РОССИЙСКИЙ ФОНД ФУНДАМЕНТАЛЬНЫХ ИССЛЕДОВАНИЙ

Iran National Science Foundation

Hydrochemistry of the Southern Deep-Water Basin of the Caspian Sea

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Caspian Sea

- The Caspian Sea is the largest inland water body on earth.
- About 130 rivers with various sizes flow into the sea with an annual freshwater inflow of about 300 km^3.
- The main input is the Volga River in Russia (85% of the total volume of inflow).
- The outflow in the Caspian Sea is mainly by evaporation at the sea surface.

Biological diversity

- The biological diversity of the Caspian and its coastal zone makes the region one of the most valuable ecosystems in the world
- The Caspian lies at the crossroads of migration routes of millions of birds and offers refuge for a number of rare and endangered species.

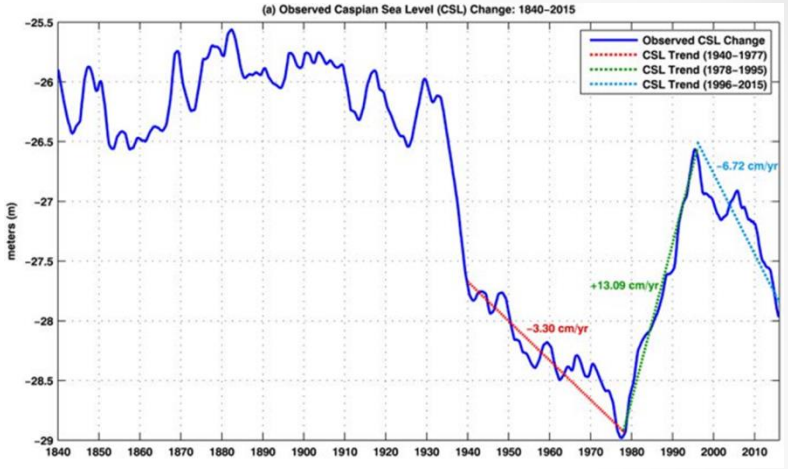
- **Phytoplankton (about 450 species, varieties, or forms**
- **Zooplankton (315 species)**
- **Phytobenthos (87 species of algae)**
- **Zoobenthos (380 species of macrofauna)**
- **Fishes (approximately 133 species)**
- **Mammals (Caspian seal)**
- **Birds (466 species of birds)**

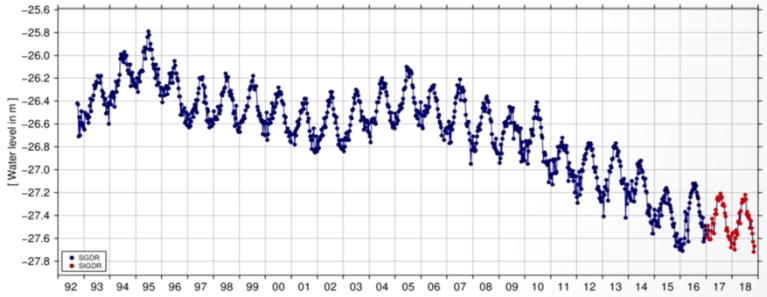
Water level fluctuations

- One of the most **important features** of the Caspian is its **changing water level**, a factor that has a significant effect on biodiversity and coastal management.

- As an inland sea, the level naturally changes in response to **changes in the balance of inputs (mostly river flow) and outputs** (primarily evaporation).

- The sea level in the Caspian Sea displays a clear **seasonal cycle**, generally reaching its lowest seasonal value in winter and increasing during May–July, following the spring floods.



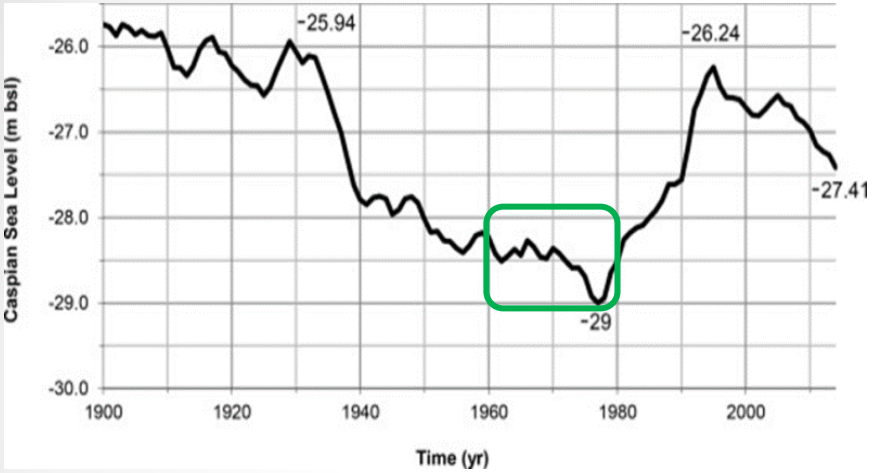


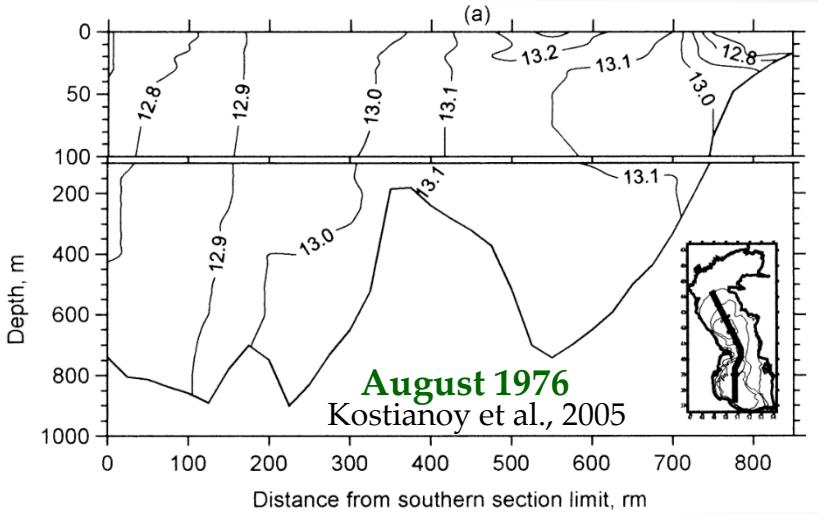
Studies showed that there is a strong relation between Caspian Sea level and its thermohaline structure and the hydro-chemical regime.

Thermohaline water structures

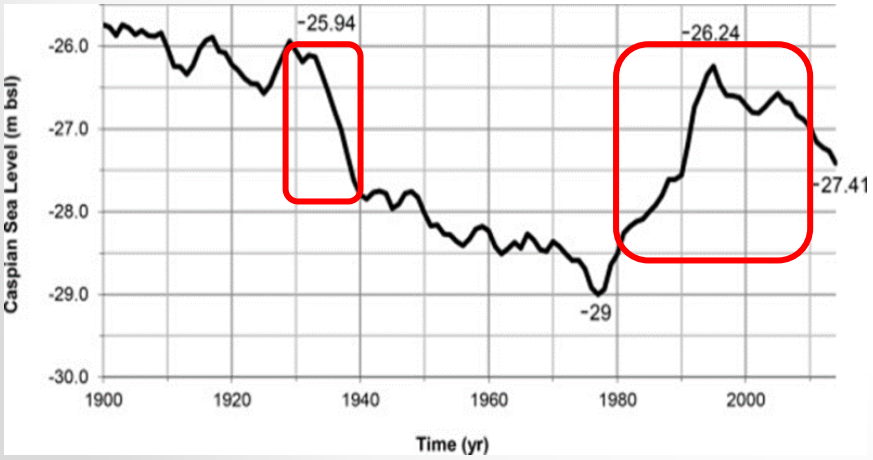
Sea level and severity of winters determine the thermohaline structure

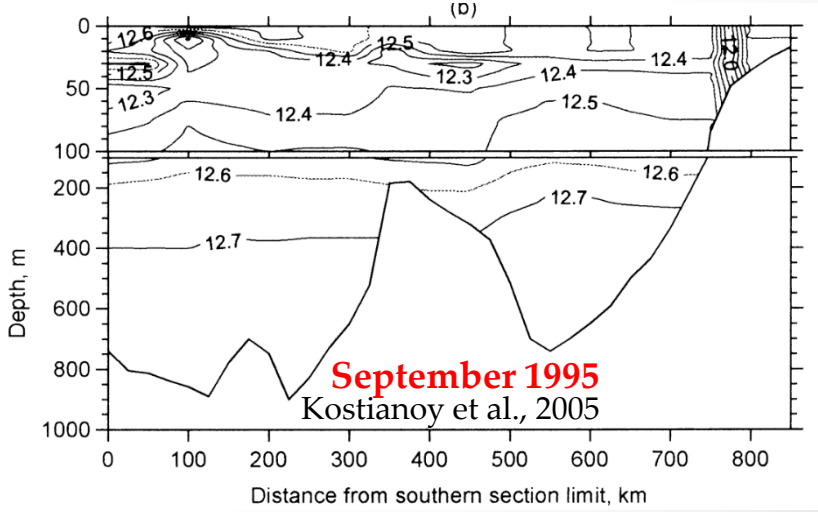
- **a)** during combination of reduced river discharge and more severe winters.





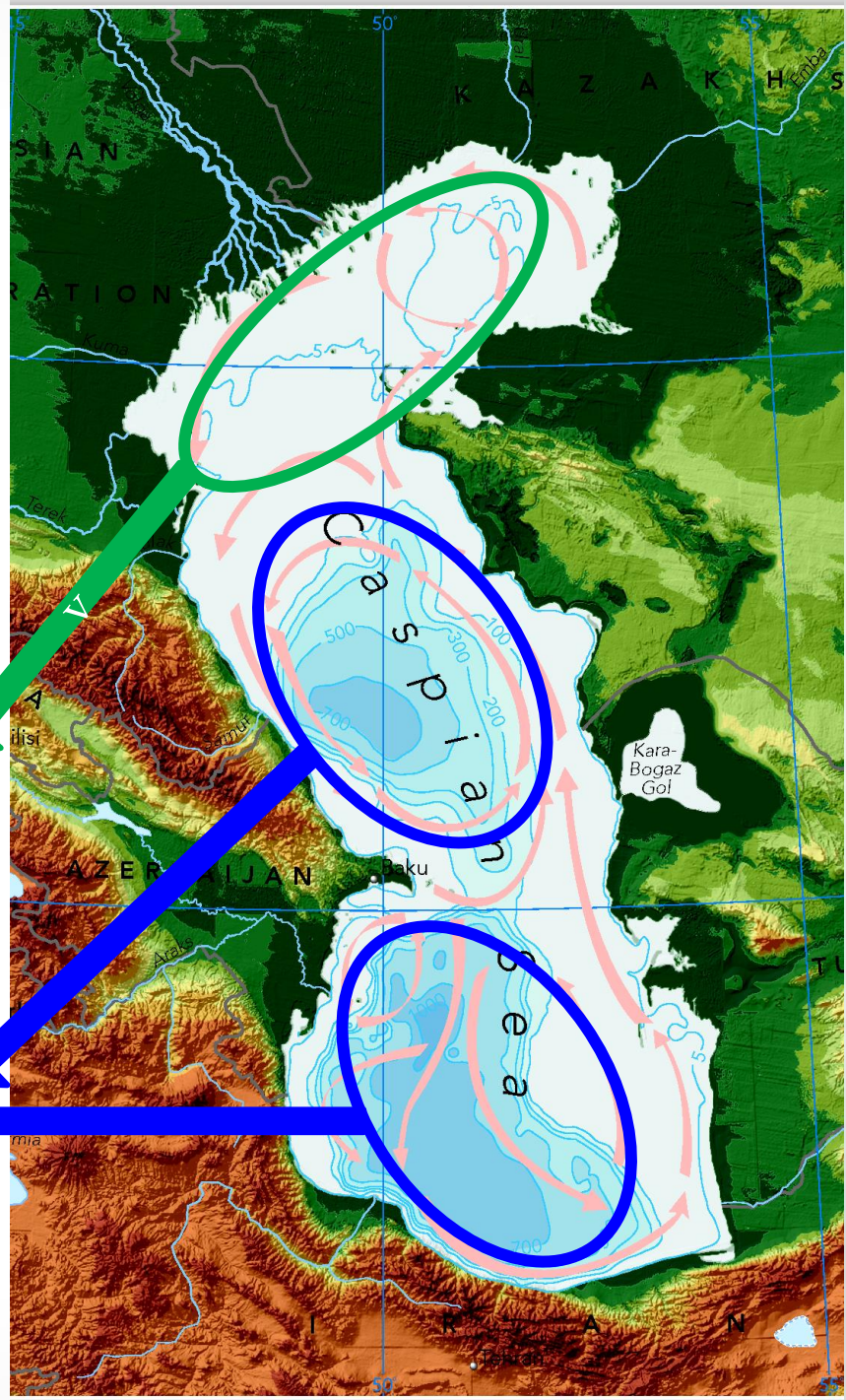
- **b)** during enhanced river discharge and prevalence of mild winters.





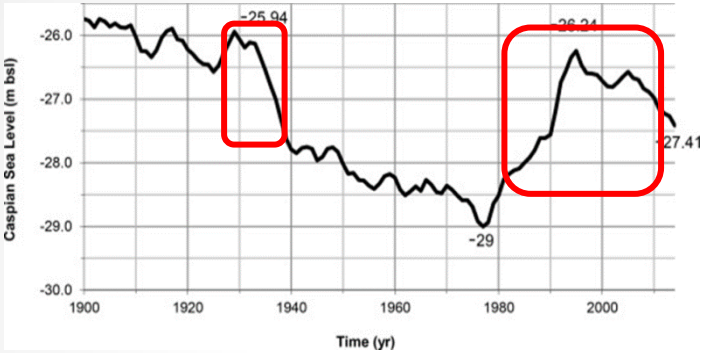
Hydro-chemical regime

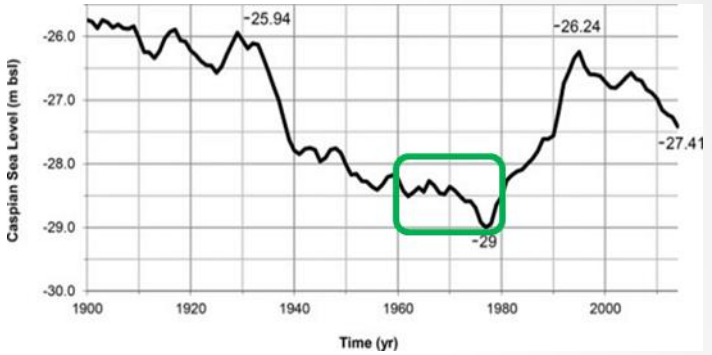
- There is a **spatial inhomogeneity** and **multiannual instability** of the hydro-chemistry in the CS.
- The hydro-chemical patterns in the **near-mouth and shallow water areas** are deferent from **deep basin areas in the middle and south parts.**
- **In near mouth areas, variations mostly depend on the volume and chemical composition of river discharge together with the composition of biomass**
- **In deep basins variations mainly are controlled by biochemical and dynamical processes in the water column.**

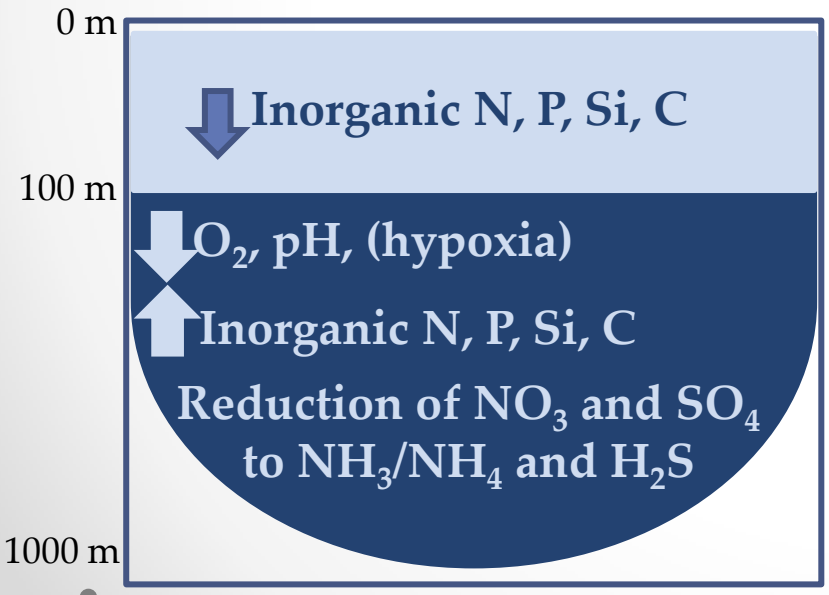


Hydro-chemical variations in deep basins

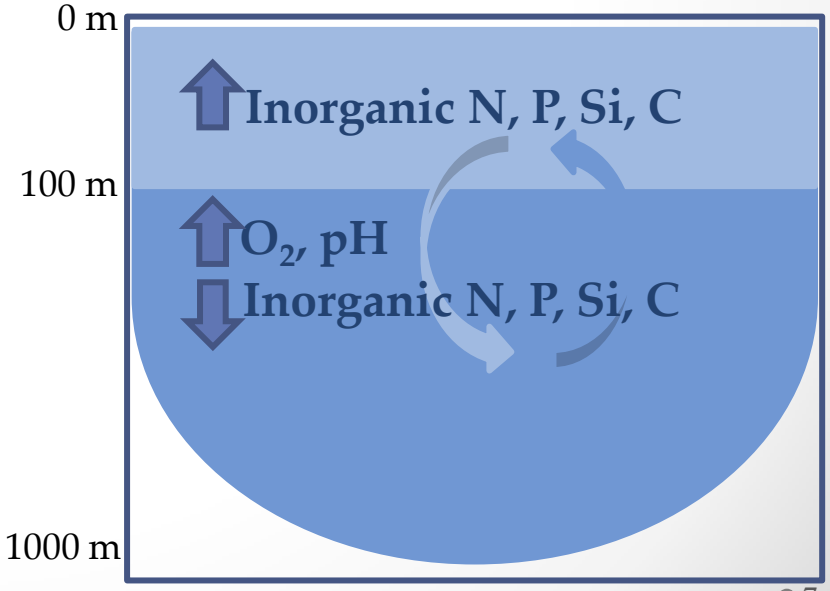
- During last decades from 1920 to now, two types of chemical distribution patterns were observed in deep basins of the Caspian Sea:







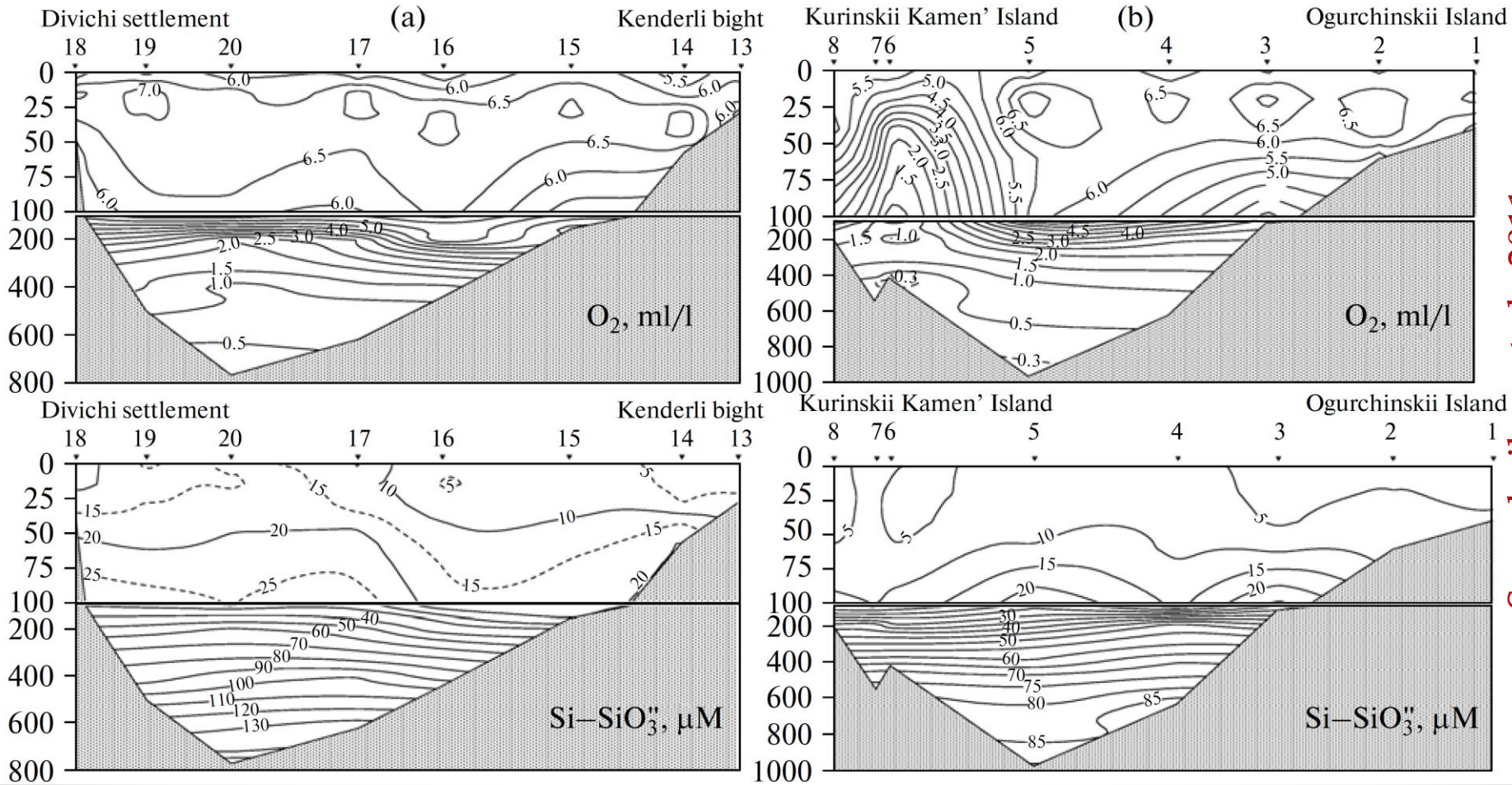
1920-1940 and 1980-2014



1960-1980

Recent hydro-chemical regime

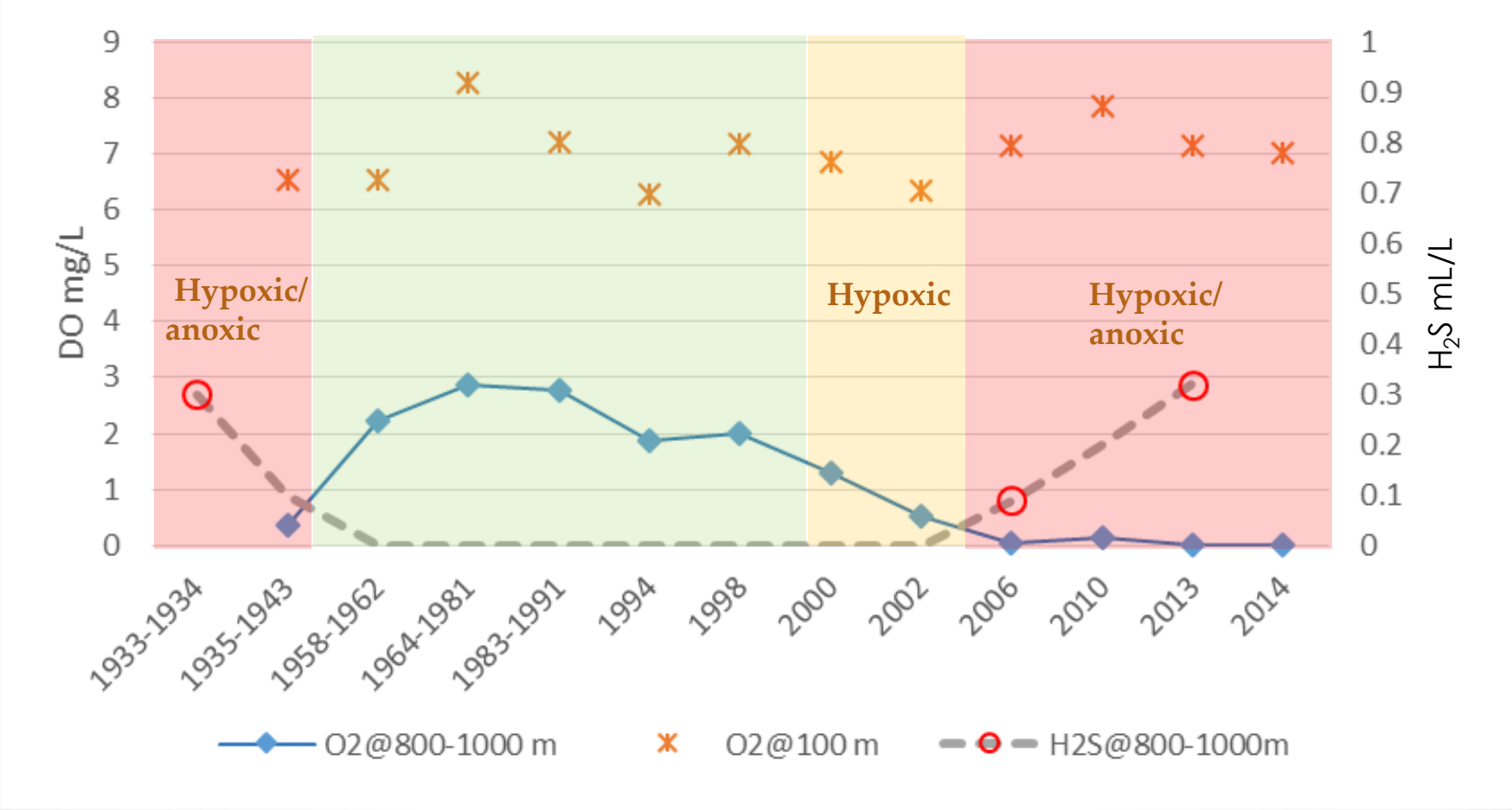
Recent studies showed that in the middle and South Caspian Sea, former pattern has been continued to be even more emphasized, from 2005 to 2014



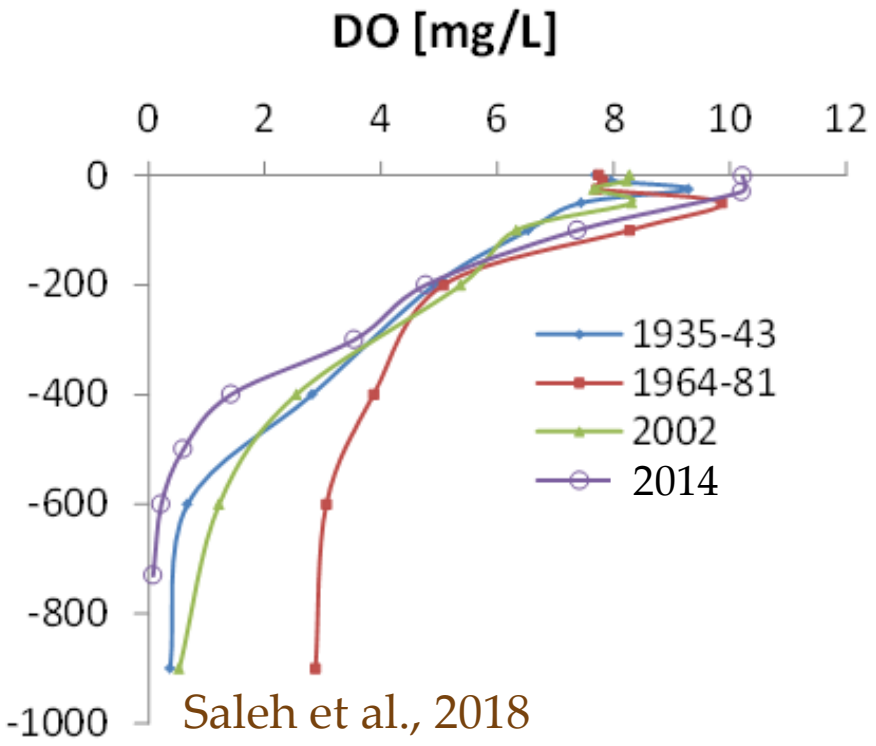
Sapozhnikov et al., 2011

(Dukhova et al. 2015; Sapozhnikov et al., 2006; Sapozhnikov et al. 2012; Sapozhnikov et al. 2007; Sapozhnikov et al. 2008a; Sapozhnikov et al. 2011, Saleh et al., 2018)

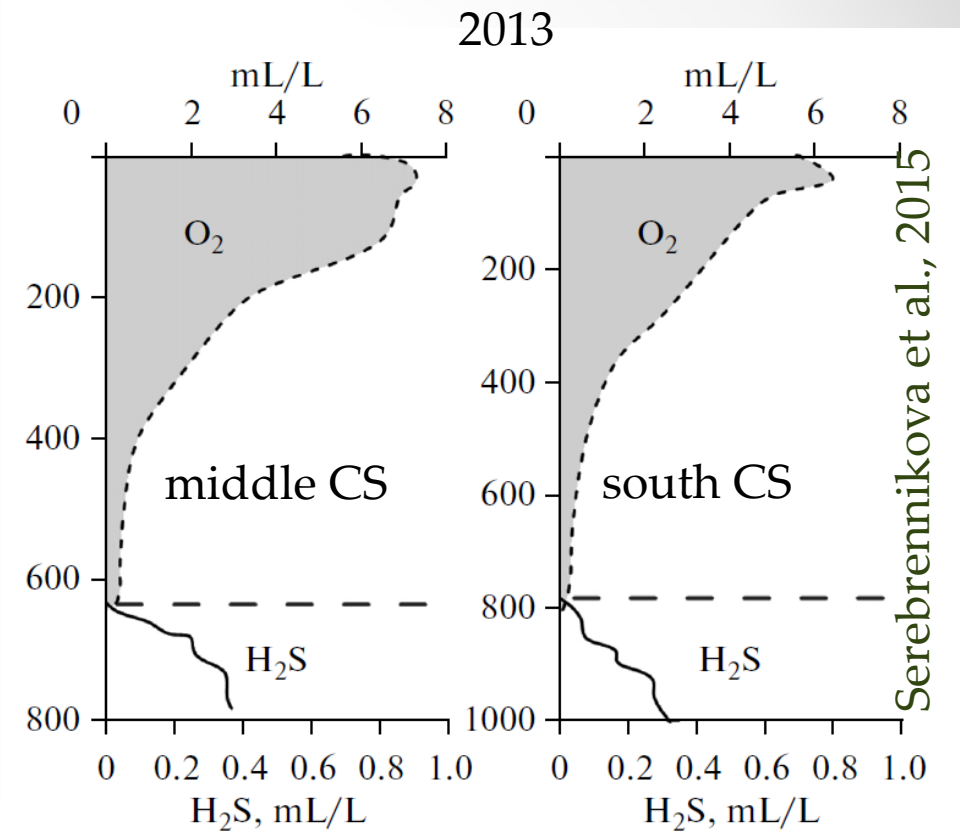
Dissolved oxygen (O_2) and H_2S in the south Caspian Sea



Dissolved oxygen (O_2) and H_2S in the south Caspian Sea

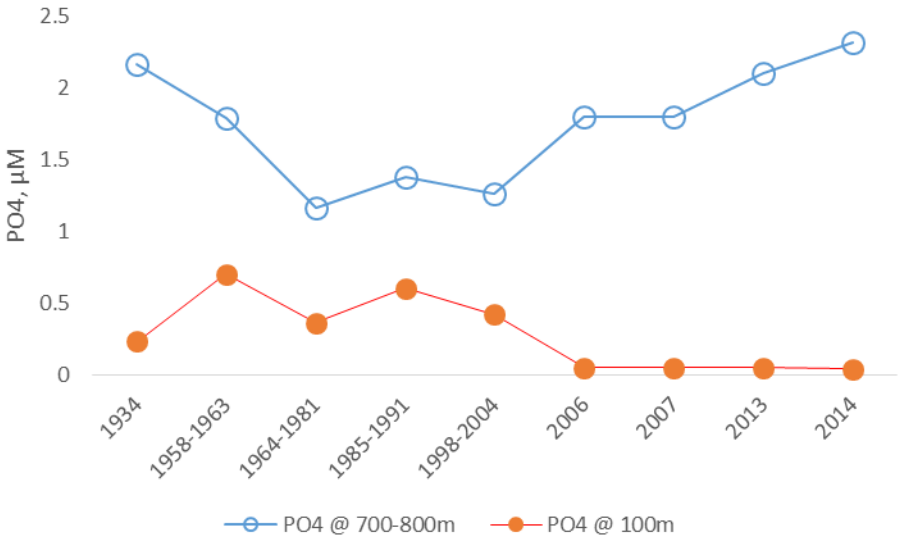


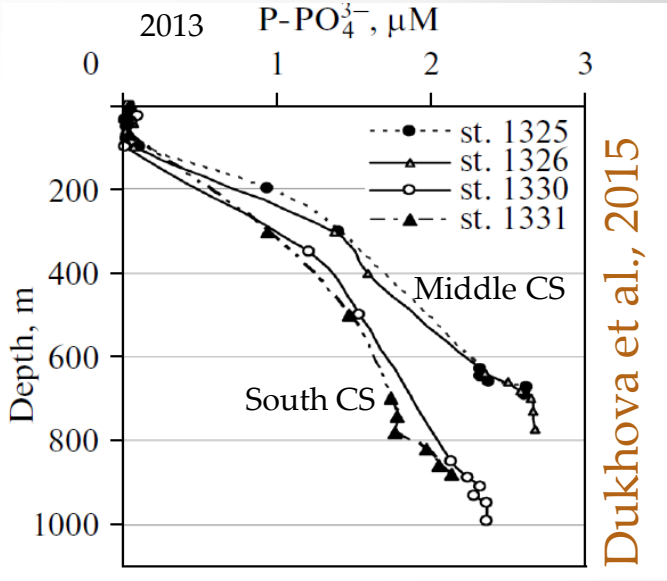
Saleh et al., 2018

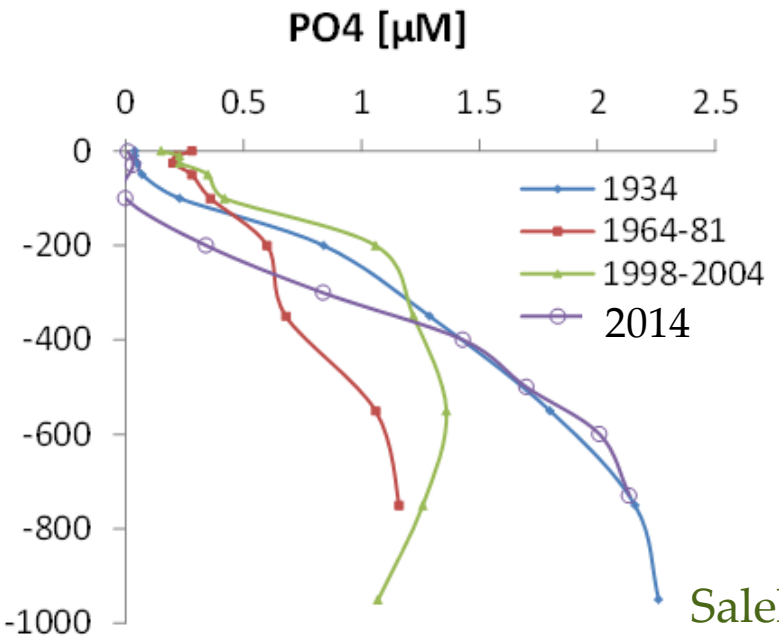


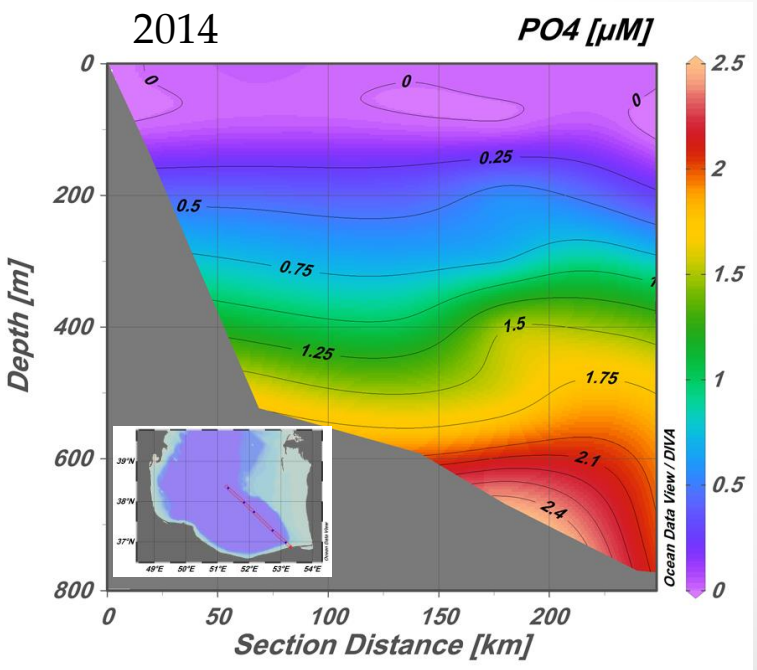
The anaerobic zone at the bottom is gradually expanding, and the thickness of the hydrogen sulfide layer has already reached 200 m from the bottom layer.

PO_4^{3-} in the south Caspian Sea



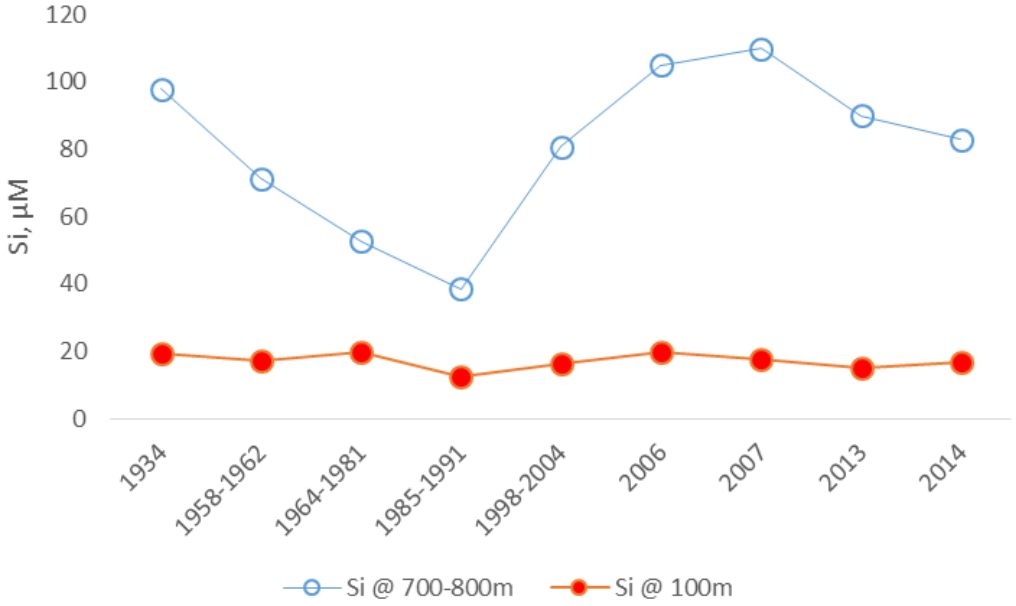


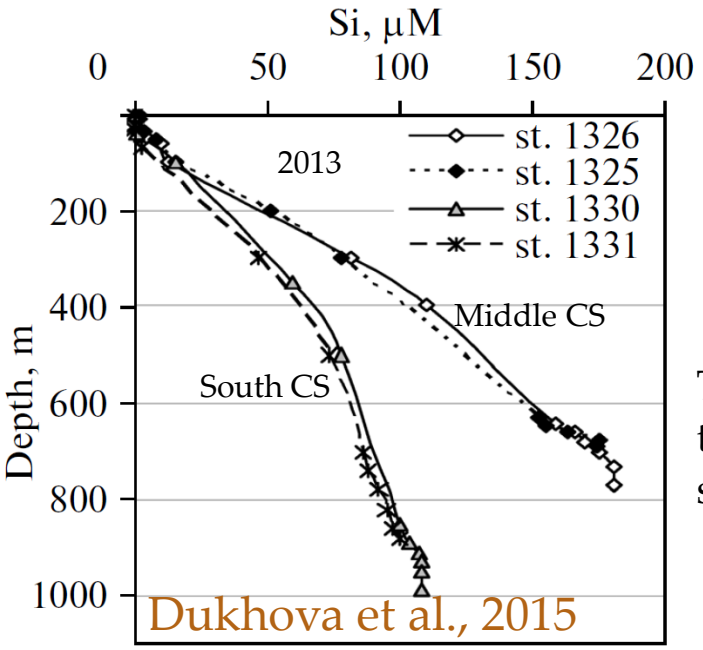


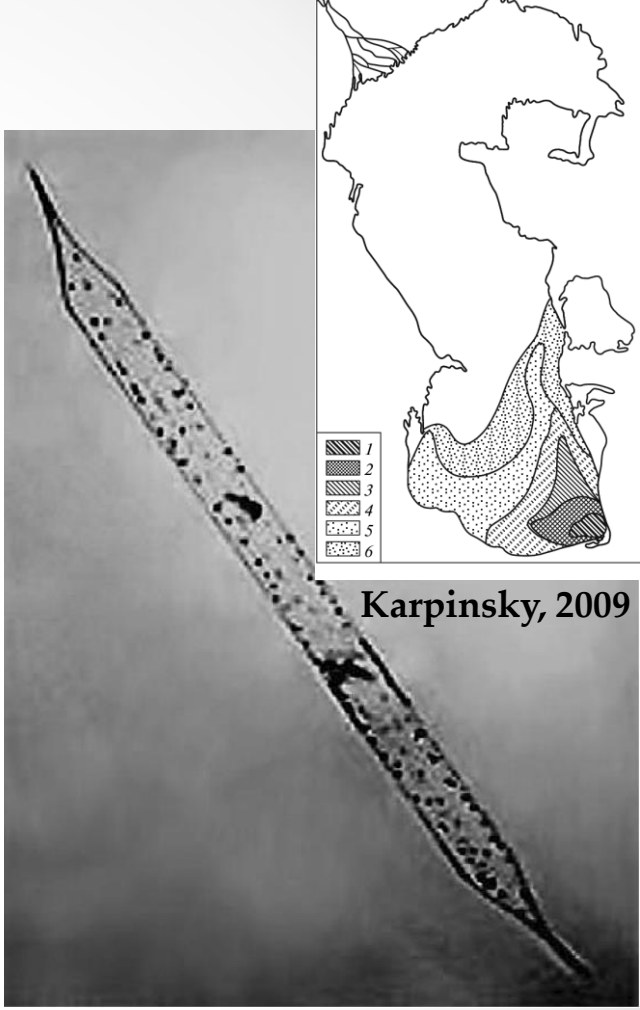


Saleh et al., 2018

Dissolved Si in the south Caspian Sea





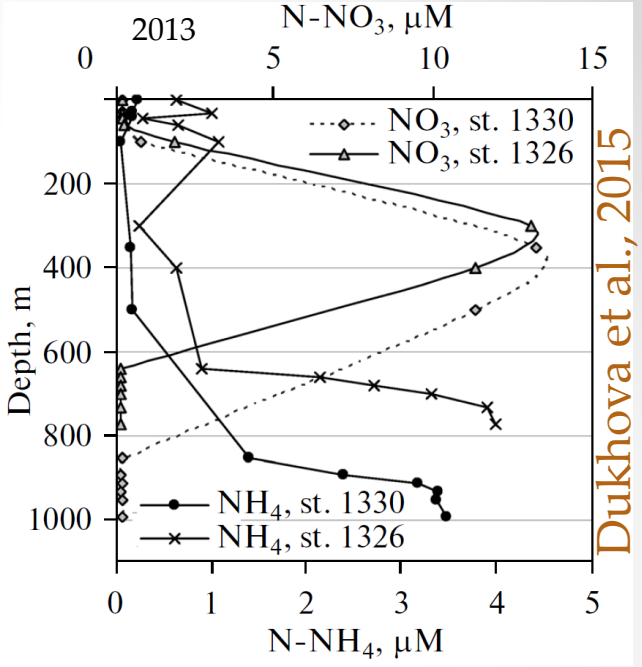


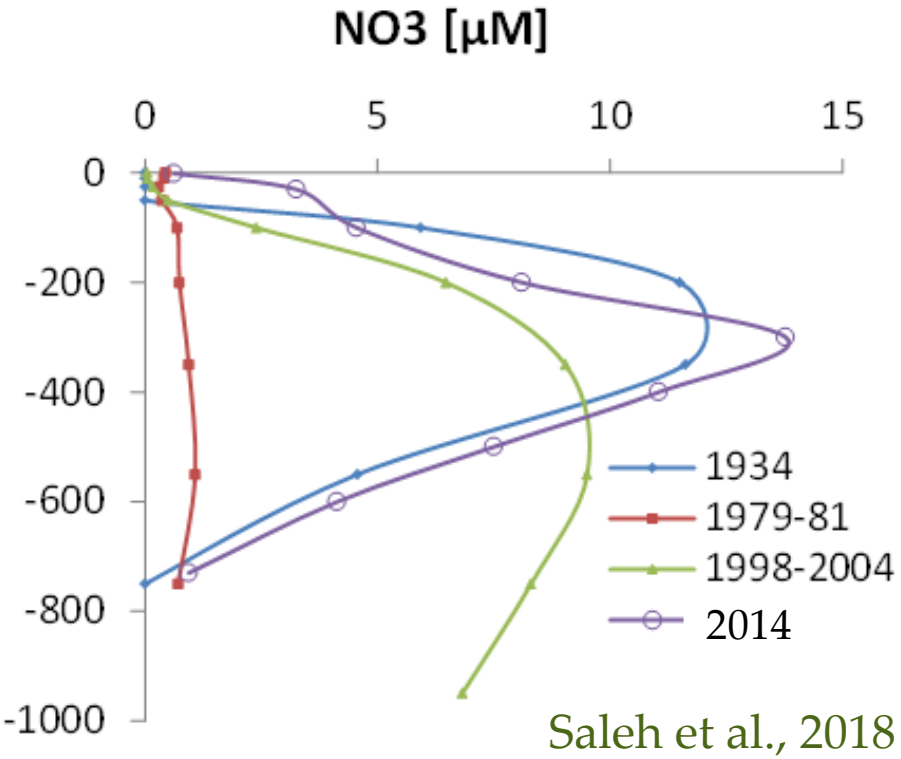
P. Calcar-avis, photo from site: http://blacksea-education.ru

The reduction of the share of ***Pseudosolenia calcar_avis*** in total biomass, led to a reduction in the rate of accumulation of silicon in the bottom waters.

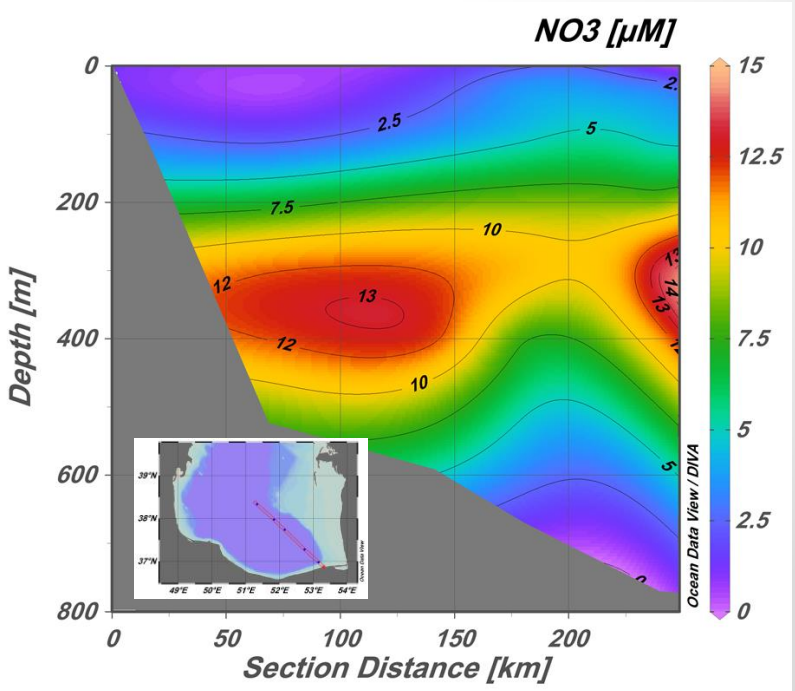
NO_3^- in the south Caspian Sea

In the CS, nitrate shows an intermediate maximum concentration which fluctuates in both terms of magnitude and depth in response to the oxygen concentration.



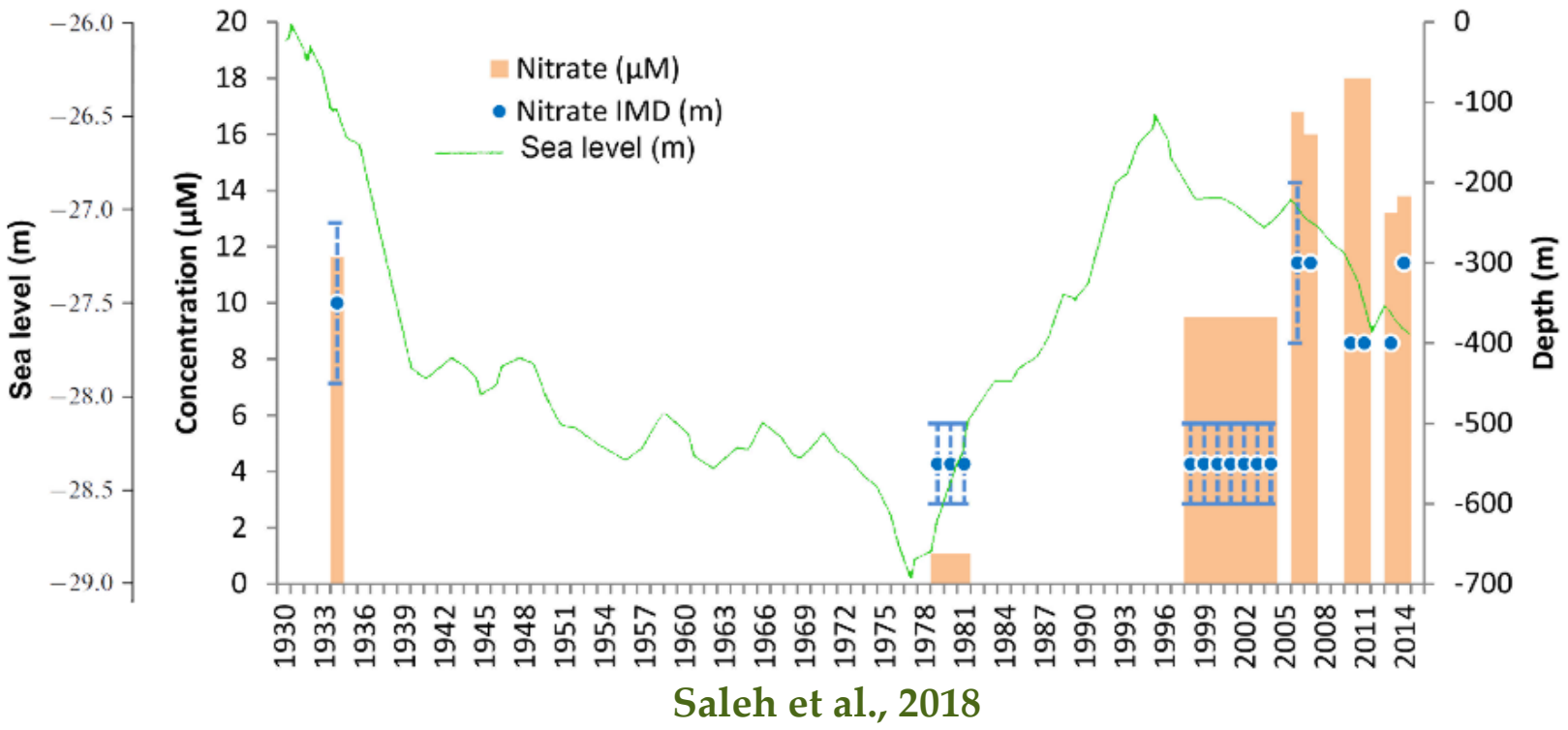


Saleh et al., 2018



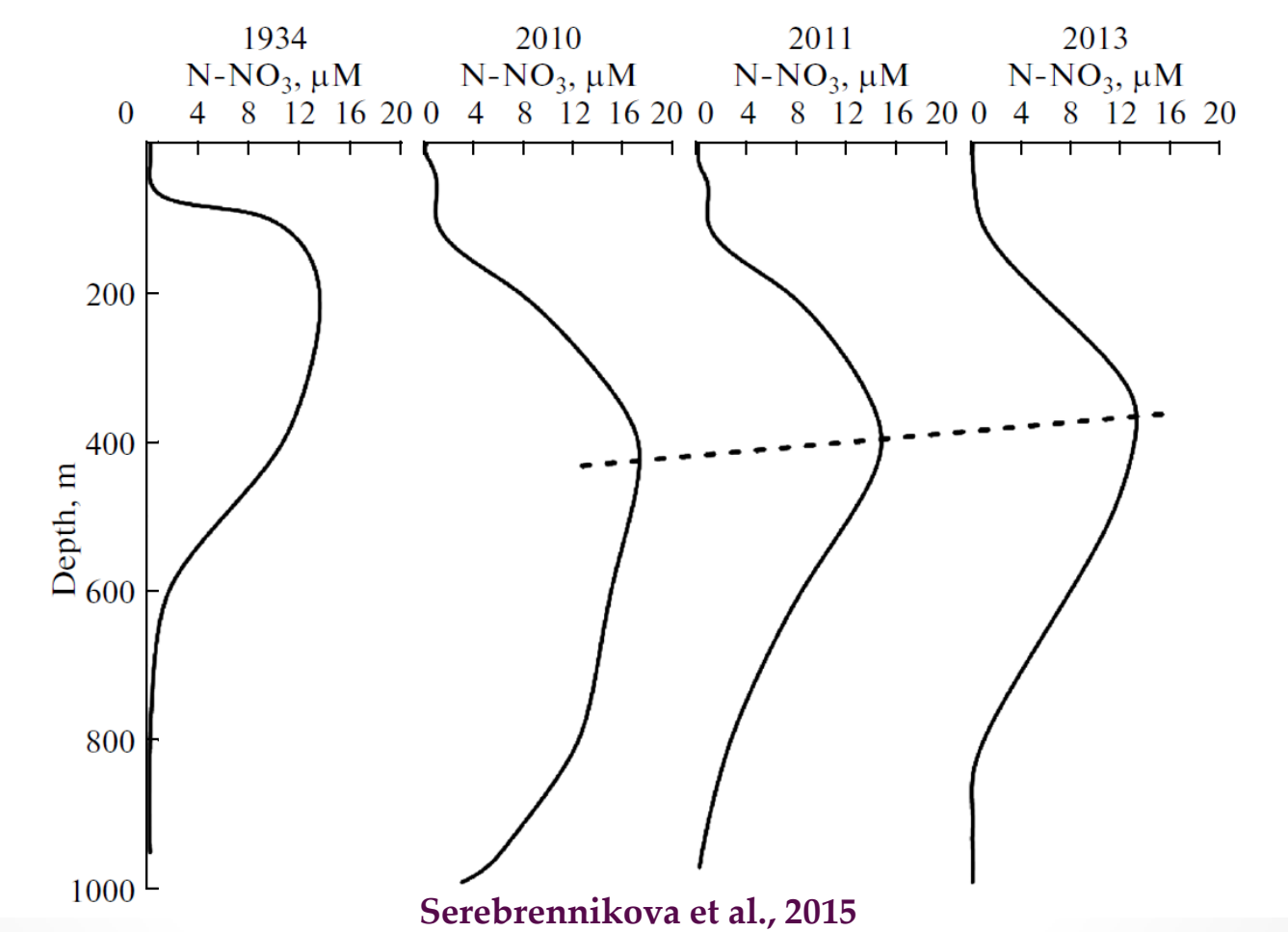
Nitrate intermediate maximum depth (IMD)

Saleh et al., 2018



Nitrate maximum concentration and intermediate maximum depth (IMD) in the southern basin of the Caspian Sea from 1934 to 2014 (Based on data reported by (Andrey G. Kostianoy 2005; Dukhova et al. 2015; Sapozhnikov et al. 2012; Sapozhnikov et al. 2008a; Sapozhnikov et al. 2011 and Saleh et al., 2018).

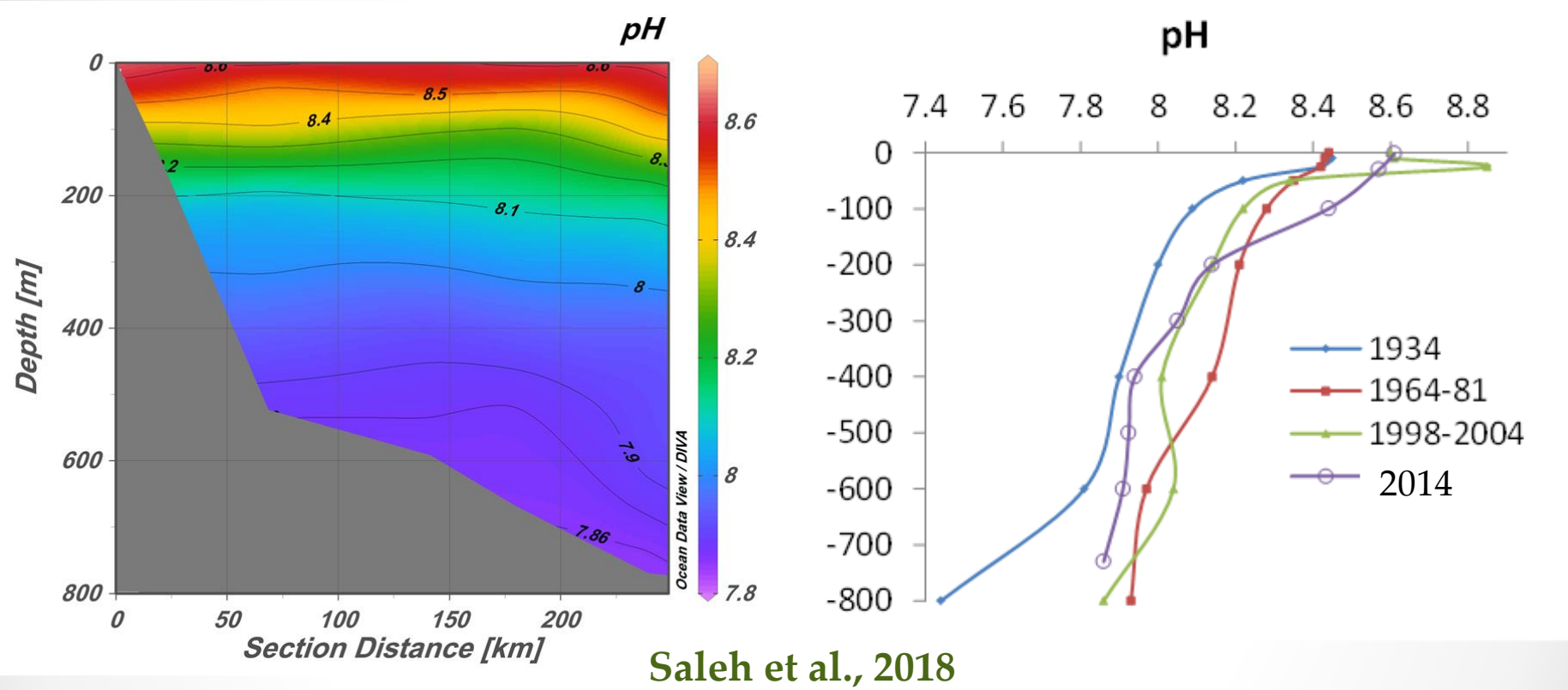
Shallowing of the nitrate IMD



Serebrennikova et al., 2015

Serebrennikova et al (2015) showed that nitrate IMD is gradually shifting closer to the surface due to intensification of nitrate reduction in the hypoxic zone: from 2010 to 2013, this layer shifted up by 50 m.

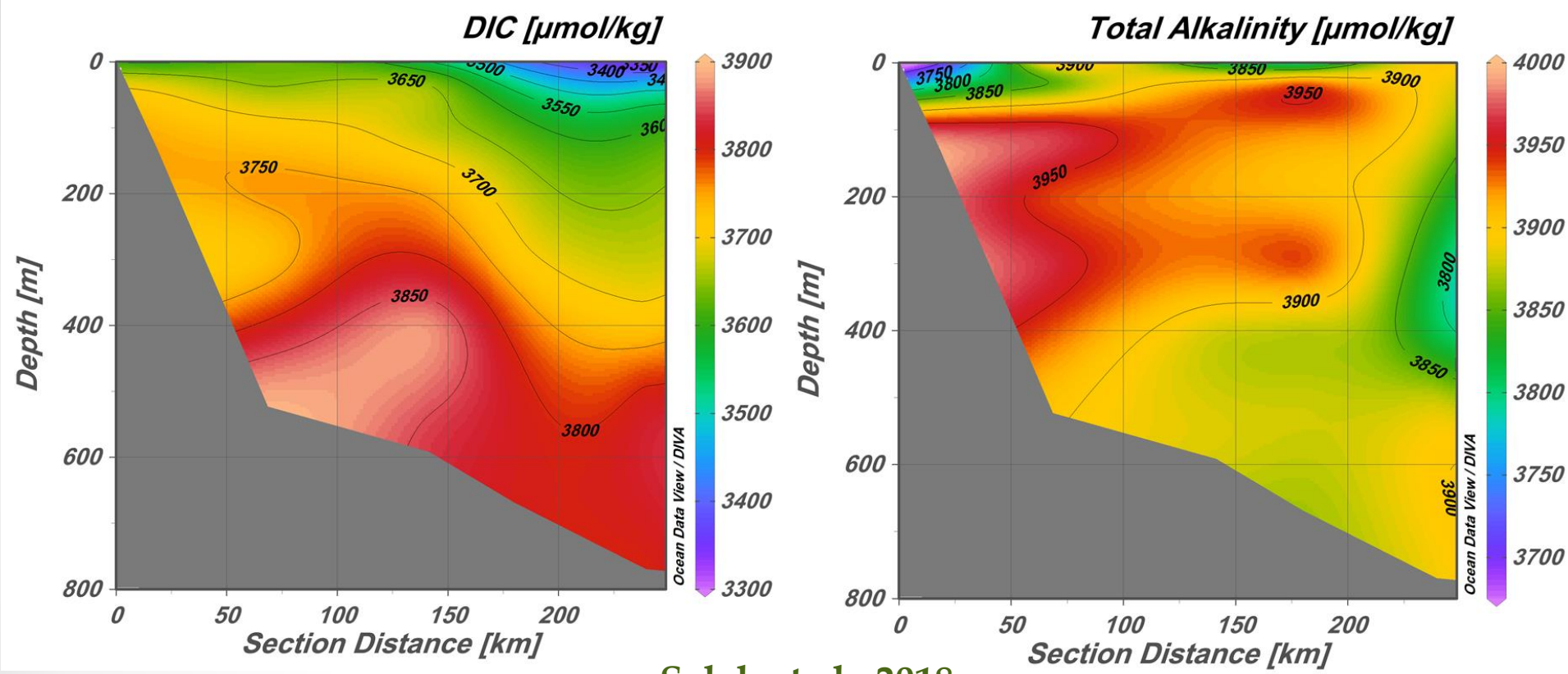
pH in south Caspian Sea



Saleh et al., 2018

The pH value of 7.91 at 600 m reducing to 7.86 at the near bottom layer.

Total alkalinity and dissolved inorganic carbon



Saleh et al., 2018

Average DIC of the surface water in the studied section in 2014 was 3500 µmol/kg and increased to about 3900 µmol/kg at the bottom water.

A_T was found to be at the range of 3690 to 3975 µmol/kg. Results demonstrated the maximum amount of A_T in the intermediate levels near the Iranian coast of southern basin of the Caspian Sea which probably was due to the underground water discharge from the southern coast of the Sea.

Summary

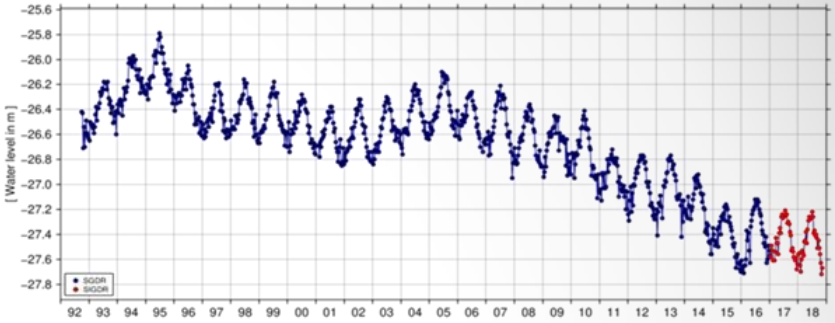
- Latest data available (dissolved oxygen, pH, temperature, dissolved nutrients and total dissolved inorganic carbon) showed that in the southern deep-basin of the Caspian Sea, water column was **strongly stratified** in term of measured parameters

- The **accumulation** of phosphate, silicate and dissolved inorganic carbon in the bottom layers was observed as a result of the organic mineralization in the absence of effective vertical winter mixing.

- Data on **nitrate intermediate maximum depth** and its concentration confirmed that the **hypoxic condition was growing** to reach higher horizon levels (300-400m) in 2014.

- prolonged processes such as **change in the dominant species** of phytoplankton, the **depletion of the photic layer**, the **development of hypoxia** in deep waters, and the **accumulation of hydrogen sulfide** at the bottom have been possible thanks to modern monitoring studies of the Caspian sea and need to continue

How will be the hydro-chemical regime of the Caspian Sea in future?

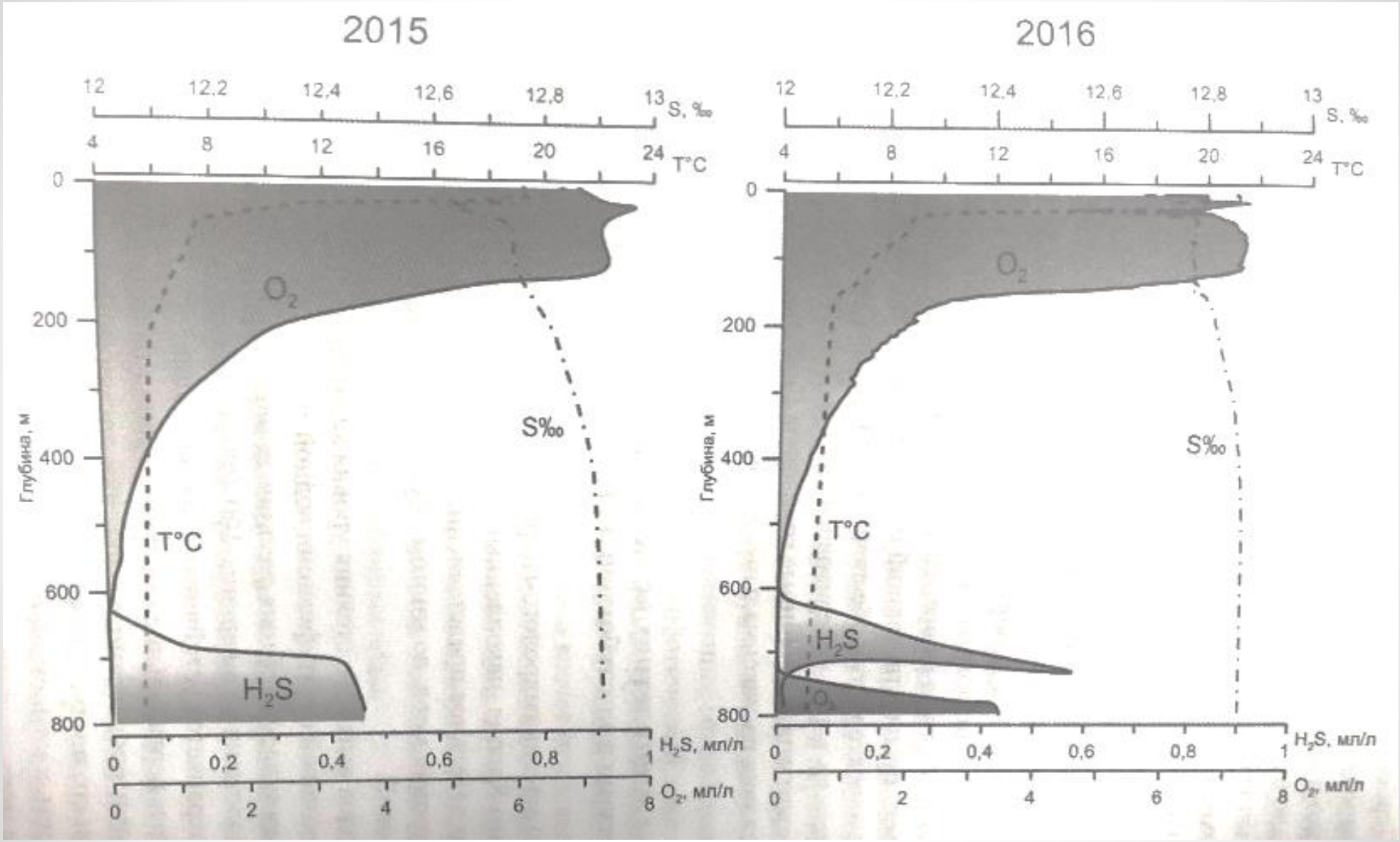


- The sea level has been lowering during last decade.

- If the sea level lowering continues we can expect effective deep-water ventilation caused by winter vertical mixing (Serebrennikova, 2017).

- This can lead to **fundamental shift in oxygen and dissolved nutrients** distribution and **fortification** of the photic layer that can **enhance the primary production and benefit all the food chain in Caspian ecosystem.**

- Similar to what happened during low sea level standing in 1960s and 1970s.


2015
2016
S, ‰
T°C
Глубина, м
O2
S‰
T°C
H2S
H2S, мл/л
O2, мл/л

Comments:

- Continuation of the **annual oceanographic studies** is needed to obtain more precise information about the long-term variability in the deep water basins of the Caspian Sea.

- **Carbonate chemistry**, anthropogenic CO_2 effects and acidification rate need to be studied, specially in deep basins.

- Establishment of **Caspian Sea Observing Network** (with 5 member countries) including joint research cruises and sharing data and researcher could promote the research in the Caspian sea.

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