three Dimensional Seismic Surveys for Oil Exploration in Block SL-2007-01-001 in Gulf of Mannar

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## I. i. Executive Summary

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Cairn Lanka Pvt. Limited (CLPL) proposes to carry out 1450 sq kilometres of 3D seismic survey in the SL-2007-01-001 block off Kalpitiya in the Gulf of Mannar. CLPL is a wholly owned subsidiary of Cairn India that holds a 100% participating interest in the Mannar block. The Block SL 2007-01-001 was awarded to CLPL in the recent Sri Lanka bid round under an agreement with the government of Sri Lanka. The Mannar basin is a frontier petroleum province for Sri Lanka that is yet to be explored. Cairn Lanka will invest in the region in exploring the block by applying the best in class technologies and industry practices in the search to establish whether commercial quantities of hydrocarbons can be found. Cairn India is currently focused on exploration and production in South Asia where it has a working interest in 15 blocks, two of which are producing hydrocarbons. Cairn has been exploring for hydrocarbons in India for more than a decade. Today it has a proven track record of making exploration discoveries and fast tracking them to production. As of today there are 40 discoveries to Cairn India's credit. Cairn India Limited is listed on the Bombay Stock Exchange and the National Stock Exchange of India. Cairn Energy PLC, the UK based parent company holds a 65% interest in Cairn India.

This project boundary includes the Indo-Lanka maritime boundary on the West, The Gulf of Mannar to the North and South and Bar Reef marine Sanctuary which is approximately 2.3 km to the East of the block. Kalpitiya is the closest town and is approximately 11 km from the south-eastern boundary of the block.

Sri Lanka's efforts in oil exploration dates back to 1960s, when Sri Lanka acquired first off - shore reflective seismic in the north western region in 1967. Thereafter, between 1974 and 1981, seven exploratory wells were drilled with assistance from Russian and US companies. Although some evidence of presence of hydrocarbons was found no serious efforts were made to extract oil, as it was said to be commercially unviable, given the depth of reserves and technology available at time (CBSL, 2007).

Recent efforts for oil exploration commenced with a 2-D seismic survey programme carried out by TGS-NORPEC, a Norwegian oil company in the Mannar basin in 2001 and 2005. The 2-D seismic survey in the Mannar basin covers an area of 33715 sq. km divided into eight blocks.

Out of these blocks, blocks 1 & 8 have already been reserved for the governments of India and China respectively for oil exploration.

Sri Lanka is highly dependent on imported crude and natural gas for meeting its energy demands. While at the same time there has been limited hydrocarbon exploration to assess potential for domestic availability and production. This exploration is thus of great national importance. Any successful discovery would lead to reduction on import of hydrocarbons and provide a boost to the economy.

A review of the Regulatory and Institutional Framework with respect to environmental clearances as applicable to this project indicates that the Petroleum Resources Act, No. 26 of 2003, and regulations under it are applicable to this project. While recognising that any petroleum operation involves certain negative impacts on the environment, the Petroleum Resources Act No.26 of 2003, specifies in article 14.5 that an Environmental Impact Study should be carried out by competent persons. In addition to Sri Lankan regulatory requirements Cairn's corporate procedures requires that Environmental Impact Assessment is carried out for all its operations. The EIA processes of Cairn's operations are guided through its HSE policy and Corporate Responsibility Management System (CRMS) procedures. Cairn Lanka Pvt. Limited has obtained the services of National Aquatic Resources Research & Development Agency (NARA) a premier Sri Lankan institution. NARA has been providing technical advisory services to the Sri Lankan government and other private agencies.

This Initial Environmental Examination (Report) (IEER) has been carried out keeping in mind existing regulatory requirements and in line with Cairn's corporate procedures and guidelines. The baseline data on various environmental components has been compiled from NARA's resource base as well as from various other recognised sources. It is a general practice to base the EIA for seismic surveys on available information. This report is prepared based entirely on secondary data available from previous studies and reports only. Cairn Lanka will invest in the region in exploring the block by applying the best in class technologies and industry practices in the search to establish whether commercial quantities of hydrocarbons can be found. Cairn has been exploring for hydrocarbons in India for more than a decade. Today it has a proven track record of making exploration discoveries and fast tracking them to production. As of today there

are 40 discoveries to Cairn India's credit. Cairn India Limited is listed on the Bombay Stock Exchange and the National Stock Exchange of India. Cairn Energy PLC, the UK based parent company holds a 65% interest in Cairn India.

The identification and assessment of impacts is based on professional judgement, simulation methods and application of mapping techniques like GIS. Distance of the block from various protected areas has been analysed so as to plan the survey accordingly. In addition, studies done in several other countries have been referred in the preparation of this report.

The fauna within the seismic survey area (i.e. inside the offshore block SL-2007-1-001) and in adjoining and neighbouring areas comprise of important fisheries resources. The Bar Reef marine sanctuary is also located in the area. The Bar Reef is one of the most productive coral reef systems as well as it is unique in terms of its bio diversity. About 400 species of reef fish and numerous species of crustaceans including commercially important species such as lobsters and sea cucumbers have been found from the area. The Puttalam Lagoon, a highly productive estuary in the Northwest coast of Sri Lanka is also located close to the block. Marine mammals have also been reported to frequent the area.

The Initial survey would be a 3D Seismic within the block and the impacts have been listed in some detail in this report. It is supposed to have less impact than exploratory drilling, which may not be necessary in the latter stage of exploration, if proper 3D Seismic is conducted. Though there have been efforts to study the impact of seismic survey on marine environment, the analysis has been very qualitative so far. The emphasis is on behavioural and physiological effects due to sounds at or above the 180 dB to as low as 10 dB level for different species. The key factors involved in assessment of risk to marine animals during seismic survey are:

- i. Knowledge of sound level at which risk of physical injury or significant behavioral change can be envisaged
- ii. Damage quantum associated with duration of exposure frequency and speed of sound
- iii. Can continuous noise at moderate levels cause more damage than intermittent noise of higher levels?

The proximity of the Bar Reef to the Eastern boundary of the block, the movement of fishing vessels within and across the block, fishery activity and fishing gear laid within the block, Reef fishery conducted by divers, Turtles, Marine Mammals and their migratory patterns are expected to be affected due to the project activities. Further, damage associated with duration of exposure frequency on other biota has also been considered.

Several other possible impacts have been considered and sensitive areas within 50 km of the the boundaries of the block have been mapped. Reefs, Sea grass beds, Wetlands and Villus, Mangroves are some of the eco-systems and their proximity to the project boundaries are indicated clearly in this report.

It would be advisable to make arrangements to inform the following Government Agencies and Departments with the consent of the PRDS. A short description of proposed activities in the exploratory block and precise schedules will be useful for them to be informed and advice on appropriate measures to be taken in case of conflicts etc.

- i. Ministry of Fisheries and Aquatic Resources Development
- ii. Department of Fisheries and Aquatic Resources
- iii. Central Environmental Authority
- iv. Marine Environmental Protection Authority
- v. Ministry of Defence
- vi. Sri Lanka Navy
- vii. Provincial Environmental Authority of North Western Province.
- viii. Chairman, Kalpitiya Pradeshiya Sabha
- ix. District Secretary-Puttalam and Mannar.
- x. Divisional Secretary, Kalpitiya

The recommended mitigatory measures are indicated in a separate chapter and a monitoring plan is also given. It is recommended that the seismic survey be conducted as soon as possible while ensuring that the precautionary principle is adopted in the consideration of impacts on biota and the mitigatory measures enumerated in this report and the Environmental Management Plan be followed with good intentions by all concerned.

## I. ii. Terms of Reference

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This report is based on the following Terms of Reference.

- i. Collation of information on methodology of proposed seismic survey.
- ii. Collation of hydrographical and bathymetry data for the region based on existing information / records / documents
- iii. Collection and Collation of existing baseline environmental quality
- iv. Identification and demarcation of environmentally sensitive areas such as marine national parks, sanctuaries, breeding grounds, wet lands etc. The sensitive areas should be mapped using GIS with area coordinates.
- v. Review of legislative requirements, rules and regulations applicable to the seismic operations. The regulatory requirements have indicated need for permits and the process for obtaining these
- vi. Identification of impacts due to seismic survey on marine ecosystem of the region
- vii. Prediction and evaluation of significant impacts due to proposed activities / operations
- viii. Delineation of appropriate measures for prevention and control of environmental damage
- ix. Suggest environmental monitoring program. Socio Economic Status of Communities around the project area and impacts and mitigatory measures needed due to project activities.
- x. Fishery Activities- Stocks of Fish resources, Types of Fishing Techniques and Gear, Landings according to seasons and Variations, Boat Types, Fishing Grounds with locations –Impacts and Mitigatory Measures



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## ABBREVIATIONS

BFO	Biology-Fisheries Observer
BRMS	Bar Reef Marine Sanctuary
CBSL	Central Bank of Sri Lanka
CCD	Coast Conservation Department
CCA	Coast Conservation Act
CEA	Central Environmental Authority
CRMS	Corporate Responsibility Management System
CPC	Ceylon Petroleum Corporation
DSD	Divisional Secretariat Division
EMC	Environmental Monitoring Committee
FA	Fisheries Act
FFPO	Fauna and Flora Protection Ordinance
FRP	Fibre Reinforced Plastic
GN	Grama Niladhari
MARPOL	International Convention for the Prevention of Marine Pollution
MEY	Maximum Economic Yield
MMO	Marine Mammal Observer
MPCSs	Multi-purpose Co-operative Societies
MSY	Maximum Sustainable Yield
NARA	National Aquatic Resources Research & Development Agency
NBRO	National Building Research Organization
NEA	National Environmental Act
NWPC	North Western Provincial Council
PAA	Project Aproving Agency
PP	Project Proponant
PRDC	Petroleum Resources Development Committee
PRDS	Petroleum Resources Development Secretariat
PTS	Permanent reduction in auditory sensitivity
RO	Reverse Osmosis
RQD	Rock Quality Designation
SLPA	Sri Lanka Ports Authority
SOFAR	SOund Fixing and Ranging channel
SOPEP	Shipboard Oil Pollution Emergency Plan
TTS	Temporary reduction in auditory sensitivity

# CHAPTER 1

## INTRODUCTION

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### **1.1 Background of the Project Proponent**

Cairn Lanka Pvt. Limited proposes to carry out 1450 square kilometres of 3D seismic survey in the SL-2007-01-001 block. Cairn Lanka (Private) Limited, is a wholly owned subsidiary of Cairn India that holds a 100% participating interest in the Mannar block. The Block SL 2007-01-001 was awarded to Cairn Lanka Pvt. Limited in the recent Sri Lanka bid round. The Mannar basin is a frontier petroleum province that is yet to be explored. Cairn Lanka will invest in the region in exploring the block by applying the best in class technologies and industry practices in the search to establish whether commercial quantities of hydrocarbons can be found. Cairn India is currently focused on exploration and production in South Asia where it has a working interest in 15 blocks, two of which are producing hydrocarbons. Cairn has been exploring for hydrocarbons in India for more than a decade. Today it has a proven track record of making exploration discoveries and fast tracking them to production. As of today there are 40 discoveries to Cairn India's credit. Cairn India Limited is listed on the Bombay Stock Exchange and the National Stock Exchange of India. Cairn Energy PLC, the UK based parent company holds a 65% interest in Cairn India.

As described earlier Cairn Lanka Pvt. Limited proposes to carry out 3D seismic survey in the SL-2007-01-001 (Mannar) block. The block area is approximately 3000 sq km with depth varying from 50m to 1800m. It is located to the NW of Colombo off the Puttalam Peninsula in the Gulf of Mannar. There are no sizeable towns near the block and the eastern extent of the bloc is some 6 km to more than 15 km from the coast low water mark. An exploration and production agreement has been signed between Government of Sri Lanka and Cairn Lanka Pvt. Ltd for identifying potential hydrocarbon reserves and production upon a successful discovery. The initiation of exploration activities in the block are planned during the first quarter of 2010. The hydrocarbon exploration process at the block would start with gathering of seismic data which will be interpreted and analysed to identify structures that could be potential hydrocarbon reserves.

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While recognising the fact that any petroleum operation may involve certain negative impacts on the environment, the Petroleum Resources Act. No.26 of 2003 specifies in article 14.5 that an Environmental Impact Study should be carried out by competent persons. In addition to Sri Lankan regulatory requirements Cairn's corporate procedures require that Environmental Impact Assessment be carried out for all its operations. The EIA processes of Cairn's operations are guided through its HSE policy and Corporate Responsibility Management System (CRMS) procedures. Cairn Lanka Pvt. Limited has obtained the services of National Aquatic Resources Research & Development Agency (NARA) a premier Sri Lankan institution. NARA has been providing technical advisory services to the Sri Lankan government and other private agencies.

## **1.2 Background on hydrocarbon exploration in Sri Lanka**

Sri Lanka is an island nation which is situated between 5° 55" - 9° 50" north latitude and 79° 42" - 81° 51" east longitude. The total land area of the island is about 65,000 km<sup>2</sup> and having a maritime jurisdiction over 517,000 km<sup>2</sup>. The total population of the country is approximately 20 million.

Sri Lanka's efforts in oil exploration dates back to 1960s, when Sri Lanka acquired first off-shore reflective seismic in the north western region in 1967. Thereafter, between 1974 and 1981, seven exploratory wells were drilled with assistance from Russian and US companies. Although some evidence of presence of hydrocarbons was found no serious efforts were made to extract oil, as it was said to be commercially unviable, given the depth of reserves and technology available at time (CBSL, 2007).

Recent efforts of oil exploration commenced with a 2-D seismic survey programme carried out by TGS-NORPEC, a Norwegian oil company in the Mannar basin in 2001 and 2005. The 2-D seismic survey in the Mannar basin covers an area of 33715 sq. km divided into eight blocks. Out of these block (block 1& 8) already has reserved for India and China respectively for oil exploration.

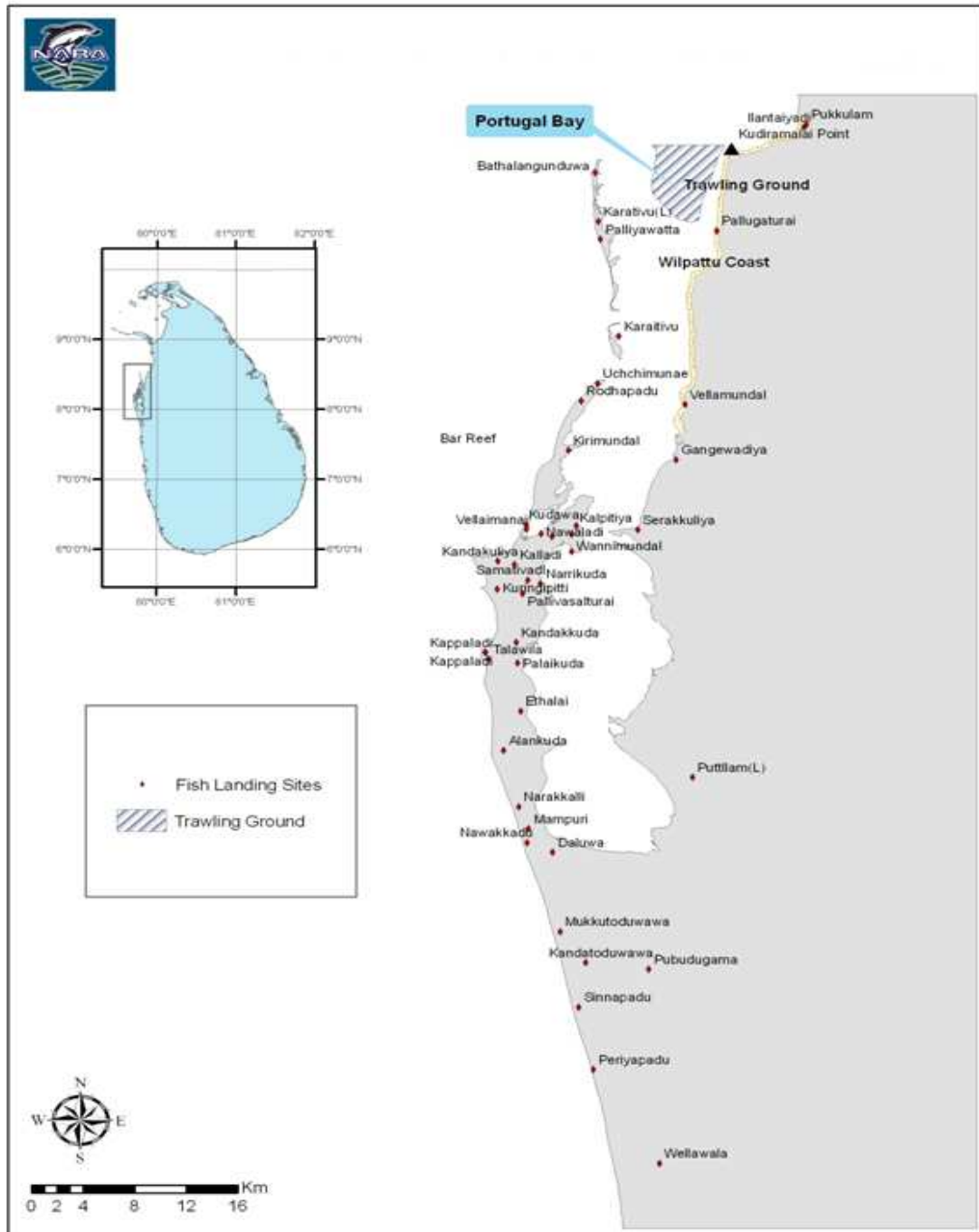


Fig: 1.2.1: Areas around Gulf of Mannar Region

Sri Lanka is highly dependent on imported crude and natural gas for meeting its energy demands. While at the same time there has been limited hydrocarbon exploration to assess potential for domestic availability and production. This exploration is thus of great national importance. Any successful discovery would lead to reduction on import of hydrocarbons and provide a boost to the economy.

### **1.3 Objective and Scope of IEE**

The scope of the IEE study has been determined based on 'Terms of Reference' assigned to NARA, professional understanding, nature of activities, geographical boundaries, marine ecosystem conditions prevailing in the block and interaction of project activities with various stakeholders.

The scope of work for the IEE includes:

- Review of regulatory and institutional framework that Cairn needs to be aware of while carrying out seismic exploration and subsequent activities in the block. Providing a regulatory framework upfront would assist Cairn in understanding compliance requirements for carrying out various activities in the block.
- Compile and analyse necessary information on environmental components like meteorology, wind & wave patterns, infrastructure, marine water quality, bathymetry, coastal & marine ecology, environmentally sensitive areas, archaeological sites, ship movements, fisheries, socioeconomic condition, security concerns, disaster proneness and stakeholder analysis.
- Identify and assess potential impacts to various environmental components as well as interactions with various stakeholders. The impacts include the ones that are adverse, beneficial, direct as well as indirect. The impacts have been identified and analysed based on professional judgement, and application of mapping tools like GIS.
- Propose mitigation measures for adverse impacts, suggestion on good practices, emergency preparedness and response, disaster preparedness plan and stakeholder management.



#### **1.4 IEE Methodology**

The IEE has been carried out keeping in mind existing regulatory requirements and in line with Cairn's corporate procedures and guidelines. The baseline data on various environmental components have been compiled from NARA's resource base as well as from various other recognised sources. It is a general practice to base the EIA for seismic surveys on available information.

The identification and assessment of impacts is based on professional judgement, simulation methods and application of mapping techniques like GIS. Distance of the block from various protected areas has been analysed so as to plan the survey accordingly.

An environment and social impact management plan has been developed to take care of adverse impacts and suggestions have been made on good practices. Recommendation on emergency preparedness and response plan as well as disaster preparedness has been covered separately.

#### **1.5 Structure of the Report**

The report has been structured in a manner to cover the complete scope of this IEE. The following sections of this report covers regulatory and institutional framework, project details, baseline environmental & social condition, assessment of environmental & social impacts, environmental & social management plan and response to emergencies & disasters. Maps, charts, tables and photograph has been used for easy reference. The report covers the following chapters:

Chapter 1	:	Introduction with Regulatory & institutional framework
Chapter 2	:	Project description
Chapter 3	:	Description of existing environment
Chapter 4	:	Environmental Impacts
Chapter 5	:	Mitigatory Measures
Chapter 6	:	Environmental Management Plan
Chapter 7	:	Conclusions and Recommendations
Chapter 8	:	References

# CHAPTER 2

## DESCRIPTION OF THE PROJECT

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### 2.1 History of Exploratory Surveys for Petroleum and Geotechnics

Oil exploration work in north-west Sri Lanka has been started from 1973 by the Soviet firm Techno-import. They have drilled three stratigraphic wells based on geophysical data gathered from the works carried out in Palk Bay and Mannar Island. The test wells were found to be of low potential but there was evidence of hydrocarbons in Lower Tertiary, Upper Cretaceous and Lower Cretaceous successions. In addition that rock successions, sand and limestone rocks were also observed throughout the succession. Two other test wells which were located at Delft and Palk bay in 1974, indicated the presence of a thick succession of clays, siltstone, sandstones and limestones ranging from Lower Cretaceous to Pliocene period. In addition to these well data, seismic data suggested the presence of structural features favourable to the accumulation of oil and gas namely stratigraphic trap. Soil cover of the coastline along the proposed area is dominant with dune sands with thickness varying from 1.90m to 5.40meters. The Geotechnical works were done by National Building Research Organization (NBRO) revealed that the soil profiles of boreholes with an extent to a distance of 2.5km from the shoreline. It also revealed that the sand deposits along the boreholes mainly composed of brown to grey, fine to medium grained angular particles with little or no plasticity.

The results from the same study shows that the deposit is gradually varying beyond 2.5km and the soil cover was found to be a dark grey, fine to medium grained sand with traces of clay down to a depth of 4 m from seabed. Also, they have noticed the sand deposit is underlain by a thick bed of sedimentary limestone which belongs to Miocene period. The borehole interpretation of this area indicates the presence of large cavities in the order of 1 to 2 m width and zones of moderately to highly karstic limestones. The karstic feature of the limestone is extended from shallow depth to entire borehole and Rock Quality Designation (RQD) is less due to such solution cavities (Offshore Geotechnical Engineering study, 1998).

### 2.2 The Petroleum Industry in Sri Lanka

The available information from Ceylon Petroleum Corporation (CPC) indicates a steady increase in demand for Petroleum Products over the years with a slight decrease in demand in 2005 as

well as in 2008 (Table 2.1) probably due to the current World Economic crisis that has affected the developed as well as developing countries, leading to recession in many countries around the world. While the oil imports have always been a major drain on the economy, development activities and the general improvements in living standards have resulted in increase in demand for petroleum products from industry, power generation and transportation in particular.

**Table 2.1 IMPORT OF PETROLEUM PRODUCTS FROM 2004 TO 2008**

TYPE OF PETROLEUM PRODUCT	UNIT	YEAR				
		2004	2005	2006	2007	2008
CRUDE OIL	MET. TONS	2,200,734	2,008,408	2,157,039	1,938,656	1,853,983
	MET. TONS	19,170	14,517	28,050	20,740	-
AUTO DIESEL	MET. TONS	939,343	715,741	746,864	1,020,057	868,418
PETROL	MET. TONS	137,643	159,652	163,613	208,764	204,675
FURNACE OIL	MET. TONS	-	270,761	157,709	191,809	266,946
JET A-1	MET. TONS	200,725	200,807	223,227	161,852	193,523
AVGAS	MET. TONS	137	103	163	196	178
BITUMEN	MET. TONS	-	8,895	25,487	27,563	48,000
<b>TOTAL</b>		<b>3,497,752</b>	<b>3,378,884</b>	<b>3,502,152</b>	<b>3,569,637</b>	<b>3,435,723</b>

Source: Ceylon Petroleum Corporation

The Ceylon Petroleum Corporation has forecast that there will be an annual increase in demand of approximately 5-8% annually, for most of the petroleum products up to the year 2012.

### 2.3 The Proposed Survey

The Government of Sri Lanka has granted Cairn Lanka Pvt. Limited the block SL-2007-01-001 ( Fig: 2.3.1) in the North Western Marine Area of Sri Lanka to conduct Seismic Surveys to assess the potential availability of Petroleum Resources within the territorial boundaries of Sri Lanka. Cairn Lanka Pvt. Limited proposes to carry out 1450 Square kilometres of 3D seismic survey in the block during this exploratory survey. The block area is approximately 3000 sq km with depth varying from 50m to 1800m. It is located to the NW of Colombo off the Puttalam/Kalpiya Peninsula in the Gulf of Mannar (Table 2.3.1). The distance of the block from the North Western Coast is some 6 km to more than 15 km from the low water line. The southern end of the project area is just north of Talawila and the western boundary extends to the Indo-Lanka maritime boundary.

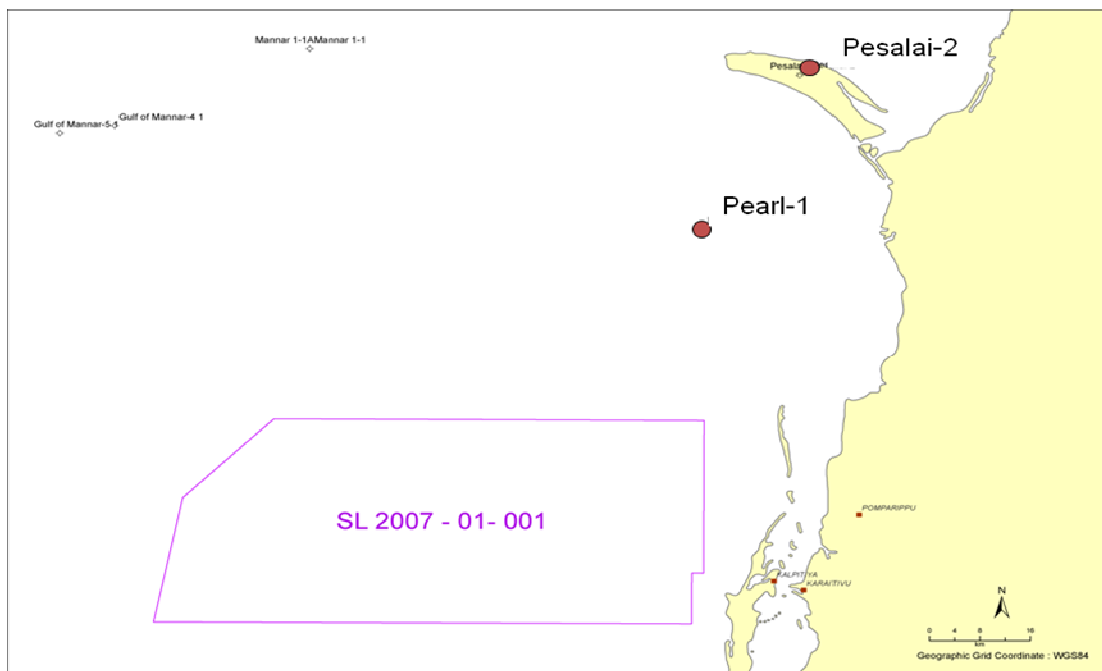
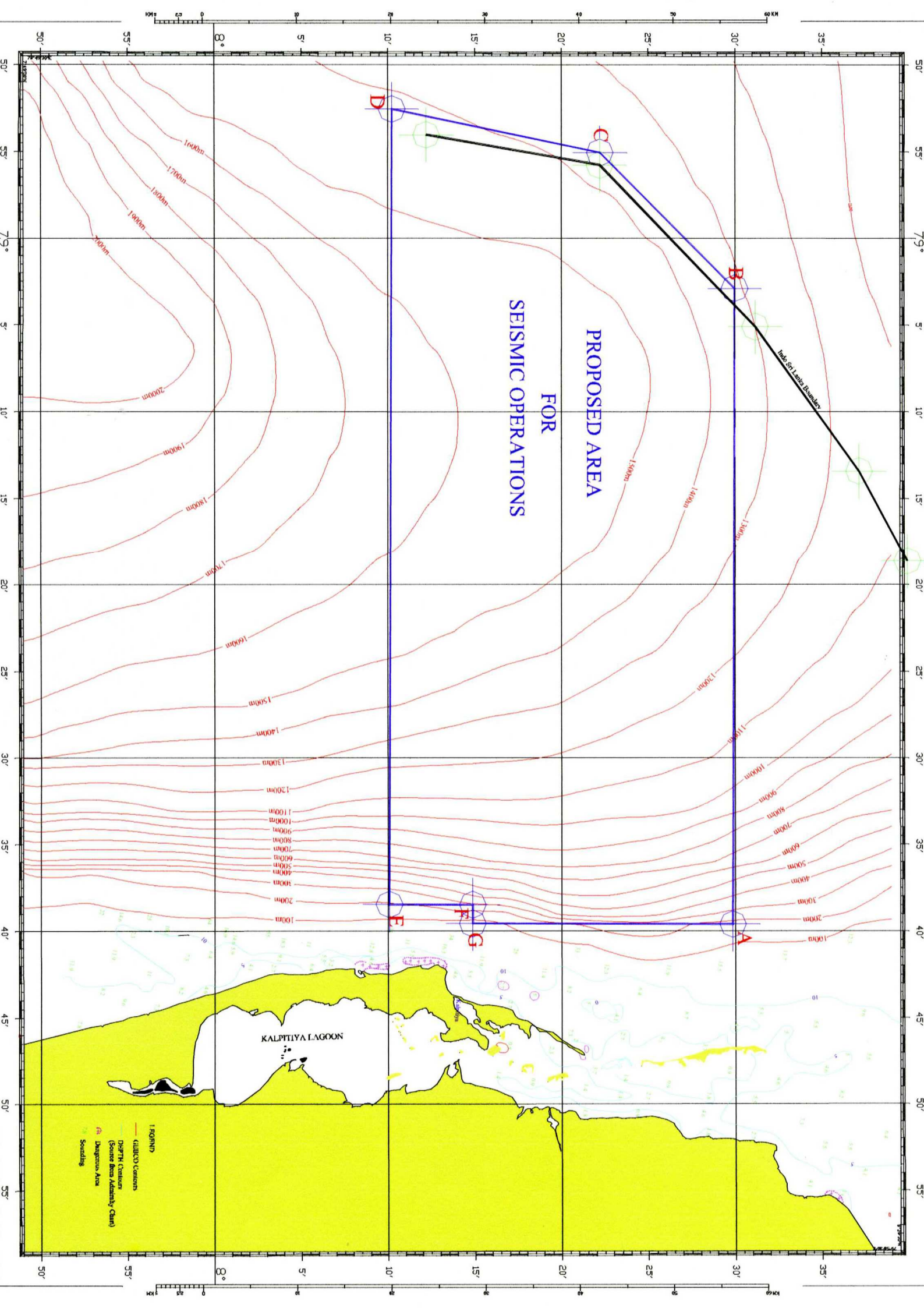


Fig 2.3.1: The Project Area

The detailed bathymetry based on the coordinates in Table 2.3.1 indicates that the western boundary of the project area is close to the Bar Reef Marine Sanctuary.



**Table 2.3.1: Coordinates of Project Area**

Point	Long				Lat			
	Decimal Degree	Degree	Minute	Second	Decimal Degree	Degree	Minute	Second
A	79.66	79	39	36	8.5	8	30	0
B	79.048	79	2	52.8	8.5	8	30	0
C	78.918	78	55	4.8	8.37	8	22	12
D	78.877	78	52	37.2	8.17	8	10	12
E	79.642	79	38	31.2	8.17	8	10	12
F	79.642	79	38	31.2	8.25	8	15	0
G	79.66	79	39	36	8.25	8	15	0

As seen from the sketch of the exploratory block, the project boundary includes the Indo-Lanka maritime boundary on the West, The Gulf of Mannar to the North and South and is off Bar Reef marine Sanctuary to the East.

Kalpitiya is the closest town to the block boundary and is approximately 11 km from the south-eastern boundary of the block. Kalpitiya has a fisheries harbour located within the Puttalam Lagoon. Access to Kalpitiya could be by Road (Via Colombo-Puttalam road turn west at Palavi) or Sea. There is a rail link from Colombo to Puttalam which is 40 km from Kalpitiya. Colombo Harbour which is approximately 180 km from Kalpitiya and is the largest commercial harbour in Sri Lanka. There are also minor fisheries landing sites at Chilaw and Negombo which abut the Colombo-Puttalam highway. The closest airport is the Bandaranaike International Airport which is about 30 km North of Colombo and 150 km South of Kalpitiya. The protected areas around a distance of 50 km of the project area is given in Fig. 2.3.2. This figure indicates that the Bar Reef Marine Sanctuary and the Wipattu National Park fall within the indicated radius.

79°0'0"E

80°0'0"E

### Protected Areas within 50 Km Boundary from the Boundary of the Seismic Survey Area



9°0'0"N

9°0'0"N

Gulf of Mannar

Mannar

Venkala

Alpitu

Silavatturai

Musali

Aruvi Aru

Kal Aru

Bar Reef Marine Sanctuary

Kuchchaveli Point

Karativu

Willpattu National Park

Madaragudi Aru

Kala Oya

Kalpitiya

Vannatevillu

Mi Oya

Talaella

Puttalam

8°0'0"N

8°0'0"N

2000

1000

500

200

20

10

5

2

1

0.5

0.2

0.1

#### Legend

----- Bathymetrical Contours

— River

Seismic Survey Area

Sea Area Within 50 Km Boundary

50 Km Area from Survey Boundary

1 cm = 9 km



79°0'0"E

80°0'0"E

## 2.4 Seismic survey process:

The marine seismic survey process consists of sound waves produced on the surface of the sea which pass through the sea and are reflected by subsea geological layers to receivers (Streamer) which are towed behind the survey vessel. The time it takes for these waves to be reflected back from sub seabed geological formations, as well as the energy content of these reflected signals, provides a basis for evaluating the structure and properties of the rocks below the seabed. Seismic surveys utilise, special ships that tow air guns (source) and pressure sensitive hydrophone receivers located in streamer cables. The air guns fire, compressed air-based sound pulses (sound waves) at regular intervals, typically every 25 meters as the vessel moves. The length of the streamers vary from 4 – 8 Kms. and for 3D seismic surveys 6-10 streamers in parallel towed at a depth of around 7 m from the vessel. Streamers are typically 100 meters apart and are spread out by two doors at each end of the streamer array which keeps the streamers in position. The survey vessel, typically up to approximately 100+ metres long travels at a speed of around 4 – 5 knots (approx. 10 Km/hr) when recording data. Vessels are self contained and have operational endurance from 30 to 90 days. Seismic vessels often operate with a support vessel which can transport personnel, spares and consumables supplies, to ensure smooth operation of the main vessel in addition to a fleet of small chase vessels (typically local fishing vessels) to ensure no obstruction takes place to the main survey vessel and its streamers by other vessels. Approximately 1 km wide swath has to be clear of fishing boats, nets etc to allow the vessel and streamers to pass safely.

A typical survey vessel operates with around 45-60 personnel onboard who would all be considered essential for 24 hour a day operation and consist of 20 ship crew with 20-30 seismic management and technical staff and client representatives. The duration of the seismic operation in the SL block is expected to be around one and half months.



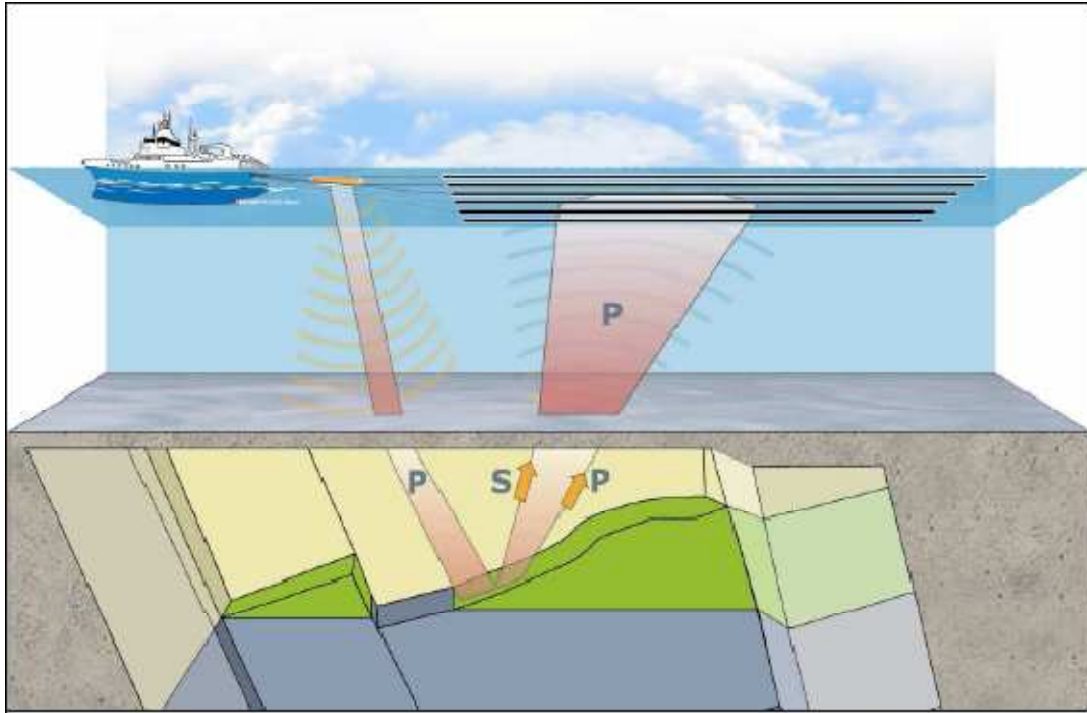
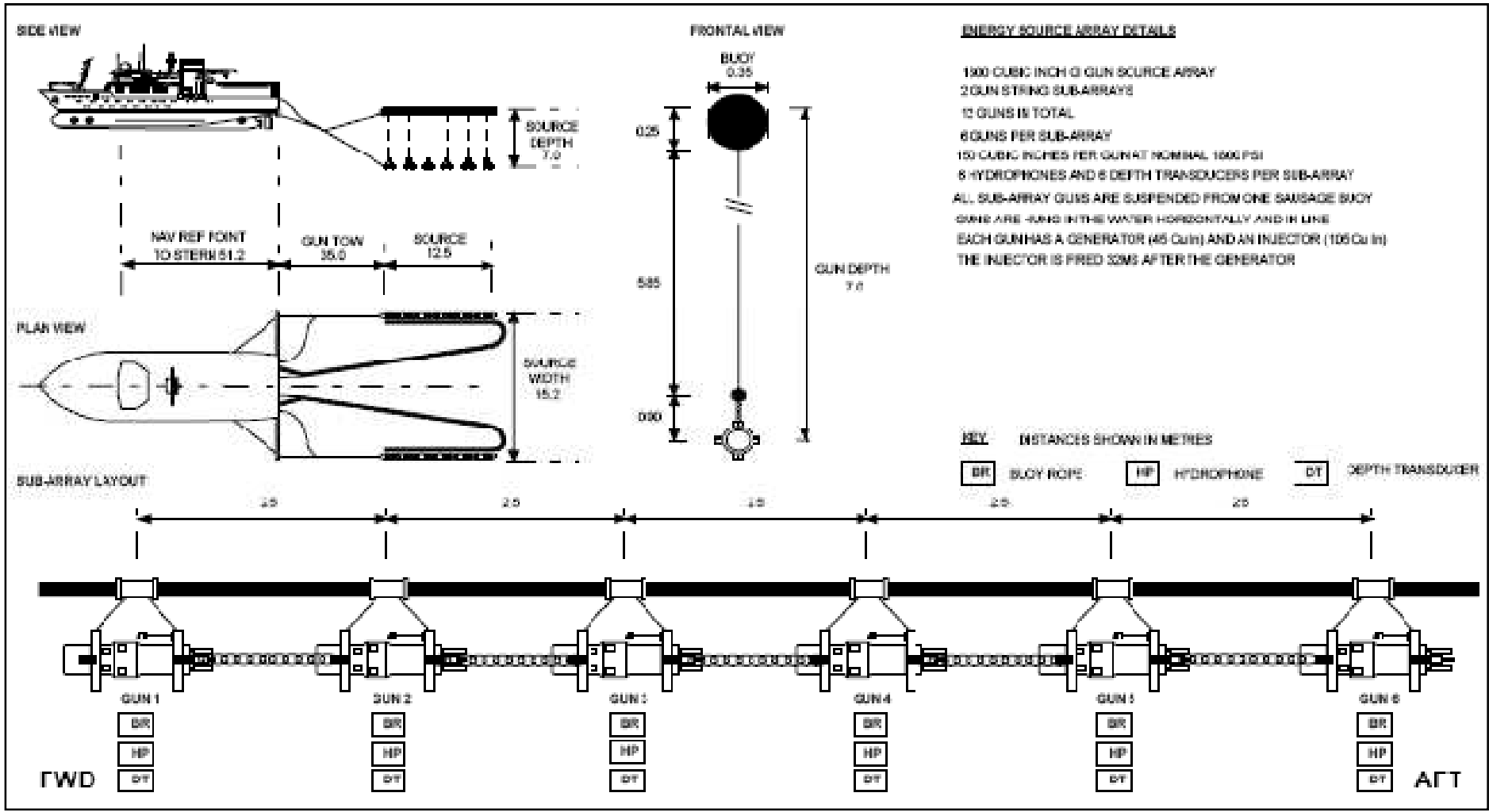


Fig 2.4.1: Schematic Diagram of Seismic Pulse Path

## 2.5 Air gun Source:

An air gun source is a mechanical device that stores high pressure compressed air in a chamber and releases it suddenly through ports into the sea in response to an electrical trigger. When the air escapes, the resulting bubble releases energy which travels into the subsurface rock structures and is reflected back. Air gun capacity typically vary from 10 cu in (0.16 litres) to 500 cu inches (8.21 litres) in volume of air discharged. 10-20 such guns in arrays are used during 3D seismic survey. By putting several air guns together into an extended air gun array, the overall chamber volume can be as much as 4000 cu in. A typical layout of air gun sub array has been shown in the following figure: 2.4.2.



## 2.6 Streamers:

The 4 – 8 km streamers are hollow flexible tubes filled with refined paraffin some of the seismic crew use foam filled streamers as well. The streamers have hydrophones (receivers) related electronics and cabling together with navigation instruments that feed data to the recording room aboard the survey vessel. The streamers are located by vanes called “doors” located at the extreme front of the streamers and held by cables towed by the survey vessel.

## 2.7 Sound waves:

The frequency of a energy wave is the number of pressure or particle fluctuations per second, measured in hertz (Hz). The human ear is sensitive to sound pressure and can normally detect sounds between 30 and 20000 Hz. Seismic signals generally contain sound energy where most of the energy is at frequencies below 200 Hz. Single air guns generate a frequency range of 5-200 Hz, while the comparable range for multiple gun array fired simultaneously is in the order of 5-150 Hz. The sound pressure for individual frequencies or bands varies, however the maximum level for falls between the range typically 10-80 Hz.

## Discription of Facilities in Survey Vessel

**Facilities within the main vessel:** As indicated earlier the seismic vessels used for 3D surveys are self sustaining. There are all facilities to maintain continuous operations for 30 – 90 days. Some of the facilities that are related to environmental impacts are as follows:

***Water treatment plant:*** There is Reverse Osmosis (RO) plant that treats sea water into potable for domestic consumption. The resulting RO reject residue is treated at the effluent treatment plant also installed in the vessel.

***Effluent treatment plant:*** The effluent treatment plant treats all types of waste water generated in the vessel i.e. RO reject, sewage, bilge water after oil removal (water collected at the bottom of the vessel hull which may contain oil from the machinery rooms) and showers, washing galley and floor wash water. The solids are separated in a centrifuge and stored in closed containers.

The treated effluent is tested to meet the highest international MARPOL standards before being discharged into the sea. The oil from the bilge water is separated and incinerated.

**Incinerator:** The incinerator is used to incinerate paper and oil separated from bilge water.

**Storage:** There is substantial storage facility for fuel, water, chemicals, cleaning reagents, paints, solvents, paraffin, equipment spares etc. There are other facilities like the engine room, control room, helipad, cabins etc. that may not be of great interest from the environmental impacts point of view.

**Support vessel and fishing boats:** There will be a support vessel of around 50 m length which mainly carries equipment spares and fuel and food supplies if required. There will be locally hired 8 – 10 fishing boats that will be used for guarding the streamers to prevent other vessels approaching the streamers.

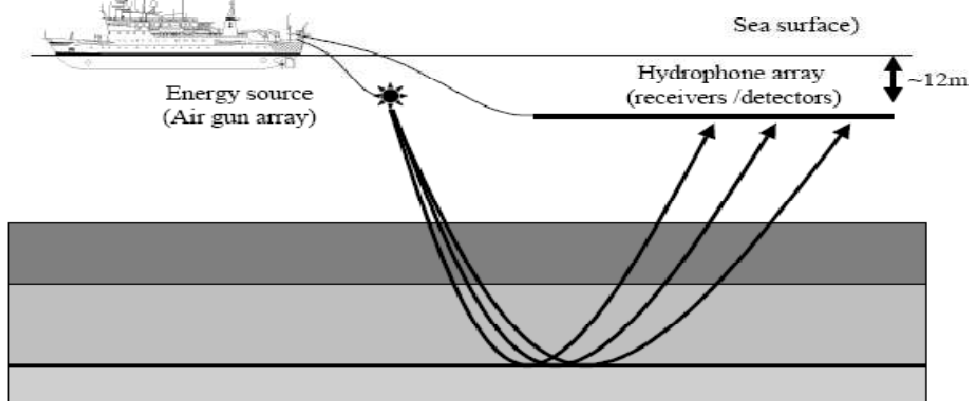


Figure 2.7.1: The basic components of a marine seismic reflection survey (the layers of the seabed are shaded) (Simmonds et al. 2004)

## 2.8 Description of the Gulf of Mannar

The Gulf of Mannar is an inlet of the Indian Ocean that lies between Southeastern India and Western Sri Lanka. It is bounded to the north east by Rameswaram Island, Adam's (Rama's) bridge (a chain of shoals) and Mannar Island which separates it from the Palk Strait. The Gulf is

130-275 km wide and 160 km long. Tampbaraparani River in India and Malwathu Oya in Sri Lanka both drain into the Gulf.

The continental shelf around Sri Lanka averages 20km with it being narrowest in the south of the island. The widest point in the northwest of the island is north of the Kalpitiya Peninsula, which lies in the Southern Gulf of Mannar, where it ranges from 30-60km (Table 2.8.1). Sri Lanka's continental shelf is divisible into a wider inner zone and narrower discontinuous outer zone which is separated by a 55m isobath. The seaward edge of the shelf occurs at a depth of approximately 90m. The shelf edge around the island is covered with a thin layer of detritus material with organic compounds consisting mainly of calcareous material, shell and coral fragments, worm tubes, echinoderm spines and foraminifera. The inorganic component consists of quartzes, sand and other coarse materials. The Gulf of Mannar, Palk Strait and Palk Bay areas act as repositories for detritus materials that are swept northwards along the west coast and southwards along the Southeast coast of India. Sand accumulation is also high (Swan 1983) in this area.

Table 2.8.1: Continental shelf morphology within the Gulf of Mannar and its surrounding areas (Swan 1983)

Location	Principal depths (m)	Shelf Edge (m)	Shelf width (km)
Adam's Bridge	<15	18-45	20
Gulf of Mannar	<15	22-45	30-40
Point Pedro	<60	119	60

## 2.9 Regulatory and Institutional Framework

A review of the Regulatory and Institutional Framework as applicable to this project indicates that since the boundaries of the project area do not fall within 1.6 km of the boundary of any National reserve, prior written approval from the Director of Wildlife is not necessary in terms of the National Environmental Act (NEA). Further, seismic survey is not listed in the list of prescribed projects under NEA. Discussion of relevant legislation below indicates that the Petroleum Resources Act, No. 26 of 2003, and regulations under it are applicable to this project.

## **2.10 Environmental legislation in Sri Lanka**

In 1980, the National Environmental Act (NEA) was enacted to serve as the main legislation for environmental protection and since then it has been amended by Act No 47 of 1980, Act No 56 of 1988 and Act No 53 of 2000. In 1983, the Cabinet of Ministers considered including in it provision for environmental assessment of development projects, which was subsequently done. Other legislation, such as the Coast Conservation Act (CCA), amended Fauna and Flora Protection Ordinance, North Western Provincial Council Environmental Statute No 12 of 1990, and the National Heritage and Wilderness Act further strengthened the regulations on the EIA process. EIA in Coastal Areas The legal requirement for an EIA was first provided in the CCA, restricted to the coastal zone. In relation to the Act the Director Coast Conservation has the discretion to identify which projects should follow the EIA process. The CCA does not specify the criteria on which such discretion would be exercised.

## **2.11 EIA in the Fauna and Flora Ordinance**

The 1993 amendment to the Fauna and Flora (Protection) Ordinance addresses the issue of EIA. Under this enactment, prior written approval from the Director of Wildlife is necessary for any development activity within one mile (1.6 km) of the boundary of any National reserve and mandates that such projects should undergo the EIA process in terms of the National Environmental Act.

## **2.12 EIA under the National Environmental Act**

Part IV C of the National Environmental Act includes provision for the EIA process. This applies only to “Prescribed Projects” which have been specified by the Minister in charge of environment and is implemented through designated Project Approving Agencies (PAAs) as prescribed by the Minister. Depending on the significance of the anticipated impacts, there are two types of reports submitted for approval, i.e. the Initial Environmental Examination (IEE) and the Environmental Impact Assessment (EIA). The evaluation of environmental impact is delegated to various government bodies, depending on the nature of the project. The EIA process is initiated by the Project Proponent (PP) and the determination of the PAA appropriate to it is on

the basis of having the largest jurisdiction over the project area, having jurisdiction over diverse unique ecosystems, within whose jurisdiction the environmental impacts are likely to be the greatest, and being the statutory authority to license or otherwise approve the prescribed project. The PP cannot perform the functions of the PAA.

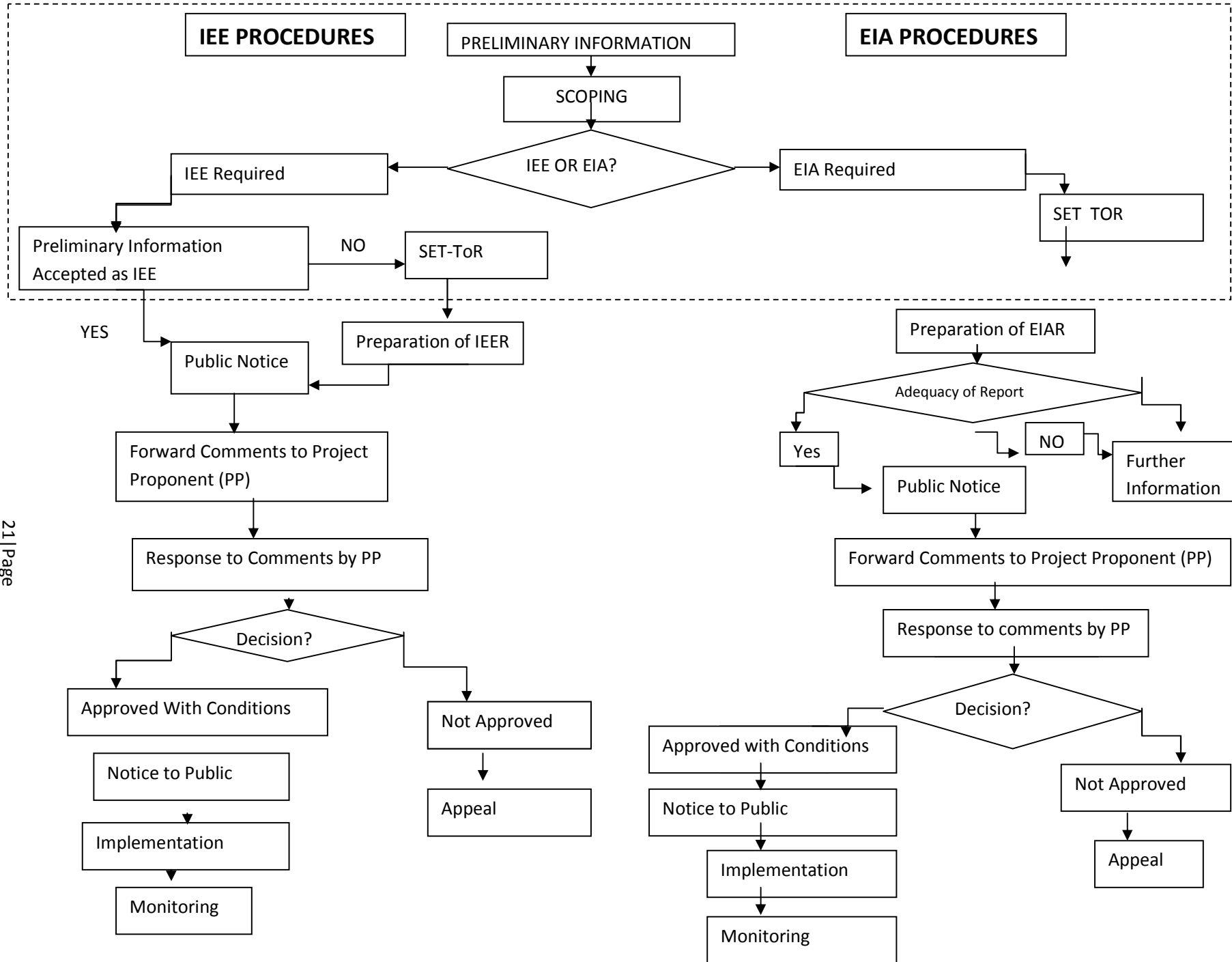
### **2.13 EIA in the Provincial Administration**

Provincial environmental protection and management was introduced by the 13th amendment to the constitution in November 1987, in Sri Lanka. So far, only the North Western Provincial Council (NWPC) has enacted legislation on environmental protection. The National Environmental Act remains suspended and inoperative within the North Western Province with effect from 10th January 1991.

### **2.14 Operating Procedure**

The EIA process is ideally made up of several steps that can be divided into two stages i.e. EIA preparation and EIA evaluation. Submission of preliminary information, environmental scoping and EIA preparation falls into the first stage, which is essentially a technical exercise (Fig. 2.14).

In Sri Lanka the project approving agencies operate, for the purpose of management, at three levels; i.e. EIA Cell, EIA Oversight Committee and EIA Inter-agency Co-ordination Committee. The EIA cell has legal responsibility for all the decisions of the PAA in respect of the EIA process; this included the evaluation of the compliance monitoring reports in liaison with the Project Proponent and the public. The EIA Oversight Committee is comprised of the technical subcommittee and co-operating Agencies, its duties being to advise the chairman on the EIA process. The EIA Inter-agency Co-ordination Committee includes representation from all PAA, NGOs being invited as well; the function of this committee is to review the status of the implementation of the EIA process, to advise and guide the PAAs and to recommend approaches for integrating EIAs into the national policy and frameworks.





The Flow chart of the EIA process for Development projects given above is the basic procedure used by all project approving agencies in considering applications for environmental clearance.

### **2.15 Prescribed Projects**

Only “prescribed projects” are required to be subjected to IEE / EIA. The list of prescribed projects requiring an IEE / EIA under the provisions of the National Environmental Act are given in the act.

The proposed Seismic Survey is not listed as a prescribed project in the list. However, the following related activities (numbered as in original list) are prescribed:

#### **6. Mining and Mineral Extraction**

All off shore mining and mineral extractions.

#### **14. Pipelines**

Laying of gas and liquid (excluding water) transfer pipelines of length exceeding 1 kilometer

#### **24. Petroleum and Petrochemical**

Petroleum refineries producing gasoline, fuel oils, illuminating oils, lubricating oils and grease, aviation and marine fuel and liquefied petroleum gas from crude petroleum

Manufacture of petro-chemicals of combined production capacity exceeding 100 tons per day from production processes of oil refinery or natural gas separation. As indicated earlier, seismic surveys are not specified as a prescribed project under NEA.

### **2.16 The Petroleum Resources Act, No. 26 of 2003**

The above Act and regulations formulated under it are applicable for the seismic survey. The relevant articles and sections with respect to this project are indicated below (numbered as in original list)

11. (1) In order to ensure the efficient conduct of petroleum operations within the area covered by the Development Licence issued under section 10 by the PRDC, the Cabinet of Ministers may from time to time determine the conditions to which such license shall be subject. Any amendment or variation of the conditions applicable shall also be done only with the approval of the Cabinet of Ministers.

(2) The Cabinet of Ministers may, in consultation with the Ministry of the Minister in charge of the subject of Petroleum Resources Development and the PRDC (Petroleum Resources Development Committee),

determine—

(a) the additional conditions to be attached to a Development License, for the maintenance of navigation, protection of the environment, mitigate adverse social impacts on communities and in the interest of national security; and (b) the amount of reasonable compensation to be paid by the Contractor to any person who may be adversely affected by petroleum operations conducted within the area for which the development license is issued.

(3) The PRDC shall issue a development license in respect of a designated area of an exploration block for a period that will ensure the maximum efficient recovery of petroleum resources from that area, so however, that such period does not exceed the period for which a Petroleum Resources Agreement has been entered into, in respect of such exploration block.

32. The provisions of this Act shall have effect notwithstanding anything contained in any other written law, and accordingly, in the event of any inconsistency between the provisions of this Act and such other law, the provisions of this Act shall prevail.

## **2.17 Conditions to be attached to Development Licences.**

28. Any person authorised in writing by the PRDC may at any time enter into, and inspect, any site where petroleum operations are being conducted and carry out such investigations or surveys thereon as may be necessary to ascertain whether the terms of a Petroleum Resources Agreement

or the conditions imposed in relation to a Development License or any provision of this Act or any regulation made there under are being complied with.

In addition to the provisions of this act, the guidelines issued by the PRDC for Geophysical, Environmental and Geotechnical Program/s specify that an Environmental survey be done for proposed technical programs.

### **2.18 Other Approvals and Consent**

It would be advisable to make arrangements to inform the following Government Agencies and Departments with the consent of the PRDS. A short description of proposed activities in the exploratory block and precise schedules will be useful for them to be informed and advice on appropriate measures to be taken in case of conflicts etc.

- xi. Ministry of Fisheries and Aquatic Resources Development
- xii. Department of Fisheries and Aquatic Resources
- xiii. Central Environmental Authority
- xiv. Marine Environmental Protection Authority
- xv. Ministry of Defence
- xvi. Sri Lanka Navy
- xvii. Provincial Environmental Authority of North Western Province.
- xviii. Chairman, Kalpitiya Pradeshiya Sabha
- xix. District Secretary-Puttalam and Mannar.
- xx. Divisional Secretary , Kalpitiya

# CHAPTER 3: DESCRIPTION OF THE EXISTING ENVIRONMENT

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## **3.1 The Socioeconomic profile of the communities in the project Area.**

The surrounding seas in block 1 of the oil exploration block stretches over coastal area of two administrative districts of Sri Lanka. These administrative districts are Mannar and Puttalam. The whole Mannar district and a part of Puttalam district (Kalpitiya DS Division) located aside the project area and hence the socioeconomic profile of those two respective was considered for the social & economic impact assessment of oil exploration.

### **3.1.1 Historical Background of Mannar**

Mannar means ‘deer river’ or ‘silt river’. The ancient port was known as Mahaotota in Mahawansa, Mantota, and Mahatheetha in Sanskrit, where it means the ‘great port’. In the period prior to the 13<sup>th</sup> century Mathottam or the great port, opposite Mannar on the north western coast facing the Arabian Sea was the most important trading port of the island. A large number of articles of foreign origin including coins and porcelain-ware have been excavated at Mannar by archaeologists.

### **3.1.2 Mannar district**

The district is one of the 25 districts of Sri Lanka. It is located in the north west of Sri Lanka in the North western Province. The district covers 2,002 sq km. approximately 3% of the total land area of Sri Lanka. Geographically the Gulf of Mannar is on the mainland within the arid and dry zone. High temperatures and low rainfall characterize the climate. The primary economic activities in Mannar are crop cultivation (mainly paddy), fisheries and animal husbandry. Employment opportunities in this district are highly seasonal.

### 3.1.3 Demography

Mannar district population was 103,688 in 2007. The population of the district is mostly Sri Lankan Tamil. The following table depicts population changes of Mannar district from 1971-2007.

**Table 3.1.3 Population of Mannar District by ethnic group 1971 to 2007**

Year	Sri Lankan Tamil	Sri Lankan Moors	Sinhalese	Other	Total
1971 Census	55,353	20,878	3,568	83	77,882
1981 Census	68,128	28,464	8,710	1,588	106,940
2001 Estimates	92,911	5,038	16	0	97,665
2007 Estimates	95,560	8,073	55	0	103,688

Source: Department of Census & Statistics, Sri Lanka

### 3.1.4 Administrative units

Mannar District is divided into five Divisional Secretary's Divisions (DS). The DS divisions are sub divided into 53 Grama Niladhari (GN) Divisions

**Table 3.1.4. DS Division wise population in Mannar District**

DS Division	GN Division	Population
Madhu	17	4,498
Mannar	49	51,249
Manthai west	36	26,741
Musali	20	0
Nannattan	31	21,200
Total	153	103,688

Source: Department of Census & Statistics, Sri Lanka

## 3.2 Livelihoods of the people in the project area

### 3.2.1 Agriculture

Agriculture is one of the key economic sectors in the district providing livelihood over 15000 families, approximately 67% of the population. Out of a land area of 200,206 ha, the total cultivable land is 37.160 ha (19%). Over 65% is under forest cover. The pattern of agriculture practiced is dependent on climate and traditions.

**Table 3.2.1 Crop distribution in Mannar District**

Perennial crop	Cultivable land (%)
Palmyrah	7
Coconut	7
Cashew	6
Highland crops	9
Paddy	62

Source: Department of Agriculture, Sri Lanka

### 3.2.2 Fisheries

Fishing is major contributor to the local economy of Mannar district. It provides principal source of livelihood for a large portion of population, particularly in Mannar and Musali Divisions. Thus nearly 50% and 40% of families respectively rely on fishing activities with over 9030 families in 41 villages engaged in fishing.

**Table 3.2.2 Basic Marine fisheries Information in the Project Area, 2007**

	<b>Mannar</b>	<b>Puttalam</b>
Number of fishing villages	41	108
Fish landing centres	50	66
Fishing households	9,030	12,500
Active fishermen	10,930	13,700
Fishing population	42,440	56,840
Total number of fishing crafts	2,315	4,638
Total fish production(MT)	9,170	17,110

Source: Sri Lanka Fisheries Year Book, 2007

The Gulf of Mannar is an ecosystem of high biodiversity and hence it is a rich area for fish resources. There are more than 42,000 fishing population and around 10,000 active fishermen conducting fishing operations in the Mannar basin. A large number of fishermen from adjacent Puttalam district too are engaged in fishing in the project area. Therefore, approximately 60,000 people are dependent on fish resources of the project area. In 2007, the total fish production from Mannar district was about 9,170 mt while Puttalam district produced 17,110 mt. This shows that the fishing in the Mannar basin is vital for the livelihood of people living in both Mannar and Puttalam districts. A large number of allied activities are linked with fishing. For an instance, dry fish making is an allied activity taking place in the Mannar district in medium scale. More over, a large number of people are linked in the chain of fish marketing and processing. So the fisheries are of immense importance for the well being of communities living on the edge of the Mannar basin.

### **3.2.3 Other income generating activities**

Though the mainstay of the economy is agriculture and fisheries, salt production and animal husbandry are practiced in the Mannar district as subsidiary livelihoods. Until 1989, Mannar Salterns produced between 3500 and 4000 Mt of salt per year. However, now its capacity has reduced drastically to 1251 Mt per year. Currently it supplies salt to fishing communities for dry fish production, to the ice factory at Pasalai and to Multi-purpose Co-operative Societies (MPCSs) and private sector for consumption.

### **3.3 Site Description and existing Physical Environment**

The survey area is located within the Mannar Basin which lies between north western part of Sri Lanka and the Indian coastline. The minimum and maximum water depths of the study area, ranging from 30 m to greater than 3000m, lies immediately to the south of the Cauvery Basin which is identified as a productive zone for both oil and gas in adjacent Indian jurisdiction.

The fauna within the seismic survey area (i.e. inside the offshore block SL-2007-1-001) and in adjoining and neighbouring areas comprise of important fisheries resources. The Bar Reef marine sanctuary is also located in the area. The Bar Reef is one of most productive coral reef systems as well as it is unique in terms of its bio diversity. About 400 species of reef fish and numerous species of crustaceans including commercially important species such as lobsters and sea cucumbers have been found from the area. The Puttalam Lagoon, a highly productive estuary in the Northwest coast of Sri Lanka is also located close to the block.

The Fig. 3.3.1.1 and Fig. 3.3.1.2 show the general bathymetry and geo-morphology of offshore Kalpitiya area. The Fig. 3.1 shows the bathymetric variations in the study area. The available



bathymetric data indicates the depth variation is 30m to 1800 meters. The morphological map of the study area indicates a narrow continental shelf which is about 5 kilometres.

### 3.3.1 Topography

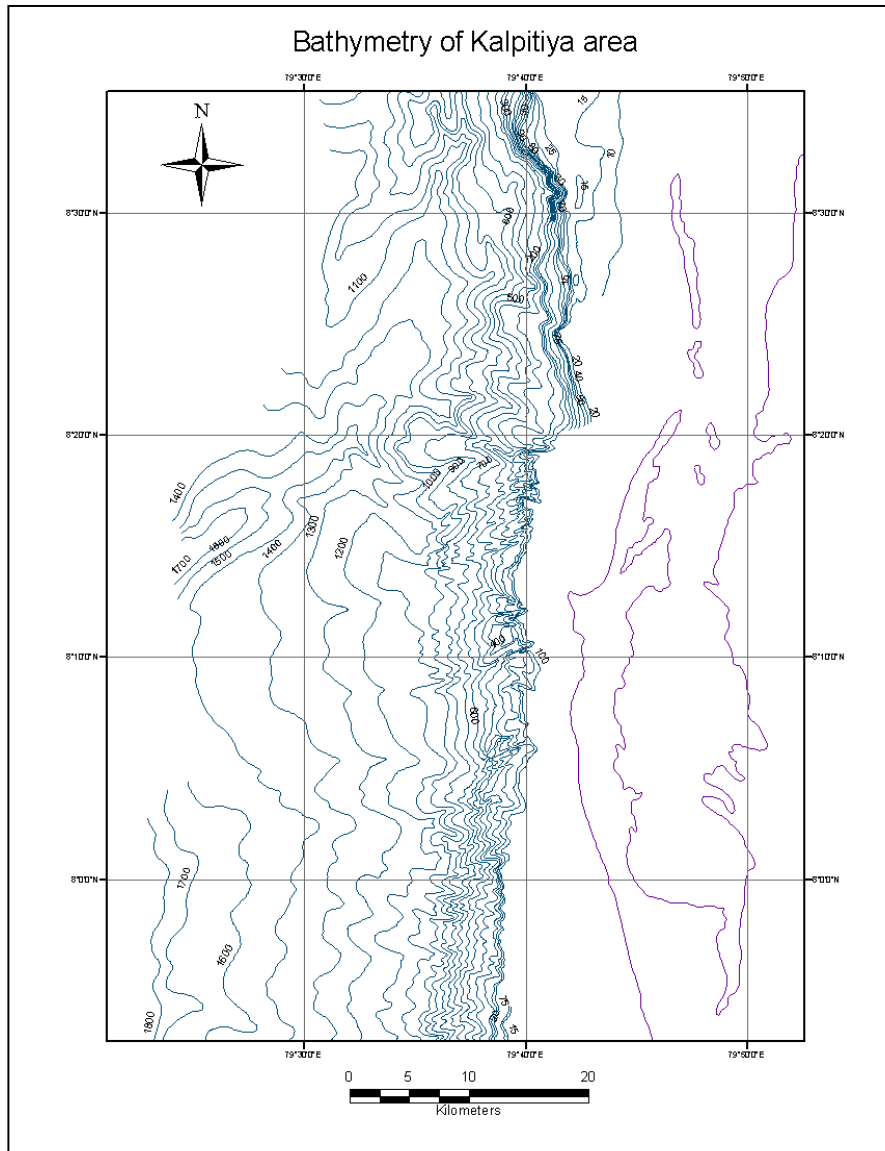


Fig 3.3.1.1. Bathymetric map of the proposed investigation area

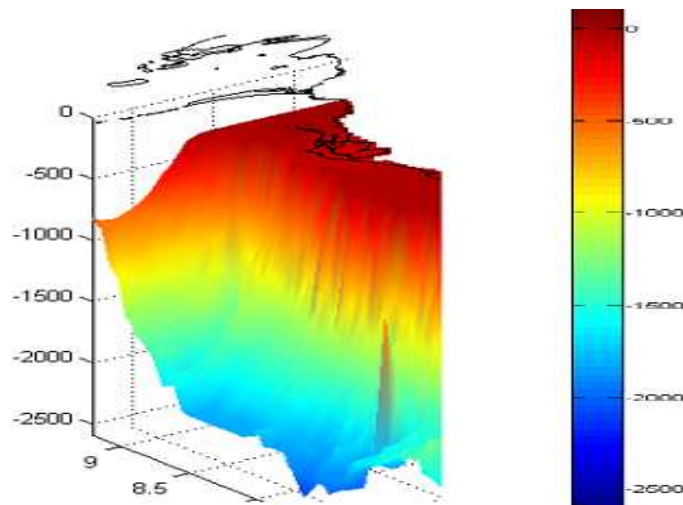


Fig 3.3.1.2 Digital elevation model of Kalpitiya including project area

### 3.3.2 General Geology of Sri Lanka

The crust of Sri Lanka predominantly composes of crystalline, non-fossiliferous rocks of Precambrian which belong to one of the ancient part of the earth's crust. The Country consists of three major crystalline rock units called Highland Complex (HC), Vijayan Complex (VC) and Wannu Complex (WC). Those are named due to lithological variation in rock units. The crystalline crust of the country represent the nine tenth of the total area.

The main rock types in the Highland Complex are interbanded meta sedimentary rocks and chanoctitic gneisses. The Wannu and Vijayan Complexes consist of groups of gneisses, granites and mixture of both. The rest of the country composed of some sedimentary formations specially in northwestern portion formed as Mesozoic (Jurassic), Tertiary (Miocene), and Quaternary (recent) sedimentary formations (some fossiliferous deposits) (Cooray, 1984).

Northwest of Negombo to Mankulam line is the largest extent of tertiary sedimentary rocks in Sri Lanka. This is Jaffna limestone of Miocene age, consisting of thick limestone together with calcareous sands and mud. The Miocene rocks, like the Jurassic, rest on an eroded basement of the crystalline complex (Cooray, 1984).

### 3.3.3 General geology of the area

The available information on this study area is predominantly over the Quaternary sand deposit, overlaid by Miocene limestone. Other common coastal features in this area are sand dunes which are strongly oriented SW-NE direction representing monsoon wind patterns. The recent and past exploratory evidence provide vertical extension of sedimentary succession is about 2600meters (Offshore Geotechnical Engineering study, 1998).

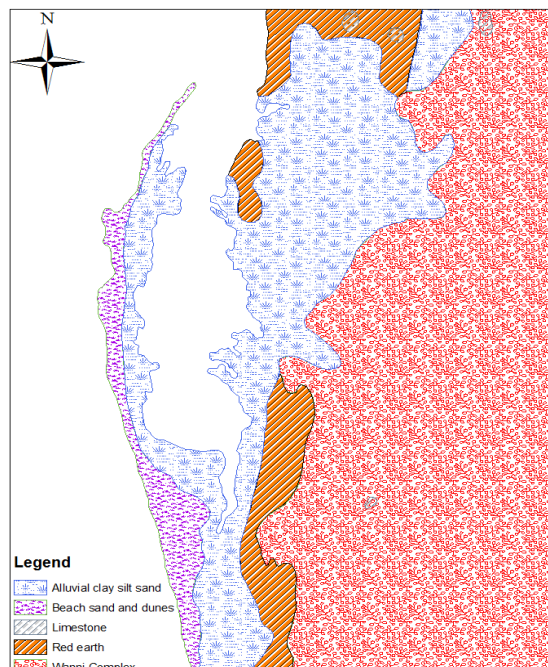


Fig 3.3.3 Geological map of the study area

Limited offshore geological works have been done in this area. According to the available surficial sedimentological information on the area shows mainly (Fig:3.3.3) terrigenous coarse sand, yellowish brown sands, rust brown ferruginous, predominantly quartzose with fossils (> 10%  $\text{CaCO}_3$ ). Also, sediment samples collected from Puttalam lagoon area consists of soft silty mud, sandy mud, grey green, green grey brownish black with shell debris, semi liquid contains Glauconite. In addition to those results, some small patches in the offshore area consist of rocky bottom, sandstone or crystalline rock adorned with or without a macro relief of calcareous algal ridges and cusps (Sedimentary map, 1985). The recent studies carried out by NARA in Palk

Strait and Mannar Bay area shows that the surficial sediment of this area represented by the coarse grained sand (87.5%) with large amount of shell fragments (0 to 1 $\phi$ ). Total organic carbonate content of this area varies from 0.13 to 2.73. The carbonate study shows that the average carbonate content of the surface sediments of this area is about 30 percent (Jinadasa, 2006).

### **3.3.4 Tectonic setting**

The Mannar basin developed during at least two periods of rifting and associated continental breakup as part of the multiphase breakup of Gondwanaland during the Mesozoic (200Ma before). The first phase began as an originator to the commencement of seafloor spreading in the Bay of Bengal and was followed by a second phase of rifting associated with the detachment of Madagascar from the western side of the developing Indian sub-continent, ending in a second breakup unconformity at the top of the Late Cretaceous (100Ma). Subsequently the Sri Lankan margins entered a phase of subsidence, driven by thermal contraction (Baillie et al, 2002).

The plate collision between Indian and Eurasia occurred in the lower Eocene and it began around 53 Ma. Together uplift and erosion of the Himalayas made rapid deposition of sediments into the Bay of Bengal. Also, influx of terrigenous sediments into deposition centres of the bordering Indo-Sri Lanka landmass, including the Cauvery Basin and the Mannar Basin (Baillie et al, 2002). Mannar Basin is lying between northeastern Sri Lanka and the Indian coastline, in water depths ranging from 30-3,000m, contains over six seconds (Travel time) of Late Jurassic-Early Cretaceous to Recent sediments. There are four tectono-stratigraphic packages have been recognised during previous studies which are consistent with the tectonic setting of the region. The oldest sedimentary sequence 1 was deposited during the initial synrift phase of basin development, prior to the commencement of seafloor spreading of the west of Sri Lanka within the Bay of Bengal. The sequence 2 sediments were deposited during the rift and sag phase, after start of seafloor spreading in the Bay of Bengal. The sequence 3 was deposited during tertiary

sag phase of basin development, which terminated in the late Miocene following compression. Subsequent basin-wide regression resulted in deposition of sequence 4 (Baillie et al, 2002).

### 3.3.5 Air temperature

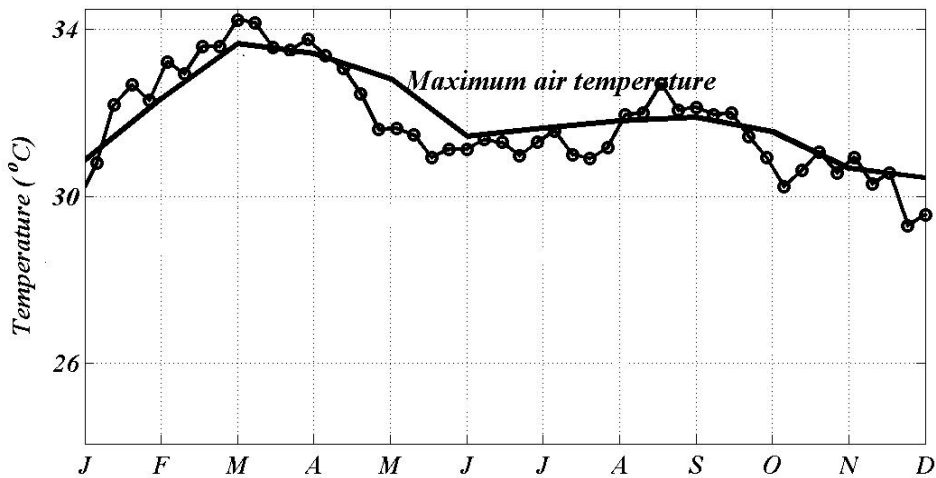


Fig. 3.4 Monthly and weekly means of air temperature

Air temperature is strongly seasonal with two maxima, one in March, during the first inter-monsoon period and one in September during the second inter-monsoon (Fig. 3.3.5). The maximum air temperature fluctuates between 30 to 34°C with a mean air temperature of 32°C. The lowest temperature of 30.5°C is recorded during the northeast Monsoon (November to early January). The air temperature increases during the First Inter Monsoon and reaches its maximum of 33.5°C in March. The temperature decreases with the onset of the Southwest monsoon and reaches a mean value of 32°C. The diurnal range in the air is typically from 6-12°C.

### Air Quality and Noise

Some data for areas far from the project boundary and measured on land is given in Annex II.

### 3.3.6 Rainfall

The site is situated in the belt of monsoon climates and governed by its tropical location as well as by the monsoonal regime, thus rainfall exhibits strong seasonal variation. The coastal belt falls under the dry zone and receives a long-term mean precipitation of about 1200 mm y<sup>-1</sup> (Arulananthan et al. 1995). More than 50% of the total rainfall is received during the Second Inter Monsoon and Northeast Monsoon (October to December) Fig. 3.3.6).

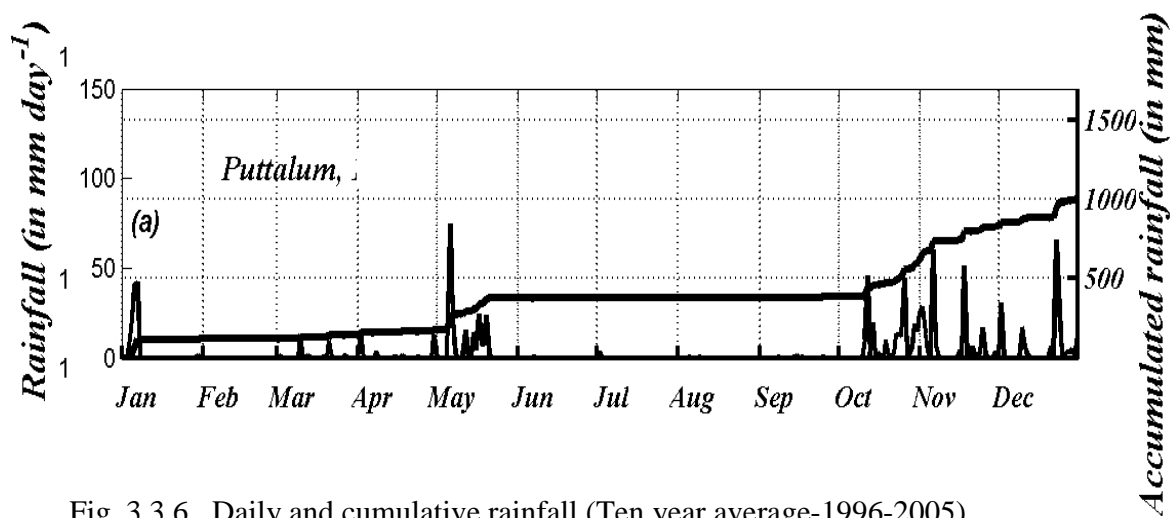


Fig. 3.3.6 Daily and cumulative rainfall (Ten year average-1996-2005)

### 3.3.7 Wind

The study site is under the monsoonal regime; two monsoons and two transitional periods in-between, four seasons are identified. They are the North-East monsoon from December to February, First inter-monsoon from March to mid May, South-West monsoon from mid May to September and Second inter-monsoon from October to November (Fig. 3.3.7).

The mean wind speed during the Southwest monsoon is about 6 m s<sup>-1</sup>, during the other period the average speed is 3 m s<sup>-1</sup>.

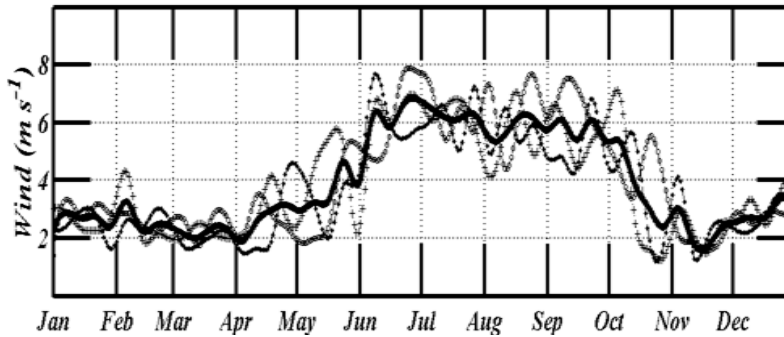


Fig. 3.3.7 Weekly mean wind speed (1990-92)

### 3.3.8 Evaporation

The average annual pan evaporation is  $1900 \text{ mm year}^{-1}$ . The pan evaporation during the southwest monsoon and the inter monsoon period following thereafter is higher ( $5.5 \text{ mm day}^{-1}$ ) than that of northeast monsoon ( $3.5 \text{ mm day}^{-1}$ ). The annual minimum and maximum are  $1.2$  and  $7.1 \text{ mm day}^{-1}$ , respectively. The average free surface evaporation is  $2500 \text{ mm year}^{-1}$ , equal to  $6.8 \text{ mm d}^{-1}$ . Relative humidity at 08:00 hrs and 15:00 hrs are 80-90% and 70-85%, respectively.

### 3.3.9 Salinity

The Fig. 3.3.9.1 shows the monthly averaged salinity variation at the study site. The manual measurements are conducted by Digital Salinometer during 1990-92. It indicates that the salinity at the study fluctuate from 32.8 to 34.93 with an average of 33.9. In general, the salinity is low Northeast Monsoon period due to the extensive freshwater discharge by rivers into the coastal zone.

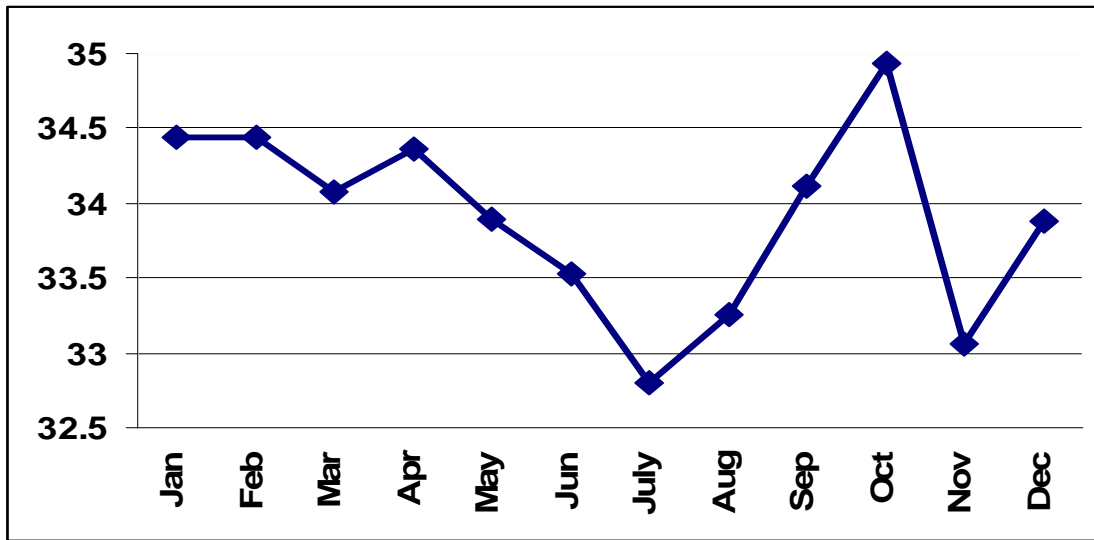


Fig. 3.3.9.1 Monthly salinity variation

Monthly CTD profiling in 2007-08 indicated (Fig.3.3.9.2 a-b) the surface salinity at the study site is 33.8 psu. Furthermore, the results also indicated that site undergoes extensive coastal; upwelling during the northeast monsoon period (November to March). The CTD profile of December (Fig. 3.8a) shows that high saline water rises to the surface due to the upwelling, while Fig. 3.8b shows the ceasing of upwelling during April.



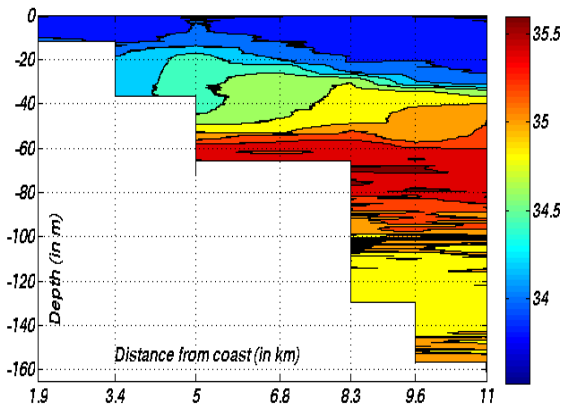


Fig. 3.3.9.2a Salinity profile – December, 2007

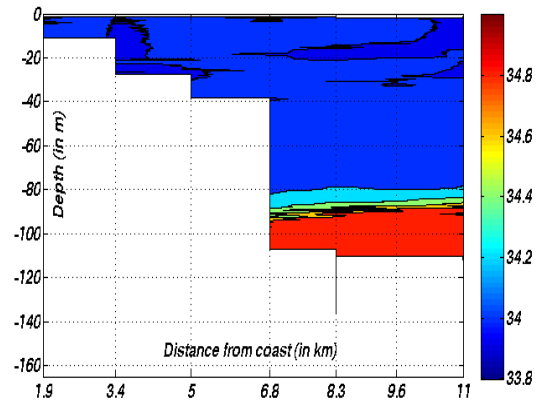


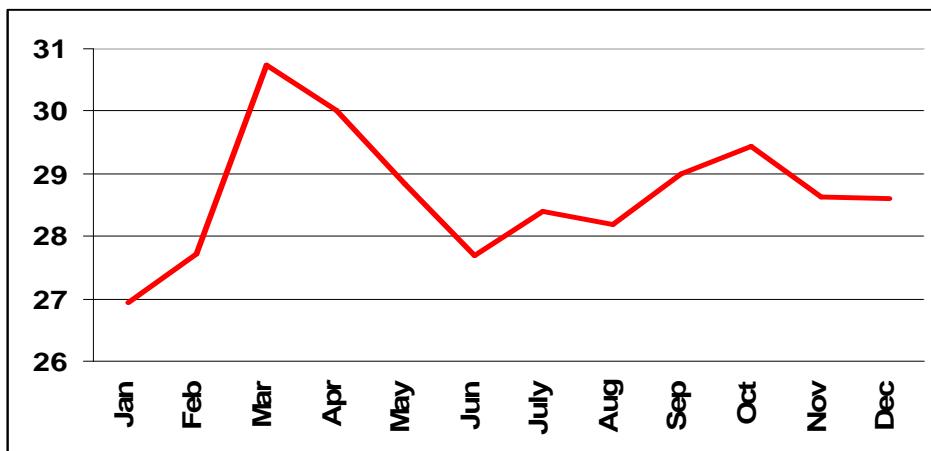
Fig. 3.3.9.2b. Salinity profile – April, 2007

### 3.3.10 Water Temperature

The average water temperature at the study site is 28.68°C with the annual fluctuation from 26.93 to 30.75°C. In general, the water temperature rise to its higher value during the first Inter Monsoon (March – April) until the onset of the Southwest Monsoon. Due to its regional phenomena including dipole heating and cooling.

The temperature profiles of study sites shows that the water temperature during the Northeast

Temperature (°C)



Monsoon (December) is generally lower than during the other periods (see Fig. 3.3.10.1 a-b). This reemphasise the fact that the study site undergoes extensive coastal upwelling during the Northeast monsoon period.

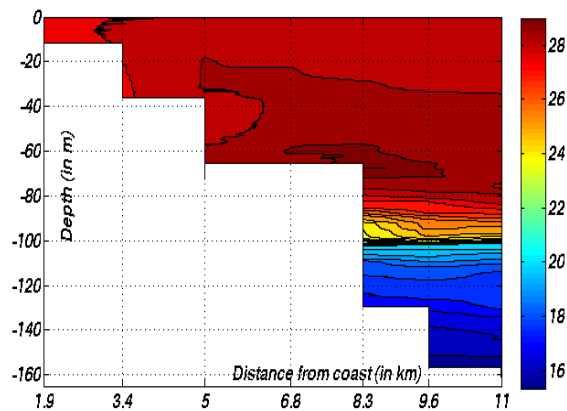


Fig. 3.3.10.1a Temperature profile – December, 2007

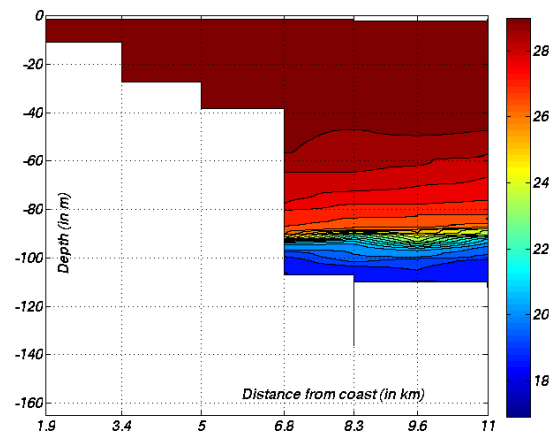


Fig. 3.3.10.1b Temperature profile – April, 2007

### 3.3.11 Mixed layer Depth

The mixed layer depth during North-east monsoon (in December) is recorded at about 70 m depth. The salinity and temperature of the mixed layer is 33.9 PSU and 28.5°C respectively. At the end of the Northeast Monsoon, i.e. during the beginning of the First inter-monsoon, the mixed layer shows higher homogeneity, however the average salinity is 0.2 is higher, while temperature is 0.5°C lower, in comparison. Furthermore, in general chlorophyll content of the water is higher and also waters at the proximity shows higher chlorophyll content, an indication of upwelling during the monsoon.

At the end of the First Inter-monsoon, the thermocline depth increases at least by 10 m. The mixed layer temperature increases by 2°C. Again at the beginning of the Northeast Monsoon, i.e.

in November the water temperature reduces by 2°C, while salinity increases by 1 PSU. The mixed layer depth varies by almost 10 m between the monsoon, deepens during the monsoon and shallows during the inter monsoon. The temperature and salinity also fluctuates by 2°C and 0.2 PSU respectively.

### 3.3.12 Nutrients

From Fig 3.3.12.2 to Fig 3.3.12.5 shows the Nutrients ( $\text{PO}_4^{3-}$ -P,  $\text{NO}_2^-$ -N and  $\text{NO}_3^-$ -N) variations among locations from coast to Offshore and their monthly average during the year.

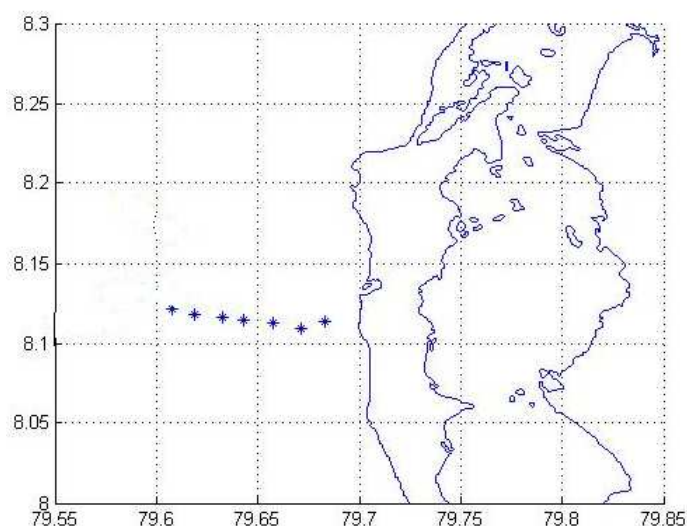


Fig 3.3.12.1. The map showing the sampling sites

#### Phosphate – Phosphorus

According to the Fig 3.3.12.2, the highest (1.0279 $\mu\text{g/l}$ ) and the lowest (0.0656 $\mu\text{g/l}$ )

$\text{PO}_4^{3-}$ -P concentrations are recorded at location number five (5) and location number one (1) in January and November respectively. During the month of April  $\text{PO}_4^{3-}$ -P concentration is less than 0.2 $\mu\text{g/l}$  at all locations. During the months of February, March and April,  $\text{PO}_4^{3-}$ -P

Concentration of all locations varies between  $0.065\mu\text{g/l}$  –  $0.766\mu\text{g/l}$ . According to the Fig 10, the highest average  $\text{PO}_4^{3-}\text{-P}$  ( $0.634\mu\text{g/l}$ ) is recorded in February while the lowest value ( $0.162\mu\text{g/l}$ ) is recorded in April.

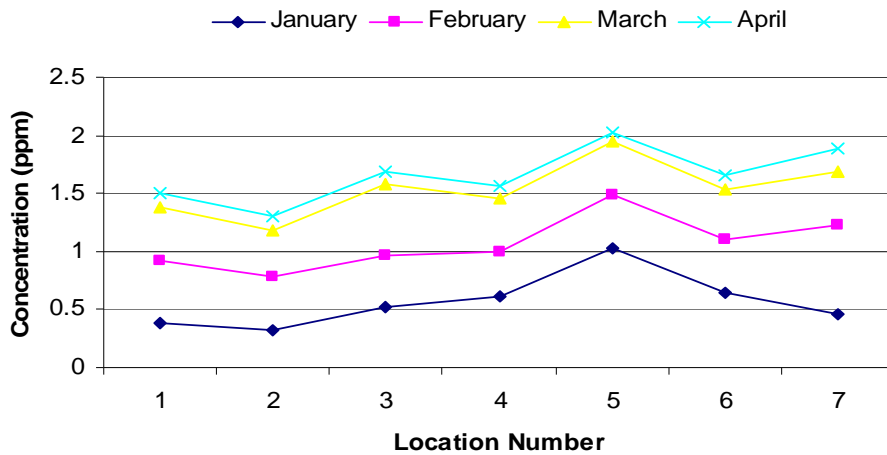


Fig 3.3.12.2. Variation of Phosphate concentration among locations

### Nitrite – Nitrogen

The highest ( $1.434\mu\text{g/l}$ ) value of  $\text{NO}_2^-$ -N concentrations are reported at location number five (5) and location number one (1) during March and November respectively (Fig. 11). Meanwhile  $\text{NO}_2^-$ -N concentration is less than  $0.100\mu\text{g/l}$  among all the locations during the month of November. During the other months  $\text{NO}_2^-$ -N concentrations are remained between  $0.0075\mu\text{g/l}$  –  $1.161\mu\text{g/l}$  among all the locations. (Fig 3.3.12.3). However the highest monthly average of  $\text{NO}_2^-$ -N concentration ( $0.634\mu\text{g/l}$ ) is recorded in month of February while the lowest value ( $0.162\mu\text{g/l}$ ) is recorded in April. (Fig 3.3.12.3).

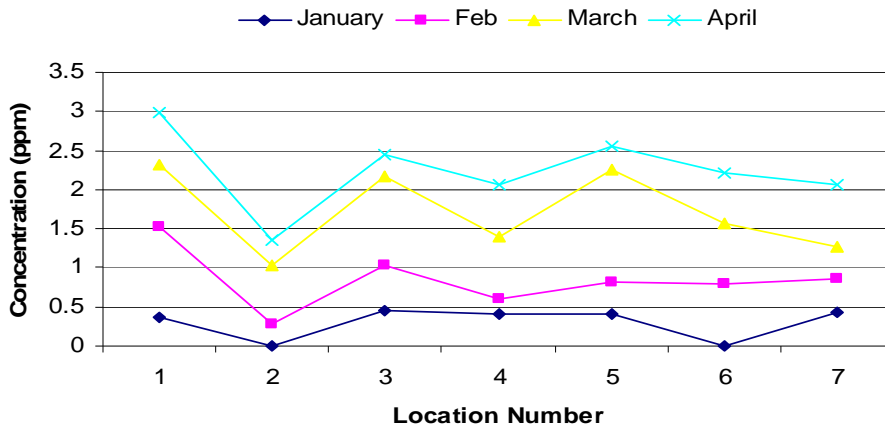


Fig 3.3.12.3. Variation of Nitrite concentration among locations

### Nitrate – Nitrogen

According to the results obtained, the highest value of  $\text{NO}_3^-$  - N concentration ( $3.5692\mu\text{g/l}$ ) is recorded at location number six (6) in January while lowest value ( $0.0008\mu\text{g/l}$ ) is recorded at location number seven (7) in April.

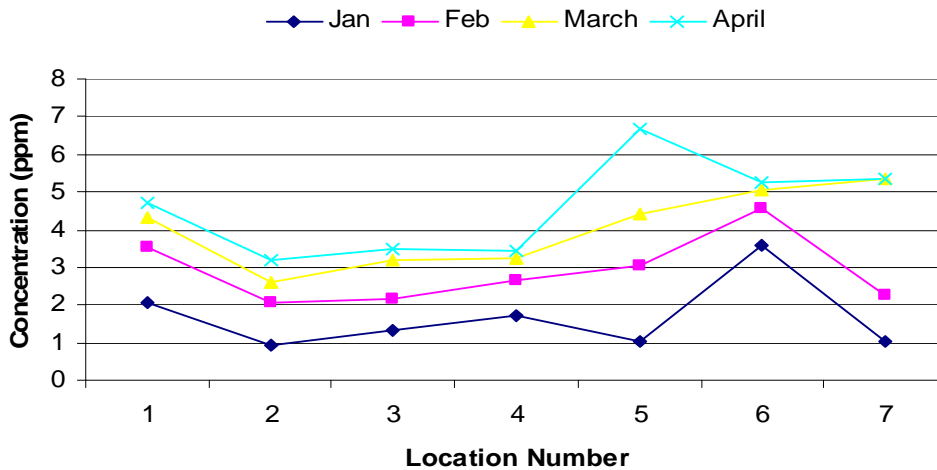


Fig 3.3.12.4. Variation of Nitrate concentration among locations from January-April 2007

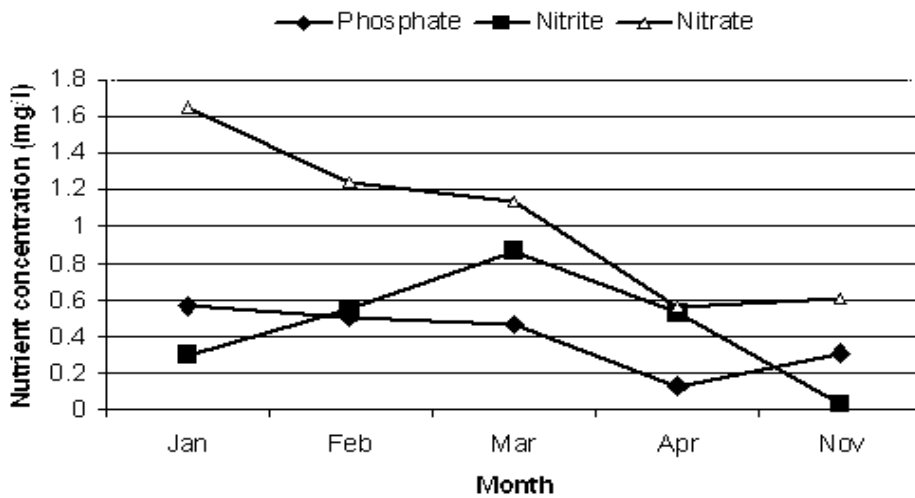


Fig. 3.3.12.5 Monthly averages of phosphate, Nitrite and Nitrate off Thalawila, 2007

### 3.4. Biological Environment

The proposed exploration area is rich in biodiversity and several important biologically sensitive areas are located close to the boundary of the seismic survey sites. Natural wetland ecosystems in the Puttalam district include rivers, streams, villus, mangrove, sea grass beds, coral reefs, salt marsh and seashore vegetation influenced wetlands include rice fields, irrigation canals, saltpans and shrimp ponds. A description of some of the biology of the area follows.

#### 3.4.1 Marine mammals of the Gulf of Mannar

Sixteen species of marine mammal have been recorded within the Northwestern maritime zone of Sri Lanka (Table 3.4.1; Illangakoon 2004, 2002; de Vos et al. 2003). In particular, many researchers have documented cetaceans in and around the Bar Reef Marine Sanctuary, which is located in the Southern Gulf of Mannar (Leatherwood et al. 1984; Alling 1986; Leatherwood and Reeves 1989; Alling et al. 1982; Illangakoon 2002). Of particular significance is the population of the globally endangered Dugong (*Dugong dugon*) which has been documented within the extensive sea grass beds north of the Kalpitiya peninsula (Illangakoon 2004). A recent survey of

the Bar Reef Sanctuary indicated that it supports a year round species richness of marine mammals and suggests that the northern and central area may be considered a cetacean ‘hotspot’ (Illangakoon 2005). Additionally, a previous survey conducted within the Southern Gulf of Mannar during the Voyage of the Odyssey (2003), highlighted the possibility that this area may be a breeding ground for at least one species of large whale (de Vos et al., 2003).

No comprehensive long term marine mammal surveys have been conducted within the Gulf of Mannar to date. This is a result of the lack of access to the area due to the civil conflict and a lack of funds. As a result the information provided here has its limitations and an Environmental Impact Assessment can benefit from a rigorous well planned survey.

**Table 3.4.1:** Marine mammals of the Gulf of Mannar checklist (Illangakoon 2002; de Vos et al. 2003)

Scientific name	Common name	Global Red List Status*	Depth at which sighted (m)
<i>Balaenoptera musculus</i>	Blue whale	EN	2000
<i>Balaenoptera acustorostrata</i>	Minke whale	LC	
<i>Megaptera novaeangliae</i>	Humpback whale	LC	
<i>Physeter macrocephalus</i>	Sperm whale	VU	80-1500
<i>Kogia sima</i>	Dwarf Sperm whale	DD	

Scientific name	Common name	Global Red List Status*	Depth at which sighted (m)
<i>Lagenodelphis hosei</i>	Fraser's dolphin	LC	1500-1900
<i>Pseudorca crassidens</i>	False Killer whale	DD	
<i>Peponocephala electra</i>	Melon-headed whale	LC	1800
<i>Sousa chinensis</i>	Indo-Pacific Humpback dolphin	NT	
<i>Delphinus delphis</i>	Common dolphin	LC	
<i>Stenella longirostris</i>	Long-snouted Spinner dolphin	DD	
<i>Stenella attenuata</i>	Pan-tropical spotted dolphin	LC	1500-1800
<i>Stenella coeruleoalba</i>	Striped dolphin	LC	1450
<i>Tursiops truncatus</i>	Bottlenose dolphin	LC	1800
<i>Orcinus orca</i>	Killer whale	DD	
<i>Dugong dugon</i>	Dugong	VU	

\* Global Red List Status from [www.redlist.org](http://www.redlist.org) where EN = Endangered, LC = Least Concern, VU = Vulnerable, DD = Data Deficient, NT = Near Threatened.

In addition to the species listed in table 3.4.1 stranded specimens of species such as the Cuvier's beaked whale (*Ziphius cavirostris* - LC), Pygmy sperm whale (*Kogia breviceps* - DD), Rough-toothed dolphin (*Steno bredanensis* - LC), Short-finned pilot whale (*Globicephala macrorhynchus* - DD) and Fin whale (*Balaenoptera physalus* - EN) have been documented from areas such as Negombo and Colombo on the West coast of the country (Illangakoon 2002).



Although there are no live sightings of these species within the Gulf of Mannar due to the lack of comprehensive year round surveys it is safe to assume that they are probably found within the Gulf of Mannar as well increasing the number of species within this area to 21.

### **3.4.2 Reefs**

The continental shelf of Sri Lanka in the Gulf of Mannar contains the most extensive shallow coral reef habitats in the country (Rajasuriya and De Silva 1988; Rajasuriya et al. 1995). They are continental patch reefs and the largest of these are Vankalai reef, Arippu reef, Silavathurai reef and the Bar Reef (Rajasuriya et al. 1995). These are approx 45 km, 38 km, 36 km and 2.3 km respectively from the boundaries of the project area. There are smaller coral patches situated further to the south around Kandakuliya (1 km from the boundaries of the project area, and Talawila). (Fig 3.4.2.1-GIS Map of Reefs around the project area). Their extent varies from a few square meters to several hectares and occurs in relatively shallow water to a depth of about 10m. Further south there are scattered coral patches growing on sandstone and limestone reef structures. In addition to coral reef habitats there are extensive sandstone reefs from near shore areas to offshore areas to a depth of more than 50m (Rajasuriya et al.1995). Sandstone reefs are conglomerates of sandstone and old coral limestone (Swan 1983) and form platforms and flat surfaces that are raised above the surrounding seabed. These habitats are widespread and occur around the coast of the country and according to Swan (1983) they indicate locations of former coastlines. The famous Pearl Banks of Sri Lanka are located among these sandstone and limestone reef areas west of Silavathurai and Arippu reefs.

The reefs in the northwestern coastal waters is special in Sri Lanka as they are linked to a much larger system which includes the Puttalam Lagoon with its mangroves, extensive sea grass beds and estuaries. The most extensive sea grass beds in the country are also found in these coastal waters from the Puttalam lagoon to the Palk Bay (Dayaratne et al. 1997). The linkages among these various ecosystems have not been well studied. The Bar Reef is the most well studied reef in the area. Reef studies have shown that the Bar Reef is rich in species diversity and support many larger forms of marine life such as whales, dolphins and sea turtles. Due to its uniqueness

79°0'0"E

80°0'0"E

### Coral Reef Distribution within 50 Km Boundary from the Boundary of the Seismic Survey Area



8°0'0"N

8°0'0"N

Gulf of Mannar

Mannar

Vankalai

Indupu

Silavatturai

Musali

Kudimelai Point

Bar Reef

Karatiku

Kalpitiya

Vannatawillu

Talaella

Puttalam

Kidlappuwa

Aruvi Aru

Kal Aru

Madaragan Aru

Kala Oya

Kala Oya

8°0'0"N

8°0'0"N

#### Legend

----- Bathymetrical Contours

~ River

Seismic Survey Area

Coral Reef

Sea Area Within 50 Km Boundary

50 Km Area from Survey Boundary

1 cm = 9 km



79°0'0"E

80°0'0"E

the Bar Reef was declared as a marine sanctuary in 1992 under the Fauna and Flora Protection Ordinance of the Department of Wildlife Conservation (Ohman et al. 1993).

There is extensive resource use in the north-western coastal waters. Reef fisheries include the harvesting of reef fish for edible purposes, spiny lobsters, collection of marine aquarium fishes and invertebrates. In addition sea cucumber and chunks are collected from the reef habitats as well as in the sandy areas among reefs. The Bar Reef Marine Sanctuary and its environs has been the subject of a Special Area Management Programme under the Coastal Resources Management Project of the Department of Coast Conservation from 2000 to 2005. An environmental profile and a management plan have been developed for the Bar Reef and Kalpitiya area (Coast Conservation Department 2005, 2007).

#### **3.4.2.1 Reef habitats**

##### **Coral reefs**

Coral reef habitats in the northwest are mainly in shallow water to a depth of about 10m. Coral growth is good due to relatively high water clarity (high transparency and very low turbidity) which is about 15m or more throughout the calm period during the northeast monsoon. During the southwest monsoon the water clarity is about 8 to 10m. In the areas there are extensive banks of corals consisting mainly of branching, tabulate and foliose coral species. These shallow coral patches vary in size from a few square meters to several hectares. They form banks of coral about 3 to 4m high and are surrounded by sandy areas. The dominant species are *Acropora cytherea*, *A. formosa*, *A. intermedia*, *Pocillopora damicornis*, *P. verrucosa*, *Montipora aequituberculata*, *M. foliosa* and *Echinopora lamellosa*. However, over one hundred species of reef building corals have been identified in the Bar Reef. Common species belong to the family Faviidae, Siderastreidae, Agariciidae, Oculinidae, Poritidae and Mussidae. Below the depth of 10m there is a reduction in the abundance of corals that occur in the shallow areas. However, there is greater species diversity due to the availability of reef substrate in the form of sandstone and limestone reefs. In these habitats there are large domes of *Porites lutea*, *P. lobata* and *Diploastrea heliopora* (Rajasuriya et al. 1998). The hard coral cover in the shallow coral area

was about 80% prior to the coral bleaching event in 1998, which destroyed most of the shallow water coral patches (Rajasuriya, 2000, 2002). However, most of the reef structures remained intact with dead coral consolidated by coralline algae and have now been recolonised by hard corals and the live hard coral cover has rapidly increased since 2001 and at present some coral patches have shown very high recovery with a hard coral cover of about 70% (Rajasuriya 2005) (Figure 3.4.2.1.). Coral reefs in Kandakuliya and Talawila and to the south contain more massive corals, especially Faviidae with smaller amounts of branching *Acropora* species and Foliose *Montipora* species.

In addition there are little known coral habitats along the 20 to 30m depth contour. These are located at N8.32503 E79.69107 and N8.24517 E79.67165. The continental shelf begins to rapidly increase in depth to the west of this depth contour. Currents are relatively strong along this edge and hard corals (mainly *Fungiidae*) have established small patches along the edge. These patches are less than 100 square meters in extent and have a relief of about 0.25m. They consist of a single species or a combination of two or three species of hard corals together with calcareous algae; *Halimeda* sp. The dominant species of hard corals are *Diaseris fragilis*, *D. distorta*, *Fungia scutaria*, *F. paumotensis*, *F. repanda* and *Stylophora pistillata*. The relief of these habitats is less than 0.25m and support specific species of fish and invertebrates. These are unique habitats support a diversity of species; reef fish and invertebrates that are uncommon in other reef areas.

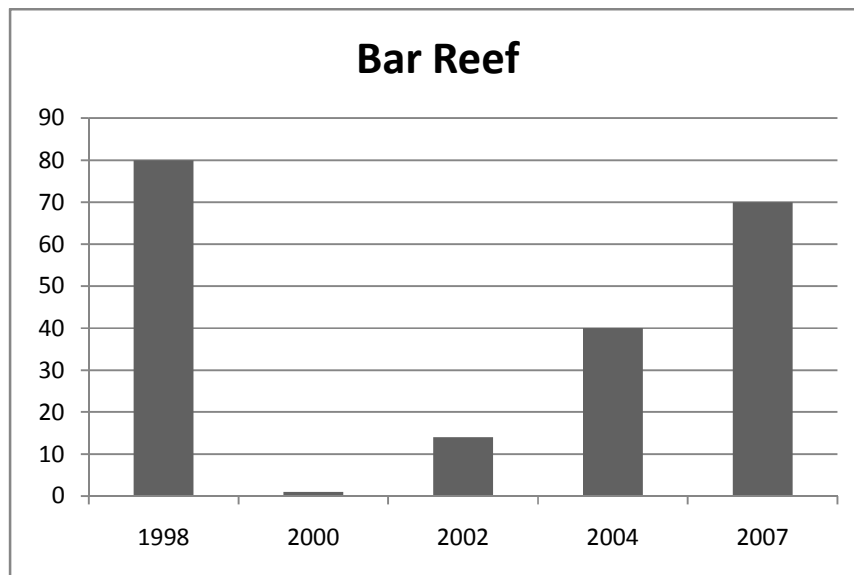


Figure 3.4.2.1. Hard coral cover at the Bar Reef Marine Sanctuary since 1998 showing the impacts of the bleaching event and recovery of hard coral cover.

### **Sandstone/Limestone reefs**

These reefs are widespread and are generally oriented in a north-south direction approximately parallel to the present shoreline. These habitats occur as discontinuous bands at different depths, and are indicative of former shorelines (Swan 1983). In the northwest most of these reefs are visible within a depth range of 10 to 30m. They can be seen scattered along the shoreline from Kala-oya towards Silavathurai. They are also visible in areas where coral growth is sparse and the underlying old reef structures are exposed. The sandstone/limestone reefs are platform like structures with varying levels of relief; with the highest having a relief of about 4m. The width of these platforms varies from about 5m to about 50m. There is sand on both sides of these long reef structures. Hard corals are not abundant throughout these structures, but occur in clusters and within them hard coral cover can be as much as 30%. But overall hard coral cover has been estimated to be about 15% in the Bar Reef area (Rajasuriya et al. 1998). In addition to the raised platforms there are low relief flat reef substrate of the same composition, but has little live corals (<5%) and is generally located at a depth of about 22m. These habitats contain widely separated depressions of 2 to 5m with many small holes and crevices that support moray eels and reef shrimps (*Lysmata amboinensis*, *L. debelius* and *Rynchocinetes uritae*) together with fairy

basslets (*Anthias* spp) and groupers (*Epinephelus undulosus*, *Cephalopholis sonnerati*) (Ohman et al. 1997; Rajasuriya et al. 1998; Ohman and Rajasuriya 1998).

### **Diversity of Reef fish**

The reefs in the northwest have high species diversity of reef fish. More than 400 species of reef in 57 families have been recorded for the Bar Reef (Coast Conservation Department 2007). The most commonly observed species belong to the families of Acanthuridae, Balistidae, Caesionidae, Carangidae, Chaetodontidae, Haemulidae, Labridae, Lutjanidae, Lethrinidae, Mullidae, Nemipteridae, Pomacentridae, Pomacanthidae, Scaridae, Serranidae and Siganidae. In addition there are many cryptic species such as blennies (Blennidae), gobies (Gobiidae) and dartfishes (Microdesmidae) that have been recorded at Bar Reef, Kandakuliya and Talawila (Ohman et al. 1997; Coast Conservation Department 2007).

Prior to the bleaching event in 1998, thirty-three species of butterfly fish (Table 3.4.2.1.) were recorded from the Bar Reef, among these were the *Chaetodon semeion*, *C. oxycephalus*, *C. bennetti*, and *C. rafflesi*, which are rare species of butterfly fish in Sri Lanka (Rajasuriya and Karunarathna 2000). Presently the latter two species have been recorded in areas that have shown good recovery after the bleaching event. Ohman et al., (1998) reported that corallivorous butterfly fish (*Chaetodon collare*, *C. kleinii*, *C. melannotus*, *C. octofasciatus*, *C. trifascialis*, *C. trifasciatus*, *C. triangulum* and *Heniochus pleurotaenia*) showed a significant positive correlation with live coral cover indicating that the presence of corallivorous species of butterfly fish is a good indicator of the live coral cover of coral reef habitats (Ohman and Rajasuriya 1998).

**Table 3.4.2.1. Butterfly fish (Chaetodontidae) species recorded in the Bar Reef showing rare species (\*) and very rare (\*\*) species in Sri Lanka.**

Species	Recorded prior to 1998	Recorded at present 2008 – 2009
<i>Chaetodon auriga</i>	X	x
<i>Chaetodon bennetti</i> **	X	x
<i>Chaetodon citrinellus</i>	X	x
<i>Chaetodon collare</i>	X	x
<i>Chaetodon decussatus</i>	X	x
<i>Chaetodon falcula</i>	X	x
<i>Chaetodon gardneri</i>	X	x
<i>Chaetodon guttatissimus</i>	X	x
<i>Chaetodon kleinii</i>	X	x
<i>Chaetodon lineolatus</i>	X	x
<i>Chaetodon lunula</i>	X	x
<i>Chaetodon melannotus</i>	X	x
<i>Chaetodon meyeri</i>	X	x
<i>Chaetodon mertensii</i> (previously called <i>C. madagascariensis</i> )	X	x

Species	Recorded prior to 1998	Recorded at present 2008 – 2009
<i>Chaetodon octofasciatus</i>	X	x
<i>Chaetodon oxycephalus</i> **	X	-
<i>Chaetodon plebeius</i>	X	x
<i>Chaetodon rafflesi</i> *	X	x
<i>Chaetodon semeion</i> **	X	x
<i>Chaetodon trifascialis</i>	X	x
<i>Chaetodon trifasciatus</i>	X	x
<i>Chaetodon triangulum</i> *	X	-
<i>Chaetodon unimaculatus</i> *	X	x
<i>Chaetodon vagabundus</i>	X	x
<i>Chaetodon xanthocephalus</i>	X	x
<i>Forcipiger flavissimus</i>	X	x
<i>Forcipiger longirostris</i>	X	-
<i>Hemitaurichthys zoster</i> *	X	x
<i>Heniochus acuminatus</i>	X	x
<i>Heniochus diphreutes</i>	X	-
<i>Heniochus monoceros</i>	X	-
<i>Heniochus pleurotaenia</i> *	X	x



Species	Recorded prior to 1998	Recorded at present 2008 – 2009
<i>Heniochus singularius</i>	X	x
Total number of species	33	28

### Reef and Reef associated invertebrates

Reefs and adjacent areas support many species of invertebrates some of which support foreign export earnings. These include invertebrates used in the marine aquarium fishery, sea cucumber, spiny lobsters and chank fisheries. The marine aquarium fishery harvests two species of reef shrimp (*Lysmata amboinensis* and *L. debelius*) that are the mainstay of the aquarium fishery in Sri Lanka. There are several species of soft corals (*Sarcophyton* spp, *Dendronephthya* spp and *Sinularia* spp), gorgonians, sea anemones (*Heteractis* spp., *Entacmaea quadricolor*, *Cryptodendrum* spp., *Stichodactyla* spp,) anemone shrimps and anemone crabs (Dayaratne et al. 1997; Coast Conservation Department 2007).

Various species of molluscs that include gastropods (Cyprinidae, Strombidae, Cerithiidae, Trochidae, Turbinidae, Cassidae, Tonnidae, Muricidae, Nassariidae, Olividae, Harpidae, Volutidae, Conidae and Terebridae), nudibrachs (Chromodoridae, Hexabranhidae, and Phyllididae) and bivalves (Pteriidae, Pinnidae, Spondylidae, and Tridacnidae) have been recorded. Several species of sponges, hydroids, tunicates, crabs, cephalopods and echinoderms (sea cucumber, starfish, crinoids and sea urchins) have also been recorded. The coral predator ‘Crown of Thorns’ Starfish (*Acanthaster planci*) is also present in the area and have caused large scale reef damage in the past (De Bruin 1972).

### Protected species

Protected species are primarily listed in the 1993 amendment to the Fauna and Flora Protection Ordinance (FFPO) of the Department of Wildlife Conservation. In addition the Fisheries Act of 1996 also contains protected species which includes some species listed in the FFPO. Species

that are found in the north-western coastal waters is listed in table 3.4.2.2. . There is a separate ‘Restricted Export Category’ under the Fisheries Act to restrict the export of live ornamental fish and live groupers for aquaculture and species that occur in the northwest are listed in table 3.4. 2. 3. . Invertebrates that include hard corals, soft corals, gorgonians, molluscs and echinoderms are listed in table 3.4.2. 4.

Table 3.4.2.2. List of protected reef fish species listed under the Fauna and Flora Protection Ordinance (FFPO) and the Fisheries Act (FA) found in the north-western coastal reefs.

<b>Species</b>	<b>Protected by FFPO or FA</b>
<i>Chaetodon semeion,</i>	FFPO & FA
<i>Coris aygula,</i>	FFPO & FA
<i>Labroides bicolor</i>	FFPO & FA
<i>Pterois radiate</i>	FFPO & FA
<i>Epinephelus lanceolatus</i>	FA
<i>E. flavocoeruleus</i>	FA
<i>Plectorhinchus albobittatus</i>	FA
<i>Chrysiptera kuiteri,</i>	FA

Table 3.4. 2. 3. Species of reef fish listed under the 'Restricted Export Category' that occur in the Gulf Mannar reefs.

<b>Species</b>
<i>Chaetodon octofasciatus</i>
<i>Chaetodon falcula</i>
<i>Chaetodon xanthocephalus</i>
<i>Chaetodon ephippium</i>
<i>Chaetodon unimaculatus</i>
<i>Chaetodon madagascariensis</i>
<i>Chaetodon bennetti</i>
<i>Chaetodon meyeri</i>
<i>Chaetodon triangulum</i>
<i>Heniochus monoceros</i>
<i>Heniochus pleurotaenia</i>
<i>Centropyge flavipectoralis</i>
<i>Balistoides conspicillum</i>
<i>Pseudobalistes fuscus</i>
<i>Variola louti</i>
<i>Variola albimarginata</i>
<i>Cephalopholis argus</i>
<i>Cephalopholis boenack</i>
<i>Cephalopholis formosa</i>
<i>Cephalopholis miniata</i>

<b>Species</b>
<i>Cephalopholis sonnerrati</i>
<i>Epinephelus areolatus</i>
<i>Epinephelus caeruleopunctatus</i>
<i>Epinephelus hexogonatus</i>
<i>Epinephelus malabaricus</i>
<i>Epinephelus merra</i>
<i>Epinephelus morrhua</i>
<i>Epinephelus tauvina</i>
<i>Epinephelus tukula</i>
<i>Epinephelus undulosus</i>
<i>Plectropomus laevis</i>

Table 3.4.2.4. Species of protected reef invertebrates that are found in the Gulf of Mannar reefs.

<b>Family or Order</b>	<b>Species</b>	<b>Protected by FFPO or FA</b>
Scleractinia	All species of hard corals	FFPO
Alcyonacea	All species of Soft corals	FFPO
Gorgonacea	All species of Gorgonians	FFPO
Crustacea	<i>Hymnocera elegans</i>	FFPO & FA
	<i>Enoplometopus spp</i>	FFPO
	<i>Dardanus magistos</i>	FFPO

Family or Order	Species	Protected by FFPO or FA
Mollusca	<i>Charonia tritonis</i>	FFPO
	<i>Tridacna spp</i>	FFPO
	<i>Tibia spp</i>	FFPO
	<i>Strombus listeri</i>	FFPO
	<i>Lambis lambis</i>	FFPO
	<i>Lambis chiragra</i>	FFPO
	<i>Cypraea tigris</i>	FFPO
	<i>C. talpa</i>	FFPO
	<i>C. mappa</i>	FFPO
	<i>C. argus</i>	FFPO
	<i>Cypreacassis rufa</i>	FFPO
	<i>Cassis cornuta</i>	FFPO
	<i>Chicoreus palmarosa</i>	FFPO
Annelida	Tube worms	FFPO
	Fan worms	FFPO
Echinodermata	<i>Heterocentrotus mammilatus</i>	FFPO
	<i>Cerianthus spp.</i>	FFPO

## **Bar Reef Marine Sanctuary**

The Bar Reef Marine Sanctuary (BRMS) is the largest marine protected area in Sri Lanka and encompasses an area of 306.7 square kilometers. It was declared in 1992 under the Fauna and Flora Protection Ordinance. The BRMS contains a core area of about 70 square kilometers that includes the shallow coral reef habitats. The eastern edge of the Survey Block is approximately 2.3 km from the eastern edge of the BRMS (See GIS Map No.1- Reefs around the project area)

### **Boundaries of the Bar Reef Marine Sanctuary as in Gazette no 708/24 of 1992**

North: From the point described by the coordinate 8° 32' 00" N and 79° 40' 75" E towards the east by an arbitrary straight line until it meets the point described by the coordinates 8° 32' 00" N and 79° 46' 00" E.

East: From the last mentioned point southwards along the arbitrary straight line until it meets the point described by the coordinates 8° 19' 30" N and 79° 45' 50" E, then southwest wards by an arbitrary line until it meets the point described by the coordinates 8° 16' 00" N and 79° 44' 00" E

South: From the last mentioned point towards the west by an arbitrary straight line until it meets the point described by the coordinate 8° 16' 00" N and 79° 40' 75" E.

West: From the last mentioned point northwards by an arbitrary straight line until it meets the starting point of the northern boundary described by the coordinate 8° 32' 00" N and 79° 40' 75" E.

The Bar Reef Marine Sanctuary and environs contain some of the high species diversity marine ecosystems in the country. In addition to coral reef resources this area contains several species of marine mammals (whales, dolphins and dugongs) and sea turtles. Furthermore the now endangered species of Hump head wrasses (*Cheilinus undulatus*) is found both among the shallow coral and deep sandstone reef habitats. Although the BRMS was declared in 1992 management is minimal (Coast conservation Department 2005; Rajasuriya 2005). A Special Area Management Project of the Coastal Resources Management project was carried out at the BRMS and Kalpitiya area from 2000 to 2005 (Coast Conservation department 2005) and at

present the community has been made aware of the sanctuary laws and restriction regarding resource extraction. However resource extraction has continued due to lack of enforcement of sanctuary regulations (Wilkinson 2002; 2008).

Fishing is the main economic activity in the northwestern coastal waters. Edible fisheries and export oriented fisheries are the main activities related to resource extraction. The marine ornamental fishery is carried out mainly on the coral reef habitats and adjacent areas. Butterfly fish (Chaetodontidae), angelfish (Pomacanthidae), wrasses (Labridae), damselfish (Pomacentridae), scorpion fish (Scorpaenidae), gobies (Gobiidae), blennies (Blennidae), sea anemones and reef shrimps (*Lysmata amboinensis*, *L. debelius* and *Rhyncocinetes uritae*) are the main species harvested from the area. They are harvested by snorkeling or scuba diving. Collectors use a variety of nets; hand nets, moxy nets and barrier nets. In addition divers harvest spiny lobsters, sacred chanks and sea cucumber throughout the north-western coastal waters to a maximum depth of about 35m. Fishing for edible species is also common using a wide range of different types of fishing nets, among them the most often employed fishing gears are stationary gill nets, drift gill nets, bottom set nets, purse seines and beach seines (Dayaratne et al. 1997).

The Bar Reef and adjacent area including the Puttalam Lagoon has been identified for a major tourism development programme by the Government of Sri Lanka. However, this project has not begun yet and development activities related to tourism in the future will also have an impact on reefs and their resources.

### **3.4.3 Benthic Invertebrates**

The benthic invertebrates of survey area are poorly understood but may support unique and diverse invertebrates, with communities that change significantly with depth along its slopes. No specific data is available on the benthic habitats and communities of the deep waters of the

survey area. The biological productivity of the benthic environment is expected to be limited due to low light availability at depth and low nutrient availability at the deep waters of the survey area.

Thirty species of invertebrates are reported by Dahanayaka *et al.* (2007) in the benthic samples from north western coastal waters. Among them were 21 species of polychaetes, 2 species of gastropods, 5 species of crustaceans and 2 species of bivalves (Table 3.2.3.1). The high values for species diversity, which were above 1.25 are reported at closer to coastline and the most of the areas, which were located far away from coastline represented low species diversity. According to Dahanayaka *et al.* (2007) % of gravel in the sediments and the water depth significantly affects the diversity and abundance of macro benthos in north western coastal waters. These benthic invertebrates were found at depths between 12-15m.

Table 3.4.3.1. The relative abundance of different species of macrobenthic invertebrates in the marine waters of North-Western coast (Dahanayaka *et al.* 2007).

Taxa	
<b>Class : Polychaeta</b>	<b>Class: Crustacea</b>
<b>Order : Errantia</b>	<b>Order: Decapoda</b>
<i>Nereis</i> sp	Decapoda sp 1
Nephtyidae sp 1	Decapoda sp 2
Nephtyidae sp 2	Decapoda sp 3
Aphroditidae sp	<b>Order: Amphipoda</b>
Eunicidae sp 1	Gammerid sp 1
Eunicidae sp 2	Gammerid sp 2
Nephtyidae sp	
Pilargidiidae sp	<b>Class: Gastropoda</b>



Goniadidae sp	Hydrobiidae sp
Un. Errantia sp 1	Assimineidae sp
Un. Errantia sp 2	<b>Class:Bivalvia</b>
Un. Errantia sp 3	Veneridae sp
Un. Errantia sp 4	Un. Bivalvia sp 1
Un. Errantia sp 5	
Un. Errantia sp 6	
<b>Order: Sedentaria</b>	
Spionidae sp 1	
Spionidae sp 2	
Orbiniidae sp	
Capitellidae sp	
Maldanidae sp	
Un. Sedentaria sp 1	
Un.- Unidentified Species	

Table 3.4.3.2. Statistically significant values for Spearman Rank Correlation Coefficient ( $p < 0.05$ ) for permutations of environmental variables and the abundance of macrobenthos in north western coastal waters (source: Dahanayaka *et al.* (2007)).

Correlation Coefficient	Environmental Variables
0.134	1
0.095	1,5

Environmental Variables: 1-gravel (%), 2-sand (%), 3-silt (%), 4-carbonate (%), 5- Depth

According to Dahanayaka (*unpublished.*) comparison studies of benthic invertebrates at sea grass areas and open areas of marine and brackish waters of Kalpitiya indicate there was significantly high biomass (Table 3.2.3.3) and high abundance (Table 3.2.3.4) association with Sea grass beds.

Table 3.4.3.3: Biomass of benthic animals (Wet weight g/ 250 cm<sup>2</sup>)

	Open area						Sea grass beds					
	1	2	3	4	5	Mean	1	2	3	4	5	Mean
Polychaeta	0.8	0	0.5	0.3	0	0.32	3.2	4	1.8	0.8	2.8	2.52
Crustacea	0	0	0.4	0.2	0.3	0.18	1.6	1	0.8	1.2	0.9	1.1
Mollusca	0.2	0	0.4	0.3	0.2	0.22	2.2	6.8	5.6	4.6	6.2	5.08
Other invertebrates	0	0	0.2	0.2	0	0.08	1.8	4.3	2.6	3.8	4.2	3.34
Vertebrates	0.5	0	0.4	0.3	0.2	0.28	3.2	4.6	3.8	2.8	2.3	3.34

Table 3.4.3. 4: No. of individuals / 250 cm<sup>2</sup>

Sample site	Open area					Sea grass beds				
	1	2	3	4	5	1	2	3	4	5
Tot. No of species	10	0	14	16	9	65	52	48	54	62
Tot. No of individuals	40	0	62	58	32	440	372	268	346	264

Table 3.4.3.5 Benthic invertebrates of coastal area along the stretch of Mannar to Talaimannar, and shallow sea area from Mannar to Vidattaltivu and from Achchakulam to Naruvilikulam listed below (2005 NARA unpublished).

Location	Species	Number/500cm <sup>3</sup>
Mannar		
	<i>Cerithidea ingulate</i>	5.5
	<i>Nereidae</i> spp	01
	Errantia spp	01
	Sedenteria sp	03
	Unidentified polchaete sp	01
	Amphipoda sp 1	01
	Amphipode sp 2	01
	<i>Balanus</i> spp	02
	Decapoda crabs	01
Naruvilikulam		
	<i>Cerithidea ingulate</i>	13
	<i>Balanus</i> spp	03
Achchankulam		
	<i>Cerithidea ingulate</i>	10
	Sedenteria spp	04
	<i>Balanus</i> spp	01
	Errantia spp	03

Benthic macro fauna play an important role in aquatic ecosystems. In the aquatic food webs, they act as primary or secondary consumers representing diversified feeding habits as grazers, omnivores, carnivores and bacteriovores. Benthic invertebrates are very important as a food resource for a large number of predators such as benthic fish and some aquatic insects, and as primary material exchangers across sediment water interface (Darby 1962; Popchenko 1971; Bouguenec & Gaini 1989).

#### **3.4.4 Mangroves**

According to the remote sensing survey of 1981 it has been estimated that the mangrove cover along the shores of the Puttalam lagoon, Dutch Bay and Portugal Bay complex alone to be 3,385ha. Only 37% of the mangroves remained in the Puttalam lagoon in 1992. But the corresponding figure in the Dutch Bay was 88% (Amarasinghe and Perera 1995). Reductions of the extent of mangroves in Puttalam lagoon are mostly due to conversion of the lands in to shrimp farms. GIS Map (Fig 3.4.4.1) indicates the patches of mangroves within 50 km radius from the project boundaries. However mangroves still remaining in the Dutch Bay can be considered as most productive. Accordingly mangrove areas in Dutch Bay can broadly be categorized into two groups, i.e. fringing mangroves and riverine mangroves. Riverine mangroves have been recorded a higher net primary production (12t ha-1yr-1) than that of the fringing (7t ha-1yr-1) mangroves (Amarasinghe and Balasubramenium, 1992).

As in many other mangroves in the dry coastal regions in Sri Lanka *Rhizophora mucronata* and *Avicennia marina* are the major species of the mangroves in Puttalam lagoon and Dutch Bay. A total of 14 exclusive mangrove species and 29 species of mangrove associated species have been reported from Puttalam lagoon Dutch Bay. Among them *Scyphihora hydrophyllacea* is a very rare species.

79°0'0"E

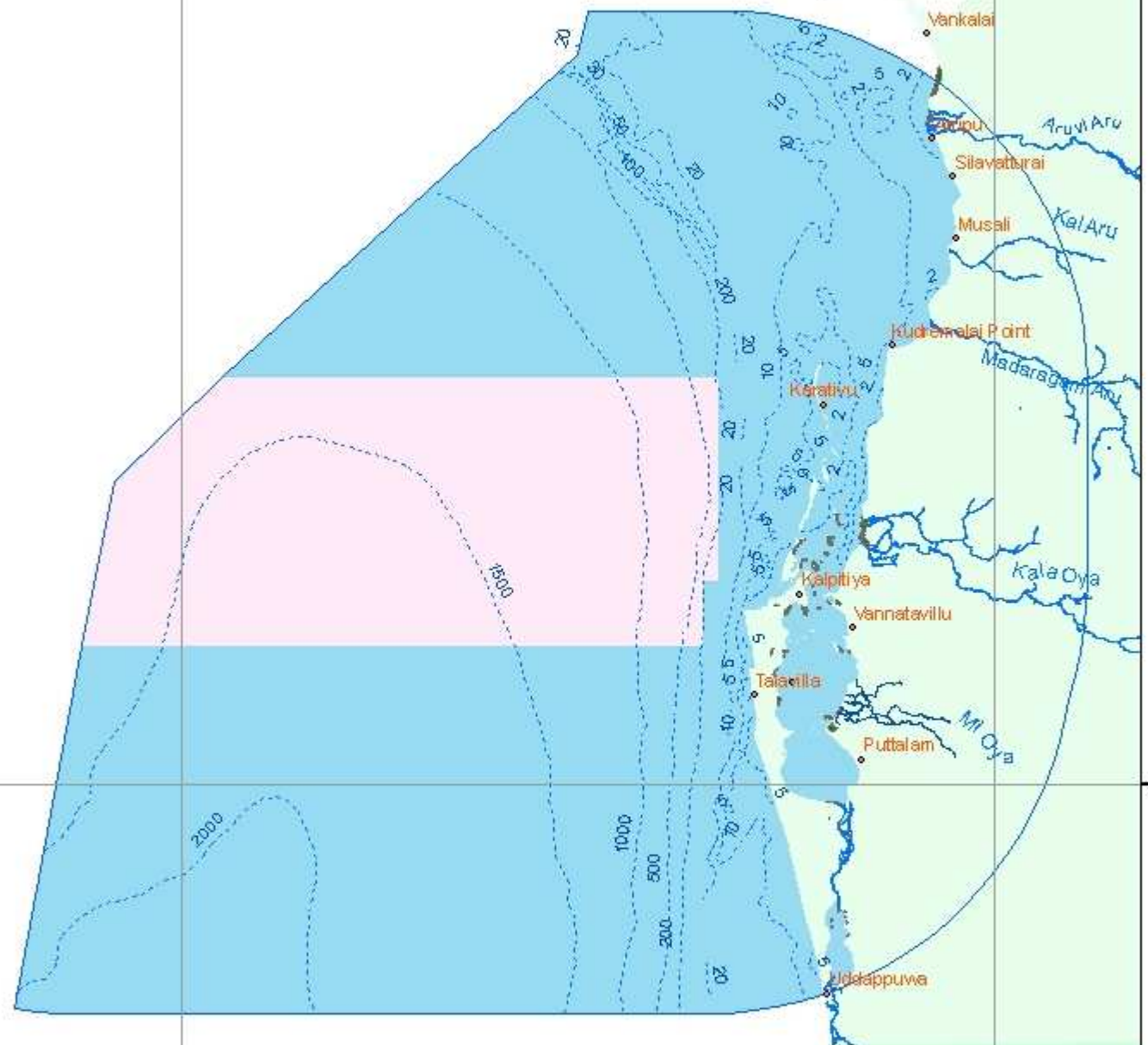
80°0'0"E

# Mangrove Distribution within 50 Km Boundary from the Boundary of the Seismic Survey Area



9°0'0"N

Gulf of Mannar



8°0'0"N

### Legend

- Bathymetrical Contours
- River
- Seismic Survey Area
- Mangrove
- Sea Area Within 50 Km Boundary
- 50 Km Area from Survey Boundary

1 cm = 9 km



79°0'0"E

80°0'0"E

Table 3.4.4.1: True mangrove and mangrove-associated species in Puttalam lagoon and Dutch Bay (Source: Amarasinghe, M.D. 1989)

True mangrove species	Mangrove associated species
1. <i>Acanthus ilicifolius</i>	1. <i>Acrostichum aureum</i>
2. <i>Aegiceras corniculatum</i>	2. <i>Ardisia eliptica</i>
3. <i>Avicennia marina</i>	3. <i>Calophyllum inophyllum</i>
4. <i>Bruguiera cylindrica</i>	4. <i>Cassia auriculata</i>
5. <i>Bruguiera gymnorhiza</i>	5. <i>Cerbera manghas</i>
6. <i>Ceriops tagal</i>	6. <i>Cissus quadrangularis</i>
7. <i>Cynometra iripa</i>	7. <i>Clerodndron inerma</i>
8. <i>Excoecaria agallocha</i>	8. <i>Cordia subcordata</i>
9. <i>Lumnitzera racemosa</i>	9. <i>Cryptolepis buchanania</i>
10. <i>Rhizophora mucronata</i>	10. <i>Derris uliginosa</i>
11. <i>Rhizophora apiculata</i>	11. <i>Flagellaria indica</i>
12. <i>Scyphiphora hydrophyllaceae</i>	12. <i>Gyrocarpus spp</i>
13. <i>Sonneratia alba</i>	13. <i>Hibiscus tiliaceus</i>
14. <i>Xylocarpus granatum</i>	14. <i>Indigofera spp</i>
	15. <i>Ipomoea maritime</i>
	16. <i>Pemphis acidula</i>
	17. <i>Phoenix sp.</i>
	18. <i>Premna integrifolia</i>
	19. <i>Salicornia brachiata</i>
	20. <i>Salvadora persica</i>
	21. <i>Sesuvium portulacastrum</i>
	22. <i>Sueda maritime</i>
	23. <i>Sueda monoica</i>

True mangrove species	Mangrove associated species
	24. <i>Sueda nudiflora</i>
	25. <i>Syzygium cumini</i>
	26. <i>Tamarix gallica</i>
	27. <i>Thespesia populnea</i>
	28. <i>Typha sp.</i>
	29. <i>Vitis camosa</i>

Fringing and island fringing are the type of mangroves observed in Mannar. Major mangroves areas bordering to the coast of Gulf of Mannar are found in the areas Achchankulam, Nrivillukulum, Vankalai and just north of the Mannar town (Kanankottiko).

Table 3.4.4.2: Mangrove and associated species encountered in the area  
(Pahalawattaarachchi:unpublished)

True mangrove species	Mangrove associated species
1. <i>Avicennia marina</i>	1. <i>Arthrocnemum indicum</i>
2. <i>Lumnitzera racemosa</i>	2. <i>Bengolensis spp</i>
3. <i>Rhizophora mucronata</i>	3. <i>Cassia auriculata</i>
4. <i>Sonneratia casseolaria</i>	4. <i>Cactus spp</i>
	5. <i>Clerodndron inerma</i>
	6. <i>Pemphis acidula</i>
	7. <i>Prophis juliflora</i>
	8. <i>Sueda maritime</i>
	9. <i>Sueda monoica</i>

Table 3.4.4.3: Structural parameters of the mangrove stand of Achchankulum  
(Pahalawattaarachchi: unpublished)

Distance from the shore(m)	No. of species	Stand density (no/ha)	Stand basal area(m <sup>2</sup> )	Stand height(m)	Complexity index
0-50	03	2300	8.34	3.68	2.1

Biggest patch of nearly 100m width mangrove belt was observed at Achchankulam area and major constituent species of mangroves are *Sonneratia cassolaries*, *Avicennia marina* observed beyond 50m.

Rare mangrove species *Pemphis acidula* which has being recorded as available only at Puttalam lagoons far was recorded at Achchankulam area of Mannar. Complexity index of the mangroves are in similar trend with fringing mangroves of Puttalam lagoon but the author of the study suggests that the low complexity value of mangroves of Puttalam lagoon caused because of low number of species but the functional value is greater (Amarasinghe & Balasubramanium, 1992).

Hence it can be concluded that the mangroves of Mannar mainland fringing mangroves have a good functional capacity.

It s observed that *Prosopsis juliflora* the thorny woody tree has become invasive in most of the coastal areas of Mannar. The tree has being recorded as invasive plant for Hambantota district (Bogahawatte & De Silva 2002). Mangroves are located at a minimum distance of 11.33 km from the block boundary (See GIS Map -Mangroves)-



### 3.4.5 Sea Grasses

Sea grass habitats are considered to be among the most productive submerged systems. This productivity supports through dependent species of epiphytes fauna, large number of fish which are important in lagoon and coastal fisheries. Through their high productivity, sea grasses build up large carbon reserves which are utilized in the tropics by herbivores such as turtles, birds and marine mammals. Many species of prawns and fish use the sea grass meadows as nurseries and even as adults are dependent on sea grasses for the food via the epiphytic community. Hence sea grass ecosystems are very high in diversity and a larger number of individuals within the community, compared to the ecosystems where sea grasses are not present (Coles *et al.*, 1993).

Such communities thus become dependent on the wellbeing of sea grasses for their own survival or success. Puttalam lagoon is one of the largest lagoons in Sri Lanka which cover an area of 237 km<sup>2</sup> and provides large shallow areas which are favourable for the growth of sea grass communities. Sea grass communities of Puttalam lagoon play a major role in various aspects such as providing food for most endangered species and economically important fish species. Such communities thus become dependent on the wellbeing of sea grasses for their own survival or success.

It has been revealed that Puttalam lagoon has a well developed sea grass community, and given the extensive fishery, sea grasses are likely to play a considerable role in supporting local fisheries production. The two most common sea grass species found in Puttalam lagoon are the Round tip sea grass *Cymodacea rotundata* and Tropical Eelgrass, *Enhalus acoroides* (Johnson and Johnstone, 1995). Sea grasses within 50km of project boundary is given in fig 3.4.5.3

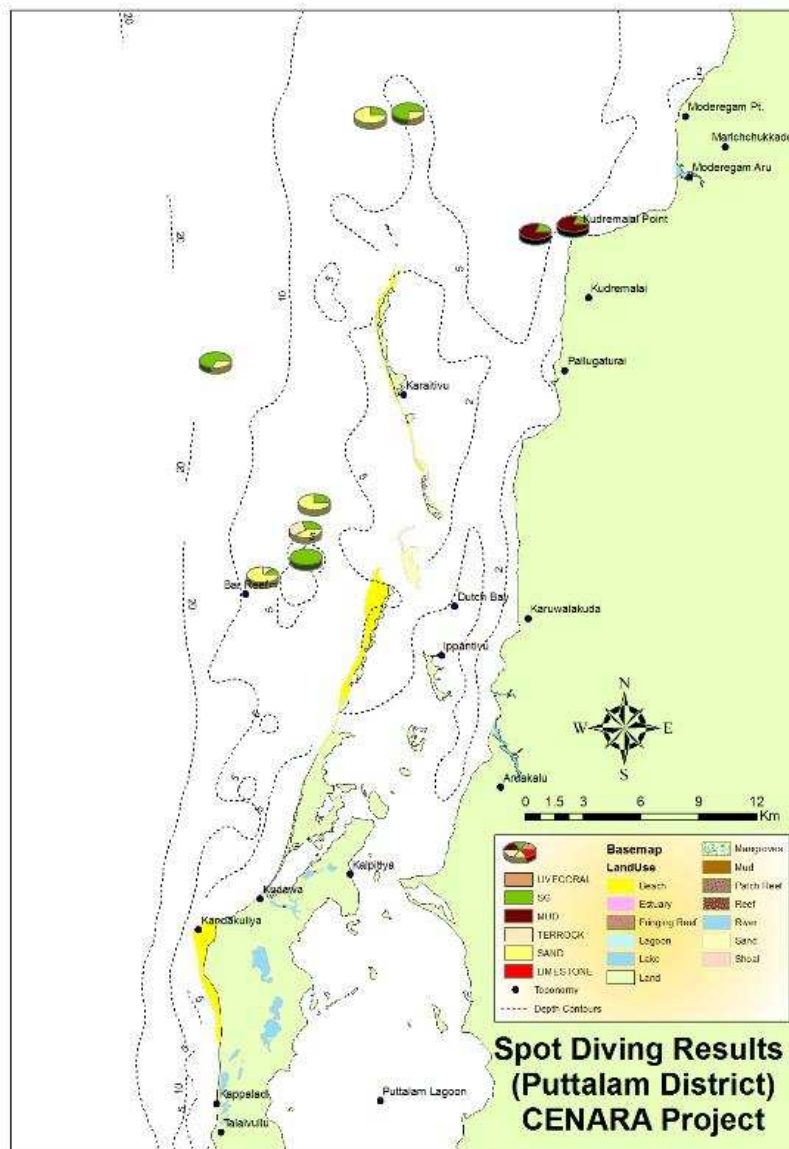


Figure 3.4.5.1: Distribution of sea grasses in near shore coastal area in Dutch Bay/Puttalam

Source: CENARA project (on going)

Other six species encountered in the lagoon is as follows;

1. *Cymodocea serrulata*

2. *Thalassia hemprichii*

3. *Halodule uninervis*

4. *Halophila ovalis*

5. *Syringodium isoetifolium*

6. *Halophila decipiens*

Distributions of sea grasses in coastal areas of Puttalam are indicated in the Fig.3.4.5.1.

Distribution of sea grass beds in Mannar is illustrated in the fig.3.4.5.2. It has being recorded that rich sea grass beds are found in the area. Most common sea grass species found in the shallow bays of Mannar Sea is *Enhalus acaroids*. Other species common to the area were *Cymodacea rotundata*, *Cymodacea serulata*, *Syringodium isotifolium*, *Halodule pinifolia*, *Halodule uninervis* and *Halophila ovalis*. Very shallower pans area mostly exposed to the air and these types of flats it could be observed *Halophila ovalis* and *Ruppia maritime*.

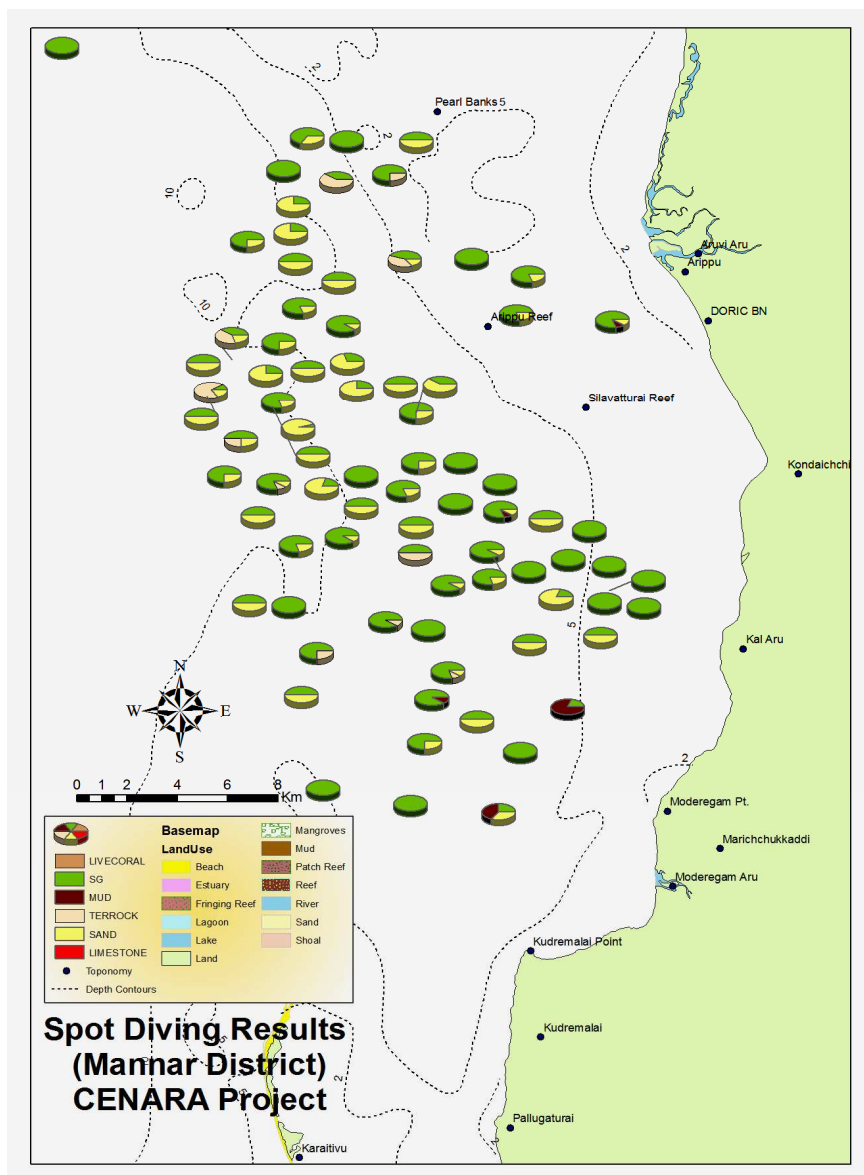


Figure 3.4.5. 2: Distribution of sea grasses in near shore coastal area in Mannar

Source: CENARA Project (on going)

79°0'0"E

80°0'0"E

### Sea Grass Distribution within 50 Km Boundary from the Boundary of the Seismic Survey Area

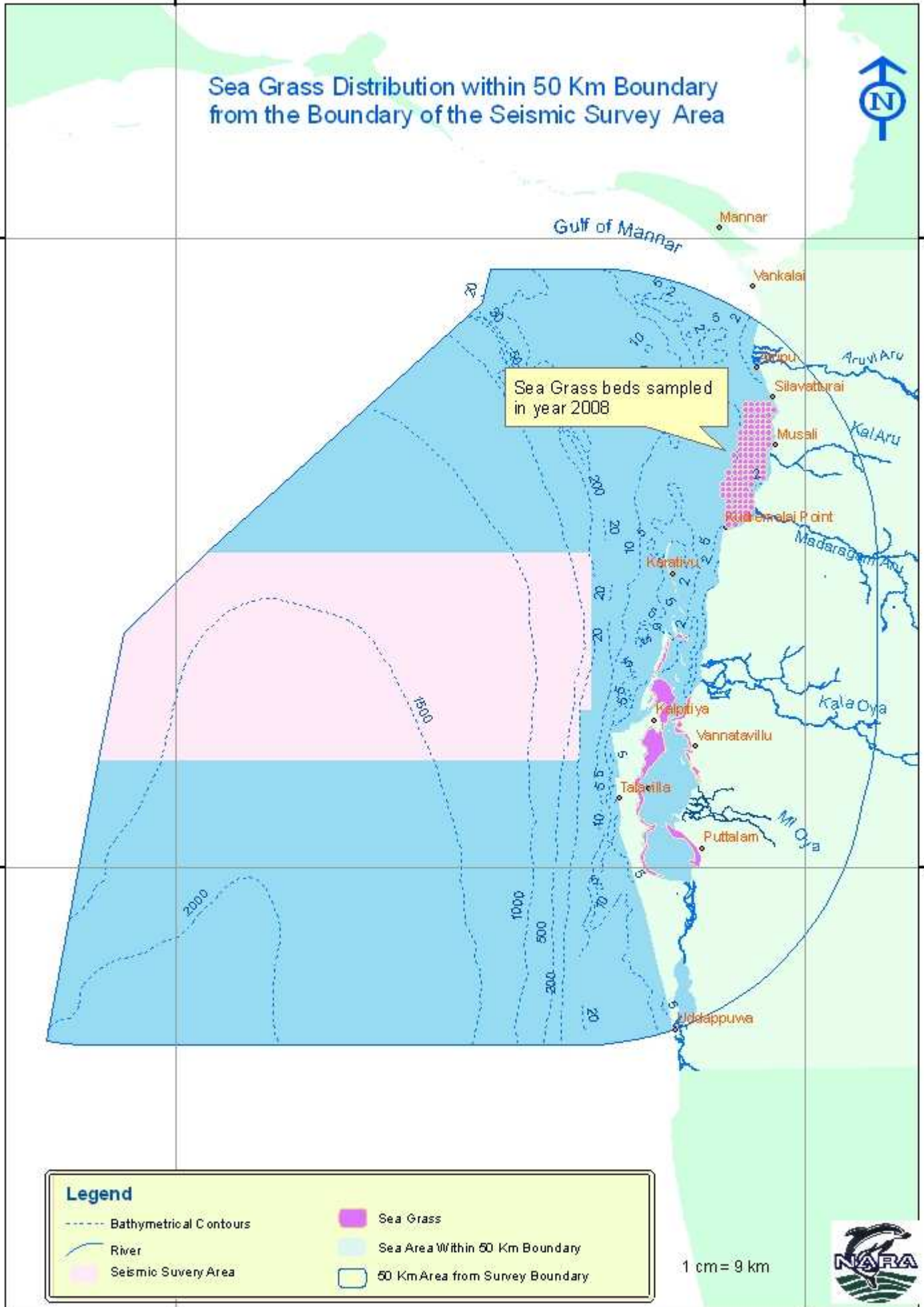


9°0'0"N

9°0'0"N

8°0'0"N

8°0'0"N



Sea Grass beds sampled in year 2008

**Legend**

Bathymetrical Contours	Sea Grass
River	Sea Area Within 50 Km Boundary
Seismic Survey Area	50 Km Area from Survey Boundary

1 cm = 9 km



79°0'0"E

80°0'0"E

### 3.4.6 Birds

The north western coast of Sri Lanka is an important area for birds, specially for the migratory species. The migratory birds that come to Sri Lanka during winter enter through two different routes and spread through out the island. Therefore this region is very important to the birds coming through the western fly way. Many sea birds and water birds are resident in the same area. The Wilpattu National Park and the islands in the lagoons provide breeding and roosting sites for many resident bird species.

The North western province contained many marshy lands and uninhabited areas along its coast, including the Wilpattu national park. With the development of the shrimp industry part of the marsh lands were lost and this affected the wader bird populations severely as large numbers that came in during the migrant season settled in these marshes with ample food and resting places. However with the shrimp disease out breaks, further destruction was prevented, while most farms became non operational and the area became more habitable to birds and other fauna that were once displaced.

#### **Present condition.**

Presently the coast contains sand dunes, marshy lands consisting of mangroves or salt marshes, and shrub jungle areas. Forested areas and abandoned shrimp farms are also observed among these, The major forested area is the Wilpattu sanctuary, which is home to a large number of wild life. Several important bird species have been recorded from the area including some of the rare threatened species such as the spotted green shank, (Nordmann's Greenshank) *Tringa guttifer*, Spoon-billed Sandpiper *Calidris pygmeus* , Spoon-billed Sandpiper *Calidris pygmeus* etc. and nationally threatened species such as Jungle Bush-quail, *Perdicula asiatica* ,Indian Courser *Cursorius coromandelicus*,etc. The coastline of the Wilpattu National Park and the islands in the lagoon area as well as the marshes have provided good feeding and resting grounds for these birds with little interference from anthropogenic activities during past years. A list of

birds observed in the area during the recent years (2007 – 2008) is in Table 3.4.7.1. Since the coastal areas are not disturbed by activities other than traditional activities which were mostly environmental friendly and did not use high technology, the migrants entering through the western route rested in the area before reaching their wintering grounds. The area also contained sufficient food sources for the different types of birds that were observed in the area - resident or migratory (see annexure: Bird list in the North western coast from Puttalam to Mannar region).

A large number of migrants therefore remained in the area, specially the waders, and the shore birds. The migrants enter the country commencing from late August until about November through this route while travelling to the south. They also use the same route to return to their breeding grounds during summer. Generally most migratory bird enter between Mannar and Puttalam to the coast of Sri Lanka and some travel south along the coast while some travel inwards along the Malwatu oya and the Mi oya river basins. Since the entrance to the country is from this area and a large number of birds fly in during migration it could cause high casualties. In addition to this winter migration there is an annual sea bird migration in this area where sea birds migrate outwards during the south west monsoon. Sea birds coming from mainly northern areas go out into the sea during the monsoons and use this same route for this purpose. Generally summer migration commences in the latter parts of February and May go on till mid May. However the most number of birds have been observed entering during September and October while most of them leave for their homes back during mid March and April.

#### 3.4.8 Sea turtles: species, nesting sites and abundance

Turtles are believed to have a life-span greater than 80 years. Most of the species are highly migratory, moving between nesting and feeding grounds, which can be thousands of kilometres apart. The only time marine turtles leave the ocean is when the females come ashore to nest.

Out of a total of seven living species of turtles in the world, five are reported to nest along the coastal belt of Sri Lanka namely; Loggerhead (*Caretta caretta*), Green turtle (*Chelonia mydas*),

Olive Ridley (*Lepidochelys olivacea*), Leatherback (*Dermochelys coriacea*) and Hawksbill turtle (*Eretmochylus imbricata*) (Amarasooriya and Dayaratne, 1997).

Three species of marine turtles have been recorded in the Gulf of Mannar region. The predominant species is the Olive Ridley (*Lepidochelys olivaceae*), followed by the Green Turtle (*Chelonia mydas*) and the Hawksbill Turtle (*Erytmochelis imbricata*). All three species are considered to be globally threatened. The Gulf of Mannar area is known to be an important foraging site and a migratory route of the Olive Ridley population inhabiting the South Asian marine region (Kapurusinghe and Cooray, 2002).

Olive Ridley (*Lepidochelys olivaceae*), and Green Turtle (*Chelonia mydas*) have been observed occasionally in Palliyawatta, Bathalangunduwa and Karaitivu areas (M.G.K. Gunawardane, pers. comm.). Also, their nesting areas have not been adequately documented although there are reports of nesting south of Kandakuliya to Talawila and in the Wilpattu coast. The coastal waters closed to the Kalpitiya peninsula (part of the Gulf of Mannar) have been identified as a foraging ground of the olive Ridley turtles nesting along the Orrissa coast of India (Pandav et al.1994).



79°0'0"E

80°0'0"E

### Marshes/Villus Distribution within 50 Km Boundary from the Boundary of the Seismic Survey Area



9°0'0"N

9°0'0"N

8°0'0"N

8°0'0"N

Gulf of Mannar

Mannar

Enkálai

Arupú

Arupú Aru

Silavatturai

Kal Aru

Mussali

Kudavala Point

Karativu

Madaragan Aru

Kala Oya

Kaipitiya

Kannátavillu

Talaella

Puttalam

Mi Oya

Nelappuwa

#### Legend

----- Bathymetrical Contours

— River

Seismic Survey Area

Marsh / Villu

Sea Area Within 50 Km Boundary

50 Km Area from Survey Boundary

1 cm = 9 km



79°0'0"E

80°0'0"E

### 3.4.6 Biomass

#### 3.4.6.1 Chlorophyll

Chlorophyll a is an indicator which determines the phytoplankton biomass in seawater. Chlorophyll a concentration was determined at seven stations with an interval of 2 km. Chlorophyll a content is decreased towards the offshore. Mean chl-a concentration at the surface waters off Thalawila is 0.53 mg m<sup>-3</sup> showing a variation of 0.21 - 1.58 mg m<sup>-3</sup> in February and November respectively (Fig.3.4.6.1).

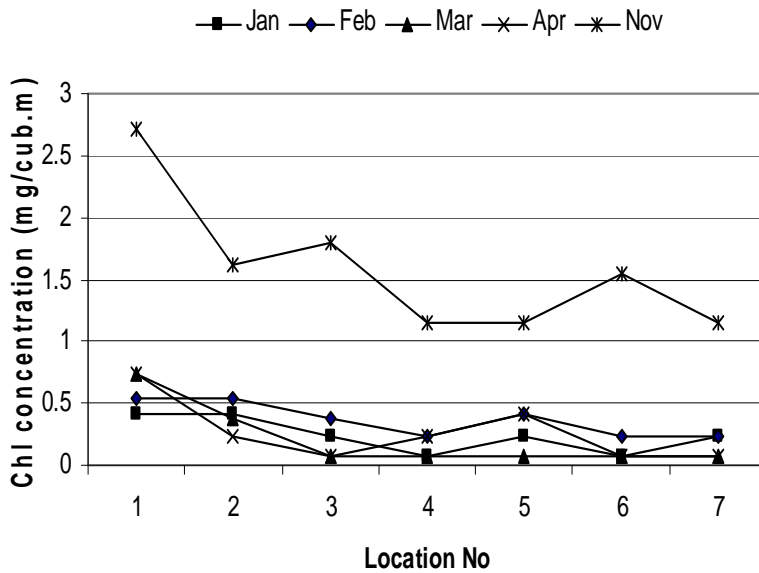


Fig. 3.4.6.1 Monthly Chlorophyll-a variation off Thalawila -2007

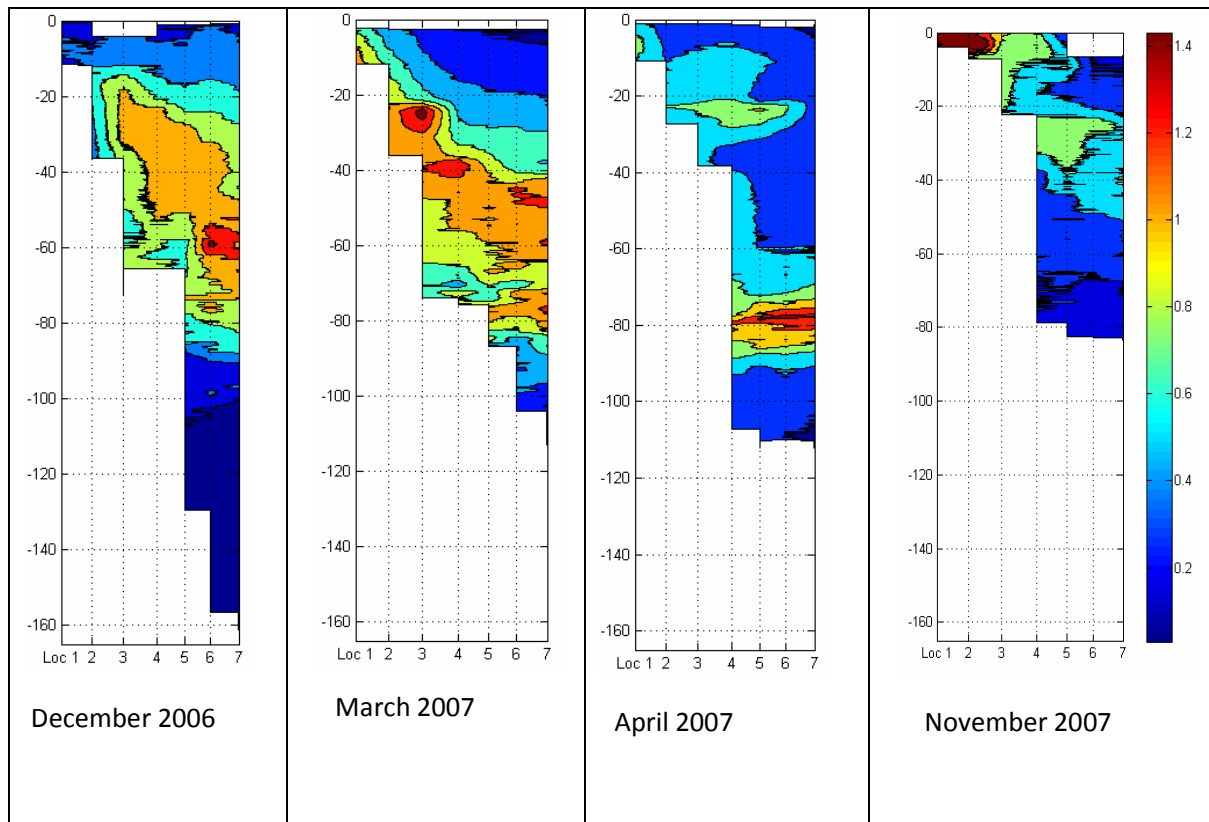


Fig. 3.4.6.2 Vertical variation of Chlorophyll-a December 2006, March, April, November 2007

Chlorophyll Fig. 3.4.6.2 shows the vertical variation of chlorophyll a at seven selected stations in December 2006 and March, April, November 2007. Vertical variation shows that maximum chlorophyll levels are not at the surface waters in the ocean. In December, Chlorophyll maximum ( $1.2 \text{ mg m}^{-3}$ ) is recorded at the depth of 60 m. But, in March Chlorophyll maximum is observed within the depth range of 20-50 m. In April, Chlorophyll maximum is observed at 80 m which is deeper than other months. The depth which is observed maxima of chlorophyll a indicates the highest abundance of phytoplankton. Therefore, due to higher abundance of primary food particles, fish may aggregate at these depths for feeding.

### 3.4.6.2 Phytoplankton

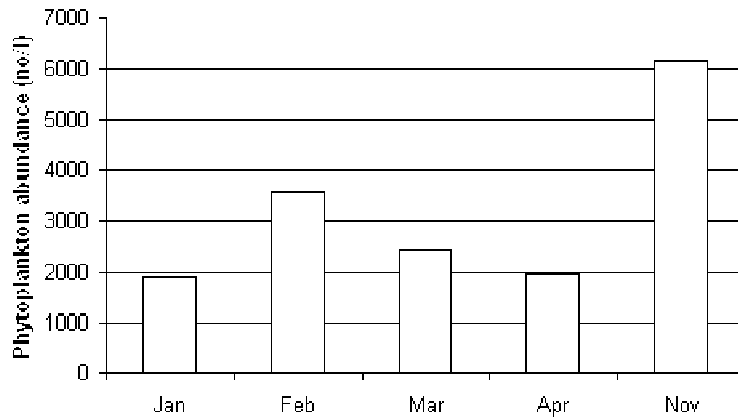


Fig. 3.4.6.2.1 Monthly variation of phytoplankton abundance off Thalawila

Phytoplankton analysis showed that mean phytoplankton abundance of the off Thalawila is 3217.257 No/l and varied monthly from 1976 (April) - 6174 (November), (Fig.3.4.6.2.1). However, higher phytoplankton densities were recorded at the Gulf of Mannar ( $0.34-5.84 \times 10^4$  no/l) and Palk Strait ( $0.12 \times 10^4$  to  $10.67 \times 10^4$  No/l), (Jayasiri,2007).

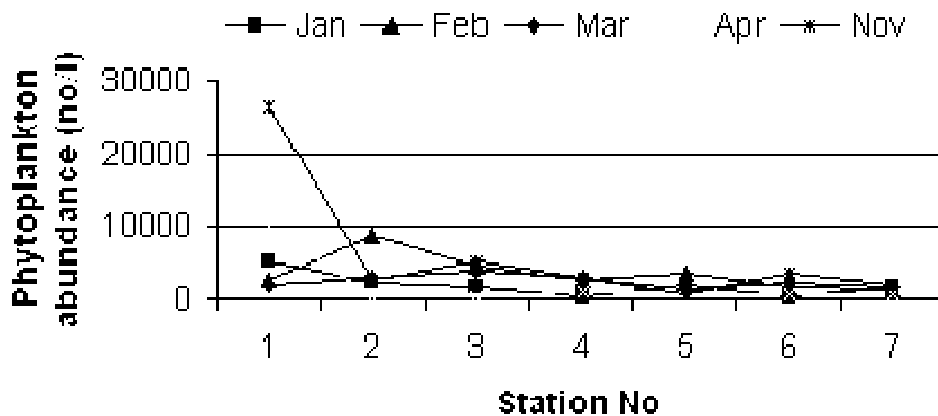


Fig. 3.4.6.2.2. Phytoplankton abundance at selected stations off Thalawila

Phytoplankton density decreases towards to offshore. Highest and lowest abundances were observed at stations no 8 and 32 respectively. High peak of abundance was associated with *Chaetoceros* sp. which accounted for 23.75% of the total abundance.

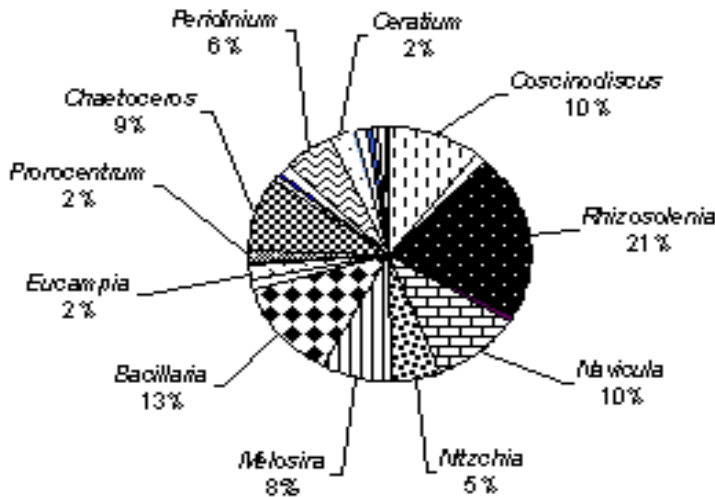


Fig. 3.4.6.2.3. Phytoplankton composition off Thalawila

The total of 27 phytoplankton taxa were reported from the area belonging to three groups identified as diatoms (23 genera), dinoflagellates (3 genera), silicoflagellates (1 genus), see table 3.2.9.2.1. However 38 and 27 genera were reported in Gulf of Mannar and Palk Strait respectively (Jayasiri, 2007). Diatoms accounted for between 85.3-99.09% of the total phytoplankton population in the 32 sampling sites followed by dinoflagellates, which contributed between 0-33 percent. Other groups accounted for between 0-15% (Fig. 4). Most dominant phytoplankton genus is *Rhizosolenia* sp. which contributed 21.25% of the total population followed by *Bacillaria* sp (12.65%), *Coscinodiscus* sp. (10.45%) and *Navicula* sp.(10.31%)(Table 3.2.9.2.1). Statistical analysis showed a significant correlation ( $r^2=0.90$ ) between phytoplankton abundance and chlorophyll-a concentration at the surface.

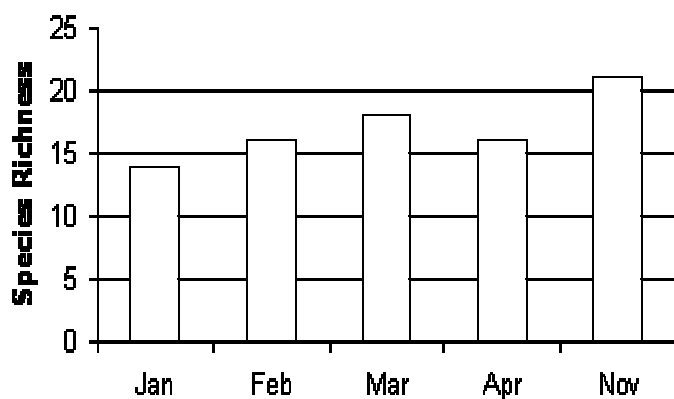


Fig. 3.2.4.6.4 Monthly variation of species richness off Thalawila

Highest species richness is observed during the month of November while lowest is observed in April (Fig. 3.4.6.2.4).

Table 3.4.6.2.1. Phytoplankton species and their mean percentages

Identified groups	Species	Mean %
Bascillariophyceae (Diatoms)	<i>Coscinodiscus</i> sp.	10.45
	<i>Pleurosigma</i> sp	1.42
	<i>Rhizosolenia</i> sp.	21.25
	<i>Pseudorhizosolenia</i> sp.	0.34
	<i>Psedosolenia</i> sp.	0.50
	<i>Navicula</i> sp.	10.31
	<i>Nitzchia</i> sp.	5.46
	<i>Melosira</i> sp.	8.17

Identified groups	Species	Mean %
	<i>Bacillaria sp</i>	12.65
	<i>Bacteriastrum sp.</i>	1.21
	<i>Eucampia sp.</i>	2.08
	<i>Pololampus sp.</i>	0.07
	<i>Prorocentrum sp.</i>	1.79
	<i>Chaetoceros sp.</i>	9.31
	<i>Skeletonema sp.</i>	0.26
	<i>Biddulphia sp.</i>	1.19
	<i>Ditylum</i>	0.18
	<i>Guinardia sp.</i>	1.19
	<i>Triceratium sp.</i>	0.13
	<i>Cosmarium</i>	0.57
	<i>Thalassionema sp.</i>	0.77
	<i>Cderatulina sp.</i>	0.78
	<i>Thalotrix sp.</i>	0.18
Dinophyceae (Dinoflagellates)	<i>Peridinium sp.</i>	5.64
	<i>Ceratium sp.</i>	2.39
	<i>Noctiluca sp.</i>	0.17
Chrysophyceae (Silicoflagellates)	<i>Dictyocha sp.</i>	0.49

### 3.4.6.3 Zooplankton

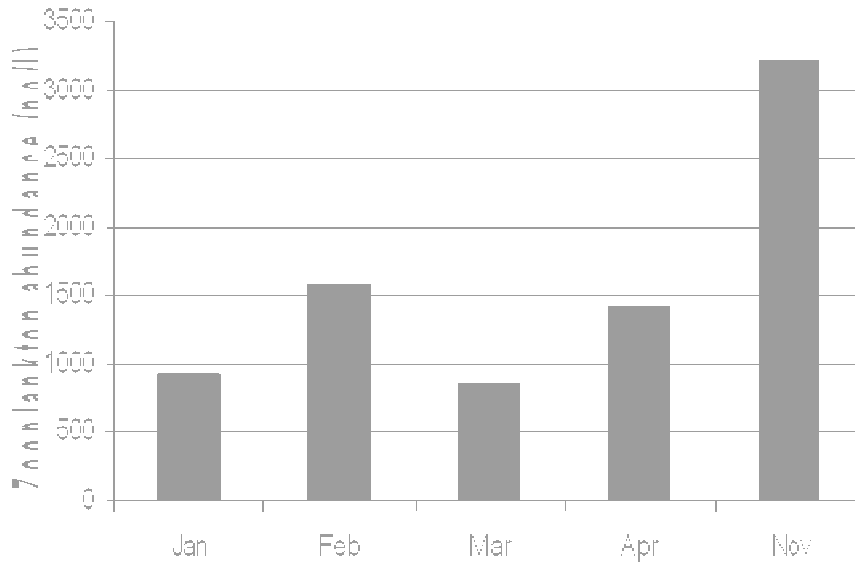


Fig. 3.4.6.3.1. Monthly variation of zooplankton abundance off Thalawila

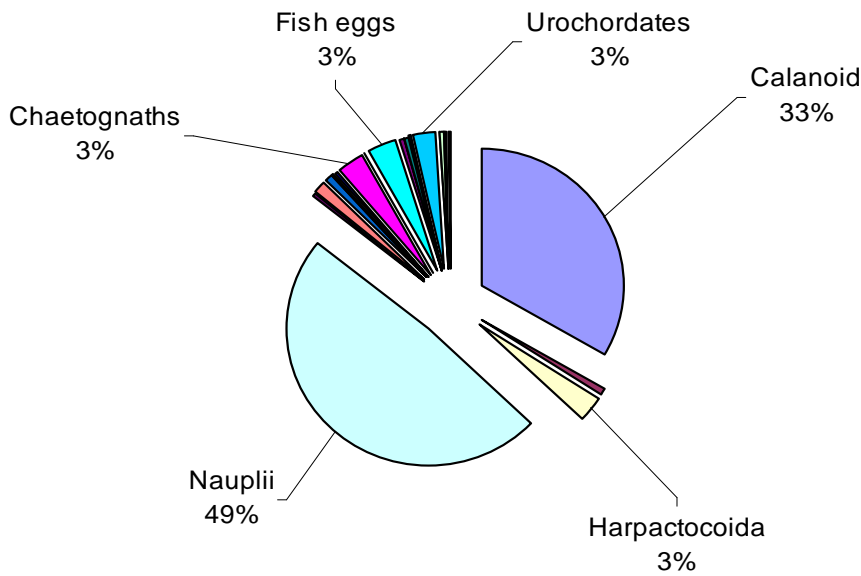


Fig.3.4.6.3.2. Composition of major zooplankton groups off Thalawila



Monthly zooplankton abundance of the area is varied from 27-134 indivi./l. Highest abundance of 134 indivi./l is recorded in November 2007 and lowest is recorded in January 2007 (Fig: 3.2.9.3.2). However zooplankton abundance was ranged from 30-244 individuals/l in Palk Strait (Jayasiri 2007). Zooplankton taxa of the area were identified under 21 groups. Most dominant group was crustacean larvae (Fig. 9), which comprise of 48.41% followed by copepods (34.5%). Urochordates contribute 2.5 % to the zooplankton composition of the area (Table 3.2.9.3.1.). Statistical analysis showed a significant correlation ( $r^2=0.89$ ) between phytoplankton abundance and zooplankton abundance.

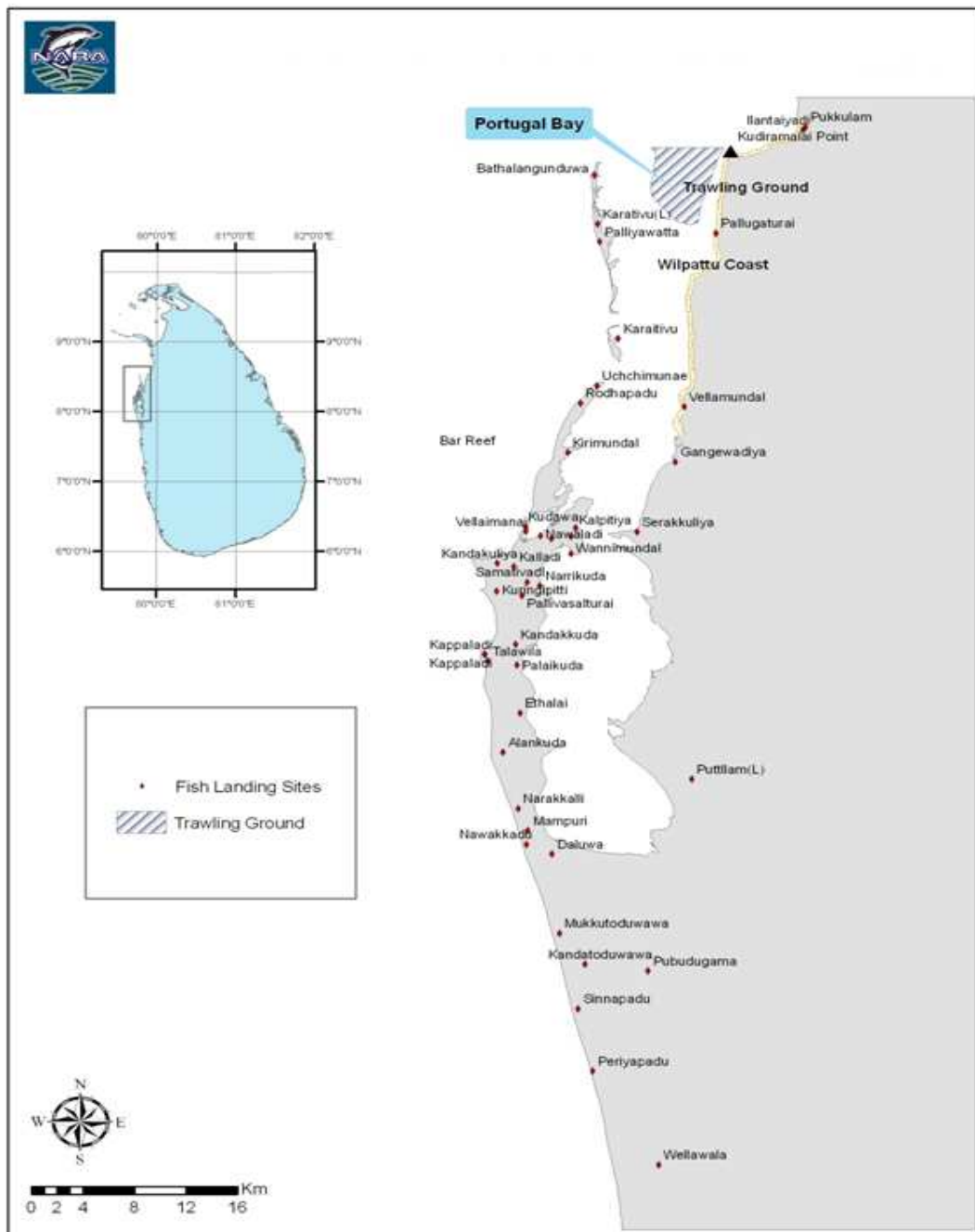
Table 3.4.6.3.1. Mean percentage of zooplankton groups in the study area

Zooplankton group	Mean %
Calanoid	33.04
Cyclopoid	0.97
Harpactocoida	3.03
Nauplii	48.41
Ostracode	0.11
Bivalvia	1.40
Gastropoda	1.00
Mollusc egg/bivalve eggs	0.07
Decapoda	0.33
Chaetognatha	3.10
Fish Larvae	0.12
Fish eggs	3.11
Polychaeta	0.71
Hemichordata	0.06

Sarcomastigophora	0.30
Ophiura	0.14
Urochordata	2.53
Cnidaria	0.07
Foraminifera	0.39
Cladocera	0.33
Unidentified	0.29

### **3.5 Fisheries, Coastal and Marine Fauna and their utilization**

The fauna within the seismic survey area (i.e. inside the offshore block SL-2007-1-001) and in adjoining and neighbouring areas comprise of important fisheries resources. The bar reef marine sanctuary is also located in the area. The bar reef is one of most productive coral reef systems as well as it is unique in terms of its bio diversity. About 400 species of reef fish and numerous species of crustaceans including commercially important species such as lobsters and sea cucumbers have been found from the area. The Puttalam Lagoon, a highly productive estuary in the Northwest coast of Sri Lanka is also located close to the block. The lagoon fishery comprises of important freshwater, marine and brackish water species of finfish and shellfish resources. The coastal fishery is conducted in the coastal waters targeting small pelagics, demersal finfish and shellfish resources. In addition, large pelagic fishery, which mostly targets tuna and tuna-like species, is conducted in the deeper waters including the areas that contain the block as well as in neighbouring areas to the block. Fishing is the main economic activity in the sea as well as in the Puttalam Lagoon.



**Figure: 3. 5. 1.** Map showing important fish landing sites and the Portugal Bay shrimp trawling ground

### 3.5.1 Fisheries in the Puttalam Lagoon

A total of about 70 species of finfish and crustacean belonging to 35 families have some commercial value in the area (Dayaratne *et al.* 1995). Around 75% of the total fish production in the lagoon comprises of finfish whereas around 25% of the total production is shellfish (Dayaratne *et al.*, 1997). Shad (*Nematalosa nasus*), Keeli shad (*Hilsa keeli*), grey mullet (*Mugil cephalus*), pony fish (*Leiognathus* spp.) and milk fish (*Chanos chanos*) are the commonly harvested finfish species. Penaeid shrimps (Green tiger prawn – *Penaeus semisulcatus* and white prawn – *P. indicus*) and swimming crab (*Portunus pelagicus*) are commercially important shellfish species harvested from this lagoon. Apart from that, several species of sea cucumber and invertebrates which are economically important commodities in the export market are also collected from this lagoon environment.

Fishing in the Puttalam lagoon is conducted by mechanised as well as non-mechanised fishing crafts. A fishing craft survey was conducted in the lagoon by NARA during the 1<sup>st</sup> quarter of 2006. According to this survey, of the total of 1 143 operated fishing crafts in the lagoon, 373 were mechanised crafts and the rest was non-mechanised fishing crafts. The mechanised crafts are either out-board engine Fibre Reinforced Plastic (FRP) boats or motorised traditional crafts. Gillnets and trammel nets are the commonly used fishing gears inside the lagoon. Apart from that, a wide range of fishing gears and methods such as push nets, pull nets, encircling nets and crab traps are also being employed in the lagoon fishery. Some fishing gears and methods are seasonally used and June – September period is the peak season. A considerable number of fishing crafts operated in the sea migrate to the lagoon during that period when the sea becomes too rough for fishing and engages in the lagoon fishery until sea is favourable to operate.

The Maximum Sustainable Yield (MSY) and Maximum Economic Yield (MEY) for the Puttalam Lagoon fishery have been estimated at 5536 MT and 4945 MT respectively (Dayaratne *et al.* 1995). But, the fish productivity of the lagoon has been considerably declining. Both environmental degradation and resource over-exploitation have significantly contributed for this.

### 3.5.2 Geographical distribution of the marine fisheries

The narrow continental shelf of Sri Lanka rarely exceeds 40 km and averages around 22 km in width. Many of the small pelagics such as sardine and herring like species are concentrated in the area of the continental shelf which is closer to the shore and less than about 50 m in depth (Sivasubramaniam, 1999). Medium pelagics such as Indian mackerel (*Rastrelliger kanagurta*), smaller sizes of Spanish mackerel (*Scomberomorus commerson*) and coastal small tunas are also distributed in shelf areas and are also concentrated in areas beyond 50m (Sivasubramaniam, 1999). Resource surveys and exploratory fishing activities have indicated that the 29-60 m depth range is the most productive range for demersal populations. Beyond 80m depths, there are concentrations of stocks of medium demersals, for instance threadfin bream (Family: Nemipteridae) and larger demersals (some species of grouper (Family: Serranidae), snapper (Family: Lutjanidae), emperor (Family: Lethrinidae) etc.), which are rather independent of the stocks in shallow waters (Sivasubramaniam, 1999). The large pelagic fish including tuna and tuna-like species are generally in the offshore/ oceanic ranges.

Deep-water shrimps and deep-water lobsters also exist in the 200-350 m depth ranges off the northwest coast (De Bruin *et al.* 1994). The Deep Water Demersal Fish Resources Survey conducted in 1972 discovered a location of a deepwater prawn and lobster ground west of Kudremalai point, located between 79° 23' to 79° 40' E latitude and 8° 30' to 8° 48' N longitude (Joseph and Dayaratne, 1994). However, at present, these resources are not really targeted. The smaller short-lived demersal species such as pony fishes (e.g. *Gazza minuta*, *Leiognathus spp.*) are predominant in the North-west coast.

### 3.5.3 Coastal Fishery

The coastal fishing is mostly confined to the shallow coastal waters within the continental shelf. The coastal fishery consists of trawl fishing conducted for targeting shrimps, small meshed gillnet fishery for small pelagics, beach seine fishery, flying-fish fishery, the fishery for

ornamental species, the fishery associated with coral reefs and other export oriented fisheries such as sea cucumber, chank and lobster.

### **3.5.3.1 Fishing crafts and gears used in the coastal fishery**

Fishing is carried out in the coastal waters using motorized boats as well as traditional non-motorized boats. There are 4 638 operating fishing crafts in the Puttalam fisheries district (MFAR, 2007). Except the 84 fishing crafts which are with inboard engines, multi-day fishing crafts normally operate in the offshore and deep sea, all other fishing crafts are engaged either in the coastal fishery or in the lagoon fishery. It should be noted that inboard engine single-day fishing boats have not been reported from Puttalam. Majority of the fishing crafts operated in the coastal waters are FRP boats. The FRP boats, non-mechanised traditional boats and non-mechanised beach seine crafts operated in the coastal waters were estimated at 2 419, 764 and 227 respectively. All mechanised traditional crafts are confined to the lagoon fishery. The types of fishing gear used in the coastal waters include gillnets, hand line, bottom set nets, beach seine etc. Scuba diving is a popular fishing method for sea cucumber, lobster, ornamental fish etc. There have also been destructive fishing gears and methods such as purse seines, use of dynamite etc.

Followings are the important fishing activities conducted in the coastal waters neighbouring to the block.

#### **3.5.3.1.1 The Trawl Fishery**

Shrimp trawling is carried out in the Portugal Bay, north of Puttalam lagoon (Figure 3.5.1). The trawl fishery is mainly conducted targeting shrimps (comprised mainly of *Penaeus semisulcatus*, *Metapenaeus moyebi* and *M. dobsoni*) but it also exploits a reasonable amount of fish as by-catch. The pony fish (*Leiognathus* spp.) is one of the major contributors to the trawler by-catch.

In the shallow trawling grounds in the Portugal Bay, trawling is conducted by 3.5 t trawlers and 11 t trawlers. The number of 3.5 t and 11 t operated trawlers in the area at present are 10 and 19 respectively. Seasonal fluctuations are noted in the trawl catches. The bottom trawling is conducted more or less all round the year and the period from October to April is the best fishing season for shrimps. The average catch rates for 3.5 t trawlers and 11 t trawlers were 23 kg per haul and 73 kg per haul respectively (Jayawardena and Dayaratne, 1995).

#### **3.5.3.1.2 The small meshed gillnet fishery**

A wide variety of mesh sizes are used in the commercial gillnet fishery. Mesh sizes ranging from 6 mm to 38 mm (small mesh) are commonly used for the exploitation of small pelagic species. Small meshed gillnet is the main fishing gear used for catching small pelagics and around 90% of small pelagics are caught by this gear (Haputhantri, 2004). The major small pelagic fish landing centres are located in Talawila and Kandakkuliya. These gillnets are mainly operated with FRP boats. Two fishermen normally participate for a fishing operation conducted by using small meshed gillnets. Both morning and night fishing operations are conducted. The time of leaving for morning fishing operations is mostly after 2.00 am. The fish catch is normally landed between 7 am and 10 am. For night fishing operations, fishermen usually leave at around 4.00 pm. The night catch is landed between 9 pm and the mid-night. Single fishing operation is normally conducted per day. Morning fishing operations are conducted more or less all round the year but, night fishing operations are confined to few months of the year. The engine size of the vessels varies on the range 9 – 40 hp. The depth at fishing has mostly confined to 7 – 180 m. The target species of the small meshed gillnet fishery are sardines. Around 80% of small meshed gillnet fishery catch comprised of sardines. The key target species is Herring (*Amblygaster sirm*). The preferred depth range for small pelagic species like herrings is below 70m (Froese and Pauly, 2008). The average catch rate was estimated at 42 kg per FRP gillnet boat. A strong seasonal variation in the catch rates of small meshed gillnet fishery is observed but, July–November is normally the peak season. It has been revealed that present level of exploitation of small pelagic stocks is not sustainable (Haputhantri *et al.* 2008).

### **3.5.3.1.3 The beach seine fishery**

The beach seine fishery is a traditional fishing method practiced in the coastal fishery. This is a seasonal fishery carried out at several beach seine landing sites in the Puttalam fisheries district during the period from October to April when the sea is calm. The main beach seine centres are located in Sinnapadu, Mukkuthoduwawa, Kandathoduwawa and Daluwa. A substantial quantity of small pelagics (around 10% of the total landings) is caught by beach seines. Key small pelagic species caught by beach seines are Indian mackerel (*Rastrelliger kanagurta*), sardines (*Sardinella* spp.) and anchovies (*Stolephorus* spp.). Silver bellies (*Leiognathus* spp.), Tunas (Scombridae) and Carangidae like species are also sometimes found in the beach seine catches. Two types of beach seine crafts are basically operated in the beach seine fishery: traditional large wooden canoes (Wallam) and modified fibre glass boats. Beach seine crafts are operated by oras and usually 8 fishermen are engaged in a craft. Traditional wooden crafts are being progressively replaced by the modified fibre glass boats. The average catch of a beach seine during the early months of the season tends to be 2 250 kg per operation, but this is reduced to about 120 kg per operation by the end of the season (Dayaratne *et al.*, 1997).

### **3.5.3.1.4 The flying fish fishery**

The flying fish fishery is a seasonally carrying out fishery and it is conducted in the coastal and offshore waters around 20 – 30 km away from the coast during the period from October to April. The fishermen engage in other fishing activities switch to the flying fish fishery during the season because of better economic returns (Dayaratne *et al.*, 1997). The involved fishermen in this fishery are either resident fishermen at Kandakuliya or seasonally migrant fishermen to Kandakuliya from other fishing villages along the west coast. The flying fish fishery is conducted by FRP boats using nets. Jayawardena and Dayaratne (1995) estimated the average catch rate at 120 kg per boat.



### **3.5.3.1.5 The coral reef associated fishery**

A considerable number of fishermen engage in the fishery targeting fish species inhabited in the coral reefs along the Kalpitiya Peninsula and north of Kalpitiya. The Bar Reef is a highly productive coral reef ecosystem, particularly due to its location, which is adjacent to Puttalam lagoon with extensive mangroves and sea grass beds. This particular fishery is carried out throughout the year targeting various reef associated species including rock fish (Mulletts) and the fishermen engaged in this fishery are from the fishing villages like Kudawa, Kandakuliya, Talawila and Mampuri as well as from the Islands located north to Kalpitiya. The major target groups of reef associated species are groupers (*Epinepheius* spp.), snappers (*Lutjanus* spp.), sea crabs (*Portunus* spp.), emperor fishes (*Lethrinus* spp.) and sweetlips (*Plectorhynchus* spp.) (Dayaratne *et al.*, 1997). Unlike small pelagic fishery, the catch composition of the dominant species varies regularly. Bottom long lines, bottom set gillnets and hand lines are frequently used fishing gears for the exploitation of reef associated fish. Bottom set gillnets are seasonally operated whereas the bottom long line and hand lines are operated throughout the year. October – April is the fishing season for bottom set gillnets. Bottom long lines comprised either large hooks or small hooks are employed to catch a wide size range of species. Bottom set gillnets which are banned under fisheries regulations were found to be one of the destructive fishing gears used on the reef and have a major impact on the physical condition of corals. In addition, purse seine nets also called ‘Laila nets’ often used in combination with explosives is another illegal but has become an extensively used method and this is the most dangerous fishing method in practise at present.

### **3.5.3.1.6 Other export oriented fisheries**

Apart from prawns and ornamental fish, other export oriented fisheries include spiny lobster, sea cucumber and chank. Exploitations of these groups have also significantly increased during the last few years since there is a high demand in the world market for these commodities.

### 3.5.3.1.7 Deep water lobsters

The Deep Water Demersal Fish Resources Survey conducted by R/V 'Optimist' in 1972 discovered deepwater prawn and lobster grounds west of Kudremalai point, located between 79° 23' to 79° 40' E longitude and 8° 30' to 8° 48' N longitude. This finding was reconfirmed by the resources survey conducted by R/V DR Fridtjof Nansen during 1978-80. The major fishery group found in this fishery ground are deep sea lobsters (*Puerulus sewelli*), prawns (*Aristeus semidentatus* and *Heterocarpus gibbosus*) and large demersal fish species (*Chlorophthalmus b/scornis*, *C. agassizi*, *Cubiceps* sp. and Myctophids). The catch rates (kg/hr) recorded were 37.4, 46.2 and 91.6 for prawns, lobsters and fish respectively. However, at present, these resources are not really targeted by Sri Lankan fisheries due to lack of facilities.

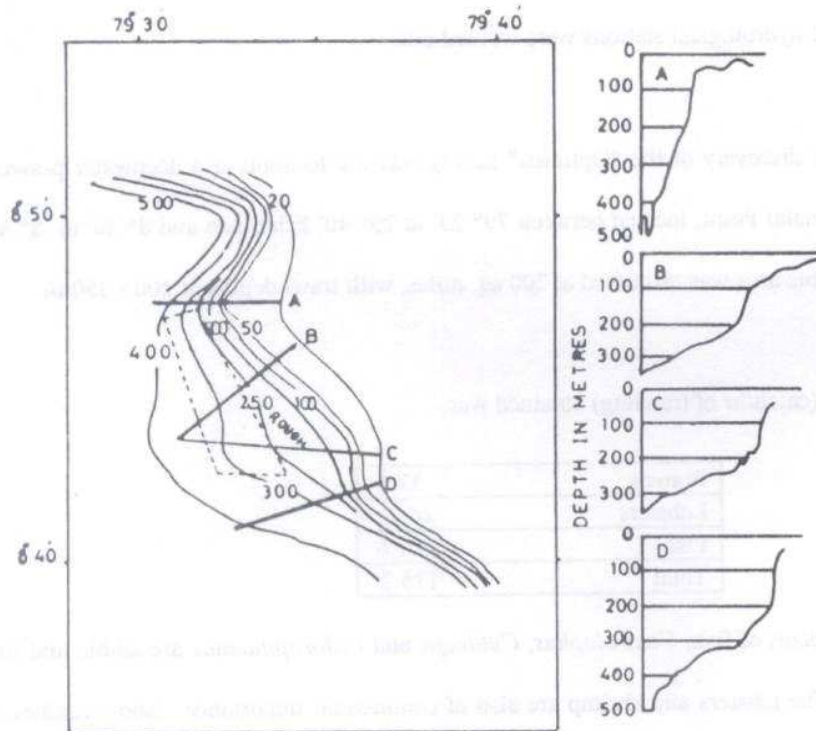


Fig 3.5.3.1.7 Deep water trawling ground off Kudremalai Point

# CHAPTER 4

## Impacts of the Project

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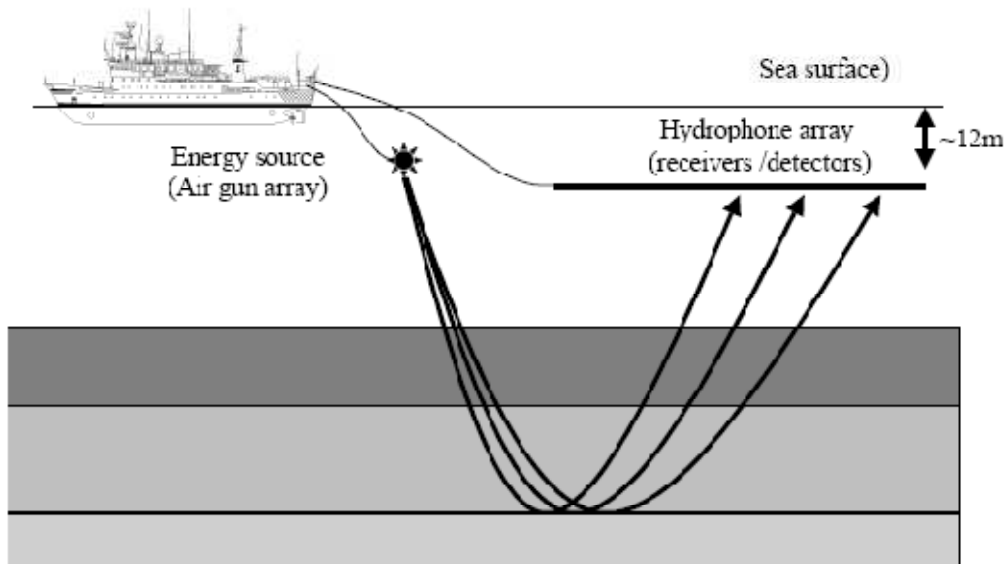
### 4.1 Oil and gas exploration: Seismic surveys

Noise is produced in all phases of oil and gas exploration and extraction with sources being continuous or impulsive, transient or permanent (Table 4.1.). However for the purposes of this report we will focus on the noises associated with oil exploration, particularly seismic surveys.

Marine seismic surveys are known to produce significant manmade noises in the oceans and may occur over extensive areas for extended periods of time. Seismic exploration or marine geophysical surveys often include bottom profiling via high intensity, low frequency sound sources. However, most seismic exploration sounds are short, discontinuous pulses separated by quiet periods (Gordon 2004; Richardson et al. 1995). These noises, referred to as impulsive sounds are created by the rapid expansion and collapse of an air-filled cavity.

These sounds are directed through the earth's crust and reflected at the geological boundaries that define the different strata. The reflected sound is then processed to provide information on the structure and composition of geological formations below the sea bed and to identify potential hydrocarbon reservoirs (Figure 4.1). The high energy sources typically used are arrays of 12-70 air guns towed at 4-6 knots at a depth of 4-10m (McCauley 1994, Gulland and Walker 1998), and the sounds reflected off the seafloor are recorded using towed hydrophone arrays several kilometers long. Air gun shots are fired at regular intervals of 6-20 seconds along planned transect lines (Richardson et al. 1995; Simmonds et al. 2004). The transects will cover an area of 1450 sq km and is expected to last around 45-50 days.

Many other sound sources are also associated with seismic surveys such as those associated with the networks of high frequency transponders used to track the positions of the arrays of hydrophone streamers (Gordon et al. 2004).



**Figure 4.1.:** The basic components of a marine seismic reflection survey (the layers of the seabed are shaded) (Simmonds et al. 2004)

While the energy produced by the air guns is below the frequencies of the calls and optimum hearing of toothed whales, the received levels are high enough to be clearly audible ( $\geq 130$  dB re 1 Pa). These pulses may have energies of between 200-500 Hz and as such maybe audible to odontocetes as far as 10-100 km away (Gordon 2004; Richardson et al. 1995). Single air guns are generally known to produce broadband source levels between 215 and 230 dB re 1  $\mu$  Pa-m possessing energies of between 10-300 Hz (McCauley 1994, Greene 1995). Broadband source levels of 248-255 re 1  $\mu$  Pa-m, zero to peak, are typical of a full scale array (Richardson et al. 1995). Although most energy is produced at the lower frequencies, air gun arrays can produce significant sound energy up to, and probably beyond, 22 kHz (Gordon and Moscrop 1996)

As the air gun arrays are directed in a downward direction sound intensity is also greatest in this direction, however, a considerable amount of energy is also radiated sideways (McCauley 1994).

As a result the far-field signature may be detected at great distances from the source (e.g. 50-75 km in water 25-50 m deep; Greene and Richardson 1987). Therefore sound levels received by animals in close proximity to the source will depend on their depth and position relative to the array's axis. However, arrays perpendicular to the axis will experience a sound pressure level greater than those in the line axis of the array (Richardson et al. 1995).

The use of three-dimensional seismic surveys is said to produce data of higher quality than two-dimensional surveys and provide more accurate data to define potential and/or existing hydrocarbon deposits. The staggered firing of multiple arrays, to reduce interference, increases the period of noise exposure (McCauley 1994). This concentration of seismic activity in a small area for a prolonged period may have the potential to cause long term exposure effects in the faunal populations.

The oil and gas exploration will take place in an area of 3000 sq km in +200m to 1800 m deep water. However, the streamers may come close to the western boundary of the Bar Reef Marine Sanctuary (about 1.5 km west) and therefore suitable precaution needs to be taken when operating in this area. This area is generally less than 200m deep and such shallow waters are known to encourage reflection and refraction of sound off the sea surface and sea bed or off different density layers (Simmonds et al. 2004). Cylindrical spreading loss is said to occur because the range of the receiver from the source is greater than the depth of the water column. As a result, in the shallower regions of the Gulf of Mannar, it is likely that sound would propagate horizontally through the entire area. Additionally, this depth would favour the arrival of higher frequencies first. However with increased distance from the source, received pulses would decrease in level but increase in duration. At the medium depths (several hundred metres) assuming free field propagation, animals directly below the array and deeper in the water column will receive higher intensity sounds than those animals closer to the surface but at the same range from the array.

## **4.2 Sound and marine mammals**

Light penetration below the ocean surface is minimal. While long wavelength light is the first to vanish, barely any light penetrates depths greater than 200m. As a result cetaceans have evolved to depend on sound rather than vision as their primary sense for communication and navigation.

### **4.2.1 Echolocation:**

Echolocation is the ability of an animal to produce mid- or high- frequency sounds and detect the echoes of these sounds that bounce off distance objects to perceive the physical features of their environment. The higher the frequency used, the greater the ability to detect small objects, however, higher frequency sounds have a more limited range underwater.

### **4.2.2 Navigation:**

Baleen whales are known to use low frequency sounds with high source levels for navigation purposes. These properties allow the sounds to travel great distances and are said to assist them on their long range migrations. These low frequency calls are said to be used in the same way odontocetes use echolocation and as such, allow them to perceive their environment.

### **4.2.3 Communication**

Cetaceans communicate inter- and intra- specifically using acoustic signals. Cetacean communication has a variety of functions which includes

Intra-sexual selection

Inter-sexual selection

Mother/calf cohesion

Group cohesion

Individual recognition

Danger avoidance

### **4.3 Impacts of sound on marine mammals**

Marine mammal's reliance on sound could cause a number of potential effects on marine mammals. These effects can be divided broadly into four categories (Gordon et al., 2004):

- i. Physical effects
- ii. Perceptual effects
- iii. Behavioural effects
- iv. Indirect effects

#### **4.3.1. Physical effects**

This could include in the extreme case damage to body tissues, gross damage to ears, permanent threshold shifts (PTS – permanent reduction in auditory sensitivity), temporary threshold shifts (TTS – temporary reduction in auditory sensitivity with eventual recovery) and chronic stress effects that may lead to reduced viability. Threshold shifts can be induced by exposure to intense short tones and sounds of moderate intensity for extended periods.

#### **4.3.2 Perceptual effects**

'Masking' of biologically significant sounds by elevated background noise levels caused by man-made noise that may prevent detection of other sounds important to marine mammals. The signal reaching the animal is appreciably weaker than the background noise. Baleen whales, low frequency specialists who vocalize below 1 kHz, are often the most vulnerable to masking effects (Clark 1990).

#### **4.3.3. Behavioural effects**

Changes in behaviour characteristic of disturbance include disruption of foraging, avoidance of particular areas, altered dive and respiratory patterns, and disruption of mating patterns. Table 4.3.3 provides a summary of research that has measured changes in behaviour in response to exposure to seismic noise. The selected studies provide data on received noise levels and/or

ranges from sources for behavioural responses. The original table has been modified to only include species that are found around Sri Lanka.

Table 4.3.3 Summary of observations of behavioural change in marine mammals in response to air guns and seismic surveys (modified from Gordon et al. 2004).

Species	Location	Observation	Source	Received level	Range	Behaviour	Water depth	Prop. Model	Reference
Common dolphin	Irish Sea	Operating seismic	2D Seismic 2,120 cu. in.		>1 km	Reduced vocalisation rate within vocal range and/or exclusion within 1 km.	50-100 m		Goold (1996)
Bottlenose dolphin	Captivity		1 sec 20 kHz pulse	-178 (75 kHz) dB-136 (3 kHz dB)		Behavioural avoidance responses at 178 dB			Ridgeway et al. (1996)
Sperm whales	Southern Ocean	Opportunistic	Seismic (x16) (263 dB re. 1 $\mu$ Pa -m)	-112 dB	>300 km	Cessation of vocalisation in response to some instances of air gun activity	>500 m 50-100 m		Bowles et al. (1994)
Humpback whale	S.E. Alaska	Experimental playback	Seismic gun 1.64L (226 dB)	-150-169	<3.2 km	Short-term startle response. No clear avoidance at levels up to 172 dB re. 1m Pa effective pulse pressure level.			Malme et al. (1985)
Humpback whale	North West Cape, W. Australia	Operating seismic	Seismic array 4.4 (258 dB re. 1 $\mu$ Pa <sup>2</sup> -m p-p)	-170 dB P-P -162 dB P-P -57 dB P-P	3-4 km 5 km 8 km	Stand-off (General avoidance) Avoidance manoeuvres Avoidance manoeuvres	100-120 m	25 logR	McCaulley et al. (1998)
Humpback whale	Exmouth Gulf, W. Australia	Experimental playback	Seismic gun 0.33L (227 dB re 1 $\mu$ Pa <sup>2</sup> -m p-p)	-159 dB P-P	1 km	General avoidance	10-20 m		McCaulley et al. (1998)
Blue whale	North Pacific Ocean	Operating seismic	Seismic source 1,600 cu. in. (215 dB re. 1 $\mu$ Pa 1-m p-p)	-143 dB P-P	10 km	Course alterations begin Closest approach 10 km? Cessation of vocalisations for c.1 hr. Resumption of vocalisations and movement away from source.	2,400 m		Macdonald et al. (1955)

#### 4.3.4 Indirect effects

Marine fish may be vulnerable to intense sounds because most possess air-filled swim bladders. Despite having less acute hearing than marine mammals, many are more sensitive than odontocetes in the range 100-500 Hz where most seismic sound is produced. The exposure of potential marine mammal prey to seismics could thus reduce their accessibility as they may move out of an area or become more difficult to catch. This could in turn affect marine mammal distributions and feeding rates. Conversely, damaged or disoriented prey could attract marine mammals to a seismic survey area, providing short term feeding opportunities but increasing levels of exposure to sound.

Deep diving odontocetes such as sperm whales may be at particular risk to increased man-made noise as their behaviour puts them in the deep sound channel or SOund Fixing And Ranging (SOFAR) channel, along which sound is channeled and can travel efficiently for hundreds to



thousands of kilometers (Simmonds et al. 2004). Downward focused seismic sources tend to expose any submerged or deep diving cetaceans to high levels of acoustic energy. Deep divers such as Sperm whales balance their energy budgets extremely finely to ensure that the oxygen stores within their bodies are managed and spend only limited periods at the surface to rest and recover. The healthy population of deep diving sperm whales in the Gulf of Mannar and its vicinity may therefore be particularly at risk as diving takes them into regions in which received sound levels are higher than those measured or predicted close to the surface. Additionally, it has been shown that within a species, different classes of individuals might be differently vulnerable and/or responsive. A mother nursing a young calf would be expected to show stronger avoidance behaviour than a male guarding a breeding territory because of the importance of communication and vulnerability of the calf. Other species such as spinner dolphins have also been documented in large groups that include numerous calves (de Vos personal observation; Illangakoon 2002). As such, multiple species depend on the food supplies and oceanography of this region and as a result breed in the area. These populations are therefore particularly vulnerable to the effects of seismic exploration.

Of the small odontocetes, bottlenose dolphins have recently been shown to possess low frequency hearing abilities (Turl 1993) while common dolphins have been known to show signs of distress when exposed to seismic activities (Goold and Fish 1998). However small odontocetes may be less vulnerable to low frequency industrial sounds but are likely quite susceptible to the higher frequency components of seismic sources.

It is evident that a majority of man-made sounds have significant amounts of energy at low frequencies, thereby leading to potential disturbance, damage and interference to the mysticete whales (figure 2). Another species frequently documented in the Gulf of Mannar, the blue whale, is also known to display avoidance behaviours followed by reduced vocalization in the presence of seismic operations (MacDonald et al. 1995). Humpback whales, also found in the Gulf of Mannar, are known to alter their songs in response to noise; the length of their mating song increases in response to low frequency sonar, perhaps in an effort to compensate for the interference. The dugong, which is found exclusively in this area around Sri Lanka, is also of particular concern because of its reasonably good low frequency hearing abilities. Unfortunately,

very little is known about the impact of seismics on this species. It is important that further studies have to be done to understand location of critical habitats and the impacts of continuous seismic activity in the vicinity of specific species.

Alterations in migratory paths caused by continuous seismic activities could drive animals out of critical habitats or move them into dangerous areas. Very few comprehensive year long marine mammal surveys have been conducted in Sri Lanka. As a result, the understanding of migratory patterns is very poor. Additionally, historical records have consistently alluded to the presence of a variety of cetacean species around Sri Lanka. Hence further studies are necessary to ascertain migratory patterns.

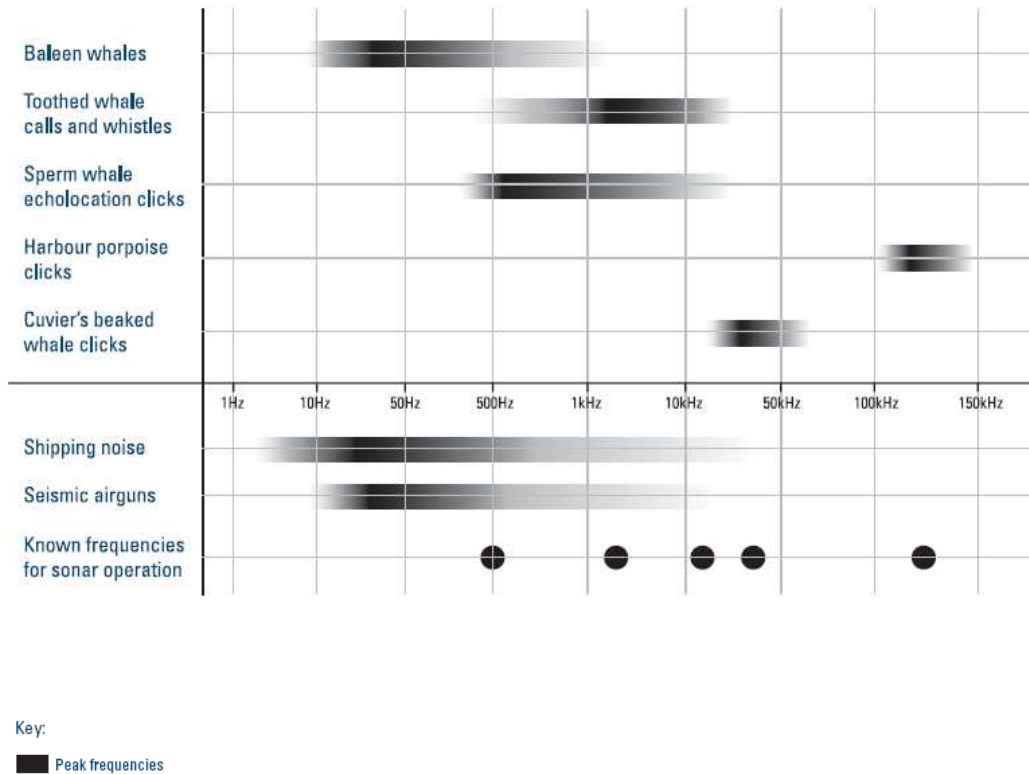


Figure 4.3 1: Some examples of sound frequencies used by marine mammals and man-made sources of ocean noise pollution (IFAW 2008).

#### 4.4 Impacts on Reefs and Divers

Coral reefs may not be directly impacted by seismic survey work. But they may be affected by accidental oil spills, if any from the marine vessels deployed for the seismic survey operations and thus good waste management and maintenance practise must be ensured during the proposed project operations.

Some impact of seismic surveys on scuba divers is to be expected as most of the diving is conducted in the 20 to 30 m depth range which is near to the depth contour where the depth of

the sea bed increases rapidly. Therefore it is advisable to exercise control and management of scuba diving during the period of seismic exploration.

#### **4.5 Impacts on Benthic Communities**

Potential environmental effects will be limited to physical impacts on benthic communities arising from the cable and associated equipment sinking to the seafloor, damage and/or destruction of seafloor habitats due to anchoring, vessel grounding or the accidental loss of equipment. Physical impacts on soft sediment communities from equipment will be limited, as the gear is not likely to penetrate the substrate to any great extent.

#### **4.6 Spawning seasons, spawning grounds and migratory routes of fish**

Even though the spawning seasons of some fish is reasonably known, little is known on spawning grounds and migratory routes. The reproductive cycle of different species has developed in respect to the natural range and habitat of the fish. The timing of spawning fish has developed as a response to “ultimate” factors that will maximize the survival of the eggs and fry. Some of these ultimate factors include the water supply and water quality, availability of food and reduced number of predators. Fish are ready to spawn when the ultimate factors are proper. The fish needs to respond to "proximate" factors or cues to adjust the reproductive cycle to match the changing environment (Sumpter, 1990). From April to July, many small pelagics respond to the ultimate factors well when having the appropriate conditions during the Southwest monsoon. Therefore, this season can be considered as the main spawning season of the small pelagics even though spawning is sometimes taken place throughout the year. Even though fish migrate to the offshore areas for spawning, spawning grounds are reasonably unknown. However, there is some possibility to either be fallen such migration routes across the seismic survey area or be positioned such grounds inside the block. Since large pelagic fish like tunas are highly migratory as well as highly abundant in the deep sea and offshore areas, it is reasonable to assume that there is a high probability of be present in massive schools where the block is located.

Many Penaeid shrimps show migratory behaviour between the lagoon and the sea. Sexually mature shrimp spawn in the deeper marine waters. Species like *Penaeus indicus*, *P. semisulcatus* and *M. dobsoni* breed in the sea and their post larvae migrate to the lagoon for growth and maturation, and then return to the sea for subsequent maturation and reproduction (Sanders et al, 2000).

Many coral reef fish species aggregate at specific times and locations for the purpose of spawning. The spawning migrations vary widely amongst coral reef fishes (Robinson et al, 2004). For example, some species of grouper involves long distance migrations whereas some other coral reef fish such as the species belong to the family of Acanthuridae spawn close to or within the areas of residence (Domeier & Colin, 1997). However, little is known on the behaviour, spawning seasons and spawning grounds of the coral reef fish inhabited in the Sri Lankan waters.

#### **4.7 Possible effects of seismic surveys on marine fish, crustaceans and sea turtles**

Effects of marine seismic surveys on fish and sea mammals have extensively been studied (Booman et al., 1992; Kosheleva, 1992; Popper et al., 2005). Seismic surveys can have an adverse impact on individual fish, fish populations and fisheries, either directly through harmful physiological effects or behavioural effects (DNV, 2007). The physiological effects will mainly affect early stages of fish such as eggs, larvae and fry (Booman et al., 1992; Kosheleva, 1992; Popper et al., 2005). This may lead to a certain reduced net production in fish populations. For later life stages and for adult fish, the behavioural effects are considered most important (DNV, 2007). This can mean that fish are scared away from fishing banks and areas. However, reef-dwelling species appear less easily scared away. There has also been reports of adult fish kill during Seismic surveys have been found to have killed adult fish. There is also the potential to cause physical damage to fish ears and other tissues and organs such as swim bladders. These effects vary by species, with distance from airgun arrays, and in relationship to sound wave characteristics etc. Although such effects may not kill fish immediately, they may lead to

reduced fitness, which increases their susceptibility to predation and decreases their ability to carry out important life processes (AMCC, 2009). Other impacts on fish include disturbances in the migration routes of the fish and reducing their ability to find food. Another issue is potential disturbances that spawning fish may be exposed to in spawning areas and during concentrated spawning journeys to the spawning grounds (DNV, 2007). This can change the areas that are used for spawning, and possibly the timing of the spawning since spawning conditions become less favourable. Pelagic fish responded to seismic sound by moving deeper rather than laterally in the water column (Slotte et al., 2004). Wardle et al., (2001) found no evidence of fish or invertebrates moving away from reef areas exposed to seismic survey.

If the proposed seismic survey is conducted during the southwest monsoon period then there is some possibility to adversely affect it on spawning populations of sardines and other small pelagic fish. More impacts of the seismic survey might probably be on large pelagics than others since large pelagic fish are relatively abundant in deeper waters including the seismic survey area. Only little impacts are likely to be on shellfish and finfish populations inhabited in the lagoon and the coral reefs.

Since important foraging sites and migratory routes of some turtles are located in the kalpitiya peninsula within the proposed region of the seismic survey operations, the sounds of the air guns may disturb the sea turtles.

Disturbance and displacement of spawning fish from their spawning areas can have an effect on recruitment to the fish population. This would be especially significant in specific spawning and nursery grounds such as Mangroves, Sea Grasses and Coral Reefs and care needs to be taken during the project operations to minimise the impact in these sensitive areas.

#### **4.8 Birds**

The negative impacts that could be anticipated include oil spills from any leaking or damaged pipes and the glare effect from the seismic vessel lights. The birds may get attracted to the vessel light during the night. The light also may cause a problem in the migratory habits of the birds. Since the birds migrate using the light for navigational purposes, an illuminated night sky would disorient the birds. Generally they are attracted to white or red light sources and therefore their navigation system may be affected.

#### **4.9 Fishery**

Approximately 15,000 fishermen are engaged in the Fishery Industry in the two districts adjoining the Seismic Survey Area. The commencement of the seismic survey may temporarily restrict the movement of fishing vessels in a limited area in and around the survey vessel. This could cause some limitations to the fishing operations during the period of the seismic survey operation in the specific area. Some of the potential damage / restrictions that may result are;

- The survey vessel and supporting may cut through fishing grounds and nets already laid.
- Restricting the movement of the fishing vessels in the immediate vicinity of the seismic survey operations.
- Vessels from landing sites in Colombo, Negombo, Chilaw etc moving North and South through the survey area may require to take local detour to avoid crossing the safe exclusion zone of the survey vessel operational area.
- Possible effects on movements of fish/fauna populations from the fishing grounds due to survey operation including vessel movement and sound effects.
- Temporary restrictions likely on Divers to operate in reef areas

#### **4.10 Other Impacts**

The survey operations are expected to be conducted in the “good weather window” from around October to March. Other activities planned to be done in the area by different organizations which may be affected would be:

- Research activities on Reefs and other sensitive areas
- Water quality and Plankton abundance studies
- Marine Mammal studies
- Bathymetric surveys
- Oceanographic studies



# CHAPTER 5

## MITIGATORY MEASURES

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The potential likely impacts due to the proposed 3D Seismic survey operations for hydrocarbon exploration in the SL-2007-01-001 block in Gulf of Mannar was detailed in the previous chapter. Though the seismic survey operation is temporary in nature, it does require due precautions to be taken to minimise the adverse impacts on the existing ecosystem and the local communities.

Proactive consultation with the concerned stakeholders, especially the local fisher community and the fishing authorities for collecting of detailed information on fishing crafts and fishing gears use inside and close to the block, the seasonality of their use and the routes of the fishing crafts etc. is required. The traditional knowledge of the fishermen can perhaps be made use for knowing the breeding seasons, migratory routes as well as breeding grounds of the fish. Therefore, interviewing the fishermen as well as conducting the group discussions with them would perhaps be very useful in the process of collecting above mentioned information that is much relevant to the proposed seismic survey. A combination of mitigation measures must be used to ensure effectiveness in the variety of contexts likely to be encountered. It is also necessary to bear in mind that the direct impact of seismic surveys on marine mammals is quite well documented, but the other threats associated with these activities such as noise generated by the survey vessel and potential oil spills have also to be considered. The cumulative impacts of these threats and others faced by marine mammals must be taken into consideration while planning the mitigatory measures and implementing a robust environmental management program while carrying out the proposed survey operations.

### **5.1 Marine Mammals**

Mitigation measures are operational techniques designed to reduce the adverse impact on the species or stock and its habitat (Roberts and Hollingshead 2002). The effect of these mitigation measures varies based on the differing sensitivities of cetaceans, different groups and age classes and underwater topography, oceanography etc that causes sound to travel in a non-uniform

manner through water. Mitigation procedures must be tailor made to the particular habitat and situation to ensure best results.

As a result of the limited cetacean surveys that have been conducted in these areas, baseline data on the populations in the Gulf of Mannar and Sri Lanka as a whole are lacking. As such, it is imperative that a precautionary approach is adopted by the oil and gas industry when conducting seismic exploration surveys to safeguard both individuals and populations. Adoption of the precautionary approach is imperative because of the imprecision and uncertainty surrounding studies of the effects of noise on cetaceans. Particularly, areas that are considered critical feeding or breeding areas of marine mammals should be kept as free from noise pollution as possible, even in the absence of conclusive scientific evidence of harm. The mother-calf pairs of sperm whales and large schools of mixed age group spinner dolphins have been detected during the months of January to April. However, no surveys have been conducted out with this period in the offshore areas and as such, it is not possible to conclusively state if this is a year round breeding ground. This highlights the greater need for application of the precautionary approach coupled with the collection of good quality data that can advise further actions.

Primarily all survey vessels should be required to carry a trained marine mammal observer on board at all times e.g. scheme run in the UK by JNCC (Gordon et al. 1994). These observers should be appropriately trained in survey, identification and recording techniques prior to commencement of operations. The observers would be required to visually detect the marine mammals in the vicinity and document any behaviours that might occur in the presence of the seismic activity. Observations from the vessel should be initiated 30 minutes before ‘ramping up’ the air guns. The ‘ramping up’ or ‘soft start’ period is intended to allow animals to move away from an area should they choose to do so and surveys should not commence until the area has been clear for at least 30 minutes. In many other countries a ‘soft start’ or ‘ramp-up’ is also common, working on the assumption that a gradual increase in sound levels gives whales and dolphins sufficient time to leave the area. During the surveys if an individual is sighted within 1km of the emitted noise, all seismic activity must be suspended for 30 minutes until after the

cetacean leaves the area. The observer will be required to document any sightings made with details such as behaviours observed, group sizes etc and the prevailing environmental conditions.

In order to ensure reasonably effective visual monitoring surveys must be scheduled for daylight hours, and not near sunrise or sunset. However, only a limited proportion of whales within the survey area are likely to be visually detected and as such, passive acoustic monitoring coupled with acoustical localization methods must be encouraged to improve chances of their detection. An eight-fold improvement in detection rates of odontocetes was reported when undertaking acoustic monitoring by Gillespie et al. (1998). Current best practice insists on the combination of acoustic and visual monitoring in an effort to detect small or deep diving animals and cause minimal damage to the marine mammals of the area particularly because of the paucity of knowledge and high level of uncertainty surrounding potential effects on marine mammals.

In addition to placing marine mammal observers on the main survey vessel it is recommended that individuals are also placed on smaller crafts in a surrounding 'safety zone'. This is useful as studies of impacts have focused on smaller numbers of animals close to the surveys but it is possible that the effects are far reaching and may have impacts on populations further away. All information related to the marine mammals and environmental conditions at the time should be documented.

As a further precautionary measure, marine mammal observers should survey the area at least prior to and post the seismic survey in an effort to gain an understanding of the densities and species present prior to activities and the longer term effect after the surveys have been concluded.

The data collected by the observers during these surveys will provide valuable information on the presence and distribution of species and contribute to the existing knowledge base. Surveys should be planned in a manner that reduces the number and power of the sources employed. Companies should be encouraged to share the results of past and future surveys in an effort to effectively achieve this. Source levels should be reduced to a level no higher than necessary and the boats should maintain a stipulated speed limit while within the survey area.

As previously mentioned consultations with local fisher communities and authorities should be conducted prior to commencing any field activities to gain insight on Traditional Ecological Knowledge. As many of the fisherfolk in the area such as the flying fish fishermen from Kandakuliya engage in resource extraction activities in the offshore areas in and around the designated area they will most probably be able to provide some indications of what types of animals are present and if there are any trends in sightings. This information will also contribute to the baseline knowledge of the cetaceans of the area.

## **5.2 Coral Reefs and Benthic Communities**

Potential environmental effects will be limited to physical impacts on benthic communities arising from the cable and associated equipment sinking to the seafloor, damage and/or destruction of seafloor habitats due to anchoring, vessel grounding or the accidental loss of equipment. Physical impacts on soft sediment communities from equipment will be limited, as the gear is not likely to penetrate the substrate to any great extent.

Some impact of seismic surveys on scuba divers may be likely as most of the diving is conducted in the 20 to 30 m depth range which is near to the depth contour where the depth of the sea bed increases rapidly. Therefore it may be required to regulate scuba diving activities in and around the seismic survey operational area during the period.

## **5.3 Birds**

The survey operational area will be in the open sea well away from the coastline. The marine fleet for the survey activities will consist of a survey vessel ship and 4 or 5 supply / guard vessels. The night lighting from these vessels are not expected to cause any significant glare in the surrounding area. Nevertheless, use of bird friendly lighting systems as introduced in some northern countries and the use of minimal lighting during the nights would help to reduce the impacts from light pollution, if any.

### 5.3 Fishery

Certain precautionary mitigatory measures need to be taken to minimize the above impacts on the marine resources as well as to the fishing activities. For example, the southwest monsoon period is found to be the important period for fishing activities (the fish catch is expected to be high over the period) as well as the best suited period for rebuilding of the fish resources by spawning and successive growing of fish via optimally utilizing the favourable conditions that are much supportive for functioning of the biological processes well. Hence, it is advisable to avoid that period for making use of conducting the seismic survey. Seismic surveys can result in reduced fishing time. Therefore, pre-planning can help to minimize this impact. In addition, following mitigation measures can also be adopted in order to minimize the impact on fish and fisheries.

- a) Formation of a fishing industry Task Force to deal with issues on an ongoing basis. This task Force may include representatives from the
  - i. Fisheries Cooperatives,
  - ii. Individual Fishermen engaged in the different types of fishery who are not members of cooperative societies,
  - iii. Representative from Department of Fisheries,
  - iv. Representative from Migrant Fishermen operating in the Area.
  - v. Other Stakeholders who may be affected by the Seismic Survey also may be included.
  - vi. High Level Representative from Cairn Lanka (Pvt) Ltd

This task Force should be convened before commencement of operations and should meet regularly to engage in consultation for the smooth implementation of the project, integrate the local fishing community concerns during the implementation of the seismic survey operations

and resolution of any disputes that may arise. It is also recommended as stated previously that at least one Biological-Fisheries observer/Marine Mammal Observer onboard the seismic ship on duty at all times throughout the duration of the survey. In addition the guard vessels should have members from the local fishermen community to effectively dialogue with the local fishermen and advise on the local sensitivities and issues

Survey vessel engaged in the seismic survey should not discharge waste oil or any other solid or liquid waste into the sea. This would be particularly relevant in order to minimize the impact especially on the sea turtles; The discharges of waste oil and liquid waste may alter the nesting environment of the female turtles.

## CHAPTER 6

# ENVIRONMENTAL MANAGEMENT PLAN

Cairn Lanka will take all measures necessary to ensure that the Seismic Survey operations will have the least possible impact on the surrounding environment including all biota in the short term as well as in the medium and long term sustainability of any fragile, sensitive ecosystems around the area of operations. In addition Cairn Sri Lanka will ensure minimal disruption of normal activities of surrounding communities. During operation, either eliminate potential environmental risks or to reduce them to as low as reasonably practicable, a number of key control and mitigation measures must be implemented. The management actions and strategies for control of the significant environmental risks associated with the proposed survey are described in the following sections.

### 6.1.1 Management of Disturbance to Marine Fauna

The proposed survey should avoid potential disruption to sensitive ecological values in the area by both spatial and temporal separation. Table 6.1 summarizes the control and mitigation measures that eliminate or reduce any significant environmental impacts on marine life. The management actions and implementation strategy are discussed further in the following sections.

Table 6.1 Control and Mitigation Measures to Minimize Marine Fauna Impacts

<b>Sensitive Ecological Values</b>	<b>Control and Mitigation Measures</b>
Cetaceans	Temporal avoidance of periods of peak whale migrations.
Fish	The survey may be operating over critical habitat for feeding, spawning, breeding or migrating fish populations. ‘Soft start’ of acoustic energy sources at the start of each line.
Epibenthic Communities	The survey is unlikely to have any significant effects on benthic communities due to the water depth.

The project activities in proposed the study area, may cause transient disturbance on whales and other higher marine mammals whose presence are reported in this area. Special attention needs to be drawn to the Dugong and the Dolphins. The main control measures to minimise the survey's potential impacts on cetaceans are temporal and spatial avoidance.

**Visual observations:** A visual check for the presence of whales must be made before the commencement of each acquisition line;

**Delay procedures:** Acoustic energy source discharge must not begin unless whales are a minimum distance of 2 km from the survey vessel;

**Soft start procedures:** A sequential build-up of warning pulses (over a period of 30 minutes) must be made at the start of each acquisition line ('soft start') to arm and deter whales from approaching the survey vessel. 'Soft starts' over a 30 minute period at the start of each new line will also serve to warn and scatter any other free-swimming fauna (i.e. dolphins, pelagic and demersal fish) in the area, thereby minimizing the likelihood of animals being within pathological effects range;

**Whale watch:** A continuous watch for whales must be maintained during 'soft start' sequences and during operations to determine the presence or absence of whales within 2 km of the vessel; and **Stop work procedures:** Acoustic energy source array discharge must cease if whales approach within 2 km, and are moving towards, the vessel. Operations must not recommence until the animals have moved outside a range of 2 km or have not been seen for thirty minutes. Any cetacean sightings during proposed survey need to be recorded with the positions time and the date.

### **6.1.2 Management of Disturbance to Benthic Habitat**

The survey is unlikely to have any significant effects on benthic communities due to the water depth. The survey vessel and support vessels may not anchor during the duration of the survey, except in an emergency situation. As a result of the water depths (approximately 30m to 3,000m) there are unlikely to be any significant effects from discharge of the acoustic energy source



arrays on the benthic environment. In the event of loss of a streamer or associated equipment (eg paravanes, tail buoys) there is the potential for some limited disturbance of benthic habitats to occur. Wherever possible, streamers and associated equipment are recovered when lost during survey activities.

### **6.1.3 Management of Waste**

Risks to the marine environmental resources in the proposed survey area and adjacent areas from disposal of wastes are considered to be negligible given that wastes other than routine sewage and putrescible material discharge will be returned to shore for recycling or disposal. The survey vessel will have a 'Garbage Management Plan' in place. This plan will be consistent with the requirements of MARPOL 73/78 (Annexe V) and include a list of ship's equipment and detail the arrangements for handling of garbage.

### **6.1.4 Sewage and Putrescible Wastes**

Sewage and food waste disposal must conform to the requirements of MARPOL 73/78 Annex IV and must be macerated to a diameter of less than 25 mm, prior to disposal. No sewage or putrescible wastes (ground or unground) is to be discharged within 12 nautical miles of any land unless vessel has a certified approved sewage treatment plant in place under Regulation 8 (1) (b) of MARPOL 73/78 Annex IV. No significant environmental impacts are expected because of the biodegradability of the waste, short period of seismic activities and large dilution factor. Total nutrient (nitrogen and phosphorus) input levels will be insignificant compared with natural nutrient flux in the area. Risks to the marine environmental resources in the proposed survey area and adjacent areas from disposal of wastes are considered to be negligible given that wastes other than routine sewage and putrescible material discharge will be returned to shore for recycling or disposal. The survey vessel will have a 'Garbage Management Plan' in place. This plan will be consistent with the requirements of MARPOL 73/78 (Annexe V) and include a list of ship's equipment and will detail arrangements for the handling of garbage.

#### **6.1.4 Solid Wastes**

No significant environmental impacts are expected as solid wastes will not be discharged to the ocean. All solid wastes, such as packaging and domestic wastes must be segregated into clearly marked containers prior to onshore disposal. In accordance with MARPOL 73/78 regulations, no plastics or plastic products of any kind are to be disposed of overboard. No domestic waste (ie cans, glass, paper or other waste from living areas) is to be discharged overboard.

#### **6.1.5 Chemical and Hazardous Wastes**

All chemical and hazardous wastes, such as cleaning products, acids, solvents, toxic waste and medical waste, will be segregated into clearly marked containers prior to onshore disposal. No significant environmental impacts are expected as chemical and hazardous wastes will not be discharged to the ocean. All storage facilities and handling equipment must be segregated in good order and designed in such a way as to prevent and contain any spillages as far as practicable. No significant environmental impacts are expected as solid wastes will not be discharged to the ocean. All solid wastes, such as packaging and domestic wastes, must be segregated into clearly marked containers prior to onshore disposal. In accordance with MARPOL 73/78 regulations, no plastics or plastic products of any kind are to be disposed of overboard. No domestic waste (i.e. cans, glass, paper or other waste from living areas) is to be discharged overboard. No maintenance wastes (e.g. paint sweepings, rags, deck sweepings, oil soaks, machinery deposits etc.) are to be disposed of overboard.

#### **6.1.6 Management of Potential Fuel and Oil Spills**

The survey vessel will have a specific fuel spill contingency procedures in the unlikely event of a fuel spill and a Shipboard Oil Pollution Emergency Plan (SOPEP). Minor spillages will be managed through housekeeping cleanliness and the use of sorbent materials to clean up any spilled fuel or oils. Any fuel or oil spills must be reported to Cairn Sri Lanka, all spills of greater than 80 L will be reported by Cairn Sri Lanka to the Designated Authority within 2 hours. Incineration of any oil sludges onboard, or disposal of any oil sludges/slops in port, must be recorded in the vessel Oil Record Book (a requirement under MARPOL 73/78). Stocks of

absorbent materials onboard the survey vessel must be checked for their adequacy and replenished as necessary prior to the commencement of activities.

### **6.1.7 Waste Reception Facilities**

It should be noted that the Colombo port does not have ship borne waste reception facilities yet, but Bunkering Agents and other contractors are available to provide such services to ships berthing in the port of Colombo. They usually have dump trucks and other waste carriers to take waste matter from ships and dispose at approved waste disposal facilities in and outside the city of Colombo. The offices of the Sri Lanka Ports Authority (SLPA), which maintains the Colombo port, and shipping agents could provide advice and guidance in this matter.

## **6.2 Roles and Responsibilities**

The organization and structure of the seismic survey to be undertaken, including roles and responsibilities for all key personnel onboard the survey vessel, are described with regard to the implementation and management of this Environment Plan, the key responsibilities are:

### **6.2.1 Vessel Master**

1. Responsible for the safe execution of all operations of the survey vessel.
2. Overall responsibility for ensuring that appropriate control and mitigation measures are implemented to minimise potential environmental effects resulting from vessel operations (eg waste management/disposal, and fuel/oil spill response).
3. Responsible for immediately notifying the Client Site Representative of any incidents/activities arising from vessel operations that are likely to have a negative impact on the performance objectives detailed in this Environment Plan.

### **6.2.2 Chief Surveyor**

1. Responsible for safe execution of all operations carried out by the seismic crew onboard the survey vessel.
2. Responsible for ensuring that appropriate control and mitigation measures are implemented to minimise potential environmental impacts resulting from seismic

acquisition (eg ‘soft start’ procedures, whale watch and stop work procedures, cetacean recording).

3. Responsible for immediately notifying the Client Site Representative of any incidents/activities arising from seismic operations that are likely to have a negative impact on the performance objectives detailed in this Environment Plan.

### **6.2.3 Client Site Representative**

1. Responsible for ensuring that, during the 3D Seismic Survey for Oil Exploration all sub-contractors perform operations in a manner consistent with the performance objectives and environmental management procedures detailed in this Environment Plan.
2. Responsible for ensuring that the Vessel Master and Chief Surveyor are adhering to the requirements of this Environment Plan.
3. Responsible for keeping himself fully appraised of ongoing operations, particularly for environmentally critical activities.
4. Responsible for immediately alerting the Cairn Sri Lanka Acquisition Project Manager of any changes in operations that could have a negative impact on environmental performance.
5. Responsible for immediately reporting any reportable incidents to the Cairn Sri Lanka Acquisition Project Manager.

### **6.2.4 Cairn Lanka Acquisition Project Manager**

1. Responsible for ensuring that the Designated Authority (PRDC or other) is notified of all reportable incidents in a timely fashion.
2. Ensure compliance to the applicable rules and regulations of the Govt. of Sri Lanka as applicable to the proposed project operations and communication to the relevant government authorities on all statutory requirements as applicable
3. Responsible for ensuring full briefing all project personnel of the environmental sensitivities of the survey area and environmental management procedures and commitments detailed in this Environment Plan.

4. Responsible for communicating details of the survey programme to relevant Government agencies in advance of operations commencing.
5. Responsible to ensure consultation and engagement with the local fishing communities / authorities prior to and during the proposed project activities and to ensure resolution of disputes in timely and amicable manner

### **6.2.5 Marine Mammal Observer (MMO)**

This would be an experienced biologist who has undertaken Cetacean surveys and is knowledgeable about Cetacean behaviour. The MMO's main responsibilities would be to:

- i. Keep watch with necessary equipment and monitoring devices, for sightings of Cetaceans (Whales, Porpoises, Dolphins and Dugongs in particular) in the vicinity of the survey vessel and streamer. The MMO should note the location and type of such sighting and record them.
- ii. Ensure that the Chief Surveyor and other responsible staff on board are informed of such sighting immediately.
- iii. Ensure that immediate action is taken to cease seismic soundings and wait for the Cetacean to move to a safe distance before recommencing seismic survey activity.
- iv. See that an action plan is ready and followed in all such instances. Any deviations should be reported according to agreed procedures.

### **6.2.6 Biology-Fisheries Observer (BFO)**

As indicated elsewhere in this report, the survey area is a highly productive area for fishery and a large number of fishing boats, trawlers and other larger vessels are expected to pass through the survey area during the operations within the block. A Biology-Fisheries Observer (BFO) is also recommended to be on board the survey vessel. The responsibilities of the BFO may be:

- i. Regulate the seismic survey activities during operations in notified / observed breeding and hatching areas and fish catch area.

- ii. A sequential buildup of the warning pulses (low energy seismic signal) be made to deter the fauna immediately before commencement of seismic activity.
- iii. At close range, Plankton and larvae may be damaged. These areas need to be carefully monitored and appropriate measures taken to during the survey. Small fish/crabs are likely to be affected due to the high pressure waves (1500-2000 Psi). A dry run with low pressure air gun shooting will help migration of aquatic fauna from the survey area so that of high pressure waves during actual survey will not affect the population.
- iv. It is recommended that the BFO has a good relationship with Fisheries cooperatives and fishermen and ensure that nets are not laid across the path of the survey vessel and streamer. If nets or boats are present in the vicinity, prior action needs to be taken by the BFO through discussion to remove such obstructions amicably. There should be a chase boat on standby to inform the local fishermen to go away from the seismic lines. The programme should be intimated by the Task force (Chapter 5) to the fishermen and the Fisheries cooperatives in advance to inform the local fishing communities.
- v. Ensure, in collaboration with the Task force (Chapter 5) that no divers are present in the area of operations and adequate notice has been given to them.

### **6.3 Awareness**

All staff and contractors taking part in the survey will be advised of their responsibilities prior to commencement of survey activities. This will occur through meetings with key contractor personnel and an induction and awareness presentation that will be given to all crew (including support vessels).

### **6.4 Monitoring Plan**

In order to ensure the implementation of necessary mitigatory measures for environmental management and pollution control, and to assess the success of mitigation and identifying residual impacts, the management of the project will conduct a comprehensive environmental monitoring program. It is the responsibility of the project Proponent to facilitate monitoring

programme while the project approving agency has the responsibility of conducting regular monitoring.

### **6.5 Institutional Arrangement for Impact Monitoring**

An environmental monitoring committee (EMC) has to be appointed to oversee the implementation of monitoring plan. The project approving agency (PRDC) has to appoint committee members from relevant Departments/Agencies as appropriate and inform CAIRN Lanka Pty Ltd of the requirements and procedures to be adopted in the implementation of the monitoring plan.

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## CHAPTER 7: CONCLUSION AND RECOMMENDATIONS

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Sri Lanka imports all its crude oil requirements and it would be a welcome boost to the economy and development of the nation if Petroleum resources could be found within the seabed of Sri Lankan territory. While it is the government of Sri Lanka which has called for bids and awarded the exploratory block to Cairn Lanka Pty Ltd, it is appropriate that everyone gives their support to the company to conduct the survey with minimal delays and problems. The fauna within the seismic survey area (i.e. inside the offshore block SL-2007-1-001) and in adjoining and neighbouring areas comprise of important fisheries resources. The Bar Reef marine sanctuary is also located in the area. The Bar Reef is one of the most productive coral reef systems as well as it is unique in terms of its bio diversity. About 400 species of reef fish and numerous species of crustaceans including commercially important species such as lobsters and sea cucumbers have been found from the area. The Puttalam Lagoon, a highly productive estuary in the Northwest coast of Sri Lanka is also located close to the block. Marine mammals have also been reported to frequent the area.

The proposed 3D seismic survey activities are temporary in nature. Any impact from such activities would also be transient and regain its original state over time. Over the years seismic survey vessels have evolved as more contained with adequate facilities for control of pollution e.g. sewage treatment plants, effluent treatment plants, waste management systems etc. The impacts assessed in this report are more qualitative in nature and based on professional judgement. The report also proposes environment & social management plan for mitigating potential adverse impacts and recommendations on good management practices.



Considering the importance of hydrocarbon exploration in Sri Lanka and its economic benefits and taking into account the transient nature of the seismic survey, the anticipated impacts are of low significance. The impacts identified during the study will be mitigated adopting a profound Environment Management Plan and precautionary principles identified and highlighted during the course of this study.

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# ANNEXURES

## ANNEX - 1

**Table 3.2.7.1: Bird list in the North western coast from Puttalam to Mannar region**

No	Common name	Scientific name
01	Grey Francolin	<i>Francolinus pondicerianus</i>
02	Lesser Whistling-duck	<i>Dendrocygna javanica</i>
03	Cotton Pygmy-goose	<i>Nettapus coromandelianus</i>
04	Garganey	<i>Anas querquedula</i>
05	Northern Shoveler	<i>Anas clypeata</i>
06	Northern Pintail	<i>Anas acuta</i>
07	Little Grebe	<i>Tachybaptus ruficollis</i>
08	Asian Openbill	<i>Anastomus oscitans</i>
09	Woolly-necked Stork	<i>Ciconia episcopus</i>
10	Black Stork	<i>Ciconia nigra</i>
11	Painted Stork	<i>Mycteria leucocephala</i>
12	Lesser Adjutant	<i>Leptoptilos javanicus</i>
13	Black-headed Ibis	<i>Threskiornis melanocephalus</i>
14	Eurasian Spoonbill	<i>Platalea leucorodia</i>
15	Yellow Bittern	<i>Ixobrychus sinensis</i>
16	Black Bittern	<i>Ixobrychus flavicollis</i>
17	Black-crowned Night-heron	<i>Nycticorax nycticorax</i>
18	Striated Heron	<i>Butorides striata</i>



No	Common name	Scientific name
19	Indian Pond-heron	<i>Ardeola grayii</i>
20	Cattle Egret	<i>Bubulcus ibis</i>
21	Grey Heron	<i>Ardea cinerea</i>
22	Purple Heron	<i>Ardea purpurea</i>
23	Great Egret	<i>Casmerodius albus</i>
24	Intermediate Egret	<i>Mesophoyx intermedia</i>
25	Little Egret	<i>Egretta garzetta</i>
26	Western Reef-egret	<i>Egretta gularis</i>
27	Little Cormorant	<i>Phalacrocorax niger</i>
28	Indian Cormorant	<i>Phalacrocorax fuscicollis</i>
29	Great Cormorant	<i>Phalacrocorax carbo</i>
30	Oriental Darter	<i>Anhinga melanogaster</i>
31	Common Kestrel	<i>Falco tinnunculus</i>
32	Oriental Honey-buzzard	<i>Pernis ptilorhyncus</i>
33	Brahminy Kite	<i>Haliastur indus</i>
34	Crested Serpent-eagle	<i>Spilornis cheela</i>
35	Osprey	<i>Pandion haliaetus</i>
36	Montagu's Harrier	<i>Circus pygargus</i>
37	Western Marsh-harrier	<i>Circus aeruginosus</i>
38	Pied Harrier	<i>Circus melanoleucos</i>
39	White-bellied Sea-eagle	<i>Haliaeetus leucogaster</i>
40	Shikra	<i>Accipiter badius</i>

No	Common name	Scientific name
41	Changeable Hawk Eagle	<i>Spizaetus cirrhatus</i>
42	Black-shouldered Kite	<i>Elanus caeruleus</i>
43	White-breasted Waterhen	<i>Amaurornis phoenicurus</i>
44	Sri Lanka Junglefowl	<i>Gallus lafayetii</i>
45	Indian Peafowl	<i>Pavo cristatus</i>
46	Watercock	<i>Gallicrex cinerea</i>
47	Purple Swamphen	<i>Porphyrio porphyrio</i>
48	Common Moorhen	<i>Gallinula chloropus</i>
49	Eurasian Thick-knee	<i>Burhinus oedicephalus</i>
50	Black-winged Stilt	<i>Himantopus himantopus</i>
51	Red-wattled Lapwing	<i>Vanellus indicus</i>
52	Pacific Golden Plover	<i>Pluvialis fulva</i>
53	Grey Plover	<i>Pluvialis squatarola</i>
54	Kentish Plover	<i>Charadrius alexandrinus</i>
55	Crab Plover	<i>Dromas ardeola</i>
56	Common Ringed Plover	<i>Charadrius hiaticula</i>
57	Long-billed Plover	<i>Charadrius placidus</i>
58	Little Ringed Plover	<i>Charadrius dubius</i>
59	Lesser Sand Plover	<i>Charadrius mongolus</i>
60	Greater Sand Plover	<i>Charadrius leschenaultii</i>
61	Pheasant-tailed Jacana	<i>Hydrophasianus chirurgus</i>
62	Black-tailed Godwit	<i>Limosa limosa</i>

No	Common name	Scientific name
63	Bar tailed Godwit	<i>Limosa lapponica</i>
64	Whimbrel	<i>Numenius phaeopus</i>
65	Spotted Redshank	<i>Tringa erythropus</i>
66	Common Redshank	<i>Tringa totanus</i>
67	Marsh Sandpiper	<i>Tringa stagnatilis</i>
68	Common Greenshank	<i>Tringa nebularia</i>
69	Green Sandpiper	<i>Tringa ochropus</i>
70	<u>Spotted green shank</u> (Nordmann's Greenshank)	<i>Tringa guttifer</i>
71	<u>Spoon-billed Sandpiper</u>	<i>Calidris pygmeus</i>
72	<u>Indian Courser</u>	<i>Cursorius coromandelicus</i>
73	Wood Sandpiper	<i>Tringa glareola</i>
74	Terek Sandpiper	<i>Xenus cinereus</i>
75	Common Sandpiper	<i>Actitis hypoleucos</i>
76	Ruff	<i>Philomachus pugnax</i>
77	Ruddy Turnstone	<i>Arenaria interpres</i>
78	Sanderling	<i>Calidris alba</i>
79	Little Stint	<i>Calidris minuta</i>
80	Temminck's Stint	<i>Calidris temminckii</i>
81	Dunlin	<i>Calidris alpina</i>
82	Curlew Sandpiper	<i>Calidris ferruginea</i>
83	Broad-billed Sandpiper	<i>Limicola falcinellus</i>
84	Brown-headed Gull	<i>Larus brunnicephalus</i>

No	Common name	Scientific name
85	Black-headed Gull	<i>Larus ridibundus</i>
86	Slender-billed Gull	<i>Larus genei</i>
87	Gull-billed Tern	<i>Sterna nilotica</i>
88	Caspian Tern	<i>Sterna caspia</i>
89	Lesser Crested Tern	<i>Sterna bengalensis</i>
90	Great Crested Tern	<i>Sterna bergii</i>
91	Roseate Tern	<i>Sterna dougallii</i>
92	Common Tern	<i>Sterna hirundo</i>
93	Little Tern	<i>Sterna albifrons</i>
94	Whiskered Tern	<i>Chlidonias hybrida</i>
95	White-winged Tern	<i>Chlidonias leucopterus</i>
96	Rock Pigeon	<i>Columba livia</i>
97	Spotted Dove	<i>Stigmatopelia chinensis</i>
98	Emerald Dove	<i>Chalcophaps indica</i>
99	Orange-breasted Green-pigeon	<i>Treron bicinctus</i>
100	Green Imperial Pigeon	<i>Ducula aenea</i>
101	Pompadour Green-pigeon	<i>Treron pompadora</i>
102	Rose-ringed Parakeet	<i>Psittacula krameri</i>
103	Alexandrine Parakeet	<i>Psittacula eupatria</i>
104	Indian Cuckoo	<i>Cuculus micropterus</i>
105	Black-headed Cuckooshrike	<i>Coracina melanoptera</i>
106	Drongo Cuckoo	<i>Surniculus lugubris</i>

No	Common name	Scientific name
107	Pied Cuckoo	<i>Clamator jacobinus</i>
108	Common Hawk-cuckoo	<i>Cuculus varius</i>
109	Grey-bellied Cuckoo	<i>Cacomantis passerinus</i>
110	Asian Koel	<i>Eudynamys scolopaceus</i>
111	Greater Coucal	<i>Centropus sinensis</i>
112	Small Minivet	<i>Pericrocotus cinnamomeus</i>
113	Scarlet Minivet	<i>Pericrocotus flammeus</i>
114	Oriental Scops-owl	<i>Otus sunia</i>
115	Brown Fish Owl	<i>Ketupa zeylonensis</i>
116	Asian Palm-swift	<i>Cypsiurus balasiensis</i>
117	Crested Treeswift	<i>Hemiprocne coronata</i>
118	Indian Roller	<i>Coracias benghalensis</i>
119	Stork-billed Kingfisher	<i>Pelargopsis capensis</i>
120	White-throated Kingfisher	<i>Halcyon smyrnensis</i>
121	Common Kingfisher	<i>Alcedo atthis</i>
122	Black-capped Kingfisher	<i>Halcyon pileata</i>
123	Pied Kingfisher	<i>Ceryle rudis</i>
124	Little Green Bee-eater	<i>Merops orientalis</i>
125	Chestnut-headed Bee-eater	<i>Merops leschenaultia</i>
126	Blue-tailed Bee-eater	<i>Merops philippinus</i>
127	Eurasian Hoopoe	<i>Upupa epops</i>
128	Brown-headed Barbet	<i>Megalaima zeylanica</i>

No	Common name	Scientific name
129	Coppersmith Barbet	<i>Megalaima haemacephala</i>
130	Black-rumped Flameback	<i>Dinopium benghalense</i>
131	Ashy Woodswallow	<i>Artamus fuscus</i>
132	Common Iora	<i>Aegithina tiphia</i>
133	Brown Shrike	<i>Lanius cristatus</i>
134	Black-hooded Oriole	<i>Oriolus xanthornus</i>
135	White-bellied Drongo	<i>Dicrurus caerulescens</i>
136	Asian Paradise-flycatcher	<i>Terpsiphone paradisi</i>
137	Asian Brown Flycatcher	<i>Muscicapa dauurica</i>
138	Tickell's Blue Flycatcher	<i>Cyornis tickelliae</i>
139	House Crow	<i>Corvus splendens</i>
140	Jungle Crow	<i>Corvus levaillantii</i>
141	Barn Swallow	<i>Hirundo rustica</i>
142	Jerdon's Bushlark	<i>Mirafraga affinis</i>
143	Oriental Skylark	<i>Alauda gulgula</i>
144	Zitting Cisticola	<i>Cisticola juncidis</i>
145	Ashy Prinia	<i>Prinia socialis</i>
146	Plain Prinia	<i>Prinia inornata</i>
147	Jungle prinia	<i>Prinia sylvatica</i>
148	Red-vented Bulbul	<i>Pycnonotus cafer</i>
149	White-browed Bulbul	<i>Pycnonotus luteolus</i>
150	Common Tailorbird	<i>Orthotomus sutorius</i>

No	Common name	Scientific name
151	Blyth's Reed-warbler	<i>Acrocephalus dumetorum</i>
152	Rusty-rumped Warbler	<i>Locustella certhiola</i>
153	Yellow-billed Babbler	<i>Turdoides affinis</i>
154	Yellow-eyed Babbler	<i>Chrysomma sinense</i>
155	Sri Lanka Brown-capped Babbler	<i>Pellorneum fuscocapillum</i>
156	Dark-fronted Babbler	<i>Rhopocichla atriceps</i>
157	Common Myna	<i>Acridotheres tristis</i>
158	Brahminy Starling	<i>Sturnus pagodarum</i>
159	Rosy Starling	<i>Sturnus roseus</i>
160	Oriental Magpie-robin	<i>Copsychus saularis</i>
161	Indian Robin	<i>Saxicoloides fulicatus</i>
162	White-rumped Shama	<i>Copsychus malabaricus</i>
163	Great Tit	<i>Parus major</i>
164	Pale-billed Flowerpecker	<i>Dicaeum erythrorhynchos</i>
165	Purple Sunbird	<i>Nectarinia asiatica</i>
166	Purple-rumped Sunbird	<i>Nectarinia zeylonica</i>
167	Long-billed Sunbird	<i>Nectarinia lotenia</i>
168	Ashy-crowned Sparrow-lark	<i>Eremopterix griseus</i>
169	House Sparrow	<i>Passer domesticus</i>
170	Black headed Munia	<i>Lonchura malacca</i>
171	Scaly-breasted Munia	<i>Lonchura punctulata</i>

No	Common name	Scientific name
172	White-rumped Munia	<i>Lonchura striata</i>
173	Paddyfield Pipit	<i>Anthus rufulus</i>
174	Richard's Pipit	<i>Anthus richardi</i>
175	Indian Pitta	<i>Pitta brachyura</i>
176	Forest Wagtail	<i>Dendronanthus indicus</i>
177	Grey-necked Bunting	<i>Emberiza buchanani</i>
178	Malabar Pied Hornbill	<i>Anthracoceros coronatus</i>
179	Sri Lanka Grey Hornbill	<i>Ocyeros gingalensis</i>
180	Oriental White-eye	<i>Zosterops palpebrosus</i>
181	Jerdon's Leafbird	<i>Chloropsis jerdoni</i>
182	Golden-fronted Leafbird	<i>Chloropsis aurifrons</i>
183	Common Nightjar	<i>Caprimulgus asiaticus</i>
184	Jerdon's Nightjar	<i>Caprimulgus atripennis</i>
185	Rusty-rumped warbler	<i>Locustella certhiola</i>
186	Large-billed Leaf Warbler	<i>Phylloscopus magnirostris</i>
187	Blyth's Reed-warbler	<i>Acrocephalus dumetorum</i>
188	Eurasian Oystercatcher	<i>Haematopus ostralegus</i>
189	Wilson's Storm-petrels	<i>Oceanites oceanicus</i>
190	Pallas's Gull	<i>Larus ichthyaetus</i>
191	Heuglin's Gull	<i>Larus heuglini</i>
192	Wedge-tailed Shearwater	<i>Puffinus pacificus,</i>
193	Lesser Frigatebird	<i>Fregata ariel</i>



<b>No</b>	<b>Common name</b>	<b>Scientific name</b>
194	Spot billed Pelican	<i>Pelecanus phillippensis</i>
195	Brown Skua	<i>Catharacta antarctica,</i>
196	Pomarine Skua	<i>Stercorarius pomarinus</i>
197	Brown Noddy	<i>Anous stolidus</i>
198	Lesser Noddy	<i>Anous tenuirostris</i>

**ANNEX II****Extracts from NBRO Report****Ambient Air Quality Measurements:**

No proper continuous air quality-monitoring programme has been established so far in the area. In June 1999, an air quality monitoring programme had been carried out at the premises of Meteorological Department, for a period of one week using Automated mobile Air Quality Monitoring Laboratory Unit by the Environmental Division of NBRO. In that programme, ambient level of SO<sub>2</sub>, NO, NO<sub>x</sub>, O<sub>3</sub>, CO, PM<sub>10</sub> were continuously monitored along with meteorological parameters.

Table 3.1. Summary of the outcome of the continuous Automated Air Quality Monitoring Data at Meteorological Department, Puttalam.

Parameter	Time Average	Average ( $\mu\text{g}/\text{m}^3$ )	Maximum ( $\mu\text{g}/\text{m}^3$ )	CEA Standard for 01 hr ( $\mu\text{g}/\text{m}^3$ )
SO <sub>2</sub>	01 hr	5.2	7.8	200
NO	01 hr	2.5	11.1	-
NO <sub>2</sub>	01 hr	3.8	7.5	250
CO	01 hr	174	1490	30,000
O <sub>3</sub>	01 hr	9.82	82.5	200
*PM <sub>10</sub>	24 hrs	*26	27	**150

\* PM<sub>10</sub> was measured as 24 hr in average

\*\* US - EPA Standards

\*\*\* Monitoring period was 07<sup>th</sup> - 15<sup>th</sup> June 1999.

*Source: Air Quality Data Base- Environmental Division of NBRO.*

In additions to above program, several short term air quality monitoring programs had been conducted in the area especially around the Puttalam and Kalpitiya areas by NBRO using active and passive sampling technologies and results are summarized in table 3.1.

Table 3.1. Summary of the outcome of the Ambient Air Quality Monitoring Data around Puttalam and Kalpitiya area.

Date	Location	Sampling Time	Concentration (mg/m <sup>3</sup> )				
			SO <sub>2</sub>	NO <sub>2</sub>	CO	SPM	O <sub>3</sub>
4/5/2006	At the premises of Air Force Camp, Palaviya, Puttalam	1 hr	0.1	0.076	<5	0.083	0.04
2/3/2006	At the premises of Mr. Malcum, Manamunawatte, Puttalam Road, Puttalam,	24 hur	0.001	0.033	<5	0.126	
	At the Railway Station, Palaviya, Puttalam, about 5 km South-East direction to the Cement factory	24 hrs	0.014	0.029	<5	0.125	
	At the premises of Mr.V. Rasalingam, Karambe, Kalpitiya road, Palaviya,	24 hur	0.009	0.022	<5	0.043	
19/07/2004	At the premises of Dammika Holding Resort, Puttalam.	24 hur	0.016	0.022	4	0.023	
	At the premises of Mr. W.J.Appuhamy, Hadi-Estate, Periyakulam, Puttalam.	24 hur	3.91	1.93			
	At the premises of Meteorological Department, Puttalam	24 hur	6.02	2.75			
	At the premises of Mr. M.T.Halid, Polles Road, Main Street, Puttalam.	24 hur	5.61	3.08			
	At the premises of Mr. Priyanka Kithsiri, Phalamanaweeriya, Sirambiyadiaya, Anuradapura Road, Puttalam.	24 hur	3.04	1.86			

Date	Location	Sampling Time	Concentration (mg/m <sup>3</sup> )				
			SO <sub>2</sub>	NO <sub>2</sub>	CO	SPM	O <sub>3</sub>
	At the premises of Mr. Sunil Shantha, Mee Oya Road, Nelumwewa.	24 hur	5.61	1.55			
	At the premises of Maanamuna Estate, Kalladiya Road, Puttalam.	24 hur	2.97	1.09			
	At the Sri Lanka Air Force camp, Palaviya.	24 hur	6.32	1.57			
03 <sup>rd</sup> July 2003	At the premises of Dammika Holding Resort, Puttalam.	24 hur	11.85	5.13	1.5	25	
	At the premises of Mr. W.J.Appuhamy, Hadi-Estate, Periyakulam, Puttalam.	24 hur	4.87	1.91			
	At the premises of Meteorological Department, Puttalam	24 hur	5.79	6.28			
	At the premises of Mr. M.T.Halid, Polles Road, Main Street, Puttalam.	24 hur	6.25	5.51			

*Source: Air Quality Data Base of NBRO Continuous Air Monitoring Programme in Colombo - Research Programme funded by National Research Council of Sri Lanka (NRC/99/15).*

Results indicated relatively high level of air pollution in the Puttalam town limits and in the vicinity of Puttalam - Colombo main road.

## **Noise**

The existing land use pattern of the proposed area could be considered as coastal. The area is undeveloped and only few isolated house, coconut plantations, porn cultural, agricultural and fishing activities are scattered in the area. No significance industries within the area except the "HOLCIM" cement factory at Attavilluwa, Palaviya which is about 3.0 Km from the Palaviya Junction and Salt industry about 2 Km from the Kalpitiya Junction. In addition there are few industries such as color tile, tar sheet manufacturing factories, timber, carpentry, lime and small-scale household industries are scattered in the area. Therefore existing noise levels in the surrounding areas of those industries are dominated by those industries and in other areas by sources such as agricultural activities, road vehicles, domestic activities and natural noises such as sea breeze, wind action, birds and insects etc. In addition, noise emission from the forthcoming coal power plant at Kalpitiya area will one of major contributor for the noise pollution in the surrounding area.

The existing noise level measurement was carried out by the NBRO on 14<sup>th</sup> and 15<sup>th</sup> January 2003 in selected locations around the proposed site are given in Table 3.5 (Refer Annexure 02). The survey results show that the proposed site usually has noise levels of Leq 67 - 68 dB(A) closed to the main road and Leq of 40 - 45 dB(A) away from the main road in day time. At night time Leq of 45 - 50 dB(A) exist over the area. Relatively high noise levels at night time is mainly due to the noise generated by "HOLCIM" cement factory and other natural noises such as wind action, birds and insects etc.

The L<sub>90</sub> value of the noise levels indicate the value of background noise and it represent the noise levels that exist 90% of the time of noise level monitored. It indicates that the area has very low background noise level of 35 - 37 dB in day and 40 - 44 dB at night time.

The Maximum permissible noise levels stipulated by the Central Environmental Authority of Sri Lanka for different land use type are given in the Table 3.6 which was gazetted as extraordinary gazette No. 924/12 of Democratic Socialist Republic of Sri Lanka in 23<sup>rd</sup> May 1996.

Leq - The equivalent noise level generated during the sampling period

L<sub>10</sub> - The equivalent noise level that exceeded 10% of the sampling period

L<sub>90</sub> - The equivalent noise level that exceeded 90% of the sampling period

**Table 3.6. Related Maximum permissible noise levels at boundaries in L<sub>Aeq</sub> stipulated by Central Environmental Authority, Gazetted Extraordinary gazette No. 924/12 of the Democratic Socialist Republic of Sri Lanka, 23.05.1996.**

**Schedule I**

<i>Area</i>	<i>L<sub>Aeq</sub>' T - Day Time</i>	<i>L<sub>Aeq</sub>' T- Night Time</i>
Low Noise	55	45
Medium Noise	63	50
High Noise	70	60
Silent Zone	50	45

**Schedule III**

	<i>L<sub>Aeq</sub>' T - Day Time</i>	<i>L<sub>Aeq</sub>' T- Night Time</i>
For Construction Activities	75	50

**Schedule IV**

<i>Area</i>	<i>L<sub>Aeq</sub>' T - Day Time</i>	<i>L<sub>Aeq</sub>' T- Night Time</i>
Rural Residential	55	45
Urban Residential	60	50
Noise Sensitive	50	45
Mix residential	63	55
Commercial	65	55
Industrial	70	60

**Vibration:**

Though an interim standard on vibrations is in existence in Sri Lanka, no vibration levels have been measured in the project area. However, no vibration measurements has been carried out in the area since the existing environment does not seem to expressed in any vibration that is not accepted in the context of vibration pollution control.

**END of Annexures**

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