Climate change in the Levantine basin – observational marine signals

Barak Herut

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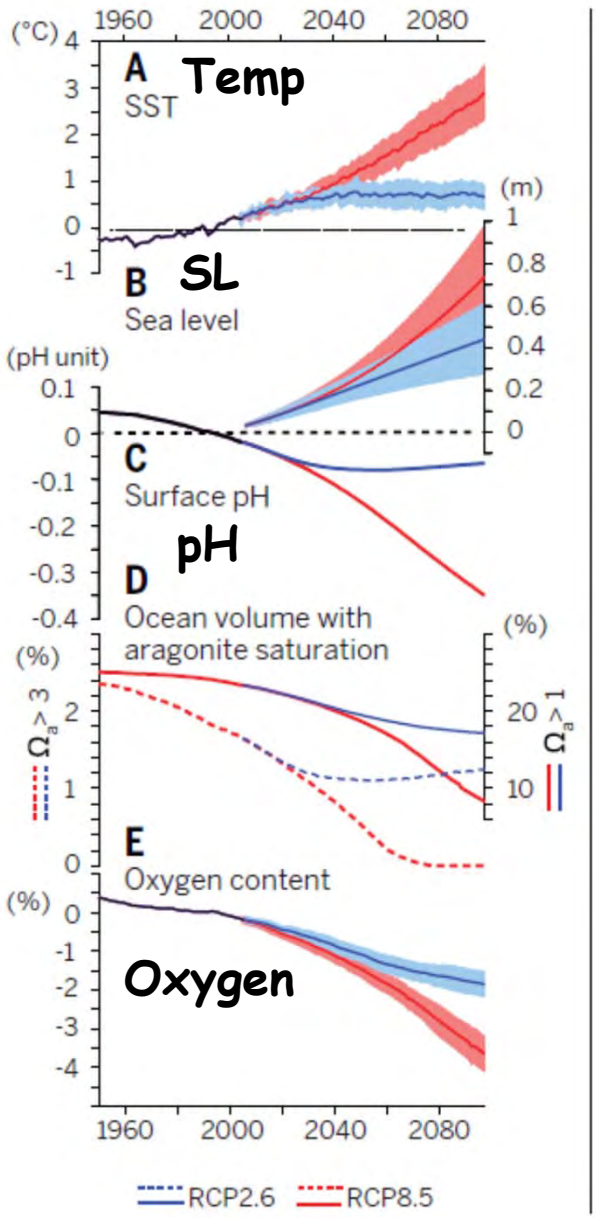
The oceans act as a climate integrator that:

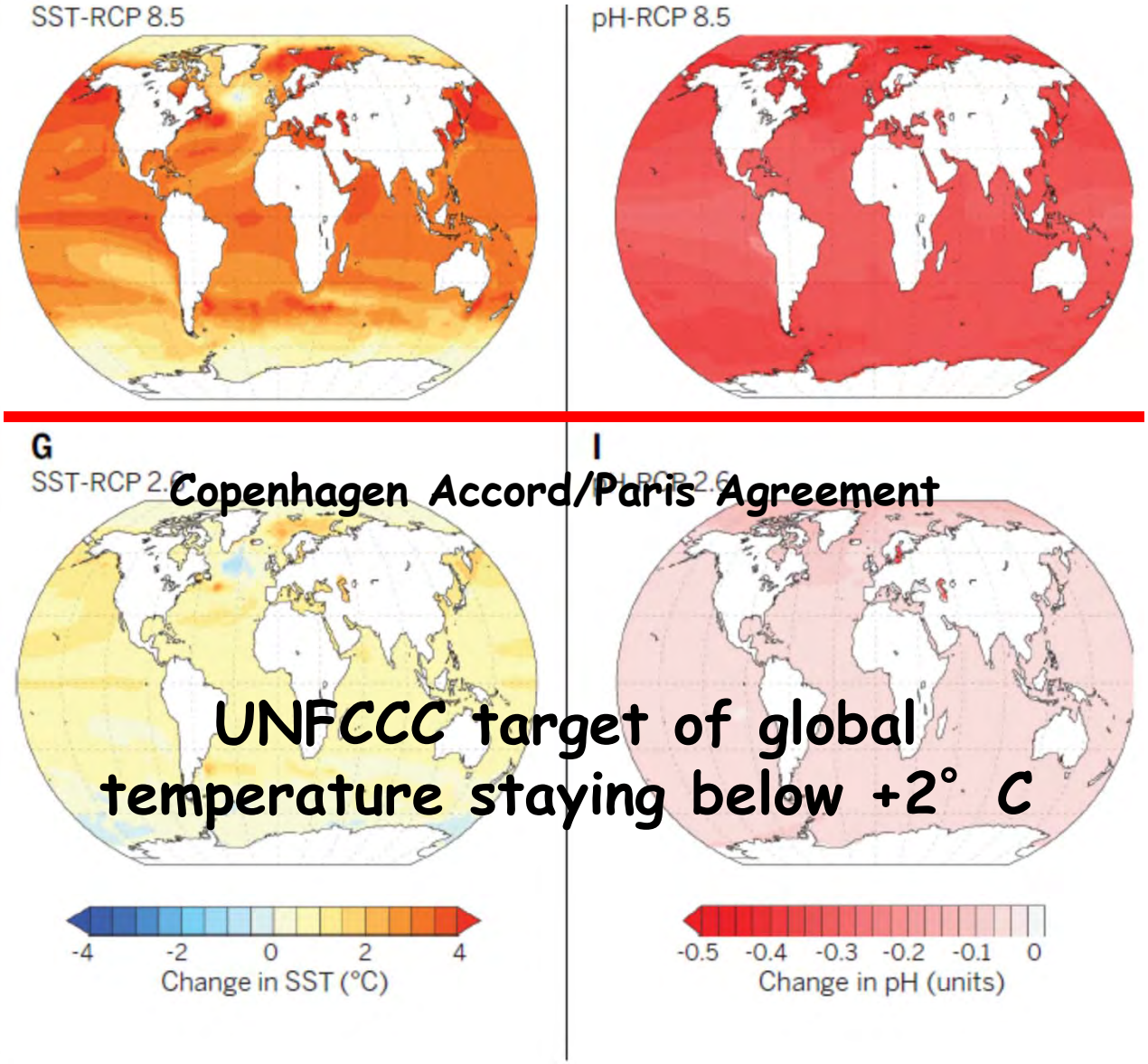
- (i) absorbed 93% of Earth's additional heat since the 1970s, offsetting much atmospheric warming but increasing ocean temperature and sea level;
- (ii) captured 28% of anthropogenic CO2 emissions since 1750, leading to ocean acidification;
- (iii) accumulated nearly all water resulting from melting glaciers and ice sheets, hence furthering the rise in sea level.
- (iV) Increasing temperatures & decreasing soil humidity may promote dust emissions & deposition mainly in Oligotrophic provinces.

Thus, the ocean moderates anthropogenic climate change at the cost of major changes in its chemistry, physics, species' biogeography and phenology, ecosystem dynamics and biogeochemical cycling.

Climate Change



business-as-usual CO2 emissions



Copenhagen Accord/Paris Agreement

UNFCCC target of global temperature staying below +2° C

Gattuso et al., 2015. ***Science***

The Levantine basin – Most Sensitive System

Characteristics

Natural

- Most Extreme S, T, Chl, Nut
- LIW formation
- Long term changes (S,T,O2,Nut)
- Changes in circulation intensity

Stressors

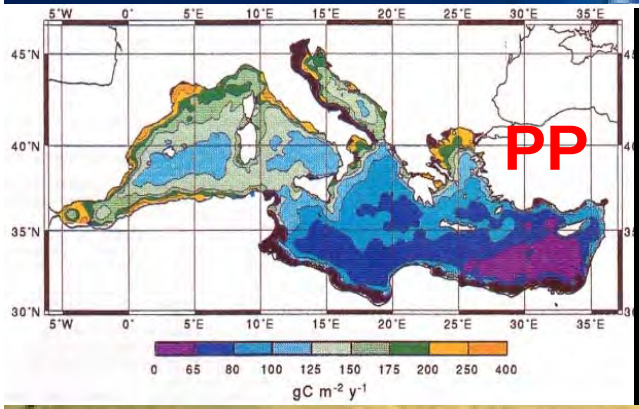
Anthropogenic

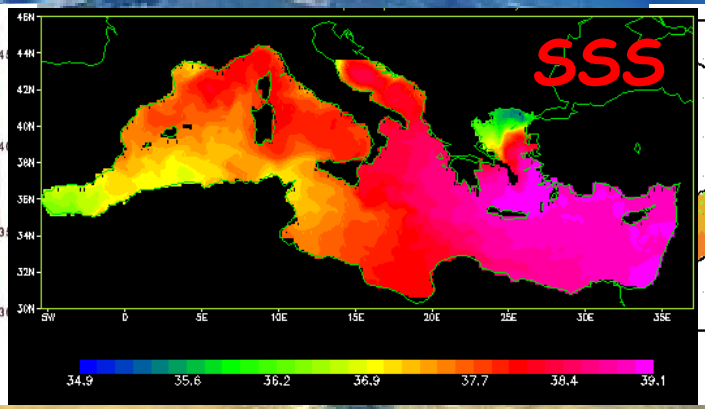
- Change in Nile floods and Damming
- Suez Canal, shipping
- Marine Infrastructures
- Deep sea drillings
- Pollution
- Fishing
- Climate change

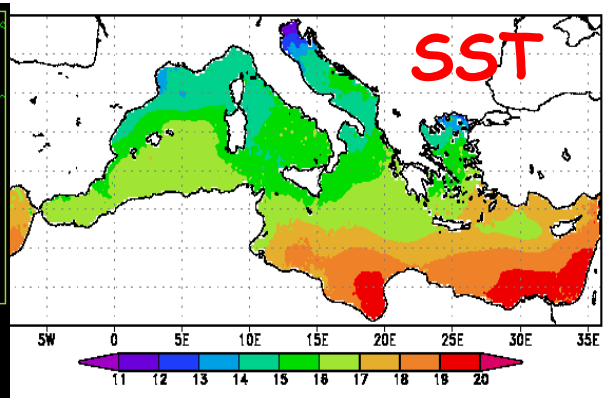
Levantine Basin

Nile Delta

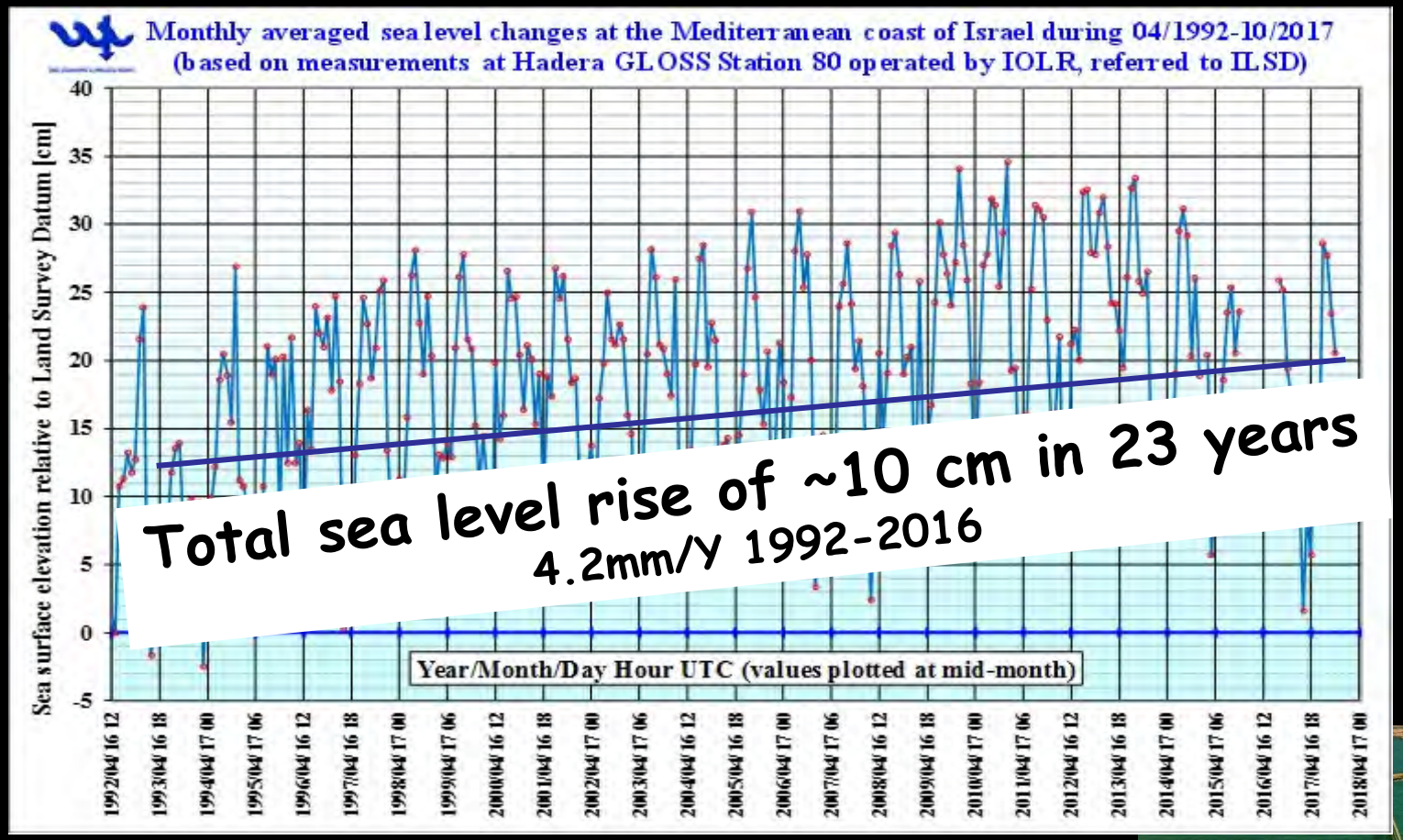
Suez Canal







Climate Change - Sea Level SE Mediterranean



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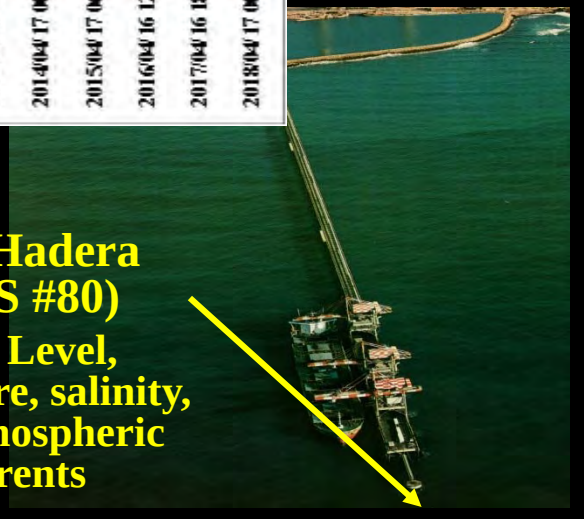
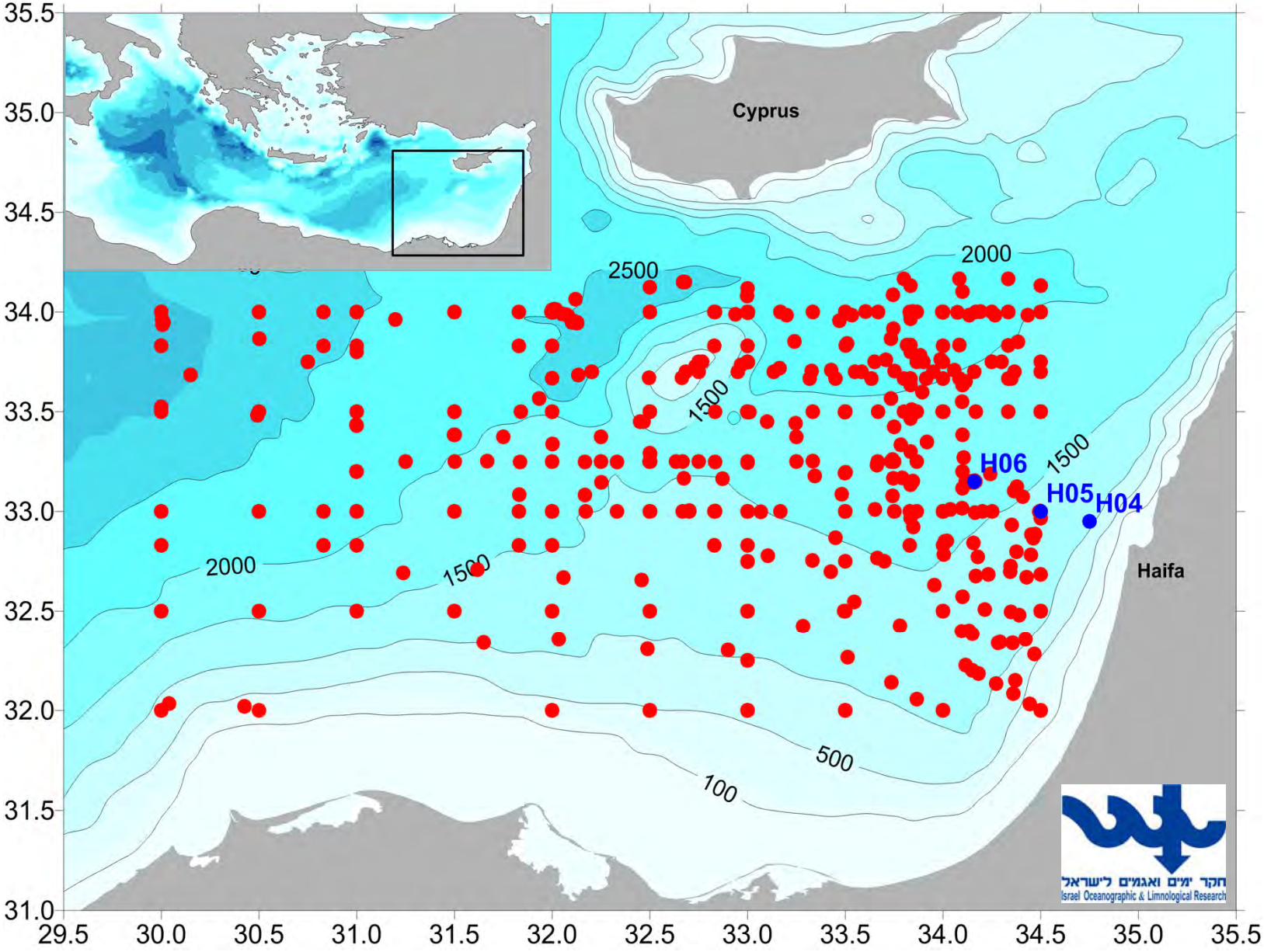
Mediterranean Hadera Station (GLOSS #80)

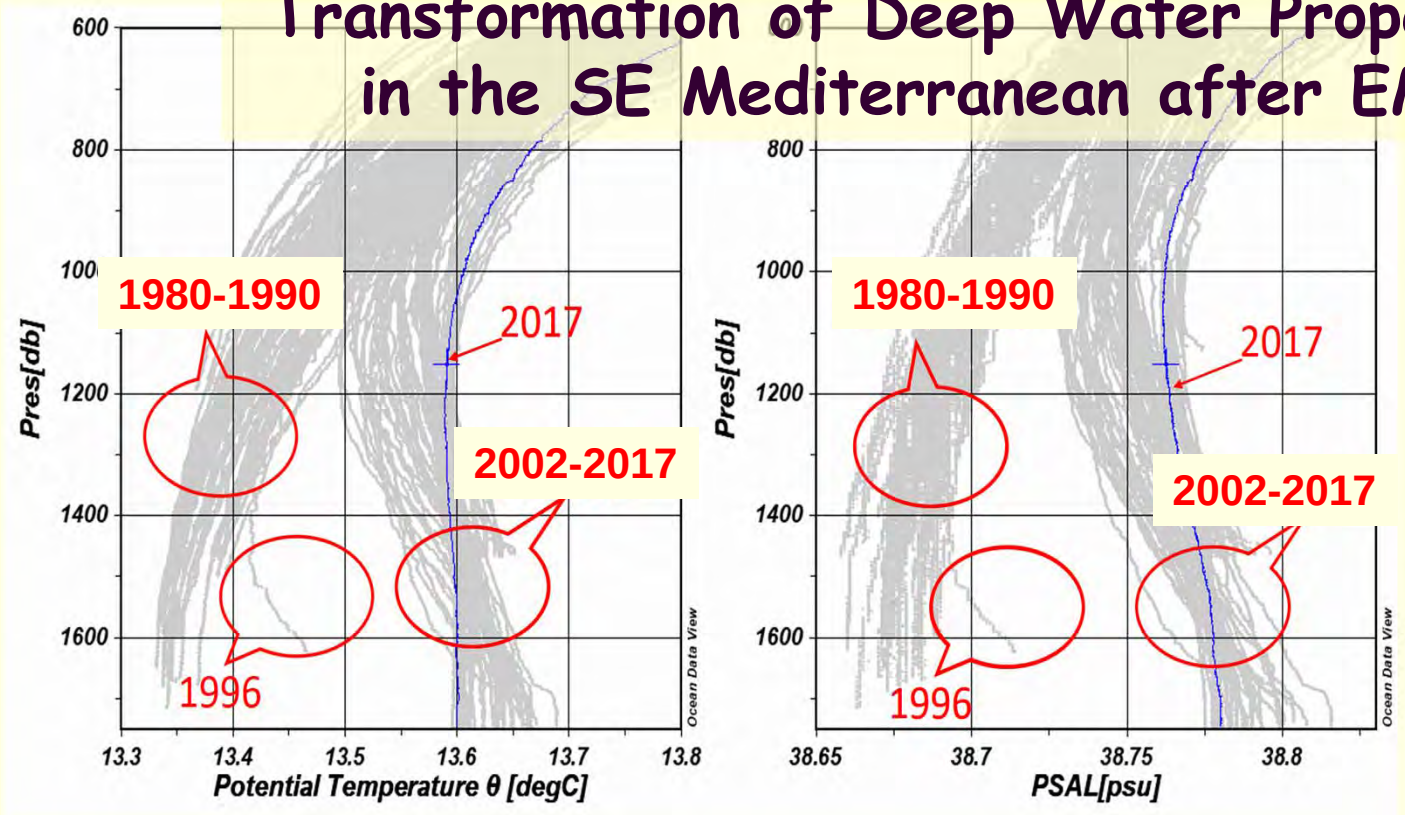
Wind, Wave, Sea Level, Seawater Temperature, salinity, turbidity, Chla, Atmospheric Pressure & currents

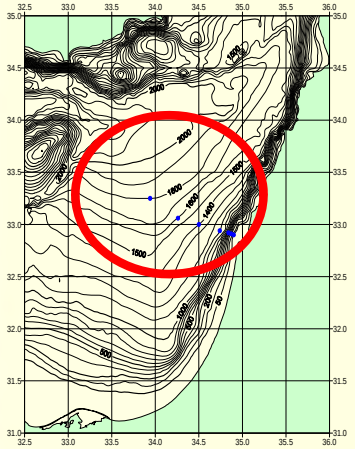


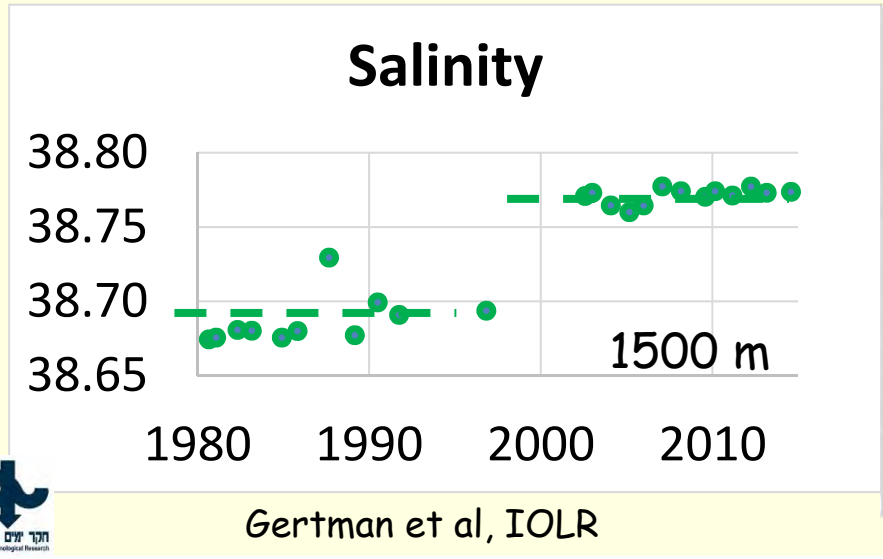
Long-term Thermohaline Changes in the Levantine basin 1980-2016

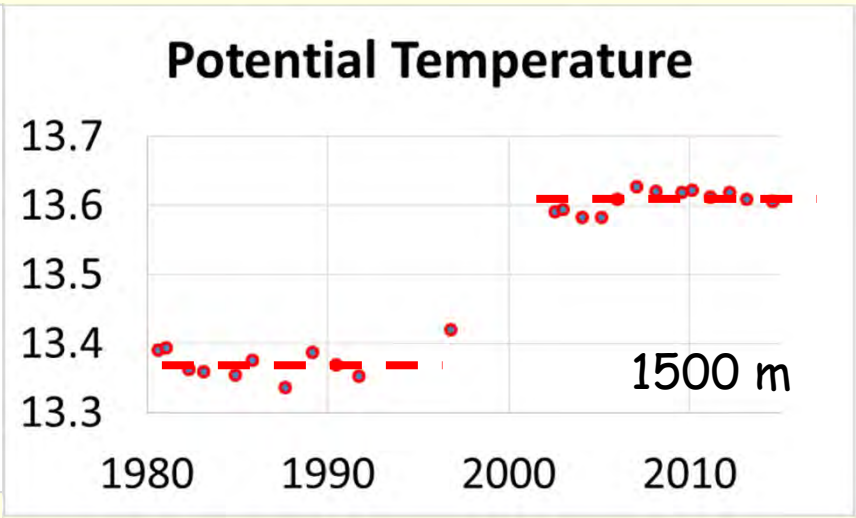


Transformation of Deep Water Properties in the SE Mediterranean after EMT

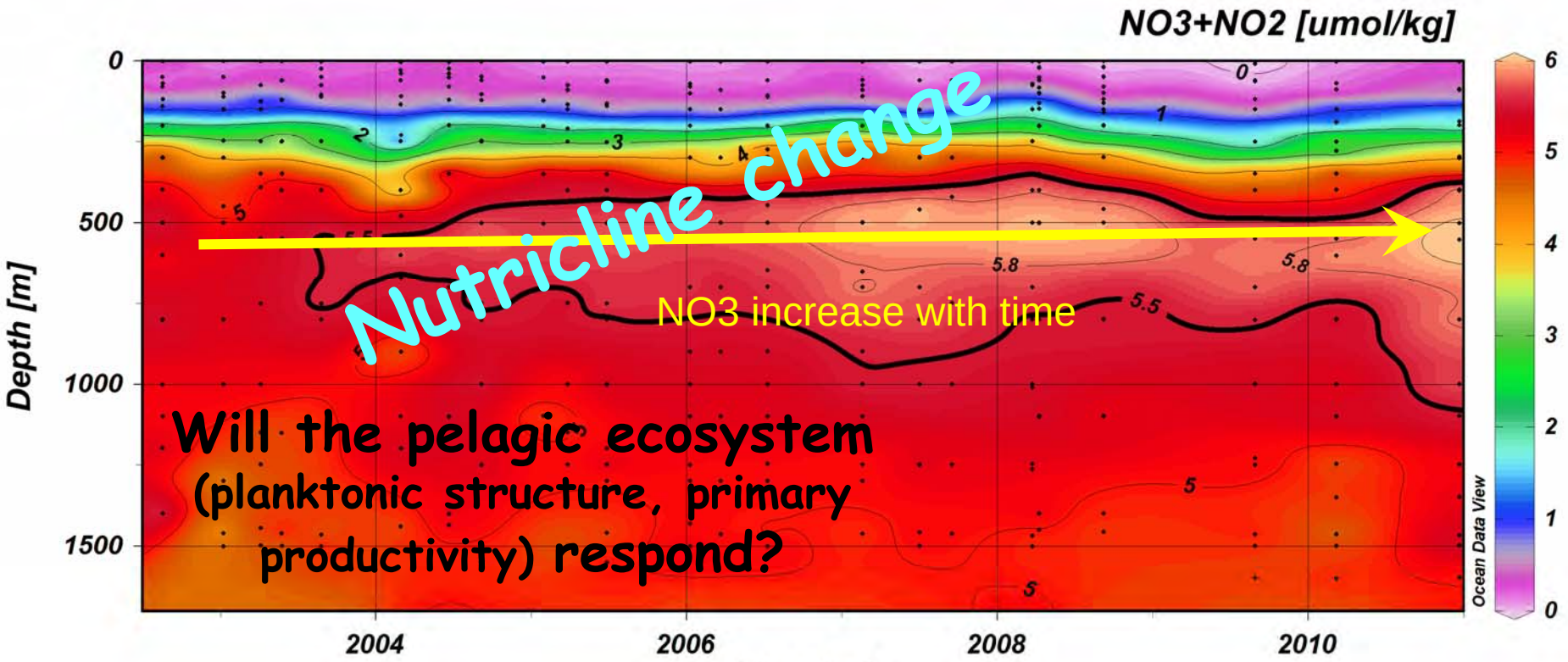


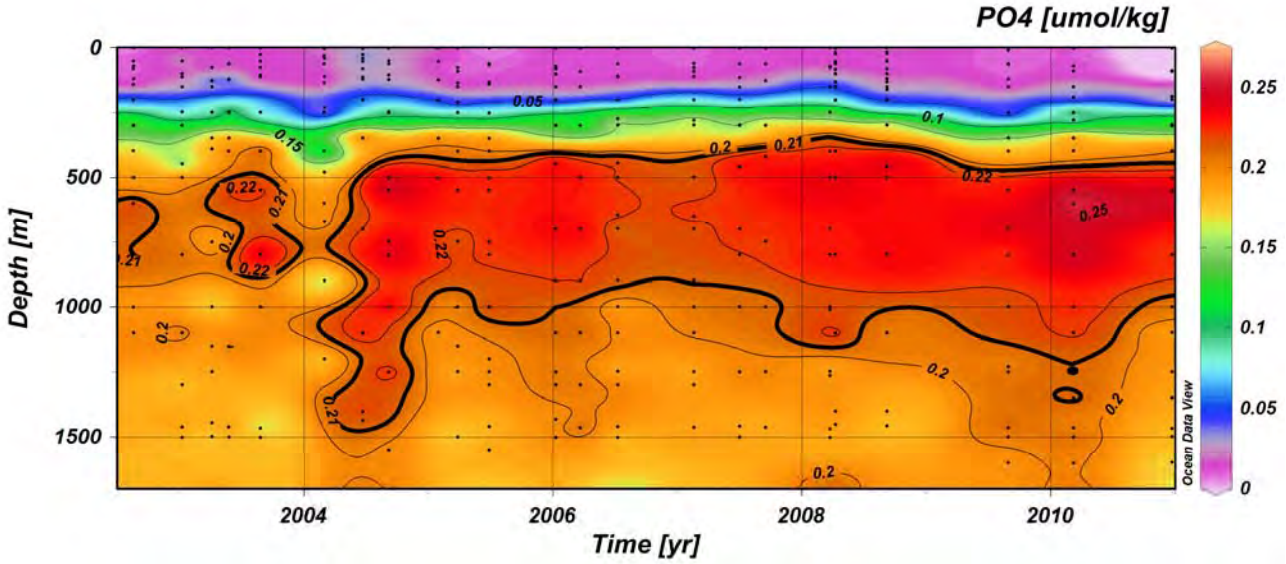


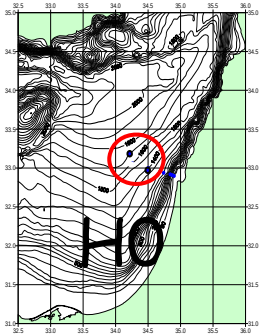




Gertman et al, IOLR







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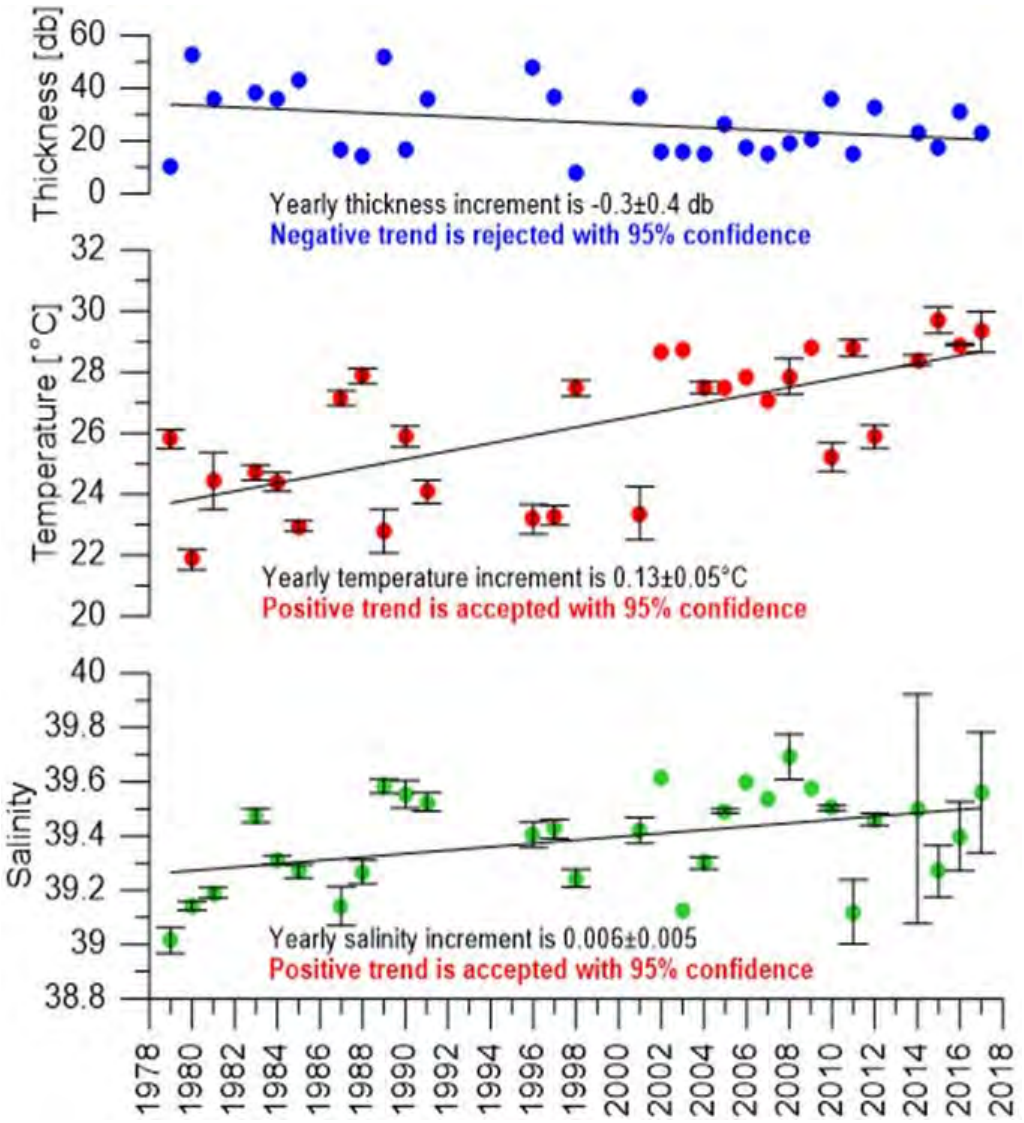
Kress, Herut, Gertman 2014 JMS

Levantine Surface Water 1980-2016



Ozer et al. 2017, Global and Planetary Change

The 35 years hydrographic observations show that the LB is getting saltier and warmer.

Salinity trends may result of the damming of the Nile River and Global Warming

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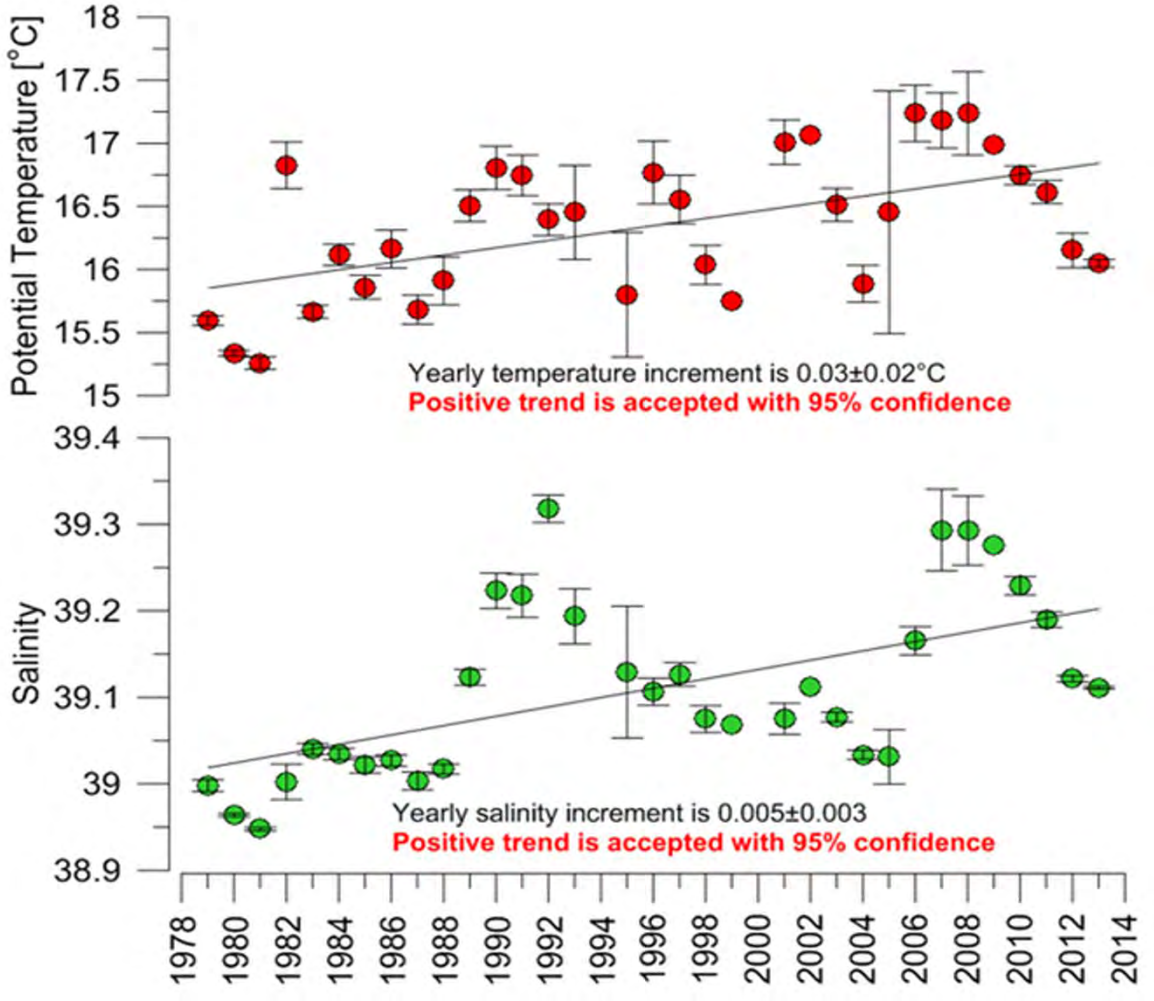
LIW - Levantine Intermidiate Water 1980-2014

130-350 m water depth



Rates of temperature increase in the LIW are in agreement with the IPCC 2014 high end prediction for the period of 2016 to 2035 (+0.7°C or +0.035°C·yr^{-1})

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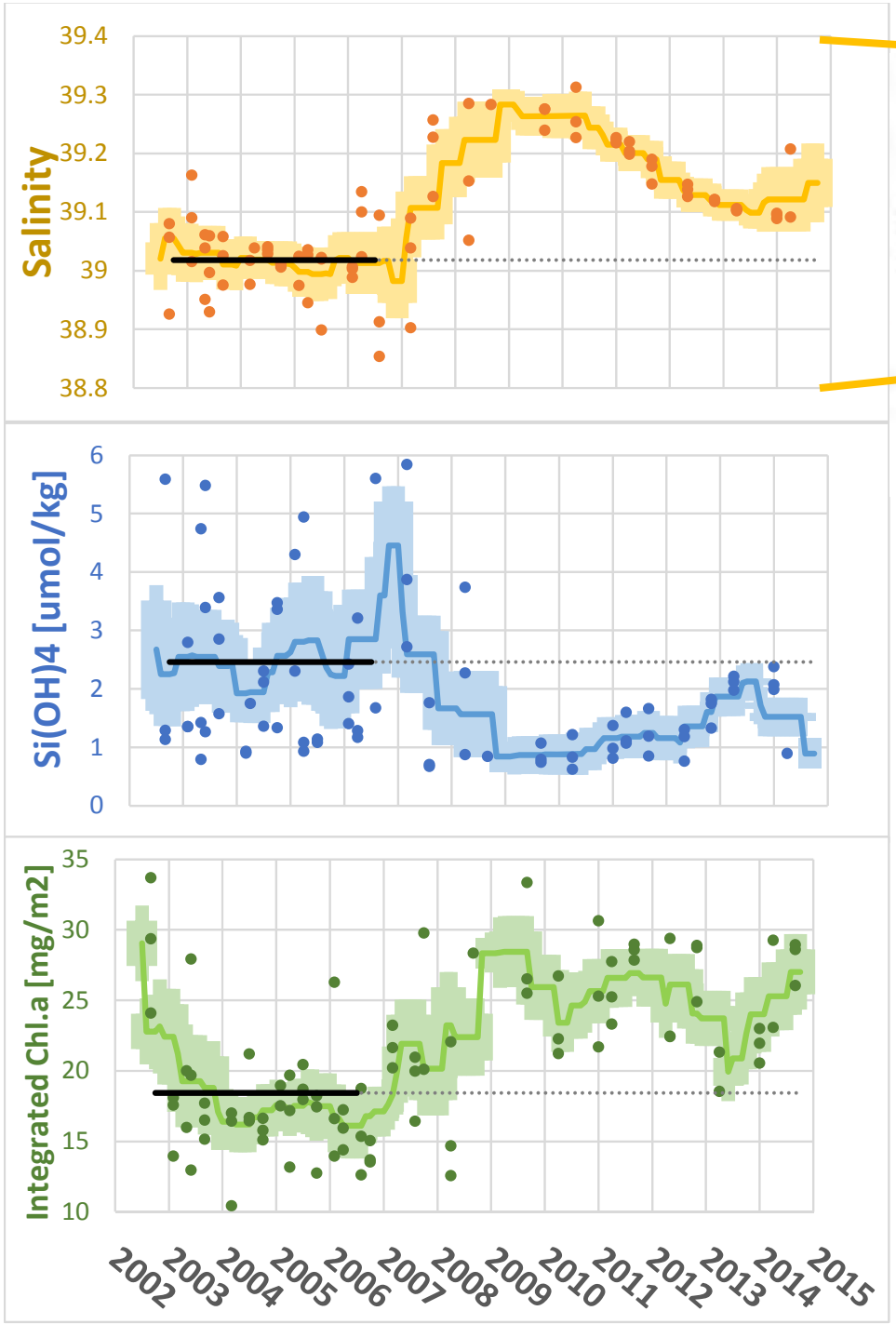
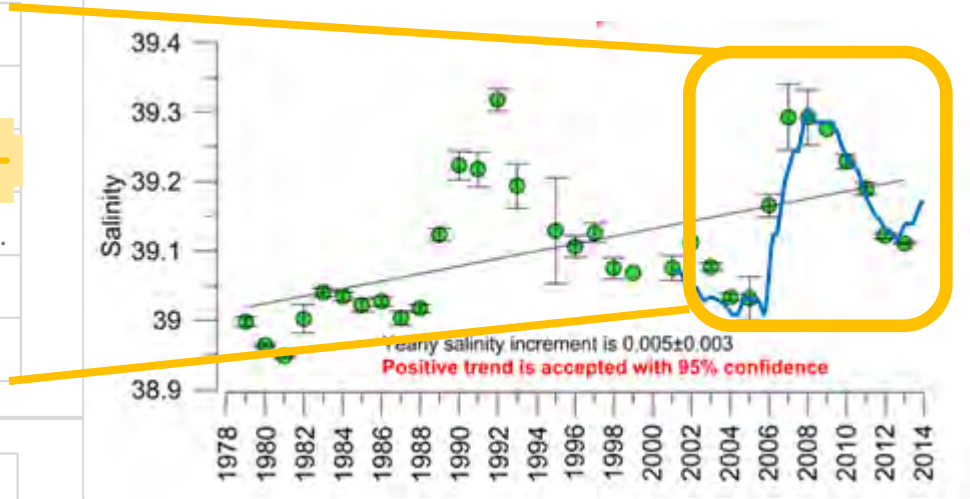
Ozer et al. 2017, Global and Planetary Change

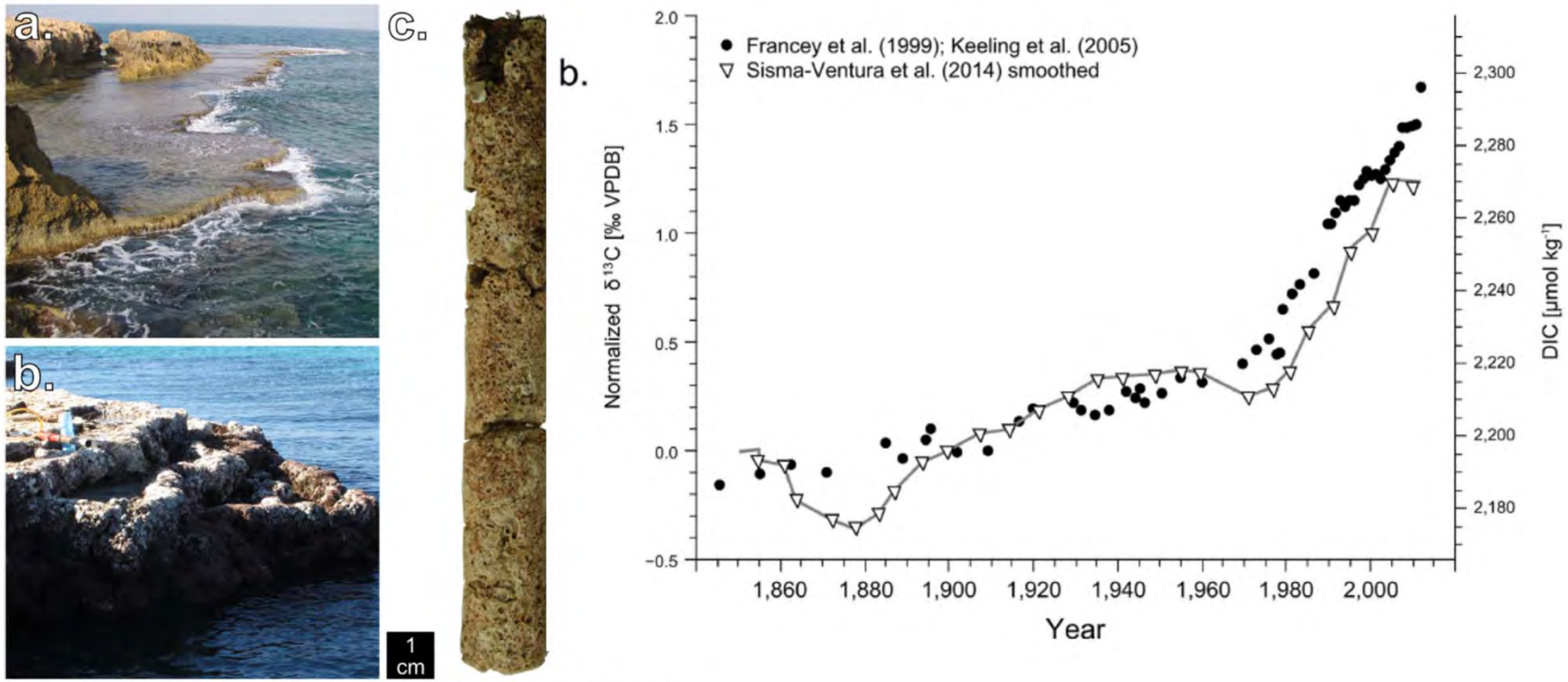




Interannual variations in the upper water masses (LSW and LIW) thermohaline and nutrient properties that may have profound consequences for biogeochemical processes.

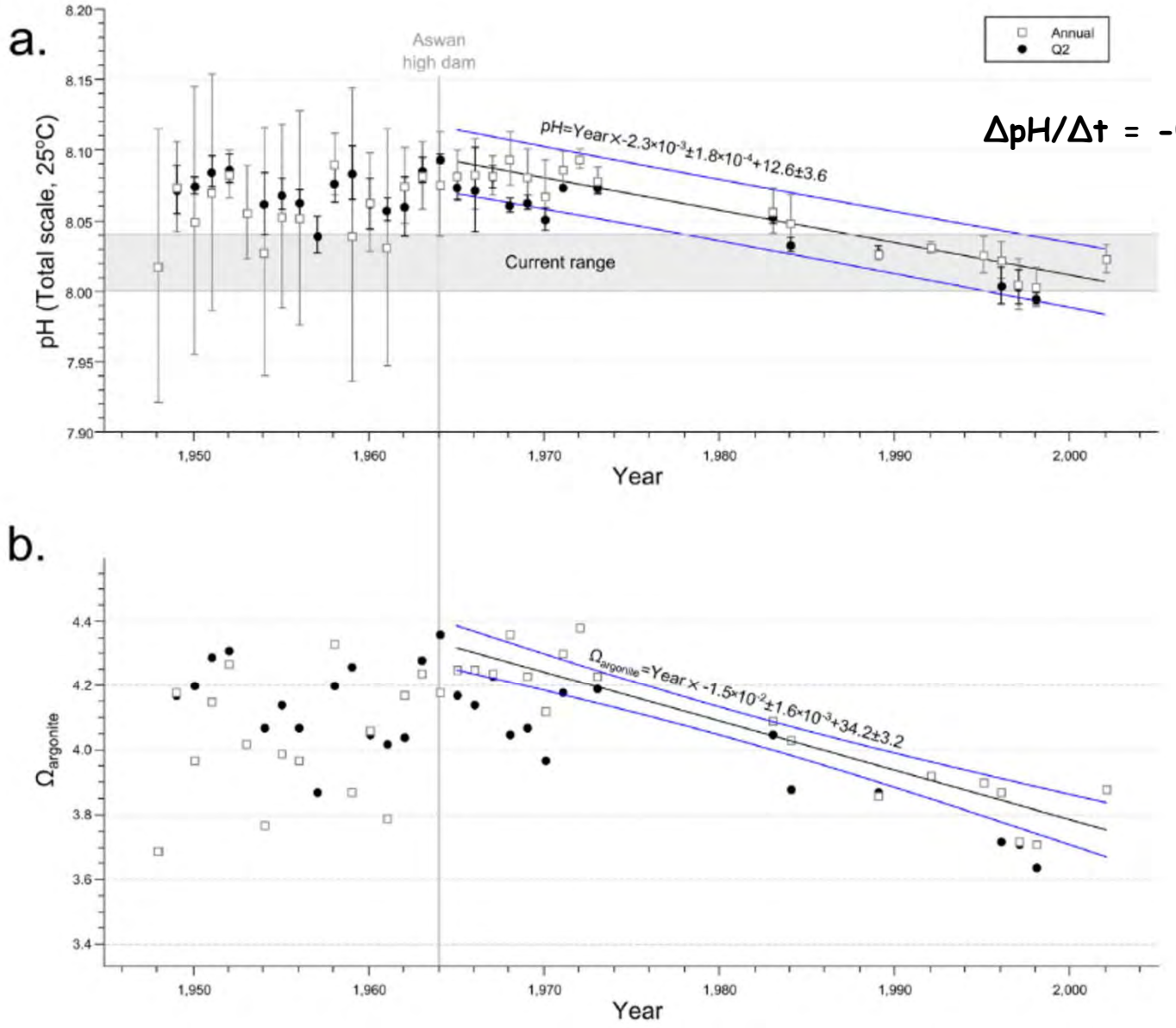
Ozer et al. 2017, Global and Planetary Change

Reconstruction of OA record during the Anthropocene in the SE Levantine basin



a. Abrasion platforms along the coast of Israel, also known as wave-cut platforms. These gently sloping platforms, extends from the high-tide level to below the low-vel. b. *Dendropoma* ledges exposed during extremely low tide. Coring equipment can be observed in the upper left of the photo. c. Short core extracted from a *ipoma* reef of the Israeli coast.

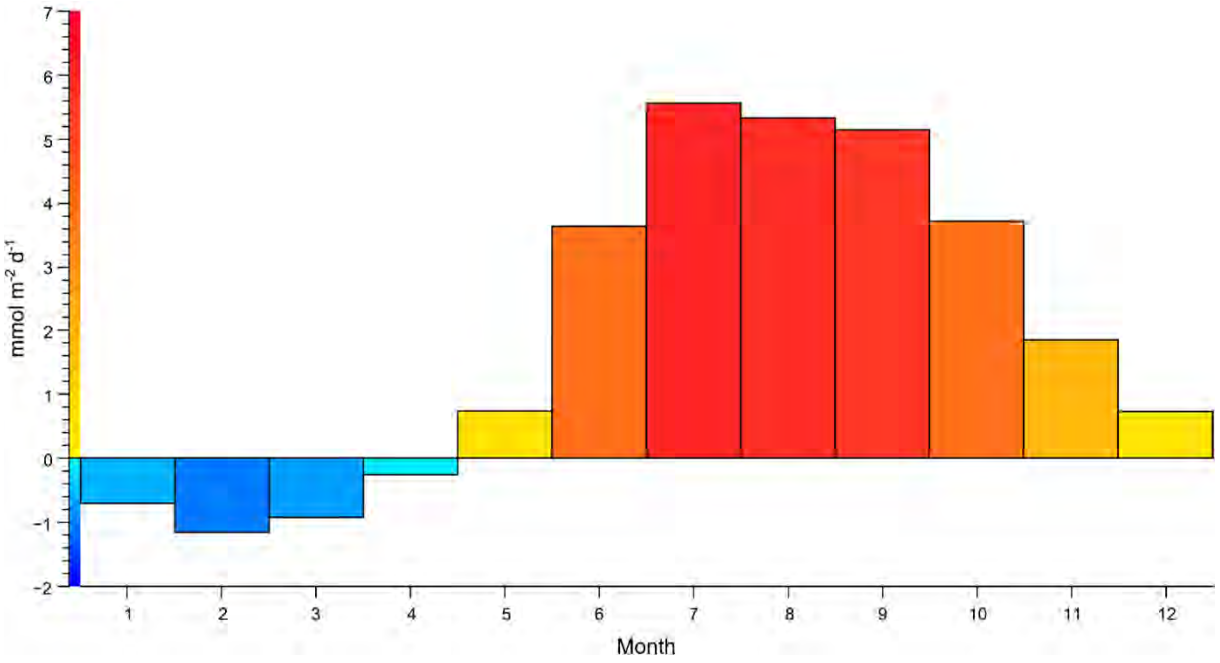
Bialik and Sisma-Ventura, 2016

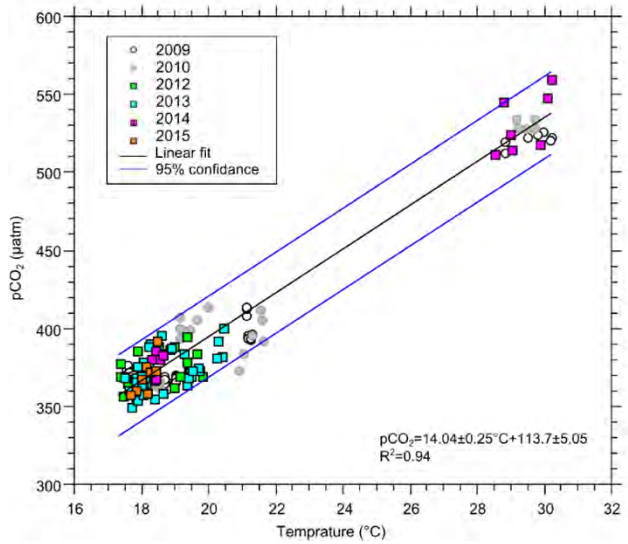


ΔpH/Δt = -0.0023 yr^{-1} since ~1970

Bialik and Sisma-Ventura, 2016

The SE Levantine Basin is a net source of atmospheric CO_2

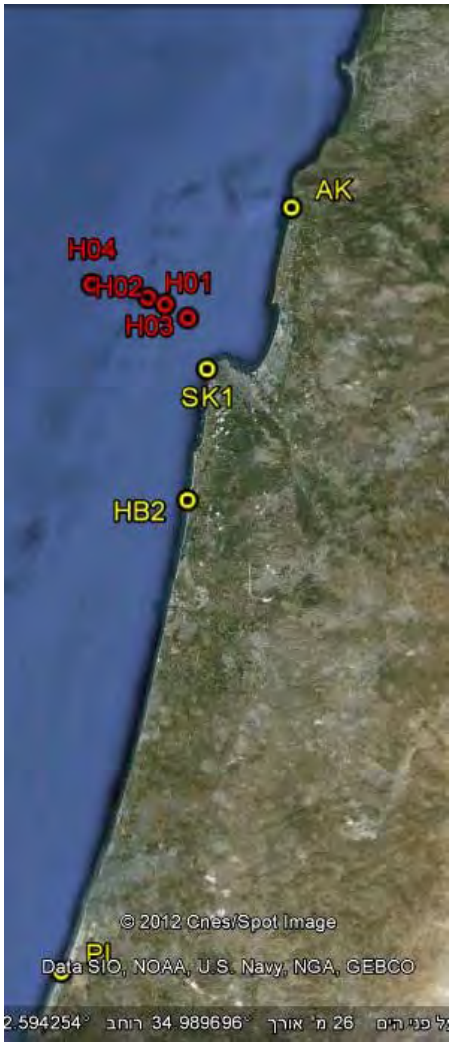




Sisma-Ventura et al., 2017

Further warming will cause the SE Levantine basin to be a stronger source of CO_2 to the atmosphere

SE Levantine basin tidal table monitoring – 2012-2017



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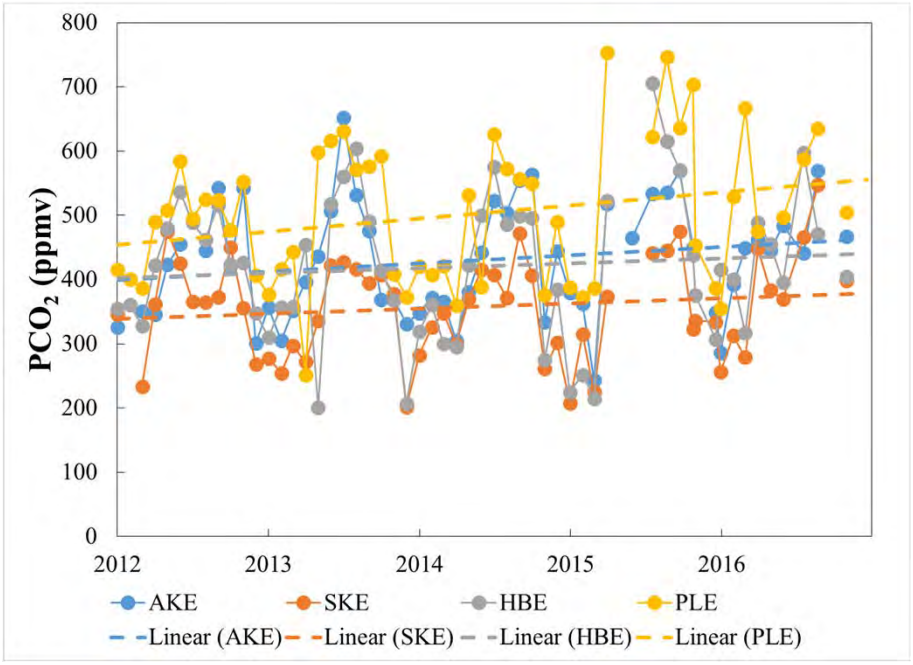
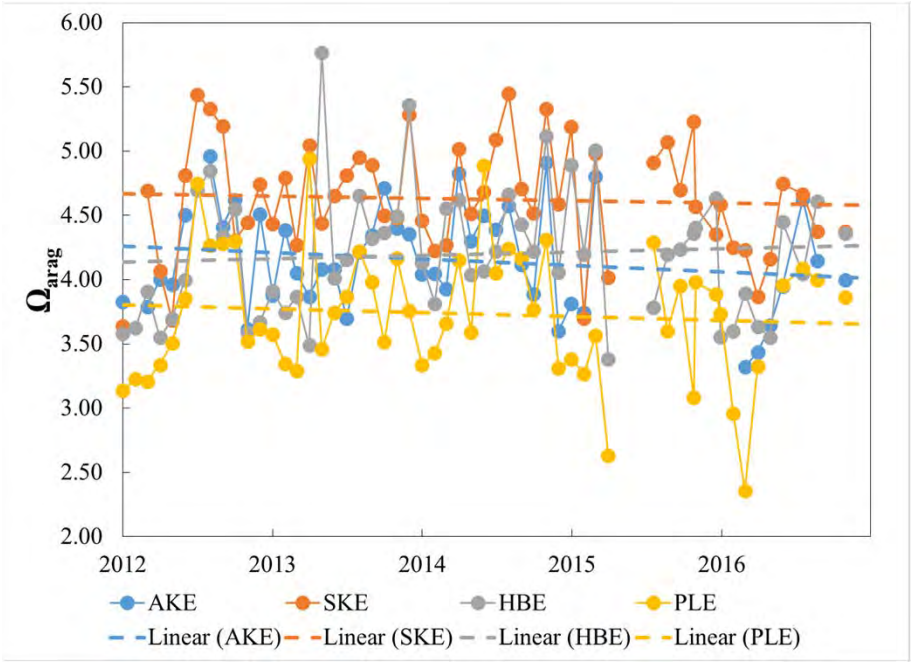
Increasing trend in pCO_2 and decreasing trend in calcium carbonate saturation of coastal seawater in the SE Levantine basin – 2012-2017





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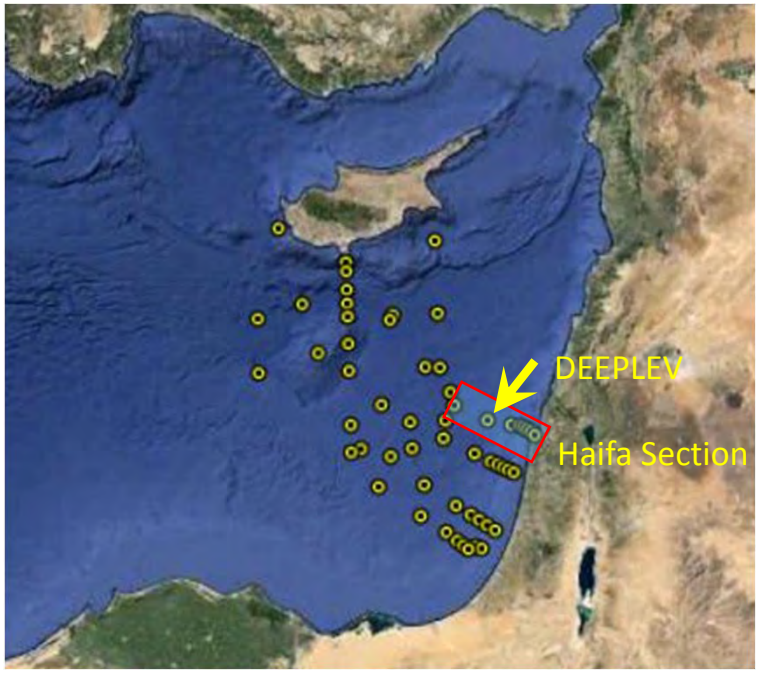
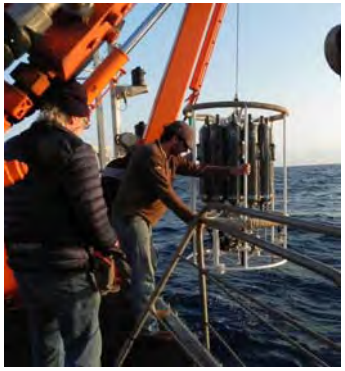
Jack Silverman, IOLR, NMP

Eastern Mediterranean sea carbonate system monitoring 2012-2017





Carbonate system parameters

1) Total alkalinity
2) Dissolved inorganic carbon
3) ~~pH~~

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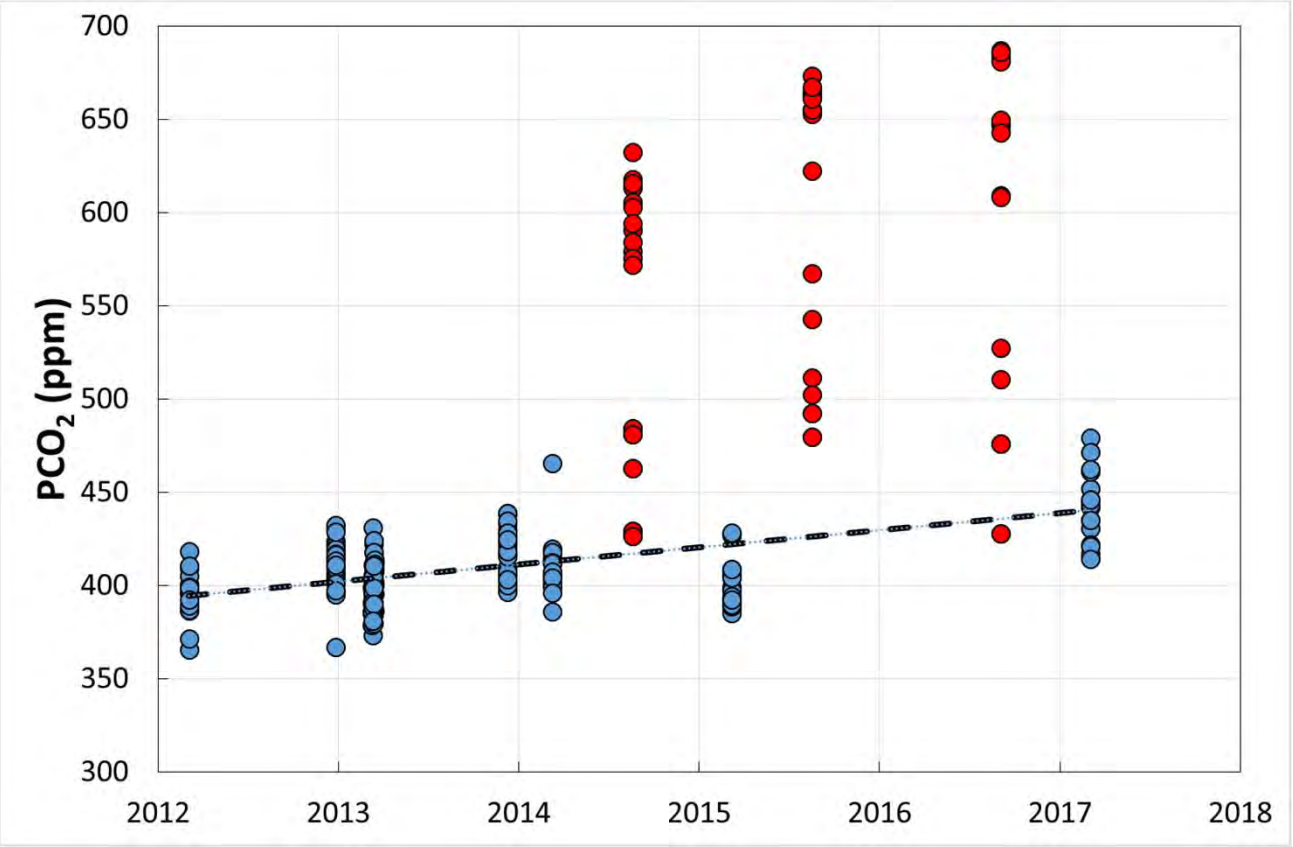
Ocean acidification in the eastern Mediterranean 2012-2017



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Potential ecological impact of ocean warming, acidification and bio-invasions on the ecology of the Eastern Levantine Basin

Experimental & *In-situ* studies

Experimental facilities to test the Metabolic responses of focal organisms to warming and acidification at IOLR - TGH PhD thesis

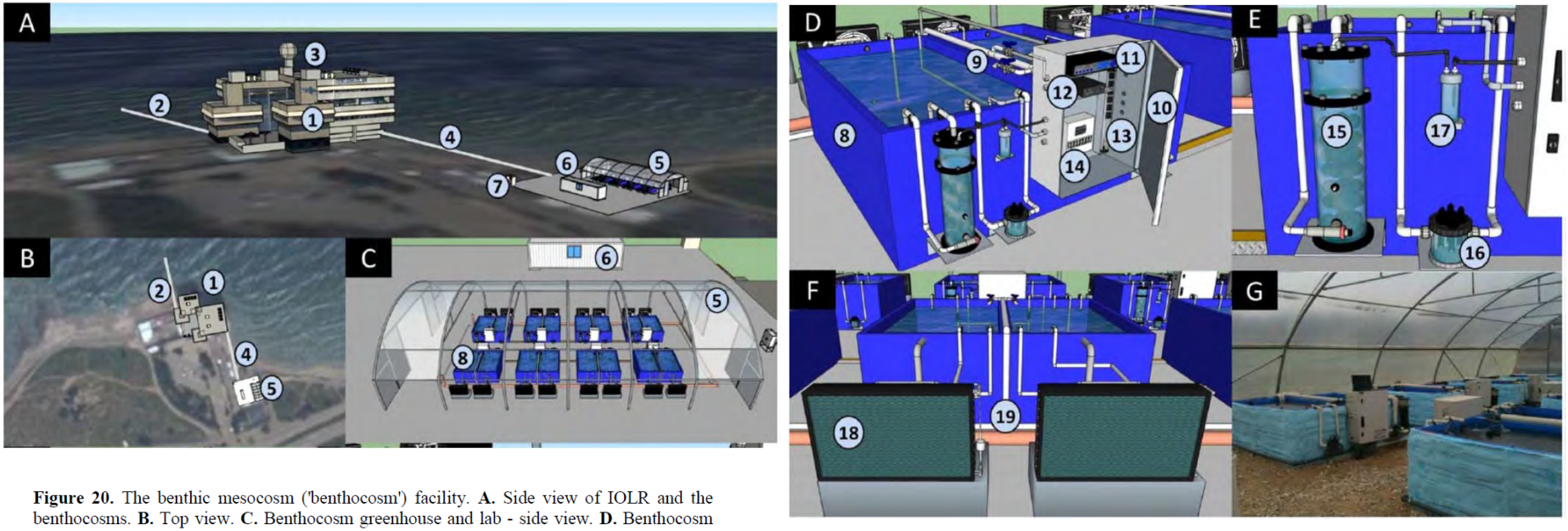

Figure 20. The benthic mesocosm ('benthocosm') facility. **A.** Side view of IOLR and the benthocosms. **B.** Top view. **C.** Benthocosm greenhouse and lab - side view. **D.** Benthocosm unit and cabinet – front view. **E.** CO_2 reactor and a measurement cell. **F.** Benthocosm units – back view. **G.** Photo of the benthocosm facility. The following items are presented by circled numbers: (1) IOLR, (2) primary inlet pipe, (3) seawater reservoir on IOLR roof, (4) connector pipe from IOLR roof to the benthocosm facility, (5) foldable greenhouse, (6) benthocosm laboratory, (7) CO_2 tanks warehouse, (8) a benthocosm unit (tank), (9) seawater inlet valve, (10) controller cabinet, (11) GHL controller Profilux 3-Nex, (12) SMS module, (13) switchable power bar, (14) electrical panel, (15) CO_2 reactor, (16) measurement cell with temperature, pH and salinity sensors, (17) drop counter, (18) chiller, (19) seawater outlet.

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Metabolic responses of focal organisms to warming and acidification in the SE Levantine Basin – TGH PhD thesis

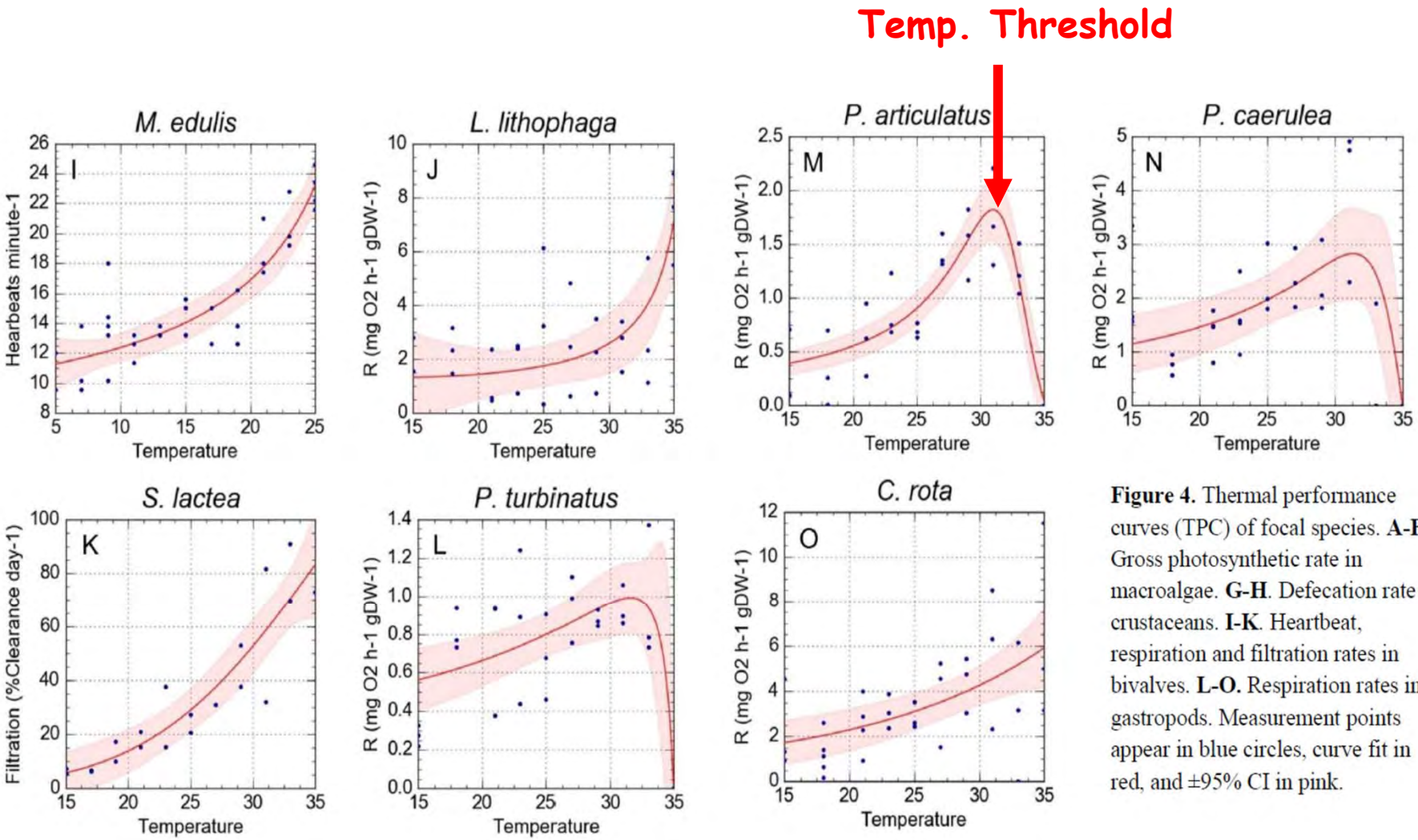
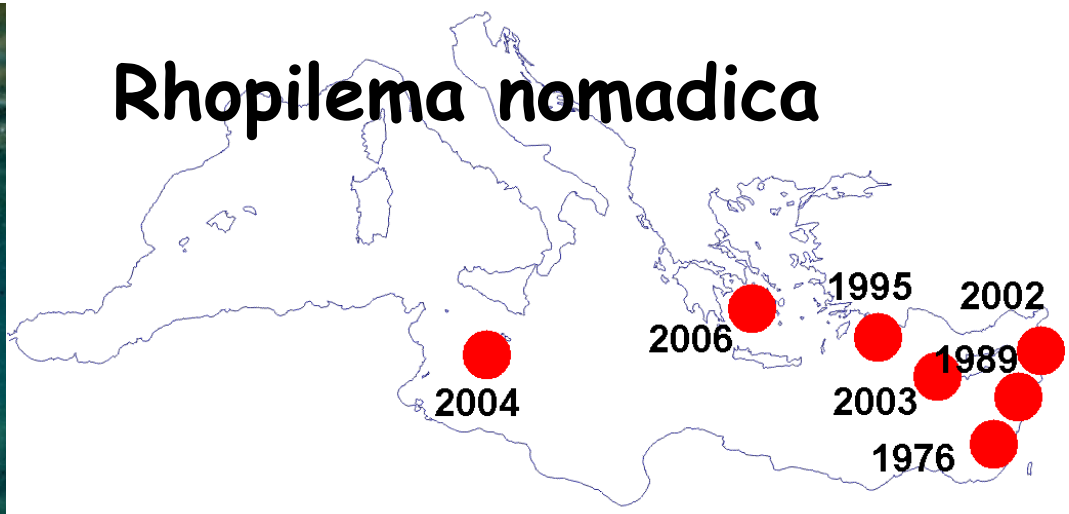


Figure 4. Thermal performance curves (TPC) of focal species. **A-F**. Gross photosynthetic rate in macroalgae. **G-H**. Defecation rate in crustaceans. **I-K**. Heartbeat, respiration and filtration rates in bivalves. **L-O.** Respiration rates in gastropods. Measurement points appear in blue circles, curve fit in red, and ±95% CI in pink.

Rhopilema nomadica

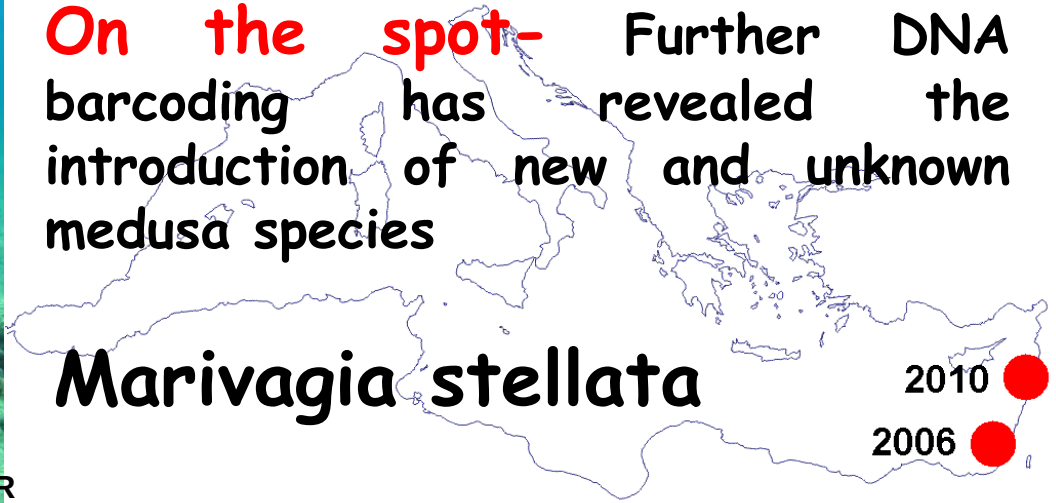


DNA barcoding revealed that this species entered at least 19 haplotypes on the COI !!! Into the Levant

Galil, B., et al 2010. *Aquatic Invasions* 5, 331-340., IOLR

On the spot- Further DNA barcoding has revealed the introduction of new and unknown medusa species

Marivagia stellata



Actinia equina in the Levant-

Impacts of increased water temperatures and elevated sea level

T- Smaller size
Less abundant
Higher genetic diversity
Sexual reproduction as compared to u-sexual

SL- Change of micro-habitat

The Israeli populations exhibit higher genetic polymorphism than other Actinia populations from the Mediterranean Sea and the Atlantic.

Furthermore, environmentally stressful conditions, especially high temperatures at the southernmost limit of this species in the Mediterranean (Levant area), restrict these populations to sexual reproduction, generating higher levels of genetic heterogeneity.

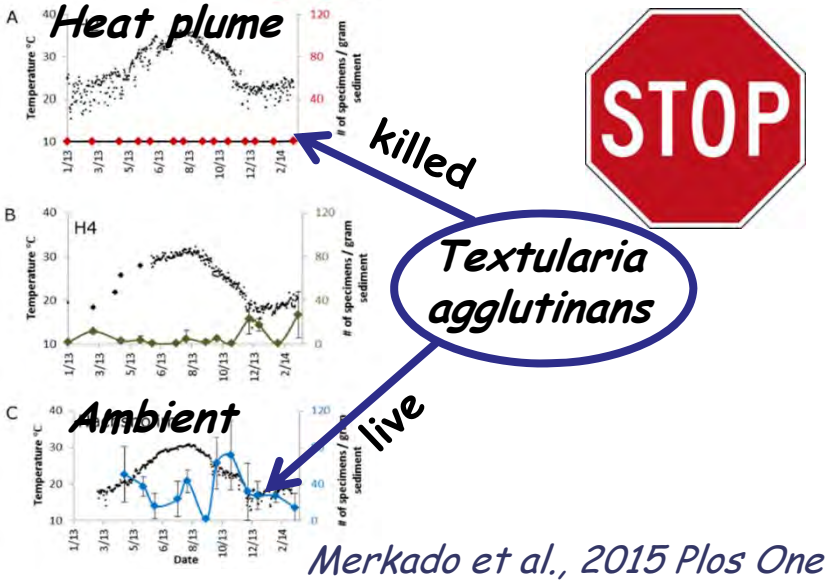
B. Rinkevitch, IOLR

Other benthic foraminifera species
less thermally tolerant

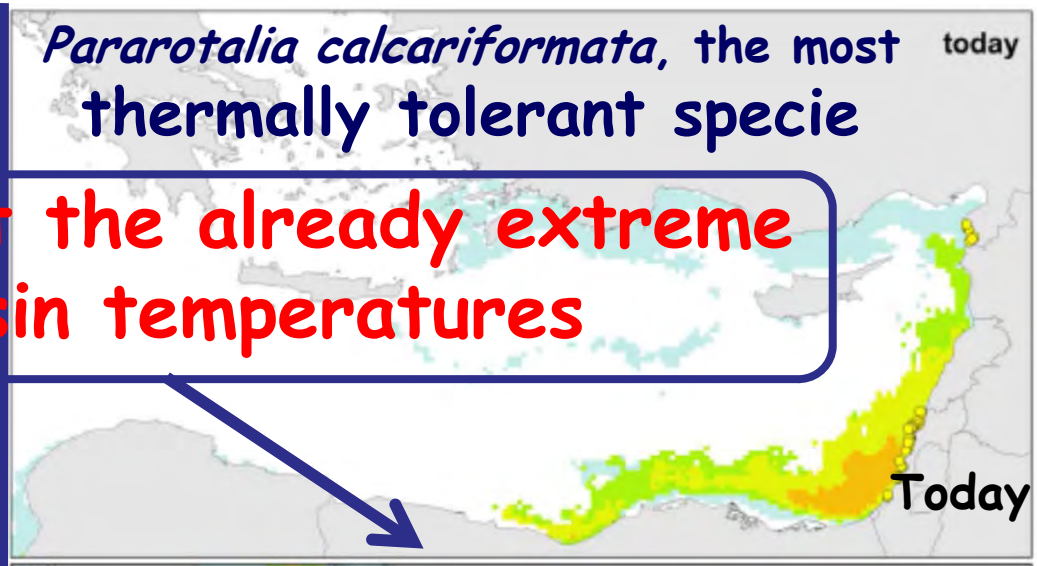
Pararotalia calcariformata, the most
thermally tolerant specie

Excess warming at the already extreme Levantine basin temperatures

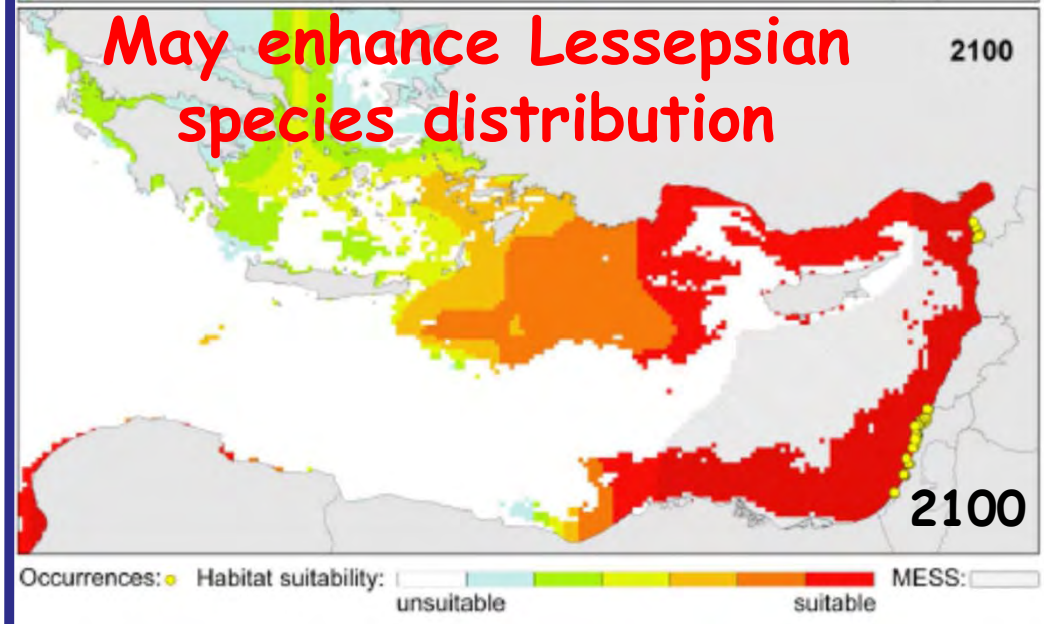
May act as a major stressor that will limit Lessepsian species distribution



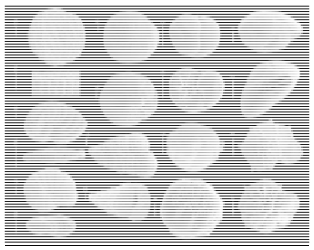
Merkado et al., 2015 Plos One
Titelboim D. et al., 2017



May enhance Lessepsian species distribution



Christiane Schmidt et al.,
2015 Plos One



Key issues

- The SE Mediterranean thermohaline and biochemistry are influenced by climate change.
- The extreme T & S in the Levantine basin may limit/enhance species distribution and enhance mortality.
- Increasing OA and dust emissions may consequently supply more nutrients into oligotrophic provinces.
- Impacts on key marine and coastal organisms, ecosystems, and services are already detectable, and several will face high risk of impacts.
- As atmospheric CO2 increases, protection, adaptation, and repair options for the ocean become fewer and less effective.

Thank you

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