Indian National Centre for Ocean InformationServices (INCOIS)

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Special El Nino Outlook Bulletin

Highlights:

- **Sea surface temperature anomalies over the central and eastern equatorial Pacific indicate the development of El Niño conditions during May 2026.**
- **El Niño is expected to remain the dominant ENSO phase from June 2026 through February 2027, with probabilities ranging from 70–90%. ENSO-neutral conditions remain the second most likely outcome (10–30% probability), while La Niña is highly unlikely (<3%).**
- **The ongoing El Niño is likely to influence Indian Ocean conditions through warmer ocean temperatures, increased marine heatwave risk, and changes in marine ecosystems and ocean state.**
- **The warming conditions associated with El Niño is likely to result in a modest decline in small pelagic fish landings (Indian Oil Sardine and Indian Mackerel) and a possible reduction in the average size of these species in catches during the upcoming fishing season.**

Introduction

El Niño refers to the warm eastern Pacific Ocean warming associated with the positive phase of the El Niño Southern Oscillation (ENSO). A prevailing ElNiño condition in the Pacific Ocean has an adverse effect on the Indian summer monsoon rainfall and, thereby on the economic well-being of the country. El Niño is also found to cause stronger and prolonged marineheatwaves in the northern Indian Ocean, damaging the ecological balance, coral reefs and causing significant losses to the fishery industry. Thus, monitoring the El Niño condition and predicting its further evolution with sufficient lead time is of prime importance for better preparedness and policymaking.

Beyond its influence on monsoon rainfall, El Niño can significantly alter ocean conditions across the Indian Ocean through changes in sea surface temperature, upper-ocean heat content, ocean circulation, marine heatwaves, and marine ecosystem productivity. These changes can influence fisheries, coral reef health, coastal hazards, and maritime activities, making ENSO outlooks valuable for a range of operational ocean services provided by INCOIS. This bulletin outlines the current state of the Pacific Ocean and an outlook on the evolution of El Niño/La Niña conditions in the subsequent seasons.

Details of the datasets and methodology used to prepare this bulletin are given in Annexure-I.

Evolution of Nino 3.4 Sea Surface Temperature Anomaly

Monthly evolution of Nino 3.4 SST anomaly in the past two years is shown in Fig. 1. The positive SST anomaly conditions prevailing in the Pacific weakened to near-neutral conditions by May 2024 (Fig. 1). Figure 2 shows that moderate positive subsurface temperature anomalies (~3°C) developed in the western equatorial Pacific from May to November 2025, while SST anomalies remained weak to moderate during the period, with patchy warming and cooling across the equatorial Pacific, indicating the gradual evolution from ENSO-neutral towards near-La Niña conditions. By February 2026, reduced surface cooling was observed across the central and eastern equatorial Pacific, while strong subsurface warming persisted in the western Pacific and extended eastward into the central Pacific, consistent with the development of ENSO-neutral conditions, with indications of emerging El Niño-like conditions (Fig. 2). As shown in Figure 3, by May 2026, negative SST anomalies over the central and eastern equatorial Pacific largely disappeared, accompanied by weakening subsurface cooling in the east-central Pacific, while strong surface and subsurface warm anomalies (>3°C) gradually extended eastward from the western Pacific across the central and eastern equatorial Pacific, indicating the development of El Niño conditions. Hence, ENSO was in an El Niño phase over the central Pacific by May 2026.

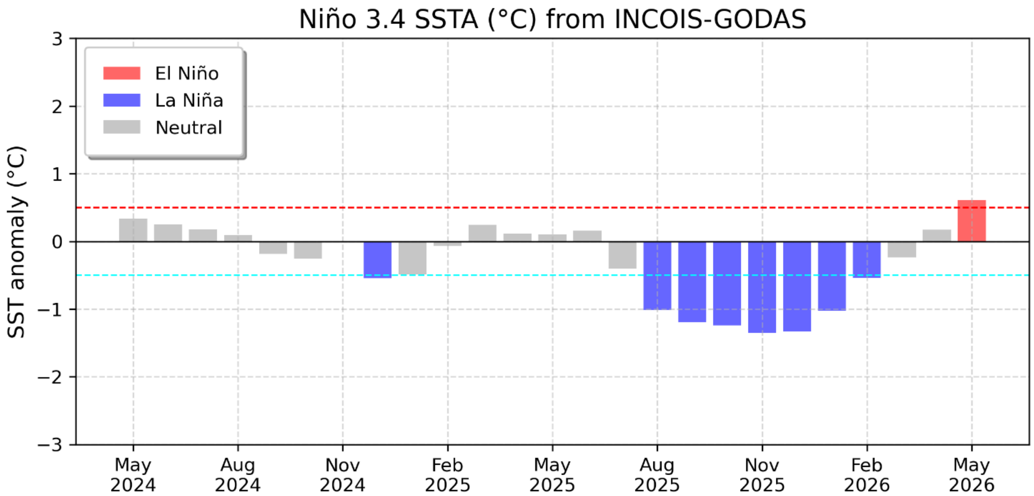

Fig. 1: Evolution of Sea Surface Temperature anomalies (ºC) in the Niño 3.4 (5°S-5°N, 170°W-120°W) region in the period May 2024 - May 2026. The RED and CYAN horizontal lines represent 0.5ºC SST anomaly

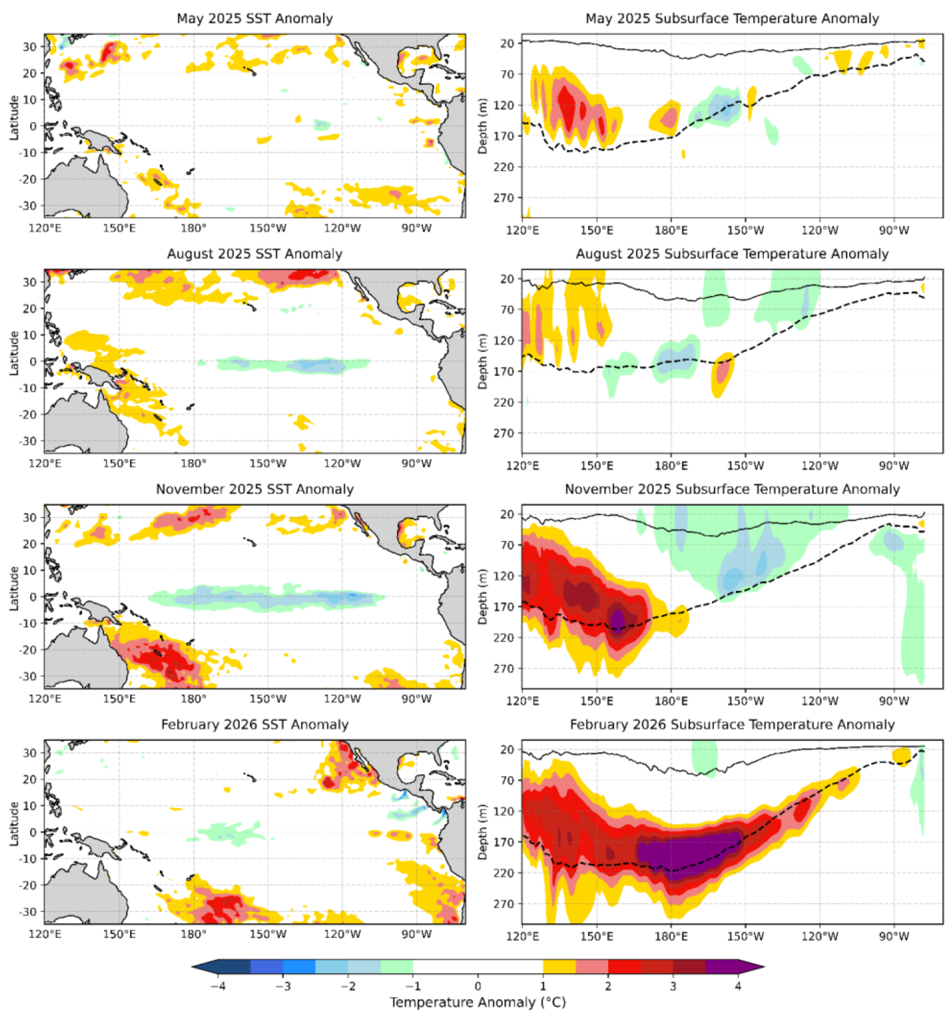

Fig. 2: (left) Monthly SST anomaly for the tropical Pacific. (Right) Subsurface temperature anomaly averaged over 5º S-5º N for the corresponding months.

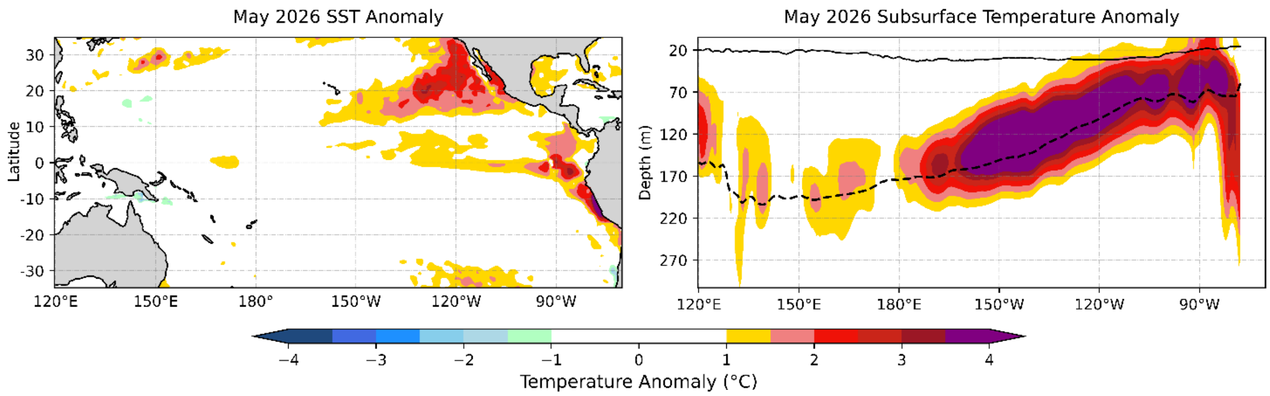

Fig. 3: (Left) Monthly SST anomaly for the tropical Pacific in May 2026. (Right) Subsurface temperature anomaly averaged over 5º S-5º N for May 2026.

INCOIS Outlook for NINO 3.4 index

INCOIS devised a deep learning-based Bayesian Convolutional Neural Network (BCNN) model to have probabilistic outlooks of the future evolutionof Nino 3.4 index. The model provides skillful prediction of Nino 3.4 index up to a lead-time of 15 months [See Annexure-I for more details of the model and its skill levels]. Median values of Nino 3.4 SST anomalies predicted by the model based on the March 2026 – May 2026 initial conditions extracted from INCOIS- GODAS are shown in Fig. 4. From June 2026 onwards through the forecast period to February 2027, El Niño is expected to be the dominant ENSO phase, with probabilities ranging from 70% to 90% (Fig. 5). ENSO-neutral conditions are projected to be the second most likely phase, with probabilities of 10% to 30%, followed by La Niña, which remains the least probable phase with probabilities of less than 3%.

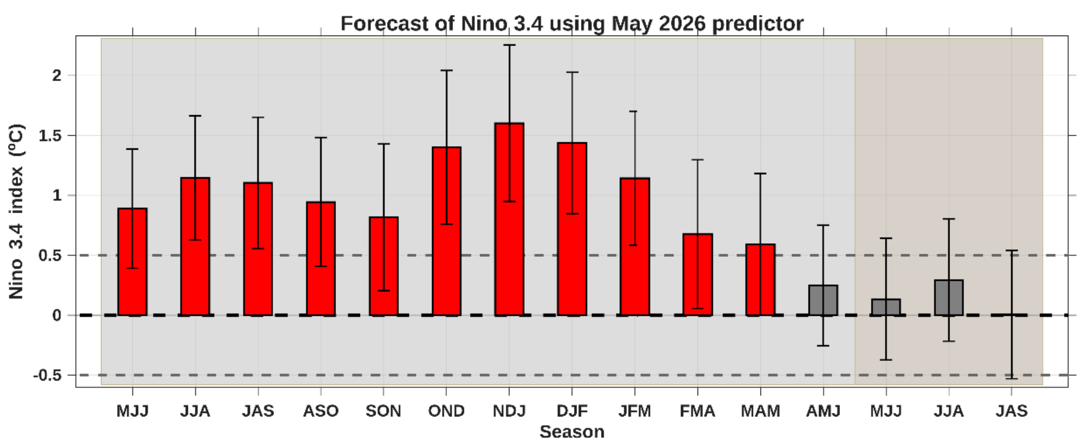

Fig. 4: Median prediction of Nino 3.4 index using March 2026 - May 2026 predictors for the upcoming seasons.

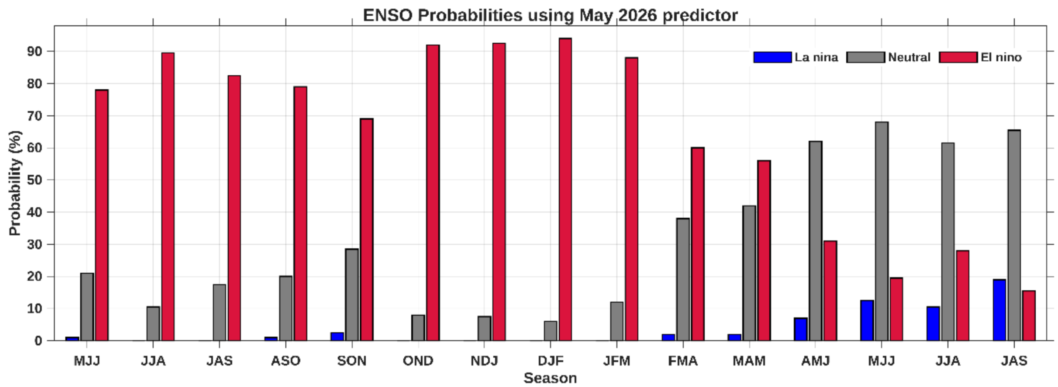

Fig. 5. Forecast of El Nino/La Nina conditions using March 2026 - May 2026 predictors.

Impact of Upcoming El Nino on the maritime sectors in Northern Indian Ocean

The persistence of El Niño through the upcoming seasons is expected to influence ocean conditions across the North Indian Ocean. Higher SST increased upper-ocean heat content, stronger stratification, and a higher likelihood of marine heatwaves may affect marine ecosystems, fisheries, and coastal environments.

- The warming conditions associated with El Niño is likely to result in a modest decline in small pelagic fish landings (Indian Oil Sardine and Indian Mackerel) and a possible reduction in the average size of these species during the upcoming fishing season.
- Prolonged warming, changes in ocean productivity, and shifts in fish habitats may alter the distribution of commercially important species.
- Given the anticipated El Niño-related warming and its potential effects on marine productivity, a reduction in the average size of important small pelagic fish in commercial landings is also expected during the upcoming fishing season.
- Coral reef ecosystems, particularly around Lakshadweep, the Gulf of Mannar, and the Andaman and Nicobar Islands, may also experience increased thermal stress during periods of sustained warming.
- Relatively calm ocean conditions and extended fair-weather windows in the Arabian Sea may support longer operational windows for most of the maritime sectors. However, Bay of Bengal may experience high wind-sea conditions during the upcoming season.
- Warmer ocean conditions can influence the background environment for extreme weather events. Coastal regions may also experience localized erosion, flooding, and storm surge impacts during severe weather episodes.

- Fishermen, maritime operators, coastal communities, tourism stakeholders, and disaster management agencies are advised to closely monitor INCOIS ocean services throughout the forecast period. Potential Fishing Zone advisories, Ocean State Forecasts, High Wave Alerts, Swell Advisories, Storm Surge Forecasts, and Coastal Inundation Services can provide valuable guidance for navigation, offshore operations, coastal tourism, and public safety.
- INCOIS also will provide Marine Heatwave Advisory System (MAHAS), Ocean State Forecasts (OSF), Coral Bleaching Alerts, and Harmful Algal Bloom (HAB) advisories taking into account of the ongoing El Nino activity.

Annexure-1

Data and Methodology

INCOIS-GODAS

INCOIS-GODAS is an ocean analysis system based on the Modular Ocean Model (MOM4p0) with 0.5° uniform zonal and varying (0.25 ° at the equator) meridional resolution and 40 vertical z-coordinate levels. It assimilates in-situ temperature and salinity profiles using 3DVAR assimilation scheme. Additionally, the model SST is relaxed to OISST with a 5-day timescale andthe surface salinity is relaxed to World Ocean Atlas at a monthly timescale. The model is forced with 6-hourly atmospheric fluxes from GFS v13 (provided by NCMRWF). The analysis is available from 1999 to date.

Bayesian Convolutional Neural Network (BCNN) model that provides probabilistic predictions for El Nino/La Nina conditions.

The advent of deep learning-based approaches marks a transformative era in climate and weather prediction. Here, we introduce a deep learning-based Bayesian Convolutional Neural Network (BCNN) model that provides probabilistic predictions for El Nino/La Nina with a lead time of up to 24 months. The Bayesian layers within the CNN maintain the capability to predict a distribution of learned parameters. The inherent capacity for uncertainty modelling enhances the reliability of BNNs, making them particularly valuable in operational services. Validation of the all-season correlation skill of the Nino3.4 index from the BCNN model demonstrates significantly higher accuracy up to 16 months leads compared to current state-of-the-art dynamical forecast systems.

Data & Methods:

This work is inspired by the recent study of Ham et al., 2019, in which El Nino/La Nina prediction was carried out using a CNN network and ocean predictors with a lead time of 2 years in advance. A significant drawback of their system wasthe absence of model uncertainty quantification and confidence in prediction, which has been addressed here using BCNN.

BCNN Model Predictors and training

The prediction approach relies on the fact that El Nino/La Nina is connected to slow oceanic variations and their atmospheric coupling, indicating the potentialfor early forecast. Here, global, gridded monthly sea surface temperature (SST) data and upper 300 m integrated ocean potential temperature (T0-300) data (at a resolution of 2.5^0x2.5^0) spanning from 0°-360°E and 55°S-60°N forthree consecutive months (n, n-1, n-2) are employed as plausible predictorsof El Nino/La Nina, while the predictand or target is the Nino3.4 index, representing thearea-averaged SST anomaly over 170°–120°W and 5°S to 5°N, predicted upto 24 months in advance.

One challenge in applying deep learning to El Nino/La Nina prediction is the scarcity of sufficient training data due to the limited observation period. Since global oceanic temperature records have only been accessible since 1871, fewer than 150 monthly samples are typically available to date. To overcome this limitation, we augment the training dataset by incorporating historical runs (1850-2014 period) from the Coupled Model Intercomparison Project phases5 (CMIP5) and 6 (CMIP6). CMIP models that exhibit good skill in reproducing historical ENSO characteristics are selected based on previous literature.

The initial training of the model incorporates 11 CMIP5 and 14 CMIP6 models, resulting in a substantial dataset of about 3200 samples. To mitigate systematic errors in the BCNN reflecting those of the CMIP samples, a learning transfer technique was employed, where the fine-tuning of the CMIP pre-trained model was conducted through another training approach utilizing Simple Ocean Data Assimilation (SODA) reanalysis predictors spanning from 1871 to 1980. Details of data listed in table 1.

Separate BCNN models were set up for each season and each lead time. The BCNN predicted Nino 3.4 index was validated using NCEP-GODAS from 1991- 2020. The results show high predictability accuracy, with an all-season correlation skill exceeding 0.8 for the first six months, decreasing to 0.5 after only a 16-month lead (see Fig. 7.

Table 1. Details of data used for the BCNN model.

	Data	Period
Training dataset	CMIP5 historical run (11 models)	1850-2005
	CMIP6 historical run (14 models)	1850-2014
Training dataset (Transfer Learning)	Reanalysis (SODA)	1871-1980
Validation dataset	Reanalysis (GODAS)	1990-2020
Operational forecast dataset	INCOIS GODAS	2024 onwards

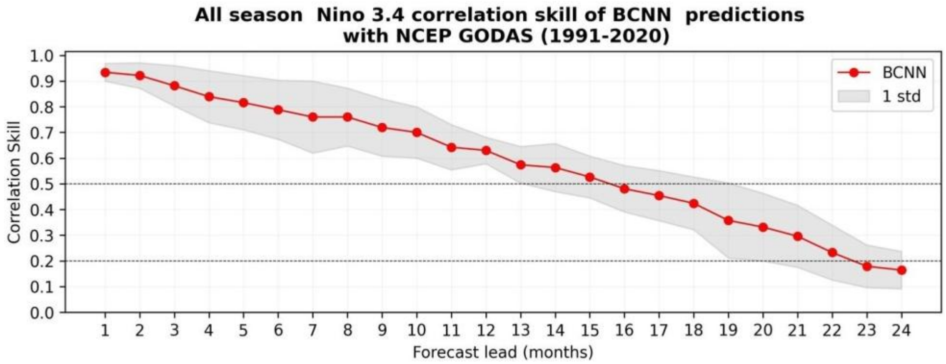

Fig 1. All-season correlation skill of BCNN-based El Nino/La Nina prediction compared with NCEP GODAS reanalysis for 1991-2020. The red line represents the median predicted El Nino/La Nina, with the 1 standard deviation of prediction shown in gray shades.

Fishery impact analysis

Historical analyses of marine fishery landings with the ENSO phases since 1950 indicate that fishery landings across the Indian Ocean region tend to decline during El Niño phases, although the overall decline in catches remains relatively weak and region-specific. To assess the potential implications of ENSO variability for Indian marine fisheries, INCOIS examined the relationships between historical ENSO phases and the landings of major small pelagic species, the Indian Oil Sardine and Indian Mackerel, in their principal landing states of Kerala and Karnataka obtained from CMFRI for the period 1985-2023. The Monthly Climate Timeseries of the Oceanic Niño Index (ONI) V2 (available from NOAA Physical Sciences Laboratory) was used as a measure of the El Niño-Southern Oscillation (ENSO) to compare annual trends in IOS and IM catch with ENSO events. The ONI is calculated as the 3-month running mean of SST anomalies (based on ERSST. v5 data) in the Niño 3.4 region (5°N–5°S, 120°–170°W), using the 1971–2000 base period. Spatiotemporal datasets were analyzed with Python (version 3.9.12) libraries and Excel to generate graphical illustrations. Further, relevant literature on the effects of ENSO- driven climate variability on fish life-history processes and fishery productivity was examined to identify the likely consequences of the anticipated El Niño on Indian marine fisheries.

Studies from Indian waters indicate that earlier events of El Niño-induced warming have adversely impacted the maturation of Indian Oil Sardine, while mismatches between phytoplankton productivity and larval feeding requirements reduced recruitment success. Also, climate variability can push fish populations towards their physiological limits, resulting in shifts in distribution towards deeper waters or higher latitudes.

Further, fish growth and size are strongly influenced by food availability and environmental conditions, particularly temperature and productivity changes associated with seasonal precipitation and upwelling. Thus ENSO-driven variability can likely impact the life history traits, especially for the small pelagic species.

Ocean State

El Niño events exert a measurable influence on the surface gravity wave climate of the North Indian Ocean (NIO) through their modulation of monsoon wind systems. Ocean surface waves, which are gravity waves primarily driven by surface winds, are significantly influenced by tropical climate variability modes such as ENSO through changes in surface winds. Over the NIO, this manifests as a spatially asymmetric response between the two sub-basins: ENSO influence on extreme significant wave heights (SWH) includes increases in the Bay of Bengal and decreases in the Arabian Sea, a pattern directly linked to the well-documented weakening of the South Asian monsoon during El Niño years. Strong El Niño events significantly suppress the spatial extent of extreme wind-wave events over the NIO basin.