

**BEFORE THE NATIONAL GREEN TRIBUNAL
WESTERN ZONE BENCH, PUNE
APPEAL No. 611 of 2025(WZ)**

IN THE MATTER OF:

MR. RUPESH SHINKRE & ORS. ...APPELLANTS

VERSUS

M/S MORMUGAO PORT TRUST & OTHERS ...RESPONDENTS

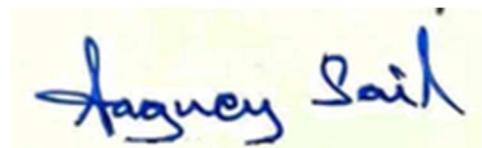
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Next Date: 02.02.2026

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APPELLANTS

THROUGH



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Filed on: 30.01.2026

Place: Goa

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ADDITIONAL AFFIDAVIT ON BEHALF OF APPELLANTS

MOST RESPECTFULLY SHOWETH:

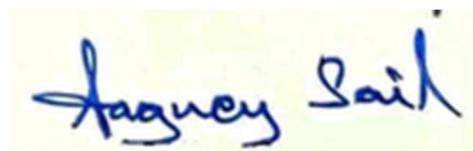
1. That the present Appeal has been filed by the Appellants against the Environmental and CRZ Clearance bearing F. No. 10-23/2014-IA.III dated 21.07.2025 issued by MoEF&CC to the project titled 'Deepening of Approach Channel for Cape-size vessels' by M/s Morumugao Port Trust.
2. That this hon'ble Tribunal was pleased to issue notice on 02.12.2025 and had directed the Appellants to bring on record the EIA Report and other documents before the next date. That the present additional affidavit is being filed in compliance of this order dated 02.12.2025.
3. That the final Environmental Impact Assessment Report dated July, 2017 is hereto marked and annexed as **ANNEXURE – A19**. The letter dated 12.05.2017 submitted to the Goa State Pollution Control Board (GSPCB) highlighting various issues concerning the public hearing is hereto marked and annexed as **ANNEXURE –**

A20. The letter dated 05.05.2017 submitted to GSPCB regarding the violations of the EIA Notification, 2006 in conducting the public hearing is hereto marked and annexed as **ANNEXURE - A21**.

4. That the present additional affidavit is made to facilitate fair and just adjudication of the present Appeal.

APPELLANTS

THROUGH

A handwritten signature in blue ink on a yellow background, reading "Aagney Sail".

AAGNEY SAIL
ADVOCATE FOR THE APPELLANTS,
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Ph. +91.9810076618,
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Filed on: 30.01.2026

Place: Goa

BEFORE THE HON'BLE NATIONAL GREEN TRIBUNAL,
WESTERN ZONE BENCH AT PUNE
APPEAL NO. 611 OF 2025 [WZ]

IN THE MATTER OF:

MR. RUPESH SHINKRE & ORS.

Solemnly affirmed before me by

...APPELLANTS

VERSUS

...RESPONDENTS

M/S MORMUGAO PORT TRUST & OTHERS

...RESPONDENTS

AFFIDAVIT

Reg. No. 2025/12/12/2025

Reg. No. 2025/12/12/2025

I, Sanjay Ankush Redkar, aged about 53 years, S/o Mr. Ankush Umaji Redkar, R/o H. No. 360, Redkar House, Maimollem, Vasco-de-Gama, South Goa District, Goa - 403802, do hereby solemnly affirm and state as under:

1. That I am the above named Appellant No. 2 and am conversant with present case hence competent to swear this affidavit. I am authorized to swear this affidavit on behalf of the other Appellant No. 1 & 3, and I have read and understood the accompanying Appeal which has been drafted on my instructions.
2. I verify that the contents of the accompanying Additional Affidavit which are true to my own knowledge and belief which I believe to be true and correct. No part of it is false and nothing material has been concealed therefrom.
3. That the Annexures A19 to A21 enclosed to the Additional Affidavit are true and correct copies of their respective originals.

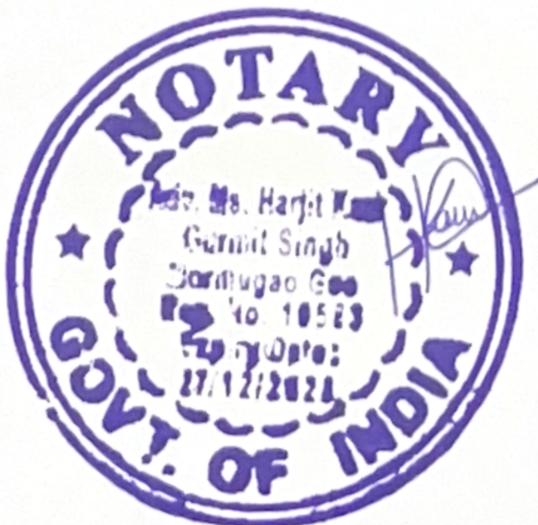
[Signature]
DEPONENT

VERIFICATION

I hereby verify that the contents of paras 1 - 3 of my above affidavit are true to my knowledge and belief, and that no part of it is false and nothing material has been concealed therefrom.

[Signature] Verified on the 9th day of January, 2026 at Goa
~~December, 2025~~

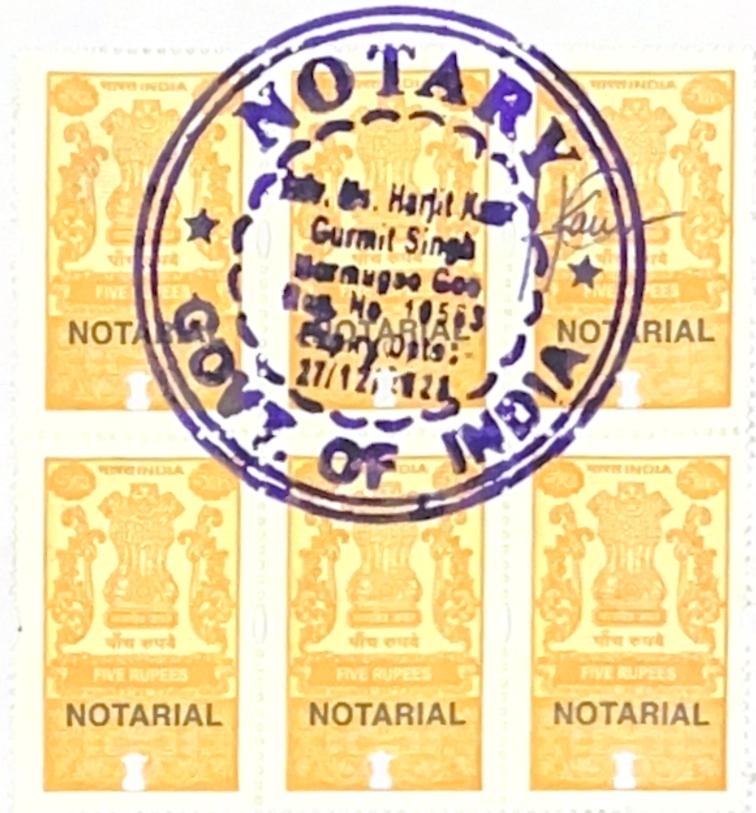
[Signature]
DEPONENT



Solemnly affirmed before me by
Sanjay Ankush Redkar
 Who is Identified to me by.....
 Who is personally know to me
 this *9th* day of *January* 20*26*
 Reg. No. *112* / 20 *26*

H Kaur

Adv. Ms. HARJIT KAUR GURMIT SINGH
NOTARY
 (Govt. Of India)
 Shop No. 26, Ground Floor
 Karma Pees Avenue,
 Vasco-de-Gama, Goa.





MORMUGAO PORT TRUST

ENVIRONMENTAL IMPACT ASSESSMENT STUDY FOR CAPITAL DEEPENING OF NAVIGATION CHENNEL AT MORMUGAO PORT FOR CAPE SIZE VESSELS



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[NABET Accreditation serial No. 166 as per list dt. 11th July 2017](#)

July 2017

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CHAPTER-I
INTRODUCTION

CHAPTER-I INTRODUCTION

1.1 GENERAL

Mormugao Port is a Major Port on the West coast of India and has completed 125 years of glorious service to the nation's maritime trade. The coordinates of the Port are 15°25' N and 73°47' E and it lies between the major Ports of New Mangalore and Mumbai. The location of Mormugao Port on the West coast of India and Google image of Mormugao Port are depicted in Figures-1.1 and 1.2 respectively.

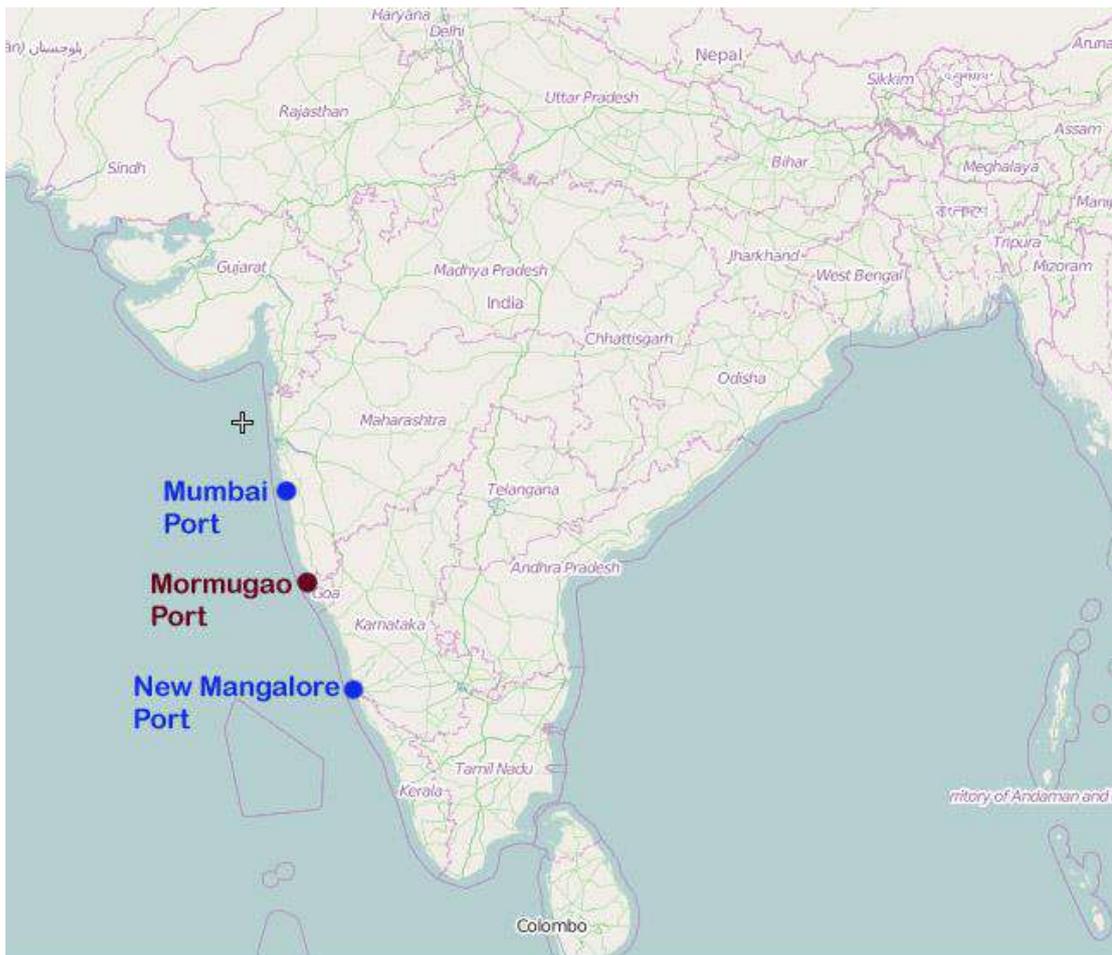


Figure-1.1: Location of Mormugao Port

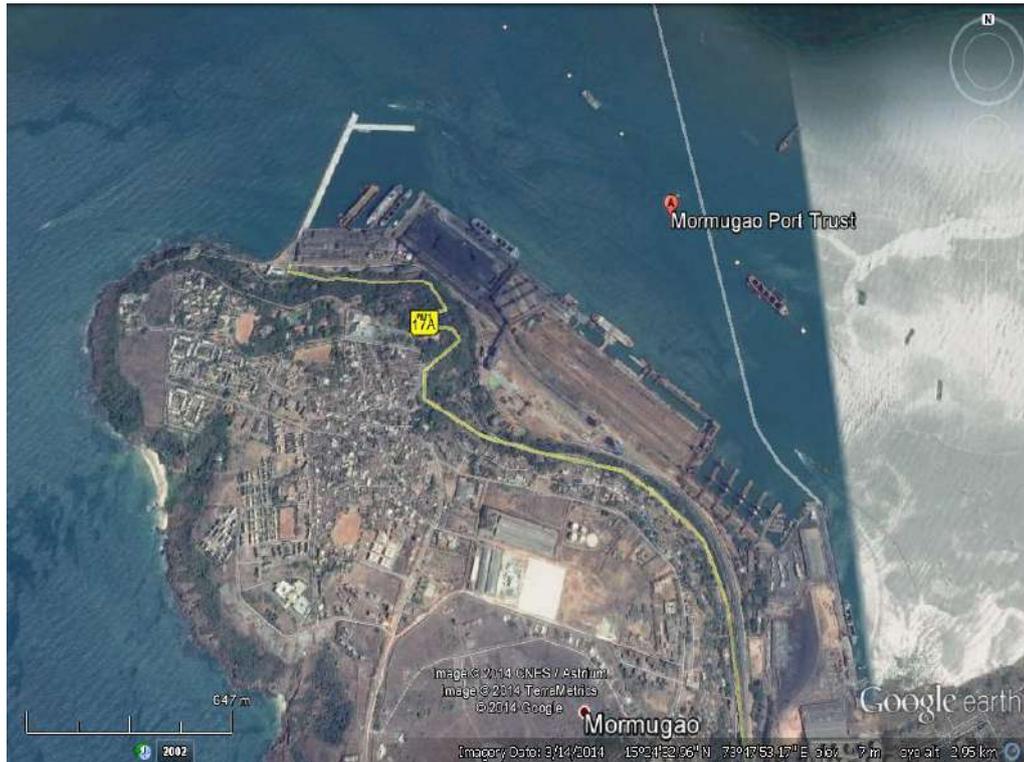


Figure-1.2: Google Image of Mormugao Port

The Port serves the geographical regions of Goa, Karnataka and parts of Maharashtra and Andhra Pradesh. Major commodities being handled at the Port are Coal, Iron Ore, POL and general cargo items. Due to the proximity of the Port with various mining regions in Goa, the Port assumed the role of a premier Iron Ore exporting port of the country. However, coal requirement from various steel industries and power generating units has also made it an attractive and cost effective destination for coal imports and steel exports. The Port has 7 cargo handling berths as listed in Table-1.1.

Table-1.1: Details of Berth and Type of Cargo

Sr. No.	Berth No.	Type of Cargo	Terminal Operator
1	5	General cargo such as Steel slabs, HR & CR Coils, etc.	M/s. SWPL
2	6	Coal & Coke	M/s. SWPL
3	7	Coal & Coke	M/s. AMPTPL
4	8	POL and Other Liquid cargo	MPT
5	9	Iron Ore (Decommissioned since November 2016 for Redevelopment of Berth No.8, 9 and Barge Berths work)	MPT



Sr. No.	Berth No.	Type of Cargo	Terminal Operator
6	10 & 11	General cargo such as Steel slabs, HR & CR Coils, Containers, Wood Chips, Granite Blocks, MOP, Imported Iron Ore, Bauxite, etc.	MPT

Apart from these 7 Berths, there is also a dedicated Berth for cruise vessels and a non-cargo Berth which is earmarked for exclusive use of Navy and Coast Guard, a Dry dock with ship repair facilities, a Berth for small craft/vessels and 6 nos. of Mooring Dolphins. In addition, there are 3 transshipment vessels and 4 floating cranes operating at outer anchorage. There is a 6.8 km long entrance channel with the depth of outer channel being 14.40 m and that of the inner channel being 14.10 m. The Port has a total land area of 546 acres (218 ha), approximately.

1.2 CONNECTIVITY OF MORMUGAO PORT

1.2.1 Air Connectivity

Goa International Airport is a civil enclave at INS Hansa, a Naval airfield located at Dabolim near Vasco da Gama. This airport is about 8.0 km from the Port and caters to scheduled domestic and international air services.

1.2.2 Road Connectivity

Goa has four National Highways passing through it. NH-66 (ex NH-17) runs along India's West coast and links Goa to Mumbai in the North and Mangalore to the South. NH-4A running across the state connects the capital Panaji to Belgaum in East, linking Goa to cities in the Deccan. The NH-366 (ex NH-17A) connects NH-66 to Mormugao Port from Cortalim. The new, under construction, NH-566 (ex NH-17B) is a four-lane highway connecting Mormugao Port to NH-66 at Verna via Dabolim Airport, primarily planned to ease pressure on the NH-366 for traffic to Dabolim Airport and Vasco da Gama. NH-768 (ex NH-4A) links Panjim and Ponda to Belgaum and NH-4. Goa has a total of 224 km (139 mi) length of national highways, 232 km (144 mi) length of state highways and 815 km (506 mi) length of district highways.

1.2.3 Rail

Goa has two rail lines, one run by the South Western Railway and the other by the Konkan Railway. The line run by the South Western Railway was built during the



colonial era linking the port town of Vasco da Gama, Goa with Belgaum, Hubli, Karnataka via Margao. The Konkan Railway line, which was built during the 1990s, runs parallel to the coast connecting major cities on the western coast.

1.3 NEED FOR THE PROJECT

Mormugao Port Trust (MPT) is a premier Iron Ore exporting Port of the country with a handling capacity of 20 million tons. Being strategically located it also caters to the needs of the coal requirement of steel and power plants of its hinterland in Karnataka. MPT has 2 dedicated coal berths which have a combined capacity of about 12 million tons per annum. Although MPT is ideally located to serve the industries in the hinterlands of Karnataka, a lot of cargo including coal is imported through some of the Ports situated in Eastern coast of India despite the fact that the rail distances from these Ports to the industries are much more compared to Mormugao Port. Apart from the fact that the South Western Railway network is heavily congested, the other reason is that these Ports have deeper channel to handle Cape-size vessels. Imports/Exports through Cape-size vis-à-vis Panamax vessels will result in freight advantage and thereby the industries stand to benefit. This will also make imports cheaper and exports more competitive leading to overall economic growth and employment creation.

The existing depth of the outer channel is -14.40 m and inner channel is -14.10 m from CD. A fully loaded Panamax vessel can be handled under these conditions by taking advantage of tide. The proposal is to deepen the outer channel to -19.80 m and inner channel and turning circle to -19.50 m from CD. This will facilitate navigation of Cape-size vessels at any state of tide.

The material to be dredged will mainly consist of silt and clay. A small quantity of weathered rock may be encountered. The total quantity to be dredged will be about 12 Mnm³. Most of the dredging work will be undertaken with a Trailer Suction Hopper Dredger (TSHD). A Cutter Suction Dredger (CSD) will also be deployed for hard material and weathered rock if encountered and blasting will not be involved. The dredged material will be dumped in the designated Spoil Disposal Grounds suggested by CWPRS.



1.4 IMPORTANCE AND BENEFITS OF THE PROJECT

Mormugao Port Trust (MPT) is strategically located to cater to the needs of the Iron Ore and Coal requirement of steel and power plants of its hinterland in Karnataka. Currently, the main users of Mormugao Port are Goan Iron Ore Exporters and JSW Steel. JSW Steel imports about 8.94 million tons of coal and exports about 1.02 million tons of finished steel products through MPT. Similarly around 15 million tons of Iron Ore produced in Goa is exported through MPT. At present, there is an upper limit of 20 million tons fixed for the production of Iron ore in the State of Goa. In future Government is likely to increase the production limit to 35 million tons and hence MPT should build its ability to meet this future requirement.

MPT is also facing challenges of cut throat competition from Ports on the East coast of the country, which are already deep drafted, such as Krishnapatnam and Gangavaram. In addition, taking into account the growing competition from private Ports and other Major Ports along the West coast, it was decided to deepen the existing approach Channel to suit the navigational requirements of Cape-size vessels. The Outer Channel was partly dredged under the capital dredging work undertaken during the period spanning from February 2016 to May 2016. Consequently, from its original depth of -14.40 m, the average depths now vary from -16.0 m in A4 zone up to -19.4 m in A0 zone. This is now proposed for deepening up to -19.80 m from the Chart Datum. Similarly, the Inner Channel, Turning Circle 1 and the approaches to Berths 5, 6 & 7 are presently partly dredged under the capital dredging work undertaken during the said period. Thus the consequent present depths, varying from -16.2 m in the approaches and -17.7 m in the Turning Circle are now proposed for dredging up to the desired depth of -19.50 m. This will facilitate the navigation of Cape-size Vessels at any state of the tide. The MPT has signed a concession Agreement with M/s. Goa Seaport Pvt. Ltd. (100% subsidiary of M/s. Vedanta Resources), for Redevelopment of Berth No.8, 9 and Barge Berths wherein two iron ore and one general cargo Berths will be constructed to cater for cape size vessels.

In order to cater to the anticipated growth in rail traffic, the South Western Railway (SWR) has planned the doubling of rail track between Hospet in Karnataka State to Vasco-da-gama town including the MPT in Goa. The work of doubling between



Hospet to Tinaighat is at an advanced stage of completion. Similarly, the work order for doubling of tracks between Madgaon to Collem was awarded in December, 2016. Track doubling work in Western Ghats (i.e. between Tinaighat to Collem) will be awarded on obtaining the requisite permissions from the MOEF & CC involving Environment and Forest clearances.

Considering the limited resources of land available with the MPT, more focus is given on quick and efficient unloading and rapid evacuation of cargo. As far as Iron Ore is concerned, rivers Mandovi and Zuari provide a cost-effective and end to end river transportation media to move the extracted Ore from inland Jetties, very close to the Mining belt, to the Port. Government of India has recently declared these rivers as 'National Waterways' to further develop the same for trade and commerce. The Inland Waterways Authority (IWA) will be undertaking an exclusive project of deepening these rivers under the 'Sagarmala' scheme.

The above plan undertaken by different Government agencies will lead to an integrated development activity with an end to end solution beneficial to the Port. If the timing of execution of work of Capital Dredging is in tune with other associated projects, it will be advantageous to the planned modernization of the MPT which is in the interest of the ensuing Trade & Commerce enhancement and thus beneficial to the State of Goa and the Country. The deepening of the navigational channel will not only provide impetus for existing steel companies to increase their capacities, but also encourage new steel plants to come up. This will be a major contribution in respect of Government's "make in India" Policy.

MPT, one of the thriving major Ports on the West coast of India, has recently lost its business substantially due to crisis involving closure of Iron Ore mines in the State of Goa. The envisaged project will improve the traffic pattern, reduce the congestion at the Port and improve the turnaround time. Due to increase in parcel size there will be saving in sea freight rates attracting Port users to use the Port and save effective costs of logistics. The benefit of this project is that the Port will be able to handle Cape-size carriers. The capacity of Cape-size ships will be of the order of 185,000 DWT. These vessels provide the economy of scale and at today's prices, the differential works out to about USD 7.00 per ton of material handled through a Cape



size vessel vis-à-vis a Pana-max Vessel. In case the Port handles a cargo of 20 million tons of cargo per annum, the savings work out to a whopping USD 140 million or INR 840 crore.

On completion of the envisaged Channel deepening Project, MPT will be one of the few Ports with a draft sufficient to attract large cape-size cargo ships to the Port. Port efficiency will be significantly improved due to handling of more cape- size vessels. The existing depth of the outer channel is 14.40 m and inner channel is 14.10 m. A fully loaded Panamax vessel can be handled under these conditions only by taking advantage of the high tide condition. The proposal is to deepen the outer channel to -19.80 m and inner channel to -19.50 m from the Chart Datum. This will facilitate navigation of Cape-size vessels at any state of tide.

The material to be dredged will mainly consist of silt and clay. A small quantity of weathered rock may be encountered. The total quantity to be dredged will be about 12 Mm³. Most of the dredging work will be undertaken with a Trailer Suction Hopper Dredger (TSHD). A Cutter Suction Dredger (CSD) will also be deployed for hard material and weathered rock, if encountered. Blasting will not be involved. The dredged material will be disposed in the designated dumping ground scientifically identified and demarcated by the CWPRS, Pune.

The benefits of the present project in terms of the enhancement and modernisation of an existing major Port in the country is mentioned in the EIA. It serves both, the interest of the State as well as the National interest in terms of the enhanced efficiency and capacity of the Port to import and export essential consumable commodities, fuels, cargo containers carrying manufactured products, bulk cargo, industrial raw materials and the like.

1.5 NEED FOR THE EIA STUDY

The proposed project envisages deepening of outer channel from -14.40 m to -19.80 m and inner basin and turning circle from -14.10 m to -19.50 m to facilitate navigation of Cape-size vessels in any state of tide. The capital dredging quantity works out to be approximately 12 Mm³ including accumulated silt after the stoppage of capital dredging works in September, 2016. The proposed project is located in the



CRZ area and listed in clause No. 7 (e) of the schedule of EIA Notification of 2006 and its subsequent amendments. Hence, proposed project requires CRZ Clearance under Coastal Regulation Zone (CRZ) Notification (January 2011) and Environmental Clearance as per the EIA Notification of 2006 and its subsequent amendments. Hence, Environmental Impact Assessment (EIA) study needs to be conducted for obtaining Environmental and CRZ Clearances. Approval of Terms Reference (TOR) for the EIA study was conveyed by MoEF&CC vide letter No. 10-23/2014-IA-III dated 10.10.2016 (Refer Annexure-I). Compliance Statement of TOR is given in Annexure-II.

As suggested by MoEF&CC in the TOR, marine biodiversity study and shoreline change study were carried out by NIO. The draft EIA report was submitted to Goa Pollution Control Board and subsequently Public Hearing was conducted by Goa State Pollution Control Board. The Public Hearing was scheduled on 27/04/2017 due to paucity of time and on account of several speakers who wanted to present their views it was adjourned and taken up on 02/05/2017, 03/05/2017 and 04/05/2017. The Public Hearing got concluded after having read out the minutes in English and Konkani. A total of 812 numbers of persons present for the public hearing and have signed the enclosed attendance sheet. A Total of 38 participants raised the issues and gave suggestions/objections regarding the proposed project. A total of 24 representations have been received. The proceedings of the public hearing are covered in Volume-II of the EIA Study.

1.6 OBJECTIVES OF THE EIA STUDY

The major thrust of the EIA study shall be to assess the impacts of various activities of proposed project on various aspects of environment. The study shall cover the impacts on water quality, noise, air quality, terrestrial ecology, wildlife, aquatic ecology including fisheries, etc. The study will include collection of baseline data, prediction of impacts and formulation of Environmental Management Plan (EMP) for amelioration of adverse impacts. The Study Area for the EIA Study shall be the area within 10 km radius of the periphery of the proposed navigation channel. The objectives of the Environment Impact Assessment study are to:

- Determine the baseline status of the Marine Ecology, Terrestrial Environmental Conditions, Ambient Air Quality, Land use, Noise Level and Socio-economic aspects of the Study Area.



- Identify and assess the probable impacts of the project on marine and terrestrial environment in the study area during dredging and dumping operations of the project.
- Suggest adequate mitigation measures to minimize the negative impacts during dredging operation and operational phases of the project.
- Recommend Environment Management Plan to ensure that the project implementation does not impact the environment adversely.
- Prepare Risk Assessment and Disaster Management Plan considering the project activity.

1.7 LEGAL STATUS OF COURT CASES AGAINST THE PROJECT

The details of legal status of Court Cases against the Project are briefly described in the following paragraphs.

- The MOEF&CC vide Communication dated 09th December, 2014 approved the Terms of Reference (ToR) for submission of EIA and EMP Reports.
- MPT has carried out detailed studies and investigations pursuant thereto and submitted to MOEF&CC the following Reports:
 - Report dated July, 2014 on Marine Geotechnical Investigation for Mormugao Port Channel in Goa by M/s. DBM Geo Techniques and Constructions Pvt. Ltd., Mumbai.
 - Detailed Feasibility Report dated December, 2014 by WAPCOS Ltd., a Government of India Undertaking.
 - Report dated November, 2014 on Geophysical Studies along the proposed channel by M/s. Geostar Surveys India Pvt. Ltd.
 - Technical Report dated February, 2015 for hydrodynamics and siltation for deepening of Approach Channel at Mormugao Port by the Central Water & Power Research Station, Khadakwasla, Pune.
 - Final Report dated November, 2015 of Environmental Impact Assessment Study for Capital Dredging of Navigational Channel at Mormugao Port by WAPCOS Ltd.
 - Disaster Management Plan dated November, 2015 by WAPCOS Ltd.



- Vide Communication dated 23rd September 2015, the MOEF&CC exempted the project activity from public consultation noting that the project activity is covered under paragraph 7 (iii) stage (3) (i) (cc) of the EIA Notification of 2006 (as amended).
- The Goa Coastal Zone Management Authority (GCZMA), at its meeting, held on 23rd November 2015, noted that the proposal of capital dredging and its possible impact is multi-disciplinary activity which involves various fields of science and that the authority does not have a technical and scientific competence to appraise the said proposal thoroughly and therefore decided to forward the proposal to the MOEF&CC, Government of India for decision on grant of the Environmental Clearance and CRZ Clearance.
- The proposal was considered by the Expert Appraisal Committee in its meetings held on 22nd December, 2015 **which recommended the proposal** for Environmental Clearance.
- MPT awarded the work of capital dredging to M/s. Dredging Corporation of India Ltd., a Government of India undertaking for a quoted amount of Rs. 193.50 crores vide Letter of Intent dated 30th December, 2015.
- The Port received MOEF&CC clearance vide MoEF letter dated 09/02/2016 along with conditions.
- Old Cross Fishing Canoe Owners Co-operative Society Ltd. and others filed an Application before the National Green Tribunal, Western Bench, Pune (Appeal No. 10/2016) challenging that the exemption given for Public Hearing was not as per the EIA Notification. 2006 and pleaded to stay the capital Dredging project.
- MPT (Respondent No. 1) filed reply dated 08th March, 2016 along with documents. Subsequently MPT filed an additional affidavit dated 21st March, 2016 along with documents and MOEF&CC (Respondent No. 2) filed its Reply Affidavit dated 06th April. 2016 along with documents.
- After hearing all the parties, vide Order dated 04th May, 2016, the National Green Tribunal (NGT), Western Branch, Pune rejected the prayer for interim relief (Stay of Capital Dredging) noting that a balanced view based on the principles of sustainable development without negating the precautionary



principle is required to ensure that development can take place without any significant adverse impacts on the environment. MPT was also directed to deposit Bank Guarantee of Rs. 50 crore with GCZMA, which was deposited by MPT within the time stipulated.

- A Committee was constituted by the NGT for ascertaining the Environmental Status and Impacts due to the dredging operations and to submit fortnightly reports to the Tribunal. The Collector, North Goa was directed to carry out investigation on the complaints filed by the Appellants regarding the damage to house and other issues and to submit the report.
- MOEF&CC and GCZMA were also directed to carry out independent compliance verification on fortnightly basis till the dredging operations are continued.
- The matter thereafter was listed before the NGT on 24th May, 2016. As per the Order dated 24/05/2016, the NGT issued fresh directions to the Committees to conduct local inspection and submit detailed reports.
- It was a condition of the EC dated 09th February, 2016 that the dredging shall not be carried out during the fish breeding season. Accordingly, no dredging activity was carried on during the fish breeding season notified by the State Government viz. 01st June, 2016 to 31st July, 2016.
- The Committee appointed by the NGT submitted its Report dated 27th May, 2016. As seen from the said Report, the Committee suggested that the actual damage already done to the estuarine environment, the biodiversity in particular, should be assessed after the completion of the proposed dredging.
- MPT filed an Additional Affidavit dated 15th July, 2016 in the said Appeal before the NGT. In the said Affidavit, it has been stated that about 64% of the project dredging work has been reported to be completed at site and that MPT has paid a total amount of Rs. 87.25 crores to M/s. DCI in respect of the subject work of capital dredging.
- Along with the said Affidavit, Monitoring and Testing Reports dated 10th March 2016, 29th March 2016, 22nd April 2016, 29th May 2016, 16th June, 2016 and 29th June, 2016 by M/s. Richardson & Cruddas (1972) Ltd. after collecting the samples of marine water and sediment during dredging, were produced on



record. The monitoring report concluded that the marine water and sediment quality was well within the standards prescribed by the MOEF&CC. There was no adverse report or any material produced on record by the Appellants.

- The matter was heard by NGT on 27th July, 2016 and the Judgment was reserved. The Impugned Judgment was pronounced in the Open Court on 02nd September 2016. However, the same was uploaded on the website only on 17th September, 2016. As per the order of NGT the port suspended the capital dredging with effect from 19/09/2016, the date of uploading of the order on website.

The Hon'ble NGT passed the following orders;

1. *The communication dt. 23rd September 2015 of MoEF granting exemption from Public consultation to the project of Respondent No.1 is quashed as illegal, arbitrary and in violation to the provisions of the EIA Notification, 2006. Consequently, the impugned EC dt. 9th February, 2016 is also quashed and set aside.*
 2. *The matter is remanded back to EAC of MoEF for further action.*
 3. *The interim order dt. 4th May 2016 stands vacated. However, in view of the further proceedings regarding the restoration and restitution, the bank guarantee deposited by respondent No.1 with GCZMA shall be retained by the Authority till further orders.*
 4. *The respondent No.1 and MoEF are directed to pay cost of Rs 2 lakhs each to both the Appellants within four(4) weeks.*
 5. *In view of this order, 1st respondent shall not proceed with dredging activity, except as provided in this order.*
- MPT has, vide Civil Appeal 9955/2016, appealed in the Supreme Court with regard to the decision of the NGT, Pune dated 2nd September, 2016. The matter originally listed on 28th October, 2016 was heard on 18th November, 2016 wherein the learned AG representing MPT submitted on instructions that the petitioner is willing to abide by the direction issued by the Tribunal for a Public hearing in terms of the EIA Notification, 2006. He further submitted that this matter could stand over by eight weeks with a view to await the outcome of the public hearing. He undertakes to keep the Bank Guarantee furnished by



the petitioner validated pending further orders from this Court. The matter was posted after 8 weeks. The matter was heard on 20th January, 2017 wherein the learned counsel for MPT stated that the public hearing will be held on 21st February, 2017 and matter was fixed on 20th March, 2017. In view of the letter circulated by the learned counsel, the matter fixed on 20th March, 2017 was listed after 10 weeks. The matter was disposed on 14th July, 2017 as the requirement of the NGT Interim Order for conducting the Public Hearing was complied with by MPT.

- The issue regarding restitution of the area and costs to be paid to the Appellants is still pending in the NGT. The same has been challenged by MPT and the hearings for the same have continued from 5th October, 2016. The last hearing was held on 7th July, 2017 and the next hearing has been fixed on 28th July, 2017 at NGT, Pune.
- The shore line study report of NIO dt. June 2017 concludes as follows;

“Initial observations in the present on-going shoreline monitoring studies within the study area of 10 km radius from Project site, conducted from July 2016 to May 2017, indicate that **there is no significant erosion/accretion**. However, continuous monitoring of these beach stretches are required at least for a period of another 2 years to ascertain the influence of any port activity on the beaches.”

In view of the above it is clear that restoration and restitution of shoreline will not be necessary. Based on this report an additional affidavit will be submitted to the NGT to drop the restoration and restitution proceedings.

1.8 STUDY AREA

As per the Ministry of Environment, Forests and Climate Change (MOEF&CC) guidelines, the Study Area for the EIA study has been considered as the 10 km radius on either side of the proposed navigation channel.



1.9 STAGES IN AN EIA STUDY

The purpose of this section is to enumerate the steps involved in an Environmental Impact Assessment (EIA) Study. The same are given in following paragraphs.

Scoping: An exhaustive list of all likely impacts drawing information from as many sources as possible shall be prepared to assess the impacts due to various activities of the proposed Dredging Project. The next step shall be to select a manageable number of attributes, which are likely to be affected as a result of the proposed project.

Various criteria applied for selection of the important impacts are as follows:

- magnitude
- extent
- significance
- special sensitivity

Baseline Study: Before the start of the project, it is essential to ascertain the baseline levels of appropriate environmental parameters, which could be significantly affected by the implementation of the project. The planning of baseline survey emanated from shortlisting of impacts prepared during identification. The baseline study involved both field work and review of existing documents, which is necessary for identification of data which may already have been collected for other purposes.

Impact Prediction: is essentially a process to forecast the future environmental conditions of the project area that might be expected to occur as a result of the proposed project. An attempt was made to forecast future environmental conditions quantitatively to the extent possible. But for certain parameters which cannot be quantified, general approach is to discuss such intangible impacts in quantitative terms so that planners and decision-makers are aware of their existence as well as their possible implications.

Environmental Management Plan: For the proposed coastal development projects an Environmental Management Plan (EMP) is formulated to maximize the positive environmental impacts and minimize the negative ones. After selection of suitable environmental mitigation measures, the cost required for implementation of various management measures is estimated, to have an idea of their cost-effectiveness.

Risk Analysis and Disaster Management Plan: Risk Analysis and Outline of the Disaster Management Plan (DMP) has been prepared considering the proposed project activities.



Environmental Monitoring Programme: An Environmental Monitoring Programme for implementation during project dredging operation and operation phases shall be suggested to oversee the environmental safeguards, to ascertain the agreement between prediction and reality and to suggest remedial measures not foreseen during the planning stage but arising during operation and to generate data for further use.

1.10 COMPLIANCE OF ENVIRONMENTAL CONDITIONS

MoEF&CC had accorded the earlier Environmental Clearance to M/s Mormugao Port Trust for the above mentioned project vide letter 10-23/2014 dated 9th February, 2015. Compliance of Environmental Conditions regarding this project was submitted to the regional Office of MoEF&CC at Bangalore vide letter dated 17.10.16 (Copy enclosed as Annexure-III).

1.11 OUTLINE OF THE REPORT

The contents of the EIA report are arranged as follows:

Chapter 1: The chapter gives an overview of the need for the project, objectives and need for EIA study etc. The methodology adopted for conducting the EIA study for the proposed dredge the existing navigation channel is also described in this chapter.

Chapter 2: A brief write-up on various project appurtenances, infrastructure available at the port, etc. has been covered in this chapter.

Chapter 3: Baseline environmental conditions regarding physio-chemical parameters, resource base and infrastructure have been described in this Chapter. The baseline study involved both field work and review of existing documents, which is necessary for identification of data which may already have been collected for other purposes.

Chapter 4: Baseline environmental conditions regarding marine ecological aspects have been described in this Chapter. The baseline study involved both field work and review of existing documents and findings of the marine biodiversity study carried out by NIO.

Chapter 5: This chapter gives an overview of the Terrestrial Ecological aspects including flora, fauna, wild life and ecologically sensitive habitats in the study area.



Chapter 6: This chapter gives an overview of the Socioeconomic aspects of the study area.

Chapter 7: This chapter covers the anticipated impacts due to the proposed project.

Chapter 8: Mitigation measures to ameliorate the anticipated adverse impacts are outlined in this Chapter.

Chapter 9: Delineate the Environmental Management Plan.

Chapter 10: Outlines the Risk Analysis and Disaster Management Plan.

Chapter 11: Delineates the Environmental Monitoring Programme for implementation during dredging.

Chapter 12: Summarizes the cost required for implementation of Environmental Management Plan and Environmental Monitoring Programme

Chapter 13: Delineates the Disclosure of Consultants.

CHAPTER-2
PROJECT DESCRIPTION



CHAPTER-2 PROJECT DESCRIPTION

2.1 BACKGROUND

Mormugao Port Trust (MPT) is a premier Iron Ore exporting Port of the country with a handling capacity of 20 million tons. The Port as a whole at its peak activity handled about 40 million tons of iron ore export. With the ban on mining lifted, the export of iron ore is expected to grow substantially. Port has proposed Redevelopment of Berths 8 & 9 and Barge Berths on PPP basis and Berths have been redesigned for handling cape-size vessels for the export of iron ore and General Cargo which is of great economic benefit to the state and country. Mormugao Port Trust (MPT) is also strategically located to cater to the needs of the coal requirement of steel and power plants of its hinterland in Karnataka. MPT has 2 dedicated coal Berths which have a combined capacity of about 12 million tons per annum. The main user for MPT is currently JSW steel. JSW steel imports coal and exports finished steel products through MPT. However their coal requirement is in excess of 15 million tons and thus, has to depend on Ports on the Eastern Coast like Krishnapatnam for coal imports despite the fact that MPT is closer to their steel plant situated at Toranagallu.

Coal imports for JSW at MPT are carried out at Berth No.6 which is operated by South West Port Ltd, a group company of the JSW. Another Coal Berth No.7 has recently been made operational by M/s. Adani Murmugao Port Terminal Pvt. Ltd. which serves a number of users. Bulk cargo Exports/Imports stand to gain significantly in terms of freight benefit, if Exports/Imports are done through Cape-size vessels. MPT, taking into account the growing competition from private ports and other Major Ports in the vicinity has decided to deepen the Approach Channel to suit the navigational requirements of Cape-size vessels. The Outer Channel which is presently partly dredged under capital dredging work from -14.40 m up to the average depths varying from -16.0 m in A4 zone and up to -19.4 m in A0 zone is to be now deepened to -19.80 m. Similarly the Inner Channel and Turning Circle 1 and approaches to the berth 5, 6 & 7 which is presently partly dredged under capital dredging work from -14.10 m upto the average depths varying from -16.2 m in the approaches and turning circle -17.7 m is to be now deepened to -19.50 m. This will



facilitate navigation of Cape-size Vessels at any state of the tide. The difference between the inner and outer channel depths is due to the fact that inner channel is calmer than the outer channel and hence the vertical motions of the vessels under the environmental conditions are far lesser than the outer channel.

MPT expects that substantial efficiency in performance and reduction in shipping cost due to economy of scale can be achieved, if larger vessels can be serviced at the Port. However, a very big factor for MPT's growth is the doubling of the South Western Railway (SWR) network which is presently choked. Doubling of the rail network coupled with MPT's expansion plan will open up a lot of opportunities for investments in the hinterland particularly for the steel and power sectors.

Mormugao is an open type natural harbour and has a natural promontory known as Mormugao Headland. The harbour is protected by a breakwater of 550 m long and a mole of 270 m long. The existing length of approach channel including first turning circle to end of channel is 6.8 km. The extension proposed to this existing channel is 3.5 km. As such the total length of the approach channel after the capital dredging will be 10.3 km. The width of the channel is 250 m from A0 upto A3 zone. The width of the channel in A4 & A5 zone varies from 250 m to 580 m till turning circle 1. The Port was envisaged using the protruding Headland which provides partial shelter from the South-West winds and monsoonal waves.

The harbour is fairly well protected and tranquil. In the monsoon season however, due to disturbed outer sea, notified draft in the channel is reduced. This reduction is also attributable to the high rate of monsoon siltation due to the seasonal littoral drift. The layout of Mormugao Port is depicted in Figure-2.1. The details of the navigation channel proposed to be dredged are shown Figure-2.2.



Figure-2.1 Layout of Mormugao Port

2.2 EXISTING BERTHING FACILITIES

The physical features of the present berth facilities are summarized Table-2.1.

Table-2.1: Existing Berthing Facilities at Mormugao Port

Berth No.	Length (m)	Dredge Depth(m)	Year of Construction	Type of cargo	Permitted Capacity (Million Tons)
Cruise Berth	450	9.50	2012	Cruise vessels	-
Mole Berth	250	9.50	2012	Naval & Coast Guard	-
1,2,3	-	9.00	1995	Ship repair facility	-
4	194	8.00	2012	Port crafts	-
5	200	14.10	2004	General Cargo	1.00
6	250	14.10	2004	Coal	6.50
7	300	14.50	2014	Coal	5.20
8	298	13.10	1976	Liquid bulk	1.00
9	357	14.10	1978	Iron ore	11.50*
10	250	13.10	1985	General cargo	2.50



Berth No.	Length (m)	Dredge Depth(m)	Year of Construction	Type of cargo	Permitted Capacity (Million Tons)
11	270	13.10	1994		
Mooring Dolphins	6 no	14.10	2003-2011	Bulk Cargo	10.00

Source: DPR : * - Handling of Iron ore discontinued since November, 2016.

2.3 EXISTING NAVIGATION FACILITIES

The Port of Mormugao has a 250 m wide channel that is 6.8 km long in the Outer Channel from A1 zone up to the Turning circle 1 and 0.67 km long in the Inner Channel up to the Turning circle 2. The depths range from 14.1 m in the Inner Channel to 14.4 m in the Outer Channel. Beyond Berth No. 9 (iron ore berth), the channel including turning circle 2 and mooring areas shoal, the depth is 13.1 m. (Refer Figure-2.2).

The maximum fully laden vessel draft that can be accommodated within the harbour at all stages of the tide is 13.4 m, allowing for under-keel clearances. However, vessels are sometimes loaded up to 14.1 m draft departing only on the high tide. In the region of Berth 10 and Berth 11, the design channel and turning basin depth is 13.1 m.

2.4 TRAFFIC FORECAST

MPT has 7 cargo handling berths and 6 Mooring Dolphins. Berth-wise cargo and vessel details with respect to Mormugao Port, during the year 2016-17, are detailed in Table-2.2. The quantum of cargo handled during past 3 years through MPT is given in Table-2.3.

Table-2.2: Cargo handled at various berths at MPT

Berth	Cargo	Capacity (MTPA)	No. of Vessels	Tonnage handled	Average Parcel size	Owned & Operated
				2016-17	2016-17	
Berth No.5	HR Coil, Steel slabs, steel plates	1.00	31	931367	30044	SWPL
		6.50				
Berth No.6	Coking coal, R.P.Coke		151	10742186	71140	SWPL
Berth No.7	R.P.Coke	5.20	46	2025094	44023	AMPTPL
Berth No.8	Ammonia, C.Soda	1.00	87	618666	7111	MPT



Berth	Cargo	Capacity (MTPA)	No. of Vessels	Tonnage handled	Average Parcel size	Owned & Operated
				2016-17	2016-17	
	Liquids					
Berth No.9	Granite, HR Coil, Iron Ore	11.50*	12	449728	37477	MPT
Berth No.10	Bauxite, Container Coils, granite woodchips, fertilizers etc.	2.50	147	1535290	10444	MPT
BerthNo.11			112	1517310	13547	MPT
Mooring Dolphins	Coal/ Pig iron	10.00	57	3016871	52927	MPT

* - Handling of Iron ore discontinued since November, 2016.

Table-2.3: Cargo handled during past 3 years at MPT

S. No.	Commodity	2014-15	2015-16	2016-17
A	Exports			
1	Iron ore & pellets	604178	3569863	14722851
2	Bauxite	267220	209745	0
3	Containers	171540	136315	168108
4	C. P. Coke	---	---	---
5	Granite	302627	313140	290322
6	H. R. Coils	1625094	841166	1820700
7	Iron & Steel	62571	---	---
8	Maize	---	---	---
9	Pig Iron	263699	306624	140350
10	Sugar	11410	6424	---
11	Wheat	---	---	---
12	POL	---	2166	---
13	Misc. Gen. Cargo	21080	22228	190549
	Total Export	3329419	5407671	17332880
B	Imports			
1	Liquid Bulk including Ammonia	1066165	1058830	1070911
2	Fertilisers	226552	223152	199558
3	Pet. Coke	430870	602050	802835
4	Met. Coke	279840	31500	971272
5	C.P.Coke	---	101076	---
6	Coking Coal	6631281	7808025	8465630
7	Thermal Coal	1936960	3727077	2513933
8	Containers	140346	209112	234522
9	Wood Chips	388341	575364	368694
10	Misc. Gen. Cargo	280893	1032534	1221065
11	Liquid Ammonia	87349	78575	62452
	Total Imports	11381248	15368720	15848420
	Total Traffic	14710667	20776391	33180300



2.5 ASSESSMENT OF FUTURE TRAFFIC POTENTIAL

The deepening of channel will mainly benefit bulk cargo importers and exporters. Iron ore exports through Goa have resumed and tending towards normalisation in the wake of likely increase in the ceiling from 20 MTPA to 35 MTPA. Therefore the Goan iron ore exporters will greatly benefit from this project.

Thermal coal demand is showing a declining trend due to the Government policy of import substitution and more indigenised production of coal. Moreover, the phenomenal developments in solar and wind energy will have an impact on thermal coal imports. The cargo handled during the past 3 years is given in Table-2.3.

Bulk carriers for Iron ore and coal (Ship type and sizes)

Scatter diagrams of the global dry bulk carrier fleet indicate a spread across the following tonnage groups:

- Handy size : 15,000 to 35,000 DWT
- Handy-max : 35,000 to 58,000 DWT
- Pana-max : 60,000 to 80,000 DWT
- Cape-size : 110,000 DWT and larger

Most Handy size and Handy-max vessels are geared, i.e., they have on-board cranes to load and unload cargo. However, except for a very small number of Pana-max bulk carriers, Pana-max and Cape-size bulk carriers do not have on-board cranes or other mechanical handling equipment for loading/discharging cargo or transshipping cargoes at sea. International fixtures are clustered in the ranges 45,000t to 70,000 t (Handy-max/Pana-max) and 120,000 to 150,000 t (Cape-size). The range of principal bulk carrier dimensions for 50% and 75% confidence limits are given in Table-2.4.

Table-2.4: Typical bulk carrier dimensions

Ship type	Type	DWT range	Typical DWT	LoA (m)		Beam (m)		Max. draught(m)	
				50%	75%	50%	75%	50%	75%
Dry bulk carrier	Handy size	20,000-40,000	30,000	176	181	26.1	27.0	10.3	10.6
	Handy-max	40,000-50,000	50,000	204	209	32.3	32.3	12.0	12.4
	Pana-max	50,000-80,000	70,000	224	231	32.3	32.3	13.3	13.7
	Afra-max	105,000	100,000	249	255	42	43	13.5	13.8



Ship type	Type	DWT range	Typical DWT	LoA (m)		Beam (m)		Max. draught(m)	
				50%	75%	50%	75%	50%	75%
	Cape-size	100,000-180,000	150,000	279	287	37.9	44.5	16.7	17.1
	VLBC	>180,000	200,000	303	311	47.0	48.7	18.2	18.6

Source: Permanent International Association of Navigation Congress (PIANC) - Report of Working Group 33

Since there is a distinct cost advantage accrued due to the economy of scale of a larger carrier, only Cape-size vessels shall be considered for the purpose of this report. This carrier would be utilised for import of the entire bulk material of the port. Design bulk carrier sizes considered for Iron ore and coal traffic are given in Table-2.5.

Table-2.5: Design ship dimensions for coal

Ship size	Cape-size
Capacity	180,000 DWT
Length overall	287 m
Maximum beam	44.5 m
Full load draught	17.1 m

As indicated in Table-2.5, vessel population generally follows a distribution, which could be fitted in to a standard distribution pattern. Coupled to this assumption, it is also true that the number of vessels belonging to the various categories would be difficult to assess at this moment. Therefore, the vessel mentioned in the Table 2.5 above would be considered as the design vessel for the purpose of this report.

2.6 DESIGN OF APPROACH CHANNEL

2.6.1 Existing Harbour

The features of the existing channel as follows:

Approach (outer) Channel (from A1 to Turning Circle 1)

Length	: 6.8km
Width	: 250 m to 580 m
Depth	: -14.40 m CD

Inner Channel (from end of Turning Circle 1 to start of Turning Circle 2)

Length	: 670 m
Width	: 580 m to 480 m
Depth	: -14.10 m CD



Turning Circle No.1 & 2 of 480 m diameter and depth of -14.40 m and -13.10 CD, respectively.

2.6.2 Details of the proposed deepning and dredging

Harbour Design Vessel

The channel has been designed for 185,000 DWT bulk carriers. The typical dimensions of design vessels area are given in Table-2.6.

Table-2.6: Dimensions of Design Vessels

Vessel size (DWT)	Length (m)	Beam (m)	Draft (m)
1,85,000 (bulk carrier)	300	45.0	18.5

2.6.3 Channel Width

Navigation channel has been designed based on the two approaches:

- Theoretical, considering design vessel and oceanographic conditions
- On the basis of operational constraints of vessel and oceanographic conditions.

The channel width is calculated on the basis of these two approaches and the larger value of channel width is adopted for the channel. At present the approach channel has a width of 250m, which is adequate.

2.6.4 Width on the Basis of Theoretical Approach

A typical one way channel width would comprise of a basic manoeuvring lane, additional widths (to allow for the effects of wind, current, etc.) and bank clearance.

The factors considered in channel width design are:

- Ship manoeuvrability
- Vessel speed
- Environmental factors like cross wind, current, waves etc.
- Aids to navigation
- Type of cargo (hazardous or otherwise)
- Depth of channel
- Type of bottom surface
- Bank clearance

There are no rational formulae, which explicitly includes all the above parameters to arrive at appropriate widths. The width of channel is expressed in multiple of beam of the design ship. The channel width is designed for one way traffic taking into account



the characteristics of the design vessel. The navigational width is estimated using the PIANC 'Guidelines for Design of Approach Channels. Width provisions for various factors are calculated separately which are described in following paragraphs.

2.6.4.1 Width of Basic Manoeuvring Lane

Moderate ship manoeuvrability, experienced pilots with ability of quick response in interpreting the visual cues indicating position and that of the ship in reacting to the rudder have been assumed. Basic width of manoeuvring lane equal to 1.5 times the beam of vessel (B) is considered.

2.6.4.2 Widths for straight channel sections

The factors and considered additional width for shore facilities are as follows:

a. Vessel speed

Vessel speed of 11 knots has been considered in approach channel and thus no additional width is proposed.

b. Cross winds

The prevailing cross wind is of the order of 25 knots, which is considered moderate and hence additional width of 0.4B for- approach channel is considered.

c. Cross and longitudinal currents

As per the recorded data, maximum current is in the order of 1.0 knots. Hence an additional width of 1.0 B is considered.

d. Wave Height

Wave height in the approach channel is about 2 m. Hence an additional width of 1.0B has been considered.

e. Bottom surface of channel

An additional width of 0.1 B has been considered since the sea bed is considered smooth and soft.

f. Depth of waterway

An allowance of 0.4B has been considered assuming depth to draft ratio as less than 1.15.



g. Additional width for bank clearance

An allowance of 0.5B has been considered on either side of the channel. The width allowances for the design vessel as discussed under them above are summarized in Table-2.7 and the required channel widths in Table-2.8.

Table-2.7: Width Allowance for the channel

S.No.	Factors	Allowances
1	Manoeuvrability	1.5B
2	Speed	0
3	Cross wind	0.4 B
4	Cross current	1.0 B
5	Waves	1.0B
6	Bottom surface	0.1B
7	Depth	0.4B
8	Bank Clearance	0.5B
	Total width	4.9 B

Table-2.8: Theoretical channel width

Design Vessel Size	Approach channel width
185,000 DWT	206m

2.6.5 Depth of Channel

For the determination of the required depths in the navigation channel and the manoeuvring areas, the methodology as described earlier is used and various parameters are superimposed to arrive at the design depths. The proposed depth of the channel has been arrived at as follows.

Draft for 185,000 DWT vessels	: 18.50 m
Under keel clearance	: 1.30 m
Total depth required	: 19.80 m.

Hence the depth for the approach channel will be -19.80 m CD. The Inner Channel and Turning Circle no.1 will be dredged to -19.50 m CD.

2.7 DREDGING PLAN FOR DEEPENING OF THE PORT

In this section a dredging plan has been prepared considering the various available equipment and site conditions. The dredging quantities for deepening the approach and entrance channel and manoeuvring areas have been estimated on the basis of



recommended dimension of channel. The maintenance dredging requirement is also discussed. The characteristics of the soil strata in the dredging channel is as follows:

2.7.1 Outer channel

- Top layer comprises of unconsolidated silty / sandy clay with silt and sand content increases with depth.
- Next layer is medium to dense and very dense silty fine to medium sand.
- Weathered to hard rock is seen in a few places.
- Rock layer is present below 18.5 m in A4 & A5 zones which is near breakwater

2.7.2 Inner Channel and Turning Circles

- The top layer consists of unconsolidated silty / sandy clay
- Next layer is stiff to hard silty clay
- No rock layer is present

Since the presence of rock is found in the outer navigational channel area, apart from normal dredging, the quality of rock found in the dredging area could be handled by cutter suction Dredger or back hoe dredger.

2.7.3 Dredgers

There are various types of dredging equipment available for executing capital dredging works. These include the following;

- Trailer Suction Hopper Dredger (TSHD)
- Cutter Suction Dredger (CSD)
- Backhoe Dredger
- Bucket Dredger
- Grab / Clamshell Dredger

The most common type of dredgers used for large scale works are TSHD and CSD. It is proposed to deploy this equipment at Mormugao Port to carry out the dredging work. The features of these dredgers are discussed in the following paragraphs:

Trailer Suction Hopper Dredger (TSHD)

The TSHD is a sea-going self-propelled vessel which is equipped with trailing suction heads provided on the sides of the vessel which can be lowered to the sea bed. The suction pipes terminate at the lower end in a drag head which is provided to draw the maximum amount of sea bed material and discharge it into a hopper in the vessel. TSHD is a very versatile dredging unit and is most suitable for deployment in busy

navigational channels. It can dredge material varying from sand, silt gravel and soft to medium clay. It can work in exposed conditions with wave heights up to 3 m. The dredged material can be used for reclamation either by pumping through pipelines or rain-bowing technique. The typical details of trailer suction hopper dredger are shown in Figure-2.3.

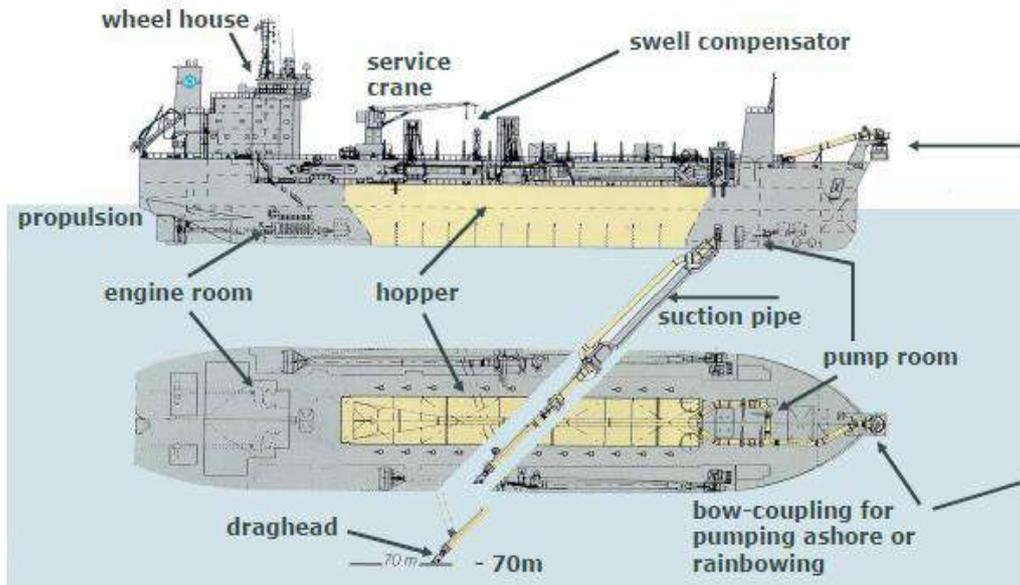


Figure-2.3: Typical details of TSHD

Cutter Suction Dredger (CSD)

The CSD comprises a rotating cutter head mounted at the end of a suction pipe and connected to a dredging pump in the main body of the dredger. The dredger pivots around a spud located at the rear of the dredger by using a system of anchor wires and winches. The cutter head cuts the material on seabed and then the material is sucked up through the suction pipe by the dredger pump and discharged through a pipeline. The CSD can dredge a variety of different type of soils, including clay, silt, sand and weak rocks. It is sensitive to wave conditions and can operate for significant wave conditions up to 1 m. Hence, deployment of CSD at Mormugao Port should be during fair weather season when the sea is relatively calm. A Cutter Suction Dredger is shown in Figure-2.4.



Figure-2.4: Typical Cutter Suction Dredger

Backhoe Dredger (BD)

For dredging in highly weathered rock area, a Backhoe Dredger (BD) will be used. Backhoe dredging involves dredging by mechanical means from a stationary platform and loading to attendant barges.

In order to determine the forces required for cutting the rock, laboratory tests are conducted. This will determine the hardness or 'N' value. The development process starts with a desktop study. This study comprises an inventory of rock cutting theory, laboratory cutting tests and collection of literature on ripping by bulldozers in various rock types. The desktop study indicates the relation between properties of the rock and the level of force required for cutting the rock. A model is set up for cutting of rock with a TSHD equipped with a drag-head. This model predicts the maximum strength of rock that can be dredged, depending on characteristics such as propulsion power, trailing speed, drag-head weight and drag-head layout. The cutting production, depending on the strength of the rock, is also predicted. A generic result of the model for a particular TSHD equipped with a drag-head with different numbers of teeth is analysed. The general set up comprises a bulldozer pulling a test cart equipped with ripper teeth or pick-points. The aim of the tests is to gain an insight of the cutting forces, penetration forces and the size of the rock to be

cut. The size of the cut rock is important because large rock lumps might block the drag-head or even worse, block the dredging pump. A typical backhoe dredger is shown in Figure-2.5.

Accordingly, cutting capabilities of drag-heads will be determined. Several types of pick-points and cutting geometries will be investigated during cutting tests with a test-cart equipped with measuring and logging instruments. The drag-head will be engineered and constructed after having determined the optimal teeth configuration with respect to forces and dimensions of the cut rock. In addition, vessel motion and vessel manoeuvring studies will be undertaken to investigate the operational limits of the dredger. The vessel crew will be trained on a dredging vessel simulator whereby the actual currents and the predicted cutting forces will be used as inputs.



Figure-2.5: Typical Backhoe Dredger

Choice of Dredger for Mormugao Port

Major part of the dredging work can be accomplished by deployment of the TSHD. However, there could be some stiff clay and rock patches for which a CSD can be deployed. Hence for the dredging project, a CSD and TSHD will be deployed. But CSD being a stationary type of dredger, if lots of shipping activities are going on it will affect the vessel traffic.



2.7.4 Methodology

Most of the dredging work will be undertaken with a Trailer Suction Hopper Dredger (TSHD), supplemented by Cutter Suction Dredger (CSD) or Backhoe Dredger (BD) for dredging hard material and weathered rock if encountered. Dredged material will be placed at the designated dumping ground suggested by CWPRS. No blasting is involved in the process.

The analysis of sea bed using seismic profiling studies by M/s Geo Star Surveys India Private Ltd. and some of the data on boreholes indicated that in the inner channel the sea bed is composed of silty and sandy clay layer which is followed by medium to dense and stiff clay mixed with gravels and pebbles. In the outer channel, loose and unconsolidated clay forms the top layer and below that stiff to dense silty / clayey sand is found. Some patches of weathered rock were also seen in the outer channel. By taking sections at 200 m interval and assuming side slope of 1 in 4 and by using trapezoidal and prismoidal formula, the capital dredging quantity has been worked out. The capital dredging quantity works out to be approximately 12 Mm³ including the accumulated silt after the stoppage of capital dredging work.

It is proposed to dredge the balance quantity using combination of two Trailing Suction Hopper Dredger of capacity 15,000m³ and Cutter suction dredger. The proposed dumping ground as per CWPRS studies is located at 14 km from the breakwater head at 27 m depth contour on 1 km north from the offshore end of the hopper requiring half an hour, one dredging cycle can be completed in 2 hours 30 min. (filling half an hour + travel time of one and a half hour to and fro to the dumping ground +emptying of hopper of half an hour). Hence in a day approximately 100000 cum will be disposed. The time required for completing capital dredging of 12 Mm³ shall be approximately 5 months which includes mobilization and demobilization. Some patches of weathered rock is anticipated for which Cutter Suction Dredger / Back Hoe Dredger will be deployed. The quantity of weathered rock anticipated is approximately 0.175 Mm³.

2.7.5 Disposal of Dredged Spoil

The dredge spoil will be disposed of in the offshore disposal area. CWPRS has carried out hydrodynamic studies and dispersion studies for finding out a suitable location in offshore to dispose of the dredged material. As per CWPRS



recommendations, two disposal areas of 2 X 2 km, located at North of -23 m depth contour (at UTM 358700E and 1704000N) and second located at North of -27 m depth contour (at UTM 356000E and 1705000N) has been identified. The location of the disposal area is show in Figure-2.2.

2.7.6 Capital Dredging

The total balance Capital dredging calculated for enabling navigation of Vessels was estimated at 12 Mm³. The quantity of hard rock has been estimated approximately as 0.175 Mm³.

2.7.7 Maintenance Dredging

Desk studies were undertaken by CWPRS to estimate maintenance dredging in the approach channel. Knowledge of velocity field outside the channel, suspended sediment concentration and fall velocity of the sediment will help in computation of likely siltation. The flow field in offshore area is at right angles to the approach channel. The flood velocity is northerly and the ebb velocity is southerly. Assuming continuity equation at right angles to the approach channel, there will be reduction in flow velocity due to deepening of approach channel. Hence, carrying capacity of the flow will be reduced. The trapping of sediments can be computed by the knowledge of velocity field and the fall velocity. In order to account for turbulence due to wave action and other factors some empirical constant is required which can be estimated from earlier maintenance dredging data. The existing maintenance dredging quantities in the referred navigation is of the order of 3 Mm³. However, as per the mathematical model study carried out at CWPRS Pune, estimated quantity of maintenance dredging works out to 6 Mm³ per annum.

2.8 DETAILED IMPACT ANALYSIS OF ROCK DREDGING

Based on the soil investigation study carried out in the existing channel, total quantity of weathered Rock material that is likely to be encountered during the proposed dredging project is estimated at -18.50 m, only in A4 and A5 zone of the Channel. The said soil investigation study determined the existence of the following soil strata:

In the Outer Channel

- i. The top layer comprises of unconsolidated “silty / sandy” clay. The content of silt and sand increases with depth.



- ii. The next layer consists of medium to dense and very dense silty, fine to medium sand.
- iii. The said weathered rock layer is present below -18.5 m depth in A4 & A5 zones near Breakwater.

In the Inner Channel and Turning Circle 1

- i. The top layer consists of unconsolidated “silty / sandy” clay.
- ii. The next layer is stiff to hard silty clay.
- iii. No rock layer is present.

The rocky strata found in the outer navigational channel area, will be handled by a Cutter Suction Dredger and a Back Hoe Dredger. The following environment related precautions shall be under taken during the execution of work:

- Entire dredging operation be closely monitored to avoid deliberate or accidental cases of spillages of spoils in the marine environment outside the designated Spoil Disposal Site.
- Anchoring plans shall be developed for safety purposes
- Monitoring of turbid plumes shall be carried out.
- Monitoring of water and sediment quality shall be undertaken at regular intervals as a part of environment monitoring report.
- Planned dredging activities shall be notified well in advance for the information and safety of all stakeholders directly connected with the functioning and use of the Port.

As such, it is seen that the rock dredging is carried out totally by safe means without resorting to blasting and chemical treatment which has adverse impact on marine life and the soil strata around rock. The method suggested above for rock dredging for this project is proven safe and inert as far environment impact are considered.

2.9 HTL/LTL DEMARCATION

As per the Coastal Regulation Zone (CRZ) notification dated 6th January 2011, project specific HTL/LTL demarcation is required for the projects requiring CRZ clearance. CRZ mapping is required to be done indicating HTL and LTL and proposed project layout for the project by one of the authorised agencies approved by MoEF&CC on a scale of 1:4000. Hence, CRZ mapping for the proposed dredging of navigation channel project has been done through Institute of Remote Sensing



(IRS) Anna University, Chennai. Findings of the HTL /LTL report prepared by Institute of Remote Sensing (IRS) Anna University, Chennai are summarised as below:

The cadastral/village map was used as the Base Map. Based on topography and geomorphic features, HTL for the project site has been identified and traced in the field by Kinematic GPS survey. The HTL were superimposed on to geo-referenced cadastral map to prepare a local level CRZ map at 1:4,000.

The objective of the present study is to examine the waterfront of Mormugao Port and its related project activities in port, with reference to Coastal Regulation Zone Notification, 2011. Keeping in view of the requirements of notification, Institute of Remote Sensing, Anna University, Chennai under took the project with following agreed scope of work:

- Demarcation of HTL/, LTL near project site by conducting field survey using DGPS survey.
- Demarcation of ecologically sensitive entities such as Mangroves, Sand dunes, Turtle breeding grounds if any in the vicinity of project site etc.
- Superimposition of Project Boundary, HTL/LTL and ecologically sensitive areas if any on cadastral map at 1:4,000 scale.

As per the HTL demarcated by the IRS, Chennai the **dredging area falls in CRZ-IV (A) and CRZ-IV (B) category**. The CRZ-IV includes the water area from the Low Tide Line to twelve nautical miles on the seaward side and the water area of the tidal influenced water body from the mouth of the water body at the sea up to the influence of tide which is measured as five parts per thousand during the driest season of the year.

2.9.1 Methodology Adopted

In order to prepare the local level map on 1:4,000 scale, the site was visited by Experts from IRS, Anna University. The tide level observations for the last 19 years were studied from the Tide Tables. From the satellite imagery of the coastal zone, geomorphology has been studied. Based on the geomorphic units, High Tide Line has been identified in the field and traced by field survey.

As per the definition of High Tide Line, it is the line on the land up to which the highest water line reaches during the spring tide. At the mapping area, there is a



clear boundary between the tidal portion and vegetation which is usually very much apparent. This boundary line coincides with the HTL line interpreted from the high resolution satellite imagery.

2.9.2 GPS Survey

The Trimble 5700 and 4000 SSE (Geodetic Surveyor Series) GPS receivers were used to conduct the surveying at the project site. The survey involves three components namely:

- Establishing Base Station
- Control Survey for Village Maps and
- Real Time Kinematic Survey for HTL Demarcation.

Dual Frequency GPS (Model: Trimble 5700) instruments were used for HTL demarcation and image control points observation. Field surveys were carried out to trace the tide levels in the project area in the third week of July 2014. Four teams involved in the field survey. During field survey, two teams had taken control points for Satellite imagery and Village maps for the corresponding area and the other two teams had taken HTL / LTL points along the coast.

2.9.3 Data Processing

The following software was used for data processing.

- Trimble Geomatics Office for GPS data downloading and Processing
- ArcGIS 9.3 for Map rectification and Map making

The observed GPS data have been downloaded and processed in the Trimble Geomatics Office software. The processed GPS coordinates were entered into ArcGIS 9.3 for Imagery Geo referencing. The processed HTL points were plotted using the same software on the Cadastral maps at the scale of 1:4,000.

2.9.4 Output

The cadastral maps of 1:4,000 scale have been used as the base maps. In these maps, High Tide Line(HTL), 100 m from HTL(for creek portions), 200m from HTL, 500m from HTL, Low Tide Line and the categories of CRZ areas in the project site as per CRZ notification 2011 have been marked. The processed coordinates of HTL lines in WGS-84 co-ordinate systems are also given in the report prepared by IRS, Anna University, which is being submitted separately. HTL/LTL Map with CRZ zoning at 1:4000 Scale is enclosed as Figure-2.6.



The CRZ mapping for the proposed project has been done by Institute of Remote Sensing (IRS) Anna University, Chennai, The CRZ mapping report includes the HTL/LTL map covering an area of 7 km radius from project site and superimposing project layout on a map of 1:4000 scale.

2.10 TIME SCHEDULE

The time schedule for dredging is 5 months, as listed in Table-2.9.

Table-2.9: Time Schedule for Dredging Activity

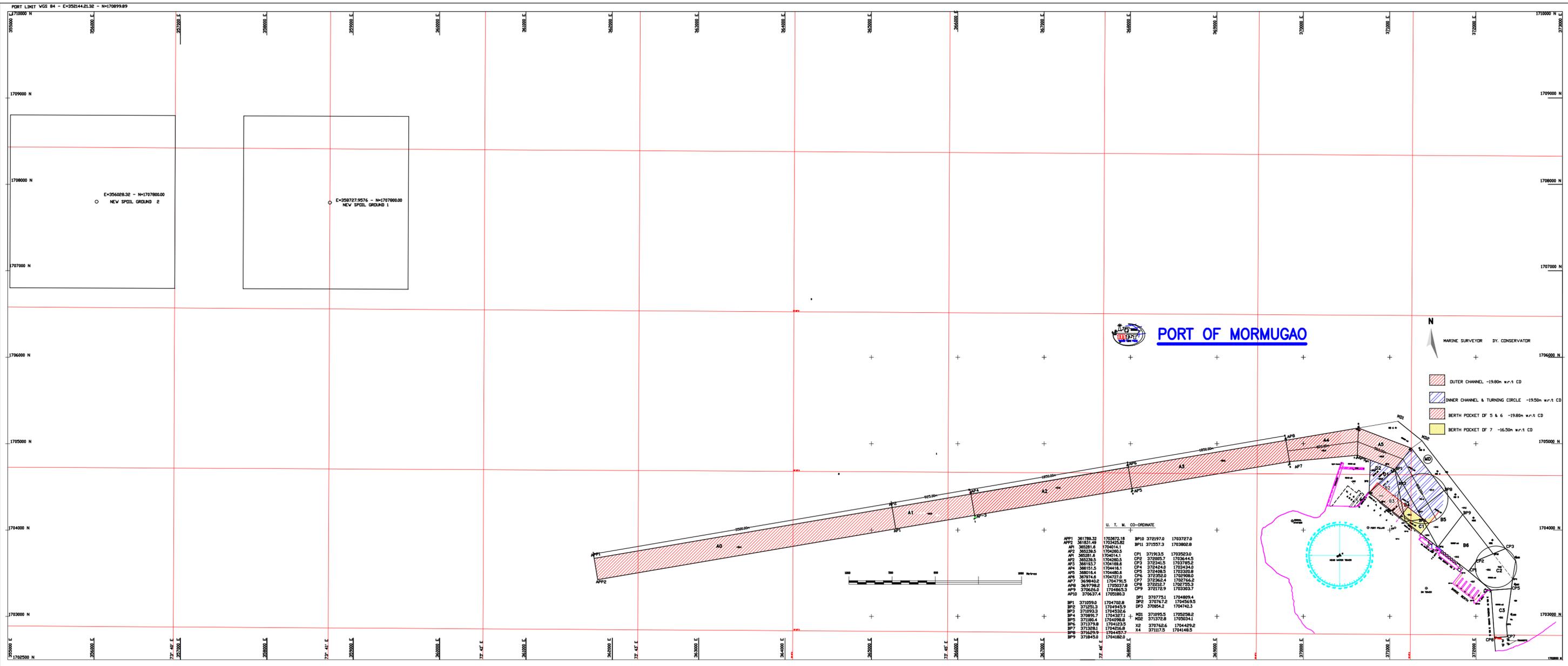
Activity	Time Required (months)
Mobilization	0.5 months
Dredging	4.0 months
Demobilization	0.5 months
Total	5.0 months

2.11 COST ESTIMATES

The cost for balance Capital dredging work is Rs.289 crore, which will be executed after obtaining the CRZ and Environmental Clearance. The details of the total cost estimates for the dredging work are given in Table-2.10.

Table-2.10:Capital Cost Estimate for the Dredging

S.No	Description	Unit	Qty.	Rate (in Rs)	Amount (Rs crores)
1	Mobilisation				
	a) Mobilization of a suitable TSHD	L.S	2	15000000.00	3.00
	b) Mobilization of CSD or BHD	L.S	1	10000000.00	1.00
2	De-mobilization of all dredgers	L.S	L.S	10000000.00	1.00
3	Dredging of Silt accumulated above previously dredged average level (-16.5 m CD)	Cu.m	4000000	75.00	30.00
4	Dredging below the previously dredged level (-16.5m CD)	Cu.m	8065000	228.00	183.88
5	Dredging of decomposed and highly weathered rock	Cu.m	175000	3500.00	61.25
6	Basic Dredging Cost				280.13
7	PMC and 3rd Party Survey	0.25%			0.69
8	Contingency (on Sr.No 6 and 7)	3%			8.4
9	TOTAL COST - Capital Dredging				289.24



CHAPTER-3
ENVIRONMENTAL BASELINE STATUS
PHYSICO-CHEMICAL ASPECTS



CHAPTER-3

ENVIRONMENTAL BASELINE STATUS-PHYSIO-CHEMICAL ASPECTS

3.1 GENERAL

The assessment of baseline environmental setting is an essential component of any EIA study. As a part of the study, a Scoping Matrix was prepared, based on which, various parameters to be covered for assessment of baseline environmental setting were identified. The assessment of environmental impacts due to construction and commissioning of the proposed capital dredging project requires a comprehensive and scientific consideration of various environmental aspects and their interaction with natural resources, namely, physico-chemical parameters i.e. meteorology, geology, soil, land use and water quality, biological parameters i.e. terrestrial flora and fauna, marine flora and fauna, fish species, etc. and socio-economic parameters i.e. demography, occupational profile, etc. As a part of the study, a large quantum of related data as available with various departments was collected. Field studies for primary data generation on various aspects too were conducted as a part of the EIA study.

3.2 STUDY AREA

The Study Area for the EIA study has been considered as the area covering 10 km on either side of the alignment of navigation channel proposed to be dredged as part of the project. The Study Area Map is enclosed as Figure-3.1. Major portion of the study area is under water, i.e. Arabian sea.

The present method adopted to delineate the Study Area is adequate considering the remote possibility of any significant impact of the dredging project beyond a radius of 5 km from both ends of the channel.

3.3 KEY ASPECTS STUDIED

As a part of the EIA study, the Baseline Status has been ascertained for the following aspects:

- Meteorology
- Bathymetry
- Cyclones
- Sediment Transport

- Topography and Geology
- Tides, Waves, Currents
- Landuse pattern
- Ambient Air Quality
- Ambient Noise Levels

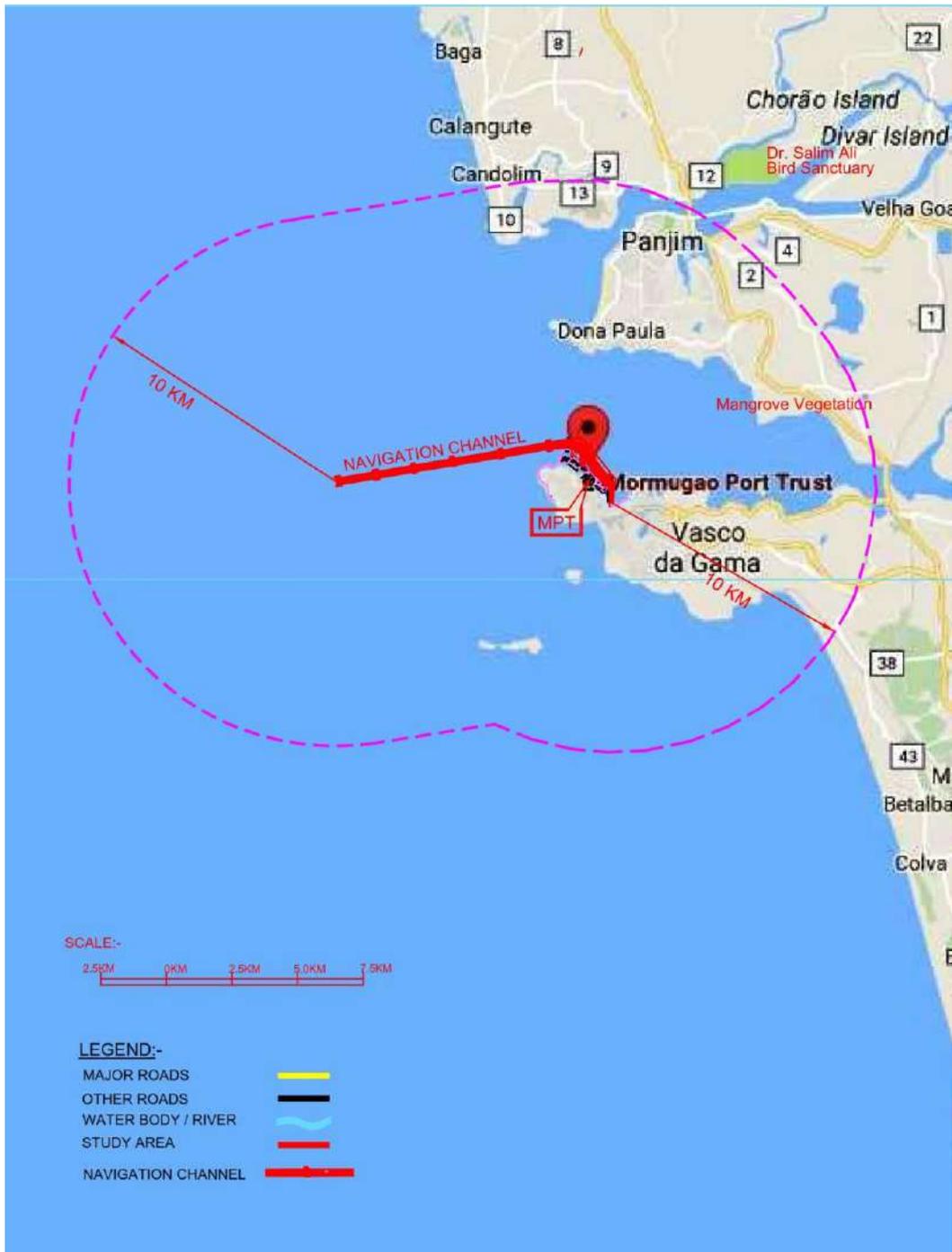


Figure-3.1 Study Area Map



3.4 METEOROLOGY

Goa experiences a tropical monsoon climate under the Köppen climate classification. Goa, being in the tropical zone and near the Arabian Sea, has a hot and humid climate for most of the year.

The calendar year in the project area can be divided into four main seasons. The winter season starts from December to February followed by pre-monsoon or summer season from March to May. The monsoon season begins in June and continues upto September. The period from October to November constitutes the post-monsoon season.

The average meteorological conditions of the Mormugao as per observation of IMD from 1981-2010 are summarized given in Table 3.1.

Table 3.1: Average Meteorological conditions in the project area

Month	Temperature (°C)		Rainfall (mm)	Relative Humidity		Mean Wind Speed (kmph)
	Maximum	Minimum		08.30	17.30	
January	31.8	21.9	0.4	72	64	7.1
February	31.3	22.3	0	75	67	8.4
March	31.9	24.2	0.2	78	71	9
April	32.8	26.2	3.7	76	71	9.4
May	33.2	27.1	90.6	76	73	9.9
June	30.7	25.2	831.5	87	84	13.4
July	29.2	24.5	824.5	89	86	14.9
August	28.9	24.2	550.2	90	87	11.7
September	29.9	24.3	256.3	88	83	7.4
October	31.6	24.6	136	82	78	6.0
November	33.1	23.8	19.7	70	67	5.4
December	32.7	22.5	5	67	63	5.9
Total			2718			
Average	31.4	24.2		79	74	9.0

Source: IMD, Mormugao

Temperature: Slight variation in the daily maximum temperatures is observed throughout the year, as it ranges from 28.9 °C to 33.7 °C. The minimum temperatures, however show greater variations, ranging from 21.9 °C to 27.1 °C. Goa has a short winter season between mid-December and February. The monthwise temperature variations in the project area is shown in Figure 3.2.

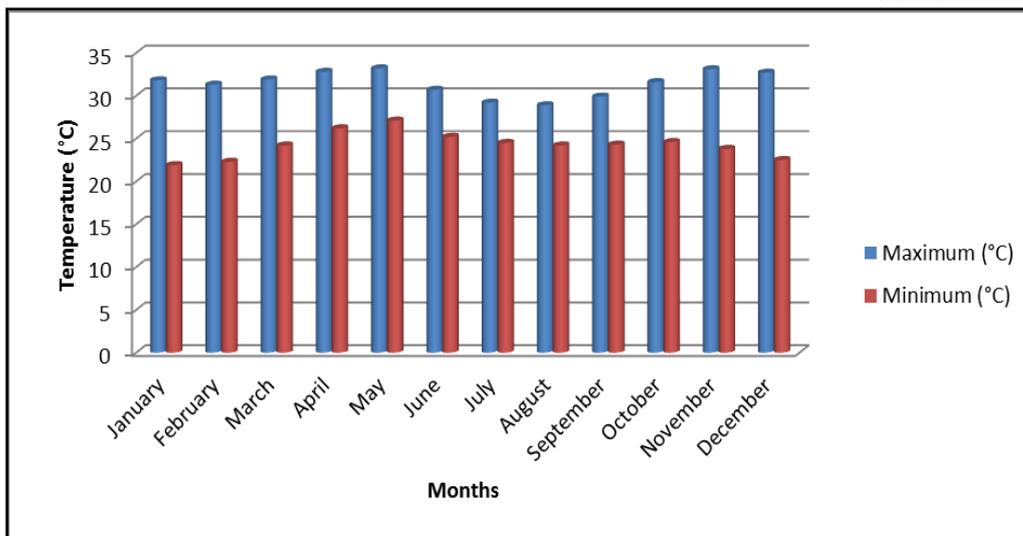


Figure-3.2: Temperature variations in the project area

Rainfall: The total annual rainfall in the project area district is 2718 mm. Majority of the rainfall is received in the months from June to September. Usually maximum average monthly rainfall of 831 mm occurs in June followed by 824 in the month of July. There is practically no rainfall from December to April. The average rainy days in a year are about 94. The monthwise rainfall received in Mormugao is depicted in Figure 3.3.

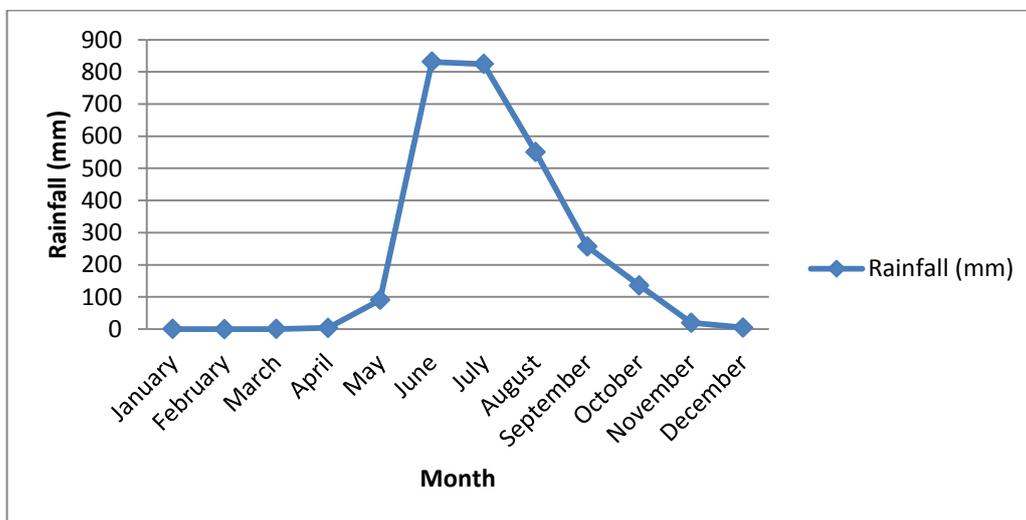


Figure-3.3: Rainfall variations in the project area

Winds: The mean sea wind varies from 2 on the Beaufort scale in November to 4 in July. The annual mean sea wind speed is of the order of 9 kmph. In an average year, there are 316 days with wind speed varying between 0 to 3 on the Beaufort scale and 48 days with winds varying between 4 to 7 on the Beaufort scale.

The predominant wind direction changes with the time of the year. During the period from June – September, wind blows from the west and south- west. During the remaining period, the wind direction is from NE, E and SE during the evening. The highest speed of 105 km/hr was recorded in June 1994. Winds of force more than 10 on the Beaufort scale are not expected. The wind speed ranged from 5.4 kmph to 14.9 kmph. The monthwise variations in mean wind speed in the project area is shown in Figure 3.4. Ambient Air quality was monitored during March, April and May 2016. Hence the Windrose diagram for the period from March to May 2015 is given in Figure 3.5.

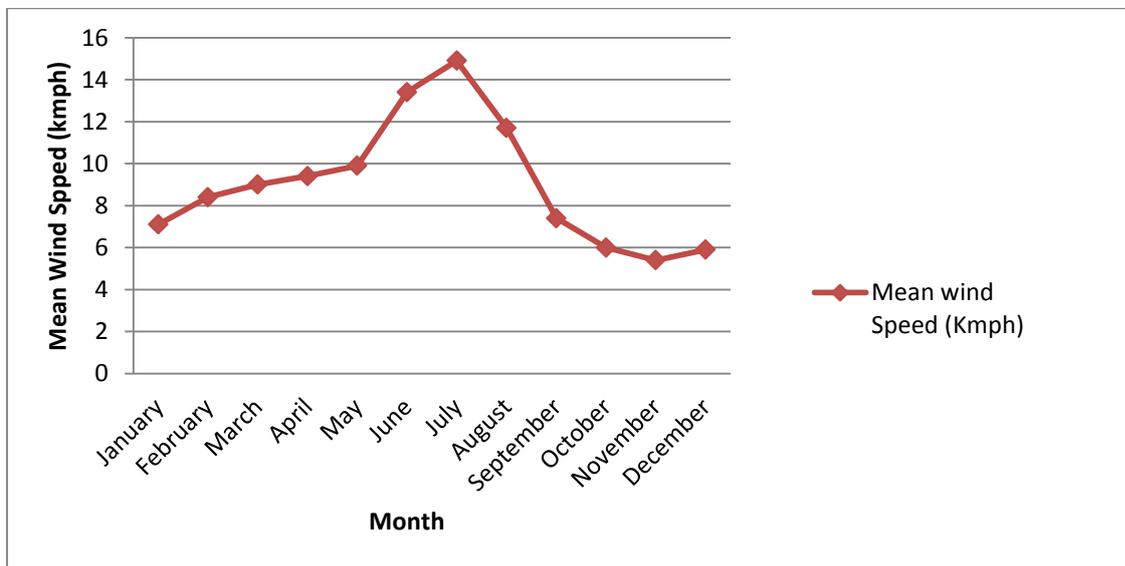


Figure-3.4: Mean wind speed variations in the project area

Relative Humidity

Mean yearly relative humidity at 0830 hours is 79% and 74% at 1730 hours. The monthly average humidity is lowest in December (63%) and highest in monsoon months from July to September (85%).

Visibility

Sometimes mist develops during sunrise on the west coast, above latitude 16° N, but disperses thereafter. Smog hangs over the land at Goa from November to March obscuring everything in view mostly after sunrise and occasionally in the evenings. However, the smog lasts only for short durations. Visibility is generally good for most part of the year.

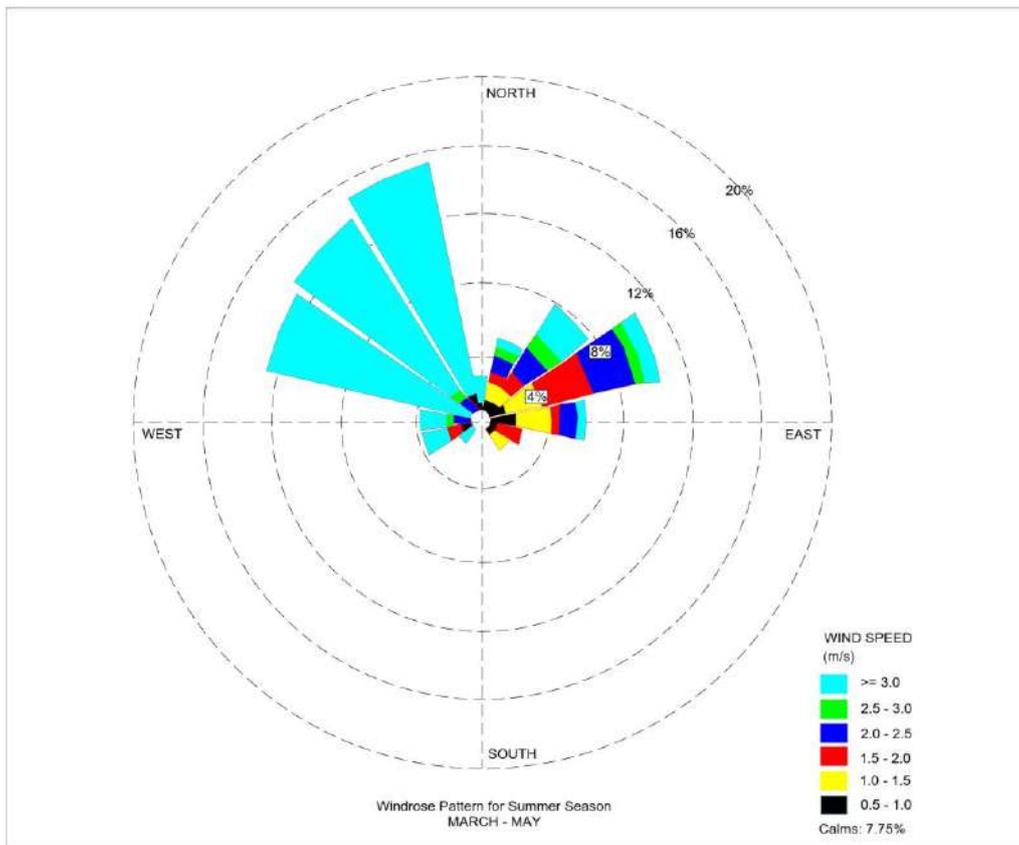


Figure 3.5: Windrose diagram for the month of March to May 2015

3.5 BATHYMETRY

The current bathymetry chart shows that in the outer channel the proposed dredge level of 19.8 m is available at a distance of 10 km away from the inner channel. The depth is of the order of 14 m at the entrance of the inner channel and reduces to 13.1 m towards the harbour basin and turning circle area.

Seabed Features

The sea bed exhibits an even low to medium level of reflectivity, indicative of silty clays and sands, with a few patches of higher reflectivity indicating the presence of isolated highly weathered bed rock. In the outer channel, highly weathered bed rock patches are also seen above the dredging limit of 19.8m.

3.6 CYCLONES

In general, west coast of India is less prone to cyclonic storms compared to the east coast. From the information reported by India Meteorological Department (IMD), a total of 1034 disturbances occurred in the Bay of Bengal during the period from 1891



to 1970, of which 363 intensified to cyclonic storms, the rest being 'depressions'. On an average the number of cyclonic disturbances per year during this period was about 13. However, if the data is updated to 1990, the number of cyclonic events per annum works out to be 16, varying from a minimum of 8 to a maximum of 18.

The above cyclones may be divided into two broad categories. The first group consists of cyclones that originate in the Bay of Bengal and cross the east coast at certain locations. These storms pass over the Indian landmass and lose their strength before crossing the west coast. The second group consists of cyclones that cross over to the Arabian Sea at the southern tip of the Indian Peninsula and veer northwards towards Saurashtra. These cyclones are much stronger and more dangerous for the west coast and normally occur during the transition months of May and November. Tracks of the cyclones in the Arabian Sea from 1877 to 1992 are presented in Figure 3.6. It may be seen there from that only 10 storms endangering the Mumbai coast have occurred in the above said period that is at a frequency of once in 12 years.

3.7 SEDIMENT TRANSPORT

Unlike the East coast, the West coast exhibits very low rates of "Littoral Drift". This is primarily due to the high tidal range, where the waves act on different parts of the flat offshore lower beach and the action on the beach above the high tide level are restricted to a very short time interval. Under such circumstances, it is difficult to discern the direction of the net drift as this is likely to change with local shoreline configuration.



late Cretaceous-lower Eocene age. Most of these rocks are often hidden below a thick weathered lateritic cap and/or a soil cover varying thickness. As per IS 1893, the site falls under Seismic Zone III.

3.9 TIDES

The nature of tide prevailing at Mormugao is mainly semi-diurnal exhibiting two high and two low waters in a tidal day. The mean tidal variation is of the order of 1.6m at spring tide and around 0.7m at neap tides.

Based on Indian Naval Hydrographic Chart No. 2020, the tide levels with respect to chart datum at Mormugao Harbour are given in Table-3.2.

Table-3.2: Tide levels with respect to Chart Datum

Higher High water at Spring	+2.3 m
Mean Higher High Water (MHHW)	+1.9 m
Mean Lower High Water (MLHW)	+1.8 m
Mean Higher Low Water (MHLW)	+1 m
Mean Lower Low Water (MLLW)	+0.5 m
Mean Sea Level (MSL)	+1.3 m

3.10 WAVES

A number of wave observations have been made at and around Mormugao harbour at different times, including both ship observations and those made from the shore and the measured wave heights by installing a wave rider buoy. Mormugao harbour on the Southern side where berths are located is protected by a breakwater and mole and generally it is the waves from directions between SW and NW that could affect the tranquillity in the harbour. The deep water waves from NW generally have a small % probability exceedence and do not affect harbour tranquillity significantly since their heights get reduced by the time they reach the harbour. Wave periods during the monsoons tend to be longer than during the rest of the year when NW winds prevail.

During the master plan study, HOWE India constructed the wave rose diagram from the visually observed wave heights during the period 1949 to 1962, in the area bounded by Latitude 10°N to 20°N and Longitude 70°E to 80°E. The deep water wave climate is summarized in Table-3.3.



Table-3.3: Deep Water Wave Climate(Probability of exceedance in % of time)

HS =	1.0 m	2.0 m	3.0 m	4.0 m
SW	12.2	8.7	4.7	2.2
W	21.6	13.6	7.4	3.0
NW	8.4	2.0	0.6	0.2

Due to refraction, shoaling and breaking, wave direction and wave height will change while travelling from deep water to the harbour entrance. Generally by refraction the waves from NW turn to WNW. Waves from W and NW reduce in height. All wave conditions higher than $H_s = 4$ m are reduced by wave breaking. The operational wave climate at the harbour entrance is presented in Table-3.4.

Table-3.4: Operational Wave Climate at Harbour (Probability of exceedance in % of time)

HS =	1.0 m	2.0 m	3.0 m	4.0 m
SW	12.2	8.7	4.7	2.2
W	21.6	13.6	7.4	3.0
NW	8.4	2.0	0.6	0.2

The extreme wave climate at the harbour entrance is as follows:

Frequency of occurrence

4.7 m
5.0 m
5.4 m
5.8 m

Hs

10/year
1/year
1/10 years
1/100 years

Extreme wave conditions at harbour entrance will occur mainly during the monsoon period. The period of the extreme waves varies between $T = 7$ S and 13 S.

3.11 CURRENTS

The currents in the region outside the sheltered harbour have been found to be generally less than one knot, during fair season and are mainly caused by tidal ebb and flow. Within the sheltered harbour, indicated current strengths are of the order of 30 to 40 cm/sec. During heavy monsoon rains, current pattern is altered from that during the fair season but the current strengths do not get appreciably altered. Summary of the current measurements observations taken at two locations in Vasco Bay (CM1 – 15° 26' 00"N, 73° 48' 18" E , CM2 – 15°24' 21"N, 73° 48' 42" E) are given in Table-3.5.

**Table-3.5: Current Measurements in Vasco Bay**

	CM1 (Water depth, 7 m)			CM2 (Water depth, 3.5 m)
	Near surface	Mid depth	Near bottom	Near bottom
Maximum Speed (cm/sec)	68	31	29	57
Minimum Speed (cm/sec)	0	0	0	0
Predominant Direction	ESE _ WNW	ESE _ WNW	ESE - WNW	ESE

Measurements at open location indicate that the predominant flow is in the ESE - WNW direction, while at the location close to the shore, the predominant direction is ESE. The flow of currents is predominantly due to the tidal currents. During flood water, flow is towards Zuari River while during the ebbing, the reversal of flow takes place. The maximum current velocity was observed as 68 cm /sec.

3.12 LANDUSE PATTERN

The landuse pattern of the study area has been assessed using Resource-Sat-2 LISS –IV MX digital satellite data of 14.12.2104 procured from National Remote Sensing Centre (NRSC), Hyderabad. The FCC of the study area is shown in Figure-3.7 and the classified imagery of the study area is shown in Figure-3.8. The landuse pattern is summarized in Table-3.6.

Table-3.6: Landuse pattern of the study area as per Satellite Data

Category	Area (ha)	Percentage of total study area
Dense Vegetation	3007	6.02
Open Vegetation	2827	5.66
Open Land/Barren Land	2595	5.19
Sand	264	0.53
Water Body	39904	79.91
Agricultural Land	753	1.51
Builtup Area	587	1.18
Total	49937	100

The major landuse category is water body accounting for about 79.91 % of the total study area. The area under dense and open vegetation in the study area is 6.02 % and 5.66 % respectively. The built-up area is only 1.18% of total area.

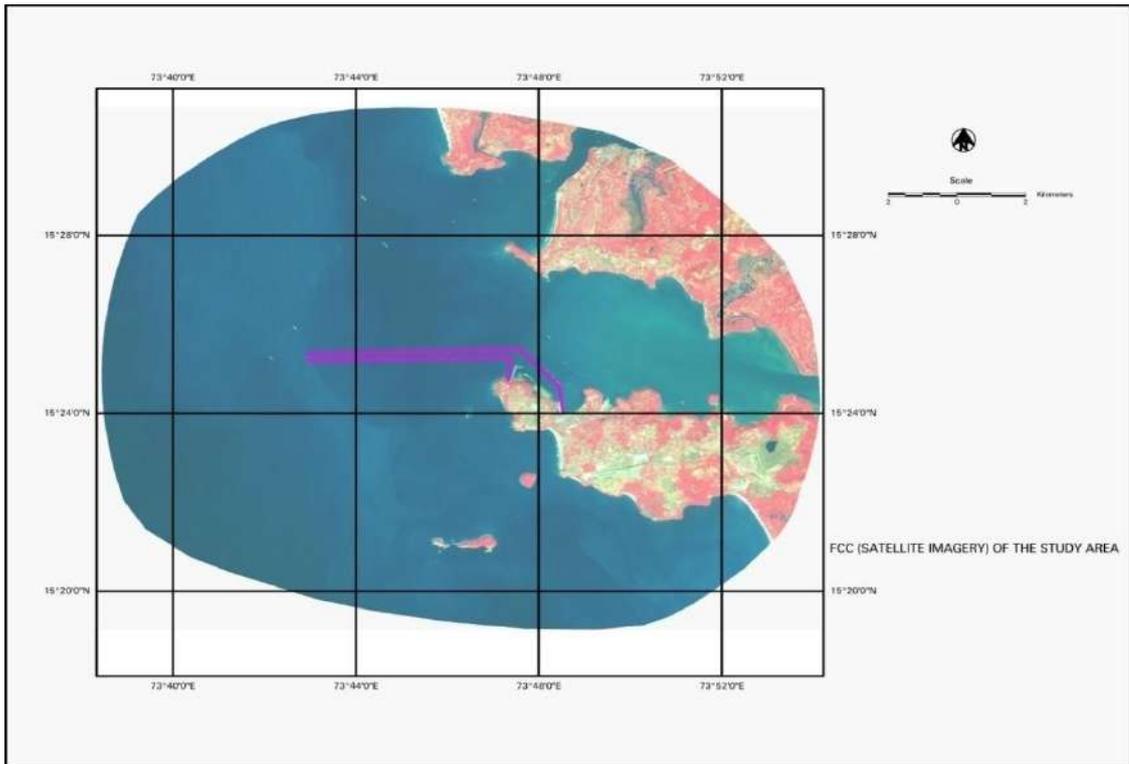


Figure-3.7: FCC of the study area

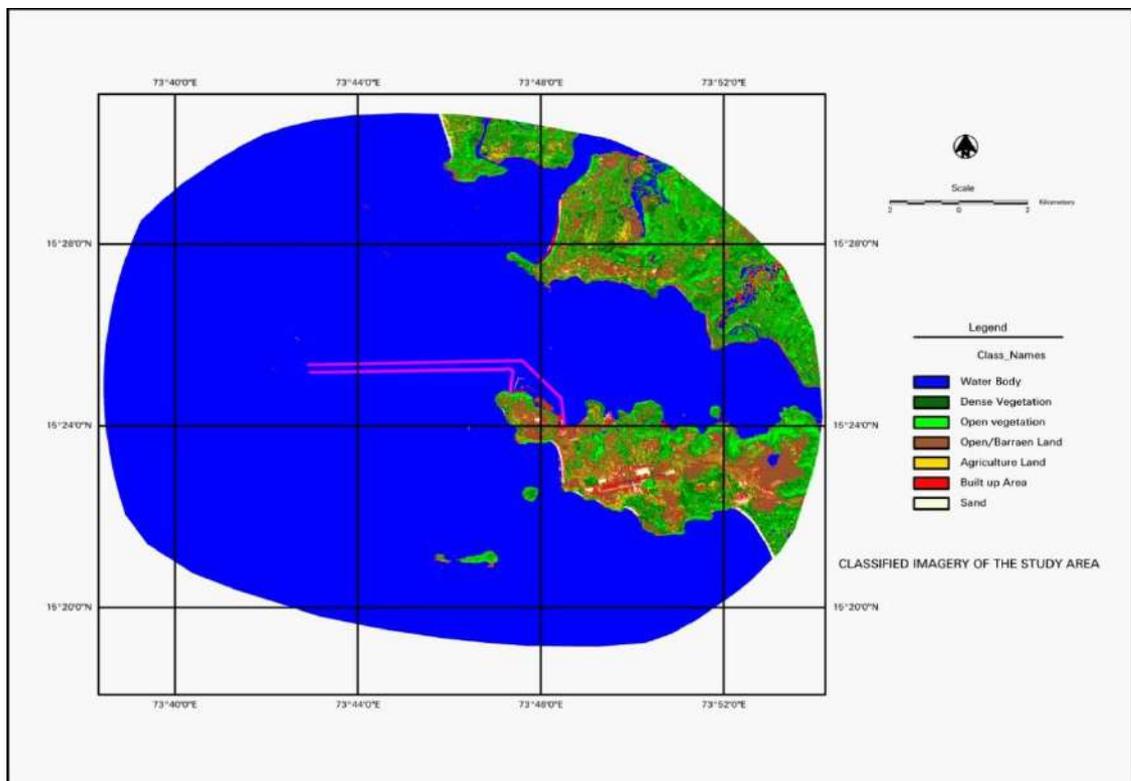
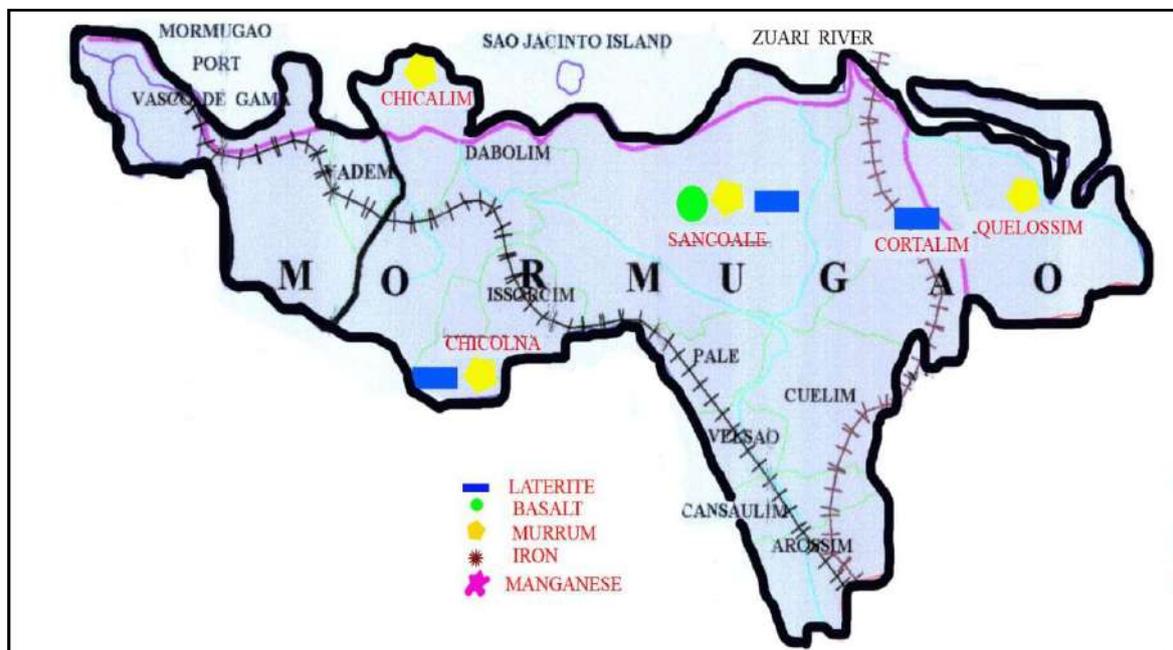


Figure-3.8. Land use pattern of the study area

3.13 MINERAL RESOURCES

The state of Goa is endowed with Mineral Resources. Iron ore, Manganese ore, Bauxite are minerals of economic importance. Besides there are minor minerals like Basalt, Laterite stones and rubbles, River sand, Murrum etc., which are in great demand as construction material. This industry is labour intensive and provides work to large number of people. Mining in Goa today is synonymous with iron ore mining. Infrastructure wise Goa has an advantage over other exporting regions in the countries in view of its being endowed with a deep sea port and waterways that crisscross the territory facilitating barge transport. The two rivers Mandovi and Zuari, provide cheap river transport. These two rivers and the Mormugao Harbour are nature's gift and are natural resources of Goa. The Bauxite Mines are situated in South Goa over an area of 1263.678 ha, with estimated reserves of 70 million tons. These are metallurgical grade bauxite which can also be used for various applications such as cement, alumina chemicals, etc. The mines are situated also in the close proximity of two major ports, viz. Marmugoa Port and Betul Port.

In the study area (on the land side), minerals present are mainly murrum, laterite and basalt. The presence of iron ore is absent in the study area Talukas. The map showing presence of minerals in Mormugao Taluka is shown in Figure-3.9.



Source: Directorate of Mines & Geology, Government of Goa

Figure-3.9: Map showing presence of minerals in Mormugao Taluka



3.14 AMBIENT AIR QUALITY

Approval for the Terms Reference (TOR) for the EIA study was accorded by MoEF&CC vide letter dated 10.10.2016. Ambient Air Quality (AAQ) was monitored at 6 locations in the study area by WAPCOS from 4th March 2016 to 28th May 2016, as a part of the EIA study for the redevelopment of Berth 8&9 project, findings of the same are described in this section to assess the ambient air quality status in the area. The ambient air quality monitoring was carried out with a frequency of two samples per week for twelve consecutive weeks at six locations in the study period. The parameters monitored as a part of the study are listed as below:

- Particulate Matter less than 2.5 microns (PM_{2.5})
- Particulate Matter less than 10 microns (PM₁₀)
- Sulphur dioxide (SO₂)
- Nitrogen dioxide (NO₂)
- Carbon Monoxide (as CO)
- Ozone (as O₃)
- Lead (as Pb)
- Ammonia (as NH₃)
- Benzene (as C₆H₆)
- Benzo (O) Pyrene (as BaP)
- Arsenic (as As)
- Nickel (as Ni)

The location of ambient air quality monitoring stations is given in Table-3.7. The results of ambient air quality survey conducted during the study period are given in Table-3.8. The summary of ambient air quality monitoring is given in Table-3.9. The ambient air quality standards specified by Central Pollution Control Board (CPCB) are enclosed as Annexure-IV. The location of Air Quality Monitoring station were selected based on the prominent wind directions during the monitoring period. The ambient air quality stations were selected considering that the upwind, downwind, and cross wind direction with respect to proposed project site are covered. The location of ambient air quality monitoring stations is shown in Figure-3.10.

Table- 3.7: Location of Ambient Air Quality Monitoring Stations

S. No.	Station Code	Location	Latitude	Longitude
1	AQ -1	Berth No 8	15 ⁰ 24'32"	73 ⁰ 48'7.13"
2	AQ -2	MPT Colony	15 ⁰ 24'43.76"	73 ⁰ 47'12.35"
3	AQ -3	MPT Guest House	15 ⁰ 24'38.15"	73 ⁰ 47'40.42"
4	AQ -4	Near Sub Jail	15 ⁰ 24'25.13"	73 ⁰ 47'44.72"
5	AQ -5	Bagoda	15 ⁰ 24'6.70"	73 ⁰ 47'53.99"
6	AQ -6	Vasco	15 ⁰ 24'5.3"	73 ⁰ 48'11.70"



Table-3.8: Results of ambient air quality monitoring

S. No.	Date of Sampling	PM _{2.5}	PM ₁₀	SO ₂	NO ₂	CO	O ₃	Pb	NH ₃	C ₆ H ₆	BaP	As	Ni
		µg/m ³	µg/m ³	µg/m ³	µg/m ³	mg/m ³	µg/m ³	µg/m ³	µg/m ³	µg/m ³	ng/m ³	ng/m ³	ng/m ³
Sampling Location -1– Berth No. 8													
1	04-05/03/2016	36.2	79.5	23.5	38.4	0.5	57	ND	13	0.2	ND	ND	ND
2	07-08/03/2016	35.5	76.8	25.3	46.7	0.5	41.2	ND	11.5	0.7	ND	ND	ND
3	10-11/03/2016	37.5	82.2	24.8	54.5	0.7	46.2	ND	14.6	0.6	ND	ND	ND
4	14-15/03/2016	42	108	27.5	44.6	0.7	48.4	ND	13.6	0.8	ND	ND	ND
5	17-18/03/2016	47.5	115	26.8	46.5	0.8	45	ND	15.6	0.6	ND	ND	ND
6	21-22/03/2016	35.8	78	26.6	42.5	0.7	48.1	ND	14.5	0.4	ND	ND	ND
7	24-25/03/2016	36	78.5	22.6	55.7	0.7	54.6	ND	13	0.3	ND	ND	ND
8	28-29/03/2016	34.5	81.2	24.7	51.4	0.8	41.6	ND	15.3	0.5	ND	ND	ND
1	04-05/04/2016	47.5	128.8	23.5	38.7	0.6	57	ND	13	0.2	ND	ND	ND
2	07-08/04/2016	32.8	85.6	24.8	46.2	0.6	51	ND	15.7	0.4	ND	ND	ND
3	11-12/04/2016	45	92.2	28.8	51.3	0.6	51	ND	14.3	0.3	ND	ND	ND
4	15-16/04/2016	34.5	85.2	24.5	36.4	0.6	43	ND	14.1	0.3	ND	ND	ND
5	18-19/04/2016	34.7	82.5	27.4	49.9	0.6	43	ND	15.1	0.4	ND	ND	ND
6	22-23/04/2016	33	79.5	27	49.6	0.9	48	ND	14.4	0.3	ND	ND	ND
7	25-26/04/2016	44.3	98.5	26.9	56.7	0.8	56	ND	13	0.3	ND	ND	ND
8	29-30/04/2016	34.2	75	25.8	56.8	0.7	43	ND	15.1	0.2	ND	ND	ND
1	02-03/05/2016	40.2	85.2	27.4	45.7	0.5	53	ND	14.6	0.5	ND	ND	ND
2	06-07/05/2016	35.5	72	27.3	45.3	0.8	47	ND	14.3	0.6	ND	ND	ND
3	09-10/05/2016	34.5	80.2	25.6	46.5	0.7	56	ND	14.2	0.5	ND	ND	ND
4	13-14/05/2016	33.2	76.5	31.5	50.4	0.6	53	ND	14.5	0.5	ND	ND	ND



S. No.	Date of Sampling	PM _{2.5}	PM ₁₀	SO ₂	NO ₂	CO	O ₃	Pb	NH ₃	C ₆ H ₆	BaP	As	Ni
		µg/m ³	µg/m ³	µg/m ³	µg/m ³	mg/m ³	µg/m ³	µg/m ³	µg/m ³	µg/m ³	ng/m ³	ng/m ³	ng/m ³
5	16-17/05/2016	30.5	69.5	29.5	49	0.6	50	ND	15.2	0.7	ND	ND	ND
6	20-21/05/2016	30.5	72.5	28.4	46	0.6	55	ND	11.7	0.4	ND	ND	ND
7	23-24/05/2016	32	72.2	29.8	44.3	0.6	56	ND	11.5	0.5	ND	ND	ND
8	27-28/05/2016	30.5	64.5	26.5	51	0.7	64	ND	11.7	0.6	ND	ND	ND
Sampling Location -2- MPT Colony													
1	04-05/03/2016	34.3	75.5	27.8	48.4	0.6	41	ND	12.4	0.3	ND	ND	ND
2	07-08/03/2016	32.6	69.6	25.8	44.6	0.5	31.7	ND	11.7	0.8	ND	ND	ND
3	10-11/03/2016	32.2	70.5	25.9	52.4	0.8	44.2	ND	14	0.3	ND	ND	ND
4	14-15/03/2016	31.3	65.2	26.3	43.8	0.8	47.1	ND	14.5	0.8	ND	ND	ND
5	17-18/03/2016	33.7	75.2	25.8	51	0.9	43	ND	13.8	0.4	ND	ND	ND
6	21-22/03/2016	35.5	75.4	26.3	57.2	0.8	39.8	ND	10.3	0.3	ND	ND	ND
7	24-25/03/2016	32.2	69.5	25.8	63.4	1	47.2	ND	10.2	0.6	ND	ND	ND
8	28-29/03/2016	32.5	80.2	29.4	50.2	0.8	44.2	ND	10.5	0.3	ND	ND	ND
1	04-05/04/2016	35.3	68	26.7	45.3	0.5	44	ND	11.9	0.4	ND	ND	ND
2	07-08/04/2016	34.8	85	26.5	49.6	0.7	42	ND	13.7	0.6	ND	ND	ND
3	11-12/04/2016	32.8	78	29.9	52.1	0.6	53	ND	11.6	0.2	ND	ND	ND
4	15-16/04/2016	36.8	72.9	28.3	33.2	0.5	45	ND	11.3	0.4	ND	ND	ND
5	18-19/04/2016	33.7	80.2	28.7	53.5	0.5	43	ND	11.7	0.5	ND	ND	ND
6	22-23/04/2016	34.8	74.4	26.3	53.2	0.5	46	ND	13.2	0.4	ND	ND	ND
7	25-26/04/2016	31.3	64.4	28.5	51.5	0.7	48	ND	13.6	0.4	ND	ND	ND
8	29-30/04/2016	31.5	70.2	24.8	51.2	0.5	43	ND	11.9	0.6	ND	ND	ND
1	02-03/05/2016	38.2	62	24.7	46.8	0.6	47	ND	12.5	0.5	ND	ND	ND



S. No.	Date of Sampling	PM _{2.5}	PM ₁₀	SO ₂	NO ₂	CO	O ₃	Pb	NH ₃	C ₆ H ₆	BaP	As	Ni
		µg/m ³	µg/m ³	µg/m ³	µg/m ³	mg/m ³	µg/m ³	µg/m ³	µg/m ³	µg/m ³	µg/m ³	ng/m ³	ng/m ³
2	06-07/05/2016	36.2	72.6	26.5	52.1	0.8	45	ND	14.6	0.7	ND	ND	ND
3	09-10/05/2016	32.7	68	26.5	49.6	0.5	57	ND	12.5	0.4	ND	ND	ND
4	13-14/05/2016	32.5	79.5	26.3	44.2	0.7	55	ND	12.5	0.5	ND	ND	ND
5	16-17/05/2016	30	72.5	31.4	54	0.6	44	ND	13.3	0.6	ND	ND	ND
6	20-21/05/2016	34.5	72.5	27.8	54.5	0.7	48	ND	12.7	0.5	ND	ND	ND
7	23-24/05/2016	31	70.2	29.6	49.7	0.5	48	ND	12.8	0.5	ND	ND	ND
8	27-28/05/2016	31.5	72.5	21.8	55.3	0.5	54	ND	13.2	0.7	ND	ND	ND
Sampling Location-3 - MPT Guest House													
1	04-05/03/2016	33.2	72.5	26.4	39.6	0.8	62	ND	17.1	0.4	ND	ND	ND
2	07-08/03/2016	31.2	70.2	27.4	49.7	0.7	44.6	ND	17.3	0.9	ND	ND	ND
3	10-11/03/2016	27.4	68.5	27.3	56	0.9	53.7	ND	10.7	0.8	ND	ND	ND
4	14-15/03/2016	31.5	76.5	27.3	58.2	0.8	64.3	ND	9.6	0.4	ND	ND	ND
5	17-18/03/2016	31.2	65	27.2	56.3	0.8	37.9	ND	16.5	0.6	ND	ND	ND
6	21-22/03/2016	26.5	68.7	27.5	59.7	0.7	47.3	ND	14.5	0.4	ND	ND	ND
7	24-25/03/2016	33.5	75	26.2	51.7	0.9	45	ND	13.7	0.3	ND	ND	ND
8	28-29/03/2016	49.2	75.2	37.3	54	0.9	61	ND	16.7	0.6	ND	ND	ND
1	04-05/04/2016	34.3	82.5	27.8	41.4	0.6	41	ND	12.4	0.3	ND	ND	ND
2	07-08/04/2016	32.8	75	27.8	51	0.7	47	ND	12.4	0.1	ND	ND	ND
3	11-12/04/2016	32.3	69.8	30.2	49.7	0.7	45	ND	14.3	0.4	ND	ND	ND
4	15-16/04/2016	37.3	88	24.9	38	0.7	42	ND	13.7	0.5	ND	ND	ND
5	18-19/04/2016	33.7	75.2	26.3	49.8	0.7	40	ND	12	0.4	ND	ND	ND
6	22-23/04/2016	33	76.5	25.9	49.9	0.5	43	ND	11.8	0.5	ND	ND	ND



S. No.	Date of Sampling	PM _{2.5}	PM ₁₀	SO ₂	NO ₂	CO	O ₃	Pb	NH ₃	C ₆ H ₆	BaP	As	Ni
		µg/m ³	µg/m ³	µg/m ³	µg/m ³	mg/m ³	µg/m ³	µg/m ³	µg/m ³	µg/m ³	µg/m ³	ng/m ³	ng/m ³
7	25-26/04/2016	30.6	65.4	27.5	53.2	0.7	49	ND	12.4	0.4	ND	ND	ND
8	29-30/04/2016	28.2	68.2	25.3	48.7	0.6	40	ND	13.5	0.3	ND	ND	ND
1	02-03/05/2016	31.2	66.5	28.3	44.5	0.7	51	ND	11.3	0.7	ND	ND	ND
2	06-07/05/2016	34.2	65	26.5	50.4	0.6	49	ND	13	0.5	ND	ND	ND
3	09-10/05/2016	32.5	72.2	28.3	51.5	0.7	49	ND	13.6	0.5	ND	ND	ND
4	13-14/05/2016	33.2	74.5	27.5	51.2	0.8	47	ND	14.5	0.6	ND	ND	ND
5	16-17/05/2016	31.5	64.5	29.7	55.2	0.8	46	ND	11.7	0.7	ND	ND	ND
6	20-21/05/2016	35.3	58	32.4	51.6	0.5	48	ND	12.5	0.7	ND	ND	ND
7	23-24/05/2016	34.8	70.2	30.4	51	0.6	49	ND	11.7	0.5	ND	ND	ND
8	27-28/05/2016	33.2	72.5	26.5	46	0.6	63	ND	11	0.5	ND	ND	ND
Sampling Location-4 – Near Sub Jail													
1	04-05/03/2016	33.3	76.5	26.9	46.7	0.8	53	ND	13	0.2	ND	ND	ND
2	07-08/03/2016	34.2	68.6	34	55.3	0.6	42.1	ND	10.2	0.7	ND	ND	ND
3	10-11/03/2016	35	63.5	31	58.3	0.9	58	ND	13.2	0.7	ND	ND	ND
4	14-15/03/2016	32.5	71.8	27.1	51.7	0.9	52	ND	10.3	0.6	ND	ND	ND
5	17-18/03/2016	34.7	74.2	31	49	0.7	44.1	ND	14.4	0.6	ND	ND	ND
6	21-22/03/2016	32.2	76.4	37.2	64.5	0.9	44.1	ND	17.2	0.2	ND	ND	ND
7	24-25/03/2016	33.5	69.5	29.7	58.2	0.9	51.7	ND	11	0.7	ND	ND	ND
8	28-29/03/2016	38.5	81.2	28.7	57.7	0.9	49.7	ND	18.2	0.2	ND	ND	ND
1	04-05/04/2016	39.3	96.5	29.3	56.2	0.8	43	ND	22.6	0.3	ND	ND	ND
2	07-08/04/2016	35.8	85.5	27.3	48.2	0.9	49	ND	18.2	0.2	ND	ND	ND
3	11-12/04/2016	42.9	100.2	34.2	50.3	0.7	49	ND	13.7	0.3	ND	ND	ND



S. No.	Date of Sampling	PM _{2.5}	PM ₁₀	SO ₂	NO ₂	CO	O ₃	Pb	NH ₃	C ₆ H ₆	BaP	As	Ni
		µg/m ³	µg/m ³	µg/m ³	µg/m ³	mg/m ³	µg/m ³	µg/m ³	µg/m ³	µg/m ³	µg/m ³	ng/m ³	ng/m ³
4	15-16/04/2016	37.3	91.2	29.3	35.1	0.6	47	ND	14.5	0.5	ND	ND	ND
5	18-19/04/2016	34.7	82.2	29.2	51.2	0.6	51	ND	13.7	0.5	ND	ND	ND
6	22-23/04/2016	36.8	74.5	27.4	48.5	0.7	47	ND	13.5	0.5	ND	ND	ND
7	25-26/04/2016	32.3	98.5	29.5	57.4	0.6	51	ND	14.2	0.3	ND	ND	ND
8	29-30/04/2016	32.5	75.2	27.3	58.3	0.8	45	ND	14.2	0.4	ND	ND	ND
1	02-03/05/2016	36.2	112	22.3	52.1	0.7	49	ND	16.8	0.5	ND	ND	ND
2	06-07/05/2016	39.5	115	25.8	54.2	0.7	51	ND	15.4	0.6	ND	ND	ND
3	09-10/05/2016	36.5	86.2	31.3	48.5	0.4	53	ND	14.6	0.5	ND	ND	ND
4	13-14/05/2016	34.2	78.5	28.3	49.8	0.8	51	ND	13.1	0.7	ND	ND	ND
5	16-17/05/2016	31	74.58	26.3	49.7	0.5	50	ND	16.4	0.6	ND	ND	ND
6	20-21/05/2016	32.5	69.58	30.6	50.6	0.5	48	ND	14.7	0.6	ND	ND	ND
7	23-24/05/2016	32	72.25	33.7	52.5	0.7	51	ND	13.4	0.4	ND	ND	ND
8	27-28/05/2016	34.5	80	28.3	49.8	0.8	58	ND	10.8	0.7	ND	ND	ND
Sampling Location-5 – Bagoda													
1	04-05/03/2016	36.2	79.5	23.5	38.4	0.5	57	ND	13	0.2	ND	ND	ND
2	07-08/03/2016	35.5	76.8	25.3	46.7	0.5	41.2	ND	11.5	0.7	ND	ND	ND
3	10-11/03/2016	37.5	82.2	24.8	54.5	0.7	46.2	ND	14.6	0.6	ND	ND	ND
4	14-15/03/2016	34.5	72	27.5	44.6	0.7	48.4	ND	13.6	0.8	ND	ND	ND
5	17-18/03/2016	32.7	75.2	26.8	46.5	0.8	45	ND	15.6	0.6	ND	ND	ND
6	21-22/03/2016	35.8	78	26.6	42.5	0.7	48.1	ND	14.5	0.4	ND	ND	ND
7	24-25/03/2016	36	78.5	22.6	55.7	0.7	54.6	ND	13	0.3	ND	ND	ND
8	28-29/03/2016	34.5	81.2	24.7	51.4	0.8	41.6	ND	15.3	0.5	ND	ND	ND



S. No.	Date of Sampling	PM _{2.5}	PM ₁₀	SO ₂	NO ₂	CO	O ₃	Pb	NH ₃	C ₆ H ₆	BaP	As	Ni
		µg/m ³	µg/m ³	µg/m ³	µg/m ³	mg/m ³	µg/m ³	µg/m ³	µg/m ³	µg/m ³	µg/m ³	ng/m ³	ng/m ³
1	04-05/04/2016	37.4	92.5	23.5	38.7	0.6	57	ND	13	0.2	ND	ND	ND
2	07-08/04/2016	32.8	85.6	24.8	46.2	0.6	51	ND	15.7	0.4	ND	ND	ND
3	11-12/04/2016	38.5	85	28.8	51.3	0.6	51	ND	14.3	0.3	ND	ND	ND
4	15-16/04/2016	32	70	24.5	36.4	0.6	43	ND	14.1	0.3	ND	ND	ND
5	18-19/04/2016	33.2	72.5	27.4	49.9	0.6	43	ND	15.1	0.4	ND	ND	ND
6	22-23/04/2016	33	79.5	27	49.6	0.9	48	ND	14.4	0.3	ND	ND	ND
7	25-26/04/2016	44.3	98.5	26.9	56.7	0.8	56	ND	13	0.3	ND	ND	ND
8	29-30/04/2016	34.2	75	25.8	56.8	0.7	46	ND	15.1	0.2	ND	ND	ND
1	02-03/05/2016	37.4	85.2	27.4	45.7	0.5	53	ND	14.6	0.5	ND	ND	ND
2	06-07/05/2016	35.5	72	27.3	45.3	0.8	47	ND	14.3	0.6	ND	ND	ND
3	09-10/05/2016	34.5	75.4	25.6	46.5	0.7	56	ND	14.2	0.5	ND	ND	ND
4	13-14/05/2016	33.2	76.5	31.5	50.4	0.6	53	ND	14.5	0.5	ND	ND	ND
5	16-17/05/2016	29.8	62.2	29.5	49	0.6	50	ND	15.2	0.7	ND	ND	ND
6	20-21/05/2016	30.5	71.3	28.4	46	0.6	55	ND	11.7	0.4	ND	ND	ND
7	23-24/05/2016	32	72.2	29.8	44.3	0.6	56	ND	11.5	0.5	ND	ND	ND
8	27-28/05/2016	30.5	69.7	26.5	51	0.7	54	ND	11.7	0.6	ND	ND	ND
Sampling Location -6-Vasco													
1	04-05/03/2016	32.3	82	23.7	39.2	0.8	58	ND	9.5	0.2	ND	ND	ND
2	07-08/03/2016	35.5	72.4	24.7	59.4	0.7	42.4	ND	16.6	0.6	ND	ND	ND
3	10-11/03/2016	30	71.2	25.6	57.2	0.8	56.6	ND	11.6	0.8	ND	ND	ND
4	14-15/03/2016	34.5	71.8	26.6	52.4	0.8	63.7	ND	12.4	0.8	ND	ND	ND
5	17-18/03/2016	38.5	95	28.5	44.6	0.9	47	ND	14.8	0.7	ND	ND	ND



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(Government of India/Ministry of Water Resources, River Development & Gangs Rejuvenation)

S. No.	Date of Sampling	PM _{2.5}	PM ₁₀	SO ₂	NO ₂	CO	O ₃	Pb	NH ₃	C ₆ H ₆	BaP	As	Ni
		µg/m ³	µg/m ³	µg/m ³	µg/m ³	mg/m ³	µg/m ³	µg/m ³	µg/m ³	µg/m ³	ng/m ³	ng/m ³	ng/m ³
6	21-22/03/2016	33.2	73	22.5	44.3	0.8	45.6	ND	15.7	0.6	ND	ND	ND
7	24-25/03/2016	31.2	72.5	27.5	53.6	0.9	55.4	ND	9.5	0.5	ND	ND	ND
8	28-29/03/2016	37.5	82	28.4	49.6	0.6	47.5	ND	16.5	0.4	ND	ND	ND
1	04-05/04/2016	40.5	102	23.7	39.5	0.8	58	ND	9.5	0.2	ND	ND	ND
2	07-08/04/2016	36.8	86.6	27.2	42.5	0.8	48	ND	19	0.4	ND	ND	ND
3	11-12/04/2016	46	102.2	31.4	48.5	0.5	48	ND	15	0.4	ND	ND	ND
4	15-16/04/2016	36.3	90.2	25.5	32.3	0.8	48	ND	16.3	0.4	ND	ND	ND
5	18-19/04/2016	38.5	82.5	27.2	48.5	0.6	45	ND	14.3	0.3	ND	ND	ND
6	22-23/04/2016	37	98	21.9	48.2	0.9	45	ND	15.3	0.3	ND	ND	ND
7	25-26/04/2016	41.5	99.5	26.6	59.5	0.8	58	ND	9.5	0.5	ND	ND	ND
8	29-30/04/2016	38	89.5	26.9	52.5	0.9	48	ND	16.3	0.2	ND	ND	ND
1	02-03/05/2016	39.4	93.2	26.1	45	0.9	57	ND	11.5	0.7	ND	ND	ND
2	06-07/05/2016	38.6	86.4	26.6	44.7	0.7	46	ND	16.8	0.6	ND	ND	ND
3	09-10/05/2016	37.5	83.2	26.7	47.2	0.6	51	ND	13.5	0.4	ND	ND	ND
4	13-14/05/2016	29.5	79.5	30.5	50.6	0.7	51	ND	15	0.3	ND	ND	ND
5	16-17/05/2016	31.5	74.5	28.2	48.9	0.7	49	ND	13.9	0.4	ND	ND	ND
6	20-21/05/2016	32.5	69.5	26.7	50	0.7	50	ND	13.8	0.4	ND	ND	ND
7	23-24/05/2016	33	72.2	27.3	49.3	0.9	58	ND	10.2	0.6	ND	ND	ND
8	27-28/05/2016	32.5	72	27.6	48.2	0.9	63	ND	12.5	0.6	ND	ND	ND

**Table- 3.9: Summary of ambient air quality monitoring (Unit: $\mu\text{g}/\text{m}^3$)**

Station	Maximum	Minimum	Average
Particulate Matter_{2.5} (PM_{2.5}) (Unit: $\mu\text{g}/\text{m}^3$)			
Berth No. 8	47.5	30.5	36.6
MPT Colony	38.2	30.0	33.3
MPT Guest House	49.2	26.5	33.0
Near Sub Jail,	42.9	31.0	35.0
Bagoda	44.3	29.8	34.6
Vasco	46.0	29.5	35.9
Particulate Matter₁₀ (PM₁₀) (Unit: $\mu\text{g}/\text{m}^3$)			
Berth No. 8	128.8	64.5	84.1
MPT Colony	85.0	62.0	72.7
MPT Guest House	88.0	58.0	71.5
Near Sub Jail,	115.0	63.5	82.2
Bagoda	98.5	62.2	77.8
Vasco	102.2	69.5	83.4
Sulphur Dioxide (SO₂) (Unit: $\mu\text{g}/\text{m}^3$)			
Berth No. 8	31.5	22.6	26.5
MPT Colony	31.4	21.8	26.9
MPT Guest House	37.3	24.9	28.0
Near Sub Jail	37.2	22.3	29.4
Bagoda	31.5	22.6	26.5
Vasco	31.4	21.9	26.6
Nitrogen Dioxide (NO₂) (Unit: $\mu\text{g}/\text{m}^3$)			
Berth No. 8	56.8	36.4	47.7
MPT Colony	63.4	33.2	50.3
MPT Guest House	59.7	38.0	50.3
Near Sub Jail,	64.5	35.1	52.2
Bagoda	56.8	36.7	47.7
Vasco	59.5	32.3	48.1
Carbon Monoxide (CO) (Unit: mg/m^3)			
Berth No. 8	0.9	0.5	0.7
MPT Colony	1.0	0.5	0.6
MPT Guest House	0.9	0.5	0.7
Near Sub Jail	0.9	0.4	0.7
Bagoda	0.9	0.5	0.6
Vasco	0.9	0.5	0.7
Ozone (O₃) (Unit: $\mu\text{g}/\text{m}^3$)			
Berth No. 8	64.0	41.2	50.3
MPT Colony	57.0	31.7	45.9
MPT Guest House	64.3	37.9	48.5
Near Sub Jail	58.0	42.1	49.4
Bagoda	57.0	41.2	50.0
Vasco	63.7	42.4	51.6

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Station	Maximum	Minimum	Average
Ammonia (NH₃) (Unit: µg/m³)			
Berth No. 8	15.7	11.5	13.9
MPT Colony	14.6	10.2	12.5
MPT Guest House	17.3	9.6	13.2
Near Sub Jail	22.6	10.2	14.5
Bagoda	15.7	11.5	13.9
Vasco	19.0	9.5	13.7
Benzene (C₆H₆) (Unit: µg/m³)			
Berth No. 8	0.8	0.2	0.4
MPT Colony	0.8	0.2	0.5
MPT Guest House	0.9	0.1	0.5
Near Sub Jail	0.7	0.2	0.4
Bagoda	0.8	0.2	0.4
Vasco	0.8	0.2	0.4

Observations on PM_{2.5} levels

The average concentration of PM_{2.5} at various stations monitored ranged from 33.0 to 36.5 µg/m³. The highest PM_{2.5} value was recorded as 47.5 µg/m³ near Project Site and lowest values of 30.0 µg/m³ were recorded near MPT colony. The PM_{2.5} values monitored during the field survey were within the permissible limit of 60 µg/m³ for industrial, residential, rural and other areas (Refer Annexure-IV).

Observations on ambient PM₁₀ levels

It is observed from Table-3.11 that average concentration of PM₁₀ at various stations ranged from 71.5 to 84.1 µg/m³. The highest PM₁₀ value was recorded as 128 µg/m³ near project site and lowest values of 58.0 µg/m³ were recorded near MPT Guest House. The average PM₁₀ values monitored during the field survey were generally within the permissible of 100 µg/m³, limits except at few occasions for industrial, residential, rural and other areas.

Observations on ambient SO₂ levels

The summary of ambient SO₂ level as monitored during field studies is given in Table-3.11. The average concentration of SO₂ at various stations in the study area was well below the prescribed limit of 80 µg/m³ specified for industrial, residential, rural and other areas (Refer Annexure-IV). The average concentration of SO₂ at various stations monitored ranged from 26.5 to 29.4 µg/m³. The highest SO₂ value was recorded as 37.3 µg/m³ near MPT Guest House and is below detectable limit in all the locations.



Observations on ambient NO₂ levels

It can be seen from Table-3.11 that during the study period, average NO₂ concentration at various sampling stations ranged from 47.7 to 52.2 µg/m³. The highest NO₂ value was recorded as 64.5 µg/m³ near Sub Jail and lowest value of 32.3 µg/m³ was recorded near Vasco. The average concentration of NO₂ at various stations in the study area was observed to be well below the prescribed limit of 80 µg/m³ specified for industrial, residential, rural and other areas.

Observations on CO levels

The average concentration of CO at various stations monitored ranged from 0.6 to 0.7 mg/m³. The highest CO value was recorded as 1 mg/m³ near MPT colony and lowest values of 0.4 mg/m³ were recorded near MPT Guest House. The CO values monitored during the field survey were below permissible limit of 2 mg/m³ for industrial, residential, rural and other areas.

Observations on ambient Ozone (O₃) levels

It is observed from Table-3.11 that average concentration of Ozone (O₃) at various stations ranged from 45.9 to 51.6 µg/m³. The highest Ozone value was recorded as 64.3 µg/m³ near MPT Guest house and lowest values of 31.7 µg/m³ were recorded near MPT colony. The Ozone values monitored during the field survey were below the permissible limit of 100 µg/m³ for industrial, residential, rural and other areas.

Observations on Ammonia (NH₃) levels

The average concentration of Ammonia (NH₃) at various stations monitored ranged from 12.5 to 14.4 µg/m³. The highest NH₃ value was recorded as 22.6 µg/m³ near Sub Jail, Headland Sada and lowest values of 9.5 µg/m³ were recorded near Vasco area. The NH₃ values monitored during the field survey were below permissible limit of 400 µg/m³ for industrial, residential, rural and other areas.

Observations on ambient Benzene (C₆H₆) levels

It is observed from Table-3.11 that average concentration of Benzene at various stations ranged from 0.4 to 0.5 µg/m³. The highest Benzene value was recorded as 0.9 µg/m³ near MPT Guest House and lowest values of 0.1 µg/m³ were also recorded in the same station. The Benzene values monitored during the field survey were below the permissible limit of 5 µg/m³ for industrial, residential, rural and other

areas. Values of Lead, Benzo (O) Pyrene, Arsenic and Nickel were below detectable limits at all the stations.



Figure-3.10: Ambient Air and Noise Quality Sampling Location Map

3.15 AMBIENT NOISE LEVELS

Baseline noise data has been measured using a weighted sound pressure level meter. The survey was carried out in calm surroundings. Sound Pressure Level (SPL) measurement in the outside environment was made using sound pressure level meter. Hourly noise meter readings were taken at each site, and equivalent day time and night time noise levels were estimated. The ambient noise levels were recorded at 7 locations and details are listed Table- 3.10. The Sampling location map is enclosed as Figure-3.10. The hourly ambient noise levels recorded during February 2015 at various locations are listed in Table-3.11. The day time and night time noise levels are presented in Table-3.12. The ambient noise standards are enclosed as Annexure-V.

**Table - 3.10: List of Noise monitoring stations**

S.No.	Station Code	Noise monitoring station
1	N -1	Near Berth No 8
2	N -2	D- Type Quarters MPT colony
3	N -3	Bharat Colony Near MPT Hospital
4	N -4	Bharat Line Bogda
5	N -5	Electrical Substation Gate No.2
6	N -6	IOCL near Gate No.7
7	N - 7	Baina Colony

Table- 3.11: Ambient Noise Level in the study area [Unit: dB(A)]

Time	Stations						
	N-1	N-2	N-3	N-4	N-5	N-6	N-7
6AM-7AM	43.2	48.2	47.6	47.1	51.2	53.1	48.3
7AM-8AM	45.6	51.3	49.1	48.3	54.1	55.4	51.3
8AM-9AM	46.3	52.6	52.6	49.2	55.3	56.3	53.6
9AM-10AM	48.6	52.3	54.8	50.2	56.3	56.6	52.3
10AM-11AM	48.9	52.5	56.1	52.3	58.7	58.3	51.5
11AM-12PM	49.8	53.8	57.6	54.2	59.8	55.5	49.8
12PM-1PM	51.2	54.3	58.6	55.1	61.2	56.3	52.3
1PM-2PM	52.6	54.8	59.2	54.2	62.2	56.4	49.3
2PM-3PM	51.2	53.6	58.4	56.2	62.4	59.8	53.5
3PM-4PM	51.6	54.6	58.6	54.3	61.7	60.8	54.5
4PM-5PM	52.6	55.2	58.4	52.3	62.5	61.4	52.8
5PM-6PM	53.4	55.9	60.2	54.6	62.8	62.6	51.1
6PM-7PM	53.4	54.2	58.1	54.1	59.6	59.4	53.6
7PM-8PM	52.2	52.1	56.2	53.2	57.5	57.4	49.6
8PM-9PM	51.6	48.2	54.2	51.2	53.2	58.3	51.3
9PM-10PM	48.8	44.3	51.6	48.6	49.1	53.6	46.6
10PM-11PM	47.2	42.2	48.2	46.5	47.6	51.6	43.1
11PM-12AM	42.6	41.2	45.6	43.3	44.4	48.1	41.5
12AM-1AM	39.6	40.6	43.2	41.2	41.5	44.7	39.2
1AM-2AM	35.2	38.3	42.6	39.6	39.4	41.5	35.6
2AM-3AM	36.6	39.3	41.6	40.2	40.1	39.9	38.8
3AM-4AM	42.1	41.6	42.8	42.6	41.6	43.9	41.2
4AM-5AM	41.3	43.2	43.4	43.6	42.5	46.8	32.8
5AM-6AM	42.1	44.6	46.9	46.5	45.6	48.8	44.3

Table- 3.12: Equivalent noise levels in the Study Area

S.No.	Noise monitoring station	Leq(day)	Leq(night)
1	Near Berth No 8	50.95	41.45
2	D- Type Quarters MPT colony	53.39	39.93
3	Bharat Colony Near MPT Hospital	57.07	44.15
4	Bharat Line Bogda	53.11	42.34

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S.No.	Noise monitoring station	Leq(day)	Leq(night)
5	Electrical Substation Gate No.2	59.83	42.52
6	IOCL near Gate No.7	58.57	46.30
7	Baina Colony	51.99	39.76

It may be seen from the Table-3.12 that the day time equivalent noise level ranged from a minimum of 50.95 dB (A) to a maximum of 59.83 dB(A). The night time equivalent noise level ranged from a minimum of 39.76 dB(A) to a maximum of 46.30 dB (A). The day and night time equivalent noise level at various sites located close to residential areas and commercial area were compared with Ambient Noise Standards (Refer Annexure-V) and were observed to be well below the permissible limit specified.

3.16 LIQUID CARGO STORAGE TANKS AT MPT

Apart from bulk cargo and containers, Mormugao Port also handles various liquid cargo at Berth 8 and 10, which includes the Petroleum products and Ammonia. The details of the liquid cargo handling and storage at MPT are given in Table 3.13. The Existing petroleum storage tanks have their own independent safety and emergency response arrangements. The details of the existing storage tanks at Mormugao Port are summarised in Table -3.12.

Table 3.13: Existing Storage Tanks at Mormugao

Tankage	Pipeline No	Origin	Booster Station	Location	Tankage Area (sqm)	Capacity in KL and No. of tanks	Approx. Pipeline Length (m)
JRF Tanks - Petroleum	Pipeline 1	Berth 8	No Booster Station	South East of B. 4	1176.3	7800.00 and 2Nos.	990
Indian Molasses Tanks - Petroleum	Pipeline 2	Berth 8	No Booster Station	South East of B. 4	701.3	15000.00 and 9Nos.	939
Zuari Agro Chemical Tank - Phosphorus Acid	Pipeline 3	Berth 10 & 11	No Booster Station	Near T. B. Cunha Chowk, Vasco	6,122.00	22500.00 and 3Nos.	825
Ganesh Benzoplast Tankage - Liquid Handling	Pipeline 4	Berth 8	Ganesh Benzoplast Booster Station (140.41sqm)	South of B.9 & Adjacent to FCI Godown	20000	92000.00 and 4Nos.	1645
ROB Baina -	Pipeline 5	Berth 8	Zuari Indian Oil Tank	Booster Station at	-	-	2597



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(Department of Water Resources, River Development & Gangs Rejuvenation)

Tankage	Pipeline No	Origin	Booster Station	Location	Tankage Area (sqm)	Capacity in KL and No. of tanks	Approx. Pipeline Length (m)
Petroleum			Booster Station (2500 sqm)	Near Fire Station			
Zuari Agro Chemical Tank – Ammonia	Pipeline 6	Berth 8	No Booster Station	Ammonia Storage tank at Near Fire Station	6600	5000.00 and 1No.	904
Indian Oil Tank – Petroleum	Pipeline 7	Berth 10	No Booster Station	South East of B. 11	9981	34660.00 and 5Nos.	1194

CHAPTER-4
ENVIRONMENTAL BASELINE STATUS-
MARINE ECOLOGY



CHAPTER-4

ENVIRONMENTAL BASELINE STATUS – MARINE ECOLOGY

4.1 GENERAL

The MoEF&CC has accorded the approval for the Terms of reference (TOR) for conducting the eia study for dredging and deepening of navigation channel for capsized vessels at Mormugao Port, vide letter dated 9.12.2014. As a part of the EIA study, marine ecological study was carried out by Centre of Advanced Study in Marine Biology (CASMB), Annamalai University Tamilnadu in the month of February 2015.

4.2 RESULTS OF MARINE ECOLOGICAL SURVEY CONDUCTED IN FEBRUARY 2015

4.2.1 SAMPLING DETAILS

The MoEF&CC has accorded the approval for the Terms of reference (TOR), vide letter dated 9.12.2014 for conducting the EIA study for deepening of approach channel for capsized vessels at Mormugao Port. As a part of the EIA study, marine ecological study was carried out by Centre of Advanced Study in Marine Biology (CASMB), Annamalai University Tamilnadu. During the survey carried out on 1st and 2nd February 2015, water, sediment and biological samples (plankton, benthos and microbial samples) were collected across two different depths (surface and subsurface) from 8 different locations. The coordinates of the sampling stations are given in Table-4.1 and depicted in Figure-4.1.

Table-4.1: Sampling Locations and its Geographical Coordinates

S. No.	Latitude (N)	Longitude (E)
1.	15°24'24.08"	73°48'35.59"
2.	15°24'51.67"	73°48'48.85"
3.	15°25'5.13"	73°48'14.23"
4.	15°25'17.98"	73°47'50.0"
5.	15°24'52.27"	73°46'45.85"
6.	15°25'23.84"	73°46'12.33"
7.	15°24'44.18"	73°45'24.71"
8.	15°25'0.16"	73°44'39.62"

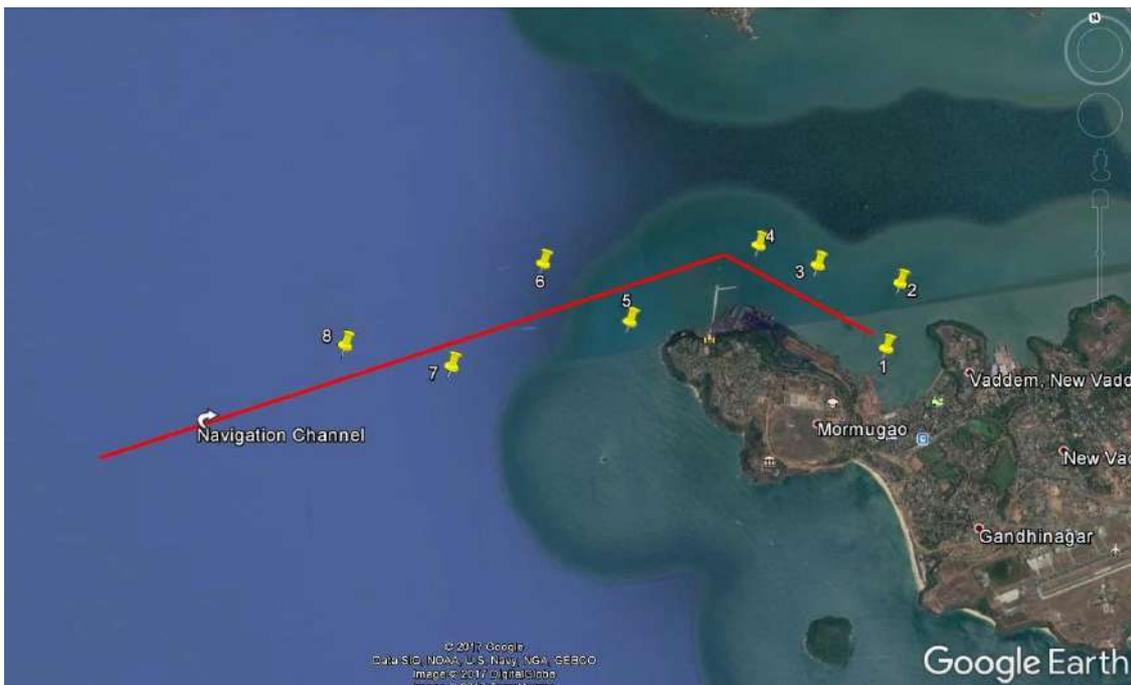


Figure-4.1: Map showing the Marine Sampling Locations

4.2.2 METHODOLOGY ADOPTED FOR SAMPLING AND ANALYSES

Water and Sediment Sampling

Water samples were collected at the surface and sub-surface level using Universal water sampler and transferred to the pre-cleaned polypropylene and glass containers. Sediment samples were collected using Van veen grab transferred to clean polythene bags and transported to the shore. The samples were air-dried and the plant root and other debris were removed and stored for further analysis.

Temperature, Salinity and pH

The physical parameters such as temperature, salinity and pH were measured *in-situ* in the field. The sub-surface temperature was measured with a mercury thermometer ($\pm 0.02^\circ\text{C}$ accuracy) and the pH was measured by a calibrated pH pen (pH ep-3 model). Salinity was estimated using a Hand Refractometer (Atago, Japan). Water samples collected for dissolved oxygen estimation were transferred carefully to BOD bottles. The DO was immediately fixed and brought to the shore for further analysis.

Preservation and Laboratory Analysis

After collection, the samples were immediately cooled to 4°C and then brought to the temporarily set up Field Lab, in an insulated thermocool box. On reaching, water samples were filtered through Whatman GF/C filter paper and analysed for organic



matter and other nutrients. Unfiltered samples were used for the estimation of total nitrogen and total phosphorus. All the analyses were carried out by adopting Standard procedures for samples of aquatic origin. The methodology for each analysis is briefly given below:

Dissolved Oxygen

The modified Winkler's method as described by Strickland and Parsons (1972) was adopted for the estimation of dissolved oxygen. The values are expressed in mg/l.

Nitrate and Nitrite

The nitrate and nitrite content of samples were analysed by following the method described by Strickland and Parsons (1972). The nitrite was estimated from highly coloured azo dye formed by the addition of N (1-Naphthyl) ethylene diaminedihydrochloride and sulfanilamide into the solution was then measured at 543 nm in a spectrophotometer. The same procedure was followed for the estimation of nitrate. For this, nitrate was reduced to nitrite by passing the sample through copper coated cadmium column. The calculated values are expressed in μmol of Nitrogen/l

Inorganic Phosphate

The single solution mixed reagent procedure developed by Murphy and Riley (1962) was followed for the estimation of dissolved inorganic phosphate levels in water samples. This involves the conversion of phosphate into phosphomolybdic acid, which was then reduced to molybdenum blue color complexes and then the intensity of colour was measured at 882 nm in a spectrophotometer. The calculated values are expressed in μmol of Phosphate/l.

Total Phosphorus

The Total Phosphorus in water samples was estimated by adopting the method described by Menzel and Corwin (1964). This procedure involves the conversion of organically bound phosphate into inorganic phosphate by wet oxidation of samples with potassium persulphate in an autoclave for 30 min at 15 lbs pressure. The converted inorganic phosphate was then estimated by using the method described by Murphy and Riley (1962). The subtraction of original dissolved inorganic phosphate from total phosphate yielded the organic phosphate in the water sample. The calculated value is expressed in μmol of Phosphorus/L.



Reactive Silicate

The reactive silicate content of water was estimated by following the method of Strickland and Parsons (1972). In this method, the intensity of blue color formed by silico-molybdate complex was measured at 810 nm in a spectrophotometer and the calculated values are expressed in μmol of Silica/l

Sediment Analysis

For the analysis of soil textural composition and pH, the air-dried sediment samples were used as such. For all other analyses, sediment samples were ground to fine powder and dried in an oven at 110°C to constant weight for an hour.

Total Organic Carbon

The estimation of total organic carbon in sediment was performed by adopting the method of El Wakeel and Riley (1956). The procedure involves chromic acid digestion and subsequent titration against Ferrous ammonium sulphate solution in the presence of 1-10 phenanthroline indicator. The values calculated are expressed in mg C/g of sediment.

Bacteriological Methods

Collection of samples

Surface water samples were collected in 30ml sterile screw capped bottles for bacteriological assessment. Enough air space was left in the bottles to allow thorough mixing. Precautionary measures were taken to avoid contamination through handling. For microbial assessment in sediment samples, a known quantity of samples was collected from the grab samples using sterilised spatula. The central portion of the collected sediment was aseptically transferred into sterile polyethylene bags. All the samples were brought to the laboratory in portable ice box soon after collection and bacteriological analyses were carried out with necessary dilution.

Enumeration of Total Viable Counts (TVC)

TVC was enumerated by adopting the spread plate method using Zobell's Marine Agar medium (EA123, Hi-Media, Mumbai). The samples (water and sediment) were diluted using the sterile sea water and 0.1 ml of the diluted sample was pipetted into the petriplates containing Zobell's Marine Agar and it was spread using a 'L' shaped glass spreader. The plates after inoculation were incubated in an inverted position at a temperature of $28\pm 2^{\circ}\text{C}$ for 24 to 48 h. The colonies were counted and the population density expressed as Colony Forming Unit (CFU) per ml or g of the



sample. The bacterial colonies were picked up from the petridishes and re-streaked in appropriate nutrient agar plates thrice before a pure culture was established in agar slants.

Enumeration of Total Coliforms

Macconkey agar with 0.15% bile salt, crystal violet and NaCl has been recommended in accordance with USP/Nfxi (1) for the detection, isolation and enumeration of coliforms and intestinal pathogens in water, dairy products, pharmaceutical preparations, etc. The agar weighing 51.5 g in 1000 ml distilled water was heated up to the boiling point to dissolve the medium completely and sterilized by autoclaving at 15 lbs pressure (121°C) for 15 min. suitably diluted samples were inoculated in the petriplates containing medium and were incubated for 48 h. After incubation, the colonies of *E. coli* appeared with pink color.

M-FC agar was employed for detection and enumeration Faecal Coliforms by the membrane filter technique at higher temperature (44.5°C). The agar weighing 52 g was suspended in 1000 ml of distilled water and heated up to the boiling point to dissolve the medium completely, 10ml of Rosolic acid (dissolved in 0.2 N NaOH) was added, heated with frequent agitation and boiled for 1 min. Then the medium was cooled to 50°C. Finally, the medium was poured into small 60mm plates. Samples filtered by Millipore apparatus using 0.45µm Whatman filter papers were impregnated in the petriplates. After 48 h of incubation, the colonies of *E. coli* appeared with blue colour.

Chlorophyll `a'

The samples were filtered through Whatman GF/C filter papers and the chlorophyll was extracted into 90% acetone. The resulting colored acetone extract was measured in a spectrophotometer at different wave lengths and the same acetone extracts were acidified and measured for the phaeo-pigments. The detailed methodology as described in APHA manual (1989) was followed.

Phytoplanktons

Phytoplankton samples were collected from the surface waters of the study area by towing a plankton net (mouth diameter 0.35 m) made of bolting silk [No.30 mesh size 48 µm) for half an hour. These samples were preserved in 5% neutralized formalin and used for qualitative analysis. For the quantitative analysis of phytoplankton, the



settling method as described by Sukhanovo (1978) was adopted. Numerical plankton analysis was carried out using Utermohl's inverted plankton microscope.

Phytoplankton species was identified using the standard works of Hustedt (1930-1966), Venkataraman (1939), Cupp (1943), Subramanian (1946), Prescott (1954), Desikachary (1959 and 1987), Hendey (1964), Steidinger and Williams (1970) and Taylor (1976) and Anand *et al.* (1986).

Zooplanktons

Zooplankton samples were collected from the surface waters of the study area by horizontal towing of plankton net with mouth diameter of 0.35 m, made of bolting silk (No. 70 mesh size 200 μm) for half an hour. After collection, the samples were preserved in 5% neutralized formalin and used for quantitative analysis. The zooplankton collected were identified to the species level using the classical works of Dakin and Colefax (1940), Davis (1955), Kasthurirangan (1963) and Wickstead (1965) and Damodara Naidu (1981). For the quantitative analysis of zooplankton, a known quantity of water (100 L) was filtered through a bag net (0.33 mm mesh size) and filtrate was made up to 1 litre in a wide mouthed bottle and then enumerated using Utermohl's inverted plankton microscope. The plankton density is expressed as number of organisms/ m^3 .

Benthic Community

For studying the benthic organisms, sediment samples were collected using Van veen grab which covered an area of 0.1m^2 . The wet sediment was sieved with varying mesh sizes (0.5mm -macrofauna and 0.062mm-meiofauna) for segregating the organisms. The organisms retained in the sieve were fixed in 5-7% formalin and stained further with Rose Bengal solution for easy spotting at the time of sorting. After a day or two, the organisms were sorted into various groups. The number of organisms in each grab sample was expressed as number per meter square. All the species were sorted, enumerated and identified to the advanced taxonomic level possible with the consultation of available literature. The works of Fauvel (1953), Day (1967) were referred for polychaetes; Barnes (1980) and Lyla *et al.* (1999) for crustaceans; Subba Rao *et al.* (1991) and Ramakrishna (2003) for molluscs.

4.2.3 MARINE WATER QUALITY

Based on the physio-chemical, biological and sediment characteristics of the study sites, an assessment of the ecological status of the study area was made. The



results of physio-chemical parameters in surface and sub-surface marine water samples at various locations are listed in Table-4.2.

Depth

The water depth varied between 10.5 and 34 m with maximum at Station-8 and minimum at station-1.

Water Temperature

Surface water temperature ranged from 28°C to 30.6°C. The sub surface water temperature as expected was found to be slightly lower than surface water temperature in all the stations. The bottom water temperature ranged between 25.4°C to 28.4°C at various sampling stations.

Salinity

The salinity values varied from 35.0 to 39.0 ppt in surface water to 30.0 to 38.5 ppt in sub-surface water at various sampling locations in the study area.

pH

The pH values varies from 8.2 to 8.9 in surface water and 7.9 to 8.5 in subsurface water at various sampling stations, which indicates that the marine water is marginally alkaline in the study area.

Total Suspended Solids

The Total Suspended Solids value ranged between 196 to 275.2 ppm for surface water and 150.4 to 268 ppm in subsurface water at various sampling location.

Turbidity

The turbidity ranged from 4.0 to 6.0 NTU in surface and 4.5 to 7 NTU in subsurface water sample.

Dissolved Oxygen

The Dissolved Oxygen level in the water samples varied between 4.2 to 5.9 mg/l in surface and 5 to 6 mg/l in subsurface water at various sampling locations.

Biological Oxygen Demand

The BOD values varied between 0.43 to 1.2 mg/l in surface and 0.47 to 1.6 mg/l in subsurface water samples at various sampling locations.

Nutrients

The life supporting processes in the sea requires an array of inorganic substances, of which the role of nitrogen, phosphorus and silicon are considered to be very vital in marine ecosystem. Among the nitrogenous nutrients, the nitrite, nitrate and



ammonia are the major constituents, which play a key role in the phytoplankton growth and proliferation. The details of values of various nutrients monitored at various sampling location is given in Table-4.2.

Nitrite

The nitrite level varied from 0.03 to 0.29 $\mu\text{mol/l}$ with maximum was recorded at station-3 and minimum was recorded at station-7.

Nitrate

Nitrate concentration ranged between 2.0 and 4.7 $\mu\text{mol/l}$.

Table-4.2: Physico - Chemical Properties of Marine Water

Stations	Unit	Station-1		Station-2		Station-3		Station-4	
		Surface	Sub Surface						
Temperature	$^{\circ}\text{C}$	28.5	26.4	29.3	27.3	28.9	25.4	28	27.4
Salinity	psu	35	30	39	32	37	32	37	30
pH		8.5	8	8.9	8.5	8.2	8	8.5	7.9
DO	mg/l	4.5	5.6	5.7	6	4.2	5	4.6	5.2
BOD	mg/l	1.2	1.6	0.67	0.9	0.56	0.78	0.67	0.89
TSS	ppm	262.4	150.4	203.2	212.4	275.2	268	226	193.6
Turbidity	NTU	4	5	5	6	6	7	5	6
NO ₂	$\mu\text{mol/l}$	0.07	0.07	0.06	0.07	0.29	0.04	0.08	0.07
NO ₃	$\mu\text{mol/l}$	2.5	3.5	3	4.7	2	4.6	2.6	4.7
NH ₄	$\mu\text{mol/l}$	0.03	0.06	0.09	0.09	0.05	0.08	0.05	0.08
TN	$\mu\text{mol/l}$	12.1	17.6	30.5	36.5	20.4	26.8	20.4	27.5
TP	$\mu\text{mol/l}$	2.89	3.05	3.06	3.56	2.78	3.89	2.05	3.09
IP	$\mu\text{mol/l}$	0.9	1.2	1.5	2	0.4	1.9	0.6	1.5
SiO ₄	$\mu\text{mol/l}$	27.45	30.54	32.45	40.32	28.54	30.56	27.54	30.56
PHC	$\mu\text{g/l}$	0.94	0.45	0.57	0.71	0.96	0.77	0.23	0.9
Iron	$\mu\text{g/g}$	20.4	10.3	12.3	10.7	10.3	12.3	12.3	20.3



Contd. Table-4.2

Table-4.2: Physico - Chemical Properties of Marine Water

Stations	Unit	Station-5		Station-6		Station-7		Station-8	
		Surface	Sub Surface						
Temperature	°C	28.4	26.4	29.3	28.4	30.6	27.5	30.6	25.4
Salinity	psu	38	35	39	37	38	37	39	38.5
pH		8.8	8	8.6	8.5	8.9	7.9	8.5	8
DO	mg/l	5	5.4	5.9	5.9	4.7	5.2	4.6	5
BOD	mg/l	0.43	0.56	0.54	0.67	0.45	0.54	0.56	0.47
TSS	ppm	196	168.4	200.2	213.2	212	220	215	262.4
Turbidity	NTU	5.5	6.5	5	6	5	4.5	5.7	4.6
NO ₂	µmol/l	0.06	0.09	0.07	0.07	0.03	0.13	0.14	0.24
NO ₃	µmol/l	2	3.6	3.7	4.6	2	2.5	3	3.2
NH ₄	µmol/l	0.05	0.08	0.06	0.07	0.03	0.05	0.03	0.06
TN	µmol/l	30.4	35.7	28.4	30.5	20.5	22.3	24.6	32.5
TP	µmol/l	3.06	4.56	3.67	3.2	2.45	4.5	2.43	4.5
IP	µmol/l	1.4	2.1	1.5	2.9	1.2	2	2.1	2.2
SiO ₄	µmol/l	30.54	36.43	29.43	38.43	20.59	34.56	20.67	40.43
PHC	µg/l	0.47	0.54	0.72	0.66	0.45	0.78	0.54	0.67
Iron	µg/g								

Ammonical Nitrogen

The concentration of Ammonical Nitrogen varied from 0.03 to 0.09 µmol/l at various stations. The maximum concentration (0.09 µmol/l) was recorded at station-2 and minimum (0.03 µmol/l) was recorded at station-7

Total Nitrogen

The Total nitrogen values in various water samples ranged from 12.1 to 36.5 µmol/l.

Total Phosphorus

The Total phosphorus values ranged from 2.05 to 4.56µmol/l with maximum was recorded at station-5 and minimum value was recorded at station-7.

Inorganic Phosphate

The inorganic phosphate values ranged between 0.4 and 2.9µmol/l with maximum value was recorded at station-3.



Reactive Silicate

The silicate values ranged between 20.59 and 40.43 $\mu\text{mol/l}$. The maximum (40.43 $\mu\text{mol/l}$) and minimum (20.59 $\mu\text{mol/l}$) values were recorded at station-8 and station-7 respectively.

Petroleum hydrocarbon

The petroleum hydrocarbon level ranged between 0.23 and 0.96 $\mu\text{g/l}$ with maximum at station-3 and minimum in station-4.

Iron

The concentration of iron in the sediment sample varied from 10.3 to 20.4 $\mu\text{g/g}$ with maximum was recorded in station-1 and the minimum concentration was recorded in station-2.

Heavy metals

The heavy metal concentration present in the marine water is listed in Table-4.3.

Table-4.3: Concentration of Heavy metals in marine water at various sampling location

ST.Code	Zn	Mn	Cr	Pb	Cu	Hg
	(μg/l)					
Station-1	20.45	25.32	1.432	1.8	6.2	0.24
Station-2	10.32	30.43	1.56	1.5	3.2	0.29
Station-3	10.45	34.32	1.85	5	4.8	0.35
Station-4	20.31	30.43	1.65	1.5	4.9	0.24
Station-5	18.54	26.31	3.78	4.9	3	0.35
Station-6	20.32	34.54	3.56	2.9	4.5	0.25
Station-7	20.56	30.43	3.45	3.4	5.9	0.32
Station-8	10.43	20.43	2.43	1.9	4.3	0.24

Zinc

The concentration of zinc in the sediment sample varied from 10.32 to 20.56 $\mu\text{g/g}$ and the maximum concentration was recorded in station-7 and the minimum was recorded in station-2.

Manganese

The concentration of manganese in the sediment sample varied from 20.43 to 34.54 $\mu\text{g/g}$ and the maximum concentration was recorded in station-6 and the minimum concentration was recorded in station-8.



Chromium

The concentration of chromium in the sediment sample varied between 1.43 and 3.78 $\mu\text{g/g}$ with maximum level was recorded in station-5 and the minimum at station-1.

Lead

The concentration of lead in the sediment sample ranged from 1.5 to 5.0 $\mu\text{g/g}$. The maximum concentration was recorded in station-3 and the minimum concentration was recorded at station-2 and station-3.

Copper

The concentration of copper in the sediment sample varied from 3.0 to 6.2 $\mu\text{g/g}$ and the maximum concentration was recorded in station-1 and the minimum concentration was recorded in station-5.

Mercury

The concentration of mercury in the sediment sample varied from 0.24 to 0.35 $\mu\text{g/g}$.

4.2.4 SEDIMENT CHARACTERISTICS

Sediment samples were collected from 8 locations in the study area. The sediment pH showed maximum value 8.8 at station 8 and minimum 7.9 at station station-1. The percentage of sand content varied from 24.8 to 67.7 % with maximum at station-7 and minimum at station-6; maximum silt content was found at station-6 (70.4%) and minimum at station-7 (28.4%) and the maximum clay was recorded at station-8 (7.4%) and minimum at station 1 (1.5%). The total organic carbon ranged between 3.7 and 8.5 mgC/g. The maximum level (5.9 mgC/g) was found at station-3 and low (3.7 mgC/g) at station-1. The concentration of iron in the sediment sample varied from 35.66 to 63.45 $\mu\text{g/g}$ with maximum was recorded in station-4 and the minimum concentration was recorded in station-7. Sediment, pH, texture Iron content and TOC are depicted in Table-4.4

Table-4.4: Results of Sediment Analysis

Station	Sediment pH	Sand (%)	Silt (%)	Clay (%)	Iron	TOC (mgC/g)
Station 1	7.9	67.1	31.4	1.5	43.28	3.7
Station 2	8.7	65.3	30.2	4.5	50.32	4.8
Station 3	8.2	25.8	69.2	5	56.43	5.9
Station 4	8.5	37.8	59.4	2.8	63.45	5.0
Station 5	8.5	46.5	49.5	4	60.34	5.1
Station 6	8.6	24.8	70.4	4.8	48.52	4.9



Station	Sediment pH	Sand (%)	Silt (%)	Clay (%)	Iron	TOC (mgC/g)
Station 7	8.7	67.7	28.4	3.9	35.66	3.9
Station 8	8.8	54.5	38.2	7.4	42.19	4.8

Heavy metal concentration in sediments

The heavy metal concentration recorded in various sediment sampling locations are given in Table-4.5.

Table-4.5: Heavy metal concentration in sediments (Unit: µg/g)

ST.Code	Zinc	Manganese	Chromium	Lead	Copper	Mercury
Station-1	34.32	20.45	8.5	12.78	12.5	0.45
Station-2	22.43	50.67	22.3	13.56	12.3	0.24
Station-3	20.43	35.67	14.3	12.32	14.3	0.23
Station-4	24.32	42.56	10.3	13.45	30.4	0.34
Station-5	12.34	29.45	13.4	14.32	20.4	0.45
Station-6	12.45	79.43	10.6	14.32	12.3	0.35
Station-7	22.32	20.43	10.4	14.43	15.9	0.36
Station-8	23.43	40.32	13.5	15.43	19.4	0.45

Zinc

The concentration of zinc in various sediment samples varied from 12.34 to 34.32 µg/g and the maximum concentration was recorded in station-1 and the minimum was recorded in station-5.

Manganese

The concentration of manganese in various sediment sample varied from 20.43 to 79.43 µg/g and the maximum concentration was recorded in station-6 and the minimum concentration was recorded in station-7.

Chromium

The concentration of chromium in sediment sample varied between 8.5 and 22.3 µg/g with maximum level was recorded in station-2 and the minimum at station-1.

Lead

The concentration of lead in various sediment samples ranged from 12.32 to 15.43 µg/g. The maximum concentration was recorded at station-8 and the minimum concentration was recorded at station-3.



Copper

The concentration of copper in various sediment samples varied from 12.3 to 30.4 $\mu\text{g/g}$ and the maximum concentration was recorded in station-4 and the minimum concentration was recorded in station-2.

Mercury

The concentration of mercury in the sediment sample varied from 0.23 to 0.45 $\mu\text{g/g}$.

4.2.5 MICROBIOLOGY

Marine Water

The *E. coli* bacteria in water sample varied between 5 to 30×10^5 CFU/ml with maximum at Station 8 and minimum at Station 4. Faecal coliform level varied from 8 to 32×10^4 CFU/ml with maximum at Station 8 and the minimum was recorded at Station 4. The Total Coliform varied between 10 to 44×10^3 CFU/ml with maximum at Station 8 and minimum at Station 1. The Total Viable Count (TVC) varied from 15 to 60×10^2 CFU/ml with maximum at Station 8 and minimum at Station 1 of water samples collected from various sampling locations.

Table-4.6: Bacterial population recorded from various Marine Sampling Locations

(Unit: CFU/ml)

Station No	<i>E. coli</i>	Faecal Coliform	Total Coliform	TVC
Station 1	10×10^5	14×10^4	10×10^3	15×10^2
Station 2	12×10^5	16×10^4	24×10^3	30×10^2
Station 3	06×10^5	10×10^4	16×10^3	20×10^2
Station 4	05×10^5	08×10^4	18×10^3	17×10^2
Station 5	10×10^5	12×10^4	23×10^3	27×10^2
Station 6	15×10^5	18×10^4	28×10^3	35×10^2
Station 7	25×10^5	30×10^4	40×10^3	52×10^2
Station 8	30×10^5	32×10^4	44×10^3	60×10^2

Sediment samples

The *Escherichia coli* in sediment samples varied between 20 and 60×10^4 CFU/g with maximum at station-8 and station-1 during the sample collection. Faecal coliform varied from 30 to 67×10^3 CFU/g with maximum at station-8 and the minimum was recorded at station-1. The Total Coliform varied between 27 and 70×10^2 with maximum at station-8 and minimum at station-3. The Total Viable Count (TVC) varied from 40 to 89×10^1 with maximum at station-7 and minimum at station-1 of water sample collected at Mormugao coastal waters.



Table-4.7: Bacterial populations recorded in various sediment samples (Unit; CFU/g)

Station No	<i>E. coli</i>	Fecal Coliform	Total Coliform	TVC
Station 1	20x10 ⁴	30x10 ³	32x10 ²	40x10 ¹
Station 2	40x10 ⁴	45x10 ³	45x10 ²	65x10 ¹
Station 3	25x10 ⁴	34x10 ³	27x10 ²	45x10 ¹
Station 4	28x10 ⁴	35x10 ³	40x10 ²	47x10 ¹
Station 5	35x10 ⁴	42x10 ³	46x10 ²	62x10 ¹
Station 6	42x10 ⁴	47x10 ³	50x10 ²	70x10 ¹
Station 7	45x10 ⁴	45x10 ³	50x10 ²	89x10 ¹
Station 8	60x10 ⁴	67x10 ³	70x10 ²	80x10 ¹

4.2.6 MARINE BIOTA

Chlorophyll –a, Phaeopigments and Total biomass

In the present study, the chlorophyll 'a' in water sample varied from 1.267 to 3.192 mg/m³ with maximum at station-6 and minimum at station 8. The Phaeopigments content varied from 0.214 to 4.112mg/m³ with maximum was observed in station-3 and minimum in station-4. The total biomass varied from 20.401 to 32.435 ml/100m³ with maximum was observed in station-8 subsurface water and minimum in station-7 subsurface water.

Table-4.8 Chlorophyll 'a', Phaeo pigments and Total Biomass

Water Sample	Station	Chlorophyll-a (mg/ m ³)	Phaeo pigments (mg/ m ³)	Total Biomass (ml/100 m ³)
Surface Water	Station 1	2.926	1.28	23.537
	Station 2	1.757	0.214	28.181
	Station 3	2.107	4.112	29.031
	Station 4	1.669	0.214	26.648
	Station 5	1.669	0.481	23.882
	Station 6	3.192	1.549	30.124
	Station 7	1.356	0.478	24.562
	Station 8	1.267	0.319	30.214
Sub Surface water	Station 1	1.973	1.308	26.374
	Station 2	2.567	0.748	26.321
	Station 3	2.207	1.976	26.012
	Station 4	1.269	1.015	28.648
	Station 5	1.567	0.748	25.748
	Station 6	2.045	0.24	27.231
	Station 7	1.567	0.219	20.401
	Station 8	1.321	0.421	32.435



Phytoplanktons

As a part of the present study, species belonging to four groups namely diatoms, dinoflagellates, blue greens and coccolithophores were recorded. Of these, diatoms were found to be the dominant group with 33 species. Dinoflagellates formed next group with 6 species and blue green algae with 3 species and coccolithophore came last in the order with 1 species in all the stations. Amongst diatoms, *Bellerochea malleus*, *Coscinodiscus centralis*, *C. granii*, *Chaetoceros affinis*, *Cerataulina orientalis*, *Leptocylindrus danicus*, *Skeletonema costatum*, *Thalassionemanitz schioides*, *Triceratium favus*, *Cyclotella* sp. *Nitzschia* sp. *N.granulata*, *Odontella mobilensis*, *O.sinensis*, *Pleurosigmanormanii*, and *Rhizosolenia styliformis* were found to be the commonly occurring species in the samples collected in various stations. Amongst dinoflagellates, *Ceratium furca*, *C. macroceros*, *Protoperidinium* sp. and *Dinophysis caudate* were observed. The blue green algae were representing *Anabeana* sp. and *Tricodesmium erythraeum* and *Cocolithus* sp. showed consistency in their occurrence in the samples collected from various sampling locations.

Population density

Density of phytoplanktons varied from 2,597 to 6,064 cells/l with maximum at station-8 and minimum at station-2. The details are given in Table-4.9.

Table-4.9: Phytoplankton recorded in various stations

Phytoplankton	Station 1	Station 2	Station -3	Station -4	Station -5	Station -6	Station -7	Station -8
Coccolithophores								
<i>Cocolithus</i> sp.	175	*	95	*	85	220	90	225
Blue greens								
<i>Anabeana nastoc</i>	*	110	*	90	*	*	35	350
<i>Microcystis</i> sp.	185	*	45	105	35	60	110	238
<i>Tricodesmium erythraeum</i>	110	155	*	*	*	*	90	476
Diatoms								
<i>Bellerochea malleus</i>	225	335	145	60	330	*	45	350
<i>Bacteriastrum comosum</i>	*	*	*	75	250	320	*	350
<i>Cerataulina orientalis</i>	75	335	65	120	110	*	220	
<i>Chaetoceros affinis</i>	30	330	115	120	60	180	75	310
<i>C. indicus</i>	150	*	*	85	33	420	*	120
<i>C. curvisetus</i>	*	*	105	90	40	*	150	0



Phytoplankton	Station 1	Station 2	Station -3	Station -4	Station -5	Station -6	Station -7	Station -8
<i>Coscinodiscus centralis</i>	750	150	110	*	425	*	*	125
<i>C. ecentricus</i>	*	55	*	20	125	225	90	0
<i>C. granii</i>	75	*	48	75	500	80	135	*
<i>C. gigas</i>	115	*	*	*	*	60	85	350
<i>Dinophysis sp</i>	*	*	*	85	95	*	110	225
<i>Ditylum brightwelli</i>	105	40	90	215	250	125	90	350
<i>Diatoma anceps</i>	180	*	130	*	125	225	*	*
<i>Eucampia zoodicus</i>	0	10	120	*	*	*	*	110
<i>Gyrosigma balticum</i>	138	200	75	105	*	150	125	350
<i>Leptocylindrus danicus</i>	*	*	*	110	180	*	90	*
<i>Lithodesmium undulatum</i>	350	*	125	90	120	175	120	120
<i>N. granulata</i>	130	10	100	200	500	*	90	*
<i>N. seriata</i>	145	*	215	350	330	60	*	135
<i>Odontella mobiliensis</i>	135	10	45	*	35	45	160	60
<i>O. sinensis</i>	85	*	75	*	175	*	185	210
<i>Planktonella sol</i>	18	90	75	*	30	30	90	*
<i>Pleurosigma normanii</i>	*	250	120	50	*	*	140	250
<i>P. directum</i>	140	*	75	75	175	330	*	*
<i>P. elongatum</i>	115	40	*	105	*	*	85	135
<i>Rhizosolenia alata</i>	*	*	90	225	330	200	120	*
<i>R. styliformis</i>	*	*	75	*	120	10	220	450
<i>Skeletonema costatum</i>	120	35	135	45	45	*	85	*
<i>Stephanophysis palmeriana</i>	*	*	*	*	350	155	*	80
<i>Thalassionema nitzschioides</i>	150	1250	45	120	*	10	420	110
<i>Thalassiothrix frauenfeldii</i>	*	420	50	120	120	120	155	*
<i>Triceratium favus</i>	165	220	*	105	80	*	60	220
<i>Triceratium reticulatum</i>	105	330	130	*	110	*	*	*
Dinoflagellates								
<i>Ceratium furca</i>	90	30	*	240	90	65	210	65
<i>C. macroceros</i>	*	*	50	*	250	250	85	*
<i>C. tripos</i>	90	330	75	90	*	*	120	*
<i>Dinophysis caudata</i>	30	*	105	*	40	110	*	80
<i>Protoperidinium oceanicum</i>	75	200	225	450	*	*	220	0
<i>Pyrophagus stenii</i>	*	220	*	165	120	220	345	220
Total	4256	5155	2953	3785	5663	3845	4450	6064



Zooplanktons

During the study period, 3 groups of macro zooplankton namely, calanoids, cyclopoids, and harpacticoids and 2 groups of micro zooplankton namely, spirotricha and larval forms and group “others” were recorded. Among the zooplankton, calanoida were found to be the dominant group with 9 species. Larval forms were the Cyclopoida and spirotricha 5 species each and harpacticoida and groups of “others” were 4 species each.

Amongst calanoida, *Acartia spinicauda*, *Acrocalanus gibber*, *A. gracilis*, *Nannocalanus minor*, *Paracalanus parvus*, *Pontella danae* and *Temoradisc audata* and cyclopoida, *Oithonarigida*, *O. brevicornis*, *O. similis*, *Corycaeus danae* and in larval forms, gastropod veliger, bivalve veliger, barnacle nauplii and in harpacticoida, *Macrosetella aculata*, *Microsetella norvegica* were found to be the common species in the collections. In the case of spirotricha, *Tintinnopsis cylindrica*, *T. tubulosa*, *Sagitta* sp, *Oikopleura* sp. showed consistency in their occurrence in the samples collected in various stations.

Population density

The density varied from 2,615 to 7,511 Nos/m³ with maximum at Station-8 and minimum at Station-3 (Table-4.10).

Macrobenthos

As a part of othe present study, four groups of benthic organisms namely polychaetes, crustaceans, bivalves and gastropods were recorded. The polychaetes constituted the dominant group followed by crustaceans, gastropods and bivalves. Altogether 40 species of macro-fauna were recorded. Of these, polychaetes topped the list with 23 species. Crustaceans were found to be the next dominant group in the order of abundance with 7 species. Bivalves and gastropods with 4 and 6 species of the total benthic organisms collected. Amongst polychaetes, *Armandia intermedia*, *Capitella capitella*, *Cossura coasta*, *Cirriformia* sp., *Goniada emerita*, *Lumbrinereis* sp., *Notomastus aberrans*, *Nereis* sp., *Ophelia* sp., *Perineries* sp., were found to be the most commonly occurring species at various sampling locations in the study Area.

Table-4.10: Zooplankton species recorded at various sampling locations in the Study Area

Zooplankton	Station 1	Station 2	Station -3	Station-4	Station-5	Station-6	Station-7	Station -8
Calanoida								
<i>Acartia spinicauda</i>	360	130	80	*	110	*	*	125
<i>A. erythrea</i>	350	*	350	50	*	425	520	525
<i>Acrocalanus gipper</i>	35	*	350	350	25	205	*	310
<i>A. gracilis</i>	540	300	*	45	*	*	600	410
<i>Cenropages furcatus</i>	*	*	85	350	160	225	*	615
<i>Nannocalanus minor</i>	*	120	120	350	50	40	*	*
<i>Paracalanus parvus</i>	150	450	120	40	*	320	*	205
<i>Pontella danae</i>	350	375	25	*	*		282	525
<i>Temora turbinata</i>	*	340	*	*	*	*	*	*
Cyclopoida								
<i>Oithona brevicornis</i>	128	715	*	350	595	*	282	600
<i>O. rigida</i>	20	*	40	50	355	410	125	*
<i>O. similis</i>	350	560	*	120	*	*	135	240
<i>Corycaeus danae</i>	*	*	125	350	*	595	*	325
<i>Copilia mirabilis</i>	80	120	350	*	20	45	225	350
Harpacticoida								
<i>Euterpina acutiformis</i>	55	308	30	224	*	*	225	840
<i>Macrosetella aculata</i>	120	410	*	*	325	816	*	540
<i>Macrosetella gracilis</i>	325	615	*	225	*	410	145	*
<i>Microsetella rosea</i>	70	*	350	*	*	*	224	*
Spirotricha								
<i>Favella brevis</i>	40	120	*	*	225	350	225	350
<i>F. philipiensis</i>	350	350	*	450	350	238	*	*
<i>Tintinnopsis cylindrica</i>	25	*	30	540	*	125	225	540
<i>T. tocaninensis</i>	20	*	225	*	350	350	135	*
<i>Tintinnopsis tubulosa</i>	540	130	*	350	125	320	60	110
Others								
<i>Lucifer hansenii</i>	*	60	40	20	120	*	350	*
<i>Sagitta sp</i>	125	30	45	350	155	*	*	85
<i>Oikopleura dioica</i>	150	350	*	*	70	350	90	45
<i>Oikopleura parva</i>	125	125	150	35	*	*	50	420
Larval forms								
Barnacle naupili	75	350	20	*	*	60	*	*



Zooplankton	Station 1	Station 2	Station -3	Station-4	Station-5	Station-6	Station-7	Station -8
Bivalve veliger	120	320	*	45	*	120	350	110
Copepod naupili	*	*	*	*	350	*	60	*
Crustacean naupili	350	75	35	350	225	60	*	*
Gastropod veliger	225	130	*	*	*	*	745	120
Shrimp zoa	70	*	45	350	25	*	75	120
Total	5148	6483	2615	4994	3635	5464	5128	7510

Coming to crustaceans *Angeliara sp.*, *Ampithoero mondi*, *Campylaspis sp.* and bivalves are represented by *Anadara*, *Donax*. Amongst gastropods *Cerithidea cingulate* and *Nassarius variegates* were found to be the common species in the collection.

Population density of Macrobenthos

The population density varied from 950 to 1725 Nos. m⁻² with maximum at station-2 and minimum at station-3 (Table-4.11).

Meio-benthos

In the present study, as many as 56 species belonging to five groups of meio-benthic organisms namely foraminiferans, nematodes, harpacticoids, ostracodes and Tanaidacea were recorded. Of these, foraminiferans topped the list with 22 species. Nematodes were found to be the next dominant group in the order of abundance with 16 species. Harpacticoids, Ostracodes and Tanaidacea came next with 8, 7 and 3 species respectively.

Among the foraminiferans, *Ammonia beccari*, *Bolivinasp.* *Laxostomum limbatum*, *Noniondepressulum* and *Planulina sp.*, were commonly found in all the stations. With respect to nematodes, *Desmoscolex sp.*, *Greeffiella sp.*, *Theristus sp.*, *Halalaimusfilum*, *Tricoma sp.*, and *Viscosiasp.*, were found to be the common species in the samples collected in various stations. Coming to ostracodes, *Bassleritesliebauti*, *Diasteropeschmitti*, *Leptocythere sp.*, *Tanellaindica* and harpacticoids, *Diarthrodes sp.*, *Tisbefurcata* were found to be common species in the collection.

Population density of meiobenthos

The population density of meiobenthos varied from 274 to 366 nos./10cm² with maximum at station-3 and minimum at station-2 (Table-4.12).

Table-4.11: Macro benthos recorded in various stations of Mormugao coastal waters

Macro benthos	Station 1	Station 2	Station -3	Station -4	Station -5	Station -6	Station -7	Station -8
Polychaetes								
<i>Armandia intermedia</i>	*	*	25	25	*	*	25	75
<i>Armandia longicaudata</i>	50	50	*	25	50	*	25	*
<i>Boccardia polybranchia</i>	*	125	*	*	*	*	*	*
<i>Capitella capitata</i>	50	50	50	*	200	150	*	100
<i>Cossura coasta</i>	*	100	*	*	50	*	*	75
<i>Cirriiformia sp.</i>	25	*	*	100	125	125	100	*
<i>Exogone clavator</i>	50	*	25	*	50	*	*	*
<i>Goniada emerita</i>	*	*	50	*	25	*	*	50
<i>Lumbrineri ssp.</i>	75	100	*	*	*	125	*	*
<i>Lumbrineris heteropoda</i>	*	*	75	*	25	*	*	*
<i>Nephtys dibranchis</i>	50	50	*	50	*	*	50	*
<i>Nephtys hombergi</i>	*	75	25	50	75	*	50	25
<i>Nereis sp.</i>	75	*	*	*	*	100	*	*
<i>Notomastus aberans</i>	*	50	*	25	25	25	25	50
<i>Perinereis capensis</i>	*		75	*	*	25	*	*
<i>Pisione africana</i>	*	*	*	*	*	*	*	25
<i>Platynereis calodonta</i>	25	*	*	75	*	*	75	*
<i>Platynereis sp.</i>	*	*	50	50	25	50	50	100
<i>Polydora ciliata</i>	*	25	*	25	*	25	25	*
<i>Prionospio capensis</i>	*	*	50	*	*	*	*	*
<i>Prionospio cirrifera</i>	50	*	*	25	50	*	25	*
<i>Prionospio pinnata</i>	100	75	*	*	50	75	*	*
<i>Syllis sp.</i>	*	*	*	100	*	50	100	100
Bivalves								
<i>Anadara veligers</i>	*	100	*	50	*	100	50	*
<i>Cardium veligers</i>	*	*	75	*	50	*	*	125
<i>Donax veligers</i>	125	*	75	*	*	*	*	50
<i>Meretrix veligers</i>	*	125	*	75	75	125	75	*
Gastropods								
<i>Bullia veligers</i>	*	*	25	*	*	*	*	175

Macro benthos	Station 1	Station 2	Station -3	Station -4	Station -5	Station -6	Station -7	Station -8
Polychaetes								
<i>Cerithidea cingulata</i>	*	125	*	*	*	175	*	*
<i>Littorina veligers</i>	100	*	*	150	75	100	150	100
<i>Nassarius variegatus</i>	50	100	50	*	*	*	*	*
<i>Natica veligers</i>	50	*	*	50	*	50	50	*
<i>Turris veligers</i>	*	100	25	*	25	*	*	25
Crustaceans								
<i>Ampithoe rubricata</i>	125	*	100	*	100	*	*	*
<i>Ampithoe romondi</i>	175	200	50	50	200	*	50	150
<i>Angeliara phreaticola</i>	*	*	*	*	*	100	*	*
<i>Campylaspis sp.</i>	150	100	125	125	150	225	125	75
<i>Gammarus sp.</i>	50	125	*	50	150	50	50	100
<i>Gynodiastylis sp.</i>	*	*	*	50	*	*	50	*
<i>Paragnathia formica</i>	*	50	*	50	*	*	50	175
Total	1375	1725	950	1200	1575	1675	1200	1575

Table-4.12: Meio-benthos recorded in various stations of Mormugao coastal waters

Meio benthos	Station 1	Station 2	Station -3	Station-4	Station-5	Station-6	Station-7	Station-8
Nematodes								
<i>Astomonema sp.</i>	21	14	15	19	14	14	6	5
<i>Daptonema conicum</i>	9	16	1	6	9	11	*	6
<i>Desmoscolex sp.</i>	20	17	14	19	22	15	12	10
<i>Draconema sp.</i>	2	3	4	2	*	2	5	6
<i>Greeffiella sp.</i>	2	5	2	*	*	3	9	12
<i>Halalaimus filum</i>	20	22	15	17	22	19	5	6
<i>Microlaimus sp.</i>	*	6	5	4	5	*	4	15
<i>Neochromodora sp.</i>	*	11	2	2	6	*	2	4
<i>Odontophora sp.</i>	2	6	*	2	4	5	13	*
<i>Pselionema sp.</i>	4	*	5	*	*	8	9	*
<i>Spirinia sp.</i>	3	11	*	1	4	5	*	6
<i>Stephanolaimus sp.</i>	*	9	5	4	5	*	8	6
<i>Synonchus sp.</i>	3	2	2	2	3	2	9	6
<i>Theristus sp.</i>	2	2	1	*	2	*	6	10
<i>Tricoma sp.</i>	2	3	3	2	2	3	8	7
<i>Viscosia sp.</i>	3	7	5	9	7	9	7	0
Foraminiferans								
<i>Ammonia beccarii</i>	14	14	14	11	11	12	6	6
<i>Bolivina sp.</i>	5	13	24	9	24	26	5	11
<i>Cibicides pseudoungerianus</i>	3	19	14	9	11	9	6	4

Meio benthos	Station 1	Station 2	Station -3	Station- 4	Station- 5	Station- 6	Station- 7	Station- 8
<i>Cibicides refulgens</i>	9	16	1	6	9	11	4	*
<i>Cibicides sp.</i>	5	3	*	6	5	6	12	5
<i>Globorotalia hiruste</i>	20	22	15	17	22	12	6	12
<i>Loxostomum limbatum</i>	*	*	1	*	2	3	*	*
<i>Loxostomum sp.</i>	24	19	12	17	15	14	6	5
<i>Miliammina sp.</i>	8	6	5	4	6	8	11	6
<i>Milionella sp.</i>	4	*	*	*	8	*	*	3
<i>Nonion depressulam</i>	17	17	15	21	14	15	7	12
<i>Nonion sp.</i>	9	9	11	7	9	5	*	4
<i>Nonionella limbata striata</i>	*	3	*	3	5	11	11	3
Macro benthos								
<i>Ophthalmidium inconstans</i>	*	3	3	4	3	*	5	3
<i>Pararotalia sp.</i>	3	5	3	*	4	*	15	19
<i>Planulina sp.</i>	22	26	*	25	22	20	6	6
<i>Quinqueloculina agglutinanas</i>	2	1	2	3	2	1	8	*
<i>Quinqueloculina oblonga</i>	3	2	3	1	3	2	14	17
<i>Triloculina irregularis</i>	3	3	1	2	*	3	9	9
<i>Triloculina sp.</i>	1	3	2	3	2	5	5	3
<i>Spiroloculina sp.</i>	2	2	1	*	5	6	3	3
<i>Triloculina austriaca</i>	2	3	4	2	*	5	4	5
Harpacticoids								
<i>Apodopsyllus vermiculiformis</i>	1	3	5	3	5	*	2	1
<i>Cervinia sp.</i>	*	1	6	2	5	2	5	3
<i>Cylindropsyllus sp.</i>	2	2	5	1	1	1	3	3
<i>Diarthrodes sp.</i>	3	3	6	2	1	8	4	5
<i>Laophonte thoracica</i>	2	3	2	2	4	1	3	1
<i>Laptastocus sp.</i>	*	*	2	1	5	1	2	3
<i>Stenhelis sp.</i>	3	2	5	2	1	2	*	2
<i>Tisbe furcata</i>	3	3	4	3	1	*	3	1
Ostrocodes								
<i>Basslerites liebau</i>	1	1	1	1	*	2	8	6
<i>Cypridies sp.</i>	2	3	1	2	1	1	3	8
<i>Cytheromorpha sp.</i>	1	1	7	1	1	1	3	5
<i>Keijella oertlii</i>	1	1	3	1	4	7	*	9
<i>Neocytheideis sp.</i>	2	4	2	*	1	*	5	5
<i>Tanella indica</i>	1	4	2	3	1	1	5	3
<i>Tanella kingmaii</i>	1	1	1	1	3	2	3	6
Tanaidacea								
<i>Heterotanais oerstedii</i>	2	1	2	1	1	1	1	5
<i>Apseudes setosus</i>	3	3	6	10	*	2	1	2
<i>Apseudes spinosus</i>	6	10	4	3	5	6	3	2
Total	283	369	274	278	327	308	300	305



4.3 STATUS OF MARINE ECOLOGY (AS per NIO Report July 2017)

Marine Biodiversity Impact Assessment and Management Plan for Deepening of Approach Channel and Inner Basin for Capesize Vessels at Mormugao Port has been carried out by NIO, Goa. Impact of dredging and dumping on marine diversity and biodiversity management plan". The detailed field study was conducted in the month of October 2016 and final report is submitted in July 2017. Results of the study on the marine biodiversity are presented in following sections.

Biological studies were carried out by NIO to understand the composition, abundance and biomass of bacteria, phytoplankton, zooplankton, benthos and demersal fish community in the mouth region of Zuari estuary covering the inner- and outer navigational channel area as well as two stations were sampled in the dumping area. Marine water and sediment sampling was carried out at 13 locations covering the proposed dredging and dumping area. Information on ecologically sensitive species such as corals and sponges, seaweeds, oysters etc was also collected from the study area within the 10 km distance of the proposed development site. The details of the sampling locations are given in Table-4.13.

Table-4.13. Details of sampling locations

Stn. No	Sampling details			Geographical positions		Water Depth (m)	
	Date	Time hrs	Tide	Latitude	Longitude		
MPT 1	27/10/2016	09:30	High	15° 24' 40.6" N	73° 48' 16.4" E	18	
			Low				
MPT 2		10:20	High	15° 24' 45.7" N	73° 48' 59.1" E	7	
		14:45	Low			6	
MPT 3		10:45	High	15° 25' 28.5" N	73° 48' 02.2" E	10	
		14:10	Low			9	
MPT 4		11:00	High	15° 26' 01.9" N	73° 48' 04.7" E	10	
		13:35	Low			9	
MPT 5		11:15	High	15° 26' 06.6" N	73° 47' 17.0" E	12	
			Low				
MPT 6	28/10/2016	09:50	High	15° 25' 22.5" N	73° 46' 25.1" E	18	
		13:40	Low			16	
MPT 7		10:15	High	15° 25' 16.7" N	73° 45' 50.6" E	19	
		13:30	Low			17	
MPT 8		10:40	High	15° 24' 53.9" N	73° 46' 44.7" E	15	
		14:00	Low			15	
MPT 9		11:50	High	15° 26' 56.9" N	73° 41' 0.46" E	27	
MPT 10		12:15	High	15 26' 6.22" N	73 39' 5.44" E	29	
Ref 1		27/10/2016	12:00	High	15° 25' 03.9" N	73° 49' 15.2" E	6.5
			14:50	Low			6
Ref 2		08:45	High	15° 26' 57.7" N	73° 48' 33.8" E	7.5	



Stn. No	Sampling details			Geographical positions		Water Depth (m)
	Date	Time hrs	Tide	Latitude	Longitude	
		12:52	Low			5.0
Ref 3	28/10/2016	14:30	Low	15 ^o 27' 01.31" N	73 ^o 45' 02.82" E	17.5

4.3.1 Physico-chemical Parameters

The physico-chemical parameters analysed by NIO in the month of October 2016 includes pH, Temperature, Salinity and Dissolved Oxygen. Amongst nutrients Nitrogen, Phosphorous and Silicon were studied. The results of physico-chemical parameters and nutrients are depicted in Table.4.14 and 4.15 respectively.

Table-4.14: Physico-chemical characteristics of marine water

Stations	Tide	Observed depth (m)	Surface (s) or bottom(b)	pH	Temp. (°C)	Salinity (%)	D.O. (mg/ml)
MPT 1	High	18	s	6.19	26.6	32.4	7.02
			b	7.08	23.1	34.2	1.1
	Low	14	s	7.7	28.2	32.43	5.56
MPT 2	High	7	s	6.63	27.4	32.5	5.38
			b	7.48	23.8	33.98	1.62
	Low	6	s	7.4	28.3	31.34	5.57
MPT 3	High	10	s	7.35	26.8	32.56	5.35
			b	7.4	24.1	34.08	1.2
	Low	9	s	7.77	29.4	31.14	6.31
MPT 4	High	10	s	7.37	28.1	32.08	4.7
			b	7.37	24.6	34.23	1.32
	Low	9	s	7.4	29.8	31.28	7.05
MPT 5	High	12	s	7.66	28.8	31.23	5.13
			b	7.03	24.8	34.01	2.78
	Low	11.5	s	7.32	29.3	31.79	6.62
MPT 6	High	18	s	7.52	25.3	33.95	4.24
			b	7.56	23.5	34.1	1.03
	Low	16	s	7.73	26.3	33.31	5.34
MPT 7	High	19	s	7.53	25.5	34.22	4.41
			b	7.52	22.6	34.68	1.02
	Low	17	s	7.32	27.6	33.48	5.2
MPT 8	High	15	s	7.52	27.2	34.23	3.59
			b	7.53	25.3	34.2	1.15
	Low	15	s	7.46	26.1	33.29	5.46
MPT 9	High	27	s	7.49	24.9	34.64	4.22
			b	7.46	22.8	34.53	3.54
	MPT10	High	29	s	7.55	25.9	33.28
			b	7.55	22.6	34.57	1.51

Stations	Tide	Observed depth (m)	Surface (s) or bottom(b)	pH	Temp. (°C)	Salinity (%)	D.O. (mg/ml)
Ref 1	High	6.5	s	7.56	29.1	30.7	6.04
			b	7.53	28.1	31.95	4.92
	Low	6	s	7.65	28.4	31.68	5.59
Ref 2	High	7.5	s	7.67	28	31.6	4.86
			b	7.39	23.9	34.68	1.34
Ref 3	Low	17.5	S	7.36	26.3	33.37	5.69
			B	7.77	23.7	34.07	3.34

There was not much variation observed in water temperatures at various sampling locations. The pH values in surface water samples varies from 6.19 to 7.73 and in bottom water from 7.03 to 7.73. Salinity was in range for the primary water quality criteria for SW-4 class water/harbour waters as recommended by the Environmental Protection Rule 1986, salinity values in surface water samples ranged from 30.7 to 34.68 and bottom samples ranged from 31.28 to 34.68. The DO values were less in the bottom water samples (0.78 to 4.92 mg/ml). DO values in surface water ranged from 7.05 to 3.59 mg/ml. When compared with earlier known values, the concentrations of DO in bottom waters indicated poor ecological (EcoQ) status both at the dredging and dumping areas.

Table 4.15: Concentration of Dissolved nutrients in marine water at various sampling locations

Stations	Tide	Surface/Bottom	Nutrient Concentrations (µm/L)			
			Silicate (Si)	Phosphate (PO ₄)	Nitrate (NO ₂)	Nitrite (NO ₃)
MPT 1	High	s	0.50	0.67	1.11	0.26
		b	8.39	1.45	1.11	0.20
	Low	s	0.64	0.51	0.25	2.27
MPT 2	High	s	0.73	0.63	0.59	0.12
		b	6.48	1.29	0.94	0.22
	Low	s	0.50	0.55	0.44	0.20
MPT 3	High	s	2.23	1.06	0.32	2.07
		b	7.34	1.65	0.84	0.28
	Low	s	0.59	0.67	0.17	1.57
MPT 4	High	s	1.05	0.55	0.79	0.26
		b	9.35	1.33	1.33	0.22
	Low	s	0.68	0.59	0.10	0.40
		b	4.38	0.67	1.26	0.32
MPT 5	High	s	0.55	0.67	0.54	0.20
		b	9.26	0.67	1.41	0.36
	Low	s	0.27	2.00	0.74	0.22
		b	7.30	0.94	1.38	0.16



Stations	Tide	Surface/ Bottom	Nutrient Concentrations ($\mu\text{m/L}$)			
			Silicate (Si)	Phosphate (PO_4)	Nitrate (NO_2)	Nitrite (NO_3)
MPT 6	High	s	1.32	0.51	0.47	0.58
		b	13.82	2.00	0.77	0.28
	Low	s	1.55	1.02	0.30	0.08
		b	7.07	0.47	0.82	1.03
MPT 7	High	s	5.38	1.29	0.47	0.70
		b	3.01	2.00	0.35	0.86
	Low	s	2.51	1.29	0.44	0.62
		b	7.30	1.33	0.67	0.70
MPT 8	High	s	2.69	0.98	0.64	0.74
		b	3.28	0.86	0.69	0.68
	Low	s	2.46	2.43	0.32	0.66
		b	6.11	1.33	0.52	1.69
MPT 9	High	s	6.06	1.45	0.57	0.68
		b	14.73	1.45	0.57	0.64
MPT 10	High	s	5.97	0.67	0.82	0.74
		b	14.64	1.02	0.79	0.70
Ref 1	High	s	1.50	0.74	0.54	0.70
		b	5.02	0.51	0.79	0.58
	Low	s	0.64	1.10	0.27	0.66
Ref 2	High	s	8.03	0.63	1.06	0.74
		b	11.08	1.53	0.84	0.86
Ref 3	Low	s	1.78	1.69	0.47	0.20
		b	2.42	1.22	0.32	0.42

In bottom water samples at dumping site (MPT-9) showed highest concentration of silica with 14.73 mg/l and the lowest concentration (3.01 mg/l) was observed in station MPT-7 bottom waters. The lowest concentration of phosphate (0.47 mg/l) was found in the bottom waters of station MPT-6. While highest values of organic phosphate (2.43 mg/l) was observed at Station MPT-8. The bottom waters of MPT-5 showed the highest concentration of nitrate (NO_3^-). Highest nitrite (NO_2^-) concentrations was recorded at station MPT-1.

Conclusions

There is no tidal variation in the concentrations of nutrients in both surface and bottom waters from the sampling stations. Low nutrient values in the surface waters is because fecal and dead matter tends to settle to the bottom which explains higher nutrient values observed in bottom waters in some sampling stations. However, the nutrient values observed in all the stations fall in the range lower than the standard values which implicates onset of depletion of nutrients and can become a limiting



factor for the growth of primary producers thus having derogatory effects on the food chains and food webs in the dredging and dumping areas.

4.3.2 MICROBIOLOGY

Abundance of indicator bacterial groups in the marine water samples collected from the study area was studied by NIO. The parameters covered as a part of the study includes the surface waters during Total Coliforms (TC), *Escherichia coli* like organisms (ECLO), *Vibrio* like Organisms (VLO), *Salmonella* like organisms (SALO), *Shigella* like organisms (SHLO), *Proteus/ Klebsiella* like organisms (PKLO) and *Pseudomonas aeruginosa* like organisms (PALO), were studied at various sampling locations. To find out the abundance of general heterotrophic and indicator bacteria, the following microbial populations were enumerated.

Total Viable Counts (TVC)

Total Viable Counts (TVC) in the seawater collected during high tide and low time at 13 stations (surface and bottom) in the study region is presented in the Table-4.16 and 4.17. In the surface waters counts of heterotrophic bacteria during high tide ranged from 6.1×10^3 to 25.4×10^4 CFU/ml, lowest bacterial count was at REF1 and highest at station MPT9, while during low tide highest bacterial count ranged from 6.4×10^3 to 59.2×10^3 CFU/ml. At all stations bacterial counts were low at low tide compared to high tide (Table.1 and Table.3). Reference station-1 has low bacterial load compared to other stations during high tide. Reference station-2 had high bacterial load at bottom waters. Overall TVC showed variations with respect to stations, with respect to depth of water column as well as with tide. An earlier investigation in Mormugao bay reported TVC of $1.6-14.7(\times 10^4)$ ml⁻¹ during November 2005 (Nagvekar and Ramaiah 2009).

Indicator bacterial groups

The distribution in the quantitative abundance of different indicator bacterial groups such as Total Coliforms (TC), *Escherichia coli* like organisms (ECLO), *Vibrio* like Organisms (VLO), *Salmonella* like organisms (SALO), *Shigella* like organisms (SHLO), *Proteus/ klebsiella* like organisms (PKLO) and *Pseudomonas aeruginosa* like organisms (PALO) retrieved from surface and bottom waters at different stations from the study area are presented in Table-4.16 and 4.17. Counts of TC ranged from 2.1 to 32.91×10^3 CFU/ml during high tide in surface waters while in bottom waters counts of TC ranged from 0.2 to 59.0×10^3 CFU/ml. TC counts ranged from 1.3



to 29.5×10^3 CFU/ml during high tide in surface waters while in bottom waters counts of TC ranged from 0 to 9.2×10^3 CFU/ml.

The abundance of specific functional groups of pathogenic bacteria in surface waters during high tide were in the range, $0.1-14.3 \times 10^3$ CFU/ml for ECLO, $0.1-4.8 \times 10^3$ CFU/ml for VLO, ND- 3.90×10^3 CFU/ml for SALO, ND- 7.1×10^3 CFU/ml for SHLO, ND- 1.8×10^3 CFU/ml for PKLO and ND- 4.2×10^3 CFU/ml for PALO. Similarly in bottom waters pathogenic bacteria were in the range, ND- 12.7×10^3 CFU/ml for ECLO, ND- 20.0×10^3 CFU/ml for VLO, ND- 2.9×10^3 CFU/ml for SALO, ND- 9.0×10^3 CFU/ml for SHLO, ND- 6.0×10^3 CFU/ml for PKLO and ND- 7.8×10^3 CFU/ml for PALO. During low tide the trend of distribution of pathogenic bacteria at surface waters was as follows:

Table-4.16: Abundance of indicator bacterial groups during high tide ($\times 10^3$ CFU/ml)

Group s	Sampling Stations											
	MPT 1	MP T 2	MP T 3	MP T 4	MP T 5	MP T 6	MP T 7	MP T 8	MP T 9	MPT1 0	REF 1	REF 2
Surface Waters												
TVC	40.9 5	11.6	94.8	24.3	15.2	72	47.6	76	254	36	6.1	143
TC	15.5	3.2	18.6	5.2	3.3	23.1	32.1	14.2	15.9	5.6	2.1	13.3
ECLO	6.5	0.1	7.1	0.9	1	6.4	14.3	6	8.85	3.8	0.7	2
VLO	2.4	0.9	5.7	0.9	0.8	4.1	4.8	8	3.45	0.1	0.5	2
SALO	0.9	0.1	0.4	ND	0.1	ND	3.9	7	1.15	0.2	0.2	ND
SHLO	3.4	0.8	1.9	2.4	0.6	6.5	7.1	3	5.05	3.7	ND	2
PKLO	1.3	0.1	2	0.2	0.1	0.6	1.8	2	0.1	0.3	ND	1
PALO	0.1	ND	0.4	ND	ND	4.2	0.2	0.3	0.05	ND	ND	ND
Bottom Waters												
TVC	0.2	0.3	6.2	16.6	8.2	81.7	30.4	4.7	0.7	0.8	3.1	110
TC	0.1	0.2	5.1	9.9	4.2	41.1	5.5	0.9	0.5	0.2	1.1	59
ECLO	ND	ND	0.3	3.3	0.6	11.9	1	0.1	0.2	ND	0.4	12.7
VLO	ND	ND	1.3	1.2	0.7	19.2	1.2	0.5	0.2	ND	0.3	20
SALO	ND	ND	1.6	1.3	0.2	2.9	1.3	ND	ND	ND	ND	2
SHLO	ND	ND	1.6	2.6	1.8	4.3	1.6	ND	ND	0.1	ND	9
PKLO	ND	0.1	0.3	0.2	ND	1.4	0	ND	ND	ND	0.1	6



Group s	Sampling Stations											
	MPT	MP	MPT1	REF	REF							
	1	T 2	T 3	T 4	T 5	T 6	T 7	T 8	T 9	0	1	2
PALO	ND	ND	ND	0.4	0.5	ND	0.3	ND	ND	ND	ND	7.8

TVC= Retrievable Colony Counts TC = Total Coliforms; ECLO = *Escherichia coli* like organisms; VLO = *Vibrio* like Organisms; SALO=*Salmonella* like organisms; SHLO = *Shigella* like organisms; PKLO = *Proteus/Klebshiella* like organisms; PALO = *Pseudomonas aeruginosa* like organisms; NS = Not sampled. ND = Not detected.

Table-4.17: Abundance of different indicator bacterial groups during Low Tide ($\times 10^3$ CFU/ml).

Group	Sampling Stations												
	MPT 1	MPT 2	MPT 3	MPT 4	MPT 5	MPT 6	MPT 7	MPT 8	MPT 9	MPT10	REF1	REF2	
Surface Waters													
TVC	8.1	6.4	31.6	21.2	20.2	59.2	30.2	11.0	NS	NS	NS	78.0	
TC	3.1	2.8	1.3	6.2	2.1	33.0	29.5	7.2	NS	NS	NS	4.1	
ECLO	0.1	1.5	0.9	1.7	0.0	17.3	16.8	5.6	NS	NS	NS	2.0	
VLO	0.2	0.3	0.1	1.3	1.3	3.3	5.2	1.0	NS	NS	NS	1.5	
SALO	0.2	0.1	0.1	0.7	0.2	0.2	1.7	ND	NS	NS	NS	ND	
SHLO	1.5	0.3	0.1	1.6	0.2	9.7	4.8	ND	NS	NS	NS	ND	
PKLO	0.5	0.1	0.1	0.3	0.1	1.5	0.5	ND	NS	NS	NS	ND	
PALO	ND	ND	ND	0.2	ND	0.4	ND	0.1	NS	NS	NS	ND	
Bottom Waters													
	MP T 1	MP T 2	MP T 3	MP T 4	MP T 5	MP T 6	MP T 7	MP T 8	MP T 9	MPT10	REF1	REF2	REF3
TVC	0.1	0.2	3.2	8.6	1.8	6.1	2	2	NS	NS	NS	NS	1.8
TC	ND	0.1	1.1	6.1	ND	5.1	0.2	0.1	NS	NS	NS	NS	0.4
ECLO	ND	0.1	0.1	0.7	ND	0.8	ND	ND	NS	NS	NS	NS	0.2
VLO	ND	ND	0.1	2.2	ND	1	0.1	ND	NS	NS	NS	NS	ND
SALO	ND	ND	0.4	0.6	ND	0.8	ND	0.1	NS	NS	NS	NS	ND
SHLO	ND	ND	0.3	1.0	ND	1	ND	ND	NS	NS	NS	NS	ND
PKLO	ND	ND	0.1	0.8	ND	0.2	ND	ND	NS	NS	NS	NS	ND
PALO	ND	ND	ND	0.4	ND	0.4	ND	ND	NS	NS	NS	NS	0.1

TVC= Retrievable Colony Counts TC = Total Coliforms; ECLO = *Escherichia coli* like organisms; VLO = *Vibrio* like Organisms; SALO= *Salmonella* like organisms; SHLO = *Shigella* like organisms; PKLO = *Proteus/Klebsiella* like organisms; PALO = *Pseudomonas aeruginosa* like organisms; NS = Not sampled, ND = Not detected.

The distribution of indicator bacteria retrieved from the sediments at different stations is presented in Table-4.18. Indicator bacterial groups were observed in 10 stations while counts were not detected at MPT10 and REF 3. Total counts of sediment samples were 1-2 orders higher magnitude than recorded from the water column, Total coliforms in 10 stations ranged from 0.5 (at MPT1) to a high of 30.0×10^5 CFU/g dry wt. (MPT3). ECLO counts ranged between 0.01 (MPT4 and MPT7) and 11.2



$\times 10^5$ CFU/g dry wt (MPT3). Counts of other bacterial groups were in the range, ND–14.30 $\times 10^5$ CFU/g dry wt for VLO, ND–7.0 $\times 10^5$ CFU/g dry wt for SALO, ND–3.10 CFU/g dry wt for SHLO, ND–0.9 $\times 10^5$ CFU/g dry wt for PKLO and ND–1.10 $\times 10^5$ CFU/g dry wt for PALO.

Total Direct Bacterial Counts (TDC)

The total direct counts of bacteria in the surface waters of MPT during high tide ranged from 14.18 (MPT8) to 29.68 $\times 10^5$ cells/ml (MPT1), during low tide direct counts of bacteria ranged from 11.94 (MPT8) TO 19.76 $\times 10^5$ cells/ml (MPT1) (Table-4.19). The total direct counts of bacteria in the bottom waters of MPT during high tide ranged from 9.44 (MPT8) to 25.02 $\times 10^5$ cells/ml (MPT1), during low tide direct counts of bacteria ranged from 7.72 (MPT8) to 13.62 $\times 10^5$ cells/ml (MPT4). Total direct bacterial counts in sediment sample ranged from 8.8 to 15.5 $\times 10^7$ cells/g of dry weight.

Conclusions

Seawaters along the Indian coasts are classified by Central Pollution Control Board of India (CPCB) as fit for commercial fishing, contact recreation and bathing activities when the TC is ≤ 200 CFU/100 ml. TC in the range ND to 33 $\times 10^3$ CFU/ml in water column and ND- 30 $\times 10^5$ CFU/ml in sediments is recorded in the present study. These values reflect the degree of contamination from anthropogenic sources in the MPT area. Comparison of present microbial data with previous reports from the study area (Table-4.20) also did not show significant differences.

Table-4.18: Abundance of different indicator bacterial groups in the sediment samples ($\times 10^5$ CFU/gm/dry wt.).

Group s	Sediment Sampling stations in designated Areas												
	Dredging Area								Dumping Area		Reference Area		
	MP T 1	MPT 2	MPT 3	MPT 4	MP T 5	MP T 6	MP T 7	MP T 8	MP T 9	MPT1 0	REF 1	REF 2	REF 3
TVC	0.66	19.30	34.00	10.80	3.60	7.60	8.70	3.70	8.40	0.39	2.80	43.00	1.30
TC	0.50	13.35	30.00	1.05	2.30	1.50	8.10	1.10	1.60	ND	4.00	19.10	ND
ECLO	0.20	4.20	11.20	0.10	0.28	0.28	0.10	0.30	0.70	ND	0.60	0.00	ND
VLO	ND	4.60	6.00	0.64	0.92	0.92	1.30	0.60	0.40	ND	1.60	14.30	ND
SALO	0.10	1.20	7.00	0.03	0.03	0.03	1.80	0.10	0.10	ND	0.50	0.90	ND
SHLO	ND	0.70	6.00	0.06	0.02	0.02	3.10	0.00	0.10	ND	ND	1.30	ND
PKLO	0.10	0.90	0.30	ND	0.09	ND	0.90	0.00	0.30	ND	ND	2.10	ND
PALO	ND	1.10	0.20	0.10	0.15	ND	0.00	0.10	0.00	ND	1.20	ND	ND

TVC= Retrievable colony counts TC = Total Coliforms; ECLO = *Escherichia coli* like organisms; VLO = *Vibrio* like Organisms; SALO= *Salmonella* like organisms; SHLO = *Shigella* like organisms; PKLO = *Proteus/Klebshiella* like organisms; PALO = *Pseudomonas aeruginosa* like organisms; NS = Not sampled, ND = Not detected.

Table-4.19: Abundance of Total Direct Bacterial Counts (TDC) in the study area.

Stations		Depth	Total Direct Bacterial Counts (TDC)		
			Seawater (High tide) ($\times 10^5$ Cells/ml)	Seawater (Low tide) ($\times 10^5$ Cells/ml)	Sediment ($\times 10^7$ Cells/g of dry wt.)
Dredging Area	REF1	Sur	23.04	NS	13.26
		Bot	19.74	NS	
	REF2	Sur	25.24	NS	15.5
		Bot	19.38	NS	
	REF3	Sur	NS	19.18	12.83
		Bot	NS	12.98	
Dredging Area	1	Sur	29.68	19.76	11.78
		Bot	25.02	NS	
	2	Sur	29.02	19.24	11.96
		Bot	22.76	NS	
	3	Sur	27.66	18.4	9.54
		Bot	21.16	NS	
	4	Sur	22.16	17	9.79
		Bot	15.84	13.62	
5	Sur	17.88	13.64	8.80	

Stations	Depth	Total Direct Bacterial Counts (TDC)		
		Seawater (High tide) (x 10 ⁵ Cells/ml)	Seawater (Low tide) (x 10 ⁵ Cells/ml)	Sediment (x 10 ⁷ Cells/g of dry wt.)
6	Bot	12.98	10.94	9.05
	Sur	16.84	13.82	
7	Bot	13.26	9.62	8.06
	Sur	15.24	13.8	
8	Bot	10.46	10.9	8.12
	Sur	14.18	11.94	
Dumping Area	Bot	9.44	7.72	13.76
	Sur	29.62	NS	
	Bot	18.88	NS	14.26
	Sur	20	NS	
Bot	15.92	NS		

Table-4.20: Comparison of present microbial data with previous reports from the study area

	Earlier report	Present report	Recommended	Fold deviation	Reference
TVC (CFU ml ⁻¹) (Water column)	1.5 x 10 ¹ to 2.9 x 10 ⁶ (July 2009-February 2011) Dona Paula bay	0.1 to 59.2 x 10 ³	-	-	Khandeparker et al 2015
TVC(CFU/g dry wt) Sediment	8.25 x 10 ² (Marmagoa -December 1997)	0.39 to 34.0 x 10 ⁴	-	-	Nagvenkar and Ramaiah, 2009
TDC (ml ⁻¹) (Water column)	1.9 x 10 ⁵ (July 2009) to 5.9 x 10 ⁷ (February 2011) Dona Paula bay	9.44 to 29.68. x 10 ⁵	-	-	Khandeparker et al 2015
TDC(g ⁻¹ dry wt) Sediment	6.31x10 ⁶ (Marmagoa-December 1997)	0.8 to 1.4 x 10 ⁷	-	-	Nagvenkar and Ramaiah, 2009
TC (CFU ml ⁻¹) (Water column)	1-587 CFU/ml (Mandovi - Zuary estuary, 2002-2003)	ND - 33 x 10 ³	≤ 200 CFU/100 ml (CPCB)	10⁴ times higher than recommended	Rodrigues et al., 2011
TC(CFU/g dry wt) Sediment	34-143 x 10 ³ CFU/g dry wt (Mandovi -	ND - 30 x 10 ⁵	-	-	Rodrigues et al., 2011



	Earlier report	Present report	Recommended	Fold deviation	Reference
	Zuary estuary, 2002-2003)				

CPCB: Central Pollution Control Board of India, TVC= Retrievable colony counts,

TC = Total Coliforms, TDC=Total Direct Bacterial Counts, ND=Not detected

4.3.3 Plankton Community

Phytoplankton, chlorophyll *a* (Chl), and zooplankton (ZP) are important determinants of the standing stocks and organic production of an estuary. These variables have often been studied by NIO to evaluate the overall health of marine water in MPT area.

Chlorophyll *a* and Phaeophytin

The Chlorophyll (chl) *a* at the Reference stations ranged from 2.2 to 2.68 mg m⁻³ in the surface and from 4.2 to 4.7 mg m⁻³ in the bottom waters at high tide. During low tide (LT), Chlorophyll *a* was higher ranging from 3 to 4 mg m⁻³ in the surface and from 3 to 5 mg m⁻³ in the bottom waters. The results are summarised in Table-4.21.

The phaeophytin was low and ranged from 0.28-0.35 in the surface and from 0.76 to 1.51 mg m⁻³ in the bottom waters during high tide. During low tide, the values were about 0.5 mg m⁻³ in the surface and 2 mg m⁻³ in the bottom waters. In the surface waters, phaeophytin was 12-13% of chl *a* during high tide and 16-17% during low tide. In the bottom waters, phaeo was greater ranging from 18-32% during high tide and 40-60% during low tide.

Phytoplankton abundance and diversity

Phytoplankton counts varied from 1160 and 4280 cells l⁻¹ in the surface and from 1240 and 3320 cells l⁻¹ in the bottom samples during high tide. During low tide the phytoplankton counts varied from 880 to 4040 cells l⁻¹ in the surface and from 760 to 4680 cells l⁻¹ in the bottom waters (Refer Table-4.22). The number of species observed was 5-11 in the surface and 5-8 in the bottom waters. Lower number of species was found at reference 2 bottom and Ref 3 surface. Higher numbers were recorded in the surface waters at stations 1 and 9. Diversity was in the range of 1.4-2.7 in the surface and 1.2-2 in the bottom water. Diversity was lowest at station 6 bottom and highest at station 10 surface.



Phytoplankton Species composition

At least 30 species of phytoplankton were observed during this study. Higher number of species was observed during high tide compared to the low tide. Diatoms were the predominant group and only 2 species of dinoflagellates were observed. In the surface waters at HT, *Coscinodiscus* and *Chaetoceros* were the most abundant genera, together contributing >36-90% of the total phytoplankton abundance (Table-4.23 to 4.26). Highest abundances of *Coscinodiscus centralis* was found since its bloom was present in the surface. *Pseudoguinaridia recta*, *Rhizosolenia imbricata*, *Skeletonema costatum* and *Thalassiosira punctigera* were also present in moderate abundances. There was no significant difference between the samples at low and high tide and between the counts at surface and bottom waters.

Zooplankton abundance and Group composition

The zooplankton biomass ranged from 0.06 to 77 ml m⁻³ during HT and from 3.4 to 12.3 ml m⁻³ during LT. This biomass is greatly overestimated due to the presence of the diatom *Coscinodiscus* bloom in all the samples. The biomass was minimum at transect S1-S2 and maximum at S7-S8. The abundance ranged from 88 to 16900 ind. m⁻³ during HT and from 1478 to 21714 ind. m⁻³ during LT. The abundance seemed to be higher during LT. The abundance was minimum at S6-S7 and maximum at S4-S5. The Zooplankton abundance and biomass are given in Table-4.27.

Composition and distribution of zooplankton abundance and biomass are given in Tables-4.28 and 4.29. Twenty groups of zooplankton were found during the study and the most dominant one was Copepoda forming 50-90% during high tide (Table-4.26), copepods Fish eggs were very important component and formed up to 46%. Very high abundances of foraminifera were found. Copepods comprised 26-86% during LT. At stations where their abundance was low, siphonophores and amphipods were present in the range of 26-50%. Cladocera, Oikopleura, fish eggs and lucifers were observed in moderate abundance ranging from 0.1-25%. The massive diatom *Coscinodiscus centralis* bloom that was observed at all stations, accumulated in the zooplankton net and led to overestimation of zooplankton biomass. The observed zooplankton abundance is similar to the earlier values observed during the post monsoon season.

Conclusions

Overall there were no significant differences in the levels of chl a, phytoplankton and zooplankton counts between the stations along the dredging path and reference stations. Results indicate moderate increase in turbidity and decrease in chl a in the bottom waters as a result of dredging. However these are small changes and the estuarine biota may be able to adapt to or recover from the same.

Table-4.21: Distribution of chlorophyll (chl) a and phaeophytin

	Chl a				Phaeo			
	High Tide		Low Tide		High Tide		Low Tide	
	Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom
Ref1	2.68	4.19	3.08	4.80	0.35	0.76	0.62	1.97
Ref2	2.22	4.73	3.52		0.28	1.51	0.52	
Ref3			3.91	3.07			0.56	1.96
S1	4.42	1.66	3.27		0.43	0.95	0.68	
S2	3.64	2.56	4.20		0.00	0.59	1.12	
S3	3.05	1.49	2.52		0.23	0.46	0.33	
S4	3.07	2.42	2.49	2.88	0.45	1.10	0.40	0.97
S5	1.47	2.15	1.68	2.00	0.79	1.01	0.02	0.63
S6	2.51	2.49	4.76	4.03	0.40	1.33	0.59	2.56
S7	3.42	2.32	4.25	3.51	0.68	1.16	0.91	2.01
S8	4.69	3.51	4.19	4.03	1.28	2.64	0.83	2.10
S9	4.20	2.52			0.96	2.28		
S10	2.68	1.80			0.44	0.94		

Table-4.22: Phytoplankton abundance (N; cells L⁻¹), total number of species (S) and diversity (H')

Station	High Tide						Low Tide					
	N	S	H'	N	S	H'	N	S	H'	N	S	H'
	Surface			Bottom			Surface			Bottom		
Ref 1	1640	6	1.79	2440	6	2.08	880	5	2.25	1240	8	2.58
Ref 2	2200	6	1.44	1680	5	2.04	3000	7	2.43	-	-	-
Ref 3	1400	5	1.36	1440	7	1.70	-	-	-	-	-	-
S1	2880	10	2.43	1240	8	2.11	1440	9	2.65	-	-	-
S2	1160	7	2.25	1760	8	1.81	2200	7	2.09	-	-	-
S3	1600	7	2.00	2120	8	2.27	1680	7	2.26	-	-	-



Station	High Tide						Low Tide					
	N	S	H'	N	S	H'	N	S	H'	N	S	H'
	Surface			Bottom			Surface			Bottom		
S4	2400	8	2.66	1560	8	2.30	2040	7	2.05	1520	7	2.16
S5	1760	8	2.46	1760	7	1.94	2560	11	2.78	760	7	2.47
S6	2280	7	2.26	3320	7	1.23	4040	8	1.48	4680	10	1.62
S7	3160	8	2.00	2240	6	1.59	1600	7	2.27	3120	9	2.30
S8	4280	9	1.81	2640	8	1.82	1600	7	2.21	3880	10	2.35
S9	4040	11	2.33	1720	7	2.31	-	-	-	-	-	-
S10	1560	8	2.62	640	5	1.72	-	-	-	-	-	-

Table-4.23: Composition (%) and abundance (nos.cells l⁻¹), of phytoplankton in the surface waters during high tide.

Species	Sampling stations												
	R 1	R 2	R 3	S1	S2	S3	S4	S 5	S6	S7	S8	S9	S10
Diatoms													
<i>Chaetoceros affinis</i>	12.2	7.3	11.4	31.9	6.9	0.0	0.0	0.0	47.4	10.1	7.5	49.5	15.4
<i>Chaetoceros decipiens</i>	0.0	0.0	11.4	0.0	0.0	0.0	0.0	13.6	0.0	0.0	0.0	0.0	12.8
<i>Chaetoceros diadema</i>	12.2	7.3	0.0	0.0	27.6	0.0	15.0	0.0	0.0	1.3	3.7	0.0	2.6
<i>Chaetoceros minimus</i>	4.9	7.3	0.0	34.7	10.3	0.0	6.7	6.8	12.3	12.7	0.9	13.9	0.0
<i>Coscinodiscus centralis</i>	61	0	71	1	41	58	0	0	0	10	63	1	18
<i>Coscinodiscus radiatus</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	0.0	0.0	2.0	0.0
<i>Coscinodiscus spp.</i>	0.0	72.7	0.0	0.0	0.0	0.0	36.7	43.2	0.0	0.0	0.0	0.0	0.0
<i>Ditylum brightwellii</i>	0.0	0.0	0.0	13.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<i>Fragilariopsis spp.</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<i>Fragilariopsis doliolus</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6
<i>Guinardia striata</i>	0.0	0.0	0.0	0.0	0.0	7.5	0.0	0.0	0.0	6.3	1.9	0.0	23.1
<i>Odontella aurita</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.3	0.0	0.0	1.0	0.0
<i>Pleurosigma directum</i>	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<i>Pleurosigma elongatum</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0
<i>Pleurosigma normanii</i>	0.0	0.0	0.0	0.0	0.0	5.0	5.0	6.8	0.0	1.3	2.8	0.0	0.0
<i>Pseudoguinardia recta</i>	0.0	0.0	2.9	5.6	0.0	5.0	0.0	2.3	8.8	57.0	17.8	5.0	23.1
<i>Rhizosolenia hyalina</i>	0.0	1.8	0.0	0.0	3.4	0.0	0.0	0.0	0.0	1.3	1.9	0.0	0.0
<i>Rhizosolenia imbricata</i>	7.3	3.6	2.9	0.0	6.9	0.0	11.7	15.9	0.0	0.0	0.0	0.0	2.6
<i>Rhizosolenia pungens</i>	0.0	0.0	0.0	2.8	3.4	0.0	0.0	0.0	12.3	0.0	0.0	9.9	0.0
<i>Rhizosolenia robusta</i>	0.0	0.0	0.0	0.0	0.0	0.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0
<i>Rhizosolenia styliformis</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0
<i>Skeletonema costatum</i>	0.0	0.0	0.0	0.0	0.0	15.0	0.0	0.0	12.3	0.0	0.0	13.9	0.0
<i>Thalassiosira punctigera</i>	0.0	0.0	0.0	0.0	0.0	0.0	10.0	4.5	0.0	0.0	0.0	0.0	0.0



Species	Sampling stations												
	R 1	R 2	R 3	S1	S2	S3	S4	S 5	S6	S7	S8	S9	S10
<i>Gyrosigma</i> spp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<i>Thalassiothrix longissima</i>	0.0	0.0	0.0	2.8	0.0	7.5	0.0	6.8	0.0	0.0	0.0	2.0	0.0
<i>Cylindrotheca closterium</i>	0.0	0.0	0.0	2.8	0.0	0.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0
<i>Nitzschia longissima</i>	0.0	0.0	0.0	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<i>Pseudo-nitzschia lineola</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dinoflagellates	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<i>Ceratium furca</i>	0.0	0.0	0.0	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<i>Dinophysis caudata</i>	0.0	0.0	0.0	0.0	0.0	2.5	0.0	0.0	0.0	0.0	0.9	0.0	0.0

Table-4.24: Composition (%) and abundance (nos.cells l⁻¹) of phytoplankton in the bottom waters during high tide

Species	Stations												
	R 1	R 2	R 3	S1	S2	S3	S4	S 5	S6	S7	S8	S9	S10
Diatoms													
<i>Chaetoceros affinis</i>	18.0	11.9	8.3	0.0	0.0	22.6	48.7	36.4	0.0	0.0	0.0	4.7	25.0
<i>Chaetoceros decipiens</i>	1.6	0.0	0.0	35.5	0.0	9.4	5.1	0.0	1.2	0.0	0.0	0.0	0.0
<i>Chaetoceros diadema</i>	0.0	16.7	2.8	0.0	0.0	0.0	0.0	0.0	2.4	3.6	3.0	0.0	6.3
<i>Chaetoceros minimus</i>	0.0	4.8	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	6.3
<i>Coscinodiscus centralis</i>	44.3	0.0	66.7	41.9	65.9	45.3	0.0	0.0	78.3	67.9	59.1	39.5	0.0
<i>Coscinodiscus radiatus</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<i>Coscinodiscus spp.</i>	0.0	40.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	56.3
<i>Ditylum brightwellii</i>	0.0	0.0	0.0	0.0	0.0	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<i>Fragilariopsis spp.</i>	21.3	0.0	0.0	0.0	0.0	0.0	0.0	43.2	0.0	0.0	0.0	0.0	0.0
<i>Fragilariopsis doliolus</i>	9.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<i>Guinardia striata</i>	0.0	0.0	0.0	0.0	0.0	0.0	2.6	0.0	0.0	0.0	1.5	9.3	0.0
<i>Odontella aurita</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	0.0	0.0	0.0	0.0	0.0
<i>Pleurosigma directum</i>	0.0	0.0	2.8	0.0	0.0	9.4	7.7	2.3	2.4	0.0	0.0	18.6	0.0
<i>Pleurosigma elongatum</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<i>Pleurosigma normanii</i>	0.0	0.0	11.1	0.0	0.0	0.0	0.0	0.0	6.0	10.7	9.1	0.0	0.0
<i>Pseudoguinardia recta</i>	0.0	0.0	0.0	3.2	2.3	5.7	0.0	0.0	0.0	10.7	1.5	0.0	0.0
<i>Rhizosolenia hyalina</i>	0.0	0.0	0.0	0.0	6.8	0.0	5.1	0.0	0.0	0.0	1.5	0.0	0.0
<i>Rhizosolenia imbricata</i>	4.9	26.2	5.6	3.2	0.0	0.0	15.4	0.0	8.4	3.6	21.2	20.9	6.3
<i>Rhizosolenia pungens</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	0.0	0.0	0.0	0.0	0.0
<i>Rhizosolenia robusta</i>	0.0	0.0	0.0	3.2	0.0	1.9	12.8	0.0	0.0	3.6	0.0	4.7	0.0
<i>Rhizosolenia styliformis</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<i>Skeletonema costatum</i>	0.0	0.0	0.0	0.0	9.1	0.0	0.0	9.1	0.0	0.0	0.0	0.0	0.0
<i>Thalassiosira punctigera</i>	0.0	0.0	0.0	6.5	6.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0



Species	Stations												
	R 1	R 2	R 3	S1	S2	S3	S4	S 5	S6	S7	S8	S9	S10
<i>Gyrosigma</i> spp.	0.0	0.0	0.0	3.2	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<i>Thalassiothrix longissima</i>	0.0	0.0	0.0	3.2	2.3	0.0	0.0	4.5	0.0	0.0	0.0	0.0	0.0
<i>Cylindrotheca closterium</i>	0.0	0.0	0.0	0.0	0.0	3.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<i>Nitzschia longissima</i>	0.0	0.0	0.0	0.0	4.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<i>Pseudo-nitzschia lineola</i>	0.0	0.0	0.0	0.0	0.0	0.0	2.6	0.0	1.2	0.0	0.0	2.3	0.0
Dinoflagellates	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<i>Ceratium furca</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<i>Dinophysis caudata</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table-4.25: Percent composition of phytoplankton abundance in the surface waters during low tide

Species	Stations										Avg.
	Ref 1	Ref 2	S1	S2	S3	S4	S5	S6	S7	S8	
Diatoms											
<i>Bacteriastratum elongatum</i>	0	0	0	0	0	0	0	0	5	0	0
<i>Chaetoceros affinis</i>	0	14.67	30.56	49.1	31	5.88	18.8	35.6	40	30	4.19
<i>Chaetoceros decipiens</i>	13.64	28	0	20	9.52	0	0	0	10	0	1.27
<i>Chaetoceros diadema</i>	18.18	13.33	19.44	7.27	0	15.7	7.81	0	17.5	20	1.57
<i>Chaetoceros minimus</i>	0	0	5.56	1.82	0	7.84	0	0.99	2.5	2.5	0.29
<i>Chaetoceros curvisetus</i>	0	0	0	0	0	0	0	0	0	5	0.06
<i>Chaetoceros peruvianus</i>	0	0	2.78	0	0	0	0	0	0	0	0.03
<i>Coscinodiscus centralis</i>	27.27	29.33	16.67	14.5	0	0	37.5	56.4	22.5	35	4.37
<i>Coscinodiscus radiatus</i>	0	0	0	0	0	0	0	0	0	0	0
<i>Coscinodiscus spp.</i>	0	0	0	0	38.1	54.9	0	0	0	0	1.31
<i>Ditylum brightwellii</i>	0	0	0	0	0	0	0	0	0	0	0
<i>Fragilariopsis doliolus</i>	0	0	0	0	0	0	1.56	0	0	0	0.03
<i>Fragilariopsis spp.</i>	0	0	0	0	0	0	0	0	0	0	0
<i>Guinardia striata</i>	0	1.33	16.67	0	4.76	0	3.13	0	0	0	0.33
<i>Odontella aurita</i>	0	0	0	0	0	0	0	0	0	0	0
<i>Pleurosigma directum</i>	0	0	0	0	2.38	3.92	3.13	0	0	0	0.149
<i>Pleurosigma elongatum</i>	0	0	0	0	0	0	0	0	0	0	0
<i>Pleurosigma normanii</i>	0	0	2.78	0	7.14	9.8	10.9	0.99	0	0	0.51
<i>Pseudoguinardia recta</i>	0	0	0	0	0	0	3.13	0	0	2.5	0.09
<i>Rhizosolenia hyalina</i>	13.64	6.67	2.78	0	0	0	1.56	2.97	2.5	5	0.48
<i>Rhizosolenia imbricata</i>	27.27	6.67	0	5.45	7.14	1.96	6.25	0.99	0	0	0.68
<i>Rhizosolenia pungens</i>	0	0	0	0	0	0	0	0.99	0	0	0.03
<i>Rhizosolenia robusta</i>	0	0	0	0	0	0	0	0	0	0	0

Species	Stations										
	Ref 1	Ref 2	S1	S2	S3	S4	S5	S6	S7	S8	Avg.
<i>Rhizosolenia styliformis</i>	0	0	0	0	0	0	0	0	0	0	0
<i>Skeletonema costatum</i>	0	0	0	0	0	0	0	0	0	0	0
<i>Thalassiosira punctigera</i>	0	0	0	0	0	0	0	0	0	0	0
<i>Gyrosigma</i> spp.	0	0	0	0	0	0	0	0	0	0	0
<i>Thalassiothrix longissima</i>	0	0	0	0	0	0	0	0.99	0	0	0.03
<i>Cylindrotheca closterium</i>	0	0	0	0	0	0	0	0	0	0	0
<i>Nitzschia longissima</i>	0	0	0	0	0	0	0	0	0	0	0
<i>Pseudo-nitzschia lineola</i>	0	0	2.78	0	0	0	6.25	0	0	0	0.15
Dinoflagellates	0	0	0	0	0	0	0	0	0	0	0
<i>Ceratium furca</i>	0	0	0	0	0	0	0	0	0	0	0
<i>Dinophysis caudata</i>	0	0	0	1.82	0	0	0	0	0	0	0.03

Table-4.26: Percent composition of phytoplankton abundance in the bottom waters during low tide

Species	Stations					
	Ref 2	S4	S5	S6	S7	S8
Diatoms						
<i>Bacteriastratum elongatum</i>	0.0	0.0	5.3	0.0	0.0	0.0
<i>Chaetoceros affinis</i>	25.8	15.8	0.0	0.9	5.1	9.3
<i>Chaetoceros decipiens</i>	25.8	0.0	0.0	1.7	0.0	0.0
<i>Chaetoceros diadema</i>	12.9	13.2	31.6	1.7	1.3	0.0
<i>Chaetoceros minimus</i>	6.5	0.0	0.0	0.0	0.0	1.0
<i>Chaetoceros curvisetus</i>	0.0	0.0	0.0	0.0	0.0	0.0
<i>Chaetoceros peruvianus</i>	0.0	0.0	0.0	0.0	0.0	0.0
<i>Coscinodiscus centralis</i>	19.4	50.0	0.0	68.4	51.3	37.1
<i>Coscinodiscus radiatus</i>	0.0	0.0	0.0	0.0	0.0	27.8
<i>Coscinodiscus spp.</i>	0.0	0.0	0.0	0.0	0.0	0.0
<i>Ditylum brightwellii</i>	0.0	0.0	0.0	0.0	0.0	0.0
<i>Fragilariopsis doliolus</i>	0.0	0.0	0.0	0.0	1.3	0.0
<i>Fragilariopsis spp.</i>	0.0	0.0	0.0	17.1	0.0	0.0
<i>Guinardia striata</i>	0.0	7.9	0.0	0.0	0.0	0.0
<i>Odontella aurita</i>	0.0	0.0	0.0	2.6	0.0	0.0
<i>Pleurosigma directum</i>	0.0	0.0	0.0	0.0	3.8	0.0
<i>Pleurosigma elongatum</i>	0.0	0.0	0.0	0.0	6.4	0.0
<i>Pleurosigma normanii</i>	0.0	7.9	15.8	1.7	0.0	0.0
<i>Pseudoguinardia recta</i>	0.0	2.6	5.3	0.0	0.0	1.0
<i>Rhizosolenia hyalina</i>	3.2	2.6	10.5	0.0	0.0	0.0
<i>Rhizosolenia imbricata</i>	3.2	0.0	26.3	4.3	10.3	1.0
<i>Rhizosolenia pungens</i>	0.0	0.0	0.0	0.0	0.0	0.0
<i>Rhizosolenia robusta</i>	3.2	0.0	0.0	0.9	6.4	1.0
<i>Rhizosolenia styliformis</i>	0.0	0.0	0.0	0.0	0.0	1.0
<i>Skeletonema costatum</i>	0.0	0.0	0.0	0.0	0.0	6.2
<i>Thalassiosira punctigera</i>	0.0	0.0	0.0	0.9	14.1	14.4
<i>Gyrosigma spp.</i>	0.0	0.0	0.0	0.0	0.0	0.0
<i>Thalassiothrix longissima</i>	0.0	0.0	0.0	0.0	0.0	0.0
<i>Cylindrotheca closterium</i>	0.0	0.0	0.0	0.0	0.0	0.0
<i>Nitzschia longissima</i>	0.0	0.0	0.0	0.0	0.0	0.0
<i>Pseudo-nitzschia lineola</i>	0.0	0.0	0.0	0.0	0.0	0.0
Dinoflagellates	0.0	0.0	0.0	0.0	0.0	0.0
<i>Ceratium furca</i>	0.0	0.0	0.0	0.0	0.0	0.0
<i>Dinophysis caudata</i>	0.0	0.0	5.3	0.0	0.0	0.0



Table-4.27: Zooplankton biomass (ml m⁻³) and abundance (ind. m⁻³) in the study area

Stations	High tide		Low tide	
	Biomass	Abundance	Biomass	Abundance
S1-S2	0.06	88	4.7	7906
S2-S3	6.32	16869	9.8	6069
S3-S4	3.62	5971	9.8	10426
S4-S5	4.79	2833	12.3	21714
S5-Ref2	6.44	13952	3.4	16441
S6-S7	10.55	3716	8.13	1478
S7-S8	76.49	16900	-	-
S8-S9	10.10	1672	-	-
S9-S10	8.21	2430	-	-
S10-	17.51	2204	-	-
S6-S8	-	-	13.59	1615
S8-Ref3	-	-	15.00	3862
Ref1- S2	6.55	5064	11.8	11741
Ref 2-S1	1.33	4093	9.1	12614
Ref 3-S1	-	-	11.57	2427



Table-4.28: Composition (%) & distribution of zooplankton groups during the high tide

Groups	Stations											
	S1-S2	S2-S3	S3-S4	S4-S5	S5-R2	S6-S7	S7-S8	S8-S9	S9-S10	S10-R1	R1-S2	R2-S1
Copepoda	68.9	71.0	89.8	81.5	86.9	64.0	49.1	66.4	80.7	59.2	88.3	66.8
Cladocera	0.7	0.7	0.1	0.3	0.9	1.1	0.8	0.0	1.8	8.6	0.5	4.7
Oikopleura	0.1	4.1	1.8	3.5	0.1	0.4	0.4	0.3	13.4	1.0	3.4	3.1
Fish egg	24.1	17.0	6.6	11.6	9.6	31.6	45.6	31.8	3.8	0.3	3.8	4.9
Fish larvae		0.4		0.1							0.1	
Euphausiid larvae	2.1	3.0	0.3	0.5	1.5	0.5	0.8	0.3	0.1	1.6	1.4	3.8
Lucifer	3.5	1.3	0.6	0.9	1.0	1.1	2.0	0.8		0.3	0.7	12.9
Copepod nauplii		0.2									0.0	0.2
Barnacle cipris	0.1	0.1				0.1		0.3	0.1		0.1	0.9
Brachuran zoea	0.3	0.3	0.3	0.1	0.2	1.0	0.8				0.1	0.2
Decapod larvae			0.3	1.2		0.1	0.6					
Foraminiferida		0.3								26.1	0.3	
Gastropoda												
Polycheta	0.2	1.6	0.3	0.1							1.0	2.0
Siphonophora												
Amphipoda								0.3				
Invertebrate egg										2.5	0.1	
Halobates										0.3		
Chaetognatha												0.4
Bivalvia											0.3	
Total ind. m ⁻³	88	16869	5971	2833	13952	3716	16900	1672	2430	2204	5064	4093

Table-4.29: Composition (%) and distribution of zooplankton groups during low tide

Groups	Stations										
	S1-S2	S2-S3	S3-S4	S4-S5	S5-R2	S6-S7	S6-S8	S8-R3	R1- S2	R2-S1	R 3
Copepoda	86.81	73.54	81.68	50.14	41.38	32.75	30.78	25.82	73.66	72.82	71.86
Cladocera	0.68	1.59	1.80	10.86	1.01	1.11	0.57	0.53			5.59
Oikopleura	6.99	17.20	11.28	11.20	19.01	7.59	0.76	1.87		1.61	1.02
Fish egg	2.59	1.59	4.53	0.56	1.63	6.80	16.73	21.08	1.29	1.47	15.59
Fish larvae				0.09							
Euphausid larvae	0.79	2.38	0.34	0.42	0.05			0.18		0.27	
Lucifer	1.58	0.26	0.08	0.10	0.77	1.27	0.86	0.29	24.49	22.49	3.39
Copepod nauplii		0.26	0.04	0.04	0.05						
Barnacle cipris			0.13	0.10	0.14	0.32	0.10	0.06		0.13	0.34
Brachuran zoea	0.23		0.08		0.10		0.10	0.06			0.17
Decapod larvae	0.11		0.04		0.10					0.13	
Foraminifera				0.04							
Gastropoda	0.11			0.04							0.17
Polycheta	0.11	2.91		0.09	0.48	0.16	0.10	0.12	0.18	0.94	1.86
Siphonophora		0.26		26.29							
Amphipoda					35.30	50.00	50.00	50.00	0.37	0.13	
TOTAL ind. m ⁻³	7906	6069	10426	21714	16441	1478	1615	3862	11741	12614	2427



4.3.4 Meiofauna

The benthic organisms living inside the sediment and ranged below 300 micron to 40 micron considered as a meiofauna. It includes Nematodes, larvae of polychaetes, Harpacticoid copepods, bivalves, gastropods, larvae of cnidarian, etc.

The large variation of meiofaunal abundance was recorded among 13 stations. Distribution & abundance of meiofaunal abundance is shown in Figure-4.2 and Distribution of meiofaunal taxa is depicted in Figure 4.3. The total meiofaunal abundance in the study area are given in Table-4.30 to 4.32. A total of 7 groups were identified from the study area out of that nematode was the most abundant followed by the Harpacticoid copepod and Nemertiana. Total 4 groups were identified in the dumping area. Comparative analysis of average meiofaunal abundance showed high (272 ind/10cm²) presence in reference sites while the low values (156 10cm²) were recorded in dumping sites. The dredging area was showing large fluctuation among the sampling sites with higher abundance of nematodes at the station MPT2-MPT4. In terms of meiofaunal group diversity, the dumping site was observed as the low diverse area compared to the reference site. Comparative analysis of average meiofaunal abundance showed high (272 ind/10cm²) presence in reference sites while the low values (156 10cm²) were recorded in dumping sites are given in Figure-4.4.



Table-4.30: Total meiofaunal abundance (nos. 10cm⁻²) in the study area

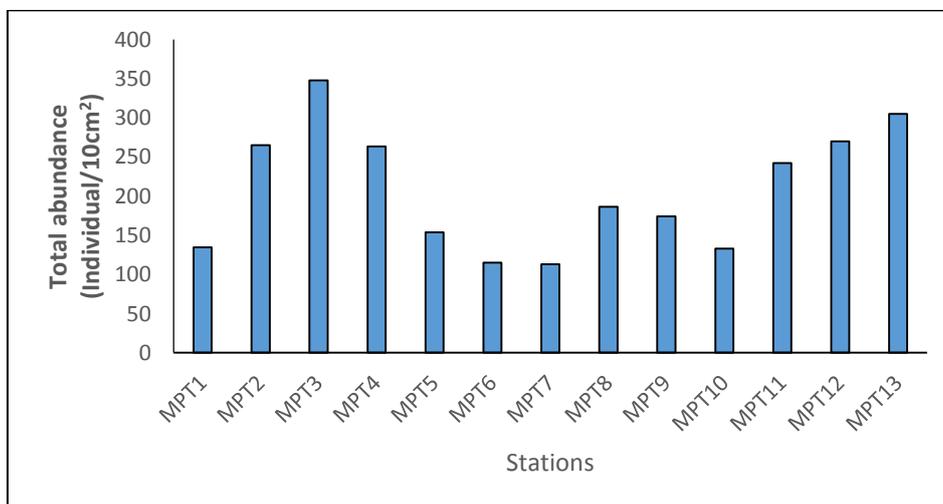
Groups	Stations								Total	%	MEAN	SD
	MPT1	MPT2	MPT3	MPT4	MPT5	MPT6	MPT7	MPT8				
Nematoda	121	257	331	222	115	103	102	176	1427	90.4	178.4	84.9
Harpacticoid Copepoda	2	2	4	14	5	1	3	2	33	2.1	4.1	4.0
Calanoid Copepoda		1		1	6				7	0.5	2.5	2.7
Bivalvia	2	2		1	6	2			15	0.9	2.9	1.9
Polychaete larvae	1	2	2	1	7	1	1		15	1.0	2.2	2.2
Nemertina	8		8	25	7	8	7	7	71	4.5	10.1	6.5
Halacarida	1		1		8				10	0.6	3.3	4.1
Total	135	265	348	263	154	115	113	186.31	1578	100		

Table-4.31: Meiofaunal abundance (no.10cm-2) at the dumping area

Groups	Stations					
	MPT9	MPT10	Total	%	MEAN	SD
Nematoda	171	131	301	98.0	151	28.3
Polychaete larvae	1		1	0.2	1	
Nemertina	3	2	6	1.8	3	0.4
Halacarida			0	0.0		
Total	174	133	307	100.0	154	29.2

Table-4.32: Meiofaunal abundance (no.10cm-2) in reference area

Groups	Stations						
	MPT11	MPT12	MPT13	Total	%	MEAN	SD
Nematoda	228	246	291	765	93.7	255	32.7
Harpacticoid Copepoda	6	4	2	12	1.5	4	2.2
Calanoid. Copepoda	1			1	0.1	1	
Bivalvia	2	4	3	10	1.2	3	0.9
Polychaete larvae	3	1		4	0.5	2	1.3
Nemertina	1	14	7	23	2.8	8	6.5
Halacarida	1		1	2	0.2	1	0.4
Total	242	270	305	817	100	272	31.4

**Figure-4.2: Distribution & abundance of meiofaunal abundance.**

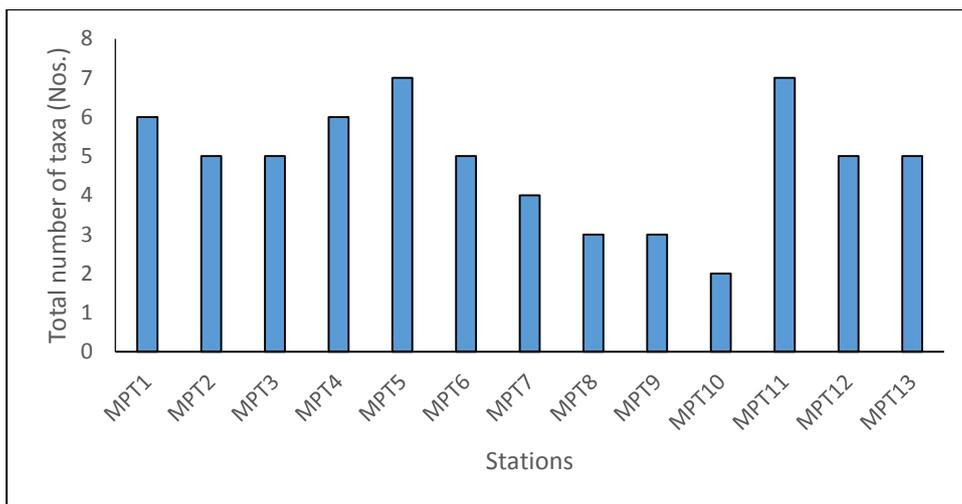


Figure-4.3: Distribution of meiofaunal taxa

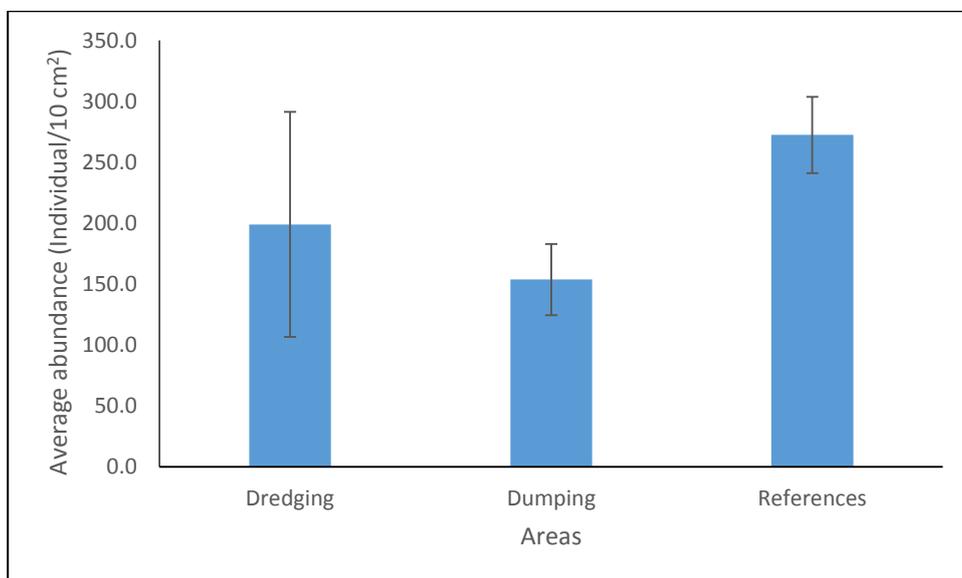


Figure 4.4: Comparative representation of total mean abundance of meiofauna.

4.3.5 Macrofauna

The macrobenthic fauna comprised of polychaetes, crustaceans, molluscs, echinoderms nemertean (ribbon worms) and nematodes. Among these groups polychaetes were the most common during all the stations (Figure-4.5). Polychaetes were most abundant, and their contribution was more than 96.42% to the total macrobenthic abundance followed by crustaceans 2.59%. Altogether 38 species were identified. Polychaetes were the most dominant with 25 species followed by Crustaceans with 7 species. The details of the composition and abundance of



macrobenthos at different stations are given in Table-4.33 to 4.35. Macrofaunal density varied from 2042 to 60029 Nos. m⁻² with maximum at station-4 and minimum at station-10. Figure-4.5 to 4.7 depict the composition of macrobenthos at dredging, dumping and reference area respectively.

Some of the families i.e. Sternaspidae, Eunicidae, Cirratulidae, Nephtyidae, Spionidae, and Cossuridae were common at all the station. While few families were found at channel and reference area but not at dumping area. These include Amphinomidae, Capitellidae, Syllidae, and Lumbrineris. Amphinomidae abundance was found to be almost equal at both the stations. Capitellidae was found to be highest in the reference area following channel area. Syllidae was found to be highest in the reference area followed by channel area. Lumbrineris was found to be highest at channel area followed by reference area.

Generally, macrofauna, especially polychaetes, reflect the ecological and environmental status of the site and this was explained in terms of number of individuals or specimens (N), number of species (S), total abundance (A), Margalef species richness (d), Pielou's evenness (J') and Shannon index (H') using log₂ scale at each station (Clarke & Gorley, 2001). Bray-Curtis similarity for species diversity for polychaetes was determined using PRIMER-v5 (Clarke & Gorley, 2011). The details of the diversity indices of macro fauna are given in Table 4.36 to 4.38. Macrofaunal abundance and biomass are shown in Figures 4.8 and 4.9 respectively.

Table-4.33: Composition (%) and abundance of macrofauna in dredging area

Taxa	Dredging Area								Total	Mean	SD	%
	MPT1	MPT2	MPT3	MPT4	MPT5	MPT6	MPT7	MPT8				
Polychaetes												
<i>Elphidium sp.</i>	0	0	0	0	44	0	0	0	44	6	16	0.0
<i>Prionospio sp.</i>	22910	29304	15096	55278	4618	36541	6172	4040	173959	21745	18109	75.9
<i>Paraprionospio sp.</i>	9901	2398	6216	2708	1820	5150	533	0	28727	3591	3311	12.5
<i>Polydora sp.</i>	2087	44	0	444	0	1687	0	266	4529	566	837	2.0
<i>Nereis sp.</i>	222	355	1110	400	44	311	44	1954	4440	555	657	1.9
<i>Dendronereis sp.</i>	0	44	0	0	0	0	0	133	178	22	47	0.1
<i>Protodorvillea sp.</i>	0	44	0	0	0	0	0	932	977	122	328	0.4
<i>Orbinia sp.</i>	0	0	0	0	0	0	0	0	0	0	0	0.0
<i>Glycera sp.</i>	0	0	133	0	44	0	0	89	266	33	52	0.1
<i>Eucine sp.</i>	0	0	44	0	0	0	0	0	44	6	16	0.0
<i>Maldanella sp.</i>	0	178	0	0	0	0	0	0	178	22	63	0.1
<i>Cirratulus sp.</i>	0	178	0	0	0	0	0	0	178	22	63	0.1
<i>Caulleriella sp.</i>	0	0	0	0	0	0	0	0	0	0	0	0.0
<i>Lumbrineris sp.</i>	0	0	44	0	0	0	0	0	44	6	16	0.0
<i>Oriopsis sp.</i>	0	266	0	0	0	0	0	0	266	33	94	0.1
<i>Neanthes sp.</i>	0	0	0	0	0	0	0	0	0	0	0	0.0
<i>Sabellaria sp.</i>	0	0	0	0	2087	0	0	0	2087	261	738	0.9
<i>Pulliella sp.</i>	0	222	0	0	0	44	0	0	266	33	78	0.1
<i>Euclymene sp.</i>	0	178	0	0	0	0	0	0	178	22	63	0.1
<i>Magelona sp.</i>	0	222	0	0	0	0	0	0	222	28	78	0.1
<i>Sternaspis sp.</i>	0	178	0	0	0	0	0	0	178	22	63	0.1
<i>Nephtys sp.</i>	0	622	0	89	0	0	0	0	710	89	218	0.3



Taxa	Dredging Area								Total	Mean	SD	%
	MPT1	MPT2	MPT3	MPT4	MPT5	MPT6	MPT7	MPT8				
<i>Syllis sp.</i>	0	0	0	0	0	0	0	0	0	0	0	0.0
<i>Cossura sp.</i>	89	2309	89	0	44	44	0	0	2575	322	804	1.1
<i>Sphaerosyllis sp.</i>	0	0	0	0	0	0	0	0	0	0	0	0.0
<i>Epidiopatra sp.</i>	0	0	0	0	0	0	0	0	0	0	0	0.0
Crustaceans												
Amphipoda	0	622	1465	133	89	0	44	44	2398	300	513	1.0
Isopoda	0	0	0	0	44	0	0	0	44	6	16	0.0
Copepoda	0	0	0	0	0	0	0	44	44	6	16	0.0
Decapod larva	0	0	0	0	0	89	0	0	89	11	31	0.0
Cumacea	0	222	1776	666	533	0	0	89	3286	411	608	1.4
<i>Lucifer sp.</i>	44	0	0	44	0	0	0	0	89	11	21	0.0
Pycnogonida	0	44	0	0	0	0	0	0	44	6	16	0.0
Bivalvia	0	44	0	266	222	0	0	0	533	67	111	0.2
Echinodermata												
Ophiuroidea	0	0	0	0	400	0	0	0	400	50	141	0.2
Others												
<i>Sipuncula sp.</i>	0	0	0	0	133	0	0	0	133	17	47	0.1
Nemertea	0	400	89	0	89	0	0	0	577	72	138	0.3
Nematoda	44	0	444	0	44	0	44	799	1376	172	294	0.6
Total	35298	37873	26507	60029	10256	43867	6838	8392	229060	28632	27601	100.0

Table-4.34: Composition (%) and abundance of macrofauna in dumping area

Taxa	Dumping area		Mean	SD	%
	MPT 9	MPT 10			
Polychaetes					
<i>Elphidium sp.</i>	0	0	0	0	0.0
<i>Prionospio sp.</i>	25796	1199	13498	17393	94.6
<i>Paraprionospio sp.</i>	0	0	0	0	0.0
<i>Polydora sp.</i>	222	0	111	157	0.8
<i>Nereis sp.</i>	0	0	0	0	0.0
<i>Dendronereis sp.</i>	0	0	0	0	0.0
<i>Protodorvillea sp.</i>	0	0	0	0	0.0
<i>Orbinia sp.</i>	0	89	44	63	0.3
<i>Glycera sp.</i>	0	0	0	0	0.0
<i>Eucine sp.</i>	0	0	0	0	0.0
<i>Maldanella sp.</i>	0	0	0	0	0.0
<i>Cirratulus sp.</i>	0	0	0	0	0.0
<i>Cauteriella sp.</i>	0	0	0	0	0.0
<i>Lumbrineris sp.</i>	0	0	0	0	0.0
<i>Oriopsis sp.</i>	0	0	0	0	0.0
<i>Neanthes sp.</i>	0	0	0	0	0.0
<i>Sabellaria sp.</i>	0	0	0	0	0.0
<i>Pullia sp.</i>	0	0	0	0	0.0
<i>Euclymene sp.</i>	0	0	0	0	0.0
<i>Magelona sp.</i>	0	0	0	0	0.0
<i>Sternaspis sp.</i>	0	0	0	0	0.0
<i>Nephtys sp.</i>	0	0	0	0	0.0
<i>Syllis sp.</i>	178	0	89	126	0.6
<i>Cossura sp.</i>	0	311	155	220	1.1
<i>Sphaerosyllis sp.</i>	0	0	0	0	0.0
<i>Epidiopatra sp.</i>	0	0	0	0	0.0
Crustaceans					
Amphipoda	266	444	355	126	2.5
Isopoda	0	0	0	0	0.0
Copepoda	0	0	0	0	0.0
Decapod larva	0	0	0	0	0.0
Cumacea	44	0	22	31	0.2
<i>Lucifer sp.</i>	0	0	0	0	0.0
Pycnogonida	0	0	0	0	0.0
Bivalvia	0	0	0	0	0.0
Echinodermata					
Ophiuroidea	0	0	0	0	0.0

Taxa	Dumping area		Mean	SD	%
	MPT 9	MPT 10			
Others					
<i>Sipuncula sp.</i>	0	0	0	0	0.0
Nemertea	0	0	0	0	0.0
Nematoda	0	0	0	0	0.0
Total	26507	2042	14275	18115	100.0

Table-4.35: Composition (%) and abundance of macrofauna in reference area

Taxa	Reference area			Mean	SD	%
	Ref. 1	Ref. 2	Ref. 3			
Polychaetes						
<i>Elphidium sp.</i>	0	0	0	0	0	0.0
<i>Prionospio sp.</i>	35254	6749	1332	14445	18223	60.2
<i>Paraprionospio sp.</i>	7637	311	0	2649	4322	11.0
<i>Polydora sp.</i>	0	355	178	178	178	0.7
<i>Nereis sp.</i>	1021	710	0	577	523	2.4
<i>Dendronereis sp.</i>	0	0	0	0	0	0.0
<i>Protodorvillea sp.</i>	0	44	0	15	26	0.1
<i>Orbinia sp.</i>	0	0	0	0	0	0.0
<i>Glycera sp.</i>	44	1376	0	474	782	2.0
<i>Eucine sp.</i>	0	0	0	0	0	0.0
<i>Maldanella sp.</i>	0	0	0	0	0	0.0
<i>Cirratulus sp.</i>	0	89	0	30	51	0.1
<i>Caulleriella sp.</i>	0	311	0	104	179	0.4
<i>Lumbrineris sp.</i>	44	0	44	30	26	0.1
<i>Oriopsis sp.</i>	89	44	0	44	44	0.2
<i>Neanthes sp.</i>	266	0	44	104	143	0.4
<i>Sabellaria sp.</i>	0	0	0	0	0	0.0
<i>Pulliella sp.</i>	1687	0	0	562	974	2.3
<i>Euclymene sp.</i>	0	0	0	0	0	0.0
<i>Magelona sp.</i>	355	0	0	118	205	0.5
<i>Sternaspis sp.</i>	0	0	0	0	0	0.0
<i>Nephtys sp.</i>	1687	0	0	562	974	2.3
<i>Syllis sp.</i>	89	0	0	30	51	0.1
<i>Cossura sp.</i>	7637	0	311	2649	4322	11.0
<i>Sphaerosyllis sp.</i>	488	1732	0	740	893	3.1
<i>Epidiopatra sp.</i>	44	0	0	15	26	0.1
Crustaceans						
Amphipoda	577	222	0	266	291	1.1
Isopoda	0	0	0	0	0	0.0

Taxa	Reference area			Mean	SD	%
	Ref. 1	Ref. 2	Ref. 3			
Copepoda	0	0	0	0	0	0.0
Decapod larva	0	44	0	15	26	0.1
Cumacea	666	133	44	281	336	1.2
<i>Lucifer sp.</i>	44	89	0	44	44	0.2
Pycnogonida	0	0	0	0	0	0.0
Bivalvia	44	89	0	44	44	0.2
Echinodermata						
Ophiuroidea	44	0	0	15	26	0.1
Others						
<i>Sipuncula sp.</i>	0	0	0	0	0	0.0
Nemertea	0	0	44	15	26	0.1
Nematoda	0	0	0	0	0	0.0
Total	57720	12299	1998	24006	32736	100.0

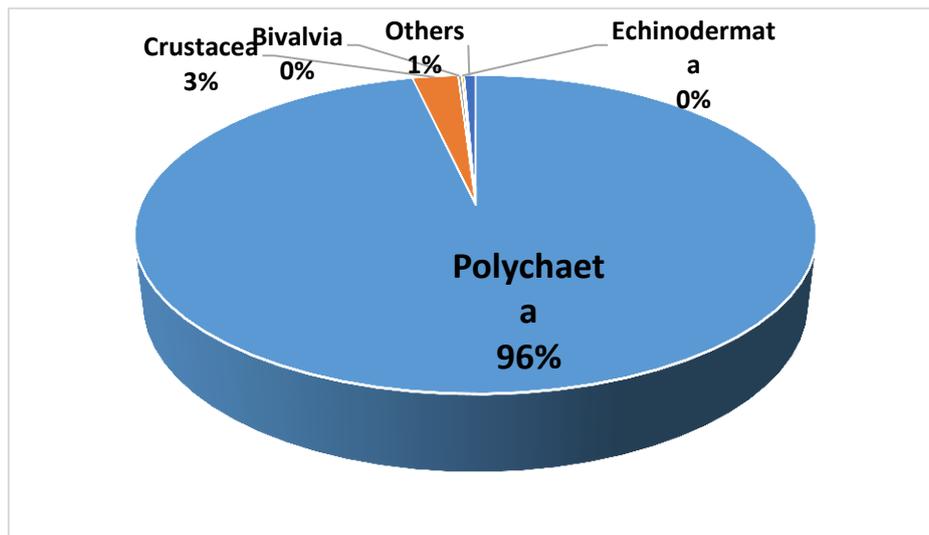


Figure-4.5: Overall composition (%) of macrofauna

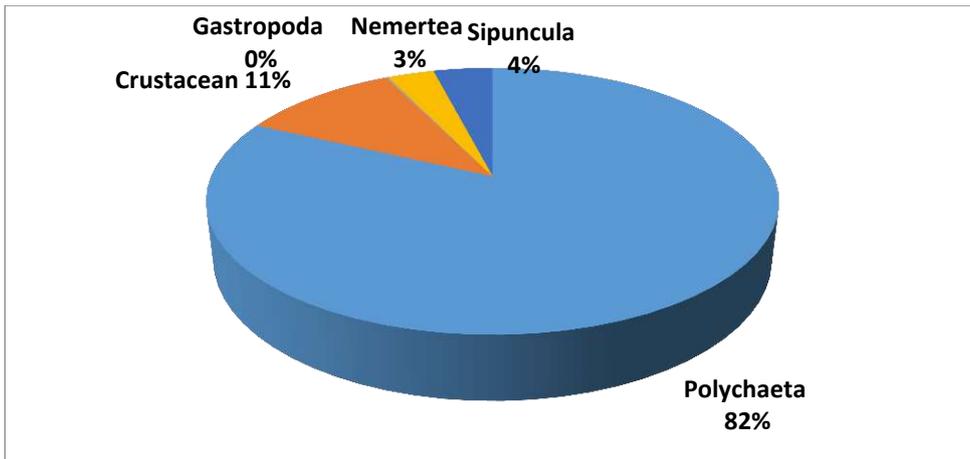


Figure-4.6: Composition (%) of macrofauna at the channel area

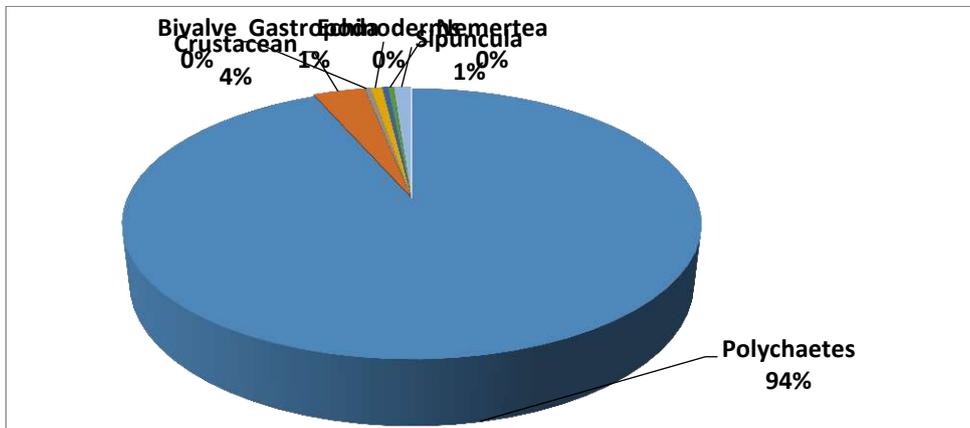


Figure-4.7: Composition (%) of macrofauna at the dumping area

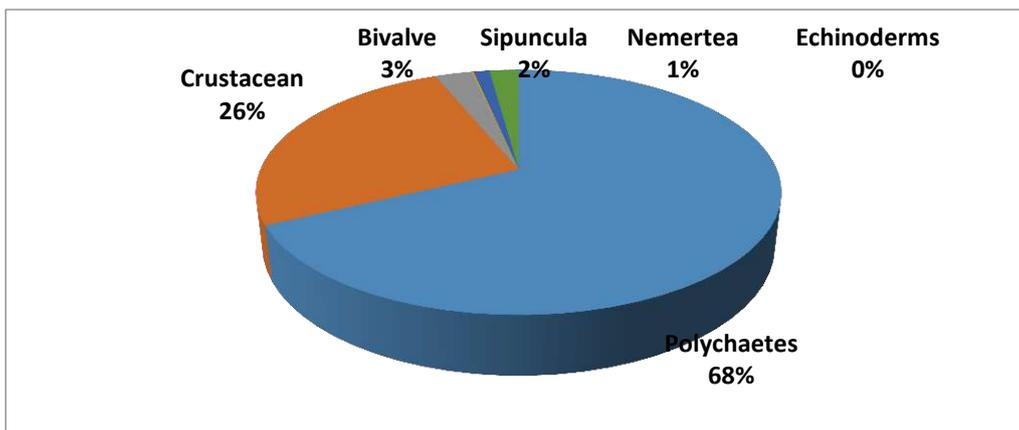


Figure-4.8: Composition (%) of macrofauna at the reference area

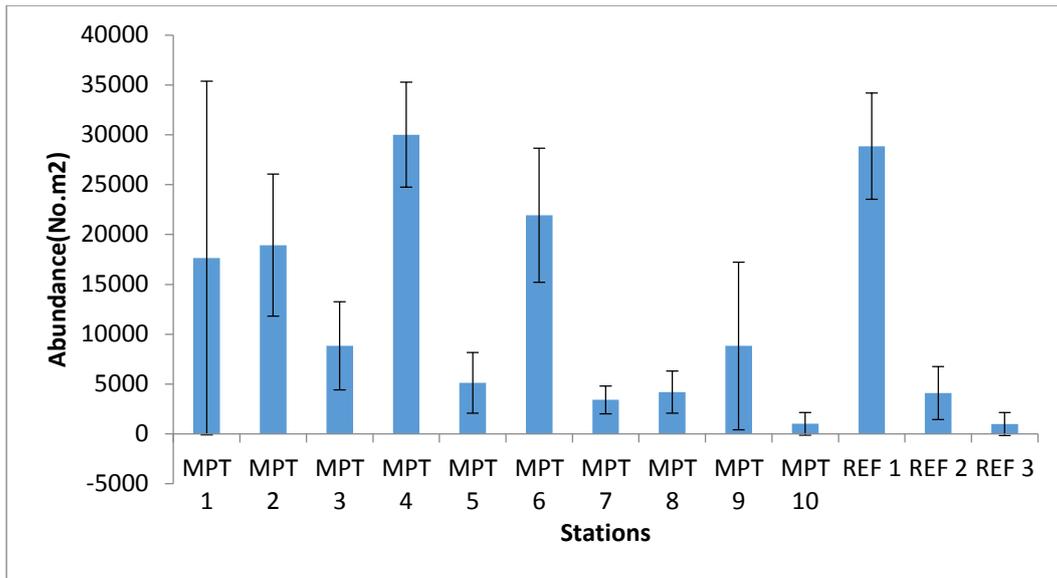


Figure-4.9: Macrofaunal abundance (No/m²) at various sampling stations

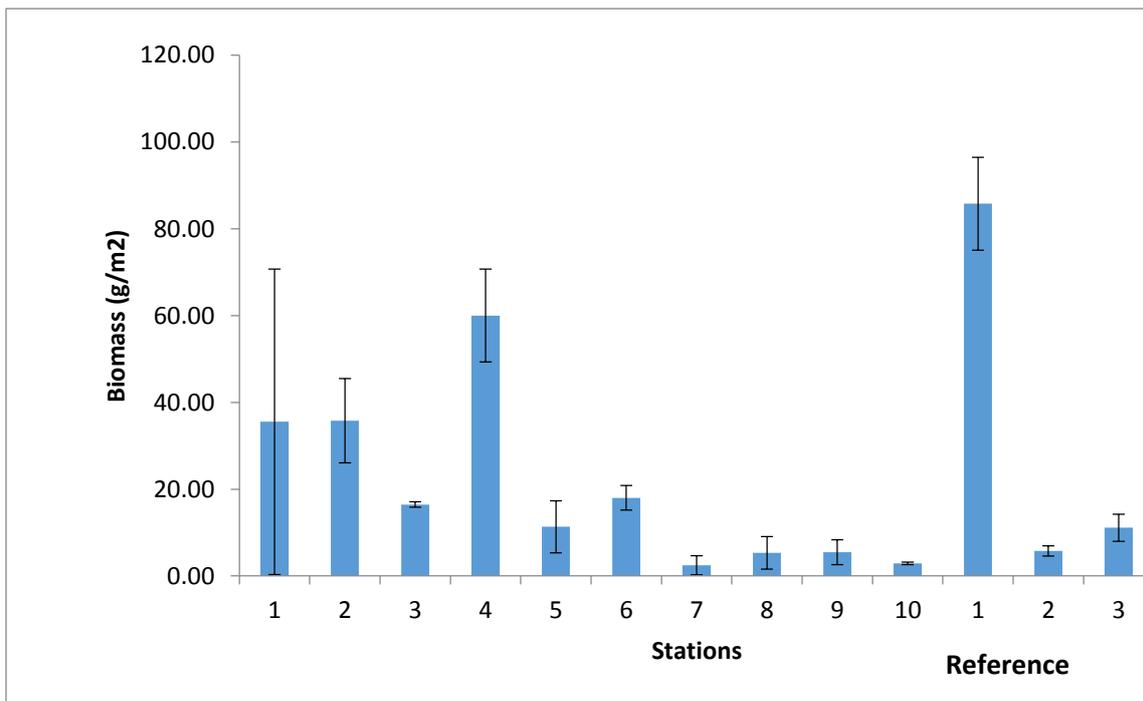


Figure-4.10. Macrofaunal biomass (wet wt. g/m²) at various sampling stations

Table-4.36: Macrofaunal diversity Indices of the Dredging area

Station		Diversity Indices							
		S	N	d	J'	Brillouin	Fisher	H'(loge)	1-Lambda'
Dredging area	MPT 1	7	35298	0.573	0.4461	0.8676	0.6413	0.8681	0.4965
	MPT 2	20	37873	1.802	0.3458	1.034	2.034	1.036	0.3926
	MPT 3	11	26507	0.9818	0.5377	1.288	1.089	1.289	0.6111
	MPT 4	9	60029	0.7271	0.1765	0.3875	0.8019	0.3879	0.1497
	MPT 5	15	10256	1.516	0.6031	1.629	1.726	1.633	0.7194
	MPT 6	7	43867	0.5613	0.3035	0.5902	0.6275	0.5906	0.2908
	MPT 7	5	6838	0.453	0.242	0.3881	0.528	0.3895	0.1791
	MPT 8	10	8392	0.9961	0.6455	1.484	1.121	1.486	0.6911
Average		10.50	28632.50	0.95	0.41	0.96	1.07	0.96	0.44

Table-4.37: Macrofaunal diversity indices at the dumping area

Station		Diversity Indices							
		S	N	d	J'	Brillouin	Fisher	H'(loge)	1-Lambda'
Dumping Ground	MP T 9	5	26507	0.3927	9.753E-2	0.1567	0.4557	0.157	5.267E-2
	MP T 10	4	2042	0.3936	0.7699	1.059	0.4785	1.067	0.5835
Average		4.50	14274.50	0.39	0.43	0.61	0.47	0.61	0.32

Table-4.38: Macrofaunal diversity indices at reference site

Station		Diversity Indices							
		S	N	d	J'	Brillouin	Fisher	H'(loge)	1-Lambda'
Reference Site	RF 1	19	57720	1.642	0.4623	1.36	1.835	1.361	0.5896
	RF 2	15	12299	1.487	0.5881	1.589	1.686	1.593	0.6605
	RF 3	7	1998	0.7895	0.5721	1.106	0.9097	1.113	0.5217
Average		13.7	24005.7	1.3	0.5	1.4	1.5	1.4	0.6

4.3.5 Coral

To study the diversity of corals around Grande Island, Goa, underwater surveys were conducted at six stations around Grande Island (Figure-4.11). The area was divided into two zones: shallow (<3.5m) and deep (>3.5m) water and Line Intercept Transect (LIT) (English et al., 1997) Two 20 meter transects were placed parallel to the shore

at each study site photographs and videography were conducted along the transects. Coral identification, abundance, and density recorded underwater using measuring tape and underwater slates. The Grande Island an uninhabited island located at a distance of ~7.0km from the dredging area/channel is home for >20 coral species, >80 reef associated fishes, >10 sponge species; 15 seaweed species and other mega-invertebrates and associated fauna.



Figure-4.11: Study Station in Grand Island

4.3.6 Seaweeds

Seaweeds are the primary producers of marine ecosystem and have wider utility in agrichemicals, cosmetics, biomaterials, energy molecules in addition to their conventional utilization as edible food, feed ingredients and hydrocolloids. Macrophytes including seaweeds, seagrass and mangroves act as blue-carbon sink as they capture atmospheric CO₂, sequester and store it in live tissue or sediment for longer durations. The continuous exploration of seaweeds for various chemicals of immense commercial value has significantly expanded their utility in agrichemicals, cosmetics, biomaterials, bioenergy and their long standing conventional utilisation as food, feed and hydrocolloids (Bixler & Porse, 2011; Holdt & Kraan, 2011).

The extensive surveys were made by Agadi and Untawale (1978), Dhargalkar (2008) and Pereira et. al (2014) to study the Seaweeds in Goa. The data compiled from

previous reports, has reported the existence of 98 species from the study area (Figure-4.12). Of these, 39 species belonging to Rhodophyta, followed by 31 species of Pheoophyta and 28 species of Chlorophyta. Total 24 species were recorded by Agadi and Untawale in 1978, 32 species were recorded by Dhargalkar (2008) and the highest number of species i.e.70 were recorded by Pereira et. al during 2014. The re-assessment of seaweed biodiversity in present study revealed the presence 40 species. Among them, 14 species were from Chlorophyta and 13 from Phaeophyta and 13 from Rhodophyta. This survey is initiated in April 2016 (Pre-monsoon) and October to December 2016 (Post-monsoon). The existence of these many species clearly indicates the supportive environment at the site for seaweed sustenance and growth. The details of seaweed species reported in various studies area given in Table-4.39.

The prevailing development of coastlines for various industrial activities like dredging, tourism etc can least serious impacts on seaweed diversity and other trophic levels disturbing the community structure and on large scale the marine ecosystem. Increased dredging events over the coasts for developments may have high negative impact by disturbing the community structure at both sub-tidal and inter-tidal levels.

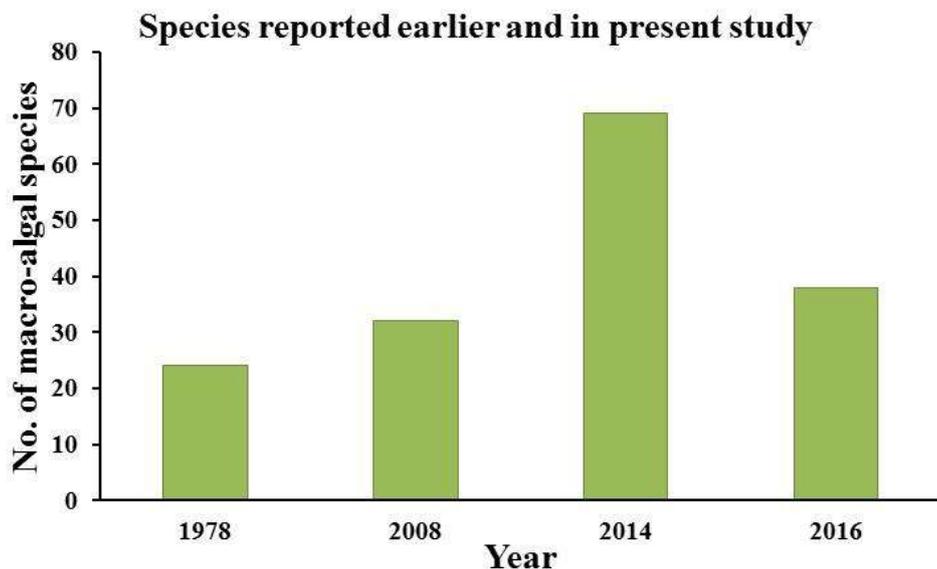


Figure-4.12: Record of macroalgal species from the Dona Paula Coast

Table-4.39: List of seaweed species reported previously and in present study

S. NO	Species	Year 1978 Agadi & Untawale)	Year 2008 (Dhargalkar)	Year 2014 (Pereira et al.)	Year 2016
	Rhodophyta				
1	<i>Acanthophoramuscoides (Linnaeus) Bory de Saint-Vincent</i>			✓	✓
2	<i>Acanthophoraspicifera (M. Vahl) Børgesen</i>	✓		✓	
3	<i>Aglaothamniontenuissimum (Bonnemaison) Feldmann-Mazoyer</i>			✓	
4	<i>Ahnfeltiaplicata (Hudson) E.M.Fries</i>	✓		✓	
5	<i>Amphiroafragilissima (Linnaeus) J.V.Lamouroux</i>		✓	✓	✓
6	<i>Antithamnioncruciatum (C.Agardh) Nägeli</i>			✓	
7	<i>Caloglossaleprieurii (Montagne) G.Martens</i>		✓	✓	✓
8	<i>Catenellarepens(Lightfoot) Batters</i>		✓		✓
9	<i>Centrocerasclavulatum (C.Agardh) Montagne</i>		✓	✓	✓
10	<i>CeramiumcimbricumH.E.Petersen</i>		✓	✓	✓
11	<i>Ceramiumfastigiatum Harvey</i>		✓		
12	<i>Chondracanthusacicularis (Roth) Fredericq</i>			✓	✓
13	<i>Chondriacapillaris (Hudson) M.J.Wynne</i>			✓	
14	<i>Crouaniaattenuata (C.Agardh) J.Agardh</i>			✓	
15	<i>Dasyaocellata (Grateloup) Harvey</i>			✓	
16	<i>Galaxauramarginata (Ellis &Solander) J.V.Lamouroux</i>				
17	<i>Galaxaurarugosa (J.Ellis&Solander) J.V.Lamouroux</i>		✓		
18	<i>Gastrocloniumcompressum (Hollenberg)</i>			✓	

S. NO	Species	Year 1978 Agadi & Untawale)	Year 2008 (Dhargalkar)	Year 2014 (Pereira et al.)	Year 2016
	<i>C.F.Chang&B.M.Xia</i>				
19	<i>Gayliellaflaccida (Harvey ex Kützing)</i> <i>T.O.Cho&L.J.Mclvor</i>			✓	
20	<i>Gelidiumpusillum (Stackhouse) Le Jolis</i>		✓	✓	✓
21	<i>Gracilariacorticata (J.Agardh) J.Agardh</i>	✓	✓	✓	✓
22	<i>Grateloupiafilicina (J.V.Lamouroux)</i> <i>C.Agardh</i>		✓	✓	
23	<i>Hildenbrandiarubra (Sommerfelt) Meneghini</i>			✓	
24	<i>Hypneamusiformis (Wulfen) J.V.Lamouroux</i>	✓	✓	✓	✓
25	<i>Hypneaspinella (C.Agardh) Kützing</i>			✓	✓
26	<i>Hypneavalentiae (Turner) Montagne</i>		✓	✓	✓
27	<i>Hypoglossumhypoglossoides (Stackhouse)</i> <i>F.S.Collins& Hervey</i>			✓	
28	<i>Janiarubens (Linnaeus) J.V.Lamouroux</i>		✓	✓	
29	<i>Laurenciapapillosa (C.Agardh) Greville</i>	✓			
30	<i>Lithophyllumorbiculatum (Foslie) Foslie</i>			✓	
31	<i>Martensiafragilis Harvey</i>	✓			
32	<i>Pterocladiacapillacea (S.G.Gmelin) Bornet</i>				✓
33	<i>PolysiphoniaatlanticaKapraun&J.N.Norris</i>			✓	
34	<i>Polysiphonia denudate (Dillwyn) Greville</i>			✓	
35	<i>Polysiphoniavariegata (C.Agardh) Zanardini</i>	✓			
36	<i>PorphyravietnamensisT.Tanaka& Pham- HoÁ ng Ho</i>		✓	✓	
37	<i>RhodymeniaaustralisSonder</i>	✓			
38	<i>Scinariafurcellata - Scinaiafurcellata (Turner)</i>	✓			

S. NO	Species	Year 1978 Agadi & Untawale)	Year 2008 (Dhargalkar)	Year 2014 (Pereira et al.)	Year 2016
	<i>J.Agardh</i>				
39	<i>Wrangeliargus (Montagne) Montagne</i>			✓	
	Chlorophyta				
40	<i>Boodleacomposita (Harvey) F.Brand</i>			✓	✓
41	<i>Bryopsisplumosa (Hudson) C.Agardh</i>	✓			✓
42	<i>Bryopsisishypnoides J.V.Lamouroux</i>		✓		
43	<i>Caulerpapeltata J.V.Lamouroux</i>			✓	
44	<i>Caulerpascalpelliformis (R. Brown ex Turner) C. Agardh</i>		✓		✓
45	<i>Caulerpasertularioides (S.G.Gmelin) M.A.Howe</i>		✓	✓	
46	<i>Caulerpaverticillata J. Agardh</i>		✓	✓	✓
47	<i>Chaetomorpha media (C. Agardh) Kutzing</i>	✓			
48	<i>Chaetomorpha spiralis Okamura</i>			✓	✓
49	<i>Chlorodesmishildebrandtii A.Gepp&E.S.Gepp</i>			✓	✓
50	<i>Cladophoraglomerata (L.) Kützing</i>			✓	
51	<i>Cladophoraherpestica (Montagne) Kützing</i>			✓	
52	<i>Cladophoraprolifera (Roth) Kützing</i>	✓		✓	
53	<i>Cladophorasaracenic Børgesen</i>			✓	
54	<i>Cladophorasocialis Kützing</i>			✓	✓
55	<i>Cladophoropsissundanensis Reinbold</i>			✓	✓
56	<i>Codiumelongatum (Turner) C.Agardh</i>	✓			
57	<i>Codiumindicum S.C.Dixit</i>		✓		
58	<i>Rhizocloniumriparium (Roth) Harvey</i>			✓	✓
59	<i>Rhizocloniumtortuosum (Dillwyn) Kützing</i>			✓	

S. NO	Species	Year 1978 Agadi & Untawale)	Year 2008 (Dhargalkar)	Year 2014 (Pereira et al.)	Year 2016
60	<i>Ulva clathrata</i> (Roth) C.Agardh			✓	✓
61	<i>Ulva compressa</i>				✓
62	<i>Ulva conglobata</i> Kjellman			✓	
63	<i>Ulva fasciata</i> Delile	✓			✓
64	<i>Ulva flexuosa</i> Wulfen			✓	✓
65	<i>Ulva intestinalis</i> Linnaeus	✓		✓	
66	<i>Ulva lactuca</i> Linnaeus		✓	✓	✓
67	<i>Struvea anastomosans</i> (Harvey) <i>Piccone & Grunow ex Piccone</i>		✓		
	Phaeophyta				
68	<i>Canistrocarpus cervicornis</i> (Kützinger) De Paula & De Clerck				✓
69	<i>Chnoospora minima</i> (Hering) Papenfuss				✓
70	<i>Colpomenia sinuosa</i> (Mertens ex Roth) <i>Derbès & Solier</i>	✓	✓	✓	
71	<i>Dictyopteria australis</i> (Sonder) Askenasy	✓	✓		
72	<i>Dictyopteria divaricata</i> (Okamura) Okamura		✓		
73	<i>Dictyotacilliolata</i> Sonder ex Kützinger			✓	
74	<i>Dictyotadichotoma</i> (Hudson) J.V.Lamouroux	✓	✓	✓	✓
75	<i>Dictyotadumosa</i> Børgesen	✓			
76	<i>Dictyotapinnatifida</i>				✓
77	<i>Feldmannia irregularis</i> (Kützinger) G.Hamel			✓	
78	<i>Hincksia mitchelliae</i> (Harvey) P. Silva			✓	
79	<i>Iyengaria stellata</i> (Børgesen) Børgesen			✓	
80	<i>Padina antillarum</i> (Kützinger) Piccone			✓	

S. NO	Species	Year 1978 Agadi & Untawale)	Year 2008 (Dhargalkar)	Year 2014 (Pereira et al.)	Year 2016
81	<i>Padinagymnospora (Kützing) Sonder</i>			✓	✓
82	<i>Padinapavonica (Linnaeus) Thivy</i>			✓	✓
83	<i>Padinatetrastromatica Hauck</i>	✓	✓		✓
84	<i>Ralfsiaverrucosa (Areschoug) Areschoug</i>			✓	
85	<i>Sargassumcinctum J. Agardh</i>		✓	✓	✓
86	<i>Sargassumcinereum J. Agardh var. berberifoliumBørgesen</i>			✓	
87	<i>SargassumcrassifoliumJ.Agardh</i>				
88	<i>SargassumglaucescensJ.Agardh</i>			✓	
89	<i>Sargassumilicifolium (Turner) C.Agardh</i>	✓	✓	✓	✓
90	<i>SargassumplagiophyllumC.Agardh</i>		✓		
91	<i>SargassumpolycystumC.Agardh</i>		✓	✓	
92	<i>SargassumprismaticumV.D.Chauhan</i>			✓	
93	<i>Sargassumtenerrimum J. Agardh</i>	✓	✓	✓	✓
94	<i>SpatoglossumaspermumJ.Agardh</i>	✓	✓	✓	✓
95	<i>SphacelariarigidulaKützing</i>			✓	✓
96	<i>Stoechospermummarginatum (C.Agardh) Kützing</i>	✓			
97	<i>Stoechospermumpolypodioides (J.V.Lamouroux) J.Agardh</i>			✓	
98	<i>VaucherialongicaulisHoppaugh</i>			✓	✓



4.4 FISHERIES

4.4.1 Fish and Shell Fish

Various fish and shellfish species occurred during trawl sampling along with their common and scientific names are listed in Table-4.40. A total of 40 species of fin fishes and shell fishes were collected during October 2016 in inner harbour area of MPT, while 31 species were collected in December 2016. Overall 812 fish and shellfish individuals belonging to 31 species, 26 genera and 18 families were collected from experimental fishing at inner harbour area of MPT. The fish assemblage in terms of biomass (Table-4.41) was dominated by the members of the families Portunidae (47.62%), Leiognathidae (16.69%), Platycephalidae (9.78%), Penaeidae (8.35%), Ariidae (7.56%) and Sciaenidae (4.73). Families such as Sillaginidae and Cynoglossidae typical of inshore fish community contributed about 5.6%. The Occurrence of fish and shell fish species during October 2016 and December 2016 is depicted in Table 4.42.

Table-4.40: Fish and shell fish species reported from the study area

Families	Species	Common name	Vernacular name	Habitat class
Hemiscylliidae	<i>Chiloscyllium griseum</i>	Bamboo shark	Pader/ Sunyaro	Demersal
Ariidae	<i>Arius jella</i>	Blackfin Sea catfish	Sangot	Demersal
	<i>Arius maculates</i>	Spotted catfish	Sangot	Demersal
Platycephalidae	<i>Platycephalus indicus</i>	Papillose flathead	Buyar	Demersal
Gerreidae	<i>Gerres erythrourus</i>	Deep-bodied mojarra	Shetuk	Demersal
Sillaginidae	<i>Sillago sihama</i>	Silver whiting	Muddoshi	Demersal
Leiognathidae	<i>Secutor insidiator</i>	Pugnose pony fish	Kapi	Demersal
	<i>Secutor ruconius</i>	Deep pugnose pony fish	Kapi	Demersal
	<i>Eubleekeria</i>	Splendid pony fish	Kapi	Demersal

Families	Species	Common name	Vernacular name	Habitat class
	<i>splendens</i>			
Sciaenidae	<i>Johnius carouna</i>	Caroun croaker	Dhodiya	Demersal
Trichiuridae	<i>Trichiurus lepturus</i>	Ribbon fish	Baye	Pelagic
Cynoglossidae	<i>Cynoglossus arel</i>	Sole fish	Lepo	Demersal
Paralichthyidae	<i>Pseudorhombus malayanus</i>	Malayan flounder	Bhogas	Demersal
Penaeidae	<i>Penaeus monodon</i>	Tiger shrimp	Vaghi	Demersal
	<i>Fenneropenaeus merguensis</i>	Banana shrimp	Safed sungat	Demersal
	<i>Marsupenaeus japonicus</i>	Kurma shrimp	Sungat	Demersal
	<i>Metapenaeus affinis</i>	Brown shrimp	Sungat	Demersal
	<i>Metapenaeus dobsonii</i>	Flower tail shrimp	Sungat	Demersal
	<i>Meapeaneus monoceros</i>	Brown shrimp	Sungat	Demersal
Portunidae	<i>Portunus sanguinolentus</i>	Tree spot swimming crab	Tin doyanchi kurli	Demersal
	<i>Portunus pelagicus</i>	Blue swimming crab	Padyachi kurli	Demersal
	<i>Charybdis feriatus</i>	Crucifix crab	Khrusachi kurli	Demersal
Squillidae	<i>Oratosquilla quinquentata</i>	Mantis shrimp	Luchi	Demersal
Loliginidae	<i>Loligo duvauceli (Juv.)</i>	Indian squid	Manki	Demersal
Sepiidae	<i>Sepia sp. (Juv.)</i>	Cuttle fish	Bebo	Demersal
Naticidae	<i>Natica tigrina</i>	Tiger moon shell	Congo	Demersal
Melongenidae	<i>Hemifusus pugilinus</i>	Sea snail	-	Demersal
Turritellidae	<i>Turritella acutangula</i>	Screw shell	Congali	Demersal

Families	Species	Common name	Vernacular name	Habitat class
Babyloniidae	<i>Babylonia spirata</i>	Whelks	-	Demersal
Conidae	<i>Conus sp.</i>	Cone shell	-	Demersal
Rhizostomatidae	<i>Rhopilema spp.</i>	Jelly fish	Zar	Pelagic

Juv. = Juveniles

Table-4.41: Biomass (kg km⁻²) and relative density (individual no. /km⁻²) of fish and shellfish species from the study area

Families	Species	Biomass	Relative density
Ariidae	<i>Arius jella</i>	11.02	180
	<i>A. maculates</i>	14.51	300
Platycephalidae	<i>Platycephalus indicus</i>	33.06	360
Sillaginidae	<i>Sillago sihama</i>	12.53	540
Leiognathidae	<i>Secutor insidiator</i>	8.42	4736
	<i>S. ruconius</i>	28.79	12950
	<i>Eubleekeria splendens</i>	19.16	9233
Sciaenidae	<i>Johnius carouna</i>	16.00	360
Cynoglossidae	<i>Cynoglossus arel</i>	6.40	1379
Penaeidae	<i>Fenneropenaeus merguensis</i>	3.08	240
	<i>Metapenaeus affinis</i>	17.83	2578
	<i>M. dobsonii</i>	4.38	899
	<i>M. monoceros</i>	2.92	1679
Portunidae	<i>Portunus sanguinolentus</i>	48.22	659
	<i>P. pelagicus</i>	34.83	420
	<i>Charybdis feriatus</i>	77.75	1259
Total biomass (kg km⁻²)		338.9	
Total No. of species (No. km⁻²)		37769	

Table-4.42: Occurrence of fish and shell fish species

S. No	Species Name	October 2016	December 2016
1	<i>Chiloscyllium griseum</i>	-	+
2	<i>Secutor insidiator</i> *	+	+
3	<i>Secutor ruconius</i> *	+	+
4	<i>Eubleekeria splendens</i> *	-	+

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S. No	Species Name	October 2016	December 2016
5	<i>Arius jella</i> *	+	+
6	<i>Arius maculatus</i> *	+	+
7	<i>Johnius carouna</i> *	+	+
8	<i>Alepes kleinii</i> *	+	-
9	<i>Alectis indicus</i> *	+	-
10	<i>Ambassis gymnocephalus</i>	+	-
11	<i>Sillago sihama</i> *	-	+
12	<i>Trichiurus lepturus</i> *	+	+
13	<i>Polydactylus plebeius</i> *	+	-
14	<i>Pampus argenteus (juv.)</i> *	+	-
15	<i>Lactarius lactarius</i> *	+	-
16	<i>Trypauchen vagina</i> *	+	-
17	<i>Pellona ditchela</i>	+	-
18	<i>Illisha melastoma</i> *	+	-
19	<i>Thryssa dussumieri</i>	+	-
20	<i>Thryssa malabarica</i> *	+	-
21	<i>Sardinella fimbriata</i> *	+	-
22	<i>Portunus sanguinolentus</i> *	+	+
23	<i>Portunus pelagicus</i> *	+	+
24	<i>Charybdis feriatus</i>	+	+
25	<i>Scylla serrata</i> *	+	-
26	<i>Penaeus monodon</i> *	+	+
27	<i>F. merguensis</i> *	+	+
28	<i>Marsupenaeus japonicas</i> *	-	+
29	<i>Metapenaeus affinis</i> *	+	+
30	<i>Metapenaeus dobsonii</i> *	+	+
31	<i>Oratosquilla quinqueidentata</i> *	+	-
32	<i>Pseudorhombus malayanus</i> *	-	+
33	<i>Cynoglossus arel</i> *	+	+
34	<i>Gerres erythrorurus</i>	-	+
35	<i>Sphyraena obtusata</i> *	+	-
36	<i>Loligo duvauceli</i> * (Juv.)	+	+
37	<i>Sepia sp.</i> * (Juv.)	+	+
38	<i>Enhydrina schistosa</i>	+	-
39	<i>Natica tigrina</i>	+	+
40	<i>Hemifusus pugilinus</i>	+	+
41	<i>Turritella acutangula</i>	+	+
42	<i>Leucosia sp.</i>	+	-



S. No	Species Name	October 2016	December 2016
43	<i>Matuta lunaris</i>	+	-
44	<i>Babylonia spirata</i>	+	+
45	<i>Pagurus sp</i>	+	-
46	<i>Conus sp.</i>	+	+
47	<i>Rhopilema spp.</i>	+	+

*commercially important, + present, - absent

4.4.2 Finfish distribution

With respect to finfish distribution, the following species namely *Pampus argentus*, *Ilisha striatula*, *Pampus chinensis*, *Hyporhamphus dussumieri*, *Scomberoides lysan*, *Lutjanus malabaricus*, *Harpadon nehereus*, *Cynoglossus lingua*, *Rastrelliger kanagurta*, *Cynoglossus arel* and *Carangoides caeruleopinnatus* were predominantly recorded nearby in and around Karwad fish landing center, which is located near Mormugoa port waters.

4.4.3 Conclusions

Dissolved Oxygen (DO) varied from 4.2 to 6 mg/l in monitoring carried out by Annamalai University in February 2015. While DO values were quite low both at the dredging (1.02-3.88 mg/l) and dumping (1.51-3.54 mg/l) sites as per NIO study carried out in October 2016.

A total of 43 species of phytoplankton were recorded by Annamalai University in February 2015. While 30 phytoplankton genera were identified in October 2016 (post-monsoon season) by NIO. Diatoms were the predominant group and only 2 species of dinoflagellates were observed. The dominant diatom genera encountered were *Coscinodiscus* and *Chaetoceros*.

At the secondary trophic level, the zooplankton community is considered as the chief index of utilization of aquatic biotope. Total 33 zooplanktons were identified by Annamalai University in February 2015 (Premonsoon season). Amongst zooplankton, calanoida were found to be the dominant group with 9 species. Larval forms came as next dominant group with 5 species. NIO recorded 20 zooplankton



groups in October 2016 (Post monsoon season). However, dominant group in both the studies was copepods. Decapod formed the common constituent of zooplankton both at the dredging and dumping sites. The zooplankton fauna included larval stages of commercially important shrimps. Fish eggs were very important component and formed up to 46%. NIO study indicates significant reduction in zooplankton abundance when compared with the baseline data collected in February 2015. The cause of reduction in zooplankton abundance may be due to the monitoring season and ongoing dredging operations at the time of survey.

Nematodes and Harpacticoid copepods were observed in all the meiobenthic samples collected within the dredging area.

Baseline data collected by CSIR-NIO reported 08 meiofaunal groups whereas WAPCOS reported presence of five meiobenthic taxa including harpacticoids during February 2015. Thus absence of all other meiofauna, except nematodes during the present study, with reduced population density underlines the relentlessness of dredging activity to meiobenthos.

Macrobenthic data abundance suggests increase in benthic abundance in May 2016 compared to February 2015 (NIO-COMAPS data). This may have been possibly due to the exposure of some of the infaunal groups due to the ongoing dredging. Abundance-Biomass Curves (ABC) calculated for all sampling stations also classify the study area as moderately stressed possibly due to ongoing dredging.

Seaweeds are the primary producers in marine ecosystem. The assessment of macrophytic diversity revealed the presence of 40 seaweed species at Dona Paula during the NIO study conducted in the month of October-November 2016. Among them, 14 species were from Chlorophyta and 13 from Phaeophyta and 13 from Rhodophyta. Presence of the main species clearly indicates that the intertidal and subtidal rocky area between Caboraj - Siridao is favourable for seaweed sustenance and growth. Thus, the rocky areas on either side of the MPT including Grande



Island (with 15 seaweed species) at can be considered as a seaweed rich resource sites.

The intertidal rocky areas between Caboraj and Siridao, at Chikalim- Sancole Bay and Grande Islands are rich in the seaweed and mangrove flora; corals and sponges, pelagic and demersal fishes and crustaceans. Moreover, cetaceans and turtles are sighted in the area occasionally. There is a regular commercial clam fishery at Chicalim- Sancole bay and at Naiuxim. Since the majority of the clam collectors are local fishermen who are largely dependent on the clam fishery the intertidal and subtidal area between Chicalim- Sancole and Nauxim bay may be considered as a “No Development Zone”.

Chicalim- Sancole Bay is rich in marine species and also considered as a ‘Hotspot’ of marine biodiversity and subtidal area between Chicalim- Nauxim bay in Zuari estuary is the only known bed of Windowpane Oyster, a schedule bivalve species, in Goa. Utmost care therefore should be taken to ensure that this oyster bed is provided necessary protection and kept away from any physical disturbance.

Molluscs (such as clams, oyster and cephalopods), crustaceans and fishes forms a valuable fish resource which is exploited by local fishermen communities throughout the year along the southern (Sancole- Chikalim Bay) and northern bank (Curka- Nauxim- Siridao rocky area) of the Zuari estuary. Being an edible renewable natural resource, necessary protection needs to be provided to promote traditional fishing by public consultations and if necessary, through environmental restoration and protection and Conservation measures.

The main principle of environmental management is to ensure that the disturbance due to dredging is kept at minimum and within the assimilative capacity of the affected environment. This has to be done by integrating action plan for mitigating predicted adverse impacts and should be done on regular basis through



comprehensive environmental monitoring with seasonal (pre-monsoon and post-monsoon) investigations.

Nutrients such as phosphate released from the bottom churning of the sediments during dredging will increase the frequency of surface phytoplankton blooms that may clog the membranes of filter feeding zooplankton and larval fish.

From the spatial trend of chl *a* values in the study area, there seem to be short term effects on the biota in terms of decreased chlorophyll in bottom waters due to light attenuation due to turbidity.

Since dredging removes material and dumps it away at another site, there are chances of meso-zooplankton being affected and or buried elsewhere, thus affecting the diversity in the water column.

4.4.4 Fisheries in Goa

The fisheries sector has provided the direct and indirect employment to the people, providing fish for the local consumption and contributing to the the economy of the state through the fish export. Goa has two kinds of fisheries, namely Inland fisheries and Marine fisheries. As per the Marine Fisheries census 2010 (Goa) Published by Ministry of Agriculture & CMFRI, there are 7 fishing taluka and 39 fishing villages in Goa, of which 23 villages falls in North Goa and 16 villages are in South Goa.

Inland Fisheries

Inland Fisheries of Goa are one of the richest source spread over 250 kms. Inland water tank in Goa has an area of 100 ha. Inland fisheries are divided into two types, that is, Brackish and Fresh water fisheries. Brackish water fisheries include extensive estuaries or river mouth, a large number of lagoons, back waters and brackish water lakes, etc. The total contribution of inland fisheries in Goa is about 4%.



Marine Fisheries

Marine Fishery Resources comprising of coastline of maximum 104 kilometers. It is a broken coastline characterized by numerous bays and head lands. Groups of oceanic Islands with numerous creeks, mangroves, swamps and coral reefs are believed to be extensive. The list of species reported from marine and inland Goa waters is given in Table-4.43.

Table-4.43: Different species reported from Goan Waters

List of Marine (Sea) Species	List of Inland (River/Creek)Species
Mackerels(Bangdo)	Prawns(Sungtam)
Oil Sardins(Tarle)	Lady fish(Muddoshi)
Other Sardins(Pedve)	Mulletts (Shevto)
Prawns(Sungtam)	Gerres (Shetki)
Seer fish(Viswan)	Lutianus(Tamso)
Shark (Mori)	Cat fish(Sangot)
Skates(Fadke)	Anchovy (Motialli)
Rays (Vagolem)	Pearl spot(Kalunder)
KowalaCoval(Velli)	Betki (Channok)
Golden Anchovy(Kapsale)	Milk Fish(Gholsi)
Cat fish(Sangot)	Megalops(Keri)
Sciaenoids(Dodiario)	Scatophagus(Mutre)
Butter fish(Saundale)	Ambasis(Burante)
Jew fish(Ghol)	Crabs(kurlio)
Indian Salmon(Rawao)	Black water Clams(kubye)
Silver belly(kampi)	False Clams(Tisrio)
Lobster(Shivod)	Oysters(Kalwam)
Soles(Lepo)	Mussel(Xinanee)
Silver Bars(karli)	Lepo
Pomfrets(Paplet)	Indian salmon
Lady fish(Muddoshi)	Balle Reddish
Mulletts (Shevto)	Others (Pedve, Saundale)
Caranx(Tonki, Concoretc)	
Others Clupeids	
Bombay Duck(Bombil)	
Sepia(Manki)	
Perches(Gobro)	
Crabs(Kurlio)	
Ambasis (Burante)	

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List of Marine (Sea) Species	List of Inland (River/Creek)Species
Ribbon fish(Balle)	
Herrings	
Tunafish	
Horse Mackerals	
Leather Jacket (Diana)	
Indian Shad	

4.4.5 Fish Landing Centers

Proposed project is located in South Goa, which has one major, 3 medium and 4 minor fish landing Centers. Three fish landing centers of North Goa also falls with in the study area of the proposed project. Inland fish landing centers are present only in the Tiswadi Taluaka of the study area. The details of marine fish landing centers in Goa are given in Tables-4.44.

Table-4.44: Marine fish landing centre in the study area

S.No.	District	Fish Landing Centre
1	North Goa	Siridao
		Nauxi
		Dauna Paula
2	South Goa	Khari wada, Vasco
		Baina
		Bogmalo

Source: Directorate of Fisheries, Government of Goa

As per the fish landing data collected from the department of fisheries, Government of Goa. Kharivada, Vasco is the largest fish landing centre in the study area. The details of fish catch recorded by the department of fisheries at different fish Landing Centers in the study area from 2013 to 2015 are given in Tables-4.45 and 4.46.

Table-4.45 : Fish catch at different Fish Landing Centers in the Study Area (South Goa) (Unit: in tonnes)

S. No	Species	Khari wada			Baina			Bogmalo		
		2013	2014	2015	2013	2014	2015	2013	2014	2015
1	Mackerals (Bangdo)	6465	2668	3711	150	339	186	17	97	16
2	Sardines(Tarlo)	4056	6022	7325	273	141	116	11	89	9
	Other sardines	0	0	1463		0	78	0	0	7
3	Catfish(Sangot)	143	195	67	0	0	28	0	0	0
4	Shark fish (Mori)	0	12	6	9	2	7	2	0	1
5	Seer fish (Wiswan)	81	98	114	14	14	23	3	5	2
6	Prawns (Sungtam)	1811	2312	1539	39	203	30	10	36	17
7	Pomfrets(Pap let)	102	18	120	2	5	76	0	0	0
8	Cuttle fish (Manki)	622	192	88	24	11	5	6	4	5
9	Tuna(Bokdo)	473	29	469	0	1	0	0	0	9
10	Ribbon fish (Balle)	119	18	80	0	2	0	0	0	0
11	Reef Cod(Gobro)	129	28	0	4	3	0	1	1	0
12	Kowalakowal (Velli)	177	45	13	14	5	0	2	21	0
13	Golden Anchovy (Kapsale)	0	0	26	2	0	0	0	0	0
14	Silver Belly (kampi)	1125	292	501	56	36	87	14	42	7
15	Soles(Lepo)	651	510	357	44	45	74	6	2	14
16	Silver Bar(karli)	0	7	41	0	0	4	0	0	0
17	Crabs (kurlio)	268	281	145	18	13	75	7	5	14
18	Sciaenoids (Dodiaro)	343	495	201	45	32	51	14	3	1
19	Butter fish (Soundale)	160	274	158	18	28	51	7	0	1
20	Lady fish	0	0	8	0	0	0	0	0	0
21	Mullet	0	0	9	0	0	7	0	0	2
22	Carnix	0	0	2	0	0	6	0	0	0
23	Perches	0	0	0	0	0	2	0	0	0
24	Lobster	0	0	0	0	0	0	0	0	1
25	Thresdfin	0	0	17	0	0	0	0	0	0
26	Others	1188	1032	716	80	107	102	47	203	40
	Total	17913	14528	17176	369	987	1008	147	508	146

Source: Directorate of Fisheries, Government of Goa

Table-4.46 : Fish Catch at different Fish Landing Centers in the study area (North Goa) (Unit: tonnes)

S. No	Species	Siridao		Nauxi		Dauna Paula	
		2013	2014	2013	2014	2013	2014
1	Mackerals(Bangdo)	31	50	17	32	50	68
2	Sardines(Tarlo)	39	91	32	52	65	99
3	Catfish(Sangot)	5	6	0	8	2	2
4	Shark fish(Mori)	0	1	0	0	0	1
5	Seer fish(Wiswan)	0	1	0	0	0	0
6	Prawns(Sungtam)	21	42	27	50	67	89
7	Pomprets(Pap let)	0	1	0	0	0	2
8	Cuttle fish (Manki)	0	2	2	7	4	6
9	Tuna(Bokdo)	0	1	0	0	0	0
10	Ribbon fish (Balle)	0	0	0	0	0	0
11	Reef Cod (Gobro)	0	5	2	0	2	3
12	Kowalakowal(Velli)	15	56	22	21	32	41
13	Golden Anchovy (Kapsale)	0	0	1	0	4	0
14	SilverBelly(kampi)	0	5	1	—	2	1
15	Soles(Lepo)	6	15	6	23	25	22
16	Silver Bar(karli)	0	2	4	3	11	2
17	Crabs (kurlio)	7	45	33	52	28	47
18	Sciaenoids(Dodiario)	1	35	3	6	7	27
19	Butter fish (Soundale)	0	0	0	4	1	0
20	Others	47	68	38	63	76	78
	Total	172	426	188	321	376	488

The maximum sustainable yield (MSY) of fish production for Goa is computed at around 85000 tonnes per year (Monteiro 200) (Goan Fish Trail#28). The fish production in the State of Goa has crossed the MSY. Marine fish production during last 15 years have been analysed. Marine fish production during last 15 years have been analysed. The marine fish production of Goa in the average consolidation of five years in last fifteen years showed a total sustainable steady growth of 81638 tonnes during the period of 2001-05 to 99427 tonnes in 2011-2015 thereby giving a hike of 21.79%. The details of five year average marine fish catch in Goa for 15 years are



given in Table-4.17. Trend of specie-wise production of marine and inland fisheries during the period 2010 to 2015 in Goa is given in Table-4.47.

Table 4.47: Five year Marine Fish Catch at Goa for 15 years (Unit : MT)

Species	Average production 2001-2005	Average production 2006-2010	Average production 2011-2015
Mackerals(Bangdo)	9279	17564	14833
Sardines(Tarlo)	29149	28084	46094
Cat Fish(Sangot)	1475	1914	651
Shark Fish(Mori)	1432	1500	283
Seer Fish(Wiswan)	3857	3044	2039
Prawns(Sungtam)	5203	8986	8730
Pomprets(Paplet)	694	402	702
Cuttle Fish(Manki)	1340	1278	2100
Tuna(Bokdo)	1035	1634	3041
Ribbon Fish(BAlle)	3110	2134	628
Reef Cod(Gobro)	788	316	1033
KowalaKowal(velli)	482	416	589
Golden Anchovy (Kapsale)	57	18	23
Silver Belly(Kampi)	2885	2020	1743
Soles(Lepo)	2087	1844	3745
Silver Bar(Karli)	451	376	89
Crabs(Kurlio)	876	1009	1210
Sciaenoids(Dodiario)	2546	2141	1654
Butter Fish(Soundale)	491	926	707
Others	14401	13200	9533
Total	81,638	88,806	99,427

Source: Goan fish trails, Volume-III-2016, Department of Fisheries, Government of Goa



Table-4.48: Marine Fish Production of Goa for the Period from 2001 to 2014 (in tones)

S. No	Species	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1	Mackerals (Bangdo)	14204	8103	5779	6303	12006	12244	19980	16597	15169	23831	22128	17860	12994	10308	10876
2	Sardine (Tarlo)	21470	30951	30874	34203	28246	30558	28574	34062	23496	23732	26391	34329	31629	80849	57270
3	Cat fish (Sangot)	2436	1585	1007	1043	1303	2586	1821	1480	2279	1402	1545	364	383	598	367
4	Shark fish (Mori)	1211	1355	1571	1305	1716	988	1007	1019	1329	3159	375	234	281	307	216
5	Seer fish (Wiswan)	2746	1230	2274	3478	9556	3522	4407	3777	2285	1229	1844	1616	2751	1621	2363
6	Prawns (sungtam)	874	2299	6656	5586	10599	9065	8642	7458	9795	9970	8008	8968	8380	9283	9012
7	Pompretts (paplet)	859	500	825	568	720	446	559	534	284	185	376	174	1342	643	977
8	Cuttle fish (Manki)	2027	832	2029	1737	73	1919	330	2201	--	--	1012	1180	4422	2150	1737
9	Tuna (Bokdo)	198	669	1241	609	2459	589	1916	2095	1044	2524	3801	2621	3520	1368	3896
10	Ribbon fish (Balle)	291	2645	3178	3647	5791	5354	1368	2551	558	839	49	644	1107	376	966
11	Reef Cod (Gobro)	699	99	769	2371	--	--	--	276	--	--	5	495	1409	1262	1993
12	Kowalkowal (velli)	553	315	268	421	854	724	226	455	395	279	438	562	1046	618	282
13	Golden Anchovy (Kapsale)	68	129	63	9	17	30	3	57	0	2	0	50	29	2	33
14	Silver Belly (Kampi)	3818	3331	2740	2489	2046	3187	1664	1688	1976	1584	1012	1146	3328	1991	1240
15	Soles (Lepo)	1747	1682	2935	2016	2054	2339	1950	1795	1532	1606	3995	3683	2579	3982	4487
16	Silver Bar (Karli)	388	312	370	336	849	435	251	336	637	219	62	98	54	121	110
17	Crabs (Kurlio)	893	654	866	972	994	1092	819	1021	1349	763	1236	1160	830	1256	1568
18	Sciaenoids(Dodiario)	2451	1629	2806	2634	3211	2404	1938	2780	2207	1376	1448	1629	1425	1802	1966
19	Butter fish (Soundale)	790	287	439	340	598	892	615	655	1353	1116	978	656	594	676	630
20	Others	11663	8956	17066	14327	19995	17952	15115	7934	14999	13246	11482	9159	9881	8894	8251
	Total	69386	67563	83756	84394	103087	96326	91185	88771	80687	87062	86185	86628	87984	128107	108240

Source: Directorate of Fisheries, Government of Goa

4.4.6 Fishermen Population

The project study area consists of 10 fishing villages, of which 4 villages falls in Mramugao and 6 villages are in Tiswadi Taluka. As per the Marine Fisheries census 2010 (Goa) Published by Ministry of Agriculture & CMFRI, total of 405 fishermen families are registered in the study area. The study area has a total 2274 fishermen population. The details of fishermen population in the study area Taluka is given in Table-4.49.

Table-4.49: Fishermen population in Study Area Taluka

S.No	Name of Village	Fishermen Families	Traditional Fishermen Families	Fisherfolk population
	Taluk:Marmagoa			
1	Vasco-Da-Gama	45	45	262
2	Baina	71	69	421
3	Bogmalo	23	15	109
4	Velsao	66	66	348
	Taluk: Tiswadi			
5	Caranzalem	20	20	100
6	Dona-Paula	20	20	98
7	Nauxi	19	19	86
8	Odxel	26	26	155
9	Siridona	90	90	548
10	Agassaim	25	25	147
	Total	405	395	2274

Source: Directorate of Fisheries, Goa

Details of vesels/trawlers operating at major fish landing centers in Goa during 2014 and 2015 are summarized in Table- 4.50.

Table- 4.50: Details of vesels/trawlers

S.No.	Fish Landing Centre	No. of vessells	
		2014	2015
1	Chapora	43	49
2	Malim	277	278
3	Cutbona	285	279
4	Cortalim	4	2
5	Vasco	230	157
6	Talpona	4	-

Source: Goan Fish Trail Vol.III-2016, Directorate of Fisheries, Government of Goa

It is evident from Table-4.50, that there is decline in the number of vesels operating from Vasco.



4.5 OTHER ECOLOGICALLY SENSITIVE HABITATS

4.5.1 Corals and associated faunal assemblages

The nearest habitat of corals from the proposed site is Grand island located at 73⁰ 46' 46.605" E, 15⁰ 21' 0.636" N, which is about 7 km from the proposed site. The occurrence of coral reef in the Grade Island has been documented by researchers recently (Shesdev Patro et al., 2015). The study also concluded that the occurrence of the species in Grande Island as a new locational record and could not assess the impact on the reef due to lack of baseline data on the reef health. Shesdev Patro et al., 2015 reported the presence of *Carijoa riisei* at Grand Island.

4.5.2 Sea weed and Sea grass

The studies carried out by NIO indicates the presence of sea weed species in various parts of Goa. The studies carried out by Pereria and Almeida -2014, indicates the presence of sea weed species in various parts of Goa. However, only patchy distribution of seaweeds namely *Ulva fasciata*, *Gracilaria corticata*, *Hypnea valentiae* and *Padina tetrastomatica* were reported in the study area. Similarly, the sea grass species namely *Cymodocea serrulata* was reported in the study area. NIO has carried out the survey for about two years covering larger study area, while the present study is limited to the project influence area. During the present survey, no significant occurrence of sea grass and sea weed species are observed in the study area.

4.5.3 Turtle Nesting

Goa with a small coastal length of 120 km, records one of the earliest community based initiatives in sea turtle conservation, next to Kerala. Sporadic nesting of Olive Ridley and Leatherback turtles has been recorded all along the coast of Goa but recent nesting records are only of olive ridleys. Of the 120 km coastline, about 8 km in Goa have been identified as major nesting sites and are being protected by the Forest Department of the State Government of Goa. These sites are Morjim in north Goa, and Galgibaga and Agonda in south Goa. Nesting takes place between October and March each year. All the turtle nesting grounds are beyond 10 km radius or outside the study area of the project. The location of the turtle nesting grounds is given in the Table 4.51 and depicted in Figure 4.13.

Table 4.51: Location of Turtle Nesting Grounds in Goa

S. No.	Nesting Beach	Co-ordinates	
1.	Mandrem	15° 38' 57.25'N	73° 42' 55.04'E
2.	Ashvem	15° 38' 47.39'N	78° 43' 00.17'E
3.	Morjim	15° 36' 53.25'N	73° 44' 09.34'E
4.	Agonda	15° 02' 24.04 N	73° 59' 16.66'E
5.	Galgibaga	14° 57' 32.07 N	74° 02' 56.64 E

Galibaga is the southern most location of nesting range with a poor density. It is a fairly undulating shoreline with sparse vegetation and witnesses the nesting of turtles in the breeding season. Besides the four major locations mentioned above, the other coastal stretches that also witness the sporadic nesting are Mobor, Kavellossim, Colva, Majorda, Varca and Betalbatim. However they do not fall in the 10 km radius of the study area. The occurrence of other endangered species like Dugongs etc. was not found during the survey.

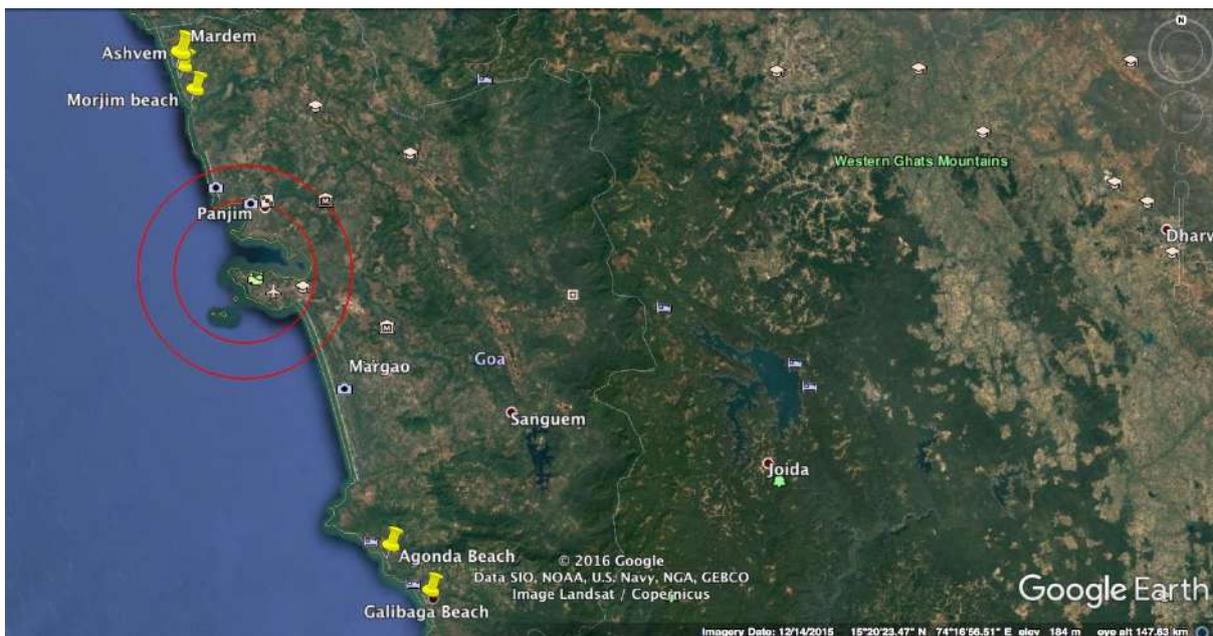


Figure-4.13 Turtle nesting grounds in Goa

4.5.4 Windowpane Oyster

The coastline of Goa is bestowed with a neumorous variety of flora fauna. The abundance of *Placuna placenta* (Linne) also called as windowpane oysters are found around the San Jacnito island and the same has been reported by many



researchers. There is a healthy population in the Chicalim Bay. They are highly assymetrical bivavle. Characteristically large, flat, thin, pearly, sub-orbicular, translucent shell with a mica-like appearance and are primarily a heterotrophic filter feeder (Campbell). Diet consists of plankton and free-floating detritus.

CHAPTER-5
ENVIRONMENTAL BASELINE STATUS-
TERRESTRIAL ECOLOGY



CHAPTER-5

ENVIRONMENTAL BASELINE STATUS – TERRESTRIAL ECOLOGY

5.1 INTRODUCTION

The State of Goa has 38.5 % of its land under forest cover, which is much higher than the national average. In absolute terms, 1,424.38 sq. km. of area is under forest, of which 1,224.38 sq. km. is government forest and 200 sq. km. is private forest. The physiography of the Goa district chiefly comprises of undulating terrain of Western Ghats in a series of hills with several off-shoots and spurs gradually merging in the west. The western ghat is the source of two prominent rivers in Goa viz. Mandovi and Zuari that flow off into the Arabian Sea near Panaji and Vasco-da-Gama. Forests are mostly confined to the eastern portion of the Western Ghats in the foothill slopes of Satari, Sanquem, and Canacona talukas. Scattered in patches are several private forests owned by the village communities, temples and private individuals.

5.2 FOREST TYPES IN PROJECT AREA DISTRICT

As per the classification of Champion and Seth 1968, following forest types can be observed in the South Goa district:

- Evergreen and Semi-Evergreen Forests
- Moist Deciduous Forest
- Littoral and Swamp Forest

Evergreen and Semi- Evergreen Forests

Along the north-eastern and south-eastern portions bordering Karnataka state, few evergreen and semi- evergreen vegetation occur in the deep gorges and ravines of Sanguem, Satari and Canacona talukas. On the precipitous aspect the tree growth is mostly stunted having low timber value. The commonly observed tree species are Babbi (*Calophyllum wightianum*), Jambul (*Syzygium cumuni*), Ambo (*mangifera indica*), Onval (*Mimusops elengi*), Otamb (*Ariocarpus lakoocha*), Patpanas (*Artocarpus hirsute*), Nag Gulum (*Mesua ferrea*), Hopea wightiana, Bhirand (*Garcinia indica*), Gulum (*Machilus Macarantha*), Chandodo (*Macaranga peltata*), Bhenoro (*Sterculia villosa*), Bibo (*Semecarpus anacardium*), Holigarna *arnottiana* and *Mallotus* sp. The undergrowth is comprised of *Colebrookea oppositifolia*, *Wendlandia* spp., *Triumfetta rhomboidea*, *Hemigraphis* spp., *Callicarpa tanata*, *Saulria indica*,



Ixora brachiata, *Woodfordia floribunda*, *Lobelia nicotianaefolia*. The common bamboos occurring in these forests are Velu (*Bambusa arundinacea*) and Kanaki (*Dendrocalamus strictus*). Bhet (*Calamus tannuas*) is the important cane of evergreen belt.

Moist Deciduous Forest

This type of forest occurs along the foot hill slopes of hill tract from north to south and spurs leading towards west. This type of forests is distributed in about 385 square kilometers, providing the timber and fuel wood requirement of the district. Natural teak is of sporadic occurrence in these forests. The prominent tree species in this zone are Maretha (*Terminalia crenulata*), Quinzol (*Terminalia paniculata*), Zambo (*Xylia xylocarpa*), Nano (*Lagerstroemia lanceolata*), Ghoting (*Terminalia belterica*), Sissoo (*Dalbergia latifolia*), Edu (*Adina Cardifolia*), Kalam (*Mitragyna parvifolia*), Karmal (*Dillenia pentagyna*), Assan (*Pterocarpus marsupium*) and Kusum (*Schleichera oleosa*).

In the understorey, common tree species found are Dhaman (*Grewia illiaefolia*), Shiras (*Albizzia lebbek*), Belati (*Albizzia procera*), Kanvanch (*Bridelia retusa*), Shivan (*Gmelina arborea*), Moi (*Lamnea coromandelica*), Bel (*Aegle marmelos*), Kadukavath (*Hydnocarpus laurifolia*), Malotus phillippinensis, Char (*Buchanania latifolia*), khair (*Acacia catechu*), Shanta Kudo (*Wrightia tinctoria*) and Mumeo (*Careya arborea*). The shrubby vegetation consists mostly of Galai (*Randia dumetorum*), Kevani (*Helicteres isora*), Karvi (*Strobilanthes callosus*), Jino (*Leea indica*), *Glycosmis pentaphylla*, *Ardisia solanacea*, *Ranbhendi* (*Urena lobatta*), Karvand (*Carissa carandas*), *Fleminhia congesta*, *Clerodendron infortunatum*, Nagur Cudo (*Holorrhena antihysenterica*) Karbel (*Murraya koenigii*) and *Tabernaemontana heynaena*. Also fern species of *Pteris*, *Selaginella* and *Ophiglossum* are seen on the moist forest floor. The common climbers of these forests are Ukshi (*Calycopteris floribunda*), Krishnasarva (*Ichnocarpus frutescens*) Ghotival (*Smilax spp.*) Shembi (*Caesalpinia sepiaria*), Vagati (*Wagatea spicata*) and *Caesalpinia nuga*. The ground flora represented by herbs and grasses.

Littoral and Swamp Forest

Littoral and Swampy forests can be further divided in three categories viz: Beach forest, Tidal or Mangrove forest and Fresh water swamp forest. The common plants of beach forests are *Casuarina equisetifolia*, *Callophyllum littoralis*, *Cocus nucifera*,



Manikara littoralis, *Thespesia sp*, *Spinifex littoreus* and number of twiners and climbers. Tidal or mangrove forest is predominant in the area. A luxuriant growth of mangrove and associated species can be observed along the estuaries and back water of the coastal region. Commonly observed species in this forest category are *Rhizophora mucronata*, *Acanthus ilicifolius*, *Avicennia officinalis*, *Sonneratia caseolaris*, *Kandelia candel* and associate species. The important plant species found in swamp forest are *Cephalanthus*, *Holoptelia sp*, *Murray sp*, *Cana sp* and variety of grasses.

5.3 VEGETATION COMPOSITION IN THE STUDY AREA

The vegetation composition at the proposed project area mainly consists of trees, shrubs and herbs. The tree components other than Mangroves occur with a composition of Phiramgisaro (*Casuarina equisetifolia*) Naal (*Cocos nucifera*), Oondi (*Calophyllum, inophyllum*), Ambo (*Mangifera indica*), Moi (*Lansea coromandelica*), Kaju (*Anacardium occidentale*), Bhendi (*Thespesia populinea*), Kudo (*Hollarhena antidysentric*), Nano (*Lagerstroemia lanceolata*), Onwal (*Mimusops elengi*), Jamun (*Syzygium cuminii*) and Zamba (*Xylia xylocarpa*) etc. The other associates such as shrubs are *Calycopteris floribunda*, *Ixora coccinea*, *Tabernamontana heyneana*, *Microcos paniculata*, *Derris trijoliata*, *Caesalpinia crista*, *Vitex negundo*, *Clerodendron inermi*, intermixed with herbs include *Achyranthes aspera*, *Malvastrum sp*, *Halophila beccarii*, *Sesuvium portulacastrum*, *Leucas aspera*, *Phylanudiflora*, *Arthrocnemum indicum*, *Melanthera biflora*, sedges like *Cyperus arenarius*, *Fimbristilis* and grasses with *Themeda triandra*, *Spinifex littorens*, *Digitariaa dscendens* etc. The list of floral species reported in South Goa Forest Division is enlisted in Table-5.1.

Table-5.1: Floral species recorded in South Goa Forest Division

Botanical Name	Common/Local Name	Family	Habit	IUCN Status
<i>Dendrocalamus strictus</i>	Mango	Poaceae	Bamboo	NA
<i>Dioscorea sp</i>	-	Dioscoriaceae	Climber	NA
<i>Mukia maderaspatana</i>	-	Cucurbitacea	Climber	NA
<i>Passiflora foetida</i>	Running pop	Passifloraceae	Climber	NA
<i>Smilax zeylanica</i>	Ghot vel or Kaval kamti.	Smilacaceae	Climber	NA
<i>Acrostichum aureum</i>	-	Pteridaceae	Fern	LC
<i>Cynodon dactylon</i>	Haryali	Poaceae	Grass	NA
<i>Dactyloctenium</i>	-	Poaceae	Grass	NA

Botanical Name	Common/Local Name	Family	Habit	IUCN Status
<i>aegyptium</i>				
<i>Digitaria adscendens</i>	-	Poaceae	Grass	NA
<i>Eragrostis uniloides</i>	-	Poaceae	Grass	NA
<i>Saccharum spontaneum</i>	-	Poaceae	Grass	LC
<i>Spinifex littoreus</i>	Saramto	Poaceae	Grass	NA
<i>Themeda triandra</i>	Karad	Poaceae	Grass	NA
<i>Achyranthes aspera</i>	Aghado	Acanthaceae	Herb	NA
<i>Ageratum conyzoides</i>	-	Asteraceae	Herb	NA
<i>Alternanthera sessilis</i>	-	Amaranthaceae	Herb	LC
<i>Arthrocnemum indicum</i>	-	Chenopodiaceae	Herb	NA
<i>Boerhavia diffusa L.</i>	Punnarva	Nyctaginaceae	Herb	NA
<i>Cyanotis axillaris</i>	-	Commelinaceae	Herb	LC
<i>Datura innoxia</i>	Datura	Solanaceae	Herb	NA
<i>Eclipta alba</i>	Mako	Asteraceae	Herb	LC
<i>Eichhornia crassipes</i>	-	Pontederiaceae	Herb	NA
<i>Elephantopus scaber</i>	-	Asteraceae	Herb	NA
<i>Halophila beccarii</i>	-	Hydrocharitaceae	Herb	Vu
<i>Hedyotis herbacea</i>	-	Rubiaceae	Herb	NA
<i>Hemidesmus indicus</i>	Dudhshiri	Asclepiadiaceae	Herb	NA
<i>Hyptis suaveolens</i>	-	Lamiaceae	Herb	NA
<i>Ipomea pes-caprae</i>	Maryadvel	Convolvulaceae	Herb	NA
<i>Justicia simplex</i>	-	Malvaceae	Herb	NA
<i>Launaea sarmentosa</i>	-	Asteraceae	Herb	NA
<i>Leucas aspera</i>	Tumbo	Lamiaceae	Herb	NA
<i>Malvastrum sp</i>	-	Malvaceae	Herb	NA
<i>Melanthera biflora</i>	-	Asteraceae	Herb	NA
<i>Mimosa pudica</i>	-	Mimosaceae	Herb	LC
<i>Mollugo oppositifolia</i>	-	Molluginaceae	Herb	NA
<i>Nymphaea nouchali</i>	KasturiSalak	Nymphaeaceae	Herb	LC
<i>Nymphaea pubescens</i>	KamalSalak	Nymphaeaceae	Herb	LC
<i>Ocimum omericanum</i>	Ramtulas	Lamiaceae	Herb	NA
<i>Phyla nudiflora</i>	-	Verbenaceae	Herb	NA
<i>Portulaca quadrifida</i>	Bhumygot	Portulacaceae	Herb	NA
<i>Sesuvium portulacastrum</i>	-	Aizoaceae	Herb	NA
<i>Sida acuta</i>	Bala, /Chikna	Malvaceae	Herb	NA
<i>Sida cordata</i>	-	Malvaceae	Herb	NA
<i>Tridax procumbens</i>	-	Asteraceae	Herb	NA
<i>Triumfetta rhomboidea</i>	Tupkati	Tiliaceae	Herb	NA
<i>Musa paradisiacal</i>	Keli	Musaceae	Large herb	NA

Botanical Name	Common/Local Name	Family	Habit	IUCN Status
<i>Cyperus pangorei</i>	-	Cyperaceae	Sedge	LC
<i>Cyperusarenarius</i>	-	Cyperaceae	Sedge	NA
<i>Azadirachta indica</i>	Aduso	Mimosaceae	Shrub	NA
<i>Ananas comosus</i>	Ananas	Annonaceae	Shrub	NA
<i>Caesalpinia sp.</i>	-	Caesalpiaceae	Shrub	NA
<i>Calamus sp.</i>	-	Arecaceae	Shrub	NA
<i>Calotropis gigantea</i>	Rui, Dhavirui	Asclepiaceae	Shrub	NA
<i>Calycopteris floribunda</i>	Uski	Combretaceae	Shrub	NA
<i>Cassia tora</i>	Taykhilo	Mimosaceae	Shrub	NA
<i>Clerodendron inermis</i>	Siritmari	Verbenaceae	Shrub	NA
<i>Colubrina asiatica</i>	-	Rhamnaceae	Shrub	NA
<i>Derris heterophylla</i>	-	Fabaceae	Shrub	NA
<i>Ixora coccinea</i>	Pitkoli	Rubiaceae	Shrub	NA
<i>Lantana camara</i>	-	Verbenaceae	Shrub	NA
<i>Leea indica</i>	Jino	Leeaceae	Shrub	NA
<i>Lobelia nicotianaefolia</i>	Baknal	Campanulaceae	Shrub	NA
<i>Microcos paniculata</i>	Asale, chivara	Malvaceae	Shrub	NA
<i>Moullava spicata</i>	Wagati	Caesalpiaceae	Shrub	NA
<i>Murraya koenigii</i>	Karphil, Karipatha	Rutaceae	Shrub	NA
<i>Phoenix loureirii</i>	-	Arecaceae	Shrub	NA
<i>Plumeria sp.</i>	-	Apocynaceae	Shrub	NA
<i>Randia deumatorum</i>	Gel	Rubiaceae	Shrub	NA
<i>Tabernaemontana heyneana</i>	Kudo	Apocynaceae	Shrub	NA
<i>Tephrosia purpurea</i>	-	Fabaceae	Shrub	NA
<i>Thespesia lampa</i>	Ran Bhendi	Malvaceae	Shrub	NA
<i>Thevetia peruviana</i>	-	Apocynaceae	Shrub	NA
<i>Vitex altissima</i>	Bavalgi	Verbenaceae	Shrub	NA
<i>Vitex negundo</i>	Limgud	Verbenaceae	Shrub	NA
<i>Ziziphus rugosa</i>	Churna	Rhamnaceae	Shrub	NA
<i>Ziziphus mauritiana</i>	Boram	Rhamnaceae	Shrub	NA
<i>Woodfordia floribunda</i>	-	Lythraceae	Shrub	NA
<i>Bambusa arundinacea</i>	Velu	Poaceae	Thorny bamboo	NA
<i>Acacia catechu</i>	Khair	Mimosaceae	Tree	NA
<i>Adenantha pavonia</i>	Gunj	Fabaceae	Tree	NA
<i>Adina cordifolia</i>	Haldu	Rubiaceae	Tree	NA
<i>Albizia lebbek</i>	Siras	Mimosaceae	Tree	NA
<i>Albizia odoratissima</i>	Kala Siras	Mimosaceae	Tree	NA
<i>Alstonia scholaris</i>	Saton	Apocynaceae	Tree	NA
<i>Anacardium occidentale</i>	Kaju	Anacardiaceae	Tree	NA
<i>Artocarpus heterophyllus</i>	Phanas	Moraceae	Tree	NA
<i>Bombax ceiba</i>	Savar	Bombacaceae	Tree	NA
<i>Borassus flabellifer</i>	Toddy palm	Arecaceae	Tree	En

Botanical Name	Common/Local Name	Family	Habit	IUCN Status
<i>Calapbyllus inophyllum</i>	Oondi	Calophyllaceae	Tree	NA
<i>Callophyllum inophyllum</i>	Undi	Callophyllaceae	Tree	NA
<i>Careya arborea</i>	Kumbiyo	Lecethidaceae	Tree	NA
<i>Carica papaya</i>	Papaya	Caricaceae	Tree	DD
<i>Caryota urens</i>	Billemad	Arecaceae	Tree	LC
<i>Cassia fistula</i>	Bayo	Caesalpiniaceae	Tree	NA
<i>Casuarina equisetifolia</i>	Phiramgisaro	Casuarinaceae	Tree	NA
<i>Ceasalpinia crista</i>	-	Caesalpiniaceae	Tree	NA
<i>Ceiba pentandra</i>	Savar	Bombacaceae	Tree	NA
<i>Cocos nucifera</i>	Naal	Arecaceae	Tree	NA
<i>Delonix regia</i>	Gulmohar	Caesalpiniaceae	Tree	LC
<i>Erythrina indica</i>	Pongaro.	Fabaceae	Tree	LC
<i>Ficus arnottiana</i>	Asti payr	Moraceae	Tree	NA
<i>Ficus asperrima</i>	Kharvat	Moraceae	Tree	NA
<i>Ficus bengalensis</i>	Vad	Moracea	Tree	NA
<i>Ficus glomerata</i>	Rumbad	Moraceae	Tree	NA
<i>Ficus racemosa</i>	-	Moraceae	Tree	NA
<i>Ficus religiosa</i>	Pipal	Moracea	Tree	NA
<i>Garcinia indica</i>	Bhiran	Clusiaceae	Tree	Vu
<i>Garunga pinnata</i>	Kakad	Burseraceae	Tree	NA
<i>Gmelina arborea</i>	Shivan	Verbenaceae	Tree	NA
<i>Grewia tillifolia</i>	Dhaman	Tiliaceae	Tree	NA
<i>Helicters isora</i>	Kivan	Malvaceae	Tree	NA
<i>Hibiscus tiliaceus</i>	Belipata	Malvaceae	Tree	NA
<i>Holigarnaarnottiana</i>	Ranbibo	Anacardiaceae	Tree	NA
<i>Hollarhena antidysentric</i>	Kudo	Apocynaceae	Tree	NA
<i>Holoptelia integrifolia</i>	Vavalo	Ulmaceae	Tree	NA
<i>Hopea wightiana</i>	Pay	Dipterocarpaceae	Tree	NA
<i>Lagerstroemia lanceolata</i>	Nano	Lythraceae	Tree	NA
<i>Lansea coromandelica</i>	Moi	Anacardiceae	Tree	NA
<i>Mallotus philippinensis</i>	Bems, Sendri.	Euphorbiaceae	Tree	NA
<i>Mangifera indica</i>	Ambo	Anacardiaceae	Tree	DD
<i>Manilkara hexandra</i>	Kirni	Sapotaceae	Tree	NA
<i>Mimusops elengi</i>	Onwal	Sapotaceae	Tree	NA
<i>Morinda citrifolia</i>	-	Rubiaceae	Tree	NA
<i>Polyalthia fragrans</i>	Miryo, Mirio	Annonaceae	Tree	NA
<i>Pongamia pinnata</i>	Karanji	Fabaceae	Tree	LC
<i>Pterocarpus marsupium</i>	Asan	Fabaceae	Tree	Vu
<i>Saraca indica</i>	Asoka	Sapindaceae	Tree	NA
<i>Schleichera oleosa</i>	Kusum	Sapindaceae	Tree	NA
<i>Semecarpus</i>	Biboi	Anacardiaceae	Tree	NA

Botanical Name	Common/Local Name	Family	Habit	IUCN Status
<i>anacardium</i>				
<i>Spondia mangifera</i>	Ambado	Anacrdiaceae	Tree	NA
<i>Sterculia villosa</i>	Aployo suplo	Sterculiaceae	Tree	NA
<i>Syzygium caryophyllatum</i>	Bhedas	Myrtaceae	Tree	NA
<i>Syzygium cumini</i>	Jamun	Myrtaceae	Tree	NA
<i>Thespecia populinea</i>	Bhendi	Malvaceae	Tree	NA
<i>Trewia nudiflora</i>	Bomovaro petari	Euphorbiacea	Tree	NA
<i>Wrightia tinctoria</i>	Kalakundo	Apocynaceae	Tree	LC
<i>Xylia xylocarpa</i>	Zamba	Mimosaceae	Tree	NA
<i>Tectona grandis</i>	Teak	Verbinaceae	Tree	NA
<i>Terminalia crenulata</i>	Maretha	Combretaceae	Tree	NA
<i>Terminalia paniculata</i>	Quinzol	Combretaceae	Tree	NA
<i>Dalbergia latifolia</i>	Sisso	Fabaceae	Tree	NA
<i>Dillenia pentagyna</i>	Karmal	Dilleniaceae	Tree	NA
<i>Albezia procera</i>	Belati	Mimosaceae	Tree	NA
<i>Aegal marmelos</i>	Bel	Rutaceae	Tree	NA
<i>Wrightia tinctoria</i>	Shanta kudo	Apocyanaceae	Tree	NA
<i>Strobilanthes callosus</i>	Karvi	Acanthaceae	Shrub	NA
<i>Urena lobatta</i>	Ranbhendi	Malvaceae	Shrub	NA
<i>Fleminhia congesta</i>	-	Fabaceae	Shrub	NA
<i>Holorrhena antihysenterica</i>	Nagur Cudo	Apocyanacea	Shrub	NA
<i>Wagatea spicata</i>	Yagati	Caesalpiaceae	Climber	NA

Note- LC= Least Concern, VU= Vulenerable, En= Endangered, NA= Not Assessed, DD-Data deficient

5.4 MANGROVE VEGETATION ALONG MORMUGAO COAST

The nearest identified mangroves are observed in Siridao area of Zuari creek, at a distance of about 7 to 8 km ranging from sparse to dense vegetation from the proposed project site. In the study area there are patches of mangroves located along the sides of the River Zuari. The mangrove species observed during the marine ecological survey includes *Acanthus ilicifolius*, *Avicennia officinalis*, *Sonneratia caseolaris*, *Kandelia candel* and *Rhizophora mucronata* were found along the nearby estuary.

5.5 ECONOMICALLY IMPORTANT PLANTS

The Goa forests are highly important for the livelihood and well-being of many peoples. The local communities retain a wealth of indigenous knowledge about the flora. The list of economically and medicinally important floral species is given in Table-5.2.

Table-5.2: List of economically and medicinally important floral species in the project area district

Botanical Name	Vernacular Name	Uses
<i>Adenanthera pavonia</i>	Gunj	Timber/Medicinal
<i>Albizia lebbek</i>	Siras	Timber
<i>Alstonia scholarias</i>	Saton	Medicinal
<i>Anacardium occidentale</i>	Kaju/ Cashew tree	Fruit edible
<i>Ananas comosus</i>	Ananas	Fruit edible
<i>Artocarpus heterophyllus</i>	Phanas	Fruit/Vegetable
<i>Boerhavia diffusa L.</i>	-	Medicinal
<i>Calapphyllus inophyllum</i>	Oondi	Fuel, medicinal
<i>Carica papaya</i>	Papaya	Fruit edible
<i>Caryota urens</i>	Billemad	Ornamental
<i>Cassia fistula</i>	Bayo	Medicinal
<i>Casuarina equisetifolia</i>	-	Medicinal/farm forestry
<i>Cocos nucifera</i>	Naal	Fruit edible
<i>Datura innoxia</i>	Datura	Medicinal
<i>Ficus religiosa</i>	Pipal	Religious
<i>Hibiscus tiliaceus</i>	-	Ornamental
<i>Hollarhena antidysentric</i>	Kudo	Ornamental
<i>Holoptelia integrifolia</i>	Vavalo	Fuel, Timber
<i>Lanea coramendalica</i>	Moi	Fuel
<i>Lindernia anagalis</i>	-	Medicinal
<i>Mangifera indica</i>	Ambo	Fruit edible, fuel
<i>Morinda citrifolia</i>	-	Medicinal
<i>Musa paradisiaca</i>	Keli	Fruit edible
<i>Odina wodier</i>	-	Fuel, gum
<i>Pongamia pinnata</i>	Karanji	Soil binder
<i>Saraca indica</i>	Asoka	Ornamental
<i>Spondia mangifera</i>	Ambado	Fruit, medicinal
<i>Syzygium caryophyllatum</i>	Bhedas	Fuelwood
<i>Syzygium cumini</i>	Jamun	Fruit edible
<i>Thevetia peruviana</i>	-	Ornamental
<i>Vitex negundo</i>	-	Medicinal
<i>Zizuphus mauriliana</i>	Boram	Fruit, fuel

5.6 FAUNA

5.6.1 Mammals

Proposed project envisages the dredging and deepening of navigation channel and there is no activity on the land portion. Hence no direct impact of the project is anticipated on forest and wildlife. Baseline data regarding the wild life and avifauna has been collected from the department of forest, government of Goa and during field studies. The major faunal species found in study area district includes Jackal (*Canis aureus*), Langur (*Presbytis entellus*) and Bonnet macaque (*Mucaca radiata*). The common grey Mongoose (*Herpestes edwardsii*), Indian hare (*Lepus nigricollis*) is also common in the area. The Flying fox (*Pteropus giganteus*) is common all over the region wherever edible fruits trees are abundant. The field mouse (*Mus booduga*) is found in the plains and is said to do much damage to the crops. The mammals reported in south Goa along with their conservation status as per IUCN are listed in Table-5.3.

Table-5.3: Mammal species reported from South Goa

S. No	Zoological Name	English Name	IUCN Status
1	<i>Axis axis</i>	Spotted deer	LC
2	<i>Bandicota indica</i>	Bandicoot rat	LC
3	<i>Bos gaurus</i>	Gaur or Indian bison	VU
4	<i>Canis aureus</i>	Jackal	LC
5	<i>Cervus unicolor</i>	Sambar	VU
6	<i>Cuon alpinus</i>	Wild dog	EN
7	<i>Cynopterus brachyotis</i>	Indian fulvous fruit bat	LC
8	<i>Delphinus tropicalis linn</i>	Common Dolphin	DD
9	<i>Prionailurus bengalensis</i>	Leopard cat	LC
10	<i>Felis chaus</i>	Jungle cat	LC
11	<i>Funambulus palmarum</i>	Common palm squirrel	LC
12	<i>Herpestes edwardsii</i>	Grey mongoose	LC
13	<i>Hyaena hyaena</i>	Striped hyaena	NT
14	<i>Hystrix indica</i>	Porcupine	LC
15	<i>Lepus nigricollis</i>	Indian Hare	LC
16	<i>Loris tardigradus</i>	Red Slender loris	EN
17	<i>Lutra lutra</i>	Eurasian Otter	NT
18	<i>Lutra perspicillata</i>	Smooth coated Otter	Vu
19	<i>Macaca radiata</i>	Bonnet macaque	LC
20	<i>Manis crassicaudata</i>	Indian pangolin	EN
21	<i>Megaderma spasma</i>	Indian vampire bat	LC
22	<i>Melursus ursinus</i>	Sloth bear	VU
23	<i>Muntiacus muntjak</i>	Barking deer	LC
24	<i>Mus booduga</i>	Indian field mouse	LC



S. No	Zoological Name	English Name	IUCN Status
25	<i>Otomopos wroughtoni</i>	Wroughton's freetailed bat	DD
26	<i>Panthera pardus</i>	Leopard	VU
27	<i>Panthera tigris</i>	Tiger	EN
28	<i>Paradoxurus hermaphroditus</i>	Palm civet cat	LC
29	<i>Petaurista petaurista</i>	Common flying squirrel	LC
30	<i>Phocoena phocoena</i>	Porpoise	LC
31	<i>Pipistrellus dormeri</i>	Dormers bat	LC
32	<i>Presbytis entellus</i>	Common Langur	VU
33	<i>Pteropus giganteus</i>	Flying Fox	LC
34	<i>Rattus rattus</i>	House Rat	LC
35	<i>Ratufa macroura</i>	Malabar Giant Squirrel	NT
36	<i>Rhinolophus luctus</i>	Horse shoe bat	LC
37	<i>Suncus murinus</i>	House shrew	LC
38	<i>Sus scrofa</i>	Wild Boar	LC
39	<i>Tatera indica</i>	Indian Gerbille	LC
40	<i>Tragulus meminna</i>	Mouse deer	LC
41	<i>Tursiops aduncus</i>	Indian bottlenose dolphin	DD
42	<i>Viverricula indica</i>	Small Indian civet cat	LC

5.6.2 Avi-Fauna

Goa is endowed with variety of magnificent avifauna. The habitat for variety of birds from open forest to scrubby tracts and dense forest at various places in Goa are ideal for birds. There are some very colourful species found in the State and among these are the three common species of kingfisher: the stork-billed kingfisher is the largest and most distinctive, the breasted kingfisher and the common kingfisher are also observed. Other common species include grass-green, blue and yellow bee-eaters, golden oriole, and Indian roller, Hoopes, purple sunbirds, and several kinds of bulbuls, babblers and drongos. The exotic paradise flycatcher is fairly widespread in Goa and among the region's most exquisite birds. The snowy white cattle egret, the large egret and the little egret and herons are most common in the paddy fields along with cows and buffaloes. The beautiful whitebellied fish eagle, the brahminy kite and the pariah kite are birds of prey found around towns and fishing villages. In the state's forests are found the grey hornbill, the Indian pied hornbill and the magnificent great pied hornbill, several species of woodpecker including the lesser goldenback woodpecker and the Indian great black woodpecker, the red junglefowl, the grey or Sonnerat's jungle fowl. The commonly reported birds in South Goa and their conservation status as per IUCN are listed in Table-5.4.

Table- 5.4: Commonly reported avi-faunal species in South Goa

S. No.	Scientific name	Common name	IUCN status
1	<i>Accipiter badius</i>	Shikra	VU
2	<i>Acridotheres fuscus</i>	Jungle Myna	LC
3	<i>Acrocephalus aedon</i>	Thick billed Warbler	LC
4	<i>Acrocephalus agricola</i>	Paddyfield Warbler	LC
5	<i>Aegithina tiphia</i>	Common lora	LC
6	<i>Alcedo atthis</i>	Common Kingfisher	LC
7	<i>Amaurornis phoenicurus</i>	White-breasted Waterhen	LC
8	<i>Anas acuta</i>	Northern Pintail	LC
9	<i>Anas clypeata</i>	Northern Shoveler	LC
10	<i>Anas crecca</i>	Common Teal	LC
11	<i>Anas poecilorhyncha</i>	Spot-billed	LC
12	<i>Anas querquedula</i>	Garganey	LC
13	<i>Anastomus oscitans</i>	Asian Openbill	LC
14	<i>Anhinga melanogaster</i>	Oriental Darter	NT
15	<i>Anthus richardi</i>	Richards Pipit	LC
16	<i>Apus pacificus</i>	Large White Rumped Swift	LC
17	<i>Aquila pomarina</i>	Lesser Spotted Eagle	LC
18	<i>Ardea cinerea</i>	Grey Heron	LC
19	<i>Ardea purpurea</i>	Purple Heron	LC
20	<i>Ardeola grayii</i>	Indian Pond-Heron	LC
21	<i>Bubulcus ibis</i>	Cattle Egret	LC
22	<i>Cacomantis passerinus</i>	Grey-bellied Cuckoo	LC
23	<i>Calandrella brachydactyla</i>	Greater Short-toed Lark	LC
24	<i>Calidris temminckii</i>	Temminck's Stint	LC
25	<i>Celeus brachyyurus</i>	Rufous woodpecker	LC
26	<i>Centropus sinensis</i>	Greater Coucal	LC
27	<i>Ceryle rudis</i>	Pied Kingfisher	LC
28	<i>Chalcophaps indica</i>	Emerald Dove	LC
29	<i>Charadrius alexandrinus</i>	Kentish plover	LC
30	<i>Charadrius dubius</i>	Little ringed plover	LC
31	<i>Chloropsis aurifrons</i>	Gold fronted chloropsis	LC
32	<i>Circaetus gallicus</i>	Short-toed Snake-Eagle	LC
33	<i>Circus aeruginosus</i>	Western Marsh Harrier	LC
34	<i>Columba elphinstonii</i>	Nilgiri Wood-Pigeon	VU
35	<i>Columba livia</i>	Rock Pigeon	LC
36	<i>Copsychus malabaricus</i>	White-rumped Shama	LC
37	<i>Copsychus saularis</i>	Magpie robin	LC
38	<i>Coracina meanoptera</i>	Black headed cuckoo shrike	LC
39	<i>Corvus macrorhynchos</i>	Jungle crow	LC
40	<i>Corvus splendens</i>	House Crow	LC
41	<i>Cuculus varius</i>	Common Hawk-Cuckoo	LC
42	<i>Cyornis tickelliae</i>	Tickell's blue flycatcher	LC
43	<i>Cypsiurus Parvus</i>	Palm Swift	LC
44	<i>Dendrocitta vagabunda</i>	Indian tree pie	LC
45	<i>Dendrocopos mahrattensis</i>	Yellow-crowned Woodpecker	LC

S. No.	Scientific name	Common name	IUCN status
47	<i>Dendrocygna javanica</i>	Lesser Whistling teal	LC
48	<i>Dicaeum agile</i>	Thick billed Flowerpecker	LC
49	<i>Dicaeum erythrorhynchos</i>	Tickell's Flowerpecker	LC
50	<i>Dicrurus aeneus</i>	Bronzed Drongo	LC
51	<i>Dicrurus caerulescens</i>	White bellied Drongo	LC
52	<i>Dicrurus hottentottus</i>	Hair crested Drongo	LC
53	<i>Dicrurus macrocercus</i>	Black Drongo	LC
54	<i>Dicrurus paradiseus</i>	Greater racket tailed drongo	LC
55	<i>Dinopium benghalense</i>	Golden back woodpecker	LC
56	<i>Dryocopus javensis</i>	White-bellied Woodpecker	LC
57	<i>Ducula badia</i>	Mountain Imperial-Pigeon	LC
58	<i>Dumetia hyperythra</i>	White throated Babbler	LC
59	<i>Egretta gularis</i>	Western Reef-Egret	LC
60	<i>Elanus caeruleus</i>	Black-winged Kite	LC
61	<i>Eremopterix grisea</i>	Ashy-crowned Sparrow-Lark	LC
62	<i>Eumyias thalassina</i>	Verditer flycatcher	LC
63	<i>Fulica atra</i>	Common Coot	LC
64	<i>Gallicrex cinerea</i>	Watercock	LC
65	<i>Gallinula chloropus</i>	Common Moorhen	LC
66	<i>Galloperdix spadicea</i>	Red Spurfowl	LC
67	<i>Gallus sonneratii</i>	Grey Junglefowl	LC
68	<i>Glareola lactea</i>	Small Pratincole	LC
69	<i>Gorsachius melanolophus</i>	Malayan Night Heron	LC
70	<i>Halcyon pileata</i>	Black-capped Kingfisher	LC
71	<i>Halcyon smyrnensis</i>	White-throated Kingfisher	LC
72	<i>Haliaeetus leucogaster</i>	White-bellied Fish-Eagle	LC
73	<i>Haliastur indus</i>	Brahminy Kite	LC
74	<i>Hemicircus canente</i>	Heart-spotted Woodpecker	LC
75	<i>Hemiprocene longipennis</i>	Crested tree swift	LC
76	<i>Hemipus picatus</i>	Pied flycatcher shrike	LC
77	<i>Himantopus himantopus</i>	Black-winged Stilt	LC
78	<i>Hirundo concolor</i>	Dusky Crag Martin	LC
79	<i>Hirundo daurica</i>	Red rumped Swallow	LC
80	<i>Hirundo smithii</i>	Wire tailed Swallow	LC
81	<i>Hypothymis azurea</i>	Black-naped Monarch	LC
82	<i>Iole indica</i>	Yellow-browed Bulbul	LC
83	<i>Irena puella</i>	Asian Fairy-bluebird	LC
84	<i>Lanius schach</i>	Long tailed Shrike	LC
85	<i>Leptoptilos javanicus</i>	Lesser Adjutant	VU
86	<i>Lonchura malacca</i>	Black headed Munia	LC
87	<i>Lonchura striata</i>	White Rumped Munia	LC
88	<i>Megalaima haemacephala</i>	Crimson breasted Barbet	LC
89	<i>Megalaima viridis</i>	White cheeked Barbet	LC
90	<i>Merops leschenaulti</i>	Chestnut headed bee-eater	LC
91	<i>Merops orientalis</i>	Little Green Bee-eater	LC
92	<i>Merops philippinus</i>	Blue-tailed Bee-eater	LC

S. No.	Scientific name	Common name	IUCN status
93	<i>Mesophoyx intermedia</i>	Intermediate Egret	LC
94	<i>Milvus migrans</i>	Black Kite	LC
95	<i>Motacilla citreola</i>	Citrine Wagtail	LC
96	<i>Motacilla madaraspatensis</i>	Large Pied wagtail	LC
97	<i>Muscicapa dauurica</i>	Asian Brown Flycatcher	LC
98	<i>Mycteria leucocephala</i>	Painted Stork	NT
99	<i>Myiophonus horsfieldii</i>	Malabar Whistling-Thrush	LC
100	<i>Nectarinia asiatica</i>	Purple Sunbird	LC
101	<i>Nectarinia lotenia</i>	Loten's Sunbird	LC
102	<i>Nectarinia zeylonica</i>	Purple rumped Sunbird	LC
103	<i>Nycticorax nycticorax</i>	Black-crowned Night-Heron	LC
104	<i>Nyctornis athertoni</i>	Blue bearded bee-eater	LC
105	<i>Oriole oriolus</i>	Golden oriole	LC
106	<i>Oriolus xanthornus</i>	Black headed oriole	LC
107	<i>Orthotomus sutorius</i>	Common Tailor bird	LC
108	<i>Oxylophus jacobinus</i>	Pied Cuckoo	LC
109	<i>Pandion haliaetus</i>	Osprey	LC
110	<i>Passer domesticus</i>	House Sparrow	LC
111	<i>Pavo cristatus</i>	Indian Peafowl	LC
112	<i>Pelargopsis capensis</i>	Stork-billed Kingfisher	LC
113	<i>Pellorneum ruficeps</i>	Spotted Babbler	LC
114	<i>Perdica asiatica</i>	Jungle Bush-Quail	LC
115	<i>Pericrocotus cinnamomeus</i>	Small minivet	LC
116	<i>Pericrocotus cinnamomeus</i>	Small Minivet	LC
117	<i>Pericrocotus flammeus</i>	Scarlet Minivet	LC
118	<i>Picumnus innominatus</i>	Speckled Piculet	LC
119	<i>Pitta brachyura</i>	Indian Pitta	LC
120	<i>Ploceus philippinus</i>	Indian Baya	LC
121	<i>Pomatorhinus horsfieldii</i>	Indian Scimitar-Babbler	LC
122	<i>Porphyrio porphyrio</i>	Purple Swamphen	LC
123	<i>Porzana fusca</i>	Ruddy-breasted Crake	LC
124	<i>Prinia hodgsonii</i>	Grey-breasted Prinia	LC
125	<i>Prinia inornata</i>	Plain Prinia	LC
126	<i>Prinia socialis</i>	Ashy Prinia	LC
127	<i>Psittacula krameri</i>	Rose ringed parakeet	LC
128	<i>Psittacula kyanoccephala</i>	Blossom headed parakeet	LC
129	<i>Pycnonotus cafer</i>	Red vented Bulbul	LC
130	<i>Pycnonotus jocosus</i>	Red whiskered Bulbul	LC
131	<i>Pycnonotus luteolus</i>	White browed Bulbul	LC
132	<i>Rhipidura albicollis</i>	White throated fantail flycatcher	LC
133	<i>Saxicola caprata</i>	Pied bush chat	LC
134	<i>Saxicoloides fulicata</i>	Indian Robin	LC
135	<i>Sitta frontalis</i>	Velvet-fronted Nuthatch	LC
136	<i>Spilornis cheela</i>	Crested Serpent-Eagle	LC
137	<i>Spizaetus cirrhatus</i>	Changeable Hawk-Eagle	LC
138	<i>Sterna aurantia</i>	River Tern	NT

S. No.	Scientific name	Common name	IUCN status
139	<i>Sterna bengalensis</i>	Lesser Crested-Tern	LC
140	<i>Sterna nilotica</i>	Gull-billed Tern	LC
141	<i>Streptopelia chinensis</i>	Spotted Dove	LC
142	<i>Sturnus pagodarum</i>	Brahminy Myna	LC
143	<i>Sturnus roseus</i>	Rosy Starling	LC
144	<i>Tachybaptus ruficollis</i>	Little Grebe	LC
145	<i>Terpsiphone paradisi</i>	Paradise flycatcher	LC
146	<i>Treron pompadora</i>	Pompadour Green-Pigeon	LC
147	<i>Tringa cinerea</i>	Terek Sandpiper	LC
148	<i>Tringa erythropus</i>	Spotted Redshank	LC
149	<i>Tringa glareola</i>	Wood Sandpiper	LC
150	<i>Tringa hypoleucos</i>	Common Sandpiper	LC
151	<i>Tringa nebularia</i>	Common Greenshank	LC
152	<i>Turdoides striatus</i>	Jungle Babbler	LC
153	<i>Turdus merula</i>	Eurasian Blackbird	LC
154	<i>Upupa epops</i>	Hoopoe	LC
155	<i>Vanellus indicus</i>	Red-wattled Lapwing	LC
156	<i>Vanellus malabaricus</i>	Yellow-wattled Lapwing	LC

5.6.3 Reptiles

The State has a large reptilian and amphibian population. This includes the ubiquitous common house gecko, a variety of frogs and the common skink, monitor lizard, Garden Lizard. Twenty-three species of snakes are found in Goa. The nonpoisonous variety of snakes include the common blind snake, the Russell sand boa, the Indian python, the Indian wart snake, trinket snake, Indian rat snake, golden tree snake, common wolf snake, chequered keelback, striped keelback, Indian gamma and common green whip snake. Commonly observed reptilian fauna in the study area district are given in Table 5.5.

Table-5.5: List of Reptile species reported in project area district

S. No.	Scientific name	Common name	IUCN Status
	Snakes		
1	<i>Ahaetulla nasutus</i>	Vine Snake	LC
2	<i>Amphiesma stolatum</i>	Buff striped keel back	NE
3	<i>Boiga forsteni</i>	Forsten's Cat Snake.	LC
4	<i>Boiga trigonata</i>	Common Indian Cat Snake.	LC
5	<i>Bungarus caeruleus</i>	Common Indian Krait	VU
6	<i>Calliophis nigrescens</i>		LC
7	<i>Cerberus rhynchops</i>	Dogfaced water Snake	LC
8	<i>Chrysopelea ornata</i>	Golden back tree Snake	LC
9	<i>Coelognathus helena</i>	Trinket Snake	VU
10	<i>Dendrelaphis tristis</i>	Bronzeback tree Snake	NE

S. No.	Scientific name	Common name	IUCN Status
11	<i>Echis carinatus</i>	Saw scaled Viper	LC
12	<i>Enhydrina schistosa</i>	Hook-nosed Sea Snake	LC
13	<i>Eryx johnii</i>	Johns sand boa	LC
14.	<i>Gongylophis conicus</i>	Common Sand Boa	DD
15	<i>Grypotyphlops acutus</i>	Beaked worm snake	LC
16	<i>Lycodon aulicus</i>	Common Wolf snake	NE
17.	<i>Macropisthodon plumbicolor</i>	Green keelback.	LC
18.	<i>Naja naja</i>	Indian Spectacled Cobra.	LC
19	<i>Oligodon arnensis</i>	Common Kukri snake	LC
20	<i>Oligodon taeniolatus</i>	Variegated Kukri Snake	LC
21.	<i>Ophiophagus hannah</i>	King Cobra	VU
22.	<i>Ptyas mucosa</i>	Indian Rat Snake	LC
23.	<i>Python molurus</i>	Indian Rock Python	VU
24.	<i>Ramphotyphlops braminus</i>	Brahminy worm snake	LC
25	<i>Trimeresurus malabaricus</i>	Malabar Pit Viper	LC
26	<i>Trimeresurus gramineus</i>	Bamboo Pit Viper	LC
27	<i>Uropeltis macrolepis macrolepis</i>	Bombay shield tail	LC
28.	<i>Vipera russelii</i>	Russels Viper	LC
29.	<i>Xenochrophis piscator</i>	Checkered keelback	LC
	Lizards, Skinks		
1	<i>Calotes rouxii</i>	Rouxii lizard	LC
2	<i>Calotes versicolor</i>	Indian garden lizard	LC
3	<i>Chamaeleo zeylanicus</i>	Indian chameleon	LC
4	<i>Draco dussumieri</i>	Flying lizard	LC
5	<i>Mabuya macularia</i>	Bronze skink	LC

Note: LC-Least Concern, VU-Vulnerable, NT- Near threatened, DD- Data deficient, NE-Not evaluated

5.6.4 Amphibians

Amphibians are important components of many ecosystem and they play a vital role as predators in the food chain. They are good indicators of habitat quality due to their permeable skins, dual life mode and limited dispersal capabilities. Most of species inhabit arboreal, aquatic and terrestrial habitat. Most of amphibians are belongs to the family Ranidae and species like common Indian toad, Painted frog, green frog and *Rana* sp are common in the area. The details of the Amphibian species reported from South Goa are given in Table-5.6.

Table-5.6: List of Amphibian species reported in project area district

S No.	Scientific name	Common name	IUCN STATUS
1.	<i>Duttaphrynus melanostictus</i>	Indian toad	LC
2.	<i>Hoplobatrachus tigerinus</i>	Indian bull frog	LC
3.	<i>Euphlyctis cyanophlyctis</i>	Indian skipper frog	LC
4.	<i>Sphaerotheca breviceps</i>	Indian burrowing frog	LC
5.	<i>Rhacophorus malabaricus</i>	Malabar gliding frog	LC
6.	<i>Rana malabarica</i>	Fungoid frog	LC

5.7 ECO-SENSITIVE ZONES IN GOA

The Eco-sensitive Zones declared as Protected Areas in Goa by the Ministry of Environment and Forests and Climate Change are:

- (i) Cotigao Wildlife Sanctuary, South Goa
- (ii) Netravali Wildlife Sanctuary, South Gao
- (iii) Bhagwan Mahaveer Wildlife Sanctuary and National Park, North Goa
- (iv) Madei Wildlife Sanctuary, North Goa
- (v) Bondla Wildlife Sanctuary, North Goa and
- (vi) Dr. Salim Ali Wildlife Sanctuary, North Goa

The location of the sanctuary is shown in Figure-5.1.

Of the above eco-sensitive zones only Dr. Saliim Ali Wildlife sanctuary falls within 15 kms radius of the study area. The Dr. Salim Ali Bird Sanctuary, Goa lies between latitudes 15° 31' 36.03" N and 15° 30' 35.35" N and longitudes 73° 52' 14.31" E and 73° 50' 44.12" E in the North Goa District of Goa State and extending over an area of 1.78 square kilometres. It is a rich mangrove formation at the confluence of Mapusa river and Mandovi river. The sanctuary exclusively shelters varieties of amphibians, otters, crocodiles, varieties of fish, aquatic birds, shore birds and arboreal birds and reptiles, fruit bat (*Pteropus spp.*) commonly occur in the area, migratory birds, adjutant storks and raptorial birds like osprey visit the protected area annually.

The mangrove forest of this sanctuary holds and protects the rich soil underneath from washing away and provides exclusively excellent place for the said varieties of wildlife to breed and shelter.



Figure-5.1 Map showing location of Salim Ali Bird Sanctuary

CHAPTER-6
BASELINE STATUS FOR SOCIO-
ECONOMIC ASPECTS



CHAPTER-6

BASELINE STATUS FOR SOCIO ECONOMIC ASPECTS

6.1 SOCIO-ECONOMIC ASPECTS

The proposed project does not envisages the acquisition of private/ forest land or settlements. Therefore socio-economic assessment of the study area has been prepared based on secondary data extracted from Primary Census Abstract, Census of India 2011. Socioeconomic profile was studied to assess the overall impact on various facets of socio-economic aspects due to the proposed project activity in the Study Area.

The present chapter outlines baseline socio-economic scenario of the study area within the 10 km radius around the proposed project site. The study area map has been prepared using Administrative Atlas of Goa published by Director of Census Operations (Census of India 2011). The study area of the proposed project is spread over two Talukas namely Tiswadi and Mormugao of North and South Goa districts respectively. The study area settlements consists of Municipal Corporation/Council Wards/Census Towns/Out Growth/Villages. The nearest settlements from the proposed site are Headland sada and Vasco, which area part of Mormugao Municipal Council.

6.2 DEMOGRAPHIC PROFILE

6.2.1 Population

The study area comprises of about 36 settlements, including 6 Census Town, 21 Municipal Corporation wards, 5 Out Growth and 2 villages. The total population in the study area is of the order of 269495 persons residing in 63711 households as per Census of India 2011. The distribution of population and demographic profile of study area is outlined in Table-6.1 and depicted in Figure-6.1.

Table-6.1: Demographic profile of Study Area

S.No	Name of Settlements	Total Household	Total Population	Total Male	Total Female	Population <6 years	Average Family Size	Sex Ratio
	District North Goa							
	Subdistrict Tiswadi							
1	Curca	560	2518	1232	1286	256	4	1044
2	Siridao	578	2417	1179	1238	218	4	1050
3	Panaji (M Corp. + OG)	17807	70991	35988	35003	6180	4	973
4	Morambi-O-Pequeno (Merces) (OG) WARD NO.-0034 (Rural MDDS CODE:626739)	209	931	444	487	78	4	1097
5	Cujira (OG) WARD NO.-0035 (Rural MDDS CODE:626740)	296	1229	601	628	122	4	1045
6	Taleigao (OG) (Part) WARD NO.-0036 (Rural MDDS CODE:645598)	6003	24201	12402	11799	2356	4	951
7	Durgawadi (OG) (Part) WARD NO.-0037 (Rural MDDS CODE:645599)	388	1610	830	780	180	4	940
8	Murda (CT)	1803	7517	3699	3818	782	4	1032
9	Calapor (CT)	3514	14077	7118	6959	1443	4	978
10	Bambolim (CT)	1165	6885	4812	2073	525	6	431
11	Goa Velha (CT)	1055	4322	2129	2193	427	4	1030
	Subtotal (A)	33378	136698	70434	66264	12567	4	941
	District South Goa							
	District Mormugao							
12	Dabolim	1433	6027	3142	2885	699	4	918
13	Issorcim	189	841	434	407	61	4	938
14	Chicolna	669	2680	1350	1330	274	4	985
15	Mormugao (M CI) WARD NO.-0001	675	3659	2483	1176	175	5	474
16	Mormugao (M CI) WARD NO.-0002	599	2518	1293	1225	205	4	947
17	Mormugao (M CI) WARD NO.-0003	675	3071	1566	1505	316	5	961
18	Mormugao (M CI) WARD NO.-0004	834	3852	2116	1736	378	5	820
19	Mormugao (M CI) WARD NO.-0005	990	4462	2356	2106	476	5	894
20	Mormugao (M CI) WARD NO.-0006	905	4059	2039	2020	425	4	991
21	Mormugao (M CI) WARD NO.-0007	746	3428	1814	1614	439	5	890
22	Mormugao (M CI) WARD NO.-0008	968	4791	2480	2311	624	5	932
23	Mormugao (M CI) WARD NO.-0009	1228	5507	2896	2611	595	4	902

S.No	Name of Settlements	Total Household	Total Population	Total Male	Total Female	Population <6 years	Average Family Size	Sex Ratio
24	Mormugao (M CI) WARD NO.-0010	1020	4387	2240	2147	391	4	958
25	Mormugao (M CI) WARD NO.-0011	494	1954	988	966	169	4	978
26	Mormugao (M CI) WARD NO.-0012	835	3897	2012	1885	435	5	937
27	Mormugao (M CI) WARD NO.-0013	922	4175	2197	1978	426	5	900
28	Mormugao (M CI) WARD NO.-0014	933	4103	2099	2004	346	4	955
29	Mormugao (M CI) WARD NO.-0015	1103	5661	3058	2603	707	5	851
30	Mormugao (M CI) WARD NO.-0016	1244	5171	2711	2460	531	4	907
31	Mormugao (M CI) WARD NO.-0017	1420	6061	3150	2911	710	4	924
32	Mormugao (M CI) WARD NO.-0018	2904	11104	5754	5350	1419	4	930
33	Mormugao (M CI) WARD NO.-0019	1006	4517	2312	2205	526	4	954
34	Mormugao (M CI) WARD NO.-0020	2023	8016	4069	3947	732	4	970
35	Chicalim (CT)	1483	6933	3921	3012	618	5	768
36	Sancoale (CT)	5035	21923	11657	10266	2693	4	881
	Sub total (B)	30333	132797	70137	62660	14370	4	893
	Total (A+B)	63711	269495	140571	128924	26937	4	917

Source: Primary Census Abstract, 2011

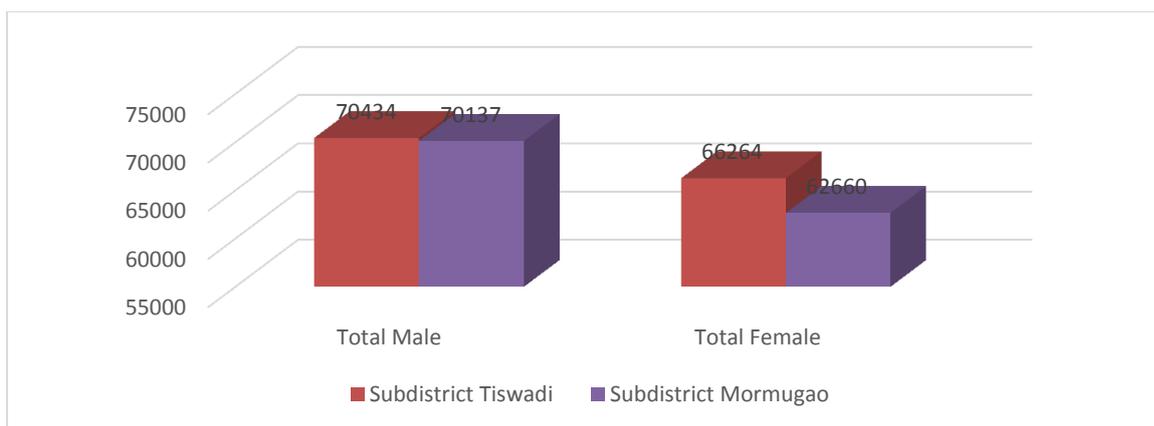


Figure -6.1: Demographic profile in Study Area Settlements

The male and female population in study area comprises about 52.16% and 47.84% respectively of the total population. The population comprising of children below the age of 6 years accounts for about 10.0% of the total population in the study area.



The sex ratio (no. of females per 1000 males) and average family size in the study area settlements is 917 and 4 persons per family respectively.

6.2.2 Caste Profile

The caste wise distribution of population in study area settlements on the basis of caste is summarized in Table-6.2 and depicted in Figure-6.2. The General Caste is the dominant caste in the study area accounting for about 92.7% of the total population followed by Schedule Tribes, which accounts for about 5.1% of the total population. Schedule Castes account for only 2.2% of the total population of Study Area Villages.

Table-6.2: Caste profile of Study Area

S. No	Name of Settlements	Total Population	Schedule Caste Population	Schedule Tribe Population	General Population
	District North Goa				
	Subdistrict Tiswadi				
1	Curca	2518	11	497	2010
2	Siridao	2417	0	1265	1152
3	Panaji (M Corp. + OG)	70991	1707	4586	64698
4	Morambi-O-Pequeno (Merces) (OG) WARD NO.-0034 (Rural MDDS CODE:626739)	931	8	4	919
5	Cujira (OG) WARD NO.-0035 (Rural MDDS CODE:626740)	1229	4	1	1224
6	Taleigao (OG) (Part) WARD NO.-0036 (Rural MDDS CODE:645598)	24201	1097	2869	20235
7	Durgawadi (OG) (Part) WARD NO.-0037 (Rural MDDS CODE:645599)	1610	29	25	1556
8	Murda (CT)	7517	81	314	7122
9	Calapor (CT)	14077	427	1211	12439
10	Bambolim (CT)	6885	172	839	5874
11	Goa Velha (CT)	4322	20	116	4186
	Subtotal (A)	136698	3556	11727	121415
	District South Goa				
	Subdistrict Mormugao				
12	Dabolim	6027	65	307	5655
13	Issorcim	841	4	5	832
14	Chicolna	2680	45	376	2259
15	Mormugao (M CI) WARD NO.-0001	3659	203	7	3449
16	Mormugao (M CI) WARD NO.-0002	2518	11	23	2484
17	Mormugao (M CI) WARD NO.-0003	3071	17	4	3050
18	Mormugao (M CI) WARD NO.-0004	3852	108	48	3696
19	Mormugao (M CI) WARD NO.-0005	4462	113	27	4322
20	Mormugao (M CI) WARD NO.-0006	4059	78	10	3971

S. No	Name of Settlements	Total Population	Schedule Caste Population	Schedule Tribe Population	General Population
21	Mormugao (M CI) WARD NO.-0007	3428	2	0	3426
22	Mormugao (M CI) WARD NO.-0008	4791	45	6	4740
23	Mormugao (M CI) WARD NO.-0009	5507	123	64	5320
24	Mormugao (M CI) WARD NO.-0010	4387	36	10	4341
25	Mormugao (M CI) WARD NO.-0011	1954	35	0	1919
26	Mormugao (M CI) WARD NO.-0012	3897	10	0	3887
27	Mormugao (M CI) WARD NO.-0013	4175	31	14	4130
28	Mormugao (M CI) WARD NO.-0014	4103	36	15	4052
29	Mormugao (M CI) WARD NO.-0015	5661	325	28	5308
30	Mormugao (M CI) WARD NO.-0016	5171	55	35	5081
31	Mormugao (M CI) WARD NO.-0017	6061	73	53	5935
32	Mormugao (M CI) WARD NO.-0018	11104	661	57	10386
33	Mormugao (M CI) WARD NO.-0019	4517	120	9	4388
34	Mormugao (M CI) WARD NO.-0020	8016	79	70	7867
35	Chicalim (CT)	6933	76	234	6623
36	Sancoale (CT)	21923	114	597	21212
	Subtotal (B)	132797	2465	1999	128333
	Total (A+B)	269495	6021	13726	249748

Source: Primary Census Abstract, 2011

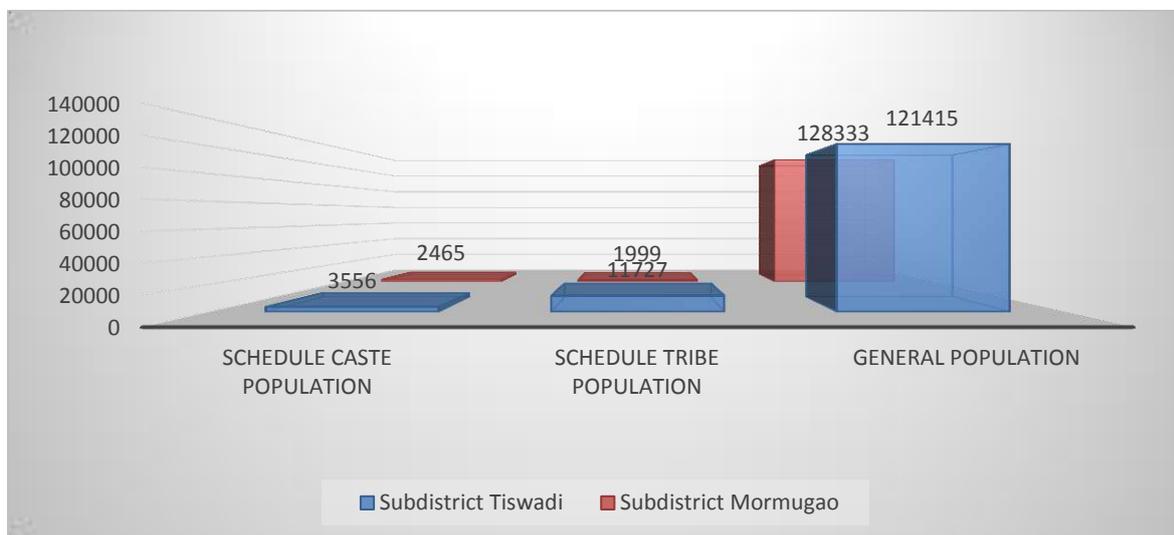


Figure-6.2: Caste profile in Study Area Settlements

6.2.3 Literacy Levels

The details of educational profile of the total population of study area are shown in Table-6.3. It is observed that about 81.7% of the total population in the study area settlements is literate, while about 18.3% are illiterate. The male and female literacy

rate of the study area settlements is 84.6% and 78.6% respectively (Refer Figure-6.3).

Table-6.3: Educational Profile of the population in Study Area

S. No	Name of Settlements	Total Population	Population Literate	Male Literate	Female Literate	Population Illiterate	Male Illiterate	Female Illiterate
	District North Goa							
	SubdistrictTiswadi (A)							
1	Siridao	2417	1786	929	857	631	250	381
2	Panaji (M Corp. + OG)	70991	60071	31090	28981	10920	4898	6022
3	Cujira (OG) WARD NO.-0035 (Rural MDDS CODE:626740)	1229	1033	516	517	196	85	111
4	Taleigao (OG) (Part) WARD NO.-0036 (Rural MDDS CODE:645598)	24201	19755	10441	9314	4446	1961	2485
5	Durgawadi (OG) (Part) WARD NO.-0037 (Rural MDDS CODE:645599)	1610	1345	710	635	265	120	145
6	Murda (CT)	7517	6117	3066	3051	1400	633	767
7	Calapor (CT)	14077	11628	6043	5585	2449	1075	1374
8	Bambolim (CT)	6885	5971	4362	1609	914	450	464
9	Goa Velha (CT)	4322	3473	1779	1694	849	350	499
	Subtotal (A)	133249	111179	58936	52243	22070	9822	12248
	District South Goa							
	Subdistrict Mormugao							
1	Dabolim	6027	4739	2550	2189	1288	592	696
2	Issorcim	841	718	383	335	123	51	72
3	Chicolna	2680	2117	1127	990	563	223	340
4	Mormugao (M CI) WARD NO.-0001	3659	3433	2379	1054	226	104	122
5	Mormugao (M CI) WARD NO.-0002	2518	2136	1127	1009	382	166	216
6	Mormugao (M CI) WARD NO.-0003	3071	2547	1355	1192	524	211	313
7	Mormugao (M CI) WARD NO.-0004	3852	3228	1828	1400	624	288	336
8	Mormugao (M CI) WARD NO.-0005	4462	3488	1949	1539	974	407	567
9	Mormugao (M CI) WARD NO.-0006	4059	3361	1715	1646	698	324	374
10	Mormugao (M CI) WARD NO.-0007	3428	2348	1348	1000	1080	466	614
11	Mormugao (M CI) WARD NO.-0008	4791	3384	1893	1491	1407	587	820
12	Mormugao (M CI) WARD NO.-0009	5507	4468	2448	2020	1039	448	591
13	Mormugao	4387	3688	1956	1732	699	284	415

S. No	Name of Settlements	Total Population	Population Literate	Male Literate	Female Literate	Population Illiterate	Male Illiterate	Female Illiterate
	(M CI) WARD NO.-0010							
14	Mormugao (M CI) WARD NO.-0011	1954	1708	882	826	246	106	140
15	Mormugao (M CI) WARD NO.-0012	3897	2841	1565	1276	1056	447	609
16	Mormugao (M CI) WARD NO.-0013	4175	3453	1894	1559	722	303	419
17	Mormugao (M CI) WARD NO.-0014	4103	3501	1839	1662	602	260	342
18	Mormugao (M CI) WARD NO.-0015	5661	3901	2290	1611	1760	768	992
19	Mormugao (M CI) WARD NO.-0016	5171	4191	2249	1942	980	462	518
20	Mormugao (M CI) WARD NO.-0017	6061	4736	2558	2178	1325	592	733
21	Mormugao (M CI) WARD NO.-0018	11104	9056	4755	4301	2048	999	1049
22	Mormugao (M CI) WARD NO.-0019	4517	3669	1948	1721	848	364	484
23	Mormugao (M CI) WARD NO.-0020	8016	6931	3570	3361	1085	499	586
24	Chicalim (CT)	6933	5886	3478	2408	1047	443	604
25	Sancoale (CT)	21923	16656	9429	7227	5267	2228	3039
	Subtotal (B)	132797	106184	58515	47669	26613	11622	14991
	Total (A+B)	266046	217363	117451	99912	48683	21444	27239

Source: Primary Census Abstract-2011

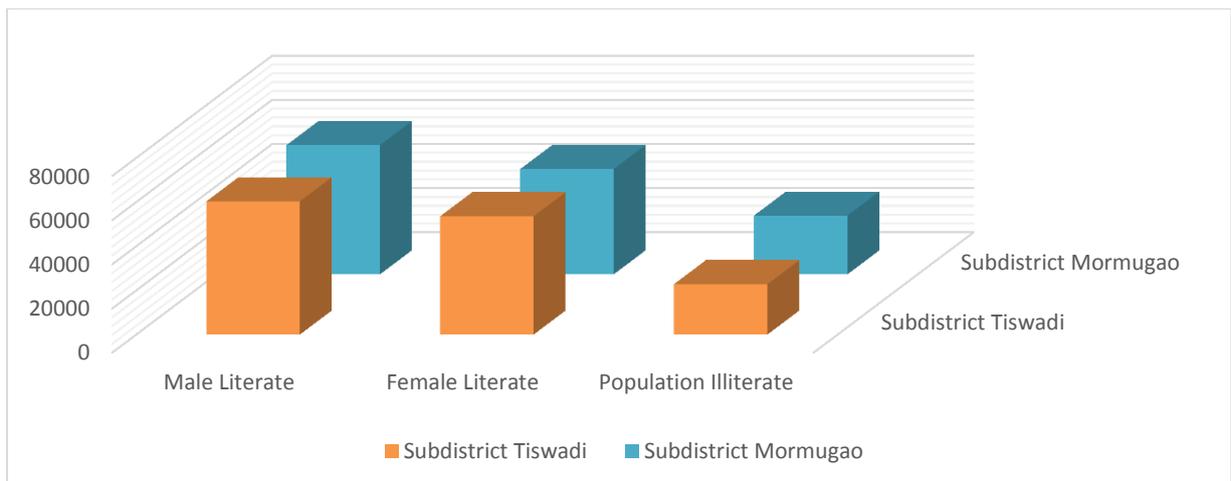


Figure-6.3: Literacy profile in Study Area Settlements



6.2.4 Occupational profile

The details on occupational profile in the study area settlements are given in Table-6.4. It is observed that 41.76% of the total population is engaged in some form of economically productive activity or vocational activity, and have been designated as Total Working population. On the other hand, Non-workers or persons who are dependent on the population, which is engaged in economically productive work accounts for about 58.24% of the total population. Among the population that is working about 89.52% has been designated as Main workers while the remaining 10.48% has been designated as Marginal workers. In main working population Main worker Cultivators are 1.27%, Main Worker Agricultural Labour 0.39%, Main Workers Household Industry 1.27% and Main Workers Other 97.08%. The occupational profile is depicted in Figure-6.4.

Table-6.4: Occupational profile in the Study Area Settlements

S. No	Name of Settlements	Total Population	Total Working Population	Main Workers	Main Workers Cultivators	Main Agricultural Labour	Main Household Industry	Main Other Occupation	Marginal Workers	Marginal Cultivators	Marginal Agricultural Labour	Marginal Household Industry	Marginal Other Occupation	Non Workers
	District North Goa													
	Subdistrict Tiswadi													
1	Curca	2518	925	877	58	9	6	804	48	3	6	1	38	1593
2	Siridao	2417	867	676	69	13	15	579	191	14	11	3	163	1550
3	Panaji (M Corp. + OG)	70991	30220	27709	206	77	299	27127	2511	57	43	125	2286	40771
4	Morambi-O-Pequeno (Merces) (OG) WARD NO.-0034 (Rural MDDS CODE:626739)	931	376	345	2	5	8	330	31	3	0	1	27	555
5	Cujira (OG) WARD NO.-0035 (Rural MDDS CODE:626740)	1229	481	409	5	2	7	395	72	2	2	3	65	748
6	Taleigao (OG) (Part) WARD NO.-0036 (Rural MDDS CODE:645598)	24201	10437	9582	67	36	111	9368	855	19	22	63	751	13764
7	Durgawadi (OG) (Part) WARD NO.-0037 (Rural MDDS CODE:645599)	1610	645	597	3	0	4	590	48	1	0	0	47	965
8	Murda (CT)	7517	3015	2626	14	14	74	2524	389	8	3	21	357	4502
9	Calapor (CT)	14077	5743	5239	46	28	87	5078	504	10	9	24	461	8334
10	Bambolim (CT)	6885	4429	4252	33	4	8	4207	177	2	14	3	158	2456
11	Goa Velha (CT)	4322	1771	1506	29	21	137	1319	265	12	19	2	232	2551
	Subtotal (A)	136698	58909	53818	532	209	756	52321	5091	131	129	246	4585	77789
	District South Goa													
	District Mormugao													



S. No	Name of Settlements	Total Population	Total Working Population	Main Workers	Main Workers Cultivators	Main Agricultural Labour	Main Household Industry	Main Other Occupation	Marginal Workers	Marginal Cultivators	Marginal Agricultural Labour	Marginal Household Industry	Marginal Other Occupation	Non Workers
12	Dabolim	6027	2563	2434	174	19	34	2207	129	15	21	4	89	3464
13	Issorcim	841	359	354	28	0	16	310	5	0	0	0	5	482
14	Chicolna	2680	1032	937	68	5	41	823	95	13	5	4	73	1648
15	Mormugao (M CI) WARD NO.-0001	3659	2176	1807	232	5	0	1570	369	11	1	1	356	1483
16	Mormugao (M CI) WARD NO.-0002	2518	952	875	4	3	21	847	77	0	1	10	66	1566
17	Mormugao (M CI) WARD NO.-0003	3071	1002	889	4	4	14	867	113	2	0	8	103	2069
18	Mormugao (M CI) WARD NO.-0004	3852	1347	1264	11	0	14	1239	83	1	0	1	81	2505
19	Mormugao (M CI) WARD NO.-0005	4462	1729	1622	15	27	10	1570	107	7	5	4	91	2733
20	Mormugao (M CI) WARD NO.-0006	4059	1565	1364	5	2	41	1316	201	1	1	5	194	2494
21	Mormugao (M CI) WARD NO.-0007	3428	1472	1355	6	3	4	1342	117	3	0	2	112	1956
22	Mormugao (M CI) WARD NO.-0008	4791	1861	1634	11	21	38	1564	227	6	6	6	209	2930
23	Mormugao (M CI) WARD NO.-0009	5507	2052	1859	12	3	20	1824	193	5	2	11	175	3455
24	Mormugao (M CI) WARD NO.-0010	4387	1634	1407	4	6	23	1374	227	6	3	7	211	2753
25	Mormugao (M CI) WARD NO.-0011	1954	801	782	9	0	4	769	19	0	0	0	19	1153
26	Mormugao (M CI) WARD NO.-0012	3897	1554	1373	11	2	17	1343	181	5	0	0	176	2343
27	Mormugao (M CI) WARD NO.-0013	4175	1996	1576	15	6	10	1545	420	4	2	72	342	2179
28	Mormugao (M CI) WARD NO.-0014	4103	1543	1413	5	7	7	1394	130	6	4	2	118	2560
29	Mormugao (M CI) WARD NO.-0015	5661	2139	1954	12	4	20	1918	185	0	0	2	183	3522
30	Mormugao (M CI) WARD NO.-0016	5171	2071	1514	5	5	13	1491	557	7	2	1	547	3100
31	Mormugao (M CI) WARD NO.-0017	6061	2195	1663	10	1	11	1641	532	3	3	15	511	3866



S. No	Name of Settlements	Total Population	Total Working Population	Main Workers	Main Workers Cultivators	Main Agricultural Labour	Main Household Industry	Main Other Occupation	Marginal Workers	Marginal Cultivators	Marginal Agricultural Labour	Marginal Household Industry	Marginal Other Occupation	Non Workers
32	Mormugao (M CI) WARD NO.-0018	11104	4121	3579	19	6	29	3525	542	7	2	2	531	6983
33	Mormugao (M CI) WARD NO.-0019	4517	1617	1457	13	4	19	1421	160	2	1	8	149	2900
34	Mormugao (M CI) WARD NO.-0020	8016	3102	2821	12	5	28	2776	281	12	0	1	268	4914
35	Chicalim (CT)	6933	3438	3201	20	5	35	3141	237	13	16	6	202	3495
36	Sancoale (CT)	21923	9310	7795	41	36	53	7665	1515	38	66	48	1363	12613
	Subtotal (B)	132797	53631	46929	746	179	522	45482	6702	167	141	220	6174	79166
	Total (A+B)	269495	112540	100747	1278	388	1278	97803	11793	298	270	466	10759	156955

Source: Primary Census Abstrac 2011

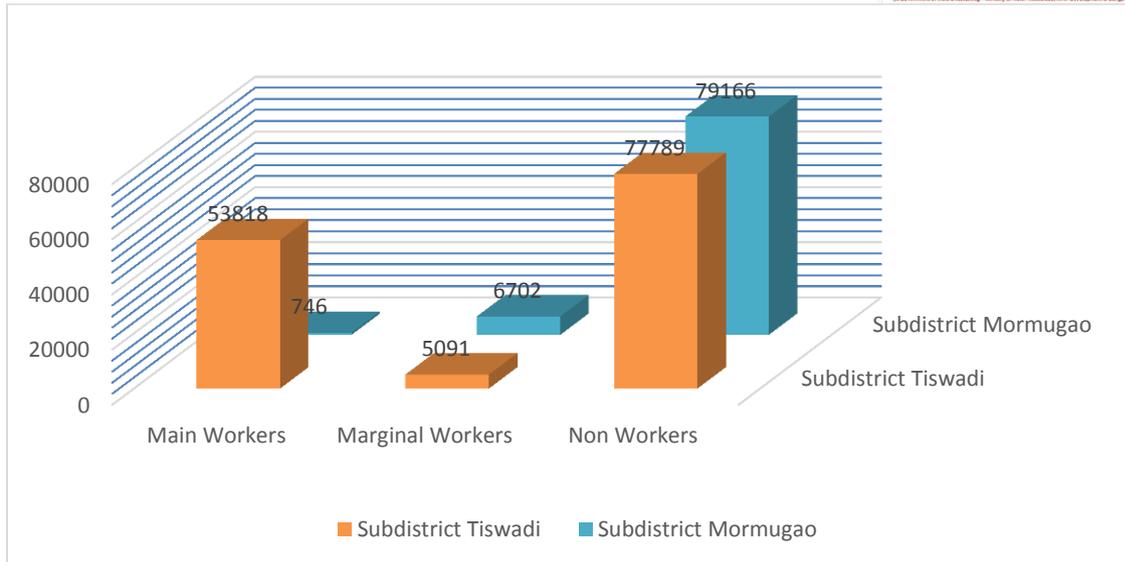


Figure-6.4: Occupational profile of Study Area Settlements

6.3 TOURISM

Tourism is one of the dominant industries of Goa. North Goa beaches act as the major tourist destination and maximum hotels are located there. There are a lot of tourist destination in and around the study area includes various beaches, monuments of archeological importance etc. Some of the beaches includes Caranzelm beach, Donna Paula view point, Bambolim beach, Bogmalo beach, Baina beach. The other destination in the study area is the Naval Aviation Museum, Mormugoa Fort, Aguada Fort, The Grande Island, Dr. Salim Ali Bird Sanctuary etc.

6.4 MAJOR DISEASES IN STUDY AREA

Information on the common diseases reported in the MPT hospital from 2010 to 2015 was collected. The most common diseases are Head Trauma (HT), followed by GF. The details of the cases registered for various diseases are given in Table-6.5.



Table-6.5: Major Disease recorded in MPT Hospital (2010 to 2015)

Year	HT	IHD	CV A	ASTH MA	COP D	AL D	GF	REN AL	PSY	MALARIA		DENG UE	CHIKUNGU NYA	ENTERIC FEVER	OTHE RS
										VIVAX +VE	FALCI PARU M				
April 2010 to March 2011	303	23	10	23	76	32	144	12	-	10	6	26	42	17	465
April 2011 to March 2012	327	12	2	19	70	37	100	5	1	13	7	1	6	4	407
April 2012 to March 2013	225	37	21	25	46	52	149	11	21	11	-	1	21	8	607
April 2013 to March 2014	215	28	11	8	52	24	111	3	2	13	2	-	15	-	386
April 2014 to March 2015	212	18	6	10	62	29	77	3	2	3	1	-	4	-	301

- HT - Head Trauma
- IHD - Ischaemic Heart Disease
- CVA - Cerebro Vascular Accident
- COPD- Chronic Obstructive Pulmonary Disease
- ALD- Adrenoleukodystrophy



6.5 ARCHEOLOGICALLY IMPORTANT SITES

The project area has several archeologically important monuments protected under the international conventions, national or local legislation. Several churches and forts of archaeological and historical importance are located in the study area and some of them are protected and /or world heritage centers site. Status of the important forts and church located with in 15 km from the proposed navigation channel are summerised in following section:

Church of Our Lady of Rosary (1542-1549), Old Goa

This Church built in Manueline style on the holy hill, located approximately 9.5 km from the present project site. There are two chapels and three altars with the main altar dedicated to Our Lady of Rosary.

REIS Magos Fort

This fort was built on the banks of the Mandovi river, located about 12 km from the project site. The Reis Magos Fort was converted to a sub-jail to lodge short term convicts. It was also used to lodge freedom fighters working for the liberation of Goa, when the movement intensified in 1950's. The Fort functioned as a jail till 1993 and during this period a number of modifications were carried out.

In 2007, a tripartite agreement was signed between the Govt of Goa, INTACH and the Hamlyn Trust to restore and re-sue the fort as a Cultural Centre. The restoration was sponsored by the HHT. The Fort was again opened on 5th June 2012.

Our Lady of Exile Church, Desterro

A primitive chapel dedicated to St Thomas was built in 1672 in Desterro, Goa. This Chapel to St Thomas was then replaced with the present chapel dedicated to Our Lady of Exile at Desterro also called 'Nossa Senhora do Desterro, Goa' in Portuguese which was affiliated to the St Andrew's Parish in Vasco. In January 1997, the new parish was created of Our Lady of Exile Church, Desterro, Goa.

Aguada Fortress (Upper), Condolim

The fort Aguada built of laterite stone in 1512 comprises a lower fortification with bastions all around and an upper fort. The fort besides offering a safe berth to Portuguese ships was also their water storing point since the place had a perennial water supply. The word Aguada in Portuguese means a watering place. This fort is located around 9 km from the present project site



Fortification Wall of Aguada Fortress (Lower), Condolim

Fortification wall of aguada fortress was built in 1612 by Portuguese and overlooking the Arabian Sea. It serves as a place for watering to Portuguese Armadas and a point for keeping close watch on intruders entering into the Mandoviriver. It has one bastion protruding towards the sea and four smaller bastions at different intervals. Fortification wall is around 9 KM from the present project site.

Our Lady of Health Church, Sancoale

Our Lady of Health Church at Sancoale is located about 12 km from the project site. This church is also known as Nossa Senhora de Saude Church. Today only a part of the church's facade stands on the banks of the Zuari River. The erstwhile Portuguese Government had declared it a national monument on 19.3.1937. The Patron of Goa Blessed Joseph Vaz wrote his famed "Letter of Bondage" at this church in 1677.

Ruins of Shanta Durga Temple, Salcete

Ruins of Shanta Durga Temple, Salcete is located about 11km from project location. The original temple at Quelossim (Keloshi) in Salsete was destroyed by the Portuguese in 1564. The goddess was transferred to Kavalem and worship was continued there.

Ruins of Mangesh Temple, Cortalim, Salcete

Shri Mangesh Temple, built in 18th Century, lies on the north-west of Ponda in Priol. Considered to be the most important temple in Goa, it belongs to the typical Goan Hindu temple style of architecture. This picturesque little temple is built on a hilltop amidst sprawling farmlands. The temple has shrines of Parvati (consort of Shiva – Destroyer of the Universe) and Ganesha (the elephant-god of Prosperity and Wisdom). Most of the Goan temples are noted for their chiseled architecture and their distinctive style.

British Cemetery at Dona Paula, Panaji

The British Cemetery is situated at a distance of 5 km from the study area. It was built around the year 1802 by the British, It is considered to be more than 180 years old and is the the only remnant of the British occupation of the territory of Goa during the Napoleonic period wars from 1799 to 1813 to prevent Goa from falling into the hands of the French The cemetery has 56 gravestones of sepulchral relics and 47 well preserved tombs are found at the site, The tombs date from 1808 and to 1912.



6.6 SENSITIVE INSTALLATIONS

6.6.1 Defense Installations

Defence installations situated within 5 Km from the proposed project location are listed below:

INS Hansa, is military airbase and operates from Dabolim Airport.

INS Mandovi is located along the banks of Mandovi river in Panaji. It was established as a Sailors Training Establishment in 1976. The National Defence College at INS mandovi aims to impart training in national and international security to select senior Civil and Defence Officers.

INS Gomantak caters to the logistics and manitance support.

INHS Jeevanti is in Vasco-da-gama is the naval hospital.

Goa Shipyard Limited designs and builds sophisticated ships for Navy and Coast Guard organisations with the aim of achieving self-sufficiency in this vital technology. It also builds commercial vessels like Offshore Supply Vessels, Oceanographic and Coastal Research Vessels, Fishing Vessels, Dredgers, Tugs, etc. Apart from shipbuilding it also carries out ship repairs and promotes use of indigenous equipment such as computers, radar, communication equipment, auxiliary machinery, electrical fittings and domestic equipment.

Signal Training Centre (HQ 2), comprises of a headquarters, a military training regiment and technical training regiments. This centre is the largest military establishment in the state of Goa and the only local services establishment available for aid to the civil power.

6.6.2 Densely Populated / Builtup Area

The headland sada and Vasco are situated beside the Marmugoa Port Trust and has a densely populated builtup area. The area also houses the MPT colonies and schools and hospital run by the MPT. The Marmugo Municipal Corporation comprises of the areas of Vasco and Sada. Panajim ia another densly populated areas with in 15 km from the proposed project site.



6.6.3 National Institute for Oceanography (NIO)

NIO is an important establishment located at about 5 km from the proposed project site located. NIO established over 40 years has grown into a large oceanographic laboratory of international repute focusing on the understanding of special oceanographic features of the Northern Indian Ocean.

6.6.4 Other Organizations

The other organisations of importance located within the study area are National Centre for Antarctica and Ocean Research (NCAOR), District Jail, Central warehouse, Indian Maritime Institute. There are schools, colleges and other educational institutions in the study area.

6.6.5 Cemeteries

The cemeteries of importance within the 15 km radius are Talegoa Church Cemetery, St. Andrews Church Cemetery, Murumugoa Cemetery, British Cemetery Sinquerim Cemetery. Apart from the above mentioned built up areas, a lot of places of worship and commercial centers include in the tourist homes, Hotels, Lodges and other State and private offices are observed. The area is well connected by roads and railways. The British Cemetery at Dona Paula, Panaji is located about 5 km from the Project Area.

6.6.6 Major Hospitals in the Study Area

The important hospitals located within 15 km area includes the Goa Medical College Cum Hospital, SMRC's V M Salgaocar Hospital, Mormugoa Port Trust Hospital, Chicalim Cottage Hospital

Goa Medical College

Goa Medical College is the successor of the 'Escola Medico Cirurgica de Goa' established by the Portuguese in the year 1842. In the year 1963, this Medical School was upgraded as Goa Medical College, attached to the Bombay University and later in the year 1983 affiliated to Goa University. This is one of the prestigious institutions of the country, recognized by the Medical Council of India, admits 100 students for undergraduate M.B.B.S. Course, while 72 Post - Graduate are admitted every year. The Goa Medical College Hospital was initially operating from Panaji and Ribandar, shifted to Bambolim in the year 1991, has presently 1000 beds, whereas 80 bedded TB and Chest Disease Hospital functions from St.Inez, Panaji. Similarly, a 20 bedded Rural Health and Training Centre is situated in Mandur. The entire



complex at Goa Medical College, Bambolim is spread in an area of 11,34,798 Sq Mts.

SMRC's V M Salgaocar Hospital, is a 118 bedded multi-specialty hospital with a 50 bedded Cardiology Department including CCU, Non-Invasive and Invasive Setup.

Mormugoa Port Trust Hospital

Mormugao Port Trust has its own 100 bed hospital, fully equipped indoor and outdoor departments at Headland and first Aid Centres at Mormugao Harbour, MPT Workshop and at MOHP area. Medical facilities in the disciplines of General Medicine, General Surgery, Obstetrics & Gynecology, Pediatrics, Ophthalmology and Dentistry are available to the employees and their dependents. These are further supported by other Anesthesiology, Pathology, Radiology, Orthopedics. The hospital has also extended medical facilities of Ayurvedic and Homeopathic treatment to the employees and their families. Whenever necessary, arrangements for external specialist consultations/ referral are made in the interest of the patient. Apart from medical officers, the hospital is enriched with qualified and experienced nursing personnel and other paramedical staff.

Chicalim Cottage Hospital

The Cottage hospital is one of the six major hospitals of Directorate of health services, Government of Goa. The Cottage Hospital, serves as referral Hospital. The primary health care infrastructure has been developed as a three tier system - Sub-Centres, Primary Health Centres and Community Health Centres. Sub-Centre is the most peripheral contact point between the Primary Health Care System and the community and is manned generally by Multi-Purpose Health Workers (Male & Female) and a Peon/Attendant. Primary Health Centre is manned by a Medical Officer supported by para-medical and other staff. Some of the PHCs (minimum 12 in number) have attached hospitals ranging with 12 to 30 beds and are headed by a Health Officer. The details of Health Centers in the study area is given in Table 6.6.



Table-6.6: List of Health centers in the study area

S.No.	Name of Taluka	Urban Health Centres	Primary Health Centres	Sub-centres
1	Tiswadi	Urban Health Centre, Panaji	P. H. C, Corlim	1. Batim 2. Taleigao (Borbot) 3. Taleigao (St. Paul) 4. Goltim (Divar) 5. Mercedes 6. Ella 7. Siridao 8. Bambolim
2	Mormugao	Urban Health Center, Vasco	P. H. C, Cansaulim	1. Seraulim 2. Betalbatim 3. Benaullim-cana 4. Benaullim 5. Arossim 6. Majorda 7. Velsao
			P. H. C, Cortalim	1. Verna 2. Naquelim Chicalim 3. Consua 4. Sindolum (Sancoale) 5. Quellossim

There are 2 Urban health centers, 3 Primary health centers and 20 sub centers that are maintained by the Goa State government.

CHAPTER-7
PREDICTION OF IMPACTS

CHAPTER-7 PREDICTION OF IMPACTS

7.1 INTRODUCTION

Based on the project details and the baseline environmental status, potential impacts that are expected to accrue as a result of the proposed project have been identified. The assessment exercise for quite a few disciplines is subjective in nature and cannot be quantified. Wherever possible, impacts have been quantified. However, for intangible impacts, qualitative assessment has been done. This Chapter deals with anticipated positive as well as negative impacts due to dredging operations and disposal of dredged material of the proposed capital dredging activities.

Dredging and disposal of dredged spoils are key elements of the present project. The dredging proposals are mainly carried out to provide navigable water depths for shipping at ports and harbours. Once the material is excavated from the seabed by a dredger, it can be handled in various ways. Often dredged material is loaded into a hopper (part of the dredger itself or on a separate vessel) and transported to a disposal site where the contents of the hopper are emptied directly in the open ocean (i.e. sea dumping) or via a pipeline that allows the dredged material to be pumped to location where it is used for engineering purposes.

7.2 DREDGING DETAILS

In the envisaged project, the total capital dredging quantity calculated for enabling navigation of Vessels was estimated at 15.4 Mm³. As per present bathymetric investigation the remaining quantity of dredged material is estimated at about 12 Mm³. Similarly, the quantity of hard rock has been estimated at approximately 0.175 Mm³. As per the mathematical model study carried out at CWPRS Pune, the volume of maintenance dredging has been estimated at 6 Mm³. The present level of annual maintenance dredging volume in the existing navigational channel is about 3 Mm³.

7.3 IMPACTS DUE TO DREDGING

7.3.1 Impacts due to Turbidity & Plume Generation

The dredging of navigation channel and disposal of dredged material would lead to the generation of a plume as the dredged spoil material is released to the water column during the dredging and spoil disposal operation. Dredging operations are likely to increase turbidity, which results in decreased primary productivity and also changes the nutrient regime in the water column. Increase in turbidity may lead to reduction in the aesthetic value of water in the Port area and surroundings. These are temporary phenomena and the marine environment will gain normalcy shortly after the termination of dredging operations. However, dredging and dumping (spoil disposal) activities are not likely to affect tourism areas as the nearest beach of tourism importance is located > 4 km away and the Grande Island is located > 6.5 km from the entire navigation channel. Similarly, nearest and most frequented tourism spot (apart from a beach) of Dona Paula Jetty, is also located > 4.5 km from the said channel.

Most of the dredging work will be undertaken with a Trailer Suction Hopper Dredger (TSHD), supplemented by Cutter Suction Dredger (CSD) or Backhoe Dredger (BD) for dredging hard material and weathered rock. The potential environmental effects of suction dredging are generally two-fold, firstly as a result of the dredging process itself and secondly as a result of the disposal of the dredged material. During the dredging process effects may arise due to the excavation of sediments from the bed of the existing navigational channel, loss of material during lifting of the dredged material to the surface and overflow from the dredger. The extent to which dredging might affect the environment is highly varied and site specific, depending upon a number of factors:

- “Magnitude / frequency” of dredging activity, method of dredging and disposal of the spoils
- Channel size and depth.
- Size, density and quality of the dredged material
- Background levels of water and sediment quality, suspended sediment and turbidity.
- Tidal range, current direction and speed

- Seasonal variability and meteorological conditions affecting wave conditions and freshwater discharges.
- Presence and sensitivity of floral and faunal assemblages, in the vicinity of dredging and disposal activity.

Normally, dredging activities increase the turbidity levels in the water column for a short period of time and turbidity level returns to the pre-project level once dredging is stopped. In addition to the environmental impacts like increase in turbidity, reduction in light penetration, decrease in primary productivity, changes in the nutrient regime, loss of benthic fauna, etc. Impacts also may occur as a result of the physical changes to bathymetry and hydrodynamic processes due to dredging. These effects are listed in Table-7.1 (IADC/CEDA 1998).

Table-7.1: Time–space matrix of potential effects associated with dredging and disposal of dredged material (IADC/CEDA 1998)

	Near-field Environmental Effects (<1km)	Far-field Environmental Effects (>1km)
Short-term Environmental Effects (<1 week)	Dredging Turbidity Smothering/removal of organisms Reduced water quality	Dredging None generally expected
	Disposal Smothering of organisms Turbidity Reduced water quality Acute chemical toxicity	Disposal Offsite movements of chemicals by physical transport
Long-term Environmental Effects (>1 week)	Dredging Disturbance by shipping traffic Removal of contaminated sediment	Dredging None generally expected
	Disposal Altered substrate type Altered community structure Chronic chemical toxicity Bioaccumulation	Disposal Offsite movements of chemicals by physical transport and/or biota migration

Redox potential (eH) and pH are two variables that control the characteristics of chemicals and heavy metals in water and sediment. The pH in the water body in the sampled site varied from 7.0 to 7.3 which is normal or neutral range. This range does not lead to any adverse impact on the biota. As long as the pH remains around 8 and

eH < 150 mV, most of the chemicals and metals will remain bound to the solid phase without being released into the surrounding water. Only anoxic conditions reduce the eH below this level and hence if dissolved oxygen level is within the normal range, no leaching of chemicals and heavy metals is expected to occur.

At the present site, pH is in normal range, and dissolved oxygen too is in the normal range for a marine ecosystem, where there are no sources of pollution. Dissolved oxygen levels are not expected reduce to anoxic conditions until and unless there is significant increase in organic pollution loading. In future, significant increase in organic pollution loading is not expected. Under these circumstances, there is no possibility of any of the chemicals or metals being leached into the water. Moreover, sediment samples collected from all the sites were uncontaminated. As such no adverse impact due to dredging on the chemical characteristics of water or sediment is expected.

The most important factor that rules out the development of anoxic conditions “and/or” sustained increase in level of “organic/inorganic” marine pollution due to the proposed dredging activity is the highly dynamic location of the entire navigational channel. The latter is a part of the wide mouth (>5 km in width) of the vast Zuari River estuary prone to the constant tidal action and oceanic currents of the Arabian Sea. Besides, the severe annual South-West monsoon also churns the marine environment of the locality ensuring the flushing out of pollutants and enhancement of dissolved oxygen.

7.3.2 Impacts of Dredging on Shoreline

The key findings are given as below:

- Port Authority's experience with respect to Capital Dredging and Annual Maintenance Dredging undertaken during last five decades indicates that the geological strata in the vicinity of the entire navigational channel are stable and not prone to landslides.
- Comparative Google images (taken at similar "tidal/current/weather" conditions) of Khariwada beach stretch of last 15 years, do not give any indication of sustained beach erosion. The navigational channel, which is dredged up to 14.1 m to 14.3 m (below CD) and more till 31.05.2016, has side

slopes in the ratio ranging from 1:4 to 1:6 which is found to be stable as confirmed through Bathymetric studies. Therefore there is no question of Khariwada beach or nearby hill slopes getting affected.

- Shoreline change study was entrusted to NIO as stipulated in the Environmental Clearance dated 09.02.2016 issued by MoEF & CC. The same study has also stipulated as necessary in the ToR issued by EAC of MoEF&CC on 16.10.2016. Accordingly, after fulfilling their commercial conditions, the NIO commenced the study in May 2016. So far, at the end of eleven months of data collection, the NIO has submitted two interim reports in this regard. The conclusion drawn in the interim report of NIO is reproduced below:

"This interim report presents the studies carried out on shoreline monitoring through beach profile measurements at about 44 cross sections covering both the North and South Goa beaches and baseline information on the Goa coast profile changes.

From the past beach profile studies carried out by CSIR-NIO, no progressive coastal erosion is observed within 10 km radius of MPT region. The coastal erosion/accretion is related to incoming dynamic wave conditions and the littoral transport. The changes of these dynamic wave and littoral transport are due to changes in tides, ocean currents, storms, monsoons, etc. In order to find any changes in the shoreline, continuous observations have to be made for a minimum period of three years

Moreover, as explained by CWPRS, the beaches consist of sand and silt generated from the sea bed. So the silt quantity coming out of maintenance dredging is not going to affect the stability of the beaches which are in dynamic equilibrium due to the prevailing littoral processes.

7.3.3 Impacts due to Aqueous Discharges

The impact of dredging on sea water quality will have a short term negative impact on the marine biota of the study area. However, the impacts of dredging will be limited to the period of dredging and dumping operations only. Once the dredging operations stop and the plumes settle down the quick natural restitution of the dredged areas will take place.

There will be no liquid discharges from the dredging activities, and this will be strictly enforced. All liquid and solid wastes will be collected in slop tanks and transported onshore at regular intervals for proper treatment and subsequent disposal at designated place.

7.3.4 Impacts of Rock Dredging

The total quantity of dredged material has been estimated at about 12 Mm³ of which approximately 0.175 Mm³ is expected to consist of weathered rocky material. The rock will be broken into smaller pieces using Cutter Suction Dredgers (CSD) or Backhoe Dredgers (BD). The dredged rock will then be collected by Trailer Suction Hopper Dredgers (TSHD) and will be discharged in the notified spoil grounds at 2 locations as already mentioned above. No rock blasting will be carried out. Due to rock dredging, no major impact due to increase in turbidity is envisaged.

7.4 IMPACTS DUE TO DISPOSAL OF DREDGED MATERIAL

The dredge spoils will be disposed at the exclusively “identified/demarcated” offshore disposal area. Central Water and Power Research Station (CWPRS), Pune, has carried out hydrodynamic and dispersion studies for identifying the locations in offshore region to dispose of the dredged material. As per CWPRS recommendation, a disposal area of 2 km X 2 km, located at a distance of about 1 km North from the intersection of the center line of the outer approach channel at the 23 m and 27 m contour depths.

Disposal of dredged materials is likely to lead to burial of benthic organisms and increase in turbidity in the said disposal area. The clayey matter will be in suspension for a period of 10 to 15 days. The particulate matter with a coarser texture is likely to remain in suspension for a much lesser duration. Normally, productivity in disposal area itself will be low during the time of disposal and will return to normal over a period of time. However, fish productivity in the vicinity of the disposal ground is expected to increase due to the release of nutrients and organic matter in the marine water column for the interim period until the return of normalcy after the end of dredging and disposal operations. The latter is supported by the past observations of

increased trawling activity in the vicinity of the designated disposal grounds during routine maintenance dredging works.

The dredged material shall be disposed off appropriately in the marine Spoil Disposal Grounds scientifically identified and earmarked by the CWPRS (Pune) through hydraulic and wave modeling studies. Maintenance dredging is an annual Port activity and the dredged material is disposed in the Spoil Ground at the 23 m contour according to the CWPRS study. The Spoil Ground is chosen in such a way that due to natural sea currents sediments are carried towards the North side, away from the coastline, in the deep sea. It has also been proved as such, on the basis of modeling study carried out by CWPRS and the "pre/post" dredging bathymetry charts prepared by the Port. No significant morphological changes are expected due to the dumping of dredged material at designated grounds. The Marine Department of the Port has observed that the local fishermen prefer to carry out fishing activities very close to the Spoil Ground area apparently as it gives them a good fish catch. This is the result of the accepted fact that the activities of dredging and disposal of spoils result in the release of a large amount of "nutrients/organic detritus" into the marine water and increases its availability for fish nutrition. The Port Administration provides regular information on their Capital and Maintenance dredging or any other marine activity to the stakeholders including the fishing community through harbor notices.

7.5 IMPACTS ON NOISE ENVIRONMENT

Noise generated by the dredging vessels is not significant and will not cause any auditory discomfort to the residents. Also, the entire existing navigational channel proposed for deepening and extension of the same to meet the desired natural draft in the Arabian Sea is far from the nearest settlement area. Proper maintenance of dredgers and DG sets to be used during the dredging will be ensured to minimize the impacts on noise environment. Personal protective equipment shall be provided to the persons working on the dredgers.

7.5.1 Impacts on Underwater Noise

The operation of diesel engines of the dredger, barges and workboats involved in the dredging activities will generate underwater noise. The physical disturbances that

occur during dredging and dumping are classified as physical forces resulting in noise and turmoil. The noise generated by the dredging of soft sediments is relatively lesser as compared to noise generated from rock dredging. The proposed project envisages the dredging of about 12 Mm³ of soft material including approximately 0.175 Mm³ of weathered rock dredging. Since, most of the dredged material is soft in nature, underwater noise is expected to result in minor impact on the marine biology of the study area.

The marine species exposed to such noise during the dredging of rocks, are accustomed to the underwater noise generated by the movement of fishing vessels, tourists boats and ships along the existing navigational channel which is constantly in use for more than 5 decades. The marine species are expected to tolerate the increased noise generated from the increased vessel movement and periodic dredging activities.

There would be a degree of avoidance behavior exhibited by some marine species initially and they would eventually be expected to return once they become accustomed to the increased noise levels or once the noise source has moved or ceased, as dredging is a short term activity. Also the noise-generating source is mobile and hence the impacts will be more localized only at the point of operation.

There are no mangroves or breeding grounds near the proposed dredging area and hence the dredging activities are not expected to cause any damage to the marine ecosystem of the locality. It is further emphasized that the proposed project activity is “brownfield” in nature and is entirely restricted to the active Port Basin that has been in operation at the present level for more than five decades and no fishing activity is permitted in the same for safety reasons, as is the case at all major Ports and Harbours.

7.6 IMPACTS ON MARINE ENVIRONMENT

Dredging being a physical activity, it is but natural that increased dredging events result in some adverse impact on biodiversity by disturbing the biological community structure both at dredging as well as dumping sites. Furthermore, dredging activities potentially affect not only the site itself, but also the surrounding area. The major

impact of dredging is the destruction of benthic habitat, within the dredged foot-print area, because of dislodging of the sediments. Resettlement of sediments is another inevitable impact on the marine eco-system. Impacts on marine biodiversity due to proposed dredging have been assessed by NIO. Thus based on marine biodiversity impact assessment report prepared by NIO in July 2017, the following likely threats to the marine environment are elucidated:

7.6.1 Impact on Pelagic Environment

Benthic organisms are particularly vulnerable to entrainment by dredges, primarily due to their sedentary habitat. Similarly, demersal and epi-benthic organisms are also vulnerable to entrainment by dredging activities. The possible impacts of dredging and disposal on pelagic environment are summarized below:

- Dredged sediments act as a potential source of nutrients which might result in eutrophication of surface waters.
- Increased turbidity leads to decrease in the dissolved oxygen (DO) in the water column during the dredging operation in progress.
- Increases in suspended sediment loads and turbidity levels due to dredging and disposal operations creates adverse effects on pelagic marine producers and consumers by reducing euphotic zone of the water column.
- Increased suspended sediments can not only limit the light penetration in water but also affects the filter feeding organisms such as zooplanktons.
- Reduced DO can cause the loss of micro-eucaryotic biomass, decrease in aerobic bacteria and the increase in sulphate-reducing and other anaerobic bacteria.
- Loss or reduction of bacteria means the re-mineralization of organic matter will be significantly slowdown and will have cascading effects on the invertebrate grazers, predators and fish community.
- Potential threat of increase in the events such as algal blooms, harmful algal blooms, jellyfish blooms and increase in the number of undesirable species.
- Dredging will lead to increased turbidity that will limit light penetration and adversely affect the phytoplankton growth. This is particularly so in bottom

waters where the photosynthesis in phytoplankton will be inhibited by decreased light intensity.

The impacts listed above are likely to be manifested significantly only in narrow river basins where the dynamic processes leading to the quick recovery of the dredged environment are severely restricted. However, as mentioned earlier, the present dredging proposal is located within the existing navigational channel situated in the highly dynamic marine environment of the mouth of the wide Zuari estuary constantly prone to sea tides, currents and severe annual monsoonal wave action. Under these circumstances the possibility of oxygen depletion and resultant eutrophication can be safely ruled out. Similarly the anticipated impacts of turbidity and associated obstruction to the process of photosynthesis, if any, are also expected to be quickly reversed in the said dynamic estuarine environment.

- From the spatial trend of chl a values in the study area, there seem to be short term effects on the biota in terms of decreased chl a in bottom waters due to light attenuation due to turbidity. But since these values are within the limits reported for this area in this season, the observed effects are reversible and will attain normalcy soon after dredging is completed.
- Since dredging removes material and dumps it away at another site, there are chances of meio-zooplankton being affected and or buried elsewhere, thus affecting the diversity in the water column. However, studies indicate stabilisation of condition after dredging. Since the dumping sites are in deeper waters, the impacts of turbidity will not be large on the abundance and diversity of zooplankton.

However, as fish grow and mature, swimming or darting speeds improve, there is a definite avoidance behaviour associated with potential entrainment from hydraulic dredging. Hence, adult fish have the ability to avoid entrainment in a suction dredge by moving to a safer location and it is unlikely that they would be sucked into a dredge in the first place.

Various NIO and ICAR studies conducted in the marine environment of Zuari estuary, earlier and in the recent past, have neither found any significant deterioration in

marine bio-diversity or any linkage between Port activities and attributes of marine environment. The letter issued by NIO Scientist, Dr. Baban Ingole, on 17th March 2015 reads as under:

“(a) The Chicalim Bay is already under the direct influence of the busy Mormugao Port, Goa Shipyard Limited and several nearby “Barge/ Ship” Building and Repair establishments, most of which are operating for the last several years. Despite the above operations in the vicinity the Chicalim Bay is rich in marine biodiversity, harbouring more than 200 faunal and 34 phytoplankton species in addition to mangroves and macrophytes. Natural stocks of windowpane oyster (Placuna placenta) inhabit the soft, muddy substrate of Chicalim Bay and their population is in a healthy condition. The results of the present study indicate that the conditions in Chicalim Bay are ideal for settlement, growth and the production of P. Placenta.

(b) Windowpane Oysters are included in Schedule IV of the Wildlife Act. As per the available published research data for Goa, the species is found in the Siridao area along the Northern bank of Zuari river and Chicalim Bay along the Southern bank of Zuari river. Sancoale area is not known (no published reports available in public domain) for the presence of the same.

(c) Even though a small number of people consume Windowpane Oysters (WPOs) in Goa, we do not know the extent of its fisheries.

(d) The first research work on WPOs in Goa was carried out in Siridao area (Achuthankutty et al 1979). They reported a catch of 350 to 400 nos. of WPOs per sq. mt. Later in 2006, in the same area, NIO also reported 335 to 420 nos. of WPOs per sq. mt. (Ingole and Clement 2006). In fact in this paper it was concluded as follows:

'The present scenario of these Oysters appears to be promising. The number of WPOs recorded in the present study is comparable with that observed earlier (Achuthankutty et al 1979). Moreover, only 8 pearls were recorded in a WPO in the 1979 study compared to 14 pearls recorded per WPO in the present study'.

(e) In a recent study conducted between October 2013 and September 2014, the Indian Council of Agricultural Research (ICAR), Old Goa (Goa), identified a total of 186 aquatic species (150 finfish and 36 shellfish) in the mouth of Zuari Estuary. It



was evidently reported that the fish and shell fish diversity along the estuarine eco system of Zuari mouth is rich and accounts for a significant quantity of Goa's Marine and brackish water fish production. The 150 finfish species comprised of 65 pelagic and 85 demersal fishes. The shellfish fauna comprised of 17 crustacean and 19 mollusc species.

(f) *This latest study along with conclusions drawn from NIO's 2006 / 2010 studies cited above, give credence to the view that the "tidal/wave "dynamics and resilience of the vast Zuari estuary has been able to "mitigate" the adverse ecological impact of the functioning of the Mormugao Port, Goa Shipyard, scores of smaller "Barge/ Ship" yards and constant Ore transportation activity, prevailing from 1970s onwards."*

As stated earlier, "Capital/Annual Maintenance" dredging works, undertaken by the MPT in the past 5 decades, have not resulted in any conceivable adverse impact on Fish Catch, Biodiversity, Tourism activity or Shoreline stability. No such complaints have also been officially received from any stakeholders.

7.6.2 Impacts on Benthic Environment

Dredging activities will lead to the removal of material from the seabed including the removal of animals living on and in the sediments which are collectively called as 'Benthos'. Initial reduction in abundance, species diversity, benthic biomass as well as recovery of the lost biota varies with scale and duration of disturbance, local hydrodynamics, and associated transport processes and lacks similarity to the habitat that existed prior to dredging. Impacts of dredging and disposal on Benthic environment as indicated by NIO include:

- Removal of the surface sediment associated biota at the dredged site.
- Increased suspended sediments can affect the filter feeding organisms (viz. shellfishes) by clogging and damaging their feeding and breathing organs.
- Increased sedimentation during the dredging may pose significant harm to the macro-algae, if present.
- The vertebrates and invertebrates are directly dependent on the macro-algae mainly for shelter and support other life forms of the ocean such as

herbivorous fish, crabs, sea urchins etc. Thus any impact on macro-algal diversity may influence other trophic levels disturbing the community structure.

- Disturbance of the upper layers of the seabed causing short-term re-suspension of sediments, re-mineralization of nutrients and contaminants and re-sorting of sediment particles. Direct removal, damage, displacement or death of a proportion of the animals and plants living in or on the seabed. A short-term attraction of carrion consumers. The alteration of habitat structure (e.g. flattening of wave forms, removal of rock, removal of structural organisms).
- Initial reduction in abundance, species diversity and biomass of benthos and recovery varies with scale and duration of disturbance, local hydrodynamics and associated transport processes and requires similarity to the habitat that existed prior to dredging
- With the exception of some deep burrowing animals or mobile surface animals that may survive a dredging event through avoidance, dredging may initially result in the complete removal of animals from the excavation site.
- Increased suspended sediments can affect filter feeding organisms, such as shellfish, through clogging and damaging feeding and respiratory organs.
- Adult fish are likely to move away from or avoid areas of high suspended solids, such as dredging sites, unless food supplies are increased as a result of increases in organic material.

Most of the impacts listed above are manifested significantly in a green-field dredging project undertaken in an undisturbed riverine ecosystem. However, the present project is a brownfield project restricted entirely to a long existing navigational channel within the active Port Basin, which is in operation for several decades under periodic (annual) maintenance dredging since 1970s. Further, no sensitive marine ecosystems are present within a radius of at least 4 km from the said channel. Hence, the manifestation (if any) of adverse impacts listed above due to the proposed project is not likely to be significant.

7.6.3 Impacts on Fisheries

The key impacts covered as a part of the present study are described in the following paragraphs:

- Dredging activities will lead to physiological stress to marine fish species by creation of short-term higher sediment loads in the water column. Reduction in habitat or loss of benthic primary producers due to dredging and dumping activity may affect the fisheries in the navigation channel and dumping area. However, Adult fish are likely to move away from or avoid areas of high suspended solids, such as dredging sites, unless food supplies are increased later on as a result of increases in organic material transformation through heterotrophy and their biomass build-up.
- Also, as pointed out earlier, international maritime regulations prohibit any fishing activity in and around the vicinity of active Port Basins and Navigational Channels.
- The Fisheries Report published by the Department of Fisheries, Government of Goa (Page 23), records that the marine Fish catch in Goa has shown sustainably steady growth from 24, 600 Tons in 1965 to 40, 000 Tons in 1988, 87,984 Tons in the year 2013 and 1,28,107 Tons in 2014.
- The dredging activity is confined to the existing old navigational channel located partly within the active Port basin and partly towards the West (beyond the estuary) in the Arabian Sea. No fishing is allowed in the navigational channel for the safety of the "fishermen/fishing boats" as well as the "crew/ships" using the Port. In the estuarine area and in the sea beyond the Port basin, where fishing is permitted, the adverse impact of dredging (if any) is restricted to a small temporary period. MPT's experience of the last five decades and the official statistics published by the Department of Fisheries, do not give any indication that past "Capital/Annual Maintenance" dredging operations have had any adverse impact on fish yields.
- No fishing is allowed in the active basins of all Major Ports and their navigational channels, due to security and safety reasons, as mandated under ISPS regulations. The Mormugao Port is ISPS compliant.

7.6.4 Impacts on Aesthetics and Socio-Economic Activity

Tourism industry in Goa comprises of water sports, pleasure boat cruises for picnics, SCUBA diving, snorkeling, and line fishing. In addition, major attraction is the dolphin watching which takes place mainly at Sinquerim bay and Aguada, with boats plying from four registered jetties and from different beaches. There is significant pressure due to tourism on the Humpback dolphin and the coral reefs surrounding Grande Island, which is the focal species for these activities and also come in the influence zone of impact due to its vicinity to the Mormugao Port.

- Reduction in water quality in the estuarine region, at nearby beaches and coastal zone decreases visibility at the dive sites and wrecks at the islands thereby impacting the tourism. As explained earlier, all Tourism related spots are located at least 4 km away from the channel and hence no such impacts are expected from the present project.
- Dredgers and associated vessel movement may appear as a potential threat to the marine mammals like dolphins, which may be harmed due to collision, propeller action and underwater rope, wires and anchorage material. However such instances have not been reported. Further, vessels associated with dredging operations move at slow speeds area ruling out the risk of vessel strike.

The Grande Island is an uninhabited island located at a distance of 6.73 km south of dredging area/channel. As per sediment dispersion modeling studies carried out by CWPRS, dredging influence is normally restricted to a maximum of 4 km of the activity. Hence, no impact is anticipated on Humpback dolphin and the coral reefs surrounding Grande Island.

Hydrodynamic and siltation studies carried out by CWPRS using MIKE -21 AD (Advection and Dispersion) indicates that sediment plume moves towards north and it spreads in 4 km² wide area. Plume crosses the north boundary of model and it could be seen from the sediment plume pattern that it may move further 5 km towards north before it attains ambient conditions. Sinquerim Beach and Aguada are located about 10 km north east of the proposed dumping grounds. Hence, no

impact is anticipated on Sinquerim Beach and Aguada due to dredging and dumping activities.

Proposed project envisages dredging in the existing navigation channel, which is already under maintenance dredging for decades. However, temporary increase in turbidity near navigation channel is expected during the dredging period. Dumping sites for the capital dredging identified by CWPRS are located about 14 km from the breakwater. Hence, no significant impact is anticipated on nearby beaches account of dredging and dumping activities. There might be some disturbance to the marine mammals due to the movement of dredgers and associated vessel during dredging operations. In order to reduce the impacts of dredging operation on marine animals, dredging will be suspended during the sensitive periods like breeding season. There are no mangroves or breeding grounds near the proposed dredging area and hence the dredging activities are not expected to cause serious damage to the ecosystem.

7.6.5 Impacts on Tourism

The activities of MPT for the last five decades have not resulted in any complaint either from the state government or from other stakeholders with respect to any adverse impact on dolphins or tourism activities. No such impact analysis with respect to individual faunal entities is envisaged in the ToR.

Official statistics clearly prove that Goa's tourism industry has prospered phenomenally during the past six decades (since Independence) and continues to improve despite the long on going operations of major establishments such as MPT, GSL and Ship Building Yards (in Vasco and Chicalim Bays), during the same period. Moreover, in recent times, Port has given an additional boost to Tourism by provision of an exclusive Terminal for large luxury Cruise Ship Liners. In the current tourist season MPT handled 39 vessels. In the next cruise season, (October 2017 to May 2018) 47 cruise vessels are likely to be handled.

The proposed brownfield projects of the MPT pertain only to modernization, increase in efficiency and adoption of advanced technologies for economically and environmentally sustainable utilization of the existing Harbour Basin area. Such modernization activities are necessary for sustenance of the Port and have no significant impacts whatsoever beyond a maximum radius of 5 km from the centre of



the active Port Basin. As per the mandate of the EIA Notification of 2006, a Study Area of 10 km radius from the proposed project is recommended as abundant precaution. Hence, the said Heritage Sites are not at all affected by the activities in question.

7.6.7 Salinity Ingress in Fresh Water

Port experienced in last five decades, does not indicate any salinity ingress in the aquifers tapped by the Port through the existing Open wells and Bore wells, located at Headland Sada. The deepest Bore well has a depth of (approx.) 140 m from the ground surface, which roughly translates into a depth of about 100 m from the sea surface. However, the maximum proposed depth of dredging is only -19.80 m. from MSL and, as such, there is no possibility of intrusion of sea water into the ground water aquifer, due to the same.

Borehole studies have confirmed that there are no fresh water aquifers at the depth to which dredging is proposed, in this area.

7.6.8 Impact on Air Pollution

During winter the effective wind direction is from North - East to South-West. As such, the wind blows towards the Arabian Sea and (hence) away from the settlement area of Vasco, located in the East.

The MPT has completed a detailed scientific study of annual wind patterns affecting the Port Complex and its Environs, vis- a- vis year-round bulk cargo handling activities of the Port, through a NABET accredited Expert Consulting Firm based in Goa and Mumbai. based on the study, 12 locations have been identified. Equipment have been procured and are being installed.

7.6.9 CUMULATIVE IMPACTS

The proposed brown-field project is entirely within the active “Port Basin/Navigational Channel” area of the MPT Complex. There are large scale activities already on-going in this region. Many industries are located on the upstream of the estuarine mouth and also the upstream area has a large urban complex of Vasco and well developed rural settlements including many Barge Yards and Ship Building units including the GSL Complex all along the Southern bank of Zuari River. The likely adverse impacts in the estuarine mouth of Zuari and the adjoining marine ecosystem will be of

cumulative nature influenced by all such activities and it will be hard to discern the singular impact of any new or old activity in the given location, and period.

7.7 IMPACTS DUE TO CONTAMINATED SEDIMENTS

Another possible impact is the release of toxicants from the sediment if the sediment is contaminated. In the case of contaminated sediments acute toxicity, chronic toxicity and bioaccumulation are the possible effects. But all these are short-term and insignificant and no serious effects have been reported from any earlier instances or experimental studies. Sediment samples analyzed from the project area did not show the presence of any appreciable levels of contamination and hence may not pose any problems of contamination.

7.8 IMPACTS ON PHYTOPLANKTONS AND PRIMARY PRODUCTIVITY

Biomass of phytoplankton depends mainly on the availability of light in nutrient rich waters. Dredging and disposal may lead to increased turbidity and consequent reduction of light penetration for short periods. This may affect primary productivity and plankton biomass. However, turbidity due to dredging and dumping will be observed only in a localized area and only for a very short duration.

Based on the marine ecological status of the project area, it may be concluded that the site supports good biodiversity, even after regular maintenance dredging in the navigation channel. Most of the environmental variables are recorded within the optimal levels, as recorded in other parts of the West coast. The dissolved oxygen is fairly good, largely due to the high water exchanges, and heavy metal content in water and sediment samples is low. Hence, it may be concluded that adverse impacts on phytoplankton and primary productivity are not expected to be significant in nature.

7.9 IMPACTS DUE TO SPILLAGE

Deliberate spillages

It is a practice in some dredging operations to maximize the amount of solid material in the hopper hold by allowing the slurry water mixed with the dredged material to overflow from the vessel. In cases where fine sediments are being dredged, this

results in high turbidity of the water surrounding the vessel which could then be transported by surface water currents over sensitive habitats. A second means of deliberate spillage occurs when the bottom gates of the hopper hold are opened slightly so as to release sediments while the vessel is on route to the reclamation site. Preventive measures can be taken to avoid or reduce the severity of the impact, and appropriate mitigation measures can be identified. Hence, close monitoring of dredging activities and disposal will reduce such deliberate spillage.

Accidental spillages

The amount of material leaking from the bottom gates of a dredger would normally be insignificant. However, if a hard object or rock becomes lodged between the gates, then material will steadily spill out of the holder into the water column. In some cases measures can be taken to avoid or reduce the severity of the impact, and appropriate mitigation measures are identified. In other cases impacts cannot be avoided or successfully mitigated if the project is implemented and these represent irreversible impacts. It is difficult to avoid the accidental spillage however the same can be minimized by strict compliance of dredging guidelines. The potential impacts related to dredging operations are summarized in Table-7.2.

Table-7.2 Summary of Potential Adverse Environmental Impacts

Activity	Potential negative impacts	Significance of Impact	Duration of Impact		Extent		Mitigation Possible
			Long	Short	Wide	Local	
Dredging	Loss of benthic biota	Moderate	√			√	N
	Increase in turbidity	Low		√		√	Y
Sediment disturbance and overfilling of dredger	Settlement of suspended solids	Moderate		√		√	Y
	Attenuation of light in water column	Low				√	Y
	Degradation of pelagic habitat	Low		√		√	Y
	Damage to fishing gear	Low		√		√	Y
Presence / location of dredges	Increased ambient noise level	Low		√		√	Y
	Impaired visual aesthetics / seascape	Low		√		√	Y

Activity	Potential negative impacts	Significance of Impact	Duration of Impact		Extent		Mitigation Possible
			Long	Short	Wide	Local	
	Hindrance to other boat traffic	Moderate		√			Y
Leakage of sediments during transportation	Increased turbidity over sensitive inshore habitats	Moderate		√		√	Y

√ mark indicates the existence of impact

7.10 IMPACTS ON AIR ENVIRONMENT

During dredging emissions from diesel run engines of the dredgers, barges and workboats might contribute to localized deterioration of air quality. The combustion of diesel in various dredging equipment could be one of the possible sources of incremental air pollution during the dredging operations. The major pollutant likely to be emitted due to consumption of diesel in various dredging equipment is SO₂. The dredging and dumping activities will be carried out in the sea and there is no habitation in the immediate vicinity of the navigation channel. As such the consequential increase in concentration of air pollutants in Mormugao area will be insignificant and thus not require any specific control measure. However, the impacts due to these activities are short-term in nature and will cease on completion of dredging. Thus, the operation of dredging equipment is not expected to have any major impact on the ambient air quality as a result of the project.

7.11 IMPACT ON SHORELINE CHANGES

CSIR-National Institute of Oceanography (NIO) has carried out shoreline monitoring study for Mormugao area through beach profile measurements and remote sensing imagery analysis. NIO has submitted the Interim Report in June 2017. This Interim Report-3 presents the studies completed during the first eleven months' period (July 2016 to May 2017) and the baseline information available with NIO on various beach profiles, of more than 15 years, at select locations in the study region.

The proposed region for monitoring the shoreline through beach profile measurements extends from Baga beach in the North (16 km from MPT) and Mobor beach in the south which (35 km from MPT). The Southern beaches are located

along a single stretch of about 26 km and therefore the whole stretch was considered in the proposal. The shoreline monitoring was carried out through monitoring of 44 beach profiles measured at 21 locations covering 16 km in the North and 35 km in the South of the Mormugao Port and baseline information on the Goa coast profile changes.

Interim report submitted by NIO in June 2017 indicated that the coastal “erosion/accretion” is related to incoming dynamic wave conditions and the littoral transport. The changes of these dynamic wave and littoral transport are due to changes in waves, tides, ocean currents, storms, monsoon, etc. The measured profiles are observed to be similar in the foreshore region for most of the locations.

Initial observations in the present on-going shoreline monitoring studies of NIO within the study area of 10 km radius from Project site, conducted from July 2016 to May 2017, indicate that there is no significant “erosion/accretion”. However, NIO has suggested that continuous monitoring of these beach stretches are required at least for a period of another 2 years to ascertain the influence of any port activity on the beaches.

7.12 HYDRODYNAMICS AND SILTATION STUDIES

Mormugao Port Trust (MPT) has proposed to deepen the existing approach channel to a depth of (-) 19.8 m and harbor areas to (-) 19.5 m covering a total planar area of about 2.90 km². Under this deepening proposal, the channel length will increase by about 3.5 km and the additional capital dredging extent will be of about 12 Mm³.

As per the dredging records of the Mormugao port, the average total volume of annual maintenance dredging is estimated at about 3.0 Mm³ to maintain the existing depths in the channel and harbor areas. This will increase to about 6.0 Mm³ after the envisaged dredging for deepening of the channel. The annual maintenance dredging activity at the Mormugao port normally takes place during the post-monsoon season for a period of about two months.

Considering the proposal for dredging and deepening of navigation channel, the Central Water & Power Research Station (CWPRS), Pune was requested to

undertake the following studies:

- Estimation of the quantity of capital and maintenance dredging
- Hydrodynamics and Siltation studies
- Identification of dumping sites for the disposal of dredged material

CWPRS carried out the studies and submitted an interim recommendation for this deepening proposal giving the estimated quantities of annual maintenance dredging and the location of the disposal ground, in November 2014. As a part of this report, detailed studies for Hydrodynamic and Siltation patterns and for identification of suitable spoil disposal ground were conducted. The 2-D Mathematical Model “MIKE 21” was used for the said purpose.

Simulation of Sediment Movement

Detailed studies for Hydrodynamics and Siltation patterns and for identifying suitable disposal grounds using 2-D Mathematical model MIKE 21 were carried out by CWPRS. In order to simulate sedimentation in the approach channel and harbor area the sediment transport modeling software MIKE 21 MT was used. The Mud Transport (MT) model is coupled with the hydrodynamic model.

Existing Condition

Model was simulated for a period of one month during monsoon period and suspended sediment concentration values were adopted as per the prototype data analysis. According to project authority, the dredging quantity of about 2.65 Mm³ per annum has been observed to occur during four months of Southwest monsoon season. This quantity was considered for calibrating the sediment model. During the non-monsoon season, the siltation is either negligible and in some cases, the effects of consolidation of the bed have also been noticed. The approach channel was divided in five zones from A1 to A5 for the assessment of sedimentation. A typical sedimentation plot in existing conditions is shown in Figure-7.1.

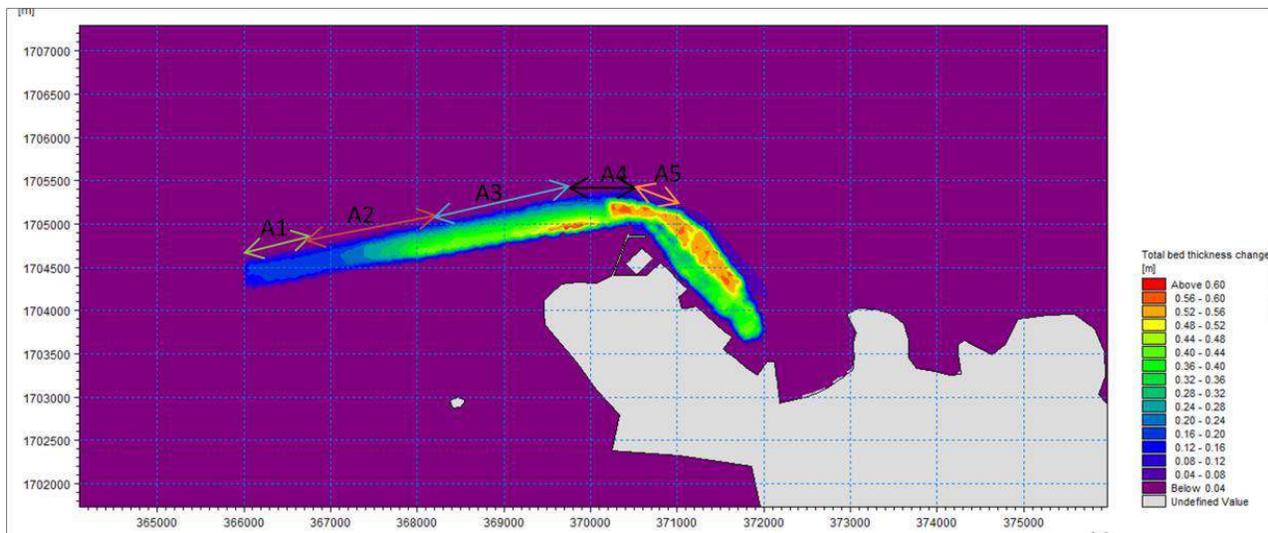


Figure-7.1: Sedimentation in Approach Channel and Harbour

Zone wise sedimentation in the approach channel and harbour under the existing condition per year is given in Table-7.3.

Table-7.3: Zone wise sedimentation in the existing condition

Zone	Sedimentation per Annum (m)
A1	0.54
A2	0.65
A3	1.40
A4	1.80
A5	1.95
Harbour	2.0

Sedimentation in the Proposed Condition

Keeping the same parameters, the model was simulated for a period of one month during monsoon period for proposed deepening of channel and sedimentation in channel was estimated. The total annual sedimentation in the harbour and approach channel, including the area proposed to be deepened, has been estimated at 6 Mm³. Zone wise sedimentation in the channel and harbour considering the proposed condition per year is given in Table-7.4.

Table-7.4: Zone wise sedimentation in proposed deepened conditions

Zone	Sedimentation per Annum (m)
A0	0.56
A1	1.64

Zone	Sedimentation per Annum (m)
A2	1.85
A3	2.55
A4	2.90
A5	3.40
Harbour	3.50

Identification of Disposal Grounds

Mike-21 AD (Advection and Dispersion) model was used to study the sediment behavior after dumping the dredged material. Model was simulated for a period of one month considering 2500 cum of slurry being dumped at an interval of one hour at -27m depth contour (356000 E and 1705000 N) north of the approach channel. It was observed from the model that sediment plume moves towards north and it spreads in 4km wide span. Plume crosses the north boundary of model and it could be seen from the sediment plume pattern that it may move further 5 km towards north before it dies. The dredging takes place during month of August-September when the flow is northward. In order to optimize the disposal ground location, disposal at other shallower contour depths viz. (-) 25m and (-) 26m were also tried but the plumes were observed to intersect the port areas, hence were not recommended. Thus, location (356000 E and 1705000 N) is recommended to dump the dredged material at -27 m depth contour in 2 km by 2 km area.

Summary of Hydrodynamics and Siltation Study

Sediment transport in the Mormugao bay due to mechanism of littoral drift is very small and is confined to a short strip of beach in the Vasco bay. Due to small tidal currents and the existence of clay and silt in the bed, the sediment transport by mechanism of bed load transport is comparatively limited. The main sediment transport mechanism in the Mormugao Port area is due to the suspended sediment transport. The maximum tidal velocities at the entrance or in the harbour areas are weak say 0.3 m/sec, hence they are not large enough so to lift the bed material and bring the same into suspension. The main mechanism causing siltation would be settlement of suspended solids due to reduction in velocities in deepened areas which is directly proportional to the sediment concentration

values of the ambient waters. It may be mentioned that contribution of Zuari river in the siltation process is limited because its average discharge is generally less than $250 \text{ m}^3/\text{s}$ which is very small compared to flows crossing the channel or entering the Mormugao Bay which are about 8000 to $10000 \text{ m}^3/\text{s}$.

Considering the database of 10 years in the outer channel and Mormugao Port the sediment concentration for different months and at different locations area vary. On the Western end of approach channel near locations 5 and 6, the natural depths are more and differential depth is small hence the sediment concentration is also less due to less wave induced bed shear stress. From west to east side along the approach channel, natural depths reduce and the differential depths increase and sediment concentration is also observed to increase due to enhanced wave induced bed shear stress. The increase of overall sediment concentration during monsoon season due to the high wave action is also evident. It has been established by statistical analysis that the sea bed is the source of prevailing sediment concentration rather than river at Mormugao Port. On an average, sediment concentration values of 0.012 ppt during non-monsoon season and 0.040 ppt during monsoon season were considered for the port region.

For the deepening proposal of the Approach channel to (-) 19.8m and harbor area to (-) 19.5m) at the Mormugao port, in the zone A0 near the west end of the approach channel, average annual siltation was estimated to be about 0.60 m . Further, in zones A1, A2, A3, and A4 along the approach channel, the average annual siltation was estimated to be increasing from 1.65 m in zone A1 to 2.90 m in zone A4. In harbor areas, average annual siltation was estimated to be about 3.5 m . The annual maintenance dredging requirement may be divided equal for the channel and harbor areas. With the deepening proposal, total requirement of annual maintenance dredging at the Mormugao port would be about 6.0 Mm^3 , just double the present quantity of annual maintenance dredging.

The main sediment transport mechanism in the Mormugao Port area and near the upstream reaches of Mormugao bay is due to suspended sediment transport. The wave induced bed shear stress is mainly responsible for bringing bed material into suspension which are further transported in suspension with prevailing tidal

currents to other areas. For the deepening proposal at Mormugao port development, the total annual maintenance dredging quantity is predicted to be about 6.0 Mm³ against 3.0 Mm³ at present. Nearly more than 90% of the total siltation in the approach channel and harbour areas was estimated to take place during the four months of southwest monsoon season and during post monsoon season, very less siltation takes. Most of the times, the sea currents are observed to be from south to north and the bed material to be dredged is very fine silty-clayey type which tends to remain in the suspended state. The disposal ground are required to be located such that the dredged material may not come back to the port or channel areas and the dredged plume should be moving northwards away from the channel. Based on Hydrodynamics and Siltation studies, 2km x 2km area with -27 m contour level located north of approach channel at UTM 356000 E and 1705000 N, were found to be suitable and was recommended for the dumping of dredged material.

CHAPTER-8
MITIGATION MEASURES



CHAPTER-8 MITIGATION MEASURES

8.1 GENERAL

The Environmental Management Plan proposes to integrate the baseline conditions, impacts likely to occur, and the supportive and assimilative capacity of the system. The most reliable way to achieve the above objective is to incorporate the management plan, constituting the envisaged mitigation measures, into the overall planning and implementation of the project. The Environmental Management Plan (EMP) for the proposed maintenance dredging activities is described below.

8.2 CONTROL OF IMPACTS ON MARINE ENVIRONMENT

The impact on coastal environment during dredging phase would be mainly on marine water quality and ecology. An important factor in minimizing adverse impacts would be optimizing the dredging period and avoidance of activities beyond the specified area of implementation. Hence, as a part of the management strategy various activities should be well coordinated and optimized to avoid time and cost over-run.

The estimated total volume of capital dredging required for enabling navigation of Cape-size Vessels in the channel is 12 Mm³. Various dredging methods have been considered for the dredging of proposed navigation channel. It is proposed to dredge the channel using a combination of Trailing Suction Hopper Dredger (TSHD) and Cutter Suction Dredger (CSD). Typical details of TSHD are shown in Figure-7.1 and a CSD is shown in Figure-8.2.

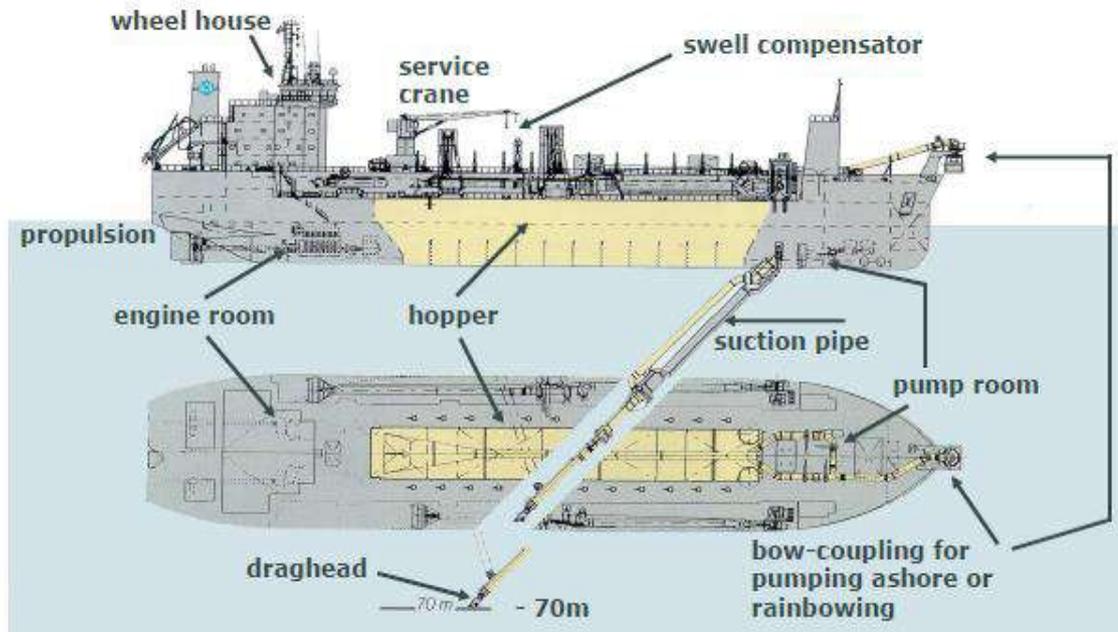


Figure-8.1: Typical details of Trailer Suction Hopper Dredger



Figure- 8. 2: Typical Cutter Suction Dredger

These methods are considered environmentally safe methods as leakage of dredged material and dispersal of sediments is minimal. Some patches of weathered rock have also been noticed. The quantity of hard rock is approximately 0.175 Mm^3 . No blasting is involved in the process. It is proposed to remove the hard rocks by using a combination of CSD and Backhoe Dredger, depending on the nature of the material encountered at the location. The loosened rock fragments will be removed by using Backhoe. A typical Backhoe Dredger is shown in Figure-8.3.



Figure 8-3: Typical Backhoe Dredger

The key measures recommended to control the possible marine pollution due to dredging and spoil disposal are listed as below:

- Selection of suitable site for the disposal of dredged material is very vital for such projects. Hydrodynamic studies and dispersion studies for finding out a suitable location in offshore region to dispose of the dredged material have been carried out through CWPRS. As per CWPRS recommendation a disposal area of 2 km X 2 km, has been identified and demarcated at a distance of about 1 km North from the intersection of the center line of the outer approach channel with the -20 m contour at a depth of about -27 m below CD.



- Disposal of dredged spoils shall be carried out at the designated site suggested by CWPRS.
- The proposed spoil disposal ground identified by CWPRS is located 14 km away from the breakwater head at 27 m depth contour. The dredged material (spoils) will be transported to the said Spoil Ground in the hoppers of the dredgers.
- Spillage of “fuel / engine” oil and lubricants from the dredging equipment are likely source of organic pollution which impacts marine life, particularly benthos. This shall be prevented by suitable precautions which include the provision of oil trapping mechanism to prevent the spillage.
- Dredging activities will be carried out in a confined manner to reduce adverse impacts on marine environment.
- Dredgers and other supporting Vessels operating during the dredging phase shall be equipped with spill response kits.
- Dredging activities to be scheduled and planned so as to avoid “and/or” cease dredging during adverse currents, fish breeding period, etc., to minimize impacts on marine ecology.
- No dredging activity shall be carried out during the fish breeding season notified by the State Government viz. 01st June to 31st July.
- Waste consignment notes to be prepared and documented to streamline the process of transport and disposal of the dredged material at the Spoil Disposal Ground.
- The MPT is engaged in Capital/Annual Maintenance dredging activities for last 5 decades and as such, has an effective plan for monitoring and controlling the same. Periodic bathymetric studies are also conducted to check the status of siltation.
- No oil spill pollution occurs during normal port operations. However, should such an incident occur, the port has the necessary Tier I Oil Spill Response Equipment. Stand by arrangements are also made with Indian Coast Guard in case of eventualities.



8.3 WATER ENVIRONMENT

The deployment level of workers and technical personnel during the dredging phase will be of the order of 25 constituting 20 workers and 5 technical persons. An amount of Rs. 0.5 million has been earmarked for providing safe drinking water and toilet facilities in dredgers and support vessels deployed for dredging. The toilets will be equipped with bio digesters.

8.4 EFFLUENT FROM WORKSHOPS, OIL STORAGE, ETC.

The effluent from workshops, oil storage, etc., will contain oil and grease waste matter which will be treated in an oil skimmer and suitably disposed after treatment or will be sold to registered recyclers. The collected non-recyclable oily matter will be securely stored in containers and disposed in the landfill site designated by the Goa State Pollution Control Board (GSPCB). An amount of Rs. 1.0 million has been earmarked for this purpose.

8.5 CONTROL OF IMPACTS ON FISHING ACTIVITIES

The following measures are recommended:

- Blasting will not be carried out for dredging.
- Dredging shall not be carried out during the fish breeding season
- Spillage of “fuel / engine oil” and lubricants from dredgers are a source of organic pollution which impacts marine life, particularly benthos. This shall be prevented and controlled by providing necessary mechanism to trap the spillage.
- Dredging will be carried out in a confined manner to reduce the impacts on marine environment.
- Dredged material shall be disposed safely in the designated marine Spoil Ground and in no case shall be disposed in the adjoining marine environment.
- Dredging shall not be undertaken during fish breeding season and during adverse weather and sea current situations.
- Dredging activities to be scheduled and planned meticulously to minimize impacts, if any, on fishing activity and marine ecology.



8.6 ACTION PLAN FOR DISPOSAL OF DREDGED SPOILS AND ROCKY MATTER

The outer channel which presently has a depth of -14.40 m is proposed to be deepened to -19.80 m and the inner Channel from -14.10 m to -19.50 m, below CD. The total quantity of estimated volume to be dredged is 12 Mnm³, containing a likely rock quantity of 0.175 Mnm³. The work is proposed to be completed in a period of 5 months. The total dredging quantity per day is estimated at 1 lakh m³ in order to complete the task within the scheduled completion period.

Major part of the dredging work planned to be accomplished by deployment of the TSHD. However, for stiff clay and rock patches a combination of CSD/Back hoe and TSHD dredgers is proposed for deployment.

The dredged spoils will be disposed off in the said offshore disposal area. As stated earlier CWPRS has carried out hydrodynamic studies and dispersion studies for earmarking the said marine disposal area.

As per CWPRS recommendation, a disposal area of 2km X 2 km at 2 locations i.e., 40% to the North of -23m contour (at UTM 358700E and 1704000 N in an area of 2.0 km x 2.0 km) and remaining to the North of -27m depth contour (at UTM 356000E and 1705000 N in an area of 2.0 km x 2.0 km) to avoid shoaling.

Proposed Monitoring Sites

Where the turbidity trigger level is determined to be attributable to dredging “and/or” spoil disposal activities, monitoring of essential marine parameters shall be carried out at identified sites and reference sites.

Monitoring Frequency

Pre-dredging monitoring will be conducted to establish transects at each site. During initial dredging, monitoring will be conducted at approximately six weekly intervals.

Monitoring will occur at sites that experience water quality exceedances which are attributable to dredging activities. For all events, monitoring will be completed at the reference locations to assist in determining the cause of variability of essential marine parameters. The targeted monitoring program will include the reference site, as well as sites in the area determined to be at risk from the water quality exceedance.



8.7 BIODIVERSITY RECOVERY PLAN

The recovery of biodiversity is dependent on various ecological and physical factors and also on the magnitude of the impact posed by anthropogenic activity. In order to reduce and recover from such multiple stressors, the competition among various species for resilience and recovery potential of sensitive species pose another hurdle in mitigation. Thus it is empirical to validate the diversity before and after the impact to detect the damage caused, if any, and to understand the recovery.

A team of experts will be assigned and will be onsite during the entire phase of the project so that the activities are in check and the impacts are minimized. As suggested by NIO following mitigations measures shall be implemented:

- A well-defined management and monitoring plan will be put in place for each of the aspects related to the proposed project activity.
- Best industrial practices in the industry so as to minimize the environmental impacts due to the project activities.
- Regular maintenance of all the activities and deployment of trained personnel to reduce impacts and unplanned events.
- Emissions from dredging vessels and dredging equipment shall be within the permissible limits described by MoEF&CC and CPCB.
- Noise levels of the machinery and equipment shall be within the permissible limits prescribed by MoEF&CC and CPCB
- Organic solid and liquid waste on the vessels involved in project will not be disposed in the ambient waters. It will be properly processed and or disposed as per the guidelines.
- Inorganic waste, hazardous waste including oil and grease will be stored appropriately and delivered to authorized vendors for proper disposal.
- Dredging and associated activities will not be undertaken during the notified fish breeding season (June-July) which is considered as egg laying and larval recruitment season.



- Disposal of dredged material will be in deeper waters so that the impact is minimized in the coastal region as recommended by CWPRS through their studies.

8.7.1 Earlier Studies on Recovery of Benthic Communities

Certain marine species and communities are more sensitive to disturbance from dredging than others. The recovery of disturbed habitats following dredging ultimately depends upon the nature of the new sediment at the dredge site, sources and types of re-colonizing animals, and the extent of the disturbance (ICES 1992). In soft sediment environment the recovery of animal communities generally occurs relatively quickly and a more rapid recovery of communities has been observed in areas exposed to periodic disturbances, such as maintained channels. A review of dredging works carried out by Nedwell & Elliot 1998; Newell, Seiderer & Hitchcock 1998 in coastal areas showed that the rates of recovery of benthic communities following dredging in various habitats varied greatly. The details of the recovery time for benthic communities, following dredging activities reported by various authors is given in **Table-8.1**.

Table-8.1 Recovery of benthic communities

Location	Habitat type	Recovery time
Coos Bay, Oregon	Disturbed Muds	4 weeks
Gulf of Cagliari, Sardinia	Channel muds	6 months
Mobile Bay, Alabama	Channel muds	6 months
Goose Creek, Long Island	Lagoon muds	>11 months
Klaver Bank, North Sea	Sands-gravels	1-2 years
Chesapeake Bay	Muds-sands	18 months
Lowestoft, Norfolk	Gravels	>2 years
Dutch coastal waters	Sands	3 years

Recovery rates were most rapid in highly disturbed sediments in estuaries that are dominated by opportunistic species. In general, recovery times increase in stable gravel and sand habitats dominated by long-lived components with complex biological interactions controlling community structure.

These findings are supported by studies of Stickney & Perlmutter (1975) in the Georgia Estuary system, USA, which suggests that maintenance dredging has only a short term effect on the animal communities of the silt and clay sediments.



Although almost complete removal of organisms occurs during dredging, recovery begins within 1 month and within 2 months in to communities which were reported to be similar to pre-dredge conditions. Other studies suggest that dredging impacts are relatively short term in areas of high sediment mobility (Hall et al., 1991). Complete recovery of benthic animals in a channel in the estuarine Dutch Wadden Sea occurred within 1 year of the removal of sediments from this highly mobile sand environment (Van der Veer et al., 1985).

In view of the above stated research data and the fact that the present Project Area is highly dynamic tropical estuarine area, recovery time after dredging can reasonably be expected to be anywhere between four months and a maximum of one year.

8.7.2 Previous Studies on Effect of Dredging

Parulekar et al., 1986 while studying effect of mining activities on clam fisheries and bottom fauna of Goa estuaries observed that besides the overall decrease in the dissolved oxygen concentration, other obvious reason for decline in the clam resources are due to the immense increase in the quantity of suspended solids and structural deformation of bottom deposits and blanketing of bottom deposits by mining rejects leading to reduction in clam production, depletion of resident fauna and appearance of low diversity bottom fauna, comprising of tolerant but vagrant species.

However, the said study is relevant to mining reject sediments and upstream locations where there is less flushing action and low DO levels, which can increase the adverse impact of pollutants. The dredged sediments which will be generated in the present dredging proposal are “physically/chemically” different and benign compared to mining reject sediments. Moreover, location of the dredging project is in an highly dynamic estuarine mouth region prone to constant waves, sea current, tidal forces and monsoonal winds, which result in quick recovery from any anthropologically induced environmental disturbance such as dredging. Also the same navigational area has been continuously dredged for maintenance (every year) for > 5 decades.

Earlier studies by Vijaykumar Rathod of NIO, conducted specifically in the same



Navigational Channel area has confirmed the above by analyzing marine parameters before and after dredging in the year 2014. As reported in his research paper, a reduction of benthic fauna by about 60-70% was observed during dredging and it took 4 months for a total recovery of the marine environment to the pre-dredge levels.

In summary, the effect of dredging upon the benthic community of navigational channel is found to be mild and short duration when lesser area of the bottom is being disturbed. Based on the above studies it is clear that the present project does not pose any detrimental impact on the biota or environment of the Study Area.

8.8 RECOMMENDATIONS

Though the anticipated adverse impacts are low it is recommended to follow safe dredging practices and regular monitoring of the impacted areas.

- Ecological and environmental impacts during suction dredging in the dredged area and in the immediate environs are inevitable. However, such disturbances are found to be minimal and localized in the dredged area and in the immediate environs and reestablishment of the fauna is expected within a period of 4 months. In view of this, dredging could be permitted with a proper environment management plan.
- Comparison of the Base line status of the diversity and population of biota along with the post dredge survey and regular monitoring surveys will give a better understanding of the response of the environment to the dredging activity.
- Environmental windows shall be provided, during the intensive breeding periods of estuarine organisms if the period of dredging is extended due to unforeseen reasons.
- Possibility of providing silt curtains around the dredged area may be explored, if the prevailing current pattern is favorable.
- The livelihood and welfare of the fishermen is not affected as the area to be dredged is already being used as the navigational channel, and is a part of the No Fishing Zone.

CHAPTER-9
ENVIRONMENTAL MANAGEMENT
PLAN



CHAPTER-9 ENVIRONMENTAL MANAGEMENT PLAN

9.1 INTRODUCTION

Marine biodiversity management plan for the proposed project has been prepared by the NIO. The present chapter outlines the Marine Environmental Management measures suggested by NIO. The aspects covered as a part of the Marine Environmental Management Plan are listed as below:

- Marine biodiversity management plan
- Development of Plan
- Vessel Management Plan
- Dredging Management Plan
- Water Quality Management Plan
- Oil Spill Prevention and Contingency Plan
- Fishery Management Plan
- Site Specific Biodiversity Enhancement Measures

9.2 MARINE BIODIVERSITY MANAGEMENT PLAN

The Indian subcontinent is bordered by the tropical seas which include an extensive coastal zone and the deep seas. Within coastal zone, there are a number of sensitive habitats including estuaries, mangroves, coral reefs, sea-grass beds, and oceanic islands. These habitats support a wide spectrum of biota whose abundance varies both spatially and temporally. These habitats have been exploited for food and aesthetic purposes with no apparent ill effects till large scale mechanisation began to be introduced. Increasing human population coupled with the greater need for development has led to intensive exploitation of coastal areas and various fisheries resources and has caused considerable stress to many habitats. Estuaries are veritable nurseries for many marine animals, but their fisheries have declined considerably due to overexploitation.

Managing a complex ecosystem to balance delivery of all of its services is at the heart of ecosystem-based management. The effects of preserving diversity can be broadly beneficial to a wide spectrum of important ecosystem processes and services, including fisheries, water quality, recreation, and shoreline protection. A management system that conserves diversity will help to accrue more “eco-service capital” for human use and will maintain a hedge against unanticipated ecosystem changes from natural or anthropogenic causes. Although maintenance of biodiversity



cannot be the only goal for ecosystem-based management, it could provide a common currency for evaluating the impacts of different human activities on ecosystem functioning and can act as a critical indicator of ecosystem status (Palumbi et al, 2009).

A management regime based on social acceptance, with the power of moral persuasion from within the group of participants, is the only way to manage widely dispersed resources which are shared by a multitude of small and large users.

9.3 DEVELOPMENT OF PLAN

Methods and systems for effective and efficient collection and utilization of information will be considered for systematic accumulation of information and knowledge regarding marine biodiversity. Marine areas of particular importance for conserving biodiversity will be identified on the basis of scientific knowledge.

Identification of factors and implementation of measures

To promote conservation of marine biodiversity and its sustainable use, causes of the problems and those responsible for the same will be identified. Methods and procedures suitable to solve these problems will be undertaken in collaboration with relevant parties.

Implementation of measures

Measures for conservation and sustainability of marine biodiversity will be implemented in accordance with characteristics of the marine area, such as differences in the ecosystems and major influencing factors between estuarine water and the near shore waters.

Enhancement of pristine areas

Designation of conservation zones will be promoted appropriately using the existing systems to improve and enhance the marine biodiversity. For conservation and sustainable use of marine biodiversity, a concept of effective networking will be considered, and if required, a new system will be considered as well.

Stakeholders' involvement

Scientific information and knowledge regarding the current status of marine biodiversity, various values associated with it and the necessity for its conservation will be publicised amongst the public. Cooperation and coordination among various



relevant actors will be enhanced and awareness of conservation and sustainable use of marine biodiversity in social activities will be raised.

Some aspects of significance for conserving and managing marine biodiversity are:

- Natural biodiversity broadly promotes the provision of marine ecosystem functions, including those critical to human survival and well-being.
- Conserving natural biodiversity increases the likelihood that marine ecosystems can continue to provide such services and serves as a hedge against environmental change, increasing the chance that ecosystems can adapt and recover post-disturbance.
- Conserving biodiversity should become a common aim of ecosystem-based management for all agencies involved in regulating the marine environment.
- Management for biodiversity may have to rely, in part, on management of surrogates such as habitat types, population size, and related biodiversity characteristics.

Characteristics of the proposed Project Site

The project is located well within the most active MPT Port zone, operating at its present level of activity for at least (last) five decades. As such, the projects are “Brownfield” in nature. The inner Port Channel and Turning Circle, as well as the 6.5 km long outer channel and turning circle, are being periodically (annually) dredged, for maintenance of their existing depths of 14.1 m to 14.3 m, for several years and has not caused any significant adverse impact on the marine environment of the Zuari Estuary. The proposed capital dredging project involves dredging of the said existing Navigational Channel and Turning Circle (Western) to an additional depth of 5.5 m to allow larger cargo ships, for economy of scale. This will improve Port efficiency and reduce the number of cargo ships visiting the Port. The additional stretch of 3.5 km of navigational channel proposed for dredging also lies within the MPT Port limits, but outside Zuari estuary, into the Arabian Sea towards the West. In this Marine stretch a natural depth of around 15 m to 16m is already available and an additional depth of 3 m to 4 m has to be dredged. However, this portion is located outside the fishing zone and sufficiently away (>4 km) from known sensitive marine biodiversity spots and beach areas.



Distance of the navigational channel from different important sites are given as below:

• Dona Paula	6.7 km
• Cidade de Goa Beach	5.0 km
• Baina Beach	5.7 km
• Siridao Beach	7.5 km
• Nauxim Bay	8.0 km
• Chicalim Bay	4.0 km
• St.Jacinto Island	6.5 km
• Bogmalo Beach	8.0 km
• Miramar Beach	9.3 km
• Nearest Mangrove patch (Sancoale)	7.5 km
• Grande Island	6.7 km
• Pequeno Island	5.9 km
• Odxel	10.0 km
• Vainguinim,	7.3 km
• Cabo Raj Niwas	6.4 km

The entire navigational channel and basin area proposed for dredging occupies only 0.89 percent of the total Study Area of 10 km radius from Project peripheries. The Marine ecosystem of Zuari in the Chicalim Bay is already under the influence of Goa Shipyard Ltd. and several nearby “Barge/Ship” building establishments, most of which are operating for the last several years. Despite the above operations in the vicinity, as per research information:

“Chicalim bay is rich in marine biodiversity harbouring more than 200 faunal and 34 phytoplankton species in addition to mangroves and macrophytes. Natural stocks of windowpane oyster *Placuna placenta* inhabit the soft, muddy substrate of Chicalim bay and their population is in healthy condition.

In a recent study, conducted between October 2013 and September 2014, Indian Council of Agricultural Research (ICAR), Old Goa (Goa) identified a total of 186 aquatic species (150 finfish and 36 shell fish) in the mouth of Zuari Estuary. It was (evidently) reported that the fish and shellfish diversity along the estuarine ecosystem of Zuari mouth is rich and accounts for a significant quantity of Goa’s marine and brackish water fish production. The 150 finfish species comprised of 65 pelagic and 85 demersal fishes. The shellfish fauna comprised of 17 crustacean and 19 molluscs species.



This latest study along with the conclusions drawn from NIO's 2006/2010 studies cited above, give credence to the view that the "tidal/wave" dynamics and resilience of the vast Zuari estuary has been able to "mitigate" the adverse ecological impacts of the functioning of the Mormugao Port, Goa Shipyard, scores of smaller "Barge/Ship" yards and constant ore transportation activity, prevailing from 1970 onwards.

It is difficult and in many cases impossible to determine the status of most species in the Marine environment. So little is known of marine species distribution or range that it cannot be determined whether they are plentiful or naturally rare or whether their populations are stable or changing. Marine species that are relatively easily monitored are those restricted to near shore habitats, especially if they are sedentary or attached (eg. sea grasses and corals) and those that spend time at the sea surface or on land (e.g. marine mammals and sea birds). The science of understanding biodiversity is young and the goal of formulating a policy to conserve marine biodiversity is younger. Hence the 'precautionary principle' is considered as best practice in the industry so that there is no unabated and commitment-less development. Thus developmental activities have to be mitigated and further enhancement strategies have to be adopted for sustaining biodiversity. Policy provisions at national and regional level for management and conservation of marine biodiversity include:

- Integrated Coastal Zone Management (ICZM), which deals with the management of the land side of the coastal eco system.
- Marine Spatial Planning, whereby different marine areas are planned for different activities in accordance to Environmental conditions.
- Watershed Management, which involves the management of drainage basins and activities that affect water flow and water quality.
- Fisheries Management.
- Designation of Marine Protected Areas.

Apparently, marine biodiversity management is a complex issue which depends on the holistic mitigation actions to be carried out by all establishments using Zuari Estuary and environs and not just MPT. As such no single agency can achieve this task which is influenced by many activities carried out by different stakeholders in



and around the marine area in question. MPT can strive to carry out different requirements which pertain to the above mentioned five strategies provided these come within their territorial and operational jurisdiction.

Translocation of certain threatened species from the areas affected by development to other areas where the said species can propagate safely. This system may yield a measurable conservation benefit at levels of population, species or ecosystem. So far most of the translocation projects involve coastal invertebrates (44%) and plants (30%). MPT can provide logistical and/or financial support to any such proposal contemplated by the Government.

9.4 VESSEL MANAGEMENT PLAN

The Vessel Management Plan is based on the design team's best professional judgment regarding the types of equipment typically needed to complete this work, the sizes of marine construction equipment typically available, rates that have been achieved for similar projects, and a prospective construction sequence that could be used to conduct the activities. The actual type, size, and quantity of equipment, production rates, work schedules, and project sequence will be determined collaboratively with the contractor to complete the work.

Vessel Waste management measures will include:

- All domestic, toxic, and hazardous waste such as oil, petroleum hydrocarbons, empty drums and other containers, and any other waste materials will be collected, handled, stored, and disposed in accordance with existing National waste management policies and procedures.
- Dredging contractor will endeavour to minimise waste generation from equipment consumables, packaging, and the like.
- Dredging contractor will ensure that adequate toilet facilities are provided on the dredgers and other vessels. All waste, including grey water, are to be contained on board and legally disposed on land.
- If there is a sewage treatment plant aboard the dredger or any other vessel, it must comply with MARPOL.



- Risk assessment to be completed prior to commencement of operations and tasks detailing possible threats, consequences and mitigation measures shall be implemented to eliminate or sufficiently reduce the threats.
- Any non-compliance will be immediately reported to the relevant authorities.

9.5 DREDGING AND DISPOSAL MANAGEMENT PLAN

Environmental impacts of dredging can occur during the excavation process, during dredged material placement and also during the transport of the materials. Management practices require a thorough understanding of the technical, environmental and economic characteristics of dredging plans and of the potential seriousness of environmental impacts. Following are the important aspects considered for dredging management

- Operational procedures for dredging will be optimised to reduce the mobilisation and dispersion of suspended sediment. Such measures include:
 - ✓ The use of a backhoe dredger and CSD, which is known to reduce turbidity generation relative to other types of dredger.
 - ✓ The spillage of material (sediment) from the vessel bucket and dredged area into the surrounding water will be minimized by using trained operators.
 - ✓ All dredging equipment and barges will be maintained in good working condition.
- Hopper door seals will be maintained in proper condition to ensure minimum loss of sediment during transport.
- Dredging operations will be timed to coincide with favourable “weather/tidal” and current conditions so as to ensure that sediment plume travels towards environmentally non sensitive zone. This is aided by Mike 21 modelling exercise.
- Timing of dredging operations shall be scheduled to avoid fish breeding season.



- Continuous loading of the hopper will be undertaken until the free water on top is displaced by sediment.
- Hopper losses will be controlled by adequate engineering and operational controls including the use of spill control valves.
- Dredging will proceed from shallower to deeper water where possible.
- Suction heads at the end of pipes will be kept above the sea bed when not in operation until the scheduled dredging area is reached so that unnecessary sea bed disturbance is prevented.
- Disposal of dredged material will occur only within the designated disposal site;
- Hopper de-watering will be confined to the dredging and spoil disposal areas.
- Vessel-based plume monitoring will be conducted during the trial period to validate the characteristics of any turbid plumes and to establish ongoing turbidity monitoring requirements.

9.6 WATER QUALITY MANAGEMENT PLAN

Port and Harbour waters are subject to a variety of potential pollutant sources such as ship anti-fouling agents, hull cleaning chemicals, other releases from boats, wastewater discharges from “municipalities/industries”, storm-water runoff from agricultural fields, etc. These sources of potential pollutants can degrade the water quality for beneficial uses. Following measures are suggested for water quality management for the proposed project.

- A proactive operational measure in dredging and disposal works to reduce sediment mobilisation.
- Predictive modelling of Total Suspended Solids (TSS) levels and plume direction.
- Vessel based monitoring to confirm estimates of TSS; visual observations of plume movement and dispersal.
- Dredging to be coordinated as per the tides and currents.
- Reactive management based on continuous turbidity monitoring at the site.
- Use of containment structures such as silt traps and curtains while dredging.



- Proper handling, removal and disposal of project waste material.
- Safe and pollution free transportation of bulky raw materials by using tarpaulin covers and water sprinkling equipment.

9.7 OIL SPILL PREVENTION AND CONTINGENCY PLAN

Proposed project envisages dredging for deepening of the existing navigational channel. Hence, minor amounts of oil may be introduced into the marine environment by a number of ways. Research on the effects of oil on the marine environment relates to major oil spill events, usually from shipping accidents and groundings, the environmental effects of which are well known. However, very little literature describes the effects of small chronic discharges from run-off other small discharges of oil which commonly occur in all Ports and Harbour environs. In the event of a spill or emergency, the following corrective actions will be involved:

- Oil Spill Contingency Plan and response strategies will be in place for prompt implementation.
- Outflow of substances will be prevented, controlled or stopped from the source.
- The In-charge of Port Control Centre will be notified as soon as practicable. The assigned authority will coordinate spill response and notification procedure under the direction of Port In-charge.
- The cause and source of a spill will be investigated and identified to promptly rectify the same.
- Procedure relating to the storage, handling and disposal of hydrocarbons and hazardous substances will be continuously reviewed for improvement.
- Procedures to be updated and staff informed of amendments, if required.

9.8 FISHERIES MANAGEMENT PLAN

The goal of a fishery management plan is to guide and manage fishing vessels in inland waters in accordance with the principles of ecologically sustainable development. This includes maintaining fishing at sustainable levels, protecting habitats and aquatic environments on which fisheries resources depend and maintaining and where possible improving the social and economic benefits to the fishing community of the Study Area.

- Movement of fishing vessels in the navigational channel and outer harbour often result in entanglement of fishing nets resulting in mutual losses. This will be prevented by strict enforcement of the prohibition on fishing imposed in all Port Basins for safety of life and property.
- The existing navigation route will be clearly demarcated in the field.
- Care will be taken to avoid spill of contaminants in the ambient water.

9.9 SITE SPECIFIC BIODIVERSITY ENHANCEMENT MEASURES

The intertidal and sub-tidal area in the mouth region of Zuari estuary (e.g. Nauxim-Chicalim- Sancoale Bay, Grande Island, Caboraj- Siridao rocky patch within the study area) has good habitat diversity with higher species diversity. There are seaweeds, mangroves; corals, mud- and sand flat in the buffer zone of the study area. Location of ecologically important areas in the study area are shown in Figure-9.1.



Figure-9.1. Ecologically important areas in the Study Area

Some of the areas harbor important species such as windowpane oyster, clam and oyster beds, seaweeds, mangroves and corals which form key components of marine biodiversity of the areas. Cumulative impacts such as land reclamation, mining, industrialization and dredging pose a considerable threat to the marine biota and the ecosystem. Apart from that the natural resources from the region have been



traditionally being collected from several mud flats and sub-tidal region as well. But over the years, with increase in population and eventually increase in demand for shellfish, these areas many times are over exploited.

Furthermore, with increase in riverine pollution, many species tend to accumulate toxicants such as metals. These toxicants thus enter the food chain and reach humans via seafood consumption. There is an urgent need to investigate and manage thus bioaccumulation. Considering this issue, it may pose a serious threat to human health in the near future, if the problem is not dealt.

However these threats and potential dangers can be minimized with effective conservation and management measures. This could be categorised in the below broad terms:

- Scientific research and regular monitoring
- Education and Public awareness
- Conservation and Eco-restoration

The sensitivities in the buffer zone (10km radius) from the proposed location are given in following sections:

9.9.1 Sancoale

This area has good mangrove vegetation and a vast expanse of mudflat exposed during the low tide. There is presence of species with conservation importance such as windowpane oyster and other commercially important molluscs such as clams, oyster, windowpane oyster and cephalopods etc. Chikalim- Sancoale bay is considered an important location for intertidal marine biodiversity. Chikalim and Nauxim Bays in the Zuari estuary is home for windowpane oyster which is schedule species. There is scarce data about the total quantity of shellfish collected from each of the habitats seasonally. Furthermore there is no information about the accumulated toxicants and its exact sources.

9.9.2 Grande Island

The area is rich in Coral, sponge, fish and associated flora and fauna on the island. Moreover Coral reefs and Mangroves are breeding ground for many commercially important fish, crustaceans, molluscs and other invertebrate species. The sub-tidal area around Grande Island is being used for unregulated tourism, underwater diving

CHAPTER- 10
RISK AND DISASTER MANAGEMENT
PLAN



CHAPTER- 10

RISK AND DISASTER MANAGEMENT PLAN

10.1 INTRODUCTION

Disaster Management planning is an integral and essential part of loss prevention strategy. The nature of the proposed project is such that there are minimal chances of accidents. The project operations involving dredging do not entail any risk or hazard. No hazardous cargo is proposed to be handled at the Berths which will be benefitted by the proposed deepening of the existing Navigational Channel. The cargo proposed to be handled include Iron Ore, Coal, Steel “Coils/Sheets”, Containers and general Cargo. However, there still remains a small possibility that disaster may occur. Effective action is possible due to existence of pre-planned and practiced procedures for dealing with emergencies. The present Chapter outlines the Disaster Management Plan to be implemented in the event of an emergency. The proposed project activity is located within the existing Navigational Channel of Mormugao Port, which has an On-site Emergency Action Plan in place.

Mormugao Port has a 100 Bed Hospital, to cater to various medical needs of MPT employees and project workers, which is well equipped to handle the emergency situations. It is also equipped with a round-the-clock ambulance service for quick response.

This Disaster Management Plan also sets out the procedures and measures to be taken into account in the event of loss of containment and consequence thereof in the proposed project.

10.2 TYPES OF EMERGENCIES

The type of emergency primarily considered here is any major emergency which has the potential to cause serious danger to persons and/or damage to property and which tends to cause disruption inside and/or outside the site and may require the co-operation of outside agencies.

Emergency is a general term implying a hazardous situation both inside and outside the premises. Thus the emergency is termed “on-site” when it confines itself within the installation even though it may require external help, and ‘offsite” when emergency extends beyond the boundaries of the installation, which in the present case is the MPT Complex. It is to be understood here, that if an emergency occurs



inside the project area and cannot be controlled properly and timely, it may lead to an “off-site” emergency.

An “on-site” emergency can arise due to certain undesired incidents resulting in fire, explosion or oil spill within the Port area.

10.3 PRIORITY IN EMERGENCY HANDLING

The general order of priority for taking control measures during the course of emergency will be as follows:

- To Safeguard life
- To Safeguard environment
- To Safeguard property

10.4 OBJECTIVES OF THE DISASTER MANAGEMENT PLAN

The main objectives of the Disaster Management Plan are to:

- Ensure that loss of life and injuries to persons are minimized
- Ensure that damage to environment and property loss are minimized.
- Provide quick and effective relief and rehabilitation measures.
- Minimize the outage of operations in the proposed facilities.

The above objectives are sought to be achieved through some of the following measures:

- Providing information to all concerned on the estimated consequences of the events that are likely to develop as a result of the emergency.
- Mobilizing on-site resources.
- Calling up assistance from outside agencies.
- Initiating and organizing evacuation of affected workmen.
- Providing necessary first aid and other medical services that may be required.
- Collecting data on the latest developments, other information and requirements.



10.5 LIKELY EMERGENCIES

Likely emergencies in the Navigational Channel proposed for deepening and at the Berths served by the same include:

- Accidents involving vessels.
- Oil spill from vessels.
- Fire/explosion on board vessels within the Port limits and berths.
- Breakdown of ship engine in the sea.
- Earthquake, cyclone and tsunami.
- Sabotage/terrorism.

10.6 COMMUNICATION SYSTEMS

Timely communication of an impending disaster may be life-saving for many people. Effective hazard communication is treated as the single most effective way of limiting losses both in terms of life and property by way of actuating preventive or remedial actions. The various aspects covered in this section are:

- Communication infrastructure
- Sounding of early warning notification
- Siren Warning Systems

10.6.1 Communication Infrastructure

It is recommended that multimodal channel of communication should be made available for effective communication in the event of any emergency:

- Telephone link(within the Terminal)
- Link between Indian Meteorological Department (IMD) and the Port
- Satellite link with other Ports and Harbors in the vicinity.
- Local cable TV network for telecasting the emergency to the public at large along with what to do and what to avoid.

Medical Services

- Chief Medical Officer, Mormugao Port.
- Chief Fire Officer, Mormugao Port.
- SHO, Mormugao (Vasco da Gama) Police Station.
- Estate Manager
- Ambulance service at the MPT Hospital and 108 Ambulance service.



The emergency control room telephone numbers should be pasted on Display Stands located in various strategic places within the Port and Environs to ensure that the number is available for ready use in the event of an emergency. The Display Boards should always list the following numbers for ease of dispatching the information and securing relief:

- Telephone numbers of Fire Station, Hospitals and Port Security Officer / Control Room.
- Installation of a Voice Paging/Public Address (PA) system is recommended. The PA system shall be such that it is capable of addressing all the harbor areas/offices, to ensure that the staff personnel and residents are informed about the ensuing emergency and preventive actions to safeguard life and property of the locality.
- All the security personnel patrolling the area should be given Wireless sets for quick communications with respect to the emergency.

10.6.2 Communication Functionary

The communication functionary appointed for dealing with emergencies shall perform the following duties:

- Ensure that all available communication links remain functional.
- Quickly establish communication links between incident site and the control room.
- To maintain voice record of significant communication with timings “received/passed” from the primary control room.

10.6.3 Sounding an early warning notification

Raising an alarm holds the key to minimize the extent of damage to both life and property. The key to raise an alarm lies in the early warning for notification of an impending disaster. The Port Complex shall have a minimum of three modes of raising an alarm:

- Hoisting of a flag atop the signal room building.
- Siren/hooter
- Public address system

In addition to the said three modes of raising alarm there could be other modes of doing the same i.e. by providing the following systems:



- Break glass fire alarm.
- Blow horn speakers mounted on vehicles.
- Local Door-darshan Kendra, Local cable TV operators
- Local AIR (Radio).

The raising of alarm becomes critical for the following events:

- An impending cyclone or any natural disaster on receiving an information from the IMD or TV Channel.
- Major fire on the Terminal.

10.6.4 Siren warning systems

Raising the alarm is the first step in the implementation of On-site Emergency Plan/Disaster Management Plan (DMP). Essentially there would be various alarms for sounding of an emergency including fire, building collapse and flooding. The alarms are basically used to notify people of an impending disaster or an event, which is likely to snowball into a major disaster.

The various categories of alarms are as follows:

- Cyclone alarm (11 levels)
- Fire
- Flooding
- Building collapse
- All clear

Various means of communicating or raising alarm shall be in the following order:

- Raising flag on top of the signal room for indicating the severity of cyclone.
- Blowing of siren having a short blast followed by a long blast and repeating it three times for indicating evacuation from the Terminal.
- Blow-horns in the vehicles being used by security people.
- Using telephone as well as fax to inform the main emergency control room of a fire.
- Establishing contact with the District Collector and requesting for help.
- Public Address System would be used to inform the public at large in the township to ensure that they do not travel in the direction of the disaster and assemble at the assembly points, as designated.



The following alarm systems may be considered or any other system, which will identify various levels of emergency:

Warning for a cyclone - the intensity level of impending cyclone as decided by the Port authority shall be made known by putting up a suitable display board or by announcements on TV or Radio as discussed earlier. Any change in cyclone level could be made known by a siren.

Similar siren may also be used for other natural disasters like floods or earthquake.

Siren – Short, intermittent.

All clear – when the Main controller considers that the accident is over and it is safe for re-entry.

Siren: - A wailing siren for 5 minutes.

10.7 TEMPORARY SAFE ZONES

In the event of an impending disaster the affected population at large will have to be transported to intermediate temporary shelter. The temporary shelters could be set up in nearby schools. The temporary shelters would greatly depend on the emergency condition and the nature of the emergency. The shelters are to be used only when there is a threat of a natural disaster.

Certain basic amenities also have to be made available before the temporary safe shelters can be decided upon which are as follows:

- Water supply
- Shelter for putting up the refugees or the affected population.
- Structure of temporary shelter need to be of concrete made in order to withstand natural disaster (earthquake) if need be. It is in this regard that schools with RCC building are ideal as sheltering spaces for the displaced population.
- Emergency shelters are also identified from the point of view of obtaining relief i.e. food supplies from the town. In the event of an impending disaster all the temporary shelters shall be provided with wireless sets.
- Provision for setting up kitchens for preparing food for the displaced population. In addition to the food supply, provision for temporary water “trailers/tankers” shall also be made.



- Prior permission will be obtained for converting schools into temporary safe shelters from educational institutions and volunteer organizations owning the same.
- The Principals of individual schools shall be appointed as record keepers before taking in the displaced population. The Principals and some of the staff members need to be trained in Disaster Management.
- The termination of emergency situations in case of the natural disasters will be decided by the District Administration i.e. the District Magistrate/Collector.

10.8 TRAINING

Training sessions need to be provided in which personnel are briefed on their specific duties in an emergency. The concerned personnel are shown how to wear and properly use the personal protective clothing and devices. Periodic drills will be conducted to test the overall efficiency and effectiveness of the emergency response plan and emergency response capabilities.

The type of training required for emergency response personnel with responsibilities in any or all phases of the emergency is based on the type of incidents most likely to occur and the consequent response and planning activities.

The contact details of hospitals in the nearby area need to be displayed at appropriate locations.

10.9 EMERGENCY CONTROL CENTRE

One Control Centre at the Port will be provided and shall be sufficiently equipped to inform the Collector, Police Department and the Coast Guard. The key characteristics of the Control Centre are as under:

- Will have a IMO web site available through Internet connection in the control room for ready reference.
- Will display a map of the whole harbor area and the population distribution in the nearby area.
- Constructed to be able to survive various manmade and natural contingencies such as, cyclone, high wind velocity, flooding, etc.



- Equipped with a diesel driven electric generator.
- Will have an automatic display of name, address and telephone numbers of any incoming call once the emergency control centre number is dialed and the same will be registered in a computer.
- Will have a Map depicting railway stations, ferry start points, bus stands and taxi stands.
- Will have a Map depicting the inter-tidal zone.
- Will have a Map depicting temporary shelters as well as food supply stores.
- Will have a list of Personal Protective Equipment (PPE), Suppliers and present availability of the same.
- Will have adequate number of flameproof searchlights.

10.10 HAZARDS ASSOCIATED WITH DREDGING

The cranes of dredgers are dangerous. Workers are prone to accidents as well. Another concern with dredging is offshore pollution. If a dredger sinks, oil can seep out into the water that they are operating in.

A dredging Process Hazard Analysis (PHA) is a systematic identification of potential hazard scenarios during dredging operation. Many central agencies are now requiring firms to perform PHAs during their mobilization phase. For example, Occupational Safety and Health Administration (OSHA) and Environmental Protection Agency (EPA) of USA require that PHAs are performed before a contract becomes operational, and are mandatory for all new processes or when modifications are made to the original PHA. The U.S. Army Corps of Engineers require that Accident Prevention Plans address the risk associated with each task when preparing a PHA. PHAs shall define the activities being performed and identify the work sequences, the specific anticipated hazards, site conditions, equipment, materials, and the control measures to be implemented to eliminate or reduce each hazard to an acceptable level of risk (USACE 2008).

A generic risk matrix is shown in Figure-10.1. The risk assessment team establishes for each identified risk "item" its level of severity (the impact upon the project, or outcome/degree of the incident, near miss or accident) and its

corresponding probability of occurrence (how many times that risk event can occur, or likelihood of the hazard to cause an incident, near miss, or accident). The result is that each item is assessed a level of risk (ranging from very high to very low). Once the level of risk is determined for the severity (x-axis of chart) and probability (y-axis of chart), a Risk Assessment Code (RAC) is selected for each hazard. This assessment and selection is then continued for each identified hazard in the PHA.

PROBABILITY (frequency of the occurrences)	very high	VH					
	high	H					
	medium	M					
	low	L					
	very low	VL					
			VL	L	M	H	VH
			very low	low	medium	High	very high
			SEVERITY (impact on the project)				

Figure-10.1: Generic Risk Matrix

Dredger Monitoring Software

Dredgers are often equipped with dredge monitoring software to help the dredge operator position the dredger and monitor the current dredge level. The monitoring software often uses Real Time Kinematic satellite navigation to accurately record where the machine has been operating and to what depth the machine has dredged to.

CHAPTER-11
ENVIRONMENTAL MONITORING
PROGRAMME

CHAPTER-11

ENVIRONMENTAL MONITORING PROGRAMME

11.1 THE NEED

Monitoring is an essential component for sustainability of any developmental project. It is an integral part of any environmental assessment process. Any development project introduces complex inter-relationships in the project area between people, various natural resources, biota and the many developing forces. Thus, a new environment is created. It is very difficult to predict with complete certainty the exact post-project environmental scenario. Hence, monitoring of critical parameters is essential during project construction and operation phases.

Monitoring of environmental indicators signal potential problems and facilitate timely and prompt implementation of effective remedial measures. It will also allow for validation of the assumptions and assessments made in the present study.

Accordingly, monitoring is implemented for one or more of the following reasons:

- To characterize and gain a good baseline understanding of the environmental setting for a proposed project;
- To detect and quantify changes in the environment arising from dredging;
- To assess compliance with conditions of environmental clearance, pollution control consents, and other “contract/license/legal” requirements; and
- To calibrate and validate numerical models which are widely used to help predict the effects of dredging and are used in the design of dredging projects.

Monitoring is undertaken during different phases of the dredging project for various reasons, as illustrated in Figure-11.1 and described below



Figure-11.1 Proposed Monitoring Procedure

The monitoring locations should be demarcated by using the presence of eco-sensitive species in the present project area. The areas of monitoring should include the Grande Island where corals are found, Mangroves in the deltaic areas of the River Mondovi, the eco-sensitive zones of Chicalim Bay and the beaches of tourist importance that fall in the area of influence of the project location.

Baseline monitoring

Baseline monitoring is undertaken prior to dredging activities to define the existing or ambient environmental conditions and thereby assist with the designing and planning of the dredging. It establishes the starting point from where environmental change can be monitored. Further, the baseline monitoring supports and documents the understanding of the aquatic environment, of the physical, chemical and biological parameters (such as tide levels, currents, waves, salinity, temperature, suspended sediment concentration and turbidity) as well as parameters indicating water and sediment chemistry and ecology

Surveillance monitoring

Surveillance monitoring compares baseline monitoring data to environmental measurements during dredging to determine whether environmental changes are occurring and are acceptable. Based on this it may be decided whether the dredging can continue unchanged or should be altered. Technological advances have allowed monitoring during the dredging process to be made on a continuous basis. Real-time observations and rapid data processing and evaluation systems can be used to identify environmental changes and, if necessary, trigger an alarm to inform decision-making about when, where and



how to alter a dredging plan to control environmental changes to an acceptable level.

Compliance monitoring

Compliance monitoring may be conducted during and after the dredging project to demonstrate whether dredging complies with the requirements of environmental protection mechanisms including legislation (e.g. permit conditions), contract conditions and, if relevant, sustainability protocols. Compliance monitoring can extend over short-term or long-term periods post-dredging, depending on the time over which the environment reacts to and recovers from the changes caused by the project. It is worth noting that altered dredging methods may translate into altered monitoring needs. Care should be taken to ensure that sufficient flexibility exists within permits, contracts, etc. to allow monitoring schemes to be reduced or increased if it is reliably established (and accepted by those in authority) that monitoring needs should be modified. Such changes are usually a substantial undertaking in terms of time and effort.

11.2 MARINE WATER & SEDIMENT QUALITY

The physico-chemical and biological characteristics of marine water and sediments should be monitored once in three months during dredging phase, at dredging and disposal sites. Both surface and bottom waters should be sampled and analysed. The parameters to be monitored are as follows:

Marine Water

Physico-chemical parameters

- pH
- Salinity
- Conductivity
- TDS
- Turbidity
- D.O.
- BOD
- Phosphates
- Nitrates
- Sulphates



- Chlorides
- Zinc
- Lead
- Total Chromium
- Hexavalent Chromium
- Mercury
- Copper

Biological parameters

- Chlorophyll
- Primary Productivity
- Density and diversity of Phytoplanktons
- Density and diversity of Zooplanktons

Sediments

Physio-chemical parameters

- Texture
- pH
- Total Kjeldahl Nitrogen
- COD
- Sodium
- Potassium
- Phosphates
- Chlorides
- Sulphates
- Zinc
- Lead
- Total Chromium
- Hexavalent Chromium
- Mercury
- Copper

Biological Parameters

- Benthic Meio-fauna
- Benthic Macro-fauna

Considering, dredging period of 5 months the monitoring can be conducted for two seasons. The marine water and sediment sampling and analysis be conducted by an external agency. A provision of Rs.1.4 million would be required for two season monitoring.



11.3 AMBIENT AIR QUALITY

Dredging Phase

Ambient air quality monitoring is recommended to be monitored at 2 appropriate locations stations at Mormugao Port area close to the proposed navigation channel. Considering, dredging period of 5 months the monitoring can be conducted for two seasons. For each season monitoring can be conducted twice a week for 4 consecutive weeks. The parameters to be monitored are PM₁₀, PM_{2.5}, SO₂ and NO₂. An amount of Rs. 0.60 million would be required for two season monitoring.

11.4 ENVIRONMENTAL MANAGEMENT CELL

Mormugao Port has constituted an Environmental Management Cell (EMC) headed by Executive Engineer along with a team. A Senior Environmental Consultant has also been appointed to advise the the EMC on a regular basis with respect to the implementation of Port's EMMP and allied matters of Environmental relevance. Environmental Management Cell (EMC) will be responsible for management of the environment in all environment retreated activities. The team comprises of environmental engineers, chemists and horticulture supervisors. The Head (Environment) will be responsible for Environmental Management activities in the proposed project. Basically, this Cell will supervise the monitoring of environmental pollution levels and management of the same (viz. source emissions, ambient air quality, "water/effluent" quality, noise levels, regular compliance with the conditions of EC and PCB Consents,etc.). This task will be achieved either departmentally or by appointing external expert agencies, wherever necessary. In case the monitored results of environmental parameters are found to exceed the permissible limits. The Environmental Management Cell will suggest remedial action and get these suggestions implemented through the said procedure.

The EMC will also coordinate relevant activities such as collection of official statistics on health (of "workers/residents" of project area), fisheries and



important socio-economic parameters likely to be influenced by Port activities. Similarly, the Cell will coordinate the “execution/upkeep” of measures such as afforestation, greenbelt development, oil-spill control, water “treatment/recycling” and the like undertaken by the Port. Analysis shall be carried out through NABL accredited laboratory.

CHAPTER-12
COST ESTIMATES

CHAPTER-12

COST ESTIMATES

12.1 ENVIRONMENTAL MANAGEMENT PLAN

The cost estimates for implementing the Environmental Management Plan shall be **Rs. 7.5 million**. The details are given in Table-12.1.

Table-12.1: Summary of cost estimate for implementing Environmental Management Plan (EMP)

S. No.	Parameter	Cost (Rs. In million)
1.	Safe drinking water and toilet facilities proposed at dredgers and barges	0.5
2.	Treatment of effluent from workshops, oil storage, etc.,	1.0
3	Fishery Management Plan	0.2
4	Biodiversity Monitoring Plan	1.20
5	Stakeholders' Participation Program	0.60
6	Conservation and Restoration Plan	2.00
7	Implementation of Environmental Monitoring Programme during dredging phase (Refer Table-9.2)	2.00
	Total	7.5

12.2 ENVIRONMENTAL MONITORING PROGRAMME

The cost estimate for implementation of Environmental Monitoring Programme during dredging phase is given in Table-12.2.

Table-12.2: Cost estimate for implementation of Environmental Monitoring Programme during dredging phase

S.No.	Item	Cost (Rs. In million)
1	Marine water and sediment quality	1.40
2	Ambient Air Quality	0.60
	Total	2.00



12.3 ENVIRONMENTAL MONITORING DURING OPERATION PHASE

The marine water quality, sediment quality, noise, air quality also need to be monitored in the project area during operation phase. The same shall be integrated with the existing Environmental Monitoring Programme of the Mormugao Port Trust. The details of Environmental Monitoring Programme during operation phase are given in Chapter-11 of this Report.

CHAPTER-13
DISCLOSURE OF CONSULTANTS
INVOLVED IN THE EIA STUDY



CHAPTER – 13

DISCLOSURE OF CONSULTANTS INVOLVED IN THE EIA STUDY

The EIA study has been conducted by WAPCOS Ltd., a Government of India Undertaking under the Ministry of Water Resources. WAPCOS Ltd., has a full-fledged Centre for Environment, through which this study has been executed. The list of Experts involved in the EIA study is given in Table-13.1.

Table-13.1: List of Experts involved in the EIA study

Sr. No.	Name	Expertise	Signature
1.	Dr. Aman Sharma	EIA Coordinator	
2.	Mr. A. S. Leo	Air Pollution Expert	
3.	Dr. S.K. Tyagi	Ecology and Bio-diversity Expert	
4.	Mr. R.V. Ramana	Noise Expert	
5.	Dr. K.K. Gaur	Social Expert	
6.	Mr. S.M. Dixit	Air Quality Expert	
7.	Mrs. Moumita Mondal Ghosh	Landuse Expert	
8.	Swapan Kumar Bandopadhyay	Risk and DMP Expert	

ANNEXURES

F. No. 10-23/2014 - IA III
Government of India
Ministry of Environment, Forest & Climate Change
(I.A. Division)

Indira Paryavaran Bhawan
 Aliganj, Jorbagh Road,
 New Delhi -110003

E-mail : aditya.narayan@nic.in

Telefax : 011: 24695398

Dated: 10th October, 2016

To,

The Chairman,
 M/s Mormugao Port Trust.
 Headland Sada,
 Goa

E-mail:mptgoa@mptgoa.com; Phone: 0832-2521100;

Subject :Deepening of approach channel for capsized vessels at Mormugao Port by M/s Mormugao Port Trust. –TOR reg.

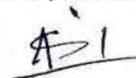
Ref.: Your online proposal no. IA/GA/MIS/59191/2016 dated 21st Sep 2016.

Sir,

Kindly refer your online proposal no IA/GA/MIS/59191/2016 dated 21 Sep 2016 alongwith project documents including Form-I, Pre-feasibility Report and draft 'Terms of Reference' as per the EIA Notification, 2006. It is noted that MoEF&CC vide letter 10-23/2014 dated 9th February, 2015 had issued environmental clearance to M/s Mormugao Port Trust. for the above mentioned project. Hon'ble NGT, Pune Bench vide order dated 2nd September, 2016 has quashed and set aside the EC letter dated 9th February, 2016.

2. In compliance of Hon'ble NGT Order dated 2nd September, 2016, M/s Mormugao Port Trust has submitted the fresh application for award of Terms of Reference. The proposed project is for deepening the outer channel from 14.40m to 19.80m and inner basin and turning circle from 14.10 to 19.50 m. This will facilitate navigation of Capsized vessels at any state of tide. Cost of project is Rs. 380 Crore. The total quantity to be dredged will be about 15.40 million cum. Most of the dredging work will be undertaken with a Trailer Suction Hopper Dredger (TSHD). A Cutter Suction Dredger (CSD) will also be deployed for hard material and weathered rock if encountered. It was informed that no land acquisition and R & R are involved in the project. It is reported that no mangroves are present at the project site. It was informed that so far, 55% work has been completed. The Committee agreed to use the following data /studies in the EIA report which have been carried out recently:

- (i) During dredging period, marine water and sediments samples were collected and analysed for the capital dredging area and dumping locations on fortnightly basis.
- (ii) For identifying the location of spoil ground for the dredged material and siltation pattern, requisite study was carried out by CWPRS, Pune in February and May, 2015.



3. Draft Terms of Reference (TOR) have been discussed and finalized by the Expert Appraisal Committee (Infrastructure -2) in its 9th meeting held on 21st -22nd September, 2016 for preparation of EIA/EMP report. The Committee prescribed the following TOR in addition to Standard TOR provided at Annexure-1 for preparation of EIA-EMP report :

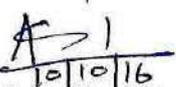
- i. Importance and benefits of the project.
- ii. A separate chapter on status of compliance of Environmental Conditions granted by State/Centre to be provided. As per circular dated 30th May, 2012 issued by MoEF, a certified report by RO, MoEF&CC on status of compliance of conditions on existing port to be provided in EIA-EMP report.
- iii. Submit a copy of layout superimposed on the HTL/LTL map demarcated by an authorized agency on 1:4000 scale.
- iv. Recommendation of the SCZMA.
- v. Layout plan of existing and proposed Port.
- vi. The Marine biodiversity impact assessment report and management plan shall deal with all micro, micro and mega biotic components and ecology within the area of influence and should be drawn up through the National Institute of Oceanography or any other institution specializing in marine ecology.
- vii. Study the impact of dredging on the shore line.
- viii. A detailed impact analysis of rock dredging.
- ix. Action plan for disposal of dredged soil and rocks.
- x. Dispersion modelling for the dumping of the dredge materials shall be carried out. The study report shall be incorporated.
- xi. Disaster Management Plan.
- xii. Status of court case pending against the project.
- xiii. A tabular chart with index for point wise compliance of above TORs.
- xiv. Public hearing to be conducted and issues raised and commitments made by the project proponent on the same should be included in EIA/EMP Report in the form of tabular chart with financial budget for complying with the commitments made.

4. These 'TORs' should be considered for deepening of approach channel for capsized vessels at Mormugao Port by M/s Mormugao Port Trust in addition to all the relevant information as per the 'General Structure of EIA' given in Appendix III and IIIA in the EIA Notification, 2006. The EIA/EMP as per TORs should be submitted to the Chairman, State Pollution Control Board, (SPCB) for public consultation. The SPCB shall conduct the public hearing/public consultation as per the provisions of EIA notification, 2006.

5. You are requested to kindly submit the final EIA/EMP prepared as per TORs and incorporating all the issues raised during Public Hearing / Public Consultation to the Ministry for considering the proposal for environmental clearance *within 3 years as per the MoEF O.M. No. J-11013/41/2006-IA.II (I) dated 8th October, 2014.*

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6. The consultants involved in the preparation of EIA/EMP report after accreditation with Quality Council of India / National Accreditation Board of Education and Training (QCI/NABET) would need to include a certificate in this regard in the EIA/EMP reports prepared by them and data provided by other Organization(s)/Laboratories including their status of approvals etc.


10/10/16
(A.N. Singh)
Scientist 'D'

Copy to:

- 1) The Additional Principal Chief Conservator of Forests (C), Ministry of Environment, Forest and Climate Change, Regional Office (SZ), Kendriya Sadan, 4th Floor, E&F Wings, 17th Main Road, Koramangala II Block, Bangalore – 560034.
- 2) The Chairman, Goa State Pollution Control Board, Dempo Towers, 1st Floor, EDC Plaza, Patto, Panaji, Goa - 403001.

STANDARD TERMS OF REFERENCE FOR CONDUCTING ENVIRONMENT IMPACT ASSESSMENT STUDY FOR PORT, HARBOURS INFORMATION TO BE INCLUDED IN EIA/EMP REPORT

- i. Reasons for selecting the site with details of alternate sites examined/rejected/selected on merit with comparative statement and reason/basis for selection. The examination should justify site suitability in terms of environmental angle, resources sustainability associated with selected site as compared to rejected sites. The analysis should include parameters considered along with weightage criteria for short-listing selected site.
- ii. Details of the land use break-up for the proposed project. Details of land use around 10 km radius of the project site. Examine and submit detail of land use around 10 km radius of the project site and map of the project area and 10 km area from boundary of the proposed/existing project area, delineating project areas notified under the wild life (Protection) Act, 1972/critically polluted areas as identified by the CPCB from time to time/notified eco-sensitive areas/interstate boundaries and international boundaries. Analysis should be made based on latest satellite imagery for land use with raw images.
- iii. Submit the present land use and permission required for any conversion such as forest, agriculture etc. land acquisition status, rehabilitation of communities/ villages and present status of such activities.
- iv. Examine and submit the water bodies including the seasonal ones within the corridor of impacts along with their status, volumetric capacity, quality likely impacts on them due to the project.
- v. Submit a copy of the contour plan with slopes, drainage pattern of the site and surrounding area
- vi. Submit the details of terrain, level with respect to MSL, filling required, source of filling materials and transportation details etc.
- vii. Examine road/rail connectivity to the project site and impact on the existing traffic network due to the proposed project/activities. A detailed traffic and transportation study should be made for existing and projected passenger and cargo traffic.
- viii. Submit details regarding R&R involved in the project
- ix. Submit a copy of layout superimposed on the HTL/LTL map demarcated by an authorized agency on 1:4000 scale along with the recommendation of the SCZMA.
- x. Submit the status of shore line change at the project site
- xi. Details of the layout plan including details of channel, breakwaters, dredging, disposal and reclamation.
- xii. Details of handling of each cargo, storage, transport along with spillage control, dust preventive measures.

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- xiii. Submit the details of fishing activity and likely impacts on the fishing activity due to the project.
- xiv. Details of oil spill contingency plan.
- xv. Details of bathymetry study.
- xvi. Details of ship tranquillity study.
- xvii. Examine the details of water requirement, impact on competitive user, treatment details, use of treated waste water. Prepare a water balance chart.
- xviii. Details of rainwater harvesting and utilization of rain water.
- xix. Examine details of Solid waste generation treatment and its disposal.
- xx. Details of desalination plant and the study for outfall and intake.
- xxi. Examine baseline environmental quality along with projected incremental load due to the proposed project/activities.
- xxii. The air quality monitoring should be carried out according to the notification issued on 16th November, 2009.
- xxiii. Examine separately the details for construction and operation phases both for Environmental Management Plan and Environmental Monitoring Plan with cost and parameters.
- xxiv. Submit details of a comprehensive Risk Assessment and Disaster Management Plan including emergency evacuation during natural and man-made disasters
- xxv. Submit details of the trees to be cut including their species and whether it also involves any protected or endangered species. Measures taken to reduce the number of the trees to be removed should be explained in detail. Submit the details of compensatory plantation. Explore the possibilities of relocating the existing trees.
- xxvi. Examine the details of afforestation measures indicating land and financial outlay. Landscape plan, green belts and open spaces may be described. A thick green belt should be planned all around the nearest settlement to mitigate noise and vibrations. The identification of species/plants should be made based on the botanical studies.
- xxvii. A detailed draft EIA/EMP report should be prepared in accordance with the above additional TOR and should be submitted to the Ministry in accordance with the Notification.
- xxviii. Any further clarification on carrying out the above studies including anticipated impacts due to the project and mitigative measure, project proponent can refer to the model ToR available on Ministry website "<http://moef.nic.in/Manual/Port and harbour>".



Annexure-II

ToR Compliance

S No.	ToR Points	Reply
1	Importance and benefits of the project	Covered in Section 1.4 of Chapter-1.
2	A separate chapter on status of compliance of Environmental Conditions granted by State/Centre to be provided. As per circular dated 30th May, 2012 issued by MoEF, a certified report by RO, MoEF&CC on status of compliance of conditions on existing port to be provided in EIA-EMP report.	Covered in Section 1.10 of Chapter-1.
3	Submit a copy of layout superimposed on the HTL/LTL map demarcated by an authorized agency on 1:4000 scale.	HTL/LTL demarcation has been done by Institute of Remote Sensing (IRS) Chennai. Findings of the report are incorporated in Section 2.9 Report prepared by IRS is being submitted with EIA report
4	Recommendation of the SCZMA.	-
5	Layout plan of existing and proposed Port	Enclosed as Figure-2.2
6	The Marine biodiversity impact assessment report and management plan shall deal with all micro, micro and mega biotic components and ecology within the area of influence and should be drawn up through the National Institute of Oceanography or any other institution specializing in marine ecology.	Impact on marine biodiversity have been Covered in Chapter-7. Mitigation and management Plan are given in Chapter8 and 9.
7	Study the impact of dredging on the shore line	Covered in Section-7.3.2 and 7.11 of Chapter-7.
8	A detailed impact analysis of rock dredging.	Covered in Section-2.8 and Section 7.3.4 of EIA report
9	Action plan for disposal of dredged soil and rocks.	Covered in Section-2.7.5 and Section 9.5 of EIA report
10	Dispersion modelling for the dumping of the dredge materials shall be carried out. The study report shall be incorporated	Detailed studies for Hydrodynamics and Siltation patterns and for identifying suitable disposal grounds using 2-D Mathematical model MIKE 21 were carried out by CWPRS. Findings of CWPRS study are given in Section 7.12

		of EIA Report
11	Disaster Management Plan	Covered Chapter-10
12	Status of court case pending against the project.	Covered in Section 1.7 of Chapter-1.

(REGIONAL OFFICE, SOUTHERN ZONE)
Bangalore-34

MONITORING REPORT
PART I

F. No. EP/12.1/26/GOA

1	Name of the project	Construction of additional general cargo berth at Mormugoa port
2	Clearance letter No.& date	J-16011/10/90-IA-III dt.13.8.91
3	Location: District & State / UT	Mormugoa port, Goa
4	Address for correspondence:	Mrs L.A Mathew, Chief Engineer, Mormugao Port Trust Civil Engineering Department, Headland Sada, Goa-403 804 Phone: 0832- 2521160/4061 Fax: 0832-2521165
5	Date of site visit for this report	01.06.2017
6	Date of previous visit(s) if any	2016, 03.07.2008 and 23.06.2004 (monitored 5 times earlier)
7	Present status of the project	

The site visit was made to this port project along with Mrs L.A Mathew, Chief Engineer, and Sh D.D Ambe EE and other officers of the Mormugao Port Trust.

Environment Clearance: EC granted for the construction of an additional cargo berth (berth No 11) in the year 1991 for handling general cargo traffic in bulk and in 2013 for modernization of berth 7 for handling coal. Mormugao Port has made M/s Adani Mormugao Port Terminal Pvt Ltd as concessionaire for operating the berth No 7. It is reported that the construction was completed in August 1995 and put into operation on 12-07-1996.

Wastewater Management: As per the information provided, the Mormugao Port Trust is having necessary facilities for the collection, treatment and disposal of liquid wastes from ships. No vessel is allowed to dispose off bilage water into the sea at the port.

The sewage is treated and used for various operation such as gardening, dust suppression etc by the berth operators. The analysis report of treated sewage produced by the Port revealed that all the parameters are within the limits.

Air and Noise pollution control: Port has water sprinkling arrangement for dust suppression. Presently mechanical ore handling is not operational at Berth 11. **The iron ore and wood ships are stocked in open yard without any cover and only water sprinkling is being done regularly. The stocks need to be covered with tarpaulins to control dust.**

The iron ore is unloaded into the berth and then loaded into the trucks which is the source for dust. **Mechanization of unloading and handling iron ore at this berth is to be given priority.** The noise levels monitored are within the limits.

Green Belt: Port has carried out plantations in and outside port premises wherever possible and more than 20,000 tree sapling have been reportedly planted so far.

Environmental Cell: Port has created a separate environmental cell comprising qualified person from different berth operators. It has a EMP and carrying out environmental monitoring regularly.

Oil Contingency Plan: Oil water separator has been installed, it has oil spill contingency plan and all the necessary arrangements like skimmers are in place.

The port was inspected on 27.01.2016 and reported the compliance is generally satisfactory and suggested actin for improvement such as cover the ore stack at berth 9 and coal at berth 7 by tarpaulins to control dust, revive the water sprinkler at berth 10 & 11, pave patches of back up area at berth 10 & 11. Now, the berth 10 & 11 are not under operational, coverage of iron ore at berth 9 is yet to be done and coal at berth 7 is partially covered.

Berth 7: Mormugao Port has leased berth 7 to M/s. Adani Mormugao Port Terminal Pvt Ltd (AMPTPL) in the year 2009 for a period of 30 years. The cargo handled is coal & coke at Berth No.7. The coal & coke is handled in a mechanized conveyor system. The dry fog system, water spray system/ canon mist spay, truck washing system are in place. **However, the majority of the coal are not covered with tarpaulin.** Wind screen of MS structure of about 15 meters height have been provided all along coal stacking yard facility. Creepers are developed on parts of wind screen. Perforated sheet have been provided partially. **PA has been advised to provide sheets on the remaining wind screen also for effective control of dust.**

Proposed Deepening of the approach channel: Mormugao Port issued EC on 09.02.2016 by MoEF &CC for Deepening of the approach channel and Inner Basin for Capesize vessels and it was reported that the work was awarded to M/s. DCI, Vishakapatnam. As on 31.05.2016 about 65% work was completed and work was suspended from 1st June, 2016 to 31st July 2016 based on the EC condition that no dredging work shall be carried out during fish breeding season. The work was resumed after fish breeding season on 18.08.2016. However, Hon'ble NGT in No.10/2016(WZ), quashed and set aside the EC because Public Hearing was exempted. Port informed that order was received by Mormugao Port on 19.09.2016 and dredging work was stopped immediately on the same day. Subsequently DCI terminated the contract vide letter dtd. 18.11.2016.

Mormugao Port applied online before EAC for issue of TOR for the dredging project and the project was presented before EAC on 23.09.2016. MoEF &CC issued TOR for Capital Dredging Project vide letter dt. 16.10.2016. WAPCOS has prepared EIA Report and GSPCB has conducted public hearing.

The detailed point wise compliance status is given in this report. The Compliance is generally satisfactory except for the above observations.



(E.Thirunavukkarasu)
Scientist 'D'

PART-II- Compliance Status in brief

Status of compliance to the Environmental clearance issued by the Ministry for the Construction of additional general cargo berth at Mormugoa port by Mormugao Port Trust issued vide Ref: No. J-16011/10/90-IA-III dt.13.8.91

<u>No</u>	<u>SPECIFIC CONDITIONS</u>	<u>COMPLIANCE</u>
1	Reclamation works to be undertaken in stages	Complied
1b	Detailed EIA study to be undertaken	Complied
2	Water Quality conditions to be inspected	Complied
3	All roads should be paved to reduce dust	pl refer Part III
4	Workers to have protective equipments	Being Complied
5	Regular monitoring of dust & noise should be carried out	Being Complied
6	Alternative measures to the fishermen	Being Complied
7	Adequate for collection & treatment of sewage	Complied
8	Devises for preventing oil pollution	Complied
9	Protective clothing to the workers handling chemicals	Complied
10	Green belt development	Complied
11	Dredging operations should not cause disturbance	Complied
12	Control the Noise and dust within the ore handling area	PI refer Part III
13	Quality of the air, noise & effluents to confirm standards	Complied
14	The quality of treated effluents, emissions, noise levels etc to confirm standards.	Complied
15	Creation of in house capability	Complied
16	Adequate financial provision for EMP	Complied
17	Deviation / alteration	Complied
18	Implementation of other regulations	Complied

Part -III

i (a) **The project should undertake reclamation work in stages.**

PA informed that reclamation work was executed in consultation with CWPRS Pune during 192-94. It was ensured that the surface water quality does not deteriorate.

i (b) **Detailed EIA Report to be submitted.**

The project authorities have already prepared and submitted a detailed EIA report through NIO, Goa to the Ministry in 1994 itself.

ii **Water quality monitoring during construction and operation stages.**

The project is completed in 1993 and regularly sea water quality is monitored

iii **All roads and service areas should be paved to reduce dust.**

Majority of roads and storage plots are paved and maintained **except few patches. PA informed that those patches will be paved in the present proposal.**

iv **The workers are to be provided with ear plugs/ ear muffs in the mechanical ore handling plant and other locations to reduce noise levels.**

All safety gears are provided for all workers

v **Periodic monitoring to study dust and noise levels.**

Port has created a separate environmental cell comprising person from different berth operators. It has a EMP and carrying out environmental monitoring regularly.

vi **Alternate measures to be created for fishermen.**

PA informed that Temporary landing platform has been constructed and has plans to construct a dedicated fishing jetty in Vasco Ba and DPR is prepared and MOU signed with government of Goa and other stakeholder.

vii **Provision for collection, treatment and disposal of liquid waste from the ships.**

As per the information provided, the Mormugao Port Trust is having necessary facilities for the collection, treatment and disposal of liquid wastes from ships. No vessel is allowed to dispose off bilage water into the sea at the port.

viii **Appropriate devices for tackling oil pollution in the port area and marine environment.**

Oil water separator has been installed, it has oil spill contingency plan and all the necessary arrangements like skimmers are in place.

ix **Appropriate protective clothing to the workers during handling chemicals.**

PA informed that workers are provided with necessary protective cloths

x **Green belt development program as proposed to be carried out.**

PA informed that plantation has been carried out in and outside port premises wherever possible and more than 20,000 tree sapling have been planted.

xi **The project authorities must ensure that the dredging operations do not cause any adverse impact.**

It was informed that their dredging operation was carried out in consultation with CWPRS Pune during 192-94. It was ensured that the surface water quality does not deteriorate. The sea water quality is monitored regularly and no adverse effect is noticed.

xii **Noise and dust pollution within the mechanical ore handling and other areas.**

PA informed that mechanical ore handling is not operational at Berth 11. **The iron ore and wood chips are stocked in open yard without any cover**, PA informed that water sprinkling is being done regularly. **PA has been advised to cover the materials with tarpaulins to control dust.**

The iron ore is unloaded into the berth and then loaded into the trucks which is the source for dust. **PA has been advised to consider mechanization of unloading and handling iron ore.**

The noise levels monitored are within the limits.

xiii **The quality of treated effluents, emissions, noise levels etc to confirm standards.**

Port has valid consent order from SPCB and is meeting the norms in respect of effluent, emissions and noise level.

xiv **Creation of in house capability**

Port has created a separate environmental cell comprising person from different berth operators. It has a EMP and carrying out environmental monitoring regularly.

xv **Adequate financial provision for EMP**

PA has informed that it has separate budget for implementation of EMP. Rs 6 lakhs has been allocated for the year 2017-18 and additional if any will be provided in RE.

xvi **Deviation / alteration**

According to PA, there is no alterations

xvii **Enforcement of other regulations**

Complied.



Part-IV**Compliance status of EC and CRZ clearance granted for modernization and operation of berth No. 7 for coal handling vide F.No. 10-39/2009-IA-III dated 30.12.2013**

	Specific Conditions	Compliance
i	"Consent for Establishment"	Complied
ii	Leachate shall be treated before disposal.	Complied
iii	Provide dry fog and sprinkling systems for effective dust suppression.	Complied
iv	Entire transportation of coal shall be in closed conveyor	Complied
v	There shall be no washing of conveyor belt	Complied
vi	Provide wind screen min 15 m height.	Pl refer Part-V
vii	Coal storage and transportation.	Complied
viii	Comply with conditions of GCZMA	Complied
ix	Periodical study on shore line changes	Not applicable
x	Oil spills Contingency Management Plan shall be put in place	Complied
xi	Recommendations of EMP/DMP	Complied
xii	Mechanical handling of cargo	pl refer Part-V
xiii	The dredge material shall be reused for low level rising	Complied
xiv	Collection, treatment and disposal of liquid wastes must be provided.	Complied
xv	Arrangements for the treatment of the effluents and solid wastes	Complied
xvi	The treated effluents, solid wastes, emissions and noise levels must confirm to the standards	Complied
xvii	Submission of compliance on EIA	Complied
xviii	Funds for environment management plan.	Complied
xix	Environmental Management Cell	Complied
	General Conditions	
i	Measures to avoid any likely degradation of water quality during dredging.	Complied
ii	Full support to the officers of this Ministry/Regional Office	Complied
iii	A six-monthly monitoring report shall need to be submitted	Complied
iv	Inform date of financial closure and final approval	Complied
v	A copy of the clearance to concerned Panchayat/local NGO	Complied
vi	Obtain all other statutory clearances	Complied
vii	Advertisement of EC in at least two local Newspapers	Complied
viii	Upload status of in its website.	Complied
ix	Submission of the environmental statement	Complied

Part- V

Compliance status of EC and CRZ clearance granted for modernization and operation of berth No. 7 for coal handling vide F.No. 10-39/2009-IA-III dated 30.12.2013

Specific Conditions

- i **"Consent for Establishment" shall be obtained from Goa Pollution Control Board under Air and Water Act and a copy shall be submitted to the Ministry before start of any construction work at the site.**

Consent to Establish (CTE) has been obtained from Goa Pollution Control Board and Copies submitted along with six monthly compliance reports .

- ii **The project proponent shall provide lining for collection of run off from coal Stockyard and the leachate shall be treated before disposal.**

Complied, Runoff from Coal Stock Yard is being collected in RCC dump pond provided with proper lining. Separated water from dump pound is reused for dust suppression and settled coal solid particles are sent back to coal stock piles.

- iii **The project proponent shall provide dry fog and sprinkling systems for effective dust suppression.**

Complied, for effective dust suppression dry fog dust suppression, Water Sprinklers and Mist Canon are provided.

- iv **Entire transportation of coal shall be in closed conveyor**

Complied, the coal is being transported through closed conveyor from jetty to Silo /stock yard.

- v **There shall be no washing of conveyor belt**

PA informed that there is no washing of conveyor belt.

- vi **The project proponent shall provide wind screen min 15 m height fabric HDPE all along the periphery. The height shall be designed taking into account the wind velocity modelling etc. Also explore creepers in consultation with forest department**

Complied, wind screen of MS structure of about 15 meters height have been provided all along coal stacking yard facility. Creepers are developed on parts of wind screen. Perforated sheet have been provided partially. **PA has been advised to provide sheets on the remaining wind screen also for effective control of dust.**

- vii **Coal shall be kept under moist conditions using water sprinklers. Transportation shall be in closed conveyors with water spray.**

Complied, coal is being stored under the moist condition by effective sprinkling and it is transported through closed conveyors.

- viii **All the conditions stipulated by Goa Coastal Zone Management Authority (GCZMA) vide letter No. GCZMA/S/13- 14/09/360 dated 07.06.2013, shall be complied with**

Agreed by the PA.

- ix **Periodical study on shore line changes shall be conducted and mitigation carried out if necessary. The details shall be submitted along with the six monthly monitoring reports**

PA informed that as the said project activity is taken up in the existing port premises of M/s. MPT by modernization of old berth, this conditions is not applicable.

- x **Oil spills if any shall be properly collected and disposed as per the Rules. Proper Oil Contingency Management Plan shall be put in place**

PA informed that AMPTPL is handling dry cargo only such as coal, however, they abide by the Oil Spill Contingency Management Plan prepared by M/s MPT.

- xi **All the conditions stipulated in the earlier Clearances including the recommendations of Environment Management Plan, Disaster Management Plan shall be strictly complied with**

PA informed that all the recommendations made in the Environment Management Plan as contained in the Environment Impact Assessment of the project are covered and effectively implemented.

- xii **Cargo shall be unloaded directly into hopper from the ship and transported to the stack yards through closed conveyor system only. Inbuilt dust suppression systems shall be provided at hoppers and all the transfer points / storage yards. Cargo shall not be unloaded directly onto the Berth. Water meters shall be provided at different locations to record the consumption of water used for dust suppression and daily log shall be maintained.**

The coal is being unloaded directly into hopper from the ship and transported to the stack yards through closed conveyor system. In-built dust suppression system has been provided in hoppers, transfer towers and storage yards to avoid fugitive emissions. **However, majority of coal have been stored without tarpaulin cover.**

- xiii **The dredge material shall be reused for low level rising wherever possible and excess shall be dumped into sea at the designated dumping areas identified based on mathematical model studies.**

Complied, Construction of the project is completed and currently it is operational

- xiv **To prevent discharge of sewage and other liquid wastes including ballast into marine environment, collection, treatment and disposal of liquid wastes must be provided.**

PA informed that the sewage is being collected in septic tank and further it is send to MPT's STP. There is no discharge from AMPTPL in marine environment.

- xv **Necessary arrangements for the treatment of the effluents and solid wastes must be made and it must be ensured that the untreated effluents and solid wastes are not discharged into the water or on the beach; and no effluent or solid wastes shall be discharged on the beach.**

Complied, domestic effluent is being sent to MPT - STP for treatment and solid waste generated is disposed to local authorities. No effluent or solid wastes is being discharged on the beach

- xvi **The quality of treated effluents, solid wastes, emissions and noise levels and the like, from project are must confirm to the standards laid authorities including the Central or State Pollution Control Board under the Environment (Protection) Act 1986**

All parameters are complying with the norms

- xvii **All the mitigation measures submitted in the EIA report shall be prepared in a matrix format and the compliance for each mitigation plan shall be submitted to MoEF along with half yearly compliance report to MoEF-RO**

PA has submitted six monthly compliance report.

- xviii **The funds earmarked for environment management plan shall be included in the budget and this shall not be diverted for any other purpose.**

PA informed that AMPTPL has kept separate budget earmarked for Environment Management Plan. Total amount spent during FY 16-17 is INR 29.88 Lakhs and Budget allocated for FY 17-18 is 34.3 Lakhs.

- xix **The project proponent shall set up separate environmental management Cell for effective implementation of the stipulated environmental safeguards under the supervision of a Senior Executive**

Complied, AMPTPL has a well structured Environment Cell staffed with qualified manpower for implementation of the Environmental Management Plan under the supervision of a Senior Executive.

7. General Conditions

- x **Appropriate measures must be taken while undertaking digging activities to avoid any likely degradation of water quality.**
Complied, construction activities is completed and project is in operation phase
- xi **Full support shall be extended to the officers of this Ministry/Regional Office**
Full support extended for the visit.
- xii **A six-monthly monitoring report shall need to be submitted**
PA has submitted six monthly compliance report.
Ministry of Environment & Forests may stipulate additional conditions
- xiii Noted by the PA
The Ministry reserves the right to revoke the EC
- xiv Noted by the PA
Inform date of financial closure and final approval
- xv Complied
- xvi **A copy of the clearance letter shall be marked to concerned Panchayat/local NGO**
Complied as reported
Goa State Pollution Control Board shall display a copy of the clearance letter
- xvii Complied as reported
These stipulations would be enforced among others Regulations
- xviii Noted by the PA
Obtain all other statutory clearances
- xix PA informed that they got all statutory clearances
The project proponent shall advertise in at least two local Newspapers widely
- xx PA informed that advertisement given in 1) Sunaparant and 2) Times of India, Goa.

Status of compliance to the various stipulated environmental conditions and environmental safeguards will be uploaded by the project proponent in its website.

xxi

PA informed the status of compliance is regularly being uploading at <http://www.adaniports.com/ports-downloads>

Submission of the environmental statement

xxii

Complied.



(E.Thirunavukkarasu)
Scientist 'D'

ANNEXURE-IV

National Ambient Air Quality Standards (Unit: $\mu\text{g}/\text{m}^3$)

S. No.	Pollutants	Time Weighted Average	Concentration in the Ambient Air	
			Industrial, Residential, Rural and other area	Ecologically sensitive area (Notified by Central Government)
1	Sulphur Dioxide(SO ₂)	Annual* 24 hours**	50 80	20 80
2	Nitrogen Dioxide (NO ₂)	Annual* 24 hours**	40 80	30 80
3	Particulate Matter (Size less than 10 μm), PM ₁₀	Annual* 24 hours**	60 100	60 100
4	Particulate Matter (Size less than 2.5 μm), PM _{2.5}	Annual* 24 hours**	40 60	40 60
5	Lead (Pb)	Annual* 24 hours**	0.5 1.0	0.5 1.0
6	Carbon Monoxide (CO)	8 hours** 1 hour**	2.0 4.0	2.0 4.0
7	Ozone (O ₃)	8 hours** 1 hours**	100 180	100 180
8	Ammonia (NH ₃)	Annual* 24 hours**	100 400	100 400
9	Benzene (C ₆ H ₆)	Annual*	5.0	5.0
10	Benzo(a) pyrene (Bap)	Annual*	1.0 ng/m ³	1.0 ng/m ³
11	Arsenic (As)	Annual*	6.0 ng/m ³	6.0 ng/m ³
12	Nickel (Ni)	Annual*	20 ng/m ³	20 ng/m ³

Note:

* Annual arithmetic mean of minimum 104 measurements in a year at a particular site taken twice a week 24 hourly at a uniform interval.

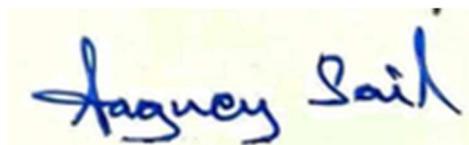
** 24 hourly or 08 hourly or 01 hourly monitored values, as applicable, shall be complied with 98% of the time in a year. 2% of the time, they may exceed the limits but not on two consecutive days of monitoring.

ANNEXURE- V

Ambient noise standards

Area Code	Category of Area	Limits in dB(A) Leq	
		Day time	Night time
A	Industrial Area	75	70
B	Commercial Area	65	55
C	Residential Area	55	45
D	Silence Zone	50	40

- Note :**
1. Day time 6 AM and 9 PM
 2. Night time is 9 PM and 6 AM
 3. Silence zone is defined as areas upto 100 metres around such premises as hospitals, educational institutions and courts. The silence zones are to be declared by competent authority. Use of vehicular horns, loudspeakers and bursting of crackers shall be banned in these zone.
 4. Environment (Protection) Third Amendment Rules, 2000 Gazettee notification, Government of India, date 14.2.2000.



GOA AGAINST COAL

C/O Custodio D'Souza, H No 116/3,
Non Mon, Dempo Bhat, Vasco-da-Gama, Goa - 403802
Tel: 9637891412

Ref No - 027/2017

Date: 12.05.2017

To
Member Secretary,
Goa State Pollution Control Board,
1st Floor, Dempo Towers, Patto, Panaji, Goa

SUB: Correction of minutes of public hearings held from 27.04.2017 onwards for deepening of approach channel and inner basin at MPT, Vasco

Dear Sir,

The attached sheets provide partly corrected minutes of the subject Public Hearing, as corrected by some of the speakers who were able to access the draft minutes. Kindly incorporate these corrections before sending the minutes to EAC or the Project Proponent. We also wish to point out the following inadequacies in the draft minutes and procedures followed:

- 1) The project proponent refused to answer most queries raised during the Hearings stating that the answers would be given in writing. As a result, no clarification or information was provided during these eight days. The people are still waiting for the clarifications and answers, which were not read out during the hearings. Hence, these minutes cannot be considered as agreed or finalized.
- 2) The hearings were held over 8 days and the minutes were read at arbitrary times during these days/nights, making it impossible for the

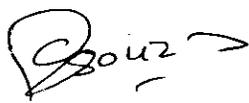
attendees to make any corrections. The minutes have not been agreed by any of the attendees and sufficient time must be provided to the speakers to check and correct the minutes.

- 3) The minutes have been prepared by PCB only on 08.05.2017 and hence it is impossible for the large number of speakers to get access to the minutes for correction.
- 4) The minutes are highly inadequate and reflect complete failure to record some of the important scientific and legal arguments placed at the Public Hearings. Many of the queries are also missed out. Hence it is important that every speaker is given an opportunity to correct the minutes of the hearing.
- 5) Many of the persons who came to the hearing to make oral submissions were denied opportunity to speak, as documented by earlier submissions by affected persons (copy of such a letter attached).

In view of the above, it is requested that the attached corrections and other corrections received be incorporated in the minutes and that sufficient time and opportunity be provided for the speakers to complete remaining corrections.

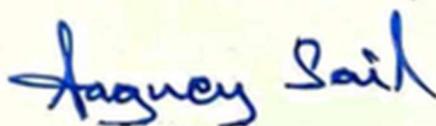
Thanking You,

Yours faithfully,


Custodio D'Souza
(Convenor)

encl: ¹⁾ Copy of letter dated 05.05.2017 (4 pages)

2) Partly corrected proceedings of PH dated 28.04.2017
(~~56~~ 82 pages)



From:

Some of Aggrieved attendees of Public Hearings,
c/o Sanjay Redkar
H No 360, Maimolem,
Vasco-da-gama-Goa.

dated: 05.05.2017

To,

1) The Chairman,
Expert Appraisal Committee, (Infra-2)
Ministry of Environment, Forests & Climate Change,
Indira Paryavaran Bhavan, Ali Garh,
Jor Bagh Road, New Delhi - 110003

2) The Chairman,
Goa State Pollution Control Board,
1st floor, Dempo Towers, Patto, Panaji.

Sub: Gross Violation of EIA Notification and
Constitution - Public Hearing for MPT & SWPL
projects Held from 26th April to 5th May 2017.

Dear Sir,

This is to draw your urgent attention
to following gross irregularities in holding
the Public Hearing for ISWPL & MPT
projects from 26th April '17 to 5th May '17 :-

① Though EIA Notification 2006, Appendix IV
Clause 6.4, clearly states that all persons
present shall be permitted together
information & clarifications from the
project proponents, the undersigned
persons are among hundreds of persons

05/5/2017

Goa State Pollution Control Board
Dempo T. 1st Floor,
EDC Plaza, Patto,
Panaji-Goa-403 001

Page 1

denied opportunity to participate in the hearing.

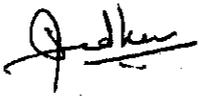
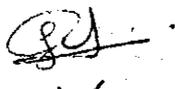
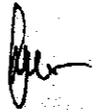
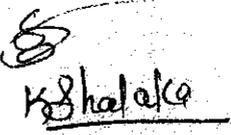
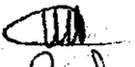
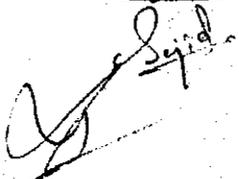
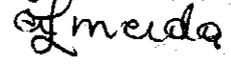
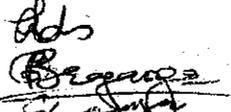
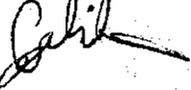
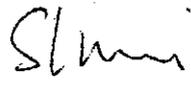
The chairman has used a register and marathon period spreading over 7 days to deny us our right to speak. Some of us had signed on a register but were also denied opportunity. Each of us has strongest opposition to this project (all 3 components) and we have issues to raise in support of our objections, but were not allowed to place them before the gathering.

② MoEF had asked GSPCB to consider holding a single Public Hearing for the 3 projects. Public had also demanded a single hearing since it is one project and not 3. However, GSPCB held 3 separate Hearings over 7 days, making it a torture and trauma for all of us. Hundreds of persons wanting to express objections to each of the 3 projects were denied opportunity.

③ Attendance sheets were not circulated, hence a large number of attendees could not sign. We condemn the denial of our rights to participate and to be heard and the violation of EIA Notification procedure for Public Hearing. We demand that the strong objections of the public and the gross corruption fraud and illegalities in these projects be scrapped and all 3 projects be scrapped.

The Undersigned persons are those who were not allowed to speak on the last day of hearing i.e. Re-development of Berth 8, 9, & barge Berth.

Thanking you,

- 1) Sanjay A. Redkar Vasco da gama 
- 2) Jack Dsilva Vasco da gama 
- 3) Edwin Dsouza Vasco da gama 
- 4) Niclau Esteibemo Vasco da gama
- 5) Jose philip Dsouza Vasco da gama 
- 6) Fiola Rego
- 7) Prashant R. Lohikar Vasco da gama 
- 8) SURESH & BARVE VASCO city 
- 9) Mrs. Shalaka Suresh Kambl. (vasco) 
- 10) Olencio Simoes Causaulim 
11. Mohamed Sajit K. Baina, Vasco 
- 12) Anetta Shudhan
- 13). Karen Andrade Ceraulim 
- 14). Lumina Almeida Ceraulim 
- 15). Aurea Lananda
- 16). Geraldin Braganza Nover Agassaim 
- 18) Sebastian Braganza Agassaim 
- 19) Gabriella D'cruz Salgado 
- 20) Shrayyagi Israni Dona Paula 

- ASHURAM BHETIJE - 9975538917 Vasco
22. PETERA ANDRADE - 9823046864 Vasco
23. Samir Kanaji - 9763657557 Head Land Sada
24. Chandrashekhar Vast Vasco 9960721439
25. Sunesh Naile Vasco
26. Mohan S. Dholkar, Sada
27. Diana Tavares Lontolim - (affected-by road connectivity)
28. Neri Fernandes - 9881903000 Benaulim-Ga
- 29) Seby Mascarenhas 9689467282

TRUE TYPED COPY**From:**

Some of Aggrieved attendees of Public Hearings,
c/o Sanjay Redkar
H. No 360, Maimolem,
Vasco-da-Gama, Goa.

dated: 05.05.2017**To,****1) The Chairman,**

Expert Appraisal Committee (Infra-2),
Ministry of Environment, Forests & Climate Change,
Indira Paryavaran Bhavan, Aliganj,
Jor Bagh Road, New Delhi – 110003

2) The Chairman,

Goa State Pollution Control Board,
1st Floor, Dempo Towers, Patto, Panaji.

Sub: *Gross Violation of EIA Notification and Constitution – Public Hearing for MPT & SWPL projects held from 26th April to 5th May 2017.*

Dear Sir,

This is to draw your urgent attention to the following gross irregularities in holding the Public Hearing for JSWPL & MPT projects from 26th April '17 to 5th May '17:

- 1)** Though EIA Notification 2006, **Appendix IV, Clause 6.4**, clearly states that all persons present shall be permitted together information & clarifications from the project

proponents, the undersigned persons are among hundreds of persons denied opportunity to participate in the hearing.

The Chairman has used a register and marathon period spreading over 7 days to deny us our right to speak. Some of us had signed on a register but were also denied opportunity. Each of us has strongest opposition to this project (all 3 components) and we have issues to raise in support of our objections, but were not allowed to place them before the gathering.

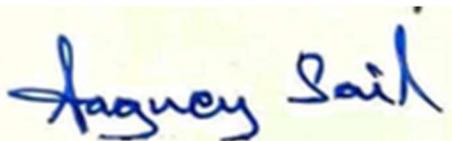
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3) Attendance sheets were not circulated; hence a large number of attendees could not sign. We condemn the denial of our rights to participate and to be heard and the violation of EIA Notification procedure for Public Hearing. We demand that the strong objections of the public and the gross corruption, fraud and illegalities in these projects be scrapped and all 3 projects be scrapped. The undersigned persons are those who were not allowed to speak on the last day of hearing i.e. Re-development of Berth 8, 9 & barge berth.

Thanking you,

1. **Sanjay A. Redkar** – Vasco-da-gama
2. **Jack Dsilva** – Vasco da gama
3. **Edwin Dsouza** – Vasco da gama
4. **Niclau Esteibero** – Vasco da gama
5. **Jose Philip Dsouza** – Vasco da gama
6. **Fiola Rego**

7. **Ramesh R. Kuttikar** – Vasco da gama
8. **Suresh S. Barve** – Vasco City
9. **Mrs. Shalaka Suresh Kambli** – Kambli (Vasco)
10. **Olencio Simoes** – Cansaulim
11. **Mohamad Sajit** – K. Baina, Vasco
12. handwriting unclear
13. **Karen Andrade** – Seraulim
14. **Lumina Almeida** – Seraulim
15. **Handwriting unclear**
16. **Anne Lemos** (or Leman)
17. **Geraldin Braganza** – Nuvem
18. **Sebastian Braganza** – Arossim / Agassaim
(handwriting unclear)
19. **Gabriella D’Cruz** – Saligao
20. **Shrayragi Israni** – Dona Paula
22. **__rshuram Shetye** – 9975538917, Vasco
23. **Petra Andrade** – 9823046864, Vasco
24. **Samit Kanoji** – 9763657557, Headland Sada
25. **Chandrashekhar Vast** (Vasco) – 9960721439
26. **Suresh Naik** – Vasco
27. **Nohan S. Dicholkar** (handwriting unclear) – Sada
28. **Diana Tavares** – Loutolim (*affected by road connectivity*)
29. **Neri Fernandes** – 9981903000, Benaulim
30. **Seby Mascarenhas** – 9689467282



Agney Sain

TRUE TYPED COPY



Aagney Sail <aagneysail@gmail.com>

ADDITIONAL AFFIDAVIT in APPEAL NO.611/2025 WZ TITLED AS RUPESH SHINKRE & ORS V/S M/S MORMUGAO PORT TRUST & ORS. - NEXT DATE 02.02.2026

1 message

Aagney Sail <aagneysail@gmail.com>

Fri, Jan 30, 2026 at 10:15 AM

To: chairman@mptgoa.gov.in, dychairman@mptgoa.gov.in, secy-moef@nic.in, gcзма gcзма <goacoastalzone@gmail.com>, ms-gspcb.goa@nic.in, Deputy Conservator of Forests Head Quarter <dcfhq-forest.goa@nic.in>, dir-env.goa@nic.in, kalabhinetri@dcil.co.in, hodci@dcil.co.in, ceo.nabet@qcin.org

To,

1. M/S MORMUGAO PORT TRUST,
(RENAMED 'M/S MORMUGAO PORT AUTHORITY'),
THROUGH ITS CHAIRPERSON,
'SAARASI', CHAIRPERSON'S OFFICE, III FLOOR, ADMINISTRATIVE OFFICE BUILDING,
MORMUGAO HEADLAND SADA, GOA – 403804.
PHONE: 0832-2521100, 07219622235(M), 08237514554(M). EMAIL: chairman@mptgoa.gov.in, dychairman@mptgoa.gov.in...RESPONDENT NO. 1

2. THE MINISTRY OF ENVIRONMENT, FORESTS & CLIMATE CHANGE (MoEF&CC), THROUGH ITS SECRETARY,
INDIRA PARYAVARAN BHAVAN, JOR BAGH ROAD,
NEW DELHI - 110003,
EMAIL ID – secy-moef@nic.in,
CONTACT NO. – 011-24645586. ...RESPONDENT NO. 2

3. GOA COASTAL ZONE MANAGEMENT AUTHORITY (GCZMA),
THROUGH ITS MEMBER SECRETARY,
1st FLOOR, PANDIT DEENDAYAL UPADHYAY BHAVAN,
NEAR PUNDALIK DEVASTHAN,
PUNALIK NAGAR, PORVORIM, GOA – 403521.
EMAIL: goacoastalzone@gmail.com
PHONE: (0832)2951089 ...RESPONDENT NO. 3

4. THE GOA STATE POLLUTION CONTROL BOARD, THROUGH ITS MEMBER SECRETARY,
NEAR PILERNE INDUSTRIAL ESTATE,
OPPOSITE SALIGAO SEMINARY,
SALIGAO, BARDEZ, GOA – 403511,
EMAIL ID- ms-gspcb.goa@nic.in PHONE: 0832-2407700....RESPONDENT NO. 4

5. FOREST DEPARTMENT,
OFFICE OF THE PRINCIPAL CHIEF CONSERVATOR OF FOREST,
GOA VAN BHAVAN, FOREST DEPARTMENT,
ALTINHO, PANAJI GOA. 403001
Phone: 0832-2492533
Email: dcfhq-forest.goa@nic.in ...RESPONDENT NO. 5

6. DEPARTMENT OF ENVIRONMENT & CLIMATE CHANGE,
GOVERNMENT OF GOA, THROUGH ITS DIRECTOR,
4TH FLOOR, DEMPO TOWERS, PANAJI, GOA 403 001.
EMAIL: dir-env.goa@nic.in,
PHONE: 0832-2951089. ...RESPONDENT NO. 6

7. DREDGING CORPORATION OF INDIA LTD.,
THROUGH ITS CHAIRMAN,
HAVING ITS REGISTERED ADDRESS AT:
CORE-2, FIRST FLOOR, SCOPE MINAR,
PLOT NO. 2A & 2B, LAXMI NAGAR,
DISTRICT CENTRAL DELHI, NEW DELHI – 110091.
HAVING ITS CORPORATE OFFICE AT:
DREDGE HOUSE, 55-1-17/8/79, HB COLONY MAIN ROAD,
SEETHAMMADHARA, Visakhapatnam, Andhra Pradesh 530022.
EMAIL: kalabhinetri@dcil.co.in, hodci@dcil.co.in
PHONE: (0891) 2523250, 2871230. ...RESPONDENT NO. 7

8. NATIONAL ACCREDITATION BOARD FOR EDUCATION AND TRAINING (NABET),
THROUGH ITS CHIEF EXECUTIVE OFFICER (CEO),
QUALITY COUNCIL OF INDIA, WORLD TRADE CENTRE,
K 100, BLOCK K, NAUROJI NAGAR, NEW DELHI-110029.
PHONE: 011 – 42600800 EMAIL: ceo.nabet@qcin.org...RESPONDENT NO. 8

Please find attached the additional affidavit in Appeal No. 611/2025(WZ) along with its Annexures for your information / necessary action.

The next date of hearing in this Appeal is 02.02.2026.

Best,

Adv. Aagney Sail,
Counsel for Appellants
Mobile: +91.9810076618

 **MPT NGT EC Appeal - Additional Affidavit.pdf**
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