**Review report**

**Recent abrupt shifts in the Adriatic Sea physical properties and their potential consequences**

The manuscript synthesizes recent evidence of substantial changes in Adriatic Sea thermohaline properties and dynamics, including warming and salinification, the shoaling of saline intermediate-water inflow, increased occurrence of near-surface saline layers, and a proposed transition from predominantly thermally driven to increasingly salinity-supported dense-water formation and cascading. It further discusses potential consequences for sea level, deep-water ventilation, biogeochemistry, regional atmospheric extremes, ecosystems, fisheries, and aquaculture.

The topic is important and timely. The Adriatic Sea is a climatically sensitive marginal sea with unusually long observational records and strong interactions among local atmospheric forcing, freshwater input, Eastern Mediterranean water-mass variability, dense-water formation, and ecosystem functioning. The manuscript reflects strong regional expertise and provides a valuable integration of historical observations, recent studies, and emerging concepts.

The proposed transition toward increasingly haline-supported dense-water formation is particularly interesting and may have significance beyond the Adriatic. The manuscript also appropriately acknowledges limitations associated with historical observations and evolving observing systems.

However, substantial revision is required before several central conclusions can be considered robust. The paper combines a review or perspective with new observational analyses, but the new methods are insufficiently documented. More importantly, the compared datasets differ considerably in temporal length, spatial and seasonal coverage, observing platform, sampling frequency, and vertical resolution. These differences may influence the apparent warming, salinification, shoaling, and especially the reported increase in the occurrence of surface saline layers. The title's reference to "abrupt shifts" also requires formal statistical support.

**I recommend major revision.**

**<u>Major comments:</u>**

**1- Clarify the article type and original contribution**

The manuscript functions simultaneously as a review, perspective, synthesis, and original observational study. Figures 1–3 appear to present new calculations, whereas Figure 4 and much of the discussion synthesize previously published work.

Please state the intended article type and clearly distinguish among:

- New analyses performed specifically for this manuscript;
- Results reproduced or updated from previous publications;

- Findings synthesized from the literature;
- Conceptual hypotheses and proposed consequences.

This distinction is important because the new analyses require sufficient methodological detail for independent reproduction.

**2- Title and "abrupt shift" framing**

The title implies that statistically identifiable abrupt transitions have occurred. However, no formal change-point or regime-shift analysis is presented. Differences between 1950–1999 and 2000–2019 do not by themselves demonstrate an abrupt transition, and a visual increase after 2017 does not establish a statistically significant break.

Please conduct a formal change-point, segmented regression, or regime-shift analysis, including uncertainty in the transition year. Otherwise, revise the title to something more cautious, such as "Recent thermohaline shifts in the Adriatic Sea and their potential consequences."

**3- Abstract**

The Abstract clearly communicates the broad message, but the statement that locally amplified Adriatic rates are several times higher than Mediterranean-wide rates requires a quantitative comparison using equivalent periods, depths, variables, and methods. The Abstract states that rates are quantified, although the manuscript mainly presents differences between period climatologies and values reported in previous publications. Please add a quantitative summary table or revise this wording. The consequences discussed in the manuscript are mostly potential rather than demonstrated effects. This distinction should remain clear in the Abstract.

**4- Data sources and observational coverage**

The description of SeaDataNet, local databases, and Argo is useful, but the manuscript should provide:

- Exact dataset versions and access dates;
- Geographic boundaries of the analysed regions;
- A list of local datasets and cruises included;
- The duplicate-removal procedure;
- Quality-control thresholds;
- The treatment of incomplete profiles;
- The number of profiles by platform, period, season, and depth;
- Identification of the exact Argo profiles used.

The primary climatologies end in 2019, although the manuscript emphasizes the last decade and states that the most rapid changes occurred after 2019. Please consider adding a separate 2020–2025 period or time series at representative stations and depth ranges.

**5- Complete methods for Figures 1–3**

Section 2 does not provide enough information to reproduce the new analyses. Please add a dedicated Methods subsection describing:

- DJ1 and DJ3 geographic boundaries;
- Seasonal definitions;
- Vertical interpolation and depth-bin thickness;
- Treatment of casts that do not reach the full depth;
- Spatial and temporal averaging;
- Whether observations are weighted by measurement, cast, cruise, month, year, or grid cell;
- Potential-density calculation, reference pressure, and equation of state;
- Meaning of the shaded envelopes;
- Uncertainty estimation and statistical tests;
- Surface saline lake detection criteria.

**6- Use the actual analysis periods**

The labels "20th century" and "21st century" may be convenient but are potentially misleading. The analysed periods cover 1950–1999 and 2000–2019 rather than full centuries. Please use the actual date ranges in the figures, captions, Results, and conclusions.

**7- Statistical uncertainty in Figures 1 and 2**

The difference profiles are interpreted as climatic changes, but the manuscript does not establish which differences are statistically distinguishable from sampling variability. Please provide confidence intervals or bootstrap-based uncertainty and indicate statistically robust depth ranges. Define the shaded envelopes in the figure captions and report effective sample sizes at depth.

**8- Southern Adriatic warming, salinification, and LIW/CIW shoaling**

Please distinguish between the first documented occurrence of a surface salinity maximum and its first physical occurrence. Absence from historical observations does not demonstrate that the feature never occurred.

The claimed shoaling of the LIW/CIW core from approximately 200–400 m to 50–150 m should be based on an objective core-depth metric with confidence intervals, rather than on visual comparison alone.

**9- Quantification of rates**

The abstract states that change rates are quantified and exceed Mediterranean-wide rates. A synthesis table would greatly improve the manuscript.

**10- Water density and sea level**

The reported thermosteric expansion of approximately 2.0 cm/yr and halosteric contraction of approximately 1.7 cm/yr are large and require additional context. How much are you sure about these results??

**11- Biological effects, fisheries, and aquaculture**

This section provides useful broader context, but it should clearly distinguish documented Adriatic impacts from projected vulnerabilities. The aquaculture discussion should be linked more directly to the specific thermohaline changes presented earlier rather than to climate change in general.