

BRIEFING NOTES ON THE CIRCE COASTAL CASE STUDIES: THE GULF OF GABÈS

Summary

- ▶ *The Gulf of Gabès (Tunisia) is an extremely shallow basin that leaves it vulnerable to atmospheric warming. High tides, a characteristic of the region, facilitate ocean mixing and modulate sea-water temperatures.*
- ▶ *The Gulf has extensive marine habitats and is*

highly biologically productive; as a consequence it is home to a fishing industry of national importance. However, the marine ecosystem faces threats on two fronts: industrial discharge, and atmospheric warming resulting in raised sea-water temperatures and changes in circulation.

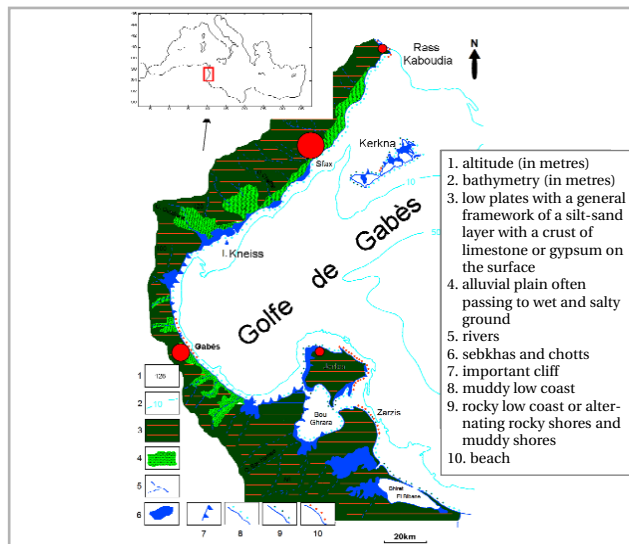
- ▶ *The region is primed for rapid expansion in*

tourism activities, but the low-lying coastline and islands are extremely vulnerable to coastal erosion and inundation from even a moderate rise in sea level.

1. Physical and socio-economic characteristics

The Gulf of Gabès is located in southeast Tunisia (Figure 1). It ex-

Figure 1:
Map of the Gulf of Gabès



tends from the city of Chebba (35.3°N) in the north of the region to the Island of Djerba (33.8°N) in the south, a distance of 200 km. In breadth, it extends from 10°E to just under 11.2°E. The Gulf is a very shallow basin with bathymetry less than 50 m as far as 110 km away from the coast (200 m at 400 km). Population density is low in the coastal areas except for the larger cities. The small city of Chebba in the north of the gulf has around 20,000 inhabitants. In contrast, the city of Sfax with more than 500,000 inhabitants is an industrial pole with an important harbour and several manufacturing industries. Offshore from Sfax, the Island of Kerkenna has

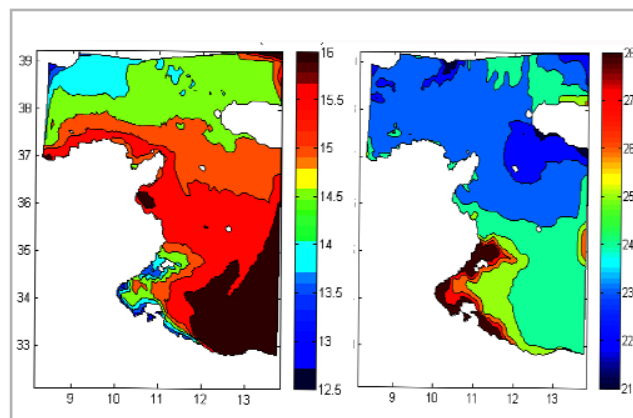
around 15,000 inhabitants. The city of Gabès in the Gulf interior has more than 140,000 inhabitants and has an important harbour and industrial poles. In the south, the Island of Djerba is a very important tourist resort with more than 120,000 inhabitants (230 inhabitants per km²) and a large influx of summer visitors.

The coastal lands of the Gulf of Gabès are formed by low plates with some alluvial plains frequently giving way to wet and salty ground and many *sebkhas* and *chotts* (ephemeral brackish water bodies). There are some cliffs along the coasts. In the southern part of the gulf there are muddy low coasts, rocky

low coasts, or alternating rocky and muddy shores. There are several stretches of beaches especially around the coastline of the Djerba Island.

There are two characteristics of particular importance in the Gulf of Gabès. The first is that the basin is very shallow. In some areas water depth does not exceed one metre over several kilometres. This particular configuration renders the water of the gulf very sensitive to atmospheric conditions. The annual cycle of water temperature is very pronounced (13°C to 29°C) and resembles that of a lagoon (Figure 2). In summer, the particularly high temperatures and salini-

*Figure 2:
Winter (left panel) and
summer (right panel)
sea surface temperature
(right axis; °C) simulated
by a numerical model*



ties (38 to 39 psu) lead to the appearance of red algae. The second important feature of the Gulf of Gabès is the amplitude of the high tide which attains 1.8 m, the highest in the Mediterranean. Tide plays a major role in dampening the seasonal cycle extremes of the "Boughrara" lagoon water temperature. The water of this lagoon, located in the southern part of the gulf, is continuously mixed by tide oscillations preventing excessive warming in summer and cooling in winter. This dampening of seasonal extremes is very important for the lagoon ecosystem.

The Gulf is an important nursery for several species of fish. It is one of the key places for fishing activity in Tunisia, especially for the highly-valued "*Crevette Royale*". Favourable geomorphological and climatic conditions have led to the successional development of a climax community consisting of one of the most extensive marine habitats 'biocenosis' of *Posidonia oceanica* (sea grass)

which extends to the Gulf of Syrte in Libya. The gulf is a highly productive zone, one of the highest in the eastern Mediterranean. There are eight fishing harbours in the Gulf of Gabès and more than 6,500 fishing boats. The total production is around 46,000 T (\$134 thousand) which is almost half the total Tunisia production (96,000 T; \$210 thousand). Fishing activity in the Gulf contributes 0.6 % to the Tunisian GDP. Tourist activity is most highly developed in the Djerba Island, and accounts for 24% of the Tunisian tourism economy. There is a high potential for further expansion in the region, and the beaches of the Gulf of Gabès comprise one of the few remaining coastline areas in Tunisia without the development of intensive tourism facilities.

The Gulf suffers from problems related to toxic industrial discharge, particularly from those chemical works handling phosphates. The pollution affects an extensive part of the oceanic environment.

Posidonia has disappeared over large areas and siltation has been observed in several locations. The scarcity of *Cymodocea nodosa* meadows and the almost complete disappearance of *Caulerpa prolifera* signal a decline in the ecological habitats of the subtidal floor. In addition to these anthropogenic effects the Gulf of Gabès has a heightened vulnerability to sea-level rise due to its low elevation (Figure 3). Large areas of the Gulf especially the islands of Kerkean, Kneis and Djerba are low-lying. Severe erosion of the littoral zone has already been observed and this could accelerate with sea-level rise.

2. Justification

Vulnerability to climate change

During the last decade new species of shrimps, apparently originating from the Red Sea, were found in the Gulf of Gabès. It is hypothesised (despite the absence of an objective study) that this is an indication of a

change in the gulf ecosystem, which is moving closer to a tropical one. For this very shallow gulf, atmospheric warming will dramatically increase water temperatures in summer. Successive episodes of very hot 'Sirocco' winds blowing from the south in summer are observed during years with red-coloured waters. Less ocean mixing of water in the southern part of the lagoon of Boughrara would have severe consequences on the marine ecosystem. A change in atmospheric circulation may affect water entering the Gulf. A plausible scenario of the impact of atmospheric warming is

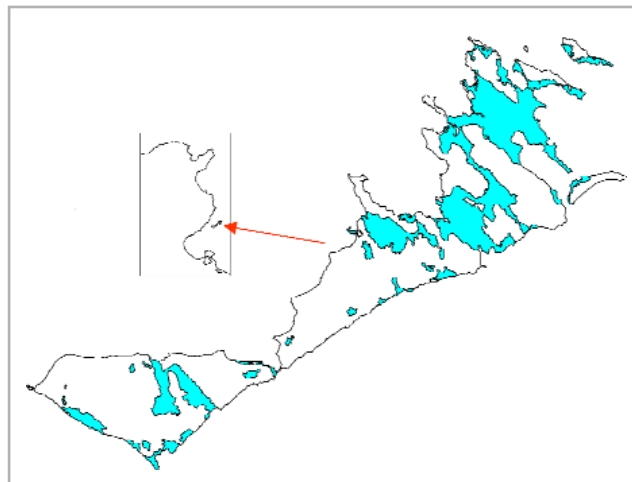
an enhancement of the anticyclonic circulation over the Mediterranean which would reinforce sea-level rise, and invade several fragile *Sebkhat* salt lakes around the gulf. Economically important and rapidly developing tourism activities in the northeast of the Djerba Island (in the southern part of the gulf) makes the flat littoral zone, particularly beaches, very vulnerable to sea-level rise and erosion. The Island of Kerkenna in the northern part of the gulf is extremely flat. Even a moderate rise in sea level will severely affect this island, and 30% of the island will be inundated by water. It is anticipated

that the four low-lying islands, *Kneiss*, located in the inner part of the Gulf, will disappear completely.

Availability of appropriate data

The Gulf of Gabès has always been a very rich fishing area, and hence it is one of the most studied sites in Tunisia. There are at least four meteorological stations located around the Gulf. Most of them have more than a century-long record of data. There are also a variety of marine datasets for the Gulf, including sea temperature and salinity as well as data related to fishing

*Figure 3:
Low-lying land
in the Kerkna Island,
the Gulf of Gabès*



activity. Some of the data are digitised; others are archived in notes and reports. One of the tidal gauges with the longest data record in Tunisia is that of Sfax harbour. This data could be used to examine potential sea-level rise.

Access to stakeholders, including decision and policy makers

There are two types of stakeholders of direct relevance to the Gulf of Gabès. First, there are fishing companies which have a vested interest in marine species richness and maintaining the natural resources. Second, there are chemical factories working principally on phosphates and discharging mainly *phosphogypsum*. A decision was recently taken to stop such pollution and to encourage tourism activity in line with other regions of Tunisia. The sustainable development of this region is a major challenge. Direct anthropogenic damage to the environment of the Gulf may have lessened, but there is a need to better

understand the integrated impacts of climate change on the Gulf. In addition to these categories of stakeholders, there is close collaboration between INSTM (Italian Interuniversity Consortium on Materials Science and Technology) and the Tunisia Agencies for Environmental Protection and for Littoral Management (who have a strong interest in the Gulf of Gabès).

3. Key Research Issues

► *Climate issues:* Two types of data will be collected:

1. Meteorological data: air temperature and precipitation
2. Ocean data: water temperature and salinity. Trends in the climate of the Gulf and changes in ocean circulation and other marine characteristics will be examined.

► *Environmental issues:* salinisation; coastal erosion; soil erosion; inundation and coastal flooding, and sea-level rise in the low-lying ar-

reas of the Gulf. Ecosystem concerns include: loss of biodiversity and invasion by new species, and changes in ocean mixing within the Boughrara lagoon and the resulting effects on the lagoon ecosystem.

► *Social issues:* the effects of sea-level rise on coastal erosion, loss of land, and tourism development; the impact of sea warming on the fishing industry and ensuing socio-economic consequences.

4. Key areas of integration

Potential areas of integration for assessing impacts of climate change in the Gulf of Gabès include:

► Climate change – atmospheric warming – water warming in the gulf with increased frequency of algal blooms – invasive species – reduction in biodiversity – low-quality fish – negative impact on the fishing industry.

- ▶ Climate change – sea level rise – coastal erosion – large areas of land lost by flooding – detrimental socio-economic impacts (beaches, tourism, individuals) – policy response through inland evacuation strategies.
- ▶ The effect of climate change on the lagoon of Boughrara is not yet known, there are two possible scenarios:
 1. water warming – reduction in biodiversity – low-quality fish – negative impact on the fishing industry.
 2. sea level increase – increased water exchange with the Gulf of Gabès and the eastern Tunisian marine waters – increased water renewal – improved water quality – increased fishing production and possible initiation of aquaculture activity.

5. Regional stakeholders, policy makers, institutions

Contacts will be made with the following stakeholders:

- ▶ National Institute of Marine Sciences and Technology
- ▶ National Agency of Environmental Protection
- ▶ Littoral Protection and Management Agency
- ▶ Regional Activity Centre for Specially Protected Areas
- ▶ Tunis National Institute of Agronomy
- ▶ Tunisia Meteorological Institute
- ▶ Tunisia Union for aquaculture and fishing
- ▶ Harbour Management Agency
- ▶ Ministry of Agriculture and Water Resources
- ▶ National Institute of Arid Areas
- ▶ Climate Change and Sustainable Development Association
- ▶ Legislation on building developments close to the littoral zone.
- ▶ Restrictions on the timing and location of shrimp fishing.
- ▶ Strategies for identifying low-lying areas vulnerable to coastal flooding.

6. Data availability

Data available for the Gulf of Gabès case study include:

- ▶ Air temperature and precipitation data from stations located in the Gulf of Gabès and available from the Tunisia Meteorological Institute. Monthly data are available from the year 1901.
- ▶ Sea-level data spanning several years.
- ▶ Fish production statistics.
- ▶ Coastal characteristics.

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Further reading

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