Regional Organization for the Protection of the Marine Environment (ROPME)

ROPME POLICY BRIEF

ROPME SEA AREA CLIMATE CHANGE RISK ASSESSMENT

The ROPME Sea Area (RSA) is characterised by extreme environmental conditions. Changes in temperature, salinity, oxygen, pH, sea level and cyclone activity threaten marine and coastal ecosystems across the RSA, and put coastal communities and industry at risk. This is the first marine and coastal climate change risk assessment for the ROPME Sea Area (RSA). It highlights where adaptation action is needed most. A total of 45 key risks are identified, 13 of which are considered severe and are already affecting biodiversity, people and industry. Many risks are transboundary, highlighting the potential benefits from coordinated regional action in addition to national responses national responses.

Temperature change and sea level rise are the main climate change drivers affecting the shallow Inner RSA, whilst cyclones and oxygen depletion are more important in the Middle and Outer RSA.

Severe biodiversity risks relate to changes in the abundance and distribution of phytoplankton, jellyfish, corals, fish and seabed organisms, as well as an increase in harmful algal blooms.

The primary physical risks from climate change to society are flooding and cyclone damage to coastal cities, communities and industries, which could cause loss of life and significant economic costs.

The primary ecological risks from climate change to society are declining fisheries and disruption of desalination plants and industrial cooling water systems from jellyfish and algal blooms

2022

SEVERE CLIMATE CHANGE RISKS TO BIODIVERSITY

DECLINING CORAL COVER, DISTRIBUTION AND HEALTH

Widespread decline and loss of corals due to temperature increases, and increased storminess, turbidity and declining pH.

INCREASING HARMFUL ALGAL BLOOMS (HABS)

Warmer temperatures and changing circulation patterns may lead to more frequent, extensive and persistent mass algal blooms. These blooms can lead to fish kills and coral bleaching events, and present risks to human health.

DECLINE IN PHYTOPLANKTON PRIMARY PRODUCTION

Changes in temperature, salinity, ocean currents and monsoon timing may lead to reduced productivity, with wider impacts on the health of marine ecosystems, including commercial fish stocks.

LOSS OF BIODIVERSITY IN CORAL ASSOCIATED COMMUNITIES

Negative climate change impacts on coral reefs are reducing the available habitat for species that depend on them for food, shelter and reproduction.

INCREASING JELLYFISH OUTBREAKS

Changes in oxygen levels, and increased salinity and temperatures may be contributing to more jellyfish outbreaks, with negative impacts on other marine species and an increased risk of blocking industrial intakes.

CHANGES IN BENTHIC (SEABED) INVERTEBRATES

Temperature change, oxygen depletion and ocean acidification are having negative impacts on some benthic invertebrates and are leading to an increase in some biofouling organisms.

CHANGES IN PELAGIC (OCEANIC) FISH

Changes in temperature, oxygen levels, salinity and changing currents are affecting abundance and distribution of pelagic fish species, with knock-on effects for their predators.

SEVERE CLIMATE CHANGE RISKS TO SOCIETY

THREATS TO COASTAL COMMUNITIES (PEOPLE, HOMES AND LOCAL AMENITIES)

Extreme events present a risk to life and an increase in long-term flood risk could impact coastal cities and communities.

CHANGING MARINE FISHERIES RESOURCES

Marine fisheries will be negatively affected by changing habitat suitability, shifts in species distribution, effects on prey, and increases of harmful algal blooms.

INCREASED FLOOD RISK TO COASTAL INDUSTRY

An increase in flood risk associated with severe storm events and long term sea level rise, will lead to damage to, or loss of, facilities and reduced efficiency of operations.

NON-FLOODING IMPACTS ON COASTAL INDUSTRIES

More severe storms will increase physical damage, disrupt operations and increase pollution risk. Marine intakes may be affected by increasing water temperatures, HABs and jellyfish blooms.

IMPACTS ON DESALINATION PLANTS

Cyclones, storms and flooding may cause physical damage to desalination plants. Increasing water temperature, turbidity, HABs and jellyfish blooms may disrupt operations.

IMPACTS ON THE MARITIME TRANSPORT SECTOR

Changes in storm, wave and wind conditions could affect operations and increase safety risks. Damage to boats and pollution incidents may increase.

THE ROPME SEA AREA

The ROPME Sea Area (RSA) covers the territorial waters of the eight ROPME Member States: Bahrain, Iran, Iraq, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates. The RSA is divided into three distinct Sub-Regions: The shallow, semi-enclosed Inner RSA, the transitional waters of the Middle RSA and the oceanic Outer RSA.

CLIMATE DRIVERS

The principal climate change drivers affecting the marine and coastal environment of the ROPME Sea Area are listed here. Their impacts are evaluated in this risk assessment.

- Sea-level rise
- Changes in ocean circulation
- Increasing air and sea temperature (including humidity)
- Changes in storms, cyclones, winds, waves and storm surges
- Ocean acidification (declining pH)
- Increased incidence of dust storms
- Changes in salinity
- Decreasing dissolved oxygen
- Changes in freshwater input
- Changes in monsoon timing
- Increasing turbidity
- Increasing coastal erosion

CLIMATE CHANGE RISK ASSESSMENT

Climate change risk assessments evaluate the full range and scale of effects on biodiversity and society to enable focussed adaptation and resilience actions. A 'long-list' of 45 risks to biodiversity and society was created following a comprehensive review of climate change impacts on the marine and coastal environment of the ROPME Sea Area. These were validated and scored in a workshop by technical experts from across the Region. Risks were evaluated for the ROPME Sea Area as a whole, and for the three Sub-Regions individually.

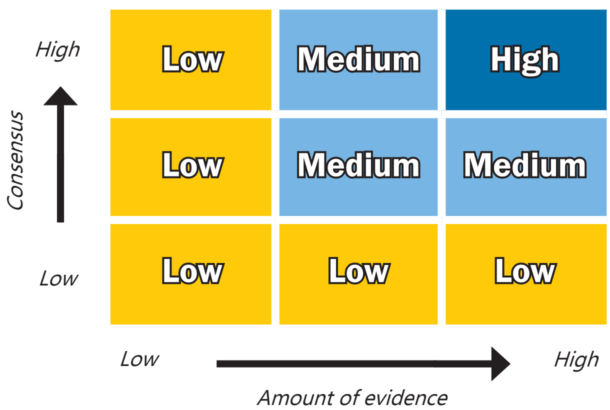
RISK SCORING

The 45 risks were each given a score between 1 and 100, based on magnitude of impact (low; medium; high), and the time to impact occurring (now; within 20 years; within 50 years; over 50 years).

The risks were categorised as severe, moderate or low depending on their overall score. Risks happening now (or soon) with a medium to high impact, were rated as 'severe'.

CONFIDENCE

Confidence levels were assigned to each risk, based on the evidence available to evaluate each risk, and level of consensus.



BIODIVERSITY RISKS

Out of 23 biodiversity risks evaluated, seven are identified as severe.

Risks to biodiversity may result from either direct or indirect effects of climate change. Direct effects are caused by changes in the environment, such as in temperature or acidification, which affect a species' abundance and distribution. Indirect effects are caused as a result of changes in food webs or habitat.

This assessment mostly identified negative impacts from climate change, however there can also be benefits as a result of climate change. Changes in food webs can lead to "climate losers" and "climate winners" with some species benefiting if their predators or competing species decline due to climate change.

CLIMATE CHANGE RISK TO...	PROXIMITY	MAGNITUDE	RISK SCORE	RISK CATEGORY	CONFIDENCE LEVEL
Biodiversity of coral associated communities	Now	High	100	Severe	High
Harmful algal blooms (HABs)	Now	High	100	Severe	Medium
Phytoplankton primary production	Now	Medium	67	Severe	High
Coral cover, distribution and health	Now	Medium	67	Severe	High
Jellyfish outbreaks	Now	Medium	67	Severe	Medium
Benthic (seabed) invertebrates	Now	Medium	67	Severe	Medium
Pelagic (oceanic) fish	Now	Medium	67	Severe	Low
Dugong	<20 Years	Medium	50	Moderate	Medium
Demersal (seabed) fish	<20 Years	Medium	50	Moderate	Low
Turtles and their nesting sites	<20 Years	Medium	50	Moderate	High
Seabirds and their nesting sites	<20 Years	Medium	50	Moderate	Low
Waterbirds and their nesting sites	<20 Years	Medium	50	Moderate	Medium
Mangrove forests	<20 Years	Medium	50	Moderate	Low
Rocky shores	<20 Years	Medium	50	Moderate	Medium
Deep sea habitats (>200 m)	<20 Years	Medium	50	Moderate	Medium
Non-gelatinous zooplankton	Now	Low	33	Moderate	Low
Microbial communities	Now	Low	33	Moderate	Low
Saltmarshes, mudflats and Sabkhas	<50 Years	Medium	33	Moderate	Low
Macroalgal beds	<50 Years	Medium	33	Moderate	Low
Seagrass meadows	<20 Years	Low	25	Moderate	Low
Sandy beaches	<20 Years	Low	25	Moderate	Low
Cetaceans	<50 Years	Low	17	Low	Medium
Alien invasive species (AIS)	<50 Years	Low	17	Low	Medium

SEVERE BIODIVERSITY RISKS

The seven severe biodiversity risks are described below. The climate change drivers generating each impact are shown, with the most important drivers highlighted in red.

- **Sea-level rise**
- **Changes in ocean circulation**
- **Increasing air and sea temperature (including humidity)**
- **Changes in storms, cyclones, winds, waves and storm surges**
- **Ocean acidification (declining pH)**
- **Increased incidence of dust storms**
- **Changes in salinity**
- **Decreasing dissolved oxygen**
- **Changes in freshwater input**
- **Changes in monsoon timing**
- **Increasing turbidity**
- **Increasing coastal erosion**

LOSS OF BIODIVERSITY IN CORAL ASSOCIATED COMMUNITIES

NOW, HIGH MAGNITUDE, HIGH CONFIDENCE

Negative climate change impacts on coral reefs is reducing the available habitat for species that depend on them for food, shelter and breeding. The risk is highest in the Inner RSA, with widespread coral bleaching and mortality already linked to climate change. In the Outer RSA, storm damage has caused substantial and long-lasting structural damage to reefs, but seasonal upwelling of cooler water prevents extensive bleaching.

INCREASING HARMFUL ALGAL BLOOMS (HABS)

NOW, HIGH MAGNITUDE, MEDIUM CONFIDENCE

Changes in currents, warming temperatures and resuspension of nutrients caused by storms and winds, are creating favourable conditions for an increase in HABs. Blooms can cause mass mortality of fish, corals and marine life and may contain toxins that are a threat to human health if they enter the food chain or water supply. The risk is greatest in the Inner RSA and Middle RSA where the frequency, scale and persistence of blooms is highest.

DECLINE IN PHYTOPLANKTON PRIMARY PRODUCTION

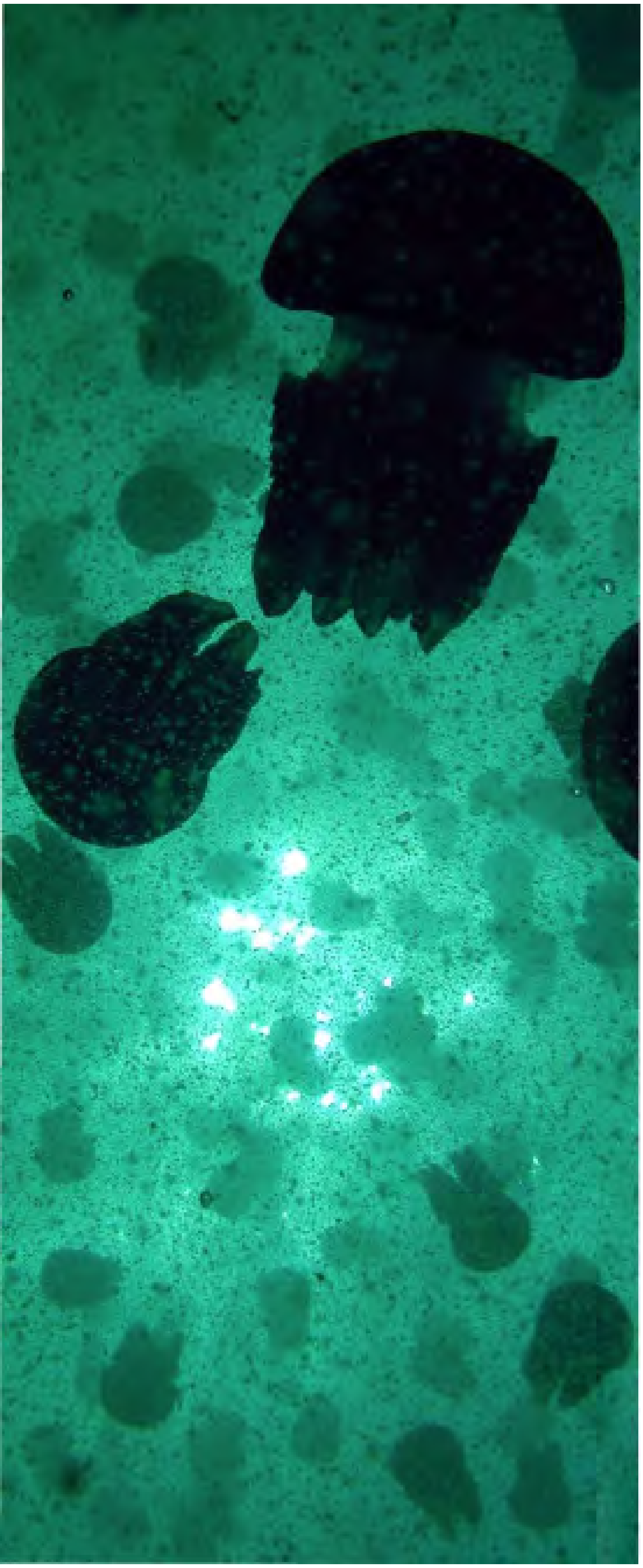
NOW, MEDIUM MAGNITUDE, HIGH CONFIDENCE

Climate change has been linked to reduced phytoplankton biomass and productivity, which could have major repercussions for marine foodwebs and ecosystems, including commercial fish stocks. This is most pronounced in the Inner RSA due to its enclosed nature, additional influence of thermal and saline stratification and changes in freshwater inputs from rivers such as the Shatt al-Arab. In the Outer RSA, changes in monsoon timing and strength may be affecting primary productivity.

DECLINING CORAL COVER, DISTRIBUTION AND HEALTH

NOW, MEDIUM MAGNITUDE, HIGH CONFIDENCE

Evidence indicates significant and widespread declines in coral cover and health in the RSA, driven by climate change and human disturbances such as pollution and coastal developments. High temperatures and bleaching are causing mass mortality with coral cover and health also affected by storm damage, turbidity, reduced oxygen, acidification and HABs. Less coral cover also means coastlines are less protected from storms and waves. Impacts are most acute in the Inner RSA. In the Middle RSA and Outer RSA, magnitude of impacts is lower, as corals appear to be less affected by climate-driven changes and other human pressures.



INCREASING JELLYFISH OUTBREAKS

NOW, MEDIUM MAGNITUDE, MEDIUM CONFIDENCE

Outbreaks of jellyfish, and other gelatinous plankton, are being increasingly documented in the RSA. Climate change impacts on oxygen levels, increased salinity and rising temperatures may be contributing to increased outbreaks. These outbreaks affect ecosystems and coastal swarms can cause serious disruption and damage to industrial water intakes. In the Outer RSA the occurrence of jellyfish outbreaks is more sporadic so the risk here is lower.

CHANGES IN BENTHIC (SEABED) INVERTEBRATES

NOW, MEDIUM MAGNITUDE, MEDIUM CONFIDENCE

Benthic invertebrates play a key role in marine foodwebs and include commercially important species (e.g. shrimp, abalone, and sea cucumber). Climate change may be negatively affecting benthic invertebrates whilst also increasing biofouling species principally due to temperature change, oxygen depletion and ocean acidification. Species with intertidal ranges are also being affected by sea-level rise and disturbances caused by strong waves, storms and cyclones, such as scouring and sedimentation. Impacts appear more prevalent in the Middle RSA and Outer RSA. However, this may reflect a lack of evidence in the Inner RSA.

CHANGES IN PELAGIC (OCEANIC) FISH

NOW, MEDIUM MAGNITUDE, LOW CONFIDENCE

Observed changes in the abundance and distribution of pelagic fish species (e.g. tuna in the Outer RSA and Middle RSA, and mackerel in the Inner RSA) suggest climate change impacts are happening now. In the Inner RSA, future declines in some species, and possible local extinctions are predicted, driven by rising temperature, declining oxygen, changes in salinity and freshwater inputs. In the Outer RSA and Middle RSA, decreasing oxygen, changes in monsoon timing and strength, and changing currents may all have important impacts on pelagic species.

SOCIETAL RISKS

Twenty-three societal risks were evaluated and six are identified as severe.

Societal impacts can be caused by the direct physical effects of climate change, such as flooding or storm damage, impacting on coastal communities and infrastructure. Societal impacts can also be caused by the ecological effects of climate change, such as reduced fish production affecting fisheries or increased harmful algal blooms affecting desalination plants.

CLIMATE CHANGE RISK TO...	PROXIMITY	MAGNITUDE	RISK SCORE	RISK CATEGORY	CONFIDENCE LEVEL
Coastal communities (people, homes and local amenities)	<20 Years	High	75	Severe	High
Marine fisheries resources	<20 Years	High	75	Severe	High
Coastal industries (flooding)	<20 Years	High	75	Severe	High
Desalination plants	<20 Years	High	75	Severe	High
Coastal industries (non-flooding)	<20 Years	High	75	Severe	Medium
Maritime transport	<20 Years	High	75	Severe	Medium
Fishing communities	<20 Years	Medium	50	Moderate	High
Offshore oil and gas	<50 Years	High	50	Moderate	Low
Natural coastal protection	<20 Years	Medium	50	Moderate	Medium
Aquaculture	<50 Years	Medium	33	Moderate	Low
Coastal tourism	<50 Years	Medium	33	Moderate	High
Pearl oysters	<50 Years	Medium	33	Moderate	Low
Human health	<50 Years	Medium	33	Moderate	Low
Coastal and marine recreational activities	<20 Years	Low	25	Moderate	High
Cultural heritage and historic sites	<20 Years	Low	25	Moderate	Low
Natural climate regulation (e.g. carbon uptake)	<20 Years	Low	25	Moderate	Low
Renewable energy	<50 Years	Low	17	Low	Low
Freshwater from groundwater sources	<50 Years	Low	17	Low	Low
Aggregate extraction operations	<50 Years	Low	17	Low	Low
Natural waste breakdown and detoxification	<50 Years	Low	17	Low	Low
Loss of education and research value	<50 Years	Low	8	Low	Low
Loss of future genetic and biological resources	<50 Years	Low	8	Low	Low

SEVERE SOCIETAL RISKS

The six severe societal risks are described below. The climate change drivers generating each impact are shown, with the most important drivers highlighted in red.

Sea-level rise

Changes in ocean circulation

Increasing air and sea temperature (including humidity)

Changes in storms, cyclones, winds, waves and storm surges

Ocean acidification (declining pH)

Increased incidence of dust storms

Changes in salinity

Decreasing dissolved oxygen

Changes in freshwater input

Changes in monsoon timing

Increasing turbidity

Increasing coastal erosion

THREATS TO COASTAL COMMUNITIES (PEOPLE, HOMES AND LOCAL AMENITIES)

<20 YEARS, HIGH MAGNITUDE, HIGH CONFIDENCE

Increasing flood and erosion risk from sea-level rise, and more extreme events (e.g. storms, heatwaves and excessive humidity) will lead to an increase in damage and loss of housing and amenities, and a greater risk to health and wellbeing. Flash floods from extreme rainfall events may compound flooding from the sea. Over time, shoreline retreat could force inland migration of communities. In the Middle and Outer RSA risks are driven by severe storms and cyclone whilst low lying population centres in the Inner RSA are more vulnerable to flooding from long-term sea level rise.

CHANGING MARINE FISHERIES RESOURCES

<20 YEARS, HIGH MAGNITUDE, HIGH CONFIDENCE

Climate change will have a major impact on marine fisheries, including fish and shellfish for human consumption, as well as fishmeal and bait. Changing habitat suitability, shifts in species abundance and distribution, effects on prey availability, and incidence of diseases and HABs will all affect fish and shellfish health or quality. Declines in commercially exploited species are likely to result in the loss of catch potential for most RSA Member States. In the Inner RSA, temperature will be the key driver, whilst in the Middle and Outer RSA, changes in currents and reduced oxygen may be more important.

INCREASED FLOOD RISK TO COASTAL INDUSTRY

<20 YEARS, HIGH MAGNITUDE, HIGH CONFIDENCE

Coastal infrastructure is at risk from storm flooding events and long-term inundation due to sea level rise. This includes threats to ports and marinas; coastal power plants; bunkering sites and shipping terminals; coastal transportation infrastructure including roads, railways, bridges and causeways; sewage treatment plants; and nearshore oil and gas refineries and terminals. Impacts include damage to, or loss of, sites or facilities, and reduced operational efficiency and disruption. Locally, land subsidence may increase risks. Inland industries reliant on coastal and maritime transport for distribution of goods could be affected. Proximity scores for the Middle RSA and Outer RSA are lower as their steeper coastlines are less vulnerable than shallow coastal plains in the Inner RSA.

NON-FLOODING RISKS TO COASTAL INDUSTRIES

<20 YEARS, HIGH MAGNITUDE, HIGH CONFIDENCE

Increased storm and cyclone activity will lead to more physical damage, disruption to operations and a greater risk of pollution. Underwater cables and pipes for power plants and nearshore oil and gas refineries may be scoured, damaged or displaced in rougher seas. Damage to ports, marinas and coastal transport infrastructure could disrupt the movement of goods. Increases in air and sea temperature could affect operating efficiencies, as could blocking of cooling intake structures by jellyfish and algal blooms. Dust storms could damage infrastructure, and in some cases cause power failures. At this time, there is not enough information on the full range and scale of impacts to differentiate risk level across the RSA.

IMPACTS ON DESALINATION PLANTS

<20 YEARS, HIGH MAGNITUDE, MEDIUM CONFIDENCE

Increased storm and cyclone activity and sea-level rise will increase risk of inundation and damage to infrastructure and sites may have to temporarily shut, affecting water supplies. Higher temperatures and salinity may increase demands on water cooling and treatment. Increased turbidity, algal blooms and jellyfish outbreaks may clog intake filters, affecting operating efficiency and causing temporary plant closures. Harmful algal blooms present a risk to human health if affected water enters drinking water supplies. The Outer RSA may be more exposed to storms and cyclones, while the Inner RSA and Middle RSA are at greater risk from sea-level rise and HABs. Given the fundamental importance of water security in the Region, this risk is rated as high magnitude.

IMPACTS ON THE MARITIME TRANSPORT SECTOR

<20 YEARS, HIGH MAGNITUDE, MEDIUM CONFIDENCE

Changes in storm, wave and wind conditions can disrupt maritime traffic at sea and in ports and increases risk to safety at sea. If seas become rougher, damage to boats and pollution incidents may increase. More dust storms could lead to further disruption, and temperature increases could affect wellbeing of operating staff. Maritime transport is important to the economy of the region, so the magnitude of impacts is potentially high across the RSA.

SUB-REGIONAL VARIATION IN CLIMATE RISKS

The nature and scale of the climate change risks described may vary significantly between the Inner, Middle and Outer RSA Differences in the physical and built environment, and the type of coastal industries, affect the likely severity of climate change impacts.

The shallow and enclosed Inner RSA is more susceptible to a rapid increase in temperature and salinity than the deeper waters of the Middle and Outer RSA. Conversely the Middle and Outer RSA are exposed to greater cyclone risk than the Inner RSA.

This creates differences in the species and habitats in the sub-regions and their exposure to climate change. This generates variation in the biodiversity risks across the sub-regions. For example, dugong only occur in the Inner RSA, where they are considered a threatened species of international conservation importance.

There is also sub-regional variation in the societal risks of climate change. The low-lying coast line and large urban developments in the south-west of the Inner RSA lead to greater risk from coastal flooding than in the Middle and Outer RSA. In contrast, fisheries are considered higher risk in the Middle and Outer RSA due to their greater economic importance in these sub regions.

Understanding these differences is important for implementing appropriate adaptation actions.

TOWARDS ADAPTATION AND RESILIENCE BUILDING

As climate change intensifies it will cause major impacts on biodiversity and society across the RSA. Implementing adaption actions to increase climate resilience is essential for protecting the societies and environment of the ROPME Member States from the most damaging impacts of climate change. By identifying priority risks this Climate Change Risk Assessment supports the development of targeted actions to build resilience against marine climate change in the RSA.

Climate change risks cut across socio-economic sectors and national boundaries, therefore multi-sectoral and Regional assessments and are required to account for these trans-sectoral and trans-sector interlinkages. At a national scale, countries are developing and implementing National Adaptation Plans (NAPs) under the UNFCCC process, this risk assessment can also support development of national scale NAPs.

Developing climate resilience should be integrated with marine environmental management. Reducing other pressures on the environment, and activities such as restoring habitats and introducing marine protected areas, can increase the resilience of species and habitats to climate change risks.

Climate adaptation actions, such as Nature Based Solutions, can deliver multiple benefits. For example, protecting and restoring coastal mangroves and coral reefs can improve coastal protection for low-lying communities vulnerable to flooding while also supporting biodiversity and fisheries productivity.

This Policy Brief and the comprehensive ROPME Marine Climate Change Risk Assessment Report that underpins it, were informed by the ROPME Marine Climate Change Evidence Report and it's associated Policy Brief. The work is part of the ROPME Marine Climate Change Regional Action Plan, which is building a coordinated Regional evidence base and sharing best practice across the RSA to support ROPME Member States to meet national commitments to the UNFCCC Paris Agreement. This Policy Brief presents the first regional risk assessment of the RSA, it is expected that future programmes will build on and develop this work.

The risk assessment workshop, and preparation of the ROPME Marine Climate Change Risk Assessment and this Policy Brief were supported by the ROPME Secretariat and the UK-GMEP Programme.

CITATION

Please cite this document as: ROPME (2021) Policy Brief: Climate Change Risk Assessment for the ROPME Sea Area (Buckley, P.J., Pinnegar, J.K., Howes, E.L., Maltby, K. and Le Quesne, W.J.F., eds.), Cefas, Lowestoft, UK, 20 pp.

WORKING GROUP ACKNOWLEDGEMENTS

This risk assessment was undertaken at a workshop in Muscat, Oman from 12th-14th November 2019.

Participants were:

- Thamer Salim Ali Al-Dawood ***(Arabian Gulf University, the Kingdom of Bahrain)***
- Badar Al Bulushi, Hilal Sultan Ali Al-Shukaili, Ahmed Mohammed Al-Habsi, Aida Khalaf Al Jabri and Muna Hashil Al Tarshi ***(Environment Authority, the Sultanate of Oman)***
- Rusyan Mamiit and Chiden Oseo Balme ***(Global Green Growth Institute, the United Arab Emirates)***
- Alanoud Al-Ragum ***(Kuwait Institute for Scientific Research, the State of Kuwait)***
- Radhouan Ben-Hamadou ***(Qatar University, the State of Qatar)***
- Hassan Mohammadi and Ali Abdullah ***(Regional Organization for the Protection of the Marine Environment (ROPME), the State of Kuwait)***
- Mohammad Reza Shokri ***(Shahid Beheshti University, the Islamic Republic of Iran)***
- Michel R. G. Claereboudt ***(Sultan Qaboos University, the Sultanate of Oman)***
- Humood A Naser ***(University of Bahrain, the Kingdom of Bahrain)***

Centre for Environment, Fisheries & Aquaculture Science

REGIONAL ORGANIZATION FOR THE PROTECTION OF THE MARINE ENVIRONMENT (ROPME)

P.O.BOX: 26388, SAFAT - 13124, STATE OF KUWAIT
Granada, Jamal Abdul Nasser Street, Area:3,
Tel: (965) 22093939 / 24861442
Fax: (965) 24864212 / 24861668
Email: ropme@ropme.org
www. ropme.org