January 2021: seawater masses characterized by high salinity affect the Gulf of Trieste

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The monitoring carried out in the Gulf of Trieste in mid-January showed the presence, especially in the external and central-eastern part of the basin, of a seawater mass characterized by high salinity (Fig. 1, 2).

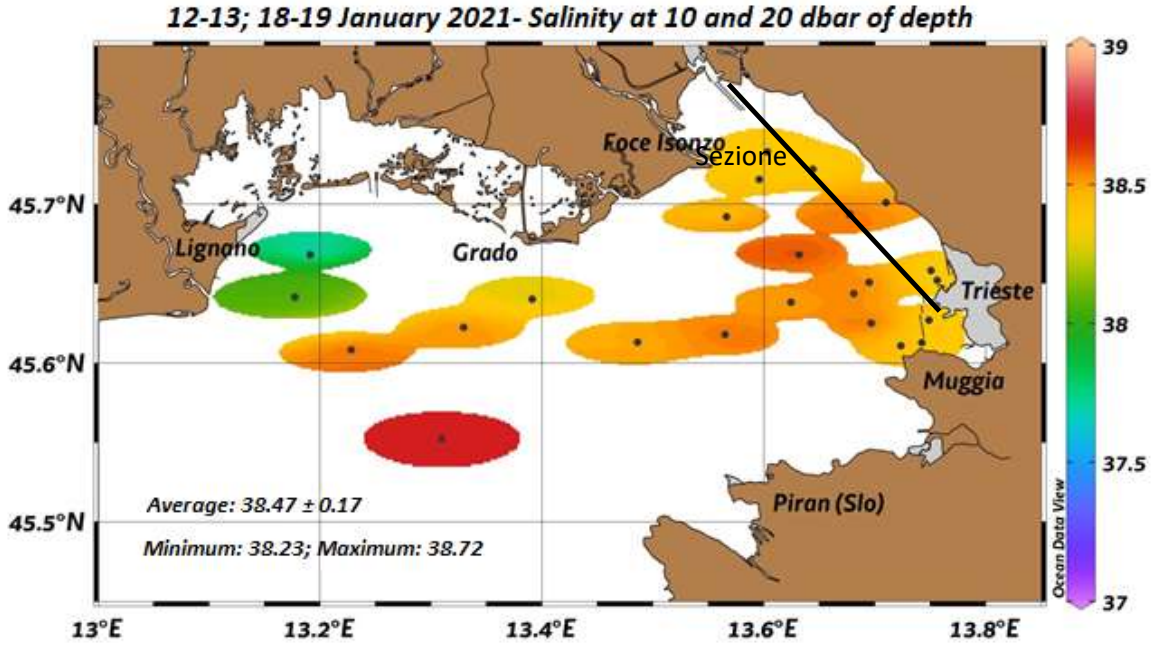

Fig.1 Horizontal salinity distribution [ref.1]

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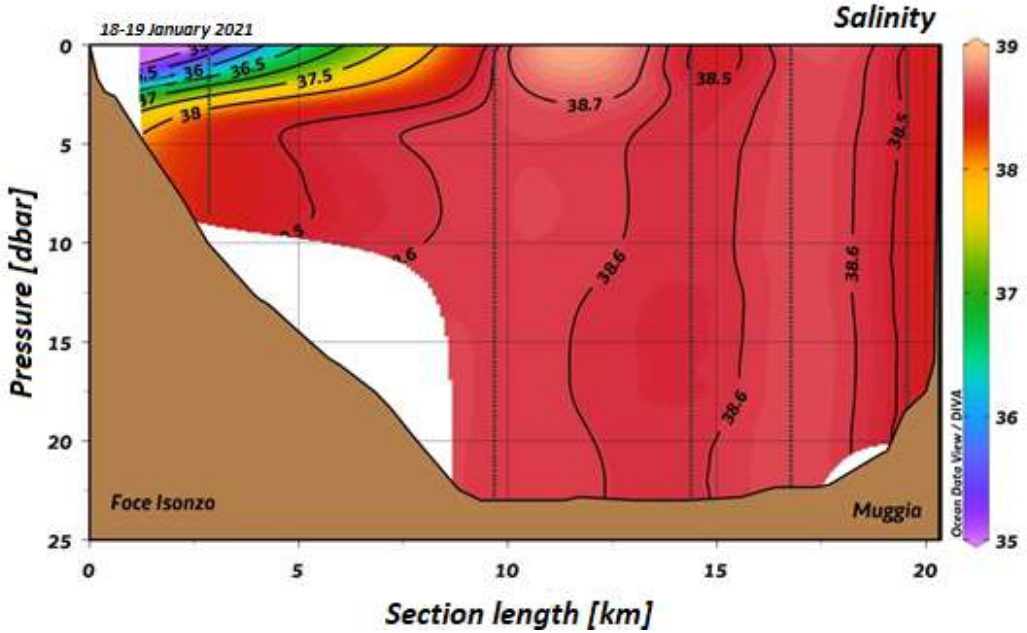

Fig.2 Vertical salinity distribution in the section: Isonzo river's mouth – Muggia. [ref.1]

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The circulation in the Gulf depends on several factors: the difference in density between seawater masses constituting the eastern and western parts of the basin, the action of winds (especially the Bora one) and tides, and the riverine inputs (in particular that of the Isonzo river), which flow into the Gulf, mainly affecting the superficial sea layer.

In general, three layers can be identified: a superficial one (0-5 m deep), whose movement is regulated by the wind field, an intermediate one (5-10 m deep) and one close to the sea bottom. The deepest layer presents a cyclonic circulation (counter clockwise), which is associated with both the difference in density between seawater masses and its connection with the circulation of the middle and lower Adriatic.
The maximum surface currents of 30-40 cm/s flow along the western coast, affecting the shoreline between Grado and Lignano. These currents are associated with both easterly winds and tides. The latter, in sizigial configuration, can increase the sea current to values greater than 1 m/s, in lagoon mouths. The sea breeze moves the surface layer from Grado to Trieste, while the land breeze and the eastern winds reverse this circulation. The Bora wind induces an intense cyclonic circulation, also producing a mechanical and convective mixing of the water column that leads to the partial or total disappearance of the pycnocline, in the summer period. The seawater masses moved by the Bora wind flow out of the Gulf along the western coast. Afterwards, these are replaced by Adriatic water entering the basin from the eastern part of the Gulf (Punta Salvore). These advected water masses are associated with the Eastern Adriatic Current (EAC), which is a sea current that flows along the Istrian-Dalmatian coast and that is characterized by higher temperature and salinity values than those typical of the Gulf. This EAC input dynamic is more frequent in Autumn and Winter.

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The monitoring carried out this January showed, for the water layer between 10 and 20 dbar of depth, the following salinity (Table 1) and temperature (Table 2) values:

Table 1 Average, minimum and maximum salinity, related to the monitoring carried out this January, for the seawater layer between 10 and 20 dbar of depth.

salinity		
average	*minimum*	*maximum*
38.47 ± 0.17	38.23	38.72

Table 2 Average, minimum and maximum temperature (°C), related to the monitoring carried out this January, for the seawater layer between 10 and 20 dbar of depth.

temperature (°C)		
average	*minimum*	*maximum*
10.82 ± 0.58	9.68	12.23

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For the same seawater layer, the historical time series collected in monthly monitoring, carried out in the Gulf from 2014 to 2020, shows the following salinity (Table 3) and temperature (Table 4) values:

Table 3 Average, minimum and maximum salinity, related to the historical time series collected in monthly monitoring, carried out in the Gulf of Trieste from 2014 to 2020.

salinity		
average	*minimum*	*maximum*
37.80 ± 0.39	36.20	38.54

Table 4 Average, minimum and maximum temperature (°C), related to the historical time series collected in monthly monitoring, carried out in the Gulf of Trieste from 2014 to 2020.

temperature (°C)		
average	*minimum*	*maximum*
10.39 ± 1.32	6.45	12.59

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Despite sea temperature does not show a remarkable difference, an increase of **0.67** in the average salinity value is observed. This definitely indicates the advection, in the Gulf, of seawater related to the Eastern Adriatic Current (EAC).

In support of this observation, the Regional Center for Environmental Modeling (CRMA) built, starting from the model data (average daily fields) made available by the *Copernicus Marine Service*, maps depicting sea current streamlines, coloured in relation to the salinity value of the seawater masses involved, and interpolated - logarithmically at 13 and 22 meters of depth. These depths are, approximately, the midpoints of the two sea layers monitored during the oceanographic measurement campaign carried out this January (whose bulletin can be consulted at the following link: http://www.arpa.fvg.it/cms/hp/news/Bollettino-Stato-oceanografico-ecologico-Golfo-Trieste-Gennaio-2021.html).
The aforementioned maps were built for the time period between December 15, 2020 and January 15, 2021, and for a geographical domain that includes the one in which the oceanographic measurement campaign has been carried out. This allowed to reproduce the trajectories and origin of the sea current flows, which affected the monitoring area, before, during and after the measurement of January 12-13.

What emerges from the modelling analysis is that before and during the monitoring, water characterized by low salinity flows southwards along the western Adriatic coast, while the eastern Adriatic coast is - as expected - characterized by a cyclonic flow of rather salty water that is advected within the Gulf of Trieste (Fig. 3, 4, 5).

The maps obtained from the modelling analysis made it possible to confirm what observed during the oceanographic measurement campaign, also providing an overall view of the dynamics of the water masses of the northern Adriatic and highlighting, for this period, the persistence of a well-defined cyclonic gyre positioned north the Po river's mouth. Part of the high salinity waters making up the gyre manages to enter the Gulf through the morpho-bathymetric threshold of the sea bottom, which is located off the town of Piran (Slovenia).

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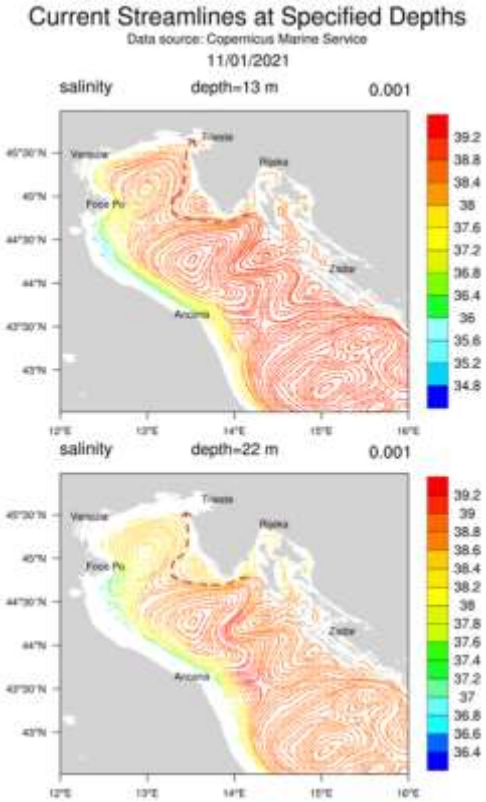

Fig. 3 Sea current streamlines at 13 and 22 m of depth, coloured in relation to the average daily salinity value of the involved seawater masses (date: January 11, 2021). [ref.2]

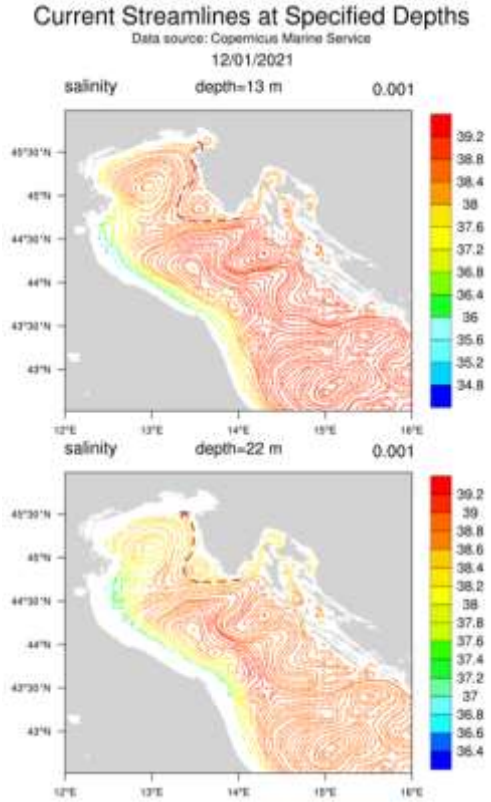

Fig. 4 Sea current streamlines at 13 and 22 m of depth, coloured in relation to the average daily salinity value of the involved seawater masses (date: January 12, 2021). [ref.2]

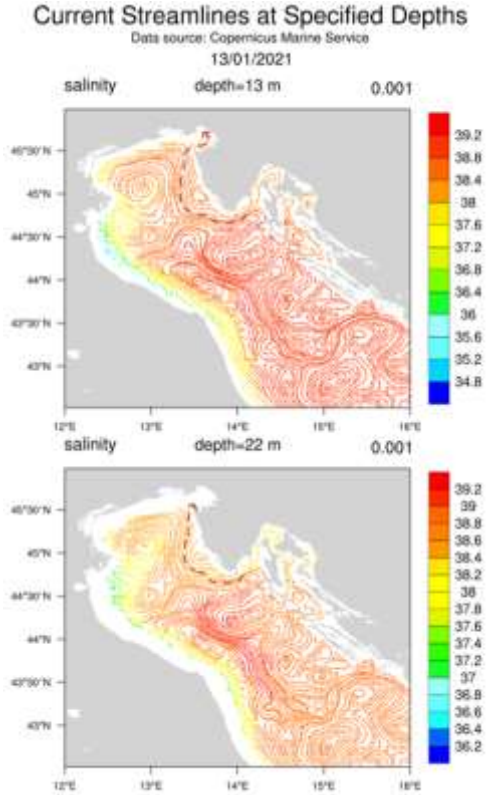

Fig. 5 Sea current streamlines at 13 and 22 m of depth, coloured in relation to the average daily salinity value of the involved seawater masses (date: January 13, 2021) [ref.2].

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