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

Assessment of marine climate change dimensions in the Inner ROPME Sea Area using time-series satellite data

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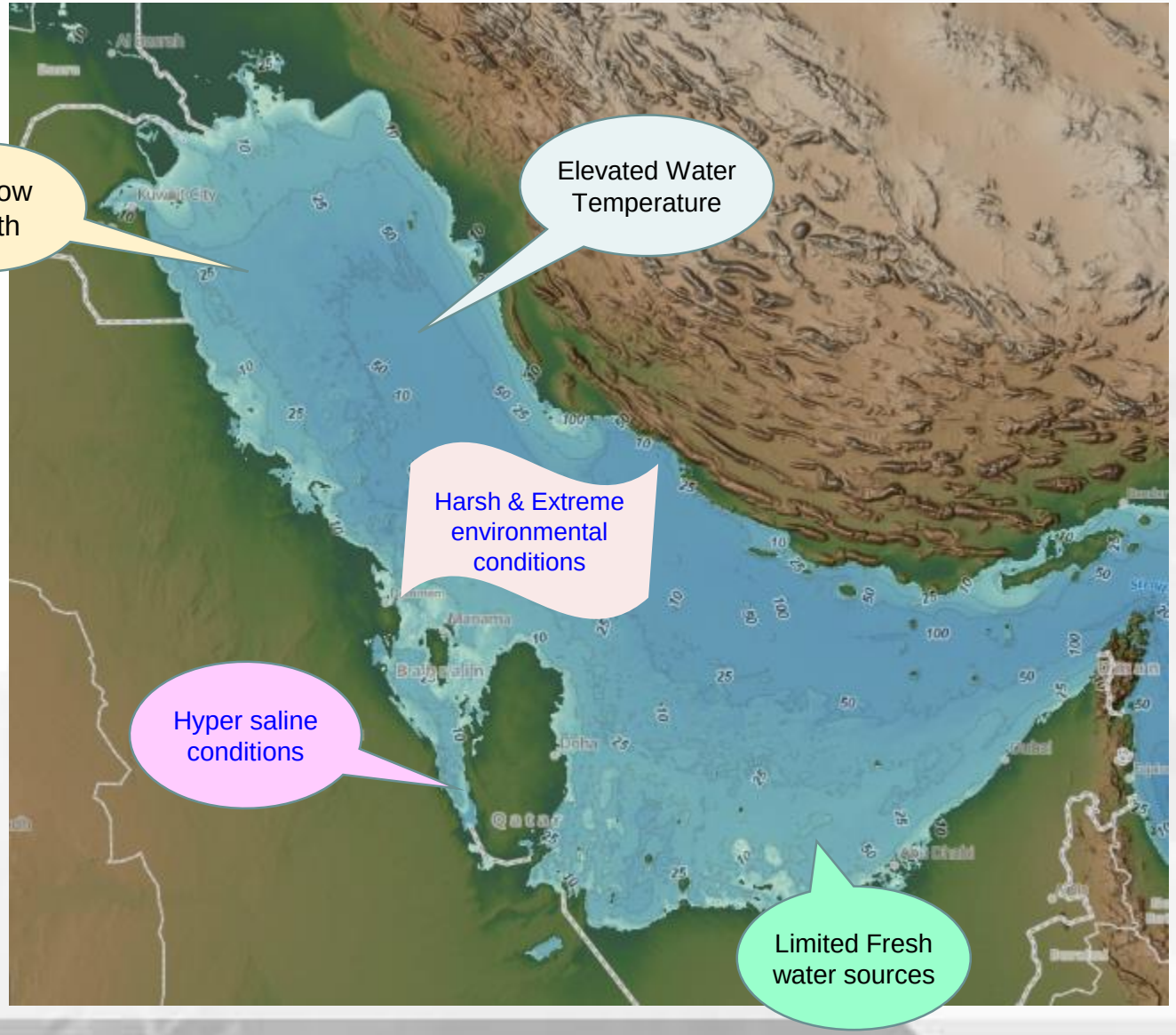
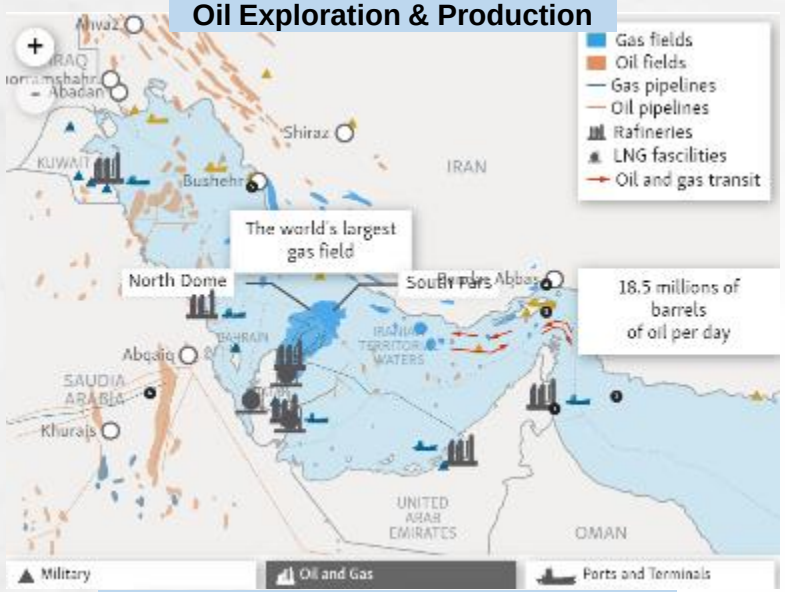
ROPME Sea Area (non-UNEP administrated)

Main Oceanographic Characteristics of the I-RSA

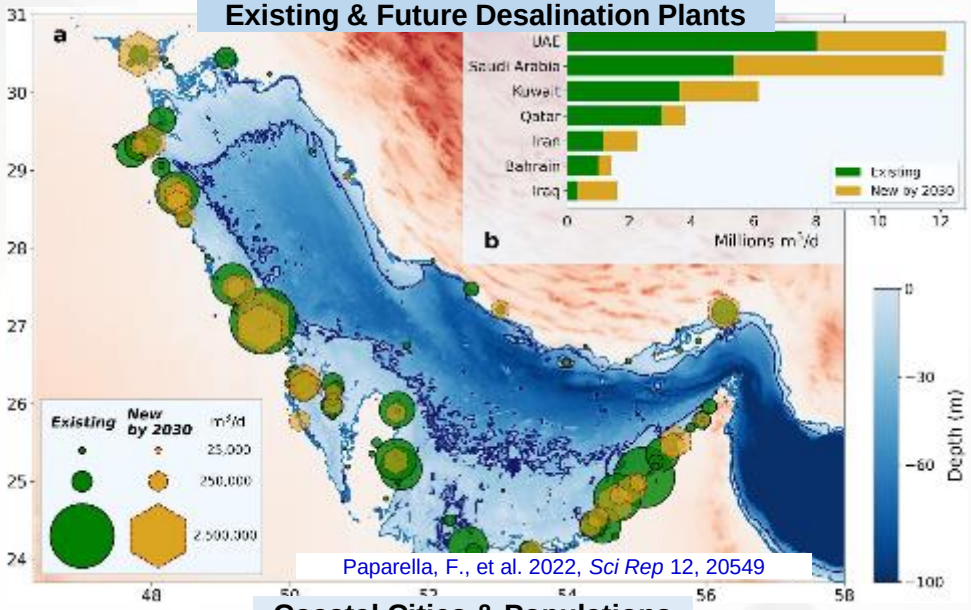


Main Anthropogenic Activities & Source of Stresses to I-RSA (other than Marine Climate Change)

Oil Exploration & Production

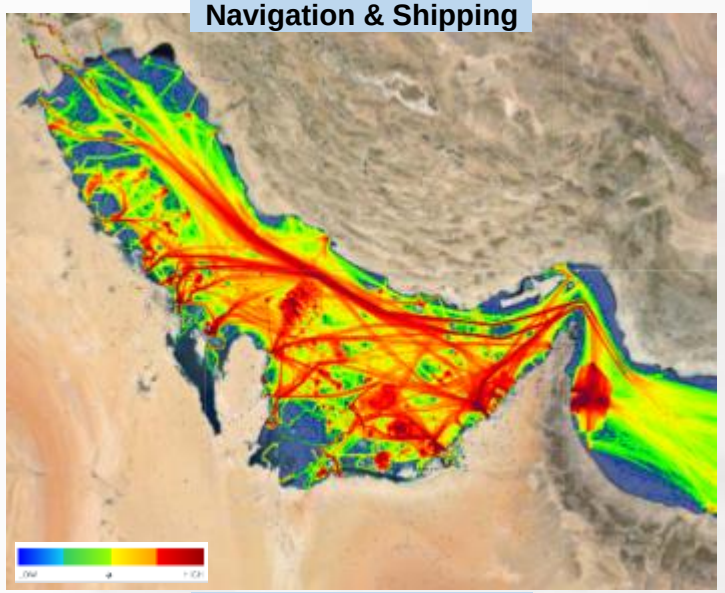


Existing & Future Desalination Plants



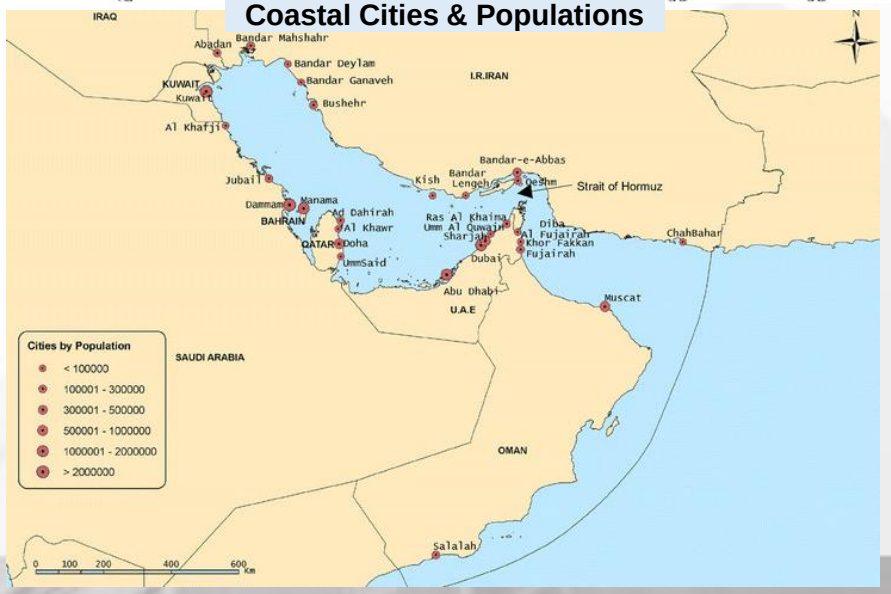
Paparella, F., et al. 2022, *Sci Rep* 12, 20549

Navigation & Shipping

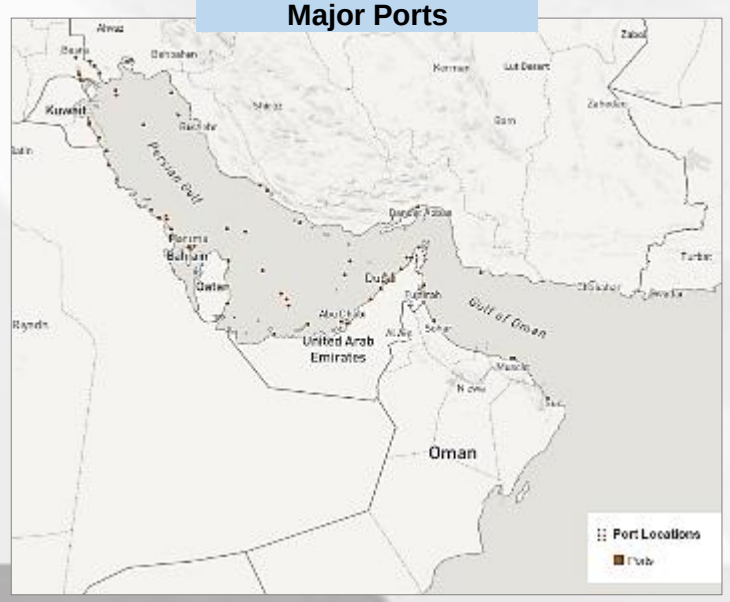


Urbanization & Coastal Development

Coastal Cities & Populations



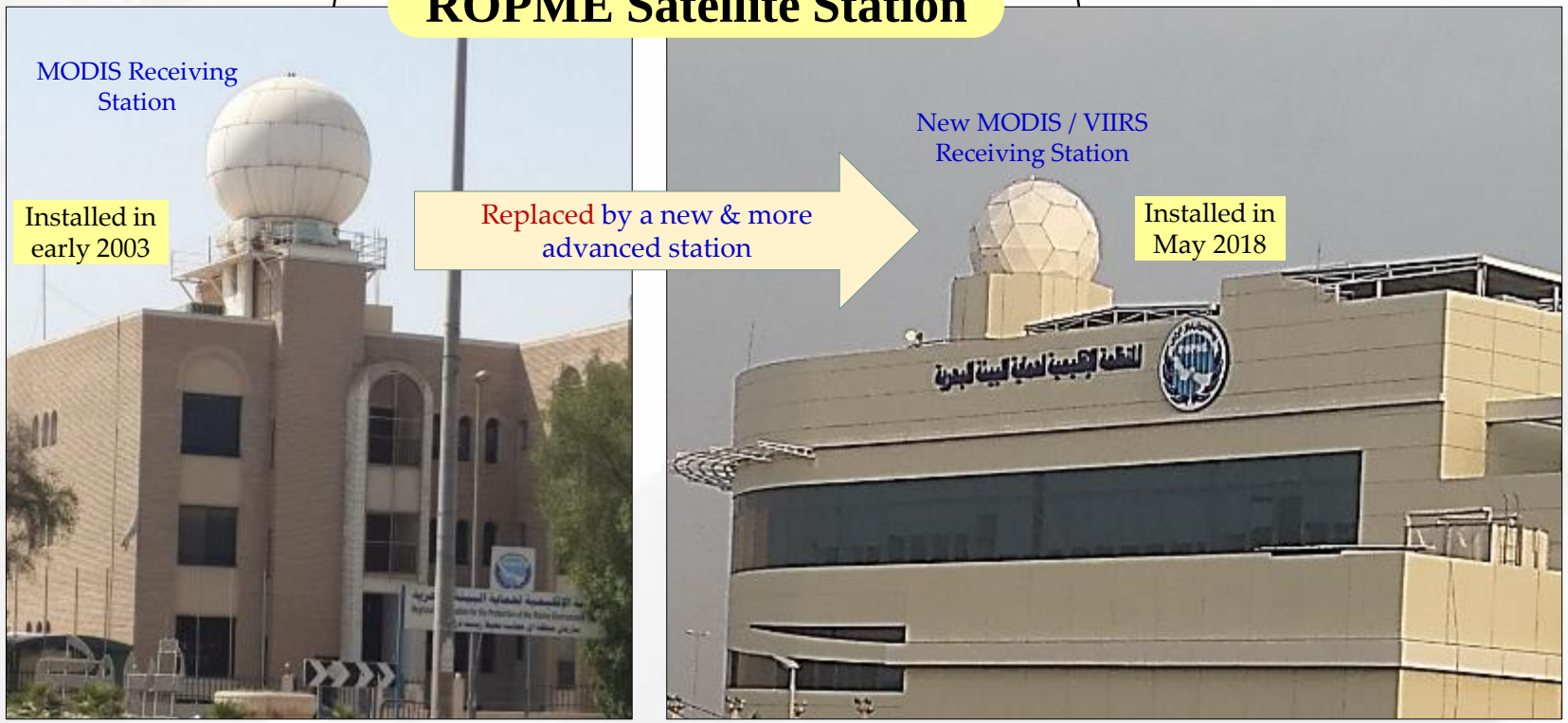
Major Ports



ROPME'S Main Environmental Monitoring Programs

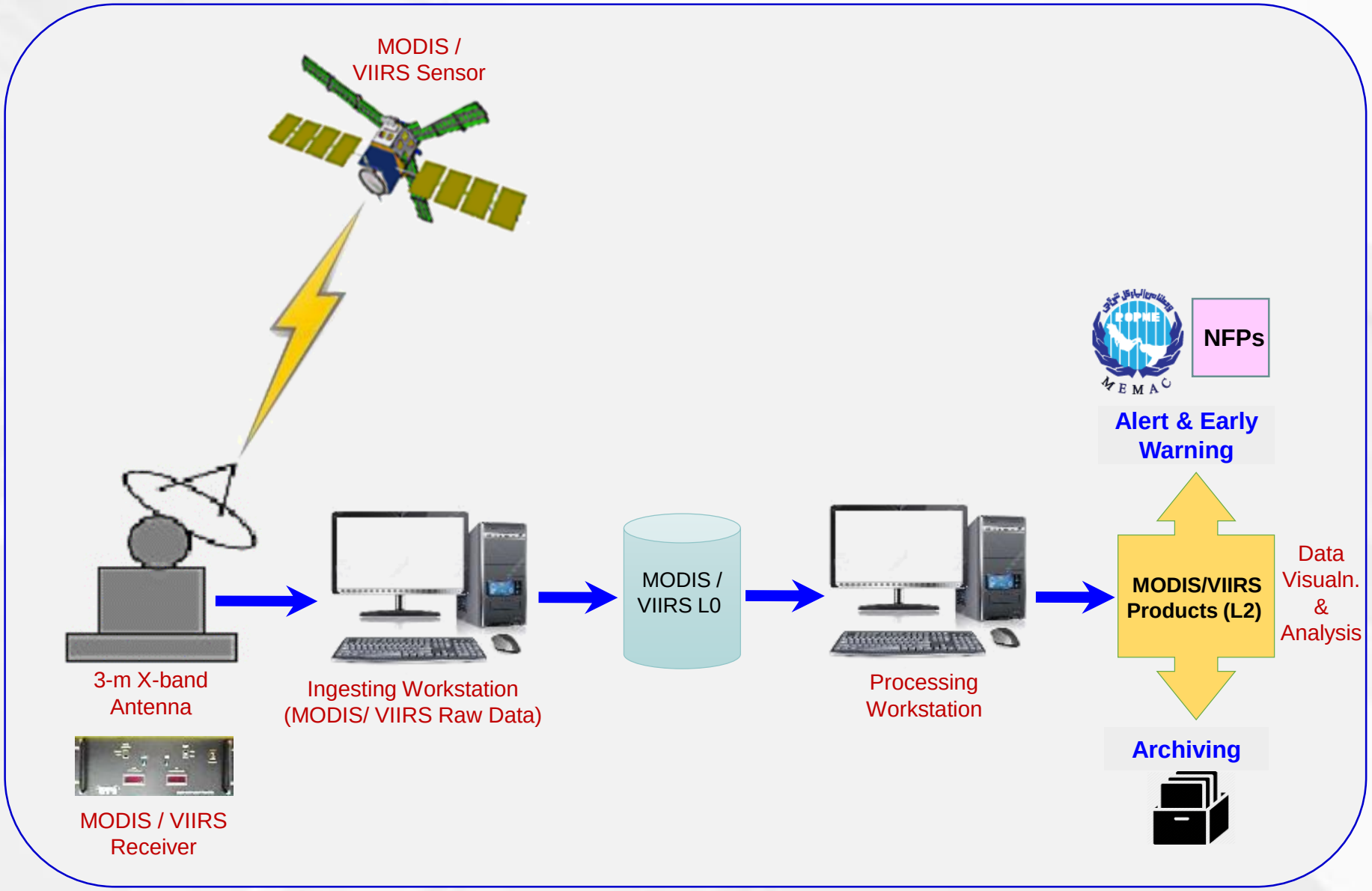
- Oceanographic Surveys
- Satellite-based
- Shore Sampling

ROPME Satellite Station



Receiving satellite imagery on daily basis from MODIS sensor on-board Terra & Aqua space platforms and from VIIRS on-board NPP & NOAA-20

MODIS / VIIRS Receiving System Concept & Overview



Standard Ocean Data Products Available from ROPME Satellite Receiving Station: MODIS (Terra & Aqua)

MODIS	Parameter
chlor_a	chlorophyll a concentration
nflh	fluorescence line height
cdom_index	colored dissolved organic matter
Kd_490	attenuation coefficient at 490 nm
pic	particulate inorganic carbon
poc	particulate organic carbon
par	photosynthetically available radiation (par)
ipar	instantaneous par
Rrs_412	remote sensing reflectances
Rrs_443	
Rrs_469	
Rrs_488	
Rrs_531	
Rrs_547	
Rrs_555	
Rrs_645	
Rrs_667	
Rrs_678	
sst	sea surface temperature (daytime)
sst4	sea surface temperature (night time)

- ✓ **Phytoplankton conc.**
- ✓ **Ocean color**
- ✓ **Turbidities & Sedimentary Processes**
- ✓ **Aerosol optical depth**
- ✓ **Physical forcing, eddies**
- ✓ **Upwelling & downwelling**

Satellite Data Utilized & Applied Methods

1. Decadal & Inter-annual MODIS-Aqua data

- Standard Sea Surface temperature (SST), Chlorophyll-a (Chl-a), Particulate Organic Carbon (POC)
- ~ 20-year time series: July 2002 – July 2022
- Monthly & 8-day averaged data (fully normalised reflectance data set)

2. SST standard retrieval algorithm

A‘window-split’ retrieval algorithms were employed. These are based on the difference between the satellite-observed water surface *apparent (brightness)* temperature, Ti determined in two several spectral channels centered at 11 μm (T11) and 12 μm (T12).

The NASA algorithm is a four-term expression with proportionality coefficients c1 – c4:

$$SST = c1 + c2T11 + c3(T11 - T12) + c4[(sec\phi - 1)(T11 - T12),$$

where ϕ is the satellite zenith angle

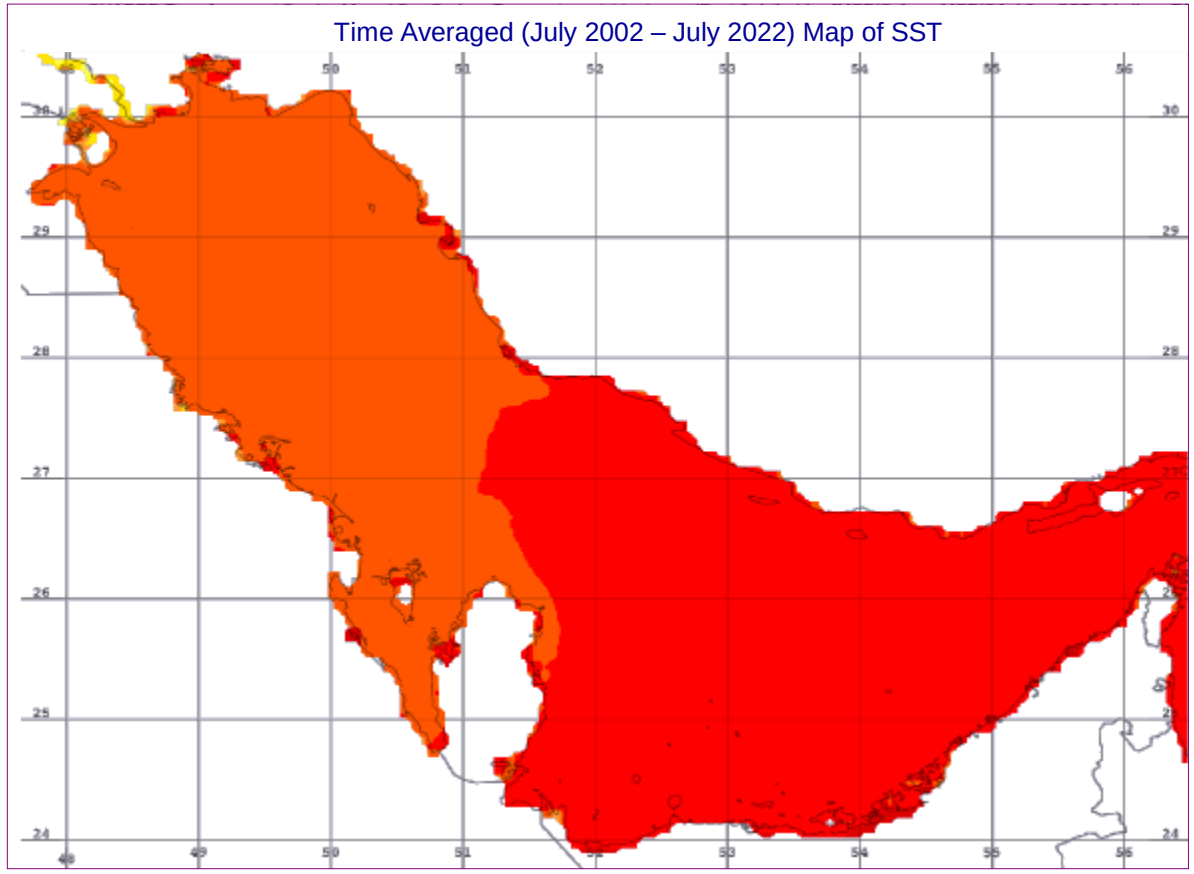
3. Chl-a standard retrieval algorithm

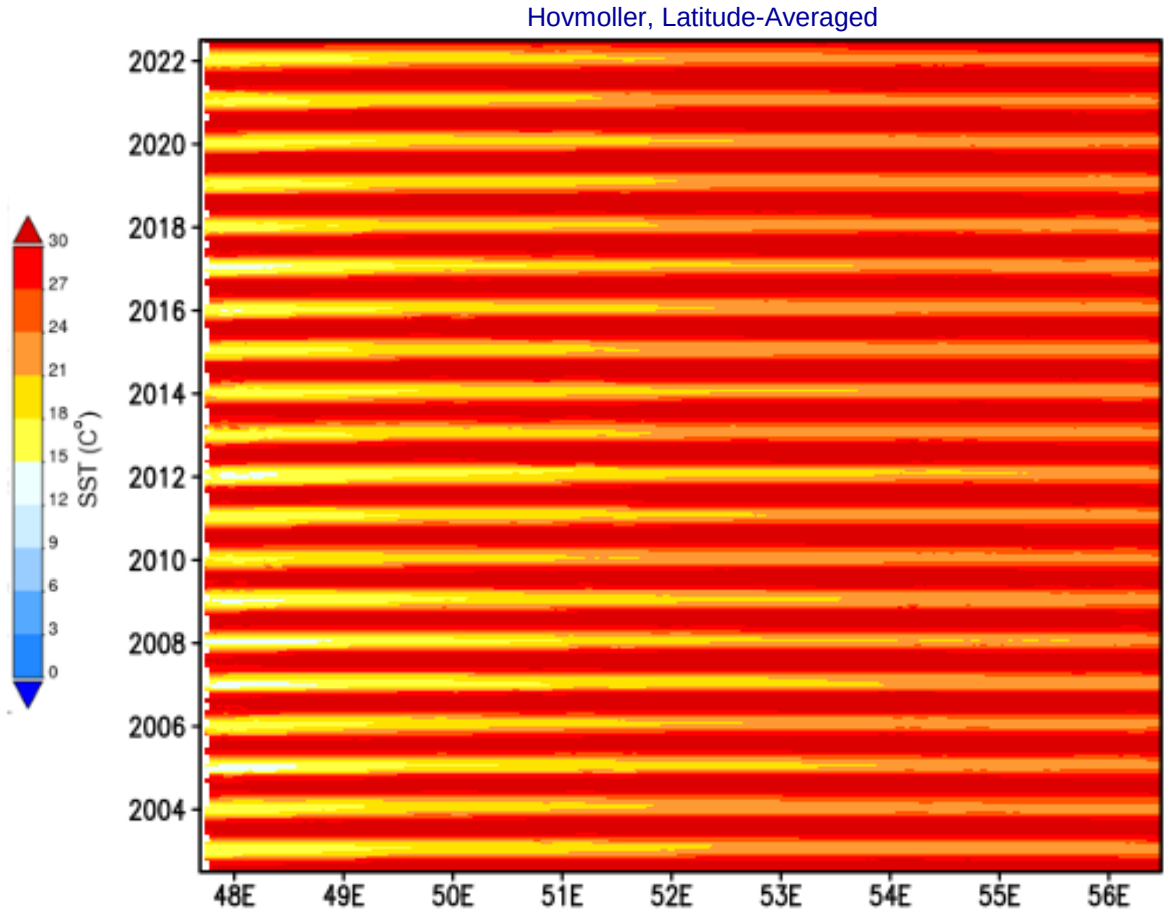
The concentration of chl-a (mg m^{-3}) was retrieved using improved NASA standard algorithm is a blend between the updated OC3 band ratio algorithm (O'Reilly and Werdell 2019) and the color index (CI) of Hu et al. (2019). These are modified cubic polynomial functions based on the band ratio paradigm and employing remote-sensing spectral reflectance in the visible and near infrared channels as the input parameter.

Further information: *https://oceancolor.gsfc.nasa.gov/resources/atbd/chlor_a/*

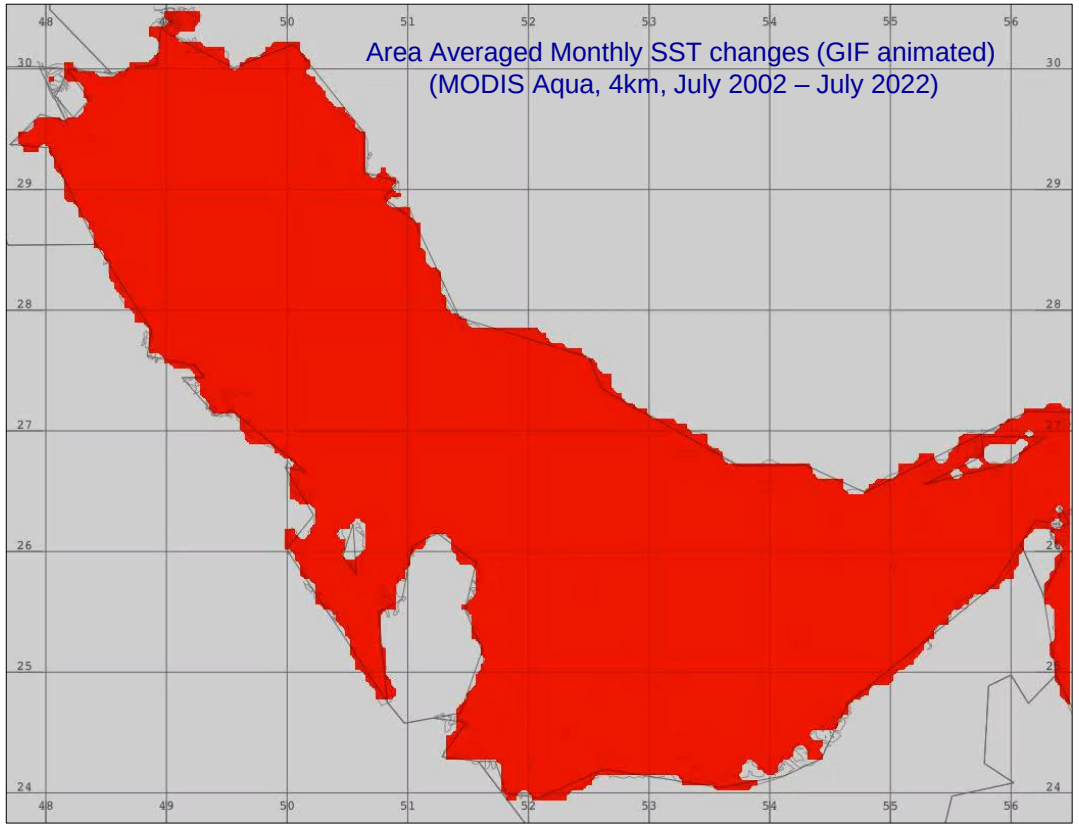
Time & Latitude Averaged of SST °C (Daytime) in the Inner ROPME Sea

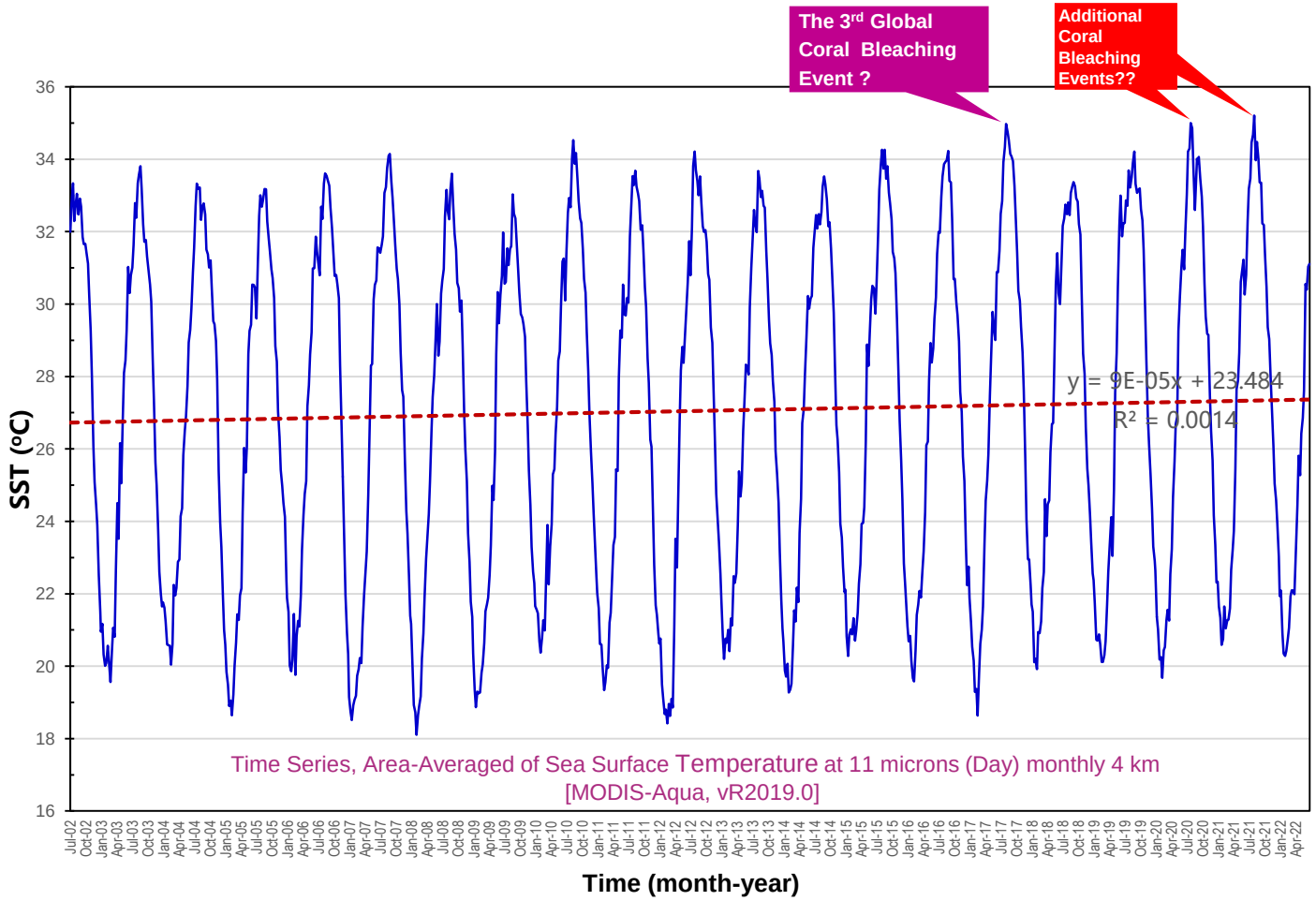
(MODIS-Aqua, 8-daily, 4km: July 2002 – July 2022)



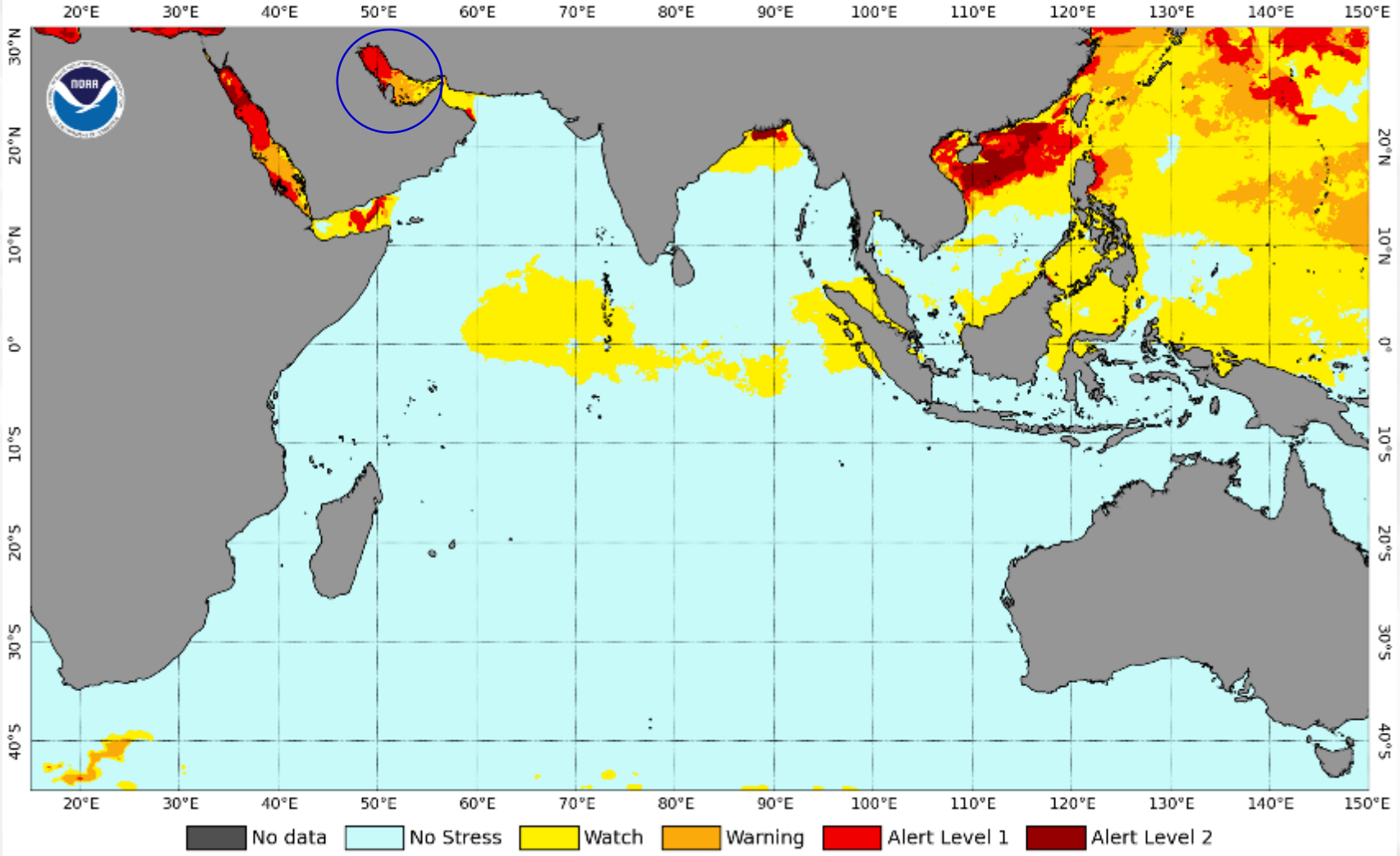


Decadal & Seasonal Variability of SST ºC in the Inner ROPME Sea Area
(Monthly, 4 km, MODIS-Aqua: July 2002 - July 2022)



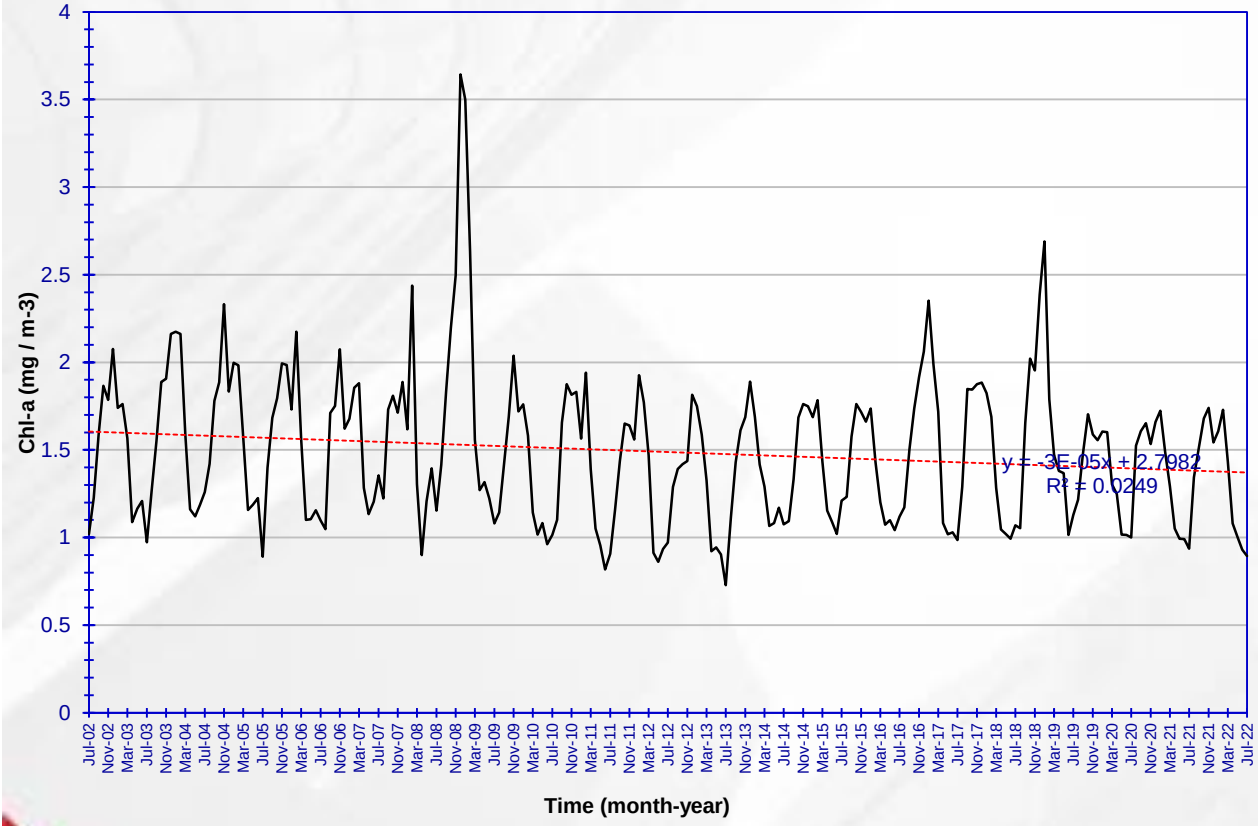


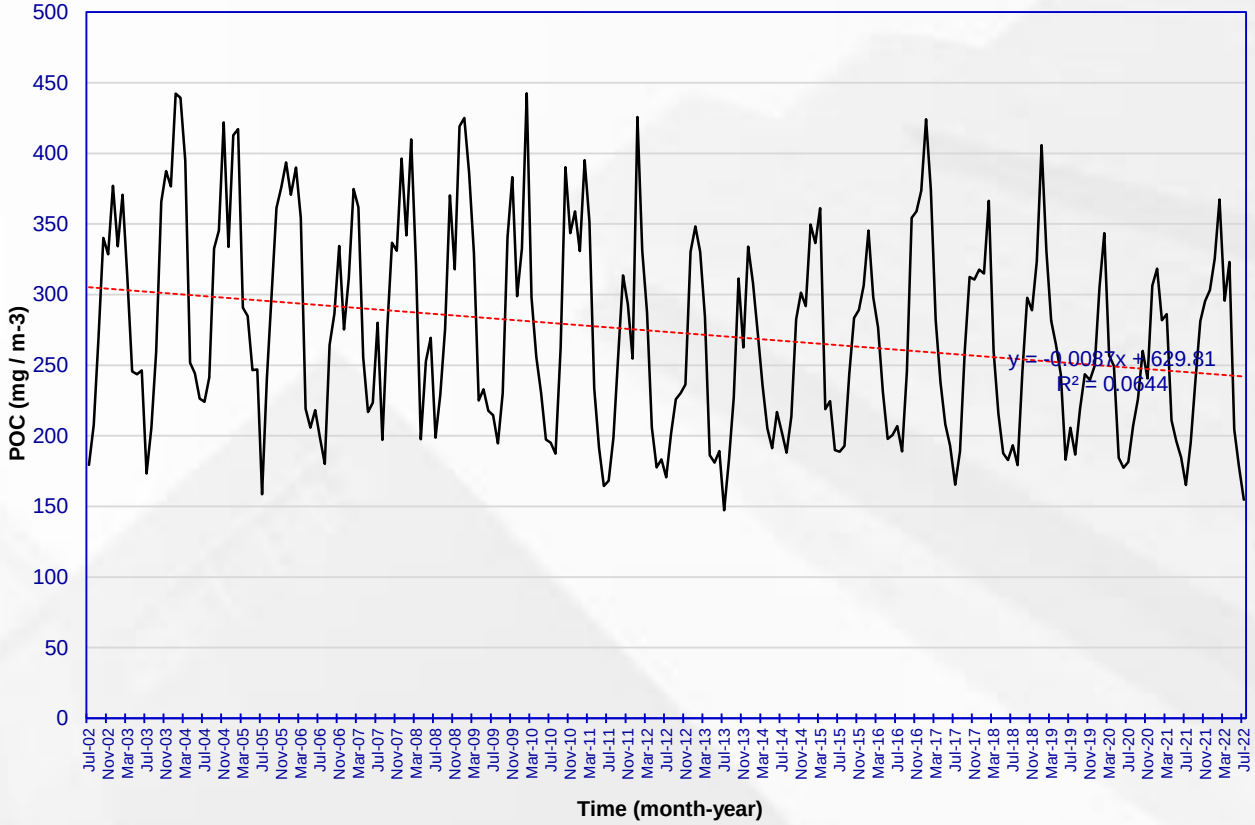
NOAA Coral Reef Watch Daily 5km Bleaching Alert Area 7-day Maximum (v3.1) 22 Aug 2023



Decadal & Seasonal Variability of Chlorophyll-a Concentration (Chl-a) and Particulate Organic Carbon (POC) in I-RSA

(Monthly, 4km, MODIS-Aqua: July 2002 – July 2022)





Concluding Remarks & Future Directions:

- Decadal satellite datasets from MODIS, VIIRS and other high temporal resolution sensors are vital for evaluation of spatial and temporal variations of SST and other climatology data and for monitoring of long-term trends and assessment of climate change dimensions.

- All key satellite-derived sea parameters and results of time series analysis of utilized MODIS data indicate identifiable and sustainable increase of the SST in the Inner ROPME Sea Area by ~ 0.6 C^{o} and downward trend in both of surface chlorophyll-a (Chl-a) & particulate organic carbon (POC).

- The downward trend of surface Chl-a conc. & POC in the Inner ROPME Sea Area raises many questions and needs further research.

- Inter-annual variations of SST & Chl-a in the Gulf will be correlated with other climatic factors such as precipitation, aerosol (atm. deposition), solar radiation to see if there is any significant match of one factor or another to Gulf ecosystem.

- Similarly, these variations will be correlated with coral bleaching events and other locus of habitats loss to see which factor has increased effect on coastal ecosystems and habitats and how climate change affect specific habitat.

THANK YOU

For further information, please contact me at:

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http://ropme.org/