Ocean warming: Evidence on SST increase from inshore waters off Cochin

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Climate change is one of the most critical challenges faced by mankind today and has greatly impacted environmental parameters such as sea surface temperature (SST), pH, annual rainfall, cyclones etc., which is being established through satellite derived remotely sensed datasets. The validity of these observations can be enhanced through ground truth data. We present here probabaly for the first time the ground truth evidence of marked differences in SST, Chl *a*, NPP and the levels of certain dissolved nutrients from the inshore regions of Cochin shelf by comparing the *in situ* data generated at two different decades viz., 1988 and 2014 from the inshore waters off Cochin within 10 – 30 m depth, north and south of Cochin Port Channel (Table 1).

Table 1. Location of sampling points in the inshore area off Cochin during 1988 and 2014.

St. no.	Latitude (N)	Longitude (E)
1	09° 59′44″ N	76°09′23″ E
2	09° 59′55″ N	76°05′58″ E
3	09° 59′30″ N	76°06′47″ E
4	09° 58′45″ N	76°05′52″ E
5	09° 57′54″ N	76°06′ 45″ E
6	09° 56′38″ N	76°05′ 50″ E
7	09° 56′36″ N	76°02′51″E,
8	10°02′60″ N	76°09′14″ E
9	10°03′17″ N	76°05′58″ E
10	10°05′40″ N	76°05′51″ E

The seawater samples were collected on a monthly / fortnightly sampling programme of the institute's FEM Division, aboard *RV Cadalmin IX* during 1998 and *FV Silver Pompano* (as part of an inter-institutional ICAR project National Innovations on Climate Resilient Agriculture (NICRA- Phase I) during 2014. Variation (increase (+) /decrease (-)) in the annual and seasonal mean of hydrographic parameters from the inshore waters off Cochin over the year 1988 (n=18) and 2014 (n=14) are evident (Table 2).The annual mean of SST in the inshore waters off Cochin during 1988 was 28.78±0.32°C and 29.14±0.28°C during 2014, registering an increase of 0.36°C after 25 years, while the subsurface water near bottom registered an increase of 0.19°C only which indicates more warming in sea surface even in near shore coastal regions. Our temporal analysis indicated that warming did not manifest during the monsoon months of 2014 (SST -0.26°C and SBT -1.25°C). However, the pre-monsoon and post-monsoon seasons recorded warming at surface as well as in bottom. This warming trend is agreeing well with the data reported for offshore area of Kerala coast (0.2°C per decade) which was observed through thermal infrared remote sensing satellite data.

Table 2: Variation {increase (+) /decrease (-)} in the annual and seasonal mean of hydrographic parameters from the inshore waters off Cochin over the year 1988 (n=18) and 2014 (n=14).

	Temperature (°C)		PO_4-P (mg/l)		NO_3-N (mg/l)		SiO_3-Si (mg/l)		Chl *a* (mg/l)		NPP (g C/ m^3/d)
Season	Sur.	Bot.	Sur	Bot	Sur	Bot	Sur	Bot	Sur	Bot	Sur
Annual	0.36	0.19	-0.321	-0.348	-1.306	-1.408	-5.73	-5.089	-1.28	-0.615	0.03
Pre monsoon	0.68	0.63	-0.298	-0.609	-0.204	-0.479	-0.608	-0.819	-2.11	-0.234	-0.075
Monsoon	-0.26	-1.25	-0.53	0.443	-2.775	-2.805	-6.343	-1.972	-1.514	-1.69	0.63
Post monsoon	0.63	0.91	-0.135	0.008	-0.553	0.941	-10.24	-12.48	-0.216	0.108	-0.56

It is reported that the SST has been consistently higher during the past three decades than at any earlier time since reliable observations began in 1880 (IPCC, 2013). The SST is known to vary regionally, while most parts of the world's oceans have seen temperature rise, some parts of North Atlantic Sea have actually experienced cooling (NOAA, 2016). It was an interesting observation that other than temperature and net primary production (NPP), the levels of dissolved nutrients and chlorophyll *a* were appreciably lower during 2014 than during 1988. Similarly the levels of Phosphates at the bottom and NPP during the monsoon months were also found lower than that of 1988 although Kerala received higher rainfall (643.2 mm higher than that of 1988) during 2014.

With the available data it could be concluded that the SST along the Cochin coast has been increasing and since 1988 to 2014 is around 0.4°C. Regular and continuous *in situ* observations on the hydrographic parameters are essential for understanding the warming trend and to validate the remotely sensed satellite data.