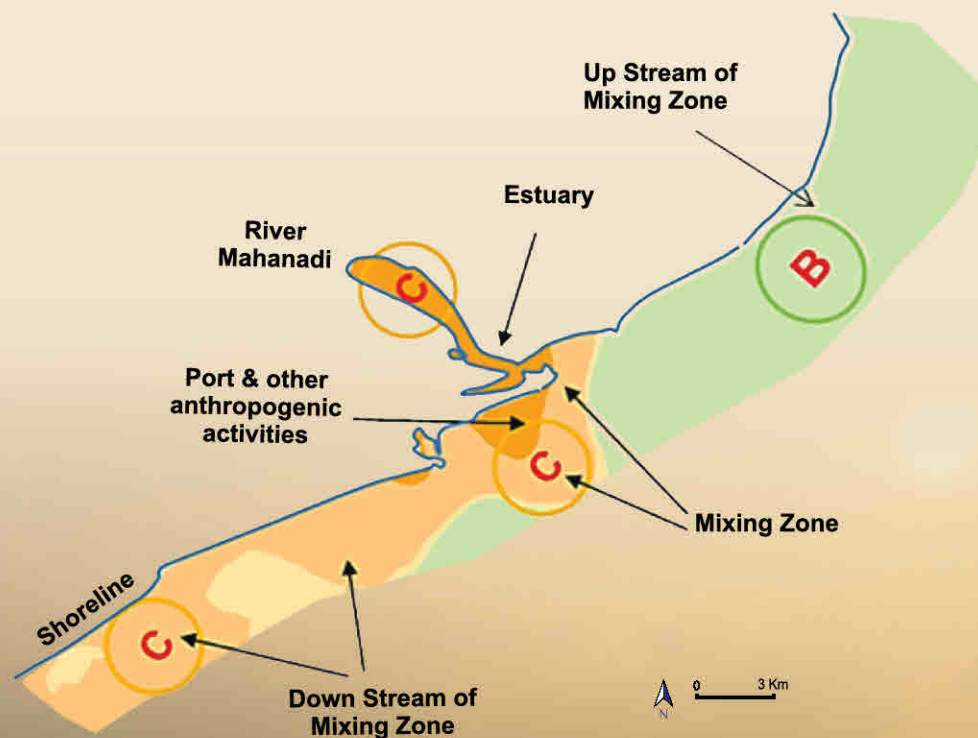


# Report card of Estuarine-Sea Ecosystem of Paradeep 2015



# Importance of Assessment of Estuarine-Sea Ecosystem

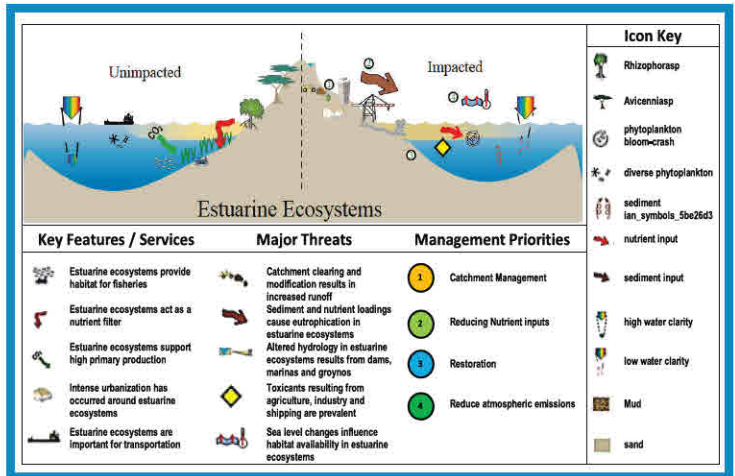
It has been noticed that human activities have impaired estuarine ecosystem either to its structure or services or both upto certain extents, especially to those estuaries where intensive exploitations have been made. The radical changes have been noticed and are in fact matter of increasing concerns. The estuarine-sea ecosystem and their impacts on ecosystem conditions/health need to be evaluated holistically to ascertain the deviation of its health from desired status in a vigilant way.

The comprehensive ecological health assessment extends to examine the deviation of multiple ecosystem parameters including nutrient, primary productivity, biodiversity, and/or its habitat. As the estuarine ecosystem is a nonlinear system, of which the structure/services are interacting in complex dynamic ways & when the components are damaged to different extents, consequent mismatching among them tends to result in dysfunction, even a sudden collapse of ecosystem observed (Chen et al., 2013). In fact, understanding the complex relationship within an ecosystem is one of the priorities and major challenges today in the research field internationally. Degradation of estuarine-sea ecosystem often occurs as syndromes of simultaneous declines in multiple structure and services, an appropriate evaluation in the deviation of ecosystem's health both in structure and its services from the desired status is a prerequisite to take appropriate steps to restore it (Carpenter et al., 2006).

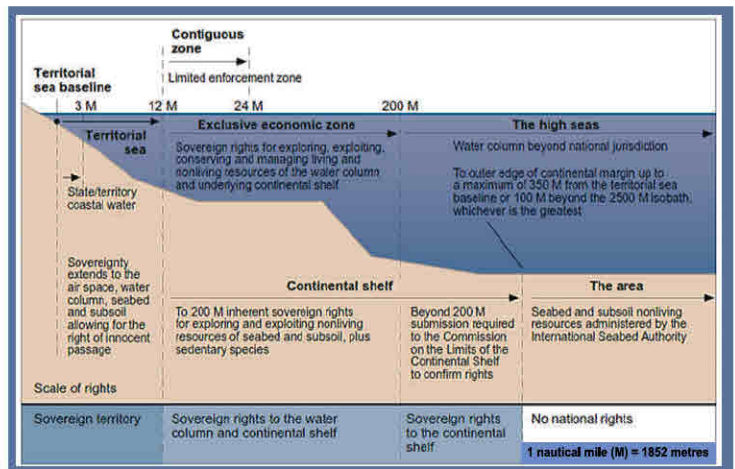
A healthy estuary is an ecosystem with its various components (biological, physical and chemical) operating effectively to maintain a functioning system within the limits of natural variability. It should also be resilient to some level of stress (Rapport et al. 1998). Assessing estuary ecosystem health (or condition) requires a framework for setting the objective of the assessment and by selecting, monitoring and reporting of appropriate indicators that measure components of an estuary-sea ecosystem that contribute to its overall health/conditions. Further, an overall measure on basic characteristics and impacts on bio-system (1<sup>st</sup> trophic level: phytoplankton) is highly required in the designated area, which in turn plays a major role on the structural and functional aspect of the ecosystem. This approach has been an effort to obtain a holistic diagnosis of ecosystem health, which would help in getting first hand information on Paradeep coastal stretch (estuary and sea) and to aware different stakeholders including decision-makers.

## Paradeep estuarine-sea ecosystem is important for local livelihood and creek environment

One of the major Ports of India is located near the Confluence of River Mahanadi and Bay of Bengal on Paradeep coast. Paradeep port is situated 210 nautical miles south of Kolkata and 260 nautical miles north of Visakhapatnam with Latitude 20°-15'-55.44"N and Longitude 86°-40'-34.62"E. The fishing from Paradeep coastal area is usually done through mechanized trawlers as well as in conventional boats by the local fishermen. Paradeep town has been developed to a semi urban agglomeration due to the existence of major industries, which in turns, created associated livelihoods and subsequent flushing of population near the coast. As this area is also rich in diversity with respects to mangroves, aquatic lives; tend to face tremendous pressure from associated anthropogenic activities.



Sources: <http://ian.umces.edu/loicz/estuaries.png>



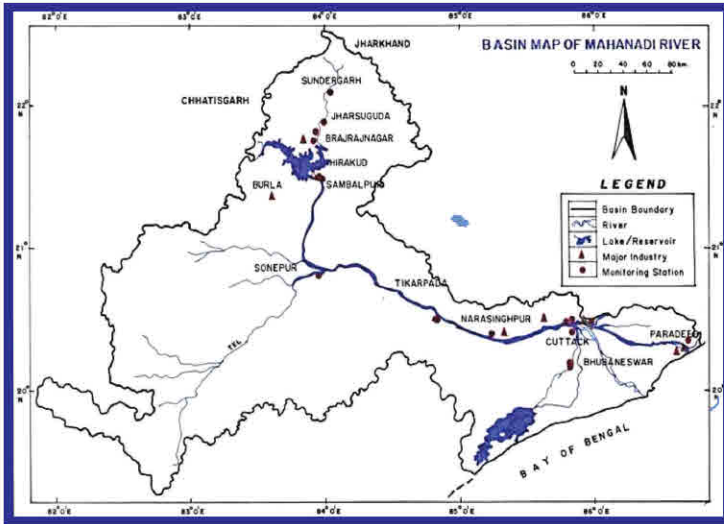
Sources: [http://www.ga.gov.au/webtemp/image\\_cache/GA13555.gif](http://www.ga.gov.au/webtemp/image_cache/GA13555.gif)



# Pressures affecting Paradeep estuarine-sea ecosystem

The major industrial clusters comprising of mainly Oil refinery (IOCL), Iron and steel (ESSAR), Port (PPT), Thermal Power (ESSAR), Fertilizer (IFFCO & PPL), Breweries (SKOL) etc. have influenced a lot and thereby exerted impacts on the said estuarine-sea ecosystem. The discharges from riverine system has been contributing the pollutants carrying from agricultural runoff, industrial flush outs, mine discharges, municipal discharges, etc. from its catchment to this estuarine-sea ecosystem.

The Paradeep coast gets pressurized constantly from both natural and anthropogenic sources. The system pressure and probable degradation of the coast are depicted below, which might be due to rampant fishing, sporadic fish culture, pollution from industries, port activities including discharge & dredging, marine transport, associated barge discharges & accidents and drifting of sediments from riverine systems.



Source: Map, SPCB, Odisha

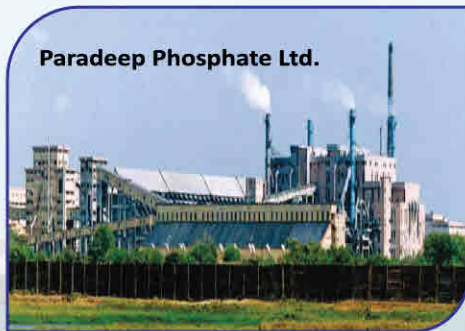


Source: Map, Behera et al, 2014

## Pressure from Fishing



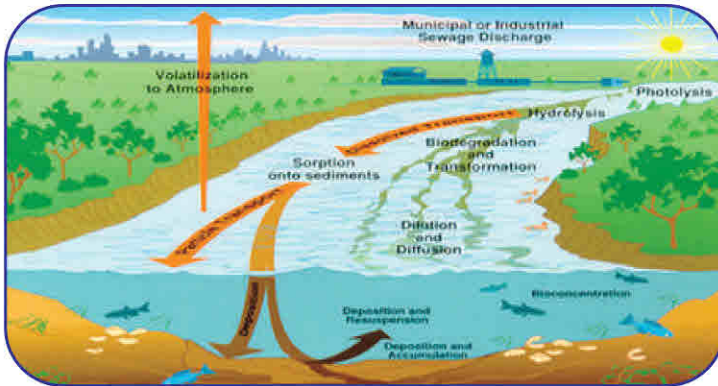
## Pressure from Industrial Pollution



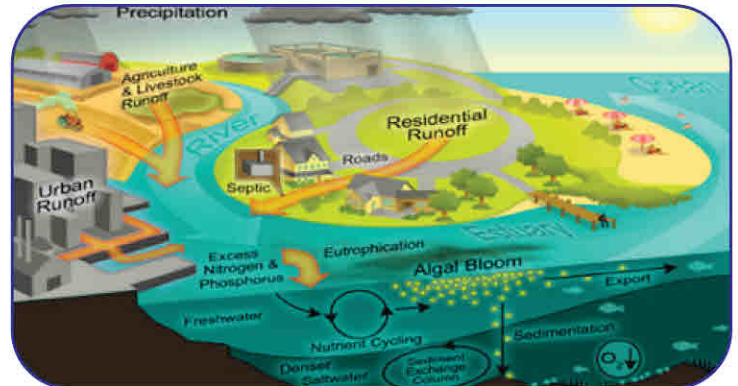
## Pressure from Port activities



## Mine discharge, agricultural runoff, Sewage and Industrial discharge in catchment area



Sources: <http://www.our-work/project/eutrophication-and-hypoxia/sources-eutrophication>



Sources: <http://pubs.usgs.gov/circ/circ1133/organic.html>

## How the report card was prepared?

Environmental sampling, analysis and reporting by following the Monitoring Protocol of Odisha State Pollution Control Board, ICZMP has resulted contributing a standardized approach to evaluate estuary-sea ecosystem conditions/health, based on best practices available. Environmental samples were collected, analyzed and results were subjected for interpretations and correlations. Water Quality Standards were selected to evaluate the Water Quality Index (WQI) for each zone as presented here. The estuarine-sea ecosystem of Paradeep has been considered into four (04) zones viz., (1) Estuary (Atharabanki creek and River Mahanadi) (2) Mixing zone (confluence of River Mahanadi and sea) (3) Mixing zone Down Stream and (4) Mixing zone up stream.

## Why Monitored?

The report card was developed as it is an integral part of the mandate of the World Bank funded ICZM Project, adopted by Odisha State Pollution Control Board in order to enhance the understanding and management of coastal stretch of 80 KM from Paradeep to Dhamra in Bay of Bengal. As Paradeep estuarine-sea ecosystem is quite vulnerable due to various activities; it is important to determine the quality of water in terms of health of the designated ecosystem, so that natural-resource-managers may oversee the condition of this ecosystem and to target investment to improve ecosystem health. This reporting would also provide prominence to determine appropriate management actions, monitoring the effectiveness of management and contributing to the ongoing management of sea, estuaries and their catchments. The report card of estuarine-sea ecosystem of Paradeep for the year 2015 is prepared to understand and to improve the quality of health/conditions by addressing different issues arising out of this assessment.

## What is Ecosystem Report card?

Ecosystem health is determined by the response of the environment to natural and human inputs; may be defined as the degree to which the actual state of an ecosystem diverges from an ideal state as described in management objectives. A healthy estuarine and marine ecosystem is said to have the desired characteristics: key processes in operation to maintain stable and sustainable ecosystems, zones of human impacts that do not expand or deteriorate and aquatic ecosystems (critical habitats) which remain intact. These characteristics are complex and really difficult to measure the attributes comprehensively. While compiling this report card, few key water quality as well as biological indicators, which were determined during the period of monitoring and were analyzed in the laboratory. The results were compared to acceptable levels with national and international reference conditions.

## Measures of Report card

**pH, temperature, TSS & Turbidity:** Indicate water column characteristics and put both direct & indirect impact on nutrient cycle and indirect impact on primary productivity & influence in controlling the food chain and food web.

**Dissolved Oxygen & BOD:** Indicate the impact on biological status or health of aquatic environment (Hypoxia/anoxia)

**Nutrients (NO<sub>2</sub>, NO<sub>3</sub>, PO<sub>4</sub>, silicate):** Signify the status of presence of nutrient and its enrichment in the ecosystem & suggest the extent of control on biological growth and health of the marine eco system.

**Pollutants (TOC, Fe, Mn, Cd, Pb, Hg):** Indicate potential biological response to marine matrix contamination (Toxicity)

**Chlorophyll, TC/FC:** Indicate the health status of the marine ecosystem for primary production and carbon cycle of the ecosystem

## Indicators Used for Assessment of Ecosystem Health

Desired conditions (Threshold) are based on available guidelines, current scientific knowledge, and/or data and trends, taking into account the influence of a variable climate from year to year. The table below outlines the desired conditions developed or identified for each indicator and the source of this information.

Category	Indicator	Desire Condition	Source of Data
Water Quality	Temperature	20°C-30°C	SPCB, ICZMP
	pH	6.5-8.5	CPCB
	Dissolved Oxygen	≥3mg/l	CPCB
	BOD	≤ 3mg/l	CPCB
	TSS	≤ 20mg/l	ANZECC(2000)
	Turbidity	8 NTU	ANZECC(2000)
	TOC	≥ 0.3 mg/l	ANZECC(1992)
	Nitrate	≤ 1 mg/l	ANZECC(2000)
	Phosphate	≤ 0.1 mg/l	ANZECC(2000)
	Silicate	0.3-1.0 mg/l	ANZECC(2000)
	Fecal Coliform	≤ 100 nos./100 ml	CPCB
	Chlorophyll-a	≤ 3.4 µg/l	ANZECC(2000)
	Mercury	≤ 1 µg/l	CPCB
	Manganese	≤ 500 µg/l	CPCB
	Iron	≤ 500 µg/l	CPCB
	Lead	≤ 1 µg/l	CPCB
Cadmium	≤ 10 µg/l	CPCB	

## Calculating the grade of estuarine-sea conditions at Paradeep

The aim of this report card is to provide a transparent, timely, and geographically detailed assessment of Paradeep Estuarine-Sea Ecosystem Health 2015. Here the estuarine-sea ecosystem health is defined as the progress of these water quality indicators (Temperature, pH, dissolved oxygen, BOD, TSS, Turbidity, TOC, Nitrate, Phosphate, Silica, Chlorophyll-a, Fecal Coliform, Fe, Mn, Hg, Pb and Cd) toward scientifically derived ecological thresholds or goals. These indicators are combined into an Overall Health Index, which is presented as percent score.

The overall water quality index is calculated by comparing the threshold of water quality standards to the average of the water quality indicators as mentioned above for the period specified. Alternately the index is the computed average of the water quality indicators.

## What do the grades mean?

- A** 80-100% All water quality indicators meet the desired levels of Standard. The water quality in those locations tends to be very good, most often leading to very good habitat condition for Marine lives
- B** 60-80% Most water quality indicators meet the desired levels of Standard. The water quality in those locations tends to be good, most often leading to good habitat condition for Marine lives
- C** 40-60% Blend of good and poor levels of water quality indicators. Quality of water in these locations tends to be fair, leading to fair habitat conditions for Marine lives
- D** 20-40% Few water quality indicators meet desired levels. Quality of water in these locations tends to be poor often leading to poor habitat conditions for Marine lives
- E** 0-20% Very few or no water quality indicators meet desired levels. Quality of water in these locations tends to be very poor, most often leading to very poor habitat conditions for Marine lives



## 1.0. Introduction

The Ministry of Environment Forests and Climate Change in Govt. of India have prescribed rules for Coastal Zone Management with an objective towards protection and sustainable development of the coastal stretches in the country. Sustainable coastal zone management practices based on sound scientific principles would be perceived by taking the account of the vulnerability of the coast from natural hazards, sustainable livelihood security for local communities and conservation of ecologically and culturally significant coastal resources. Responsibilities of zoning and regulation of coastal stretches has been entrusted upon the National and State or Union Territory Coastal Zone Management Authorities constituted under the Environment (Protection) Act, 1986 in 1991 and subsequently amended as Coastal regulation Zone Notification in 2011.

Coastal environment is very dynamic. To understand the status of pollution of coastal water/sediments etc. and its influence on estuaries, creek or water bodies, a proper assessment is required in a more systematic manner. The effort to increase the capability of Odisha State Pollution Control Board at the sea front through World Bank funded Integrated Coastal Zone Management Project (ICZMP); which will address the marine pollution in a continuous manner. Under this Pilot Executing Project, a coastal stretch of 80 km has been assigned, from Paradeep to Dhamra (in Odisha Coast) for which, a "Monitoring Protocol" is proposed. It will address all aspects of monitoring system, such as selection of monitoring station, monitoring process, methods of measurement, data validation etc.

### 1.1. Significance

The coastal stretch between Paradeep and Dhamra has been gaining importance after the establishment of Paradeep and Dhamra ports. Besides, many big industrial units like PPL, IFFCO, IOCL and Essar etc. have been established and at present, particularly, after commissioning of oil refinery at Paradeep, these areas are going to witness rapid infrastructure development. It will augment configuration of Special Economic Zones (SEZ) and establishment of mega projects leading to industrialization and urbanization.

The development of this coastal stretch and utilization of its resources is required to be balanced mutually for

developing competitive enterprises in existing and up-coming industries, ports, fisheries, tourism, offshore fishing, aquaculture, waste disposal, etc. This protocol is devised to assess the wholesomeness of coastal health of the area and focusing its sustainability.

### 1.2. Objectives of the Protocol

- To prepare a guideline for sampling and monitoring of the designated coastal stretch.
- To select the sampling site basing on its use, impact, trend and baseline configuration.
- To standardize the sampling with respect to frequency and method of sampling to designate those as the representative samples of the region.
- To standardize the collection, preservation and transportation of sample
- To standardize the monitoring methodology for its suitability for on Board (Vessel) and Laboratory process
- To select and standardize the method of analysis within the detection limit of modern/ sophisticated instruments for required indicator parameter.
- To standardize the data validation process
- To standardize the reporting method and process
- To prepare/augment facilities required for the occupational safety for coastal monitoring.

## 2.0. Coastal Monitoring

Monitoring of environmental quality in sea needs to be done through a systematic collection and analysis of samples (including in situ collection and on-board measurements). The coastal monitoring would be effective through well-planned & designed programs to measure/quantify and report or provide an understanding about a particular situation or multiple issues ensuring the objectives.

### 2.1. Odisha Coast

Odisha, located in the northeastern coast of India, is a maritime state with immense potential in natural resources. It is located between 17°49' N and 22°34' N latitudes and 81°27' E and 87°29' E longitudes. Odisha State covers an area of 156,000 km<sup>2</sup> and has a total population of 41.97 million (2011 census). The state has a population density of 269 persons/ km<sup>2</sup> (2011 census)

# Current and emerging risks to the Estuarine-marine environment of Paradeep

Reasons almost certain for Risks					Reasons Likely to be Responsible				
CATASTROPHIC	MAJOR	MODERATE	MINOR	INSIGNIFICANT	CATASTROPHIC	MAJOR	MODERATE	MINOR	INSIGNIFICANT
<p><b>T</b>emperature increases, with impacts on fish and plankton</p> <p><b>A</b>cidification, with impacts on plankton and primary production</p>	<p><b>P</b>ort development or coastal urban development, leading to destruction or disturbance of the environment</p> <p><b>F</b>ishing (recreational and illegal), leading to change or loss of species or impacts on ecosystems.</p> <p><b>M</b>arine debris, which may poison species</p> <p><b>S</b>ea level rise and impacts of coastal erosion and inundation</p> <p><b>E</b>xtrême or severe event (storm, tidal, rainfall, flooding), which may increase run-off and sediment/nutrient levels</p> <p><b>I</b>ncrease in catchment-sourced nutrients, sediments and toxins</p> <p><b>A</b>lgal blooms in estuaries, which can be toxic or may result in hypoxic water</p> <p><b>O</b>cean current changes, leading to shifts in production</p>	<p><b>F</b>ishing (commercial), leading to change or loss of species or impacts on ecosystems</p> <p><b>S</b>hipping, leading to the wider introduction of pests</p> <p><b>B</b>each or shoreline modifications, leading to change or loss of habitat</p> <p><b>O</b>il and gas extraction, Refinery activities leading to increased shipping and onshore development, and consequent impacts on ecosystems</p>	<p><b>F</b>ishing (traditional), leading to change or loss of species</p> <p><b>V</b>essel strikes &amp; accidents</p> <p><b>C</b>oast fishing- lost nets that may entangle species</p>	<p><b>F</b>ishing by local fisherman for lively hood by non-mechanized boat</p>	<p><b>A</b>quaculture with impacts on native species</p>	<p><b>O</b>il and gas accidents, or oil spills, with impacts on species, populations, ecosystems and habitat.</p> <p><b>S</b>hipping accidents, with impacts on species populations and habitats</p> <p><b>M</b>ining or dredging of sand in shorelines and islands, leading to destruction or disturbance to species populations and habitats.</p> <p><b>L</b>ack of integrated affecting the conservation of ecosystems.</p>	<p><b>A</b>quaculture and related risks of waste disposal, dependence of wild species, impactson feed stock</p> <p><b>I</b>ndustrial discharges, with impacts on water quality and habitats</p> <p><b>R</b>iver damming or flood mitigation that changes local habitats and freshwater flows into the ocean</p>	<p><b>O</b>il refinery activities and related risks of seabed disturbance</p> <p><b>C</b>oastal and island tourism facilities, leading to disturbance or destruction of the environment</p>	<p><b>T</b>idal influence on intermixing of nutrients and toxicants into and from estuarine ecosystem</p>

## Estuarine-Sea Ecosystem condition of Paradeep

The overall score of Paradeep Estuary broadly falls under grade-C due to pressure from riverine influx, port activities and discharges from industrial activities in and around Paradeep. The score of 44 % for estuarine zone and 47% in the in mixing zone in the grading scale indicated the impacts of load in the estuary which in turn might have been diluted at confluence. The impact of load in downstream of mixing zone further reduced inspite of the influence of Badanadi (Jatadhari) with score of 59%; which still falls in grade-C quality. However, upstream towards Gahirmatha beyond the mixing zone being observed having better water quality with score of 65%, which falls under grade-B. Storm water contributes a high load of sediment, nutrients and heavy metals to the Mahanadi River estuary. Port stockyard with piles of different ore, huge industrial waste deposits (Gypsum of IFFCO and PPL), discharges from mechanized trawlers/boats in fishing jetty, agricultural runoff & other industrial discharges from Paradeep as well as from catchment area which is flowing with riverine systems; indicated further deterioration of the water quality in the estuary and also in the mixing zone (Grade-C). This is required to control with different mitigation plan by restricting the incoming pressures by upgrading the water quality and ultimately the ecosystem.

### Key management response strategies to be adopted :

**Establishing hierarchical and multi scalar inventory** of hydrological, ecological, socioeconomic and institutional features and ecosystem services to support management planning and decision making including different Stakeholders (Water Resource, Wildlife, Fisheries, IMD, Coast Guard, PPT, Different Industries in the periphery of the assign stretch of the Paradeep such as IOCL, PPL, IFFCO, ESSAR etc.) to understand the complexities of the ecosystem.

**Detailed studies of rivers, estuary and sea** by collaborating with different institutes/organizations on inter-related issues like sea dynamics, silt movement and nutrient dynamic of the estuary-sea ecosystem to promote sustainable management practices.

**Help to promote sustainable livelihood** by maintaining nutritional security ensuring health of the coastal ecosystem and promoting institutional integration with other institutes such as Universities, IITs and other working groups/stakeholders in this field for sharing of knowledge and formulating innovative strategies to restore.

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# Photographs of field monitoring and Sampling of Paradeep Coastal Stretch in 2015



Laboratory Facilities



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An electronic copy of this report can be found in [www.ospcbboard.org](http://www.ospcbboard.org)

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Nodal Officer & Scientists with Prof. M.C. Dash at ICZMP, SPCB, BBSR



Meetings of Monitoring Protocol Preparation Committee

