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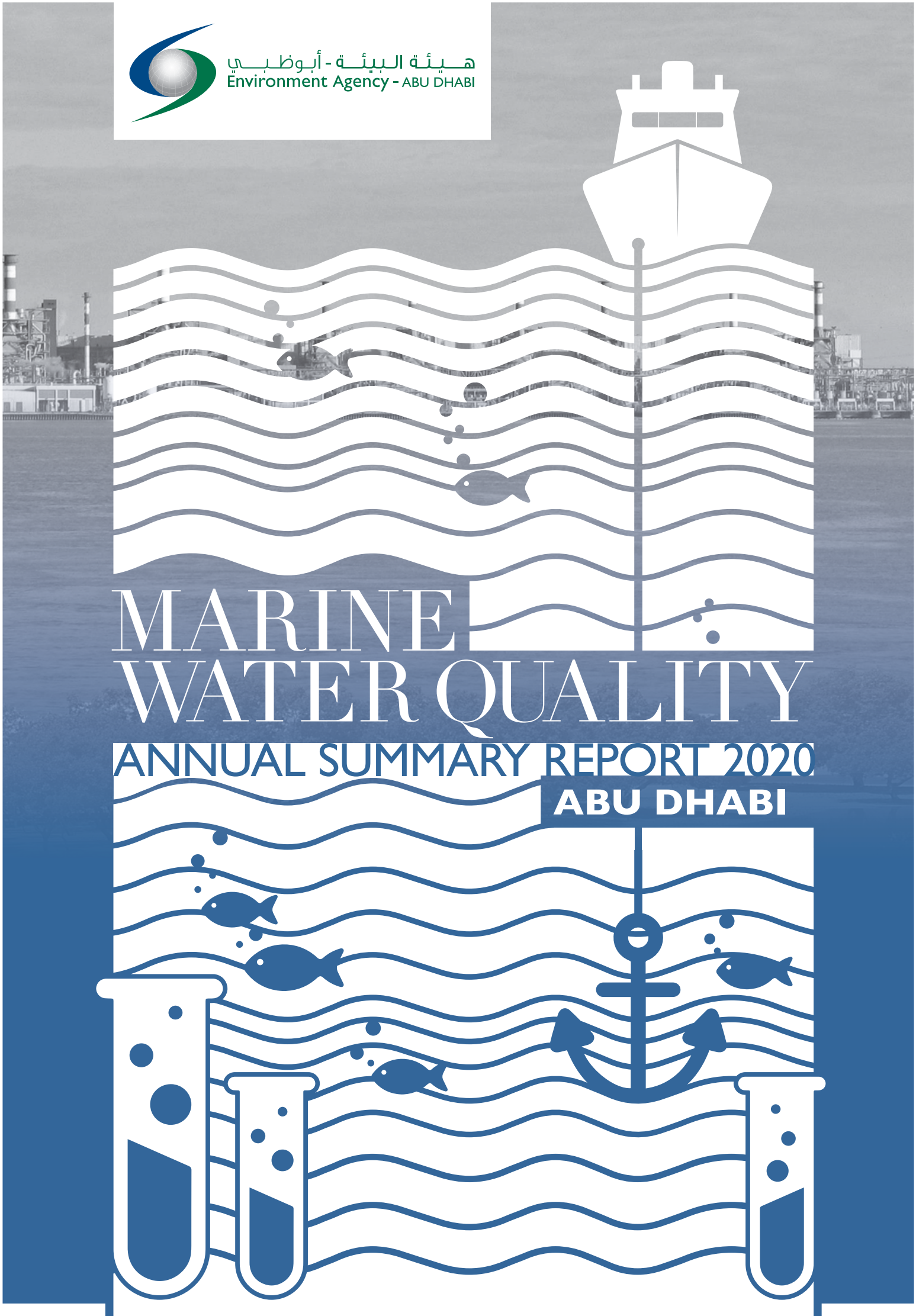
Environment Agency - ABU DHABI



MARINE WATER QUALITY

ANNUAL SUMMARY REPORT 2020

ABU DHABI

01

INTRODUCTION

1.1 BACKGROUND

The Marine Water Quality Monitoring Programme (MWQMP) of the Environmental Agency - Abu Dhabi (EAD) initiated with the goal of identifying the potential MWQ threats in order to develop measures to ensure the coastal waters are safe and healthy for people, plants and animals. Abu Dhabi's marine waters face potential environmental challenges due to urbanisation, industrialisation, tourism, and factors associated with these. The coastal waters have been exposed to pollutants, including nutrients, organic matter, heavy metals, and microorganisms.

EAD's MWQMP has collected ambient marine water quality data to monitor the status since 2006. During 2020, 22 sites in Abu Dhabi coastal waters were monitored under the MWQ sampling programme. The data obtained through this programme elucidate the current status of various water quality parameters including microbial pollutants and its trend. The long-term monitoring is important for not only assessing the quality of Abu Dhabi's waters but also allows to develop regulations, policies and implementing strategies to protect marine resources and public health. The present summary report provides insight into the status of the marine environment by highlighting key findings from the 2020 MWQMP.

1.2 DRIVING FORCES, PRESSURES, & IMPACTS TO ABU DHABI WATERS

EAD employs the drivers, pressures, states, impacts, and responses (DPSIR) model to assess how human activities may affect the environment. Figure 1 illustrates the causal chain that links human activities and environmental pressures to environmental impacts and policy responses.

Drivers	Pressures	States	Impacts	Responses
•Increased population •Coastal development	•Discharges into marine waters •Atmospheric deposition •Dredging and fill	•Declines in water quality •Loss and deterioration of ecosystems	•Fishery declines •Increased cost to desalinate or clean water •Population declines of dugongs and turtles	•Establish standards and regulations •Monitor water quality •Minimise discharges into marine waters

Figure 1. DPSIR model with examples relevant to Abu Dhabi.

The two major driving forces that apply pressures on Abu Dhabi's marine environment are human population growth and the associated rapid economic development. These drivers create pressures such as discharges into marine waters, atmospheric deposition of pollutants, and sediment dredge and fill operations. These pressures can introduce excess nutrients, sediments, and chemical contaminants into marine waters, leading to the decline of water quality and to loss and deterioration of habitats.

Development and population growth also spur demands for more fresh water from desalination plants and an increased need for wastewater treatment facilities. Responses to these changes in the state of the environment could involve promulgating rules and regulations for activities that cause environmental pressure, expanding the marine monitoring program, and taking steps to minimize discharges into marine waters.

Impacts in Abu Dhabi include a decline in biotic communities and increases in eutrophication, harmful algal blooms (HABs), bacterial contamination, and contaminated sediments as well as increased costs to desalinate or clean water. EAD and other agencies respond by monitoring and enacting regulations to protect water quality.

EUTROPHICATION

- Caused by an excessive amount of nutrients (nitrogen and phosphorus) in water bodies, which come from point and non-point sources.
- Leads to enhanced growth of algae, especially phytoplankton, resulting in Harmful Algal Blooms and subsequent depletion of dissolved oxygen.
- Oxygen depletion generates fish kills and mass mortality of Marine organisms.

HARMFUL ALGAL BLOOMS

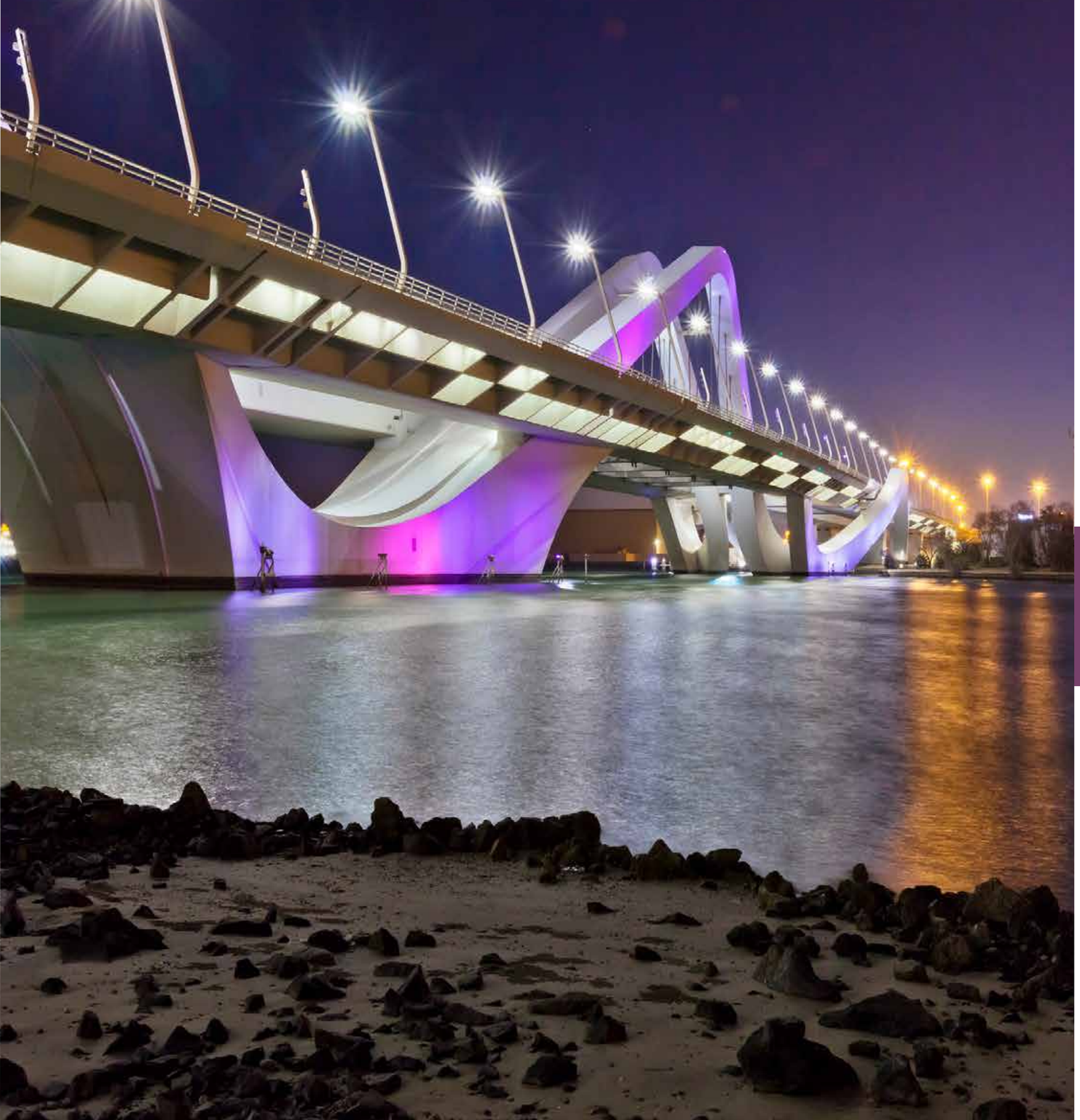
- When the environment is suitable, the phytoplankton proliferates and produce harmful algal blooms (HAB).
- Some algal species produce toxins, which is harmful to human health and animals.
- HABs can cause mass mortalities of marine organisms and desalination plants in Abu Dhabi.

MICROBIAL CONTAMINATION

- Results from the discharge of inadequately treated municipal wastewater into the marine environment.
- Contaminated water or seafood can cause gastrointestinal illnesses, respiratory illnesses, and skin infections in people.
- Microbial contamination of beach water affects recreational activities and tourism.

CONTAMINATED SEDIMENTS

- In general, marine sediments act as a sink for heavy metal pollutants and play a vital role in the monitoring and assessment.
- It can accumulate and assimilate heavy metals even from low concentrations in the overlying water column.
- Human health is threatened when contaminants bio-accumulate in fish eaten by humans.
- It affects the biological activities of marine organisms, including reproductive functions and tumors.



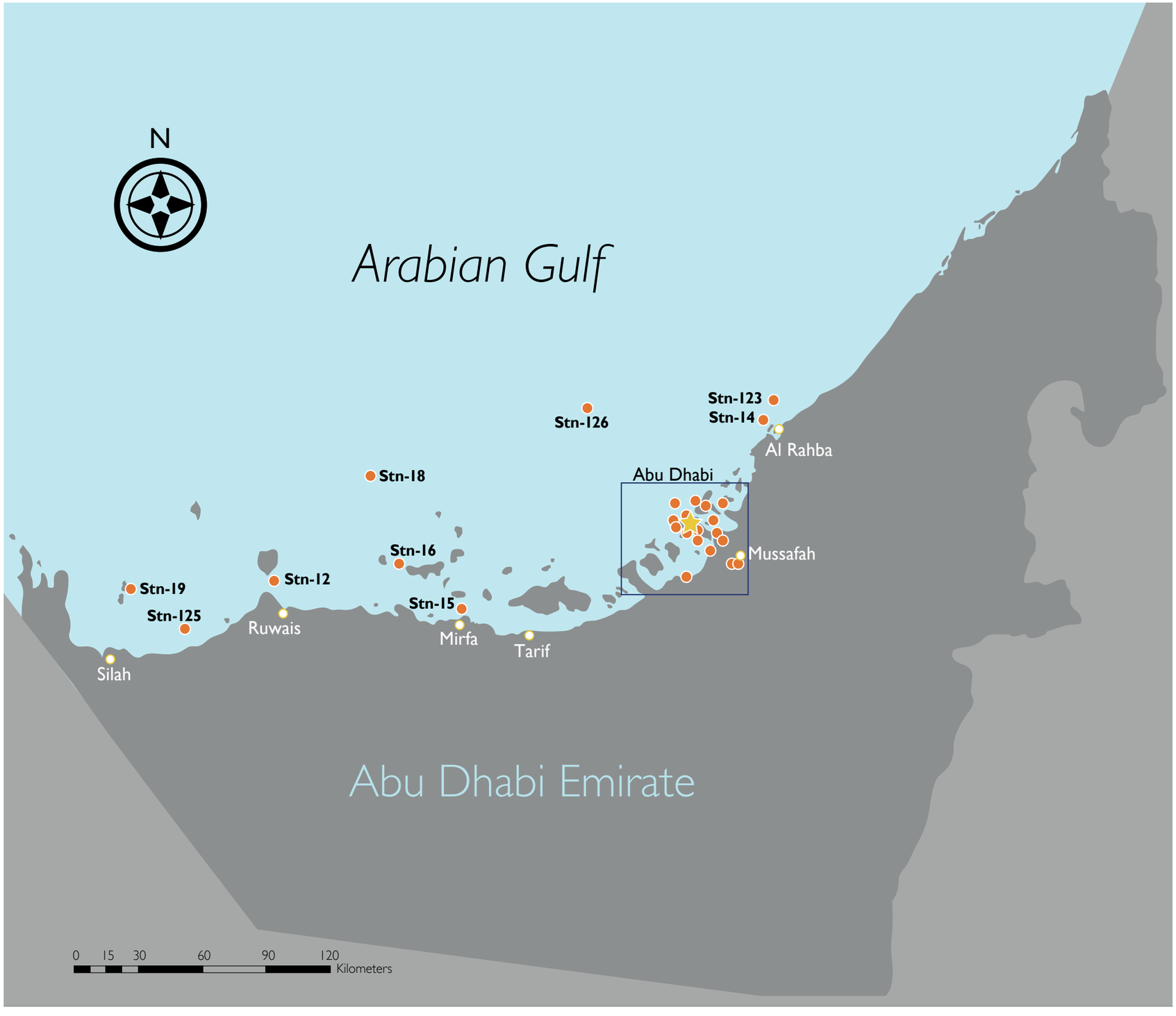
02 METHODS

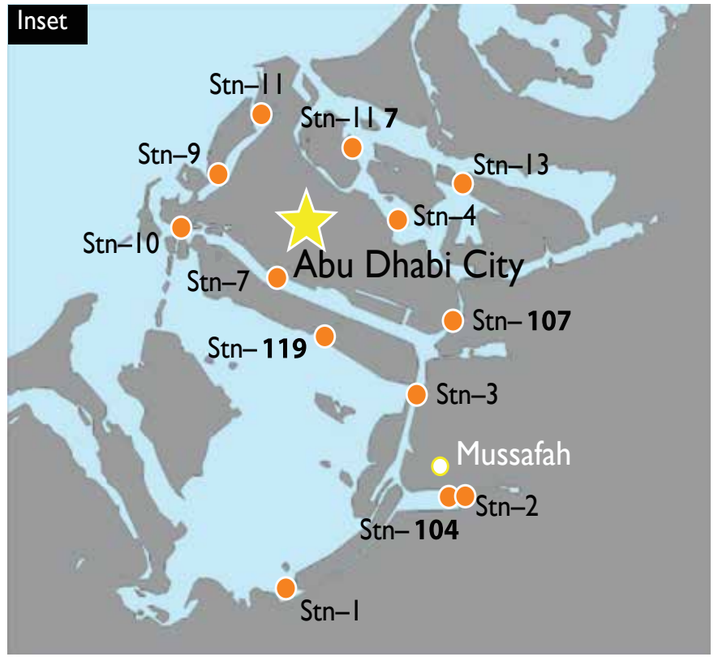
2.1 SAMPLING STATIONS

Marine water quality sampling stations cover the entire emirate, from ecologically important areas to more heavily used areas, important natural habitats, and from Abu Dhabi City to the Al Dhafra Region of Abu Dhabi Emirate (Figure 2).

The ecological importance and the activities or uses that occur near the sampling stations were used to group them into the following different categories:

- Confined areas
- Public beaches
- Ports and marinas
- Desalination plants
- Point source
- Marine protected areas (MPAs) and natural habitats
- Newly developed and developing areas
- Nuclear power plant
- Reference station





Stations

Confined Areas
Stn1- Al Salamiyah Channel
Stn2- Mussafah South Channel
Stn3- Mussafah Industrial Area
Stn4- Mangrove Area - Eastern Corniche

Point Source
Stn-104 Mussafah South Channel-Outfall

Public Beaches
Stn7- Bateen Beach
Stn-9 Corniche Beach
Stn-107 Fairmont Beach

Ports & Marinas
Stn10- Intercontinental Jetty
Stn11- Port Mina Zayed
Stn12- Ruwais

Desalination Plants
Stn13- Um Al Nar
Stn14- Taweelah
Stn15- Mirfa

MPAs
Stn-16 Marawah
Stn-18 Butinah
Stn-19 Al Yasat
Stn-123 Ras Ghanada

Newly Developed and Developing Areas
Stn-117 Al Reem Island
Stn-119 Al Hudayriat Island

Nuclear Power Plant
Stn-125 Barakah

Reference
Stn-126 Reference

Note: Mussafa South Channel (Station 104) is a point source and is not included in the indices that capture ambient water quality.

Figure 2. Sampling site details

2.2 SAMPLING FREQUENCY

The sampling strategy incorporates two types of sampling frequencies. The stations around Abu Dhabi City (*i.e*, Stations 1–11, 13–14, 107, 117, 119, 123, and 126) were monitored monthly. The stations outside of the city and in Al Dhafra Region (*i.e*, Stations 12, 15–19, and 125) were monitored less frequently.

2.3 MATERIALS AND METHODS

Water samples were collected and analysed by standard methods in Abu Dhabi Quality and Conformity Council- Central Testing Laboratory for nutrients, organic compounds, biochemical oxygen demand (BOD), total suspended solids (TSS), heavy metals, and fecal indicator bacteria (Enterococci and faecal coliforms). Concurrently sediment samples were collected and analyzed for heavy metals. Along with the MWQ samples, observations of weather, wind, and water appearance (*e.g., colour, odour,* tide) were recorded.

03

DATA ANALYSIS

Continuous monitoring of Abu Dhabi's waters over the past 15 years has provided critical data that were used to characterise the physical, chemical, and microbial conditions in the marine environment. Descriptive statistical analysis was made in 2020 to find out the status and trend of marine water quality.

Water Quality Indices

Three water quality indices provide summary analytics through a generic Water Quality Index (WQI) method (developed by the Canadian Council of Ministers of the Environment in 2001). The indices are based on three groupings of parameters that represent different aspects of MWQ:

Eutrophication Index

Indicates the level of nutrient over-enrichment of the coastal waters and is based on parameters associated with eutrophication, including nutrients (*i.e*, nitrate, phosphate, and ammonia), dissolved oxygen, and chlorophyll *a*.

Microbial Index

Indicates the level of bacterial contamination in marine waters that can pose a threat to public health and is based on the faecal indicator bacteria, enterococci, and faecal coliforms.

Heavy Metals Index

Indicates the extent of metal contamination in marine sediments and is based on parameters that are heavy metal contaminants (*i.e*, cadmium, copper, lead, nickel, mercury, and zinc) in sediments.

The WQI produces a score between 0 and 100 for each monitoring station for the year. Scores are grouped into condition-rating categories of "Good" (a score of 75 and higher), "Fair" (a score of 50 to 74), or "Poor" (a score of 0 to 49).

04 RESULTS

EAD monitored 22 stations for 28 water quality parameters and 11 sediment quality parameters. Results from the 2020 sampling programme indicate that the mean concentrations of nitrite and nitrate were reduced whereas other parameters like phosphate, ammonia, and silicate concentrations were relatively stable.

The basic water quality parameters such as temperature, salinity, pH, and dissolved oxygen were monitored through an *in-situ* instrument, and it indicated that the variations between the stations were minimum except confined areas and point sources. The temperature values fluctuated along with the atmospheric temperature and ranged between 18.52 and 35.52 °C. Since the precipitation was less in Abu Dhabi, the fluctuation of salinity values was insignificant, and it varied between 31.87 and 49.49 ppt. The pH values were normal (7.85-8.5). The dissolved oxygen concentration was very low (hypoxic) at bottom waters of confined areas (3.22 mg/L) and high in surface waters of confined areas (9.85 mg/L) due to algal blooms. The chlorophyll values were normal in all stations except the confined areas where the values were fluctuated between 0.16 µg/L (bottom waters) and 32.76 µg/L (surface waters). Water clarity was highest in reference and offshore western region stations.

Results from the 2020 sampling programme indicated that mean heavy metal concentrations in sediment appear relatively stable except copper, it showed elevated concentration than the standard. Mercury was not detected in water or sediments.

Microbial pollutants were not detected in most samples collected in 2020, particularly at the stations outside of Abu Dhabi city. The stations in the confined areas (two times) and the newly developed area (one time only) had elevated bacterial values.

Eutrophication Index

- In 2020, the eutrophication index annual mean score reached 72 and it is stable for the past two years.
- First time the Eutrophication Index score reached 73 points in 2019 and the trend is continuing (72) in 2020.
- Overall a significant improvement in the average annual score and increasing 22 points from 50 (Poor) in 2018 to 72 (Fair) in 2020.
- Among the 22 sampling stations, 12 stations achieved Eutrophication scores of above 75.
- The annual average eutrophication score for Fairmont beach reached fair to good and improvements were recorded in Taweela (desalination plant), Reeem Island and Al Hudayriat island (newly developed areas).
- For the ninth consecutive year, the Mussafah South Channel showed the lowest score (17.7).

Microbial Index

- 18 sites showed a Microbial index score of 100 in 2020.
- Station categories farther away from the city (Marine Protected Areas, Newly Developed and Developing Areas, Nuclear Power Plant, and Reference) achieved perfect Microbial Index scores.

Heavy Metal Index

- The Heavy Metals scores were reduced in confined areas.
- Among the sites analyzed Al Hudayriat (newly developing area) exhibited a very low index value (49.3).
- Nuclear Power Plant station index score increased and reached 100.
- No stations achieved heavy metals scores of 100 in 2019, whereas in 2020 at least six stations achieved a score of 100.

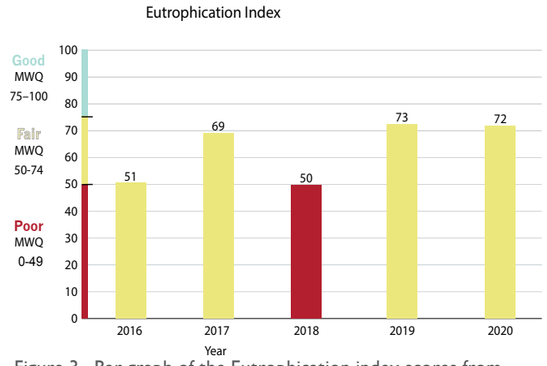


Figure 3. Bar graph of the Eutrophication index scores from 2016 to 2020

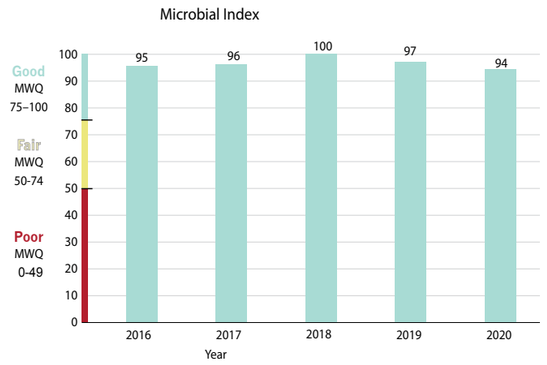


Figure 4. Bar graph of the Microbial index scores from 2016 to 2020

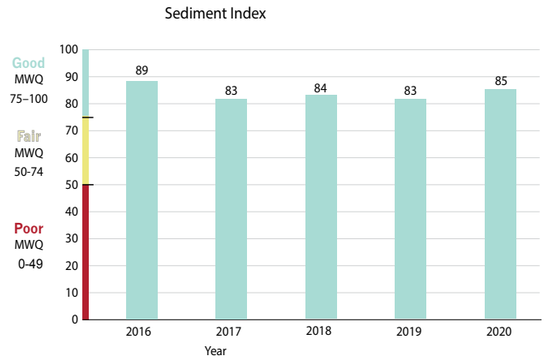


Figure 5. Bar graph of the Heavy Metals index scores from 2016 to 2020

Stations		Eutrophic				Microbial				Heavy Metal			
No.	Name	2017	2018	2019	2020	2017	2018	2019	2020	2017	2018	2019	2020
Confined Areas													
1	Al Salamiyah Channel	56	35	57	61	72	100	100	100	79	69	90	80
2	Mussafah South Channel	10	13	33	18	83	100	100	41	57	67	70	51
3	Mussafah Industrial Area	42	30	60	70	100	100	100	100	63	57	69	68
4	Mangrove Area - Eastern Corniche	45	33	62	59	97	100	100	100	80	90	89	90
Desalination Plants													
13	Um Al Nar	64	46	65	65	100	100	100	71	71	88	80	80
14	Taweela	65	56	76	88	100	100	100	71	90	80	88	100
15	Mirfah	100	51	88	88	100	100	100	100	100	90	90	100
MPAs/Natural Habitats													
16	Marawah	88	64	88	76	100	100	100	100	80	100	89	90
18	Butinah	100	70	100	88	100	100	100	100	100	100	89	100
19	Al Yasat	100	76	100	88	100	100	100	100	100	100	87	100
123	Ras Ghanadah - Corals	77	52	75	76	100	100	100	100	81	90	78	81
Newly Developed and Developing Areas													
117	Al Reem Island	76	51	76	88	100	100	100	100	90	88	79	81
119	Al Hudayriat Island	64	40	74	76	100	100	100	100	90	88	80	49
Nuclear Power Plant													
125	Barakah	86	74	100	88	100	100	100	100	90	80	83	100
Ports and Marinas													
10	Intercontinental Jetty	53	47	75	64	83	100	71	100	70	77	88	60
11	Port Mina Zayed	65	46	61	63	84	100	70	100	80	66	55	90
12	Ruwais	76	82	88	76	100	100	100	100	100	100	84	100
Public Beaches													
7	Al Bateen Beach	52	40	64	64	96	100	100	100	79	78	90	80
9	Corniche Beach	88	43	58	64	100	100	100	100	81	89	90	80
107	Fairmont Beach	52	43	63	75	97	100	100	100	79	78	88	81
Reference													
126	Reference	88	62	75	76	100	100	100	100	90	90	80	80

Poor score of 0-49 **Fair** score of 50-74 **Good** score of 75-100

05

SPECIAL PROGRAMMES

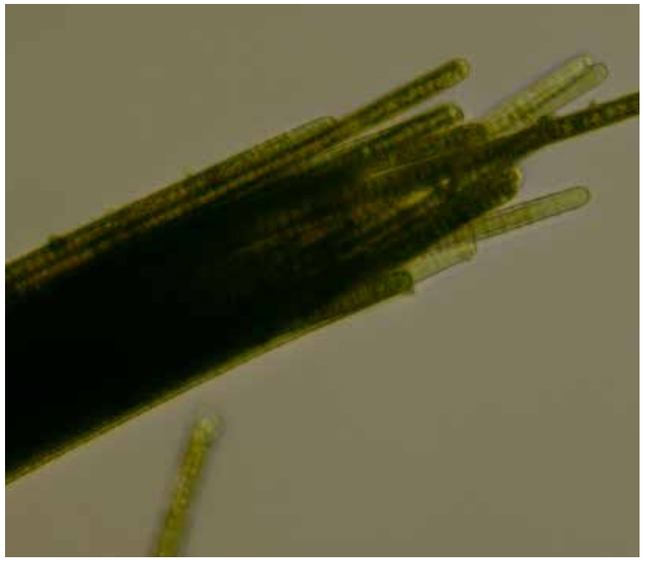
MARINE WATER QUALITY AUTOMATION

Since 2005, EAD has been running the marine water quality monitoring programme in Abu Dhabi coastal waters. The programme supports meeting EAD's goals for protecting public health and the environment. In 2014, EAD initiated the automated marine water monitoring program through the deployment of three automated buoys and the network was expanded by eight additional buoys in 2016. Currently, the network consists of 10 stations that continuously monitor MWQ on a real-time basis in ecologically important and sensitive sites such as confined areas, beaches, critical marine habitats (coral reef, seagrass, and mangroves), newly developed areas, and nuclear powerplant area. These buoys measure seven key marine water quality parameters (salinity, conductivity, temperature, pH, dissolved oxygen, chlorophyll, and cyanobacteria) every 15 minutes and transmit the data to EAD's central database every hour. In addition, these buoys allow the MWQP to detect immediate changes and act as an early warning system for harmful algal blooms (HAB) and marine water quality.

RED TIDE MONITORING

The United Arab Emirates has experienced severe and widespread HAB outbreaks in the Arabian Gulf and the Gulf of Oman. These outbreaks have resulted in the loss of thousands of tonnes of fish and limited traditional fishery operations, damaged coral reefs, impacted coastal tourism, and forced the closure of desalination plants in the region.

EAD's research indicates that there are many bloom-forming and toxin-producing algal species in Abu Dhabi's waters. Algal bloom incidence is increasing annually until 2015 (Figure 6), after that the trend started decreasing. HABs, especially blooms of toxin-producing species, pose a serious risk to public health and plant operations, scientific understanding and engineering approaches are vital to mitigate the impact of HABs on marine environment and public health. EAD



Red tide monitoring progamme continue to find evidence of red tides. It recorded and investigated 13 incidents in 2020. There was no remarkable casualty noted in Abu Dhabi waters.

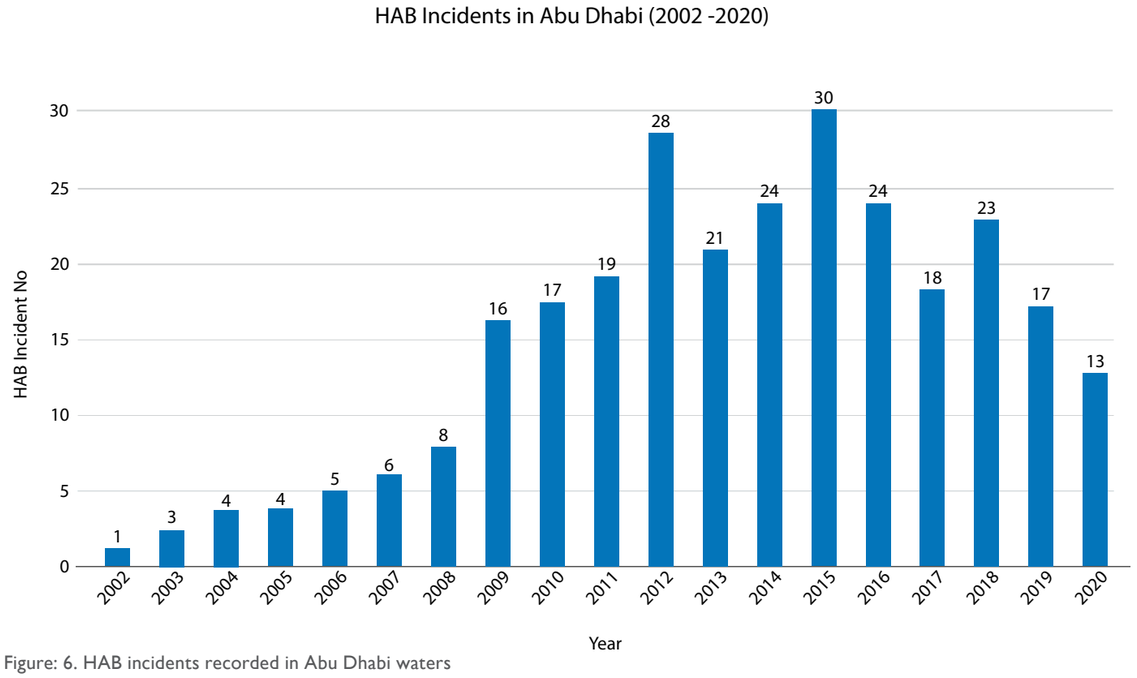


Figure: 6. HAB incidents recorded in Abu Dhabi waters

HYDRODYNAMIC AND WATER QUALITY MODELLING CAPACITY BUILDING PROJECT

Hydrodynamics and Water Quality Modelling (HWQM) project was initiated in early 2019 that aims to build internal capacity and expertise and establish a fully validated HWQ model of Abu Dhabi territorial waters. Building this modeling capacity will support our system holistically to understand the water dynamics and pollutants concentrations as they move through the environment. Especially in a rapidly developing waterfront of Abu Dhabi that includes commercial, strategic and industrial types of activities, this tool will help determine the source of pollutants and forecast the impacts of any coastal activities. In addition, through a series of long-term training, in-house capacity/experts will be confidently able to understand, run, and modify the model as needed by the end of 2021.

The project was launched with a startup workshop in April 2019 where the EAD Modelling Team was given an introductory course in HWQMs. Over the following period the team has been working through a series of task assignments setting the background, objectives and conceptual models for case studies designed to integrate HWQMs into proactive environmental management planning. A review of the literature of HWQMs applied to the Arabian Gulf and Abu Dhabi coastal waters was presented in a follow-up workshop. A series of workshops took place up to June 2020, train in data requirements for HWQMs (Figure 7). A total of ten Case Studies were identified in 2020 and formed the basis of the theoretical component of the training programme. EAD Modelling group has not been completed the training due to COVID-19.

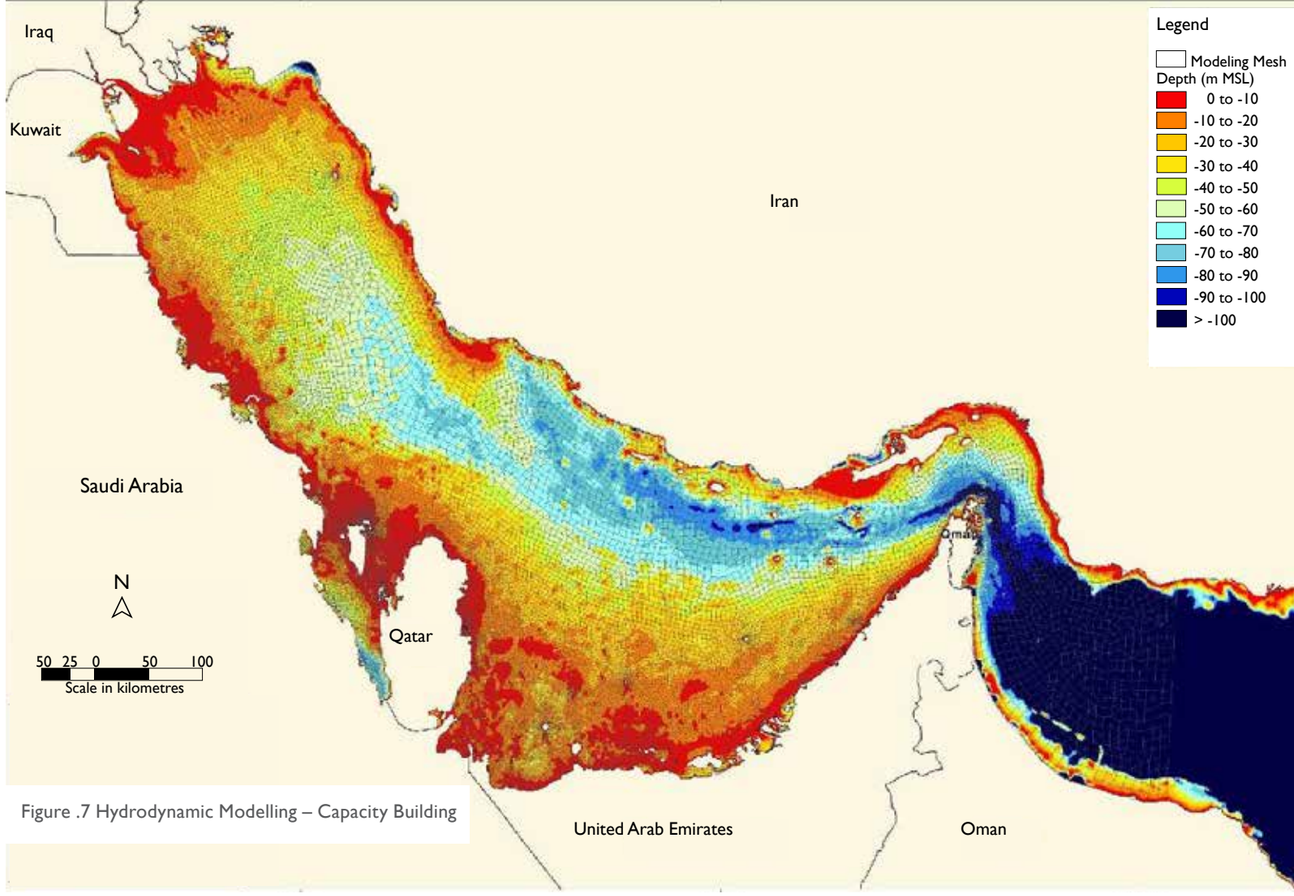


Figure .7 Hydrodynamic Modelling – Capacity Building

PUBLISHING THE MWQ ACHIEVEMENTS

In 2020, the Marine Water Quality team of EAD published three scientific papers in peer-reviewed journals.

The first study explained the eutrophication sources, impacts, and management in Abu Dhabi waters, published in the journal Aquatic Ecosystem Health & Management, 23:2, 175-186, DOI: 10.1080/14634988.2020.1800961.

Second scientific paper deals about the MWQ index and explains how to use this tool for MWQ monitoring, published in Aquatic Ecosystem Health & Management, 23:2, 145-153, DOI: 10.1080/ 14634988.2020.1798144.

The third paper deals with the MWQ standards, it also published in the peer-reviewed journal Aquatic Ecosystem Health & Management, 23:2, 154-165, DOI: 10.1080/14634988.2020.1794171

06

MARINE WATER QUALITY REGULATIONS

Inconsistent with EAD strategy, EAD board approved in November 2020 the marine water quality regulations that aim at maintaining ambient marine water and sediments quality through regulating land-based discharges, and implementing anti-degradation requirements through environmental impact assessment studies and permitting processes. EAD developed as well the implementation plan and the communication and outreach plans for the regulations.

The regulations include scientifically-based quality criteria for ambient marine water as well as liquid discharges to marine from land-based activities. The incorporated specifications establish goals for marine waters and sediment to ensure the protection of the marine environment including its wildlife and biodiversity along the coastline of the emirate.

ABU DHABI GUIDANCE DOCUMENT FOR SAMPLING AND TESTING OF LAND-BASED LIQUID DISCHARGES TO THE MARINE ENVIRONMENT

As the competent authority in the emirate, EAD issued the Marine Water Quality Regulation that regulates all land-based discharges to the marine environment. The regulation states that the regulated community shall report to EAD on regular basis about the quality and quantities of discharges to marine. This implies a collection of representative samples from the discharges and testing in accredited laboratories.

A working group was established with the task of developing a guidance document for collecting samples from land-based activities liquid effluents that are discharged to the marine environment in Abu Dhabi Emirate. The document copes with best international practices, takes into consideration other local/federal relevant guidelines, and is agreed upon by all relevant agencies/entities in Abu Dhabi Emirate.

The objective of the guidance document is to set relevant and appropriate requirements for sampling and analysis of liquid discharges to the marine environment from land-based activities. This includes physical, chemical and microbiological constituents of discharges based on best local and international practices for the long-term protection of the marine ecosystem and human health.

Requirements of the document apply to all entities that dispose liquid discharges from land-based activities to the marine environment. These requirements include the following:

1) Collections of representative samples from the targeted discharges.

2) Field and laboratory-based analysis of samples.

3) Record keeping as per requirements of EAD.

Protecting and Sustaining Marine Water Quality in Abu Dhabi Emirate

2012 - 2018

HIGHER COMMITTEE FOR ENHANCING MARINE WATER QUALITY

هيئة البيئة - أبوظبي
Environment Agency - ABU DHABI

07

CONCLUSION

The result of the 2020 MWQ monitoring programme reveals that the marine water quality in Abu Dhabi is generally good, stable and meets public health criteria for swimming and other recreational activities. It is noteworthy to mention that the eutrophication index of confined areas showed significant progress and that the annual mean value is maintained, and improvements were noted in Fairmont Beach, Taweela desalination plant and newly developed areas such as Reeem Island, and Al Hudayriat island. Result of this reduction in eutrophic conditions, the harmful algal bloom (HAB) incidents are on a decreasing trend. No stations achieved heavy metals scores of 100 in 2019, whereas in 2020 at least six stations achieved a score of 100.

WAY FORWARD

- In 2021, EAD will study the impacts of Mirfa desalination plants on the marine environment with the collaboration of TMBS.
- Study the impact of sandstorms on the marine environment.
- Study the influence of MWQ on the bioaccumulation of heavy metals in the flora and fauna of Abu Dhabi waters.

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