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## Hypothesis on impact of winter conditions on annual organic production in the northern Adriatic

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This study evaluates existing hypothesis according to which intensity of local winter primary production (may be high, influencing annual means), controlled by the degree of the spreading of Po River waters across the northern Adriatic (NAd), reflects on secondary annual production (microzooplankton and anchovy) of the ongoing year.

The analysis extends over a four-year period 2017-2020.

In 2017, in the open western NAd, close to the Po River delta, nutrients and phytoplankton abundances reached their yearly maximum in winter (February and March, respectively). By the end of winter, an anticyclonic gyre formed in the eastern part of the NAd, capturing waters advected from western NAd region. In the gyre area, microzooplankton abundance reached the yearly maximum in spring (June). A month later, at the same position, the abundance of the allochthonous Ctenophora *Mnemiopsis leidyi* that feeds on microzooplankton, along with the concentration of Dissolved Organic matter and its Carbon (DOC) fraction, reached yearly peaks. In the western NAd, within another gyre (cyclonic), maxima in the microzooplankton abundances and DOC were recorded in spring. Results point to importance of winter conditions in yearly production cycle. In line with the existing hypothesis, phytoplankton abundance in winter 2017 was above the long-term average and coupled with extremely high zooplankton abundances and DOC concentrations in some of the following, spring or summer, months. Later, during summer, phytoplankton abundances were rather low.

In 2018 and 2019, the data collected in the NAd were rather scarce. In 2018 no winter data were available to test the hypothesis. In 2019, high abundances of microzooplankton was observed in

March, and later in September an increase in *M. leidyi*, which might indicate that 2019 was again a year rich in organic production.

In 2020, the above average concentrations of nutrients and chlorophyll a in winter occurred along with very high concentrations of DOC and an abundance of *M. leidyi* in summer.

Data collected in 2017, 2019 and 2020 support the hypothesis, pointing to large organic outputs after winters rich in production. Numerical models show that the NAd was mostly “separated” from the rest of the Adriatic Sea during 2017-2020 by a northern branch of a large cyclonic gyre with high salinity water (from central Adriatic and/or Kvarner Bay) entering the NAd along the eastern (Istrian) coast. Such circulation system could favour the Po River waters spreading across the NAd, inducing high primary production in winter, at the beginning of the yearly pelagic cycle, with the retention/accumulation of organic matter produced in the following months.

The NAd basin has been exposed to very high salinity water intrusions since 2015 (CMR data). These occurrences, together with the formations of specific circulation patterns described above, result from regional atmospheric and/or oceanographic processes which are not yet fully understood. However, using projections of temperature and salinity from a numerical approach, and following the observed biological relations, a prediction of the organic matter production in the NAd can be obtained.

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