Nine-year monitoring of environmental changes over the continental shelf in the Catalan Sea from multi-parametric measurements

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Rationale

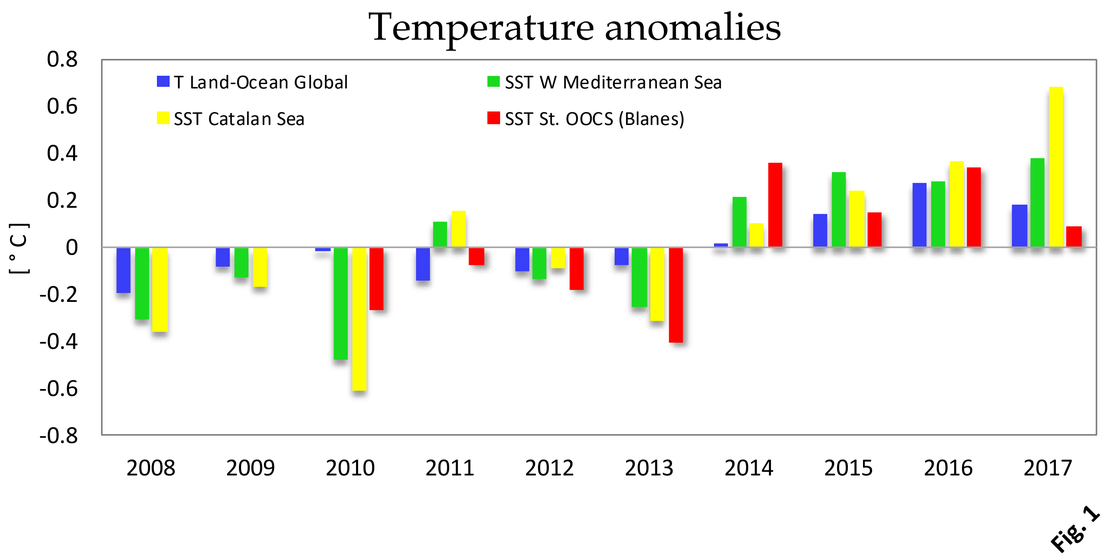

Fig. 1

Average global land and **ocean temperatures** stepped up since 2014 above the decadal average [1] (Fig. 1) and there is no expectation for it to reverse in the next years [2]. The western Mediterranean sea surface temperature has followed the same trend (Fig. 1).

The impact of water warming rate change on the coastal ecosystem dynamics may be remarkable, as the continental shelf holds highly sensitive biodiversity. Warming has been claimed as responsible for changes in growth, reproduction and survival of a number of coastal marine species [3].

Over the continental shelf in the Catalan Sea (NW Mediterranean), with oligotrophic conditions shaped by hydrodynamics linked to submarine canyons [4], stepped warming pattern has also been recorded since 2014 (Fig. 1), as monitored from a multi-parametric standalone oceanographic buoy and from regular on-board measurements (St. OOCS) [5].

Findings

Analyses of 9-year environmental in-situ time series (St. OOCS), along with remote sensing data (NOAA) analysis, reveal that after 2014, the winter **mixed layer depth (MLD)** (Fig. 2) deepens by about 20 m and lasts for about a period of 2.5 months that exceed the previous years. These findings seem counterintuitive to the overall water warming and are probably due to the loss of heat during this period combined with the intensification of winds.

The impact of mesoscale events that may be altered by water warming such as winter cascading (Fig. 2) is variable. The depth of MLD suggests that the cascading event in 2012 did not reach the station site, unlike the event in winter 2018.

Reported events of mass mortalities of benthic organisms have been linked to both indirect effects of water warming e.g. through microbiological pathogens [6], and to direct effects that may be linked to the MLD dynamics e.g. mass mortality of *P. nobilis* in late 2015 [*7] (Fig. 2).

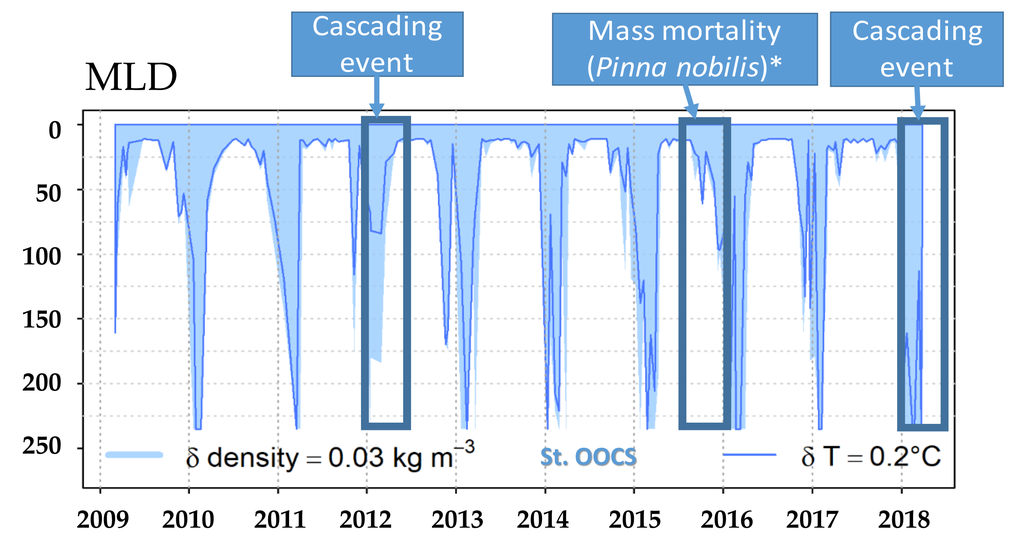

Fig. 2

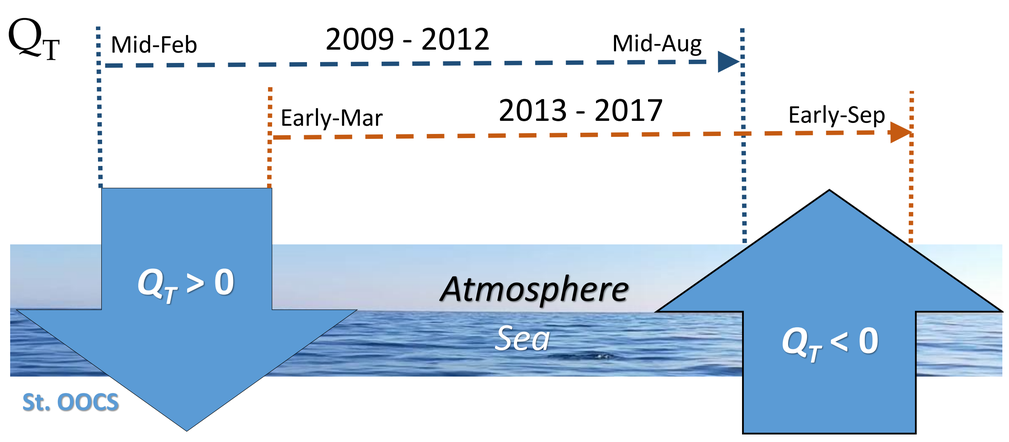

Fig. 3

Since 2013, i.e. one year before the stepped warming starting, average shifting times of total **air-sea heat fluxes** (*Qt*) from negative to positive (i.e. water warming, *Qt* > 0) and from positive to negative (i.e. water cooling, *Qt* < 0) have moved back in time, starting earlier in winter by mid of Feb instead of starting by Mar, though they have lasted for about the same period (170 – 180 dies) (Fig 3).

The relatively steady summer duration related to *Qt* shifting times may explain the yearly heat budget around the historical average to remain slightly above zero.

Qt did not show any significant trend over time. No shifting pattern of *Qt* magnitudes in line with the shifting patter of water temperatures was found, probably due to the advective heat not accounted here.

The analysis of the anomalies of vertically-integrated biogeochemical properties (Fig. 4) over the water column revealed that:

- Phytoplankton biomass (chlorophylls) generally remain unaltered by water warming, though the temporal pattern of nearshore surface chlorophylls may be responding to stronger local stratification conditions.
- According to the turbidity measurements, the water column is becoming more transparent (i.e. less turbid) since 2013, being more noticeable nearshore in the last three years. More transparent waters may indicate the strengthening of the oligotrophic conditions.
- There is no significant trend of nitrate concentration, that shows relatively high inter-annual variability.

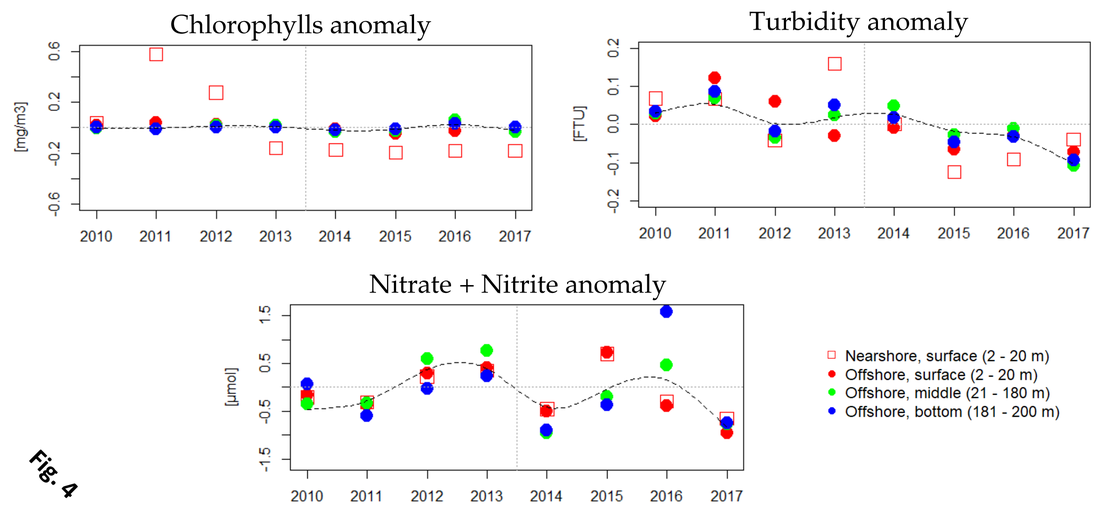

Fig. 4

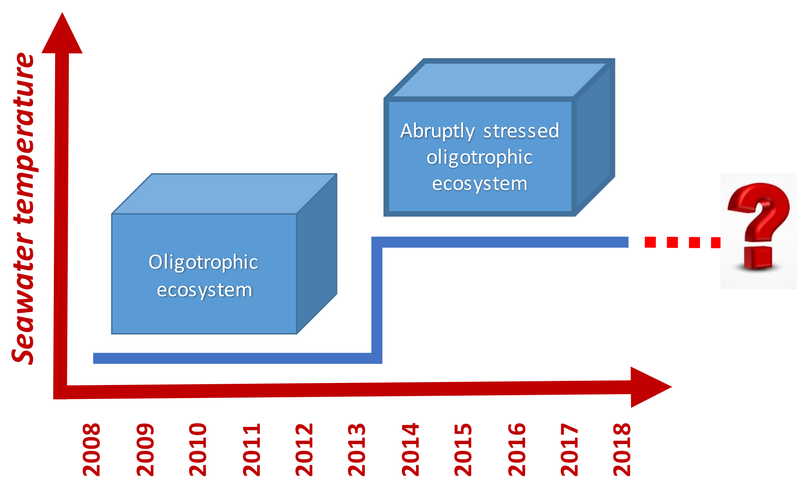

Fig. 5

Conclusions

The analysis of time-series of the marine environmental conditions over the continental shelf in the Catalan Sea, suggests that since 2013/2014, some oligotrophic characteristics of the marine ecosystem are being strengthening, in line with the stepped pattern of water warming (Fig. 5). The changes recorded in this area may be extrapolated to other oligotrophic areas around the world subject to a similar environmental stressor.

As current climatic predictions suggest the anomalously warming conditions recorded in the last years will extend during 2018-2022 [2], strengthening of the oligotrophic conditions of coastal water with negative impacts on the biology and ecology of neritic and benthic species is expected.

References

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