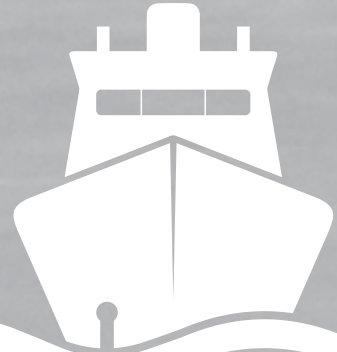




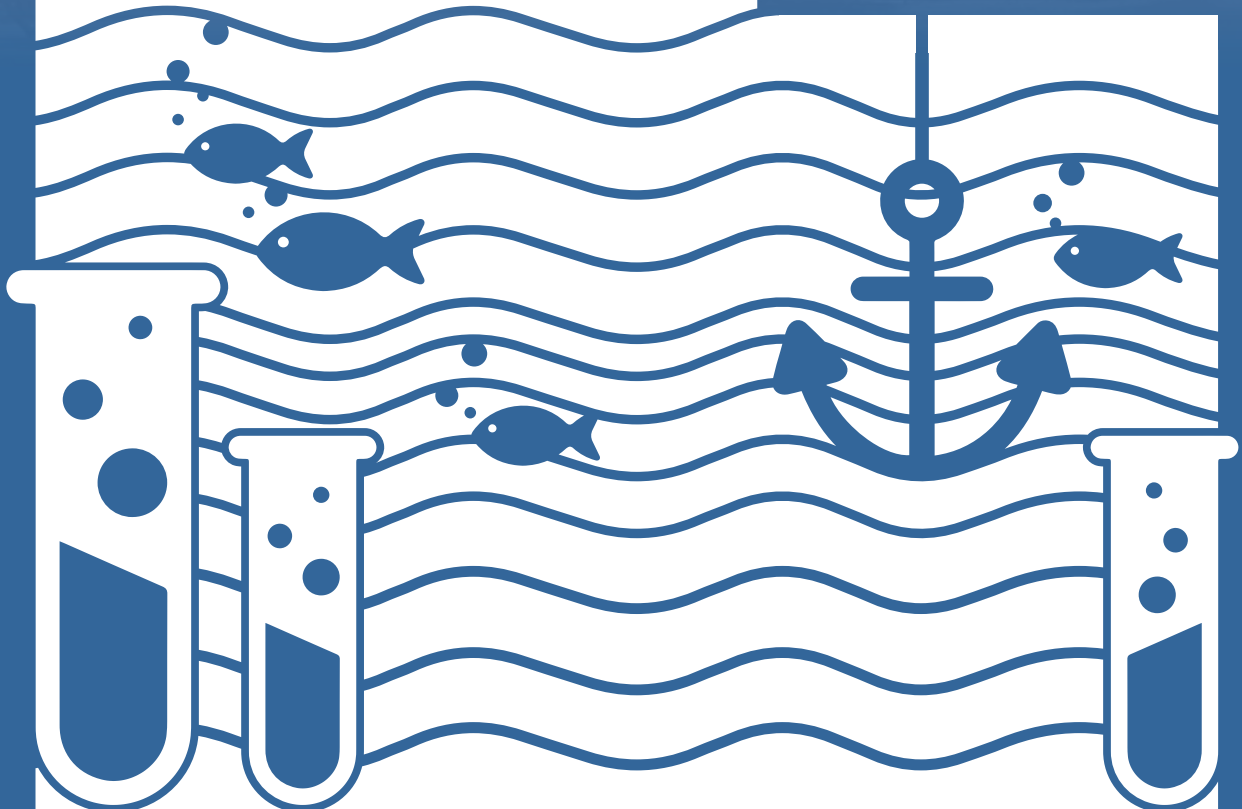
هيئة البيئة - أبوظبي
Environment Agency - ABU DHABI



MARINE WATER QUALITY

ANNUAL SUMMARY REPORT 2023

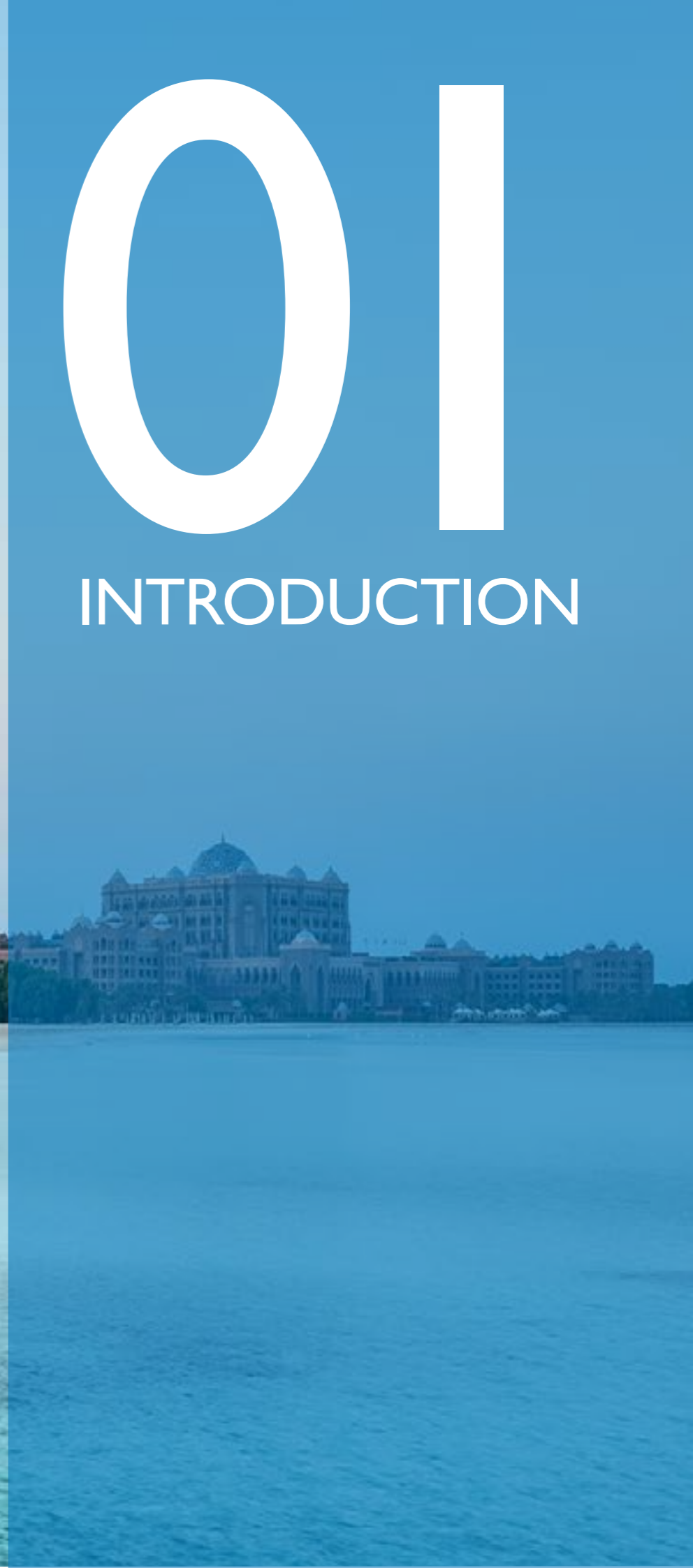
ABU DHABI





01

INTRODUCTION





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.

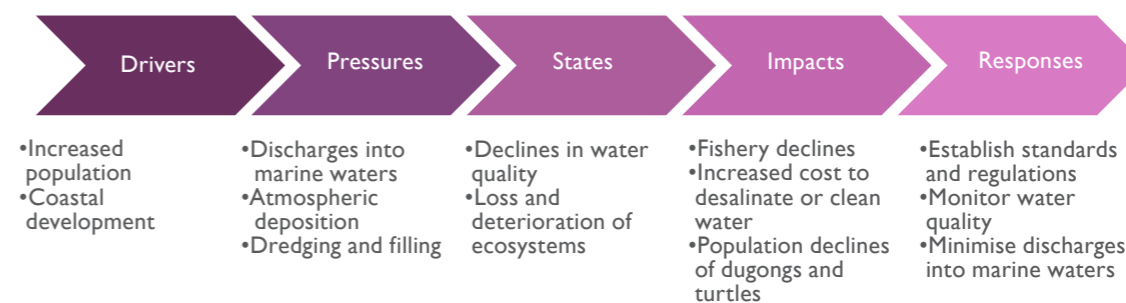


Figure 1. DPSIR model with examples relevant to Abu Dhabi.

1.1 BACKGROUND

The Marine Water Quality Monitoring Program (MWQMP) of the Environment Agency– Abu Dhabi (EAD) was launched with the aim of identifying potential threats to marine water quality and developing measures to ensure that the coastal waters remain safe and healthy for people, plants, and animals. The marine environment of Abu Dhabi faces significant challenges due to aspects such as urbanization, industrialization, tourism and other anthropogenic activities. These pressures have led to the exposure of coastal waters to various pollutants, including nutrients, organic matter, heavy metals, and microorganisms.

EAD began its Marine Water Quality Monitoring Program in 2006, which entails the collection of ambient marine water quality data to assess the health of Abu Dhabi’s coastal waters. In 2023, monitoring was conducted at 23 sites, and EAD had expanded the program in August 2023 by adding 20 new sites for assessment and enhancement of EAD operations by a consultancy. Marine water quality data from these sites will be collected until August 2024. The data from these sites will be analyzed by the consultancy as part of a monitoring network review aimed at improving the representation of the quality of the territorial waters of Abu Dhabi.

The consultancy will develop enhanced site selection criteria and index calculation methods, and review key monitored parameters. Marine water quality data collected by EAD provides valuable insight into various water quality factors, including microbial pollutants and heavy metals, while revealing long-term trends. Continuous monitoring is vital for assessing the condition of the marine waters of Abu Dhabi and shaping regulations, policies, and strategies to protect marine resources and public health. This summary report outlines key findings from the monitoring conducted on the main 23 sites in 2023, providing a detailed overview of the status of the marine environment.

The two major driving forces that apply pressures on Abu Dhabi’s marine environment are human population growth and 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 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, enhancing the marine monitoring program, and taking steps to minimize discharges into marine waters.

Impacts in Abu Dhabi include effects on marine biotic communities and public health due to rising eutrophication in the marine environment, which leads to harmful algal blooms (HABs). In addition, an increase in pollutants from heavy metals and bacterial contamination, affect marine ecosystems due to water and sediment contamination. Changes to water quality result in increased costs of desalination and water treatment. In response, the Environment Agency–Abu Dhabi (EAD) and other organizations monitor the situation and implement regulations to safeguard water quality.

EFFECTS OF EUTROPHICATION

- Caused by an excessive amount of nutrients (mainly nitrogen and phosphorous) 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 generate fish kills and mass mortality of Marine organisms.

EFFECTS OF HARMFUL ALGAL BLOOMS

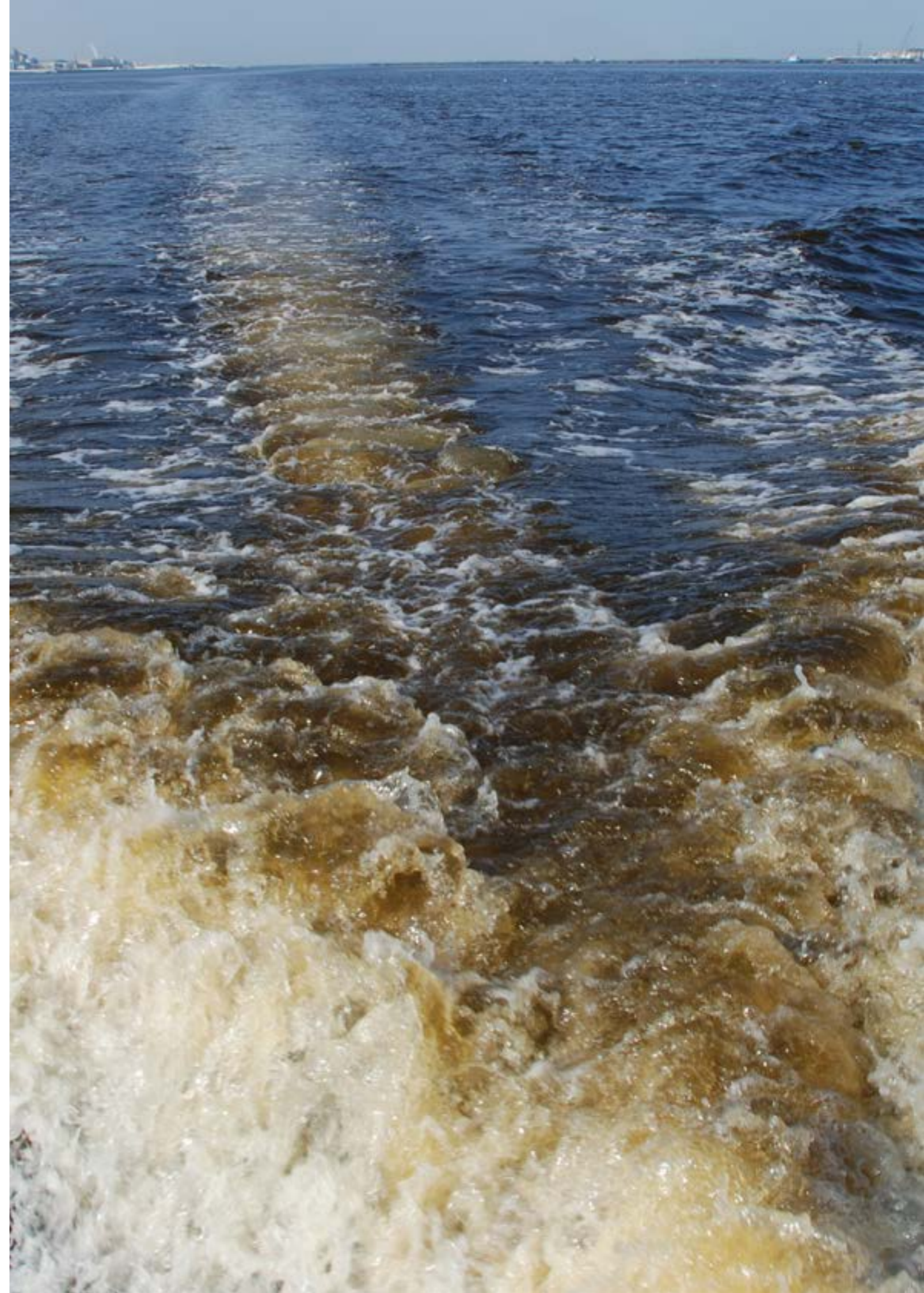
- When the environment is suitable, the phytoplankton proliferate and produce harmful algal blooms (HAB).
- Some algal species produce toxins, which are harmful to human health and animals.
- HABs are responsible for mass mortalities of marine organisms and closure of public beaches and desalination plants in Abu Dhabi.

EFFECTS OF 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.

IMPACT OF CONTAMINATION IN MARINE SEDIMENTS

- Marine sediments serve as a sink for heavy metal pollutants, making them a significant component within the monitoring program. Sediments have the ability to accumulate and assimilate heavy metals even from low concentration in the overlying water column. Contaminants in sediments are an indication of water quality contamination.
- Contaminated sediments expose marine organisms to harmful substances, which can lead to poisoning, impaired growth and reproduction, and biomagnification up the food chain.
- Contaminants degrade sediment quality, altering habitat structure and nutrient availability, which affects benthic organisms and overall ecosystem health.
- Human health is threatened when contaminants bio-accumulate in fish ingested by humans.





02

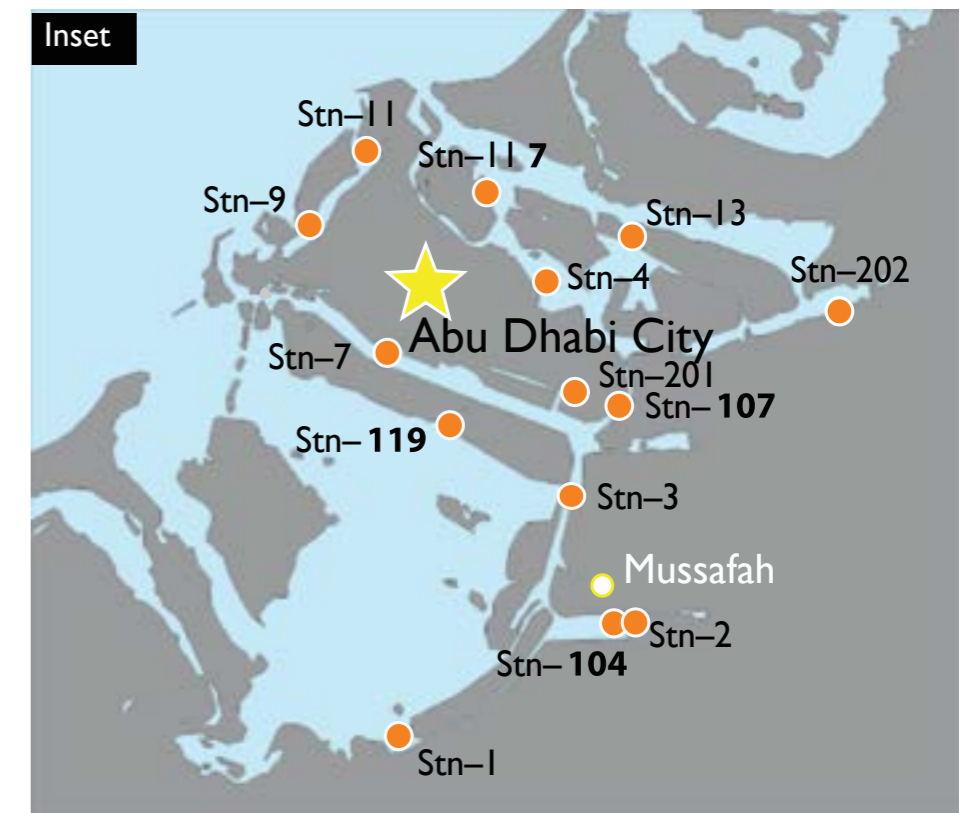
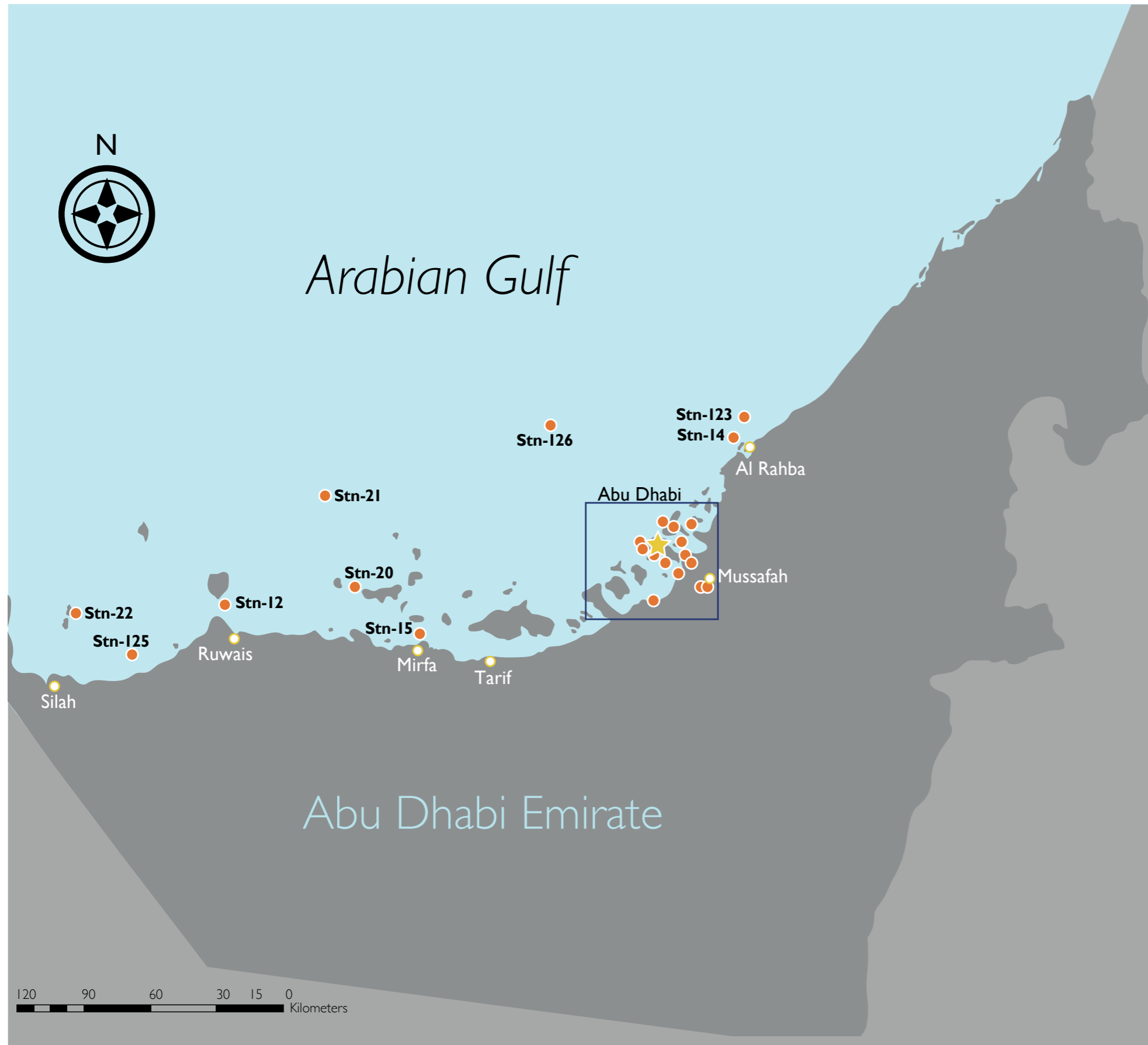
METHODS

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**.

In 2023, sampling was conducted across a total of 23 locations, with 17 sites in Abu Dhabi city and 6 sites in Al Dhafra. EAD has categorized the monitored sites in Abu Dhabi into the following:

- Confined Areas
- Public Beaches
- Ports and Marinas
- Point Source
- Desalination Plants
- 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-201 Al Muzoon channel

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-11 Port Mina Zayed
- Stn-12 Ruwais

Desalination Plants

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

MPAs

- Stn-4 Mangrove Area - Eastern Corniche
- 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
- Stn-202 Al Muneera channel

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

All locations along Abu Dhabi City coastal areas were sampled monthly, except for areas considered natural habitats and areas in the Al Dhafra Region, which are sampled quarterly.

2.3 MATERIALS AND METHODS

Water samples were collected and analyzed using standard methods at the Arab Centre for Engineering Studies (ACES) facilities, a Quality Conformity Council-approved laboratory. The analysis included 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 analyzed for heavy metals. Along with the MWQ samples, observations of weather, wind, and water appearance (e.g., color, odor, tide) were recorded.



03

DATA ANALYSIS

Continuous monitoring of Abu Dhabi's waters over the past 17 years has provided critical data that was used to characterize the physical, chemical, and microbial conditions in the marine environment. Descriptive statistical analysis was made in 2023 to assess 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) methodology (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 marine water quality:

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

PROGRAM RESULTS

EAD monitored 23 stations, assessing 28 water quality parameters and 11 sediment quality parameters. The 2023 sampling program revealed an increase in the mean concentrations of nutrients with a decline in the eutrophic conditions of marine waters compared to the previous year.

Key water quality indicators such as temperature, salinity, pH, and dissolved oxygen were measured using in-situ instruments. Variations between stations were minimal, except in confined areas and areas adjacent to point sources. Temperature values fluctuated with atmospheric conditions, ranging from 20.49°C to 39.07°C. Due to limited precipitation in Abu Dhabi, salinity fluctuations were insignificant, with values between 39.05 and 50.13 ppt. The pH values ranged between 6.86 and 8.53. Dissolved oxygen concentrations were notably low in the bottom waters of confined areas (2.98 mg/L) and significantly higher in surface waters of these areas (13.68 mg/L) due to the presence of algal blooms. Chlorophyll levels remained normal across most stations, except in confined areas, where they fluctuated between 0.38 µg/L (surface waters) and 91.07 µg/L (surface waters). Water clarity was highest at reference and offshore stations in the Al Dhafra Region.

Heavy metal concentrations in sediments were relatively stable, with elevated levels recorded only in confined areas. Mercury was not detected in either water or sediments.

Microbial pollutants were absent from most samples collected in 2023, particularly at stations outside of Abu Dhabi City. Although confined areas showed occasional detections, the values remained within standard limits.





05

SPECIAL PROGRAMS

MARINE WATER QUALITY AUTOMATION

Since 2006, EAD has operated a marine water quality monitoring program in Abu Dhabi's coastal waters to help achieve its goals of protecting public health and the environment. In 2014, EAD enhanced the program by introducing an automated marine water monitoring system, starting with the deployment of three buoys. The network was further expanded in 2016 with the addition of eight more buoys, currently the network consists of 10 stations. These stations continuously monitor marine water quality in real-time at ecologically important and sensitive locations, including confined areas, beaches, critical marine habitats (such as coral reefs, seagrass beds, and mangroves), newly developed areas, and the nuclear power plant area.

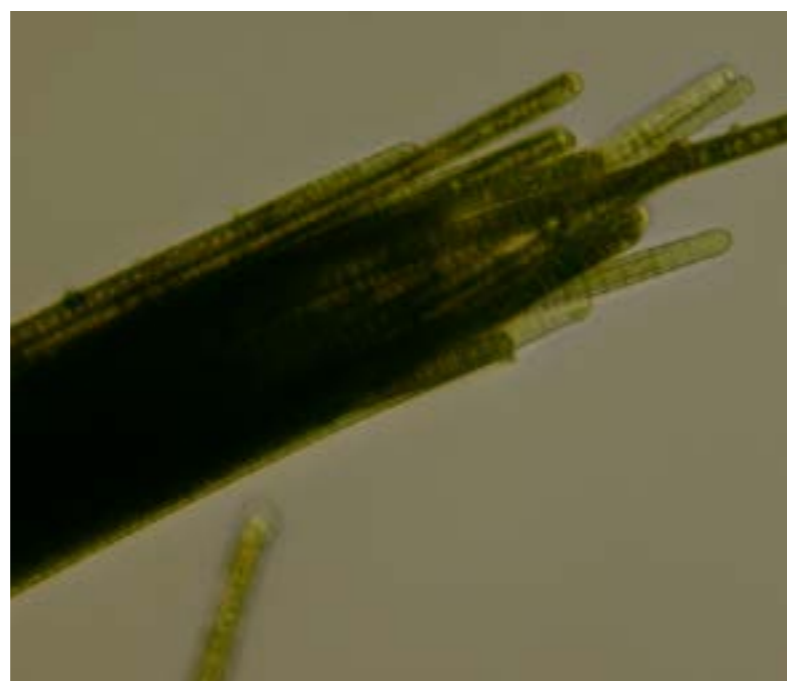
The buoys measure seven key marine water quality parameters—salinity, conductivity, temperature, pH, dissolved oxygen, chlorophyll, and cyanobacteria—every 15 minutes and transmit the data to EAD's central database every hour. This real-time monitoring enables the program to detect immediate changes, functioning as an early warning system for harmful algal blooms (HABs) and other water quality issues.





ALGAL BLOOM INCIDENT REPORTING

Algal blooms occur when phytoplankton species rapidly increase, often with harmful effects on other marine organisms or humans. While harmful algal blooms (HABs) can form due to natural conditions, severe eutrophic environments also create favorable conditions for their development. Some HAB-causing species produce toxins that can be dangerous to marine life and humans. HABs can lead to fish kills, shellfish poisoning, and disruptions in desalination plant operations by clogging seawater filtration systems. The number of HAB incidents in Abu Dhabi since 2002 is shown in **Figure 6**.



Routine monitoring of algal blooms and water quality has consistently shown that the Mussafah South Channel is impacted by nutrient enrichment, low dissolved oxygen concentrations in bottom waters, and year-round phytoplankton blooms. These outbreaks have increased over the past decade, likely driven in part by eutrophic conditions resulting from discharges into the marine environment. However, some of the increase in numbers recorded may also be attributed to improved monitoring efforts. In 2023, 23 algal bloom incidents were recorded in Abu Dhabi.

One Red Tide incident was recorded at Raha Beach in April 2023, which was caused by a species called *-Pseudo nitzschia multistriata* which releases the toxin domoic acid.

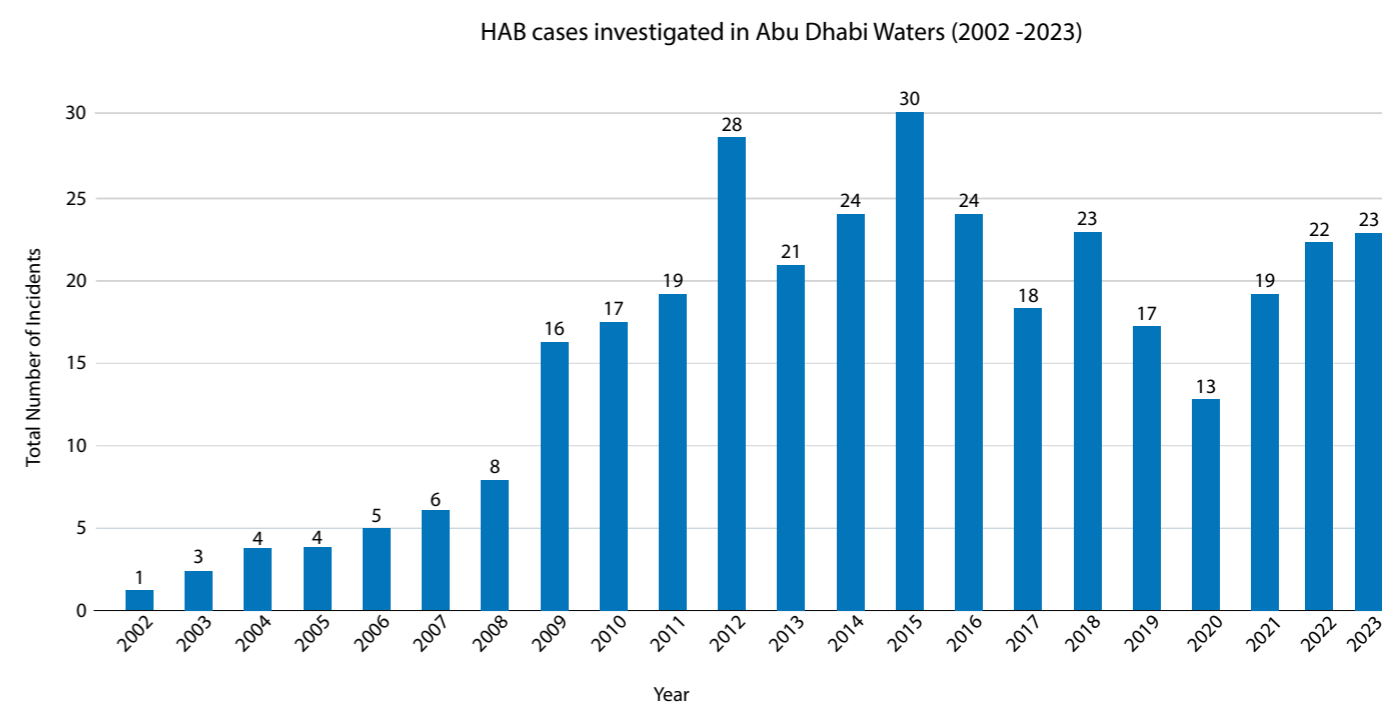


Figure 6. HAB cases investigated in Abu Dhabi Waters

MARINE WATER QUALITY NETWORK REVIEW

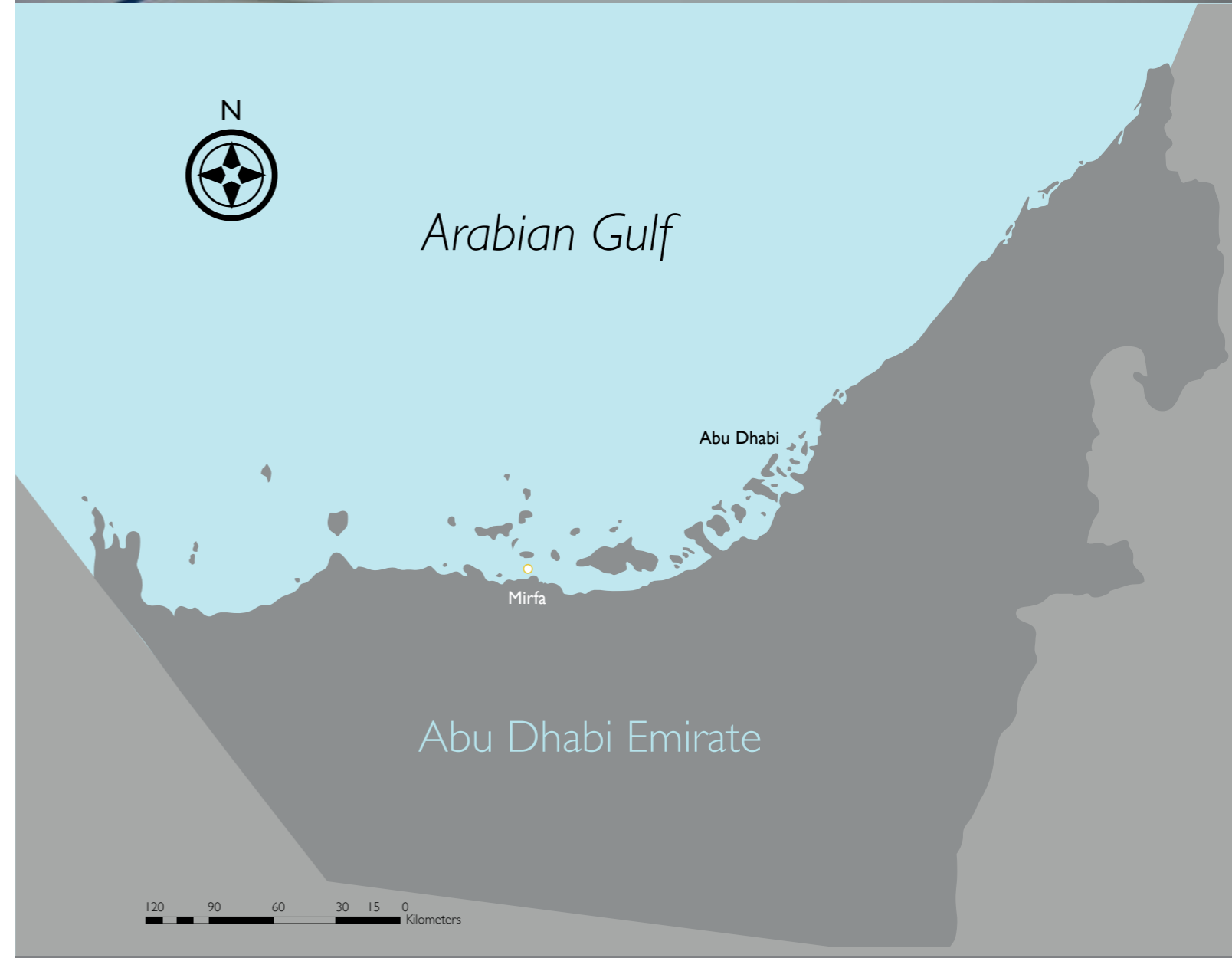
To ensure that the Marine Water Quality Monitoring Program continues to address the current and future needs of Abu Dhabi, comprehensive reviews of the monitoring stations, parameters, sampling protocols, and analysis methods are periodically conducted. In 2023, the MWQMP underwent a thorough review, which included incorporating international best practices for marine water quality programs and conducting a statistical analysis of the temporal and spatial variations within the existing monitoring framework.

As a result of this review, and in response to the need for additional water quality data for critical habitats, 20 new sites have been selected to be added to the ongoing monitoring network, with the addition of new categories such as aquaculture activities. These newly added sites will be monitored for one year, to capture data for an assessment and enhancement of the program by a consultancy in 2025. 46 parameters in total were also analyzed for this purpose (34 for seawater and 12 for sediment). The monitoring network will be reviewed in 2025 to better reflect the environmental conditions of Abu Dhabi.

IMPACT OF DESALINATION PLANTS ON MARINE

For the past few decades, the number of desalination plants is increasing globally and there are around 200 desalination plants located in more than 150 countries. Among them, 50% are in West Asia and Abu Dhabi has been operating more than 20 desalination plants for its drinking water purpose. During the desalination process, these plants discharge a large amount of brine and other chemicals into the marine environment, affecting the marine environment and its biodiversity in many ways. The high salinity of the brine discharge with high temperature negatively influences the marine organisms in their development, and reproduction including breeding and survival of eggs and larva. Since there is no detailed study available in Abu Dhabi waters on the ecological impact, The Environment Agency – Abu Dhabi (EAD) commissioned HydroQual ASA to conduct a three-year ecological assessment adjacent to the Mirfa Desalination Plant, focusing on the plant's impact on the marine environment.

The study, conducted from 2021 to 2023 with quarterly sampling at seven sites, analyzed various biological and chemical parameters. In situ measurements revealed expected seasonal variations, but salinity and chlorophyll-a levels were notably high near the discharge site. Chemical analyses showed most parameters within standard limits except for Chromium, Copper, Lead, Manganese, Nickel, Mercury, and Chromium and Nickel in sediment during 2022 and 2023. Microbial parameters were undetectable, while plankton and benthic surveys identified numerous species, with notable changes in seagrass coverage. The study highlights concern about elevated salinity, chemical exceedances, and ecological variations, recommending continued monitoring for at least five more years to better understand the long-term impacts and inform mitigation measures.





MICROPLASTIC ASSESSMENT PROJECT

Microplastic is a pollutant present in the marine environment across the globe. These are plastic particles less than five millimeters in size and are widely dispersed in the water column, on beaches and on the seabed. These particles are harmful to marine life, and can also accumulate in marine food chains, posing a potential risk to human health. The UAE has recognized the issue of pollution from plastic and has taken several measures to reduce plastic waste, including implementing a ban on single-use plastics. The volume of plastic material used has increased with a growing population and an increasingly industrialized society. There are multiple routes of entry of plastics into the ocean, and ocean currents have transported plastics to other regions. These small pieces of plastic are thought to enter the ocean through liquid discharges, plastic waste, or through dispersion into the atmosphere and its entrance into the ocean.

To further understand the extent of microplastic contamination in Abu Dhabi Emirate, the Environment Agency – Abu Dhabi (EAD) has initiated a microplastic assessment project for the marine environment in 2022 and will continue until 2025. EAD performed a pilot survey on marine water in 2022, undertaken by EAD's marine team who operated onboard EAD research vessel 'Jaywun'. A comprehensive survey on Abu Dhabi waters and sediment to measure microplastic content has begun in October 2023. 32 sites have been strategically selected for biota sampling, and marine water and sediment sampling. Water and sediment samples have and continue to be collected from sites which include confined areas, developed areas, desalination plant discharge areas, ports and marinas, and offshore islands. EAD has collaborated with QCC for analysis of all samples. Assessment by EAD has started to illuminate the extent of microplastic pollution.

EXPANDING MONITORING NETWORK BY ENGAGING STAKEHOLDERS

EAD has expanded marine water quality monitored coverage through stakeholder engagement through the incorporation of data from the Department of Municipalities and Transport (DMT), Abu Dhabi Ports, and ADNOC (and are periodically provided) into EAD's database. Data is received from 10 ADNOC sampling stations, 15 DMT tidal stations, and 3 AD Port marine buoys. EAD initiated the project to optimize resource utilization, to integrate efforts among all strategic partners in the emirate, and to connect all available marine water quality monitoring programs and improve decision making. This enhanced coverage will tackle challenges such as pollution from marine dredging, backfilling operations, and harmful discharges into the marine environment. The geographical distribution of the monitoring network has now expanded to cover 82.3% (using the economic zone boundary calculation) of Abu Dhabi waters exceeding the targeted percentage of EAD's strategy by 7.3%. The project will support the evaluation of EAD's marine quality monitoring program to add new standards or new monitoring sites in the future.



07

CONCLUSION

The results of the 2023 Marine Water Quality (MWQ) monitoring program indicate that the overall quality of Abu Dhabi's marine waters is generally good. Recreational waters meet public health standards for swimming and other activities. However, it is important to note that the eutrophication index has slightly declined from (73), with the annual mean value now categorized as "Fair" (64). As a result of these eutrophic conditions, there has been an upward trend in algal bloom (HAB) incidents.

WAY FORWARD

- Assessment and Improvement of EAD Marine Water Quality Network.
- Spatial Survey of Marine Water, Sediment Quality, and Marine Debris in Abu Dhabi.
- Microplastic Assessment in biota, sea water and sediment – Phase - study.
- Utilising remote sensing technology for pollution tracking.
- To apply new technologies and innovative solution for algal bloom affected area.
- Develop an Abu Dhabi emirate hydrodynamic model.





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