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Let's Solve Water

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Coastal Water Quality

Monitoring, Modelling and Prediction

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Environmental Monitoring Workshop '22

Outline

- *Importance of Marine and Coastal water quality*
- *Coastal Pollution – a threat*
- *Processes & challenges in coastal area*
- *Monitoring activities at NCCR, India*
- *Coastal WQ Modelling and prediction system*

Conservation of Oceans : Why it Matters?

Our Ocean provides :

THE AIR WE BREATHE

>50% The ocean produces over half of the world's oxygen and stores 50 times more carbon dioxide than our atmosphere.

CLIMATE REGULATION

70% Covering 70% of the Earth's surface, the ocean transports heat from the equator to the poles, regulating our climate and weather patterns.

TRANSPORTATION

76% Percent of all U.S. trade involving some form of marine transportation.

RECREATION

From fishing to boating to kayaking and whale watching, the ocean provides us with so many unique activities.

ECONOMY

$282 billion Amount the U.S. ocean economy produces in goods and services. Ocean-dependent businesses employ almost 3 million people.

FOOD

The ocean provides much more than just seafood. Ingredients from the sea are found in surprising foods such as peanut butter and soymilk.

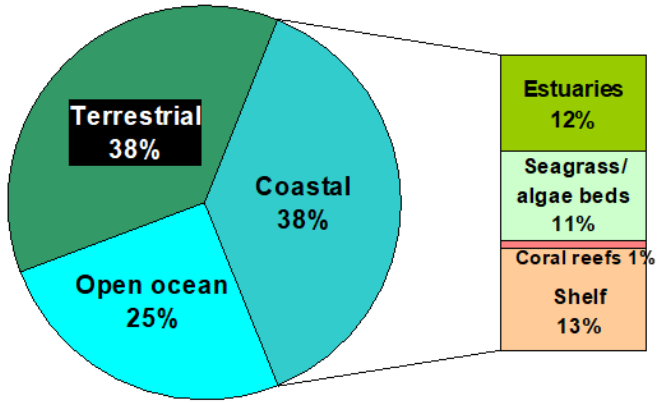
MEDICINE

Many medicinal products come from the ocean, including ingredients that help fight cancer, arthritis, Alzheimer's disease, and heart disease.

Why Focus on Marine and Coastal Areas?

The sustainable use of coastal and ocean resources is linked to public health, food security, and economic and social benefits, including cultural values and traditional livelihoods.

- Coastal waters are highly affected by pollution because they are:
  - Heavily used
  - Close to sources of pollution
  - Shallow-water bodies
  - Not as well circulated as the open ocean
- It affects the health and survival of all forms of life.
- **It is a major problem in developing countries---and the trends are expected to increase.**

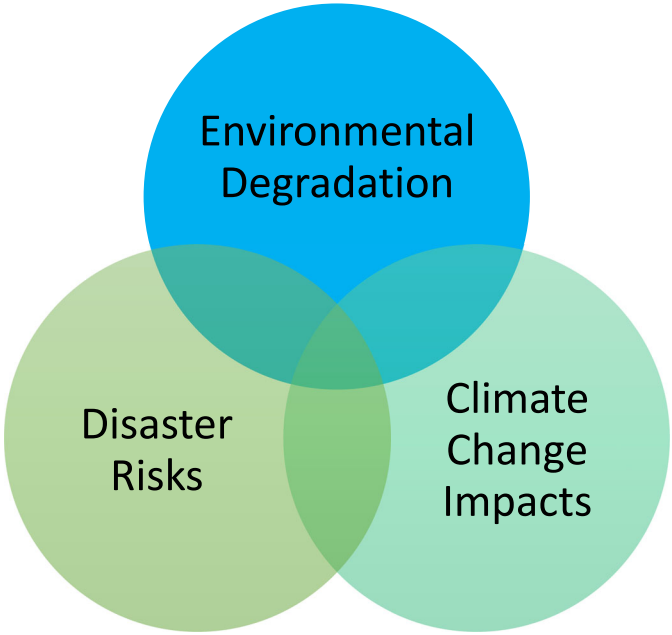


Contribution of Coastal Resources in Global GDP

Why Focus on Marine and Coastal Areas?

The sustainable use of coastal and ocean resources is linked to public health, food security, and economic and social benefits, including cultural values and traditional livelihoods.

- Extensive over-development of coastal and marine economy
- High population density
- Land-based and sea-based marine pollution
- Threats to biological diversity (conversion of natural habitat to human uses)
- Critical depletion of coastal resources and environment
- Increasing conflicts on coastal development
- Disaster risks from coastal hazards
- Impacts of climate change ex. Sea Level Rise



Marine Spatial Planning

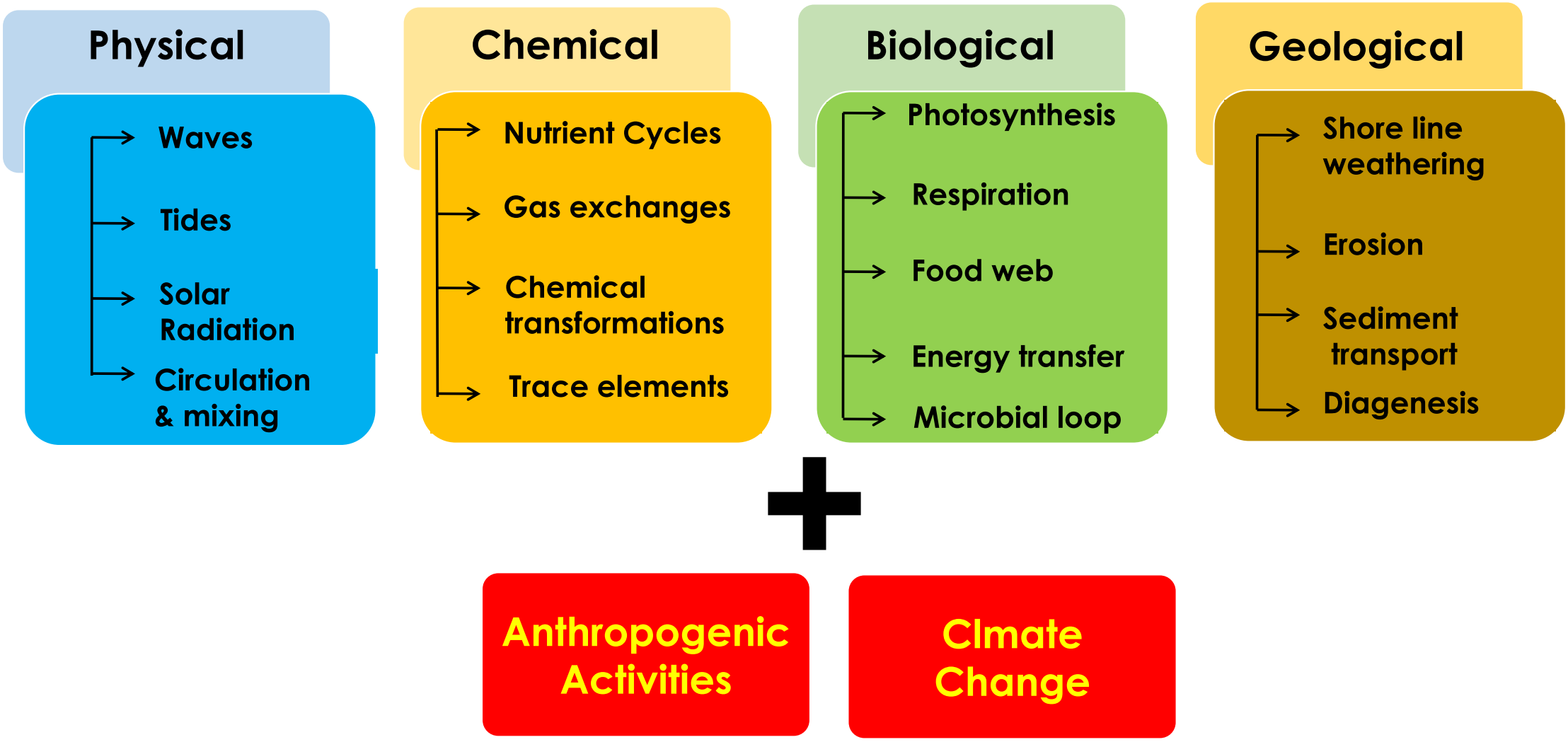
Global Agreements that Regulate the use of Oceans

15 Years **17** Goals **169** Targets **230** Indicators

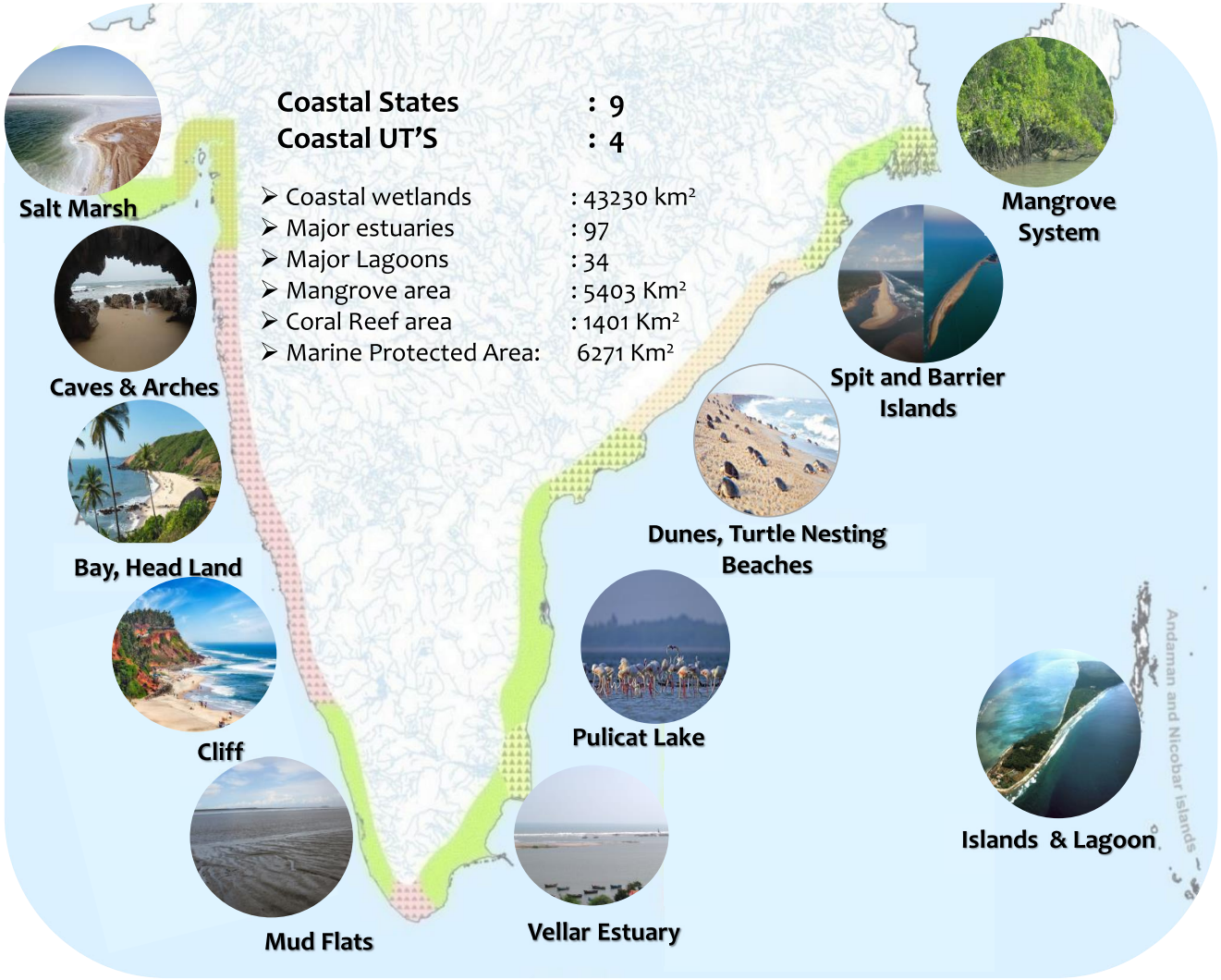
Goal 14 >> Targets =10 >> Indicators 10

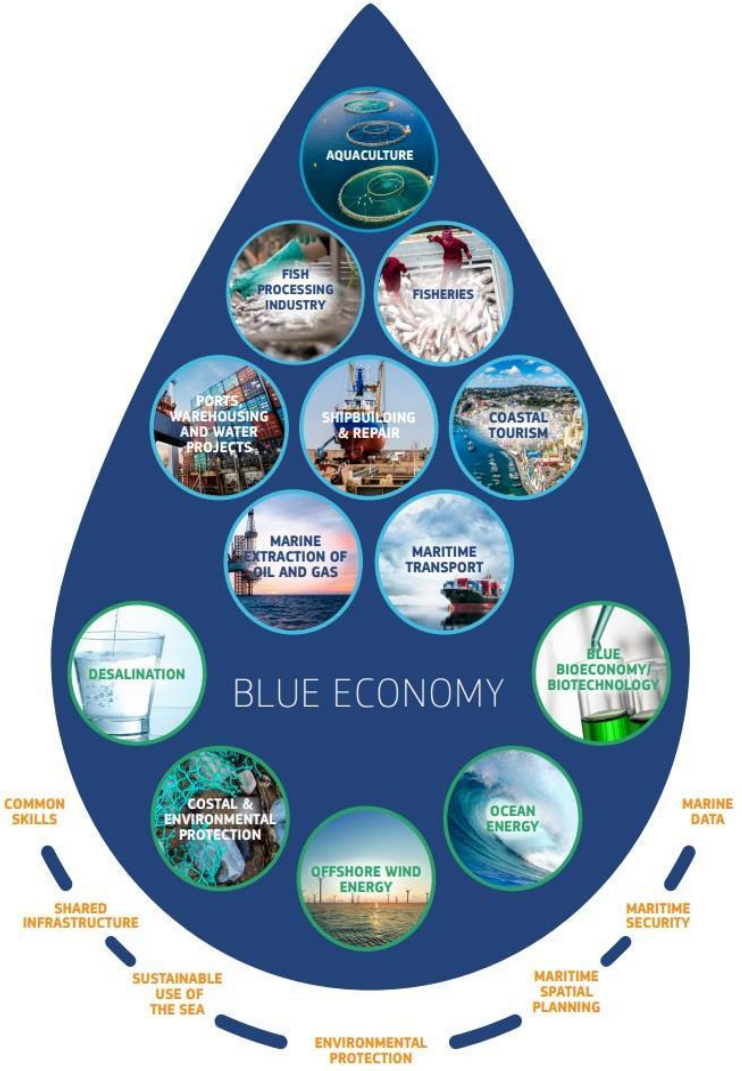
SDG14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development

Processes in Coastal/Marine Ecosystems

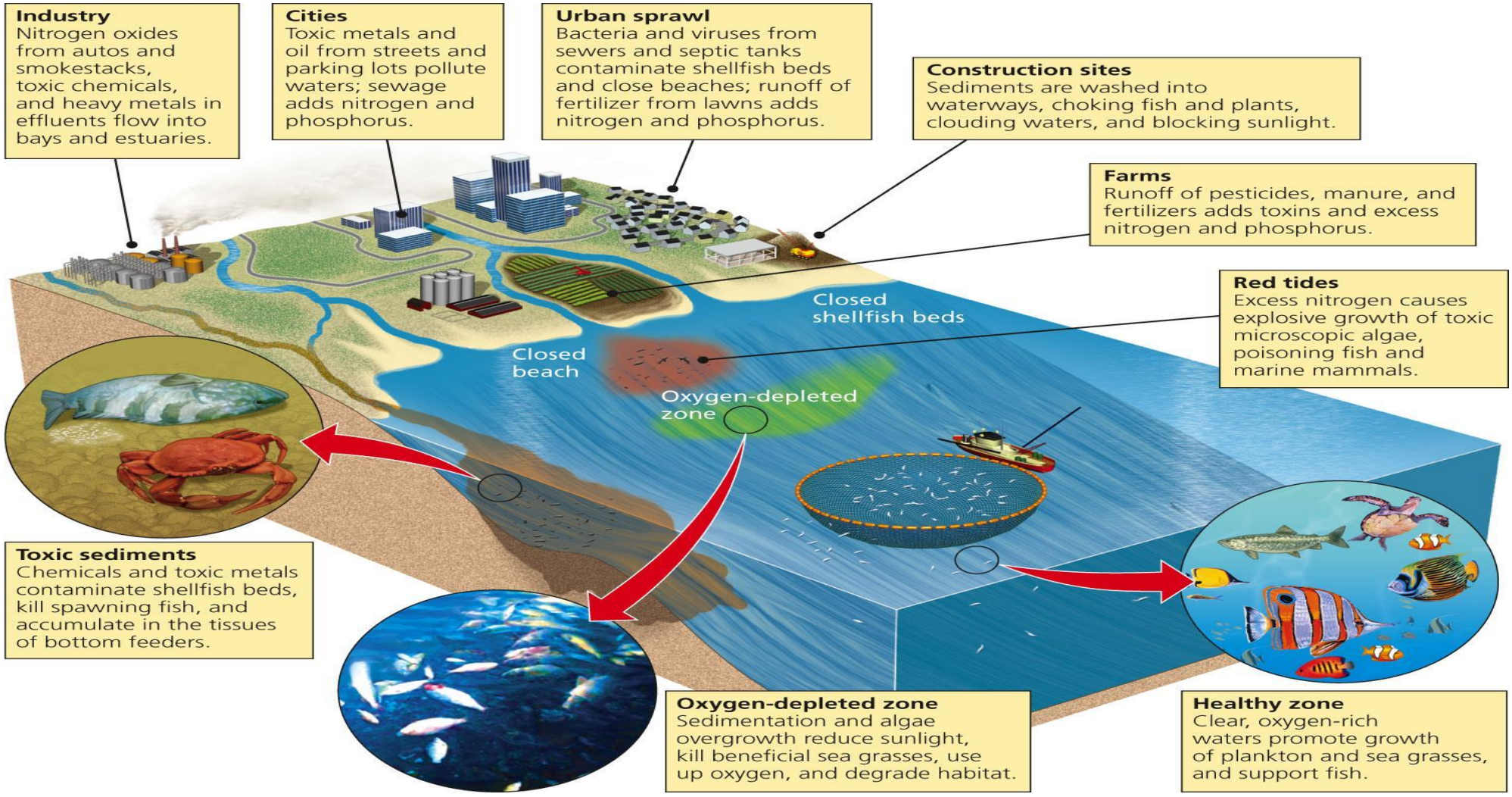


Coastal Systems : Benefits



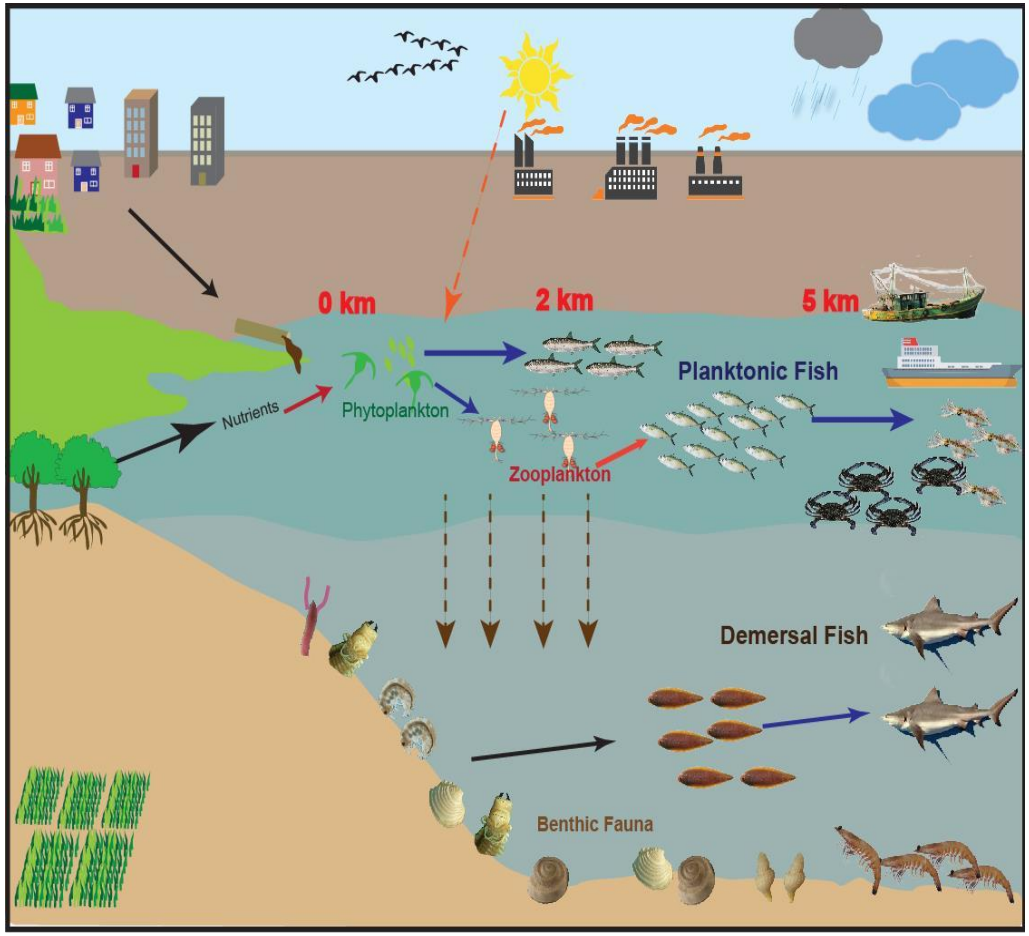


Sources of Coastal and Marine Pollution

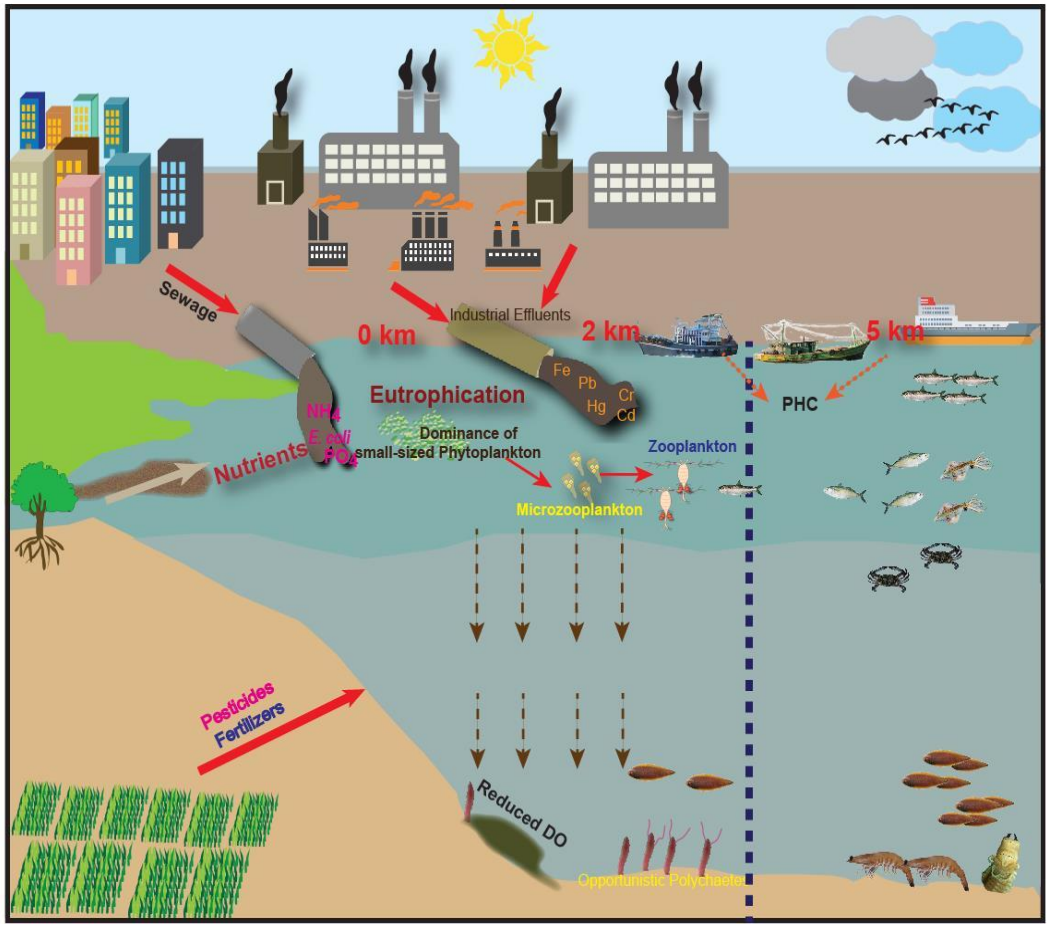


Coastal System: Pristine vs. Polluted

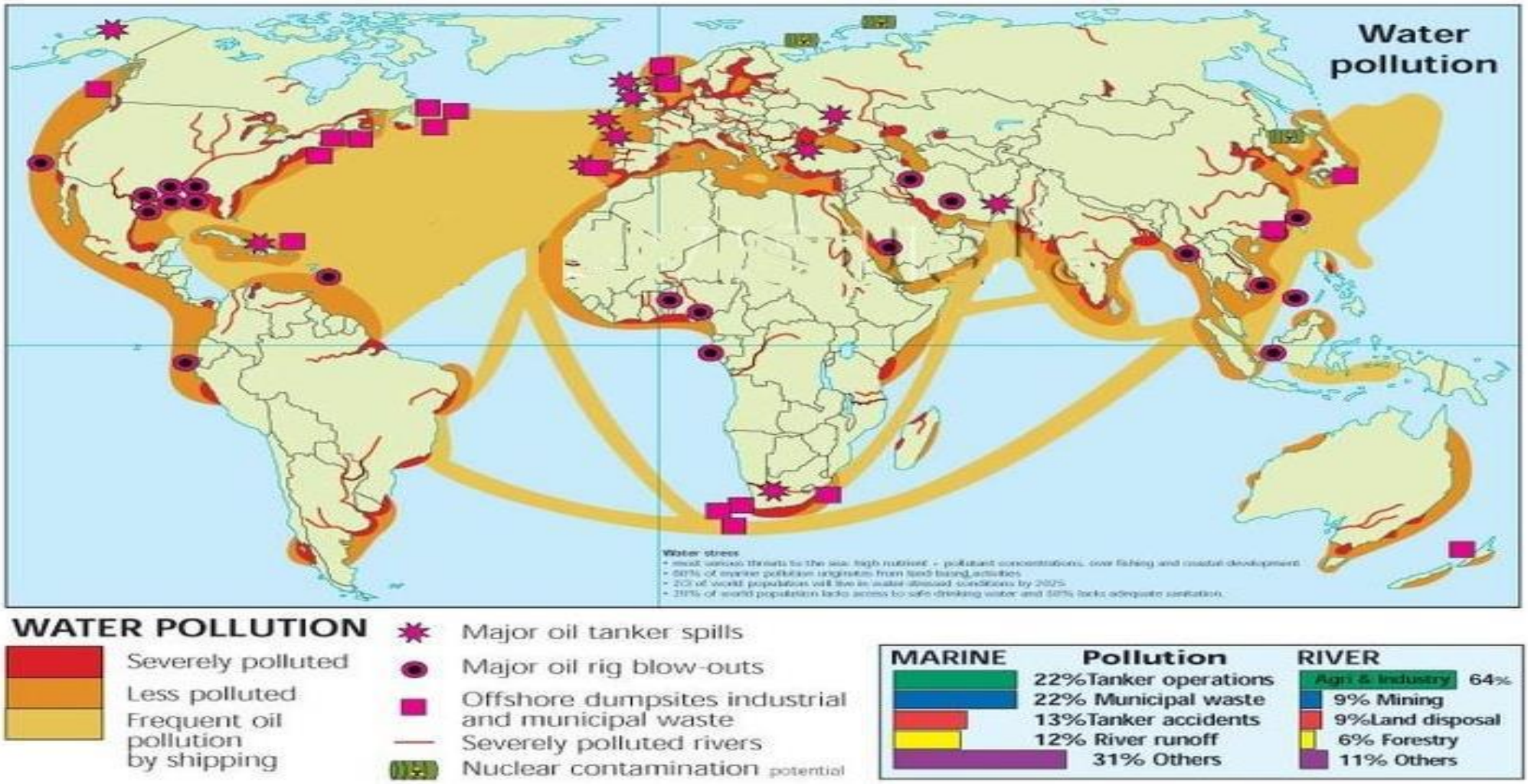
Undisturbed Coastal System



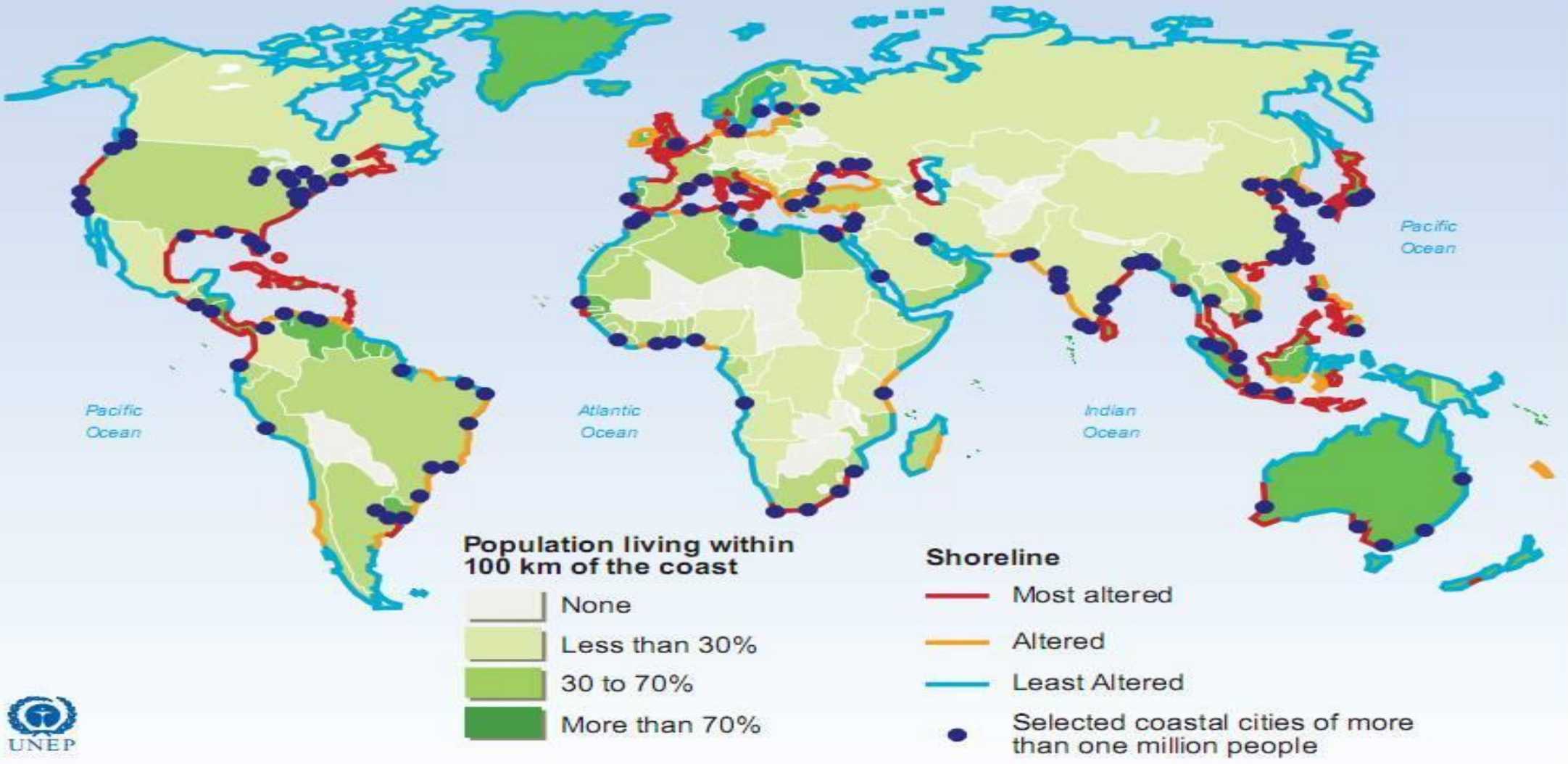
Disturbed Coastal System



Marine Pollution



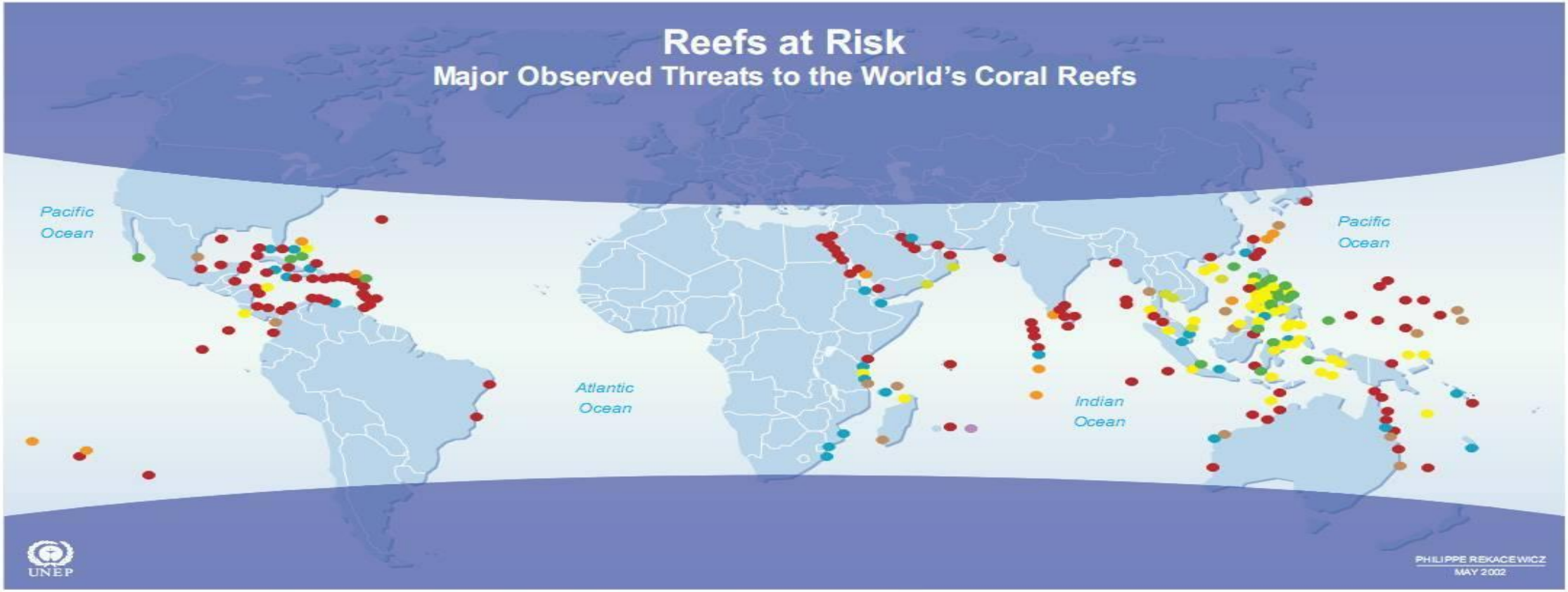
Coastal Populations and Shoreline Degradation



Source: Burke et al., World Resources Institute, Washington DC, 2001; Paul Harrison and Fred Pearce, *AAAS Atlas of Population and Environment 2001*, American Association for the Advancement of Science, University of California Press, Berkeley.

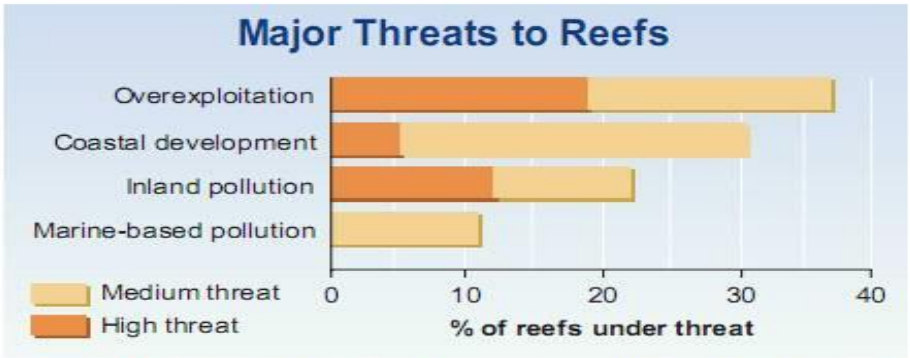
Reefs at Risk

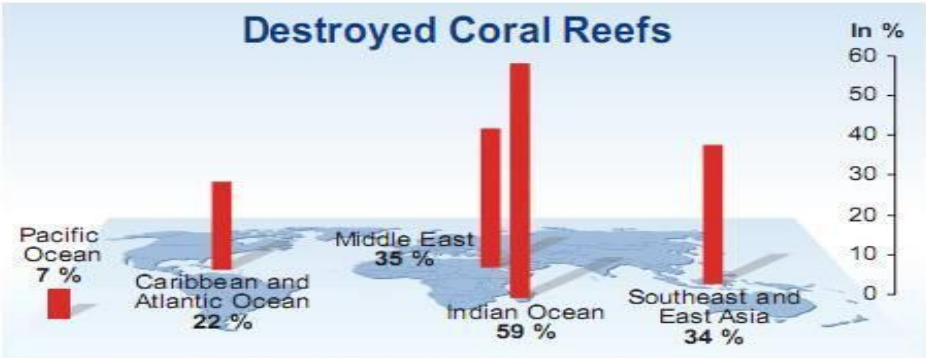
Major Observed Threats to the World's Coral Reefs



Categories

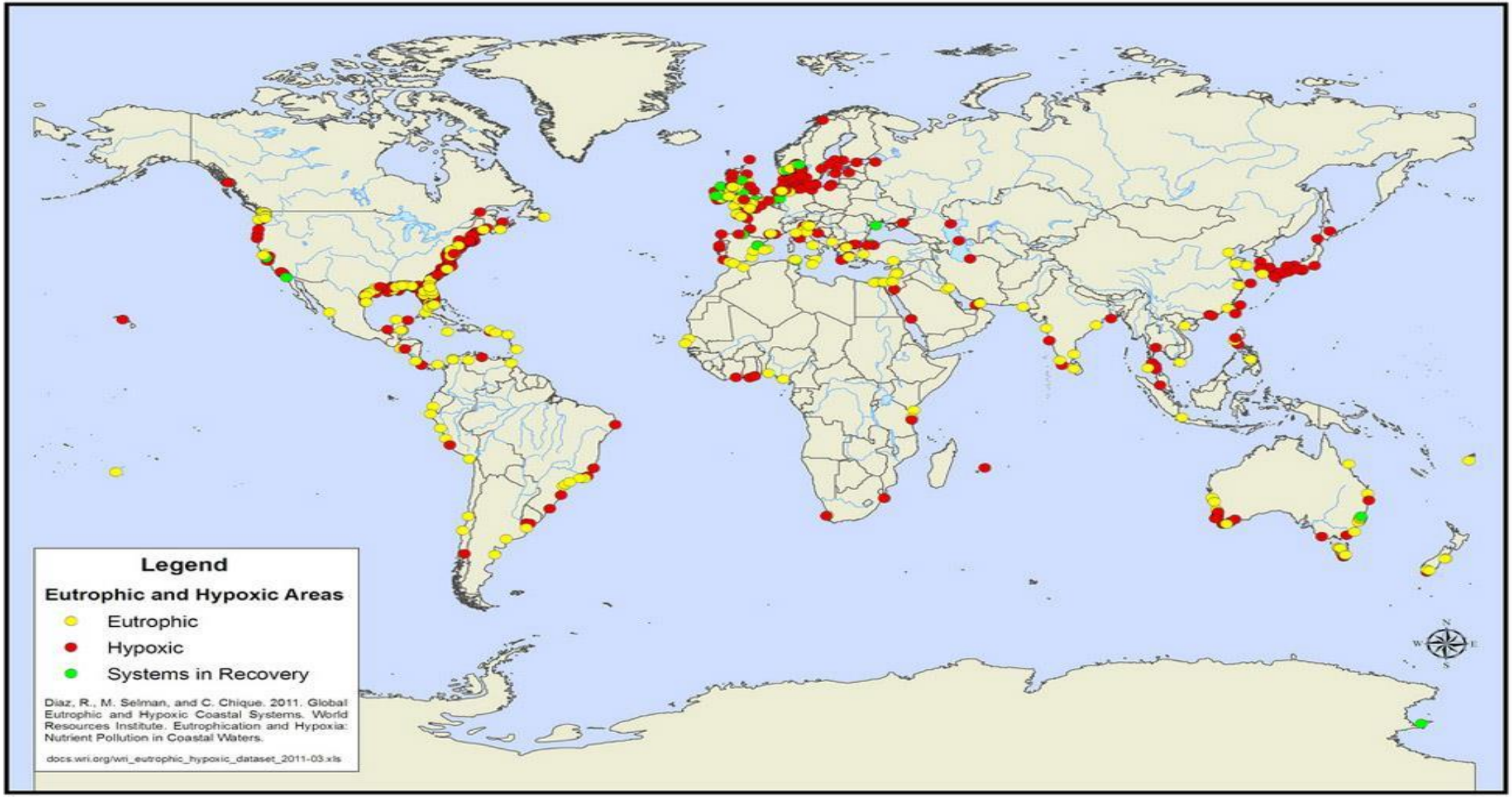
- Tourism
- Poison fishing
- Overexploitation
- Sedimentation
- Coral harvesting
- Dynamite fishing
- Pollution





Source: Bryant et al., *Reefs at Risk: a Map-Based Indicator of Threats to the World's Coral Reefs*, World Resources Institute (WRI), Washington DC, 1998.

World Hypoxic and Eutrophic Coastal Areas



Types of Pollutants - Major Categories

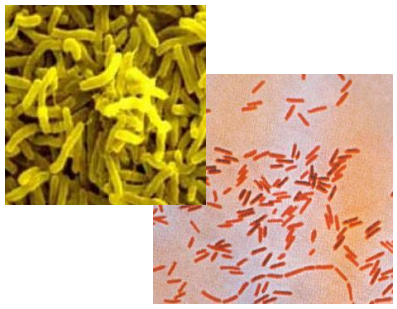
- ***Sewage*** *(a wide range of substances)*
- ***Nutrients*** *(nitrates and phosphates)*
- ***Heavy Metals*** *(Cd, Cu, Hg, Pb, Co, Mn, Zn,...)*
- ***Hydrocarbons/oil***
- ***Toxic organic compounds*** *(pesticides,insecticides, herbicides etc.)*
- ***Industrial waste products*** *(PCBs, PAHs, DDT etc.)*
- ***Trash*** *(Plastics/garbage)*
- ***Radio-nuclides*** *(power/reprocessing plants-Cs-137, Sb-125, etc.)*
- ***Hot water*** *discharge from power plants*
- ***Pharmaceutical wastes***
- ***Emerging pollutions (Electronic wastes, plastics, mobiles etc.)***

- **Non-point-source pollution** (Diffuse sources and atmospheric fluxes)

Water Quality and Public Health

Swimming related illness

- Acute Respiratory disease
- Gastrointestinal illness
- Diarrhea
- Vomiting
- Nausea
- Fever
- Sore throat
- Runny nose
- Ear or Eye infection
- Skin rash



Bacteria

- *Escherichia coli*
- *Salmonella typhi*
- *Vibrio Cholerae*
- *Campylobacter*

Viruses

- Adenovirus
- Enterovirus
- Hepatitis A
- Rotavirus

Hence, it is important to understand water quality, and protect ourselves from exposure to contaminated waters.

Research activities of NCCR

Shoreline Management

Marine Spatial Planning

Marine Pollution

Marine Litter & Microplastics

Ecosystem based Services

Coastal Hazards & Vulnerability

Capacity Building

Monitoring systems

- In-situ observation and laboratory analysis
- Remote sensing and GIS
- Smart Sensors
- IOT and Cloud Based Monitoring System
- Drone based remote monitoring

- Numerical Modelling / reanalysis
- ANN/ ML approach

Coastal Water Quality– Monitoring, Modelling and Risk Assessment

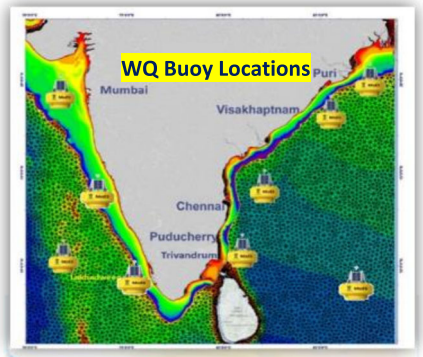
Coastal Water Quality (CWQ) is being monitored at 50 locations along the Indian coast (since 1990)

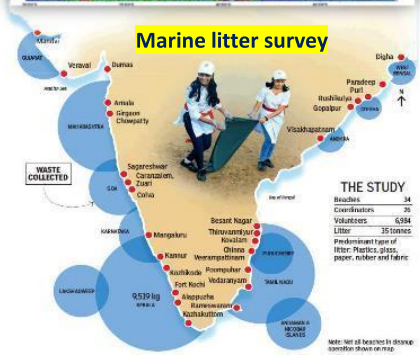
The CWQ data shared with NITI Aayog and MoSPI to support the National Indicator Framework for SDG-14.

Real-time monitoring of coastal waters by sensor-based buoy system and developed a 5-day coastal water quality forecast..

Sea water quality criteria in the form of Standards developed for 7 metals and 1 pesticide.

Quantification of marine litter and microplastic –its origin, fate and transport from source to sink.





Marine Pollution research is an important component under SDG-14, Coastal Mission and Blue economy. The activities are either pan India or expanding to address various issues and recommending solutions for sustainable management.

Coastal Water Quality Index (CWQI)

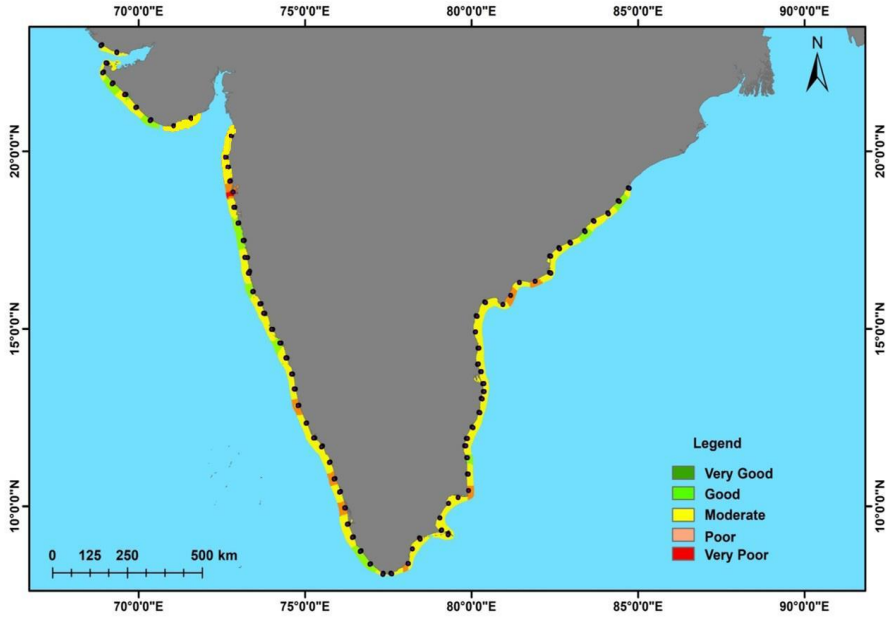
Parameters Considered

Oxygen Saturation (%)
Biological Oxygen Demand (mg/l)
Total Nitrogen (µM)
Total Phosphorus (µM)
pH
Suspended Particulate matter (mg/l)
Chlorophyll (µg/l)
Faecal coliform (CFU/100ml)

CWQI
A Single dimensionless number

0-20 → Very Poor
21-40 → Poor
41-60 → Moderate
61-80 → Good
81-100 → Very Good

To detect periodical changes in water quality along the Indian coast

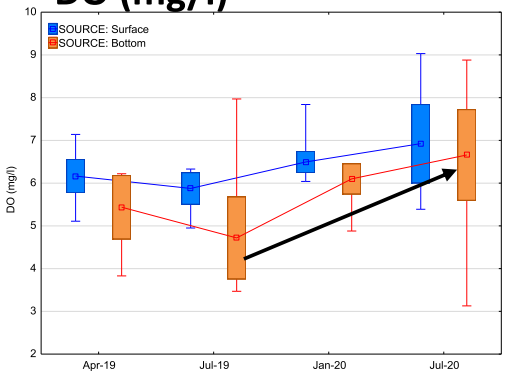


Addresses Target 14.1 of SDG-14 (*By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution*)

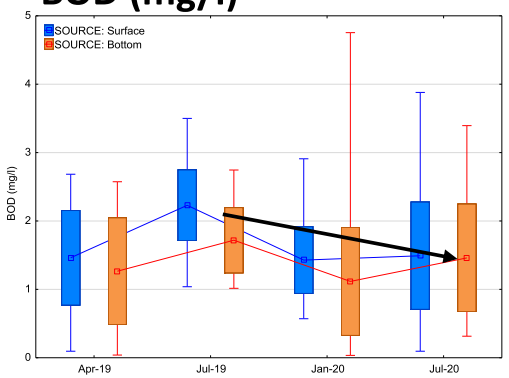
Coastal Water Quality- COVID Lockdown impact

April- 2019 | July -2019 |January-2019 | July 2020

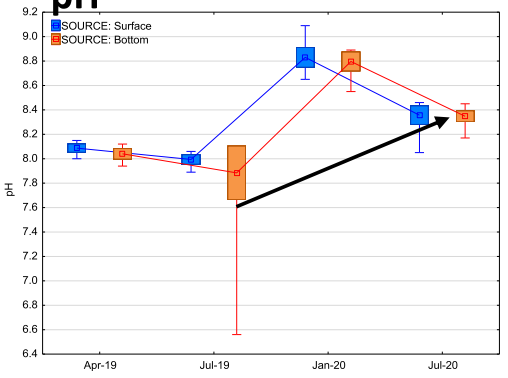
DO (mg/l)



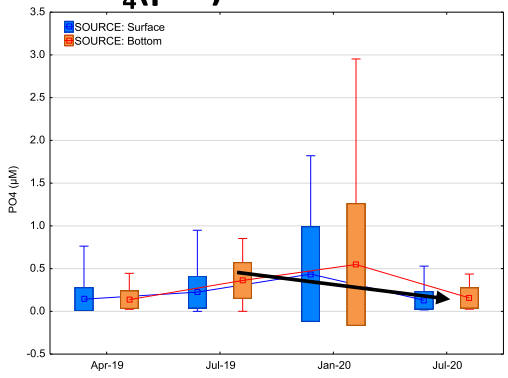
BOD (mg/l)



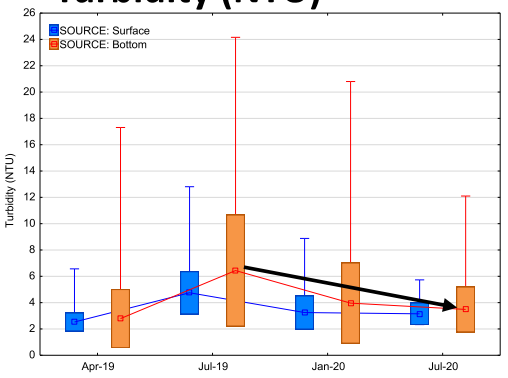
pH



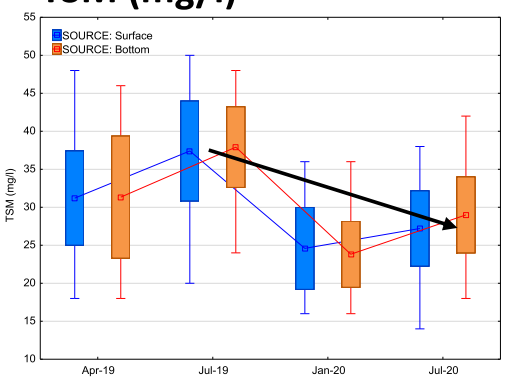
PO_4(µM)



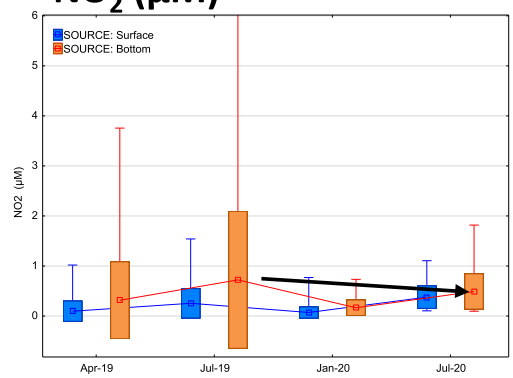
Turbidity (NTU)



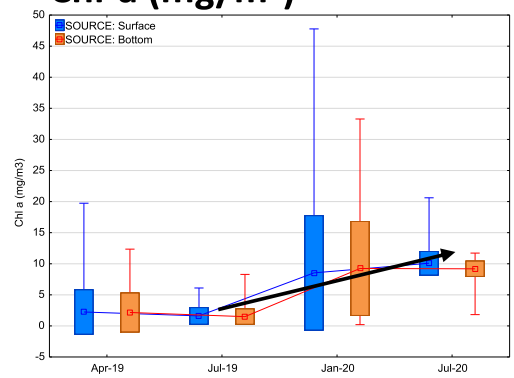
TSM (mg/l)



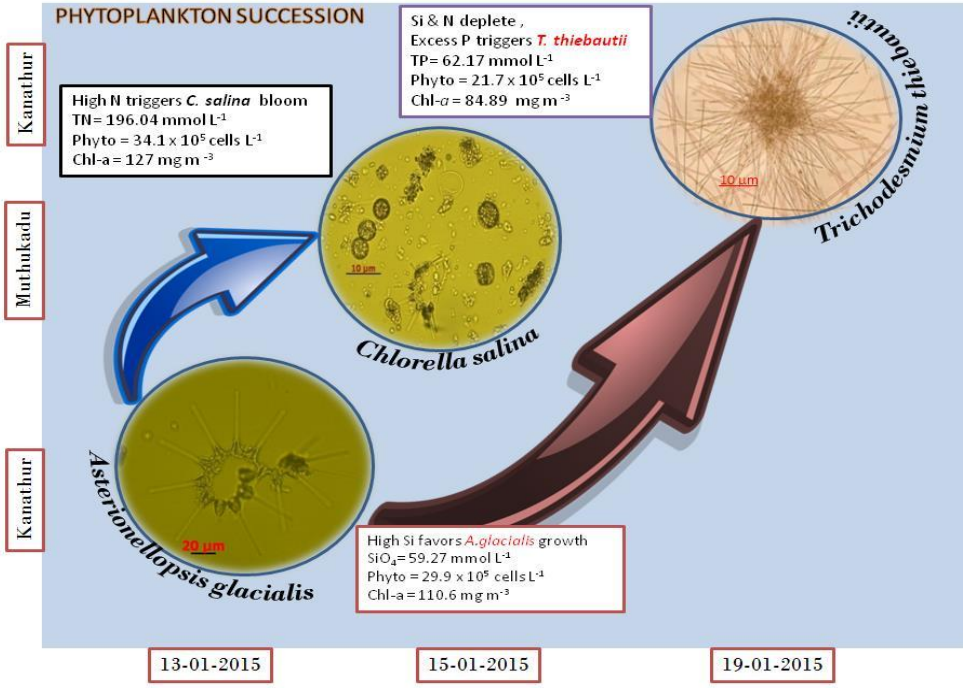
NO_2 (µM)



Chl-a (mg/m^3)



Occurrence and Succession of Phytoplankton Blooms
- *Regular Phenomena along the Coast*

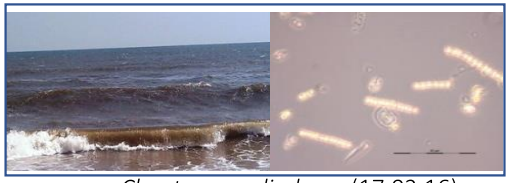


Asterionellopsis glacialis (13.01.15)

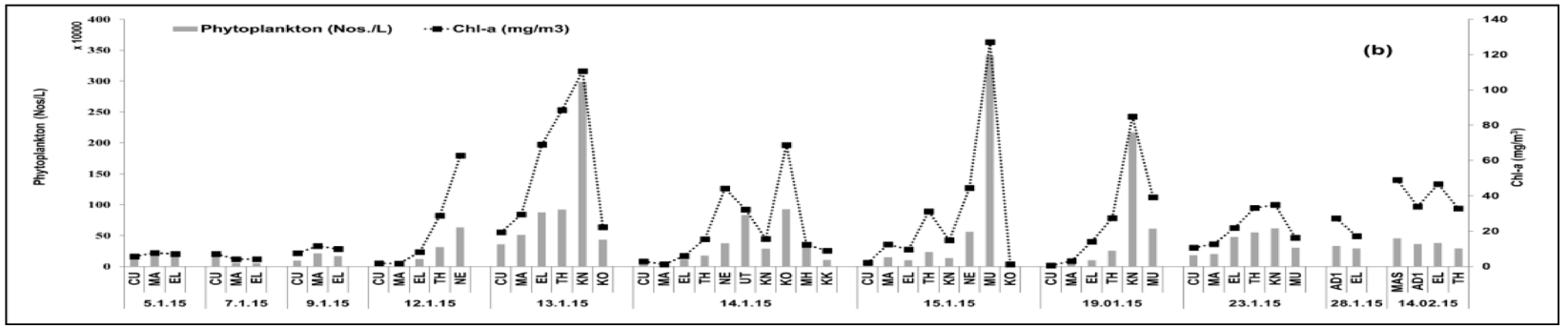
Chlorella salina (15.01.15)

Trichodesmium thiebautii (19.01.15)

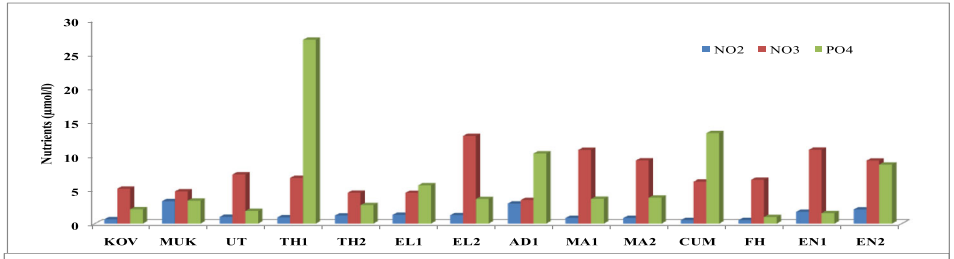
Phaeocystis sp., (16.04.15)

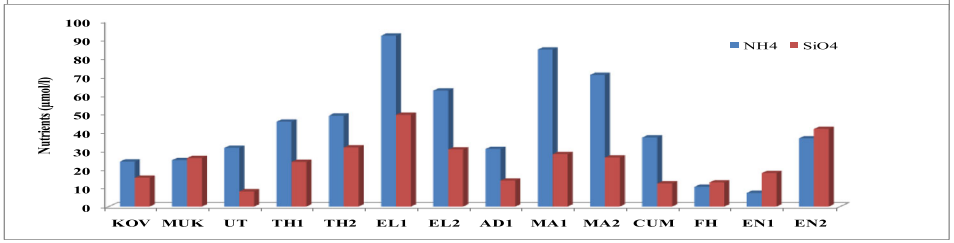


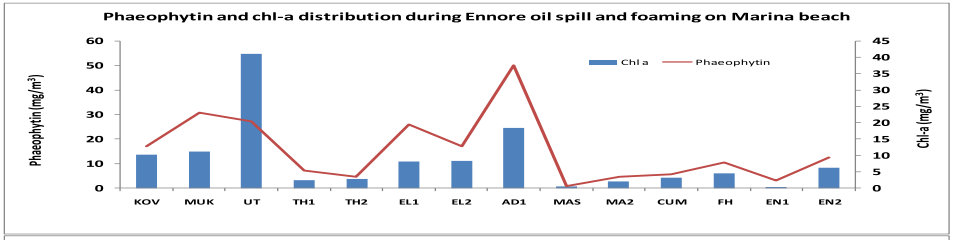
Chaetoceros diadema (17.02.16)

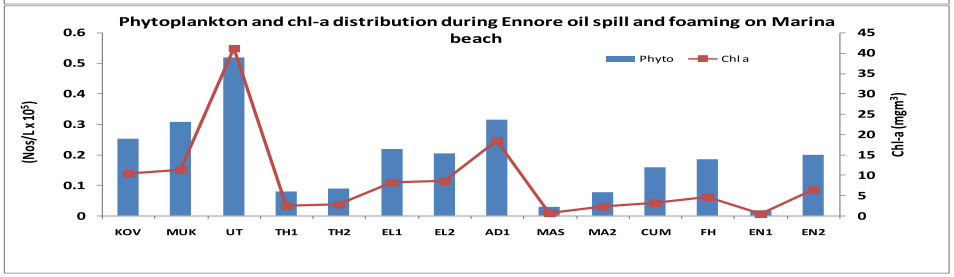


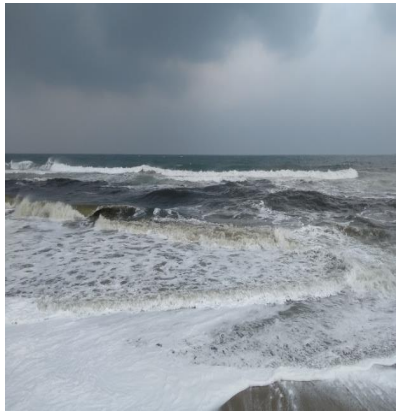
Sea Foaming in Marina Beach, Chennai

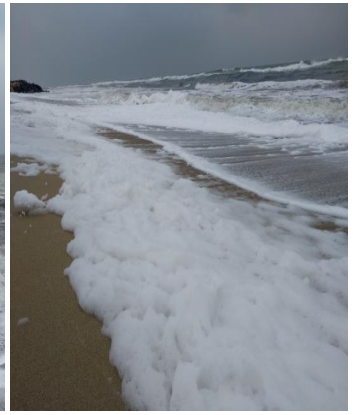


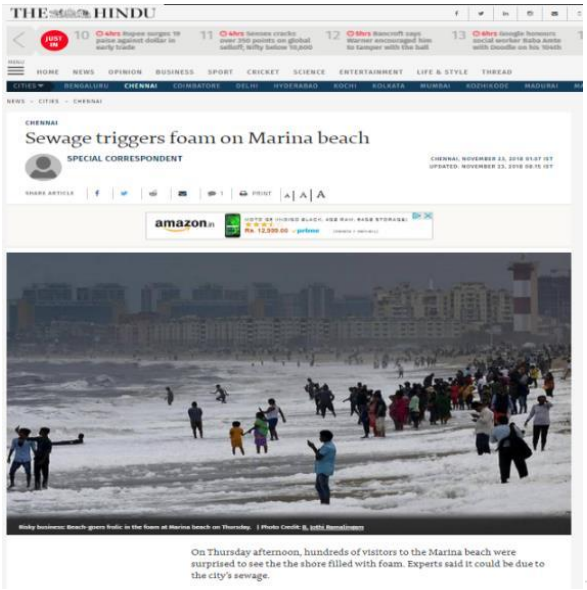






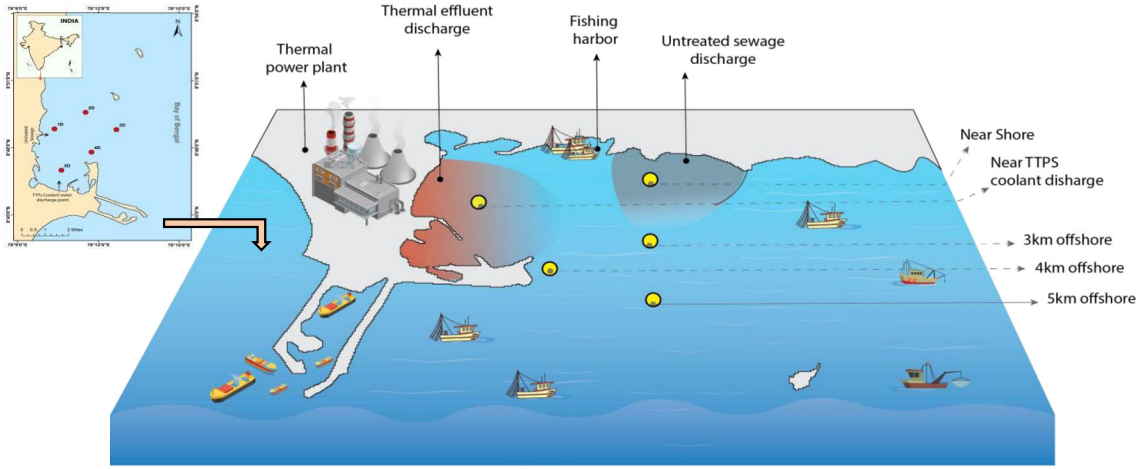


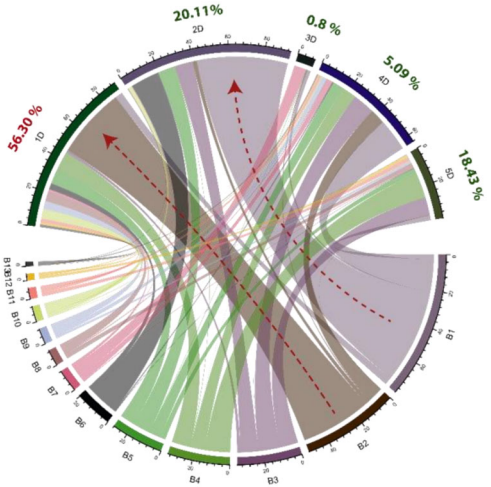


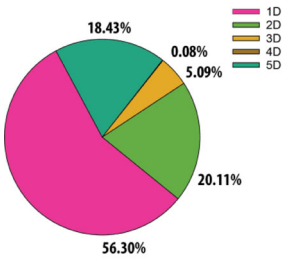


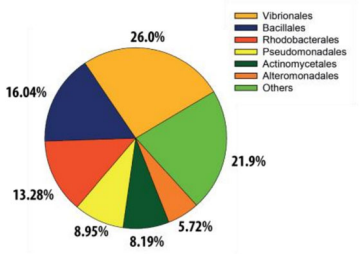
High PO_4 and NH_4 recorded which is coming from sewage through Cooum and Adyar river mouth

Environmental DNA (eDNA) Analysis – Molecular Tool for Assessing Bacterial Diversity









- The study showed the presence of > 10 bacterial orders and > 550 species from nearshore to offshore waters.
- 56% of bacterial contribution is seen at site (untreated sewage discharge point) and 0.8% at (offshore 5km waters).
- The bacterial abundance decreased from shore to 5km. Dominance of pathogenic bacterial strains observed at sampling location (1) where untreated sewage enters the coastal waters

Marine Ecotoxicology and Ecological risk Assessment

Developing standards for the nation to deal with pollution by priority contaminants

- To develop Seawater Quality Criteria (SWQC) for coastal waters, waste disposal zones, fishing ports, harbours and ecologically sensitive habitats for protection of marine life.
- Ecological risk assessment of metals (Cd, Cu, Hg, Zn, Pb, As, Cr) and priority pollutants for protection of coastal and marine organisms.
- Monitoring of selected marine outfall locations along the Indian coast.

Purpose: To support the regulatory actions that ensure the protection of coastal and marine organisms from the priority pollutants for the sustainable management of ecosystem services besides fisheries and the livelihood of dependent population.


Diatom


Copepod


Shrimp


Mussel


Fish


Mesocosm


Big Bag Open Sea mesocosm experiment

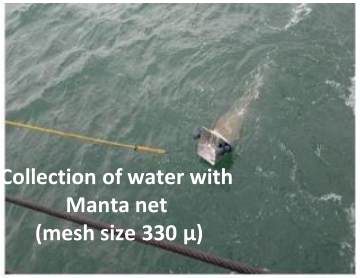
Global Scenario: Use of safe limits

Country	Agency	Principal method	Pollutants
India	MoEF&CC	Designated best uses (SW-I,SW-II,SW-III, SW-IV, SW-V), Primary water quality criteria based on expert opinion	Metals- Hg, Pb, Cd
United States of America	Unites States Environmental Protection Agency (USEPA)	National and Site specific numerical water quality criteria; Toxicity data, local water conditions, maximum daily load of pollutants, designated uses of water body.	PP-120 NPP-47
Australian and New Zealand	Australian and New Zealand Environment & Conservation Council (ANZECC)	Ecotoxicity data including partial or full life cycle studies, risk-based methodology, statistical approach with adverse effects, Significant adverse effects.	OP- 8 Metals- 13 Pesticide-4
UK & Europe	European Commission-Environment (EEC)	Maximum Acceptable Concentration (MAC) based on EC50 values and Species Sensitivity Distribution (SSD) based on NOEC data.	62

Toxicity data is the functional unit of water quality criteria (WQC) developed by USEPA, ANZECC and EEC

Microplastics in Marine water and sediments

Sampling & Analysis



Sample Collection

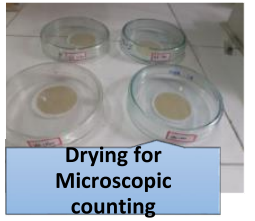
- Using Van Veen Grab (Sediment)
- Manta net & Micro plastic pump (Water)

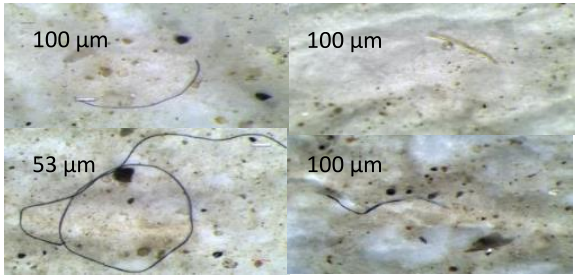
Sample Processing

- Density Flotation
- Wet peroxide oxidation
- Vacuum Filtration

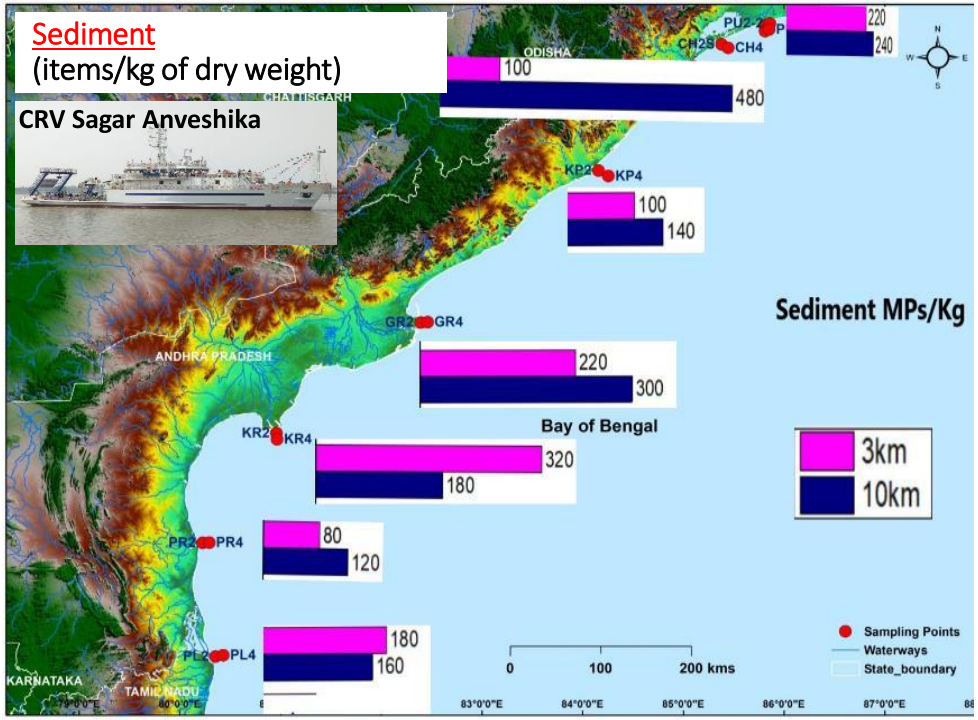
Quantitative & Qualitative Analysis

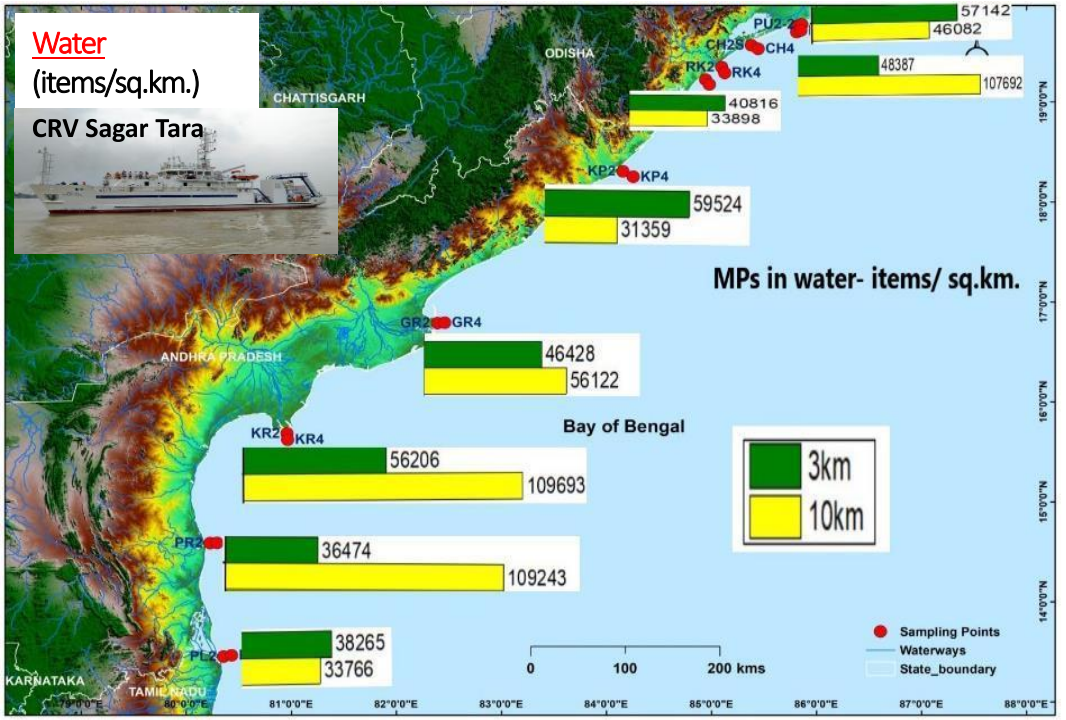
- Optical Microscope (Abundance)
- Raman Microscopy(Polymer type)





Microplastics in coastal waters and sediments





Sediment MPs (items/ kg of dry weight):
Average-196 items/ kg of d.w
Highest- Chilika 10km -480 items/ kg of d.w
Lowest-Penna River 1km -80 items/ kg of d.w

Water MPs (items/ sq.km.)
Average- 4960 items/ sq.km.
Highest- Krishna River 10km (109693 items/ sq.km.)
Lowest- Kalingapatnam 10km (3139 items/ sq.km.)

Drone Technology for Marine Applications

NIOT developing a customized Hexa-copter type of Drone (small category) for Marine Applications with Industry partner.

1. Self weight of the Drone is ~23 kg.
2. Scientific payload of 10 kg weight can be mounted.
3. Can withstand wind conditions up to 45 - 50 kmph.
4. Good stability was observed even with swing type payload.
5. Endurance – up to 30 minutes.

Demonstration of Drone with Marine Instruments and Sensors

Functional Demonstration of Drone mounted with CTD sensor & other instrumentation payload for Ocean Data Collections

Carried out Beach Topography & High tide line mapping using Drone

Demonstration of Sea Water Sample Collection using Drone @ Chennai Kovalam Coast

Courtesy: Adapting Drone Technology for Marine Applications by Srinivasan. R., et. al.: Journal of the institution of Marine Engineers India.

Modelling and Prediction of Coastal Water Quality

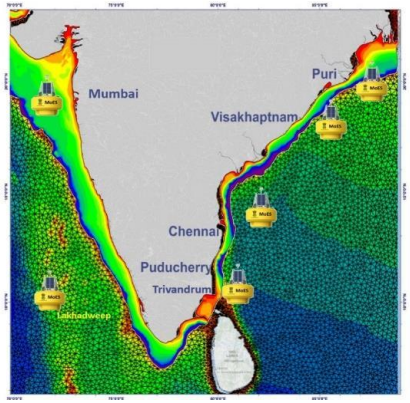
Prediction and dissemination of coastal water quality at tourist beaches through the development of a high-resolution coastal water quality model using water quality buoys and *in-situ* data

Observation

- In-situ observation : Coastal cruises
- Sensor based time series observations : WQ buoys
- Expansion of buoy network for wider coverage

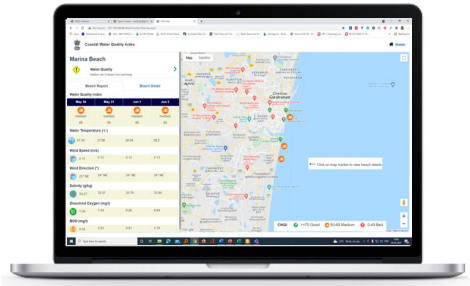
Modelling

- 5 day forecast of coastal Water Quality
- High resolution hydro-ecological model
- 15 variables state variables, 83 Rate constants



Information

- Web portal
- Mobile App
- Print media
- Bulletins



Users

- Public information system,
- Beach tourism, Fishery, Ports, coastal communities,
- Government agencies and policy makers.

Coastal Water Quality Buoys- sensors

Sensors:

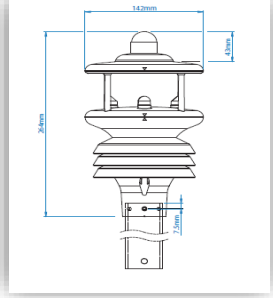
Meteorological Sensors

1. Air temperature; -40 to 70°C (±0.3°C)
2. Relative humidity; 0 to100% ((±2%)
3. Barometric pressure; 300 to 1100 hPa (±0.5 hPa)
4. Wind speed; 0.1 to 60m/s (3 to 5%)
5. Wind Direction; 0 to 359° (3 to 5°)
6. Solar Radiation; 300 to 3000nm

Water Quality Sensors

1. Temperature; -5 to 50°C (±0.2°C)
2. Conductivity ; 0 to100 mS/cm (±1%)
3. DO; 0 to 500% air sat (±1%)
4. pH; 0-14 (±0.1)
5. Chlorophyll; 0 to 400 µg/L (0.01 µg/L)
6. Turbidity; 0 to 4000 NTU (0.01 NTU)
7. Blue Green Algae; 0 to 280 µg/L (0.01 µg/L)

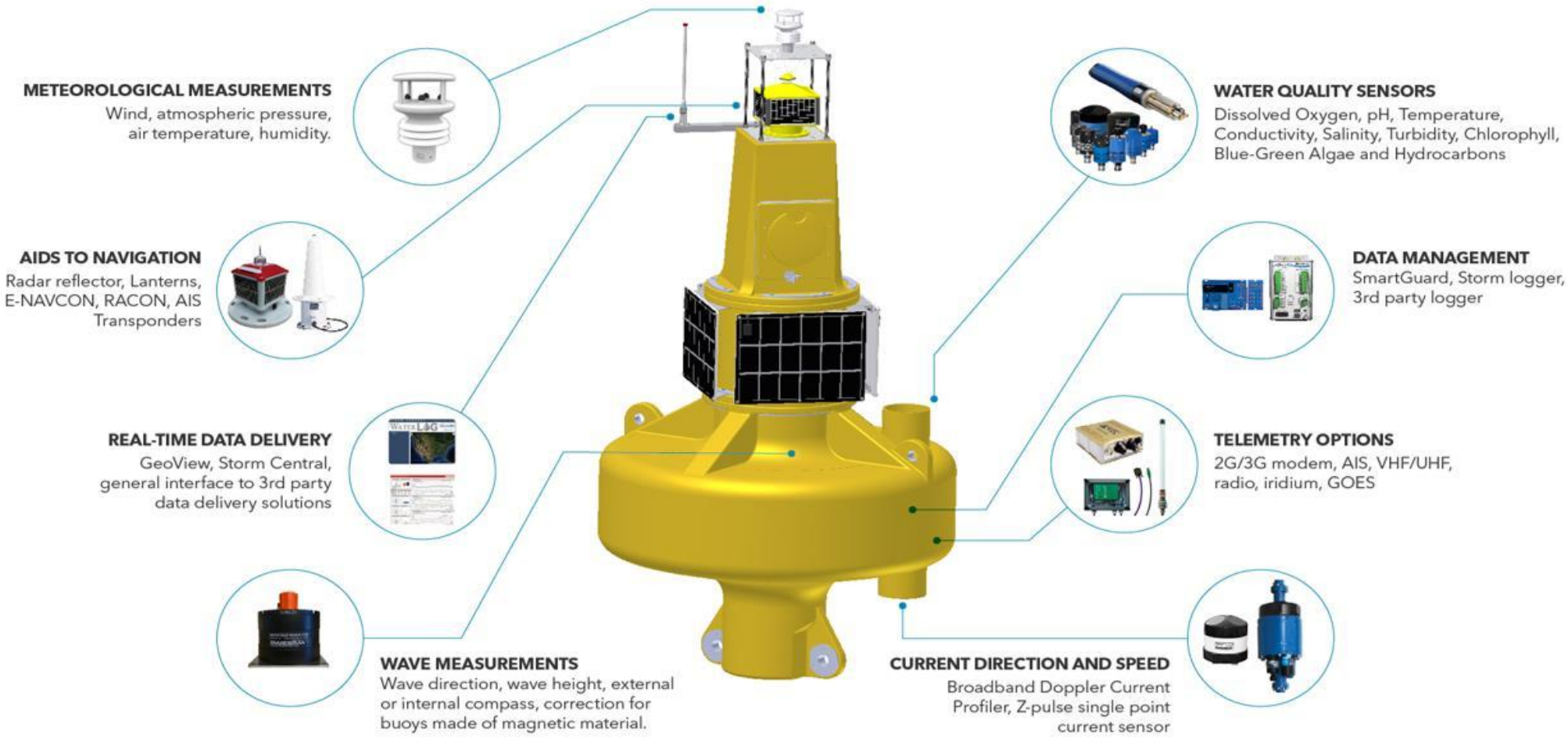
Maximet GMX501



YSI Exo-2 WQ Sonde

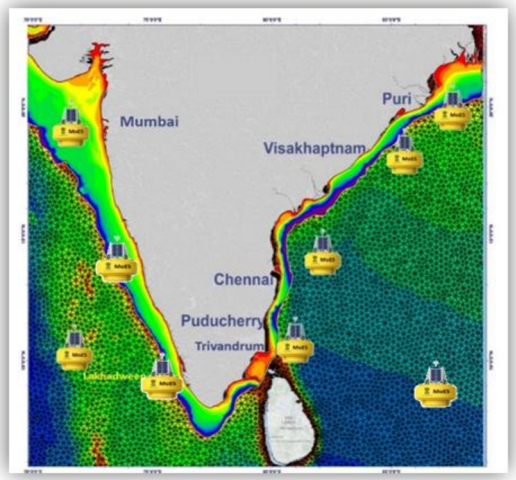
RTMS Data Display Software

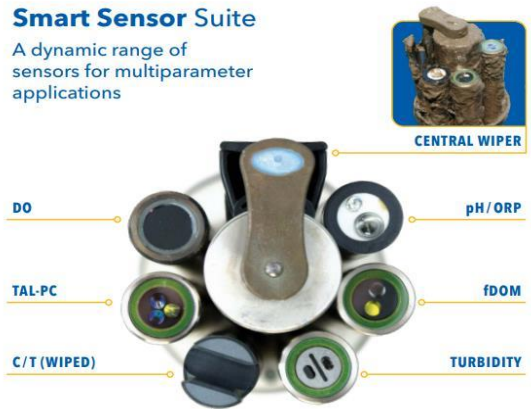
Water quality buoy



Coastal Water Quality Buoy – Realtime Monitoring

WQ Buoy Network





Dashboard – Data display

Meteorological Sensors

1. Air temperature; -40 to 70°C (±0.3°C)
2. Relative humidity; 0 to100% ((±2%)
3. Barometric pressure; 300 to 1100 hPa (±0.5 hPa)
4. Wind speed; 0.1 to 60m/s (3 to 5%)
5. Wind Direction; 0 to 359° (3 to 5°)
6. Solar Radiation; 300 to 3000nm

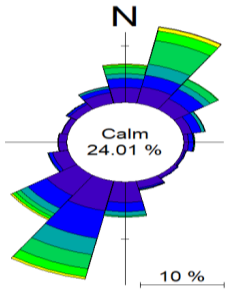
Water Quality Sensors

1. Temperature; -5 to 50°C (±0.2°C)
2. Conductivity ; 0 to100 mS/cm (±1%)
3. DO; 0 to 500% air sat (±1%)
4. pH; 0-14 (±0.1)
5. Chlorophyll; 0 to 400 µg/L (0.01 µg/L)
6. Turbidity; 0 to 4000 NTU (0.01 NTU)
7. Blue Green Algae; 0 to 280 µg/L (0.01 µg/L)

Operational – WQ Buoys

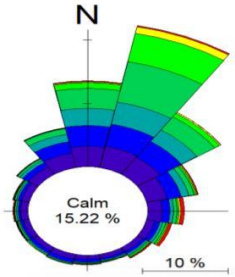
Observation :: Water Quality Buoys

Oceanography



Surface Current (Dec – Mar)

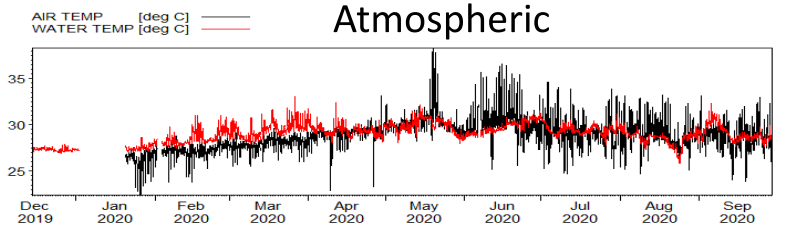
Surface Current (m/s)
- Above 0.500
- 0.400 - 0.500
- 0.300 - 0.400
- 0.200 - 0.300
- 0.150 - 0.200
- 0.100 - 0.150
- 0.050 - 0.100
- Below 0.050

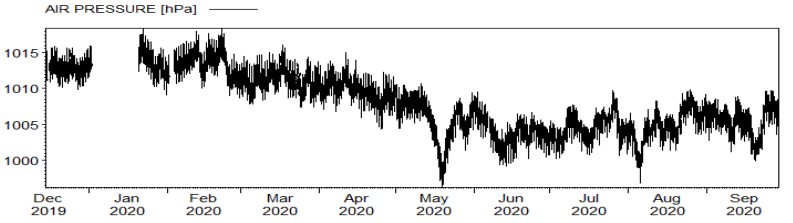


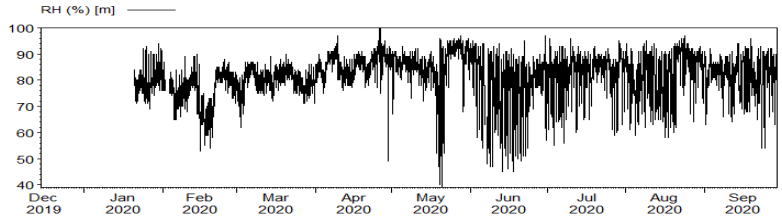
Surface Current (Mar– Sept)

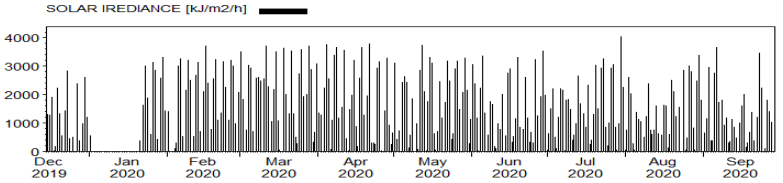
Surface Current (m/s)
- Above 0.500
- 0.400 - 0.500
- 0.300 - 0.400
- 0.200 - 0.300
- 0.150 - 0.200
- 0.100 - 0.150
- 0.050 - 0.100
- Below 0.050

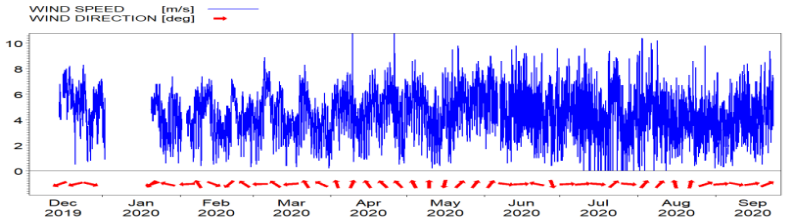
Atmospheric



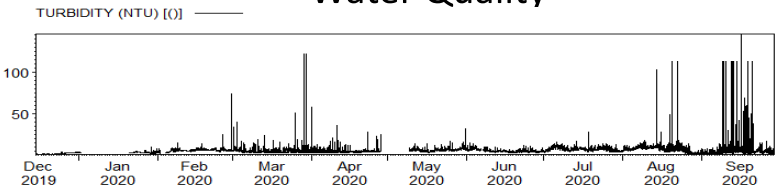


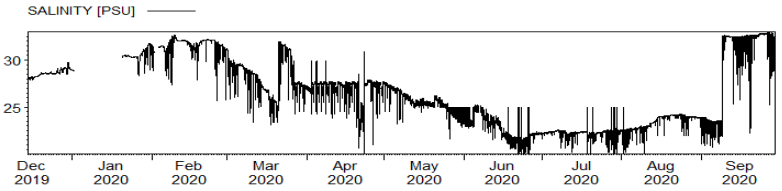


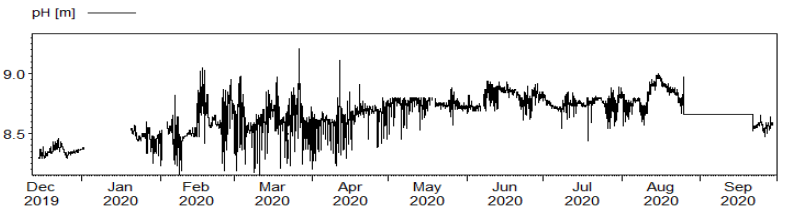


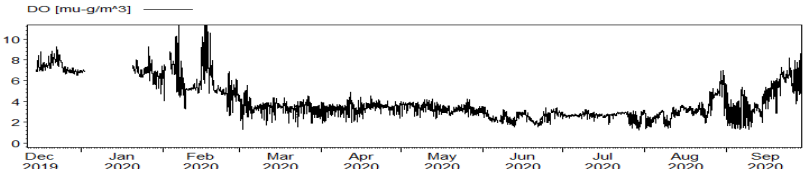


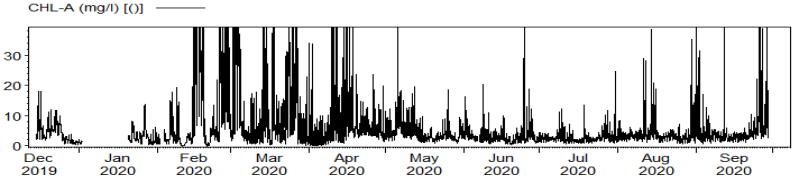
Water Quality

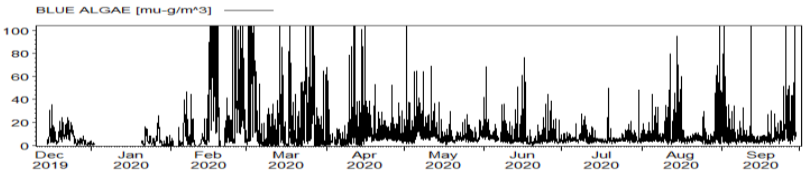






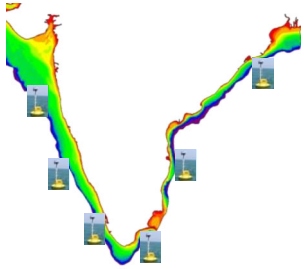






Prediction of Coastal Water Quality (PWQ)

1) Field observation and Data integration



Real-time data

Mathematical Modelling

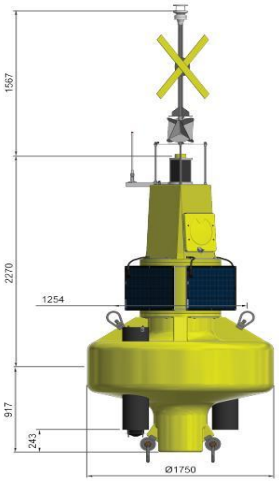
Prediction

Water Quality Forecast

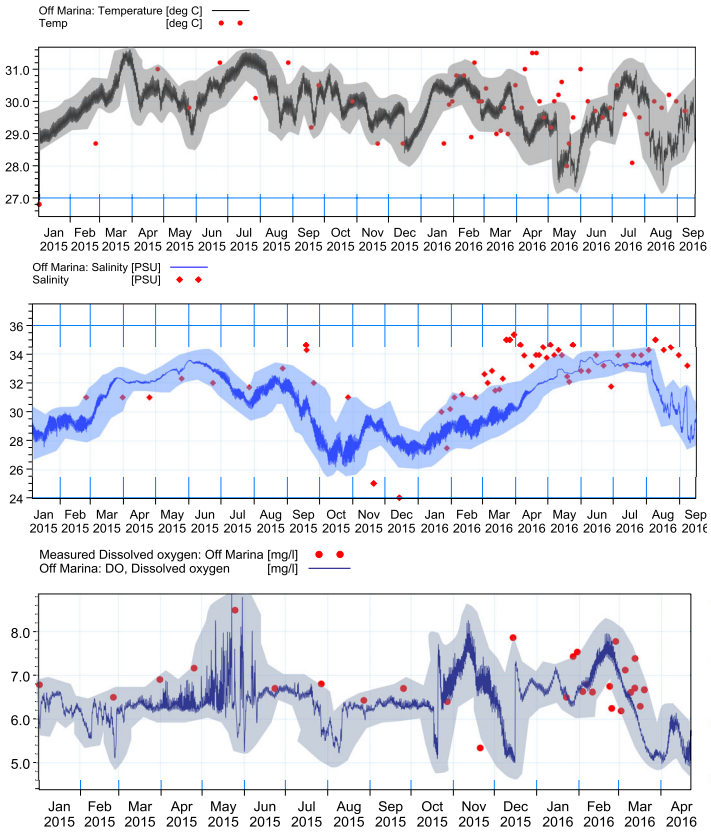
WQI

Safe
unsafe

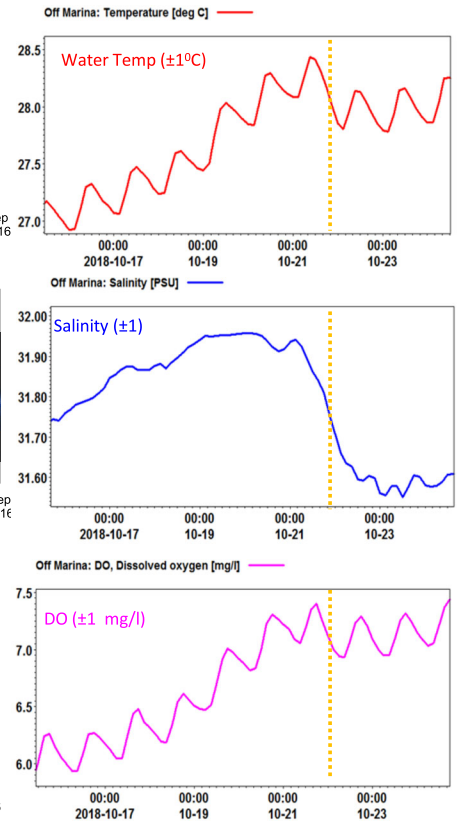
2) Coastal water quality buoy

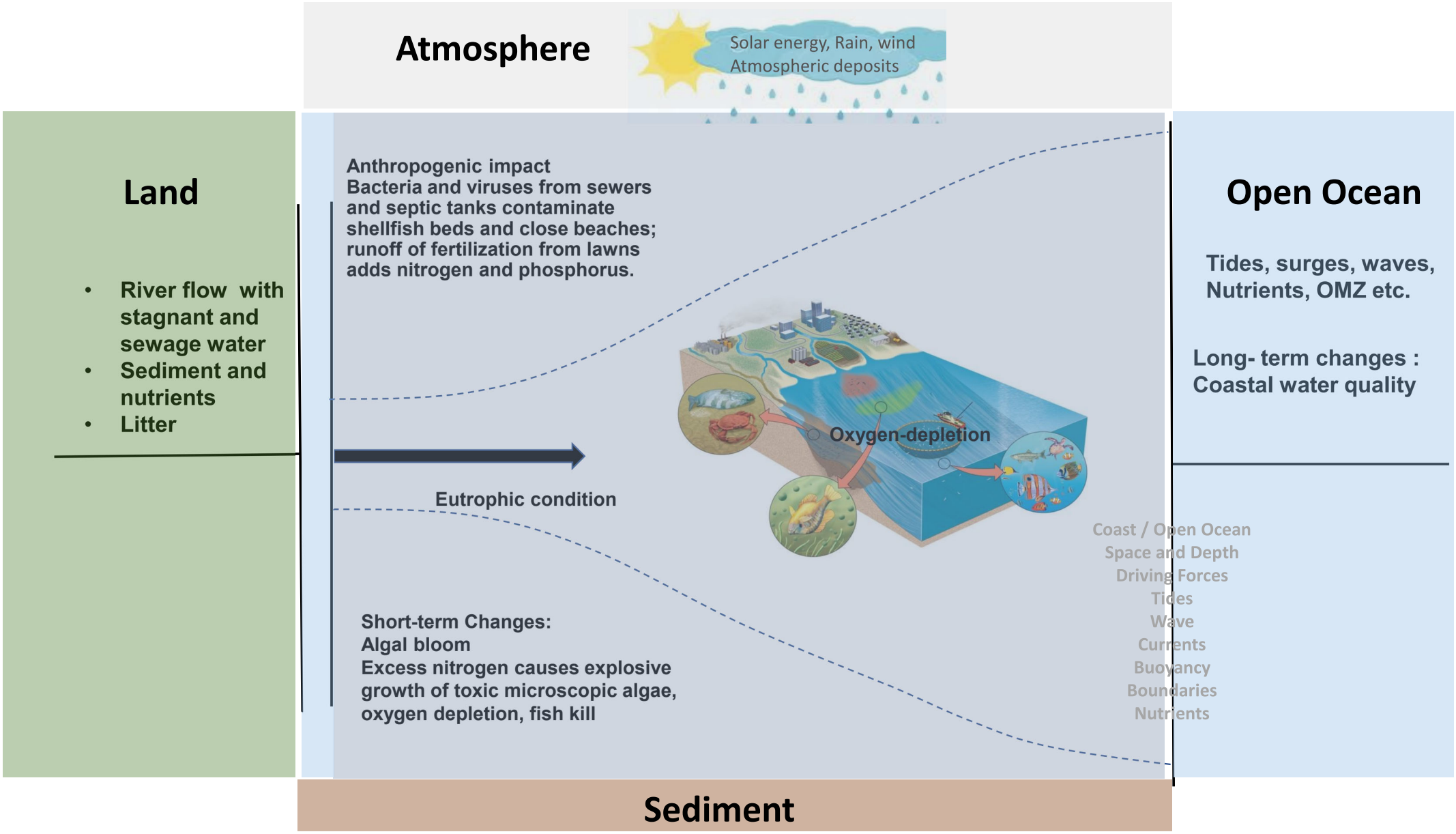


3) Hind cast

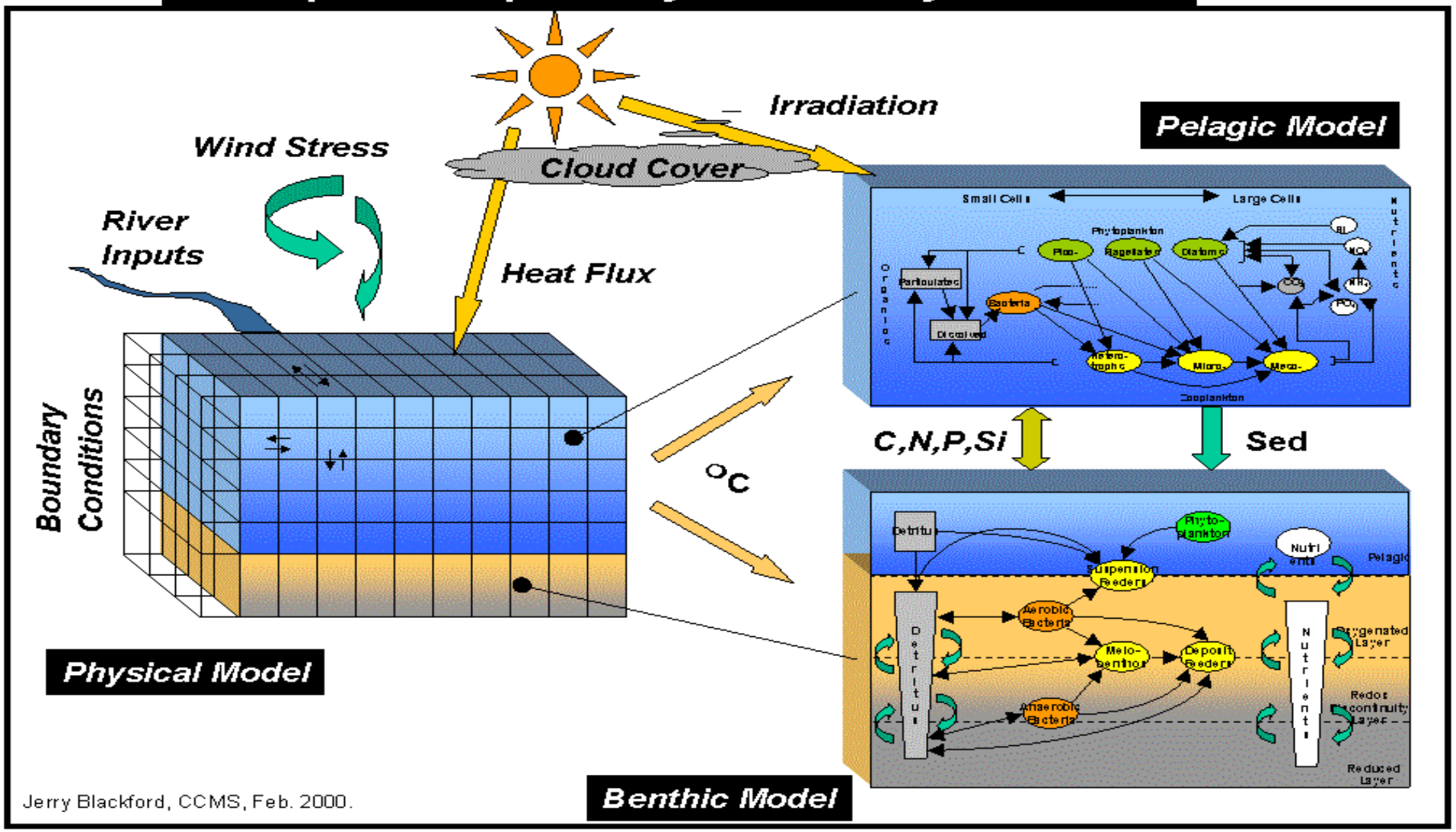


4) 5-day forecast




Atmosphere
Solar energy, Rain, wind
Atmospheric deposits
Land
River flow with stagnant and sewage water
Sediment and nutrients
Litter
Anthropogenic impact
Bacteria and viruses from sewers and septic tanks contaminate shellfish beds and close beaches; runoff of fertilization from lawns adds nitrogen and phosphorus.
Oxygen-depletion
Eutrophic condition
Short-term Changes:
Algal bloom
Excess nitrogen causes explosive growth of toxic microscopic algae, oxygen depletion, fish kill
Open Ocean
Tides, surges, waves, Nutrients, OMZ etc.
Long- term changes :
Coastal water quality
Coast / Open Ocean
Space and Depth
Driving Forces
Tides
Wave
Currents
Buoyancy
Boundaries
Nutrients
Sediment

Conceptual Coupled Physical - Ecosystem Model



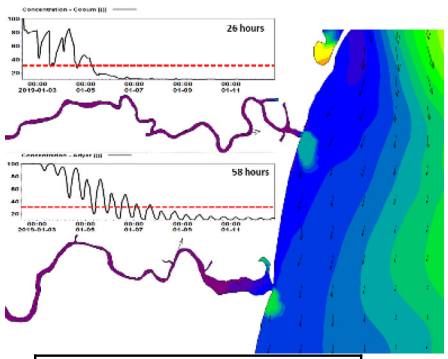
Jerry Blackford, CCMS, Feb. 2000.

Model configuration

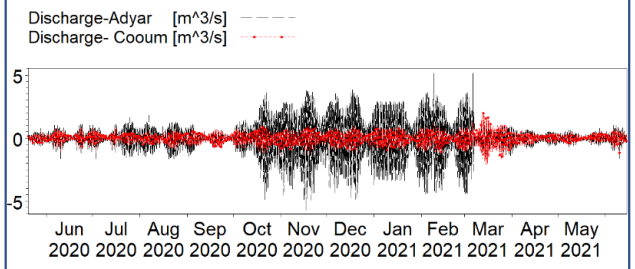
Forcing: NCMRWF (0.25^0), IMD-AWS

Land /River run offs

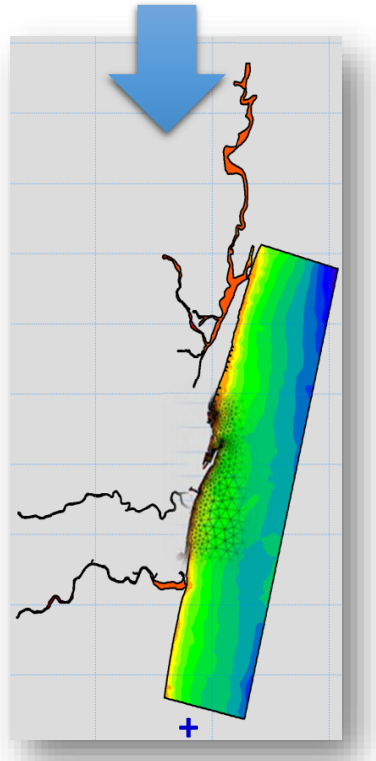
Measured inputs / Inlet openings



Residence Time (hrs)			
Cooum		Adyar	
Dry	Wet	Dry	Wet
52	26	112	58



Load L (g/s) = Dis. Q (m^3/s) * Conc. C (g/m^3)

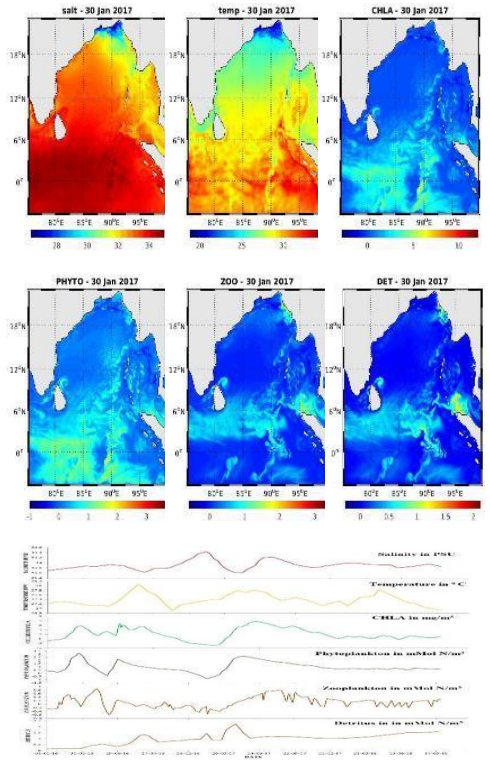


Water Quality Model

WQ variables	: 15
Forcing	: 15
Processes	: 57
Auxiliary variables	: 37
Rate constants	: 83

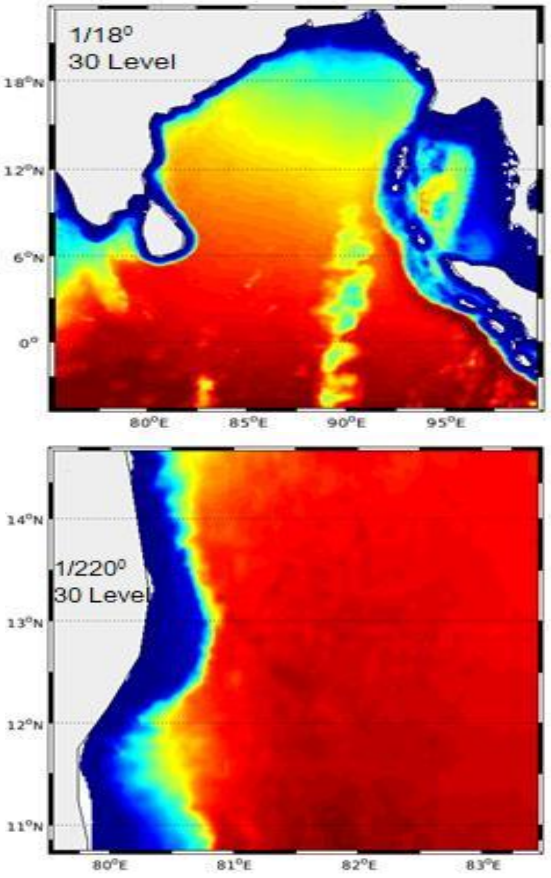
Open Boundary Conditions

Downscaled from Regional models (INCOIS/NCCR)/ CME



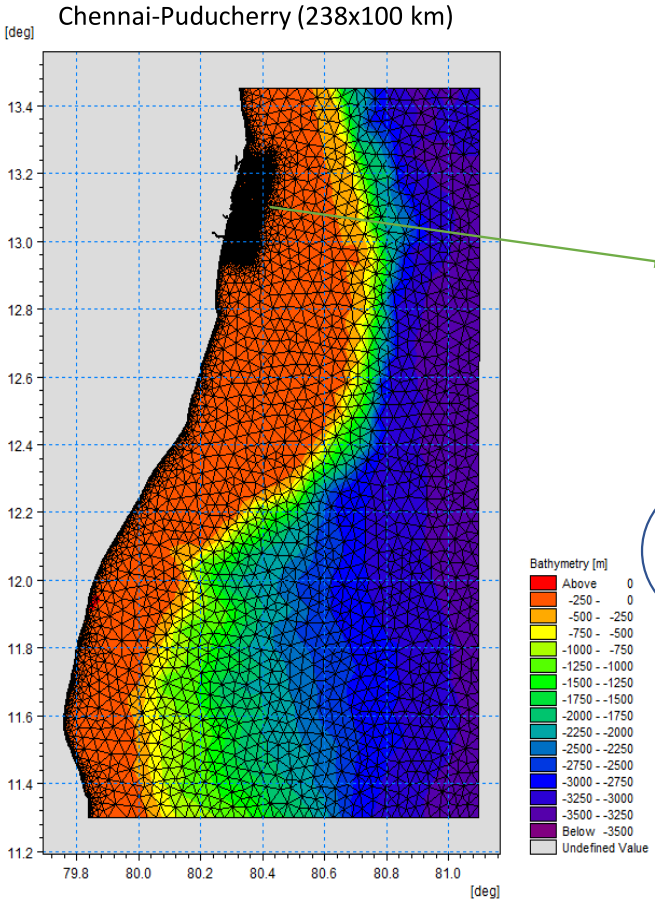
Model Domain

Regional Scale

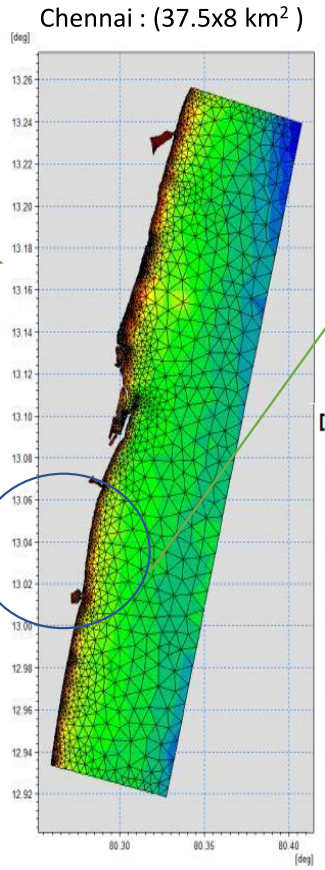


Local Scale

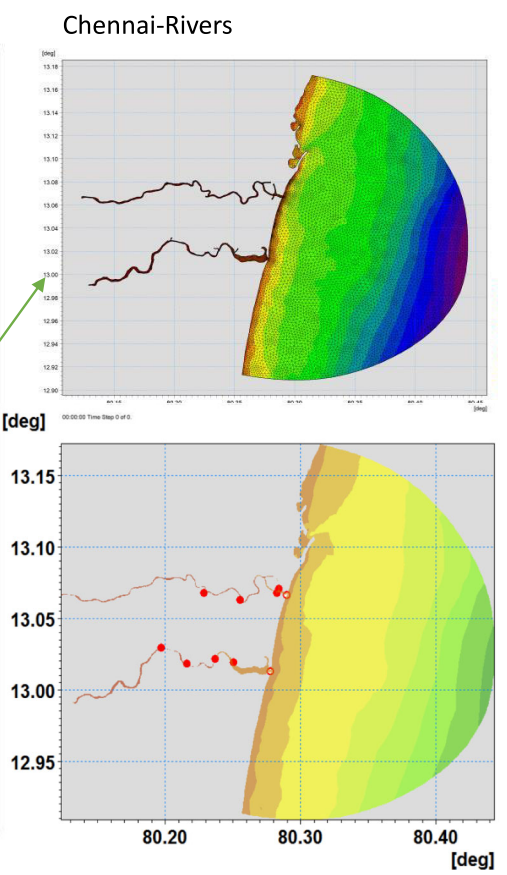
Chennai-Puducherry (238x100 km)



Chennai : (37.5x8 km^2)



Chennai-Rivers



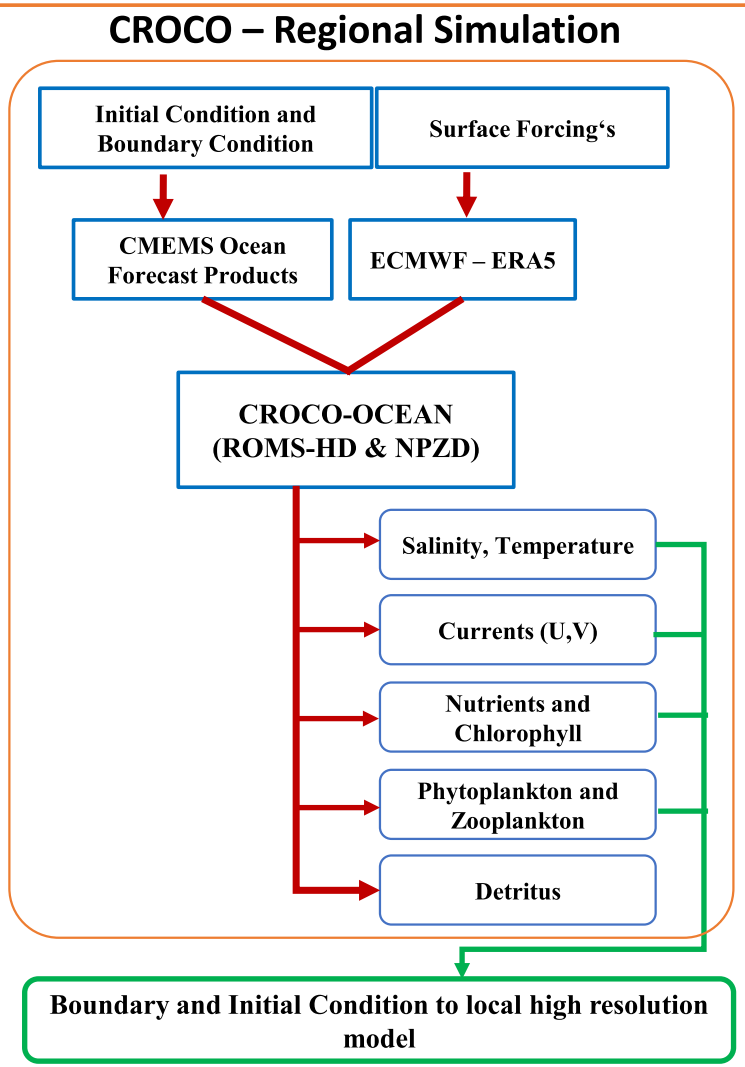
- Finite Element technique adopted based on an unstructured mesh and uses a cell-centred finite volume solution technique.
- Mesh intelligently adapts high-resolution requirements for uneven coastal morphology and topography like river mouths etc.

Coastal and Regional Ocean COmmunity model (CROCO-ROMS)

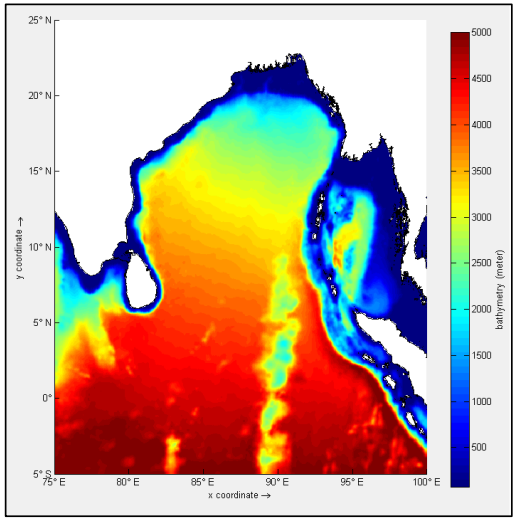
- **CROCO Model is an Oceanic modeling system built upon ROMS_AGRIF :**
  a) Includes i) non-hydrostatic kernel of SNH, ii) including algorithms from MARS3D (sediments) and iii) HYCOM (vertical coordinates).
  b) An important objective for CROCO is to resolve very fine scales (especially in the coastal area), and their interactions with larger scales.
  c) It is the oceanic component of a complex coupled system including various components, e.g., atmosphere, surface waves, marine sediments, biogeochemistry and ecosystems.

- Model setups
  a) Bay of Bengal (**1/18, 30 level**)
  b) SE Coastal region (**1/220**, **30 levels**)

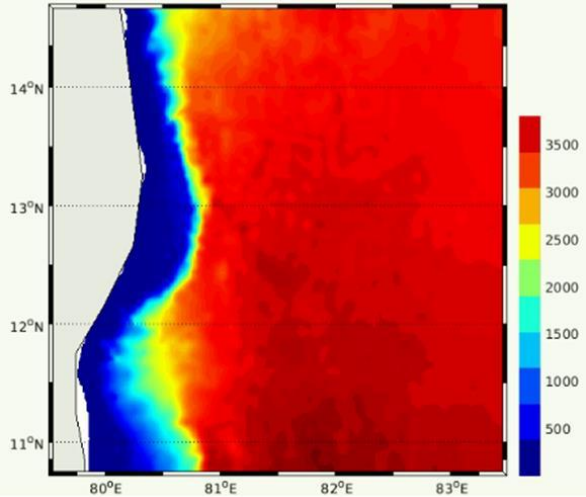
- Model is forced with ECMWF ERA5 winds and CMEMS forecast products for physical and biochemical boundary forcing



CROCO – Model Configuration



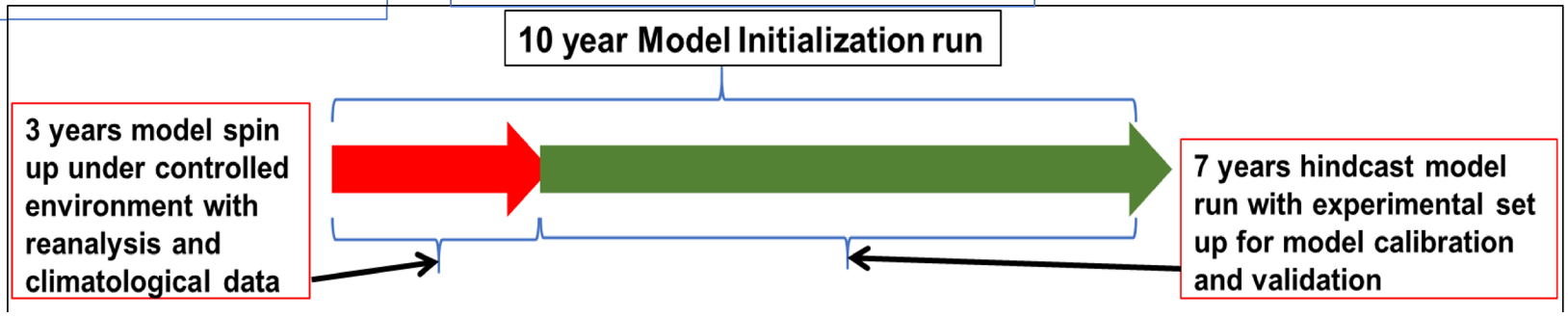
Model Configuration: BoB
5S to 23N & 75E to 100 E
Model Resolution:
1/18 horizontal & 30 Vertical



Model Configuration:
10.7S to 14.7N & 79.5E to 83.5 E
Model Resolution:
1/220 horizontal & 30 Vertical

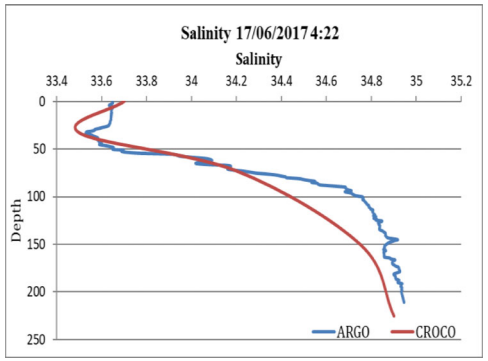
Atmospheric Forcing's:
ECMWF ERA 5 (0.25 degree)
Ocean Boundary Forcing's:
CMEMS Reanalysis products (0.25 degree)
Ocean Nutrients & Biology:
CMEMS Reanalysis products (0.25 degree)
WOA 2013 Climatology (0.5 degree)

Major Output Parameters:
Physical: Temperature, Salinity, Current Vectors,
Nutrients & Biology: O2, NO3, Chl-a, Phyto and Zooplankton, Detritus

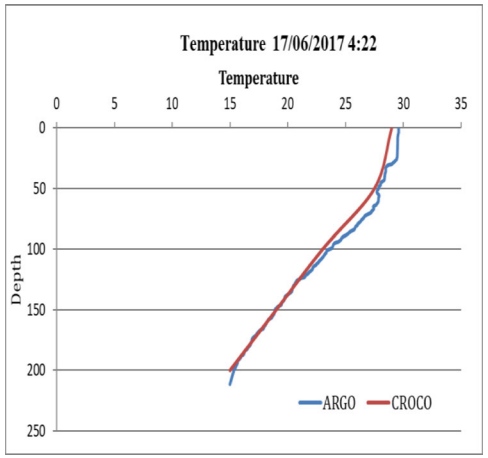


CROCO Model Validation – January and July 2020 Cruise

Validation: Salinity
Location : 16.53^0, 87.95^0
Date and Time: 17-06-2017 04:22
Argo ID: 2470



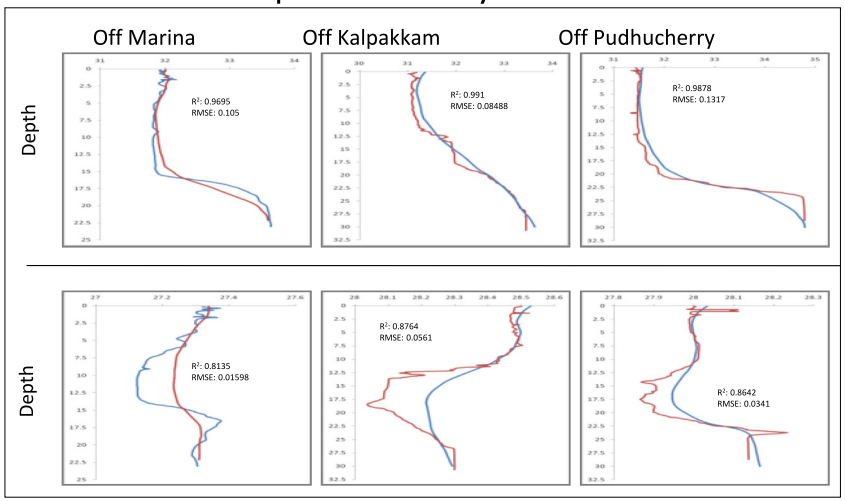
Validation: Temperature
Location : 16.53^0, 87.95^0
Date and Time: 17-06-2017 04:22
Argo ID: 2470

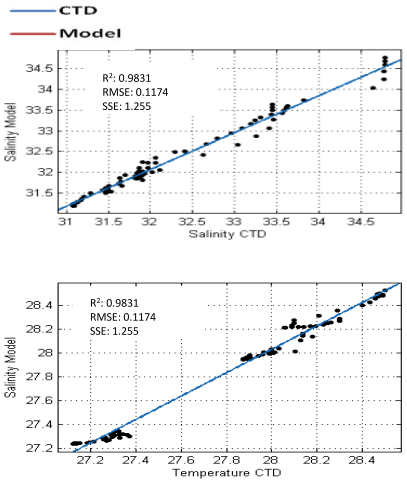


Salinity Profiles – Jan 2020

Temperature Profiles – Jan 2020

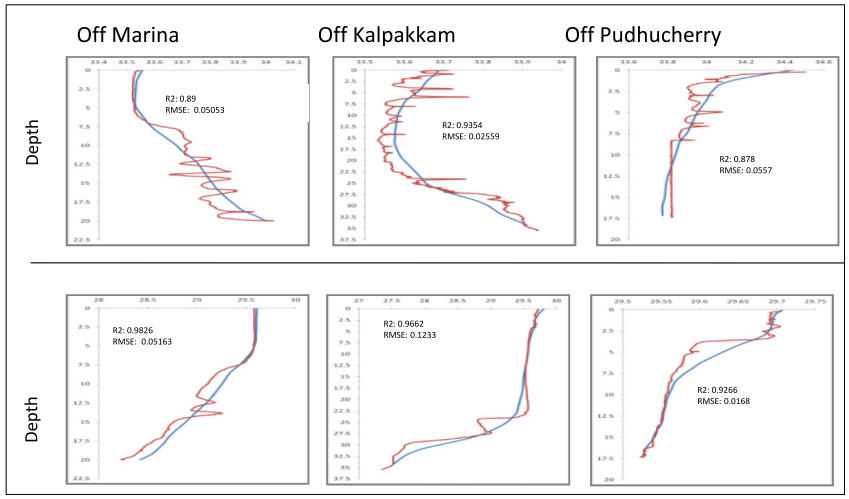
Temperature and Salinity Validation with CTD

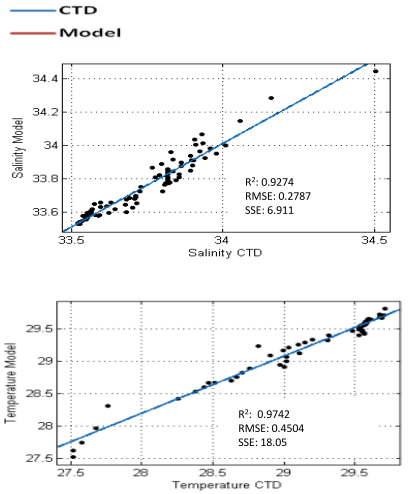




Salinity Profiles – July 2020

Temperature Profiles – July 2020





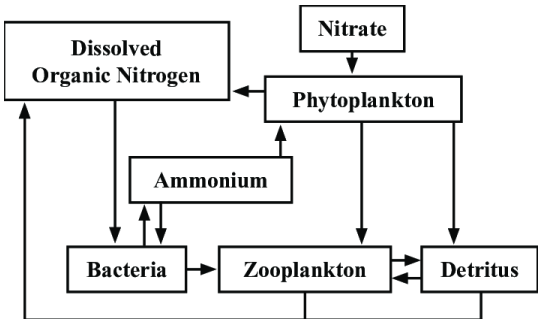
Validation of Biochemical variables

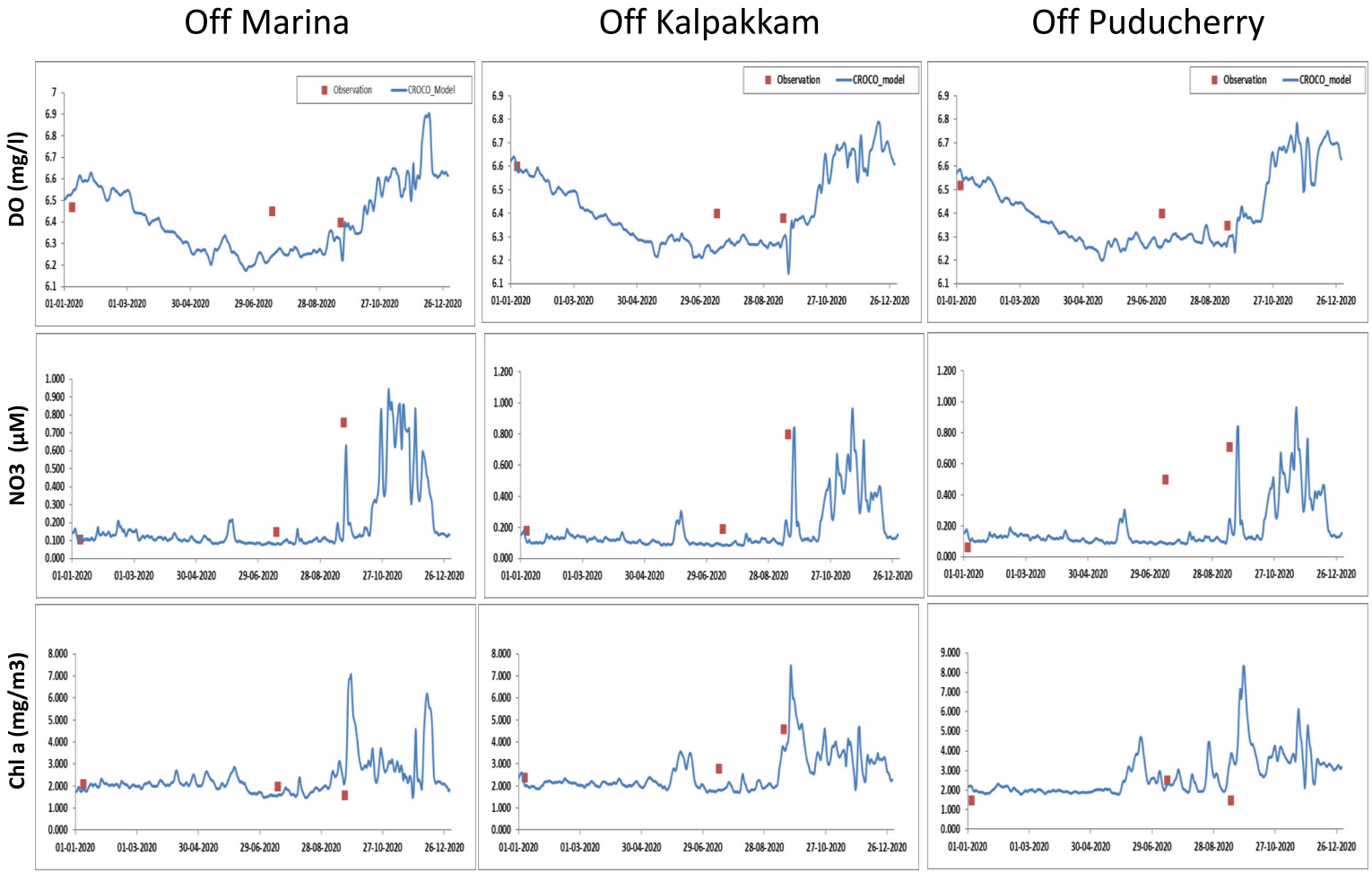
Biogeochemical model

NPZD model coupled with CROCO-ROMS for Biochemical variables

Boundary conditions are derived from the CMEMS biological forecast products / INCOIS Regional model.

Major output parameters : NO_3, Chla, Phytoplankton, Zooplankton, Detritus, DO and Oxygen Saturation





CROCO – Governing Equations

The momentum balance in zonal x and meridional y directions, written in terms of grid-scale (resolved) and subgrid-scale velocity components:

$$\frac{\partial u}{\partial t} + \vec{\nabla}.(\vec{\mathbf{v}}u) - fv = -\frac{\partial \phi}{\partial x} + \mathcal{F}_u + \mathcal{D}_u$$
$$\frac{\partial v}{\partial t} + \vec{\nabla}.(\vec{\mathbf{v}}v) + fu = -\frac{\partial \phi}{\partial y} + \mathcal{F}_v + \mathcal{D}_v$$

The time evolution of scalar concentration field, C(x,y,z,t) (e.g. salinity, temperature, or nutrients is governed by the advective-diffusive equation

$$\frac{\partial C}{\partial t} + \vec{\nabla}.(\vec{\mathbf{v}}C) = \mathcal{F}_C + \mathcal{D}_C$$

The equation of state

$$\rho = \rho(T, S, P)$$

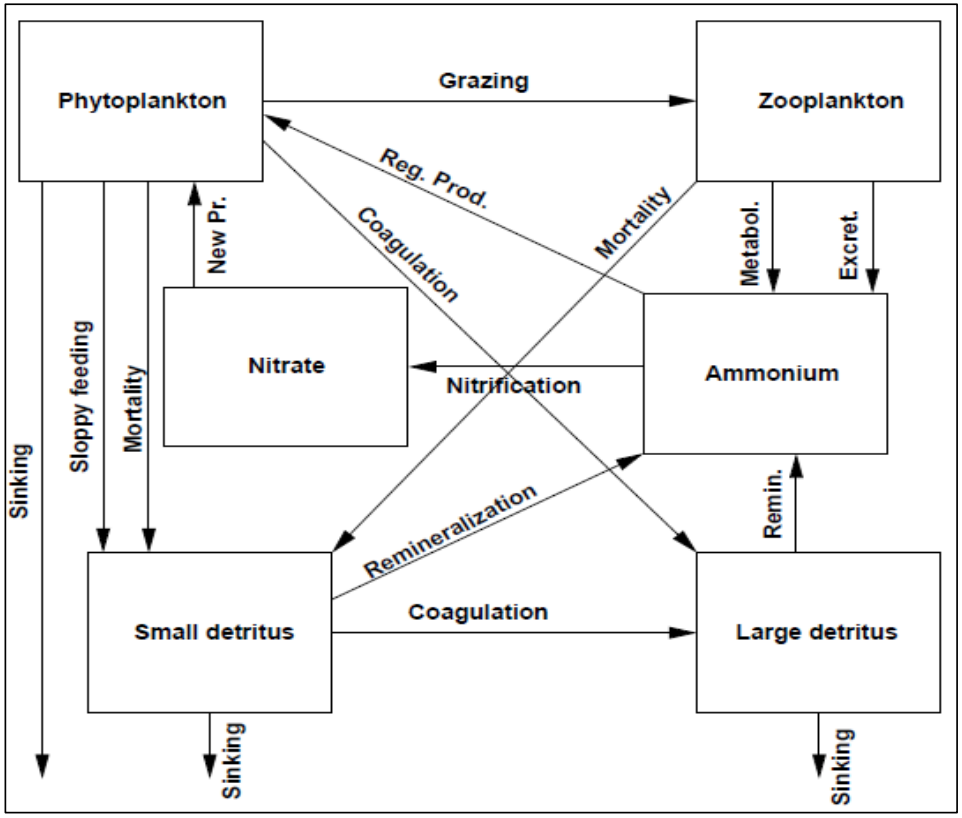
Hydrostatic approximation

$$\frac{\partial \phi}{\partial z} = -\frac{\rho g}{\rho_0}$$

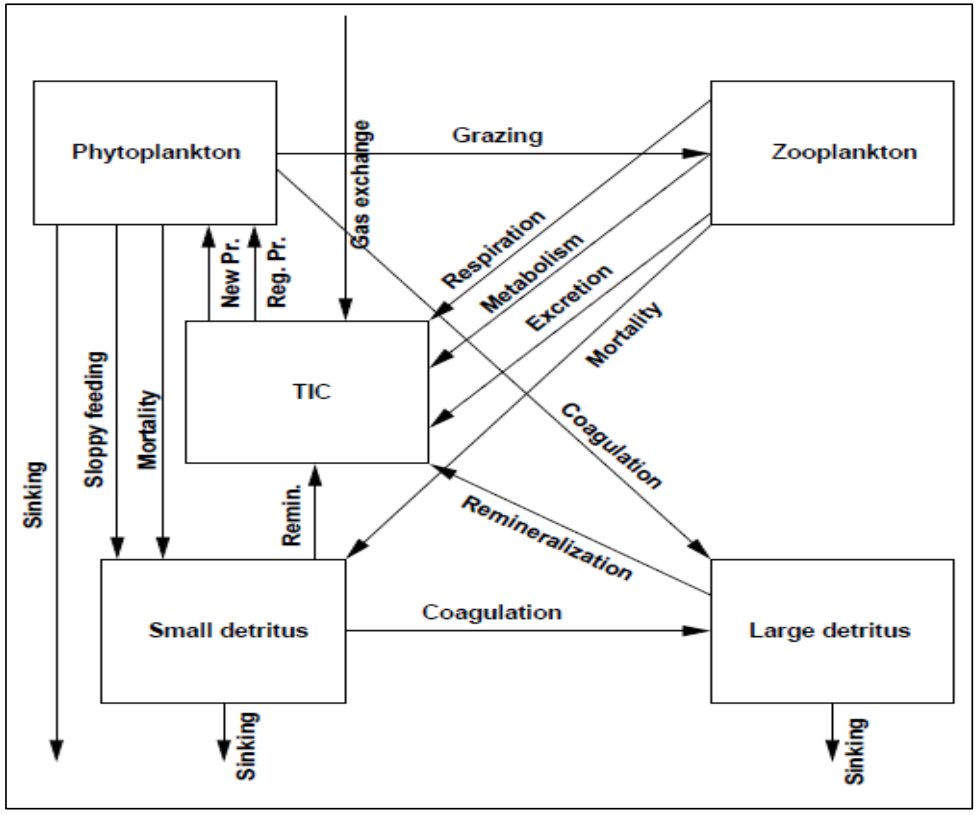
The final equation expresses the continuity equation for an incompressible fluid

$$\vec{\nabla}.\vec{\mathbf{v}} = \frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z} = 0$$

Coupled Biochemical Model – NPZD



Schematic representation of the fluxes of nitrogen in the model



Schematic representation of the fluxes of carbon in the model

CROCO – NPZD Equations

Mass balance governing equations solved in CROCO as part NPZD simulations

- ✓ Nitrate
- ✓ Ammonia
- ✓ Detritus
- ✓ Phytoplanton
- ✓ Zooplankton
- ✓ Oxygen

$$\frac{\partial [NO_3]}{\partial t} = - t_{PPmax} \cdot Q_{NP} \cdot [Phyto] + Q_{nitr} \cdot [NH_4]$$

$$\frac{\partial [NH_4]}{\partial t} = - t_{PPmax} \cdot Q_{RP} \cdot [Phyto] - Q_{nitr} \cdot [NH_4] + (t_{Zbmet} + Q_{excr}) \cdot [Zoo] + t_{SDremin} \cdot [SDetN] + t_{LDremin} \cdot [LDetN]$$

$$\frac{\partial [SDetN]}{\partial t} = Q_{graze} \cdot (1 - AE_N) \cdot [Zoo] + t_{Pmort} \cdot [Phyto] + t_{Zmort} \cdot [Zoo] - t_{coag} \cdot ([SDetN] + [Phyto]) \cdot [SDetN] - t_{SDremin} \cdot [SDetN] + L_{vs}$$

$$\frac{\partial [Phyto]}{\partial t} = t_{PPmax} \cdot (Q_{NP} + Q_{RP}) \cdot [Phyto] - t_{Pmort} \cdot [Phyto] - Q_{coag} \cdot [Phyto] - Q_{graze} \cdot [Zoo] + L_{vs}$$

$$\frac{\partial [Zoo]}{\partial t} = Q_{graze} \cdot AE_N \cdot [Zoo] - t_{Zbmet} \cdot [Zoo] - t_{Zmort} \cdot [Zoo] - Q_{excr} \cdot [Zoo]$$

$$\frac{\partial [O_2]}{\partial t} = t_{PPmax} \cdot (Q_{NP} \cdot r_{O_2:NO_3} + Q_{RP} \cdot r_{O_2:NH_4}) \cdot [Phyto] - 2 \cdot Q_{nitr} \cdot [NH_4] - (t_{Zbmet} \cdot r_{O_2:NH_4} + Q_{resp}) \cdot [Zoo] - (t_{SDremin} \cdot [SDetN] + t_{LDremin} \cdot [LDetN]) \cdot r_{O_2:NH_4} + Q_{ge} * (O_{2,sat} - O_2)$$

Data Assimilation

- Data assimilation (DA) improves the model predictions with the use of measurements. – dynamically integrates (Observation- Buoy, Spatial- Satellite)

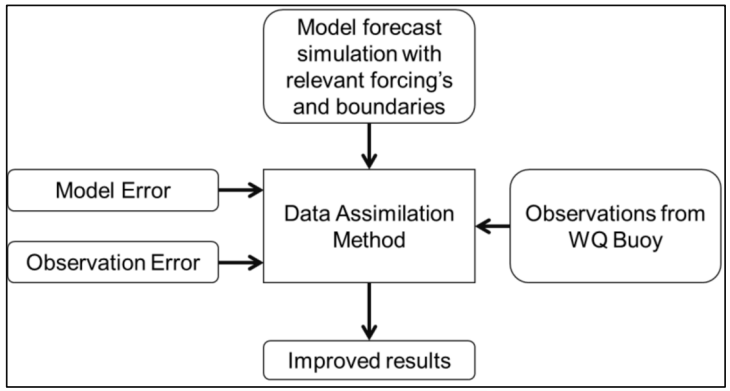
- The typical sources of uncertainties are attributed to:

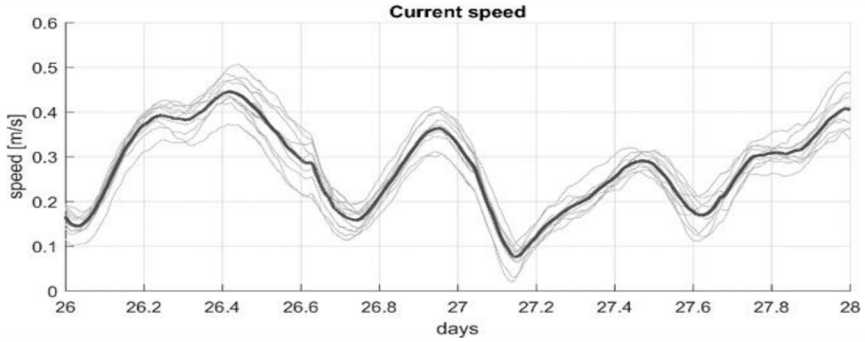
  a) **Initial condition** errors (initial state)
  b) **Forcing** errors
  c) **Model formulation** errors
  d) **Parameter** errors (e.g. bottom friction)

- DA methods

  a) The Kalman filter (KF)
  b) Optimal interpolation (OI)
  c) The Ensemble Kalman filter

- Model errors can be reduced using DA in forecast simulations





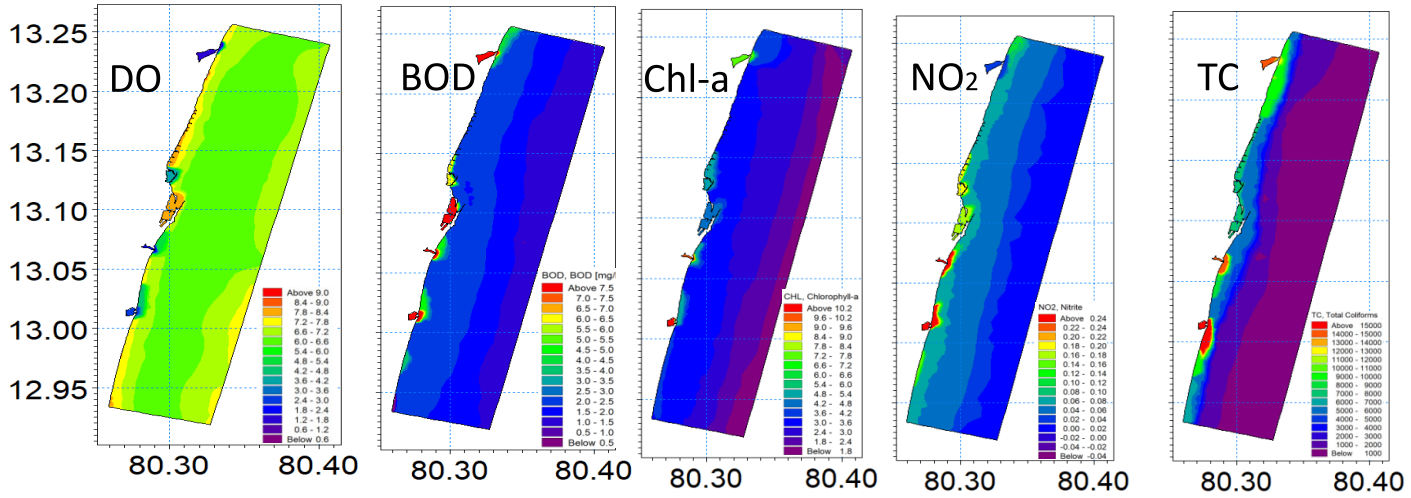

```
 start_time_step_assimilation = 1200
 time_step_factor_assimilation = 5
EndSect  // TIME
```

```
[METHOD]
 type = 1                 // 0=Free, 1=EnKF (ensemble), 2=Simple, 3=Steady, 4=EnOI
 ensemble_size = 10
 algorithm = 1            // (for type=1) 1=serialESRF, 2=DEnKF, 3=ETKF
EndSect  // METHOD
```

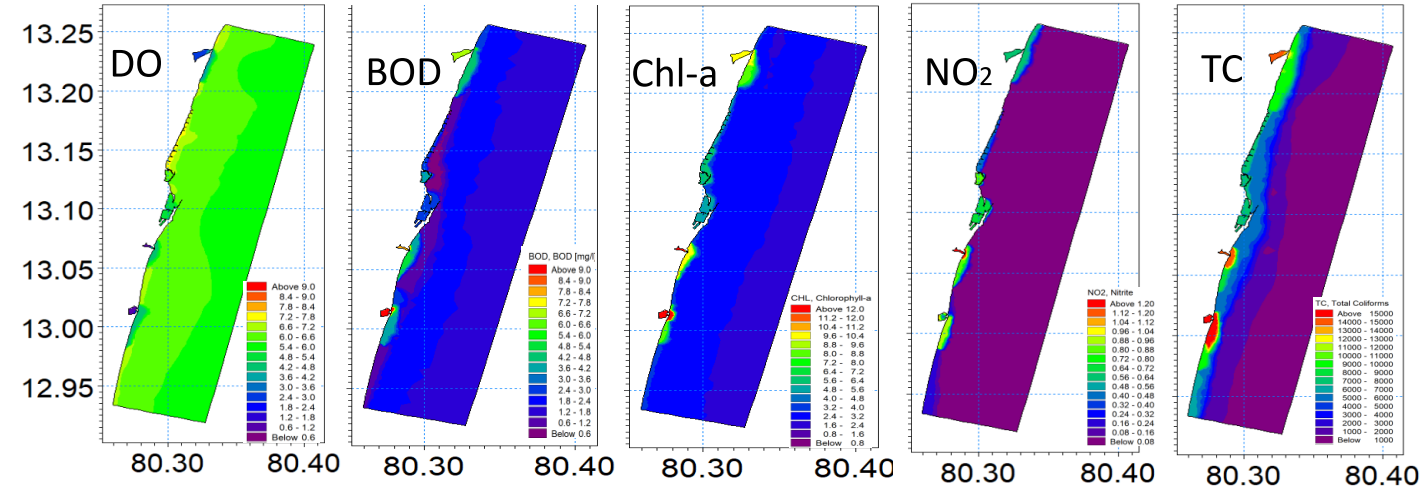
```
[MODEL ERROR MODEL]
```

Spatial Dispersion patterns from the point sources

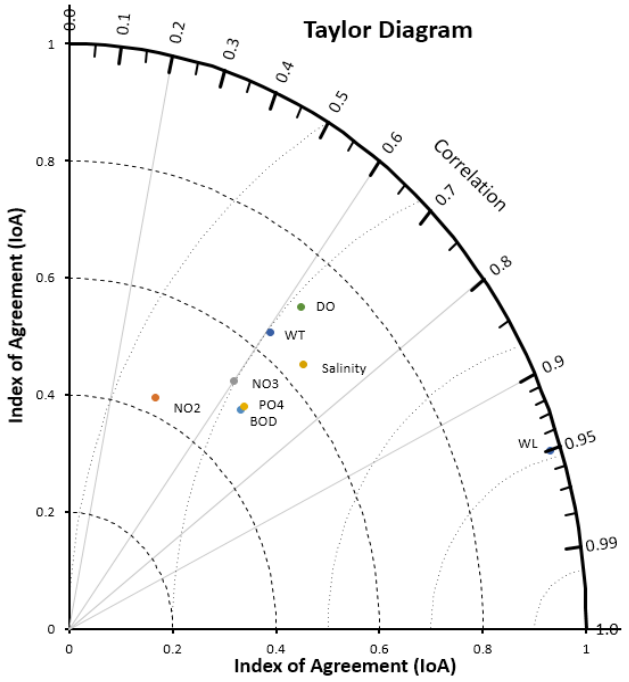
SWM (May 2021)



NEM (Jan 2021)

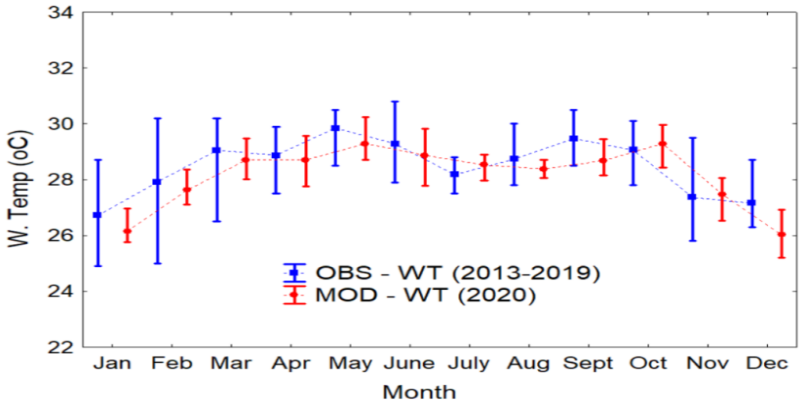


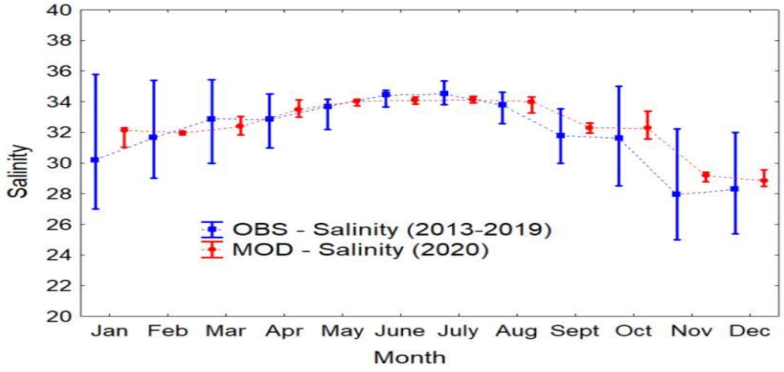
Water Quality Validation



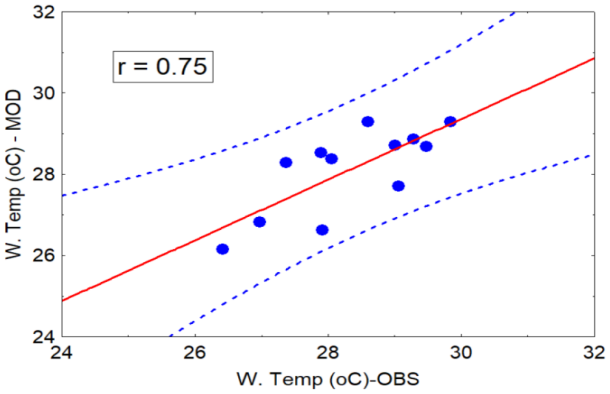
Model Validation : Temperature and Salinity

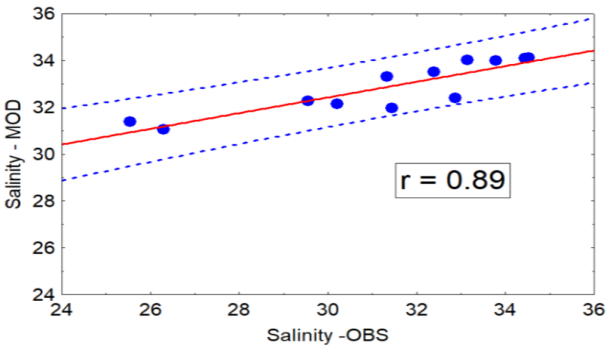
Long term (~7 years)





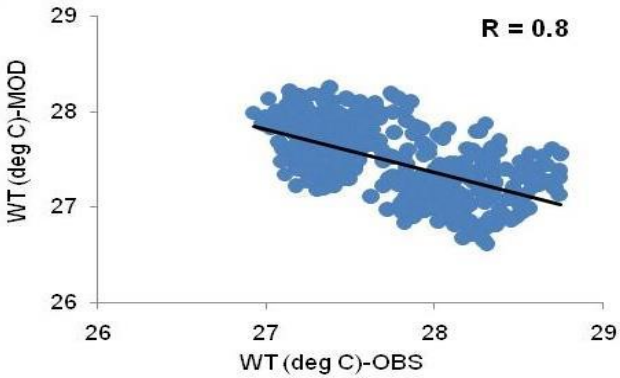
Monthly

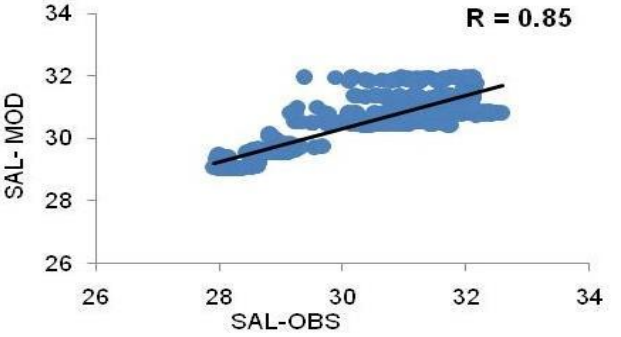




Real time (WQB: time series)

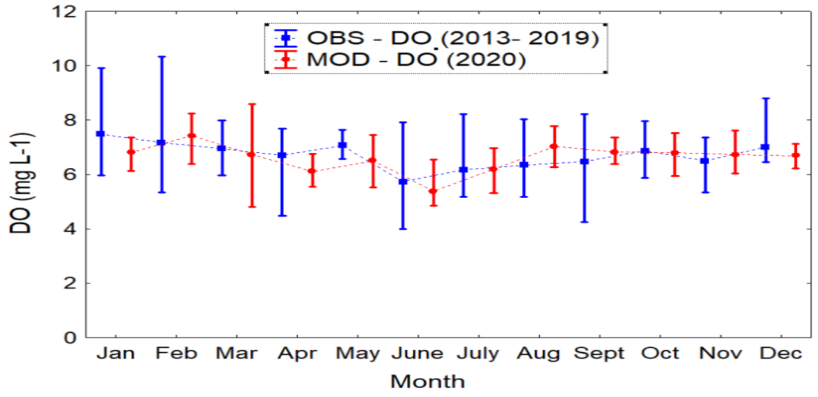
Mach-2021

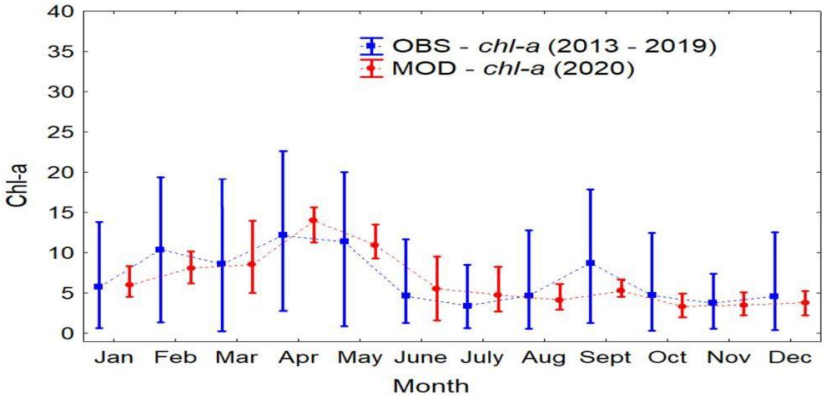




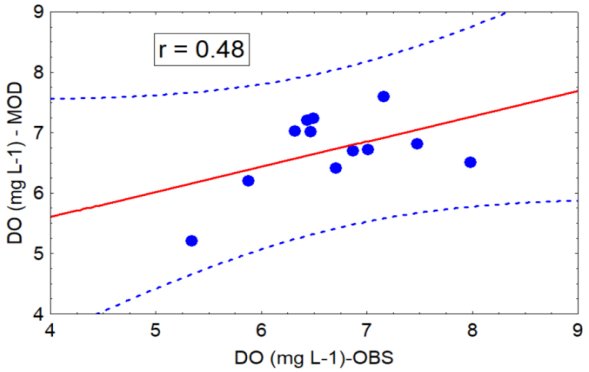
Model Validation : DO and *Chl-a*

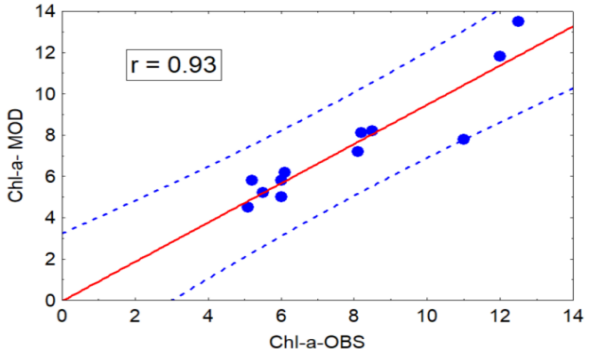
Long term (~7 years)





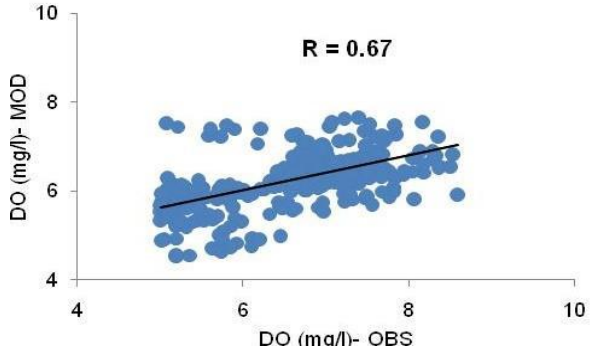
Monthly

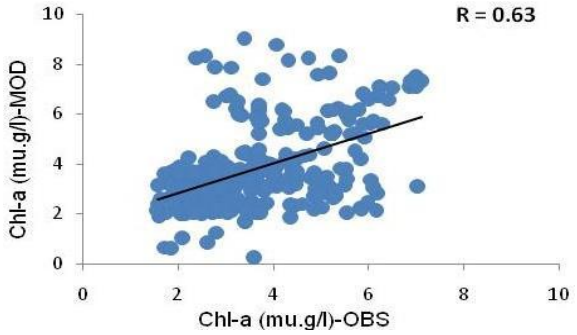




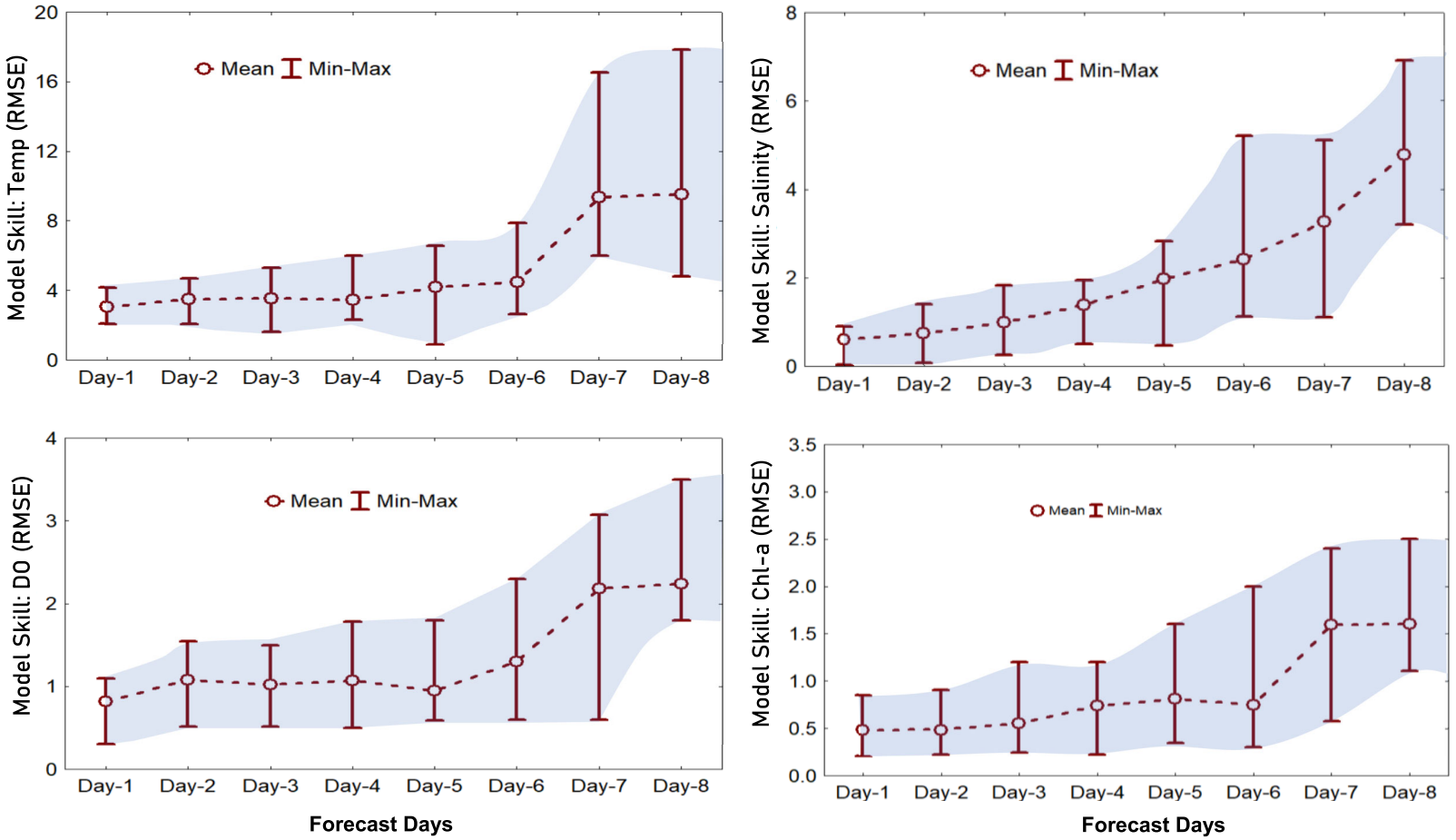
Real time (WQB: time series)

Mach-2021



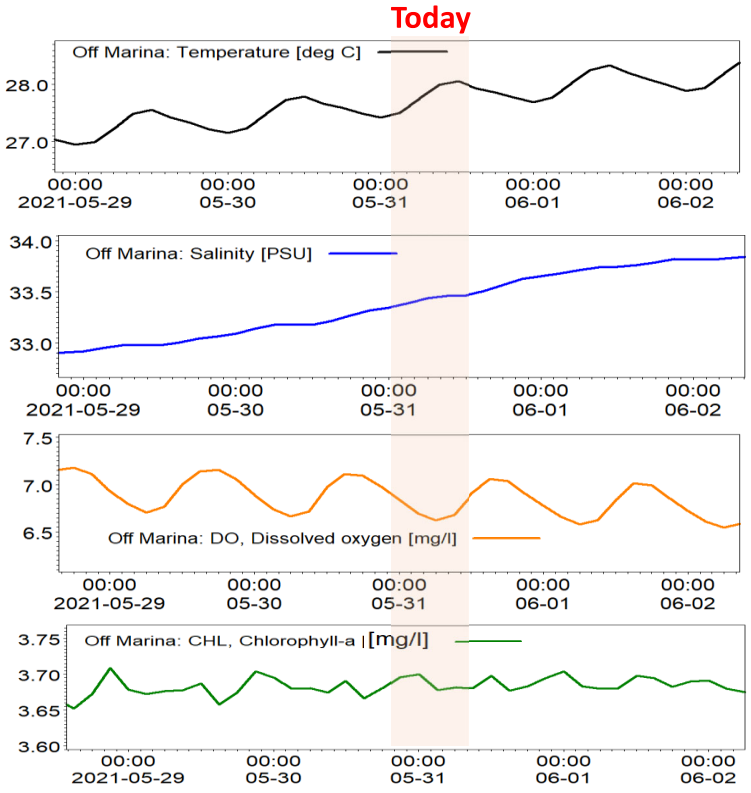


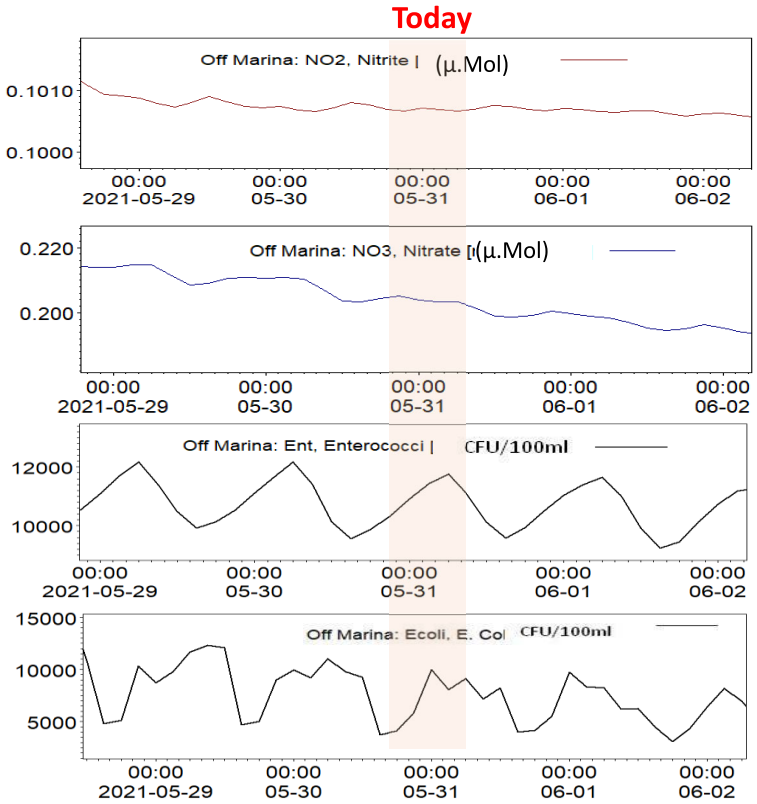
Bias and Model skill - forecast data



Model skill vs. forecast days : RMSE variations of 3 hourly data for 8 days shows that upto 5 days model can still perform better

5 day- Forecast of Water Quality parameters





Beaches (31-May)	WT (^{O}C)	Salinity	DO (mg/L)	Chl-a (mg/m^3)	NO2 (µM)	NO3 (µM)	PO4 (µM)	Ent. Ccoi (CFU/ml)	E.Coli (CFU/ml)
Marinna	27.4 – 28.1	33.3 – 33.6	6.6 – 7.1	3.68 – 3.7	0.101 – 0.101	0.199 – 0.204	0.558 – 0.576	9579 - 11779	3983 - 9993
Elliot	27.2 – 27.8	33.2 - 33.5	6.7 – 7.1	3.68 – 3.71	0.101 (N.V)	0.191 – 0.197	0.556 - 0.563	7010 - 7738	2478 - 7584
Thirvanmyur	27.2 – 27.5	33.2 – 33.4	6.7 – 7.1	3.69 – 3.71	0.101(N.V)	0.188 – 0.195	0.558 – 0.562	6983 - 7662	2213 -7411

RTMS Software | Search results - mail2usp@gmail | WQI Map

Not secure | 137.116.143.63/WaterQuality/Wqimap.aspx

Apps | Operational Foreca... | IMD :: AWS DATA_C... | ELCIRC Model | IRCTC Online Passe... | Animated Wave (S... | Tide Times and Tid... | Water Resources M... | Geologynet - Earth... | Demo UHD-3D - UI... | PPT – Hydrology an... | 44 DHI MIKE 21 Po... | Reading list

Coastal Water Quality Index

Prediction of Coastal Water Quality (CWQ)

Home

Marina Beach

Water Quality

Medium risk of illness from swimming

Beach Report | Beach Detail

Water Quality Index

May 30	May 31	Jun 1	Jun 2
medium	medium	medium	medium
68	68	68	68

Water Temperature (℃)

27.59	27.86	28.09	28.2

Wind Speed (m/s)

0.11	0.12	0.12	0.13

Wind Direction (°)

23° NE	24° NE	24° NE	24° NE

Salinity (g/kg)

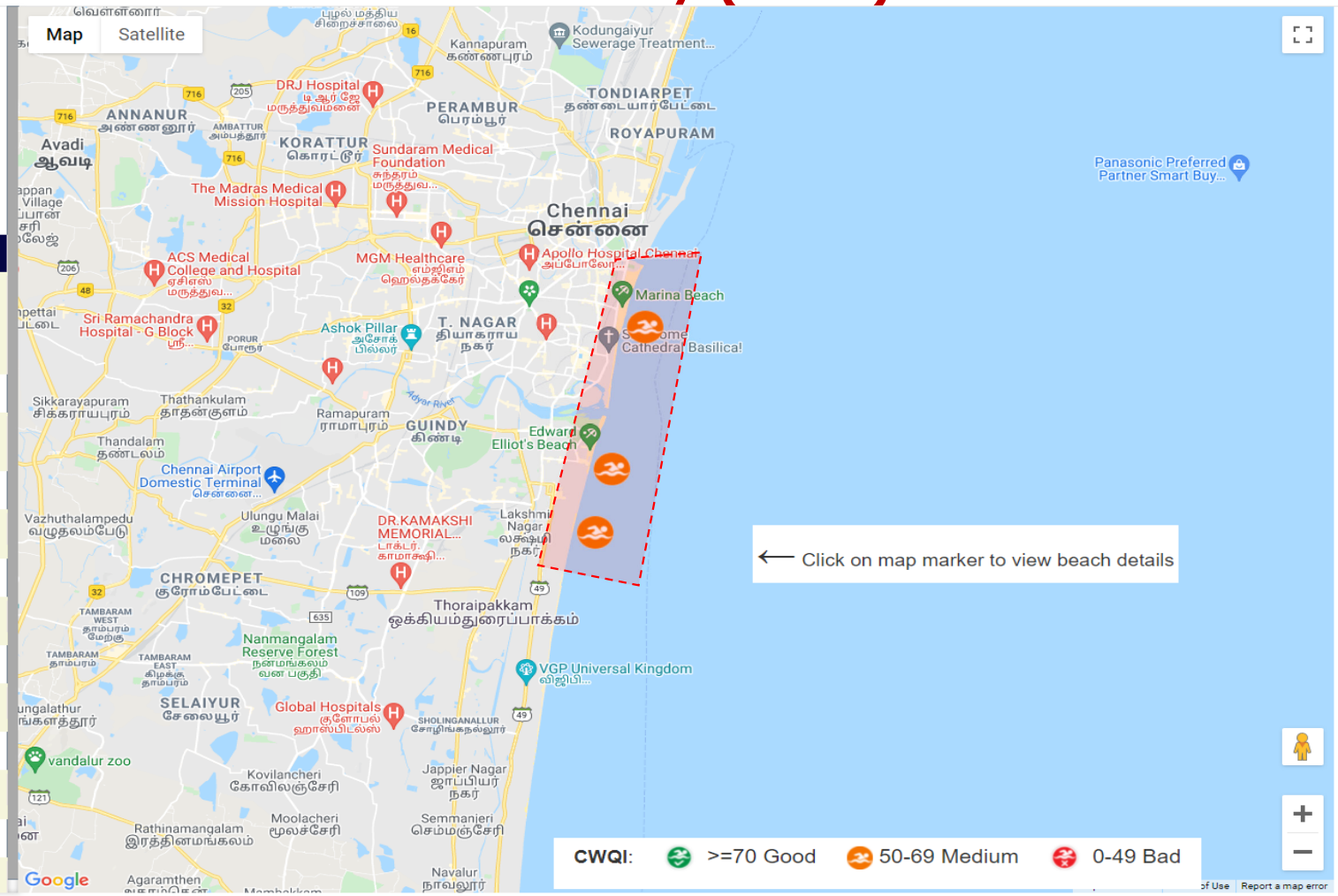
33.27	33.57	33.79	33.84

Dissolved Oxygen (mg/l)

7.09	7.04	6.99	6.94

BOD (mg/l)

0.85	0.83	0.81	0.79



Wednesday, October 19, 2022

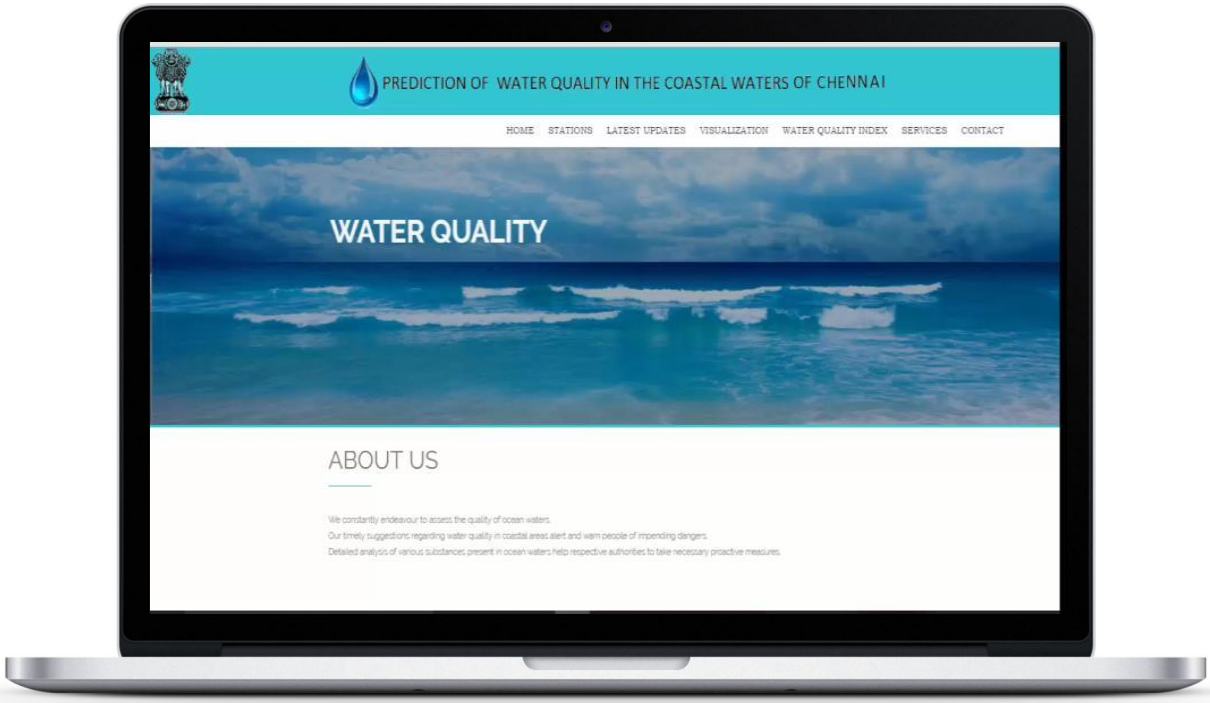
Type here to search | 29°C Partly cloudy | ENG | 19:08 30-05-2021

RTMS :: Real-time Monitoring System

- Data Reception at –NCCR Server
- Real-time data acquisition @ 10 min.
- Public domain: https://www.nccr.gov.in/nccrtems2/Home.aspx

Information System

Clean coast



http://137.116.143.63/WaterQuality/Default.aspx

OCEAN SERVICES : VISION 2030

To develop an Advanced Ocean Modelling system for predicting the variability of the Indian Ocean (at 1/16th of degree for the Indian Ocean basin and 1/64th degree resolution for the coastal waters around India) for best quality Ocean Services, forecasts of the Ocean State, water quality and coastal hazards.

To develop Regional Ocean Service Centres to cater the needs of region specific needs and requirements for ocean services like Potential Fishing Zones (PFZ) and Coastal Ocean State Forecast services for each and every fisherman and stake holder (coastal population, ports and harbours, maritime industry) in the locality.

To develop an Observational and Modelling Strategy specific to Estuarine Systems, Water quality, Ocean Biogeochemistry, Climate change and its impacts on the Oceans including Ocean Acidification, Greenhouse Gasses, Marine Ecosystems and Living Resources and Primary Productivity.

सत्यमेव जयते

Ministry of Earth Sciences
Government of India

Thank You

Final Thoughts

"Coastal Pollution and habitat modification are relatively widespread but can be addressed through long-term natural resource monitoring on real-time, modelling and their prediction, stronger political will and strengthening of institutions responsible for environmental management and enforcement"

The coastal ocean is essential for all life on Earth, including humans. To ensure a sustainable future, we must protect and preserve healthy marine ecosystems