MUNICIPAL CORPORATION OF GREATER MUMBAI

No. Ch.E/1092/ Coastal Road, date: 17/08/2020

Office of
Chief Engineer (Coastal Road),
3rd Floor, Engineering Hub building,
Dr E Moses Road, Worli,
Mumbai 400 018
Email: che.coastalroad@mcgm.gov.in

To,
Mr.Suresh Kumar Adapa
Scientist –D
Ministry of Environment, Forest & Climate Change,
Regional office (WCZ), Ground floor, East wing
New Secretariat Building, Civil Lines Nagpur – 440001
Apccfcentral-ngp-mef@gov.in

Sub: Mumbai Coastal Road Project (South) from Princess Street Flyover to Worli end of BWSL

Ref: 1. MoEF&CC letter no. 19-74/2016-IA.III dated 11.05.2017
2. Ch.E/1000 (v) /Coastal Road Project date 08.06.2017
3. F. No. EC-427/RON/2017-NGP/1975 dated 27.06.2017
4. Ch.E/1237/Coastal Road Project date 03.10.2017
5. Ch.E/1357/Coastal Road Project date 25.10.2018
6. Ch.E/1901/Coastal Road Project date 28.05.2019
7. Ch.E/3222/Coastal Road Project date 29.06.2019
8. Ch.E/9246/Coastal Road Project date 4.02.2020

Sir,

With reference to above referred CRZ clearance dated 11.05.2017, the half yearly compliances report for the period of October 2019 to March is submitted herewith. The data sheets are attached herewith accompanying with the required information.

1. Present status of work:-

Work is divided into three Packages as mentioned below and present status of work is attached as Annexure I.

Sr.No	Package	Description	Contractors	Date of Commencement
1	Package - I	Priyadarshani Park to Baroda Palace	M/s L&T Limited	13.10.2018
2	Package - II	Baroda Palace to Worli end of BWSL	M/s HCC-HDC	16.10.2018
3	Package -IV	Princess Street flyover to Priyadarshani Park	M/s L&T Limited	13.10.2018

2. Copies of Consent to Establish/Operate from MPCB:-
   Attached as Annexure II.

3. The information in the enclosed data sheet :-
   The information in the Standard format is attached herewith

4. Copy of EIA/EMP report :-
   The EIA/EMP report including EMP prepared by DPR consultant is submitted to MoEF&CC while obtaining CRZ clearance. The salient features of EMP is attached as Annexure III

This information is submitted as a status of Compliance. Copy of the same is also sent through mail on email id Apccfcentral-ngp-mef@gov.in .

Yours Faithfully,

30/07/20

Niranjan Khanolkar

Chief Engineer (Coastal Road)

CC to

1.The Member Secretary,
Maharashtra Pollution Control Board,
Kalpataru Point, 3rd and 4th floor,
Opp. PVR Cinema, Sion Circle, Mumbai-400 022.

2. The Regional Director, Vadodara
Regional office of CPCB
Parivesh Bhawan, Opp. Ward No. 10
VMC Office Subhanpura, Vadodara – 390 023
STD code: 0265, EPABX Number: 0265 – 2392831 Fax No. 0265-2392987
Direct: 0265 – 2392603-04

C/47

Monitoring the Implementation of Environmental Safeguards
Ministry of Environment, Forest & Climate Change
Regional Office (West Central Zone), Nagpur
Monitoring Report
Part -1
DATA SHEET

1.	Project Type: River-Valley / Mining / Industry / Thermal / Nuclear /Other (Specify)	Mumbai Coastal Road (South)
2.	Name of the Project	Mumbai Coastal Road (South) from Princes Street Flyover to Worli End of Bandra worli sea link. 1) Package I: Priyadarshini Park to Baroda Palace. 2) Package II: Baroda Palace to Worli End of BWSL. 3) Package IV: Princess Street Flyover to Priyadarshini Park.
3.	Clearance Letter (S) /OM No. and Date	F. No. 19-74/2016-IA-III dated 11th May 2017
4.	Location a. District (S) b. State (S) c. Latitude (S) d. Longitude (S)	 Mumbai City Maharashtra
5.	Address for correspondence a. Address of concerned Project Chief Engineer (with Pin Code & Telephone / Telex/Fax Numbers) & address of Executive Project Engineer / Manager (with pin code/fax numbers)	Chief Engineer (Coastal Road), Municipal Engineering Hub Building, 3rd Floor, Dr. E. Moses Road, Worli Naka, Worli, Mumbai-400 018, Maharashtra, India. Telephone No. 022-24958211
6	Salient Features a. Of the project	Mumbai Coastal Road Project (South): • Length- 9.98 km • Length of Tunnel- 3.452 km 02 Tubes each having lanes 02+01 (emergency) • Number of Interchanges : 03 No's • Total Reclamation: approx 95 Ha. • Road : 4+4 lanes • Project Cost: 12,721.59, Crs.
	b. Of the Environment Management Plan	The Salient Features of Environment Management Plan submitted as Annexure III along with this data sheet
7.	Breakup of the Project Area a. Submergence Area Forest & Non-Forest	Not Applicable being Coastal Road Project.

Louis Berger Consulting Pvt. Ltd.   YOOSHIN TEC-4 PROJECT MANAGER (PMC) (PKG-4)   MUMBAI COASTAL ROAD PROJECT PKG II ★ JV (EGIS-CGRCUK)   AECOM Asia Company Limited MUMBAI

	b. Others	
	a. Total plot Area	As submitted earlier
	b. Built – up Area (Including Road)	Not applicable since Coastal Road Project
	c. Open Space Available	Not Applicable since Coastal Project Road
	d. Green belt Area	Green Belt 70 Ha. Area
8.	Breakup of the Project affected population with enumeration of those losing houses / dwelling units & both dwelling units & agricultural land & landless laborers / artisan a. SC, ST/Adivasis b. Others (Please indicate whether these figures are based on any scientific and systematic survey carried out or only provisional figures, if a survey carried out gives details and years of survey).	Nil
9.	Financial details a. Project costs as originally planned & subsequent revised estimates and the year of price reference.	12,721.59, Cr
	b. Allocation made for Environmental Management Plan with item wise & Year wise breakup.	1. October 2019 to March 2020 = 0.97 (Cr.) 2. April 2019 to March 2020 = 7.35 (Cr.)
	c. Benefits Cost Ration / Internal rate of Return and the year of assessment.	Benefit Cost Action: 1.15 (2018-2019)
	d. Whether (C) includes the cost of Environmental Management as shown in the above	Yes
	e. Actual expenditure incurred on the Project so far	686.30 Cr
	f. Actual expenditure incurred on the Environmental Management Plan so far	0.97 (Cr.) October 2019 to March 2020
10.	Forest land Requirement a. The status of approval for diversion of forestland for non-forestry use. b. The status of clearing felling. c. The Status of compensatory afforestation program in the light of actual field experience.	NIL

Louis Berger Consulting Pvt.

YOOSHIN ★ TEC-4 ★ PROJECT MANAGER

COASTAL ROAD PROJECT PKG II ★ JV (EGIS-CGRCUK) ★ MUMBAI

AECOM Asia Company Limited MUMBAI

11.	The status of clear felling in non-forest area (such as submergence area of reservoir, approach roads), if any with quantitative information.	NIL
12.	Status of Construction a. Date of Commencement (Actual and/or Planned)	1. Contractors for Package – I and Package IV-M/s L & T Limited. Date of Commencement – 13.10.2018. Construction Work is in progress 2. Contractors for Package – II- M/s HCC – HDC. Date of Commencement – 16.10.2018. Construction work is in progress
	b. Date of Completion (Actual and/or Planned)	15.10.2022 (Planned)
13.	Reasons for the delay if the project is yet to start	Not applicable
14.	Date of site visits a. The dates on which the Project was monitored by Regional Office on previous occasions, if any b. Date of site visit for this monitoring Report	Nil Nil
15.	Details of correspondence with project authorities for obtaining action plan /information on status of compliance to safeguard other than the routine letters for logistic support for site visit. (Monitoring report may obtain the details of all the letters issued so far but the later reports may cover only the letters issued subsequently)	1. Monitoring Report (EMP-Report) (October 2019 till March 2020) for three Packages are attached as Annexure IV. 2. MoEF&CC- CRZ Clearance compliance report & MCZMA – Compliance report attached as Annexure V

20/04/2020

Chief Engineer (Coastal Road)
MCGM, Mumbai -18

Louis Berger Consulting Pvt. Ltd.

YOOSHIN TEC-4 PROJECT MANAGER (PMC) MCR (PKG-4)

MUMBAI COASTAL ROAD PROJECT PKG II (EGIS-CGRCUK) JV

AECOM Asia Company Limited MUMBAI

c/51

Annexure 01

Project Progress Report
October 2019 - March 2020

MUMBAI COASTAL ROAD PROJECT PKG-IV (EGIS-CGRCUK) JV

YOOSHIN TEC-4 PROJECT MANAGER (PMC) MCR (PKG-4)

Louis Berger Consulting

AECOM Asia Company Limited MUMBAI

Mumbai Coastal Road Package - 01

Description	Unit	Scope	Planned	Achieved	Planned %	Achieved %
GTI Works	nos	329	-	-	0.0%	0.0%
Seawall Core	Rm	3,800	619	579	16.3%	15.2%
Seawall Armour	Rm	3,800	182	55	4.8%	1.4%
Reclamation upto +4.42m CD	Sqm	603,400	105,000	128,524	17.4%	21.3%
Piling Gantry Erection & Commissioning at Amarson garden	LS	1	0.5	0.5	50.0%	50.0%
Piling Gantry Erection & Commissioning at Haji Ali	LS	1	1.0	0.9	100.0%	90.0%
1st Set Test Piles-Amarsons Garden	nos	2	-	-	0.0%	0.0%
2nd Set Test Piles-Amarsons Garden	nos	3	2	2	66.7%	66.7%
3rd Set Test Piles-Haji Ali	nos	3	-	-	0.0%	0.0%
4th Set Test Piles-Haji Ali	nos	3	3	-	100.0%	0.0%

Mumbai Coastal Road Package - 02

S.NO.	ITEM DESCRIPTION	TOTAL SCOPE		Works Till Sep'19	FTM Oct'19	FTM Nov'19	FTM Dec'19	FTM Jan'20	FTM Feb'20	FTM Mar'20	Cumilative till Mar'20.
		Unit	Qty								
1	GEO TECHNICAL INVESTIGATIONS	NOS	174	98	0	0	0	11	29	0	138
2	SEAWALL-QUARRY RUN	Cum	239020	39646	0	0	0	20969	22213	25200	108028
3	Seawall - Bedding Layer	CUM	7336	1069	0.1	0	0	521.9	2486	1138	5215
4	Sea wall - Geotextile Layer	SQ.M	28096	2555	0	0	0	1145	2855	660	7215
5	Sea wall - Armour Layer	CUM	99258	6338	50	0	0	0	2709	5065	14162
6	Reclamation Works +1.92 MSL	CUM	530000	89662	0	0	0	16719	36098	33381	175860
7	Selected Fill +6.00MSL	CUM	567573	27133	0	0	0	1073	21679	15548	65433
8	Car Park-1 Excavation	CUM	13000	623	0	0	0	0	0	0	623

MUMBAI COASTAL ROAD PROJECT PKG-2 (HCC-CBRCUKI) JV

Berger Consulting Pvt Ltd

YOOSHIN ★ TEC-4 PROJECT MANAGER (PMC) MCR (PKG-4)

AECOM Asia Company Limited MUMBAI

Mumbai Coastal Road Package - 04

Description	Scope	Status	Remarks
Bathymetry Survey	0.144 sq.km	Completed.	Report submitted vide letter no-MCR4/LNT/411/LL/405106 dated 25th Dec 18.
Topographic Survey	44 Hectare	Completed.	
Hydro Graphical Survey	3.93 km	Scope finalization in progress	
Existing Building Survey	3.93 km	Completed	45 Nos Reports Submitted
Utilities Survey	3.93 km	Completed	
Geotechnical Investigation	33 Nos	33 Nos completed.	
Sea wall – Core Rock	685 RM	120 RM Completed	
Sea wall – Armour Rock	685 RM	40 RM Completed	
Secant Piling – Launching Shaft	547 Nos	547 Nos Completed	
Excavation – Launching Shaft	90000 Cum	12045 Cum Completed	
Secant Piling – Cut and Cover- RHS	590	175 Nos Completed	
Secant Piling – Retrieval Shaft	188 Nos	132 Nos Completed	
Secant Piling – Cut and Cover Tunnel – Chowpatty	2137 Nos	94 Nos Completed	
PWD Outfall Extension at Ch 5+352	107 Rmtr	100 Rmtr Completed	
Box Culvert at Ch 5+800	253 Rmtr	144 Rmtr Completed	
Temporary Construction facility for Tunnel Segment and Road Element Casting – Foundation Piles	48 nos	33 Nos completed	
Cantilever Promenade - Test Piles	2 Nos	2 Nos completed	

MUMBAI COASTAL ROAD PROJECT

Louis Berger Consulting Pvt. Ltd.

YOOSHIN ★ TEC-4 PROJECT MANAGER (PMC) MCR (PKG-4)

AECOM Asia Company Limited MUMBAI

Annexure 02

Package I

Consent to Establishment

MUMBAI COASTAL ROAD PROJECT PKG

YOOSHIN TEC-4 PROJECT MANAGER (PMC) MCR (PKG-4)

Louis Berger Consulting

AECOM Asia Company Limited MUMBAI

Mumbai Coastal Road Package - 01

Consent to Establishment – Casting Yard Applied online– Status – In process
Please refer S. No 01 (MPCB-CONSENT-0000087976)

Consent to Establishment – Batching Plant - Applied online– Status – In process
Please refer S. No 01 (MPCB-CONSENT-0000085647)

Ticketing system has been rolled out for your convinience.Kindly find the guidelines here Click here

Bank Guarantee module has been rolled out for your convinience.Kindly find the guidelines here Click here

Select Unit: All Units | Select Plant: All Plants | Filter Applications | View Unit Information

My Applications

Sr No.	UAN No.	Application Name	Application IIN	Application Date	Amount	Documents
1	MPCB-CONSENT-0000087976 Status: In Process	CONSENT		30-01-2020	Rs 75000	Documents Payments Download
2	MPCB-CONSENT-0000085647 Status: In Process	CONSENT		26-12-2019	Rs 15000	Documents Payments Download

Louis Berger Consulting Pvt. Ltd.

YOOSHIN ★ TEC-4 ★ PROJECT MANAGER (PMC) MCR (PKG-4)

AECOM Asia Company Limited ★ MUMBAI

c/55

Maharashtra Pollution Control Board

महाराष्ट्र प्रदूषण नियंत्रण मंडळ

Application for Consent/ Authorisation

Sir,
I/We hereby apply for*

1. Consent to Establish/Operate/Renewal of consent under section 25 and 26 of the Water (Prevention & Control of Pollution) Act, 1974 as amended.

2. Consent to Establish/Operate/Renewal of consent under Section 21 of the Air (Prevention and Control of Pollution) Act, 1981, as amended.

3. Authorization/renewal of authorization under Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016 in connection with my/our/existing/proposed/altered/ additional manufacturing/processing activity from the premises as per the details given below.

Consent Information

UAN No:
MPCB-CONSENT-0000087976

Application submitted on:
30-01-2020

Industry Information

Consent To:	***IIN No.:***	***Submit to:***	
Establish (New)		SRO - Mumbai I	
Type of institution:	***Industry Type:***	***Category:***	***Scale:***
Industry	G11 Cement products (without using asbestos / boiler / steam curing) like pipe,pillar, jafri, well ring, block/tiles etc.(should be done in closed covered shed to control fugitive emissions)	Green	S.S.I
EC Reqd.	***EC Obtained***	***EC Ref. No.***	
No	No	-	

Whether construction-buildup area is more than 20,000 sq.mtr.(Existing Expansion Unit) No

General Information

1. Name, designation, office address with Telephone/Fax numbers, e-mail of the Applicant Occupier/Industry/Institution / Local Body.

Name
RAKESH SINGH SISODIA

Address
TOWER-B, TC-II, 1ST FLOOR,L&T GATE-5, POWAI,Mumbai City,Mumbai City

Designation
PROJECT DIRECTOR

Taluka
Mumbai City

Area
Parking Place, Amarsons Garden, Near Tata Tea Garden, AMARSONS GARDEN, AMARSONS GARDEN, MUMBAI CITY

District
Mumbai city

Telephone

Fax

9870061308

Email
jadhavani@lntecc.com

Pan Number
AHFPS2369L

2. (a) Name and location of the industrial unit/premises for which the application is made (Give revenue Survey Number/Plot number name of Taluka and District, also telephone and fax number)

Industry name
Larsen & Toubro

Location of Unit
MCRP-1, Amarson Garden, Near Breach Candy Hospital

Survey number/Plot Number
Amarson Garden

Taluka

District
Mumbai city

(b) Details of the planning permission obtained from the local body/Town and Country Planning authority/Metropolitan Development authority/ designated Authority.

Planning permission

Planning Authority

Name of the local body under whose jurisdiction the unit is located and Name of the licence issuing authority

Name of Local Body

Name of the licence issuing authority

3. Names,addresses with Telephone and Fax Number of Managing Director / Managing Partner and officer responsible for matters connected with pollution control and/or Hazardous waste disposal.

Name of Managing Director
RAKESH SINGH SISODIA

Telephone number
9167061106

Fax number

Officer responsible for day to day business
7710009765

4. (a.) Are you registered Industrial unit ?

No

Registration number
L99999MH1946PLC004768

Date of registration
Feb 7, 1946

5. Gross capital investment of the unit without depreciation till the date of application (Cost of building, land, plant and machinery). (To be supported by an affidavit/undertaking on Rs.20/- stamp paper, annual report or certificate from a Chartered Accountant for proposed unit(s), give estimated figure)

Gross capital (in Lakh)	*** Verified***	*** Terms***	*** Consent Fee***
3161.00		1	75000.00

6. If the site is located near sea-shore/river bank/other water bodies/Highway, Indicate the crow fly distance and the name of the water body, if any.

Distance From	***Distance(Km)***	*** Name***
SH/NH	80.00	Mumbai-Pune Highway
River	20.00	Mithi
Human Habitation	25.00	MIDC
Religious Place	3.00	Maha Laxmi Temple
Historical Place	43.00	Belapur Fort
Creek/Sea	0.12	Creek/Sea

6b. Enter Latitude and Longitude details of site

Latitude

Longitude

YOOSHIN TEC-4 PROJECT MANAGER (PMC)

MUMBAI COASTAL ROAD PROJECT PKG-II EGIS-CHOUKI JV

AECOM Asia Company Limited MUMBAI

7. Does the location satisfy the Requirements Under relevant Central/State Govt. Notification such as Coastal Regulation Zone. Notification on Ecologically Fragile Area, Industrial Location policy, etc. If so, give details.

Location	***Approved Industry Area***	***Sensitive Area***	***If Yes, Name Of Area***	***Industry Location with Reference to CRZ***
	No	No		

8. If the site is situated in notified industrial estate,

		Details
(a) Whether effluent collection, treatment and disposal system has been provided by the authority.	No	
(b) Will the applicant utilize the system, if provided.	No	
(c) If not provided, details of proposed arrangement.		

9.

(a) Total plot area (in squear meter)	***(b) Built up area and (in squear meter)***	***(c) Area available for the use of treated sewage/ trade effluent for gardening/irrigation. (in squear meter)***
51000	34926	10000

10. Month and year of commissioning of the Unit.

1946-02-07

11. Number of workers and office staff

Workers	***staff***	***Hrs. of shift***	***Weekly off***

12.

(a) Do you have a residential colony Within the premises in respect of Which the present application is Made No

(b) If yes, please state population staying

Number of person staying	***Water consumption***	***Sewage generation***	***Whether is STP provided?***
			No

(c) Indicate its location and distance with reference to plant site.

Number of person staying	***Water consumption***

13. List of products and by-products Manufactured in tonnes/month, Kl/month or numbers/month with their types i.e.Dyes, drugs etc. (Give figures corresponding to maximum installed production capacity

Products Name and Quantity

Product Name	***UOM***	***Product Name***	***Existing***	***Consented***	***Proposed Revision***	***Total***	***Remarks***
Casting	m3/day	Casting Bridge Elements	0	180	0	180	

Products Name and Quantity

Product Name	***UOM***	***Quantity***	***Remarks***
na	--NA--	0	0

MUMBAI COASTAL ROAD PRO... EGIS-CONSULTING JV

Asia Company Limited MUMBAI AECOM

YOOSHIN TEC PROJECT MANAGEMENT (PMC) MCR (PKG-4)

Louis Berger Consulting

14. List of raw materials and process chemicals with annual consumption corresponding to above stated production figures, in tonnes/month or kl/month or numbers/month.

Name of Raw Material	*UOM*	*Quantity*	*Hazardous Waste*	*Hazardous Chemicals*	*Remarks*
Bee Wax	Kg/M	29104	No	No	NA
Curing Compound	Ltr/M	34925	No	No	NA
Shuttering Oil	Ltr/M	17462	No	No	NA
Ready Mix Concrete	m3/day	200	No	No	NA
Reinforcement	MT/M	40	No	No	NA

15. Description of process of manufacture for each of the products showing input, output, quality and quantity of solid, liquid and gaseous wastes, if any from each unit process.

Part B : Waste Water aspects

16. Water consumption for different uses (m3/day)

Purpose	*Consumption*	*Effluent Generation*	*Treatment*	*Remarks*	*Disposal*	*Remarks*
Domestic Pourpose	100	0	--NA--	NA	--NA--	NA
Water gets Polluted & Pollutants are Biodegradable	15000	600	OTHERS	Sedimentation Tank	--NA--	NA
Water gets Polluted,Pollutants are not Biodegradable & Toxic	0	0	--NA--	0	--NA--	NA
Industrial Cooling,spraying in mine pits or boiler feed	0	0	--NA--	0	--NA--	NA
Others	0					

17. Source of water supply, Name of authority granting permission if applicable and quantity permitted.

Source of water supply	*Name of authority granting permission*	*Qauntity permitted*

18. Quantity of waste water (effluent) generated (m3/day)

Domastic	*Boiler Blowdown*	*Industrial*	*Cooling water blowdown*
Process	***DM Plants/Softening***	***Washing***	***Tail race discharge from***

* 19. Water budget calculations accounting for difference between water consumption and effluent generated.

20. Present treatment of sewage/canteen effluent (Give sizes/capacities of treatment units)*

Capacity of STP (m3/day)

Treatment unit	*Size (mxm)*	*Retention time (hr)*

YOOSHIN TEC-4 PROJECT MANAGER (PMC) MCR (PKG-4)

Louis Berger Consulting ... Company Limited

MUMBAI COASTAL ROAD PROJECT PKG ...

AECOM MUMBAI

c/59

21. Present treatment of trade effluent (Give sizes/capacities of treatment units) (A schematic diagram of the treatment scheme with inlet/outlet characteristics of each unit operation/process is to be provided. Include details of residue Management system (ETP sludges)

Capacity of ETP (m3/day)

Treatment unit	***Size (mxm)***	***Retention time (hr)***

22.

(i) Are sewage and trade effluents mixed together? No

If yes, state at which stage-Whether before, intermittently or after treatment.

23. Capacity of treated effluent sump, Guard Pond if any.

Capacity of treated effluent sump (m3)	
Effluent sump/Guard pond details	No
If yes, state at which stage-Whether before, intermittently or after treatment.	No

24. Mode of disposal of treated effluent With respective quantity, m3/day

(i) into stream/river (name of river)

(ii) into creek/estuary (name of Creek/estuary)

(iii) into sea

(iv) into drain/sewer (owner of sewer)

(v) On land for irrigation on owned land/ase land. Specify cropped area.

(vi) Connected to CETP

(vii) Quantity of treated effluent reused/ recycled, m3/day Provide a location map of disposal arrangement indicating the outler(s) for sampling. Treated effluent reused / recycled (m3/day)

25. (a) Quality of untreated/treated effluents (Specify pH and concentration of SS, BOD,COD and specific pollutants relevant to the industry. TDS to be reported for disposal on land or into stream/river.

Untreated Effluent

pH	Min 6	
SS (mg/l)	Max 200	
BOD (mg/l)	Max 100	
COD (mg/l)	Max 250	
TDS (mg/l)	2000	
Specific pollutant if any	***Name***	***Value***
1		Max 2000

Treated Effluent

pH	min 6
SS (mg/l)	Less than 100
BOD (mg/l)	Less than 100
COD (mg/l)	Less than 250

YOOSHIN TEC-4 PROJECT MANAGER (PMC) MCR (PKG-4)

TDS (mg/l)	2100	
Specific pollutant if any	***Name***	***Value***
1	0	0

(b) Enclose a copy of the latest report of analysis from the laboratory approved by State Board/ Committee/Central Board/Central Government in the Ministry of Environment expected characteristics of the untreated/treated effluent

26. Fuel consumption

Fuel Type	***UOM***	***Fuel Consumption TPD/LKD***	***Calorific value***
--NA--	--NA--	0	0
Ash content	***Sulphur content***	***Quantity***	***Other (specify)***
0	0	1	0

27. (a) Details of stack (process & fuel stacks: D. G.)

(a) Stack number(s)	***(b) Stack attached to***	***(c) Capacity***	***(d) Fuel Type***
1	DG	250 kva	Diesel
(e) Fuel quantiy (Kg/hr.)	***(f) Material of construction***	***(g) Shape (round/rectangular)***	***(h) Height, m (above ground level)***
25	metal	round	3.5
(i) Diameter/Size, in meters	***(j) Gas quantity, Nm3/hr.***	***(k) Gas temperature °C***	***(l) Exit gas velocity, m/sec.***
0.3	300	na	14
(m) Control equipment preceding the stack	***(n) Nature of pollutants likely to present in stack gases such as Cl2, Nox, Sox TPM etc.***	***(o) Emissions control system provided***	***(p) In case of D.G. Set power generation capacity in KVA***
NA	NOx. SOx	yes	250

27. (B) Whether any release of odoriferous compounds such as Mercaptans, Phorate etc. Are coming out from any storages or process house.

28. Do you have adequate facility for collection of samples of emissions in the form of port holes, platform, ladder\etc. As per Central Board Publication "Emission regulations Part-III" (December, 1985)

Poart hole	No	***Details***
Platform	No	***Details***
Ladder	No	***Details***

29. Quality of treated flue gas emissions and process emissions. Quantity of treated flue gas emissions and process emissions.

Sr. No.	***Stack attached to***	***Parameter***	***Concentration mg/Nm3***	***flow (Nm3/hr)***
1				

(Specify concentration of criteria pollutants and industry/process-specific pollutants stack-wise. Enclose a copy of the latest report of analysis from the laboratory approved by State Board/Central Board/ Central Government in the Ministry of Environment & Forests. For proposed unit furnish expected characteristics of the emissions..

YOOSHIN TEC-4 PROJECT MANAGER (PMC) MCR (PKG-4)

Part - D: Hazardous Waste aspect

COASTAL ROAD PROJECT PKG-II CGRCUKI JV

AECOM Asia Company Limited MUMBAI

Louis Berger Consulting Pvt. Ltd.

c/61

30. Information about Hazardous Waste Management as defined in Hazardous Waste (Management & Handling) Rules, 1989 as amended in Jan.,2000. Type/Category of Waste as per

Waste (Annually) Schedule I

Cat No	***Type***	***Qty***	***UOM***
5.1	5.1 Used or spent oil	200	Ltr/M
Max	***Method of collection***	***Method of reception***	***Method of storage***
	Manual	Manual	Barrel
Method of transport	***Method of treatment***	***Method of disposal***	
Road	NA	Through Approved vendor	

Waste (Annually) Schedule II

31. Details about use of hazardous waste

Name of hazardous waste/Spent chemical	***Quantity used/month***	***Party from whom purchased***	***Party to whom sold***

32.

a. Details about technical capability and equipments available with the applicant to handle the Hazardous Waste

. Characteristics of hazardous waste(s) Specify concentration of relevant pollutants. Enclose a copy of the latest report of analysis from the laboratory approved by State Board/Central Board/Central Govt. in the ministry of Environment & Forests. For proposed units furnish expected characteristics

33.

Copy of format of manifest/record Keeping practiced by the applicant.

34.

Details of self-monitoring (source and environment system)

35.

Are you using any imported hazardous waste. If yes, give details.

36.

Copy of actual user Registration/certificate obtained from State Pollution Control Board/Ministry of Environment & Forests, Government of India, for use of hazardous waste.

37.

Present treatment of hazardous waste, if any (give type and capacity of treatment units)

38. Quantity of hazardous waste disposal

(i) Within factory

(ii) Outside the factory (specify location and enclose copies of agreement.)

(iii) Through sale (enclosed documentary proof and copies of agreement.)

(iv) Outside state/Union Territory, if yes particulars of (1 & 3) above.

(v) Other (Specify)

YOOSHIN TEC-4 PROJECT MANAGER (PMC) MCR (PKG-4)

Louis Berger Consulting

AECOM India Company Limited MUMBAI

COASTAL ROAD PROJECT

Part - E: Additional information

39.

a. Do you have any proposals to upgrade the present system for treatment and disposal of effluent/emissions and/or hazardous waste.

b. If yes, give the details with time- schedule for the implementation and approximate expenditure to be incurred on it.

40.

Capital and recurring (O & M) expenditure on various aspect of environment protection such as effluent, emission, hazardous waste, solid waste, tree- plantation, monitoring, data acquisition etc. (give figures separately for items implemented/to be implemented).

41.

To which of the pollution control equipment, separate meters for recording consumption of electric energy are installed ?

42.

Which of the pollution control items are connected to D.G. Set (captive power source) to ensure their running in the event of normal power failure

43. Nature, quantity and method of disposal of non- hazardous solid waste generated separately from the process of manufacture and waste treatment. (Give details of area/capacity available in applicant's land)

Type	*Quantity*	*UOM*	*Treatment*	*Disposal*	*Other Details*
Reinforcement Steel	15	MT/M	NA	Sell	NA

44. Hazardous Chemicals - Give details of Chemicals and quantities handled and Stored.

(i) Is the unit a Majot Accident Hazard unit as per Mfg.Storage Import Hazardous Chemicals Rules ?

(ii) Is the unit an isolated storage as defined under the MSIHC Rules ?

(iii) Indicate status of compliance of Rules 5,7,10,11,12,13 and 18 of the MSIHC Rules.

(iv) Has approval of site been obtained from the concerned authority?

(v) Has the unit prepared an off-site Emergency Plan? Is it updated ?

(vi) Has information on imports of Chemicals been provided to the concerned authority?

(vii) Does the unit possess a policy under the PLI Act?

45. Brief details of tree plantation/green belt development within applicant's premises (in hectors)

Open Space Availability	*Plantation Done On*	*Number of Trees Planted*
Square meter	Square meter(%)	

YOOSHIN TEC-4 PROJECT MANAGER (PMC) MCRP (TC-4)

46.

Information of schemes for waste Minimization, resource recovery and recycling - implemented and to be implemented, separately.

Reuse, Recycle

COASTAL ROAD PROJECT PKG-II CIRCUIT JV

AECOM Asia Company Limited MUMBAI

Louis Berger Consulting Pvt. Ltd.

47.

(a) The applicant shall indicate whether Industry comes under Public Hearing, if so, the relevant documents such as EIA, EMP, Risk Analysis etc. shall be submitted, if so, the relevant documents enclosed shall be indicated accordingly.

(b) Any other additional information that the applicants desires to give

(c) Whether Environmental Statement submitted ? If submitted, give date of submission.

48.

I/We further declare that the information furnished above is corect to the best of my/our knowledge.

49.

I/We hereby submit that in case of any change from what is stated in this application in respect of raw materials, products, process of manufacture and treatment and/or disposal of effluent, emission, hazardous wastes etc. In quality and quantity; a fresh application for Consent/Authorization shall be made and until the grant of fresh Consent/Authorization no change shall be made.

50.

I/We indertake to furnish any other information within one month of its being called by the Board

Yours faithfully

Signature : RAKESH SINGH SISODIA
Name : RAKESH SINGH SISODIA
Designation : PROJECT DIRECTOR

Additional Information

Air Pollution

Sr No.	***Air Pollution Source***	***Pollutants***	***APCS Provided***	***Remark***
1	vehicular movement	PM	water sprinkling	water sprinkling

Separate EM Provided	No	***Other Emission Sources***	Yet to be provided
Measures Proposed	Yet to be Provided	***Foul Smell Coming Out***	No
Air Sampling Facility Details	Yet to be Provided		

D.G. Set Details

Description	***Capacity(KVA)***	***Remarks***
DG	250	250kva

Hazardous Waste Generation

Hazardous Waste	***Quantity***	***UOM***	***Treatment***	***Disposal***	***Other Details***

CHWTSDF Details

Member of CHWTSDF	***CHWTSDF Name***	***Remarks***

Cess Details

Cess Applicable	***Cess Paid***	***If Yes, UpTo***

PROJECT MANAGER (PMC)

No	No	Jan 1 1900 12:00:00:000AM

Legal Actions

Legal Action Taken	*Legal Record Of Company*	*Legal Action Details*	*Remarks*
No			

C/65

MAHARASHTRA

Maharashtra Pollution Control Board

महाराष्ट्र प्रदूषण नियंत्रण मंडळ

Application for Consent/ Authorisation

Sir,
I/We hereby apply for*

1. Consent to Establish/Operate/Renewal of consent under section 25 and 26 of the Water (Prevention & Control of Pollution) Act, 1974 as amended.

2. Consent to Establish/Operate/Renewal of consent under Section 21 of the Air (Prevention and Control of Pollution) Act, 1981, as amended.

3. Authorization/renewal of authorization under Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016 in connection with my/our/existing/proposed/altered/ additional manufacturing/processing activity from the premises as per the details given below.

Consent Information

UAN No:
MPCB-CONSENT-0000085647

Application submitted on:
26-12-2019

Industry Information

Consent To:	***IIN No.:***	***Submit to:***	
Establish (New)		SRO - Mumbai I	
Type of institution:	***Industry Type:***	***Category:***	***Scale:***
Industry	G37 Ready mix cement concrete	Green	S.S.I
EC Reqd.	***EC Obtained***	***EC Ref. No.***	
No	No	-	

Whether construction-buildup area is more than 20,000 sq.mtr.(Existing Expansion Unit) No

General Information

1. Name, designation, office address with Telephone/Fax numbers, e-mail of the Applicant Occupier/Industry/Institution / Local Body.

Name
RAKESH SINGH SISODIA

Designation
PROJECT DIRECTOR

Area
Parking Place, Amarsons Garden, Near Tata Tea Garden, AMARSONS GARDEN, AMARSONS GARDEN, MUMBAI CITY,

Telephone
9870061308

Email
jadhavani@lntecc.com

Address
TOWER-B, TC-II, 1ST FLOOR,L&T GATE-5, POWAI,Mumbai City,Mumbai City

Taluka
Mumbai City

District
Mumbai city

Fax

Pan Number
AHFPS2369L

PROJECT MANAGER (PMC) MCR (PKG-4)

MUMBAI

2. (a) Name and location of the industrial unit/premises for which the application is made (Give revenue Survey Number/Plot number name of Taluka and District, also telephone and fax number)

Industry name
Larsen & Toubro Ltd.

Location of Unit	***Survey number/Plot Number***
Mumbai Coastal Road Project PKG 1	Amarson Garden & Haji Ali
Taluka	***District***
	Mumbai city

(b) Details of the planning permission obtained from the local body/Town and Country Planning authority/Metropolitan Development authority/ designated Authority.

Planning permission	***Planning Authority***

Name of the local body under whose jurisdiction the unit is located and Name of the licence issuing authority

Name of Local Body	***Name of the licence issuing authority***

3. Names,addresses with Telephone and Fax Number of Managing Director / Managing Partner and officer responsible for matters connected with pollution control and/or Hazardous waste disposal.

Name of Managing Director	***Telephone number***
Rakesh Singh Sisodia	9870061308
Fax number	***Officer responsible for day to day business***
	Rakesh Singh Sisodia
4. (a.) Are you registered Industrial unit ?	No
Registration number	***Date of registration***
L99999MH1946PLC004768	Oct 13, 2018

5. Gross capital investment of the unit without depreciation till the date of application (Cost of building, land, plant and machinery). (To be supported by an affidavit/undertaking on Rs.20/- stamp paper, annual report or certificate from a Chartered Accountant for proposed unit(s), give estimated figure)

Gross capital (in Lakh)	**** Verified***	**** Terms***	**** Consent Fee***
286.75	CA Certificate	1	15000.00

6. If the site is located near sea-shore/river bank/other water bodies/Highway, Indicate the crow fly distance and the name of the water body, if any.

Distance From	***Distance(Km)***	**** Name***
SH/NH	88.00	Mumbai-Pune Highway
River	23.00	Mithi
Human Habitation	0.20	
Religious Place	0.30	Maha Laxmi Temple
Historical Place	0.10	
Creek/Sea	0.10	Creek/Sea

6b. Enter Latitude and Longitude details of site

Latitude	***Longitude***

7. Does the location satisfy the Requirements Under relevant Central/State Govt. Notification such as Coastal Regulation Zone, Notification on Ecologically Fragile Area, Industrial Location policy, etc. If so, give details.

Location	***Approved Industry Area***	***Sensitive Area***	***If Yes, Name Of Area***	***Industry Location with Reference to CRZ***

c/67

	No	No

8. If the site is situated in notified industrial estate,

		Details
(a) Whether effluent collection, treatment and disposal system has been provided by the authority.	No	
(b) Will the applicant utilize the system, if provided.	No	
(c) If not provided, details of proposed arrangement.		

9.

(a) Total plot area (in squear meter)	***(b) Built up area and (in squear meter)***	***(c) Area available for the use of treated sewage/ trade effluent for gardening/irrigation. (in squear meter)***
2500	2000	500

10. Month and year of commissioning of the Unit.

020-03-15

11. Number of workers and office staff

Workers	***staff***	***Hrs. of shift***	***Weekly off***

12.

(a) Do you have a residential colony Within the premises in respect of Which the present application is Made ? No

(b) If yes, please state population staying

Number of person staying	***Water consumption***	***Sewage generation***	***Whether is STP provided?***
			No

(c) Indicate its location and distance with reference to plant site.

Number of person staying	***Water consumption***

13. List of products and by-products Manufactured in tonnes/month, Kl/month or numbers/month with their types i.e.Dyes, drugs etc. (Give figures corresponding to maximum installed production capacity

Products Name and Quantity

Product Name	***UOM***	***Product Name***	***Existing***	***Consented***	***Proposed Revision***	***Total***	***Remarks***
RMC	m3/day	Concrete	0	12000	0	12000	NA

Products Name and Quantity

Product Name	***UOM***	***Quantity***	***Remarks***
Concrete	m3/month	12000	NA

14. List of raw materials and process chemicals with annual consumption corresponding to above stated production figures, in tonnes/month or kl/month or numbers/month.

Name of Raw Material	***UOM***	***Quantity***	***Hazardous Waste***	***Hazardous Chemicals***	***Remarks***
Cement	MT/M	6600	No	No	NA

Admixtures	MT/M	132	No	No	NA
Aggregates	MT/M	15000	No	No	NA
sand	MT/M	15000	No	No	NA
water	MT/M	3600	No	No	NA
Micro-Silica	MT/M	3000	No	No	NA

15. Description of process of manufacture for each of the products showing input, output, quality and quantity of solid, liquid and gaseous wastes, if any from each unit process.

Part B : Waste Water aspects

16. Water consumption for different uses (m3/day)

Purpose	***Consumption***	***Effluent Generation***	***Treatment***	***Remarks***	***Disposal***	***Remarks***
Domestic Pourpose	10000	8000	Septic Tank	Sedimentation tank	Recycle	NA
Water gets Polluted & Pollutants are Biodegradable	4000	3200	OTHERS	Sedimentation tank	Recycle	NA
Water gets Polluted,Pollutants are not Biodegradable & Toxic	0	0	--NA--	NA	--NA--	NA
Industrial Cooling,spraying in mine pits or boiler feed	5000	4000	--NA--	NA	--NA--	NA
Others	NA					

17. Source of water supply, Name of authority granting permission if applicable and quantity permitted.

Source of water supply	***Name of authority granting permission***	***Qauntity permitted***

18. Quantity of waste water (effluent) generated (m3/day)

Domastic	***Boiler Blowdown***	***Industrial***	***Cooling water blowdown***
Process	***DM Plants/Softening***	***Washing***	***Tail race discharge from***

* 19. Water budget calculations accounting for difference between water consumption and effluent generated.

20. Present treatment of sewage/canteen effluent (Give sizes/capacities of treatment units).

Capacity of STP (m3/day)

Treatment unit	***Size (mxm)***	***Retention time (hr)***

21. Present treatment of trade effluent (Give sizes/capacities of treatment units) (A schematic diagram of the treatment scheme with inlet/outlet characteristics of each unit operation/process is to be provided. Include details of residue Management system(ETP sludges)

Capacity of ETP (m3/day)

Treatment unit	***Size (mxm)***	***Retention time (hr)***

22.

(i) Are sewage and trade effluents mixed together? No

If yes, state at which stage-Whether before, intermittently or after treatment.

23. Capacity of treated effluent sump, Guard Pond if any.

Capacity of treated effluent sump (m3)	
Effluent sump/Guard pond details	No
If yes, state at which stage-Whether before, intermittently or after treatment.	No

24. Mode of disposal of treated effluent With respective quantity, m3/day

(i) into stream/river (name of river)

(ii) into creek/estuary (name of Creek/estuary)

(iii) into sea

(iv) into drain/sewer (owner of sewer)

(v) On land for irrigation on owned land/ase land. Specify cropped area.

(vi) Connected to CETP

(vii) Quantity of treated effluent reused/ recycled, m3/day Provide a location map of disposal arrangement indicating the outler(s) for sampling.

Treated effluent reused / recycled (m3/day)

25. (a) Quality of untreated/treated effluents (Specify pH and concentration of SS, BOD,COD and specific pollutants relevant to the industry. TDS to be reported for disposal on land or into stream/river.

Untreated Effluent

pH	NA	
SS (mg/l)	NA	
BOD (mg/l)	NA	
COD (mg/l)	NA	
TDS (mg/l)	NA	
Specific pollutant if any	***Name***	***Value***
1	NA	NA

Treated Effluent

pH	NA	
SS (mg/l)	NA	
BOD (mg/l)	NA	
COD (mg/l)	NA	
TDS (mg/l)	NA	
Specific pollutant if any	***Name***	***Value***
1	NA	NA

(b) Enclose a copy of the latest report of analysis from the laboratory approved by State Board/ Committee/Central Board/Central Government in the Ministry of Environment expected characteristics of the untreated/treated effluent

YOOSHIN TEC-4 PROJECT MANAGER (PMC) MCR (PKG-4)

AECOM Asia Company Limited MUMBAI

26. Fuel consumption

Fuel Type	UOM	Fuel Consumption TPD/LKD	Calorific value
--NA--	--NA--	0	0
Ash content	**Sulphur content**	**Quantity**	**Other (specify)**
0	0	1	NA

27. (a) Details of stack (process & fuel stacks: D. G.)

(a) Stack number(s)	(b) Stack attached to	(c) Capacity	(d) Fuel Type
01	0	0	Diesel
(e) Fuel quantiy (Kg/hr.)	***(f) Material of construction***	***(g) Shape (round/rectangular)***	***(h) Height, m (above ground level)***
0	metal	round	6m
(i) Diameter/Size, in meters	***(j) Gas quantity, Nm3/hr.***	***(k) Gas temperature °C***	***(l) Exit gas velocity, m/sec.***
0	0	0	0
(m) Control equipment preceding the stack	***(n) Nature of pollutants likely to present in stack gases such as Cl2, Nox, Sox TPM etc.***	***(o) Emissions control system provided***	***(p) In case of D.G. Set power generation capacity in KVA***
0	0	0	250

27. (B) Whether any release of odoriferous compounds such as Mercaptans, Phorate etc. Are coming out from any storages or process house.

28. Do you have adequate facility for collection of samples of emissions in the form of port holes, platform, ladder\etc. As per Central Board Publication "Emission regulations Part-III" (December, 1985)

Poart hole No ***Details***

Platform No ***Details***

Ladder No ***Details***

29. Quality of treated flue gas emissions and process emissions. Quantity of treated flue gas emissions and process emissions.

Sr. No.	Stack attached to	Parameter	Concentration mg/Nm3	flow (Nm3/hr)
1				

(Specify concentration of criteria pollutants and industry/process-specific pollutants stack-wise. Enclose a copy of the latest report of analysis from the laboratory approved by State Board/Central Board/ Central Government in the Ministry of Environment & Forests. For proposed unit furnish expected characteristics of the emissions..

Part - D: Hazardous Waste aspect

30. Information about Hazardous Waste Management as defined in Hazardous Waste (Management & Handling) Rules, 1989 as amended in Jan.,2000. Type/Category of Waste as per

Waste (Annually) Schedule I

Cat No	Type	Qty	UOM
5.1	5.1 Used or spent oil	0.3	KL/A
Max	***Method of collection***	***Method of reception***	***Method of storage***

c/71

	manual	NA	Temp. with Secondary conatiners
Method of transport	***Method of treatment***	***Method of disposal***	
Vehicle	NA	Authorized agenncy	

Waste (Annually) Schedule II

31. Details about use of hazardous waste

Name of hazardous waste/Spent chemical	***Quantity used/month***	***Party from whom purchased***	***Party to whom sold***

32.

a. Details about technical capability and equipments available with the applicant to handle the Hazardous Waste

b. Characteristics of hazardous waste(s) Specify concentration of relevant pollutants. Enclose a copy of the latest report of analysis from the laboratory approved by State Board/Central Board/Central Govt. in the ministry of Environment & Forests. For proposed units furnish expected characteristics

33.

Copy of format of manifest/record Keeping practiced by the applicant.

34.

Details of self-monitoring (source and environment system)

35.

Are you using any imported hazardous waste. If yes, give details.

36.

Copy of actual user Registration/certificate obtained from State Pollution Control Board/Ministry of Environment & Forests, Government of India, for use of hazardous waste.

37.

Present treatment of hazardous waste, if any (give type and capacity of treatment units)

38. Quantity of hazardous waste disposal

(i) Within factory

(ii) Outside the factory (specify location and enclose copies of agreement.)

(iii) Through sale (enclosed documentary proof and copies of agreement.)

(iv) Outside state/Union Territory, if yes particulars of (1 & 3) above.

(v) Other (Specify)

YOOSHIN ★ TEC-4 ★ PROJECT MANAGER (PMC) MCR (PKG-4)

MUMBAI COASTAL ROAD PROJECT EGIS CGRDUP

Asia Company Limited MUMBAI

Part - E: Additional information

39.

a. Do you have any proposals to upgrade the present system for treatment and disposal of effluent/emissions and/or hazardous waste.

b. If yes, give the details with time- schedule for the implementation and approximate expenditure to be incurred on it.

40.

Capital and recurring (O & M) expenditure on various aspect of environment protection such as effluent, emission, hazardous waste, solid waste, tree- plantation, monitoring, data acquisition etc. (give figures separately for items implemented/to be implemented).

41.

To which of the pollution control equipment, separate meters for recording consumption of electric energy are installed ?

42.

Which of the pollution control items are connected to D.G. Set (captive power source) to ensure their running in the event of normal power failure

43. Nature, quantity and method of disposal of non- hazardous solid waste generated separately from the process of manufacture and waste treatmen
(Give details of area/capacity available in applicant's land)

Type	*Quantity*	*UOM*	*Treatment*	*Disposal*	*Other Details*
Municipal Waste	10	Kg/Day	Locally	Local Body	NA
C&D	1.5	m3/day	Recycle /Reuse	Recycle /Reuse	NA

44. Hazardous Chemicals - Give details of Chemicals and quantities handled and Stored.

(i) Is the unit a Majot Accident Hazard unit as per Mfg.Storage Import Hazardous Chemicals Rules ?

(ii) Is the unit an isolated storage as defined under the MSIHC Rules ?

(iii) Indicate status of compliance of Rules 5,7,10,11,12,13 and 18 of the MSIHC Rules.

(iv) Has approval of site been obtained from the concerned authority?

(v) Has the unit prepared an off-site Emergency Plan? Is it updated ?

(vi) Has information on imports of Chemicals been provided to the concerned authority?

(vii) Does the unit possess a policy under the PLI Act?

45. Brief details of tree plantation/green belt development within applicant's premises (in hectors)

Open Space Availability	*Plantation Done On*	*Number of Trees Planted*
Square meter	Square meter(%)	

46.

Information of schemes for waste Minimization, resource recovery and recycling - implemented and to be implemented, separately.

Reuse & Recycle

47.

(a) The applicant shall indicate whether Industry comes under Public Hearing, if so, the relevant documents such as EIA, EMP, Risk Analysis etc. shall be submitted, if so, the relevant documents enclosed shall be indicated accordingly.

(b) Any other additional information that the applicants desires to give

(c) Whether Environmental Statement submitted ? If submitted, give date of submission.

c/73

48.

I/We further declare that the information furnished above is corect to the best of my/our knowledge.

49.

I/We hereby submit that in case of any change from what is stated in this application in respect of raw materials, products, process of manufacture and treatment and/or disposal of effluent, emission, hazardous wastes etc. In quality and quantity; a fresh application for Consent/Authorization shall be made and until the grant of fresh Consent/Authorization no change shall be made.

50.

I/We indertake to furnish any other information within one month of its being called by the Board

Yours faithfully

Signature : Rakesh
Name : Rakesh Singh Sisodia
Designation : Project Manager

Additional Information

Air Pollution

Sr No.	*Air Pollution Source*	*Pollutants*	*APCS Provided*	*Remark*
1	Vehicular Movement	PM SO2 , NO2 , CO	yes	Water sprinkling
2	Loading & Unloading	PM	No	Water sprinkling

Separate EM Provided	No	***Other Emission Sources***	NA
Measures Proposed	NA	***Foul Smell Coming Out***	No
Air Sampling Facility Details	0		

D.G. Set Details

Description	*Capacity(KVA)*	*Remarks*
DG	250	Will be used as stand by

Hazardous Waste Generation

Hazardous Waste	*Quantity*	*UOM*	*Treatment*	*Disposal*	*Other Details*

CHWTSDF Details

Member of CHWTSDF	*CHWTSDF Name*	*Remarks*

Cess Details

Cess Applicable	*Cess Paid*	*If Yes, UpTo*
No	No	Jan 1 1900 12:00:00:000AM

Legal Actions

Legal Action Taken	Legal Record Of Company	Legal Action Details	Remarks
No			

Mumbai Coastal Road Package - 02

MAHARASHTRA POLLUTION CONTROL BOARD

Phone : 022-25505928
Fax : 022-25505926
Email : Sromumbai1@mpcb.gov.in
Visit At : http://www.mpcb.gov.in

Raikar Chambers, A- Wing, 216, 2nd floor Deonar Gaon Road,Near Jain Mandir,Govandi (E)
Mumbai - 400088

Green / S.S.I

Consent No: SRO-MUMBAI I/CONSENT/1901000695 **Date: 10.1.2019**

Consent to Operate under Section 25 of the Water (Prevention & Control of Pollution) Act, 1974 & under Section 21 of the Air (Prevention & Control of Pollution) Act, 1981 and Authorization / Renewal of Authorization under Rule 5 of the Hazardous Wastes (Management, Handling & Transboundry Movement) Rules 2008

[To be referred as Water Act, Air Act and HW (M&H) Rules respectively].

....

CONSENT is hereby granted to

> **M/s. HCC HDC JV Mumbai Coastal Road Project**
> **Package II, Worli ,**
> **Address - HCC HDC JV Mumbai Coastal Road Project Package II, Worli Sea - Face Khan Abdul Gaffar Khan Road , Oppo ,Mumbai City Ward G – South , Opposite Worli Dairy , Worli , Mumbai 400018**

located in the area declared under the provisions of the Water Act, Air act and Authorization under the provisions of HW(M&H) Rules and amendments thereto subject to the provisions of the Act and the Rules and the Orders that may be made further and subject to the following terms and conditions:

1. The consent is granted for a period upto <u>**commissioning of the Unit OR 5 year Period whichever is earlier**</u>

2. **The Consent is valid for the manufacture of –**

Sr. No.	Product Name	Maximum Quantity	UOM
1	**Ready Mix Concrete**	**10000.0**	**M^3/Month**

3. CONDITIONS UNDER WATER ACT:

(i) The daily quantity of trade effluent from the factory shall be **0.25 M^3**.

(ii) The daily quantity of sewage effluent from the factory shall not exceed **2.0 M^3**.

(iii) **Trade Effluent :**

Treatment: The applicant shall provide comprehensive treatment system consisting of primary / secondary or tertiary treatment as is warranted with reference to influent quality and operate and maintain the same continuously so as to achieve the quality of the treated effluent to the following standards:

(iv) **Trade Effluent Disposal:** The treated effluent shall be recycled into the process.

(v) **Sewage Effluent Treatment:** The applicant shall provide comprehensive treatment system as is warranted with reference to influent quality and operate and maintain the same continuously so as to achieve the quality of treated effluent to the following standards.

(1) Suspended Solids	Not to exceed	100	mg/L
(2) BOD 3 days 27o C.	Not to exceed	100	mg/L

(vi) **Sewage Effluent Disposal:** The treated domestic effluent shall be soaked in a soak pit, which shall be got cleaned periodically. Overflow, if any, shall be used on land for gardening / plantation only.

(vii) **Non-Hazardous Solid Wastes:**

Sr. No.	Type Of Waste	Quantity	UOM	Treatment	Disposal
1	Aggregates	200.00	MT/M	Disposed in low lying area approved by MCGM	----

(viii) **Other Conditions:** Industry should monitor effluent quality regularly.

4. **The applicant shall comply with the provisions of the Water (Prevention & Control of Pollution) Cess Act, 1977 (to be referred as Cess Act) and amendment Rules, 2003 there under**

The daily water consumption for the following categories is as under:

(i) Domestic purpose	...	3.00 CMD
(ii) Water gets Polluted & Pollutants are Biodegradable(Mixing)	...	95.00 CMD
(iii) Water gets Polluted, Pollutants are not Biodegradable & Toxic	...	0.00 CMD
(iv) Industrial Washing, spraying in mine pits or boiler feed	...	2.00 CMD

The applicant shall regularly submit to the Board the returns of water consumption in the prescribed form and pay the Cess as specified under Section 3 of the said Act.

4. **CONDITIONS UNDER AIR ACT :**

(i) The applicant shall install a comprehensive control system consisting of control equipments as is warranted with reference to generation of emission and operate and maintain the same continuously so as to achieve the level of pollutants to the following standards:

5. **Control Equipment:**

a) Air Pollution Control;

(i) In-house measures;

1. All material transfer points should be covered

2. The dust containment system shall be provided incorporating either of the following
   - Barricading all around the periphery of the plot boundary of height
     minimum 20 feet or 5 feet above free fall air emission area, whichever is higher with tin sheets. Same may extend above with netlon clothing whenever required
   - Water sprinkling/Chemical dust stabilizing agent spraying system along the periphery inside the premises of RMC.
3. Internal work area shall be, cement concreted/Asphalted.
4. Daily cleaning / Removal of dust accumulation inside the plant (dry/wet) shall be carry out, with industrial vacuum cleaner.
5. Two level tyre washing facility shall be provided at entry and exit points, for transit mixture vehicle.

(ii) Raw material storage & handling;

1. Storage silos of cement & fly-ash shall be equipped with adequate capacity of dust Collection system such as multi-cyclone followed by bag house assembly.
2. Handling of Cement, sand, fly ash and aggregates shall be carried out with mechanical closed system only.
3. Manual operations shall be permitted only in a closed shed, equipped with dust control system at the loading point as well as roof top secondary dust control system.
4. All Conveyor belts of Sand, aggregate shall be covered with tin sheets and at transfer points dust collection system to be installed to avoid secondary fugitive emissions.
5. Mixing section of cement, aggregate & sand shall be equipped with adequate capacity dust collection system, such as multi-cyclone followed by bag house, so as to limit dust emissions.
6. Storage area of sand & aggregate shall be equipped with roof top water sprinkler system.
7. The air pollution control devices shall be operated regularly.
8. Alternative power supply system, should cover both the production and Air pollution control system.

5. Standards for Air Emission

Ambient air quality at a distance of 10 mtr from source OR the plant boundary, whichever is nearer, shall meet the following standards

Particulate Matter PM_{10} $\mu g/m^3$	**Not to Exceed**	**100**
Particulate Matter $PM_{2.5}$ $\mu g/m^3$	**Not to Exceed**	**60**

6. Standards for Stack Emissions:

(i) The applicant shall observe the following fuel pattern:-

Sr. No.	Type Of Fuel	Quantity	UOM
1.	**Diesel**	**2000 as and when required**	**Lit/D**

c/87

MAHARASHTRA POLLUTION CONTROL BOARD

Phone : 022-25505928
Fax : 022-25505926
Email : Sromumbai1@mpcb.gov.in
Visit At : http://www.mpcb.gov.in

Raikar Chambers, A- Wing, 216, 2nd floor Deonar Gaon Road,Near Jain Mandir,Govandi (E)
Mumbai - 400088

Green / S.S.I

Consent No: SRO-MUMBAII/CONSENT/1904000649
Date: 15.4.2019

Consent to Operate under Section 25 of the Water (Prevention & Control of Pollution) Act, 1974 & under Section 21 of the Air (Prevention & Control of Pollution) Act, 1981 and Authorization / Renewal of Authorization under Rule 5 of the Hazardous Wastes (Management, Handling & Transboundry Movement) Rules 2008

[To be referred as Water Act, Air Act and HW (M&H) Rules respectively].

....

CONSENT is hereby granted to

M/s. Larsen & Toubro Limited
Mumbai Coastal Road Pkg 4
Nepean Sea Road, Next to Priya Darshni Park
Malbar Hill Mumbai City

located in the area declared under the provisions of the Water Act, Air act and Authorization under the provisions of HW(M&H) Rules and amendments thereto subject to the provisions of the Act and the Rules and the Orders that may be made further and subject to the following terms and conditions:

1. **The Consent to Establish is granted up to: commissioning of the Unit Or 5 Years which ever is Earlier .**
2. **The Consent is valid for the manufacture of –**

Sr. No.	Product Name	Maximum Quantity	UOM
1.	Tunnel Lining Pre-cast Segment (Casting) (Category G11 Cement products (without using asbestos / boiler / steam curing) like pipe,pillar, jafri, well ring, block/tiles etc.(should be done in closed covered shed to control fugitive emissions)	200	Nos/Month

3. CONDITIONS UNDER WATER ACT:

(i) The daily quantity of trade effluent from the factory shall be **NIL M^3**.
(ii) The daily quantity of sewage effluent from the factory shall not exceed **5.0 M^3**.

PROJECT MANAGER (PMC) YOOSHIN ... MCR (PKG-4)
AECOM Asia Company Limited MUMBAI

(iii) **Trade Effluent :**

Treatment: The applicant shall provide , comprehensive treatment system consisting of primary / secondary or tertiary treatment as is warranted with reference to influent quality and operate and maintain the same continuously so as to achieve the quality of the treated effluent to the following standards:

(iv) **Trade Effluent Disposal:** The treated effluent shall be 100 percent recycled into process again .

(v) **Sewage Effluent Treatment:** The applicant shall provide comprehensive treatment system as is warranted with reference to influent quality and operate and maintain the same continuously so as to achieve the quality of treated effluent to the following standards.

(1)	Suspended Solids	Not to exceed	100	mg/l.
(2)	BOD 3 days 27o C.	Not to exceed	100	mg/l.

(vi) **Sewage Effluent Disposal:** The treated domestic effluent shall be soaked in a soak pit, which shall be got cleaned periodically. Overflow, if any, shall be used on land for gardening / plantation only.

(vii) **Non-Hazardous Solid Wastes:**

Sr. No.	Type Of Waste	Quantity	UOM	Disposal
1	Bentonite Muck	440	M3/M	Landfilling .

(viii)**Other Conditions:** Industry should monitor effluent quality regularly.

4. The applicant shall comply with the provisions of the Water (Prevention & Control of Pollution) Cess Act, 1977 (to be referred as Cess Act) and amendment Rules, 2003 there under

The daily water consumption for the following categories is as under:

(i) Domestic purpose	...	5.5 CMD
(ii) Water gets Polluted & Pollutants are Biodegradable(Mixing)	...	00 CMD
(iii) Water gets Polluted, Pollutants are not Biodegradable & Toxic	...	0.00 CMD
(iv) Industrial Washing of Vehicles , Water Sprinkling for dust suppressions		00 CMD

The applicant shall regularly submit to the Board the returns of water consumption in the prescribed form and pay the Cess as specified under Section 3 of the said Act.

4. CONDITIONS UNDER AIR ACT :

(i) The applicant shall install a comprehensive control system consisting of control equipments as is warranted with reference to generation of emission and operate and maintain the same continuously so as to achieve the level of pollutants to the following standards:

5. Control Equipment:

a) Air Pollution Control- NIL

6.Standards for Air Emission

Ambient air quality at a distance of 10 mtr from source OR the plant Boundary, whichever is nearer, shall meet the following standards

Particulate Matter PM_{10}	**Not to Exceed**	**100**	**$\mu g/m^3$**
Particulate Matter $PM_{2.5}$	**Not to Exceed**	**60**	**$\mu g/m^3$**

7.Standards for Stack Emissions:

(i) **The applicant shall observe the following fuel pattern:-**

Sr. No.	Type Of Fuel	Quantity	UOM
---------------------- NIL ----------------------------			

(ii) **The applicant shall erect the chimney(s) of the following specifications:-**

Sr. No.	Chimney Attached To	Height in mt
-------------------------------------NIL ---------------------------------		

(iii)The applicant shall provide ports in the chimney/(s) and facilities such as ladder, platform etc. for monitoring the air emissions and the same shall be open for inspection to/and for use of the Board's Staff. The chimney(s) vents attached to various sources of emission shall be designated by numbers such as S-1, S-2, etc. and these shall be painted/ displayed to facilitate identification.

(iv)The industry shall take adequate measures for control of noise levels from its own sources within the premises so as to maintain ambient air quality standard in respect of noise to less than 75 dB(A) during day time and 70 dB(A) during night time. Day time is reckoned in between 6 a.m. and 10 p.m. and night time is reckoned between 10 p.m. and 6 a.m.

(v) **Other Conditions:**

1) The industry should not cause any nuisance in surrounding area.

2) The industry should monitor stack emissions and ambient air quality regularly.

8.CONDITIONS UNDER HAZARDOUS WASTE (MANAGEMENT, HANDLING & TRANSBOUNDRY MOVEMENT) RULES, 2008:

(i) The Industry shall handle hazardous wastes as specified below.

Sr. No.	Type Of Waste	Quantity	UOM	Disposal
NIL				

(ii) Treatment: - NIL

1. The authorization is hereby granted to operate a facility for collection, storage, transport & disposal of hazardous waste.
2. The industry should comply with the Hazardous Waste (M&H) Rules, 2003.

YOOSHIN ★ TEC-4 ★ PROJECT MANAGER (PMC) MCR (PKG-4)

AECOM Asia Company Limited

a. Whenever due to any accident or other unforeseen act or even, such emissions occur or is apprehended to occur in excess of standards laid down, such information shall be forthwith Reported to Board, concerned Police Station, office of Directorate of Health Services, Department of Explosives, Inspectorate of Factories and Local Body. In case of failure of pollution control equipments, the production process connected to it shall be stopped.

b. The unit has to display and maintain the data online outside the factory main gate in Marathi & English both on a 6'x4' display board in the manner and the report of the compliance along with photograph shall be submitted to this office & concerned Regional Office/ Sub Regional Office.

c. It shall be ensured that the Hazardous waste is handled, managed & disposed of strictly in accordance with the Hazardous Waste (Management & Handling) Rules, 1989 as amended on 2003 and shown & submitted to the Board as & when asked for.

9.Industry shall comply with following additional conditions:

i. The applicant shall maintain good housekeeping and take adequate measures for control of pollution from all sources so as not to cause nuisance to surrounding area / inhabitants.

ii. Solid waste – The non hazardous solid waste arising in the factory premises, sweepings, etc., be disposed of scientifically so as not to cause any nuisance / pollution. The applicant shall take necessary permissions from civic authorities for disposal to dumping ground.

iii. The applicant shall provide for an alternate electric power source sufficient to operate all pollution control facilities installed by he applicant to maintain compliance with the terms and conditions of the consent. In the absence, the applicant shall stop, reduce or otherwise, control production to abide by terms & conditions of this consent regarding pollution levels.

iv. The applicant shall not change or alter quantity, quality, the rate of discharge, temperature or the mode of the effluent / emissions or hazardous wastes or control equipments provided for without previous written permission of the Board.

v. The applicant shall provide facility for collection of environmental samples and samples of trade and sewage effluents, air emissions and hazardous wastes to the Board staff at the terminal or designated points and shall pay to the Board for the services rendered in this behalf.

vi. The firm shall submit to this office, the 30th day of September every year, the Environmental Statement Report for the financial year ending 31st March in the prescribed Form-V as pre the provisions of rule 14 of the Environment (Protection) (Second Amendment) Rules, 1992.

vii. As inspection book shall be opened and made available to the Board's officers during their visit to the applicant.

viii. The applicant shall install a separate electric meter showing the consumption of energy for operation of domestic and industrial effluent treatment plants and air pollution control system. A register showing consumption of chemicals used for treatment shall be maintained.

ix. Separate drainage system shall be provided for collection of trade and sewage effluents. Terminal manholes shall be provided at the end of collection system with arrangement for measuring the flow. No effluent shall be admitted in the pipes / sewers down- stream of the terminal manholes. No effluent shall find its way other than in designed and provided collection System.

xi. Neither storm water nor discharge from other premises shall be allowed to mix with the effluents from the factory.

10. The consent is issued subject to direction issued by CPCB under section 18(1) (b) of Water (Prevention and Control of Pollution) Act, 1974, regarding classification of Industries dated 07th March 2016. 11.

12. This is issued as per NOC given by Chief Engineer (Coastal Road of MCGM vide letter no. Ch.E/3932 Coastal Road dated – 16.2.2019

13. The Capital investment of the industry is Rs. 2490.0 Lakhs

14. The Board reserve right to revoke, amend or suspend the consent granted

15. applied for consent to operate application after commissioning of the unit .

For and on behalf of the
Maharashtra Pollution Control Board

(Sanjay R. Bhosale)
Sub Regional Officer, Mumbai-I

To,
M/s. Larsen & Toubro Limited
Mumbai Coastal Road Pkg 4
Nepean Sea Road, Next to Priya Darshni Park
Malbar Hill Mumbai City

Received Consent fee of –

Sr. No.	Amount(Rs.)	Transaction number	Transaction number	Approved Date
1	200000/-	TXN1903002085	19.3-2019	20.032019

Copy Submitted to :-

1. Chief Account officer, MPCB, Sion, Mumbai-22.,
2. Regional Officer, MPCB, Mumbai.

c/93

MAHARASHTRA POLLUTION CONTROL BOARD

Phone : 022-25505928
Fax : 022-25505926
Email : sromumbai1@mpcb.gov.in
Visit At : http://www.mpcb.gov.in

MAHARASHTRA

Raikar Chambers, A- Wing, 216, 2nd floor, Deonar Gaon Road, Near Jain Mandir, Govandi (E), Mumbai - 400088

Green / S.S.I

Consent No: SRO-MUMBAI I/CONSENT/1904000454 **Date: 10/04/2019**

Consent to Establish under Section 25 of the Water (Prevention & Control of Pollution) Act, 1974 & under Section 21 of the Air (Prevention & Control of Pollution) Act, 1981 and Authorization / Renewal of Authorization under Rule 5 of the Hazardous Wastes (Management, Handling & Transboundry Movement) Rules 2008

[To be referred as Water Act, Air Act and HW (M&H) Rules respectively].

....

CONSENT is hereby granted to

M/s. Larsen And Toubro Limited, (RMC Plant),
Mumbai Coastal Road Project Pkg 4
Near Priyadarshani Park, Nepean Sea Road,
Malabar Hill, Mumbai-400006

located in the area declared under the provisions of the Water Act, Air act and Authorization under the provisions of HW(M&H) Rules and amendments thereto subject to the provisions of the Act and the Rules and the Orders that may be made further and subject to the following terms and conditions:

1. **The Consent to Establish is granted for a period up to: Commissioning of the unit /5 year whichever is earlier.**
2. **The Consent is valid for the manufacture of –**

Sr. No.	Product Name	Maximum Quantity	UOM
1.	Ready Mix Concrete (For Captive purpose only)	18000	M^3/M

3. **CONDITIONS UNDER WATER ACT:**

(i) The daily quantity of trade effluent from the factory shall be **6.00 M^3**.

(ii) The daily quantity of sewage effluent from the factory shall not exceed **10 M^3**.

(iii) **Trade Effluent :NIL**

Treatment: The applicant shall provide comprehensive treatment system consisting of primary / secondary or tertiary treatment as is warranted with reference to influent quality and operate and maintain the same continuously so as to achieve the quality of the treated effluent to the following standards:

Sr. No	Parameter	Limits	
1	pH	Between	5.5 to 9.0
2	BOD,3 Days 27 degree C	Not to exceed	100 mg/l.
3	COD	Not to exceed	250 mg/l.
4	Oil & Grease	Not to exceed	10 mg/l.
5	Suspended Solids	Not to exceed	100 mg/l.
21	TDS	Not to exceed	2100 mg/l.

(iv) **Trade Effluent Disposal:** The treated effluent is recycled into the process again.

(v) **Sewage Effluent Treatment:** The applicant shall provide comprehensive treatment system as is warranted with reference to influent quality and operate and maintain the same continuously so as to achieve the quality of treated effluent to the following standards.

(1)	Suspended Solids	Not to exceed	100	mg/l.
(2)	BOD 3 days 27o C.	Not to exceed	100	mg/l.

(vi) **Sewage Effluent Disposal:** The treated domestic effluent shall be soaked in a soak pit, which shall be got cleaned periodically. Overflow, if any, shall be used on land for gardening / plantation only.

(vii) **Non-Hazardous Solid Wastes:**

Sr. No.	Type Of Waste	Quantity	UOM	Treatment	Disposal
1	NIL				

(viii)**Other Conditions:** Industry should monitor effluent quality regularly.

4. **The applicant shall comply with the provisions of the Water (Prevention & Control of Pollution) Cess Act, 1977 (to be referred as Cess Act) and amendment Rules, 2003 there under**

The daily water consumption for the following categories is as under:

(i)	Domestic purpose ...	10.00 CMD
(ii)	Water gets Polluted & Pollutants are Biodegradable(Mixing) ...	20.00 CMD
(iii)	Water gets Polluted, Pollutants are not Biodegradable & Toxic ...	00.00 CMD
(iv)	Industrial Washing, spraying` in mine pits or boiler feed ...	00.00 CMD

4. **CONDITIONS UNDER AIR ACT :**

(i) The applicant shall install a comprehensive control system consisting of control equipment as is warranted with reference to generation of emission and operate and maintain the same continuously so as to achieve the level of pollutants to the following standards:

5. **Control Equipment:**

a) Air Pollution Control;

(i) In-house measures;

1. All material transfer points should be covered
2. The dust containment system shall be provided incorporating either of the following
   - Barricading all around the periphery of the plot boundary of height Minimum 20 feet or 5 feet above free fall air emission area, whichever is higher with tin sheets. Same may extend above with netlon clothing whenever required
   - Water sprinkling/Chemical dust stabilizing agent spraying system along the periphery inside the premises of RMC.

3. Internal work area shall be, cement concreted/Asphalted.
4. Daily cleaning / Removal of dust accumulation inside the plant (dry/wet) shall be carry out, with industrial vacuum cleaner.
5. Two level tyre washing facility shall be provided at entry and exit points, for transit mixture vehicle.
6. Industry has to be install fogger system, to suppress dust emissions inside RMC premises.

(ii) Raw material storage & handling;

1. Storage silos of cement & fly-ash shall be equipped with adequate capacity of dust Collection system such as multi- cyclone followed by bag house assembly.
2. Handling of Cement, sand, fly ash and aggregates shall be carried out with mechanical closed system only.
3. Manual operations shall be permitted only in a closed shed, equipped with dust control system at the loading point as well as roof top secondary dust control system.
4. All Conveyor belts of Sand, aggregate shall be covered with tin sheets and at transfer points dust collection system to be installed to avoid secondary fugitive emissions.
5. Mixing section of cement, aggregate & sand shall be equipped with adequate capacity dust collection system, such as multi-cyclone followed by bag house, so as to limit dust emissions.
6. Storage area of sand & aggregate shall be equipped with roof top water sprinkler system.
7. The air pollution control devices shall be operated regularly.
8. Alternative power supply system should cover both the production and Air pollution control system.

6. Standards for Air Emission

Ambient air quality at a distance of 10 mtr from source OR the plant Boundary, whichever is nearer, shall meet the following standards

Particulate Matter PM_{10}	**Not to Exceed**	**100**	**$\mu g/m^3$**
Particulate Matter $PM_{2.5}$	**Not to Exceed**	**60**	**$\mu g/m^3$**

a. A proper routine and preventive maintenance procedure for DG set should be set and followed in consultation with the DG manufacturer which would help to prevent noise levels of DG set from deteriorating with use.

b. D.G. Set shall be operated only in case of power failure

c. The applicant should not cause any nuisance in the surrounding area due to operation of D.G. Set

7. Standards for Stack Emissions:

(i) **The applicant shall observe the following fuel pattern:-**

Sr. No.	Type Of Fuel	Quantity	UOM
	...............NA............		

(ii) **The applicant shall erect the chimney(s) of the following specifications:-**

Sr. No.	Chimney Attached To	Height in mt
	.................NA.............	

(iii)The applicant shall provide ports in the chimney/(s) and facilities such as ladder, platform etc. for monitoring the air emissions and the same shall be open for inspection to/and for use of the Board's Staff. The chimney(s) vents attached to various sources of emission shall be designated by numbers such as S-1, S-2, etc. and these shall be painted/ displayed to facilitate identification.

(iv) The industry shall take adequate measures for control of noise levels from its own sources within the premises so as to maintain ambient air quality standard in respect of noise to less than 75 dB(A) during day time and 70 dB(A) during night time. Day time is reckoned in between 6 a.m. and 10 p.m. and night time is reckoned between 10 p.m. and 6 a.m.

(v) **Other Conditions:**

1) The industry should not cause any nuisance in surrounding area.

2) The industry should monitor stack emissions and ambient air quality regularly.

8. CONDITIONS UNDER HAZARDOUS WASTE (MANAGEMENT, HANDLING & TRANSBOUNDRY MOVEMENT) RULES, 2008:

(i) The Industry shall handle hazardous wastes as specified below.

Sr. No.	Type Of Waste	Quantity	UOM	Disposal
		NIL		

(ii) Treatment: - NIL

a. Whenever due to any accident or other unforeseen act or even, such emissions occur or is apprehended to occur in excess of standards laid down, such information shall be forthwith Reported to Board, concerned Police Station, office of Directorate of Health Services, Department of Explosives, Inspectorate of Factories and Local Body. In case of failure of pollution control equipment, the production process connected to it shall be stopped.

9. Industry shall comply with following additional conditions:

i. The applicant shall maintain good housekeeping and take adequate measures for control of pollution from all sources so as not to cause nuisance to surrounding area / inhabitants.

ii. Solid waste – The nonhazardous solid waste arising in the factory premises, sweepings, etc., be disposed of scientifically so as not to cause any nuisance / pollution. The applicant shall take necessary permissions from civic authorities for disposal to dumping ground.

iii. The applicant shall provide for an alternate electric power source sufficient to operate all pollution control facilities installed by the applicant to maintain compliance with the terms and conditions of the consent. In the absence, the applicant shall stop, reduce or otherwise, control production to abide by terms & conditions of this consent regarding pollution levels.

c/95

iv. The applicant shall not change or alter quantity, quality, the rate of discharge, temperature or the mode of the effluent / emissions or hazardous wastes or control equipment provided for without previous written permission of the Board.

v. The applicant shall provide facility for collection of environmental samples and samples of trade and sewage effluents, air emissions and hazardous wastes to the Board staff at the terminal or designated points and shall pay to the Board for the services rendered in this behalf.

vi. The applicant shall make an application for renewal of the consent at least 60 days before the date of the expiry of the consent.

vii. The firm shall submit to this office, the 30th day of September every year, the Environmental Statement Report for the financial year ending 31st March in the prescribed Form-V as pre the provisions of rule 14 of the Environment (Protection) (Second Amendment) Rules, 1992.

viii. As inspection book shall be opened and made available to the Board's officers during their visit to the applicant.

ix. The applicant shall install a separate electric meter showing the consumption of energy for operation of domestic and industrial effluent treatment plants and air pollution control system. A register showing consumption of chemicals used for treatment shall be maintained.

x. Separate drainage system shall be provided for collection of trade and sewage Effluents. Terminal manholes shall be provided at the end of collection system with arrangement for measuring the flow. No effluent shall be admitted in the pipes / sewers down- stream of the terminal manholes. No effluent shall find its way other than in designed and provided collection System.

xi. Neither storm water nor discharge from other premises shall be allowed to mix with the effluents from the factory.

10. The consent is issued subject to direction issued by CPCB under section 18(1) (b) of Water (Prevention and Control of Pollution) Act, 1974, regarding Classification of Industries dated 07th March 2016.

11. Operation of RMC plant shall be in day time only. The Day time is Reckoned in between 6 a.m. and 6 p.m. i.e from sun rise to sunset.

12. The Capital investment of the industry is Rs. 376.00 Lakhs.

13. The Board reserve right to revoke, amend or suspend the consent granted.

14. The Board may make the standards stringent for the RMC / batching Plants located within Corporation areas.

15. **The consent is issued on the basis of undertaking submitted by industry and NOC issued by MCGM vide No. Ch.E./1098/Costal Road dated 28/09/2018, for temporary activity.**

For and on behalf of the
Maharashtra Pollution Control Board

(Sanjay R. Bhosale)
Sub Regional Officer, Mumbai-I

To,
M/s. L&T Construction (RMC Plant),
Mumbai Coastal Road Project Pkg 4
Near Priyadarshani Park, Nepean Sea Road,
Malabar Hill, Mumbai-400006

Received Consent fee of –

Sr. No.	Amount(Rs.)	DD. No.	Date
1	60000/-	TXN1903002078	19.03.2019

Copy Submitted to:-

1. Chief Account officer, MPCB, Sion, Mumbai-22.,
2. Regional Officer, MPCB, Mumbai.

c/99

Annexure 03

Salient Features of Site Environment Management Plan

MUMBAI COASTAL ROAD PROJECT PKG-II (EGIS CSRCIIK) JV

YOOSHIN TEC-4 PROJECT MANAGER (PMC) MCR (PKG-4)

AECOM Asia Company Limited MUMBAI

Salient Features of Site Environment Management Plan for the Project

Project: Mumbai Coastal Road (South) from Princes Street Flyover to Worli End of Bandra worli sea link.

MCGM has awarded all three Coastal Road Packages Civil Contracts to recognized International Contractors like L&T, HCC-HDC (JV) etc. with experienced International joint venture partners.

These contractors are having ISO 14001 (Environmental Management System) and OHSAS 18001 (Occupational Health and Safety Assessment Series) certifications prior to award of formal contract. (Certificate Photos for each package are attached in appendix).These steps will ensure almost all Environmental Related Compliances are compiled by these contractors. In addition to these following compliances are done or already in progress by all contractors regarding Environmental Compliances mentioned in Site specific Environment Plan as well as stipulated in Legal Requirements applicable to them

1. Preconstruction Air & Noise Monitoring is going on in sites to establish Base Line Air and Noise Monitoring Results. These results will establish Air Pollution Levels and Noise Levels on Coastal Road Project alignment before start of Actual Major Construction Activities. Actual Air and Noise Monitoring results during major Construction works will be compared with Preconstruction results and Standards mentioned legally by MOEF and CPCB. Consent to Establish are being taken by Contractors from MPCB to establish Casting Yard and Batching Plant.

2. For controlling dust on sites Contractors are doing Water Sprinkling on their sites during their work. Wheel Wash Facilities will also be provided at every Main Entrance and Exit of site where Vehicle Movement is there. Wastewater will be treated and will be used for Water Sprinkling and Wheel Washing. Maximum recycling and Reuse of Water will be done.

3. For Controlling Noise, following precautions are being taken on sites:
   I. Noise Barriers will be provided at all Critical Locations like Near Schools and Hospitals etc. At some locations, provision of Noise Barriers is under progress and started as per requirement. Please refer attached appendix for compliance photos.
   II. All Construction vehicles are provided with Noise Mufflers, Good Silencers on sites. Please refer pictures shown in attached appendix.
   III. All Construction sites barricaded by 2m X 2.5 m barricading boards in addition to Noise Barriers to Control Noise and demarcate site from General Public and Road users. Please refer picture shown in appendix. These boards are provided as per IRC SP 55, Type IV (Board).
   IV. All Contractors are using acoustically enclosed DG sets. Sample photos of DG sets are attached in appendix. Presently DG sets provided on site are between ranges of 62.5 KVa to 500 KVa.
   V. Preventive Maintenance schedule for all construction Machinery at site are maintained. All construction machinery is having PUC certificates and they are with in limit. Preventive Maintenance of Machinery will also reduce noise from Machinery. Sample PUC certificate photo is shown in attached appendix.
   VI. All rotating parts of construction machineries will be provided with canopies and grills to control rotating parts noise during construction phase.

YOOSHIN TEC-4 PROJECT MANAGER (PMC) MCR (PKG-4)

MUMBAI COASTAL ROAD PROJECT PKG II EGIS-CGRECUKI JV

AECOM Asia Company Limited MUMBAI

C/101

4. All Environmental Monitoring Data will be displayed on sites at conspicuous places like Casting Yard, all site offices and Entry and Exit of sites. This Environmental Monitoring date will contain, Air and Noise Monitoring Results for Month, Drinking Water Testing Results, and Wastewater Monitoring Results.

5. Every Contractor is having dedicated Environmental Team as stipulated in contract. They have specially dedicated and qualified Environmental Manager along with enough subordinates on sites.

6. All Environmental Monitoring is carried by third party Environmental Monitoring Agency approved by MoEF&CC and NABL. Details of agencies are attached in appendix.

7. Contractors have provided Bio-Toilets on sites. Photos for the same are attached in appendix.

8. All Trucks are covered with Tarpaulin Sheets to avoid fall of soil/material on public Roads. Road cleaning will be done regularly to control dust on public roads.

9. Compliances with evidence photos are attached in Appendix 1, 2 and 3 as Pkg 1, Pkg 2 and Pkg 4 respectively.

Louis Berger Consulting Pvt. Ltd. *

YOOSHIN * TEC-4 * MCR (PKG-4) * PROJECT MANAGER (PMC)

AECOM Asia Company Limited * MUMBAI

MUMBAI COASTAL ROAD PROJECT PKG-4 * HCC-HDC * CGRCUKI JV *

MCRP Package -1 (Appendix 1)

Compliance Status of Environmental Issues

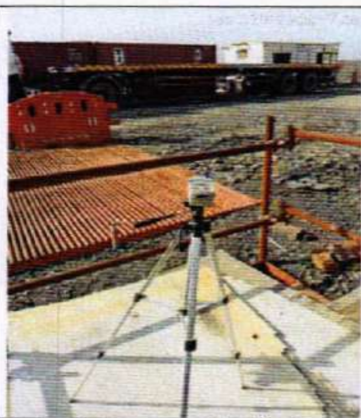
S. No.	Description	Sample Photograph	Remarks
1.	L&T is ISO 14001 (Environmental Management System) and ISO 45001 (EHS Management) certified. M/s. DNV.GL is a third party certification agency and validity of certificate is until; • ISO 45001:2018 – 25 March 2022. • ISO 14001:2018 – 25 March 2022.	 DNV·GL MANAGEMENT SYSTEM CERTIFICATE Larsen & Toubro Limited (L & T Construction - Heavy Civil Infrastructure Independent Company) ISO 14001:2015  DNV·GL MANAGEMENT SYSTEM CERTIFICATE Larsen & Toubro Limited (L & T Construction - Heavy Civil Infrastructure Independent Company) ISO 45001:2018	
2.	Preconstruction Air & Noise Monitoring is going on in sites to establish Base Line Air and Noise Monitoring Results. These results will establish Air Pollution Levels and Noise Levels on Coastal Road Project alignment before start of Actual Major Construction Activities. Actual Air and Noise Monitoring results during major Construction works will be compared with Preconstruction results and		Environment Monitoring is being carried out at site; 1. Ambient Air quality is being monitored at two locations on site, based on the activity. 2. Noise level is being monitored at two locations on site based on the activity.

MUMBAI COASTAL ROAD PROJECT PKG-IV

Louis Berger Consulting Pvt. Ltd.

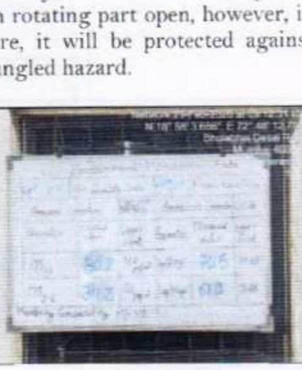
YOOSHIN * TEC-4 * PROJECT MANAGER (PMC) MCR (PKG-4)

AECOM Asia Company MUMBAI

	Standards mentioned legally by MOEF and CPCB.		
3.	For controlling Dust: 1. On-site Water Sprinkling is being carried out on regular basis. The frequency is defined as three times a day. 2. Load carrying vehicles are covered to control the spread of dust particles while transportation. 3. Wheel wash facility is provided. 4. Sedimentation tank (two chambered) will be provided to maximum recycling and Reuse of Water. 5. Green net is placed along the boundary to arrest dust.	  	
4.	For Controlling Noise, following precautions are being taken on sites:		
	1. Noise Barriers at all Critical Locations like Near Schools and Hospitals etc. will be provided.	Will be provided in near future.	
	2. All Construction vehicles are provided with Noise Mufflers, Good Silencers on sites.		

YOOSHIN ★ TEC-4 ★ PROJECT MANAGER (PMC) MCR (PKG-4)

AECOM Asia Company Limited MUMBAI

	3. All Construction sites barricaded by 2m X 2.5 m barricading boards at site in order to demarcate site from General Public and Road users.		As per IRC SP 55 type IV (Board).
	4. DG is provided with acoustic enclosures. Noise reduced up to 75 dB at 1m distance.		
	5. Preventive Maintenance schedule for all construction Machinery at site are maintained. Copy of PUC certificate is provided herewith.	 	
	6. All rotating parts of construction machineries will be provided with canopies and grills to control rotating parts noise.	Presently no machines are placed with rotating part open, however, in future, it will be protected against entangled hazard.	
5.	The Environmental Monitoring Data is displayed on sites at conspicuous places like site & offices. This Environmental Monitoring date will contain, Air and Noise Monitoring Results.		
6.	All Environmental Monitoring is carried by third party Environmental Monitoring Agency approved by MoEF & CC and NABL.		M/s. Netel (India) Limited is MoEF & CC and NABL accredited lab. The copy of MoEF&CC is displayed.

PROJECT MANAGER (PMC)

AECOM Asia Company Limited MUMBAI

c/105

7.	Bio-Toilets are provided at site.		

YOOSHIN * TEC-4 * PROJECT MANAGER (PMC) MCR (PKG-4)

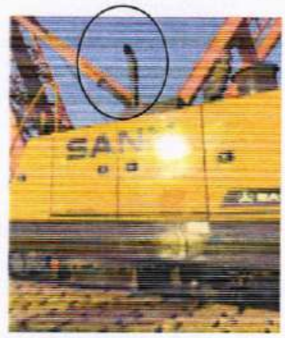
AECOM Asia Company Limited * MUMBAI

MCRP Package -2 (Appendix 2)

Compliance Status of Environmental Issues

S. No.	Description	Sample Photograph	Remarks
1.	HCC is ISO 14001 (Environmental Management System) and OHSAS 18001 certified. M/s. DNV.GL is a third party certification agency and validity of certificate is until; • ISO 14001:2015 – 19 March 2020. • BS OSHAS 18001:2007 – 19 March 2020.		
2.	Preconstruction Air & Noise Monitoring is going on in sites to establish Base Line Air and Noise Monitoring Results. These results will establish Air Pollution Levels and Noise Levels on Coastal Road Project alignment before start of Actual Major Construction Activities. Actual Air and Noise Monitoring results during major Construction works will be compared with Preconstruction results and Standards mentioned legally by MOEF and CPCB.	 	Environment Monitoring is being carried out at site; 1. Ambient Air quality is being monitored at 4 locations on site, based on the activity. 2. Noise level is being monitored at 4 locations on site based on the activity.

c/107

3.	For controlling Dust: 1. On-site Water Sprinkling is being carried out on regular basis. The frequency is defined as two times a day. 2. Load carrying vehicles are covered to control the spread of dust particles while transportation. 3. Wheel wash facility will be provided. 4. Sedimentation tank (two chambered) will be provided maximum recycling and Reuse of Water.	  	
4.	For Controlling Noise, following precautions are being taken on sites:		
	1. Noise Barriers at all Critical Locations like Near Schools and Hospitals etc. will be provided.	Will be provided in future	
	2. All Construction vehicles are provided with Noise Mufflers, Good Silencers on sites.		Vehicles are provided with mufflers and silencers and the same is given in reference
	3. All Construction sites barricaded by 2m X 2.5 m barricading boards at site in order to demarcate site from General Public and Road users.		IRC SP 55 type IV (Board).

COASTAL ROAD PROJECT PKG II EGIS EGRCUKI JV

YOOSHIN TEC-4 PROJECT MANAGER (PMC) MCR (PKG-4)

Asia Company Limited MUMBAI

	4. DG is provided with acoustic enclosures noise reduced upto 75 dB at 1m distance		DG set Provided in acoustic enclosure and the same is given in reference
	5. Preventive Maintenance schedule for all construction Machinery at site are maintained. Copy of PUC certificate is provided herewith.		PUC certificate for the machineries operating in the site
	6. All rotating parts of construction machineries will be provided with canopies and grills to control rotating parts noise.	Presently no machines are placed with rotating part open, however, in future, it will be protected against entangled hazard	
	The Environmental Monitoring Data is displayed on sites at conspicuous places like site & offices. This Environmental Monitoring date will contain, Air and Noise Monitoring Results.	Will be provided in future	
5	All Environmental Monitoring is carried by third party Environmental Monitoring Agency approved by MoEF & CC and NABL.		M/s. Sky Lab Analytical Laboratory has be accredited by NABL/ MOEFCC and the same is given in reference
6	Bio Toilets are provided at site.	-	No bio toilets in MCRP Pkg – II

MCRP Package -4 (Appendix 3)

Compliance Status of Environmental Issues

S. No.	Description	Sample Photograph	Remarks
1.	L&T is ISO 14001 (Environmental Management System) and ISO 45001 (Safety Standard) certified. M/s. DNV.GL is a third party certification agency and validity of certificate is until; • ISO 45001:2018 – 25 March 2022. • ISO 14001:2018 – 25 March 2022.	 MANAGEMENT SYSTEM CERTIFICATE Larsen & Toubro Limited  MANAGEMENT SYSTEM CERTIFICATE Larsen & Toubro Limited	
2.	Preconstruction Air & Noise Monitoring is going on in sites to establish Base Line Air and Noise Monitoring Results. These results will establish Air Pollution Levels and Noise Levels on Coastal Road Project alignment before start of Actual Major Construction Activities. Actual Air and Noise Monitoring results during major Construction works will be compared with Preconstruction results and Standards mentioned legally by MOEF and CPCB.	 	Environment Monitoring is being carried out at site; 1. Ambient Air quality is being monitored at two locations on site, based on the activity. 2. Noise level is being monitored at two locations on site based on the activity.
3.	For controlling Dust: 1. On-site Water Sprinkling is being carried out on regular basis. The frequency is defined as once a day.		

MUMBAI COASTAL ROAD PROJECT PKG-4 AEGIS CGRCUKI JV

AECOM Asia Company Limited MUMBAI

	2. Road cleaning is being carried out on regular basis. 3. Load carrying vehicles are covered to control the spread of dust particles while transportation. 4. Wheel wash facility will be provided. 5. Sedimentation tank (two chambered) will be provided maximum recycling and Reuse of Water. 6. Noise barrier along the residential apartments also restrict the dust to mix in the outer environment.	   	
4.	For Controlling Noise, following precautions are being taken on sites:		
	1. Noise Barriers at all Critical Locations like Near Schools and Hospitals etc. will be provided.		Noise barrier erection work is in progress.
	2. All Construction vehicles are provided with Noise Mufflers, Good Silencers on sites.		

C/118

			
	3. All Construction sites barricaded by 2m X 2.5 m barricading boards at site in order to demarcate site from General Public and Road users.		IRC SP 55 type IV (Board).
	4. DG is provided with acoustic enclosures noise reduced up to 75 dB at 1 m distance		
	5. Preventive Maintenance schedule for all construction Machinery/vehicle at site are maintained. Copy of PUC certificate is provided herewith.		
	6. All rotating parts of construction machineries will be provided with canopies and grills to control rotating parts noise.		

5	The Environmental Monitoring Data is displayed on sites at conspicuous places like site & offices. This Environmental Monitoring date will contain, Air and Noise Monitoring Results.	The Environmental Monitoring Data will be displayed on sites at conspicuous places like site & offices.	
6	All Environmental Monitoring is carried by third party Environmental Monitoring Agency approved by MoEF & CC and NABL.	 भारत का राजपत्र The Gazette of India	M/s Horizon Service engaged for the environmental monitoring work. Company having MoEF & CC and NABL accredited lab facility.
7	Bio Toilets are provided at site.		

C/113

Annexure 04

Environment Monitoring Report
October 2019 - March 2020

Mumbai Coastal Road Package - 01

C/115

Mumbai Coastal Raod Project (Package-1)
Ambient Air Quality Monitoring

#	Date	Parameters (24 Hrs) & Unit	Result	NAAQS Limit	Parameters (24 Hrs) & Unit	Result	NAAQS Limit
Location		Amarson Garden			Location : Amarson Garden		
1	01-Oct-19		28.6	60		73.7	100
2	04-Oct-19		34.3	60		77.5	100
3	09-Oct-19		36	60		76.8	100
4	11-Oct-19		36.5	60		77.2	100
5	15-Oct-19	PM 2.5 µg/m3	26.8	60	PM 10 µg/m3	67.4	100
6	18-Oct-19		33	60		68.9	100
7	23-Oct-19		32.6	60		61.5	100
8	25-Oct-19		26.3	60		71.4	100
9	30-Oct-19		20.4	60		62.5	100
10	01-Nov-19		35.2	60		79.3	100
11	05-Nov-19		32.6	60		66.4	100
12	08-Nov-19		39.9	60		78.1	100
13	12-Nov-19		32.1	60		69.9	100
14	15-Nov-19	PM 2.5 µg/m3	34.7	60	PM 10 µg/m3	70.5	100
15	19-Nov-19		33.8	60		71.8	100
16	22-Nov-19		24.3	60		69.6	100
17	27-Nov-19		39.5	60		84	100
18	29-Nov-19		34.7	60		78.7	100
19	03-Dec-19		29.5	60		78.1	100
20	06-Dec-19		36.9	60		87.7	100
21	10-Dec-19		33.9	60		78.5	100
22	13-Dec-19		30.4	60		77.8	100
23	17-Dec-19	PM 2.5 µg/m3	38.2	60	PM 10 µg/m3	90.5	100
24	20-Dec-19		30.8	60		86.2	100
25	24-Dec-19		31.5	60		83.4	100
26	27-Dec-19		38.5	60		90.7	100
27	31-Dec-19		41.2	60		74.9	100
28	03-Jan-20		35.6	60		76	100
29	07-Jan-20		31.3	60		84	100
30	10-Jan-20		48.6	60		88	100
31	14-Jan-20		40.4	60		84.8	100
32	17-Jan-20	PM 2.5 µg/m3	51.3	60	PM 10 µg/m3	91.2	100
33	21-Jan-20		43.1	60		88.5	100
34	24-Jan-20		38.2	60		81.9	100

Mumbai Coastal Raod Project (Package-1)
Ambient Air Quality Monitoring

#	Date	Parameters (24 Hrs) & Unit	Result	NAAQS Limit	Parameters (24 Hrs) & Unit	Result	NAAQS Limit
Location		Haji Ali			Location : Haji Ali		
1	01-Oct-19		39.9	60		81.1	100
2	04-Oct-19		37.3	60		82.7	100
3	09-Oct-19		32.1	60		78.3	100
4	11-Oct-19		27.8	60		79.8	100
5	15-Oct-19	PM 2.5 µg/m3	-	60	PM 10 µg/m3	-	100
6	18-Oct-19		21.6	60		58.8	100
7	23-Oct-19		36.5	60		69.8	100
8	25-Oct-19		31.6	60		78.2	100
9	30-Oct-19		23.5	60		68.3	100
10	01-Nov-19		39.5	60		74.3	100
11	05-Nov-19		25.2	60		71.9	100
12	08-Nov-19		35.2	60		65.3	100
13	12-Nov-19		25.6	60		71.4	100
14	15-Nov-19	PM 2.5 µg/m3	41.2	60	PM 10 µg/m3	79.4	100
15	19-Nov-19		29.5	60		67.3	100
16	22-Nov-19		33.4	60		73.2	100
17	27-Nov-19		37.3	60		81.3	100
18	29-Nov-19		48.6	60		81.6	100
19	03-Dec-19		33.4	60		85.3	100
20	06-Dec-19		30.8	60		75.4	100
21	10-Dec-19		40.4	60		83.8	100
22	13-Dec-19		30.8	60		78.2	100
23	17-Dec-19	PM 2.5 µg/m3	45.1	60	PM 10 µg/m3	83.9	100
24	20-Dec-19		40.8	60		81.9	100
25	24-Dec-19		37.3	60		88.5	100
26	27-Dec-19		34.3	60		79.6	100
27	31-Dec-19		47.3	60		90.6	100
28	03-Jan-20		30.4	60		82	100
29	07-Jan-20		36	60		76.5	100
30	10-Jan-20		31.3	60		76.7	100
31	14-Jan-20		34.8	60		82.3	100
32	17-Jan-20	PM 2.5 µg/m3	48.5	60	PM 10 µg/m3	86.7	100
33	21-Jan-20		45.8	60		80.6	100
34	24-Jan-20		43.2	60		82.6	100

35	28-Jan-20		38.2	60		79.8	100
36	31-Jan-20		31.8	60		76.9	100
37	04-Feb-20		41.2	60		91.2	100
38	07-Feb-20		37.3	60		78.2	100
39	11-Feb-20		28.6	60		79.3	100
40	15-Feb-20	PM 2.5 µg/m3	46.9	60	PM 10 µg/m3	93.6	100
41	18-Feb-20		39.9	60		79.6	100
42	21-Feb-20		34.3	60		80.2	100
43	25-Feb-20		32.6	60		83.2	100
44	28-Feb-20		43.8	60		88.4	100
45	03-Mar-20		30.8	60		79.3	100
46	06-Mar-20		43.8	60		87.9	100
47	11-Mar-20	PM 2.5 µg/m3	52.1	60	PM 10 µg/m3	94.8	100
48	14-Mar-20		47.5	60		95.2	100
49	18-Mar-20		34.2	60		70.4	100

35	28-Jan-20		43.1	60		84.8	100
36	31-Jan-20		29.8	60		78.5	100
37	04-Feb-20		32.6	60		83.4	100
38	07-Feb-20		36.5	60		88.7	100
39	11-Feb-20		36	60		90.3	100
40	15-Feb-20	PM 2.5 µg/m3	49.2	60	PM 10 µg/m3	95.8	100
41	18-Feb-20		44.7	60		89.5	100
42	21-Feb-20		48.6	60		91.8	100
43	25-Feb-20		36.5	60		86.7	100
44	28-Feb-20		48.7	60		93.4	100
45	03-Mar-20		44.7	60		83.5	100
46	06-Mar-20		43.4	60		86.7	100
47	11-Mar-20	PM 2.5 µg/m3	31.3	60	PM 10 µg/m3	85	100
48	14-Mar-20		43.8	60		91.3	100
49	18-Mar-20		32.2	60		75.5	100

Sign:

c/117

Mumbai Coastal Raod Project (Package-1)						
Ambient Noise Level Monitoring						
S. No	Amarson Garden- Leq-Day			Amarson Garden- Leq-Night		
	Date	Value	Standard	Date	Value	Standard
1	01-Oct-19	71.1	75	01-Oct-19	65.2	70
2	09-Oct-19	70.1	75	09-Oct-19	66.3	70
3	15-Oct-19	70.9	75	15-Oct-19	64.9	70
4	23-Oct-19	68.5	75	23-Oct-19	65.5	70
5	30-Oct-19	70.5	75	30-Oct-19	64.5	70
6	05-Nov-19	69.7	75	05-Nov-19	66.2	70
7	12-Nov-19	70.5	75	12-Nov-19	64.9	70
8	19-Nov-19	69.4	75	19-Nov-19	63.8	70
9	27-Nov-19	68.6	75	27-Nov-19	65.5	70
10	03-Dec-19	69.3	75	03-Dec-19	66	70
11	10-Dec-19	68.3	75	10-Dec-19	63.8	70
12	17-Dec-19	68.9	75	17-Dec-19	62.6	70
13	24-Dec-19	70.6	75	24-Dec-19	64.1	70
14	31-Dec-19	69.2	75	31-Dec-19	65.5	70
15	07-Jan-20	68.3	75	07-Jan-20	63.2	70
16	14-Jan-20	67.9	75	14-Jan-20	63.6	70
17	21-Jan-20	69.3	75	21-Jan-20	65.1	70
18	28-Jan-20	70.9	75	28-Jan-20	66.2	70
19	04-Jan-20	70.9	75	04-Jan-20	69.3	70
20	11-Feb-20	68.7	75	11-Feb-20	65.9	70
21	18-Feb-20	72.4	75	18-Feb-20	68.2	70
22	25-Feb-20	69.4	75	25-Feb-20	68	70
23	03-Mar-20	72.1	75	03-Mar-20	67.4	70
24	11-Mar-20	74.3	75	11-Mar-20	67.5	70
25	18-Mar-20	68.9	75	18-Mar-20	63.5	70

Mumbai Coastal Raod Project (Package-1)						
Ambient Noise Level Monitoring						
S. No	Haji Ali- Leq-Day			Haji Ali- Leq-Night		
	Date	Value	Standard	Date	Value	Standard
1	01-Oct-19	69.7	75	01-Oct-19	68.9	70
2	09-Oct-19	70.3	75	09-Oct-19	67.2	70
3	15-Oct-19	69	75	15-Oct-19	64	70
4	23-Oct-19	68	75	23-Oct-19	65.9	70
5	30-Oct-19	69.4	75	30-Oct-19	65	70
6	05-Nov-19	65.2	75	05-Nov-19	58.9	70
7	12-Nov-19	68.5	75	12-Nov-19	63.5	70
8	19-Nov-19	64.5	75	19-Nov-19	60.9	70
9	27-Nov-19	68.3	75	27-Nov-19	67	70
10	03-Dec-19	68.6	75	03-Dec-19	64.9	70
11	10-Dec-19	70.2	75	10-Dec-19	65.5	70
12	17-Dec-19	68	75	17-Dec-19	60.6	70
13	24-Dec-19	71.8	75	24-Dec-19	65.3	70
14	31-Dec-19	71.9	75	31-Dec-19	66.9	70
15	07-Jan-20	68.9	75	07-Jan-20	66.8	70
16	14-Jan-20	70.4	75	14-Jan-20	67.5	70
17	21-Jan-20	68.9	75	21-Jan-20	67	70
18	28-Jan-20	70.8	75	28-Jan-20	65.1	70
19	04-Jan-20	68.2	75	04-Jan-20	64.9	70
20	11-Feb-20	69.3	75	11-Feb-20	66.7	70
21	18-Feb-20	70.8	75	18-Feb-20	64.9	70
22	25-Feb-20	70.2	75	25-Feb-20	68.1	70
23	03-Mar-20	71.1	75	03-Mar-20	64.9	70
24	11-Mar-20	72.1	75	11-Mar-20	61.2	70
25	18-Mar-20	70	75	18-Mar-20	68.3	70

AECOM Asia Company Limited MUMBAI

Louis Berger Consulting Pvt. Ltd.

L&T CONSTRUCTION LTD. MCRP. PKG.-1 Sign:

C/119

Mumbai Coastal Raod Project

Ambient Air Quality Monitoring

#	Date	Parameters (24 Hrs) & Unit	Result	NAAQS Limit	Parameters (24 Hrs) & Unit		Result	NAAQS Limit
Location		Worli Sea Face Public Toilet			Location : Worli Sea Face Public Toilet			
1	04.10.2019	PM 2.5 µg/m3	30.5	60	PM 10 µg/m3	04.10.2019	52.6	100
2	07.10.2019		30.5	60		07.10.2019	56.6	100
3	11.10.2019		28.3	60		11.10.2019	55.3	100
4	14.10.2019		32.7	60		14.10.2019	63.8	100
5	18.10.2019		32.5	60		18.10.2019	64.5	100
6	22.10.2019		36.3	60		22.10.2019	56.4	100
7	25.10.2019		33.4	60		25.10.2019	67.2	100
8	30.10.2019		32.5	60		30.10.2019	63.9	100
9	02.11.2019		29.6	60		02.11.2019	62.6	100
10	08.11.2019		25.3	60		08.11.2019	52.3	100
11	15.11.2019		35.6	60		15.11.2019	89.4	100
12	18.11.2019		36.2	60		18.11.2019	76.1	100
13	22.11.2019		35.3	60		22.11.2019	78.3	100
14	25.11.2019		40.5	60		25.11.2019	80.4	100
15	29.11.2019		38.3	60		29.11.2019	82.6	100
16	02.12.2019		32.5	60		02.12.2019	66.2	100
17	07.12.2019		33.5	60		07.12.2019	65.3	100
18	13.12.2019		30.3	60		13.12.2019	63.2	100
19	16.12.2019		30.1	60		16.12.2019	70.5	100
20	20.12.2019		32.3	60		20.12.2019	65.5	100
21	23.12.2019		40.5	60		23.12.2019	82	100
22	27.12.2019		39.6	60		27.12.2019	81.3	100
23	30.12.2019		46.7	60		30.12.2019	85.8	100
24	03.01.2020		39.4	60		03.01.2020	74.1	100
25	06.01.2020		52.2	60		06.01.2020	91	100
26	10.01.2020		45.6	60		10.01.2020	87.7	100
27	13.01.2020			60		13.01.2020	88.3	100
28	17.01.2020		49.1	60		17.01.2020	92.8	100
29	20.01.2020		48.4	60		20.01.2020	85.4	100
30	24.01.2020		46	60		24.01.2020	89.5	100
31	27.01.2020		44.2	60		27.01.2020	86.3	100
32	31.01.2020		53.5	60		31.01.2020	93.6	100
33	03.02.2020		51.4	60		03.02.2020	90.5	100
34	07.02.2020		50.3	60		07.02.2020	91.5	100
35	10.02.2020		54.3	60		10.02.2020	92.7	100
36	14.02.2020		53.4	60		14.02.2020	94.7	100
37	17.02.2020		51.3	60		17.02.2020	90.1	100

L&T-ECOM Asia Company Limited MUMBAI

MUMBAI COASTAL ROAD PROJECT PKG II JV (EGIS-CORCUKI)

Pritam

C/223

38	21.02.2020	50.6	60		21.02.2020	93.3	100
39	24.02.2020	46.7	60		24.02.2020	94.4	100
40	28.02.2020	47.3	60		28.02.2020	89.7	100
41	02.03.2020	41.5	60		02.03.2020	84.6	100
42	06.03.2020	52.2	60		06.03.2020	92.4	100
43	09.03.2020	48.4	60		09.03.2020	89.6	100
44	13.03.2020	38.4	60		13.03.2020	84.7	100
45	16.03.2020	24.6	60		16.03.2020	48.4	100
46	20.03.2020	18.2	60		20.03.2020	40.5	100
47	24.03.2020	24.6	60		24.03.2020	48.4	100

AECOM Asia Company Limited

C|225

Mumbai Coastal Raod Project

Ambient Air Quality Monitoring

#	Date	Parameters (24 Hrs) & Unit	Result	NAAQS Limit	Parameters (24 Hrs) & Unit		Result	NAAQS Limit
Location		Worli Dairy			Location : Worli Dairy			
1	04.10.2019	PM 2.5 µg/m3	31.7	60	PM 10 µg/m3	04.10.2019	58.3	100
2	07.10.2019		32.6	60		07.10.2019	60.2	100
3	11.10.2019		29.6	60		11.10.2019	56.7	100
4	14.10.2019		35.6	60		14.10.2019	66.7	100
5	18.10.2019		32.2	60		18.10.2019	53.8	100
6	22.10.2019		30.8	60		22.10.2019	57.7	100
7	25.10.2019		31.9	60		25.10.2019	60.2	100
8	30.10.2019		30.7	60		30.10.2019	66.6	100
9	02.11.2019		28.5	60		02.11.2019	58.3	100
10	08.11.2019		24.3	60		08.11.2019	53.4	100
11	15.11.2019		34.3	60		15.11.2019	68.2	100
12	18.11.2019		37.5	60		18.11.2019	72.6	100
13	22.11.2019		38.7	60		22.11.2019	75.5	100
14	25.11.2019		37.8	60		25.11.2019	76.3	100
15	29.11.2019		42.1	60		29.11.2019	78.8	100
16	02.12.2019		36.2	60		02.12.2019	70.5	100
17	07.12.2019		32.7	60		07.12.2019	68.8	100
18	13.12.2019		30.5	60		13.12.2019	60.4	100
19	16.12.2019		32.6	60		16.12.2019	71.6	100
20	20.12.2019		29.5	60		20.12.2019	64.2	100
21	23.12.2019		38.6	60		23.12.2019	78.3	100
22	27.12.2019		42.4	60		27.12.2019	84.1	100
23	30.12.2019		44.9	60		30.12.2019	86.4	100
24	03.01.2020		41.5	60		03.01.2020	77.9	100
25	06.01.2020		48.4	60		06.01.2020	90.5	100
26	10.01.2020		47.1	60		10.01.2020	86.8	100
27	13.01.2020		50.6	60		13.01.2020	92.3	100
28	17.01.2020		51.4	60		17.01.2020	93.2	100
29	20.01.2020		47.5	60		20.01.2020	88.3	100
30	24.01.2020		43.5	60		24.01.2020	87	100
31	27.01.2020		45.3	60		27.01.2020	84.4	100
32	31.01.2020		48.3	60		31.01.2020	91.5	100
33	03.02.2020		48.6	60		03.02.2020	87.8	100
34	07.02.2020		46.6	60		07.02.2020	89.3	100
35	10.02.2020		51.6	60		10.02.2020	89.5	100
36	14.02.2020		50.7	60		14.02.2020	91.6	100
37	17.02.2020		48.7	60		17.02.2020	86.6	100

Pritam

C|227

38	21.02.2020	45.4	60		21.02.2020	88.6	100
39	24.02.2020	52.4	60		24.02.2020	91.5	100
40	28.02.2020	42.3	60		28.02.2020	85.6	100
41	02.03.2020	45.4	60		02.03.2020	79.5	100
42	06.03.2020	38.5	60		06.03.2020	87.3	100
43	09.03.2020	43.5	60		09.03.2020	86.8	100
44	13.03.2020	37.8	60		13.03.2020	80.4	100
45	16.03.2020	47.7	60		16.03.2020	90.3	100
46	20.03.2020	24.6	60		20.03.2020	37.3	100
47	24.03.2020	21.3	60		24.03.2020	45.3	100

AECOM Asia Company Limited
MUMBAI

Mumbai Coastal Raod Project

Ambient Noise Quality Monitoring

S. No	Worli Sea Face Public Toilet- Leq-			Worli Sea Face Public Toilet- Leq-		
	Date	Value	Standard	Date	Value	Standard
1	04.10.2019	63.3	75	04.10.2019	59.8	70
2	07.10.2019	63.6	75	07.10.2019	57.9	70
3	11.10.2019	61.1	75	11.10.2019	57.6	70
4	14.10.2019	62.2	75	14.10.2019	57.6	70
5	18.10.2019	68.8	75	18.10.2019	65.1	70
6	22.10.2019	61.2	75	22.10.2019	57.7	70
7	25.10.2019	64.9	75	25.10.2019	62.2	70
8	30.10.2019	62.2	75	30.10.2019	59	70
9	02.11.2019	67.8	75	02.11.2019	59.3	70
10	08.11.2019	64.3	75	08.11.2019	59.2	70
11	15.11.2019	66.3	75	15.11.2019	61	70
12	18.11.2019	62.1	75	18.11.2019	58.4	70
13	22.11.2019	66.4	75	22.11.2019	60.3	70
14	25.11.2019	59	75	25.11.2019	56.3	70
15	29.11.2019	66.5	75	29.11.2019	62.9	70
16	02.12.2019	56	75	02.12.2019	53.9	70
17	07.12.2019	60	75	07.12.2019	56.6	70
18	13.12.2019	62	75	13.12.2019	59.3	70
19	16.12.2019	63	75	16.12.2019	57.7	70
20	20.12.2019	61.1	75	20.12.2019	59.8	70
21	23.12.2019	61.8	75	23.12.2019	52.6	70
22	27.12.2019	63.7	75	27.12.2019	51	70
23	30.12.2019	60.8	75	30.12.2019	55.5	70
24	03.01.2020	65.8	75	03.01.2020	58.6	70
25	06.01.2020	65.3	75	06.01.2020	58.6	70
26	10.01.2020	61.8	75	10.01.2020	56.6	70
27	13.01.2020	62.5	75	13.01.2020	57.5	70
28	17.01.2020	67.4	75	17.01.2020	58	70
29	20.01.2020	62.8	75	20.01.2020	56.8	70
30	24.01.2020	62.6	75	24.01.2020	56.4	70
31	27.01.2020	66.2	75	27.01.2020	61	70
32	31.01.2020	65.1	75	31.01.2020	63.8	70
33	03.02.2020	65	75	03.02.2020	61.2	70
34	07.02.2020	64	75	07.02.2020	59.7	70
35	10.02.2020	65.1	75	10.02.2020	60.5	70
36	14.02.2020	65	75	14.02.2020	62.1	70
37	17.02.2020	64.3	75	17.02.2020	60	70
38	21.02.2020	62	75	21.02.2020	57.9	70
39	24.02.2020	65.3	75	24.02.2020	60.1	70
40	28.02.2020	63.4	75	28.02.2020	59.7	70
41	02.03.2020	64.5	75	02.03.2020	62	70
42	06.03.2020	67.9	75	06.03.2020	63.2	70
43	09.03.2020	66.2	75	09.03.2020	63.1	70
44	13.03.2020	64.6	75	13.03.2020	60.5	70
45	16.03.2020	65.4	75	16.03.2020	57.5	70
46	20.03.2020	66.2	75	20.03.2020	56.1	70
47	24.03.2020	63.4	75	24.03.2020	57.4	70

AECOM India Company Limited MUMBAI

Pritam

MUMBAI COASTAL ... PKG II JV

C|231

Mumbai Coastal Raod Project

Ambient Noise Quality Monitoring

S. No	Worli Dairy - Leq-Day			Worli Dairy - Leq-Night		
	Date	Value	Standard	Date	Value	Standard
1	04.10.2019	67.5	75	04.10.2019	57.7	70
2	07.10.2019	66	75	07.10.2019	62.2	70
3	11.10.2019	66.4	75	11.10.2019	60.5	70
4	14.10.2019	65.2	75	14.10.2019	61.2	70
5	18.10.2019	65.3	75	18.10.2019	57.1	70
6	22.10.2019	61.3	75	22.10.2019	60.4	70
7	25.10.2019	68	75	25.10.2019	62.2	70
8	30.10.2019	67.8	75	30.10.2019	59.3	70
9	02.11.2019	64.7	75	02.11.2019	62.7	70
10	08.11.2019	67.4	75	08.11.2019	58.6	70
11	15.11.2019	66.7	75	15.11.2019	60.5	70
12	18.11.2019	67.4	75	18.11.2019	61.9	70
13	22.11.2019	67.2	75	22.11.2019	59.5	70
14	25.11.2019	69.7	75	25.11.2019	59.3	70
15	29.11.2019	61.2	75	29.11.2019	58.1	70
16	02.12.2019	68.7	75	02.12.2019	61.4	70
17	07.12.2019	69.5	75	07.12.2019	57.8	70
18	13.12.2019	64.8	75	13.12.2019	60.4	70
19	16.12.2019	65.6	75	16.12.2019	62.6	70
20	20.12.2019	63.5	75	20.12.2019	61	70
21	23.12.2019	67.9	75	23.12.2019	56.9	70
22	27.12.2019	70.6	75	27.12.2019	62.1	70
23	30.12.2019	68.6	75	30.12.2019	60.7	70
24	03.01.2020	68.5	75	03.01.2020	61.8	70
25	06.01.2020	69.9	75	06.01.2020	63.2	70
26	10.01.2020	66.4	75	10.01.2020	61.1	70
27	13.01.2020	69.1	75	13.01.2020	62	70
28	17.01.2020	66.7	75	17.01.2020	61	70
29	20.01.2020	66.7	75	20.01.2020	63.9	70
30	24.01.2020	64.7	75	24.01.2020	62.5	70
31	27.01.2020	69.9	75	27.01.2020	66.4	70
32	31.01.2020	70.8	75	31.01.2020	65.5	70
33	03.02.2020	67.8	75	03.02.2020	64.5	70
34	07.02.2020	72.7	75	07.02.2020	62.6	70
35	10.02.2020	71.9	75	10.02.2020	66	70
36	14.02.2020	72.4	75	14.02.2020	65.8	70
37	17.02.2020	74.8	75	17.02.2020	67.4	70
38	21.02.2020	70.4	75	21.02.2020	67.2	70
39	24.02.2020	69.8	75	24.02.2020	66.4	70
40	28.02.2020	65.9	75	28.02.2020	60.8	70
41	02.03.2020	66.9	75	02.03.2020	62.6	70
42	06.03.2020	67.2	75	06.03.2020	64.5	70
43	09.03.2020	67.9	75	09.03.2020	63.9	70
44	13.03.2020	67.2	75	13.03.2020	61.3	70
45	16.03.2020	69.6	75	16.03.2020	62.7	70
46	20.03.2020	70.1	75	20.03.2020	52.9	70
47	24.03.2020	63.7	75	24.03.2020	51	70

MUMBAI

Pritam

MUMBAI COASTAL ROAD PROJECT PKG II * JV

C/253

		 5. Wheel wash facility will be placed for checking and controlling mud/soil from vehicles. These vehicles will be washed before leaving site.
10	MCGM to implement Green Belt Development plan	Noted
11	MCGM to implement all suggestions /recommendation given in the EIA, EMP, DMP studies for the project.	Noted, will be complied
12	All other required permissions should be obtained before the commencement of the project.	Noted

Louis Berger Consulting Pvt. Ltd.

YOOSHIN TEC-4 PROJECT MANAGER (PMC) MCR (PKG-4)

MUMBAI COASTAL ROAD PROJECT PKG II (EGIS-CGRCUK) JV

AECOM Asia Company Limited MUMBAI

C/233

Mumbai Coastal Raod Project

Ambient Air Quality Monitoring

S.No	Date	Parameters (24 Hrs) & Unit	Result	NAAQS Limit	Parameters (24 Hrs) & Unit	Date	Result	NAAQS Limit
Location: Priyadarshini Park Project Area								
1	03.10.2019	PM 2.5	26.5	60	PM 10	03.10.2019	47.5	100
2	05.10.2019	µg/m3	23.2	60	µg/m3	05.10.2019	42.1	100
3	09.10.2019		30.2	60		09.10.2019	57.3	100
4	11.10.2019		26.5	60		11.10.2019	54.8	100
5	15.10.2019		26.4	60		15.10.2019	50.2	100
6	17.10.2019		30.2	60		17.10.2019	58.5	100
7	22.10.2019		24.3	60		22.10.2019	51.3	100
8	23.10.2019		22.1	60		23.10.2019	45.3	100
9	30.10.2019		30.3	60		30.10.2019	58.7	100
10	01.11.2019		32.1	60		01.11.2019	65.2	100
11	06.11.2019		24.2	60		06.11.2019	50.5	100
12	08.11.2019		23.0	60		08.11.2019	46.4	100
13	13.11.2019		20.8	60		13.11.2019	43.2	100
14	15.11.2019		25.2	60		15.11.2019	48.7	100
15	20.11.2019		23.2	60		20.11.2019	48.8	100
16	22.11.2019		20.5	60		22.11.2019	43.3	100
17	27.11.2019		18.7	60		27.11.2019	41.7	100
18	29.11.2019		20.9	60		29.11.2019	46.0	100
19	04.12.2019		23.1	60		04.12.2019	49.9	100
20	06.12.2019		20.7	60		06.12.2019	41.3	100
21	11.12.2019		20.7	60		11.12.2019	42.1	100
22	13.12.2019		23.5	60		13.12.2019	46.4	100
23	18.12.2019		25.0	60		18.12.2019	49.1	100
24	19.12.2019		20.0	60		19.12.2019	42.3	100
25	26.12.2019		35.7	60		26.12.2019	71.7	100
26	28.12.2019		42.1	60		28.12.2019	84.3	100
27	02.01.2020		77.1	60		02.01.2020	140.8	100
28	04.01.2020		63.3	60		04.01.2020	124.8	100
29	08.01.2020		76.2	60		08.01.2020	152.5	100
30	10.01.2020		62.9	60		10.01.2020	135.1	100
31	15.01.2020		65.6	60		15.01.2020	130.2	100
32	17.01.2020		55.2	60		17.01.2020	110.5	100
33	22.01.2020		63.7	60		22.01.2020	130.2	100
34	24.01.2020		78.8	60		24.01.2020	152.7	100
35	29.01.2020		50.4	60		29.01.2020	106.0	100
36	30.01.2020		70.4	60		30.01.2020	122.8	100
37	05.02.2020		48.8	60		05.02.2020	90.9	100
38	07.02.2020		56.3	60		07.02.2020	110.3	100
39	12.02.2020		81.7	60		12.02.2020	170.3	100
40	14.02.2020		92.9	60		14.02.2020	180.7	100
41	19.02.2020		82.9	60		19.02.2020	152.2	100
42	21.02.2020		62.4	60		21.02.2020	138.4	100
43	26.02.2020		70.3	60		26.02.2020	135.9	100
44	28.02.2020		75.2	60		28.02.2020	140.2	100
45	04.03.2020		70.0	60		04.03.2020	132.4	100
46	06.03.2020		80.2	60		06.03.2020	145.7	100
47	11.03.2020		64.3	60		11.03.2020	125.7	100
48	13.03.2020		72.2	60		13.03.2020	140.4	100
49	18.03.2020		72.7	60		18.03.2020	120.5	100
50	20.03.2020		78.6	60		20.03.2020	134.8	100

AECOM Asia Company Limited MUMBAI

YOOSHIN TEC-4 PROJECT MANAGER (PMC) MCR (PKG-4)

C/235

Mumbai Coastal Raod Project

Ambient Air Quality Monitoring

S.No	Date	Parameters (24 Hrs) & Unit	Result	NAAQS Limit	Parameters (24 Hrs) & Unit	Date	Result	NAAQS Limit
Location: Giragaon Chowpatty Project Area								
1	03.10.2019	PM 2.5 µg/m3	20.1	60	PM 10 µg/m3	03.10.2019	41.7	100
2	05.10.2019		23.7	60		05.10.2019	47.5	100
3	10.10.2019		24.1	60		10.10.2019	48.8	100
4	12.10.2019		22.1	60		12.10.2019	43.3	100
5	15.10.2019		20.4	60		15.10.2019	42.2	100
6	17.10.2019		17.9	60		17.10.2019	38.5	100
7	22.10.2019		30.0	60		22.10.2019	54.4	100
8	23.10.2019		25.4	60		23.10.2019	50.6	100
9	30.10.2019		22.4	60		30.10.2019	42.2	100
10	01.11.2019		24.5	60		01.11.2019	48.8	100
11	06.11.2019		23.1	60		06.11.2019	46.5	100
12	08.11.2019		19.6	60		08.11.2019	40.6	100
13	13.11.2019		20.6	60		13.11.2019	40.2	100
14	15.11.2019		19.8	60		15.11.2019	36.5	100
15	20.11.2019		19.7	60		20.11.2019	35.5	100
16	22.11.2019		21.5	60		22.11.2019	41.4	100
17	27.11.2019		25.1	60		27.11.2019	48.2	100
18	29.11.2019		28.6	60		29.11.2019	53.2	100
19	04.12.2019		19.9	60		04.12.2019	40.2	100
20	06.12.2019		26.5	60		06.12.2019	53.3	100
21	11.12.2019		21.1	60		11.12.2019	53.3	100
22	13.12.2019		23.2	60		13.12.2019	46.4	100
23	18.12.2019		24.6	60		18.12.2019	48.7	100
24	19.12.2019		25.4	60		19.12.2019	52.1	100
25	26.12.2019		47.7	60		26.12.2019	92.7	100
26	28.12.2019		41.2	60		28.12.2019	85.7	100
27	02.01.2020		59.2	60		02.01.2020	110.4	100
28	04.01.2020		73.3	60		04.01.2020	148.5	100
29	08.01.2020		49.6	60		08.01.2020	109.9	100
30	10.01.2020		64.6	60		10.01.2020	130.2	100
31	15.01.2020		41.3	60		15.01.2020	91.8	100
32	17.01.2020		57.1	60		17.01.2020	120.4	100
33	22.01.2020		54.9	60		22.01.2020	111.0	100
34	24.01.2020		62.1	60		24.01.2020	121.7	100
35	29.01.2020		64.8	60		29.01.2020	110.3	100
36	30.01.2020		75.3	60		30.01.2020	130.6	100
37	05.02.2020		70.3	60		05.02.2020	135.7	100
38	07.02.2020		64.5	60		07.02.2020	123.1	100
39	12.02.2020		72.9	60		12.02.2020	140.3	100
40	14.02.2020		67.5	60		14.02.2020	114.8	100
41	19.02.2020		55.3	60		19.02.2020	105.1	100
42	21.02.2020		63.7	60		21.02.2020	125.8	100
43	26.02.2020		72.5	60		26.02.2020	132.2	100
44	28.02.2020		81.2	60		28.02.2020	148.5	100
45	04.03.2020		65.1	60		04.03.2020	120.5	100
46	06.03.2020		71.6	60		06.03.2020	135.2	100
47	11.03.2020		69.1	60		11.03.2020	128.6	100
47	13.03.2020		..	60		13.03.2020	110.4	100
47	18.03.2020		72.1	60		18.03.2020	135.7	100
47	20.03.2020		65.3	60		20.03.2020	118.2	100

AECOM Asia Company Limited MUMBAI

PROJECT MANAGER (PMC) MCR (PKG-4)

Mumbai Coastal Raod Project						
Ambient Noise Quality Monitoring						
S. No	Location: Giragaon Chowpatty Project Area					
	Leq- Day			Leq- Night		
	Date	Value	Standard	Date	Value	Standard
1	05.10.2019	72.88	75	05.10.2019	61.99	70
2	11.10.2019	73.02	75	11.10.2019	62.00	70
3	17.10.2019	71.79	75	17.10.2019	57.20	70
4	23.10.2019	71.66	75	23.10.2019	57.39	70
5	01.11.2019	72.07	75	01.11.2019	62.68	70
6	08.11.2019	72.90	75	08.11.2019	59.23	70
7	15.11.2019	72.94	75	15.11.2019	60.08	70
8	22.11.2019	71.59	75	22.11.2019	60.92	70
9	29.11.2019	72.23	75	29.11.2019	65.57	70
10	06.12.2019	71.09	75	06.12.2019	67.77	70
11	13.12.2019	70.76	75	13.12.2019	63.50	70
12	20.12.2019	73.80	75	20.12.2019	60.61	70
13	28.12.1920	73.95	75	28.12.1920	59.15	70
14	04.01.2020	73.42	75	04.01.2020	58.28	70
15	08.01.2020	74.40	75	08.01.2020	58.79	70
16	17.01.2020	71.28	75	17.01.2020	58.77	70
17	24.01.2020	77.03	75	24.01.2020	66.27	70
18	31.01.2020	73.72	75	31.01.2020	88.45	70
19	07.02.2020	66.37	75	07.02.2020	63.30	70
20	14.02.2020	67.47	75	14.02.2020	65.27	70
21	21.02.2020	69.97	75	21.02.2020	66.53	70
22	28.02.2020	73.83	75	28.02.2020	72.28	70
23	06.03.2020	80.65	75	06.03.2020	72.79	70
24	18.03.2020	73.92	75	18.03.2020	68.53	70

AECOM Asia Company Limited MUMBAI

YOOSHIN PROJECT MANAGER (PMC) MCR (PKG-4)

C|241

ANNEXURE – V

Status of Compliances of EC Conditions

(Oct 2019 – March 2020)

Louis Berger Consulting Pvt. Ltd.

YOOSHIN TEC-4 PROJECT MANAGER (PMC) MCR (PKG-4)

MUMBAI COASTAL ROAD PROJECT PKG II EGIS-CGRCUK JV

AECOM Asia Company Limited MUMBAI

MUNICIPAL CORPORATION OF GREATER MUMBAI

Reply to Minutes of the Specific and General Conditions Stipulated in CRZ Clearance Accorded by MoEF & CC for "Coastal Road (South) from Princess Street Flyover to Worli end of Sea Link in Mumbai by Municipal Corporation of Greater Mumbai"

The following Specific and General Conditions in CRZ Clearance letter no. 19-74/2016-IA.III

A. Specific Conditions:

Sr. No.	Condition	Compliance
i	All the terms and conditions stipulated by the MCZMA in their letter No.CRZ 2016/CR 1/TC 4, dated 04th January, 2017, shall be strictly complied with and the status of implementation shall be submitted to all concerned agencies including regional office of the Ministry of Environment, Forest and Climate Change.	Noted
ii	The project/activity shall be carried out strictly be in accordance with the provisions of CRZ Notification, 2011, and shall render the coastal ecology of the area including flora and fauna at its original state after completion of the project.	Noted. There are no mangroves in Mumbai Coastal Road (South)
iii	The project proponent shall not undertake any blasting activities during night hours. Blasting activity (if any) shall be carried out strictly in conformity with applicable statutory requirements.	Noted, norms of Statutory Regulatory Authority will be followed.
iv	The project proponent shall ensure that during construction phase no adverse impact on tidal behaviour is attracted. It shall also be ensured that no human access/interventions in the CRZ area beyond the reclaimed land is made by preventing any access to the area.	Noted, during construction human access/interventions in the CRZ area beyond the reclaimed land can be controlled.

Sr. No.	Condition	Compliance
v	Break up of 90 ha of land to be reclaimed shall be submitted with *six months* of receipt of the clearance to the regional office of the Ministry and to concerned agencies in the State Government along with justification thereof with a written undertaking that the reclaimed land shall not be used for any commercial or residential purpose.	The breakup of reclamation land is submitted in previous compliances. Any variations will be with due process.
vi	The project proponent will ensure that open spaces created by reclamation as well as any ancillary facilities related to road maintenance are fully protected against encroachment, illegal parking, public events/processions of any kind, hawkers, religious structures, street vendors or any illegal occupants etc. Violation of this will amount to revocation of clearance. A clearly drafted prevention plan with necessary budget allocations shall be submitted to the concerned authority, including the regional office of the Ministry *within 30 days of receipt* of the clearance.	MCGM's published circular. Copy of the same is submitted in previous compliance.
vii	The green spaces as proposed should be done in eco-friendly manner by developing it with open air nature information centre with novel concepts as open air butterfly garden, marine and coastal biodiversity display and dioramas, or botanical theme based information walkways as such that these spaces also carry educational value on environment to general public. *A specific allocation of Rs 10 crores shall be earmarked for the same.* A blue print of the same including timeline shall be developed within *six months* from the date of receipt of this clearance and submitted to regional office of the Ministry and implemented in a time bound manner.	Development of open air butterfly garden will be examined for feasibility. Marine and Coastal Biodiversity Display will be done through reputed Institution. Any other activity will be carried out as per MCGM's Policy, Rules & Regulations. The project already involves fund provision for landscaping, plantation and various green works on proposed reclaimed land wherein it is proposed to develop butterfly garden. This will be developed in reclaimed land after construction of super structure, as final activity.

Louis Berger Consulting Pvt. Ltd. YOOSHIN TECA PROJECT MANAGER (PMC) MCR (PKG-4) COASTAL ROAD PROJECT PKG II JV MUMBAI (EGIS-CGRCUK) AECOM Asia Company Limited MUMBAI

Sr. No.	Condition	Compliance
viii	The project proponent shall provide alternative arrangement for Fish Drying beds with prior consultation with the fishing community, in the event, the project entails damages/destruction to the existing fish drying beds located in the project area. In addition, the project proponent shall ensure rehabilitation and resettlement of the fishermen communities in the event the project impacts existing livelihood pattern of these communities. Bridges with navigable spans will be provided by the project proponent as committed, so that there are no obstructions to fishing boats.	There are no Fish drying beds along proposed alignment of Mumbai Coastal Road (South). The issue of rehabilitation and resettlement of the fishermen communities does not arises since project does not entail damages /destruction to the existing fish drying beds. CMFRI is engaged for studying the impact on livelihood pattern of fishermen communities and suitable policy is being formulated accordingly. At present navigational span of existing Bandra Worli Sea link is 29m. However, adequate navigational spans of 60m are proposed in Coastal Road.
ix	The project proponent shall develop a marine biodiversity conservation plan for the region from an institute which has expertise in the field of marine biodiversity of the region. The plan will be submitted to the Ministry within one year and implementation shall be monitored by the Ministry.	Marine biodiversity conservation plan for the region is being prepared by CSIR-National Institute of Oceanography, Versova , Mumbai and copy of the final report by NIO is attached herewith.
x	The project proponent shall periodically carry out studies through the National Institute of Oceanography (NIO) during and after the construction of the coastal road to assess the actual impact (in comparison with the projected impacts as stated in EIA) on human habitations and shore morphology of adjacent areas and shall report its findings and mitigating steps taken every six months to the MCZMA, the State Pollution Control Board and the regional office of the Ministry.	National Institute of Oceanography (NIO) Dona Paula, Goa is engaged to assess the actual impact (in comparison with the projected impacts as stated in EIA) on human habitations and shore morphology of adjacent areas during and after the construction of the coastal road and its findings and mitigating steps report will be submitted. Copy of the Interim report 1 by NIO is submitted in previous compliances.

C/245

Sr. No.	Condition	Compliance
xi	The project proponent shall ensure that noise barriers all along the coastal road on areas facing residential areas are erected and maintained.	Noise barriers all along the coastal road on areas facing residential areas are proposed to be provided as per IRC guidelines. 
xii	The project proponent shall deposit 2% of the total cost of the project for conservation of coastal and marine biodiversity, to the Mangrove Foundation of Maharashtra. Interest from the fund must be used exclusively to improve coastal and marine biodiversity of Mumbai and Thane region and as such be clearly earmarked in annual budget of the Foundation. The funds to be transferred on or before commencement of the construction work and a report in this regard to be forwarded to regional office of Ministry.	The MCGM deposited as first installment of Rs.25.00 Crs to the Mangrove Foundation of Maharashtra. The receipt is submitted in previous compliance.
xiii	In case tree cutting is unavoidable, three times the number of trees cut shall be planted along the ROW and its survival ensured.	It is proposed to be complied as directed.
xiv	Adequate public access to the natural waterfront areas shall be provided and maintained free of cost by the project proponent without affecting road traffic.	Public access to the natural waterfront area is proposed to be provided at convenient locations.
xv	The proposed coastal road will be permanently toll free.	Noted.

Sr. No.	Condition	Compliance
xvi	The muck produced during tunnel digging should be tested for suitability for reclamation purpose prior to its use. A certificate in this regard from competent authority shall be submitted to the concerned authority in the State including the regional office of Ministry.	Noted. Tunnel digging is not yet started, hence no mucks produced.
xvii	There shall be no disposal of solid or liquid wastes on the coastal area. Solid waste management shall be as per Solid Wastes Management Rules, 2016. A team comprising of members of the EAC and others with expertise in the subject may visit the project site periodically during the construction phase to supervise and suggest additional measures if desire.	Solid and Liquid Waste Disposal plan will be as per Site Environmental Plan.
xviii	A dedicated BRTS lane as stated by the project proponent must be maintained and will be used exclusively for public transport as well as medical and fire evacuation or other rescue operations. Under no circumstances this lane will be used for general, commercial or VIP transport.	Dedicated BRTS lane is proposed to be developed which will be utilized during medical as well as for other emergencies including disasters.
xix	The project proponent shall ensue that the quality of the coastal road must be of high international standard and shall be rigorously maintained ensuring free of pot holes at all times. A severe fine will be levied on the project proponents if the quality of work is found/ reported compromised.	The international standards for measuring smoothness of road are "Roughness Indices". The care is taken in RFP documents as per IRC and high International standards to measure riding quality. During construction we will adhere to better quality as per standard.

B. General Conditions:

Sr. No.	Condition	Compliance

i	Adequate provision for infrastructure facilities including water supply, fuel and sanitation must be ensured for construction workers during the construction phase of the project to avoid any damage to the environment.	The contractors have adhered.
ii	Full support shall be extended to the officers of this Ministry/Regional Office at Nagpur by the project proponent during inspection of the project for monitoring purposes by furnishing full details and action plan including action taken reports in respect of mitigation measures and other environmental protection activities.	Noted
iii	A six-Monthly monitoring report shall need to be submitted by the project proponents to the Regional Office of this Ministry at Nagpur regarding the implementation of the stipulated conditions.	Environmental Monitoring done. Reports are attached as annexure IV
iv	The Ministry of Environment, Forest & Climate Change or any other competent authority may stipulate any additional conditions or modify the existing ones, if necessary in the interest of environment and the same shall be complied with.	Noted
v	The Ministry reserves the right to revoke this clearance if any of the conditions stipulated are not complied with to the satisfaction of the Ministry.	Noted
vi	In the event of a change in project profile or change in the implementation agency, a fresh reference shall be made to the Ministry.	Noted
vii	The project proponents shall inform the Regional Office of the Ministry, the date of financial closure and final approval of the project by the concerned authorities and the date of start of land development work.	Being complied.

Louis Berger Consulting Pvt. Ltd.

YOOSHIN TECH PROJECT MANAGER (PMC) MCR (PKG-4)

MUMBAI COASTAL ROAD PROJECT PKG II (EGIS-CGRCUK) JV

AECOM Asia Company Limited MUMBAI

viii	A copy of the clearance letter shall be marked to concerned Panchayat/ local NGO, if any, from whom any suggestion/ representation has been made received while processing the proposal.	Complied and reported in earlier correspondence.
ix	A copy of the CRZ Clearance letter shall also be displayed on the website of the concerned State Pollution Control Board. The Clearance letter shall also be displayed at the Regional Office, District Industries centre and Collector's Office/Tehsildars Office for 30 days.	Complied and reported in earlier correspondence.

Other Conditions:

Sr. No.	Condition	Compliance
7.	The above stipulations would be enforced among others under the provisions of Water (Prevention and Control of Pollution) Act 1974, the Air (Prevention and Control of Pollution) Act 1981, the Environment (Protection) Act, 1986, the Public Liability (Insurance) Act, 1991 and EIA Notification 1994, including the amendments and rules made thereafter.	Noted.
8	All other statutory clearances such as the approvals for storage of diesel from Chief Controller of Explosives, Fire Department, Civil Aviation Department, and clearances under the Forest Conservation Act, 1980 and Wildlife (Protection) Act, 1972 etc. shall be obtained, as applicable by project proponents from the respective competent authorities.	Noted. Will be obtained as applicable from competent authority.

Louis Berger Consulting Pvt. Ltd.

YOOSHIN ★ TEC-4 PROJECT MANAGER (PMC) MCR (PKG-4)

COASTAL ROAD PROJECT PKG II ★ AJ (EGIS-CGRCUK) ★ MUMBAI

AECOM Asia Company Limited MUMBAI

C1249

9.	The project proponent shall advertise in at least two local Newspapers widely circulated in the region, one of which shall be in the vernacular language informing that the project has been accorded CRZ Clearance and copies of clearance letters are available with the State Pollution Control Board and may also be seen on the website of the Ministry of Environment, Forest & Climate Change at http://www.envfor.nic.in. The advertisement should be made within Seven days from the date of receipt of the Clearance letter and a copy of the same should be forwarded to the Regional office of this Ministry at Nagpur.	Complied and reported in earlier correspondence.
10.	This Clearance is subject to final order of the Hon'ble Supreme Court of India in the matter of Goa Foundation Vs. Union of India in Writ Petition (Civil) No.460 of 2004 as may be applicable to this project.	Noted.
11.	Any appeal against this clearance shall lie with the National Green Tribunal, if preferred, within a period of 30 days as prescribed under Section 16 of the National Green Tribunal Act, 2010.	Noted
12.	Status of compliance to the various stipulated environmental conditions and environmental safeguards will be uploaded by the project proponent on its website.	Noted
13.	A copy of the clearance letter shall be sent by the proponent to concerned Panchayat, Zilla Parishad/Municipal Corporation, Urban Local Body and the Local NGO, if any, from whom suggestions/representations, if any, were received while processing the proposal. The clearance letter shall also be put on the website of the company by the proponent.	Complied.
14.	The proponent shall upload the status of compliance of the stipulated EC conditions, including results of monitored data on their website and shall update the same periodically. It shall simultaneously be sent to the Regional Office of MoEF, the respective Zonal Office of CPCB and the SPCB.	Noted, will be complied.

Louis Berger Consulting Pvt. Ltd.
YOOSHIN TEC-4 PROJECT MANAGER (PMC) MCR (PKG-4)
MUMBAI COASTAL ROAD PROJECT PKG II (EGIS-CGRC(UK) JV)
AECOM Asia Company Limited MUMBAI

15.	The project proponent shall also submit six monthly reports on the status of compliance of the stipulated EC conditions including results of monitored data (both in hard copies as well as by e-mail) to the respective Regional Office of MoEFCC, the respective Zonal Office of CPCB and the SPCB.	Noted, being complied.
16.	The environmental statement for each financial year ending 31st March in Form-V as is mandated to be submitted by the project proponent to the concerned State Pollution Control Board as prescribed under the Environment (Protection) Rules, 1986, as amended subsequently, shall also be put on the website of the company along with the status of compliance of EC conditions and shall also be sent to the respective Regional Offices of MoEFCC by e-mail.	Noted, being complied.

20/06/2020

Chief Engineer (Coastal Road)
MCGM, Mumbai -18

EE(CR2)

Louis Berger Consulting Pvt. Ltd.

YOOSHIN TEC-4 PROJECT MANAGER (PMC) MCR (PKG-4)

COASTAL ROAD PROJECT PKG II ★ MUMBAI ★ (EGIS-CGRCUK) JV

AECOM Asia Company Limited ★ MUMBAI

Compliance Status against MCZMA Conditions as per Minutes of 114th meeting of Maharashtra Coastal Zone Management Authority held on 2nd and 3rd November, 2016

Sr. No	Conditions	Present Status
1	MCGM to ensure that proposed construction of coastal road is as per provisions of CRZ notification, 2011 (amended time to time)	All the construction work will be carried out as per the CRZ notification (amended time to time).
2	MCGM to ensure that all construction equipment are fully fitted with mufflers and exhaust silencers to contain the noise levels. Machinery used during construction should be properly maintained to minimize the air and noise emissions.	The Site Environment Management Plan is in place. Noise control measures mentioned in the plan will be followed such as ; 1. All the machines/equipment/vehicle use for material transportation having valid PUC certificates. 2. All the vehicles are well maintained. Vehicle inspection done periodically. 3. Equipment's are with mufflers and exhaust silencers. 4. Noise barrier will be installed at sensitive locations such as Schools, hospital & temples. Work in progress. (290 M Length * 6 M Height is completed.) 5. Ear muff/plug will be provided to workmen working in high noise areas as and when required. 6. Ambient Noise level and Ambient Air quality monitoring is being carried out periodically.
3	MCGM as proposed, to set aside an amount of about 2% of the project cost towards mitigation measures; restoration & conservation of mangroves/birds/flora/fauna and mudflats restoration.	The MCGM deposited as first instalment of Rs.25.00 Crs to the Mangrove Foundation of Maharashtra. ~~Please refer Annexure C-III~~
4	MCGM to ensure that no fishing activity is hampered during construction and operation phase of the project	Noted
5	MCGM to submit the impact of clearing of mangroves if any on surrounding low lying areas from flood. However post construction such areas should be restored with mangroves plantation if affected.	No mangrove are in Mumbai Coastal Road Project
6	MCGM to obtain prior high court permission for clearing of mangrove, if any.	No mangrove are in Mumbai Coastal Road Project

7	MCGM to undertake green belt development as suggested in the EMP	Noted
8	For road safety, guidelines in respect of road signage, service roads, bus bays, inter-sections, pedestrians crossing etc. shall be strictly adhered to.	Noted, will be complied.
9	Dust suppression measure during construction and operation phase	Measures adopted to supress Dust particles during construction and operation phases are; 1. Monitoring for environment and health effects. This requires sampling of ambient concentrations of defined particle size fractions (such as PM2.5 & PM10) at Construction activities.  2. Regular water sprinkling is being done manually and through tankers, as water sprinkling is very much effective system to supress dust to form agglomerate to settle down.  3. Load carrying vehicles are covered to control the spread of dust particles while transportation.  4. Speed limit is restricted to 5 KM/H at construction site.

C/237

Mumbai Coastal Road Project						
Ambient Noise Quality Monitoring						
S. No	Location: Priyadarshini Park Project Area					
	Leq- Day			Leq- Night		
	Date	Value	Standard	Date	Value	Standard
1	03.10.2019	69.86	75	03.10.2019	54.03	70
2	09.10.2019	70.24	75	09.10.2019	57.92	70
3	15.10.2019	70.94	75	15.10.2019	55.65	70
4	22.10.2019	69.89	75	22.10.2019	56.38	70
5	30.11.2019	70.76	75	30.11.2019	56.80	70
6	06.11.2019	67.77	75	06.11.2019	54.33	70
7	13.11.2019	68.26	75	13.11.2019	54.49	70
8	20.11.2019	66.55	75	20.11.2019	53.22	70
9	27.11.2019	67.51	75	27.11.2019	53.63	70
10	04.12.2019	66.92	75	04.12.2019	56.09	70
11	11.12.2019	67.68	75	11.12.2019	53.64	70
12	18.12.2019	69.11	75	18.12.2019	53.16	70
13	26.12.2019	73.44	75	26.12.2019	52.97	70
14	02.01.2020	72.56	75	02.01.2020	57.74	70
15	10.01.2020	74.90	75	10.01.2020	57.03	70
16	15.01.2020	73.52	75	15.01.2020	57.71	70
17	22.01.2020	64.74	75	22.01.2020	62.92	70
18	01.02.2020	78.25	75	01.02.2020	72.44	70
19	05.02.2020	75.47	75	05.02.2020	73.43	70
20	12.02.2020	65.29	75	12.02.2020	59.67	70
21	19.02.2020	75.11	75	19.02.2020	62.96	70
22	26.02.2020	68.70	75	26.02.2020	60.00	70
23	04.03.2020	67.81	75	04.03.2020	61.12	70
24	11.03.2020	67.50	75	11.03.2020	61.88	70
25	20.03.2020	68.25	75	20.03.2020	59.76	70

AECOM Asia Company Limited MUMBAI

YOOSHIN TEC-4 PROJECT MANAGER (PKG) MCR (PKG-4)

DISTRIBUTION RESTRICTED

(GAP3292)

Marine Biodiversity Conservation Plan for Mumbai Coastal Road Project (South) from Princess Street Flyover to Worli End of Bandra Worli Sea Link

SPONSORED BY

Municipal Corporation of Greater Mumbai (MCGM)
Mumbai - 400018, Maharashtra

SEPTEMBER 2019

सीएसआईआर - राष्ट्रीय समुद्र विज्ञान संस्थान
CSIR - NATIONAL INSTITUTE OF OCEANOGRAPHY
(वैज्ञानिक तथा औद्योगिक अनुसंधान परिषद)
(COUNCIL OF SCIENTIFIC & INDUSTRIAL RESEARCH)
क्षेत्रीय केंद्र, चार बंगला, अंधेरी (प.), मुंबई - 400 053
Regional Centre, 4 Bungalows, Andheri (W), Mumbai - 400 053
(फोन) Tel.: 022-26359605-08 • (फैक्स) Fax: 022-26364627
(ई-मेल) e-mail: rcm@nio.org

HQ: दोना पावला, गोवा / Dona Paula, Goa - 403 004

(GAP3292)

Marine Biodiversity Conservation Plan for Mumbai Coastal Road Project (South) from Princess Street Flyover to Worli End of Bandra Worli Sea Link

Project Leader

Dr. Sabyasachi Sautya

Associate Project Leaders

Dr. Abhay B. Fulke

Dr. Umesh Pradhan

SEPTEMBER 2019

सी.एस.आई.आर. – राष्ट्रीय समुद्र विज्ञान संस्थान

CSIR-NATIONAL INSTITUTE OF OCEANOGRAPHY

छेत्रीय केंद्र/ REGIONAL CENTRE

अंधेरी (प०) / Andheri (W), मबई / Mumbai-400 053

फ़ोन/Tel : +91(0)22-26359605-08 : फक्स /Fax: +91(0)22-26364627

HQ- दोना पावला, गोवा / Dona Paula, Goa- 403004

Contents

A. Project team

Dr. Sabyasachi Sautya	Biological Oceanography Division
Dr. Umesh Pradhan	Chemical Oceanography Division
Dr. Abhay Fulke	Biological Oceanography Division
Dr. Mohandass C.	Biological Oceanography Division
Dr. Mandar Nanajkar	Biological Oceanography Division
Dr. Soniya Sukumaran	Biological Oceanography Division
Dr. Anirudh Ram	Chemical Oceanography Division
Dr. Haridevi C. K.	Biological Oceanography Division
Dr. Rakesh P. S.	Biological Oceanography Division
Dr. Udhaba G. Dora	Physical Oceanography Division
Mr. Santosh Gaikwad	Biological OceanographFy Division
Mr. Prathamesh Sarang	Biological Oceanography Division
Ms. Neelam Pednekar	Biological Oceanography Division
Mr. Laxman Kumbhar	Chemical Oceanography Division
Mr. Angad Gaud	Chemical Oceanography Division
Mrs. Komal Khade	Biological Oceanography Division
Mrs. Sanofar Khokar	Biological Oceanography Division

B. Executive summary

The Joint Technical Committee (JTC) constituted by Govt. of Maharashtra under the Chairmanship of the Municipal Commissioner, MCGM had recommended that about 35.60 km of Coastal Road be constructed, comprising of a combination of road based on reclamation, bridges, elevated roads and tunnels along the western side of Mumbai. The entire length will be divided into two parts North Part and Southern Part from Princess Street Flyover to Worli end of Bandra-Worli Sea link. The proposed Coastal Road (South) will have approximately a length of about 9.98 km and shall comprise of a combination of land reclamation, land fill road, bridges on the sea, tunnel (2 tubes, each of about 3.452 km in length) and elevated roads. In view of this, Ministry of Environment, Forest and Climate Change, Govt. of India has been issued CRZ clearance letter to Municipal Corporation of Greater Mumbai (MCGM). Develop a marine biodiversity conservation plan for the region is one of the conditions suggested by MoEF & CC. In this context MCGM requested CSIR-National Institute of Oceanography (CSIR-NIO) to develop a marine biodiversity conservation plan for southern part of Coastal Road project.

The present report therefore is based on the result obtained from the data collected during study in March-April 2019 from the proposed work area of coastal road Mumbai (South) as well as the data from the surrounding buffer zone. Results of the study and in-depth analysis of the impact of the proposed project on the marine biodiversity is present in following sections.

Biological studies were carried out to understand the composition and abundance of bacteria, phytoplankton, zooplankton, benthos and demersal fish community in the coastal waters of Mumbai which fall within 10 km distance of the proposed development site. The water samples for microbiological analysis, chemical and biological (phytoplankton) studies were collected by Niskin water sampler, whereas sediment samples were collected using a van Veen Grab. The diversity of flora and fauna were studied following the standard methods.

The data on benthic flora and faunal community (meio and macro) were collected from the intertidal region of the proposed project activity areas for quantitative analysis. Further studies on benthic megafauna, seaweeds, avifauna and fisheries were also undertaken for qualitative and quantitative analysis in the present study. Ecologically sensitive species such as corals, shellfishes and sponges were also collected from the study area.

Salient Findings:

- The baseline data of environmental parameters collected from the study area suggested that most of the parameters fell within the permissible limit of various national and international guidelines. Dissolved oxygen and nutrients in the water column fall within the range of admissible levels. In surface sediment, most of the elements are within the normal range. Metal content showed higher values in subtidal surface sediments in comparison with intertidal areas except CR4 transect. PHc also recorded higher in intertidal transect at CR4 and CR7 in comparison with subtidal areas.
- In microbial analysis, the water column as well as sediments are showing within permissible amount of coliforms with the presence of other indicator pathogenic bacteria except surface water H5 where fecal coliform was found to be above the permissible limit.
- Phytoplankton standing stock in Mumbai in terms of phytopigments and population varied from low to normal suggesting oligotrophic conditions. Overall, 46 genera were observed during the present study. *Thalassiosira* and *Skeletonema* were most abundant genera. Stations G1 and M5 reported the minimum and maximum number of phytoplankton genera, 3 and 18 respectively.
- Zooplankton biomass ranged between 0.1 to 7.0 ml/100m^3 in study area. Maximum biomass was observed at station G15, while the minimum at station P15. The population ranged from 1.1 to 13.8 x103/100m^3 with maximum and minimum were recorded at station H5 and G15 respectively.
- The large variation of meiofaunal biomass was recorded between subtidal and intertidal areas while density did not deviate much. Total 16 groups were identified in the present study. Nematoda was dominant and followed by Copepoda, Polychaeta, Amphipoda respectively in subtidal areas. Whereas, in intertidal areas were dominated by Nematoda followed by Polychaeta, Amphipoda etc.
- Macrofaunal activity impacts carbon, nitrogen and sulphur cycling, transport, burial and metabolism of pollutants, secondary production including commercial species,

and transport of sediments. Overall 11 and 26 macrofaunal groups were found in subtidal and intertidal areas respectively. Total analysis of subtidal and intertidal benthic macro fauna concludes that the abundance and presence of macrofaunal richness and diversity are more in intertidal areas than subtidal.

- Low tidal zones of intertidal rocky areas were rich in seaweeds, crabs, sponges, crustacean, molluscs etc.
- Seaweeds are the autotrophs of marine ecosystem, which are known as a source of food, fodder and manure are mostly found attached to various substrate like sandy, muddy and coralline sediments as well as rocky areas. They play a significant role in enriching the sea by adding dissolved organic matter, nutrients and detritus besides serving as nursery areas for the larvae and juveniles of innumerable marine organisms. During present study total nine species of seaweeds were found. There is no record of seagrass from the study area.
- Total six varieties of coral species were observed along the intertidal areas during the present study. Two species of Rhizangiidae family were observed in Worli as well as Haji Ali and Marine drive rocky shore. Another four species *Polycyathus* sp, *Goniopora* sp, *Pseudosiderastrea* sp and species under family Dendrophylliidae were found in Marine drive rocky shore.
- Apart from the quantitative benthic macrofaunal observations varieties of other benthic faunal community such as crabs, shrimps, shellfishes, sponges, bryozonas, ascidians, sea fans etc. were observed during the qualitative documentation in the present study.
- Fish diversity of the study area is also rich as many commercial important fin fishes and shell fishes were recorded from the area. Total fifteen varieties of catch included nine species of fish, three species of prawn, two species of crab and one cephalopoda during the experimental trawling.
- Marine mammals also have been recorded from the study area. In the present study, the Humpback dolphin were sighted in few locations during the subtidal survey.
- 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 ensure the damage caused and to understand the recovery. However, it is hard to avoid all ecological damage by any means of mitigation nevertheless the impact can be minimized as far as possible.

- The Marine Biodiversity Management Plan (MBMP) covers the key environmental issues across the project and provides strategies and plans for managing them effectively. It also defines the legal requirements for the project and identifies the regulatory permits and licenses required for construction activities. Based on this objective, key Marine Biodiversity Conservation Plan have been identified requiring management during operation including: marine fauna, marine environmental quality, and benthic communities and habitat.

C. List of figures

D. List of tables

E. List of plates

F. Common abbreviations

BWSL	-	Bandra Worli sea link
CPCB	-	Central Pollution Control Board
CRZ	-	Coastal Regulation Zone
CSIR-NIO	-	CSIR-National Institute of Oceanography
EAC	-	Expert Appraisal Committee
EEZ	-	Exclusive economic zone
EIA	-	Environmental Impact Assessment
EPA, 1986	-	Environmental Protection Act, 1986
GoI	-	Government of India
GOM	-	State Government of Maharashtra
JTC	-	Joint Technical Committee
MCGM	-	Municipal Corporation of Greater Mumbai
MCZMA	-	Maharashtra Coastal Zone Management Authority
MFRA	-	Marine Fishing Regulation Act
MoEF&CC	-	Ministry of Environment, Forest and Climate Change
NOC	-	No Objection Certificate
SPCB	-	State Pollution Control Boards
Av	-	Average
S	-	Surface
B	-	Bottom
Eb/Ebb	-	Ebb tide
Fl/Fld	-	Flood tide
Max	-	Maximum
Min	-	Minimum
BOD	-	Biochemical Oxygen Demand
DO	-	Dissolved Oxygen
C_{org}	-	Organic Carbon
ND	-	Not detected

NH_4^+-N	-	Ammonium nitrogen
NO_3^--N	-	Nitrate nitrogen
NO_2^--N	-	Nitrite nitrogen
PHc	-	Petroleum Hydrocarbons
Phenols	-	Total phenols
PO43--P	-	Reactive phosphate phosphorus
SS	-	Suspended Solids
CFU	-	Colony forming unit
ECLO	-	Escherichia coli like organisms counted on MacConkey medium
MF	-	Membrane filter
PALO	-	Pseudomonas aeruginosa like organisms
PKLO	-	Proteus klebsiella like organisms
SFLO	-	Streptococcus faecalis like organisms
SHLO	-	Salmonella like organisms
SLO	-	Salmonella like organisms
TC	-	Total coliforms
TVC	-	Total viable counts
VCLO	-	Vibrio cholerae like organisms
VLO	-	Vibrio like organisms
VPLO	-	Vibrio parahaemolyticus like organisms

1. Introduction

1.1. Background

CRZ notification 2011 issued on 06.01.2011 has permitted to make coastal road on stilt. To provide solution of Traffic Congestion issue in Greater Mumbai. Government of Maharashtra, Environment Department vide Resolution No. ENV-2011/CR-55/TC3, dated 30.06.2011 decided to Constitute a Joint Technical Committee (JTC) under Chairmanship of then Municipal Commissioner with the following Term of References: -

i) To examine various options in the construction of a Coastal Road, including Road on Stilt or Sea Link, in Mumbai.

ii) To evaluate these options on the basis of technical feasibility and environmental impact and impact on neighborhoods.

iii) To recommend the best option which provides improved mobility, enhanced environment and leads to sustainable development of open spaces/greenery.

Thereafter, committee submitted its report on 29.12.2011, by recommending coastal road from Nariman Point up to Kandivali for length of 36.5 Km. in two alignment options comprising Tunnel, Road on Reclamation, Bridges, Road on Stilt, etc. Committee in its report at Para 7.2 mentioned that the Coastal Freeway System proposed by Committee provides a feasible solution to ameliorate traffic congestion and the consequent health hazards. It generates the much-needed recreational spaces (about 75 Ha) by the sea side through creation of beautiful sea side promenades, and cycle tracks. The committee considers reclamation for the purpose of coastal freeway in some length as a highly cost-effective option and one that also entails other benefits through creation of the Large open green spaces to the citizens. In the Para 7.7, it is mentioned that the Committee has found that the proposed reclamation in an average width of about 100 m does not cause any impact on the tidal movements and no adverse effects to the coastline are envisaged. Also, in Para 7.8, the Committee recommends that the appropriate amendments be made in the current CRZ notification (which does not allow reclamation) for the proposed coastal road system in

Mumbai. For this purpose, the state Government needs to move a proposal to the MoEF&CC, GoI for the limited purpose of the proposed reclamation.

Accordingly, MCGM has appointed the Consultants M/s. STUP Consultant Pvt. Ltd + E & y consortium for "Consultancy for preparation of Feasibility Report, DPR Preparation, Report on Environmental Studies and obtaining MoEF&CC clearance And Bid Process Management for Mumbai Coastal Road Project" in March 2014.

Also, application was submitted to MCZMA on 21.01.2015 to recommend to MoEF&CC for necessary amendment in CRZ notification dated 06.01.2011 for allowing reclamation in CRZ area for construction of Mumbai Coastal Road. The MoEF&CC issued draft notification for making certain amendment in CRZ notification 2011 on 25.06.2015 inviting objection & suggestions from all persons likely to be affected thereby within 60 days. Thereafter final notification allowing road on reclaimed surface in CRZ area was issued by MoEF&CC on 30.12.2015.

Thereafter MCGM applied to MCZMA on 11.01.2016 to recommend the proposal of Mumbai Coastal Road Project from Nariman Point to Kandivali for CRZ clearance of MoEF&CC.

The 111th meeting was held by MCZMA on 16th January 2016 and recommended the proposal of Mumbai Coastal Road for CRZ Clearance of MoEF&CC by putting of their 17 observations with directions to MCGM for necessary compliance. MoEF&CC had sought some clarification vide its letter u/no. F.No. 19-74/2016-IA, Ill dated 22th July 2016.

Thereafter being policy matter as the decision on implementation strategy on North Side of Coastal Road i.e. from Bandra to Kandivali is yet to be decided by GOM. Therefore, only for the Southern Part of Coastal Road i.e. from Princess Street Flyover to Worli end of BWSL a fresh application was submitted by MCGM to MCZMA by withdrawing earlier application for recommending the same to MoEF&CC for CRZ clearance on 18.10.2016. The mandatory documents i.e. Comprehensive EIA report (Volume-Ill), CRZ maps in 1:4000 scale with project layout superimposed, Risk Assessment & Disaster Management Plan, Main Report (Volume-I), Drainage Report (Volume-Vl), Traffic Report (Volume - IV) and Social Impact Assessment Report (Volume-IX). Environment Cost Benefit Analysis Report are submitted with application. MCGM also submitted the clarification on the issues raised by MCZMA and MoEF&CC along with revised application by dividing the proposal in two parts as under.

Part A (South Side) - Princess Street Flyover to Worli end of BWSL, 9.98 km (**Figure 1**)

Part B (North Side) – Bandra End of BWSL to Kandivali Junction of Line Road, 19.22 km.

The proposed Coastal Road (South) will have approximately a length of about 9.98 km and shall comprise of a combination of land reclamation, land fill road, bridges on the sea, tunnel (2 tubes, each of about 3.452 km in length) and elevated roads.

The issue was discussed in 114th meeting of MCZMA held on 2nd & 3rd November 2016 and it was decided in the said meeting to recommend the Southern Part A of the Coastal Road to MoEF&CC for NOC from CRZ point of view and accordingly the said proposal was forwarded by member Secretary, MCZMA vide their letter No. CRZ 2016/CR1/TC-4 dated 04.01.2017 to the MoEF&CC for grant of CRZ clearance in terms of the provisions of MoEF&CC (CRZ) Notification 2011 issued under the Environment (Protection) Act, 1986.

Thereafter the proposal was considered by the Expert Appraisal Committee (EAC) in its 168th meeting held on 17-03-2017. MCGM had made detailed presentation to EAC in the said meeting along with the Environmental expert of Consultants. The EAC deliberated in detail the environmental issues likely to be associated with proposed Project. The EAC opined that on perusal of the documents/project reports including EIA report, social Impact Assessment Report Risk Assessment and Disaster Management Plan etc. submitted indicates that a detailed study has been carried out as required for the project of such a large dimension.

The committee also noted that 'Reclamation' for the purpose of coastal freeway in some length can not only be a highly cost-effective option but also would benefits citizens of Mumbai through creation of much needed large open spaces. Recognizing that the main purpose of this project is to reduce burden of traffic and transport system of Mumbai, the Committee felt that construction of this project will make travelling in the congested Metropolitan city like Mumbai more economical, safe and faster besides entailing long term environmental benefits.

The committee concluded that the Coastal Road is the need of the hour. The committee observed that denial of the project from recommending for CRZ clearance will not serve any public interest, as in the long run the social benefits outweigh the marginal impact likely to be incurred on the environmental aspects.

Thereafter, the MoEF&CC vide its letter u/no. F.No. 19-74/2016-IA-Ill dated 11th May 2017 issued CRZ clearance for the project. The CRZ clearance is subject to conditions mentioned in the letter. To develop a marine biodiversity conservation plan for the region is one of the conditions suggested by MoEF & CC. In this context MCGM requested CSIR-National Institute of Oceanography (CSIR-NIO) to develop a marine biodiversity conservation plan for southern part of Coastal Road project.

1.2. Objectives

a) Collection of samples, analysis and interpretation for the physico-chemical and biological characteristics of water and sediment samples.
b) The samples shall be collected within 10 km radius in the coastal water from the proposed project locations.
c) Develop a marine biodiversity conservation plan for proposed project region.

1.3. Scope of work

The **scope of work** for conducting the marine ecological studies shall be as follows:

1.3.1. Physio-chemical parameters

1.3.1.1. Water

Water samples would be collected from 12-15 different sites at the proposed project area. The samples would be collected at the surface and bottom (wherever the water depth exceeds 3 m) and analysed for Temperature, pH, Salinity, Suspended Solids (SS), TDS, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), phosphate, nitrates, nitrite, ammonical nitrogen, sulphates, chlorides, Petroleum Hydrocarbons (PHc) and phenols; Two critical locations would be sampled temporally to assess tidal variability of selected water quality parameters. Other locations would be considered as spot sampling in duplicate.

Surface and bottom sample would be collected where and when depth exceeds 3 m and only surface sampling would be done where depth is less than 3 m.

1.3.1.2. Sediment

Subtidal and intertidal sediment would be studied for texture, selected metals (aluminum, manganese, chromium, iron, cobalt, nickel, copper, zinc and mercury), total organic carbon, total Phosphorous and PHc, in the study area.

1.3.2. Biological parameters

1.3.2.1. Water

Microbial counts [Total Viable Counts, Total Coliforms (TC), Faecal Coliforms (FC) etc.], Chlorophyll *a*, Phaeophytin, Phytoplankton, Zooplankton (group level density, abundance, total biomass, evenness, richness and dominance) considered.

1.3.2.2. Sediment

Microbial counts [Total Viable Counts, Total Coliforms (TC), Faecal Coliforms (FC), etc.], benthic organisms (meiobenthos and macrobenthos) (possible lowest taxonomic level identification, density, abundance, total biomass, evenness, richness and dominance) would be considered.

1.3.2.3. Fisheries

The experimental trawling would be carried out at two/three locations of the proposed study area. Fish diversity, abundance and biomass (kg/haul) would be mentioned. Other marine products like crabs, prawn, chanks, pearls, oysters and other marine animals in the study area would be studied.

1.3.2.4. Seaweeds/Corals

As a part of the study, the presence or absence of mangroves/seaweeds/sea grasses, corals, etc. in and around the study area of proposed project site would be identified, if any.

1.3.2.5. Avifauna

The status of the Avifauna in the area would be assessed.

1.4. Ecological and biodiversity assessment

Based on the results of the study, the potential environmental impact due to proposed activities would be assessed. Suitable mitigation measures and environmental management plan will be suggested to minimize the adverse impact if identified. The assessment would be to meet the 'Objectives' as stated above. Findings of the marine ecological survey will be compared with the secondary data/ reports available for the project study area if any and observations on the status of marine ecology in the project area will be made part of the marine ecological survey report.

1.5. Marine biodiversity conservation plan (MBCP)

A suitable marine biodiversity conservation plan would be formulated for maintaining a healthy ecosystem around the proposed project site.

1.6. Approach strategy

It is necessary to investigate the project site and surrounding locations for some critical environmental parameters to establish the prevailing water quality, sediment quality and biological characteristics in an ecological investigation. In well-planned coastal developments, the probable adverse impacts are identified in advance so that the mitigation measures can be integrated into the design itself. Reliable prediction of impacts on marine ecology requires detailed information on water quality, sediment quality and biological characteristics of the area likely to be impacted. Ideally, the field data collection is required to be carried out in detail.

The data of present study and the earlier data available in the CSIR-NIO databank on water quality, sediment quality and biological characteristics were used to assess the ecological status and establish the baseline data for proposed development area.

2. General description of the study area

Mumbai, earlier known as Bombay, is one of the largest cities in India and the capital of Maharashtra state. Mumbai was originally a combination of seven islands on the Konkan coastline which over time were joined to form the island city of Bombay. The island was in turn joined with the neighbouring island of Salsette to form Greater Bombay. The city has an estimated metropolitan population of about 25 million (2019) [1], making it one of the largest cities in the world. Mumbai consists of two distinct regions: Mumbai City district and Mumbai Suburban district, which form two separate revenue districts of Maharashtra[2]. The city district region is also commonly referred to as the Island City or South Mumbai. The total area of Mumbai is 603.4 km^2 [3]. Mumbai is bounded by the Arabian Sea to the west. Many parts of the city lie just above sea level, with elevations ranging from 10 m (33 ft) to 15 m (49 ft); the city has an average elevation of 14 m (46 ft) [4].

2.1. Geomorphology

The soil cover in Mumbai city is predominantly sandy due to its propinquity to the sea. In the suburbs, the soil cover is largely alluvial and loamy [5]. The underlying rock of the region is composed of black Deccan basalt flows, and their acidic and basic variants dating back to the late Cretaceous and early Eocene eras[6]. The area is classified as a Seismic Zone III region,[7] which means an earthquake of up to magnitude 6.5 on the Richter magnitude scale may be expected.

2.2. Land environment

2.3. Climate

The Climate of Mumbai is a tropical, wet and dry climate. Mumbai's climate can be best described as moderately hot with high level of humidity. Its coastal nature and tropical location ensures temperatures do not fluctuate much throughout the year. Mumbai generally has humid and muggy weather, which is influenced by its proximity to Arabian Sea. This proximity is the main reason for ups and downs of the temperature. The month of May is the warmest one in Mumbai wherein the temperature spins between 32°Cand 40°C. Mumbai is coolest in the month of January as the maximum temperature recorded is around 24°C, and the minimum so far has been 18°C. Humidity is highest during the summer months, when the weather boils. Due to the moderating effect of the sea, the city of Mumbai experiences less variety of seasons. The main three seasons- summer, winter and monsoon exist in Mumbai. The monsoon months are June to September that record the average total rainfall of 2514 mm in Mumbai. The winds from the western side are the most noticeable feature of Mumbai monsoons. This season sees high waves and rough sea, it so becomes too turbulent for the boats. The Mumbai summers are the most unbearable weather there with high temperatures and humidity because of the recently ended monsoon season. This season continues till October end. The temperature at times even touches the mark of 40 degree Celsius. The months of November to February sees the fall in humidity and temperature. It attains the maximum low in the month of January. The weather is dry and cool, and the temperature falls down.

Meteorological parameters for the year 2015-2019 recorded in Mumbai are presented in **Figure 2-5** (data sources: www.worldweatheronline.com).

A wet day is one with at least 1mmof liquid or liquid-equivalent precipitation. The chance of wet days in Mumbai varies very significantly throughout the year. The wetter season lasts 4.0 months, from first week June to first week of October , with a greater than 39% chance of a given day being a wet day (**Figure 2**). The chance of a wet day peaks at 77% in end of July. The drier season lasts 8.0 months, from early October to beginning of June. The smallest chance of a wet day is 0% during mid March.

The average hourly wind speed in Mumbai experiences significant seasonal variation over the course of the year. The windier part of the year lasts for 2.9 months, from beginning of June 1 to end of August , with average wind speeds of more than 17.05 kmph (**Figure 3**). The windiest day of the year is during last week of July, with an average hourly wind speed of 23.33 kmph. The calmer time of year lasts for 9.0 months, from August end to June starting. The calmest day of the year is during mid of October, with an average hourly wind speed of 10.78 kmph.

The predominant average hourly wind direction in Mumbai varies throughout the year. The wind is most often from the west for 6.5 months, from last week of March to early October, with a peak percentage of 96% during first week of August (**Figure 4**). The wind is most often from the north for 2.3 weeks, from starting of October to October last week and for 3.2 months, from mid December to March last week, with a peak percentage of 40% during mid October. The wind is most often from the east for 1.9 months, from last week of October to mid December, with a peak percentage of 50% during beginning of November .

In Mumbai, the average percentage of the sky covered by clouds experiences extreme seasonal variation over the course of the year. The clearer part of the year in Mumbai begins around mid October and lasts for 7.4 months, ending around late May. In mid February, the clearest day of the year, the sky is clear, mostly clear, or partly cloudy 85% of the time, and overcast or mostly cloudy 15% of the time (

Figure 5). The cloudier part of the year begins around end of May and lasts for 4.6 months, ending around mid October. During end of July, the cloudiest day of the year, the sky is overcast or mostly cloudy 84% of the time, and clear, mostly clear, or partly cloudy 16% of the time.

Mumbai experiences extreme seasonal variation in the perceived humidity. The muggier period of the year lasts for 9.0 months, from beginning of March to early December, during which time the comfort level is muggy, oppressive, or miserable at least 34% of the time. The muggiest day of the year is during mid of July, with muggy conditions 100% of the time. The least muggy day of the year is in last week of January, with muggy conditions 12% of the time.

3. Programme of the study

3.1. Period of the study

The field investigations were planned in a manner to obtain a detailed picture of the marine biodiversity and ecology of intertidal region of proposed project area (Princess street Marine drive to Worli sea-link) in Mumbai and its 10-km radius coastal waters during March-April, 2019.

3.2. Sampling locations

Ten intertidal transects and thirteen subtidal stations were selected to study in the proposed project area (**Figure 6** & **Table. 1**).

3.3. Studies undertaken

Sampling was done at all stations in duplicate for water quality and biological characteristics. Temporal measurements over a tidal cycle were conducted at four stations located at 5 m depths. Spot sampling was done for the other nine stations. Sediment samples were attempted to collect from all stations but nine stations were possible to collect and remaining four could not be collected due to the presence of rocky bottom and other technical issues. Ten intertidal transects were sampled once along each transect in the area between the Low Tide Line (LTL) and the High Tide Line (HTL). Intertidal transects were mainly focused on benthic faunal observations and sampling.

3.3.1. Setting up of the intertidal region (*Plate. 1* to *Plate. 3*)

3.3.1.1. Package II

CR1

The intertidal region of this transect is located near the Bandra-Worli sea link bridge. The intertidal region here is fully covered with big rocky boulders (> 1 m^2) at high tide to mid tide zone while low tidal zone is presented with comparatively small rocks (<0.5 m^2), gravel and cobbles type of substratum. Expansion of the intertidal zone is about 90-120 m in this transect. Mid tide zone was also not recorded with benthic fauna except few patches of attached Oyster on big rocky outcrops and boulders.

CR2

This transect is observed with big rocky outcrops from high to low tide zone. Small boulders or cobbles structures mixed with sand were scare in the low tidal zone. There were sediments available in between and inside the big boulders. Tide pools were observed in this transect. High tide zone of this transect was mostly avoid of algae or any other benthic faunal community. Mid tide zone was found with patchy oyster bed. Low tide zone was represented with algae coverage along with oysters. The expansion between high and low tide was about 80-100 m in this transect.

3.3.1.2. Package I

CR3

This transect is recorded with medium size (0.5 – 1.0 m^2) to small boulders (<0.5 m^2) and cobbles mixed with sandy gravels. Tide pools were not observed in this transect. The expansion between high and low tide was about 90-105 m in this transect.

CR4

This transect is located in the Haji Ali Bay and mostly covered with cobbles and mud mixed with sandy texture.

CR5

This transect is observed with big rocky outcrops from high to low tide zone. Big boulders, small boulders or cobbles structures mixed with sand were scare in the low tidal zone. There were sandy sediments available in between and inside the big boulders. Many tide pools were observed in this transect. High tide zone of this transect was mostly avoid of algae or any other benthic faunal community. Mid tide zone was found with patchy barnacle and oysters bed. The expansion between high and low tide was about 90-130 m in this transect.

CR6

This transect is observed with rocky from high to low tide zone and Low slope tidal zone. The area receives drainage system from local community. Many tide pools were observed in this transect. High tide zone of this transect was mostly avoid of algae or any other benthic faunal community. Mid tide zone was found with patchy barnacle and oysters bed. The expansion between high and low tide was about 100-150 m in this transect.

3.3.1.3. Package IV

CR7

This transect was located near the Amerson Garden. The expansion of this transect was about 10 m due to the steepness of the concrete wall located at this transect, which is making barrier the tide expands more. There was no area for sampling in the high tide zone in this transect. The transect is observed to be algae on the rocky outcrops.

CR8

This transect is located near the outlet of the 3.5 km tunnel near Priyadarshini Park. As the water filling work towards to the sea has been initiated, we have collected the samples at two different sites which located both the sides of construction (**Figure 6**). The expansion of this transect was about 80-120 m. The high tide region was found to be silty mixed with cobbles and cobble mixed with boulders. The low tide zone was abundant with algae attached on the boulders. Tide pools were observed in the low tide region.

CR9

This transect was located near the Girgaon Chowpatty which is the entry point of the proposed tunnel after the road come from Princess Street Flyover. This area is example of typical sandy beach ecosystem. The expansion of this intertidal region was about 70 m during the present study. The substratum was observed as sandy here.

CR10

This transect is located near the Princess Street Flyover. This transect is found to be similar with the transect CR9.

3.4. Sampling procedures

3.4.1. Chemistry

3.4.1.1. Water quality

Surface water samples for general analysis were collected using a clean polyethylene bucket while an adequately weighted Niskin sampler with the closing mechanism at the desired depth was used for obtaining subsurface water samples. Sampling at the surface and bottom (1 m above the seabed) was done when the station depth exceeded 3 m.

3.4.1.2. Sediment quality

For the analyses of metals, P, Corg, PHc, texture and benthos subtidal sediment samples were collected using a van-Veen grab of 0.04 m^2 area. All the samples for metals, Corg and P analysis were kept in plastic containers.

3.4.2. Flora and fauna

3.4.2.1. Microbiology

To detect the presence of faecal contamination in water certain microbial indicators such as Faecal indicator bacteria (FIBs) are used. These FIBs are part of normal intestinal flora. The two important bacteria that form the indicator system are Escherichia coli and faecal streptococci. As detection of every pathogenic bacterium from water is a tedious and expensive task, detection of indicator bacteria offers a faster approach. Bacteriological analyses for present study included the enumeration of total Viable Counts (TVC), Total Coliform (TC), faecal coliforms (FC), Escherichia coli like organisms (ECLO) and Streptococcus faecalis like Organism (SFLO).

Samples were analysed by plating method. Spread plate technique was used for total viable counts (TVC) determination, total coliforms (TC), Escherichia coli like organisms (ECLO), faecal coliforms (FC), and Streptococcus faecalis like organisms (SFLO). The media employed for growth of colonies are as follows:

Marine agar for TVC, Mac Conkey agar for TC, M-Fc agar for faecal coliforms, M7HrFC for ECLO and M. Enterococcus agar for SFLO.

3.4.2.2. Phytoplankton

Pigments: A known volume of water (500 ml) was filtered through a 0.45 µm membrane filter paper (Millipore) and the pigments retained on the filter paper were extracted in 90% acetone. For the estimation of Chlorophyll *a* and Phaeophytin, the extraction of the acetone extract was measured at 665 and 750 nm respectively before and after treatment with 0.1 N HCl on Turner design fluorometer.

Population: Samples for cell count were preserved in Lugol's iodine solution. Enumeration and identification of phytoplankton settled at the bottom of the bottle were done under a compound microscope using Sedgewick Rafter slide.

3.4.2.3. Zooplankton

Zooplankton samples were collected by oblique hauls using a Heron Tranter net (mesh size 0.3 mm, mouth area 0.25 m^2) with an attached calibrated General Oceanic digital flow meter. All collections were of app 4-5 min duration. Samples were preserved in 5 % buffered formaldehyde. Total volume (biomass) of zooplankton was obtained by displacement method. A portion (25-50%) of the sample was analyzed under a microscope for faunal composition and population count.

3.4.2.4. Benthos

3.4.2.4.1. Meiobenthos

Undisturbed sediment is brought on deck in duplicate by the deployment of van Veen grab (0.04 m^2). The meiofauna samples were collected using syringe cores of 6.61 cm^2 surface area and 10 cm length. The cores were pushed through sediment vertically down up to 5-6 cm depth wherever possible. In rocky habitats, samples were collected by scrapping algae present on the rocks. Three replicates were collected per station and transferred to plastic sediment containers. After which, relaxation, staining and fixation were carried out using 7% of Magnesium Chloride ($MgCl_2$), 1% Rose bengal stain and 5% Formaldehyde respectively. The samples were homogenized and stored for further analysis. In intertidal transect three numbers of core or similar area coverage of algae/oysters mixed with rocky sediments have been scratched to collect meiofaunal samples from the rocky outcrops. Further it is processed with above mentioned procedure.

In the laboratory, samples were sieved through a 63 µm mesh. Decantation and extraction of meiofauna were done by gently stirring the sample and decanting upper aliquot, at least 4-5 times. The remaining precipitated sediment is also analyzed for heavier meiofaunal groups (e.g. Ostracoda). The meiofauna is sorted and enumerated using stereo (S8APO Leica) and compound (Primostar Carl Zeiss) microscope.

For estimation of biomass, less abundant faunal groups were entirely picked out onto slides, wherever the abundance of the faunal group is high, 100 individuals per group per core were randomly picked out for biomass estimation. The length-width measurements were then used to determine the biomass of the organisms following the formulae given by Nozais et al. (2005)[8]. Biomass of 10 groups (viz., Nematoda, Ostracoda, Kinorhyncha, Polychaeta, Oligochaeta, Halacaroidea, Nauplii, Tardigrada, Turbellaria) was computed. The remaining groups were excluded from biomass calculations due to less density per core and lack of conversion factors.

3.4.2.4.2. Macrobenthos

The sediment was sieved through a 0.5 mm mesh sieve and animals retained were preserved in 5% buffered formaldehyde and Rose Bengal. In intertidal area, four replicate quadrants (total area coverage 0.25 m^2) have been placed to collect the macrofaunal samples at each tide level. The total population was estimated as a number of animals in 1m^2 areas and biomass on wet weight basis. The biomass was estimated by using microbalance and denoted gram per sq. meter.

3.4.2.5. Seaweeds

To study the seaweeds sampling was undertaken along a Line Intercept horizontal transect (10 m) at each low tide location to quantify (% coverage) the intertidal seaweeds.

3.4.2.6. Sponge

To study the diversity of sponges along study area the areas were surveyed and sponges were photographed and collected for laboratory analysis. Photograph was taken by Nikon D5200 and Olympus TG-3 camera. Species were identified by using standard protocol and identification keys.

3.4.2.7. Corals

Presences of live corals were assessed by physical examination of the intertidal zone during low tide. Presence or absence of live corals were assessed by applying manual as well as photography and video documentation methodology. As the coral colony (30-500 no of polyps; area covered ranged between 50 and 600 cm^2) of *Polycyathus* sp. is patchy and solitary in nature rather than continuous reef formatting corals, the rapid survey was undertaken to quantify the corals in Worli and Haji Ali region. Further we also surveyed Marine drive rocky shore area to see the presence or absence of corals (the area is located about 1.8 km away from the proposed project site).

3.4.2.8. Megafauna

To study the mega fauna of rocky intertidal shores quadrant of $1m^2$ was used, which is made of PVC pipes. Megafauna have been identified mainly based on field observations and collected for laboratory analysis (when required). Photograph was taken by Nikon D5200 and Olympus TG-3 camera, and organisms were identified using standard keys.

3.4.2.9. Fishery

Fishery potential of the area has been assessed by the data from Department of Fisheries, Govt. of Maharashtra, Mumbai; actual fish landing and Census reports. Two experimental hauls for fishing have been carried out at two locations in the study area.

3.4.2.10. Avifauna

A list of varieties of migratory and resident birds inhabiting the Mumbai coast was prepared and presented based on field survey for Mumbai area. High-resolution photographs were taken with using Nikon D5200 added 70-300 mm zoom lens for further identification.

3.4.2.11. Mammals

Marine mammals noticed along Mumbai coast were spotted during the present study.

Schematic diagram shows the benthic sampling (meio, macro fauna, megafauna and seaweeds) strategies in rocky intertidal shores during the present study in March-April 2019 (figure not in scale).

4. Prevailing Environment

4.1. Chemistry

4.1.1. Water quality

The prevalent water quality of subtidal area at bay, near-shore, far-shore and off-shore regions around Mumbai was assessed. Water samples were collected with respect to tidal condition (i.e. during high tide and low tide periods) in nearshore stations, which helped us to understand the variability of water quality parameters with respect to tide. The stations within the coastal and offshore regions were spot sampled twice and the average values of water quality parameters measured in them are reported. The results of water quality parameter concentrations are presented in tables and the spatial variation observed in them are displayed in Figures. The concentration of water quality parameters observed during this study in different region are further compared with available data (with CSIR-NIO) collected in the past around similar location, which will help to understand the changes (if any) in water quality during the period of present monitoring (March 2019). Summary of average surface and bottom physicochemical parameters are shown in **Table. 43** and **Table. 44**

4.1.1.1. Temperature

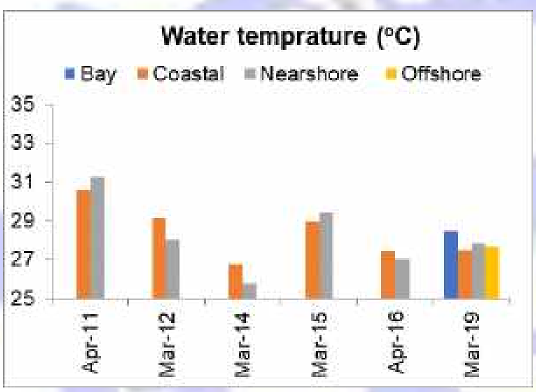
Water temperature generally regulates distribution, composition and activity of living organisms in aquatic environment. Majority of the aquatic animals are cold blooded; therefore, the water temperature regulates their metabolism and ability to survive and reproduce effectively. In shallow coastal areas, seawater temperature varies in accordance with the air temperature. An upper threshold limit of 35°C is considered for tropical aquatic species though many may be less tolerant.

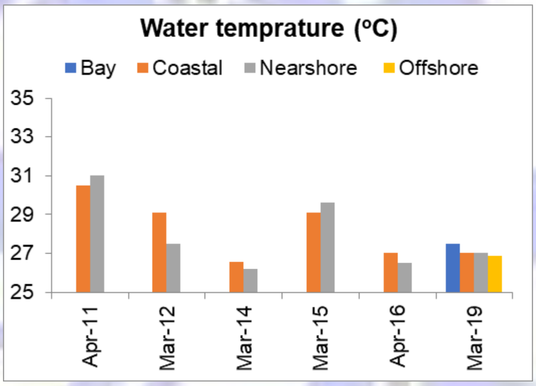
During the study period, water temperature off Mumbai varied within a wide range (26.5−29.0°C; av. 27.7°C) in surface as well as in bottom water (25.5−28.5°C; av. 27.0°C). The observed air temperature was ranged at 26.0−32.0°C, with an average value of 29.1°C. The variation of water temperature in surface and bottom layer was significant and their water column ranges in bay (27.5−28.5°C; av. 28.0°C), nearshore (25.5−29.0°C; av. 27.3°C), coastal

(26.0−29.0°C; av. 27.5°C) and offshore (25.5−29.0°C; av. 27.3°C) stations were different. The average values of water column temperature varied within a narrow range between 27.3 and 28.0°C during present study (***Table. 2***). The values of water temperature did not exceed 35°C (considered as threshold limit for tropical aquatic species), therefore may not have any significant impact on aquatic organisms.

The limits of water temperature recorded during this study period at all the samples region are in line with previously measured values around the same region as displayed in figure below.

Surface Bottom



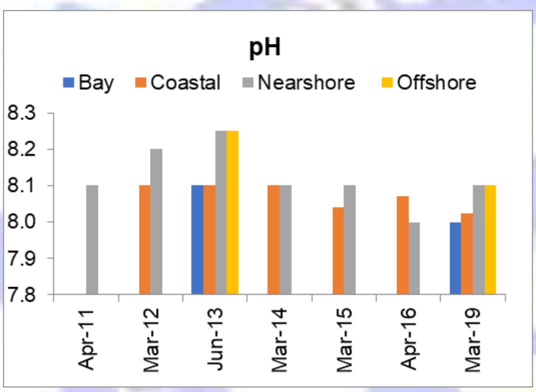


4.1.1.2. pH

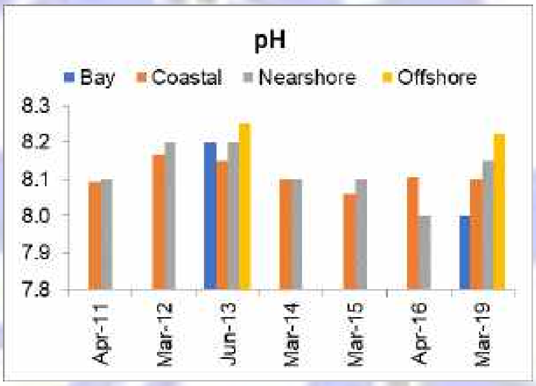
The principal system that regulates pH of the seawater are carbonate system (CO_2, HCO_3^- and CO_3^{2-}), salt content and borate alkalinity. Generally, seawater pH varies within a range between 7.8 and 8.3. The major carbon reservoir in the ocean is dissolved inorganic carbon (DIC), which is total of aqueous CO_2, bicarbonate (HCO_3^-) and carbonate (CO_3^{2-}) ions. The pH of seawater generally varies from 7.9–9.0 in the present day, with predominant HCO_3^- ions. The concentrations of CO_3^{2-} ion increase with increasing pH, so as to become more acidic due to more dissolved CO_2. The atmospheric CO_2 reacts with seawater to form carbonic acid (H_2CO_3), which is unstable and get dissociated to form HCO_3^- and CO_3^{2-} ions. The CO_3^{2-} ions react with calcium ions (Ca^{2+}) present in seawater to form calcium carbonate ($CaCO_3$) mainly utilized by organisms to build their exo-skeleton. In shallow and biologically active tropical water, diurnal pH varies between 7.3 and 9.5; this may be due to photosynthesis process. In nearshore environment, mixing of freshwater, especially during monsoon season, can affect the buffering effect, thus pH remains below 8.0. Also, this area is vulnerable to pH change owing to release of anthropogenic low pH water discharges. Albeit, the pH range of 5 to 9 is not directly harmful to aquatic life but such changes can make many common pollutants more toxic.

The variation of pH between surface and bottom water was not significant, which indicates apparently a well-mixed condition. Briefly, the average values of pH in Bay, nearshore, coastal and offshore stations were 8.0, 8.1, 8.1 and 8.2, respectively (***Table. 3***). Moreover, the limits of pH obtained for surface and bottom water during this study are in line with previously observed pH limits around the same region as displayed in figure below.

Surface



Bottom

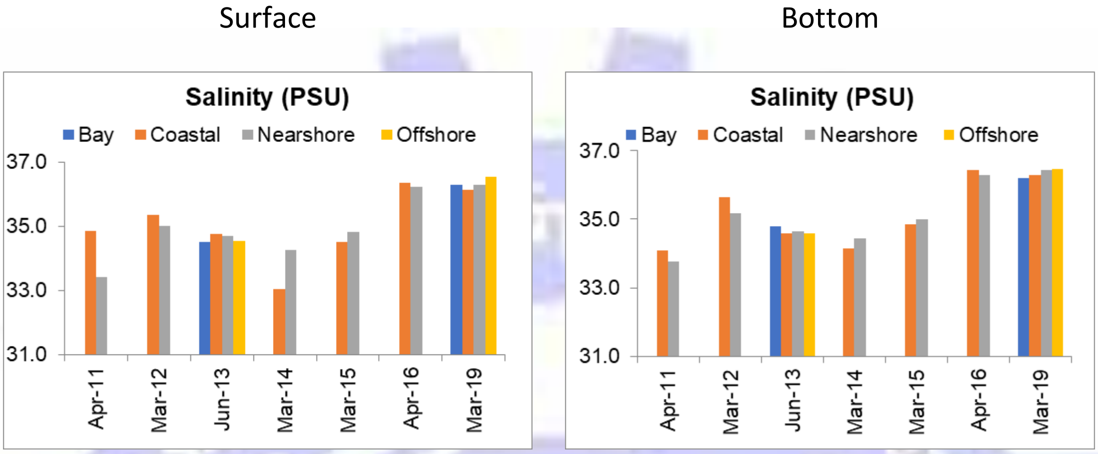


4.1.1.3. Salinity

Normally seawater salinity is 35.5 ppt, which may vary depending on the balance between evaporation and precipitation, also freshwater addition. Salinity is an ecological factor of considerable importance, influencing the types of organisms that live in a water body. Biota is generally acclimatized to a certain range of salinity where they thrive. Hence, wide variation in salinity levels can result in adoption, with modification and dominance of selected species in the lower order, while higher order biota may migrate. Sudden changes in salinity may cause high mortality of biota including fish due to salinity shock.

During the study period, salinity values off Mumbai were varied within a narrow range (35.7−36.7 psu; av. 36.3 psu) in surface as well as in bottom (36.2−36.6 psu; av. 36.4 psu). The variation of salinity between surface and bottom water column was not significant and the ranges of salinity in water column of bay (36.2−36.3 psu), nearshore (35.7−36.5 psu; av.

36.2 psu), coastal (35.9−36.5 psu; av. 36.3 psu) and offshore (36.4−36.7 psu; av. 36.5 psu) were nearly similar during the study period indicating well mixing condition (***Table. 4***).



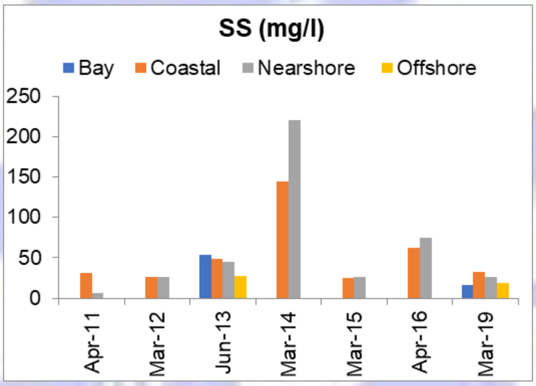
The ranges of salinity observed in different regions of this study and in surface and bottom water columns were more or less similar to the range of salinity values reported previously around this region as displayed above.

4.1.1.4. Suspended Solids

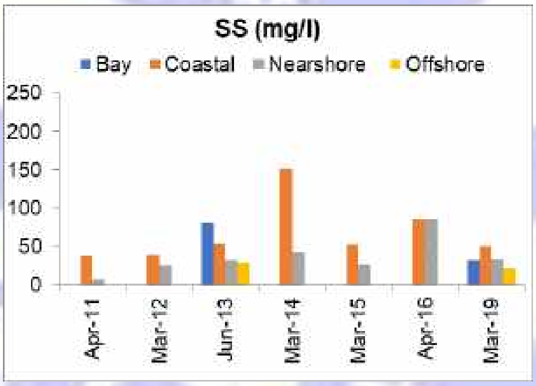
Suspended Solids (SS) are mainly made up of inorganic and organic materials from hinterland soils, degraded and fresh residues of plant, plankton and algae etc. float in the water column and eventually sink into sediment due to effects of physicochemical properties of seawater. They contribute to turbidity of seawater and higher concentrations of SS can affect health of the aquatic animals and submerged vegetation by reducing the photosynthesis. The reduced rates of photosynthesis cause less dissolved oxygen production by the plants. In case of complete blockage of light by turbidity, the photosynthesis by bottom dwelling plants will be ceased, therefore they die and start to degrade. The bacteria act up on the degrading plant by using up the dissolved oxygen. SS in the water column also adversely affects certain sensitive populations through mortality, reducing growth rate and resistance to diseases, preventing proper development of fish eggs and larvae, modifying natural movement and migration and reducing abundance of available food. SS settling on the bed can damage the benthic invertebrate population, block spawning etc.

The SS concentrations were ranged at 9−41 mg/l (av. 27 mg/l) in surface and 10−74 mg/l (av. 39 mg/l) in bottom water during this study. The variation of SS concentrations between surface and bottom water was significant. Broadly the ranges of water column SS were from 16 to 32 mg/l, 18 to 74 mg/l, 14 to 39 mg/l, and 9 to 32 mg/l in bay, nearshore, coastal and offshore regions respectively (***Table. 5***). On an average, the mean SS concentration were decreased from nearshore (41 mg/l) to coastal (29 mg/l) and offshore region (20 mg/l) during the study period.

Surface



Bottom



The SS concentrations found in different regions of this study and in surface and bottom water columns were more or less similar to the range of SS values reported previously and much lower when compared to the values obtained during March 2014, especially in coastal and nearshore waters as displayed in figure above.

4.1.1.5. Turbidity

Turbidity of water relates to optical clearness and is affected by contents of dissolved matter and SS present in it. In general, turbidity has direct relationship with SS in water. However, some deviations may occur as SS includes silt, sediment, non-settleable solids, bacteria, clay, algae and settleable solids, whereas turbidity may be the contribution of these plus dyes, coloured dissolved organic matter and humic acids excluding settleable solids. Measurement of turbidity is one of key parameter in deciding the quality of water as high turbidity can harm fish and other aquatic life by reducing food supplies, degrading spawning beds, and affecting gill function.

The turbidity levels off Mumbai were ranged at 1.3−40.7 NTU (av. 10.8 NTU) in surface and 1.6−46.6 NTU (av. 13.6 NTU) in bottom water during this study. Like SS, the differences in turbidity levels between surface and bottom was significant. Broadly the water column turbidity in bay, nearshore, coastal and offshore regions were ranged at 11.9−13.3 NTU, 3.2−46.6 NTU, 1.3−7.2 NTU and 1.6−4.8 NTU respectively, with their average limits decreasing from nearshore (19.3 NTU) to coastal (3.7 NTU) and lowest in offshore region (2.9 NTU) (***Table. 6***). The higher turbidity levels in bottom water were in line with the higher concentrations of SS. However, the difference in average concentrations of SS and turbidity between surface and bottom water is low (i.e. 12 mg/l and <2.9 NTU), which indicated apparently mixed water column.

4.1.1.6. Chloride (Cl^-)

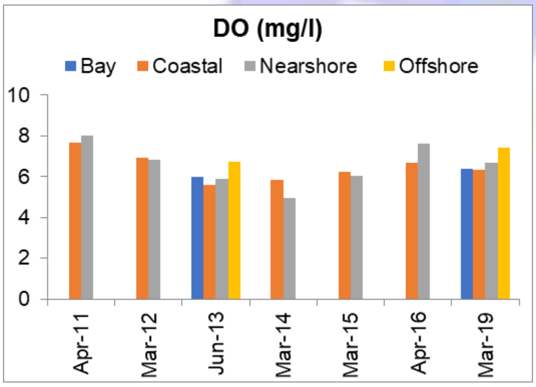
The Chloride, in the form Cl^- ion, is one of the major inorganic anions or negative ions in saltwater. Seawater (Salinity 35 ppt) has natural Cl^- concentration of 19400 mg/l. Natural spikes in chloride concentration can occur during summer and/or "low-flow" periods, when the evaporation exceeds precipitation. The Cl^- in the environment can come from sodium chloride (NaCl) or from other chloride salts such as potassium chloride (KCl), calcium chloride ($CaCl_2$) and magnesium chloride ($MgCl_2$) and anthropogenic factors such as road salt and due to contamination by the sewage. During March 2019, the Cl^- concentrations around off Mumbai varied between 19800 and 20300 mg/l, averaged at 20074 mg/l in surface, whereas it varied between 20000 and 20200 mg/l, averaged at 20132 mg/l in bottom water (***Table. 7***). The difference in Cl^- concentrations between surface and bottom water was not significant. The average Cl^- concentrations in bay, nearshore, coastal and offshore regions were 20050 mg/l, 20069 mg/l, 20138 mg/l, 20163 mg/l respectively increased from bay towards offshore region. The value of Cl^- indicated general mixing condition in entire study area due to tidal incursion of seawater.

4.1.1.7. Dissolved oxygen (DO) and Biochemical oxygen demand (BOD)

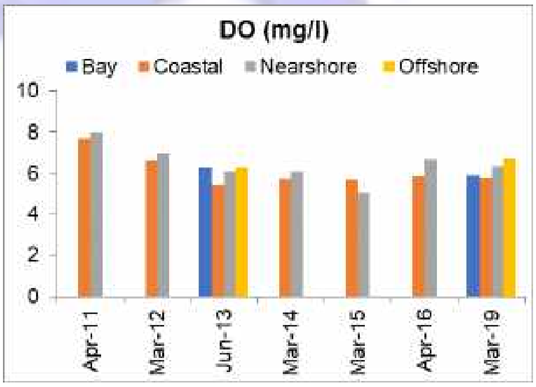
DO is an important parameter of water quality and its concentration in water highlights the ability of a water body to support aquatic life. The sources of DO in aquatic environments such as bay, nearshore and offshore are combining due to photosynthesis, atmosphere exchange and addition of oxygen-rich water by river runoff. Consumption of DO during heterotrophic oxidation of oxidable organic matter and respiration by aquatic flora and fauna gives rise to biochemical oxygen demand (BOD). It is difficult to attain the threshold limit of DO for aquatic life, since environmental conditions, waste loading and natural levels of DO vary considerably and the existent composite aquatic life has variable demand for DO depending on their composition, age, activity, nutritional status etc. However, it has been observed that below 3 mg/l concentration of DO, good and diversified aquatic life may not sustain since feeding of many organisms is stopped and their growth is retarded at low DO levels. Embryonic and larval stage of aquatic life are especially vulnerable to reduced oxygen conditions, may result in retarded development and even partial mortality. It is considered that the level should not fall below 4 mg/l consistently for a longer period of time.

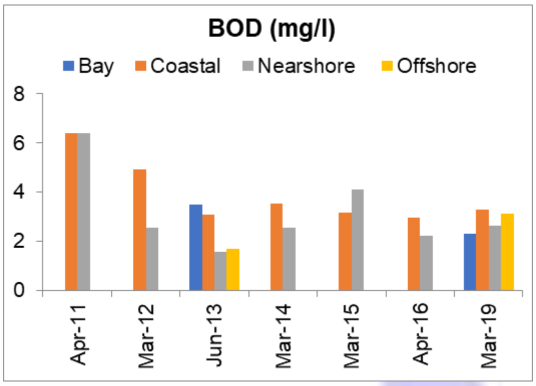
During the study period, DO values off Mumbai were ranged at 4.9−7.7 mg/l; (av. 6.6 mg/l) in surface and 3.9−7.5 mg/l; (av. 6.1 mg/l) in bottom water, with significant variation of DO found between surface and bottom water column. The ranges of water column DO in bay (5.9−6.4 mg/l), nearshore (3.9−7.7 mg/l; av. 6.0 mg/l), coastal (6.1−7.1 mg/l; av. 6.5 mg/l) and offshore (6.2−7.7 mg/l; av. 7.0 mg/l) were varied from each other but have similar average values during the study period (***Table. 8***). The ranges of DO obtained in this study indicated a well oxygenated water column prevailed for the healthy aquatic life to sustain. The levels of DO found in different regions of this study and in surface and bottom water columns were more or less similar to the range of DO reported previously in nearshore, coastal and offshore regions off Mumbai as displayed in figure below.

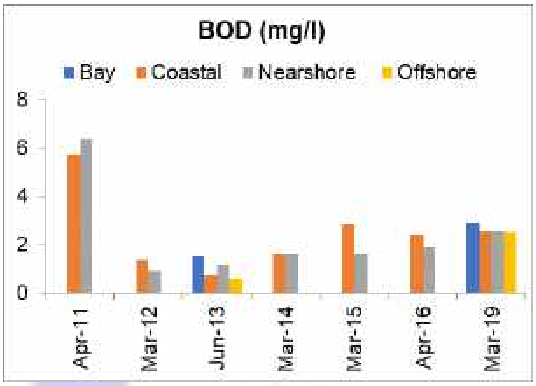
Surface



Bottom







Consumption of DO during heterotrophic degradation of oxidizable organic matter creates oxygen demand referred as BOD, measured after incubation of DO samples for 3 days at 27^{o}C soon after the collection. Presence of sufficient DO through replenishment keeps this demand low. However, input of oxidizable organic matter often cause enhancement of BOD, which is the indicator of unfavorable conditions for the aquatic life. The levels of BOD were ranged from 1.2−4.6 mg/l; (av. 3.0 mg/l) in surface and 0.8−4.3 mg/l; (av. 2.6 mg/l) in bottom water, with their significant variation between surface and bottom water column. The ranges of water column BOD in bay (2.3−2.9 mg/l), nearshore (0.8−4.6 mg/l; av. 2.9 mg/l), coastal (1.2−3.9 mg/l; av. 2.6 mg/l) and offshore (1.6−4.5 mg/l; av. 2.9 mg/l) were varied from each other but have nearly similar average values during this study (***Table. 8***). Relatively higher levels of BOD (>4 mg/l) associated with fairly higher DO (>7mg/l) were observed in northern transect, both in nearshore and offshore station could be related with efficient biochemical oxidation by the heterotrophs present in the water or could be due to localized impact of sewage, which were not seen in other regions. Moreover, the levels of BOD found in different region of this study were nearly similar or lower than the BOD levels in past observed around similar region as displayed in figure above.

4.1.1.8. Nutrients

The nutrients such as forms of phosphate, nitrogen and silicon, along with trace metals are used by phytoplankton during primary productivity. Amongst, nitrogen and phosphorus occur in estuarine and coastal water mainly in forms of nitrate (NO_3^- ; oxidation state +5) and ammonium (NH_4^+; oxidation state -3) with other compounds. The dominant forms of nitrogen exist in seawater are nitrate (NO_3^--N), nitrite (NO_2^--N) and ammonium (NH_4^+-N).

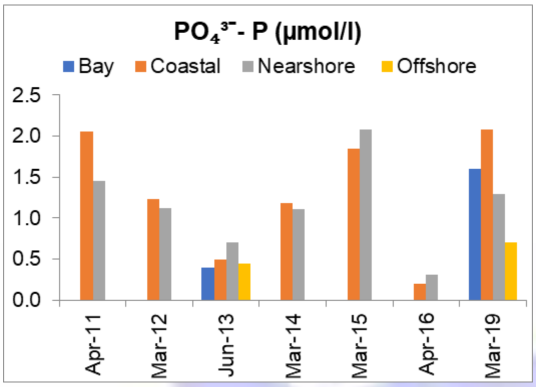
NH_4^+-N is produced during the oxidation of organic matter, which later oxidized to produce NO_3^--N via NO_2^--N, with presence of sufficient quantities of DO in the environment. NO_2^--N is an intermediate product of oxidation of NH_4^+-N and reduction of NO_3^--N and is thermodynamically unstable. Nitrogen cycle involving elementary dissolved nitrogen; oxides: NO_3^-, NO_2^- and reduced forms: NH_4^+, plays a significant role in sustaining life within aquatic environment. NO_3^--N is the end product of oxidation and most stable form at pH 7. The principal source of nitrogen in marine environment is fixation of atmospheric N_2. NO_2^- occur in seawater as an intermediate product of NO_3^- reduction in microbial processes i.e. denitrification at low oxygen level at which NO_2^- is further transformed into N_2 under anoxic conditions. Inorganic phosphorus occurs most often as the phosphate (PO_4^{3-}-P). Though these nutrients are essential for life support in the aquatic environment, their enrichment in nearshore regions may hamper the coastal nutrient status and in extreme cases it can lead to eutrophication. Collectively, the compounds of phosphate, nitrogen and silicon, are prime nutrients used for primary productivity. However, occurrence of high levels of these nutrients in creek and nearshore regions may hamper the coastal nutrient status and in extreme cases it can lead to eutrophication.

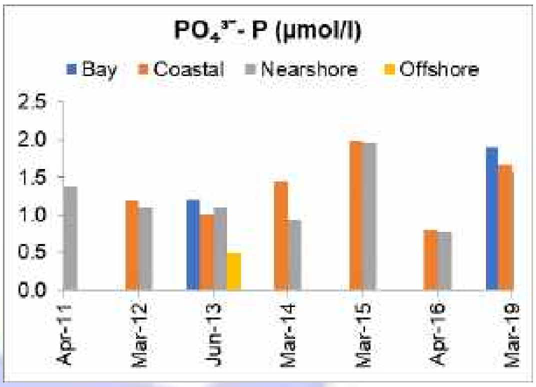
4.1.1.8.1. Phosphate (PO_4^{3-}-P)

Phosphorus as phosphate (PO_4^{3-}−P) is an essential nutrient required for plant nutrition. Anthropogenic sources of PO_4^{3-}−P in coastal marine environment include domestic sewage, detergents, effluents from agro-based and fertilizer industries, agricultural runoff, organic detritus such as leaves, cattle waste etc.

During March 2019, PO_4^{3-}−P concentrations were ranged between 0.4 µmol/l and 5.0 µmol/l, averaged at 1.7 µmol/l in surface layer, whereas it ranged from 0.8 µmol/l and 2.3 µmol/l, averaged at 1.5 µmol/l in bottom layer. The difference in PO_4^{3-}−P concentrations of surface and bottom water column was significant. The ranges of water column PO_4^{3-}−P in bay (1.6−1.9 µmol/l), nearshore (0.4−5.0 µmol/l; av. 2.0 µmol/l), coastal (0.9−2.2 µmol/l ; av. 1.5 µmol/l) and offshore (0.6−1.0 µmol/l ;av. 0.8 µmol/l) were distinctly varied from each, with their average values decreasing from bay towards offshore region (***Table. 9***). Moreover, the average concentrations of PO_4^{3-}−P in surface and bottom waters were nearly similar.

Surface Bottom



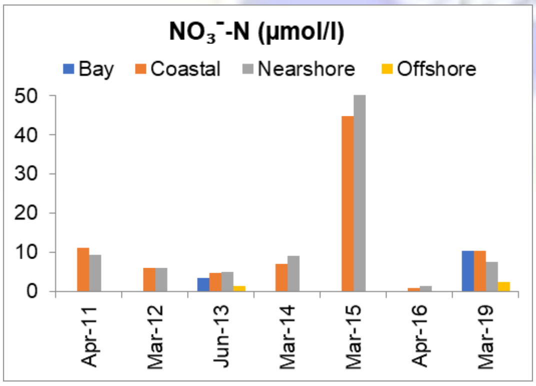


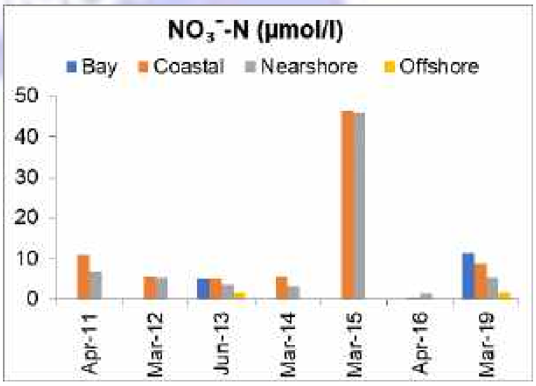
When compared to the levels of PO_4^{3-}–P observed in nearshore, coastal and offshore regions off Mumbai (shown in figure above), the levels of PO_4^{3-}–P observed in this study are higher than that in June 2013. This indicated seasonal variation of PO_4^{3-}–P in the studied region.

4.1.1.8.2. Nitrate (NO_3^--N)

The ranges of NO_3^-–N in surface water was between 0.2 and 17.1 µmol/l (av. 8.0 µmol/l), whereas in bottom water NO_3^-–N concentration was between 0.2 and 13.5 µmol/l (av. 6.5 µmol/l) during March 2019. The difference in NO_3^-–N concentrations in surface and bottom water was significant. The ranges of water column NO_3^-–N in bay (10.5–11.3 µmol/l), nearshore (1.6–17.1 µmol/l; av. 9.5 µmol/l), coastal (0.2–13.5 µmol/l; av. 6.6 µmol/l) and offshore (0.2–4.3 µmol/l; av. 2.2 µmol/l) were distinctly different, with their average values decreasing from bay towards offshore region (***Table. 10***).

Surface Bottom



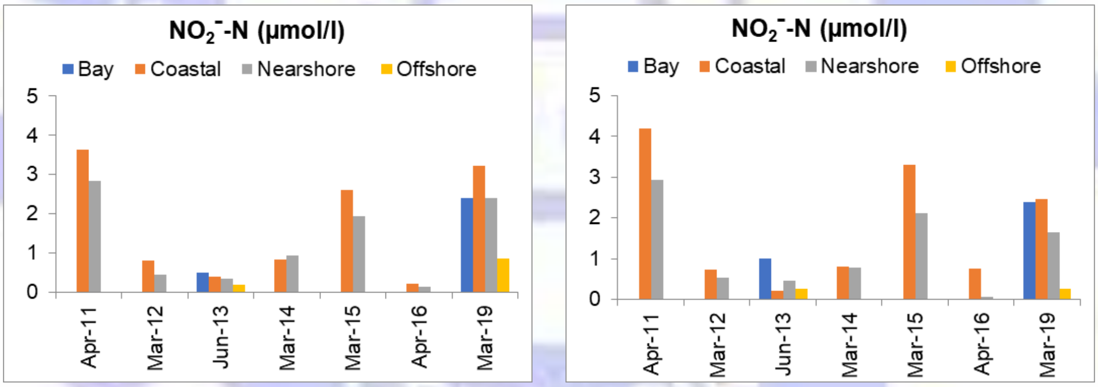


The average concentrations of NO_3^-−N in surface water was higher than that in bottom water around off Mumbai region during the study period. The levels of NO_3^-−N found in different region of this study were nearly similar as compared to NO_3^-−N in past, except that in March 2015, when exceptionally higher NO_3^-−N values were seen in nearshore and coastal regions off Mumbai.

4.1.1.8.3. Nitrite (NO_2^--N)

The NO_2^-−N concentration in surface water off Mumbai was ranged at 0.1−5.5 µmol/l (av. 2.5 µmol/l), in bottom water, range of NO_2^-−N varied from 0.3−3.7 µmol/l (av. 1.9 µmol/l) during March 2019. The difference in NO_2^-−N concentrations between surface and bottom was significant. Likewise NO_3^-−N, the ranges of water column NO_2^-−N in nearshore (0.7−5.5 µmol/l; av. 2.8 µmol/l), coastal (0.3−4.0 µmol/l; av. 2.1 µmol/l) and offshore (0.1−2.7 µmol/l ; av. 0.8 µmol/l) were distinctly different, with their average values decreasing from bay towards offshore region (***Table. 11***).

Surface Bottom

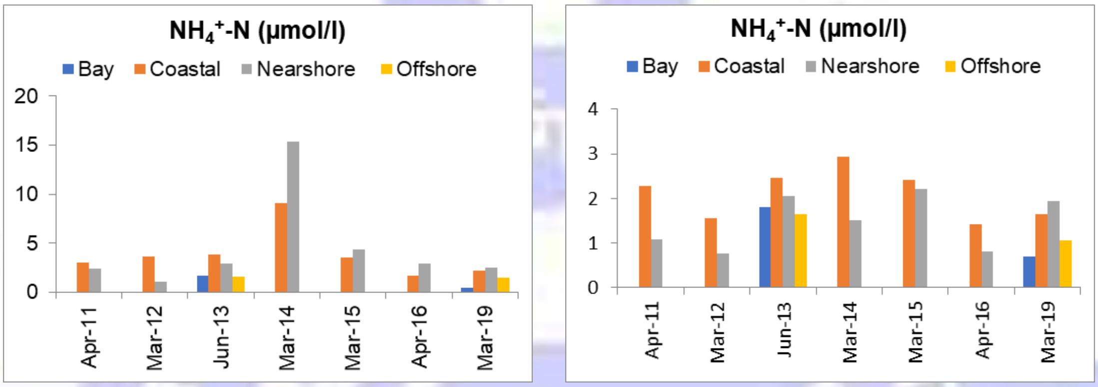


The levels of NO_2^-−N found in different region of this study were nearly similar as compared to NO_2^-−N in past, except that in March 2014, when exceptionally higher NO_2^-−N values were seen in nearshore and coastal regions off Mumbai.

4.1.1.8.4. Ammonium (NH_4^+-N)

The NH_4^+-N is unstable in natural surface waters, therefore further oxidized to NO_3^--N via NO_2^--N. The concentration of NH_4^+-N were ranged at 0.5–5.8 µmol/l (av. 2.2 µmol/l) in surface water and 0.7-3.8 µmol/l (av. 1.6 µmol/l) in bottom water off Mumbai during March 2019, with significant variation of NH_4^+-N resulted in surface and bottom water samples.

The levels of average NH_4^+-N decreased from nearshore to offshore region in the study area. Broadly, the ranges of water column NH_4^+-N in nearshore (0.7−5.8 µmol/l; av. 2.1 µmol/l), coastal (1.0−5.8 µmol/l; av. 2.5 µmol/l) and offshore (0.8−2.2 µmol/l ; av. 1.3 µmol/l) were distinctly different, with their average value lowest in offshore region (***Table. 12***).

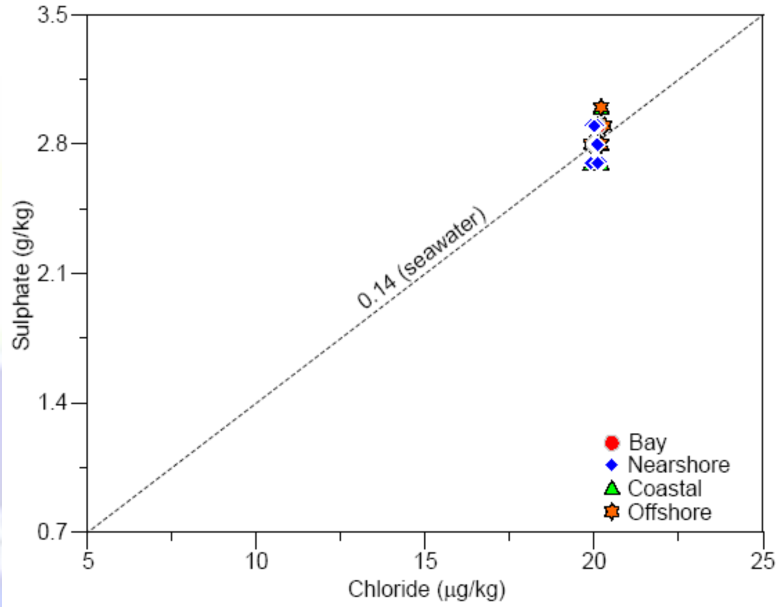


As shown in figure above, the levels of NH_4^+-N found in different region of this study were nearly similar as compared to NH_4^+-N in past, except that in March 2014, when exceptionally higher NH_4^+-N values were seen in nearshore and coastal regions off Mumbai.

4.1.1.8.5. Sulphate (SO_4^{2-})

Sulphate (SO_4^{2-}) is one of the conservative elements, which co-varies with chlorinity in seawater with a constant ratio of SO_4^{2-}: Cl is 0.14 (Morris and Riley 1966). The principal source of Sulphur in coastal marine environment could be from sea salt during rain and continental and anthropogenic sources (Kroopnick, 1977). The SO_4^{2-}: Cl ratio may vary with the addition or removal of SO_4^{2-}. Hence, if there is addition of SO_4^{2-} rich substance, which can enhance the concentration of SO_4^{2-} and thereby the SO_4^{2-}: Cl ratio. Furthermore, reduction due to removal or dilution of SO_4^{2-} salts, which cause decrease of SO_4^{2-}: Cl ratio. The concentrations of sulphate (g/kg) in water samples collected at different locations off Mumbai during March 2019 is given in ***Table. 13***. Overall, the sulphate concentrations varied at similar range in surface as well as bottom water during this study. The range of sulphate was from 2.8 to 3.1 g/kg, averaged at 2.9 g/kg. There was no significant variation in average sulphate levels among nearshore, coastal and offshore samples. The SO_4^{2-}: Cl ratio varied within a very narrow range in surface as well as bottom water samples i.e. between

0.14 and 0.15, averaged at 0.15. From the table, it is evident that the SO_4^{2-}: Cl at all the stations is nearly identical and, in the range, observed for the natural seawater. The SO_4^{2-} vs. Cl plot for all data collected during March 2019 around off Mumbai waters is presented below:



The results indicated that all the data points are in line with the average SO_4^{2-}: Cl ratio of sea water (i.e. 0.14; Morris and Riley 1966). Few of the observation indicated higher or lower SO_4^{2-}: Cl ratio, which may be due to natural variation of Cl in water samples. The Cl enrichment in nearshore and coastal areas are normal, however, the processes such as sulphate reduction is ruled out as indicated by fairly normal DO values. Therefore, it appears that there is no build up or removal of sulphate in the study area.

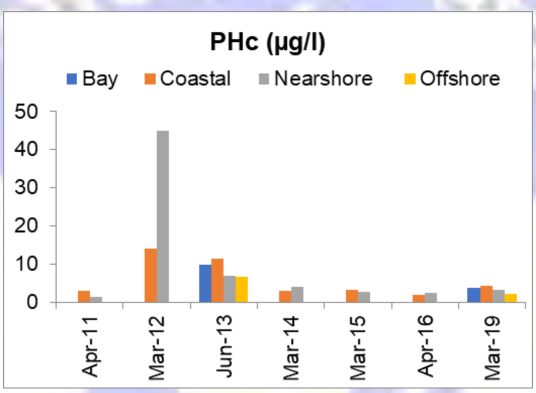
4.1.1.9. Petroleum Hydrocarbon (PHc)

Naturally occurring hydrocarbons in aquatic environment are in trace amounts of simple forms produced by microbes. PHc derived from crude oil and its products are added to marine environment by anthropogenic activities namely production of crude oil and its products, their transport, ship traffic, etc. Prominent land-based sources are domestic and industrial effluents, atmospheric fallout of fuel combustion products, condensed vapors etc. PHc can cause severe damage to the aquatic life when there are sudden discharges in large quantities during accidents such as tanker collision, pipeline rupture, fire etc. Samples for PHc was collected 1m below the surface water.

The concentration of PHc measured in at surface layer (1m water depth) around off Mumbai were ranged at 1.6–6.8 µg/l (av. 3.4 µg/l) during March 2019. The average values of PHc were decreased from nearshore to the offshore region, with average values 4.2 µg/l, 3.2 µg/l and 2.2 µg/l respectively at nearshore, coastal and offshore region during the study period (***Table. 14***).

The ranges of PHc obtained during this study are lower as compared to the higher PHc levels obtained in the past, especially during March 2012 and June 2013 as displayed in figure below.

Surface (1m)



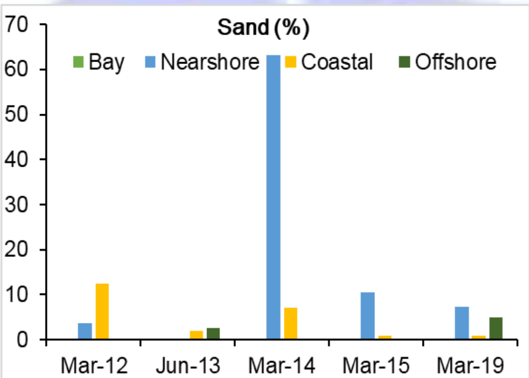
4.2. Sediment quality

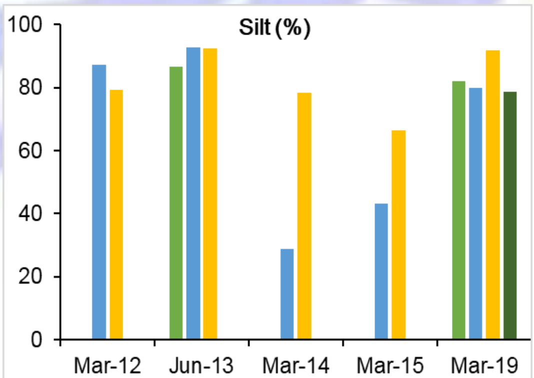
The sedimentary bed in coastal aquatic systems act as an eventual sink of SS, which often carries significant amount of chemical substance (metals, organic carbon and pollutants) from the source region via water column. The pollutants removed through adsorption and attached to the SS. In several instances, it is observed that even close to a location of effluent release, the metal content in receiving water often decreases to a normal value making assessment of contamination through analysis of water, a difficult task.

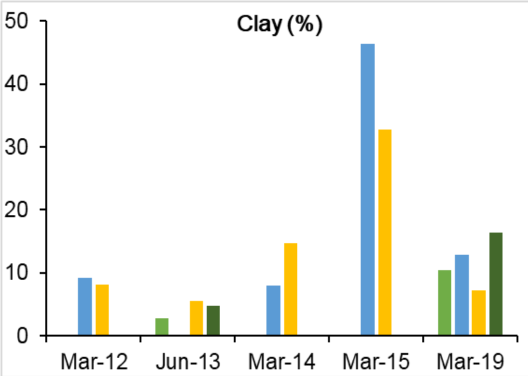
The concentrations of metals, organic carbon (C_{org}) and pollutants increase over a period of time at sinking interface dependent upon the balance between their receiving fluxes, accumulation and removal rates. Moreover, the accumulation of metals, C_{org} and pollutants in sediment over period of time can substantially indicate the quality of sediment that is essential for a sustainable healthy benthic ecosystem. The sediment samples in this study were collected during Mach 2019 using a stainless-steel van-Veen grab from different regions off Mumbai (Bay, nearshore, coastal and offshore). Post collection, the samples were dried and homogenously powdered for chemical analyses of parameters such as heavy metal content. The grainsize (texture) and petroleum hydrocarbon (PHc) analyses were performed on un–grinded dry and wet sediment respectively and results are presented in Table. The metal and PHc contents in sediment samples from this study are further compared with available sedimentary data available in similar region in order to evaluate the changes (if any) in geochemical parameters in sediments over the period of time.

4.2.1. Texture

Overall, the bed sediment within the off-Mumbai region showed a wide range of texture property (clay, silt and sand), mainly dominated with silt (57-94%). The percentages of sand content were varied from 1% to 20% in subtidal stations, with highest measured in coastal station H10. Similarly, the silt and clay contents were varied from 57–94%, averaged at 80% and 6–37%, averaged at 15% respectively at the sub tidal stations of this study (***Table. 15***). Overall, the silt content in sediment were predominated, which is a general characteristic around this region, also observed in previous monitoring by CSIR-NIO and shown in below figure. The distribution of sediment texture did not indicate any pattern from the nearshore to offshore stations. The average silt and clay content of sediments from intertidal stations were 16% and 14% respectively.







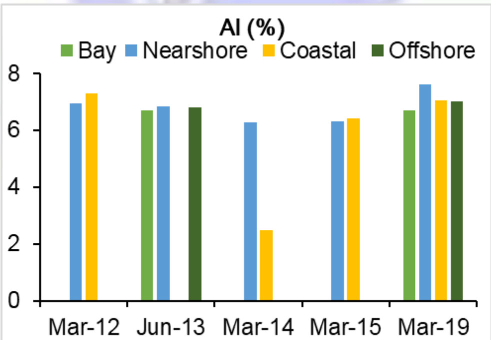
Predominantly silty bottom with fairly low clay content present in the study area irrespective of the prevalent seasons. The variability in sediment texture at a given location could be due to seasonal changes, high wave action and active transport by currents especially during monsoon season. Overall, the present study indicated changes in the texture of subtidal as well as intertidal sediments, where the intertidal sediments were mostly sand and silt, with fairly low amount of clay content (***Table. 15***).

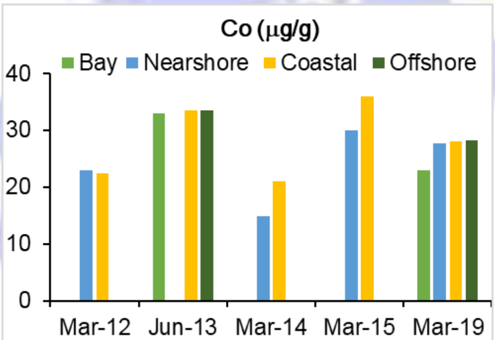
4.2.2. Metals

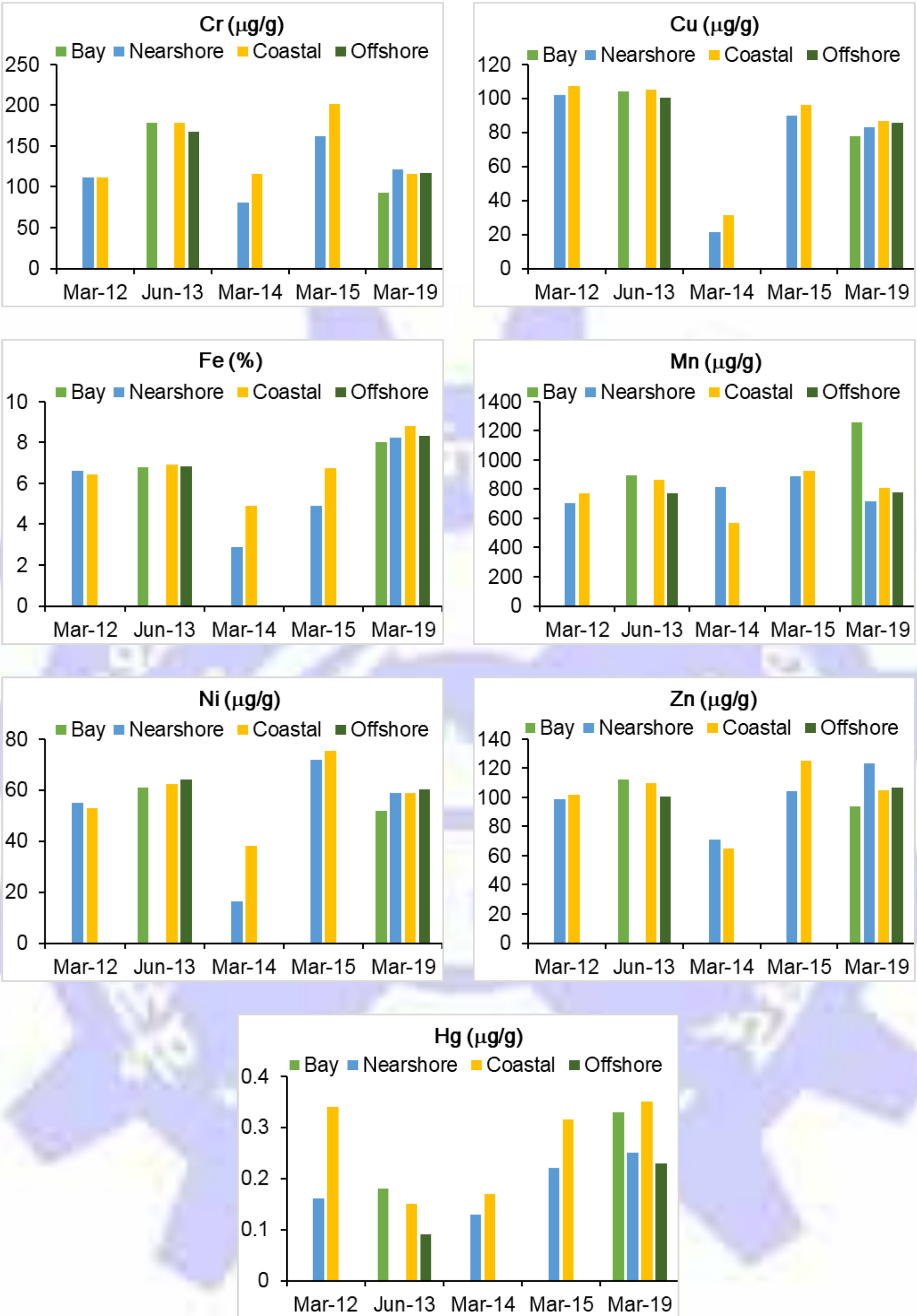
Bed sediment in uncontaminated areas has lithogenic metal concentrations, which are derived from rocks and soils encountered. However, these levels can get altered when the coastal water receive discharges of industrial effluents. The forms of metals in sediment namely hydroxides, sulfides, carbonates associated with organic substances entering through aqueous phase are influenced by several factors that determine their residence time in thermo-dynamically metastable phase. They are enriched as detrital minerals, chemically absorbed and complexed, co-precipitated, flocculated eventually settled in sediment. The variation of metal content largely depends upon the grain size composition of bed sediment. For example, smaller grain size and higher clay matter may result in higher levels of metals in sediment. Studies have demonstrated that marine sediments from industrialized coastal areas are greatly contaminated by metals; therefore, the evaluation of metal distribution in surface sediments is useful to assess pollution in the marine environment. The results of metal content in subtidal and intertidal sediment of the present monitoring are presented in ***Table. 15***.

Results of present monitoring highlighted that, the average concentrations of metals in subtidal were always higher than that in intertidal sediment, except for few metals such as

Copper (Cu), and Zinc (Zn), which indicated their direct enrichment in intertidal sediment. Exceptionally higher mercury (Hg) was observed at intertidal station CR4, which was associated with higher inputs of other metals such as nickel (Ni), Cu and Zn, with fairly large amounts of sand (97%) and organic carbon (4.6%), together indicative towards anthropogenic enrichment in the location. The metal enrichment along the intertidal sediments from west coast of India is a long running problem and have been studied in site specific manner. Physical properties such as adsorption of metals onto iron oxide-coated sand particles also could correspond to higher metal content in sand dominated intertidal sediment. The metal contents in sediments from off Mumbai region have been increased over the period of time, as displayed in figure below, this is although the enrichment of metals along the dispersal pathways e.g. from bay to offshore region have not followed any significant trend. Variations in lithogenic fraction of metals in sediment across the eastern Arabian Sea often noticed common due to various factors such as, variable inputs of SS through land drainage, littoral transport, and continental sediment movement during tidal epochs etc. The variations in the concentration of trace metals could also be due to changing levels of Al and Fe, which generally influence the concentration of trace metals. Thus, though metals such as Cr and Zn were occasionally high, they were invariably associated with high Al and/or Fe contents. Periodic monitoring is required to understand the trend in concentrations of trace metals in the subtidal sediments around this region.



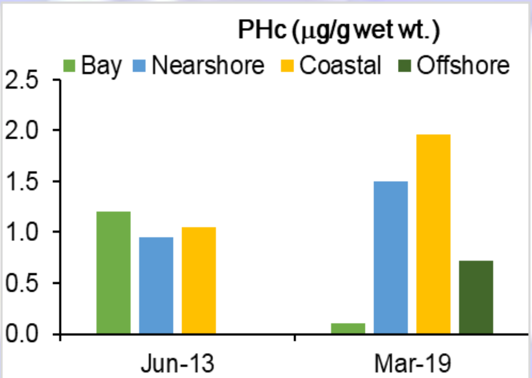




4.2.3. Petroleum hydrocarbon (PHc)

The concentration of PHc in sediments off Mumbai is a vital parameter in the context of operations and activities such as operational fishing boats, ships and barges. The petroleum residue left after their release into water either due to transportation activity or major oil spillage adsorbed by SS, thereby eventually deposited on the sediment. Hence, PHc levels in sediment serves as a useful indicator of cumulative effect of oil contamination.

The PHc concentrations in sediments from subtidal stations were ranged at from 0.1−2.5 µg/g wet wt., averaged at 1.2 µg/g wet wt. The average concentrations of PHc in nearshore as well as coastal sediment were identical and valued to 1.9 µg/g wet wt. The sediments in offshore station constitute lower PHc (av. 0.7 µg/g wet wt.) as compared to the nearshore and coastal regions (***Table. 15***). The PHc concentrations in sediments from intertidal region were ranged at from 0.1−8.9 µg/g wet wt., averaged at 2.7 µg/g wet wt. The average concentration of PHc in in sediments from intertidal region was higher than that in subtidal stations. Relatively higher PHc levels were noticed in intertidal stations, especially at CR4 and CR7, which may be due to presence of oil compounds on the shore sediment in that region.

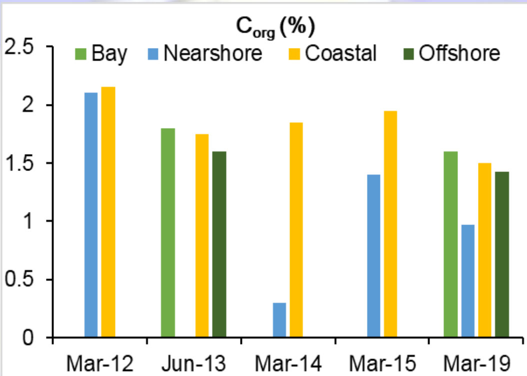


The average PHc in the sediments from nearshore and coastal regions off Mumbai found during this study was higher than that observed in same region during June 2013 by CSIR-NIO. The lower PHc during later period presumably related to the dilution of PHc or higher dispersion of oil compounds during to monsoon season. Such fluctuations are within a narrow range, thus can be monitored further to assess long-term trends. Overall, the present study on both Intertidal and subtidal sediments revealed low PHc and are comparable with the baseline.

4.2.4. Organic carbon (C_{org})

Generally, organic matter in nearshore and coastal sediments contributed from terrestrial runoff, mainly utilized by the benthic organisms present in the same region. Anthropogenic organic inputs however can increase the content of C_{org} to abnormal levels disturbing the equilibrium of the ecosystem. Organic matter settling on the bed is scavenged by benthic organism to a large extent. The balance is decomposed in the presence of DO by heterotrophic microorganisms. Hence, DO in sediment-interstitial water is continuously consumed and anoxic conditions develop if the organic matter is more than that can be oxidised through oxygen as an oxidant. Such anoxic conditions are harmful to benthic fauna.

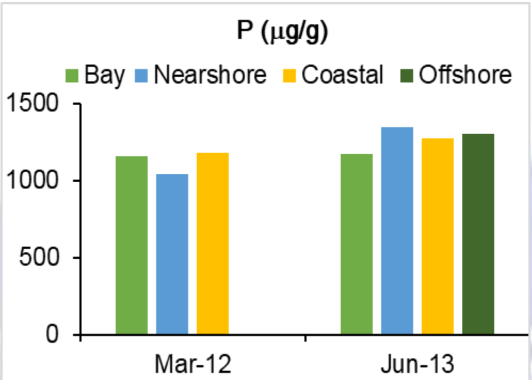
The content of C_{org} in subtidal sediments off Mumbai varied from 0.2% to 1.7 %, averaged at 1.3%, similarly the intertidal sediments showed average C_{org} content 0.6%, which is excluding the exceptionally higher value of C_{org} (4.6%) observed at CR4 (***Table. 15***). The C_{org} content around off Mumbai is further compared with the results obtained during previous studies and displayed in figure below;



The results indicated, roughly similar values of C_{org} observed during the study period as compared to the previous studies in the region, nearshore stations have lower C_{org} than bay, coastal and offshore region during this study as in previous studies also. The contents of C_{org} often corresponds to their nature and origin, however the content itself may not represent with any specific source but when compared alongside of other parameters such as C_{org} to total nitrogen content ratio and the isotopic signatures, the potential C_{org} sources can be identified.

4.2.5. Total phosphorus (P)

Lithogenic phosphorus in nearshore marine sediments mostly derived from the geological sources through river flows, while, the anthropogenic phosphorus is the result of sewage and industrial discharges, agricultural runoff etc. The sediment phosphorous off Mumbai region during March 2019 varied from 1059 to 1866 µg/g averaged at 1298 µg/g in subtidal stations, whereas it varied between 785 and 2065 µg/g, averaged at 1511 µg/g in the intertidal stations (***Table. 15***). The sedimentary P found around the study region is compared with the available earlier data and displayed in figure below;



Results indicated slightly higher average P values in sediments from nearshore and offshore region as well as the intertidal station (CR5) during this study period. Such fluctuations could be due to re-accumulation of sediments due sedimentary bed resuspension owing to strong tidal condition.

In summary, it was considered that the sedimentary parameters such as texture, metals, PHc, C_{org}, and P in the subtidal and intertidal sediments around off Mumbai though varied within the region, but hardly indicate any abrupt rise in values as compared to the previous monitoring results across the same region. Nevertheless, regular periodic monitoring of ecology off Mumbai is desirable to establish the trends in variation of sediment quality in future.

4.3. Flora and fauna

4.3.1. Microbiology

Marine microbes play an important role in the various bio geochemical cycles occurring in nature. A healthy marine ecosystem is not only beneficial to living beings but to all the life forms. As said with the increasing population use of sea as site of waste disposal is also rising. The discharge of improperly treated and untreated sewage in sea causes faecal contamination Coastal water serves various purposes from navigation to food supply to the ever growing population. Consumption and recreational activities in this water causes illness. This contaminated water can lead stomach aches, diarrhoea and rashes to those who accidentally swallow harmful microbes or come into contact with them.To detect the presence of faecal contamination in water certain microbial indicators such as faecal indicator bacteria (FIBs) are used. These FIBs are part of normal intestinal flora. The two important bacteria that form the indicator system are *Escherichia coli* and faecal *Streptococci*. As detection of every pathogenic bacterium from water is a tedious and expensive task, detection of indicator bacteria offers a faster approach

The TVC at the four stations in Girgaon ranged from $10×10^3$ to $120×10^3$CFU/ml. The faecal coliforms were not detected at any stations (***Table. 16*** & **Figure 7**). However, *Streptococcus fecalis* like organism was detected at only station G5. In sediment TVC ranged from $40×10^4$ to $140×10^4$CFU/g and no coliforms were not detected in sediments (***Table. 17***). The TVC at Priyadarshini stations ranged from $30×10^3$ to $650×10^3$ CFU/ml. The faecal coliforms were detected at P5 and P10. The counts were above the permissible limit of 100 CFU/100ml of CPCB. *Escherichia coli* like organism and *Streptococcus fecalis* like organism were also detected in high number at these stations. In sediment TVC ranged from $20×10^4$ to $60×10^4$ CFU/g and no coliforms were not detected in sediments (**Figure 8**).

The TVC ranged from $190×10^3$ to $960×10^3$ CFU/ml. the TVC was highest at the Haji Ali stations as compared to other locations (**Figure 7**). The faecal coliform was detected at station H5 was found to be above the permissible limit of 100CFU/100ml CPCB. In sediment, maximum TVC was $520×10^4$ and minimum $360×10^4$CFU/g (**Figure 8**). Station H5 was rocky bottom. The TVC ranged from $20×10^3$ to $130×10^3$ CFU/ml at Mahim transect. The faecal coliforms were not detected at any stations. Rocky bottom was found at station M5 and the TVC at station M10 and M15 were $40×10^4$ and $10×10^4$ CFU/g.

Whereas, for intertidal regions 10 stations were sampled and also analyzed for TVC, TC, FC, ECLO AND SFLO parameters. The TVC ranged from $10×10^4$ to $620×10^4$ CFU/g (***Table. 18***). No faecal coliforms were detected at any stations. The intertidal stations in project area were mostly rocky.

4.3.2. Phytoplankton

Phytoplankton are microscopic aquatic drifting autotrophs. They are the chief primary producers in the world oceans and confined to the euphotic zone. Despite their small size, by virtue of sheer numbers they contribute greatly to the global oxygen cycle. Phytoplankton are food source for all herbivorous aquatic fauna ranging from microscopic zooplanktons to large fishes. Phytoplankton have long been used as indicator of water quality. Some species flourish in highly eutrophic waters while others are very sensitive to organic and/or chemical wastes. Some species develop noxious blooms, sometimes creating offensive tastes and odors or anoxic or toxic conditions resulting in animal death or human illness. Hence their standing crop is likely to indicate the quality of the water mass in which they are found.

Generally, phytoplankton standing crop is studied in terms of biomass by estimating chlorophyll *a* and primary productivity and also in terms of population by counting total number of cells and their generic composition. When under stress or at the end of their life cycle, chlorophyll in phytoplankton decomposes to form phaeophytin as one of the major products. The phytoplankton standing stock off Mumbai is summarized and station-wise variations are given in ***Table. 19*** to ***Table. 22***.

Phytoplankton standing stock in Mumbai in terms of phytopigments and population varied from low to normal suggesting oligotrophic conditions. Chlorophyll *a* ranged 1.54 to 13.49 mg/m^3 in Surface water while in bottom water it was lower i.e. 1.7 to 8.06mg/m^3. Phaeophytin ranged 0.22 to 1.38 mg/m^3 while 0.25 to 1.68 mg/m^3 in surface and bottom waters respectively. In 5 out of 11 stations, bottom chlorophyll *a* values were greater than surface although the difference was low showing even distribution. The relative concentrations of Chlrophyll *a* and Phaeophytin in an aquatic system suggest a delicate balance between the growth and mortality. Chlorophyll *a* and Phaeophytin ratios in the study area ranged from 1.29 to 9.95 and 2.01 to 9.92 in the surface and bottom waters respectively suggesting normal phytoplankton sustainability, without any bloom formation (**Error! Reference source not found.**). The average Chlorophyll *a* value was recorded maximum at M5 while minimum at P15 whereas average phaeophytin value was high at G5 and lowest at P10. Phytopigments depicted decreasing trend from nearshore to offshore region (**Figure 10**).

Phytoplankton abundance in the study area ranged from 86.2 x 10^3 cells/L to 3975.4 x 10^3 cells/L in surface waters while in bottom it ranged between 60.4x 10^3 cells/L to 4232x 10^3 cells/L. Phytoplankton composition depicted high generic diversity in surface as well as bottom waters ranging between 6 to 20 and 6 to 20genera's respectively (**Error! Reference source not found.**). The average phytoplankton population was lowest at station G15 (105 x 10^3/ L) and highest in station M5 (3181 x 10^3/ L) (**Figure 11**).

Overall, 46 genera were observed during the present study (***Table. 22***). *Thalassiosira* and *Skeletonema* were most abundant genera. *Chaetoceros, Dactyliosolen, Thalassionema, Pseudo-nitzschia, Odontella Leptocylindricus, Cylindrotheca, Pleurosigma, Ditylum, Bacteriastrum, Guinardia, Thalassiothrix, Rhizosolenia* and *Gyrodinium* were also found in considerable numbers suggesting high species evenness. Stations G1 and M5 reported the minimum and maximum number of phytoplankton genera, 6 and 20 respectively.

Tidal variation was also observed in G5, H5, M5 and P5 stations (***Table. 19*** & ***Table. 21***). It was observed that phytopigments were high during low tide than in high tide chlorophyll *a* was high in surface waters than in bottom waters while phaeophytin were more in bottom waters than in surface waters while phytoplankton abundant depicted inverse of chlorophyll *a* concentrations i.e. 1352.2 x 10^3 cells/L in surface water during high tide at G5 station (**Figure 12**). H5 & M5 station illustrated phytopigments high during high tide in surface waters while in bottom waters they were high during low tide. Phytoplankton abundance was found maximum during high tide at H5 station while in M5 it was maximum at low tide (**Figure 13** & **Figure 14**). Phytopigments were maximum during high tide in surface as well as bottom waters while phytoplankton abundance was found maximum at high tide in surface waters where as in bottom waters it was maximum during low tide at P5 station (**Figure 15**).

4.3.3. Zooplankton

Zooplanktons are myriads of heterotrophic organisms that drift with currents. By virtue of sheer abundance and intermediate role between phytoplankton and fish, they are considered as the chief index of trophic efficiency. The herbivorous zooplanktons are efficient grazers of the phytoplankton and have been referred to as living machines transforming plant material into animal tissue. They occur at different depths and constitute a complicated ecological system. The zooplankton can be used as the indicator organisms for the physical, chemical and biological processes in the aquatic body.

Zooplanktons, characterized by their faunal diversity, includes arrays of organisms varying in size from the microscopic protozoan to jellyfish. The physico-chemical boundaries play an important role in the distribution in the sea as there are usually strong gradients in terms of light, temperature and salinity from surface to bottom layers. Besides light, food availability, inter and intraspecies competition, predation pressure, niche selection, energy conservation and physiological state are the other factors responsible for distribution. The zooplanktons are dispersed according to the scales of water turbulence.

The detailed zooplankton parameters are represented in ***Table. 23***. The Zooplankton standing stock as observed in the present study is summarized in the table below and the station wise variations is given in ***Table. 24*** & ***Table. 26***.

Zooplankton biomass ranged between 0.1 to 7.0 ml/100m^3 in study area of Mumbai coastal water during 2019. Maximum biomass was observed at station G15, while the minimum at station P15 (**Figure 16**). The population ranged from 1.1 to 13.8 x10^3/100m$^{3.}$ Maximum and minimum population were recorded at station H5 and G15 respectively (**Figure 16**).

It was observed that as we go spatially from P5 to P15 and H5 to H15 the density, biomass and Group composition decreases while G1 to G15 and M5 to M15 shows irregular distribution (**Figure 16**).

It was observed that at G5 station during low tide zooplankton biomass, density and diversity were high compared at high tide (**Figure 17**) M5 represented high density at high tide compared to low tide whereas biomass depicted inverse i.e. biomass was high at low tide compared to low tide (**Figure 18**).The taxonomical groups were found to be more at High tide due to presence of Gastropods, Medusae and Chaetognaths. H5 station depicted significant variation based on tide level, it was recorded high biomass, density and diversity during low tide when compared at high tide (**Figure 19**).

The zooplankton population comprised of 20 faunal groups in the study area during March 2019 (***Table. 26***). In general, copepoda was the most dominant group which on average created 68.1% of total zooplankton population in all the stations it was followed by Decapoda which on average created13.5% of total zooplankton population in all the stations. Contribution of Copepods to the total zooplankton density at different stations ranged from 88.5% at station M10 to 22% at station P10. It was observed that M15 was most diverse group while M5 and P15 were least diverse stations.

4.3.4. Benthos

Benthic fauna refers to various organisms found on (epifauna) and in (infauna) the bottom of aquatic bodies. These animals are divided into three categories i.e. microfauna (<63µm), meiofauna (>63µm and <500µm) and macrofauna (>500µm) based on their size differences. Most of the recognized animal phyla have benthic representatives living in marine, estuarine or freshwater environments. Benthic organisms serve as critical links between a variety of primary producers and organic matter sources (e.g., phytoplankton, benthic microalgae and macroalgae, detritus) and economically, ecologically, and recreationally important fish and crustaceans. Benthic communities also provide many ecosystem services that help to maintain good water and sediment quality. Filter feeders remove particles from the water column, which improve water clarity. Bioturbation (sediment mixing) of the bottom by infauna has been show to enhance the degradation of some pollutants due to stimulation of microbial processes. Due to their sedentary habit, benthic assemblages are most affected by ecological changes and respond quickly to habitat disturbances. Hence, they are useful in assessing the impact of anthropogenic perturbations on environmental quality.

In the present study, macrofauna and meiofauna were studied from 13 subtidal stations and 10 intertidal transects of Mumbai.

4.3.4.1. Meiofauna

Benthic fauna ranging from 500-63µm are termed as meiofauna. These organisms are omnipresent in the world oceans, and are widely studied for ecological purposes due to their effective response to even minute environmental perturbations. Their small size and short life cycles make them efficient tools for environmental monitoring.

The detailed meiobenthic parameters presented in the ***Table. 27*** to ***Table. 30***. The following table summarizes the meiofaunal parameters from the present study from two different sampling habitat types (subtidal and intertidal) of Mumbai.

Sampling Zone	Biomass (µg/10cm²)			Population (no./10cm²)			Total Groups (no.)		
	Min	Max	Av.	Min	Max	Av.	Min	Max	Av.
Subtidal	14.51	1009.91	299.23	35	977	346	1	7	3
Intertidal	5.80	9139.35	1444.18	14	3001	606	1	10	4

In subtidal area, meiobenthic standing stock in term of biomass and population ranged from 14.51 to 1009.91 µg/10cm² (av. 299.23 µg/10cm²) and 35 to 977 nos./10cm² (av. 346 nos./10cm²) respectively (***Table. 27***). Whereas, biomass and population in intertidal region ranged from 5.80 to 9139.35 µg/10cm² (av. 1444.18 µg/10cm²) and 14 to 3001 no./10cm² (av. 606 Nos./10cm²) respectively (***Table. 29***). In comparison to both sampling zones Intertidal showed high average group diversity (av. 4) than subtidal (av. 3).

4.3.4.1.1. Subtidal

The subtidal meiobenthic biomass, population and total groups are presented in the **Figure 20**.

The highest meiobenthic biomass has been observed at station H15 (av. 791.60 µg/10cm²) and lowest biomass observed at P5 (av. 26.11 µg/10cm²) and M10 (av. 28.05 µg/10cm²) (**Figure 20**). Population showed near similar trend in accordance to biomass. The highest population recorded at P10 and H15 (783 and 724 no./10cm² respectively) and lowest at P5 and M10 (64 and 71 Nos./10cm² respectively). Faunal groups were also found highest at H15 and lowest at P5 and M10.

The percentage composition of subtidal meiobenthos was presented in (***Table. 28***). Nematoda (89.45%) was the dominant group from subtidal stations of Mumbai followed by Foraminifera (3.57%), Copepoda (3.03%) and Polychaeta (1.44%).

4.3.4.1.2. Intertidal

4.3.4.1.2.1.*Overall*

In total, 10 intertidal transects have been sampled to study meiobenthic fauna from two water tide levels wherever possible such as Hide tide (HT) and Low tide (LT). The intertidal meiobenthic biomass, population and total groups are presented in the **Figure 21**.

The highest meiobenthic biomass has been observed at CR5LT (av. 8554.64 µg/10cm²) and followed by CR1LT (av. 4729.82 µg/10cm²). The lowest meiobenthic biomass has been observed at CR4HT (av. 11.61 µg/10cm²) then CR9HT and CR8HT (av. 106.61 and 108.19 µg/10cm²) (***Table. 29*** and **Figure 21**). The highest population recorded at CR4LT (av. 2496 no./10cm²) and lowest from CR4HT (28 no./10cm²) followed by CR8HT and CR3HT (av. 43 and 56 no./10cm²). Faunal groups were also found highest at CR8LT, CR7LT, CR5LT and CR1LT, and lowest at CR4HT and CR10LT.

The percentage composition of intertidal meiobenthos was presented in ***Table. 30*** Nematoda (52.71%) was the dominant group from intertidal zone of Mumbai followed by Copepoda (17.04%), Polychaeta (16.11%), Amphipoda (6.35%), Nemertina (2.65%), Isopoda (1.82%) and Foraminifera (1.75%).

4.3.4.1.2.2.*Intertidal transect-wise*

CR1

Meiofaunal standing stock at low tide of biomass and population ranged from 4330.22 – 4970.35 µg/10 cm² and 1182 – 1387 no./10 cm² respectively. The average biomass and population were of 4729.82 µg/10 cm² and 1307 no./10 cm² respectively. Total 7 meiofaunal groups were present in group composition, maximum contribution was by polychaetes and copepods, rather than this nematode, amphipods, nemertean, ostracods and cumacean were also present. (**Figure 22**).

CR2

Meiofaunal standing stock at low tide of biomass and population ranged from 860.44 – 1253.93µg/10 cm² and 311 – 425 no./10 cm² respectively. The average biomass and population were of 1107.55 µg/10 cm² and 375 no./10 cm² respectively. Total 5 meiofaunal groups were present in group composition, maximum contribution was by polychaetes and copepods, rather than this nematodes, nemertean and ostracods were also present (**Figure 23**).

CR3

Meiofaunal standing stock varied at low tide and high tide. At low tide biomass and population ranged from 808.42 – 916.84 µg/10 cm² and 538 – 644 no./10 cm² respectively while at high tide biomass ranged from 70.39 - 191.44 µg/10 cm²and Population ranged from 33 – 78 no./10 cm². The average biomass and population were of 854.97 and 135.39 µg/10 cm²; 604 and 56 no./10 cm² during low tide and high tide respectively. Total 4 meiofaunal groups were present in group composition, maximum contribution was by polychaetes, nematodes and copepods at low as well as high tide. Rather than this nemertean was present during low tide while at high tide halacaroids were present. It was observed low tide was having high biomass and population compared to high tide (**Figure 24**).

CR4

Meiofaunal standing stock varied at low tide and high tide. At low tide biomass and population ranged from 1102.19– 1907.71µg/10 cm² and 2095 – 3001 no./10 cm² respectively while at high tide biomass ranged from 5.80- 17.41µg/10 cm²and Population ranged from 14 – 42 no./10 cm². The average biomass and population were of 1505.21and 11.61µg/10 cm²; 2496 and 28 no./10 cm² during low tide and high tide respectively. Total 4 meiofaunal groups were present in group composition, maximum contribution was by nematodes, polychaetes and copepods, rather than this nemertean were also present at low tide. While at high tide only nematodes were present due to which high tide had minimum biomass and population (**Figure 25**).

CR5

Meiofaunal standing stock at low tide of biomass and population ranged from 7408.56–9139.35 µg/10 cm² and 1415 – 1769 no./10 cm² respectively. The average biomass and population were of 8554.64µg/10 cm² and 1630 no./10 cm² respectively. Total 9 meiofaunal groups were present in group composition, maximum contribution was by nematodes and amphipods, rather than these copepods, polychaetes, isopods, foraminiferans, cumacean, phoronids and ostracods were also present (**Figure 26**).

CR6

Meiofaunal standing stock varied at low tide and high tide. At low tide biomass and population ranged from 84.71 – 339.35 µg/10 cm² and 149 – 375 no./10 cm² respectively while at high tide biomass ranged from 193.77 - 716.49 µg/10 cm²and Population ranged from 57 – 396 no./10 cm². The average biomass and population were of 194.10 and 501.39 µg/10 cm²; 243 and 262 no./10 cm² during low tide and high tide respectively. Total 5 meiofaunal groups were present in group composition, maximum contribution was by polychaetes, nematodes, copepods and nemertean at low as well as high tide. Rather than this halacaroids was present during low tide while at high tide amphipods were present. It was observed high tide was having high biomass and population compared to low tide (**Figure 27**).

CR7

Meiofaunal standing stock at low tide of biomass and population ranged from 2629.58–3757.18µg/10 cm² and 510 – 736 no./10 cm² respectively. The average biomass and population were of 3200.00 µg/10 cm² and 632 no./10 cm² respectively. Total 8 meiofaunal groups were present in group composition, maximum contribution was by nematodes, polychaetes and amphipods, rather than these copepods, nemerteans, halacaroids, cumaceans, and ostracods were also present (**Figure 28**)

CR8

Meiofaunal standing stock varied at low tide and high tide. At low tide biomass and population ranged from 1224.95 – 1311.73 µg/10 cm² and 192 – 224 no./10 cm² respectively while at high tide biomass ranged from 47.73 - 167.71 µg/10 cm²and Population ranged from 30 – 62 no./10 cm². The average biomass and population were of 1257.86 and 108.19 µg/10 cm²; 208 and 43 no./10 cm² during low tide and high tide respectively. Total 10 meiofaunal groups were present at low tide i.e. nematodes, polychaetes, amphipods, ostracods, halacaroids, bivalves, naupilus, Turbellarians and tainaids. While at high tide 8 groups were present in which naupilus were absent. In group composition, maximum contribution was by nematodes at high tide, whereas low tide was evenly distributed. It was observed low tide was having high biomass and population compared to high tide (**Figure 29**).

CR9

Meiofaunal standing stock varied at low tide and high tide. At low tide biomass and population ranged from 256.90 – 384.01 µg/10 cm^2 and 524 – 694 no./10 cm^2 respectively while at high tide biomass ranged from 94.90 - 115.29 µg/10 $cm^2$and Population ranged from 142 – 234 no./10 cm^2. The average biomass and population were of 322.41and 106.61µg/10 cm^2; 620 and 189 no./10 cm^2 during low tide and high tide respectively. Total 5 meiofaunal groups were present at low tide i.e. nematodes, copepods, polychaetes, halacaroids and nemertean, while at high tide only 4 groups were present in which nemertean were absent. In group composition, maximum contribution was by nematodes at low as well as high tide. It was observed low tide was having high biomass and population compared to high tide (**Figure 30**).

CR10

Meiofaunal standing stock varied at low tide and Mid tide. At low tide biomass and population ranged from 206.02 – 255.34 µg/10 cm^2 and 502 – 623 no./10 cm^2 respectively while at Mid tide biomass ranged from 214.51 – 374.6 µg/10 cm^2 and Population ranged from 333 – 580 no./10 cm^2. The average biomass and population was of 223.43 and 293.75 µg/10 cm^2; 545 and 462 no./10 cm^2 during low tide and mid tide respectively. Only Nematodes were present at low tide, while at mid tide Copepods and Nematodes were present. (**Figure 31**).

4.3.4.2. Macrofauna

Macrofauna is also called macrobenthos. Annelid worms, bivalves, gastropods, crustaceans, tunicates, and insect larvae are the most commonly encountered macrofauna in marine and estuarine area.

The following table summarizes the macrofaunal parameters from proposed project area in Mumbai during the present study.

Region	Biomass (g/m^2, Wet weight)			Population ($no./m^2$)			Faunal groups (no.)		
	Min.	Max.	Av.	Min.	Max.	Average	Min.	Max.	Av.
Subtidal	0.04	18.9	3.6	25	1250	469	1	13	8
Intertidal	0.00	270.01	20.93	0	25312	2141	0	11	4

4.3.4.2.1. Subtidal

The macrobenthic standing stock of subtidal region is represented in tables ***Table. 31*** and ***Table. 32*** The macrobenthic standing stock was found to be varied in the present study in terms of biomass and population. The biomass of macrobenthic fauna ranged from 0.04 to 18.9 g/m^2 with an average 3.6 g/m^2. The population of macrobenthic fauna ranged from 25 to 1250 $no./m^2$ with an average 469 $no./m^2$. Overall, the faunal groups varied from 1 to 13 nos. (***Table. 31***). Among all the transects, H10 represented better macrobenthic standing stock with highest biomass (av. 11.4 g/m^2) as well as highest population (av. 813 $no./m^2$). However, lowest biomass was observed at M15 (av. 0.9 g/m^2) and lowest population at P5 (av. 169 $no./m^2$). It has been observed that macrobenthic standing stock in terms of overall biomass and population was high at 5m and 10m depth stations than 15m depth stations where as faunal groups high at 15m depth stations (**Figure 32**). Overall, Polychaeta (80.5%) was the most dominant group in the subtidal region followed by Tanaidacea (6.5%), Amphipoda (4.6%), Sipuncula (2.6%), Pelecypoda (1.7%), Ophiuroidea (1.6%), Nemertea (0.9%), Phoronida (0.8%), Copepoda (0.4%), Fish larvae (0.3%) Echiurida (0.1%). Furthermore, diversity was found to be increasing towards far off coastal stations.

4.3.4.2.2. Intertidal

In the present study, 10 intertidal transects were considered to assess macrobenthic community namely CR1, CR2, CR3, CR4, CR5, CR6, CR7, CR8, CR9 and CR10. Furthermore, each transect was subjected to study in division based on tide levels wherever possible i.e. high tide level (HT) and low tide level (LT). The intertidal macrobenthic standing stock in terms of biomass and population was high and also varied greatly in the study region. The summary of macrobenthic community of the intertidal zone of Mumbai is presented in ***Table. 33*** and ***Table. 34*** For quantification of macrobenthic community, the groups were considered which are collected during the quadrate sampling method, further random photographic and collection methods were undertaken to explore other benthic macrofauna in the quantitative manner included and represented in this report.

The biomass of macrobenthic fauna ranged from 0 to 270.01 g/m^2 with an average 20.93 g/m^2. The population of macrobenthic fauna ranged from 0 to 25312 no./m^2 with an average 2141 no./m^2. Overall, 26 faunal groups (quadrate sampling method) were observed in the study region and varied from 0 to 11 nos. per replicate (***Table. 33*** & ***Table. 34***). The macrobenthic standing stock was lowest in term of biomass and population at CR9HT (0.12 g/m^2 and 20 no./m^2 respectively). Highest biomass and population were observed at CR1LT (106.41 g/m^2) and CR5LT (10100 no./m^2) respectively. Population was found to be higher at LT than most of the HT at respective transects except at CR3, CR6 and CR10 (**Figure 33**).

Among all the transects, CR5LT and CR8LT sustained highest overall macrobenthic faunal groups (9 and 8 respectively) and followed by CR2LT and CR1LT. Overall, Polychaeta (51.78%) and Amphipoda (38.17%) were the most dominant group in the intertidal region followed by Oligochaeta (4.33%), Isopoda (1.68%) and Gastropoda (1.1%) (***Table. 34***).

CR1

The macrobenthic standing stock varied in terms of biomass from 39.28 to 270.01 g/m^2 and population from 688 to 19616 no./m^2. An average biomass and population was 106.41 g/m^2 and 9212 no./m^2 respectively. In total, 11 groups were observed at LT of CR1. Whereas, Faunal diversity of macrobenthos varied from 4 to 8 nos. with an average of 6 nos. per quadrate. The dominant faunal group was Polychaeta (92.67%) followed by Amphipoda (3.39%), Nemertea (1.22%), Gastropoda (1.17%), Turbellaria (0.74%), Turbellaria (0.74%), Bivalvia (0.3%), Polyplacophora (0.17%), Oligochaeta (0.13%), Isopoda (0.13%), Anomura (0.04%) and Decapoda Larvae (0.04%) (**Figure 34**).

CR2

The macrobenthic standing stock varied in terms of biomass from 5.77 to 76.01 g/m^2 and population from 2000 to 5728 no./m^2. An average biomass and population was 34.51 g/m^2 and 3368 no./m^2 respectively. In total, 12 groups were observed at LT of CR2. Whereas, Faunal diversity of macrobenthos varied from 5 to 9 nos. with an average of 7 nos. per quadrate. The dominant faunal group was Polychaeta (86.92%) followed by Amphipoda (7.01%), Nemertea (1.31%), Ophiuroidea (1.31), Gastropoda (0.86%), Bivalvia (0.71%), Polyplacophora (0.59%), Oligochaeta (0.36%), Isopoda (0.36%), Anomura (0.36%), Caridean shrimp (0.12%) and Fish larvae (0.12%) (**Figure 35**).

CR3

The macrobenthic standing stock varied in terms of biomass from 0.80 to 19.88 g/m^2 and population from 112 to 2832 no./m^2. Overall, an average biomass and population was 5.52 g/m^2 and 724 no./m^2 respectively. Biomass was found lowest at HT (1.21 g/m^2) whereas highest was recorded at LT (9.83 g/m^2). Conversely, population was found lowest at LT (456 no./m^2) and highest was recorded at HT (992 no./m^2). Faunal diversity of macrobenthos varied from 1 to 5 nos. with an average of 4 nos. per quadrate, and average faunal group was found to be lowest in LT (3) and highest in HT (4) (***Table. 33***). In total, 7 faunal groups were observed at CR3. In HT of CR3, 6 faunal groups were observed. Oligochaeta (72.98%) was dominant and followed by Polychaeta (19.37%), Amphipoda (4.03%), Isopoda (2.82%), Nemertea (0.4%) and Nematoda (0.4%) (**Figure 36**). In LT of CR3, 5 faunal groups were observed. Polychaeta (72.82%) was dominant and followed by Amphipoda (21.05%), Bivalvia (2.63%) Oligochaeta (1.75%) and Nematoda (1.75%) (**Figure 36**).

CR4

The macrobenthic standing stock varied in terms of biomass from 0 to 61.58 g/m^2 and population from 0 to 5856 no./m^2. Overall, an average biomass and population was 31.15 g/m^2 and 1810 no./m^2 respectively. Average biomass was found lowest at HT (0.26 g/m^2) whereas highest was recorded at LT (31.03 g/m^2). Similarly, average population was found lowest at HT (136 no./m^2) and highest was recorded at LT (3484 no./m^2). Faunal diversity of macrobenthos varied from 0 to 8 nos. with an average of 4 nos. per quadrate, and average faunal group was found to be lowest in HT (2) and highest in LT (5) (***Table. 33***). In total, 10 faunal groups were observed. In HT of CR4, 2 faunal groups were observed. Oligochaeta (88.24%) was dominant and followed by Polychaeta (11.76%) (**Figure 37**). In LT of CR4, all 10 faunal groups were observed. Polychaeta (68.79%) was dominant and followed by Amphipoda (24.91%), Oligochaeta (3.9%), Gastropoda (1.15%), Bivalve (0.46%), Nemertea (0.23%), Brachyura (0.23%), Tanaidacea (0.11%), Anomura (0.11%) and Copepoda (0.11%) (**Figure 37**).

CR5

The macrobenthic standing stock varied in terms of biomass from 0 to 208.45 g/m^2 and population from 0 to 25312 no./m^2. Overall, an average biomass and population was 48.16 g/m^2 and 5116 no./m^2 respectively. Average biomass was found lowest at HT (2.57 g/m^2) whereas highest was recorded at LT (93.75 g/m^2). Similarly, average population was found lowest at HT (132 no./m^2) and highest was recorded at LT (10100 no./m^2). Faunal diversity of macrobenthos varied from 0 to 11 nos. with an average of 6 nos. per quadrate, and average faunal group was found to be lowest in HT (2) and highest in LT (9) (***Table. 33***). In total, 17 faunal groups were observed. In HT of CR5, 4 faunal groups were observed. Polychaeta (48.49%) was dominant and followed by Amphipoda (39.39%), Isopoda (9.09%) and Ophiuroidea (3.03%) (**Figure 38**). In LT of CR5, all 17 faunal groups were observed. Amphipoda (86.77%) was dominant and followed by Polyplacophora (0.55%), Tanaidacea (0.55%), Brachiopoda (0.48%), Oligochaeta (0.32%), Bivalvia (0.32%), Nemertea (0.24%), Caridean shrimp (0.12%), Nematoda (0.08%), Anthozoa (0.08%) Ophiuroidea (0.04%), Anomura (0.04%), Copepoda (0.04%) and Ostracoda (0.04%) (**Figure 38**).

CR6

The macrobenthic standing stock varied in terms of biomass from 0 to 30.65 g/m^2 and population from 0 to 1184 no./m^2. Overall, an average biomass and population was 9.39 g/m^2 and 586 no./m^2 respectively. Average biomass was found lowest at LT (3.88 g/m^2) whereas highest was recorded at HT (14.89 g/m^2). Similarly, average population was found lowest at LT (548 no./m^2) and highest was recorded at HT (624 no./m^2). Faunal diversity of macrobenthos varied from 0 to 4 nos. with an average of 3 nos. per quadrate, and average faunal group was found to be lowest in LT (2) and highest in HT (3) (***Table. 33***). In total, 8 faunal groups were observed. In HT of CR6 , 7 faunal groups were observed. Isopoda (51.28%) was dominant and followed by Amphipoda (32.69), Oligochaeta (10.9%), Gastropoda (3.21%), Polychaeta (0.64%), Tanaidacea (0.64%) and Copepoda (0.64%) (**Figure 39**). In LT of CR6 , 5 faunal groups were observed. Polychaeta (83.21%) was dominant and followed by Oligochaeta (10.95%), Amphipoda (3.65%), Gastropoda (1.46%) and Turbellaria (0.73%) (**Figure 39**).

CR7

The macrobenthic standing stock varied in terms of biomass from 0 to 9.44 g/m^2 and population from 0 to 10192 no./m^2. Overall, an average biomass and population was 1.48 g/m^2 and 1422 no./m^2 respectively. Average biomass was found lowest at HT (0.32 g/m^2) whereas highest was recorded at LT (2.64 g/m^2). Similarly, average population was found lowest at HT (172 no./m^2) and highest was recorded at HT (2672 no./m^2). Faunal diversity of macrobenthos varied from 0 to 4 nos. with an average of 1 nos. per quadrate, and average faunal group was found to be similar in HT and in LT (***Table. 33***). In total, 7 faunal groups were observed. In HT of CR7, 4 faunal groups were observed. Polychaeta (55.81%) was dominant and followed by Amphipoda (39.53%), Nemertea (2.33%), Sipuncula (2.33%) (**Figure 40**). In LT of CR7, 5 faunal groups were observed. Amphipoda (95.06%) was dominant and followed by Polychaeta (4.34%), Ophiuroidea (0.3%), Isopoda (0.15%) and Tanaidacea (0.15%) (**Figure 40**).

CR8

The macrobenthic standing stock varied in terms of biomass from 0.17 to 98.33 g/m^2 and population from 96 to 9360 no./m^2. Overall, an average biomass and population was 33.49 g/m^2 and 3066 no./m^2 respectively. Average biomass was found lowest at HT (8.85 g/m^2) whereas highest was recorded at LT (58.13 g/m^2). Similarly, average population was found lowest at HT (1540 no./m^2) and highest was recorded at LT (4592 no./m^2). Faunal diversity of macrobenthos varied from 2 to 11 nos. with an average of 6 nos. per quadrate, and average faunal group was found to be lowest in HT (4) and highest in LT (8) (***Table. 33***). In total, 19 faunal groups were observed. In HT of CR8, 7 faunal groups were observed. Polychaeta (61.29%) was dominant and followed by Oligochaeta (31.95%), Amphipoda (4.68%), Tanaidacea (0.78), Gastropoda (0.52%), Isopoda (0.52%) and Penaeid shrimp (0.26%) (**Figure 41**). In LT of CR8, 17 faunal groups were observed. Polychaeta (58.1%) was dominant and followed by Amphipoda (30.05%), Tanaidacea (3.05%), Gastropoda (2.79%), Isopoda (1.83%), Turbellaria (1.22%), Nemertea (0.96%), Bivalvia (0.52%), Ophiuroidea (0.26%), Sipuncula (0.26%), Cumacea (0.26%), Nematoda (0.17%), Anthozoa (0.17%), Anomura (0.09%), Brachyura (0.09%), Ostracoda (0.09%), Pycnogonida (0.09%) (**Figure 41**).

CR9

The macrobenthic standing stock varied in terms of biomass from 0 to 14.89 g/m^2 and population from 0 to 624 no./m^2. Overall, an average biomass and population was 3.40 g/m^2 and 206 no./m^2 respectively. Average biomass was found lowest at HT (0.12 g/m^2) whereas highest was recorded at LT (6.68 g/m^2). Similarly, average population was found lowest at HT (20 no./m^2) and highest was recorded at LT (392 no./m^2). Faunal diversity of macrobenthos varied from 0 to 4 nos. with an average of 2 nos. per quadrate, and average faunal group was found to be lowest in HT (1) and highest in LT (3) (***Table. 33***). In total, 7 faunal groups were observed. In HT of CR9, 3 faunal groups were observed. Isopoda (40.00%) and Insecta (40.00%) were dominant and followed by Polychaeta (20%) (**Figure 42**). In LT of CR9, 5 faunal groups were observed. Polychaeta (77.55%) was dominant and followed by Amphipoda (14.29%), Gastropoda (6.12%), Nemertea (1.02%) and Penaeid shrimp (1.02%) (**Figure 42**).

CR10

The macrobenthic standing stock varied in terms of biomass from 0 to 2.67 g/m^2 and population from 0 to 160 no./m^2. Overall, an average biomass and population was 0.85 g/m^2 and 52 no./m^2 respectively. Average biomass was found lowest at HT (0.72 g/m^2) whereas highest was recorded at LT (0.98 g/m^2). Similarly, average population was found lowest at LT (48 no./m^2) and highest was recorded at HT (56 no./m^2). Faunal diversity of macrobenthos varied from 0 to 3 nos. with an average of 2 nos. per quadrate, and average faunal group was found to be lowest in HT (1) and highest in LT (2) (***Table. 33***). In total, 6 faunal groups were observed. In HT of CR10, 4 faunal groups were observed. Isopoda (71.43%) was dominant and followed by Polychaeta (14.29%), Amphipoda (7.14%) and Oligochaeta (7.14%) (**Figure 43**). In LT of CR10, 3 faunal groups were observed. Polychaeta (41.66%) and Penaeid shrimp (41.67%) were dominant and followed by Turbellaria (16.67%) (***Table. 34*** & **Figure 43**).

4.3.4.2.3. Diversity indices and cluster analysis

The intertidal zone was also studied based on the diversity indices such as Margalef's index (d), Pielou's evenness index (J'), Shannon index (H') and Simpson index (λ=1-Lambda'). The d was used as a measure of species richness. The evenness of a community can be represented by J'. H' and λ were used as a measure of diversity, these are most similar indices. All the indices were represented in **Figure 44** with taxa number (S) and Total abundance (N). d found be lowest at CR4HT (0.61) and highest at CR8LT (4.86). J' was ranged from lowest at CR7LT (0.13) to highest at CR10HT and LT (0.96 and 0.94 respectively). H' was ranged from lowest at CR7LT (0.28) to highest at CR4LT (2.71). λ ranged from lowest at CR7LT (0.10) to highest at CR4LT (0.89). Cluster analysis of based on density of intertidal macrobenthic community showed the clear distinction between habitat types during the present study. It was observed that low tide areas made a group together. Rocky habitat was found to be most abundant, species richness and diversified among all the habitat types.

4.3.4.2.4. K-dominance

The K-dominance curves presented in **Figure 45**. This curve shows the cumulative dominance in the form of ranked species abundance curves. It can be seen that the K-dominance curve from the different intertidal transects showed different curves. This indicates a balanced and unbalanced community of marine macroinvertebrates in intertidal zones. Those sites which does not have typical sigmoidal curve placed top in the plot i.e. CR7LT, CR4HT, CR5LT, etc. are with unbalanced community. This is due to dominance of single species in the area with less diversity. Whereas, all those sites having a typical sigmoidal curve, are with balanced community (CR2LT, CR3LT, CR4LT, CR6LT, CR8LT, etc.). Thus, no dominance of a single species can be observed which means that as the abundance of the macroinvertebrates increased, the diversity also increased.

4.3.4.2.5. Oysters

Oyster (*Saccostrea cucullate*) was found dominantly in the mid to low tide zone in the study area. The size of the oysters ranged between 36 and 10 cm^2 with average of 23 cm^2 during the present study. The highest production of oyster recorded at CR8 followed by CR5, CR2 etc in the present study. The biomass and their percentage cover are shown in Table below.

Distribution coverage (%) and estimated biomass of Oyster species *Saccostrea cucullate* per 100 m^2 along the different transect in the study area.

	CR1	CR2	CR3	CR4	CR5	CR6	CR7	CR8	CR9	CR10
HT	0	0	-	-	0	0	0	0	-	-
MT	0.08	0.1	-	-	0.3	0.04	0	0.5	-	-

LT	0.5	0.8	-	-	1.2	0.6	0.05	1.3	-	-
Estimated biomass (g.100 m^{-2})	263.2	408.4	-	-	680.7	290.4	45.4	953.0	-	-

***** '-' indicates no observation of oyster***

4.3.5. Seaweeds

Marine flora like seaweeds and mangroves play a significant role in enriching coastal waters by adding dissolved organic matter, nutrients and detritus besides serving as nursery areas for larvae and juveniles of several marine organisms.

Seaweeds, which are known as a source of food, fodder and manure are mostly found attached to various substrate like sandy, muddy and coralline sediments as well as rocky areas. They play a significant role in enriching the sea by adding dissolved organic matter, nutrients and detritus besides serving as nursery areas for the larvae and juveniles of innumerable marine organisms. Some green seaweeds are edible; red algae are the important source of agar, which can be used in microbiological techniques. Some of the brown algae are used for manufacturing algin and alginic acid also used to produce some bioactive compounds.

The substratum of the intertidal region is rocky in nature. All ten intertidal transect along with other nearby areas to these transects were studied perpendicular to the shores for evaluating marine vegetation. The intertidal expanse along these transects varied from ~5 to 10 m. The percentage coverage of seaweed during present study is represented in ***Table. 35***. CR1 and CR2 was similarly distributed with 3 & 2 phyla while, CR5 and CR8 were dominated by Chlorophyta (75% and 69%). Total nine varieties of seaweed found during the present study (***Table. 36***). The maximum varieties (6 no) were observed at CR5 Haji Ali area only. Transect CR8 was dominated by *Valonia* sp.

4.3.6. Sponge

Sponges, the members of the phylum Porifera. They are multicellular organisms that have bodies full of pores and channels allowing water to circulate through them, consisting of jelly-like mesohyl sandwiched between two thin layers of cells. Sponges have unspecialized cells that can transform into other types and that often migrate between the main cell layers and the mesohyl in the process. Sponges do not have nervous, digestive or circulatory systems. Instead, most rely on maintaining a constant water flow through their bodies to obtain food and oxygen and to remove wastes.

Sponges are similar to other animals in that they are multicellular, heterotrophic, lack cell walls and produce sperm cells. Unlike other animals, they lack true tissues and organs, and have no body symmetry. The shapes of their bodies are adapted for maximal efficiency of water flow through the central cavity, where it deposits nutrients, and leaves through a hole called the osculum. Many sponges have internal skeletons of sponge in and/or spicules of calcium carbonate or silicon dioxide. All sponges are sessile aquatic animals. Although there are freshwater species, the great majority are marine (salt water) species, ranging from tidal zones to depths exceeding 8,800 m (5.5 mi). Sponges were traditionally distributed in three classes: calcareous sponges (Calcarea), glass sponges Hexactinellida) and demosponges (Demospongiae). However, studies have shown that the Homoscleromorpha, a group thought to belong to the Demospongiae, is actually phylogenetically well separated. Therefore, they have recently been recognized as the fourth class of sponges. Sponges are divided into classes mainly according to the composition of their skeletons. Total eight varieties of sponges were recorded during the present study (***Table. 37*** & **Plate. 13**).

4.3.7. Corals

Studies were undertaken to see the presence/absence of corals in and around the proposed project site located in the intertidal region.

The coral reef noticed along the Mumbai coast known as patchy to fringing reef. The reef flat of the typical fringing reef is covered during high tide with exposure during low tide. The reef flat varies in length and width depending on the geomorphological features of the coastal segment. The shoreward point generally known as the shore covers about 50 to 150 m width in proposed project area in Mumbai region.

The coral survey was undertaken at all ten intertidal transect locations during the present study. Due to the absence of live corals in the high tides to lower mid tide level, Belt Transect method was used to survey the corals. Two to three transects have been selected at each site from high tide to low tide area. We have also surveyed to see the presence of corals along the low tide areas at each site.

Observations:

Total six species of corals have been observed during the present study along the proposed project site. Two species of Rhizangiidae family (*Oulangia* sp. and unidentified) are azooxanthellate scleractinian corals that were observed in Worli (between CR1 and CR2), Haji Ali and Marine drive rocky shore. Another four species *Polycyathus* sp,. *Goniopora* sp., *Pseudosiderastrea* sp. and species under family Dendrophylliidae were found in Marine drive rocky shore. It is to be noted that the Marine drive rocky shore is located about 1.8 km away from the proposed project activity (**Figure 52**).

Worli (CR1 and CR2)

In Worli region both the corals of Rhizangiidae family (*Oulangia* sp and unidentified) are found in tide pool located near the low tide region. Corals were found about 100-105 m distance from the high tide line. Total 18 nos. of colony found during the present study which covered about 0.251 m^2 area in proposed project site Worli region. These corals were found at the outer most boundary of the proposed project site (**Figure 52**).

Haji Ali (CR5)

Similar to Worli, Haji Ali also was recorded with both the corals of Rhizangiidae family and another species under family Dendrophylliidae. The area coverage of corals in Haji Ali were 0.11 m^2 which was lower than Worli sites. The corals found in this area mostly falling out of the proposed project site (**Figure 52**).

4.3.8. Megafauna

Benthic megafaunal inventoritation were carried out by random survey method in the intertidal zone of the proposed development site. The list of organisms observed during the survey is given in the ***Table. 37*** along with other benthic macrofauna collected in the region (**Plate. 5** to **Plate. 13**).

4.3.9. Fisheries

Fisheries contributes in socio-economic developments of the state. Fisheries is one the major source of livelihood for economically backward population. The fishery production is controlled by the physicochemical properties of the system, planktons, macrophytes and other aquatic organisms. The composition of a fish assemblage is often sensitive to variation in pH, salinity, temperature, solutes, flow, clarity, DO, substrate composition or human activities.

The fishery status of the Mumbai coast was evaluated on the basis of the data obtained from the Dept. of fisheries, Government of Maharashtra and other local sources (Tables 1 to 11). The present study fish production includes the fishery data of Greater Mumbai comprises 1) Manori Zone (VII), 2) Versova Zone (VIII), 3) Mumbai Zone (IX), 4) Sasoon Dock Zone (X) and 5) Ferry Warff zone (X-A). Since 2012 to 2017, The marine fish production was highest (227307 tonne) in the year 2016-17 and lowest (168698 tonne) in the year 2012-13 (***Table. 38***). Among all zones, Ferry warff has contributed significantly high to the total fish production.

Overall in Greater Mumbai, Penaeid Prawns, Non-Penaeid Prawns and *Loligo duvaucelli* (Cephalopoda), *Upeneus* Spp., Mackerals and Otolithoides species were most abundant variety of fish in the year 2016-17 (***Table. 39***). Penaeid Prawns and Non-Penaeid Prawns are most common from city and suburban area of greater Mumbai respectively. In Greater Mumbai, the Non-Penaeid Prawns were found highest in the year 2012-13, followed by Penaeid Prawns in 2015-16 and 2016-17.

The zone wise estimation of fish production indicates that in Manori the fish production has constantly increased from 2012 to 2016. However, it decreased in 2017. Conversely, the fish production has decreased from 2012 to 2016 from Versova, but in 2017 it has increased twice the amount of production in 2016. At Sasoon dock the production has increase from 2013 to 2017. At Ferry-Warff the production is constantly increasing since 2012-15 (**Figure 46**).

In Manori zone the Non-Penaeid Prawns were obtained in high quantities than any other variety (**Figure 47**). At Versova, Non-Penaeid Prawns *and* Penaeid Prawns were the dominant and *Harpadon Nehereus* was obtained in highest quantity from 2012 to 2016 (**Figure 48**). In Mumbai, Non-Penaeid Prawns were caught in high quantity than other varieties in 2016-17 (**Figure 49**). At Sasoon dock variety of fishes dominated in quantity over the years. In 2016-17 Penaeid Prawns dominated the marine system followed by *Loligo duvaucelli* (Cephalopoda) (**Figure 50**). Similarly, at Ferry Warff, the fish catching was mainly dominated by Penaeid Prawns from 2016-17 followed by *Loligo duvaucelli* (Cephalopoda) (**Figure 51**). A total number of registered fishing vessels in Mumbai region are presented in the ***Table. 40***. Three types of mechanized vessels were used for fishing such as Mechanized, Non-mechanized and Rampan. Majorly, mechanized boats have been used more for fishing than non-mechanized. From the year 2016-17, 65334 and 137349 boats have been registered. The net type and the per unit production is represented in the ***Table. 41*** & ***Table. 42***.

4.3.9.1. Experimental fishing

Experimental trawling has been carried out during the present study at two locations (**Figure 6**). Trawl net (50 m long) was used to haul for fish catch and each haul duration was 2.5 hrs with 0.5 – 1.0 knot speed. The experimental fishing was carried out between 10-15 m depths near perpendicular to the coast and proposed project site. Total fifteen varieties of catch included nine species of fish, three species of prawn, two species of crab and one Cephalopoda species, and total of 4.3 kg have been caught during the first haul (**Plate. 4**). The second haul came with low catch about 2.7 kg and 8 varieties of species including two species of prawn.

4.3.10. Avifauna

Birds find near perfect environment in the mangrove forests lining the islands and along the coasts, coral reefs, reef vegetation, mudflats, sandy beaches, rocky shores, tidal creeks, marsh vegetation and salt pans that provide an assemblage of micro-habitats which facilitates suitable conditions for feeding, breeding and sheltering areas of a variety of birds included coastal waters of Mumbai region.

Total 17 varieties of birds were observed in the intertidal region during the present study. The diversity of birds was varied between the transects due to differences in microhabitats. The bird like little egret, black kite (*Milvus migrans*), pond heron (*Ardeola grayii*), green sand piper (*Tringa ochropus*) were the most common and dominated the intertidal region.

List of avifauna observed during the present study in March-April, 2019

Common name	**Scientific name**
Little Egret	*Egretta garzetta*
Black-tailed Godwit	*Limosa limosa*
Red billed Gull	*Chroicocephalus novaehollandiae scopulinus*
Black-headed Gull	*Chroicocephalus ridibundus*
Indian Pond Heron	*Ardeola grayii*
Western Reef Heron	*Egretta gularis*
Black-headed Ibis	*Threskiornis melanocephalus*
Common Kingfisher	*Alcedo atthis*

Brahminy Kite	*Haliastur indus*
Black kite	*Milvus migrans*
Common Crow	*Corvus splendens*
Jungle Crow	*Corvus culminatus*
Eurasian Curlew	*Numenius arquata*
Little Egret	*Egretta garzetta*
Green Shanks	*Tringa nebularia*
Gull-billed Terns	*Gelochelidon nilotica*
green sand piper	*Tringa ochropus*

4.3.11. Marine mammals

The coast of Maharashtra is known for occurrence of Humpback dolphin (Genus: *Sousa*). There was major sighting recorded in southern Maharashtra than northern Maharashtra coast. In the present study, the Humpback dolphin were sighted in few locations during the subtidal survey. Sighting locations are shown in the table below.

Locations of Dolphin sighting in Mumbai coast during the present study

Date	Longitude (E)	Latitude (N)
26-03-2019	72.772	18.86872
26-03-2019	72.76003	18.95759
26-03-2019	72.78487	18.89362
27-03-2019	72.77413	18.94439
29-03-2019	72.78219	18.98202

5. Ecological and biodiversity assessment

5.1. Anticipated Impacts

Piling and reclamations are being the major physical activity in the project. It is known that increased these events have adverse impact on biodiversity. Furthermore, these activities potentially affect not only the site itself, but also the surrounding areas. The major impact of these activities could be habitat destruction because of dislodging of the sediment and reclamations. Resettlement or sedimentation is another inevitable impact to coastal community. The important parameters that influence the impacts are the scale of the aforementioned activities, its extent and duration. Thus, based on present study and using available information, following possible major threats to the marine environment in the coastal areas of proposed Coastal Road Mumbai (South) have been identified.

5.1.1. Turbidity & Plume Generation

At the proposed project site, a turbid plume would eventuate as material is released to the water column during the piling and reclamations operation.

- Increased turbidity results in decreased primary productivity in the water column.
- The above-mentioned physical activity changes the nutrient regime in the water column and results in increased pollutant such as PAPs, PHCs, O&G, heavy metals, organic matter and other contaminants and toxins from the sediment.

5.1.2. Pelagic Environment

One of the potential sources of nutrients which are of greater concern resulting in eutrophication of surface waters. The increased turbidity leads to decrease in the dissolved oxygen (DO) in the water column during the piling and reclamation operation in progress. Generally, the sediments contain highly variable levels of nutrients, typically on the order of several hundred to several thousand. Increases in suspended sediment loads and turbidity levels due to these activities 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 microeukaryotic biomass, decrease in aerobic bacteria and the increase in sulphate-reducing and other anaerobic bacteria.

- ❖ Loss or reduction of bacteria means the remineralization of organic matter will be significantly slowdown and will have cascading effects on the invertebrate grazers, predators and fish community.
- ❖ Disruption in pelagic food chain with increase in contaminants in the water column.
- ❖ Potential threat of increase in the events such as algal blooms, harmful algal blooms, jellyfish blooms and increase in the number of undesirable species.
- ❖ It may increase the frequency of surface phytoplankton blooms that could clog the membranes of filter feeding zooplankton and larval fish.
- ❖ The project site is basically rocky intertidal except 1.2 km sandy shore (Princess Street Flyover to Girgaon Chowpatty tunnel). The turbidity may be generated during trenching of sand and reclamation of rocky shores with rocks mixed with various sediments. Thus, it can be concluded that turbidity and the related effects may happen in short-term basis during the project activities. Further no other significant effect on pelagic marine biota due to piling and reclamation is anticipated.

5.1.3. Benthic Environment

- ❖ During all piling and reclamation operations, the removal or disposal of material from and to the seabed also destroy the 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 these physical activities.
- ❖ Piling and reclamation may initially result in complete destruction of the surface sediment associated biota at the project activity site.
- ❖ Increased suspended sediments can affect the filter feeding organisms shellfishes by clogging and damaging their feeding and breathing organs.
- ❖ This can be expected to lead to a patchy distribution of organisms, reflecting the differences between the piled furrows and the intervening un-piled surfaces. Such

recolonization as occurs within the piled areas is likely to be by migration of adults through transport on tidal currents.

- Increased sedimentation during the piling may pose significant harm to the macroalgae. Generally, the destruction of seaweed is irreparable and cause huge ecological loss.
- The vertebrates and invertebrates are directly dependent on the macroalgae mainly for shelter and support other life forms of the ocean such as herbivorous fish, crabs, sea urchins etc. Density and diversity of macroalgae along with benthic community were increased at low tide zone along the transect CR1, CR2, CR5 and CR8. Thus, any impact over seaweed diversity may influence drastically 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 of seabed causes loss or death of a proportion of the animals and plants living in or on the seabed. The alteration of habitat structure (e.g. flattening of wave forms, removal of rock) can remove the structural organisms in the region.
- 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.
- Increased suspended sediments can affect filter feeding organisms, such as shellfish, through clogging and damaging feeding and respiratory organs.

The loos of biodiversity due to sedimentation depends on its rate and quantity in an area. In the present study, the placing of sea wall and shaft will be done through piling activity which is proposed to be covered but the rate of sedimentation might not impact on nearby biodiversity due the low area coverage of activities. Total eight intertidal transects (CR1 to CR8) covering under Package I, II and IV areas were mostly rocky. Two transect (CR9 and CR10) were studied in the Marine Drive region and found with sandy sediment in nature. The benthic fauna will be impacted due to piling and converting from sea to land by reclamation activity and the total area benthic habitat is calculated to be lost permanently in intertidal and subtidal areas are 872889 m^2 and 164449 m^2 respectively. However, to find out how much benthic fauna will get affected, samples were collected for analysis of benthic macro and meio faunal community. Analysis was done and biomass was also calculated of macro and meiobenthic fauna. In meiofauna total 16 groups were recorded in the proposed project site and Nematoda was dominant and followed by Copepoda, Polychaeta, Amphipoda respectively in subtidal areas. Whereas, in intertidal areas were dominated by nematodes followed by Polychaeta, Amphipoda etc. The estimated biomass of benthic meiofauna calculated to be lost considering the area planned for the proposed project activity will be about 2312.39 kg in intertidal and 17.83 kg in subtidal area.

In macrofauna total of 26 groups were encountered in the study area. Polychaeta was most dominant group in macrofauna followed by Amphipoda, Oligochaeta, Isopoda, Gastropoda and others respectively. In polychaeta total 24 families were found with dominancy of spionidae family. The estimated biomass of benthic macrofauna calculated to be lost permanently considering the approximate area planned for proposed project activity will be 46,319 kg (intertidal) and 988 kg (subtidal).

5.1.4. Fisheries

- Any physical activities such as piling, reclamation in the coastal areas harms the ecology, destruction of habitats and nearby areas to function as a nursery area, or feeding ground for all the marine fauna.
- Physiological stress to marine fish and commercially important species by creation of short-term higher sediment loads in the water column.
- Adult fish are likely to move away from or avoid areas of high suspended solids, such as activity sites, unless food supplies are increased later on as a result of increases in organic material transformation through heterotrophy and their biomass build-up.
- Increased bioaccumulation of contaminants in commercially important species.
- Reduction in habitat due to loss of benthic primary producer habitat.
- Temporary reduction/increase or change in fish catch may occur due to the proposed activities.

As per previous data shown overall in coastal waters Greater Mumbai, Penaeid Prawns, Non-Penaeid Prawns and *Loligo duvaucelli* (Cephalopoda), *Upeneus* Spp., Mackerals and Otolithoides species were most abundant variety of fish. Experimental fishing also suggested the dominancy of Prawn at 10-15 m depths near by the proposed project.

5.1.5. Impact on sensitive sites and species

- Increased turbidity and organic matter may change the microbial water quality at nearby recreational sites.
- Vessel movement associated during the project activities are a potential threat to the marine mammals especially the dolphins (*Sousa* sp.), which may be harmed due to collision, propeller action and underwater rope, wires and anchorage. But the operations during execution of the proposed project take place majorly at intertidal region, so a smaller number of vessels will be used in the case. Further Vessels associated during project activity are likely to be moving at slower speeds in the project area reducing the risk of vessel strike.
- There are several important benthic faunas residing in the study area. The Scleractinia *Polycyathus* sp, *Goniopora* sp, *Pseudosiderastrea tayamai* and family Rhizangiidae (cup corals) which featured as Schedule I (Part IVA) on Indian Wildlife Protection Act 1972 and Vulnerable/Least Concern/Near Threatened status on the IUCN Red List. Further, these ahermatypic corals (*Polycyathus* sp and Rhizangiidae) are known to be grown with poorly illuminated environments.
- There were other marine invertebrates such as *Gafrarium divaricatum*, oyster (*Saccostrea cucullate*), green mussel (*Perna viridis*) which are socio-economically important in the region, have recorded in the intertidal area of the proposed project site (***Plate. 1*D**). The oyster *Saccostrea cucullate* showed the biomass production range between 45.4 to 953 g.100 m^{-2} in the proposed project region. Total estimated biomass of oyster is calculated to be lost permanently will be 2896 kg. These bivalves were observed along the mid to low intertidal areas of CR1, CR2, CR5, CR6, CR7 and CR8. Moreover, varieties of crab species e.g., maroon stone crab (*Menippe rumphii*), *Charybdis japonica* etc. which are also having socio-economic importance, found in the study area. These crabs were observed at CR1, CR2, CR5 and CR8 transects during the present study. Although robust looking species, they too are sensitive towards disturbance and human presence. Any unabated and extreme activity may result change in behavior.

Total 17 numbers of avifaunal species have been observed during the study period in the intertidal region. They were mainly observed near CR1, CR5, CR6 and CR8 transects during the present study. Few migratory birds were documented during the present study which could be related to sampling season and time. But transects like CR5 or CR8 which were recorded with abundant seaweeds, may provide the feeding grounds for migratory birds. Destruction of habitat may hamper these birds to the intertidal region. Further these are most sensitive to any sort of disturbance such as noise during project activities (e.g., operations of cranes, dodgers etc.), use of mechanized vessels, change in turbidity, productivity or change in water quality. The disturbance by noises and other during operations may affect the foraging behavior of birds, mainly the migratory aquatic birds. These birds may likely move away from or avoid areas where the project activity is going on.

5.2. Cumulative Impacts

The proposed project is located in open coast areas of southern side of Mumbai city. Major sewage and drainage system located in this region which drains in the intertidal region of the proposed project area. Further other side of the proposed project are, inner side in the Thane creek there is an active major port Mumbai port located. There are large scale activities already on-going in the region. The most likely adverse impacts will be of cumulative nature and it will be hard to discern the singular impact of any new or old activity in the given location, and period.

- The probable impacts might include, introduction of alien and invasive species due to the combined action of long-distance vessel movement in the region and proposed dredging activity.
- The transport and spillage (due to non-maintained and un-managed transportation) of ore and other chemicals may have exacerbated impacts due to proposed activity.
- Dolphins have been sighted in subtidal areas which were located within 10 km radius of the proposed project activity. The increase turbidity and noise levels may drive away these highly sensitive species.

- The rocky intertidal habitat is present in the study area (except CR9 and CR10) have high abundance and diversity of benthic fauna, seaweeds & shellfish which are constantly under pressure due to high anthropogenic activities.
- Likely occurrence of unintended events such as vessel collision, accidents, fire and other inadvertent events. These occur mainly due to lack of coordination, casual approach, un-managed activity and associated activities (eg: fishing) and no timely communication within and between the stakeholders involved in nearby areas. These events may result in human casualties if there are no precautions taken.
- Oil spills due to any unplanned eventuality is one of the major threats to the marine biota and can have a major long-term irreversible loss depending on the extent, quantity and expanse of spillage. However, the likeliness of this occurrence will be very low if proper precaution and contingency plans are in place.
- Many areas and many economically important species have been over exploited. Constant demand for coastal marine fish and shellfish has led to increase in extraction of these fin and crayfish. Exploitation over the years has resulted in size reduction of molluscs and crustaceans and low recruitment rates.

5.3. Positive anticipated impacts of the project:

- Roads, highways etc. have great benefits to industries, educational institutions, tourist centers, hospitals, to mention but few. It plays an indispensable role in the economy of both the developed and the developing countries of the world in making travels easier and faster. The proposed coastal road will help to relieve traffic congestion in city area and to reduce delay for through traffic.
- Good transport infrastructure, like highway network enhances transport system that reduces transportation costs and this, in turn, definitely reduces the production costs while it increases productivity and profitability of organizations.
- Modern road/highways make journeys faster, comfortable and safer than usual while at the same time reduce fuel consumption and also helps in carbon mitigation.

6. Mitigation Measures

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 ensure the damage caused and to understand the recovery. However, it is hard to avoid all ecological damage by any means of mitigation nevertheless the impact can be minimized as far as possible. Following are a few major mitigation measures:

A well-defined management and monitoring plan need to be in place for each of the aspects related to the proposed project activity.

A team of experts should be assigned and should be onsite during the entire phase of the project so that the activities are in check and the impacts are minimized.

- The project proponent should consider and adhere to all the international treaties and agreements to which India is a signatory and party.
- All the international, national and state level legislations have to be followed and necessary approvals from the statutory bodies have to be taken before commencement of the proposed activities.
- Adhere to the 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 will reduce many impacts and unplanned events will not occur.
- Quality and standards have to the priority for usage of resources, raw material, equipment and man power with regular calibration and checking with proper record keeping.
- Emissions from the vessels and the instruments will be used during project execution, should be within the permissible limits and the baseline described in the proposed project DPR.

- Noise levels of the machinery and equipment should be within the permissible limits and the baseline described in the proposed project DPR.
- Organic solid and liquid waste on the vessels involved in project should not be disposed in the ambient waters. It should be properly processed and or disposed as per the guidelines.
- Inorganic waste, hazards waste including oil and grease should be stored appropriately and should be delivered to authorized vendors for proper disposal.
- Piling, reclamation and associated activities should be taken care (minimized or avoided) during the notified fish breeding season (June-July) which is considered as egg laying and larval recruitment season.
- The intertidal region that is being proposed to be reclaimed is majorly rocky in nature (except CR9 and CR10 region located in Marine Drive) and habitat for abundant marine flora and fauna. As per project design it is proposed that the reclaimed area will be protected by the sea wall and shaft using tetrapod and the area beyond this will be remain submerged. Building of these structure and reclamation may result in loss of habitats and its related biotic communities. Nevertheless, it should be considered to create a partial intertidal habitat which may be parallel to these proposed structure (sea wall and reclaimed area) by placing piece of natural rocks (as per suitable size in design) wherever possible or other materials which are eco-friendly and can be supported as habitat for biological communities. These structural designs should be developed or modified in consultation with expert to minimize and recovery of disturbance of benthic communities.
- Wherever filling for construction activity has been done; same area has to be restored to its pre-disturbance conditions, once the construction phase is completed.
- Previous data and the experimental fishing conducted during fair weather season during the present study clearly suggests that the coastal waters of Mumbai is rich in commercially important fishery resources.
- Fish fauna is very diverse and is comprised of commercial and non- commercial species, hence necessary care should be taken to avoid damaging this important resource insuring its sustainable utilization.

- The fishermen population is normally engaged in fishing during both the tides, while a large quantity of mollusks, crustacean and fish species are collected from the intertidal region. Care should be taken that the project activities do not obstruct the activities of these communities.
- Fish, crabs and prawns are also generally trawled on mechanized vessel during high tide. The interference with their vessel movement should be avoided during the project operation phase.

7. Marine biodiversity management plan (MBMP)

The Indian subcontinent is bordered by the tropical seas which include an extensive coastal zone and the deep seas. Within the coastal zone there are a number of sensitive habitats including the estuaries, mangroves, coral reefs, sea-grass beds, rocky intertidal 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 mechanization 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.

Several of the Indian estuaries and coastal waters have become danger-prone zones. Stress due to damming the rivers, fishing pressure and pollution is the principle cause of biodiversity degradation and ecosystem deterioration. Coastal areas 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. But how can this balance be accomplished amidst the conflicting demands of stakeholders, managers, and policy makers? In marine ecosystems, several common ecological mechanisms link biodiversity to ecosystem functioning and to a complex of essential services. As a result, 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 “ecoservice 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.

7.1. Mitigation Measures

Mitigation measures are most successful when they are considered from the outset of the project rather than as a late stage solution to an identified problem. This can allow the design of the facility to include solutions to potential environmental problems rather than finding a solution, which fits with the design. Mitigation measures should therefore be considered from the outset of the project and discussions on the appropriate mitigation measures will likely to continue after submission of the ES as planning conditions are agreed upon. An appropriate specialist who has assessed the impacts usually suggests mitigation measures.

Mitigation can take varying forms including, in order of Best Practice, first:

A. **Avoidance –**This would require the project to be designed or the site selected to avoid any environmental impacts.
B. **Reduction –**This can be achieved by the addition of mitigation measures such as bunding, screening, or applying abatement technology;
C. **Compensation –**Where impacts have been unavoidable this method can be used and can involve the improvement of a related environmental issue for example replanting of a deforested area in an alternative location.
D. **Remediation –**This option would involve the cleanup and restoration of an area where the environmental impact is unavoidable; and
E. **Enhancement –**This method involves the improvement of the site beyond the existing baseline.

Mitigation measures for a site will be highly specific for each development. It is recommended that the developer provides detailed information about each of the mitigation measures including, what is proposed, where and when it will be proposed, duration of the measure, how effective the measures will be, and responsibilities for monitoring the measure. Additionally, any uncertainty in the effectiveness of the measures should be noted in the ES. When considering mitigation, consideration should be given to 'design' mitigation and site-specific mitigation. Compliance with the Code of Good Practice for Scottish Finfish Aquaculture is essential when considering mitigation.

7.2. Marine Activity Zone

7.2.1. Objective framework

Overall management framework describes how the MBMP integrates with the overall management framework. Put the plan in the context of the local environment, including baseline of proposed project activity and allied activities at the site;

The described project provides information on type of activities scale and design of the project along with the term of plan, including the location, staging, and timing of activities;

Information on approvals – provide details of any approvals, relevant conditions and any other statutory requirements. Description of the existing environment provides characterize the piling and reclamation proposed project sites and adjacent areas, including its water column, sediments, biota, resources and other uses (existing and potential) of the area. Description of potential impacts – address both potential short-term and long-term impacts and any uncertainties regarding the predicted impacts.

Management strategies and actions – describe strategies and actions to mitigate impacts – including specific and auditable measures; performance indicators; monitoring requirements; corrective actions; and responsibilities and timing for management and monitoring activities. Contingency arrangements to identify corrective actions and contingency plans should undesirable or unforeseen impacts occur. Continuous improvement to identify opportunities for continuous improvement to prevent, minimize or mitigate environmental impacts in the longer term. Auditing requirements and reporting to outline reporting and documentation standards, timing and responsibility of any auditing or reporting. Review of management plan to make provisions for a review of the management plan, including consultation with the statutory authorities, to ensure it remains current.

7.2.2. Legal Framework

A number of rules and laws regulate activities on the Indian coast. India has regulatory agencies such as the Central Pollution Control Board (CPCB) at the central level and State Pollution Control Boards (SPCB) at the state levels, constituted under Water (Prevention and Control of Pollution) Act, 1974. The Aquaculture Authority of India has been constituted and guidelines on sustainable aquaculture development for regulating coastal aquaculture have also been developed.

A National Contingency Plan has been formulated to combat oil spills in the EEZ of India with the Coastal Guard as the nodal agency. The disposal of ship-based wastes is regulated by the Merchant Shipping Act, 1958 and by the adoption of MARPOL 73/78. Standards for discharging effluents are listed in the Environmental Protection Act, 1986. This serves as an umbrella act providing for the protection and improvement of the environment including coastal and marine areas. The effluents/discharges from various resources have to meet these standards before being discharged into marine waters.

The Coastal Zone Regulation Notification was issued in 1991 in India, under the EPA, 1986. The Notification aims at protecting and improving the quality of the coastal environment. The Notification declares the limits of the Coastal Zone and classifies it into four categories for purpose of regulation. A state-wise Mangrove Committee has been formed for effective management of the mangrove ecosystem. Mining of corals and coral sands has been banned. The CRZ notification also offers protection to coastal communities such as traditional fishermen.

The Recycled Plastics Manufacture and Usage Rules, 1999; Municipal Solid Wastes (Management and Handling) Rules, 2000; Ozone Depleting Substances (Regulation) Rules, 2000; The Prevention and Control of Pollution (Uniform Consent Procedure) Rules, 1999, are some of the rules framed under EPA, 1986, with an aim to providing environmental protection and are relevant to the coastal environment. Since 1982, the CPCB has been carrying out a rapid inventory annually to assess the pollution status of coastal waters of India. This programme known as the Coastal Pollution Control Series (COPOCS), comprises among other things, a) Identification of the uses of coastal water at different stretches and the best use among them; class designation of the sector or a portion thereof, and b)

Identification of land-based pollutants and polluting activities and those that require immediate control.

Efforts have been made to set up sewage treatment plants in all coastal states. Treated effluents are being discharged into deeper waters through pipelines. The Government is also preparing an action plan for treatment of domestic wastes. Legislation has helped in the treatment of industrial wastes. In India, the Water (Prevention and Control of Pollution) Act includes tidal waters, unlike some other countries. The Act is applicable upto 5 km into the sea. Though the discharge of effluents from small-scale industries is still a problem, efforts are being made to set up common treatment plants. This will help in minimizing the load that is discharged to the sea.

The Indian Coast Guard is empowered to prevent capture of endangered marine species under the Wild Life (protection) Act, 1972. A number of threatened marine species have been placed in Schedules I and III of the Wild life (Protection) Act, 1972. Some of these are the whale shark, sea horse, sea cucumber, sea shells and different types of corals.

To prevent overexploitation of fish stocks and protect the interests of coastal communities, the following legislation/rules/acts are in force in the country:

The Maritime Zones of India (Regulation of fishing by Foreign Vessels) Act, 1981 provides regulations for foreign fishing vessels operating in Indian waters. The Coast Guard and the State/UT Police has been authorized under the Act to apprehend and prosecute unauthorized foreign fishing vessels/crew for fishing/poaching in Indian waters.

The Marine Fishing Regulation Act (MFRA), 1978. Consistent with the guidelines contained in the MFRA, 1978, which is a model act, providing guidelines to the maritime states, legislations have been enacted and enforced for regulating fishing and conservative measures in territorial waters. Such state enactments provide for regulation of mesh size to avoid catching juvenile fish, regulation of gear to avoid over-exploitation of certain species, reservation of zones for various fishing sectors to provide exclusive rights to traditional fishermen to fish unhindered in near-shore areas and also for declaration of closed seasons during the fish-breeding period to avoid catching of young juvenile fish.

India also is actively involved in the Inter-Governmental Oceanographic Commission, UN Convention on the Law of the Sea, Antarctic Treaty System, and the UNEP Regional Seas Programme. Scientific and technical bilateral cooperation with other nations, e.g. Russia, Germany, Republic of Korea, Argentina, Peru, Italy and others, has been established. India has also ratified the International Convention for the Prevention of Pollution from Ships (MARPOL Convention 73/78). Some of the other international conventions on environment ratified by India are the International Convention for the Regulation of Whaling, International Plant Protection Convention, 1951, Convention on Facilitation of International Traffic, 1965, International Convention on Load lines, International Convention on Tonnage Measurement of Ships, International Convention on Civil Liability for Oil Pollution Damage, 1969, Special Trade Passenger Ships Agreement, 1971, International Convention on Establishment of an International Fund for Compensation for Oil Pollution Damage, 1971, Convention on the International Regulations for Preventing Collisions at Sea, 1971, as amended (COLREG 1972), International Convention of Safe Containers, 1972, Convention on International Trade in Endangered Species of Wild Fauna and Flora, 1973, International Convention for the Safety of Life at Sea, 1974, Framework Convention on Climate Change, 1992, Convention on Biodiversity, 1992. India is also a signatory to the Convention of Wetlands of International Importance, protocol of 1978 relating to the International Convention for the Prevention of Pollution from Ships, Vienna Convention for the Protection of the Ozone Layer, Convention on Migratory Species, Basel Convention on Trans-Boundary Movement of Hazardous Substances, Montreal Protocol on Substances that Deplete the Ozone Layer.

All the acts with existing acts/rules with their salient features are given in Table 7.2.2.1. Table 7.2.2.2. shows the conventions and international treaties to which India is signatory.

Table 7.2.2.1. Table showing the existing act/rules and their salient features.

Existing Act/Rules	Salient Features
Environment Protection Act (EPA), 1986	*An umbrella Act* Regularizes the various activities in coastal zone.

Existing Act/Rules	Salient Features
Coastal Regulation Zone Notification, 1991 Coastal Zone Management Plans (CZMPs) Hazardous Waste Management Act, 1989 Environmental Impact Assessment Notification, 1994 & 2006.	Supreme Court Intervention that all the Coastal States prepare their CZMPs by 1996.This Act provides guidelines for hazardous waste management and also for the import and export of hazardous waste in Country. The objective of this Act is to conserve and protect the environment.
Water (Prevention and Control of Pollution) Act, 1974, Amended in 1988	Control of pollution from land-based sources Pollution Control Board was constituted under this Act.
Indian Ports Act,1908	Enactment relating to ports and port charges. Provides for rules for the safety of shipping and conservation of ports
Major Port Trust Act, 1963	The Act makes provision for the constitution of port authorities for certain major ports in India and to vest the administration, control and management of such ports in such authorities and for matters connected therewith.
Merchant Shipping Act,1958	Control of pollution from ships and off-shore platforms.
Coast Guard Act, 1950	Provides levying of heavy penalties for the pollution of

Existing Act/Rules	Salient Features
	port waters. In 1993, Coast Guard under Ministry of Defense, made directly responsible for combating marine pollution.
Maritime Zones Act, 1976	Describes various zones such as territorial waters, EEZ, Continental shelf etc.
Forest Conservation Act, 1980, Amended in 1988	Protection to (Marine) Biodiversity
Wildlife Protection Act, 1972 (Amended in 1983, 1986, 1991, 1997, 2001)	Offers protection to marine biota. Creates conditions favorable for in site conservation of fauna and flora. Amended in 2001 to include several species of fish, corals, sea cucumbers and sea shells in Schedule I and III Whale sharks placed in schedule I
Indian Fisheries Act, 1897	Offers protection to fisheries against explosives or dynamites.
Marine Fishing Regulation Act, 1978	A model act, which provides guidelines to the maritime States to enact laws for protection to marine fisheries by regulating fishing in the territorial waters. The measures include: regulation of mesh size and gear, reservation of zones for various fishing sectors and also declaration of closed seasons. Laws framed and amended from time to time by different maritime States.

Existing Act/Rules	Salient Features
National Environmental Tribunal Act, 1995	This has been created to award compensation for damages to persons, property and the environment arising from any activity involving hazardous substances.
The National Environment Appellate Authority Act, 1997	Addresses appeals with respect to restrictions of areas in which classes of industries etc. are carried out or prescribed subject to certain safeguards under the EPA. The objective is to bring in transparency and accountability and to ensure the smooth and expeditious implementation of developmental schemes and projects.
Biodiversity Act, 2002	The Act that has been passed, with an aim to protect and conserve biodiversity and sustainable use of its components.

Table 7.2.2.2. Convention to which India is a signatory.

UNCLOS	Disposal of ship-based wastes.
Basel Convention,1992	The Basel Convention contains specific provisions for the monitoring of hazardous waste. A number of Articles in the Convention oblige Parties (national governments which have acceded to the Convention) to take appropriate measures to implement and enforce its provisions, including measures to prevent and punish

	conduct in contravention of the Convention.
Ocean Policy Statement	Sets out basic principles through which the development of ocean is to be carried out.
Convention on Migratory species	Convention gives protection to many species of crocodiles, Sharks, turtles etc.
MARPOL 73/78	Disposal of ship-based wastes.
IUCN	For influence, encourage and assist the global societies to preserve and conserve nature. They also ensure that the natural resources are used sustainably.
Ramsar	Provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources.

7.3. Roles and responsibilities:

The following parties have responsibilities under this MBCP:

- Project Proponents' Chief/Executive/ Superintendent Engineer
- Contractor assigned for project
- Sub-contractors assigned by Contractor
- In-house/Consultant by project proponent to carry out environmental monitoring (Construction/Operational Phase)
- EHS Officer of Contractor/ Project proponent and Environmental Site Supervisor

Management strategies may be revised and updated based on experience. It is intended that specific work instructions be prepared for staff and contractors as the details of methods and conditions of approval for each project are finalized. The following management measures will be implemented to minimize the marine biodiversity impacts.

7.3.1. Chief Engineer / Project in-charge

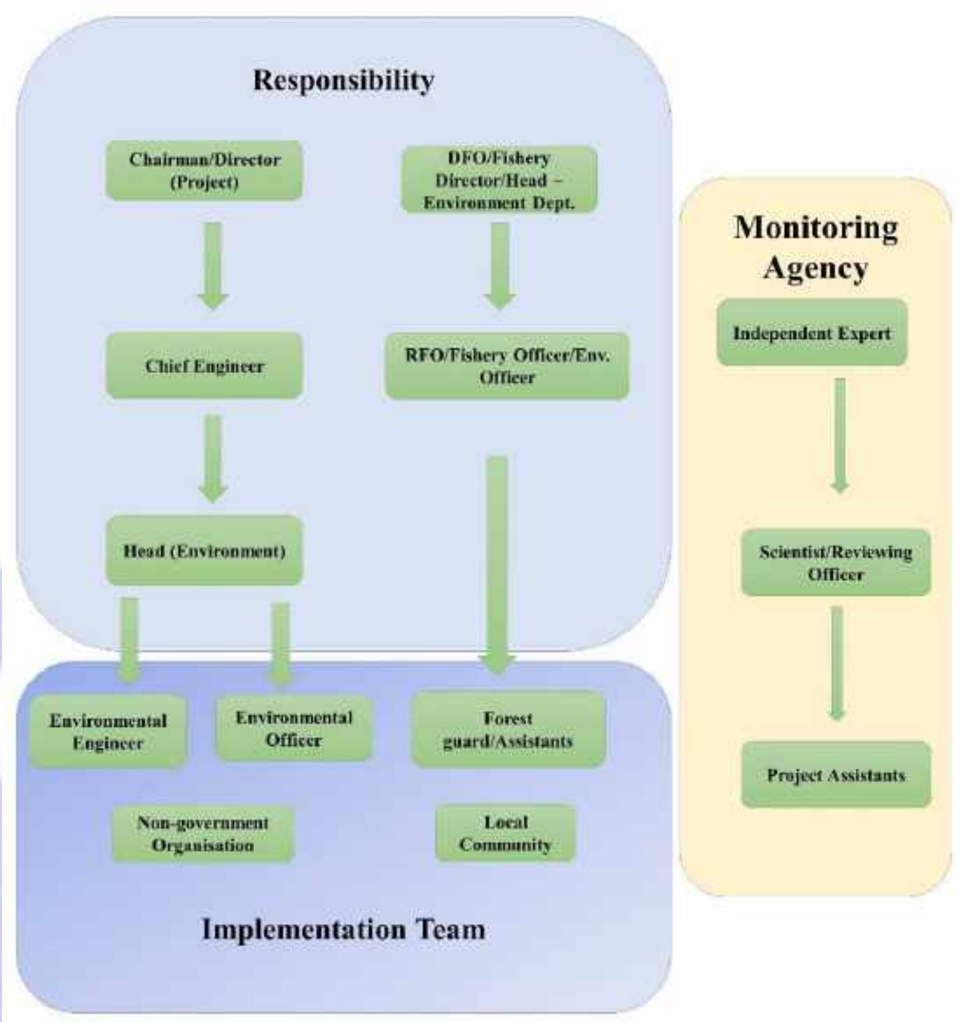
- Overall accountability for the implementation and compliance with MBCP.
- Provide support to all project personnel as required ensuring this MBCP is implemented and complied with.
- Provide advice to the Construction Manager and Environmental Coordinators to ensure compliance with the legal requirements, achievement of environmental objectives and improving environmental performance.
- Obtain relevant approvals as required.
- Review and closing out any corrective actions listed in the Complaints Register maintained by project in charge.

7.3.2. Construction Manager

- To ensure all staff are trained as to their responsibilities with respect to the MBCP.
- To investigate and subsequently rectify issues that may arise as a result of non-conformance.

7.3.3. Site Supervisor

- To provide work place induction of requirements of their team(s) under this MBCP.
- To ensure work is undertaken cognizant of the commitments made in this Plan.
- To provide feedback into any MBCP review process.



Flow chart 1. Implementation team, responsibility and monitoring agency

7.3.4. Head Environment

- Provide training and induction on relevant control measures as outlined in this MBCP.
- Provide monitoring teams and programme.
- Assist with investigating incidents and coordinating corrective actions, if required;
- To liaise with the Site Supervisor and Construction Manager and other relevant personnel on the MBCP implementation effectiveness.
- To review the MBCP as required and disseminate any changes to affected personnel.
- To report as required to regulating authorities.

7.3.5. Sub- Contractors

- Shall complete project inductions and abide by project proponent policies, procedures and plans including but not limited to Biodiversity Conservation Plans;

- Manage activities so as to avoid contamination of marine waters.

7.3.6. All Project Personnel

- To comply with this MBCP and the overall DPR as it pertains to their activities; and to report incidents and support environmental investigations and audits.

Given below are the roles and responsibilities of the parties involved in the MBCP, Flow chart 1 mentioned below gives the framework for the team for this MBCP along with monitoring agency.

7.4. Execution of Plans

As mentioned above an in-house team for the plan should be in place to monitor the activities mentioned below. The tasks will be sub-divided as the contracts and sub-contracts seconded by the project proponent. The activities given below require specialized expertise and fall under certain legal jurisdictions; hence the activities have to be carried out under the purview of respective governmental departments. All the biodiversity related activities have to be carried out by the local forest department and the Biodiversity Board or any organization authorized to carry out such activities. The fishery related aspects or social aspects related to fishery should be handled by the local fishery department. The aspects mentioned in this plan related to civil work should be dealt by the respective sub-contractor and the reclamation and piling related environmental aspects shall be dealt by the contractor/s. The implementation and successful execution of each aspect requires certain team of skilled personnel which are to be monitored accordingly by the project proponent and this responsibility lies with the in-house team.

The role of the in-house team is to seek log from the sub-contractors and teams engaged in carrying out this plan, daily/weekly and monthly report, consult, monitor, correct, update and report all the aspects carried out as part of this plan. The team shall also carry out audits and financial scrutiny to ensure successful implementation of the plan.

7.4.1. Piling/Reclamation/Construction Management Plan

Piling, reclamation and other construction activities will be conducted so as to minimize turbidity, however, if the turbid plumes significantly exceed the modelled impacts spatially or temporally, additional management strategies will be implemented as appropriate. Reclamation and construction will be conducted in a manner so as to minimize, the impacts on the coastal sensitive species as well as habitats.

Biodiversity impacts can occur during the excavation process, piling, reclamation work and also during the transport of the materials. These practices can identify risks, evaluate them and hopefully manage them. Management practices require a thorough understanding of the technical, environmental and economic characteristics of the several work activity plans and of the potential seriousness of environmental impacts. In some cases, these management practices may require rather minor changes, such as the project may call for major innovative technologies requiring substantial investments.

7.4.2. Management Measures

7.4.2.1. Reclamation

- The reclamation should be within legal framework and areas should be treated accordingly.
- The intertidal areas reclamation should be in accordance with the state and central legislative framework.
- The areas to be reclaimed should be earmarked and accordingly the assessment of lost areas for road, flyover, jetty or overhead- bridge and piling should be considered.
- Post- project restoration should be carried out for all the temporarily reclaimed areas which have not gone under construction.
- Soil strata excavated during reclamation should be stored appropriately and restored after project is completed.

7.4.2.2. Construction

Construction material should not be left on the intertidal or in subtidal areas, and in areas where they should not be displaced due to tidal water flow.

Any chemicals or metals should not be discarded in the sensitive intertidal areas or in the subtidal region. They should be stored/discarded in designated areas at the construction site.

Construction machinery and vehicles should be well maintained and there should not be any leakages of oil & grease reaching the marine areas.

- During the project activity in sub tidal areas, the vessel will operate at a slow speed of 1 to 2.5 knots (depending on the surrounding marine activities, sea conditions and material being carried).

7.5. Marine Biodiversity Conservation Plan

The plan aims to create an enabling integrated coastal and marine biodiversity management and protection, and to mainstream marine and coastal biodiversity into national plans and coastal zone management plans, with particular focus on biodiversity. As such, it provides an opportunity to coordinate with past and new initiatives in the region to address gaps in assessments, and seek sustainable and economically viable policy and technological options for the protection of key marine and coastal biodiversity to be included in coastal zone management plans, Marine Protected Area (MPA) plans and integrated into national plans.

The future aim of the above studies will consider the coastal rich areas as a "Biodiversity Conservation Zone" so that fishing and tourism activities can be regulated. This should be proactively supported with regular monitoring resulting in review and recommendation for improvement on feedback of conservation efforts. Being an area of edible renewable natural resource, necessary protection should be provided to promote the traditional fishing by public consultations and if necessary, through environmental protections.

7.5.1. Objectives

- To minimize direct and indirect disturbance to marine flora and fauna other than within the immediate works areas.
- To ensure turbid plumes from the works and re-suspension of material from the activity site do not significantly impact the long-term ecological values and integrity of the adjacent benthic assemblages.
- To reduce the impacts to the intertidal sensitive habitats to the extent possible.

7.5.2. Specific Biodiversity Enhancement Measures

The intertidal and subtidal area in the coastal region of proposed project located in Mumbai (south) has good habitat diversity with species diversity. There are varieties of habitats such as rocky shore, sand flat etc. which also supports profusely of micro habitats (biological; Plate 11), exists in the buffer zone of the study area. Some of the areas harbor important species such as seaweeds, shellfishes, corals, sponges, nudibranchs, bryozoans and other various organisms which form key components of marine biodiversity of the areas. Cumulative impacts such as industrialization, dredging pose, reclamations are considerable threat to the marine biota and the ecosystem.

7.5.2.1. Conservation Plan for (Marine) Mammals

There are currently 125 recognized species of marine mammals in the world (whale, dolphins, porpoises, dugong, seals, sea lion, sea otters etc.). IUCN has listed 25% of these species as threatened (IUCN 2009).

Under the Marine Mammal Protection Act (MMPA, 1972), conservation plans are required for species that have been designated as "depleted". Endangered and threatened marine mammals are also protected under the Endangered Species Act (ESA). Stocks of marine mammals may also be considered "strategic" under the MMPA.

In India, 27 species placed under Wildlife Protection Act, 1972. Under the Act, three species, namely Gangetic dolphin, Irrawaddy dolphin and dugong are under Schedule I and others are under Schedule II. Capture, use and trade of marine mammals are punishable under the Act (Marine mammal research and conservation in India, 2010). Following measures have to follow to ensure the conservation of marine mammals in the study area:

- An on-site marine mammal observer has to be deployed to monitor the movement of these important species.
- Vessel movement has to be regulated.
- Vessel movement has to be immediately halted at the sighting of any marine mammals in the active working zone.

Management of marine litter, garbage and plastic is one of the important aspects with respect to the project.

7.5.2.2. Conservation Plan for Intertidal habitats

The shoreline of sandy, rocky and muddy area harbor important benthic faunal and floral diversity. In order to conserve these shore lines, they are needed to be monitored regularly as they are dynamic habitat and constantly exposed to anthropogenic pressures. Generally, these areas are mostly polluted due to drainage discharge, solid waste by directly disposal and garbage coming with every tide. Hence proper management plan for solid waste and oil pollution is needed to be followed and precautionary measures for any incident should be in place. Along with this, beach cleaning programme, participatory approach for sustainable resource utilization from rocky shores and following are the specific measures to be undertaken: (Refer execution plan from section 7.3 and flow chart 1).

7.5.2.2.1. Shellfish conservation:

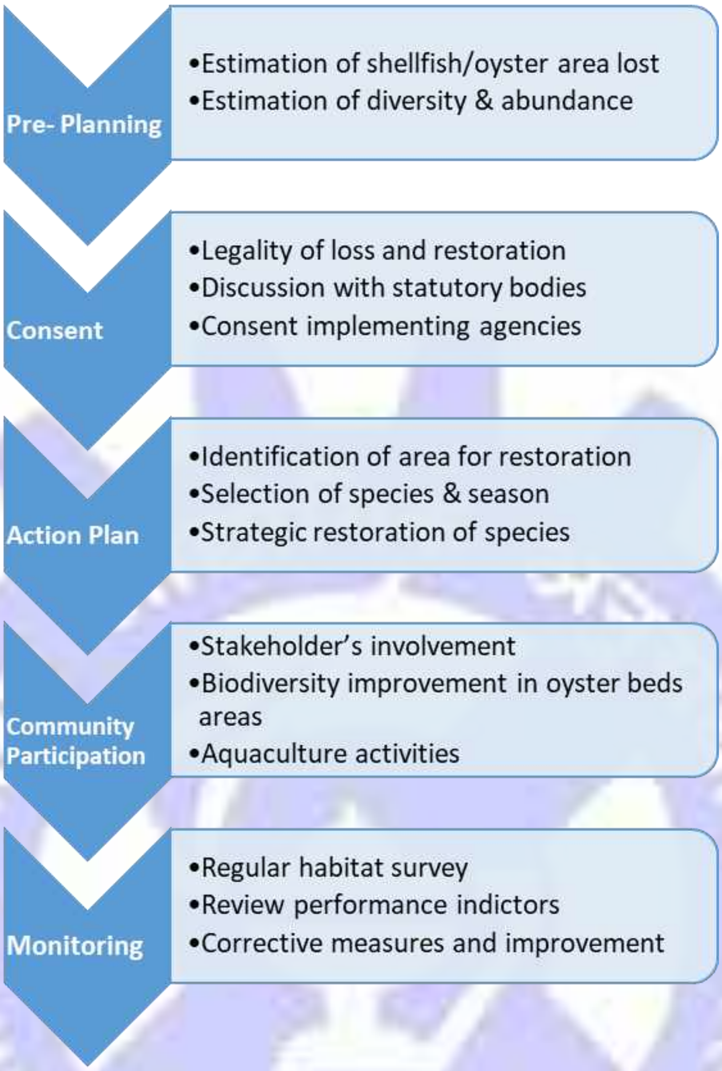
Bivalve shellfish are some of the prominent component of benthic communities in many coastal areas (estuaries, mudflats, rocky shores etc.) in worldwide. They also have been and continue to be an important food source for people throughout the world, serving as both as a delicacy and a staple. Based on the scientific literature there is growing recognition of the shellfish which can play key role in the maintenance and stability of coastal ecosystems. Oysters have been considered as “keystone species” in many places in the world. As a keystone species, they support a complex community of species by performing a number of functions essential to the diverse array of species that surround them. There is also increasing recognition that some shellfish species may impact or control in multiple way they play roles in shaping the environments in which they live and so that they are labelled as “ecosystem engineers”—organisms that physically, biologically or chemically modify the environment around them in ways that influence the health of other organisms[9]. Many of the ecological functions and processes performed or affected by shellfish contribute to human well-being by providing a stream of valuable services over time. Such services are commonly referred to as “ecosystem services”[10].

Ecosystem Services Provided by Shellfish	
Provisioning	• Commercial, recreational and subsistence fisheries • Aquaculture

	• Fertilizer and building materials (lime) • Jewellery and other decoration (shells)
Regulating	• Water quality maintenance • Protection of coastlines from storm surges and waves • Reduction of marsh shoreline erosion • Stabilization of submerged land by trapping sediments
Supporting	• Cycling of nutrients • Nursery habitats
Cultural	• Tourism and recreation • Symbolic of coastal heritage

***Source: Adapted from Brumbaugh and Toropova (2008)*[11]**

Several species of bivalves of its commercial importance occur in the present study area. These clams mostly inhabit the rocky shore and preferably collected during the low tide along the Worli (CR1 and CR2), Haji Ali (CR5), Mahalakshmi (CR6) and Priyadarshini (CR8) areas falls under the proposed project region. Species of *Grafrium*, *Meretrix* in the rocky habitats occur in the study area. There is necessity to protect them. It is necessary to block certain areas as no harvest zone, so as to ensure their population to replenish. Shellfishes especially oysters in the study area are exploited due to its high price as a food source. Most of the rocky outcrops within the study area are good sites for the growth of oyster (*S. cucullate*) and other shellfishes. However, in the recent times due to over exploitation of these edible bivalves, the annual stock replenishment showed great fluctuations. A special program for their cultivation has to be initiated. Harvest of the natural population requires regulation and regular restoration is to be carried out. Measures can be taken by culturing these oysters/mussels by raft/pole/rope cultivation. Restoration and sustainable use of such species helps in good ecological and economic gains. Refer execution plan from section 7.3 and Figure 7.3.1. Restoration framework for shellfish/oysters shown in below:



7.5.2.2.2. Conservation of corals:

Various scleractinian corals have been observed during the present study along the proposed project site. Corals like *Polycyathus* sp, Rhizangiidae and Dendrophylliidae are ahermatypic azooxanthellate scleractinian corals that were observed in Worli, Haji Ali and Marine Drive rocky shore. The Another two species of hermatypic corals *Goniopora* sp and *Pseudosiderastrea tayamai* were found in Marine drive rocky shore. Though corals found in Worli and Haji Ali are patchy in their distribution but their destruction should be avoided during the proposed activities. As all scleractinian have been included under Schedule I Part IVA of Wild Life (Protection) ACT 1972, India, it is therefore necessary to protect these animals. Transplantation and restoration of the corals which are falling inside the proposed project activity, at suitable place is one of the possible ways to conserve and protect these animals. Further regular monitoring during and after the proposed project execution will keep the sustainability of coral health in the region.

Conservation of habitat for the above mentioned commercially important species will also aid in conserving other species that are not commercially important but are ecologically very vital for sustenance of healthy and functional ecosystem.

All these activities give best positive results if they are executed via local participation. There are several schemes by central and state bodies and government aided subsides for carrying out such activities. The seed money can be provided by the project proponent and the remaining can be from the government agencies to run the projects successfully. Along with the above, the intertidal habitat has to be protected and monitored.

Below chart shows the management measures for intertidal habitats.

7.5.3. Stakeholder’s / Community 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 distributed for publicity among the public. To establish a network for 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 following 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.

Gadgil (2002) lists the following 6 factors as important considerations in a participatory assessment program;

- ❖ Motivating local people to revive and build on their traditional conservation practices;
- ❖ Establishing a positive relationship between local communities and government agencies;
- ❖ Identifying and establishing a system of positive incentives for local communities to adopt conservation management;
- ❖ Enhancing elements of good governance such as efficiency, participation and transparency;
- ❖ Incorporating local information into the formal system of scientific knowledge so as to make it richer and more immediately relevant; and

Stakeholder's Participation Program	• Shall bring out publication material for awareness in the print form, hoardings, and boards and on social media. • Carry out outreach program to educate all the stakeholders on available marine resource and its conservation efforts. • Should carry out workshops for fisherman to infuse the concept of 'sustainable fisheries'. • Shall set aside funds for tapping government funds, subsidies and schemes for agro-businesses and aquaculture. • Shall carry out programs for fisherman community on women's empowerment and form self-help groups.

- Ensuring that folk knowledge of conservation management and sustainable resource use is preserved and at the same time giving recognition to the validity of such knowledge.

Based on the above concepts it is imperative to carry out the conservation, restoration and monitoring with community participation. Local village committee can be formed to carry out the responsibilities of the restoration and conservation plan. These committees can be in conjunction with the people's biodiversity register (PBRs) or self-help groups (SHGs). A technical team of experts will be attached for the smooth working and guidance from subject experts. These procedures will help to develop responsibility and equitable sharing of resources as well as conservation of the area.

Below mentioned techniques and methods are mostly financed by many governmental schemes. There are several schemes which provide training, setting up and technical guidance to carry out sustainable integrated fishery and culture. The schemes are fully or partially funded, wherein the role of technical team and experts is important to bridge the gap between the involved stakeholders. The financial support in case of a prerequisite can be taken up by the project proponent as part of their CSR.

8. Marine Monitoring Plan

The guiding principal of marine environment management is to ensure that the perturbations due to the proposed coastal activities are within the assimilative capacity of the marine zone. All monitoring strategies and programme have reasons and justifications which are often designed to establish the current status of an environment or to establish trends in environmental parameters. In all cases the results of monitoring will be reviewed, analysed statistically and published. This is best done by integrating into the project itself, a plan of actions for mitigating predicted adverse effects as discussed in Section 6. The design of a monitoring programme must therefore have regard to the final use of the data before monitoring starts. Table 8.1 shows the marine monitoring plan.

8.1. Monitoring

It is necessary to verify the predicted environmental changes from the pre-project baseline.

8.1.1. Baseline quality

In Sections 4.1, baseline settings of relevant environmental components with respect to the marine environment of proposed project areas of coastal road Mumbai (south) are discussed pertaining to short-term measurements conducted during the field studies. Like all-natural ecosystems, the marine environment also undergoes seasonal variations. To understand these variations, it is necessary to conduct periodic investigations, ideally monthly, but at least seasonally at carefully selected monitoring locations. These should include intertidal as well as subtidal segments. In the present case, the prevailing stations should be adequate to represent the subtidal environment, while, the intertidal transects CR1 to CR10 can be selected for evaluation of the intertidal ecology. The data presented in this report can be considered for comparing the results of future monitoring studies. The monitoring however should be confined to the months in which the data are collected.

Table 8.1: Marine monitoring plan.

Sr. No	Cluster	Parameters*	Locations	Frequency	
				Construction Phase	Operation Phase
1	Sea Water	Temp., Salinity, DO, BOD, Oil & Grease, Nutrients, Heavy Metals.	10 locations (Subtidal)	Once every three months	Once every Six months
2	Sediment	Texture, Grain Size, OC, Oil and Grease, Heavy Metals	10 locations (Subtidal)	Once every three months	Once every Six months
3	Plankton & Benthos	Phytoplankton, Zooplankton, Meio-, Macro- fauna	10 locations (Subtidal)	Once every three months	Once every Six months
4	Benthos	Meio-, Macro- fauna	6 locations (Intertidal; CR1, CR2, CR5, CR6, CR8, CR10)	Monthly Once during project execution period only	Once every Six months
5	Flora & Megafauna	Seaweeds, Marine mammals, reptiles & avifauna	Identified habitats in the study area	Once every three months	Once every Six months
6	Fisheries	Benthic & demersal fish species & intertidal shellfish.	One bottom trawl & intertidal survey	Once every three months	Once every Six months

**: All the parameters to be analysed using standard methodology*

8.2. Budget for the MBCP:

Budgetary planning is the process of constructing a budget and then utilizing it to control the operations of a business. In this present study, there are few management/monitoring plans are described below with their estimated budget cost:

Sr No	Description of Item	Initial Cost (Crore INR)	Recurring Cost /yr (Crore INR)
1	Biodiversity Restoration/Translocation Plan (intertidal areas)	1.50	0.70
2	Biodiversity Monitoring Plan (intertidal areas)	0.60	1.20
3	Stakeholder's Participation Program	1.00	1.00
	Total (INR)	**3.10**	**2.90**

9. References

1. https://indiapopulation2019.com/population-of-mumbai-2019.html
2. "Mumbai Suburban". National Informatics Centre *(Maharashtra State Centre). Archived on 13 May 2012.*
3. Krishnamoorthy B. (2008). *Environmental Management: Text and Cases*. PHI Learning Pvt. Ltd. ISBN 978-81-203-3329-1.
4. "Mumbai, India". Weather base. Archived from the original on 16 March 2006. Retrieved 25 July 2019.
5. "Mumbai Plan". Department of Relief and Rehabilitation (Government of Maharashtra). Archived from the original on 10 March 2009. Retrieved 25 July 2019.
6. "Mumbai Plan". Geology and geomorphology. Department of Relief and Rehabilitation (Government of Maharashtra). Archived from the original on 10 March 2009. Retrieved 25 July 2019.
7. Seismic Zoning Map (Map). India Meteorological Department. Archived from the original on 15 September 2008. Retrieved 25 July 2019.
8. Nozais, C., Perissinotto, R., Tita, G., 2005. Seasonal dynamics of meiofauna in a South African temporarily open/closed estuary (Mdloti Estuary, Indian Ocean). Estuar. Coast. Shelf Sci. 62, 325–338. doi:10.1016/j.ecss.2004.09.020
9. Jones Clive G., Lawton J.H, Shachak M. (1994) Organisms as Ecosystem Engineers. Oikos, 69, 373-386.
10. The Millennium Ecosystem Assessment. 2005. Ecosystems and Human Well-Being: Synthesis. Washington, D.C.: Island Press.
11. Brumbaugh R.D., Toropova C (2008) Economic valuation of ecosystem services: A new impetus for shellfish restoration? Basins and Coasts News, 2(2), 8-15.

10. Figures

Figure 1. Proposed project locations

Figure 2. Average rainfall amount (mm) and rain days in Mumbai region during 2015-2019.

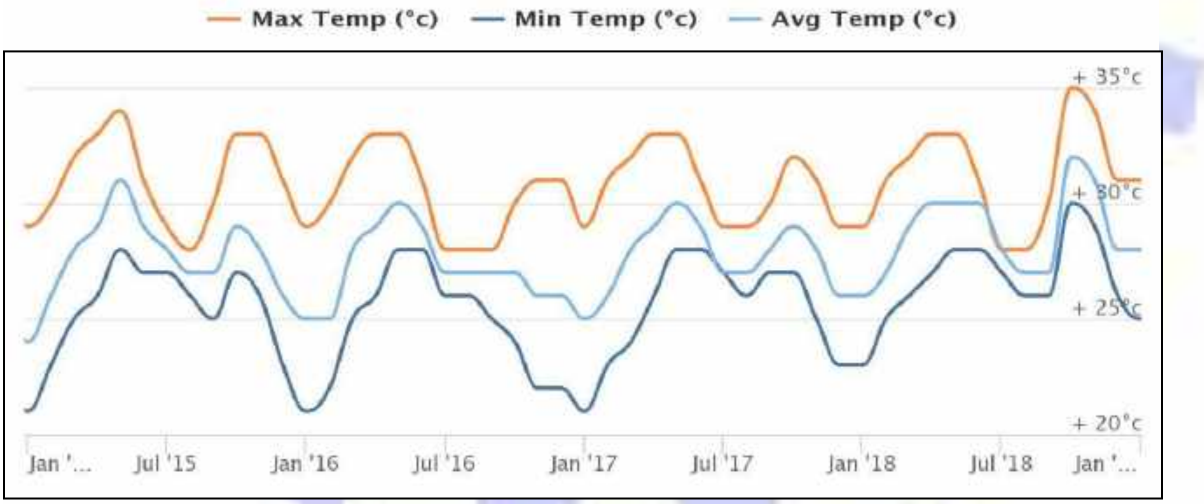


Figure 3. Maximum, minimum and average temperature in Mumbai region during 2015-2019.

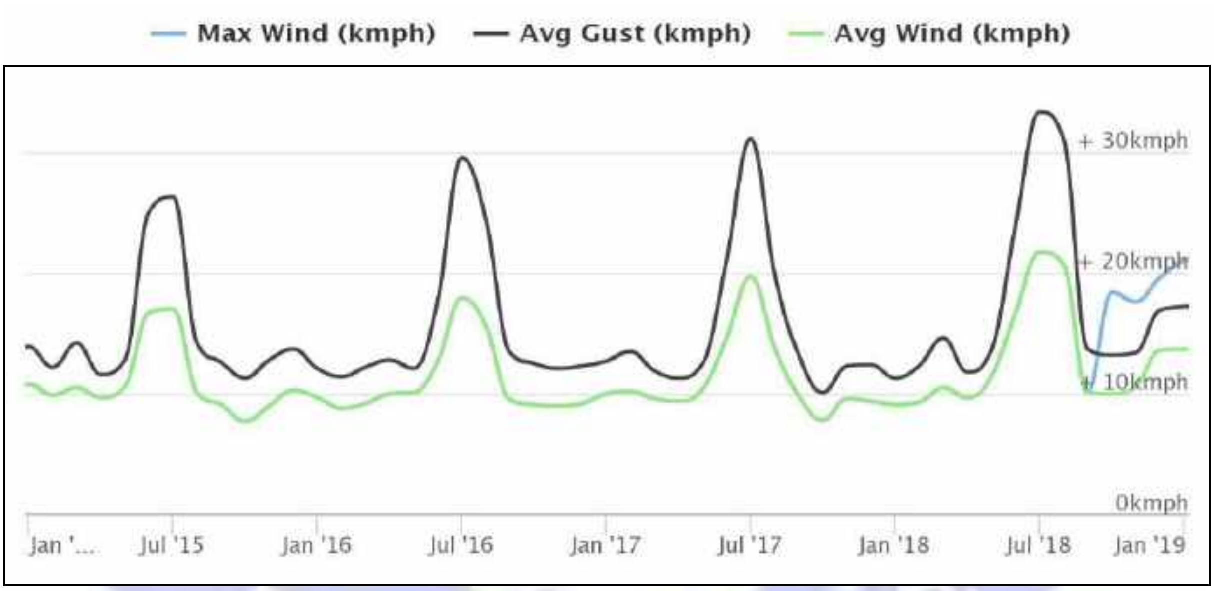


Figure 4. Average and maximum wind speed and gust (kmph) in Mumbai region during 2015-2019.

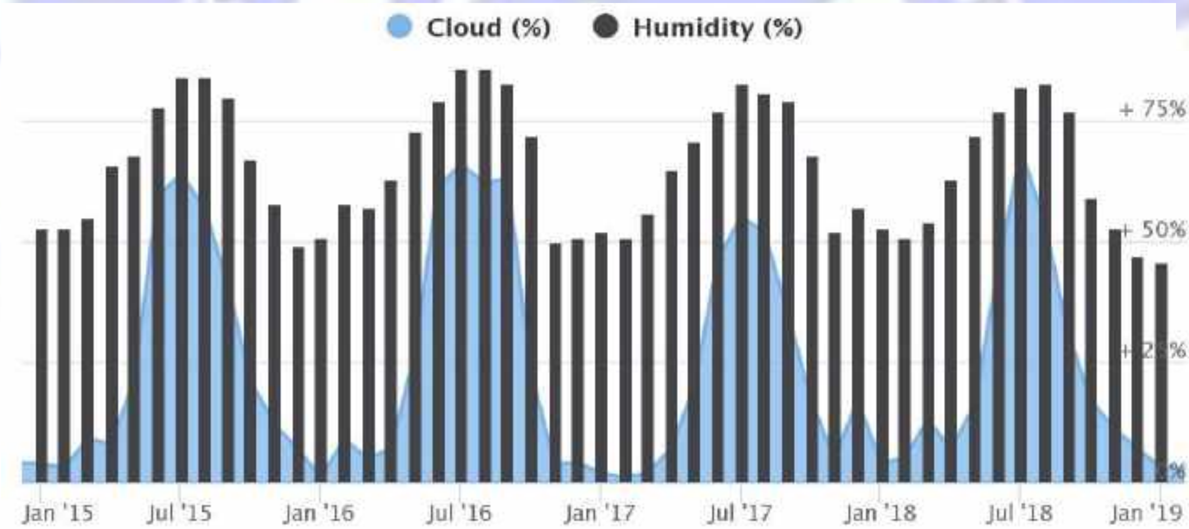


Figure 5. Average cloud and humidity (%) in Mumbai region during 2015-2019.

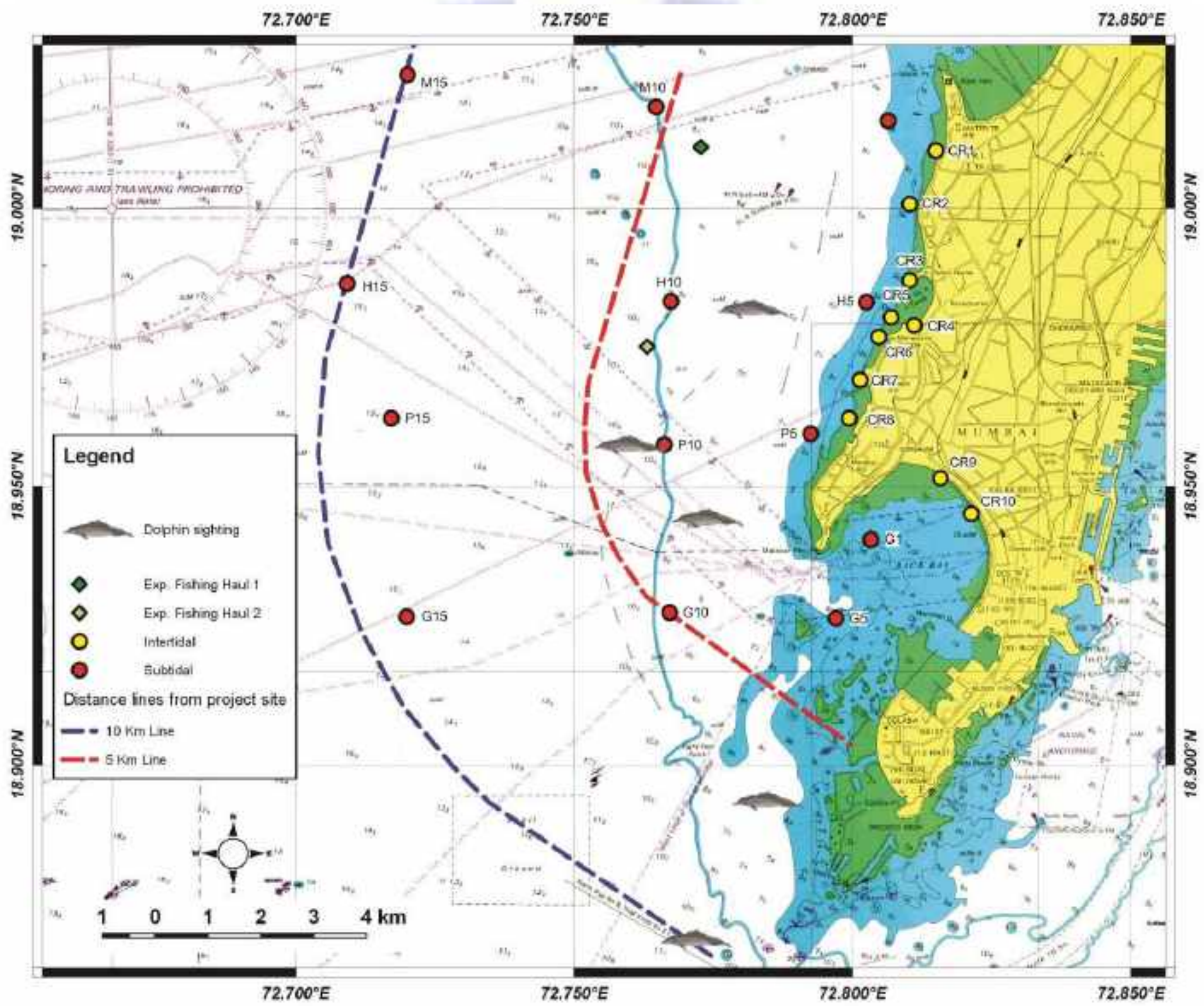


Figure 6. Map showing sampling locations of the study area (10 km radius).

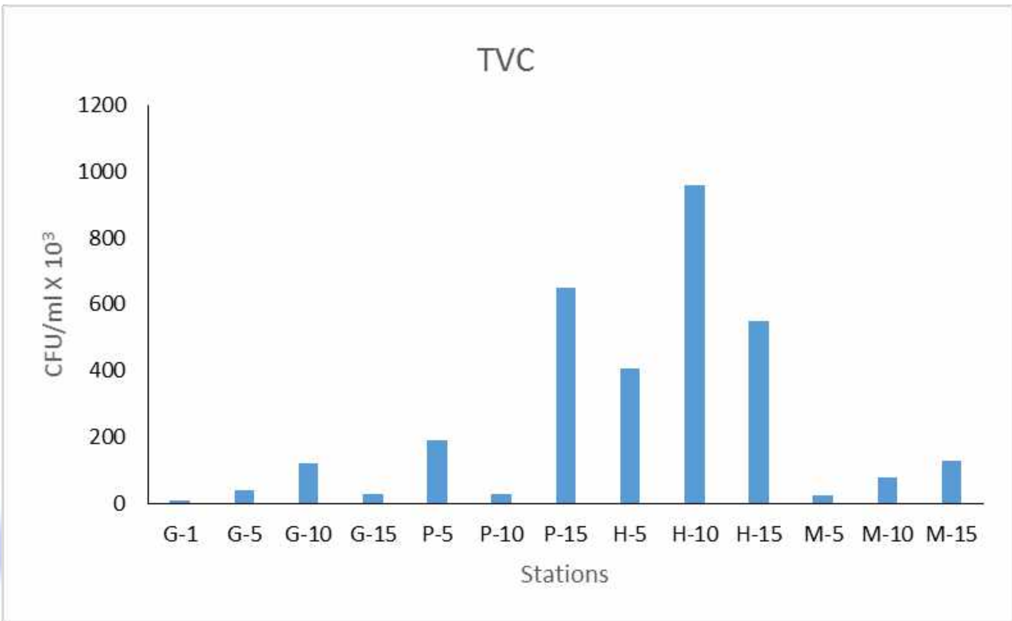


Figure 7. Total viable count (TVC) in water at Mumbai during March 2019.

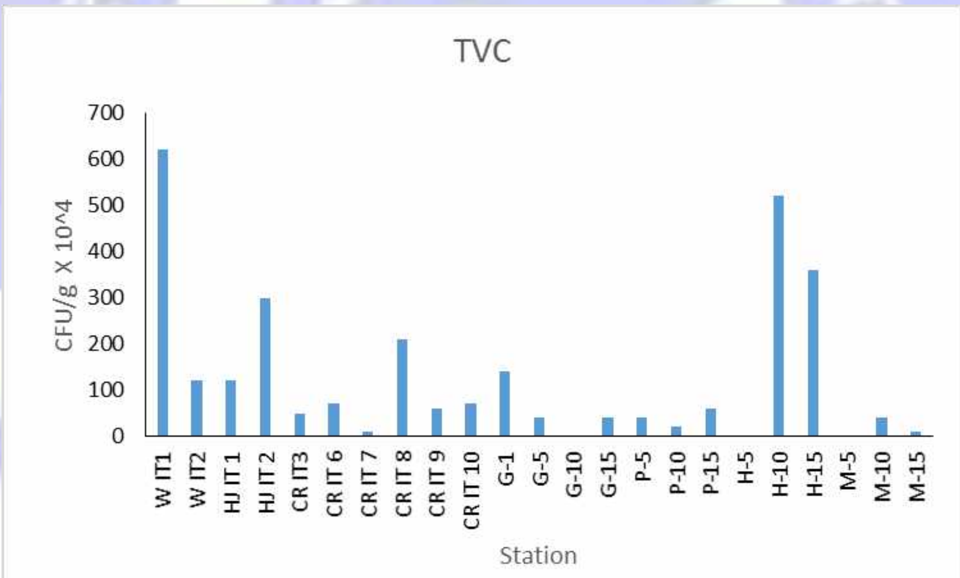


Figure 8. Total viable count in sediments of subtidal and intertidal stations at Mumbai during March 2019.

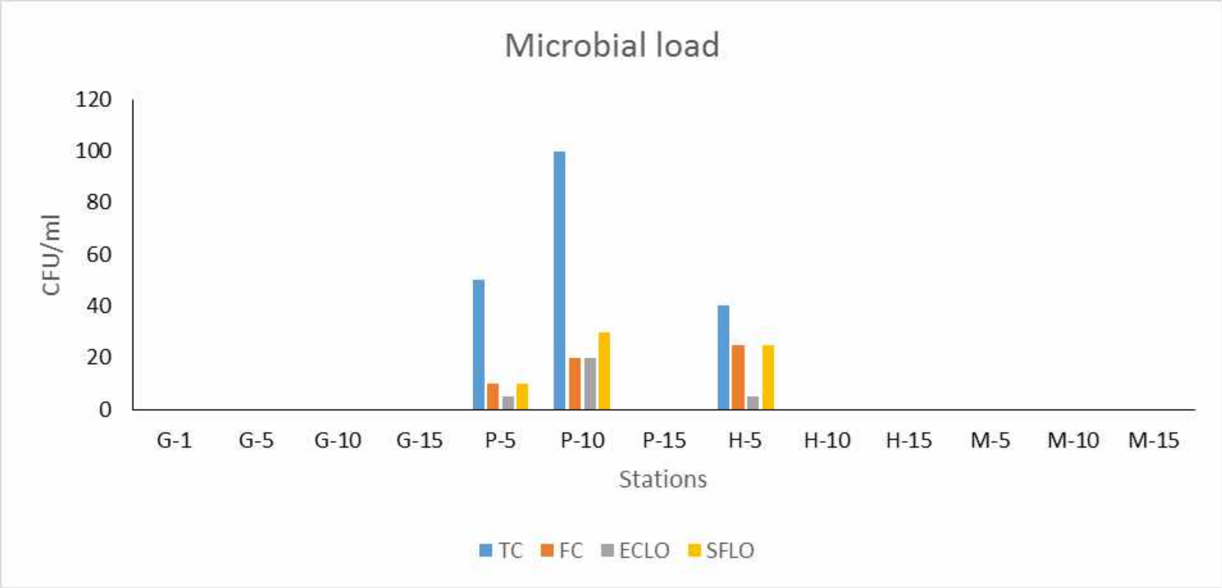


Figure 9. Pathogenic microbial load in water at Mumbai during March 2019.

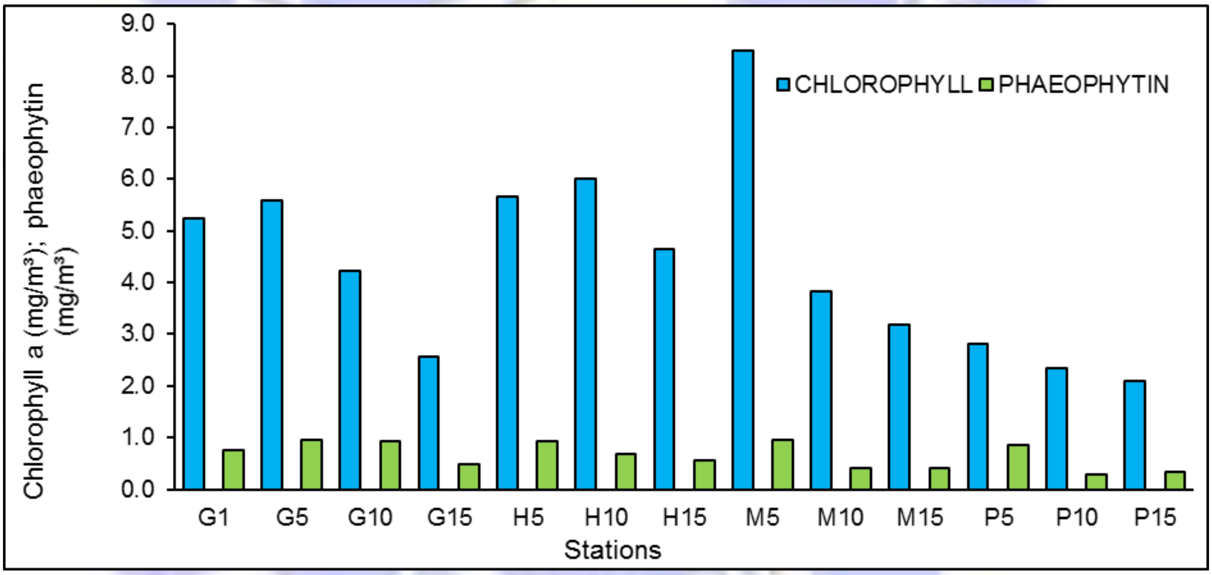


Figure 10. Distribution of phytopigments at various stations at Mumbai coast during March 2019.

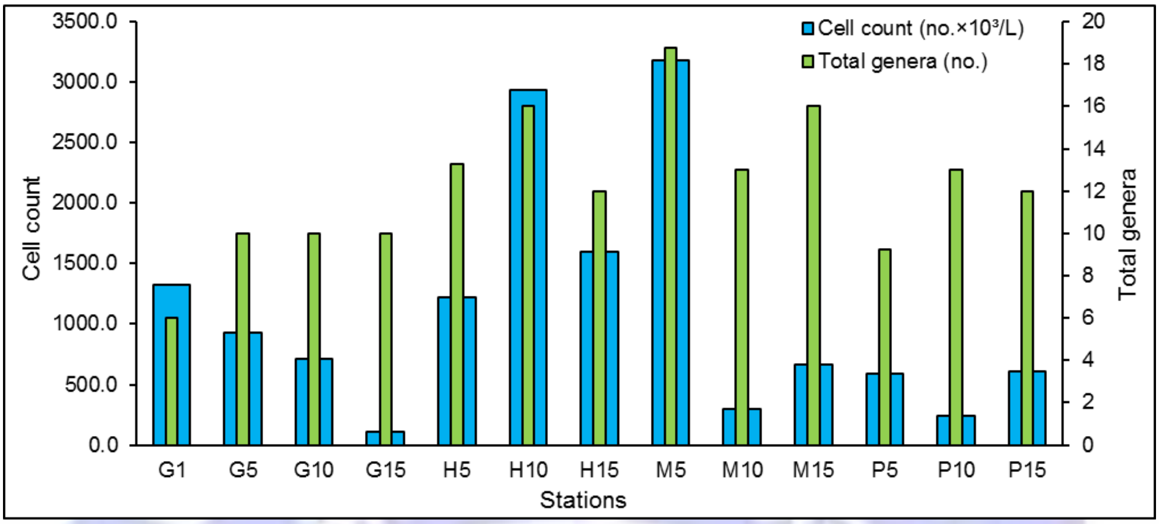


Figure 11. Phytoplankton abundance and composition at various stations at Mumbai coast during March 2019.

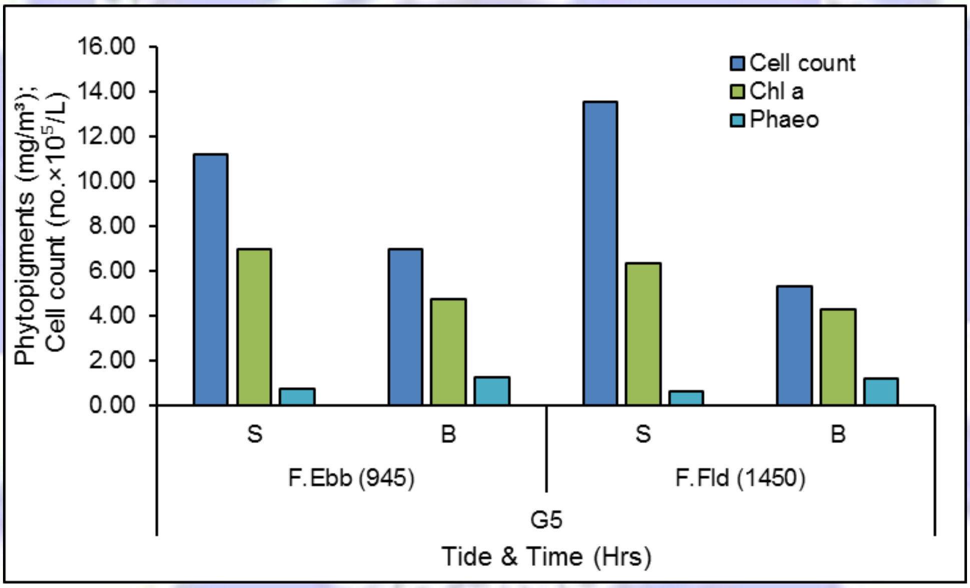


Figure 12. Temporal variation at G5 station at Mumbai coast during March 19.

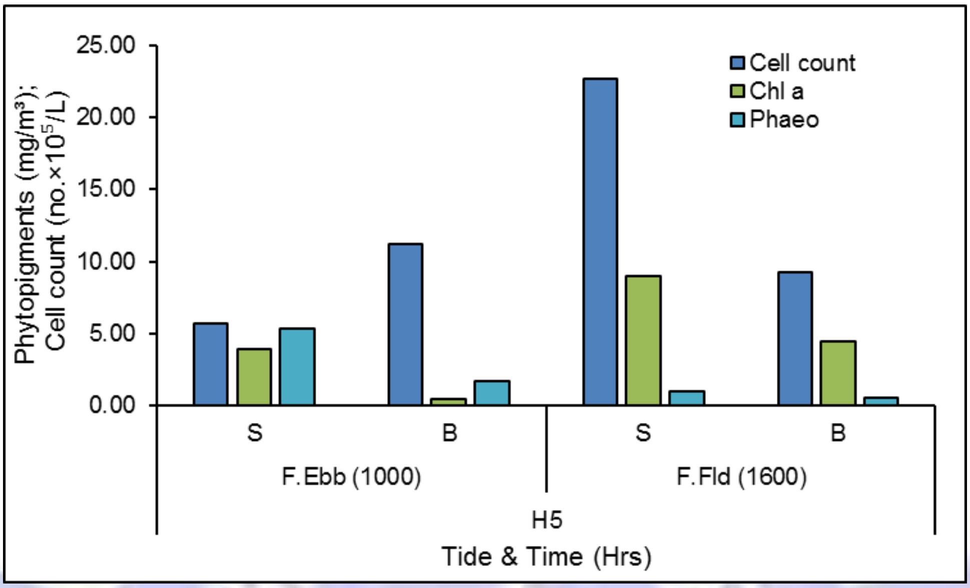


Figure 13. Temporal variation at H5 station at Mumbai coast during March 19.

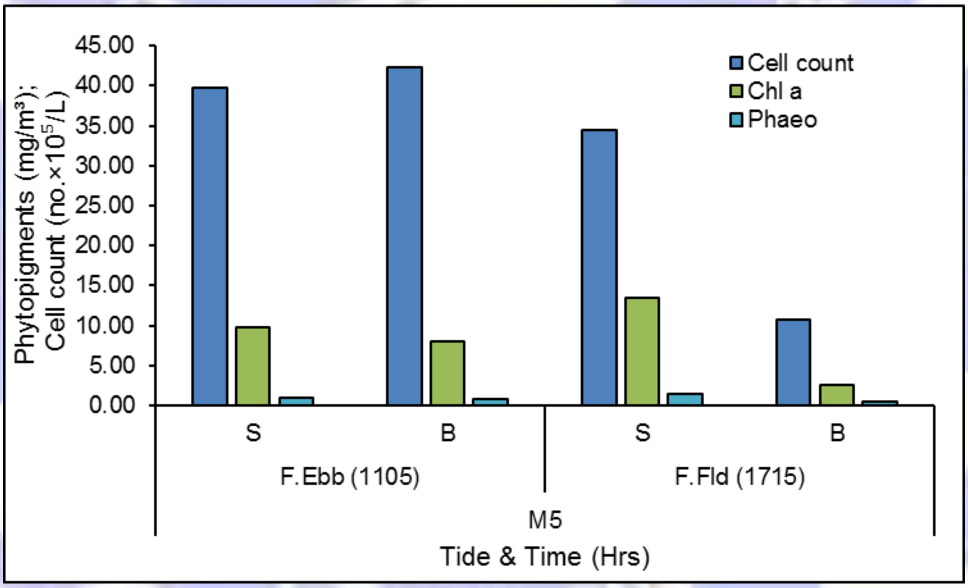


Figure 14. Temporal variation at M5 station at Mumbai coast during March 19.

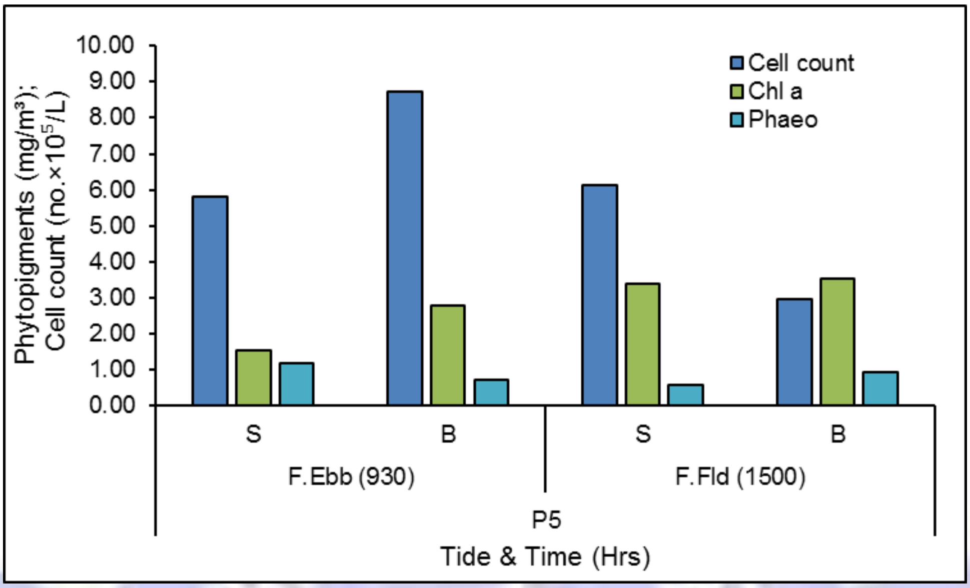


Figure 15. Temporal variation at P5 station at Mumbai coast during March 19.

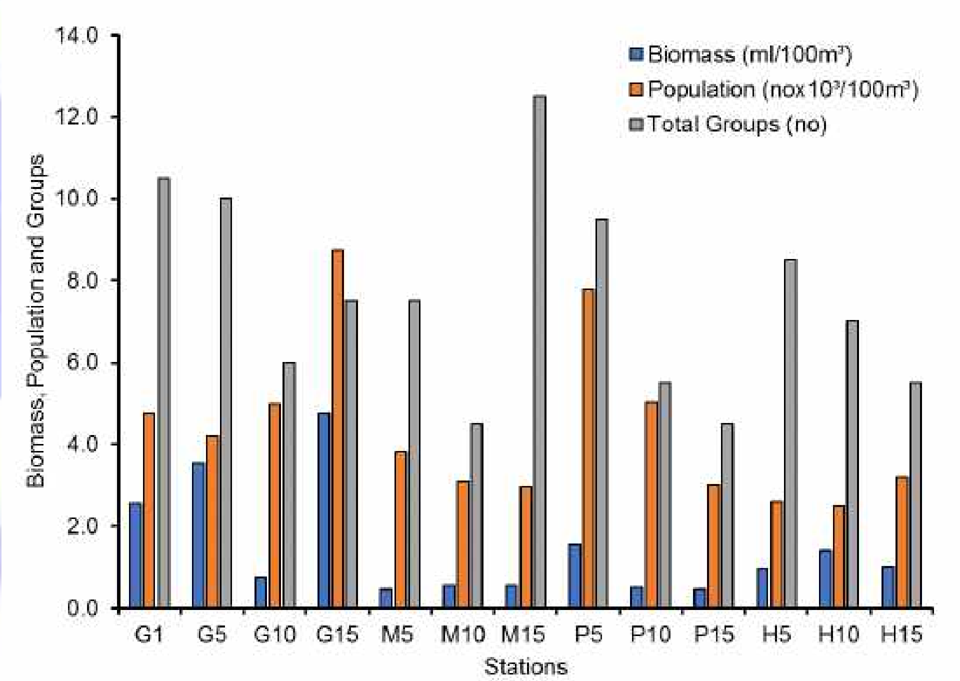


Figure 16. Spatial variation of Zooplanktons parameter at Mumbai during March 2019.

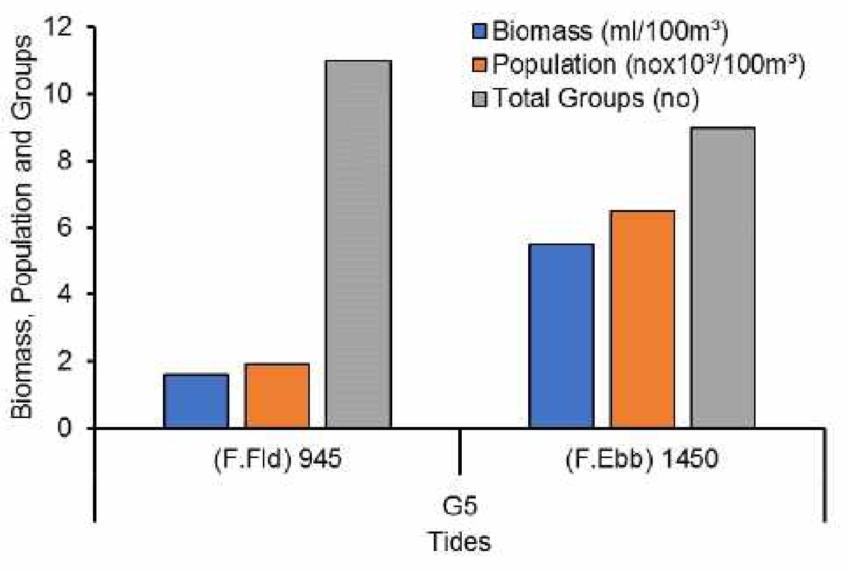


Figure 17. Tidal variation at G5 station during March 2019.

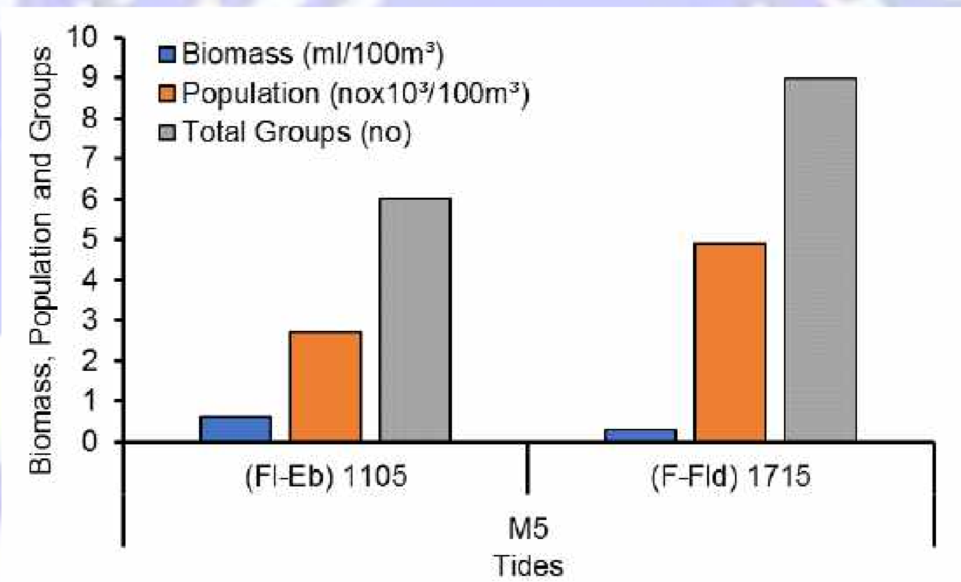


Figure 18. Tidal variation at M5 station during March 2019.

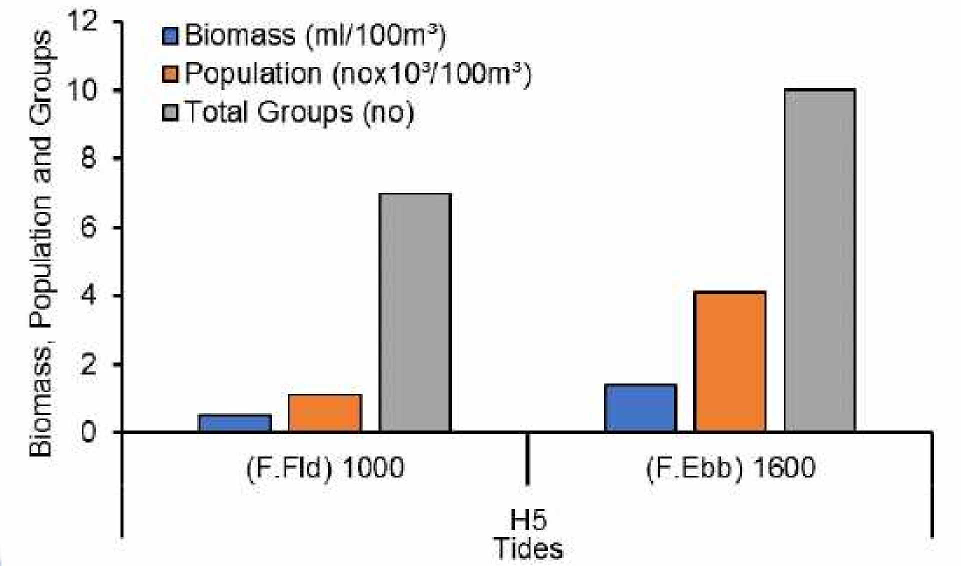


Figure 19. Tidal variation at H5 station during March 2019.

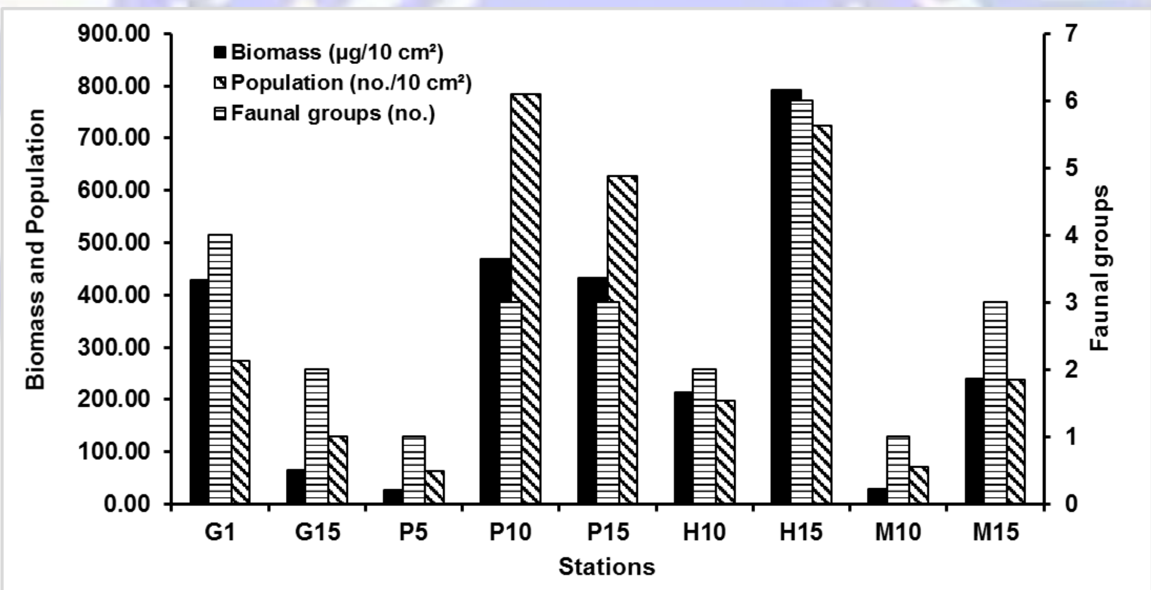


Figure 20. Meiobenthic parameters at subtidal stations of Mumbai during March 2019.

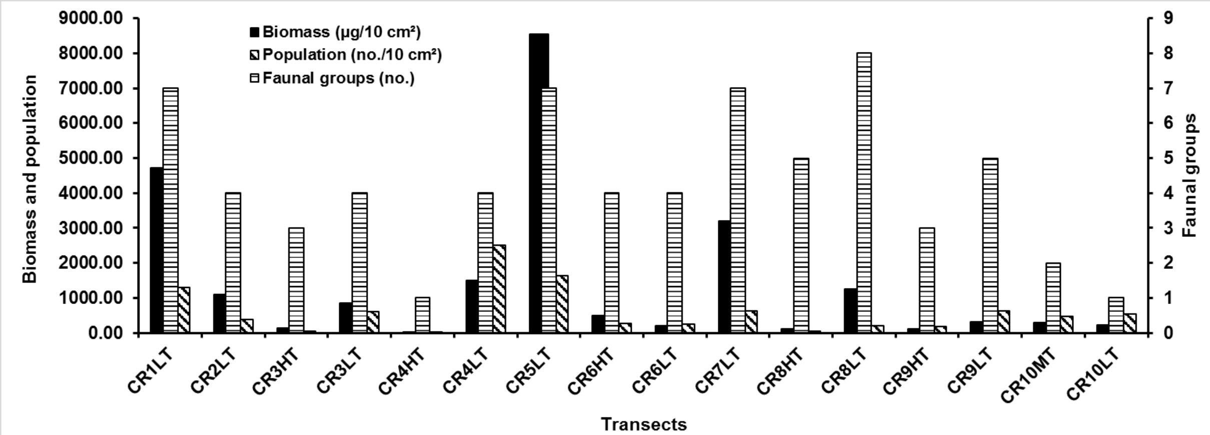


Figure 21. Meiobenthic parameters at Intertidal transects of Mumbai during March 2019.

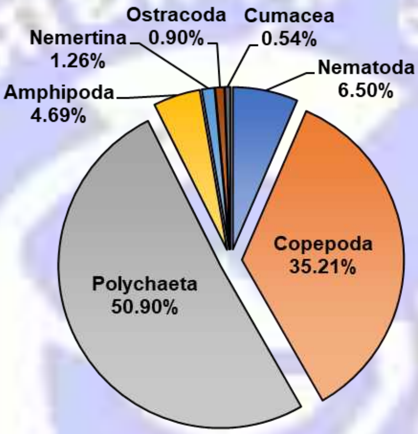


Figure 22. Percentage group composition of meiofauna at CR1 during low tide of Mumbai coast during March 2019.

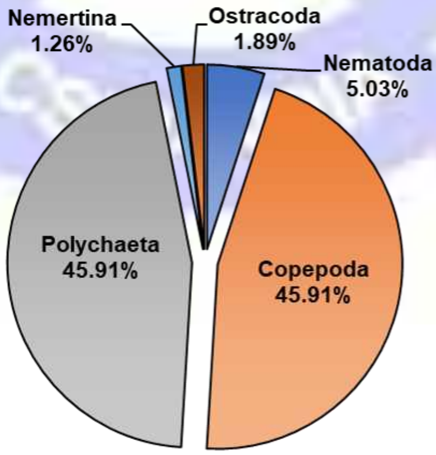


Figure 23. Percentage group composition of meiofauna at CR2 during low tide of Mumbai coast during March 2019.

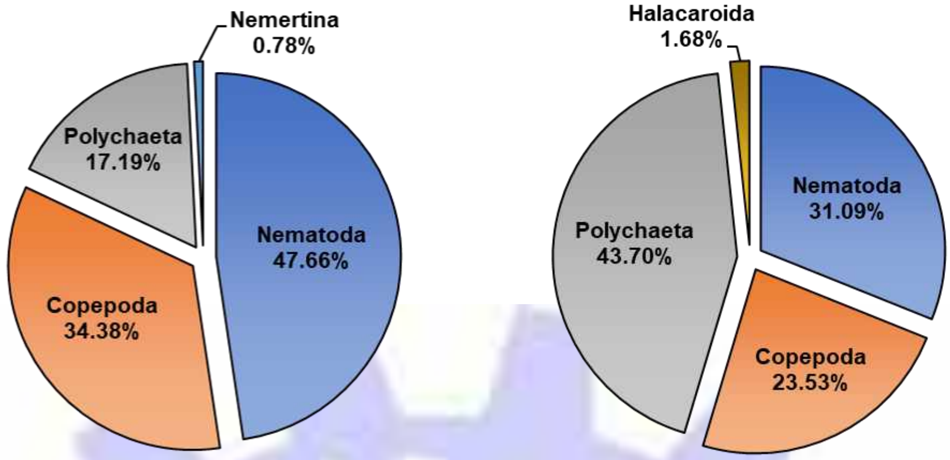


Figure 24. Percentage group composition of meiofauna at CR3 during low tide (left) and high tide (right) of Mumbai coast during March 2019.

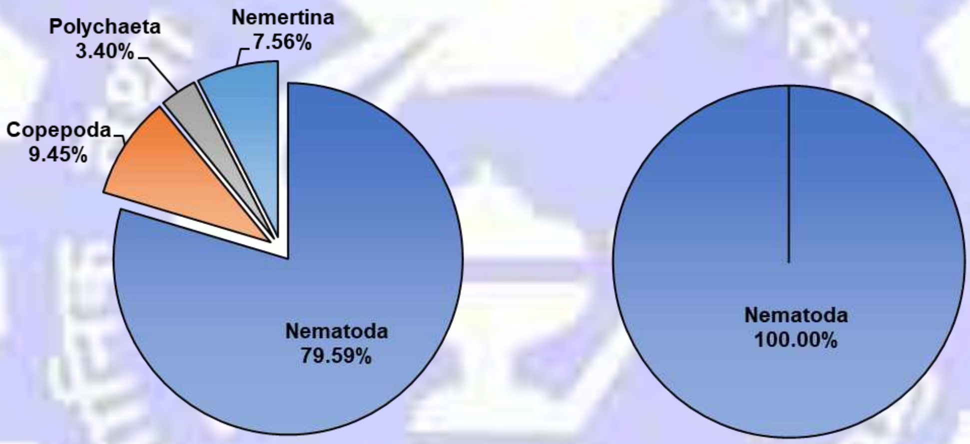


Figure 25. Percentage group composition of meiofauna at CR4 during low tide (left) and high tide (right) of Mumbai coast during March 2019.

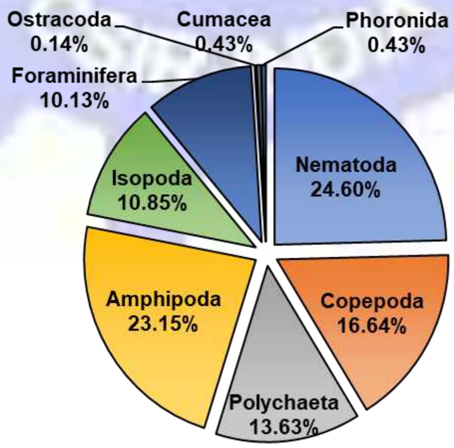
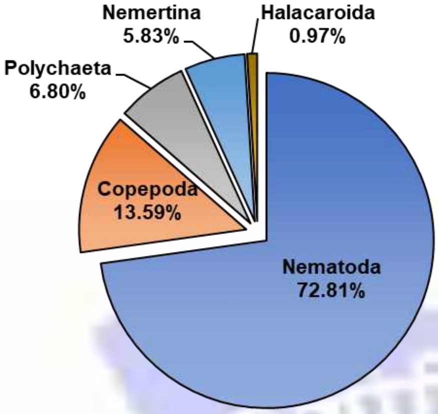


Figure 26. Percentage group composition of meiofauna at CR5 during low tide of Mumbai coast during March 2019.



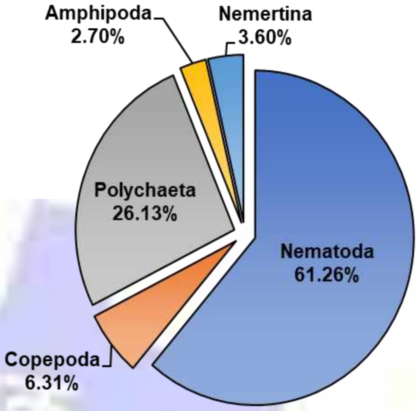


Figure 27. Percentage group composition of meiofauna at CR6 during low tide (left) and high tide (right) of Mumbai coast during March 2019.

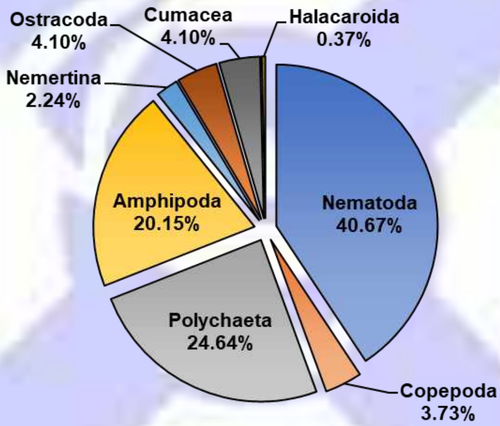
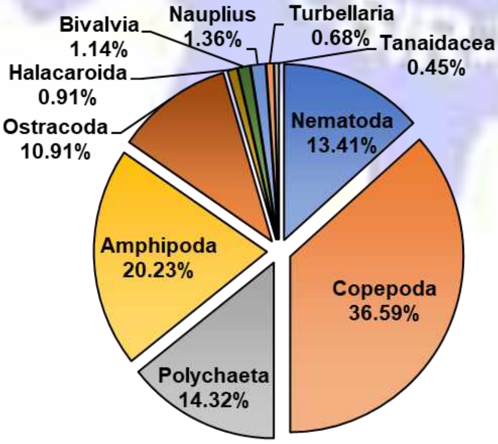


Figure 28. Percentage group composition of meiofauna at CR7 during low tide of Mumbai coast during March 2019.



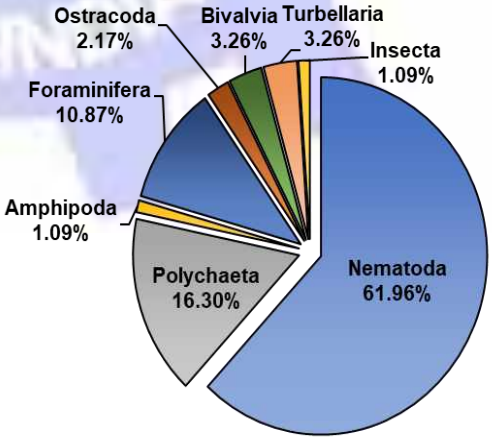


Figure 29. Percentage group composition of meiofauna at CR8 during low tide (left) and high tide (right) of Mumbai coast during March 2019.

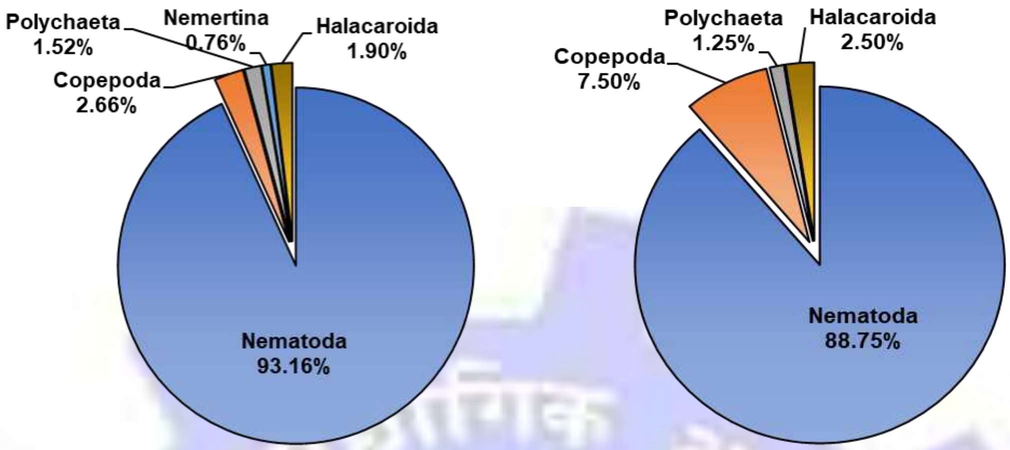


Figure 30. Percentage group composition of meiofauna at CR9 during low tide (left) and high tide (right) of Mumbai coast during March 2019.

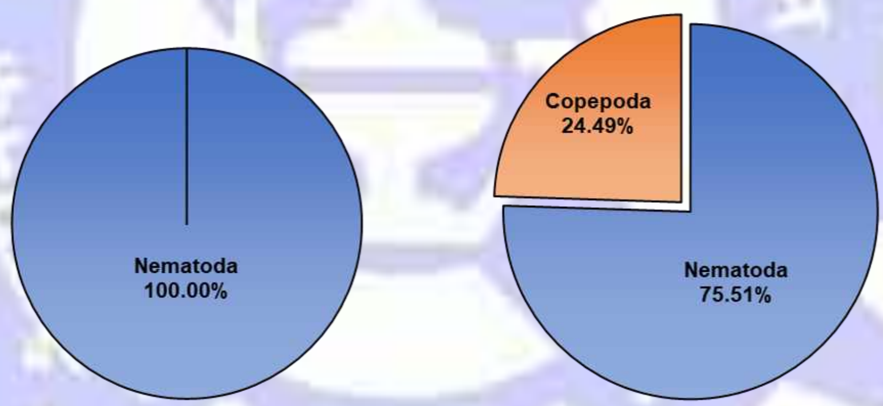


Figure 31. Percentage group composition of meiofauna at CR10 during low tide (left) and high tide (right) of Mumbai coast during March 2019.

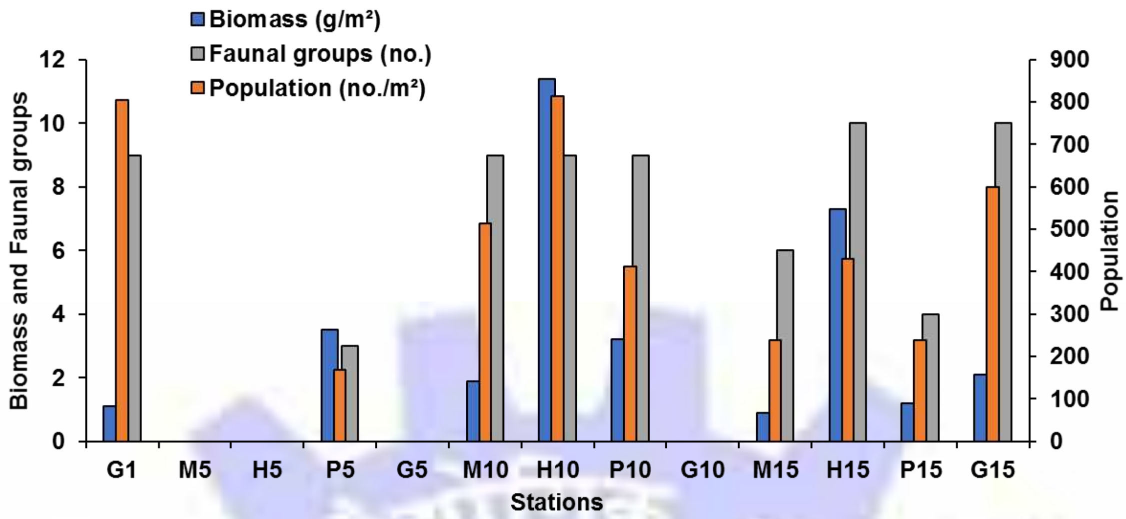


Figure 32. Spatial variation of macrobenthic parameters at subtidal stations of Mumbai intertidal region during March, 2019.

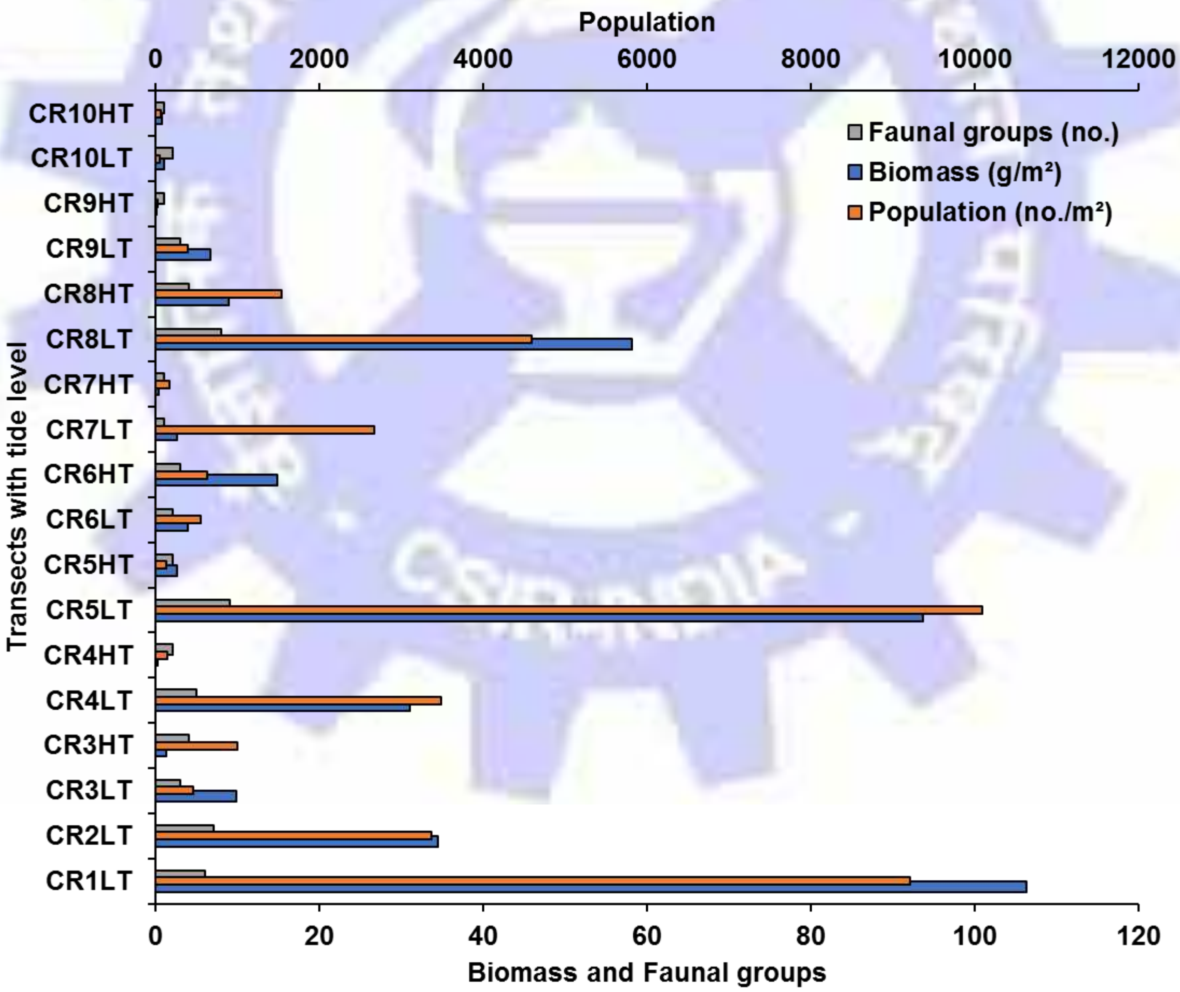


Figure 33. Spatial variation of macrobenthic parameters at intertidal transects of Mumbai intertidal region during March, 2019.

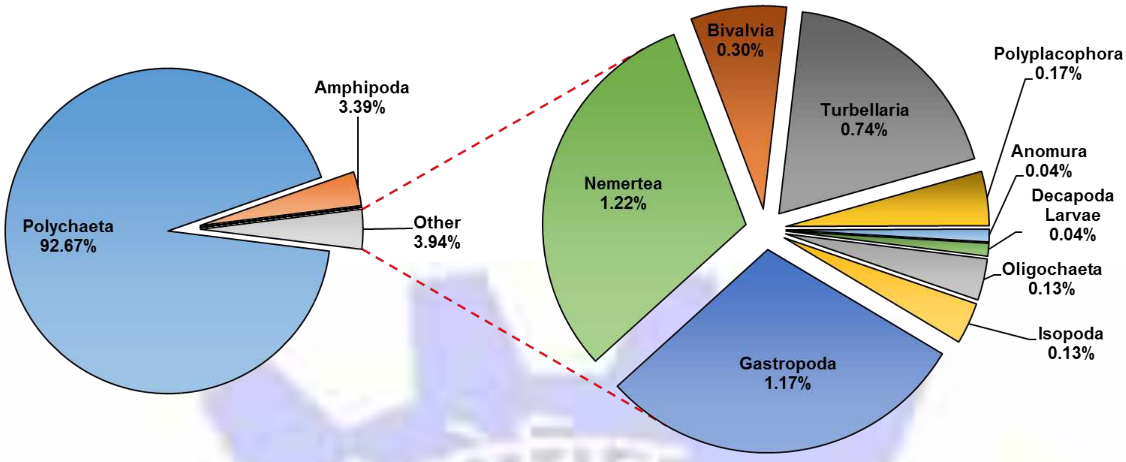


Figure 34. Macrobenthic percentage composition at intertidal transect CR1 from low tide level during March, 2019.

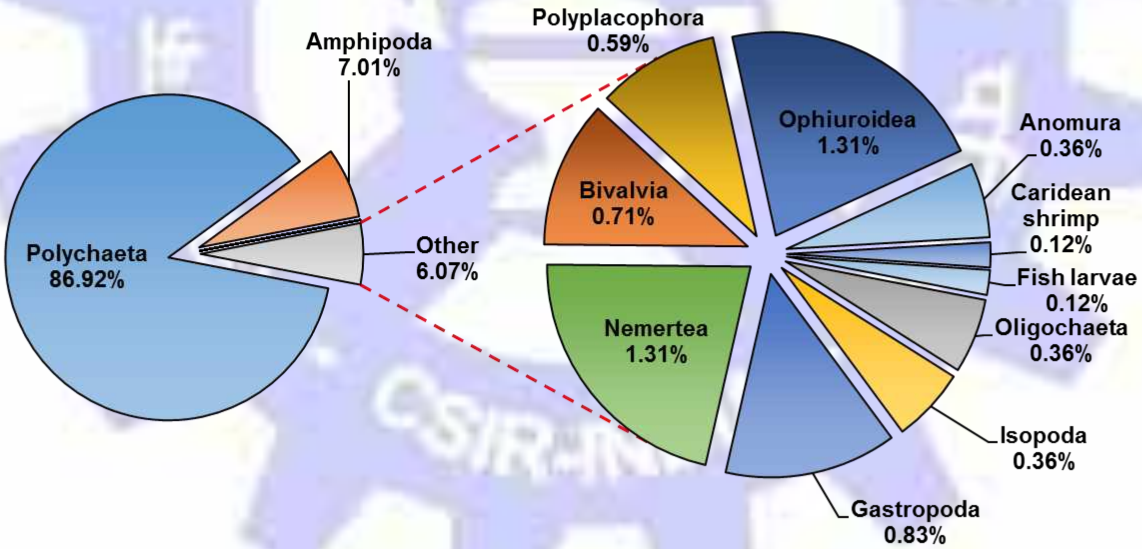


Figure 35. Macrobenthic percentage composition at intertidal transect CR2 from low tide level during March, 2019.

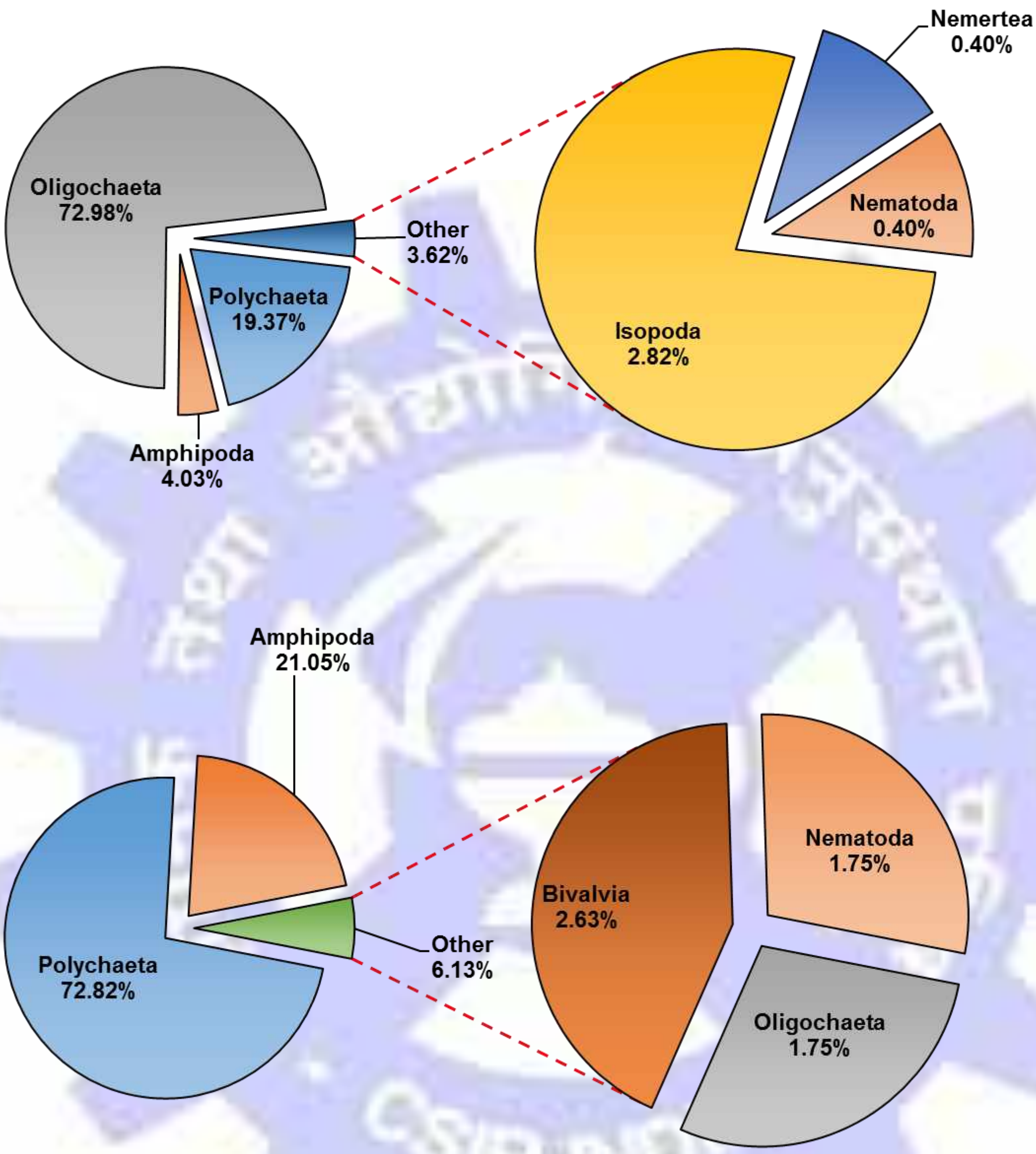


Figure 36. Macrobenthic percentage composition at intertidal transect CR3 from high tide (upper) and low tide (lower) level during March, 2019.

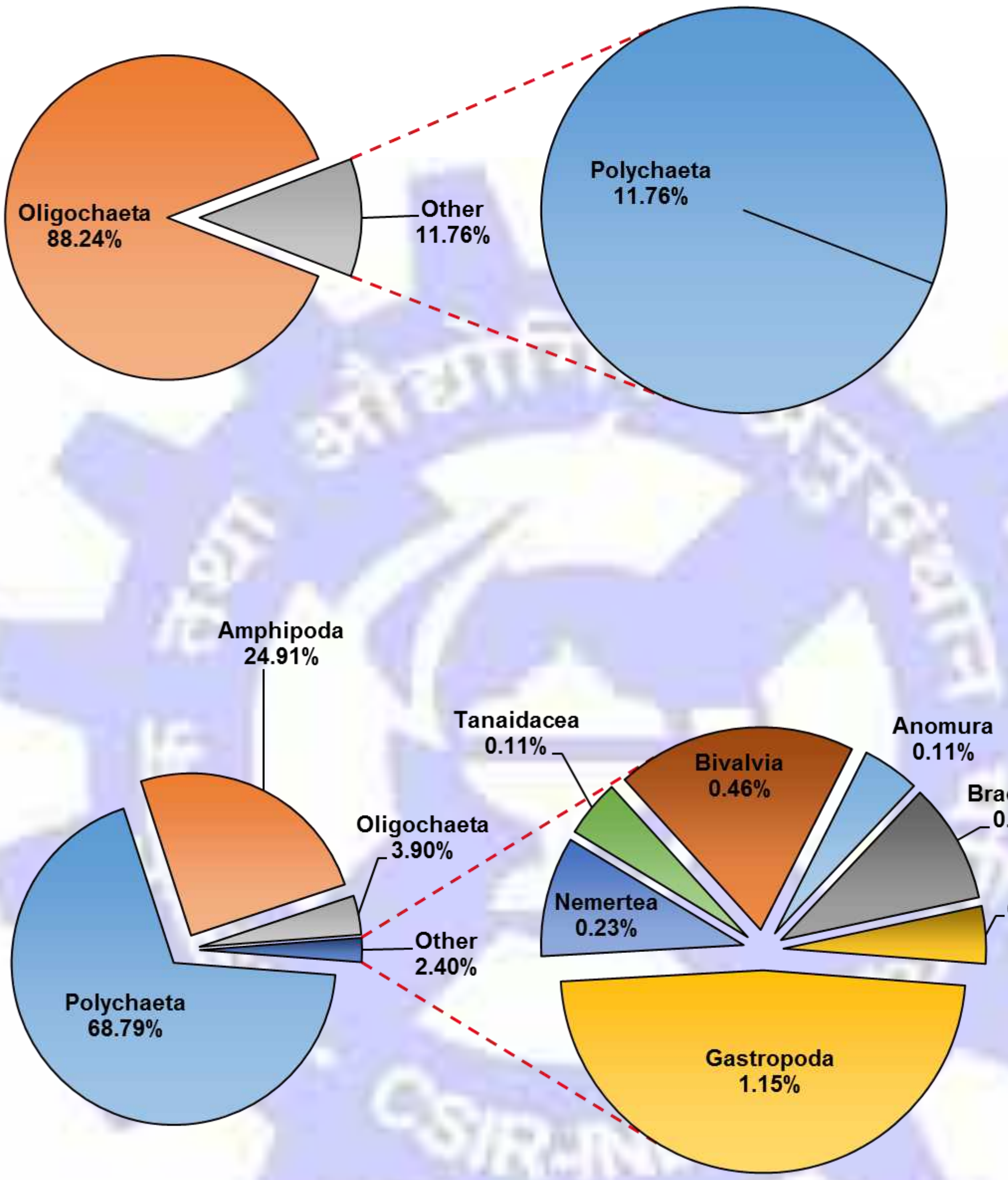


Figure 37. Macrobenthic percentage composition at intertidal transect CR4 from high tide (upper) and low tide (lower) level during March, 2019.

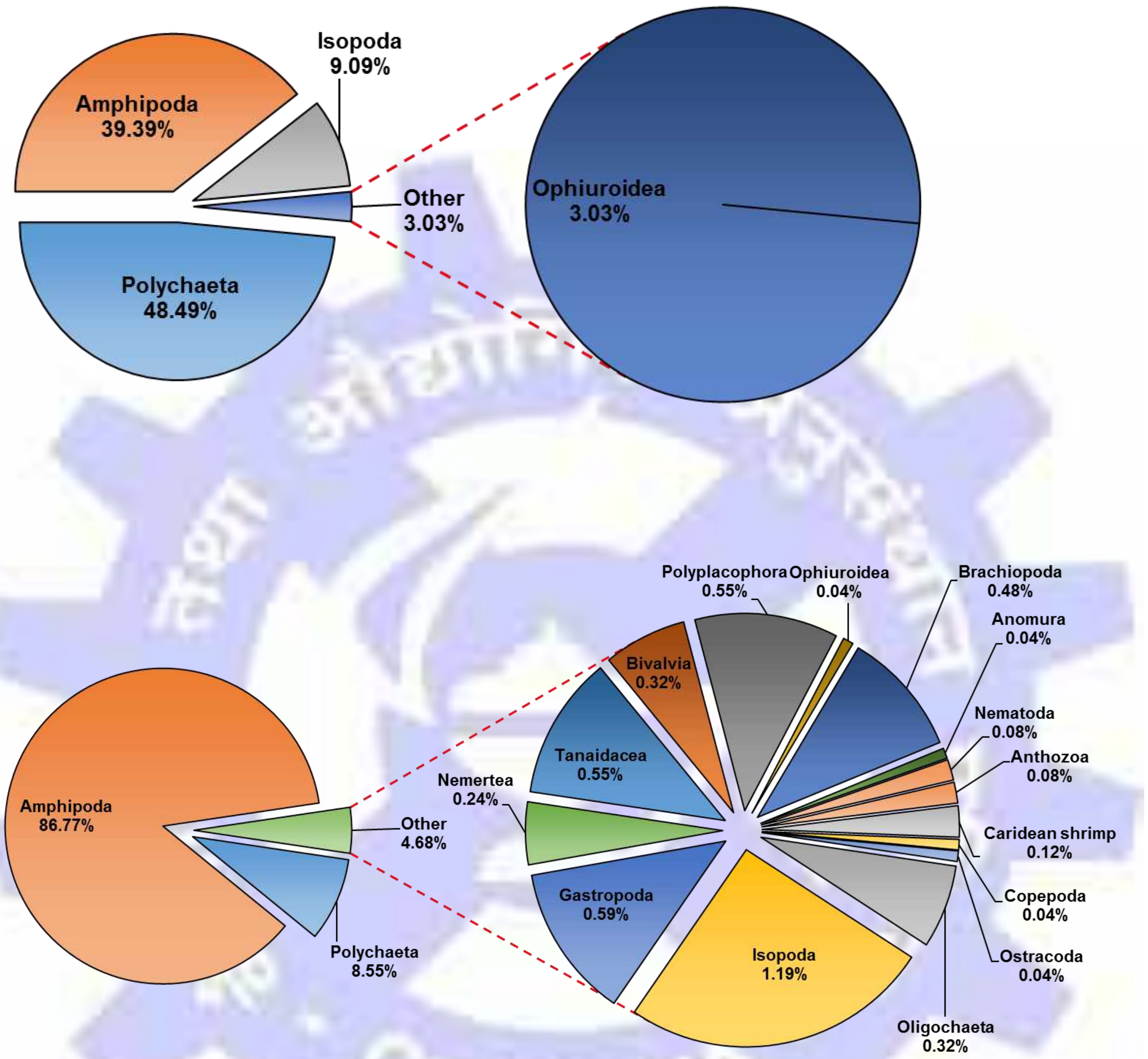
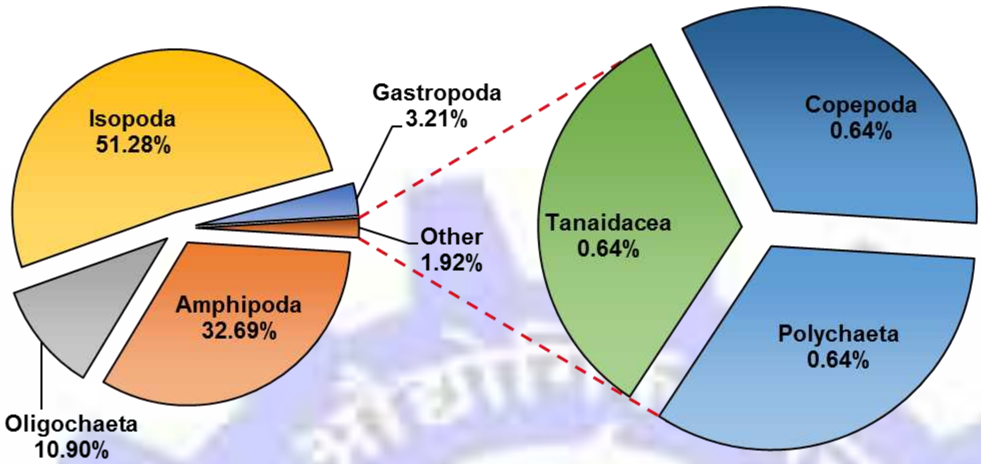


Figure 38. Macrobenthic percentage composition at intertidal transect CR5 from high tide (upper) and low tide (lower) level during March, 2019.



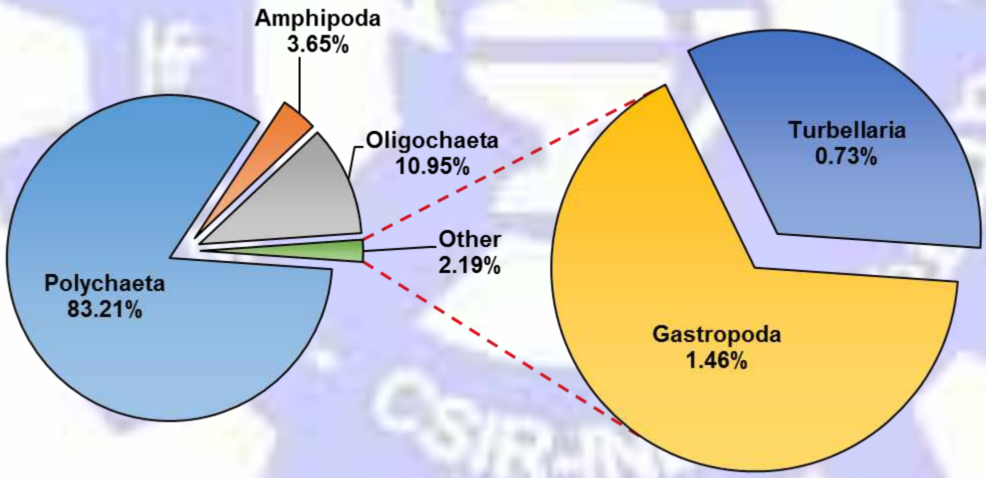


Figure 39. Macrobenthic percentage composition at intertidal transect CR6 from high tide (upper) and low tide (lower) level during March, 2019.

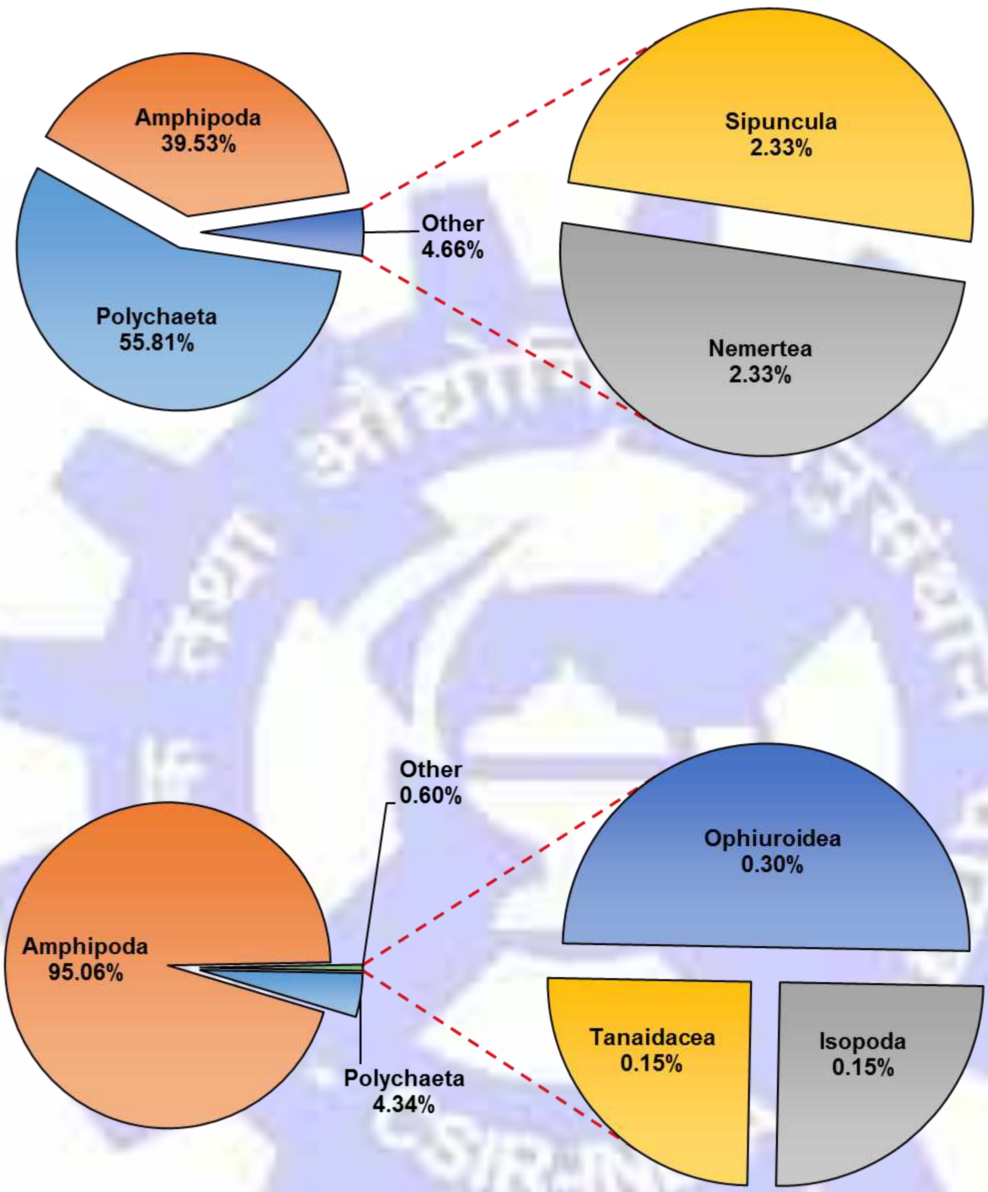


Figure 40. Macrobenthic percentage composition at intertidal transect CR7 from high tide (upper) and low tide (lower) level during March, 2019.

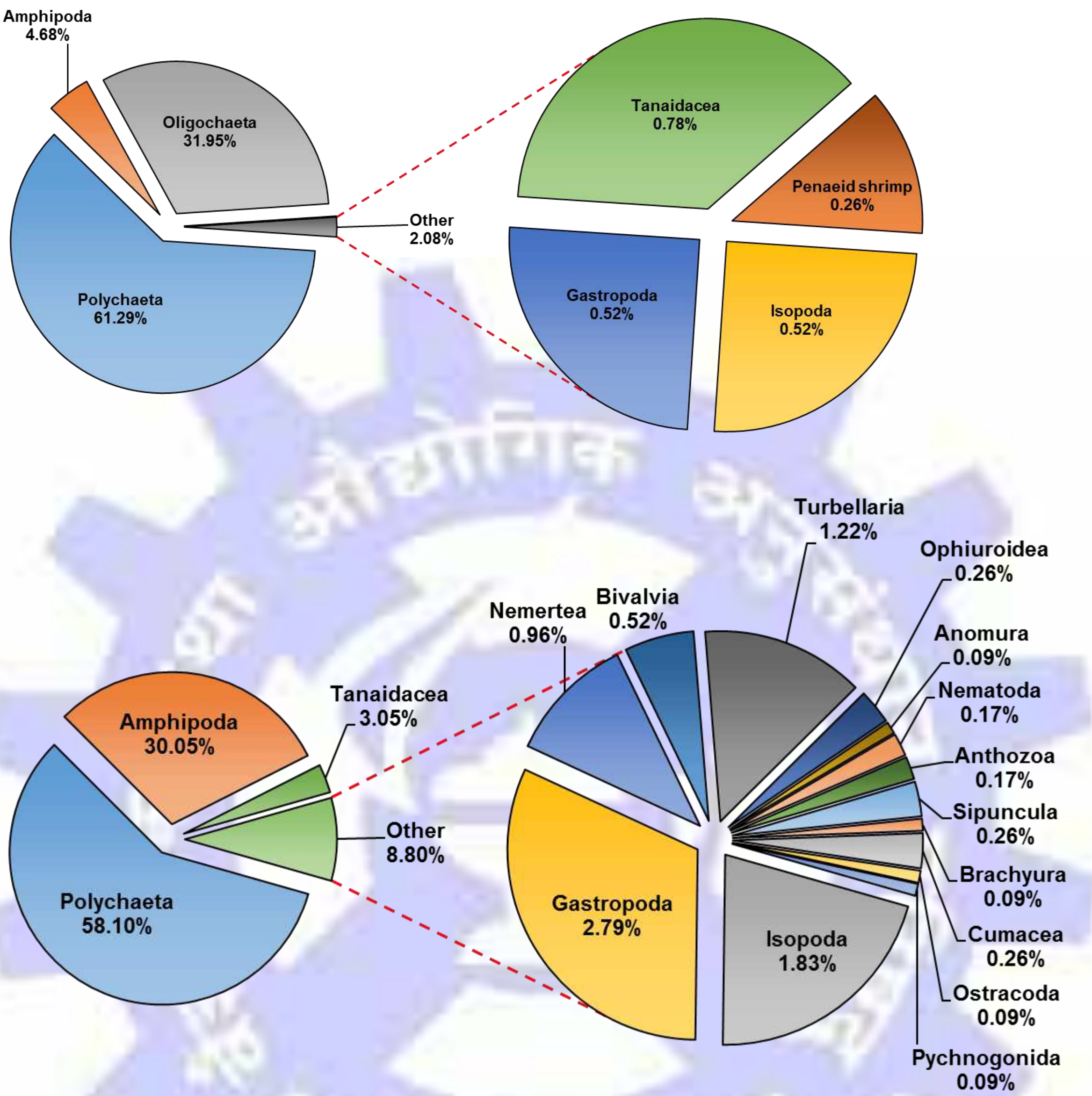
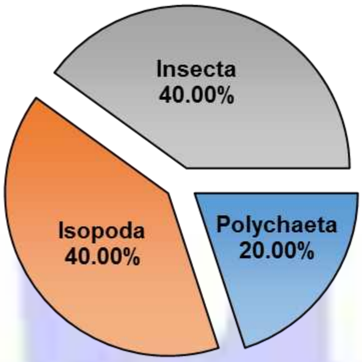


Figure 41. Macrobenthic percentage composition at intertidal transect CR8 from high tide (upper) and low tide (lower) level during March, 2019.



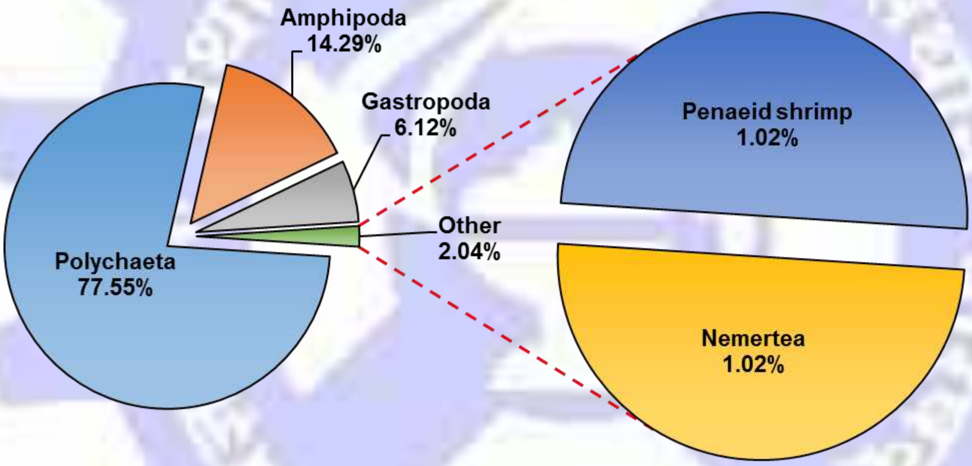
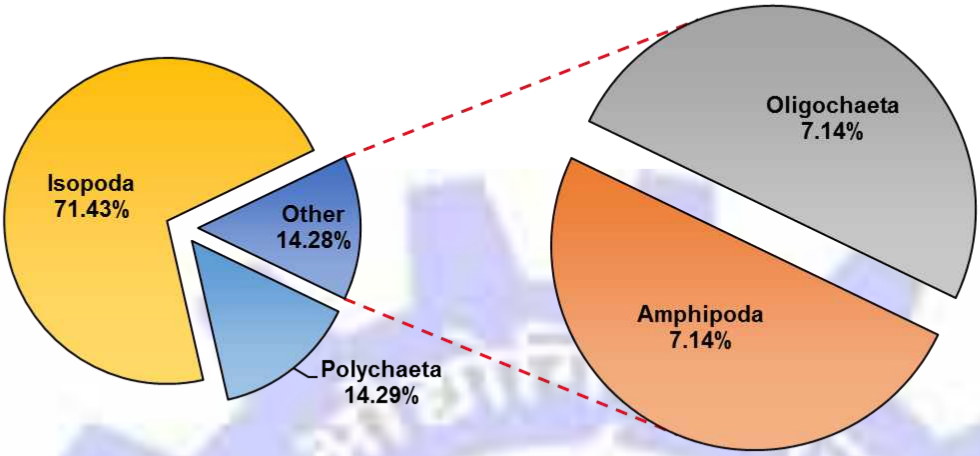


Figure 42. Macrobenthic percentage composition at intertidal transect CR9 from high tide (upper) and low tide (lower) level during March, 2019.



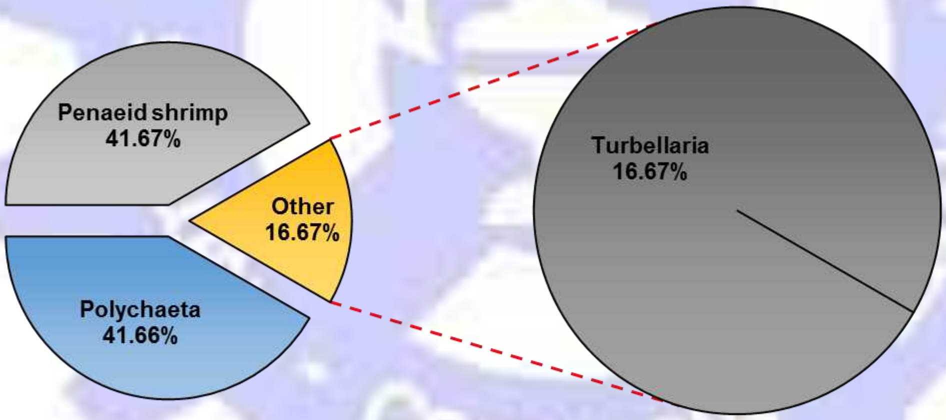


Figure 43. Macrobenthic percentage composition at intertidal transect CR10 from high tide (upper) and low tide (lower) level during March, 2019.

	d	J'	H'	λ	S	N	
Sn	0.78	0.94	1.31	0.72	4	48	CR10 ▷
Sn	0.67	0.96	1.06	0.67	3	20	CR9 ◀
Sn	0.99	0.62	0.99	0.48	5	56	CR10 ◀
SMB	0.61	0.35	0.48	0.22	4	136	CR4 ◀
SG	1.84	0.78	1.81	0.78	10	132	CR5 ◀
Sn	1.68	0.74	1.78	0.77	11	392	CR9 ▷
Rk	2.52	0.27	0.86	0.34	24	9212	CR1 ▷
Rk	2.83	0.47	1.50	0.67	24	3368	CR2 ▷
Rk	3.90	0.21	0.75	0.24	37	10100	CR5 ▷
Rk	4.86	0.67	2.51	0.85	42	4592	CR8 ▷
Rk	2.12	0.81	2.15	0.85	14	456	CR3 ▷
MR	4.41	0.75	2.71	0.89	37	3484	CR4 ▷
Rk	2.85	0.83	2.43	0.88	19	548	CR6 ▷
SMB	2.86	0.70	2.16	0.82	22	1540	CR8 ◀
Rk	1.01	0.13	0.28	0.10	9	2672	CR7 ▷
MSG	0.93	0.59	1.16	0.62	7	624	CR6 ◀
RG	1.16	0.47	1.03	0.45	9	992	CR3 ◀
Rk	1.17	0.72	1.40	0.71	7	172	CR7 ◀

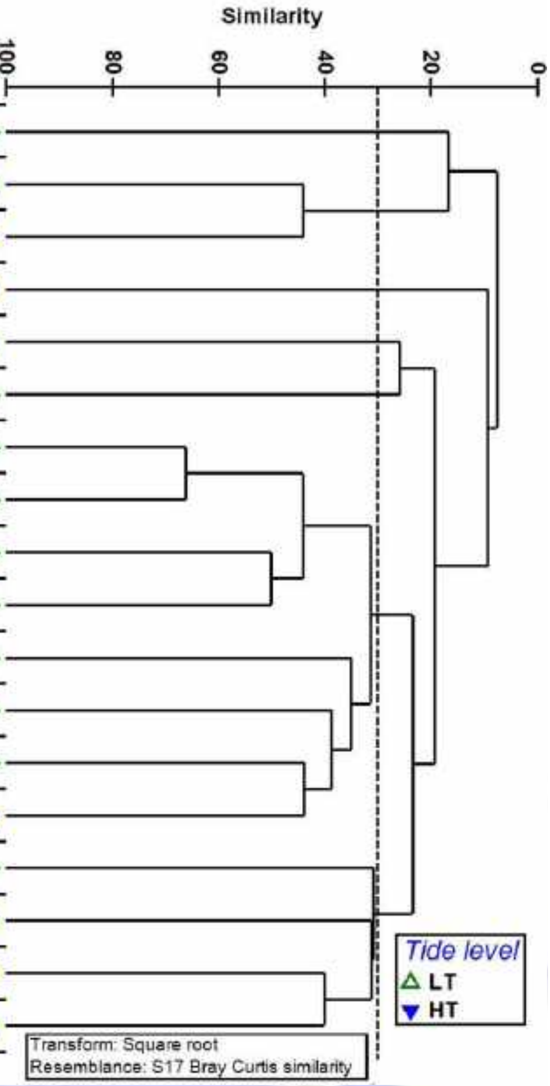


Figure 44. Benthic macrofaunal diversity indices and Cluster analysis (grouping at 30% similarity) based on density at intertidal transects with respect to their habitat from high tide and low tide levels in the study during March-April 2019. Colour indicates the higher to lower values (e.g., Red – Lower; Green – Higher, Yellow – Medium) (Habitat code***: Sn-Sandy; SMB – Sand and mud mixed with cobbles; SG – Sand and gravel; Rk -Rocky, MR-Muddy with rock; MSG – Mud with sandy gravels; RG – Rock and gravels)***

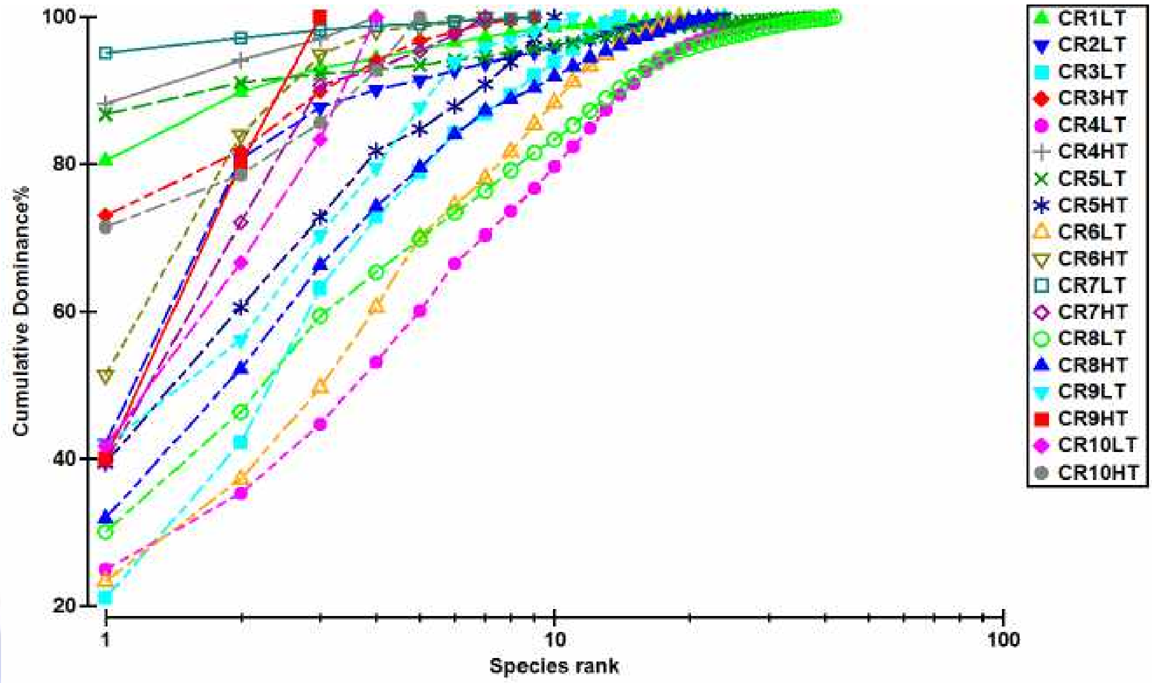


Figure 45. K-dominance plot based on density of benthic macrofaunal taxa at intertidal transects from high tide (upper) and low tide (lower) levels at Mumbai during March, 2019.

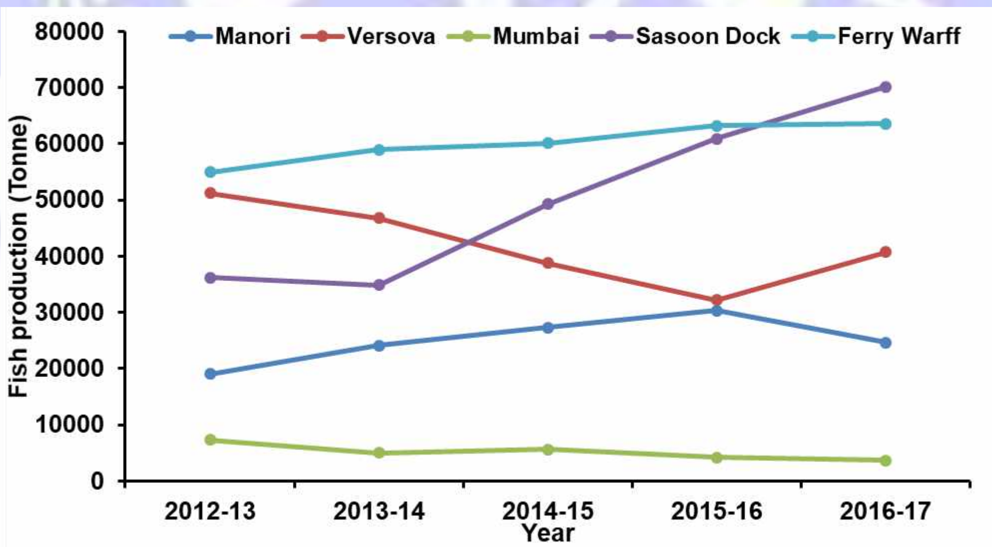


Figure 46. Zone-wise marine fish production (In Tonne) in Greater Mumbai from year 2012 to 2017.

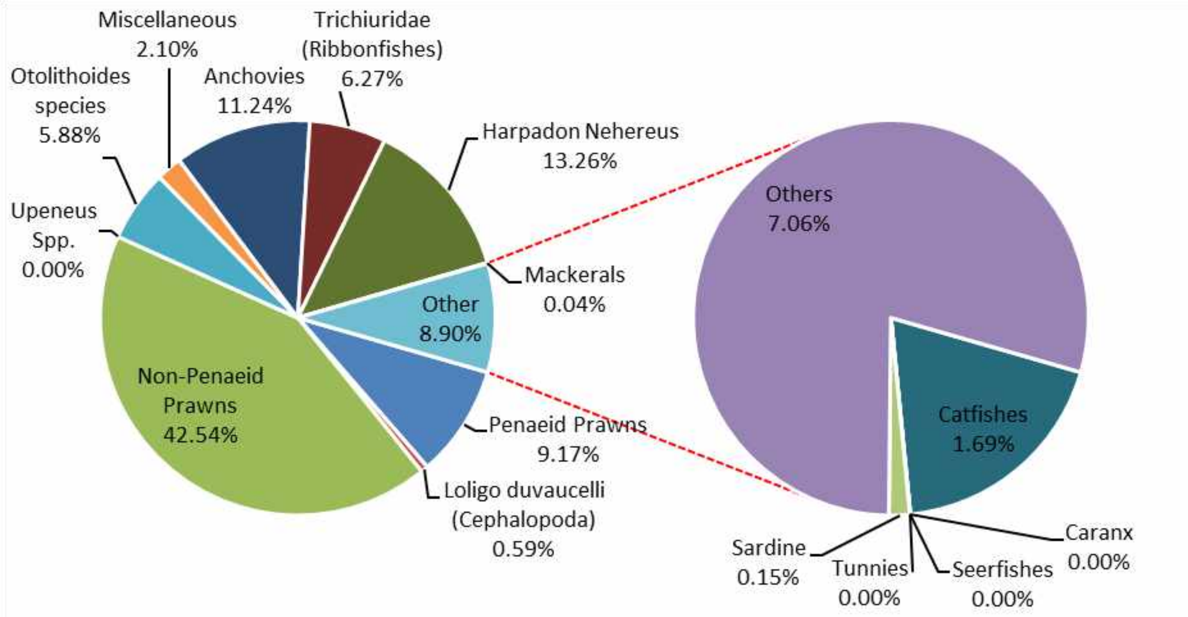


Figure 47. Percentage composition marine fish production of various groups from Manori during 2016-17.

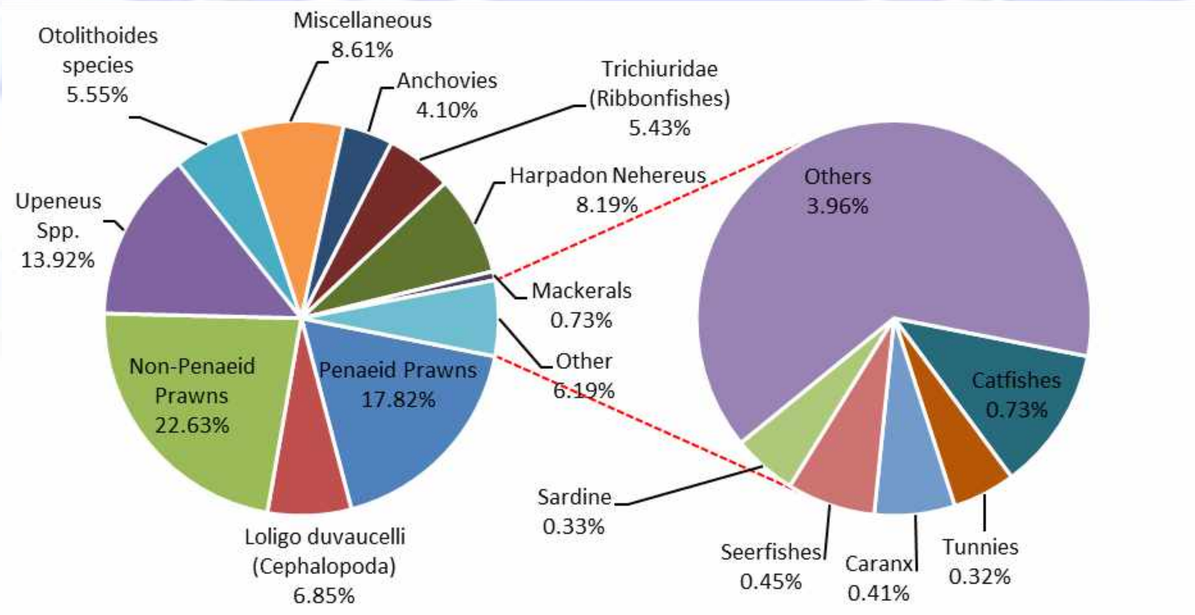


Figure 48. Percentage composition marine fish production of various groups from Versova during 2016-17.

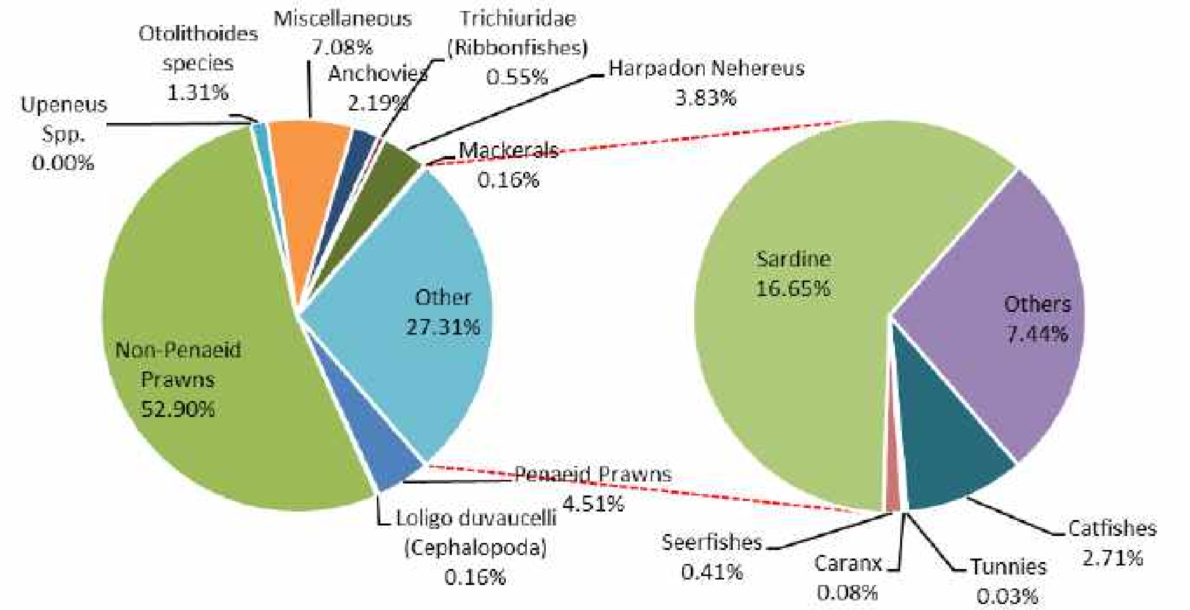


Figure 49. Percentage composition marine fish production of various groups from Mumbai during 2016-17.

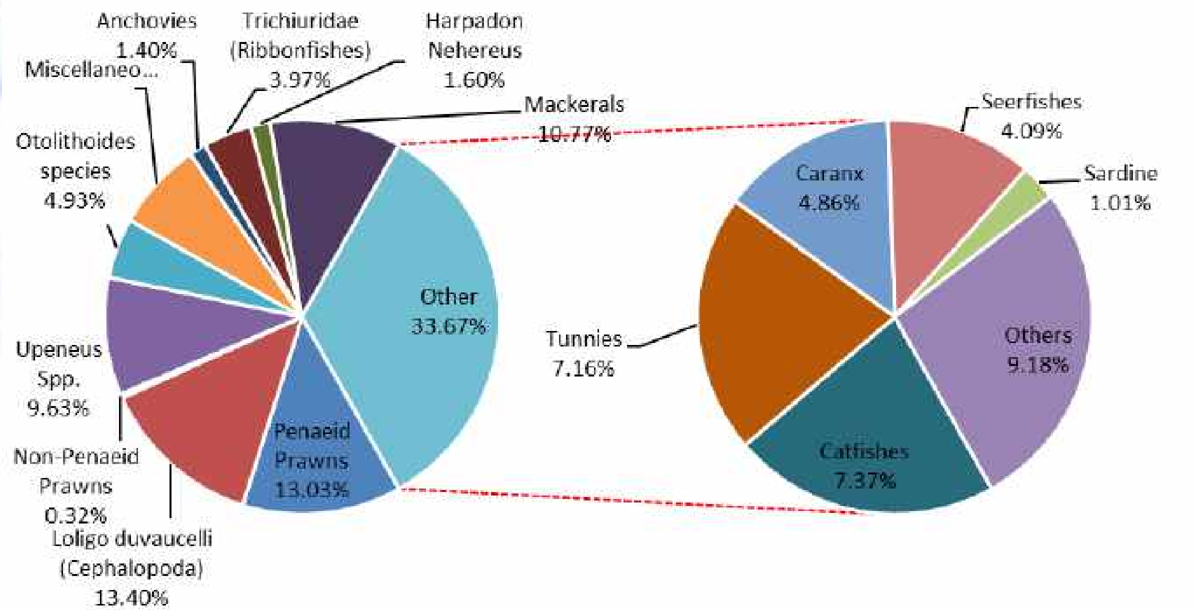


Figure 50. Percentage composition marine fish production of various groups from Sasoon dock during 2016-17.

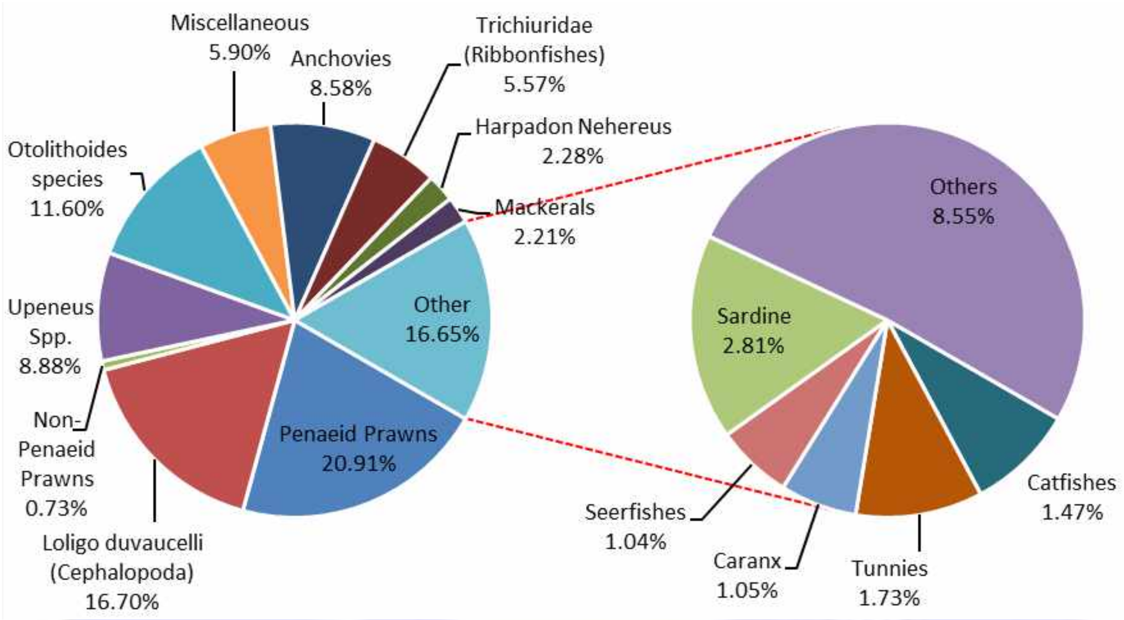


Figure 51. Percentage composition marine fish production of various groups from Ferry Warff during 2016-17.

Figure 52. Map showing proposed project site and coral spotted along the A) Worli and Haji Ali; and B) Marine Drive Rocky shore area located about 1.8 km away from the proposed project site of installation during the present study. **Below table showing the locations of corals recorded during the present study.**

Latitude (N)	Longitude E	Area
18°58´55.668"	72°48´22.56"	Haji Ali
18°58´43.508"	72°48´18.441"	Haji Ali
18°58´45.883"	72°48´21.544"	Haji Ali
19°02´26.608"	72°48´46.511"	Worli
19°0´26.621"	72°48´46.538"	Worli
19°0´28.262"	72°48´46.868"	Worli
19°0´30.171"	72°48´47.28"	Worli

11. Tables

Table. 1. Details of the sampling locations during the study period in Mumbai.

Type of sampling	Area name	Site area type	Station Code	Longitude (°E)	Latitude (°N)
Subtidal	Girgaon	Bay	G1	72.8033	18.9405
		Near-shore	G5	72.79704	18.92637
		Far-shore	G10	72.76717	18.92739
		Off-shore	G15	72.7199	18.9267
	Haji Ali	Near-shore	H5	72.80251	18.98315
		Far-shore	H10	72.7674	18.9833
		Off-shore	H15	72.7092	18.9865
	Priyadarshani park	Near-shore	P5	72.7925	18.9595
		Far-shore	P10	72.7662	18.9576
		Off-shore	P15	72.7171	18.9623
	Worli	Near-shore	M5	72.80643	19.01576
		Far-shore	M10	72.7647	19.0183
		Off-shore	M15	72.7201	19.0240
Intertidal	Worli	On-shore	CR1HT	72.8150	19.0102
		On-shore	CR1LT	72.8150	19.0104
		On-shore	CR2HT	72.8111	19.0008
		On-shore	CR2LT	72.8103	19.0008
		On-shore	CR3HT	72.8108	18.9873
		On-shore	CR3LT	72.8103	18.9871
	Haji Ali	On-shore	CR4HT	72.8114	18.9788
		On-shore	CR4LT	72.8111	18.9790
		On-shore	CR5HT	72.8089	18.9789
		On-shore	CR5LT	72.8069	18.9804
	Mahalaxmi	On-shore	CR6HT	72.8058	18.9762
		On-shore	CR6LT	72.8047	18.9769
	Amarsons garden	On-shore	CR7HT	72.8014	18.9692
		On-shore	CR7LT	72.8014	18.9692
	Priyadarshani park	On-shore	CR8HT	72.8006	18.9625
		On-shore	CR8LT	72.7994	18.9623
	Girgaon	On-shore	CR9HT	72.8164	18.9519
		On-shore	CR9LT	72.8158	18.9515
		On-shore	CR10HT	72.8219	18.9453
		On-shore	CR10LT	72.8214	18.9451

Table. 2. Variation in Air and water temperature (°C) at different locations off Mumbai during March 2019.

Area	Station	Tide	AT (°C)	Water temperature (°C)	
				S	B
Bay	G1	*	29.0	28.5	27.5
Nearshore	G5	HT	31.0	28.5	28.0
		LT	27.0	26.5	26.5
	P5	HT	30.0	28.5	27.5
		LT	26.0	25.5	25.5
	H5	HT	32.0	29.0	28.5
		LT	29.0	27.0	26.5
	M5	HT	28.0	27.5	27.0
		LT	27.0	27.5	26.5
Coastal	G10	*	31.0	28.5	27.0
	P10	*	29.0	27.5	26.5
	H10	*	31.0	29.0	28.5
	M10	*	27.5	26.5	26.0
Offshore	G15	*	29.0	28.0	27.5
	P15	*	32.0	27.0	26.0
	H15	*	27.0	29.0	28.5
	M15	*	29.0	26.5	25.5

Table. 3. Variation in pH at different locations off Mumbai during March 2019.

Area	Station	Tide	pH	
			S	B
Bay	G1	*	8.0	8.0
Nearshore	G5	HT	8.1	8.1
		LT	8.0	8.0
	P5	HT	8.1	8.2
		LT	8.0	8.0
	H5	HT	8.1	8.1
		LT	8.1	8.1
	M5	HT	8.1	8.3
		LT	8.0	8.1
Coastal	G10	*	8.1	8.2
	P10	*	8.1	8.2
	H10	*	8.1	8.1
	M10	*	8.1	8.1
Offshore	G15	*	8.1	8.1
	P15	*	8.1	8.1
	H15	*	8.1	8.3
	M15	*	8.1	8.3

Table. 4. Variation in salinity at different locations off Mumbai during March 2019.

Area	Station	Tide	Salinity (psu)	
			S	B
Bay	G1	*	36.3	36.2
Nearshore	G5	HT	36.3	36.4
		LT	36.3	36.3
	P5	HT	36.3	36.3
		LT	35.7	36.2
	H5	HT	36.1	36.4
		LT	36.0	36.5
	M5	HT	36.2	36.2
		LT	36.2	36.4
Coastal	G10	*	36.3	36.5
	P10	*	35.9	36.4
	H10	*	36.4	36.4
	M10	*	36.5	36.5
Offshore	G15	*	36.5	36.4
	P15	*	36.4	36.4
	H15	*	36.7	36.5
	M15	*	36.5	36.6

Table. 5. Variation in SS at different locations off Mumbai during March 2019.

Area	Station	Tide	SS (mg/l)	
			S	B
Bay	G1	*	16	32
Nearshore	G5	HT	18	38
		LT	29	63
	P5	HT	37	42
		LT	29	44
	H5	HT	41	46
		LT	30	74
	M5	HT	33	47
		LT	41	45
Coastal	G10	*	14	28
	P10	*	24	29
	H10	*	34	39
	M10	*	34	36
Offshore	G15	*	17	25
	P15	*	9	10
	H15	*	17	18
	M15	*	31	32

Table. 6. Variation in turbidity at different locations off Mumbai during March 2019.

Area	Station	Tide	Turbidity (NTU)	
			S	B
Bay	G1	*	11.9	13.3
Nearshore	G5	HT	8.1	17.8
		LT	10.1	16.3
	P5	HT	19.7	22.4
		LT	9.6	11.6
	H5	HT	3.6	4.6
		LT	3.2	4.9
	M5	HT	32.9	46.6
		LT	40.7	45.3
Coastal	G10	*	5.5	7.2
	P10	*	2.2	3.8
	H10	*	1.3	3.7
	M10	*	2.5	2.0
Offshore	G15	*	2.3	4.8
	P15	*	2.5	1.6
	H15	*	4.5	2.8
	M15	*	1.7	2.0

Table. 7. Variation in Chloride (Cl^-) at different locations off Mumbai during March 2019.

Area	Station	Tide	Chloride (mg/l)	
			S	B
Bay	G1	*	20100	20000
Nearshore	G5	HT	20100	20100
		LT	20100	20100
	P5	HT	20100	20100
		LT	19800	20000
	H5	HT	20000	20200
		LT	19900	20200
	M5	HT	20100	20100
		LT	20100	20100
Coastal	G10	*	20100	20200
	P10	*	19900	20200
	H10	*	20200	20100
	M10	*	20200	20200
Offshore	G15	*	20200	20100
	P15	*	19900	20200
	H15	*	20300	20200
	M15	*	20200	20200

Table. 8. Variation in DO and BOD at different locations off Mumbai during March 2019.

Area	Station	Tide	DO (mg/l)		BOD (mg/l)	
			S	B	S	B
Bay	G1	*	6.4	5.9	2.3	2.9
Nearshore	G5	HT	6.8	6.5	2.0	2.3
		LT	5.9	5.9	3.0	2.9
	P5	HT	6.2	6.0	3.0	2.6
		LT	5.9	5.4	4.5	2.7
	H5	HT	5.9	4.8	1.7	0.8
		LT	4.9	3.9	3.6	2.0
	M5	HT	7.7	6.8	4.6	3.0
		LT	7.5	7.1	4.1	4.1
Coastal	G10	*	7.1	6.9	3.2	3.2
	P10	*	6.8	6.2	3.9	2.8
	H10	*	6.6	6.2	1.2	2.9
	M10	*	6.2	6.1	2.3	1.3
Offshore	G15	*	7.2	6.7	3.0	2.1
	P15	*	7.0	6.4	3.1	2.0
	H15	*	7.7	6.2	1.9	1.6
	M15	*	7.7	7.5	4.5	4.3

Table. 9. Variation in PO_4^{3-}−P at different locations off Mumbai during March 2019.

Area	Station	Tide	PO_4^{3-}−P (µmol/l)	
			S	B
Bay	G1	*	1.6	1.9
Nearshore	G5	HT	1.9	2.3
		LT	0.4	1.2
	P5	HT	2.1	2.0
		LT	2.4	2.0
	H5	HT	1.6	1.5
		LT	2.4	1.1
	M5	HT	0.8	1.9
		LT	5.0	1.6
Coastal	G10	*	0.9	2.2
	P10	*	1.9	1.4
	H10	*	1.4	1.7
	M10	*	1.0	1.0
Offshore	G15	*	0.6	1.0
	P15	*	0.9	1.0
	H15	*	0.6	0.8
	M15	*	0.7	0.8

Table. 10. Variation in NO_3^-−N at different locations off Mumbai during March 2019.

Area	Station	Tide	NO_3^--N (µmol/l)	
			S	B
Bay	G1	*	10.5	11.3
Nearshore	G5	HT	8.3	7.5
		LT	10.5	11.2
	P5	HT	12.4	10.0
		LT	13.3	13.5
	H5	HT	13.8	8.5
		LT	17.1	11.8
	M5	HT	1.6	3.1
		LT	5.9	4.1
Coastal	G10	*	7.3	6.0
	P10	*	13.5	8.2
	H10	*	8.7	7.1
	M10	*	1.2	0.2
Offshore	G15	*	2.1	1.0
	P15	*	4.3	3.0
	H15	*	3.7	2.5
	M15	*	0.2	0.2

Table. 11. Variation in NO_2^-−N at different locations off Mumbai during March 2019.

Area	Station	Tide	NO_2^--N (µmol/l)	
			S	B
Bay	G1	*	2.4	2.4
Nearshore	G5	HT	1.8	1.5
		LT	2.8	2.2
	P5	HT	3.1	3.0
		LT	4.5	2.9
	H5	HT	4.6	3.5
		LT	5.5	3.7
	M5	HT	0.7	1.4
		LT	2.6	1.2
Coastal	G10	*	1.5	0.9
	P10	*	4.0	2.5
	H10	*	3.4	2.9
	M10	*	0.7	0.3
Offshore	G15	*	0.2	0.3
	P15	*	2.7	0.3
	H15	*	0.5	0.4
	M15	*	0.1	ND

Table. 12. Variation in NH_4^+-N at different locations off Mumbai during March 2019.

Area	Station	Tide	NH_4^+-N (µmol/l)	
			S	B
Bay	G1	*	0.5	0.7
Nearshore	G5	HT	0.7	0.8
		LT	2.1	1.2
	P5	HT	2.3	3.0
		LT	5.8	3.8
	H5	HT	1.4	1.7
		LT	1.2	1.0
	M5	HT	2.3	0.9
		LT	1.9	0.7
Coastal	G10	*	1.4	1.7
	P10	*	5.8	3.0
	H10	*	1.3	1.0
	M10	*	1.8	2.1
Offshore	G15	*	1.3	1.6
	P15	*	1.6	0.9
	H15	*	1.0	0.8
	M15	*	2.2	0.9

Table. 13. Variation in SO_4^{2-} and SO_4^{2-}: Cl ratio at different locations off Mumbai during March 2019.

Area	Station	Sulphate(g/kg)		SO_4^{2-}: Cl^-	
		S	B	S	B
Bay	G1	3.0	2.9	0.15	0.15
Nearshore	G5	3.0	2.9	0.15	0.14
	P5	2.8	3.0	0.14	0.15
	H5	3.0	2.8	0.15	0.14
	M5	2.9	2.8	0.15	0.14
Coastal	G10	2.8	2.8	0.14	0.14
	P10	2.8	2.8	0.14	0.14
	H10	3.1	2.9	0.15	0.14
	M10	2.9	2.9	0.14	0.14
Offshore	G15	2.9	3.0	0.14	0.15
	P15	2.9	2.9	0.15	0.14
	H15	3.0	3.1	0.15	0.15
	M15	2.9	2.9	0.14	0.14

Table. 14. Variation in PHc at different locations off Mumbai during March 2019.

Area	Station	PHc (µg/l)
		S (1m)
Bay	G1	3.7
Nearshore	G5	2.5
	P5	3.1
	H5	6.8
	M5	4.2
Coastal	G10	3.5
	P10	3.3
	H10	3.4
	M10	2.7
Offshore	G15	1.6
	P15	1.6
	H15	2.4
	M15	3.1

Table. 15. Sediment quality of subtidal and intertidal stations at Mumbai during March 2019.

Station Code	Sand (%)	Silt (%)	Clay (%)	Al (%)	Cr (µg/g)	Mn (µg/g)	Fe (%)	Co (µg/g)	Ni (µg/g)	Cu (µg/g)	Zn (µg/g)	Hg (µg/g)	C_{org} (%)	P (µg/g)	* PHc (µg/g)
Subtidal															
G1	7.5	82.1	10.4	6.7	93	1260	8.0	23	52	78	94	0.33	1.6	1171	0.1
G5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
P5	1.0	91.8	7.2	7.6	116	807	8.8	28	59	87	105	0.35	1.5	1274	1.5
H5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
M5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
G10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
P10	1.3	88.4	10.3	7.2	109	769	8.4	27	56	78	94	0.24	1.3	1059	1.9
H10	19.8	57.3	22.9	6.8	150	650	8.0	30	65	92	190	0.18	0.2	1866	1.5
M10	0.6	94.0	5.5	7.1	104	730	8.3	26	56	79	87	0.32	1.4	1109	2.5
G15	0.7	90.8	8.4	6.7	96	748	8.0	24	53	74	84	0.24	1.7	1107	0.1
P15	0.7	62.6	36.7	7.0	103	797	8.4	26	54	76	87	0.22	1.4	1155	0.6
H15	10.5	74.8	14.7	7.0	168	682	8..4	38	78	108	164	0.16	1.2	1848	0.1
M15	7.8	86.2	6.0	7.4	102	883	8.6	25	56	84	91	0.3	1.4	1095	2.1
Intertidal															
CR1	94.9	2.3	2.7	2.4	27	580	3.8	11	12	40	73	0.16	0.1	1452	0.1
CR2	87.9	5.7	6.3	4.6	79	885	7.0	21	36	72	109	0.29	0.5	1710	0.2
CR3	1.9	54.9	43.2	7.0	100	623	8.7	24	56	135	171	0.16	0.1	1857	3.0
CR4	97.2	2.6	0.2	6.2	136	660	8.6	27	71	230	356	4.23	4.6	1815	6.1
CR5	94.6	4.2	1.2	4.0	58	814	9.5	23	30	70	101	0.25	0.5	2065	0.3
CR6	18.5	42.0	39.5	6.4	101	1032	8.3	25	53	85	129	0.39	2.4	1568	4.0
CR7	95.8	1.8	2.4	5.6	148	1269	9.8	33	57	73	125	0.27	0.1	1475	8.9
CR8	69.8	16.5	13.7	5.6	132	1130	9.0	27	52	76	125	0.3	0.8	1403	0.1
CR9	92.7	1.6	5.7	0.8	15	581	1.9	5.1	8.3	255	40	0.15	0.4	785	0.1
CR10	92.8	1.6	5.8	0.8	16	542	1.9	5.0	9.3	14	31	0.15	0.1	976	0.1

Table. 16. Microbial counts in surface water (CFU/mL) at Mumbai during March 2019.

Type of Bacteria	G1	G5		G10	G15	P5		P10	P15	H5		H10	H15	M5		M10	M15
	Spot	Tidal		Spot	Spot	Tidal		Spot	Spot	Tidal		Spot	Spot	Tidal		Spot	Spot
		Ebb	Fld			Ebb	Fld			Ebb	Fld			Ebb	Fld		
TVC×10^3	10	60	20	120	30	270	110	30	650	620	190	960	550	20	30	80	130
TC	NG	NG	NG	NG	NG	100	NG	100	NG	80	NG	NG	NG	NG	NG	NG	NG
FC	NG	NG	NG	NG	NG	20	NG	20	NG	50	NG	NG	NG	NG	NG	NG	NG
ECLO	NG	NG	NG	NG	NG	10	NG	20	NG	10	NG	NG	NG	NG	NG	NG	NG
SFLO	NG	10	NG	NG	NG	20	NG	30	NG	50	NG	NG	NG	NG	NG	NG	NG

Table. 17. Microbial counts in Sediments (CFU/g) at Mumbai during March 2019.

Types of bacteria	G1	G5	G10	G15	P5	P10	P15	H5	H10	H15	M5	M10	M15
TVC×10^4	140	40	ROCKY BOTTOM	40	40	20	60	ROCKY BOTTOM	520	360	ROCKY BOTTOM	40	10
TC	NG	NG		NG	NG	NG	NG		NG	NG		NG	NG
FC	NG	NG		NG	NG	NG	NG		NG	NG		NG	NG
ECLO	NG	NG		NG	NG	NG	NG		NG	NG		NG	NG
SFLO	NG	NG		NG	NG	NG	NG		NG	NG		NG	NG

Table. 18. Microbial counts in Sediments (CFU/g) at Mumbai Intertidal stations during March 2019.

Types of bacteria	CR1	CR2	CR3	CR4	CR5	CR6	CR7	CR8	CR9	CR10
$TVC \times 10^4$	620	120	50	120	300	70	10	210	60	70
TC	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG
FC	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG
ECLO	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG
SFLO	NG	10	NG	NG	NG	NG	NG	NG	NG	NG

Table. 19. Distribution of Phytopigments at different stations of MCGM Mumbai during March 2019.

Station	Date	Time & Tide	Chlorophyll		Phaeophytin		Ratio	
			S	B	S	B	S	B
G1	25-03-2019	1600 Fld-Eb	6.15	4.19	0.79	0.65	7.78	6.45
		1615 Fld-Eb	5.17	5.42	0.70	0.85	7.39	6.38
G5	25-03-2019	945 F.Ebb	6.95	4.77	0.75	1.26	9.27	3.79
		1450 F.Fld	6.37	4.28	0.64	1.21	9.95	3.54
G10	25-03-2019	1330 Eb-Fld	5.40	2.88	0.59	1.43	9.15	2.01
		1345 Eb-Fld	5.54	3.12	0.59	1.12	9.39	2.79
G15	25-03-2019	1215 Eb-Fld	2.49	2.62	0.29	0.73	8.59	3.59
		1230 Eb-Fld	2.56	2.54	0.29	0.64	8.83	3.97
H5	27-03-2019	1000 F.Ebb	3.90	5.31	0.49	1.68	7.96	3.16
		1600 F.Fld	8.98	4.44	0.97	0.55	9.26	8.07
H10	27-03-2019	1140 Eb-Fld	4.47	7.69	0.58	0.79	7.71	9.73
		1155 Eb-Fld	4.33	7.54	0.56	0.76	7.73	9.92
H15	27-03-2019	1240 Eb-Fld	8.36	1.23	0.89	0.25	9.39	4.92
		1255 Eb-Fld	7.80	1.17	0.80	0.29	9.75	4.03
M5	28-03-2019	1105 F.Ebb	9.86	8.06	1.03	0.87	9.57	9.26
		1715 F.Fld	13.49	2.52	1.38	0.54	9.78	4.67
M10	28-03-2019	915 Fld-Eb	3.69	4.35	0.39	0.45	9.46	9.67
		930 Fld-Eb	3.46	3.80	0.35	0.44	9.89	8.64
M15	28-03-2019	830	3.15	3.39	0.43	0.43	7.33	7.98

		Fld-Eb						
		845 Fld-Eb	2.97	3.25	0.39	0.42	7.62	7.74
P5	26-03-2019	930 F.Ebb	1.54	2.79	1.19	0.72	1.29	3.88
		1500 F.Fld	3.39	3.54	0.58	0.95	5.84	3.73
P10	26-03-2019	1215 Eb-Fld	2.22	2.63	0.24	0.33	9.25	7.97
		1230 Eb-Fld	1.94	2.61	0.22	0.37	8.82	7.05
P15	26-03-2019	1100 Eb-Fld	2.58	1.64	0.27	0.40	9.56	4.10
		1115 Eb-Fld	2.61	1.53	0.27	0.37	9.67	4.14

Table. 20. Range and average of phytopigments at different stations of MCGM Mumbai during March 2019.

Station	Date	Chlorophyll				Phaeophytin				Ratio			
		S		B		S		B		S		B	
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
		Av.		Av.		Av.		Av.		Av.		Av.	
G1	25-03-2019	5.2	6.2	4.2	5.4	0.7	0.8	0.7	0.9	7.4	7.8	6.4	6.4
		5.7		**4.8**		**0.7**		**0.8**		**7.6**		**6.4**	
G5	25-03-2019	6.4	7.0	4.3	4.8	0.6	0.8	1.2	1.3	9.3	10.0	3.5	3.8
		6.7		**4.5**		**0.7**		**1.2**		**9.6**		**3.7**	
G10	25-03-2019	5.4	5.5	2.9	3.1	0.6	0.6	1.1	1.4	9.2	9.4	2.0	2.8
		5.5		**3.0**		**0.6**		**1.3**		**9.3**		**2.4**	
G15	25-03-2019	2.5	2.6	2.5	2.6	0.3	0.3	0.6	0.7	8.6	8.8	3.6	4.0
		2.5		**2.6**		**0.3**		**0.7**		**8.7**		**3.8**	
H5	27-03-2019	3.9	9.0	4.4	5.3	0.5	1.0	0.6	1.7	8.0	9.3	3.2	8.1
		6.4		**4.9**		**0.7**		**1.1**		**8.6**		**5.6**	
H10	27-03-2019	4.3	4.5	7.5	7.7	0.6	0.6	0.8	0.8	7.7	7.7	9.7	9.9
		4.4		**7.6**		**0.6**		**0.8**		**7.7**		**9.8**	
H15	27-03-2019	7.8	8.4	1.2	1.2	0.8	0.9	0.3	0.3	9.4	9.8	4.0	4.9
		8.1		**1.2**		**0.8**		**0.3**		**9.6**		**4.5**	
M5	28-03-2019	9.9	13.5	2.5	8.1	1.0	1.4	0.5	0.9	9.6	9.8	4.7	9.3
		11.7		**5.3**		**1.2**		**0.7**		**9.7**		**7.0**	
M10	28-03-2019	3.5	3.7	3.8	4.4	0.4	0.4	0.4	0.5	9.5	9.9	8.6	9.7
		3.6		**4.1**		**0.4**		**0.4**		**9.7**		**9.2**	
M15	28-03-2019	3.0	3.2	3.3	3.4	0.4	0.4	0.4	0.4	7.3	7.6	7.7	8.0
		3.1		**3.3**		**0.4**		**0.4**		**7.5**		**7.9**	
P5	26-03-2019	1.5	3.4	2.8	3.5	0.6	1.2	0.7	1.0	1.3	5.8	3.7	3.9
		2.5		**3.2**		**0.9**		**0.8**		**3.6**		**3.8**	

P10	**26-03-2019**	1.9	2.2	2.6	2.6	0.2	0.2	0.3	0.4	8.8	9.3	7.1	8.0
		2.1		**2.6**		**0.2**		**0.4**		**9.0**		**7.5**	
P15	**26-03-2019**	2.6	2.6	1.5	1.6	0.3	0.3	0.4	0.4	9.6	9.7	4.1	4.1
		2.6		**1.6**		**0.3**		**0.4**		**9.6**		**4.1**	

Table. 21. Distribution of phytoplankton population at different subtidal stations off Mumbai during March 2019.

Station	Date	Time & Tide	Cell count (no x 10^3 Cells/ l)		Total genera	
			S	B	S	B
G1	25-03-2019	1600 Fld-Eb	1260.4	1398.0	6	6
G5	25-03-2019	945 F.Ebb	1117.2	698.8	8	11
		1450 F.Fld	1352.2	530.6	10	11
G10	25-03-2019	1330 Eb-Fld	890.6	530.2	9	11
G15	25-03-2019	1215 Eb-Fld	86.2	124.6	10	10
H5	27-03-2019	1000 F.Ebb	571.8	1120.2	13	6
		1600 F.Fld	2269.6	921.4	20	14
H10	27-03-2019	1140 Eb-Fld	2394.4	3473.8	15	17
H15	27-03-2019	1240 Eb-Fld	3136.0	60.4	16	8
M5	28-03-2019	1105 F.Ebb	3975.4	4232.0	20	20
		1715 F.Fld	3446.2	1072.0	19	16
M10	28-03-2019	915 Fld-Eb	173.2	415.4	12	14
M15	28-03-2019	830 Fld-Eb	442.6	881.0	16	16
P5	26-03-2019	930 F.Ebb	582.4	872.6	9	11
		1500 F.Fld	612.4	297.6	9	8
P10	26-03-2019	1215 Eb-Fld	138.4	351.4	13	13
P15	26-03-2019	1100 Eb-Fld	942.0	280.4	11	13

Table. 22. Percentage composition of phytoplankton population at different stations of MCGM Mumbai during March 2019.

	Stations													
Genera name	**G1**	**G5**	**G10**	**G15**	**H5**	**H10**	**H15**	**M5**	**M10**	**M15**	**P5**	**P10**	**P15**	**Av.**
Achnanthes								<0.1						<0.1
Alexandrium					0.14	<0.1		<0.1			<0.1	<0.1		<0.1
Amphiprora		<0.1			<0.1	<0.1					<0.1			<0.1
Asterionella			<0.1				0.13	0.18		<0.1		0.41		<0.1
Asteromphalus						<0.1								
Bacteriastrum					1.15	0.20	0.25	1.63		<0.1			1.15	0.34
Ceratium		0.59			<0.1			<0.1						<0.1
Chaetoceros			2.39	22.77	<0.1	0.61	3.07	7.15	4.42	12.99	0.68	0.33	4.42	4.53
Corethron		<0.1				<0.1		<0.1						<0.1
Coscinodiscus	<0.1	<0.1	<0.1		<0.1						<0.1	0.45	0.16	<0.1
Cyclotella		0.16												<0.1
Cylindrotheca	0.30	0.32	0.28	<0.1	1.80	0.31	0.19	0.31	<0.1	0.15	1.61	1.63	1.64	0.67
Dactyliosolen			0.56	0.19	<0.1	0.11	2.94	4.40	13.25	16.92		<0.1	0.82	3.02
Dinophysis										0.15				<0.1
Diploneis	<0.1	0.22	0.14		<0.1	<0.1		<0.1	<0.1		<0.1	<0.1		<0.1
Distephanus		<0.1	0.28		<0.1				<0.1	0.30				<0.1
Ditylum	<0.1	0.27	0.28	2.85	0.29	0.17	0.13	0.11			0.45	0.82	0.82	0.48
Dictyocha													0.16	<0.1
Eucampia										0.30				<0.1
Eutreptiella										<0.1				<0.1
Gonyaulax					<0.1		<0.1							<0.1
Guinardia								0.38	2.04	1.96				0.34

Gymnodinium					<0.1		0.13							<0.1
Gyrodinium		<0.1			0.20	0.10	<0.1	0.13	0.68	<0.1	<0.1		0.16	0.11
Gyrosigma													0.16	<0.1
Hemiaulus								<0.1	0.10	0.15				<0.1
Lauderia								0.16		0.30				<0.1
Leptocylindrus					1.56	0.49	0.56	3.44	1.36	2.12	0.34			0.76
Lithodesmium		<0.1				<0.1		<0.1				0.41		<0.1
Navicula				<0.1		<0.1		<0.1	<0.1		<0.1	0.41		<0.1
Odontella		0.49	0.32	4.74	0.22	<0.1	0.26	0.23	1.02	0.91	<0.1	1.63	0.33	0.79
Pleurosigma	<0.1	0.39	0.14	2.94	<0.1	<0.1	0.63	<0.1	0.10	0.30	0.25	1.22	0.49	0.51
Podolampas										0.15			<0.1	<0.1
Prorocentrum					<0.1			<0.1			<0.1		0.16	<0.1
Protoperidinium					<0.1	<0.1		<0.1	<0.1		<0.1			<0.1
Pseudo-nitzschia	<0.1	0.11	0.28	5.69	0.34	0.34	2.13	6.59	0.68	2.27	0.52	2.04	2.78	1.83
Rhizosolenia		0.11	0.14		0.21	0.11	0.25	0.27	1.36	0.60	0.09	<0.1	<0.1	0.24
Skeletonema	12.71	15.57	15.20	14.14	41.53	38.00	18.58	43.36	72.04	59.23	44.31	19.60	35.83	33.09
Streptotheca								<0.1						<0.1
Surirella	<0.1							<0.1						<0.1
Synedra			<0.1	0.95									0.16	<0.1
Teleaulax					<0.1			<0.1						<0.1
Thalassionema		22.76	0.11	11.39				0.22			<0.1			2.65
Thalassiosira	86.67	58.61	79.81	32.26	52.30	59.23	70.64	30.88	2.04	0.76	51.25	70.40	50.72	49.66
Thalassiothrix		<0.1		1.90	<0.1			0.16	0.75	0.32		0.41		0.27
Trachyneis		<0.1												
Total	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Table. 23. Details of zooplankton parameters at different stations off Mumbai during March, 2019.

Station	Time(h)/Tide	Biomass (ml/100m³)	Population (nox10³/100m³)	Total Groups (no)	Major group (%)
M5 (1)	1105 (F-Ebb)	0.6	2.7	6	Copepods (93.9),
					Decapod larvae (3.0),
					Fish eggs (1.6),
					Appendicularians (0.8),
					Ostracods (0.3),
					Lucifer sp. (0.3),
					Others (0.1).
M5 (2)	1715 (F-Fld)	0.3	4.9	9	Copepods (71.1),
					Fish eggs (10.4),
					Decapod larvae (6.7),
					Gastropods (6.0),
					Medusae (3.7),
					Fish larvae (1.2),
					Chaetognaths (0.3),
					Appendicularians (0.3),
					Ostracods (0.1),
					Others (0.1).
H5 (1)	1000 (F.Ebb)	1.4	4.1	10	Fish eggs (51.0),
					Copepods (44.6),
					Decapod larvae (3.2),
					Medusae (0.3),
					Lamellibranchs (0.3),
					Gastropods (0.3),
					Fish larvae (0.2),
					Chaetognaths (0.1),
					Ostracods (0.1),
					Others (0.1).
H5 (2)	1600 (F.Fld)	0.5	1.1	7	Copepods (62.1),
					Appendicularians (20.7),
					Fish eggs (9.7),
					Lamellibranchs (4.7),
					Decapod larvae (2.1),
					Ostracods (0.3),
					Amphipods (0.3),

					Others (0.1).
P5 (1)	930 (Eb-Fl)	0.3	9.3	7	Fish eggs (50.5), Copepods (45.2), Decapod larvae (2.6), Polychaetes (0.5), Lamellibranchs (0.5), Gastropods (0.3), Chaetognaths (0.2), Others (0.1).
P5 (2)	1230 (Fl-Eb)	2.8	6.1	12	Copepods (88.4), Fish eggs (3.6), Decapod larvae (3.0), Medusae (2.1), Ctenophores (1.1), Lamellibranchs (0.9), Foraminiferans (0.6), Gastropods (0.2), Chaetognaths (0.1), Polychaetes (0.1), Amphipods (0.1), Others (0.1).
G1 (1)	1600 (F.Fld)	1	1.6	9	Copepods (48.0), Decapod larvae (37.8), Medusae (5.8), Fish eggs (3.5), Lamellibranchs (2.5), Fish larvae (1.6), Gastropods (0.3), Appendicularians (0.3), Chaetognaths (0.1), Others (0.1),
G1 (2)	1615 (F.Fld)	4.5	7.9	12	Copepods (43.2), Medusae (30.0), Decapod larvae (20.7), Gastropods (4.4), Fish larvae (0.6), Fish eggs (0.4), Lamellibranchs (0.2), Appendicularians (0.1),

					Ostracods (0.1), Amphipods (0.1) *Lucifer* sp. (0.1), Stomatopods (0.1), Others (0.1).
G5 (1)	945 (F.Ebb)	5.5	6.5	9	Copepods (79.8), Decapod larvae (8.9), Fish eggs (6.2), Medusae (4.5), Chaetognaths (0.2), Cladocerans (0.1), Fish larvae (0.1), Stomatopods (0.1), Marine insect (0.1), Others (0.1).
G5 (2)	1450 (F.Fld)	1.6	1.9	11	Copepods (84.2), Decapod larvae (4.9), Medusae (4.0), Fish eggs (3.0), Appendicularians (1.2), Lamellibranchs (1.1), Fish larvae (0.5), Polychaetes (0.4), Chaetognaths (0.4), Ostracods (0.2), *Lucifer* sp. (0.1), Others (0.1).
M10 (1)	830 (Fl -Eb)	7	3.6	8	Copepods (90.0), Fish eggs (5.3), Decapod larvae (4.5), Chaetognaths (0.1), Appendicularians (0.1), Others (0.1).
M10 (2)	930 (Fl-Eb)	0.5	2.5	4	Copepods (86.2), Decapod larvae (8.4), Fish eggs (5.2), Chaetognaths (0.1), Others (0.1).
H10 (1)	1140 (Eb-Fl)	0.8	1.9	5	Copepods (86.2), Fish eggs (10.6), Decapod larvae (2.7)

					Medusae (0.2),
					Fish larvae (0.1),
					Others (0.1).
H10 (2)	1155 (Eb-Fl)	2	3.1	9	Fish eggs (64.8),
					Copepods (33.6),
					Decapod larvae (0.5),
					Appendicularians (0.4),
					Medusae (0.2),
					Foraminiferans (0.1),
					Polychaetes (0.1),
					Fish larvae (0.1),
					Ostracods (0.1),
					Others (0.1).
P10 (1)	1215 (F-Fld)	0.5	8.7	5	Fish eggs (38.4),
					Foraminiferans (30.4),
					Copepods (30.4),
					Decapod larvae (0.4),
					Fish larvae (0.1),
					Others (0.1).
P10 (2)	1230 (F.Fld)	0.5	1.4	6	Fish eggs (54.8),
					Foraminiferans (27.4),
					Copepods (16.8),
					Decapod larvae (0.6),
					Fish larvae (0.2),
					Ostracods (0.1),
					Others (0.1).
G10 (1)	1300 (Eb-Fl)	1	4.8	5	Copepods (85.7),
					Decapod larvae (7.7),
					Fish eggs (6.4),
					Amphipods (0.1),
					Others (0.2).
G10 (2)	1345 (Eb-Fl)	0.5	5.2	7	Copepods (87.8),
					Fish eggs (7.2),
					Decapod larvae (4.0),
					Chaetognaths (0.3),
					Appendicularians (0.3),
					Amphipods (0.1),
					Fish larvae (0.1),
					Others (0.1).
M15 (1)	830 (Fl-Eb)	0.7	3.6	8	Copepods (82.9),
					Decapod larvae (9.5),

					Fish eggs (6.1), Polychaetes (0.5), Chaetognaths (0.3), Lamellibranchs (0.2), Appendicularians (0.1), Others (0.1).
M15 (2)	845 (Eb-Fl)	0.4	2.3	14	Copepods (75.8), Fish eggs (14.9), Decapod larvae (7.1), Lamellibranchs (0.4), Chaetognaths (0.3), Gastropods (0.3), Appendicularians (0.3), Foraminiferans (0.2), Polychaetes (0.2), *Lucifer* sp. (0.2), Fish larvae (0.1), Siphonophores (0.1), Ostracods (0.1), Amphipods (0.1), Others (0.1).
H15 (1)	1240 (Eb-Fl)	0.9	3.2	6	Copepods (82.3), Fish eggs (10.7), Decapod larvae (6.7), Fish larvae (0.1), Foraminiferans (0.1), Appendicularians (0.1), Others (0.1).
H15 (2)	1255 (Eb-Fl)	1.1	3.2	5	Copepods (81.8), Fish eggs (16.1), Decapod larvae (1.8), Appendicularians (0.2), Chaetognaths (0.1), Others (0.1).
P15 (1)	1100 (Eb-Fl)	0.8	3	3	Copepods (94.8), Fish eggs (4.4), Decapod larvae (0.7), Others (0.1).
P15 (2)	1115 (Eb-Fl)	0.1	3	6	Copepods (79.0), Fish eggs (20.2),

					Decapod larvae (0.5), Medusae (0.3), Appendicularians (0.1), Others (0.1).
G15 (1)	1200 (Eb-Fl)	2.6	3.7	7	Copepods (69.5), Decapod larvae (13.7), Fish eggs (13.7), Appendicularians (1.8), Lamellibranchs (0.7), Amphipods (0.4), Fish larvae (0.1), Others (0.1).
G15 (2)	1215 (Eb-Fl)	6.9	13.8	8	Copepods (45.8), Decapod larvae (49.0), Fish eggs (3.8), Appendicularians (1.0), Fish larvae (0.2), Siphonophores (0.1), Others (0.1).

Table. 24. Range and average (parenthesis) of zooplankton at different stations during March, 2019.

Station	Biomass (ml/100m^3)			Population (nox10^3/100m^3)			Total Groups (no)		
	Min	Max	Av.	Min	Max	Av.	Min	Max	Av.
G1	1	4.1	2.6	1.6	7.9	4.8	9	12	11
G5	1.6	5.5	3.6	1.9	6.5	4.2	9	11	10
G10	0.5	1	0.8	4.8	5.2	5.0	5	7	6
G15	2.6	6.9	4.8	3.7	13.8	8.8	7	8	8
M5	0.3	0.6	0.5	2.7	4.9	3.8	6	9	8
M10	0.5	0.6	0.6	2.5	3.7	3.1	4	5	5
M15	0.4	0.7	0.6	2.3	3.6	3.0	8	17	13
H5	0.5	1.4	1.0	1.1	4.1	2.6	7	10	9
H10	0.8	2	1.4	1.9	3.1	2.5	5	9	7
H15	0.9	1.1	1.0	3.2	3.2	3.2	5	6	6
P5	0.3	2.8	1.6	6.3	9.3	7.8	7	12	10
P10	0.5	0.5	0.5	1.4	8.7	5.1	5	6	6
P15	0.1	0.8	0.5	3	3	3.0	3	6	5
Overall	0.1	7.0	1.72	1.1	13.8	4.35	3	14	8

Table. 25. Percentage composition of zooplanktons during March, 2019.

Faunal Groups	G1	G5	G10	G15	M5	M10	M15	H5	H10	H15	P5	P10	P15	Av.
Foraminiferans	-	-	-	-	-	-	0.1	-	0.1	<0.1	0.5	28.6	-	0.7
Siphonophores	-	-	-	0.1	-	-	<0.1	-	-	-	-	-	-	<0.1
Medusae	25.8	4.4	-	-	2.4	-	-	0.3	0.2	-	1.8	-	<0.1	3.4
Ctenophores	-	-	-	-	-	-	-	-	-	-	0.9	-	-	0.1
Chaetognaths	<0.1	0.3	0.1	-	0.2	0.1	0.3	<0.1	-	<0.1	0.1	-	-	0.1
Polychaetes	-	0.1	-	-	-	-	0.4	-	<0.1	-	0.1	-	-	<0.1
Cladocerans	-	0.1	-	-	-	-	-	-	-	-	-	-	-	<0.1
Ostracods	0.1	<0.1	-	<0.1	0.2	-	<0.1	0.1	<0.1	-	-	0.1	-	<0.1
Copepods	44	80.9	86.8	50.3	79.2	88.5	80.2	48.3	53.7	82.1	82.7	22	87	68.1
Amphipods	0.1	-	0.1	0.1	-	-	<0.1	0.1	-	-	0.1	-	-	<0.1
Lucifer sp.	0.1	<0.1	-	-	0.1	-	0.1	-	-	-	0.1	-	-	<0.1
Decapod larvae	23.7	8.1	5.9	42.1	5.4	6.1	8.5	3	1.4	4.2	2.9	0.5	0.6	13.5
Stomatopods	0.1	<0.1	-	<0.1	-	-	-	-	-	-	-	-	-	<0.1
Gastropods	3.7	-	-	-	3.9	-	0.1	0.2	-	-	0.3	-	-	0.7
Lamellibranchs	0.6	0.3	-	0.2	-	-	0.3	1.2	-	-	0.8	-	-	0.3
Appendicularians	0.2	0.3	0.1	1.2	0.5	0.1	0.2	4.3	0.3	0.1	-	-	<0.1	0.6
Fish Eggs	1	5.4	6.8	5.9	7.3	5.3	9.6	42.4	44.2	13.4	9.7	48.6	12.3	12.1
Fish Larvae	0.7	0.2	0.1	0.2	0.8	-	<0.1	0.1	0.1	<0.1	-	0.2	-	0.2
Acetes sp.	-	-	-	-	-	-	-	-	-	-	-	-	<0.1	<0.1
Marine Insects	-	<0.1	-	-	-	-	-	-	-	-	-	-	-	<0.1

Table. 26. Presence and absence data of zooplanktons during March, 2019.

Faunal Groups	G1	G5	G10	G15	M5	M10	M15	H5	H10	H15	P5	P10	P15
Foraminiferans	-	-	-	-	-	-	+	-	+	+	+	+	-
Siphonophores	-	-	-	+	-	-	+	-	-	-	-	-	-
Medusae	+	+	-	-	-	-	-	+	+	-	+	-	+
Ctenophores	-	-	-	-	-	-	-	-	-	-	+	-	-
Chaetognaths	-	+	+	-	+	+	+	+	-	+	+	-	-
Polychaetes	-	+	-	-	-	-	+	-	+	-	+	-	-
Cladocerans	-	+	-	-	-	-	-	-	-	-	-	-	-
Ostracods	+	-	-	+	-	-	+	+	-	-	-	+	-
Copepods	+	+	+	+	+	+	+	+	+	+	+	+	+
Amphipods	+	-	+	+	-	-	+	+	-	-	+	-	-
Lucifer sp.	-	-	-	-	-	-	+	-	-	-	+	-	-
Decapod larvae	+	+	+	+	+	+	+	+	+	+	+	+	+
Stomatopods	+	+	-	+	-	-	-	-	-	-	-	-	-
Gastropods	+	-	-	-	-	-	+	+	-	-	+	-	-
Lamellibranchs	+	+	-	+	-	-	+	+	-	-	+	-	-
Appendicularians	+	+	+	+	+	+	+	+	+	+	-	-	+
Fish Eggs	-	+	+	+	+	+	+	+	+	+	+	+	+
Fish Larvae	+	+	+	+	-	-	+	+	+	+	-	+	-
Acetes sp.	-	-	-	-	-	-	-	-	-	-	-	-	+
Marine Insects	-	+	-	-	-	-	-	-	-	-	-	-	-

Table. 27. Range and average of subtidal meiobenthos at different stations of Mumbai during April 2019.

Stations	Biomass (µg/10 cm²)			Population (no./10 cm²)			Faunal groups (no.)		
	Min	Max	Av.	Min	Max	Av.	Min	Max	Av.
G1	221.51	575.16	428.52	170	361	274	3	5	4
G15	56.55	70.35	65.25	106	156	130	2	3	2
P5	14.51	34.82	26.11	35	85	64	1	1	1
P10	356.55	611.54	468.46	623	977	783	3	4	3
P15	384.64	517.48	431.82	573	715	628	3	3	3
H10	202.34	231.71	214.18	170	226	198	2	3	2
H15	480.96	1009.91	791.60	609	899	724	6	7	6
M10	23.21	34.82	28.05	57	92	71	1	2	1
M15	162.35	336.09	239.09	212	283	238	2	4	3
Overall	14.51	1009.91	299.23	35	977	346	1	7	3

Table. 28. Composition (%) of subtidal meiobenthos at different stations of Mumbai during April 2019.

Groups	G1	G15	P5	P10	P15	H10	H15	M10	M15	Av.
Nematoda	57.76	87.27	100	96.99	94.74	89.29	88.27	96.67	87.13	89.45
Foraminifera	12.07	0	0	0	2.63	9.52	5.54	0	0.99	3.57
Copepoda	25.86	10.91	0	0	0	0	1.3	0	0	3.03
Polychaeta	2.59	0	0	0.3	2.63	1.19	1.3	0	2.97	1.44
Nemertina	0	1.82	0	0	0	0	0.33	3.33	5.94	0.68
Ostracoda	0	0	0	0	0	0	1.63	0	2.97	0.61
Halacaroidea	1.72	0	0	0	0	0	1.3	0	0	0.46
Gastropoda	0	0	0	1.51	0	0	0	0	0	0.38
Amphipoda	0	0	0	1.2	0	0	0	0	0	0.3
Nauplius	0	0	0	0	0	0	0.33	0	0	0.08
Total	100	100	100	100	100	100	100	100	100	100

Table. 29. Range and average of intertidal meiobenthos at different stations of Mumbai during April 2019.

Stations	Biomass (µg/10 cm²)			Population (no./10 cm²)			Faunal groups (no.)		
	Min	Max	Av.	Min	Max	Av.	Min	Max	Av.
CR1LT	4330.22	4970.35	4729.82	1182	1387	1307	6	7	7
CR2LT	860.44	1253.93	1107.55	311	425	375	4	5	4
CR3LT	808.42	916.84	854.97	538	644	604	3	4	4
CR3HT	70.39	191.44	135.39	33	78	56	2	4	3
CR4HT	5.80	17.41	11.61	14	42	28	1	1	1
CR4LT	1102.19	1907.71	1505.21	2095	3001	2496	4	4	4
CR5LT	7408.56	9139.35	8554.64	1415	1769	1630	7	8	7
CR6LT	84.71	339.35	194.10	149	375	243	3	4	4
CR6HT	193.77	716.49	501.39	57	396	262	4	5	4
CR7LT	2629.58	3757.18	3200.00	510	736	632	7	8	7
CR8LT	1224.95	1311.73	1257.86	192	224	208	6	10	8
CR8HT	47.73	167.71	108.19	30	62	43	3	6	5
CR9LT	256.90	384.01	322.41	524	694	620	4	5	5
CR9HT	94.90	115.29	106.61	142	234	189	2	4	3
CR10LT	206.02	255.34	223.43	502	623	545	1	1	1
CR10MT	214.51	374.66	293.75	333	580	462	2	2	2
Overall	5.80	9139.35	1444.18	14	3001	606	1	10	4

Table. 30. Composition (%) of intertidal meiobenthos at different stations of Mumbai during April 2019.

Groups	CR1LT	CR2LT	CR3LT	CR3HT	CR4HT	CR4LT	CR5LT	CR6LT	CR6HT	CR7LT	CR8LT	CR8HT	CR9LT	CR9HT	CR10LT	CR10MT	Av.
Nematoda	6.5	5.03	47.66	31.09	100	79.59	24.6	72.82	61.26	40.67	13.41	61.96	93.16	88.75	100	75.51	52.71
Copepoda	35.21	45.91	34.38	23.53	0	9.45	16.64	13.59	6.31	3.73	36.59	0	2.66	7.5	0	24.49	17.04
Polychaeta	50.9	45.91	17.19	43.7	0	3.4	13.63	6.8	26.13	24.64	14.32	16.3	1.52	1.25	0	0	16.11
Amphipoda	4.69	0	0	0	0	0	23.15	0	2.7	20.15	20.23	1.09	0	0	0	0	6.35
Nemertina	1.26	1.26	0.78	0	0	7.56	0	5.83	3.6	2.24	0	0	0.76	0	0	0	2.65
Isopoda	0	0	0	0	0	0	10.85	0	0	0	0	0	0	0	0	0	1.82
Foraminifera	0	0	0	0	0	0	10.13	0	0	0	0	10.87	0	0	0	0	1.75
Ostracoda	0.9	1.89	0	0	0	0	0.14	0	0	4.1	10.91	2.17	0	0	0	0	0.73
Cumacea	0.54	0	0	0	0	0	0.43	0	0	4.1	0	0	0	0	0	0	0.41
Halacaroidea	0	0	0	1.68	0	0	0	0.97	0	0.37	0.91	0	1.9	2.5	0	0	0.25
Phoronida	0	0	0	0	0	0	0.43	0	0	0	0	0	0	0	0	0	0.07
Bivalvia	0	0	0	0	0	0	0	0	0	0	1.14	3.26	0	0	0	0	0.04
Nauplius	0	0	0	0	0	0	0	0	0	0	1.36	0	0	0	0	0	0.03
Turbellaria	0	0	0	0	0	0	0	0	0	0	0.68	3.26	0	0	0	0	0.03
Tanaidacea	0	0	0	0	0	0	0	0	0	0	0.45	0	0	0	0	0	0.01
Insecta	0	0	0	0	0	0	0	0	0	0	0	1.09	0	0	0	0	0.005
Total	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Table. 31. Range and average of macrobenthos at Mumbai subtidal region during March, 2019.

Stations	Biomass (g/m²)			Population (no./m²)			Faunal groups (no.)		
	Min.	Max.	Av.	Min.	Max.	Av.	Min.	Max.	Av.
M5	NCR								
H5	NCR								
P5	0.04	13.5	3.5	25	425	169	1	7	3
G1	0.2	2	1.1	325	1250	806	7	10	9
G5	NCR								
M10	0.4	3	1.9	225	850	513	4	12	9
H10	5.6	18.1	11.4	475	975	813	2	13	9
P10	0.5	10.9	3.2	150	675	413	4	13	9
G10	NCR								
M15	0.4	1.3	0.9	150	325	238	4	8	6
H15	0.9	18.9	7.3	225	650	431	7	13	10
P15	0.1	3	1.2	75	675	238	2	8	4
G15	1.5	2.8	2.1	400	775	600	8	12	10
Overall	0.04	18.9	3.6	25	1250	469	1	13	8

Table. 32. Composition (%) of subtidal macrobenthos at Mumbai subtidal region during March, 2019 (based on density).

Phylum	Faunal Groups	M5	H5	P5	G1	G5	M10	H10	P10	G10	M15	H15	P15	G15	Av.
Nemertea	Nemertea								4.5		2.6	1.4		1	0.9
Sipuncula	Sipuncula				2.3		7.3	1.5	1.5			2.9		3.2	2.6
Phoronida	Phoronida											2.9		3.2	0.8
Mollusca	Pelecypoda						6.3	3.1	1.5		2.6			1	1.7
Echiura	Echiurida							0.8							0.1
Annelida	Polychaeta	NCR	NCR	66.6	54.2	NCR	77.9	86.1	87.8	NCR	89.4	88.5	100	91.6	80.5
Arthropoda	Amphipoda				9.4		7.3	7.7	3.2			1.4			4.6
Arthropoda	Tanaidacea				34.1										6.5
Arthropoda	Copepoda						1.2				5.4				0.4
Echinodermata	Ophiuroidea			33.4				0.8	1.5						1.6
Chordata	Fish larvae											2.9			0.3
Total				100	100		100	100	100		100	100	100	100	100

Table. 33. Range and average of macrobenthos at Mumbai intertidal region during March, 2019.

Stations	Biomass (g/m^2)			Population ($no./m^2$)			Faunal groups (no.)		
	Min	Max	Av.	Min	Max	Av.	Min	Max	Av.
CR1LT	39.28	270.01	106.41	688	19616	9212	4	8	6
CR2LT	5.77	76.01	34.51	2000	5728	3368	5	9	7
CR3LT	0.96	19.88	9.83	112	1392	456	1	5	3
CR3HT	0.80	2.38	1.21	192	2832	992	3	5	4
CR4LT	10.34	61.58	31.03	2576	5856	3484	3	8	5
CR4HT	0.00	0.72	0.26	0	448	136	0	2	2
CR5LT	20.16	208.45	93.75	1632	25312	10100	7	11	9
CR5HT	0.00	8.82	2.57	0	304	132	0	4	2
CR6LT	0.87	6.97	3.88	32	1184	548	1	3	2
CR6HT	0.00	30.65	14.89	0	1152	624	0	4	3
CR7LT	0.00	9.44	2.64	0	10192	2672	0	2	1
CR7HT	0.00	1.29	0.32	0	688	172	0	4	1
CR8LT	0.17	98.33	58.13	96	9360	4592	3	11	8
CR8HT	0.51	19.42	8.85	192	2640	1540	2	6	4
CR9LT	1.26	14.89	6.68	160	624	392	1	4	3
CR9HT	0.00	0.26	0.12	0	32	20	0	2	1
CR10LT	0.68	1.17	0.98	16	96	48	1	3	2
CR10HT	0.00	2.67	0.72	0	160	56	0	3	1
Overall	0.00	270.01	20.93	0	25312	2141	0	11	4

Table. 34. Composition of macrobenthos at Mumbai intertidal region during March, 2019 (based on density).

Phylum	Faunal group	CR1LT	CR2LT	CR3LT	CR3HT
Annelida	Polychaeta	92.67	86.92	72.82	19.37
Arthropoda	Amphipoda	3.39	7.01	21.05	4.03
Annelida	Oligochaeta	0.13	0.36	1.75	72.98
Arthropoda	Isopoda	0.13	0.36		2.82
Mollusca	Gastropoda	1.17	0.83		
Nemertea	Nemertea	1.22	1.31		0.4
Arthropoda	Tanaidacea				
Mollusca	Bivalvia	0.3	0.71	2.63	
Platyhelminthes	Turbellaria	0.74			
Mollusca	Polyplacophora	0.17	0.59		
Echinodermata	Ophiuroidea		1.31		
Brachiopoda	Brachiopoda				
Arthropoda	Anomura	0.04	0.36		
Nematoda	Nematoda			1.75	0.4
Arthropoda	Penaeid shrimp				
Cnidaria	Anthozoa				
Arthropoda	Caridean shrimp		0.12		
Sipuncula	Sipuncula				
Arthropoda	Brachyura				
Arthropoda	Copepoda				
Arthropoda	Cumacea				
Arthropoda	Insecta				
Arthropoda	Ostracoda				
Arthropoda	Decapoda Larvae	0.04			
Chordata	Fish larvae		0.12		
Arthropoda	Pycnogonida				
Total		100	100	100	100

Table. 34 **(Contd…)**

Phylum	Faunal group	CR4LT	CR4HT	CR5LT	CR5HT
Annelida	Polychaeta	68.79	11.76	8.55	48.49
Arthropoda	Amphipoda	24.91		86.77	39.39
Annelida	Oligochaeta	3.9	88.24	0.32	
Arthropoda	Isopoda			1.19	9.09
Mollusca	Gastropoda	1.15		0.59	
Nemertea	Nemertea	0.23		0.24	
Arthropoda	Tanaidacea	0.11		0.55	
Mollusca	Bivalvia	0.46		0.32	
Platyhelminthes	Turbellaria				
Mollusca	Polyplacophora			0.55	
Echinodermata	Ophiuroidea			0.04	3.03
Brachiopoda	Brachiopoda			0.48	
Arthropoda	Anomura	0.11		0.04	
Nematoda	Nematoda			0.08	
Arthropoda	Penaeid shrimp				
Cnidaria	Anthozoa			0.08	
Arthropoda	Caridean shrimp			0.12	
Sipuncula	Sipuncula				
Arthropoda	Brachyura	0.23			
Arthropoda	Copepoda	0.11		0.04	
Arthropoda	Cumacea				
Arthropoda	Insecta				
Arthropoda	Ostracoda			0.04	
Arthropoda	Decapoda Larvae				
Chordata	Fish larvae				
Arthropoda	Pycnogonida				
Total		100	100	100	100

Table. 34 **(Contd…)**

Phylum	Faunal group	CR6LT	CR6HT	CR7LT	CR7HT
Annelida	Polychaeta	83.21	0.64	4.34	55.81
Arthropoda	Amphipoda	3.65	32.69	95.06	39.53
Annelida	Oligochaeta	10.95	10.9		
Arthropoda	Isopoda		51.28	0.15	
Mollusca	Gastropoda	1.46	3.21		
Nemertea	Nemertea				2.33
Arthropoda	Tanaidacea		0.64	0.15	
Mollusca	Bivalvia				
Platyhelminthes	Turbellaria	0.73			
Mollusca	Polyplacophora				
Echinodermata	Ophiuroidea			0.3	
Brachiopoda	Brachiopoda				
Arthropoda	Anomura				
Nematoda	Nematoda				
Arthropoda	Penaeid shrimp				
Cnidaria	Anthozoa				
Arthropoda	Caridean shrimp				
Sipuncula	Sipuncula				2.33
Arthropoda	Brachyura				
Arthropoda	Copepoda		0.64		
Arthropoda	Cumacea				
Arthropoda	Insecta				
Arthropoda	Ostracoda				
Arthropoda	Decapoda Larvae				
Chordata	Fish larvae				
Arthropoda	Pycnogonida				
Total		100	100	100	100

Table. 34 **(Contd…)**

Phylum	Faunal group	CR8LT	CR8HT	CR9LT	CR9HT
Annelida	Polychaeta	58.1	61.29	77.55	20
Arthropoda	Amphipoda	30.05	4.68	14.29	
Annelida	Oligochaeta		31.95		
Arthropoda	Isopoda	1.83	0.52		40
Mollusca	Gastropoda	2.79	0.52	6.12	
Nemertea	Nemertea	0.96		1.02	
Arthropoda	Tanaidacea	3.05	0.78		
Mollusca	Bivalvia	0.52			
Platyhelminthes	Turbellaria	1.22			
Mollusca	Polyplacophora				
Echinodermata	Ophiuroidea	0.26			
Brachiopoda	Brachiopoda				
Arthropoda	Anomura	0.09			
Nematoda	Nematoda	0.17			
Arthropoda	Penaeid shrimp		0.26	1.02	
Cnidaria	Anthozoa	0.17			
Arthropoda	Caridean shrimp				
Sipuncula	Sipuncula	0.26			
Arthropoda	Brachyura	0.09			
Arthropoda	Copepoda				
Arthropoda	Cumacea	0.26			
Arthropoda	Insecta				40
Arthropoda	Ostracoda	0.09			
Arthropoda	Decapoda Larvae				
Chordata	Fish larvae				
Arthropoda	Pycnogonida	0.09			
Total		100	100	100	100

Table. 34 **(Contd…)**

Phylum	Faunal group	CR10LT	CR10HT	Av.
Annelida	Polychaeta	41.66	14.29	51.78
Arthropoda	Amphipoda		7.14	38.17
Annelida	Oligochaeta		7.14	4.33
Arthropoda	Isopoda		71.43	1.68
Mollusca	Gastropoda			1.1
Nemertea	Nemertea			0.63
Arthropoda	Tanaidacea			0.57
Mollusca	Bivalvia			0.35
Platyhelminthes	Turbellaria	16.67		0.35
Mollusca	Polyplacophora			0.24
Echinodermata	Ophiuroidea			0.19
Brachiopoda	Brachiopoda			0.12
Arthropoda	Anomura			0.07
Nematoda	Nematoda			0.07
Arthropoda	Penaeid shrimp	41.67		0.07
Cnidaria	Anthozoa			0.04
Arthropoda	Caridean shrimp			0.04
Sipuncula	Sipuncula			0.04
Arthropoda	Brachyura			0.03
Arthropoda	Copepoda			0.03
Arthropoda	Cumacea			0.03
Arthropoda	Insecta			0.02
Arthropoda	Ostracoda			0.02
Arthropoda	Decapoda Larvae			0.01
Chordata	Fish larvae			0.01
Arthropoda	Pycnogonida			0.01
Total		100	100	100

Table. 35. Percentage distribution of seaweed in study area during March 2019.

Phylum	CR1	CR2	CR3	CR4	CR5	CR6	CR7	CR8	CR9	CR10
Chlorophyta	35	50	0	0	75	0	0	69	0	0
Pheophyta	32	50	0	0	20	0	0	0	0	0
Rhodophyta	33	0	0	0	5	0	0	31	0	0

Table. 36. Presence and absence data of seaweed of Mumbai during March, 2019.

Phylum	Species	CR1	CR2	CR3	CR4	CR5	CR6	CR7	CR8	CR9	CR10
Chlorophyta	*Valonia* sp	+	+	-	-	-	-	-	+	-	-
Chlorophyta	*Enteromorpha prolifera*	-	-	-	-	+	-	-	-	-	-
Chlorophyta	*Caulerpa* sp	-	-	-	-	+	-	-	-	-	-
Pheophyta	*Sargasum* sp.	-	-	-	-	+	-	-	-	-	-
Pheophyta	Unidentified	+	+	-	-	-	-	-	-	-	-
Rhodophyta	*Predae felmannii*	-	-	-	-	+	-	-	-	-	-
Rhodophyta	*Gellidium* sp	+	-	-	-	+	-	-	-	-	-
Rhodophyta	*Spyridae* sp.	-	-	-	-	+	-	-	-	-	-
Rhodophyta	*Champia* sp.	-	-	-	-	-	-	-	+	-	-

Table. 37. List of benthic macro and megafauna in the study area during March 2019.

Taxa no.	Kingdom	Phylum	Class	Order	Family	Genus	Species	Authority
1	Animalia	Porifera	Demospongiae	Clionaida	Spirastrellidae	*Spirastrella*	*sp.*	Schmidt, 1868
2	Animalia	Porifera	Demospongiae	Haplosclerida	Niphatidae	*Amphimedon*	*sp.*	Duchassaing & Michelotti, 1864
3	Animalia	Porifera	Demospongiae	Haplosclerida	Callyspongiidae	*Callyspongia*	*sp.*	Duchassaing & Michelotti, 1864
4	Animalia	Porifera	Demospongiae	Haplosclerida	Chalinidae	*Haliclona*	*sp.*	Grant, 1841
5	Animalia	Porifera	Demospongiae	Haplosclerida	Chalinidae	*Haliclona*	*sp.*	Gray, 1867
6	Animalia	Porifera	Demospongiae	Suberitida	Halichondriidae	*Halichondria*	*sp.*	Fleming, 1828
7	Animalia	Porifera	Demospongiae	Suberitida	Suberitidae	*Suberites*	*sp.*	Nardo, 1833
8	Animalia	Porifera	Demospongiae	Tetractinellida	Tetillidae	*Tetilla*	*sp.*	Schmidt, 1868
9	Animalia	Cnidaria	Anthozoa	Actiniaria	Actiniidae	*Anthopleura*	*handi*	Dunn, 1978
10	Animalia	Cnidaria	Anthozoa	Scleractinia	Caryophylliidae	*Polycyathus*	*sp.*	Duncan, 1876
11	Animalia	Cnidaria	Anthozoa	Scleractinia	Rhizangiidae	*Astrangia*	*sp.*	Milne Edwards & Haime, 1848
12	Animalia	Cnidaria	Anthozoa	Scleractinia	Rhizangiidae	*Oulangia*	*sp.*	Milne Edwards & Haime, 1849
13	Animalia	Cnidaria	Anthozoa	Scleractinia	Poritidae	*Goniopora*	*sp.*	de Blainville, 1830
14	Animalia	Cnidaria	Anthozoa	Scleractinia	Siderastreidae	*Pseudosiderastrea*	*tayamai*	Yabe & Sugiyama, 1935
15	Animalia	Cnidaria	Anthozoa	Zoantharia	Zoanthidae	*Zoanthus*	*sansibaricus*	Carlgren, 1900
16	Animalia	Cnidaria	Anthozoa	Zoantharia	Sphenopidae	*Palythoa*	*mutuki*	Haddon & Shackleton, 1891
17	Animalia	Cnidaria	Anthozoa	0	0	*0*	*spp.*	Ehrenberg, 1834
18	Animalia	Cnidaria	Hydrozoa	Leptothecata	Sertulariidae	*Dynamena*	*crisioides*	Lamouroux, 1824
19	Animalia	Cnidaria	Hydrozoa	Leptothecata	Haleciidae	*Nemalecium*	*lighti*	Hargitt, 1924
20	Animalia	Chordata	Ascidiacea	Stolidobranchia	Styelidae	*Botrylloides*	*sp.*	Milne Edwards, 1841

21	Animalia	Chordata	Ascidiacea	Stolidobranchia	Styelidae	*Botryllus*	*sp.*	Gaertner, 1774
22	Animalia	Mollusca	Cephalopoda	Octopoda	Octopodidae	*Octopus*	*sp.*	Cuvier, 1797
23	Animalia	Mollusca	Gastropoda	[unassigned] Caenogastropoda	Planaxidae	*Planaxis*	*sulcatus*	Born, 1778
24	Animalia	Mollusca	Gastropoda	Caenogastropoda	Planaxidae	*Planaxis*	*acutus*	Krauss, 1848
25	Animalia	Mollusca	Gastropoda	Caenogastropoda	Cerithiidae	*Clypeomorus*	*batillariaeformis*	Habe & Kosuge, 1966
26	Animalia	Mollusca	Gastropoda	Caenogastropoda	Cerithiidae	*Cerithium*	*sp.*	Bruguière, 1789
27	Animalia	Mollusca	Gastropoda	Caenogastropoda	Potamididae	*Pirenella*	*cingulata*	Gmelin, 1791
28	Animalia	Mollusca	Gastropoda	Caenogastropoda	Thiaridae	*Melanoides*	*tuberculata*	O. F. Müller, 1774
29	Animalia	Mollusca	Gastropoda	Cycloneritida	Neritidae	*Nerita*	*albicilla*	Linnaeus, 1758
30	Animalia	Mollusca	Gastropoda	Cycloneritida	Neritidae	*Nerita*	*oryzarum*	Récluz, 1841
31	Animalia	Mollusca	Gastropoda	Cycloneritida	Neritidae	*Nerita*	*chamaeleon*	Linnaeus, 1758
32	Animalia	Mollusca	Gastropoda	Cycloneritida	Neritidae	*Nerita*	*polita*	Linnaeus, 1758
33	Animalia	Mollusca	Gastropoda	Littorinimorpha	Bursidae	*Bursa*	*granularis*	Röding, 1798
34	Animalia	Mollusca	Gastropoda	Littorinimorpha	Cypraeidae	*Mauritia*	*arabica*	Linnaeus, 1758
35	Animalia	Mollusca	Gastropoda	Littorinimorpha	Littorinidae	*Littorina*	*intermedia*	Philippi, 1846
36	Animalia	Mollusca	Gastropoda	Littorinimorpha	Littorinidae	*Litorina*	*ventricosa*	Gould, 1859
37	Animalia	Mollusca	Gastropoda	Littorinimorpha	Littorinidae	*Littorina*	*scabra*	Linnaeus, 1758
38	Animalia	Mollusca	Gastropoda	Littorinimorpha	Naticidae	*Natica*	*zonalis*	Récluz, 1850
39	Animalia	Mollusca	Gastropoda	Neogastropoda	Babyloniidae	*Babylonia*	*spirata*	Linnaeus, 1758
40	Animalia	Mollusca	Gastropoda	Neogastropoda	Columbellidae	*Zafra*	*atrata*	Gould, 1860
41	Animalia	Mollusca	Gastropoda	Neogastropoda	Conidae	*Conus*	*biliosus*	Röding, 1798
42	Animalia	Mollusca	Gastropoda	Neogastropoda	Conidae	*Conus*	*figulinus*	Linnaeus, 1758
43	Animalia	Mollusca	Gastropoda	Neogastropoda	Conidae	*Conus*	*piperatus*	Reeve, 1843
44	Animalia	Mollusca	Gastropoda	Neogastropoda	Fasciolariidae	*Peristernia*	*violacea*	Reeve, 1847
45	Animalia	Mollusca	Gastropoda	Neogastropoda	Melongenidae	*Volegalea*	*cochlidium*	Linnaeus, 1758
46	Animalia	Mollusca	Gastropoda	Neogastropoda	Melongenidae	*Hemifusus*	*pugilinus*	Linnaeus, 1758
47	Animalia	Mollusca	Gastropoda	Neogastropoda	Muricidae	*Thais*	*bufo*	Lamarck, 1822

48	Animalia	Mollusca	Gastropoda	Neogastropoda	Muricidae	*Drupa*	*tuberculata*	Duclos, 1832
49	Animalia	Mollusca	Gastropoda	Neogastropoda	Muricidae	*Coralliophila*	*clathrata*	A. Adams, 1854
50	Animalia	Mollusca	Gastropoda	Neogastropoda	Muricidae	*Morula*	*uva*	Röding, 1798
51	Animalia	Mollusca	Gastropoda	Neogastropoda	Muricidae	*Semiricinula*	*tissoti*	Petit de la Saussaye, 1852
52	Animalia	Mollusca	Gastropoda	Neogastropoda	Pisaniidae	*Engina*	*zea*	Melvill, 1893
53	Animalia	Mollusca	Gastropoda	Nudibranchia	Facelinidae	*Cratena*	*peregrina*	Gmelin, 1791
54	Animalia	Mollusca	Gastropoda	Nudibranchia	Plakobranchidae	*Elysia*	*hirasei*	Baba, 1955
55	Animalia	Mollusca	Gastropoda	Nudibranchia	Goniodorididae	*Okenia*	*sp.*	Menke, 1830
56	Animalia	Mollusca	Gastropoda	Nudibranchia	Actinocyclidae	*Hallaxa*	*sp.*	Eliot, 1909
57	Animalia	Mollusca	Gastropoda	Pleurobranchida	Pleurobranchidae	*Berthella*	*sp.*	Blainville, 1824
58	Animalia	Mollusca	Gastropoda	Seguenziida	Chilodontaidae	*Euchelus*	*asper*	Gmelin, 1791
59	Animalia	Mollusca	Gastropoda	Stylommatophora	Partulidae	*Partula*	*hyalina*	Broderip, 1832
60	Animalia	Mollusca	Gastropoda	Trochida	Trochidae	*Trochus*	*radiatus*	Gmelin, 1791
61	Animalia	Mollusca	Gastropoda	Trochida	Trochidae	*Trochus*	*stellatus*	Gmelin, 1791
62	Animalia	Mollusca	Gastropoda	Trochida	Turbinidae	*Turbo*	*brunneus*	Röding, 1798
63	Animalia	Mollusca	Gastropoda	0	0	*0*	*spp.*	Cuvier, 1795
64	Animalia	Mollusca	Bivalvia	Carditida	Carditidae	*Cardita*	*antiquata*	Linnaeus, 1758
65	Animalia	Mollusca	Bivalvia	Mytilida	Mytilidae	*Perna*	*viridis*	Linnaeus, 1758
66	Animalia	Mollusca	Bivalvia	Mytilida	Mytilidae	*Brachidontes*	*striatulus*	Hanley, 1843
67	Animalia	Mollusca	Bivalvia	Ostreida	Ostreidae	*Saccostrea*	*cucullata*	Born, 1778
68	Animalia	Mollusca	Bivalvia	Venerida	Veneridae	*Gafrarium*	*divaricatum*	Gmelin, 1791
69	Animalia	Mollusca	Bivalvia	Venerida	Veneridae	*Meretrix*	*meretrix*	Linnaeus, 1758
70	Animalia	Mollusca	Bivalvia	0	0	*0*	*spp.*	Linnaeus, 1758
71	Animalia	Mollusca	Polyplacophora	Chitonida	Chitonidae	*Chiton*	*granoradiatus*	Leloup, 1937

72	Animalia	Mollusca	Polyplacophora	0	0	*0*	*spp.*	Gray, 1821
73	Animalia	Arthropoda	Hexanauplia	0	0	*0*	*spp.*	Milne Edwards, 1840
74	Animalia	Arthropoda	Hexanauplia	Sessilia	Tetraclitidae	*Tetraclitella*	*karandei*	Ross, 1971
75	Animalia	Arthropoda	Hexanauplia	Sessilia	Balanidae	*Fistulobalanus*	*pallidus*	Darwin, 1854
76	Animalia	Arthropoda	Hexanauplia	Sessilia	Balanidae	*Balanus*	*amphitrite*	Darwin, 1854
77	Animalia	Arthropoda	Malacostraca	Amphipoda	0	*0*	*spp.*	Latreille, 1816
78	Animalia	Arthropoda	Malacostraca	Decapoda	Menippidae	*Menippe*	*rumphii*	Fabricius, 1798
79	Animalia	Arthropoda	Malacostraca	Decapoda	Grapsidae	*Pachygrapsus*	*crassipes*	Randall, 1840
80	Animalia	Arthropoda	Malacostraca	Decapoda	Oregoniidae	*0*	*sp.*	Garth, 1958
81	Animalia	Arthropoda	Malacostraca	Decapoda	Pinnotheridae	*0*	*sp.*	De Haan, 1833
82	Animalia	Arthropoda	Malacostraca	Decapoda	Portunidae	*Portunus*	*sp.*	Weber, 1795
83	Animalia	Arthropoda	Malacostraca	Decapoda	Sesarmidae	*Aratus*	*sp.*	H. Milne Edwards, 1853
84	Animalia	Arthropoda	Malacostraca	Decapoda	Portunidae	*Thalamita*	*sp.*	Latreille, 1829
85	Animalia	Arthropoda	Malacostraca	Decapoda	Epialtidae	*0*	*sp.*	MacLeay, 1838
86	Animalia	Arthropoda	Malacostraca	Decapoda	Xanthidae	*Atergatis*	*sp.*	Lamarck, 1818
87	Animalia	Arthropoda	Malacostraca	Decapoda	Porcellanidae	*Petrolisthes*	*boscii*	Audouin, 1826
88	Animalia	Arthropoda	Malacostraca	Decapoda	Alpheidae	*Synalpheus*	*tumidomanus*	Paulson, 1875
89	Animalia	Arthropoda	Malacostraca	Decapoda	Alpheidae	*Alpheus*	*lottini*	Guérin-Méneville, 1838
90	Animalia	Arthropoda	Malacostraca	Decapoda	Alpheidae	*Alpheus*	*sp.*	Fabricius, 1798
91	Animalia	Arthropoda	Malacostraca	Decapoda	Alpheidae	*Alpheus*	*heterochaelis*	Say, 1818
92	Animalia	Arthropoda	Malacostraca	Decapoda	Portunidae	*Charybdis*	*japonica*	A. Milne-Edwards, 1861
93	Animalia	Arthropoda	Malacostraca	Decapoda	Paguridae	*Eupagurus*	*sp.*	Fabricius, 1775
94	Animalia	Arthropoda	Malacostraca	Decapoda	Eriphiidae	*Eriphia*	*sp.*	Latreille, 1817
95	Animalia	Arthropoda	Malacostraca	Decapoda	0	*0*	*spp.*	MacLeay, 1838
96	Animalia	Arthropoda	Malacostraca	Decapoda	0	*0*	*spp.*	Latreille, 1802
97	Animalia	Arthropoda	Malacostraca	Decapoda	0	*0*	*spp.*	Dana, 1852
98	Animalia	Arthropoda	Malacostraca	Cumacea	0	*0*	*spp.*	Krøyer, 1846

99	Animalia	Arthropoda	Malacostraca	Decapoda	0	*0*	*spp.*	Latreille, 1802
100	Animalia	Arthropoda	Malacostraca	Decapoda	Penaeidae	*0*	*spp.*	Rafinesque, 1815
101	Animalia	Arthropoda	Malacostraca	Isopoda	0	*0*	*spp.*	Latreille, 1817
102	Animalia	Arthropoda	Malacostraca	Tanaidacea	0	*0*	*spp.*	Dana, 1849
103	Animalia	Arthropoda	Insecta	0	0	*0*	*spp.*	0
104	Animalia	Arthropoda	Ostracoda	0	0	*0*	*spp.*	Latreille, 1802
105	Animalia	Arthropoda	Pycnogonida	0	0	*0*	*sp.*	Latreille, 1810
106	Animalia	Echinodermata	Ophiuroidea	Ophiurida	0	*0*	*sp.*	Müller & Troschel, 1840 sensu O'Hara et al., 2017
107	Animalia	Echinodermata	Ophiuroidea	Amphilepidida	Ophiactidae	*Ophiactis*	*sp.*	Lütken, 1856
108	Animalia	Echinodermata	Ophiuroidea	0	0	*0*	*Unidentified*	Gray, 1840
109	Animalia	Annelida	Polychaeta	0	Capitellidae	*Capitella*	*sp.*	Blainville, 1828
110	Animalia	Annelida	Polychaeta	0	Capitellidae	*Scyphoproctus*	*sp.*	Gravier, 1904
111	Animalia	Annelida	Polychaeta	0	Capitellidae	*Mediomastus*	*sp.*	Hartman, 1944
112	Animalia	Annelida	Polychaeta	0	Capitellidae	*Heteromastus*	*sp.*	Eisig, 1887
113	Animalia	Annelida	Polychaeta	0	Capitellidae	*Notomastus*	*sp.*	M. Sars, 1851
114	Animalia	Annelida	Polychaeta	0	Magelonidae	*Magelona*	*sp.*	F. Müller, 1858
115	Animalia	Annelida	Polychaeta	0	Maldanidae	*Gravierella*	*sp.*	Fauvel, 1919
116	Animalia	Annelida	Polychaeta	0	Orbiniidae	*Scoloplos*	*sp.*	Blainville, 1828
117	Animalia	Annelida	Polychaeta	0	Sabellariidae	*Sabellaria*	*sp.*	Lamarck, 1818
118	Animalia	Annelida	Polychaeta	0	Saccocirridae	*Pharyngocirrus*	*sp.*	Di Domenico, Martínez, Lana & Worsaae, 2014
119	Animalia	Annelida	Polychaeta	Amphinomida	Amphinomidae	*Eurythoe*	*sp.*	Kinberg, 1857
120	Animalia	Annelida	Polychaeta	Eunicida	Dorvilleidae	*Schistomeringos*	*sp.*	Jumars, 1974
121	Animalia	Annelida	Polychaeta	Eunicida	Eunicidae	*Eunice*	*sp.*	Cuvier, 1817
122	Animalia	Annelida	Polychaeta	Eunicida	Eunicidae	*Marphysa*	*sp.*	Quatrefages, 1866

123	Animalia	Annelida	Polychaeta	Eunicida	Eunicidae	*Lysidice*	*sp.*	Lamarck, 1818
124	Animalia	Annelida	Polychaeta	Eunicida	Eunicidae	*Nematonereis*	*sp.*	Lamarck, 1818
125	Animalia	Annelida	Polychaeta	Eunicida	Lumbrinerida e	*Lumbrineris*	*sp.*	Blainville, 1828
126	Animalia	Annelida	Polychaeta	Eunicida	Onuphidae	*Diopatra*	*sp.*	Audouin & Milne Edwards, 1833
127	Animalia	Annelida	Polychaeta	Phyllodocida	Glyceridae	*Glycera*	*sp.*	Lamarck, 1818
128	Animalia	Annelida	Polychaeta	Phyllodocida	Hesionidae	*Ophiodromus*	*sp.*	Grube, 1855
129	Animalia	Annelida	Polychaeta	Phyllodocida	Hesionidae	*Hesione*	*sp.*	Lamarck, 1818
130	Animalia	Annelida	Polychaeta	Phyllodocida	Nephtyidae	*Aglaophamus*	*sp.*	Kinberg, 1865
131	Animalia	Annelida	Polychaeta	Phyllodocida	Nereidae	*0*	*sp.*	Blainville, 1818
132	Animalia	Annelida	Polychaeta	Phyllodocida	Nereidae	*0*	*sp.*	Blainville, 1818
133	Animalia	Annelida	Polychaeta	Phyllodocida	Nereidae	*0*	*sp.*	Blainville, 1818
134	Animalia	Annelida	Polychaeta	Phyllodocida	Nereididae	*Dendronereis*	*sp.*	Peters, 1854
135	Animalia	Annelida	Polychaeta	Phyllodocida	Phyllodocidae	*Phyllodoce*	*sp.*	Lamarck, 1818
136	Animalia	Annelida	Polychaeta	Phyllodocida	Pilargidae	*Sigambra*	*sp.*	Müller, 1858
137	Animalia	Annelida	Polychaeta	Phyllodocida	Polynoidae	*0*	*sp.*	Kinberg, 1856
138	Animalia	Annelida	Polychaeta	Phyllodocida	Sigalionidae	*Sthenelais*	*sp.*	Kinberg, 1856
139	Animalia	Annelida	Polychaeta	Phyllodocida	Syllidae	*Syllis*	*sp.*	Lamarck, 1818
140	Animalia	Annelida	Polychaeta	Phyllodocida	Syllidae	*Exogone*	*sp.*	Örsted, 1845
141	Animalia	Annelida	Polychaeta	Phyllodocida	Syllidae	*Pionosyllis*	*sp.*	Malmgren, 1867
142	Animalia	Annelida	Polychaeta	Sabellida	Sabellidae	*0*	*sp.*	Latreille, 1825
143	Animalia	Annelida	Polychaeta	Sabellida	Sabellidae	*Amphiglena*	*sp.*	Claparède, 1864
144	Animalia	Annelida	Polychaeta	Sabellida	Sabellidae	*Laonome*	*sp.*	Malmgren, 1866
145	Animalia	Annelida	Polychaeta	Sabellida	Sabellidae	*Potamilla*	*sp.*	Malmgren, 1866
146	Animalia	Annelida	Polychaeta	Sabellida	Sabellidae	*Sabellastarte*	*sp.*	Krøyer, 1856
147	Animalia	Annelida	Polychaeta	Spionida	Spionidae	*0*	*sp.*	Grube, 1850
148	Animalia	Annelida	Polychaeta	Spionida	Spionidae	*Aonides*	*sp.*	Claparède, 1864
149	Animalia	Annelida	Polychaeta	Spionida	Spionidae	*Dipolydora*	*sp.*	Verrill, 1881

150	Animalia	Annelida	Polychaeta	Spionida	Spionidae	*Paraprionospio*	*sp.*	Caullery, 1914
151	Animalia	Annelida	Polychaeta	Spionida	Spionidae	*Prionospio*	*sp.*	Malmgren, 1867
152	Animalia	Annelida	Polychaeta	Terebellida	Cirratulidae	*0*	*sp.*	Ryckholt, 1851
153	Animalia	Annelida	Polychaeta	Terebellida	Cirratulidae	*Chaetozone*	*sp.*	Malmgren, 1867
154	Animalia	Annelida	Polychaeta	Terebellida	Cirratulidae	*Cirratulus*	*sp.*	Lamarck, 1818
155	Animalia	Annelida	Polychaeta	Terebellida	Cirratulidae	*Cirriformia*	*sp.*	Hartman, 1936
156	Animalia	Annelida	Polychaeta	Terebellida	Cirratulidae	*Tharyx*	*sp.*	Webster & Benedict, 1887
157	Animalia	Annelida	Polychaeta	Terebellida	Ampharetidae	*Isolda*	*sp.*	Mueller, 1858
158	Animalia	Annelida	Polychaeta	Terebellida	Ampharetidae	*0*	*sp.*	Malmgren, 1866
159	Animalia	Annelida	Polychaeta	Terebellida	Terebellidae	*Lysilla*	*sp.*	Malmgren, 1866
160	Animalia	Annelida	Polychaeta	Terebellida	Terebellidae	*Terebella*	*sp.*	Linnaeus, 1767
161	Animalia	Annelida	Polychaeta	Terebellida	Terebellidae	*Thelepus*	*sp.*	Leuckart, 1849
162	Animalia	Annelida	Clitellata	0	0	*0*	*spp.*	Grube, 1850
163	Animalia	Chordata	Actinopterygii	Perciformes	Terapontidae	*Terapon*	*jarbua*	Forsskål, 1775
164	Animalia	Chordata	Actinopterygii	Perciformes	Gobiidae	*Bathygobius*	*sp.*	Bleeker, 1878
165	Animalia	Chordata	Actinopterygii	0	0	*0*	*spp.*	0
166	Animalia	Brachiopoda	0	0	0	*0*	*sp.*	Duméril, 1805
167	Animalia	Nematoda	0	0	0	*0*	*spp.*	0
168	Animalia	Nemertea	0	0	0	*0*	*spp.*	0
169	Animalia	Platyhelminthes	Turbellaria	0	0	*0*	*spp.*	0
170	Animalia	Sipuncula	0	0	0	*0*	*spp.*	0
171	Chromista	Ochrophyta	Phaeophyceae	Fucales	Sargassaceae	*Sargassum*	*sp.*	C.Agardh, 1820
172	Chromista	Radiozoa	Polycystina	Nassellaria	Spyridae	*0*	*sp.*	Haeckel, 1881, emend. Goll, 1968
173	Plantae	Chlorophyta	Ulvophyceae	Bryopsidales	Caulerpaceae	*Caulerpa*	*sp.*	J.V. Lamouroux, 1809
174	Plantae	Chlorophyta	Ulvophyceae	Cladophorales	Valoniaceae	*Valonia*	*sp.*	C.Agardh, 1823
175	Plantae	Chlorophyta	Ulvophyceae	Ulvales	Ulvaceae	*Enteromorpha*	*prolifera*	O.F.Müller, 1778

176	Plantae	Rhodophyta	Florideophyceae	Corallinales	Lithothamniaceae	*Lithothamnion*	*sp.*	Heydrich, 1897
177	Plantae	Rhodophyta	Florideophyceae	Gelidiales	Gelidiaceae	*Gelidium*	*sp.*	J.V. Lamouroux, 1813
178	Plantae	Rhodophyta	Florideophyceae	Nemastomatales	Nemastomataceae	*Predaea*	*feldmannii*	Børgesen, 1950
179	Plantae	Rhodophyta	Florideophyceae	Rhodymeniales	Champiaceae	*Champia*	*sp.*	Desvaux, 1809

Table. 38. Zone-wise estimated marine fish production (In Tonne) of Greater Mumbai.

Name of Zone	2012-13	2013-14	2014-15	2015-16	2016-17
Manori	19009 (11.3)	24077 (14.2)	27290 (15.1)	32291 (16.7)	24624 (10.8)
Versova	51218 (30.4)	46749 (27.6)	38787 (21.4)	32186 (16.7)	65334 (28.7)
Mumbai	7277 (4.3)	4960 (4.3)	5650 (3.1)	4224 (2.2)	3658 (1.7)
Sasoon Dock	36220 (21.5)	34853 (20.5)	49230 (27.2)	60927 (31.6)	70104 (30.8)
Ferry Warff	54974 (32.5)	58935 (34.8)	60077 (33.2)	63185 (32.8)	63587 (28.0)
District total	168698 (100.0)	169574 (100.0)	181034 (100.0)	192813 (100.0)	227307 (100.0)

Table. 39. Variety-wise marine fish production (In Tonne) in Greater Mumbai.

Variety	2013-14		2014-15		2015-16		2016-17	
	(Sub.)	(City)	(Sub.)	(City)	(Sub.)	(City)	(Sub.)	(City)
Elasmobranchs	507	1231	393	1673	837	2146	313	1166
Eels	36	283	54	426	25	1547	73	1495
Catfishes	427	7023	444	8999	445	5521	710	6204
Chirocentrus SPP.	53	441	64	613	55	240	29	306
Sardine	194	3508	342	3757	573	2920	169	3101
Hilsallisha	96	291	121	176	61	145	40	71
Anchovies	7928	4232	6850	3425	7096	7180	4725	6512
Thrissocles	332	592	365	894	795	1134	387	1025
Other Clupieds	142	14	0	125	29	124	9	37
Harpadon Nehereus	16553	5850	16949	3436	19704	2413	6573	2712
Perches	0	233	0	272	66	504	3	90
Redsnapper	0	377	0	275	0	155	3	97
Polynemidae	27	254	27	217	19	1062	91	271
Sciaenids	330	1218	339	2887	122	2648	215	1496
Otolithoides species	2791	8696	2419	10460	2731	12255	3692	10800
Trichiuridae (Ribbonfishes)	3001	7587	2268	5431	2296	5060	3739	6345
Caranx	3	3352	10	1811	22	2310	165	4077
Pomfrets	340	596	116	1528	313	3641	506	1251
Black Pomfret	43	584	71	901	42	880	86	1510
Mackerals	163	4766	282	3158	83	2328	304	8962
Seerfishes	116	2040	166	4767	115	2207	182	3542
Tunnies	0	1364	20	2871	65	1196	129	6123
Bregmaceros Macelendi	0	40	0	27	552	3	24	21
Soles	1661	555	1458	1028	1667	2339	1410	466
Sphyraena Spp. (Baracudas)	0	728	0	636	8	678	26	1791
Leiognathus	0	2	0	29	0	21	0	14
Upeneus Spp.	358	8070	1259	8112	1346	15928	5624	12399
Penaeid Prawns	10903	17000	9174	21345	8037	29638	9458	22592
Non-Penaeid Prawns	22390	5481	20638	2744	13150	1886	19618	2618
Natantion Decapods (Lobsters)	23	68	36	158	141	261	30	358
Lactarius	171	328	111	766	23	1114	92	681
Loligo duvaucelli (Cephalopoda)	1189	8482	1348	17279	1140	9552	2912	20017

Miscellaneous	1049	3462	753	4731	919	9300	3997	9119
Total	70826	98748	66077	114957	62477	128336	65334	137249

Table. 40. Estimated marine fish production (In Tonne) of Mechanised, Non-Mechanised and Rampan Boats in Greater Mumbai.

Type of Boats	2012-13	2013-14	2014-15	2015-16		2016-17	
				(Suburban)	(City)	(Suburban)	(City)
Mechanised	70173 (99.9)	97940 (99.5)	70761 (99.9)	66030 (99.9)	62457 (99.9)	65309 (99.9)	137237 (99.9)
Non - Mechanised	54 (0.1)	631 (0.5)	65 (0.1)	47 (0.1)	20 (0.1)	25 (0.1)	112 (0.1)
Rampan	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
District total	70227 (100.0)	98471 (100.0)	70826 (100.0)	66077 (100.0)	62477 (100.0)	65334 (100.0)	137349 (100.0)

Table. 41. Table showing per unit production by different types of boats & nets in Mumbai (Suburban) 2016-2017.

Particulars	Types of Net							Total
	Trawl net	Bag net	Gillnet	Purseine	Long lines	Rampan	Others	
No. of efforts of Mech. Boats	12404	76513	8078	0	490	0	165	97650
Production of Mech. Boats (Tonnes)	26449	38412	441	0	4	0	3	65309
Per unit efforts production (kg.)	2132	502	55	0	8	0	18	669
No. of efforts of Non. Mech. Boats	0	1758	1504	0	0	0	140	3402
Production of Non. Mech. Boats (Tonnes)	0	11	13	0	0	0	1	25
Per unit efforts production (kg.)	0	6	9	0	0	0	7	7

Table. 42. Table showing per unit production by different types of boats & nets in Mumbai (City) 2016-2017.

Particulars	Types of Net							Total
	Trawl net	Bag net	Gillnet	Purseine	Long lines	Rampan	Others	
No. of efforts of Mech. Boats	25669	18983	18286	7792	1313	0	4032	76075
Production of Mech. Boats (Tonnes)	108218	3336	3650	21817	110	0	106	137237
Per unit efforts production (kg.)	4216	176	200	2800	84	0	26	1804
No. of efforts of Non-Mech. Boats	0	294	3469	0	0	0	7841	11604
Production of Non-Mech. Boats (Tonnes)	0	6	46	0	0	0	60	112
Per unit efforts production (kg.)	0	20	13	0	0	0	8	10

Table. 43. Limits of water quality parameters in surface water collected at different regions around the proposed study area (off Mumbai).

Location	Air temp. (°C)	Water Temp. (°C)	pH	Salinity (psu)	SS (mg/l)	Turbidity (NTU)	Chloride (mg/l)	DO (mg/l)	BOD (mg/l)	PO_4^{3-}-P (µmol/l)	NO_3^--N (µmol/l)	NO_2^--N (µmol/l)	NH_4^+-N (µmol/l)	Sulphate (g/kg)	PHc (µg/l)
Bay	29.0-29.0 (29.0)	28.5-28.5 (28.5)	8.0-8.0 (8.0)	36.3-36.4 (36.3)	16-16 (16)	12-12 (12)	20109-20111 (20110)	6.4-6.5 (6.4)	2.3-2.3 (2.3)	1.3-1.8 (1.6)	8.9-12.1 (10.5)	2.4-2.4 (2.4)	0.5-0.6 (0.5)	3.0*	3.7*
Nearshore	26.0-32.0 (28.8)	25.5-29.0 (27.5)	8.0-8.1 (8.1)	35.7-36.3 (36.1)	18-41 (32)	3-41 (16)	19800-20100 (20025)	4.9-7.7 (6.4)	1.7-4.6 (3.3)	0.4-5.0 (3.3)	1.6-17.1 (10.4)	0.7-5.5 (3.2)	0.7-5.8 (2.2)	2.8-3.0 (2.9)	2.5-6.8 (4.3)
Coastal	27.5-31.0 (29.5)	26.5-29.0 (27.8)	8.1-8.1 (8.1)	35.9-36.5 (36.3)	14-34 (26)	1-6 (3)	19900-20200 (20083)	6.2-7.1 (6.7)	1.2-3.9 (2.6)	0.9-1.9 (1.3)	1.2-13.5 (7.6)	0.7-4.0 (2.4)	1.3-5.8 (2.9)	2.8-3.1 (2.9)	2.7-3.5 (3.2)
Offshore	27.0-32.0 (29.3)	26.5-29.0 (27.7)	8.1-8.1 (8.1)	36.4-36.7 (36.5)	9-31 (19)	2-5 (3)	19900-20300 (20133)	7.0-7.7 (7.4)	1.9-4.5 (3.2)	0.6-0.9 (0.7)	0.2-4.3 (2.5)	0.1-2.7 (1.1)	1.0-2.2 (1.6)	2.9-3.0 (2.9)	1.6-3.1 (2.2)

*Values are presented as their range with average value in parenthesis. Values with asterisk are the average of two data.

Table. 44. Limits of water quality parameters in Bottom water collected at different regions around the proposed study area (off Mumbai).

Location	Water Temp. (°C)	pH	Salinity (psu)	SS (mg/l)	Turbidity (NTU)	Chloride (mg/l)	DO (mg/l)	BOD (mg/l)	PO_4^{3-}-P (µmol/l)	NO_3^--N (µmol/l)	NO_2^--N (µmol/l)	NH_4^+-N (µmol/l)	Sulphate (g/kg)
Bay	27.5-27.5 (27.5)	8.0-8.0 (8.0)	36.2-36.3 (36.3)	32-32 (32)	12-14 (13)	20000*	5.8-6.0 (5.9)	2.9-2.9 (2.9)	1.9-1.9 (1.9)	10.4-12.2 (11.3)	2.3-2.6 (2.4)	0.6-0.8 (0.7)	2.9*
Nearshore	25.5-28.5 (27.0)	8.0-8.3 (8.1)	36.2-36.5 (36.3)	38-74 (50)	5-47 (21)	20000-20200 (20113)	3.9-7.1 (5.8)	0.8-4.1 (2.6)	1.1-2.3 (1.7)	3.1-13.5 (8.7)	1.2-3.7 (2.4)	0.7-3.8 (1.6)	2.8-3.0 (2.9)
Coastal	26.0-28.5 (27.1)	8.1-8.2 (8.2)	36.4-36.5 (36.5)	28-39 (33)	2-7 (4)	20100-20200 (20167)	6.1-6.9 (6.4)	1.3-3.2 (2.5)	1.0-2.2 (1.6)	0.2-8.2 (5.0)	0.3-2.9 (1.6)	1.0-3.0 (2.0)	2.8-2.9 (2.9)
Offshore	25.5-28.5 (26.9)	8.1-8.3 (8.2)	36.4-36.6 (36.5)	10-32 (21)	2-5 (3)	20100-20200 (20167)	6.2-7.5 (6.8)	1.6-4.3 (2.7)	0.8-1.0 (0.9)	0.2-3.0 (1.7)	0.3-0.4 (0.3)	0.8-1.6 (1.1)	2.9-3.1 (3.0)

*Values are presented as their range with average value in parenthesis. Values with asterisk are the average of two data.

12. Plates

Plate. 1. Images representing the intertidal areas of transect CR1 (A & B), CR2 (C & D), CR3 (E & F).

Plate. 2. Images representing the intertidal areas of transect CR4 (A & B), CR5 (C & D), CR6 (E & F).

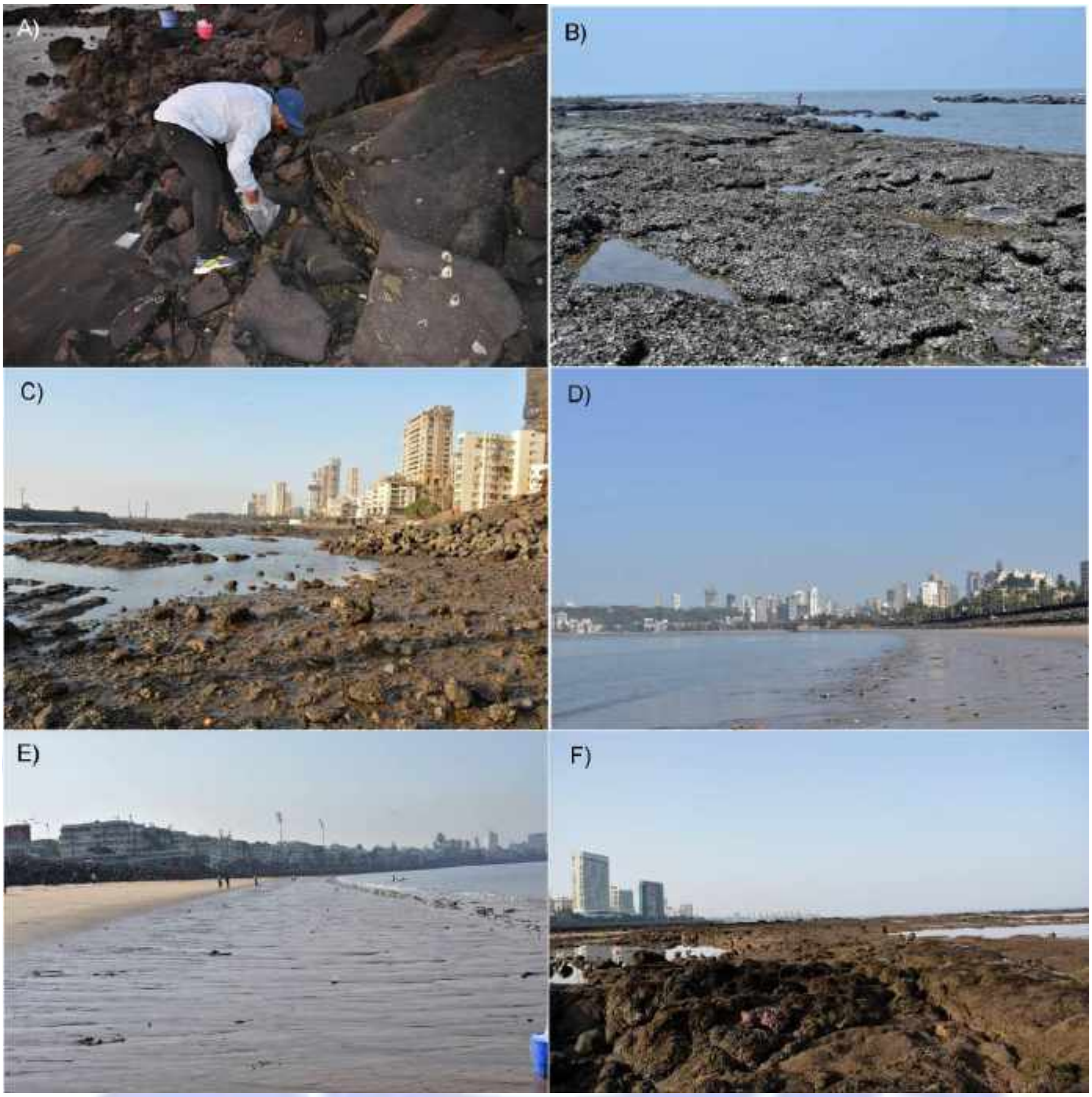


Plate. 3.Images representing the intertidal areas of transect CR7 (A), CR8 (B & C), CR9 (D), CR10 (E), MDR (F).

Plate. 4. Trawling and fishing carried out during the present study in March-April 2019. Various fish, prawns carbs have been caught during the survey.

Plate. 5. Benthic macro and megafauna observed during the present study in March-April, 2019. A & B) – Burnacles; C & D)- Alpheidae; Polychaetes (E – Sabellidae, F – Amphinomidae, G – Hesionidae, H – Eunicidae); I – Ophiuroidae; J – Octopus sp.; K & L – Styelida (Ascidians)

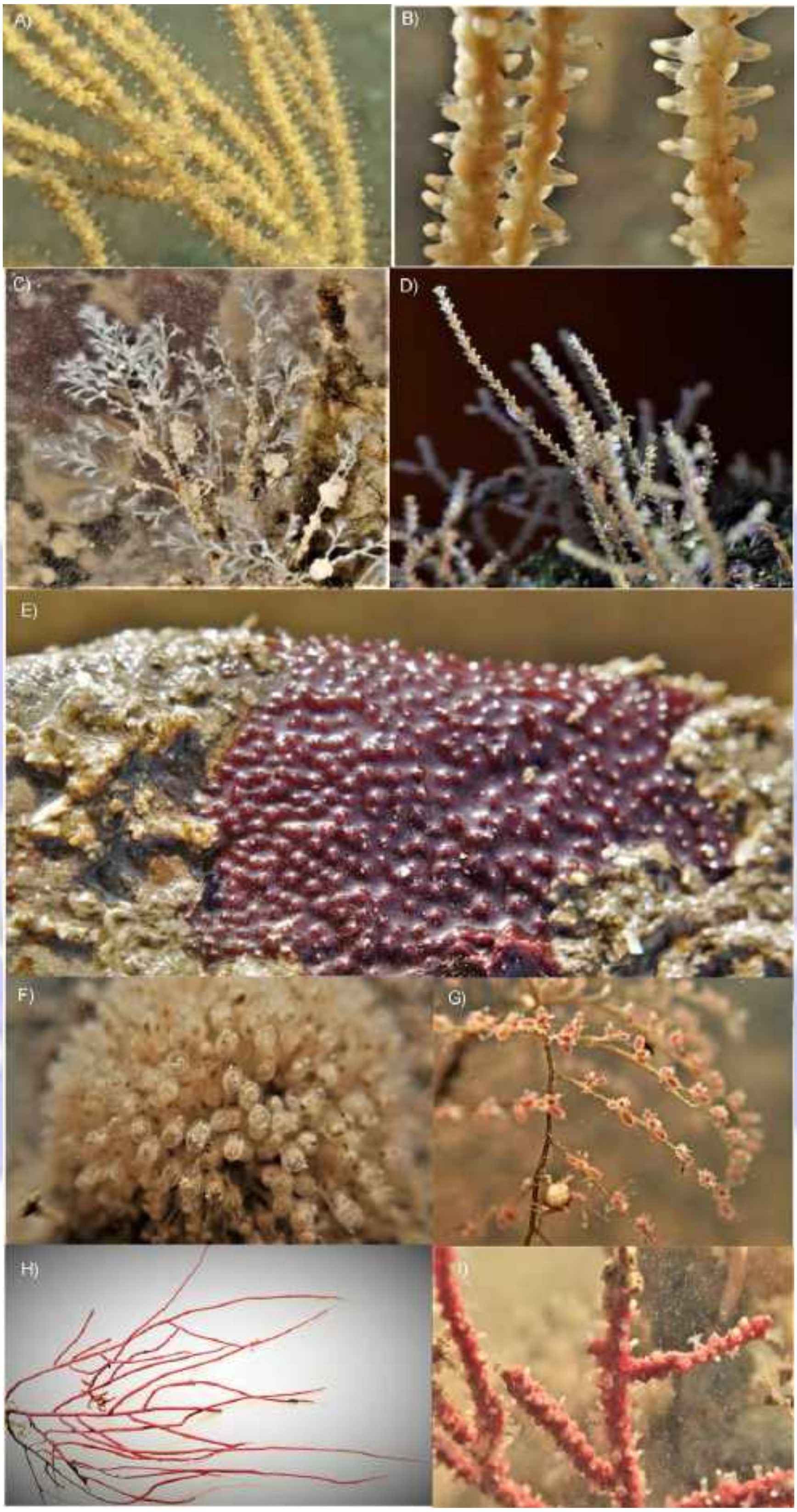


Plate. 6. Benthic sessile fauna observed during the present study in March-April, 2019
A & B) – Alcyonacea; C) - *Nemalecium* sp.; D) - *Dynamena* sp.; E, F & G) – Bryozoans; H & I - Plexauridae.

Plate. 7. Varieties of crab observed during the present study in March-April 2019.
A) Oregoniidae; B) Pinnotheridae; C) Petrolisthes boscii; D) Pachygrapsus crassipes; E) Portunus sp.; F) Unidentified crab; G) Charybdis lucifera; H) Charybdis japonica; I) Menippe rumphii; J) Menippe sp; K) Aratus sp; L) Thalamita sp; M) Epialtidae; N) Unidentified cab; O) Atergatis integerrimus

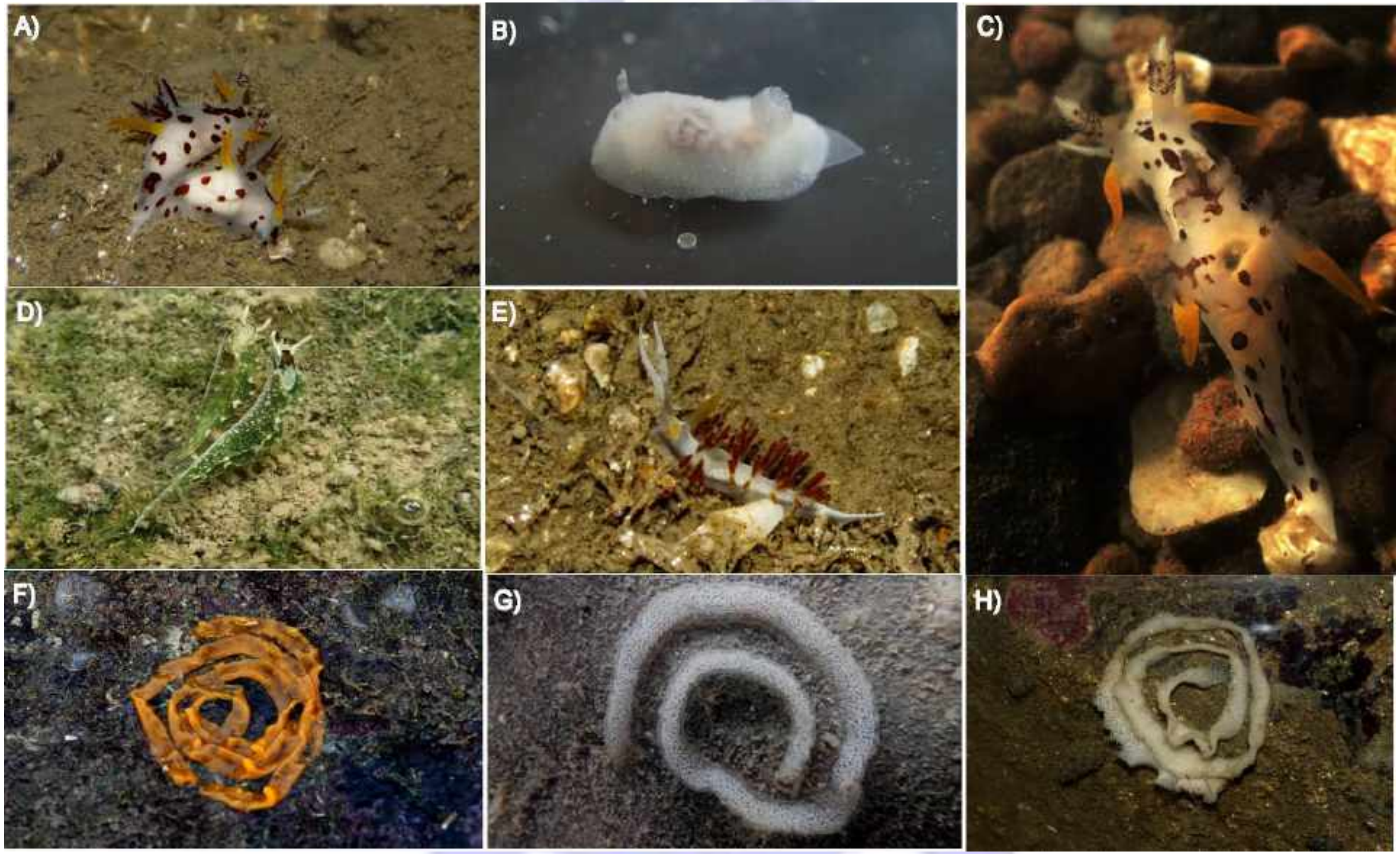


Plate. 8. Sea slugs found in the intertidal region during the present study March-April 2019. A & C) *Okenia* sp.; B) *Hallaxa* sp.; D) *Elysia hirasei*; E) *Cratena peregrina*; F, G & H – Eggs.

Plate. 9. Varieties of Sea anemone observed during the present study in March-April 2019.

Plate. 10. Coral observed in the study area during March-April 2019: A) - *Oulangia* sp. (Worli, Haji Ali and MDR); B – Rhizangiidae (Worli, Haji Ali and MDR; C) *Polycyathus* sp. (MDR); D) Dendrophylliidae (Haji Ali and MDR); E) *Goniopora* sp. (MDR); (F) *Pseudosiderastrea tayamai* (MDR)

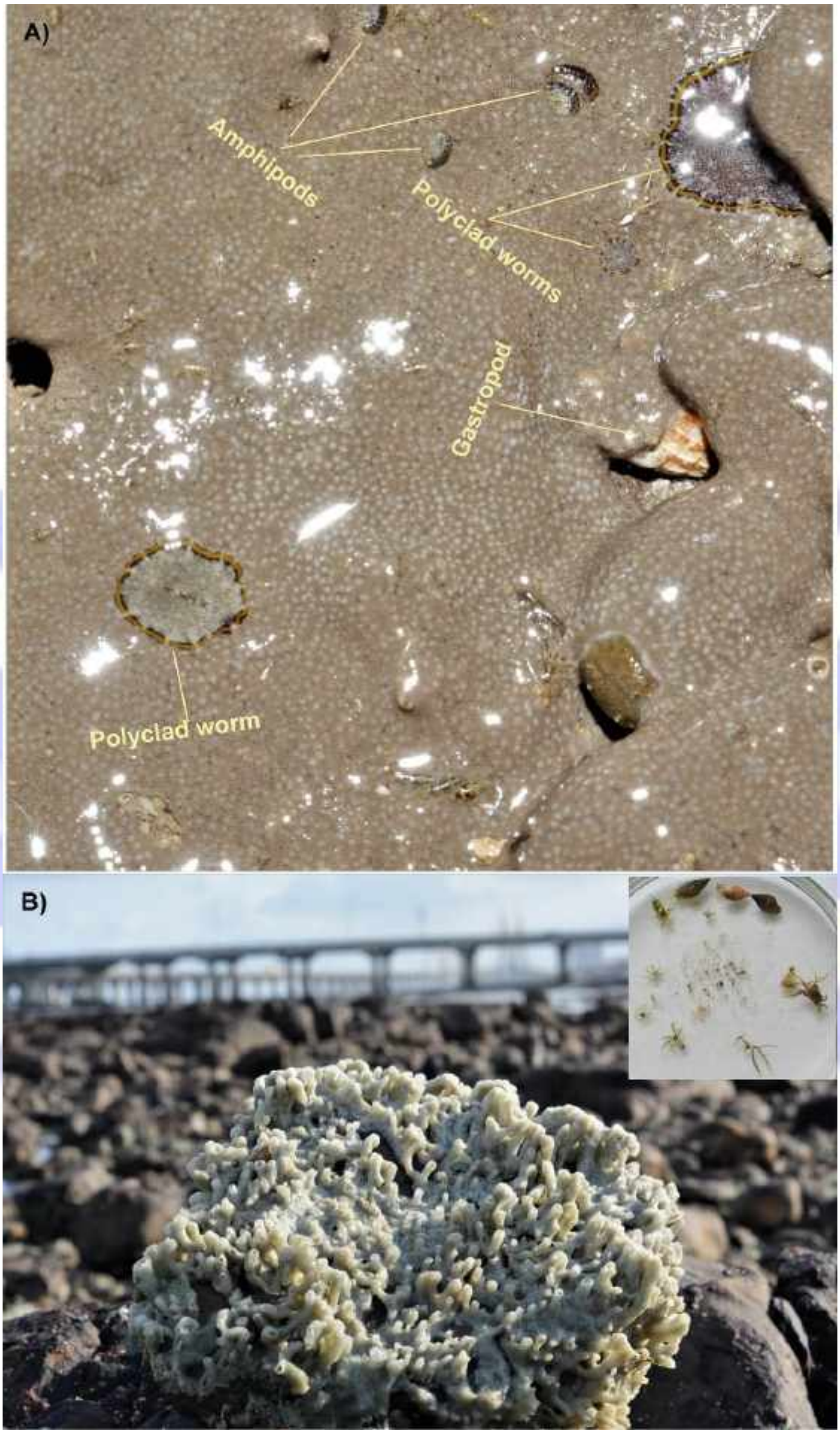


Plate. 11. Example of micro-habitat mediated by biological associations A) Ascidian and B) Sponge as habitat for other organisms observed during the present study in March-April 2019.

Plate. 12. Varieties of shellfishes observed along the intertidal areas during the present study in March-April 2019. A to E and G – Gastropoda; F – Bivalvia (*Gafrarium divaricatum*); H- Oyster (*Saccostrea cucullate*).

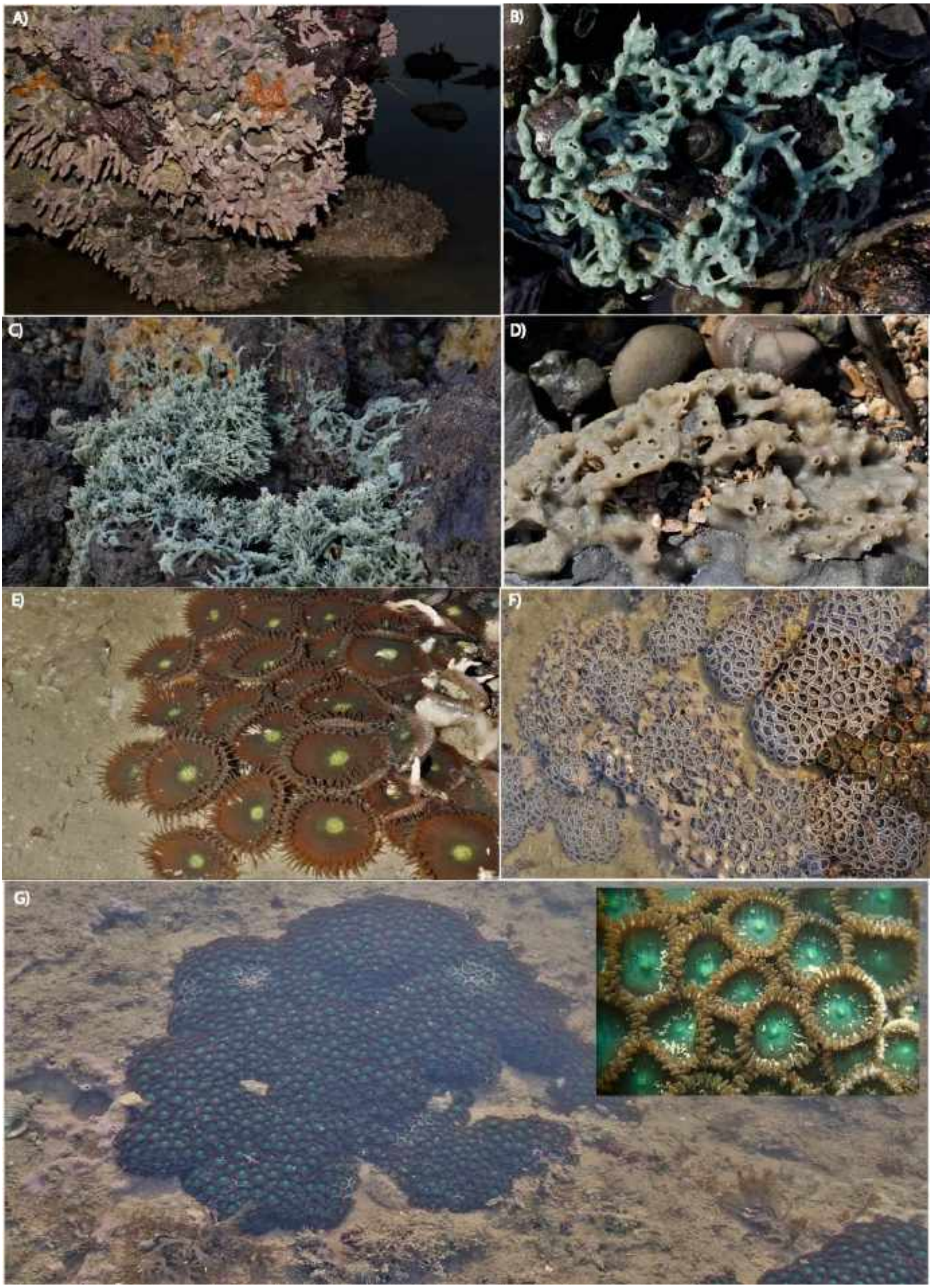


Plate. 13. Photographs of sponges (A – D) and zooanthids (E - G) were taken during the intertidal survey in the present study in March-April 2019.