ROPME POLICY BRIEF

# MARINE CLIMATE CHANGE IMPACTS IN THE ROPME SEA AREA

## KEY MESSAGES

Climate change is increasingly affecting the ROPME Sea Area (RSA), which already experiences environmental extremes and is one of the world's warmest seas.

Increases in temperature and salinity, reduced oxygen and ocean acidification are being observed in the RSA, along with a rising sea-level. The risk of cyclones in the Middle and Outer RSA could also be increasing. Changes in these conditions are expected to accelerate in the future, with far-reaching consequences for biodiversity and society.

Climate change and other human impacts are causing extensive degradation and loss of habitats, such as coral reefs, mangroves, saltmarshes and seagrasses leading to declines in the species and services they support (food, water quality, carbon storage, recreation and coastal protection).

Phytoplankton, the microscopic algae that are the basis of the marine food web, could decline in abundance, with negative impacts on important fish stocks.

Coastal settlements and infrastructure are highly vulnerable to sea-level rise, flooding, erosion, storms and cyclones, and the risk of major damage is increasing. Future changes in storm and wave conditions could affect offshore activities, including fishing, oil and gas extraction and shipping.

Potential increases in jellyfish and harmful algae could disrupt operations at desalination plants and other coastal industries, and potentially affect human health.

# INTRODUCTION

Climate change is increasingly impacting the ROPME Sea Area (RSA), which already experiences environmental extremes and is one of the world's warmest sea areas. However, the RSA remains relatively understudied compared to other regions of the world. This Policy Brief synthesizes and translates findings from a comprehensive review of marine climate change impacts in the RSA.

For the first time, the effects of climate change on coastal and marine environments of the RSA are summarised in one place. This includes impacts on ecosystems, infrastructure and people. Understanding these impacts is critical to support evidence-based decision making in the Region.

The effects of climate change do not recognise national boundaries. These headline messages can help ROPME and its Member States develop joint responses to marine climate change impacts in the RSA.

## WHAT IS ROPME AND WHAT AREA DOES IT COVER?

The Regional Organization for the Protection of the Marine Environment (ROPME) was established in 1979 to coordinate efforts of the eight Member States towards protecting marine and coastal ecosystems. The eight ROPME Member States are Bahrain, Iran, Iraq, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates.

The ROPME Sea Area (RSA) can be divided into three distinct zones, the Inner, Middle and Outer ROPME Sea Area, which vary in terms of their physical characteristics and vulnerability to climate change impacts.




**THE INNER ROPME SEA AREA** is a shallow, semi enclosed sea with an average depth of 38 m. The profile of the seafloor across the Inner RSA is asymmetrical, with shallower slopes on the southwest shore and steeper slopes alongside the coast of Iran. Sea surface temperature and salinity vary significantly by location and season. Average sea surface temperatures range from 13 to 35°C and salinity from 36 to 70 practical salinity units.

**THE MIDDLE ROPME SEA AREA** is a deep sea that extends for almost 400 km and connects the Indian Ocean with the Inner ROPME Sea Area through the shallow and narrow Strait of Hormuz. It is partially affected by the northern Indian Ocean monsoons, but the effect diminishes with increasing distance from the Indian Ocean. Average sea surface temperatures range from 22 to 32°C.

**THE OUTER ROPME SEA AREA** is in the northern part of the Indian Ocean and has a monsoonal climate. The summer monsoon (June to September) produces strong seasonal upwelling events along the southeast coast of the Arabian Peninsula. Average sea surface temperatures range from 22 to 26°C. Water depth reaches more than 1000 m on the oceanic fringe of the Outer RSA.

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# SOURCES OF INFORMATION

This analysis has drawn on a variety of sources, including peer review scientific journals, scientific and technical reports, book chapters, monitoring datasets, Intergovernmental Panel on Climate Change (IPCC) outputs, and public media. Five decades worth of data and information have been compiled and interpreted through a combination of quantitative and qualitative analyses.

The types of information sources used to characterise each of the impacts in this document include observed impacts as well as future projections, according to the following geographical scales: Site-based Monitoring, Local Climate Impact Studies, and Regional and Global Studies.

## REGULAR MONITORING

Time-series of local data collected for monitoring status and trends in ecosystem components. This information can be used to identify climate change impacts.

**EXAMPLE:** Four-year time-series of pH monitoring in the Inner RSA.

## REGIONAL STUDIES

Monitoring or research studies from across the RSA and wider region (e.g. Middle East or Northern Indian Ocean).

**EXAMPLE:** Studies of future habitat suitability across the Inner RSA or tropical cyclonic activity over the northern Indian Ocean.

## LOCAL CLIMATE IMPACT STUDIES

Research studies conducted by ROPME States that provide information and understanding on the impact of climate change on ecosystem components or human activities.

**EXAMPLE:** Local modelling studies on observed and projected trends in temperature, salinity and sea-level within the Inner RSA.

## GLOBAL STUDIES

Studies conducted internationally that identify trends that can be used to broadly evaluate and interpret ecosystem components. For some topics, a lack of local or Regional studies mean climate change impacts in the RSA can only be inferred from global studies.

**EXAMPLE:** IPCC assessments based on global climate models.



## ROPME REGIONAL ACTION PLAN

In 2019 ROPME launched a 3-year Regional Action Plan on Marine Climate Change Risk Assessment, Adaptation and Mitigation for the RSA. The Regional Action Plan is designed to establish a consolidated Regional evidence base on marine climate change impacts and adaptation options across the RSA. It also identifies best practice for the management of blue carbon habitats, which helps mitigate climate change.

The outputs of the Regional Action Plan can be used to help ROPME Member States fulfil their commitments to the United Nations Framework Convention on Climate Change (UNFCCC), and other international agreements including the UN Convention on Biological Diversity and UN Sustainable Development Goals.

The UNFCCC requires that all signatory countries report regularly on how they are addressing climate change by publishing Nationally Determined Contributions (NDCs) documents. These NDCs provide an update on countries' efforts to adapt to the consequences of climate change and reduce national emissions.

This analysis, and the accompanying technical report, are intended to support ROPME Member States to identify priority impacts that could be the focus of adaptation actions.

# MARINE ENVIRONMENT

This section outlines how climate change is affecting physical and chemical conditions in the RSA. This includes how conditions have changed in the past, and how they are anticipated to change in the future.

There are few high-resolution projections that cover the RSA, although recent climate modelling impact studies are starting to provide some insights for the Inner RSA. Historic time-series and long-term monitoring programmes for the Region are also limited.



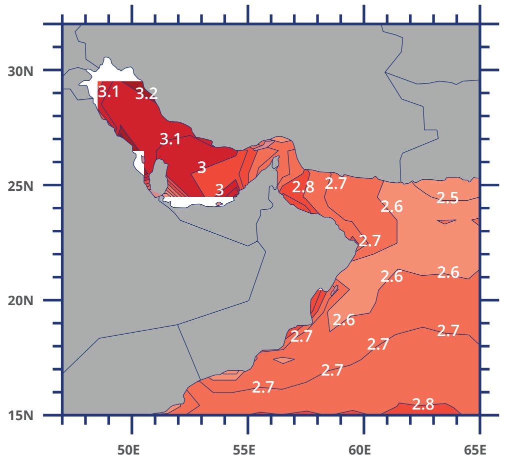
## SEA TEMPERATURE

REGULAR MONITORING
REGIONAL STUDIES
LOCAL CLIMATE IMPACT STUDIES
GLOBAL STUDIES

An analysis of sea surface temperature (SST) for the period 1982–2015 covering the Inner RSA and Middle RSA identified overall warming of around 1°C, with shallower areas warming faster than deeper waters. In the Outer RSA, occasional surveys during the summer monsoon season suggest a similar temperature increase has occurred.

Climate models indicate that future SST increases in the Inner RSA will be higher than for the Middle and Outer Regions. Under a high-emissions scenario, SST could increase by 2.8–4.3°C in the Inner RSA, compared to around 2.5°C in the Middle RSA and Outer RSA, by end of century. Warming is expected to be greatest during the summer season.

Marine heatwaves, where extreme temperatures persist for five or more days, are occurring more frequently across the globe.




**The projected difference in the annual average sea surface temperature (SST) in 2050–2099 under a high emission scenario compared to the historical reference period (1956–2005). White shading denotes areas where data are missing. Adapted from the Climate Change Web Portal (2018).**

## SEA LEVEL

REGULAR MONITORING
REGIONAL STUDIES
GLOBAL STUDIES

There are few long time series of sea-level change in the RSA, and those that exist are restricted to the Inner RSA. Based on seven tide gauge records in the northwest of the Inner RSA, an average sea level rise of 2.2 mm per year has been estimated for the period 1979–2007.

For the Middle RSA and Outer RSA, estimates of change based on measurements in the wider Northern Indian Ocean are lower at around 1.29 mm per year over a similar period.

Regional sea level rise projections for the RSA are very limited. The most recent estimates published by the IPCC in 2019 suggest a mean global increase of 0.84 m by the end of century under a high-emissions scenario. This is higher than previous IPCC estimates.

## SALINITY

REGIONAL STUDIES · LOCAL CLIMATE IMPACT STUDIES · GLOBAL STUDIES

Salinity of surface waters in the Inner RSA has increased by 0.5–1.0% over the past 60 years, due to increased evaporation, progressive reductions in freshwater inputs and more locally, the influence of hypersaline discharges from desalination plants.

Under a high-emissions scenario, an increase in salinity is suggested for the Inner RSA. In the eastern Middle RSA near the Strait of Hormuz, salinity could also increase, whilst the Outer RSA may experience declines in salinity.

## DISSOLVED OXYGEN

REGIONAL STUDIES · LOCAL CLIMATE IMPACT STUDIES · GLOBAL STUDIES

An oxygen minimum zone occurs between 200 and 1000 m depth across the Outer RSA and Middle RSA. This is a permanent feature and is one of the most intense oxygen minimum zones in the world. Oxygen concentrations are projected to decline further.

Seasonal or transitory areas of low oxygen concentrations also occur in shallow coastal waters in the Inner RSA, and are expected to become larger and more persistent over the coming century, partly in response to climate change.

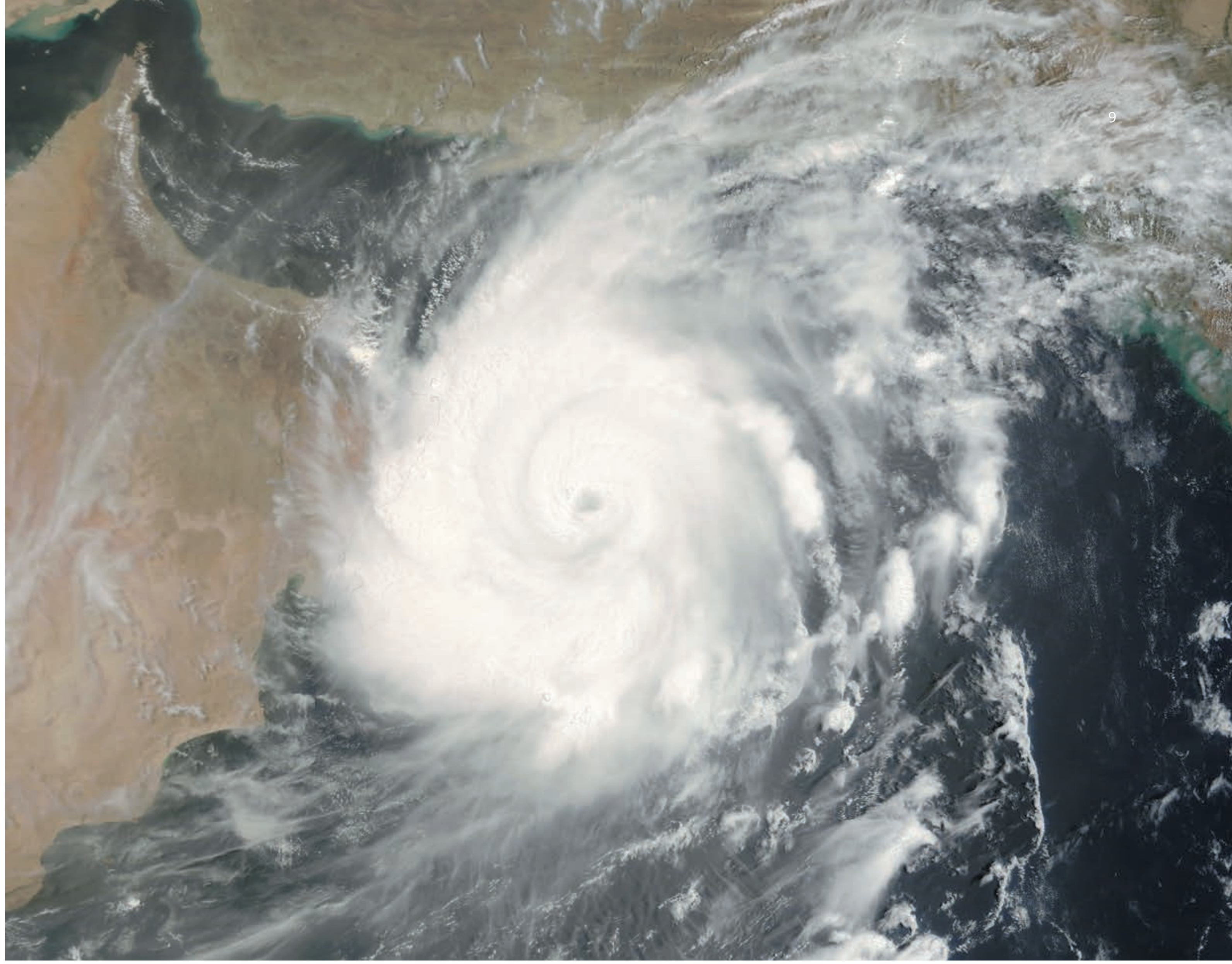
## CARBONATE CHEMISTRY AND PH

REGULAR MONITORING · LOCAL CLIMATE IMPACT STUDIES · GLOBAL STUDIES

Few pH measurements exist for the RSA, and where they do, the time period covered is too short to detect significant trends. In the Outer RSA where pH is affected by the seasonal upwelling, summer pH is as low as 7.93, compared to 8.05–8.09 during the winter months.

Repeat measurements from survey cruises in the Outer RSA suggest an overall decrease in average pH between 1960 and 2000. This decrease is approximately 0.1 pH units in the upper 50 m and 0.2 pH units at 300 m depth.

Recent global projections under a high emissions scenario suggest that pH in the RSA could decrease by approximately 0.25 units.



## TROPICAL CYCLONES

REGIONAL STUDIES · GLOBAL STUDIES

Since 2007 there have been several tropical cyclones in the RSA. The strongest cyclones to make landfall in the RSA to date were Gonu and Phet. These coincided with periods of elevated SST in the Outer RSA.

One modelling study suggests that, under a high-emissions scenario, the number of tropical cyclones in the Outer and Middle RSA will increase by the end of this century and that some cyclones may reach the Inner RSA.

## SHAMAL WINDS AND DUST STORMS

REGULAR MONITORING · LOCAL CLIMATE IMPACT STUDIES

In the Inner RSA, Shamal winds, which can generate storms and surge events, and are also important for dust accumulation, appear to have increased since 2000.

Dust storms have become more frequent and intense in the RSA with adverse consequences for air quality and public health.

# REGIONAL IMPACTS

A wide range of climate change impacts are being experienced across the RSA. Some Regional and local examples are provided here.

Warming sea temperatures have already caused severe coral bleaching events and major coral decline. Irreversible loss of reef areas and of some coral species is projected across the Inner RSA.

Seasonal fish kills are becoming more common, and have been associated with warming waters, increasing salinity and higher incidence of harmful algal blooms, particularly in the Inner RSA.

The loss of saltmarshes, mudflats and sabkhas will affect migratory water birds and lead to a decline in coastal protection and other ecosystem services.

A decline in fish diversity and reductions in fishery catches are predicted due to warming temperatures. This may affect the whole Inner RSA but will be most significant in shallow water areas along the western shores.

Low lying coastlines of the southern and western Inner RSA will be most exposed to flooding associated with long-term sea-level rise and storm surges.

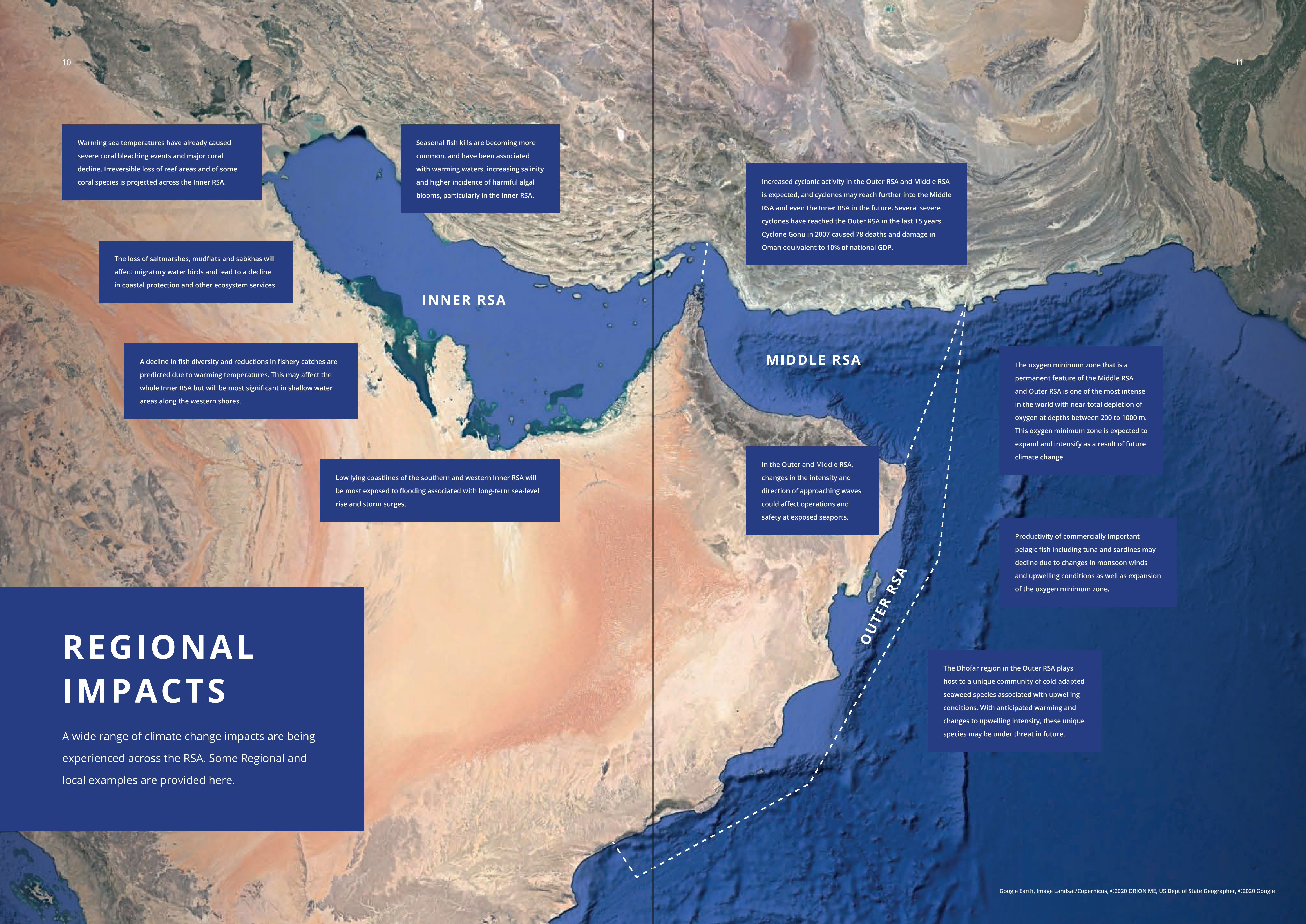
Increased cyclonic activity in the Outer RSA and Middle RSA is expected, and cyclones may reach further into the Middle RSA and even the Inner RSA in the future. Several severe cyclones have reached the Outer RSA in the last 15 years. Cyclone Gonu in 2007 caused 78 deaths and damage in Oman equivalent to 10% of national GDP.

In the Outer and Middle RSA, changes in the intensity and direction of approaching waves could affect operations and safety at exposed seaports.

The oxygen minimum zone that is a permanent feature of the Middle RSA and Outer RSA is one of the most intense in the world with near-total depletion of oxygen at depths between 200 to 1000 m. This oxygen minimum zone is expected to expand and intensify as a result of future climate change.

Productivity of commercially important pelagic fish including tuna and sardines may decline due to changes in monsoon winds and upwelling conditions as well as expansion of the oxygen minimum zone.

The Dhofar region in the Outer RSA plays host to a unique community of cold-adapted seaweed species associated with upwelling conditions. With anticipated warming and changes to upwelling intensity, these unique species may be under threat in future.

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# BIODIVERSITY

The RSA is home to a diverse range of species including many of global conservation importance. This includes populations of turtles, rare seabirds, dugongs, dolphins and whales, which are supported by key habitats such as coral reefs, seagrasses and mangroves. These habitats also provide critical ecosystem services, such as storing carbon, protecting coastlines and supporting productive fisheries and a growing tourism sector.

Climate change can affect biodiversity in a number of ways, and these impacts can be exacerbated by other human pressures such as resource over-exploitation, pollution and habitat degradation associated with coastal development.



## PHYTOPLANKTON PRODUCTIVITY

REGIONAL STUDIES
LOCAL CLIMATE IMPACT STUDIES
GLOBAL STUDIES

Climate models indicate a decline in plankton productivity across the RSA over this century due to changes in water currents, nutrients and oxygen supply. A decline in plankton productivity would have negative impacts on the marine food chain, including fisheries.

The area influenced by tropical monsoon systems may increase over the 21st Century, changing the timing, strength, and direction of winds that control the upwelling of nutrient-rich waters in the Outer RSA.

## HARMFUL ALGAL BLOOMS (HABs)

LOCAL CLIMATE IMPACT STUDIES

HABs in the RSA are an important issue and their geographical scale and persistence appear to be increasing. For example, HABs have become more frequent in the Outer RSA in recent years.

HABs can cause severe disruption and damage, including blocking cooling water intakes in coastal desalination and industrial plants, and causing large-scale mortality of fish and other marine organisms.

Currently, a link between occurrence of HABs and climate change in the RSA has not yet been fully established.

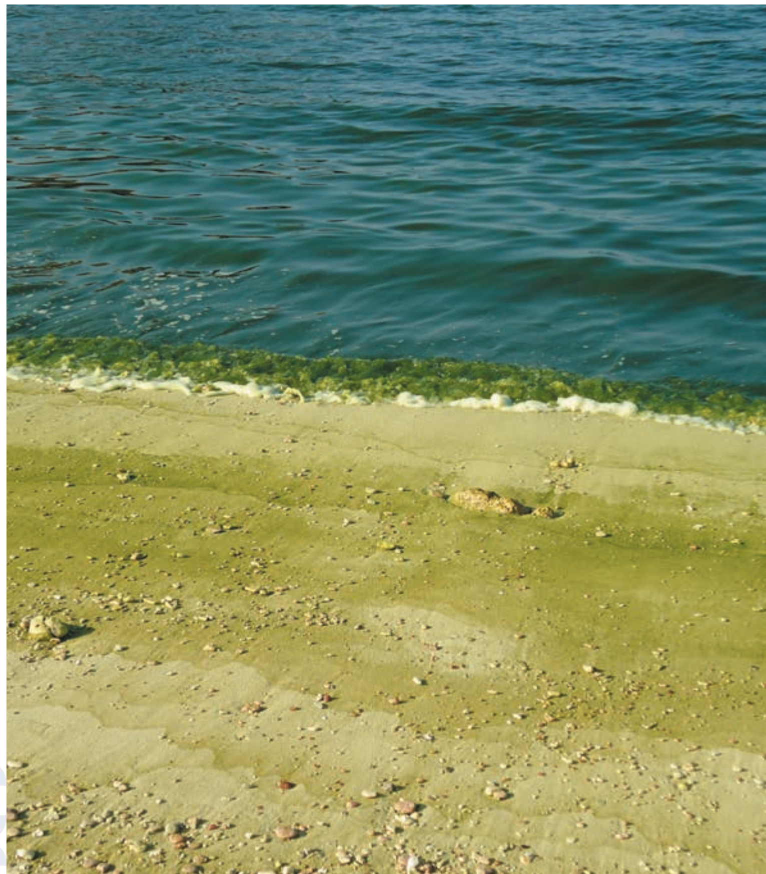
## FISH

REGULAR MONITORING
REGIONAL STUDIES
LOCAL CLIMATE IMPACT STUDIES
GLOBAL STUDIES

Up to 10% of fish species occurring in the Inner RSA may become Regionally extinct by the end of the century as a result of increasing temperature and salinity. This is at least twice as high as predictions for other regions where similar assessments have been undertaken.

Productivity of important pelagic fish species such as tuna and sardine in the Middle and Outer RSA may decline due to an expansion of the oxygen minimum zone.

Following coral bleaching events, reef fish assemblages have been observed to change. As the coral dies there is a decline in the total number of fish species and the relative proportion of herbivorous fish species increase.



# JELLYFISH BLOOMS

LOCAL CLIMATE IMPACT STUDIES GLOBAL STUDIES

Jellyfish blooms are known to occur across the RSA, and outbreaks and aggregations are becoming more frequent. This has been partly attributed to increases in water temperature.

Jellyfish blooms can block intakes of desalination plants and cooling water systems in coastal industries. There are increasing reports of these events occurring across the RSA.

# BIRDS

GLOBAL STUDIES

There is growing evidence that extreme weather events, which could become more severe and/or frequent, can have adverse effects on populations of seabirds by disturbing their breeding habitats and creating unfavourable feeding conditions.

Wetlands in the RSA, which are important for coastal and migratory birds, are highly vulnerable to sea-level rise. This could have serious implications for bird populations that depend on them.



# MARINE MAMMALS AND TURTLES

REGIONAL STUDIES GLOBAL STUDIES

Turtle populations will be impacted as warmer temperatures can alter the sex ratio of hatchlings, and compromise their fitness. In addition, rising sea levels and storms could severely damage beach nesting grounds. Any localised declines in seagrass would reduce an important food source for some turtle species.

Projections of direct temperature impacts on dugongs are inconclusive, with some models showing that the Inner RSA will become less hospitable while others suggest no change overall. However, this does not take into account the potential loss of seagrass, the sole source of food for dugongs, due to climate change.

Dolphins and whales are more tolerant to changes in temperature and salinity compared to other species. Indirect climate impacts on their food sources, such as fish, are likely to be more significant in determining their abundance and distribution.

## CORAL REEFS

REGULAR MONITORING · REGIONAL STUDIES · LOCAL CLIMATE IMPACT STUDIES

There has been a rapid decline in coral reefs across most of the RSA in the last two decades. This has been linked to a wide range of climatic drivers as well as other human pressures.

Repeated and widespread bleaching events have taken place across both the Inner and Middle RSA due to increasing summer water temperatures. This has led to mass mortality of most of the staghorn (Acropora) corals in these areas.

In the Inner RSA, corals are already experiencing extreme high temperatures that are not projected to occur until the end of century in other low-latitude regions.

In future decades, most reefs in the Inner RSA will be under threat from the combined effects of warming, ocean acidification and other local stressors. However, some coral communities with reduced species diversity and physical complexity may be able to adapt and persist.

## MANGROVES

REGIONAL STUDIES · GLOBAL STUDIES

Up to 96% of RSA coastal wetlands are threatened by a combination of sea-level rise, subsidence and physical constraints on landward migration due to coastal development (also known as 'coastal squeeze'). This includes mangroves, which could be lost by the end of this century.

Projected increases in air temperature by the end of the century could reduce mangrove growth rates due to moisture limitation and temperatures exceeding their maximum tolerance.

Across the Region, reduced rainfall, higher evaporation and increasing salinity are likely to limit build-up of sediments. Sediment accretion is important for keeping pace with sea-level rise.

Storms and cyclones can cause severe damage to mangrove forests. If these become more frequent or intense, the trees may not have enough time to recover between severe events, leading to long-term degradation.



## SEAGRASS

REGIONAL STUDIES · GLOBAL STUDIES

Tropical seagrasses in the RSA can withstand periods of elevated temperatures but are adversely affected by prolonged exposure. Extended periods of sea temperatures above 40 degrees are lethal.

Any increase in the frequency and/or magnitude of storms and cyclone events would threaten seagrasses throughout the RSA, particularly those in intertidal and shallow locations, by subjecting meadows to persistent conditions of turbidity and siltation.

Seagrass productivity may be enhanced under elevated concentrations of carbon dioxide. This could provide a positive feedback, with seagrass beds buffering pH levels and creating local refugia for calcifying organisms within coastal zones.

## ROCKY SHORES AND MARINE ALGAE COMMUNITIES

LOCAL CLIMATE IMPACT STUDIES

The easternmost point of the Arabian Peninsula, Ras Al Hadd, Oman, currently acts as a boundary for marine macroalgae (seaweeds), with distinctly different species in the Middle RSA compared to the Outer RSA. Distribution patterns, associated with differing temperature affinity of the species, could alter with future climate change.

Storms and cyclones can have serious impacts on rocky shores communities. A combination of strong wave action and sand scouring can cause severe physical damage along large stretches of coast.

# ECONOMY AND SOCIETY

Climate change is expected to have significant impacts on marine-related social and economic activities in the RSA. Major urban settlements and critical infrastructure are situated along the coast, including on reclaimed land, increasing their exposure.

Sea-level rise, flooding, coastal erosion and cyclones present major risks to coastal communities and infrastructure in the RSA. Coastal industries may be increasingly exposed to nuisance species such as jellyfish, non-native species and harmful algae that block and damage water intakes and cooling systems, to the point of forcing temporary closure of services.

Offshore activities, including fishing, oil and gas extraction and maritime shipping are critical to the economy of the Region. These may suffer disruptions by changing conditions at sea, especially where extreme weather events prevent safe operations.



## FOOD PROVISION (MARINE FISHERIES AND AQUACULTURE)

REGULAR MONITORING

REGIONAL STUDIES

GLOBAL STUDIES

Warming sea temperature, oxygen depletion and changes in salinity are likely to have significant adverse effects on fisheries in the RSA. Fisheries in Bahrain and Iran were ranked as most vulnerable to climate change in an assessment of national economies.

The adaptive capacity of fish communities within the Inner RSA and Middle RSA may be limited due to their lower species diversity compared to the adjacent Indian Ocean where conditions are less extreme. Deep-sea fish resources in the Middle and Outer RSA however are at risk from an expanding oxygen minimum zone due to climate change.

Cephalopods like squid and cuttlefish appear to adapt well to warming sea temperatures as well as changes in salinity, oxygen and currents. As such they may become more abundant in the RSA in the future.

The suitability of coastal areas dedicated to fish and shrimp farming may be compromised due to changes in seawater temperature, which may increase HAB and jellyfish outbreaks, and the presence of marine pathogens and diseases.

Lagoons, sea-cages and storage facilities used for seafood farming are at risk of physical damage from coastal flooding and extreme weather events such as cyclones.

## DESALINATION PLANTS AND WATER SUPPLY

REGULAR MONITORING

LOCAL CLIMATE IMPACT STUDIES

Potential increases in the occurence of jellyfish aggregations and HABs due to climate change could aggravate disruption from clogging and damage of intake screens at desalination plants.

Increased turbidity, HABs and higher salinity could negatively affect the quality of seawater used to produce drinking water at desalination plants.

The coastal location of desalination plants makes them highly vulnerable to sea-level rise and coastal flooding.

Ground water aquifers near the coast are at risk of contamination from saltwater intrusion due to the combined effect of diminishing freshwater levels and sea level rise.

## POWER PLANTS

REGIONAL STUDIES LOCAL CLIMATE IMPACT STUDIES

GLOBAL STUDIES

The thermal efficiency at coastal power stations is determined by ambient sea temperature at the cooling water intake, so reduced efficiency may be anticipated with future warming. A 1.5°C increase in sea water temperature, which is projected for the Inner RSA by the 2040s, could lead to a power loss of around 0.5%.

Conversely, wave energy generators and offshore or coastal wind turbines could benefit if conditions become windier and waves stronger.

## MARITIME TRANSPORT

REGIONAL STUDIES GLOBAL STUDIES

Future changes in cyclones, storm and wave conditions may disrupt navigation, increasing the risk of maritime accidents and pollution incidents.

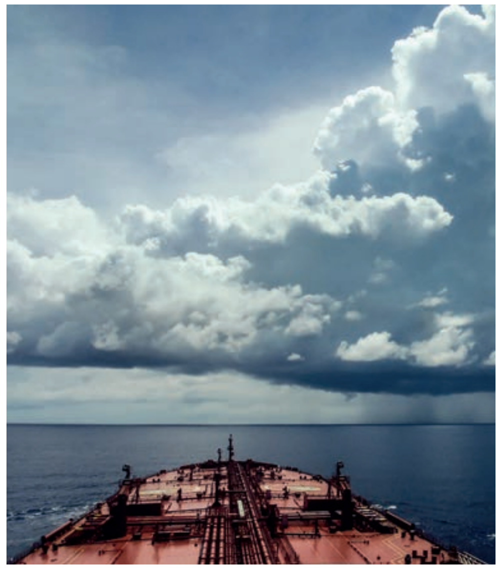
Any increase in intense cyclones, storms and flooding could cause major damage and disrupt normal operations at major seaports and threaten the integrity of site infrastructure and cargo storage areas.

## OIL AND GAS

REGIONAL STUDIES LOCAL CLIMATE IMPACT STUDIES

Coastal infrastructure including oil refineries and liquefied natural gas plants will face increased flood risk, both from the sea and also from heavy rain. Sites may suffer flooding more often, and pollution events may become more commonplace, making drainage systems more likely to be overwhelmed.

Changing storm and wind conditions could affect offshore oil and gas operations and lead to scouring and displacement of seabed pipes and cables.





## COASTAL SETTLEMENTS

REGIONAL STUDIES LOCAL CLIMATE IMPACT STUDIES

Low-lying coastal cities in the RSA are highly vulnerable to the impacts of sea-level rise and inundation. At a national level, Bahrain, Kuwait, Qatar, and UAE are most vulnerable to coastal flooding.

Throughout the RSA, natural and man-made islands are connected to the mainland by sea bridges and causeways. Both the islands and the connecting structures are highly exposed and are therefore vulnerable to high wind and wave conditions during extreme weather events as well as sea-level rise.

Wastewater infrastructure could face greater risks of damage and service disruption due to sea-level rise and storm surges which could lead to effluent discharges into the sea causing pollution of coastal areas.

Harmful phytoplankton as well as marine pathogens including bacteria and viruses are expected to expand their geographical range into new areas as seawater becomes warmer, with implications for human health.

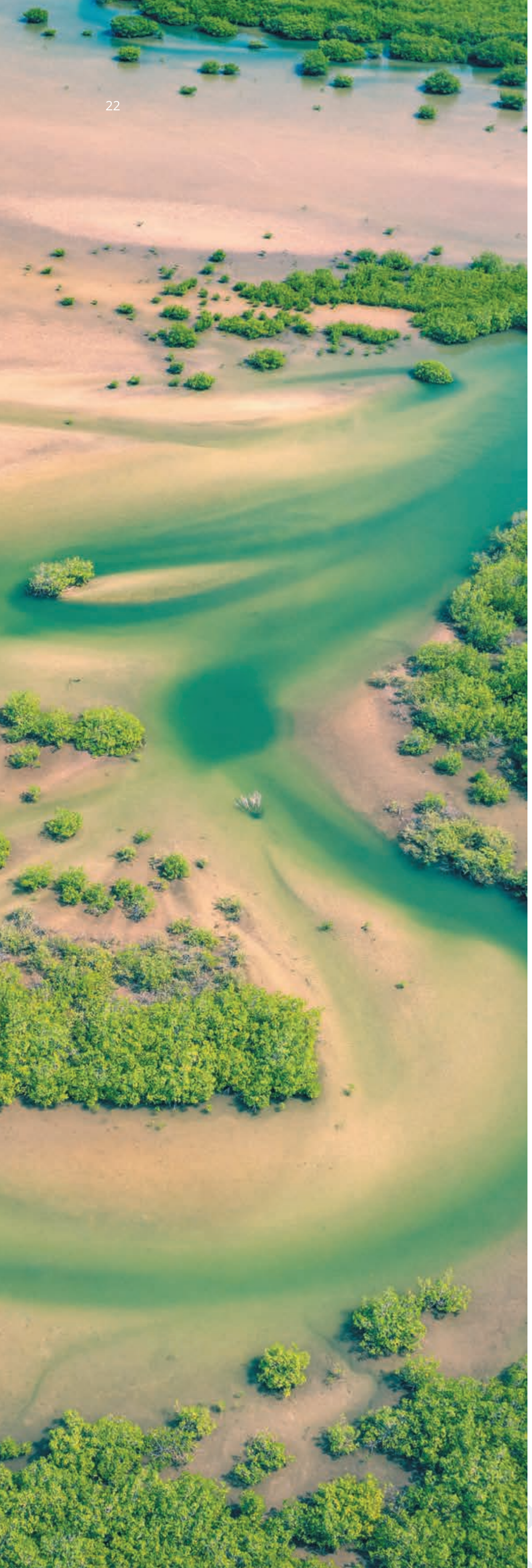
## RECREATION, TOURISM AND CULTURAL HERITAGE

REGIONAL STUDIES LOCAL CLIMATE IMPACT STUDIES

Warming average air temperatures may lead to a significant decline in coastal tourism throughout the Region. Some areas currently classified between "good" and "excellent" in terms of tourism climate comfort index may become "marginal" or even "unfavourable" in the future.

Climate change is expected to further degrade coastal and marine habitats, with negative consequences for popular charismatic species such as coral reef fish, birds, turtles, dugongs and dolphins.

Sea-level rise and changes in storms could accelerate beach erosion and deteriorate coastal tourist destinations, especially where stretches of sandy beach are narrow and tourist resort facilities are exposed.





## NATURE BASED SOLUTIONS

Human activities and climate change are already contributing to the loss and degradation of extensive areas of coral reef, mangrove forests, saltmarsh and seagrass. These habitats filter pollutants, store sediments, offer food and recreation and provide natural barriers that protect the coastline. Further degradation could compromise these services, increasing the risk of pollution, flood and erosion.

The vegetated coastal habitats of the Inner RSA, mangroves, seagrasses and saltmarshes, are active $CO_2$ sinks, removing $CO_2$ from the atmosphere through photosynthesis and burial as plant material in the sediment. The destruction or disturbance of these habitats will prevent them from functioning as effective $CO_2$ sinks and could result in some of the stored carbon being released back into the atmosphere.

The restoration and protection of habitats and species throughout the RSA is important for building natural climate resilience in coastal communities and ecosystems.

### EXAMPLES OF ACTIONS TO ENHANCE NATURAL RESILIENCE INCLUDE:

- Sustainable fisheries management
- Restoration and re-planting of mangroves or seagrasses
- Alleviating other man-made pressures, such as inputs of untreated waste.

## KNOWLEDGE GAPS

**Long-term data sets on key physical changes such as sea-level, water temperature and pH are limited in this Region.** This makes it difficult to identify long-term trends across the RSA in response to climate change.

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**There is a lack of high-resolution climate models for the RSA**, especially for the Middle and Outer RSA, which hinders the confidence of Regional projections. In turn, this means that understanding of the impact of climate change on biodiversity and society in the Region lacks the necessary detail and resolution.

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**The physiological capacity of marine organisms to adapt to future conditions has yet to be examined** for many species in the RSA.

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**The combined effects of climate change and other human stressors on the vulnerability of habitats and species is poorly understood.**

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**A lack of social and economic climate change impact studies in the RSA** means likely impacts are often based on expert opinion or on extrapolation from global studies.

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**Understanding the transboundary nature of climate change impacts, including shifting species distributions, will be necessary to develop effective response actions.**

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# NEXT STEPS

Working at a Regional scale, ROPME aims to develop a greater understanding of, and encourage action on, trans-boundary issues. Through the ROPME Regional Action Plan on climate change, knowledge and experience will be shared in order to develop options for the future.

This Policy Brief and the comprehensive ROPME Marine Climate Change Impacts Evidence Report that underpins it, were used to develop a marine and coastal Climate Change Risk Assessment for the ROPME Sea Area, that was subsequently validated by experts from across the RSA. The adaptation options to address the priority impacts identified by the Risk Assessment will be considered in the next phase of the ROPME Regional Action Plan on climate change.

A component of the ROPME Regional Action Plan focusses on building the Regional evidence base on blue carbon habitats such as mangroves, saltmarshes and seagrasses.

The outputs from the ROPME Regional Action Plan on climate change are supporting Member States to develop national climate change responses, and provide an opportunity to highlight climate risks, and priority action areas for the RSA on the international stage.

## ACKNOWLEDGEMENTS

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Centre for Environment Fisheries & Aquaculture Science

## IMAGE CREDITS