Systematic Operational Procedure for Marine Heat Wave Advisory Services

I. Background:

Climate change is a global phenomenon and the impacts vary locally, hence it is necessary to estimate the intensity and variability of the heat content in the sea. In this regard, a Marine Heat Wave (MHW) is a parameter to understand the persistence of heat content in the marine environment. The MHW is a discrete prolonged anomalously warm water event. The requirements for a warm water event to be described as an MHW are a duration of five or more days, temperatures greater than the 90th percentile of minimum 30-year local measurements and should not more than 2 days of cooling occurrence in a specific region (Hobday et al., 2016). It is caused by a combination of atmospheric and oceanographic processes that have a strong influence on marine ecosystem structure and function. The Spatio-temporal changes of the MHW should be relative to a baseline period (climatology) and a particular time of the year from which the intensity, duration and spatial extent of the MHW could be defined. That means MHW is not just limited to the warmer months, but also for some biological applications, the consideration of heat waves in colder months is also essential. Therefore, it is necessary to calculate MHW on spatiotemporal scales with respect to the baseline of climatology and established relationship with sensitive analysis of Marine habitat. In the recent decade, frequent MHW events associated with the degradation of marine habitats, high-intensity cyclones, etc. have been reported that led to socioeconomic losses. Owing to their devastating nature, MHWs and their generating mechanisms have received a lot of attention in the recent past. Studies of major MHWs that appeared in various parts of the world over the last decade suggest that the evolution and the forcing mechanisms of such events differ considerably from region to region and predominantly depend on the local air-sea coupling, atmospheric conditions, oceanic preconditions, and remote climatic teleconnections (Holbrook et al., 2019; Oliver et al., 2021). Hence Indian National Center for Ocean Information Services (INCOIS) has carried out research on the frequency and intensity of Marine Heat Wave variability in intra and inter-annual cycles and their forcing mechanisms to address the impact of MHW on marine ecology using satellite and model-derived SST data (Mohanty et al. 2021; Chatterjee et al, 2022).

Based on these experimental case studies, INCOIS has setup a Marine Heat Wave Advisory (MHWA) service on daily basis comprising the parameters Intensity of Marine Heat Wave (IMHW), MHW categories (MHWCAT), percentage of the area of MHW spread over the different basin and sector over the Indian Ocean and south China Sea through the web interface for users. These advisory services can be helpful for understanding the impact of Marine habitat and the frequency and intensity of disaster events for Indian rim country and research communities.

II. Study Area of MHW advisory

The daily marine heat wave products are issued on the Indian Ocean and adjacent basin of the geographical domain extent of 15E to 120E Longitude and 45S to 30 N Latitude regions. Based on homogeneous physical and geographical characteristics, the current study is divided into six major basins: Arabian Sea (AS), Bay of Bengal (BOB), "Gulf of Aden and Red Sea", Persian Gulf, Rest of Indian Ocean (RestofIO), South Chain Sea and others (Other Sea) for better interpretation. Apart from this, state-wise sector boundaries such as: Gujarat (GUJ), Maharashtra (MHA), Goa (GOA), Karnataka (KAR), Kerala (KERALA), Lakshadweep (LKA), South Tamil Nadu (SNT), North Tamil Nadu (NTN), South Andhra Pradesh (SAP), North Andhra Pradesh (NAP), Odisha (ORI), West Bengal (WB), Andaman (ANDM) and Nicobar (NIC) have been delineated for Indian coastal country. Based on these basins and sector domains, users can quantify the area and intensity of MHW at any selected time.

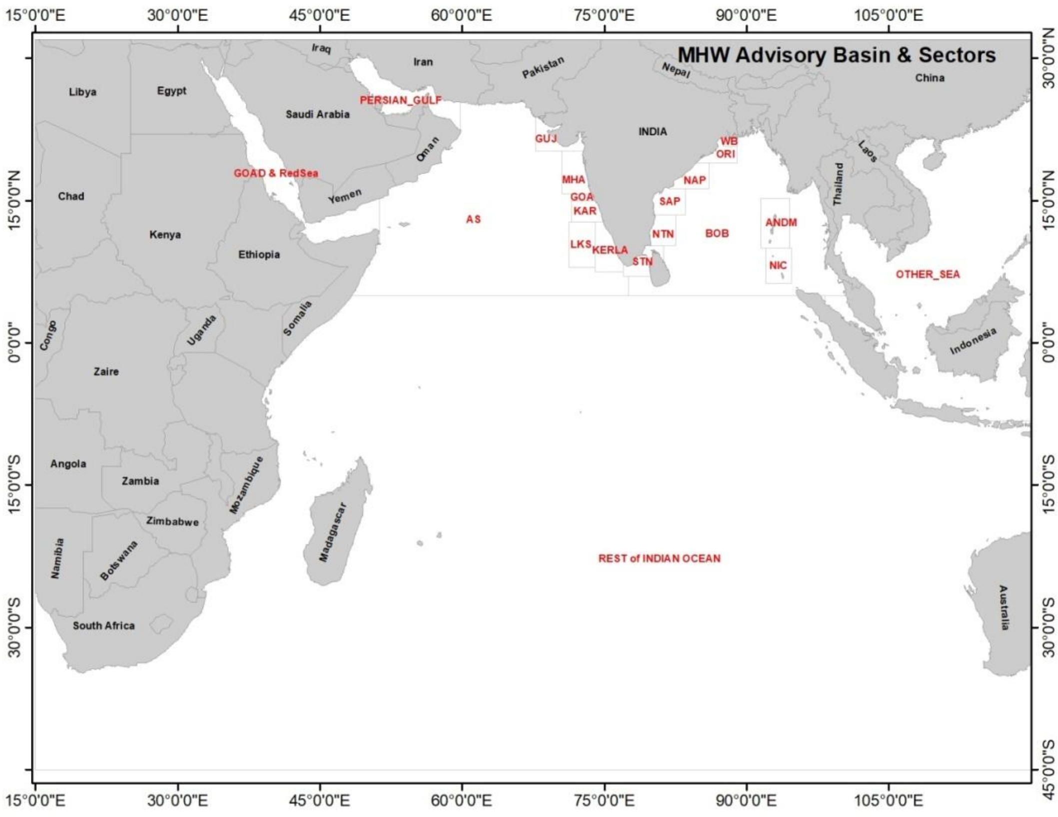

Figure 1: Study area of MHW advisory with Major Basin and sectors

III. Methodology

Marine Heat Wave: The Optimum Interpolation Sea Surface Temperature (OISST) data is downloaded from the data portal of NOAA from 1991 to 2020. The 90 percentile of daily climatology (90PerClim) is calculated based on 11 days centered daily window from 1991 to 2020 period. The five or more days of continued persistence of the Threshold anomaly value (OISST value above T_{90} percentile) is defined as a the MHW event. If a gap of more than 2 days exists without meeting above criteria, then it is considered as a separate event. The intensity of MHW on a given date is calculated by subtracting daily Average Climatology (AvgClim) from OISST.

The severity of MHW: The severity has been calculated based on the intensity of the MHW scaled by the threshold temperature anomaly exceeding climatology. The MHW severity is classified as Moderate, Strong, Severe and Extreme for corresponding MHW advisory. These categories are defined by the intensity of the MHW scaled by the threshold temperature anomaly exceeding the climatology, defined as a “unit” (Hobday et al., 2018). For example, the event has a severity of less than 2 units is indexed as “moderate”, 2-3 units as “strong”, 3-4 is “severe” and more than 4 units as “extreme” (Hobday et al. 2018).

Percentage of Area of MHW in Basin level: The percentage of total MHW area spread over a particular basin/sector in a specific time. The percentage cumulative sum of severe and extreme categories spread over a basin is referred as cumulative sum of Strong, Severe and Extreme events (cum-SSE) .

These above metrics are useful for assessing the exposure of marine ecosystems to elevated thermal stress (i.e., persisted marine heat conditions). The methodology used for the generation of MHW advisory as shown in figure 2.

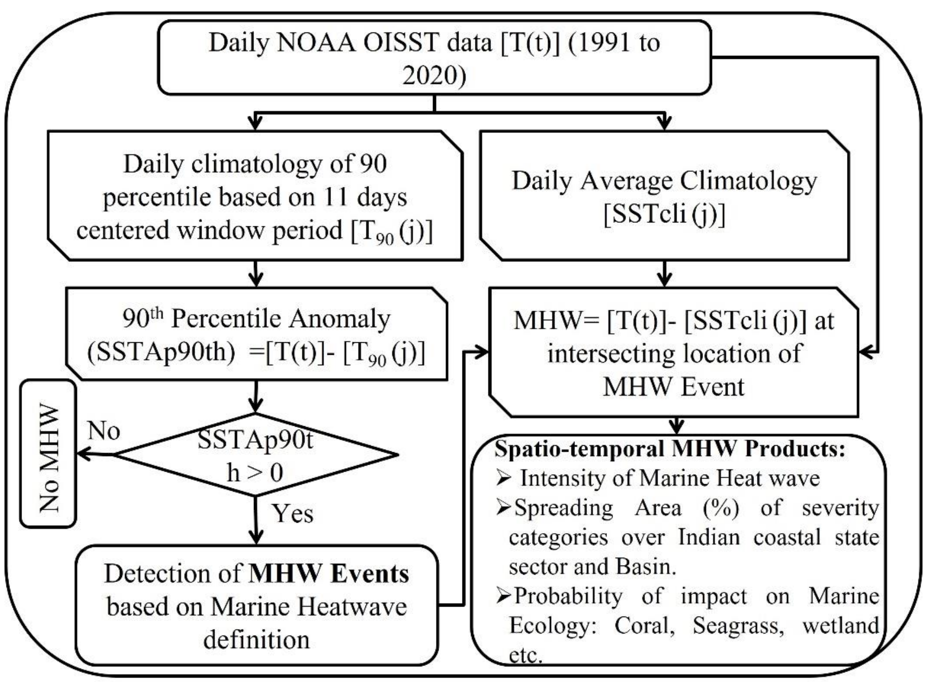

Figure 2: Flow chart of the methodology used for MHW computation and advisory generation.

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Reference:

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