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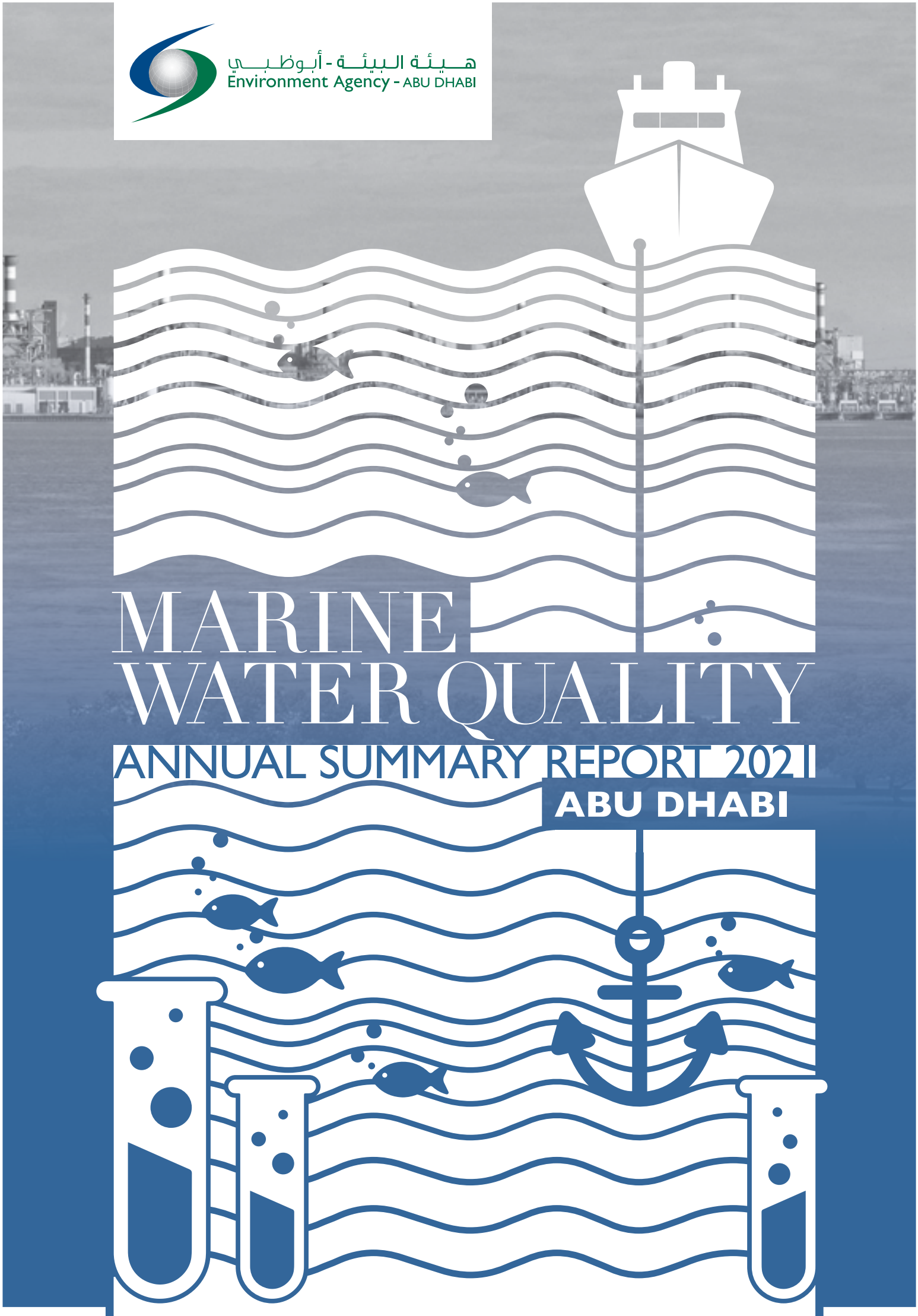
Environment Agency - ABU DHABI



MARINE WATER QUALITY

ANNUAL SUMMARY REPORT 2021

ABU DHABI

01

INTRODUCTION

1.1 BACKGROUND

The Marine Water Quality Monitoring Programme (MWQMP) of the Environmental Agency - Abu Dhabi (EAD) was initiated in 2006 with the goal of identifying the potential MWQ threats 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 natural events like climate change. The coastal waters have been exposed to pollutants, including nutrients, organic matter, heavy metals, microorganisms, pharmaceutical residues, and micronutrients.

EAD's MWQMP has collected ambient marine water quality data since 2006 to monitor the status of MWQ at various ecological important sites. During 2021, 22 sites come under 9 categories (including Reference) 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.

Long-term monitoring is important for not only assessing the quality of Abu Dhabi's waters but also allows for developing regulations, and 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 2021 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.

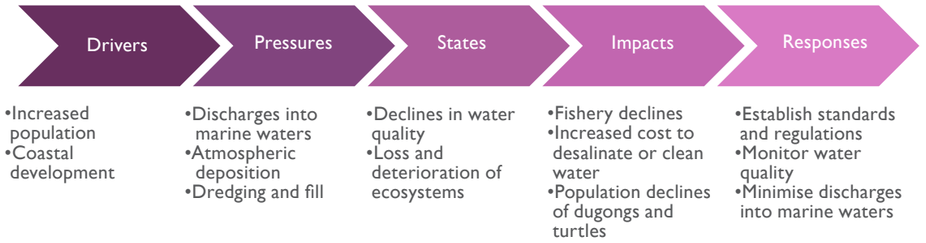


Figure 1. DPSIR model with examples relevant to Abu Dhabi.

The two major driving forces that apply pressure 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, microplastic and chemical contaminants including pharmaceuticals residues 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 freshwater 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 programme, and taking steps to minimise discharges into marine waters.

Impacts in Abu Dhabi waters include 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, which may result 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 produces harmful algal blooms (HAB).
- Some algal species produce toxins, which are harmful to human health and animals.
- HABs are responsible for mass mortalities of marine organisms and the closure of public beaches 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 bioaccumulate in fish eaten by humans.
- It affects the biological activities of marine organisms, including reproduction and growth.

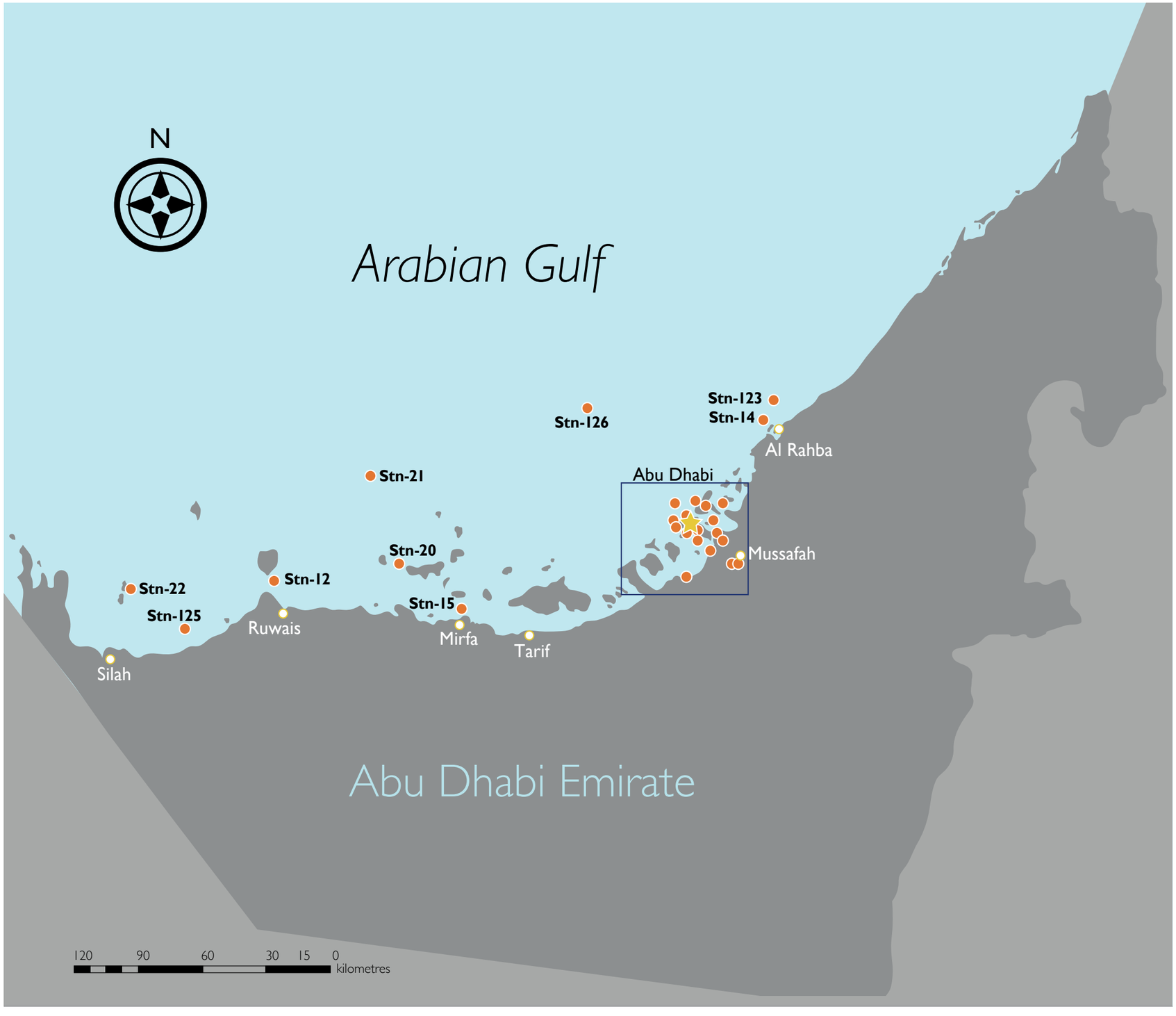
02 METHODS

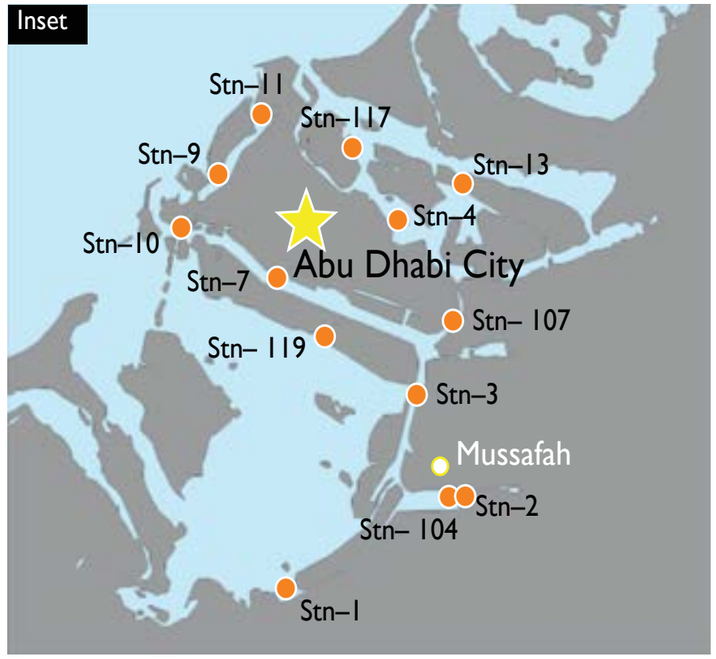
2.1 SAMPLING STATIONS

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 that occur near the sampling stations were used to group them into the following different categories:

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





Stations

Confined Areas
Stn-1 Al Salamiyah Channel
Stn-2 Mussafah South Channel
Stn-3 Mussafah Industrial Area
Stn-4 Mangrove Area - Eastern Corniche

Point Source
Stn-104 Mussafah South Channel-Outfall

Public Beaches
Stn-7 Bateen Beach
Stn-9 Corniche Beach
Stn-107 Fairmont Beach

Ports & Marinas
Stn-10 Intercontinental Jetty
Stn-11 Port Mina Zayed
Stn-12 Ruwais

Desalination Plants
Stn-13 Um Al Nar
Stn-14 Taweelah
Stn-15 Mirfa

MPAs
Stn-20 Marawah
Stn-21 Butinah
Stn-22 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 the Al Dhafra Region (i.e., Stations 12, 15–22, and 125) were monitored less frequently (quarterly).

2.3 MATERIALS AND METHODS

Water samples were collected and analysed by standard methods in Quality Conformity Council (QCC) approved Arab Centre for Engineering Studies (ACES) laboratory for nutrients, organic compounds, biochemical oxygen demand (BOD), total suspended solids (TSS), heavy metals, and fecal indicator bacteria (enterococci and fecal coliforms). Concurrently sediment samples were collected and analysed 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 16 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 2021 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 fecal indicator bacteria, enterococci, and fecal 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 sites for 28 water quality parameters and 11 sediment quality parameters. 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 variation between the stations was minimum except in confined areas and point sources.

The temperature values fluctuated along with the atmospheric temperature and ranged between 19.67 and 36.30 °C. Since the precipitation was less in Abu Dhabi, the fluctuation of salinity values was insignificant, and it varied between 32.96 and 48.13 ppt. The pH values were normal (7.59 - 8.74). The dissolved oxygen concentration was very low (hypoxic) in bottom waters of confined areas (0.29 mg/L) and high in surface waters of confined areas (9.84 mg/L) due to algal blooms. The chlorophyll values were normal in all stations except the confined areas where the values fluctuated between 0.13 µg/L (bottom waters) and 28.31 µg/L (surface waters). Water clarity was highest in reference and offshore western region stations.

Results from the 2021 sampling programme indicated that mean heavy metal concentrations in sediment appear relatively stable and elevated concentrations (copper, nickel & zinc) were recorded only in confined areas. Mercury was not detected in water or sediments.

Microbial pollutants were not detected in most samples collected in 2021, particularly at the stations outside of Abu Dhabi city.

Eutrophication Index

- In 2021, the eutrophication index annual mean score reached only 67 and indicated that the values were slightly lower than the recent past two years (2019 and 2020) but higher than in 2018.
- Overall comparison indicated 9 stations achieved good, among them three sites (Mirfa, Al Yasat and Intercontinental Jetty) maintain the values same and three sites showed higher values than 2020.
- The eutrophication values recorded in the Baraka area showed a decline in 2020 and 2021.
- For the seventh consecutive year, the Mussafah South Channel showed the lowest score.
- All the MPA stations except the Ras Ghanadah coral reef area achieved good eutrophication scores.
- Results from the 2021 sampling programme indicate that the mean concentrations of nutrients were marginally increased, and the eutrophic nature of the marine water quality was slightly declined than in previous years.

Microbial Index

- All 21 sites including the confined areas showed a Microbial score of 100 in 2021
- Scores improved and were maintained at all sites.

Heavy Metal Index

- The heavy metal scores were improved and showed an increasing trend.
- Except for confined areas such as Mussafah South Channel and Mussafah industrial area, all other sites reached a good heavy mental index score in 2021.
- At least 13 sited reached the heavy metal index score of 100 in 2021.

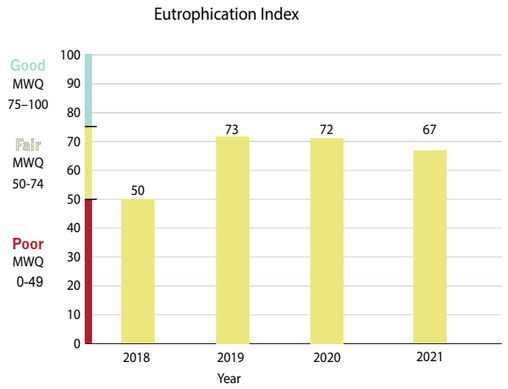


Figure 3. Bar graph of the Eutrophication index scores from 2018 to 2021

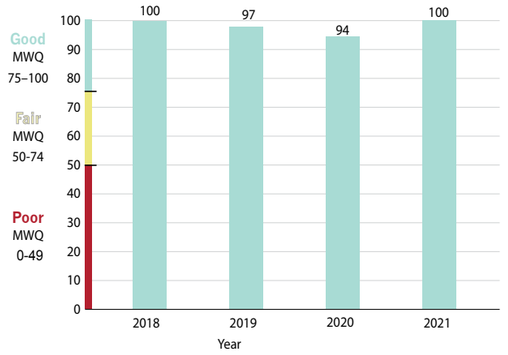


Figure 4. Bar graph of the Microbial index scores from 2018 to 2021

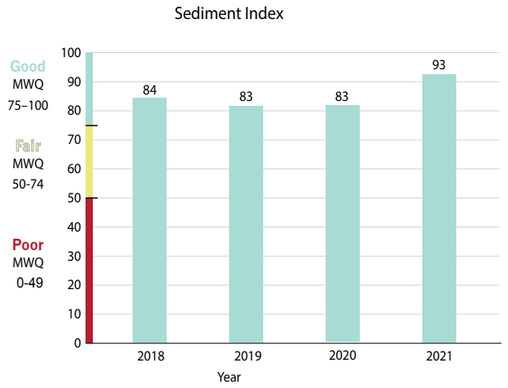


Figure 5. Bar graph of the Heavy Metals index scores from 2018 to 2021

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

Stations		Eutrophic				Microbial				Heavy Metal			
No.	Name	2018	2019	2020	2021	2018	2019	2020	2021	2018	2019	2020	2021
Confined Areas													
1	Al Salamiyah Channel	35	57	61	46	100	100	100	100	69	90	80	80
2	Mussafah South Channel	13	33	18	9	100	100	41	100	67	70	51	57
3	Mussafah Industrial Area	30	60	70	57	100	100	100	100	57	69	68	70
4	Mangrove Area - Eastern Corniche	33	62	59	57	100	100	100	100	90	89	90	100
Desalination Plants													
13	Um Al Nar	46	65	65	64	100	100	71	100	88	80	80	90
14	Taweela	56	76	88	76	100	100	71	100	80	88	100	100
15	Mirfah	51	88	88	88	100	100	100	100	90	90	100	100
MPAs/Natural Habitats													
20	Marawah	64	88	76	87	100	100	100	100	100	89	90	100
21	Butinah	70	100	88	76	100	100	100	100	100	89	100	100
22	Al Yasat	76	100	88	88	100	100	100	100	100	87	100	100
123	Ras Ghanadah	52	75	76	65	100	100	100	100	90	78	81	100
Newly Developed and Developing Areas													
117	Al Reem Island	51	76	88	76	100	100	100	100	88	79	81	100
119	Al Hudayriat Island	40	74	76	64	100	100	100	100	88	80	49	100
Nuclear Power Plant													
125	Barakah	74	100	88	63	100	100	100	100	80	83	100	100
Ports and Marinas													
10	Intercontinental Jetty	47	75	64	64	100	71	100	100	77	88	60	81
11	Port Mina Zayed	46	61	63	75	100	70	100	100	66	55	90	90
12	Ruwais	82	88	76	88	100	100	100	100	100	84	100	100
Public Beaches													
7	Al Bateen Beach	40	64	64	63	100	100	100	100	78	90	80	90
9	Corniche Beach	43	58	64	76	100	100	100	100	89	90	80	100
107	Fairmont Beach	43	63	75	63	100	100	100	100	78	88	81	90
Reference													
126	Reference	62	75	76	64	100	100	100	100	90	80	80	100

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 programme 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. The data generated in this system (MWQ Automation) has been used for the prediction of Marine Heat Waves (MHW) on the Abu Dhabi coast.

RED TIDE MONITORING

Red tide (Harmful Algal Blooms) occurs when phytoplankton species increase rapidly with deleterious effects on other marine organisms or humans. Although HABs may form because of natural conditions, severe eutrophic conditions also are favourable for the formation of HABs. Some HAB-causing species also produce toxins that may be harmful to other marine organisms and humans. HABs can cause fish kills and shellfish poisoning and can disrupt the normal operation of desalination plants by clogging seawater filtration systems.

Toxic and nuisance blooms may limit the recreational use of water. EAD's Red tide monitoring project has identified more than 250 species of phytoplankton in Abu Dhabi waters. Among them, nine species produce toxins, and 34 species form blooms and pose a growing risk to public health and desalination plant operations, respectively. The number of HABs in Abu Dhabi since 2002 is presented in Figures 6. Red tide outbreaks in the UAE have resulted in the loss of thousands of tonnes of fish, limited traditional fishery operations, damaged coral reefs, impacted coastal tourism, and forced the closure of desalination plants in the region. In Abu Dhabi waters the fish-kill incidents have been recorded in the South Mussafah Channel since 1998. The red tide monitoring and water quality analyses have routinely shown that the Mussafah South Channel is impacted by nutrient enrichment, low DO concentrations in bottom waters, and phytoplankton blooms throughout the year. These outbreaks have increased over the past decade and are likely associated in part with the eutrophic conditions caused by discharges into the marine environment; however, some of the increase shown overtime may be from increased monitoring. During the year 2021, there were 19 red tide incidents recorded in Abu Dhabi.

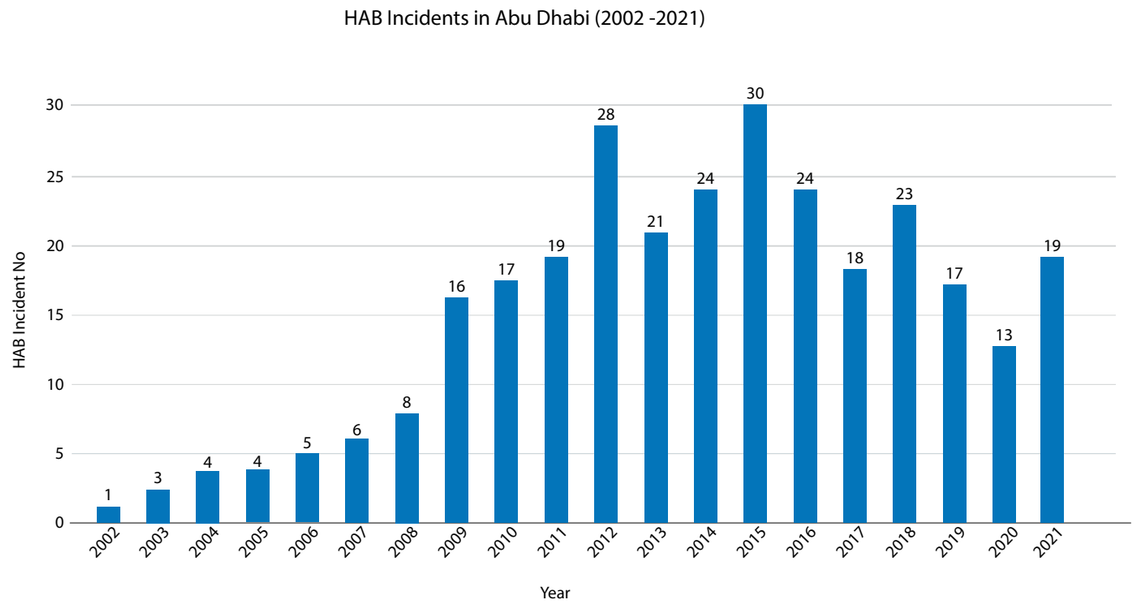


Figure: 6. HAB incidents recorded in Abu Dhabi waters

MWQ NETWORK REVIEW

To ensure that the MWQMP continues to meet the current and future needs of Abu Dhabi, comprehensive reviews of the monitoring stations, parameters, sampling protocols, and analysis methods are periodically conducted. The network reviews were performed in 2010 and 2015. In 2021, EAD completed the third review, which was designed to build upon knowledge gained over the past 5 years. This comprehensive review of the monthly MWQMP included reviewing and summarizing the international best practices for MWQ programme and conducting a statistical analysis of the temporal and spatial variabilities of the current monitoring programme.

Based on their requirement and need for additional water quality data for habitats, two sites have been included in the ongoing monitoring network, namely, a confined area (Mazoon Channel) and a newly developed area (Al Muneera). One of the survey stations under the port and marina group has been discontinued. The MWQ team will continue the programme with an analysis of the same number of parameters (seawater: 28 parameters; sediment 11 parameters) in the coming years. These changes optimise the MWQMP and ensure that it continues to regard the short-and long-term needs of both the public and marine life of Abu Dhabi.

MARINE HEAT WAVE MONITORING (MHW)

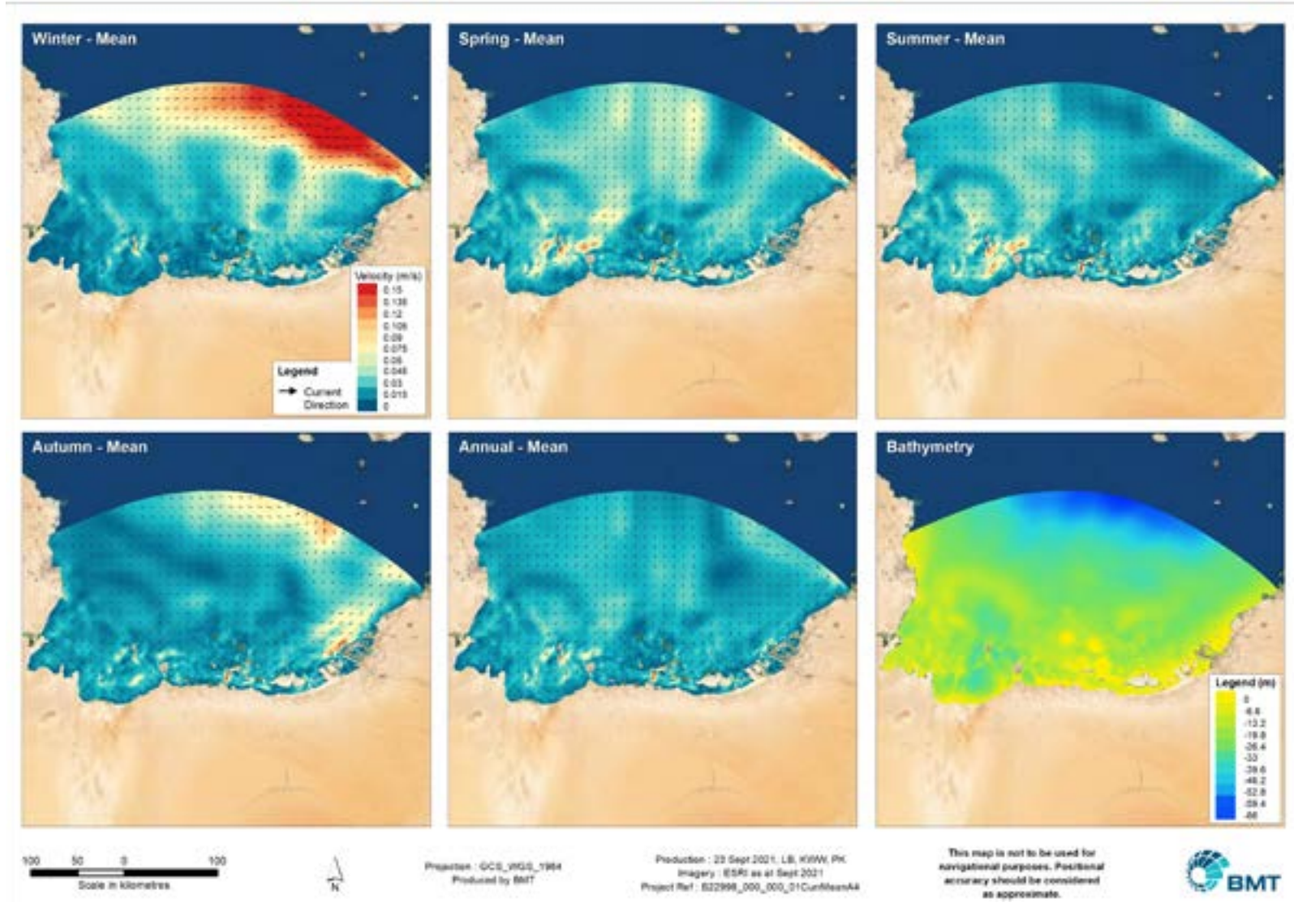
Marine heatwaves (MHW) are prolonged extreme oceanic warm water events. In recent years, MHWs have been observed around the world from open oceans to marginal seas and coastal regions, including the Arabian Gulf, particularly in Abu Dhabi waters. It has severe impacts on marine ecosystems and human society such as increasing fish mortality and coral bleaching, altered the habitats of seagrasses, corals, and fish, resulting in fish deaths and population structure. For the past two years, the EAD has been monitoring the marine heatwave (MHW) in Abu Dhabi waters. EAD discovered that the Abu Dhabi coastal waters have become the victim of the marine heatwave (MHW) in 2020 and 2021 and it has been continued for more than 15 days and created mass mortality of different species of fish along the coast.

In 2020 EAD recorded 148 tonnes of dead fish belonging to 15 species and during the year 2021 documented that 12.75 tons of fish belong to the same number of species. In addition, the MHW coincided with other unusual observations of sea turtle (Green turtle) mortalities and deposition of dead seagrass and macroalgae along the coast outside their normal range. Since these marine heatwaves are already affecting many ecosystems causing species range shifts, reproductive failure, growth implications, and increased mortalities in marine species mass coral bleaching, the EAD marine water quality team develops proactive responses through continued MHW monitoring.

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 the commercial, strategic, and industrial type of activities, this tool will help determine the source of pollutants and forecast the impacts of any coastal activities. During the year 2021, due to COVID-19, the Environmental Modelling Team participated in a series of online workshops for the Hydrodynamic and Water Quality Modelling (HWQM) Capacity Building Project (CBP), marking the completion of the training programme where EAD staff have been trained in the use of purpose-built numerical modeling tools to proactively manage the precious marine environment of the Abu Dhabi emirate. The capacity-building workflow comprised a series of workshops, assignments, and tutorials to develop advanced knowledge and understanding of the use of hydrodynamic and water quality model case studies used to access the impacts of a range of conceptualised scenarios. Workshop sessions were conducted in an interactive format to guide and inform understanding of the limitations in modeling, realistic outcomes, and scenario conceptualisation. The initial sessions guided the participants through the development of a series of 3D model case studies, exploring the limitations and assumptions of the software and modeling process to expand on the conceptual models developed during the initial stages of the CBP. Workshop participants were then asked to develop conceptual scenarios for the Mussafah Channel case study designed to predict environmental response to proposed solutions to long-term water quality issues in the region.

The final series of workshops provided the skills needed to interrogate and view results both from direct model output and processed model results. Hands-on training utilising the TUFLOW FV viewer plugin with QGIS guided the participants to undertake model assessments within the areas of interest, delving into a range of methods to view results such as depth average time series at a point, curtain graphs, and domain maps of modelled parameters. Results for the water quality scenario modelling were presented in a range of percentile maps that could be interrogated by participants to engage, developing an understanding of the results and limitations of 3D modelling of a complex coastal system. The interactive sessions enabled participants to be involved in model design and conceptual scenario development and thus learn of both the usefulness and limitations of hydrodynamic and water quality models in supporting the digitisation of environmental impact assessment. In addition, three scientific papers related to the Abu Dhabi marine environment are planned for publication in 2022.



IMPACT OF DESALINATION PLANT ON MARINE ENVIRONMENT

For the past few decades, the number of desalination plants is increasing globally and there are nearly 200 desalination plants located in more than 150 countries. Among them, 50 % are in West Asia and Abu Dhabi has been using more than 20 desalination plants for its drinking water purpose. During the process, these desalination plants discharge a huge amount of brine and other chemicals into the marine environment, and it affects the marine environment including biodiversity in many ways. The high salinity of the brine discharge with high temperature negatively influences the marine organisms on their species development, and reproduction, including breeding and survival of eggs and larva. Since there is no detailed study available in Abu Dhabi waters, the present project intends to investigate the impact of the desalination plants on the marine environment including marine water quality, habitat, and biodiversity to prevent and mitigate the impacts by using modern scientific methods and state of art technology based on location-specific studies. The first comprehensive survey was completed in December 2021, it included marine water quality, phytoplankton, zooplankton, fish eggs and larvae, macrobenthic organisms, habitat, and seagrass distribution.

06

MARINE WATER QUALITY REGULATIONS

In 2021, the Marine Water Quality Regulation was officially endorsed and published in the Official Gazette of Abu Dhabi Emirate. EAD developed the regulation in close cooperation and consultation with all stakeholders. The regulation aims 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 started in 2021 implementing requirements of the regulation, the permitting and enforcement processes were updated as per the new requirements of the regulation. In addition, other governmental entities in Abu Dhabi took initiatives to implement the regulation (e.g. smart city project for stormwater network by DMT; developing the regulatory framework for the maritime sector by Abu Dhabi Maritime; and developing the TSE criteria for reuse in agricultural and irrigation activities by ADAFSA).

TECHNICAL GUIDANCE DOCUMENT FOR SAMPLING, TESTING, RECORDKEEPING AND REPORTING REQUIREMENTS OF DISCHARGES TO MARINE

In 2021, EAD developed a technical guidance document (TGD) to streamline and harmonise the process of sampling and testing of discharges to the marine environment, as well as recordkeeping and reporting requirements to EAD. The purpose of this TGD is to provide guidance for the following:

1) Assist project proponents in the development of sampling and testing plans for discharges to the marine environment.

2) Provide guidance on the quality assurance/quality control (QA/QC) requirements during sampling and testing activities.

3) Familiarise proponents with EAD requirements for recordkeeping and reporting.

The objectives of discharge quality monitoring are to minimise the impact of the project on the environment and ensure compliance with all applicable laws and regulations. As the competent authority, EAD reviews and evaluates data received from proponents to ensure compliance to permitting and other regulatory requirements.

07

CONCLUSION

The result of the 2021 MWQ monitoring programme reveals that the marine water quality in Abu Dhabi is improving. The microbial index reached 100 in all sampling sites and meets public health criteria for swimming and other recreational activities. The sediment index also reached good in the majority of the sites (90.4 %). However, the eutrophication index was marginally decreased compared to 2020 but improved than in 2018. Result of this eutrophic condition, the harmful algal bloom (HAB) incidents increased this year.

WAY FORWARD

- In 2022, EAD will study the impacts of Mirfa desalination plants on the marine environment with the collaboration of terrestrial and marine biodiversity sector (TMBS).

- Study the impact of sandstorms on the marine environment.

- Monitoring the impact of the heatwave in Abu Dhabi waters.

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