General comments:

The manuscript has been improved; however, several critical issues remain unaddressed. My main concerns lie with the main current patterns in the Yellow Sea, and the effects of wind and tidal forcing on these patterns. The current version lacks a logical, thorough, and convincing analysis of these dynamics. I therefore recommend a major revision.

We would like to thank the editor and reviewers for their time in evaluating our manuscript. We have addressed all the points raised by the reviewers, particularly those that improve the clarity of the manuscript. In cases where we did not accept a suggestion, we have provided a clear justification. In the following, reviewer comments are shown in **black**; our responses are in **blue**.

Major comments:

1. What made me confused during the revision for the last two version is the main current patterns in the Yellow Sea in summer. After some literature studies, now, I have some understandings. In Figure 1, the authors show only the YSCC, which is corresponding to the southward current in Figure 8a 122.5E–124E. This is the eastern boundary of the Qingdao cold water mass. However, the northeastward current in the Lu'nan coast (seeing figure below) and the northward current in Subei coastal current were not shown in Figure 1 and discussed thoroughly. These two currents are at the western boundary of the Qingdao cold water mass. The listed 3 currents together generate the summer anticyclonic circulation discussed in this work. Besides, the currents shown in the below figure and the Figure 1 in the manuscript are surface currents, however, the authors aimed to analysis the current patterns at near bottom (25 m). First, the authors should prove that the patterns of these 3 current systems are similar at surface and near bottom. This is what I have pointed out in the last revision. However, in the updated manuscript, the authors still didn't provide detailed analysis on it. Secondly, before the discussion on any effects on the current patterns, the authors should identify and label the current systems in their simulations (i.e., label the current system in Figure 8a). Additionally, the current system in Figure 8a should cover the entire computational domain.

After carefully reviewing the reviewer's concern and re-examining both Fig. 1 and the schematic diagram mentioned by the reviewer, we would like to respectfully point out the following two points: (1) all the currents mentioned in Fig.1a in previous manuscript—the North Shandong Coastal current (NSCC), Yellow Sea Coastal Current (YSCC) and Yellow Sea warm current (YSWC)—are not limited to surface currents (depth<10m), giving our model results and previous studies (Xia et al., 2006; Yu et al., 2010). Therefore, the concern that "Besides, the currents shown in the below figure and the Figure 1 in the manuscript are surface currents, however, the authors aimed to analysis the current patterns at near bottom (25 m)" may not be applicable in this case. (2) We would also like to clarify that our study focuses on the seasonal development of the anticyclonic circulation around the Qingdao Cold Water Mass, which intensifies in spring and typically weakens or disappears by June. This seasonal evolution is consistent with previous observational and modeling studies (Qiu et al. 2025; Huang et al., 2019). However, in the reviewer's comment, the discussion seems to mix the spring and summer circulation regimes, particularly in the sentence: "the listed three currents together generate the summer anticyclonic circulation discussed in this work." Given the strong seasonal cycle of the Yellow Sea circulation, it is important to distinguish between spring and summer patterns.

Even though the two points mentioned above may have been misunderstood, we carefully considered the rest of the reviewer's comment and examined the depth-averaged current structure around the Qingdao Cold Water Mass. The results show a similar anticyclonic circulation pattern as presented in Fig. 3. Therefore, we believe that an additional figure is not necessary in the main text. However, we remain open to including it in the supplementary materials if the reviewer considers it is helpful.

In addition, following the reviewer's suggestion, we have added labels for the northeastward current along the Lu'nan coast and the Subei Coastal Current in Fig. 1a. The simulation results confirm the existence of both currents, with directions consistent with those illustrated in the diagram cited by the reviewer. Please note that the northeastward current along the Lu'nan coast is very close to the shoreline and only appears in shallow waters (depth <10 m), which is why it is not visible in Fig. 8 (25 m depth).

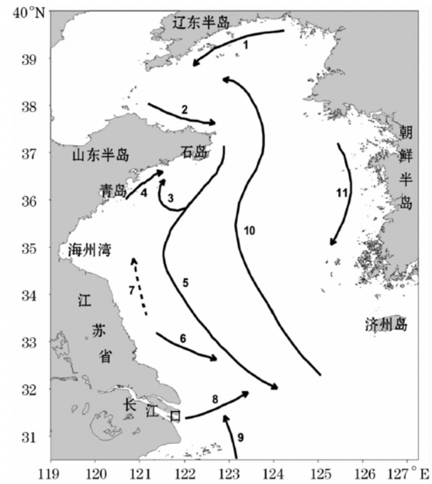

图 1　黄海流系示意图(据文献[6,9,14]重绘)

Fig. 1　Diagram of coastal current systems in the Yellow Sea (Redrawn after references [6,9,14])

1. 辽南沿岸流;2. 鲁北沿岸流;3. 青岛—石岛近海的反气旋中尺度涡旋,青岛冷水团;4. 山东南部沿岸的东北向流动;5. 黄海西部沿岸流;6. 苏北沿岸水;7. 夏季苏北沿岸的北向流动;8. 东北向扩展的长江冲淡水;9. 台湾暖流前缘水;10. 黄海暖流;11. 朝鲜半岛西部沿岸流

1. Liaonan coastal current; 2. Lubei coastal current; 3. Mesoscale anticyclonic eddy in Qingdao-Shidao offshore, Qingdao cold water mass; 4. Northeastward current in Lu′nan coast; 5. Yellow Sea western coastal current; 6. Subei costal current; 7. Northward current in Subei coast in summer; 8. Northward extension of Yangtze River diluted water; 9. Taiwan warm current; 10. Yellow Sea warm current; 11. Korean peninsula western coastal current

Figure from Wei et al., (2011)

Wei, Q., Yu, Z., Ran, X., & Zang, J. (2011). *Characteristics of the Western Coastal Current of the Yellow Sea and Its Impacts on Material Transportation*. Advances in Earth Science, 26(2), 145–156. doi: 10.11867/j.issn.1001-8166.2011.02.0145

2. I am lost during the exploration of the wind and tidal effects on the anticyclonic circulation. Based on my understanding in physical oceanography and my careful revision on this

manuscript, I am providing my points of view on how the wind and tides affects the studied anticyclonic circulation.

Wind effects. As shown in Figure A3 (please show the wind and wind stress patterns over the entire computational domain), surface currents in the west Yellow Sea are northeastward and eastward. There are at least three effects. (1) Waters piles up on the east side leading to barotropic pressure gradient forces pointing westward. Going down into deeper layers, as the existence of the Qingdao cold water mass, the temperature gradient is pointing westward at the west side of the cold water mass, generating a baroclinic pressure gradient force pointing westward. So, at 25 m depth, both barotropic and baroclinic gradient forces are negative, as denoted by Figure 10b-10c (but I think the authors messed up the signs in these plots). Such **local wind effects** on the deep water will generate a northward current. (2) As the waters move offshore, a basin-wide (at least over west of 123E because over this region, depth is shallower in the west than in the east as shown in Figure 1b) upwelling system will be stimulated. This is the results due to Ekman transports. (3) Summer monsoon in the Yellow Sea and East China Sea should be similarly southwesterly (I am not quite sure if it is true in summer 2019). The currents from the southern boundary are highly affect by East China Sea coastal currents, which are highly affected by the same southwesterly monsoon. This is the **remote wind effects**. The authors, however, did not provide any discussion on it.

Ok. For suggestions (1) and (2), we have shown it in the Section 3.5 and Section 4.1. Regarding the remote wind effects (suggestion (3)), we included it in the outlook, since our model domain does not include the East China Sea. Previous studies used a model domain that did not include most of the East China Sea, however, the models were still able to capture the key features of the Qingdao Cold Water Mass and the surrounding circulation, as confirmed by observational data (Huang et al., 2019; Qiu et al., 2025).

Tidal effects. (1) As shown in the Figures 8a-8b, northward coastal currents on the west side of the Qingdao cold water mass are weaken when tides are considered, while the currents (the YSCC) on the east side of the cold water mass turn to northward when tides are turned off. These patterns have been pointed out in the manuscript, which is good. The authors provide discussion on tidal-induced changes in barotropic and baroclinic terms. But what are the specific tidal effects that cause such changes? Residualtidal current? Tidal mixing? Or others? (2) In section 4.1, the authors aimed to discuss the tidal effects on the upwelling. However, discussion on changes in barotropic and baroclinic terms does not answer which tidal processes affect the upwelling system. To my understanding, upwelling systems are compensate current due to the surface water divergence across coastal shelf and the mass balance, but not due to the changes in barotropic and baroclinic conditions at deep layers. Instead, alike the upwelling, the changes in barotropic and baroclinic conditions at deep layers are also the results of changing surface current patterns.

Regarding suggestion (1), the reviewer confirmed our result that the eastside of the anticyclonic circulation turns northward when the tides are turned off. The reversal of the current direction on the east side of the anticyclonic circulation when tides are turned off is linked to the broader-scale Yellow Sea gyre. Unlike the circulation around the Qingdao cold water mass, the tidal effects on the broader-scale Yellow Sea have been studied extensively in previous research (He et al., 2022; Xia et al., 2006). These studies indicate that the strong tidal mixing over the western and central parts of the shelf leads to the formation of a pronounced tidal front. This front induces strong lateral density gradients, which generate currents around the front. Additionally, the residual tidal currents strengthen the cyclonic circulation.

Our model results support this explanation, showing an anticyclonic circulation around the front area in the Yellow Sea (Fig. 8). However, to avoid redundancy with previous publications, we addressed and summarized the effects of tidal mixing and residual currents in section 3.4 (mentioned but not emphasized in the previous version) and focused more on the seasonal anticyclonic circulation around the Qingdao Cold Water Mass, which has not been discussed thoroughly in the literature.

Regarding suggestion (2), contrary to the reviewer's assertion, many studies show that Yellow Sea upwelling is largely tide-driven via baroclinic mechanisms. In particular, Lü et al., (2010) and Sun et al. (2022) demonstrate that strong tidal mixing over sloping topography creates a sharp bottom density front, producing a large cross-front baroclinic pressure gradient that forces an onshore (upwelling) branch of circulation. This "secondary circulation" occurs when the tilted isopycnals at the tidal front induce a pressure gradient near the bottom, drawing deep water upward along the shelf. Numerical simulations confirm that in Yellow Sea tidal-front zones, upwelling is mainly caused by baroclinic processes associated with tidal mixing. Thus, the compensating flow (upwelling) is directly linked to the baroclinic pressure differences generated by tides, not only to the changes of surface current patterns.

The upwelling around the Qingdao Cold Water Mass has not been studied previously. We therefore address the existence of upwelling (lines 310–323, 324–326) and explain it in terms of changes in front intensity (lines 343–354) caused by tidal forcing (lines 355–367). This explanation is consistent with previous research. We also restructured and expanded the explanation to address the reviewer's concerns (lines 361–365).

Detailed comments:

1. Figure 1a. Please provide a reference for this plot. It seems like from this work:

Liu, Shichu, et al. "Interannual variation in winter thermal front to the east of the Shandong Peninsula in the Yellow Sea." Journal of Sea Research 193 (2023): 102370.

Ok, added.

2. Line 176-177. Please show evidence to support the baroclinic effects on the differences in current patterns along vertical direction. If not, please remove this sentence.

We have removed the sentence.

3. The arrows in Figure 5 are hard to see.

We have updated a new high-resolution diagram.

4. Line 195-196. The geostrophic balance is hardly violated in the cold water area (122E-123E, 34.5N-36N), which is shown in Figure 5d and is also mentioned in Line 239.

If I understand correctly, the reviewer would like to address that geostrophic balance is maintained in 122-123$°E$, 34.5-36$°N$. However, this paper we focus on Qingdao cold water mass area, which is outside of 122-123$°E$, 34.5-36$°N$. We reformulated lines 195-196 to clarify our expression.

5. Line 213-214. Should be “between the control and the no-tide experiment (Fig. 6)”

Ok.

6. Line 219. As shown in Figure 8a and 8b, the velocity is greater in the no-tide experiment than in the control ones.

Ok.

7. Line 221. Without tidal forcing east of $122°E$, the magnitude of the barotropic term also increase.

Ok. After reformulating the lines 220-225, this sentence has been deleted in the new version.

8. Line 219-214. I don’t understand what the main conclusion or the main purposes of this paragraph is. I lost here. Please see the major comments 2 for the tidal effects.

It seems that the line numbers (219–214) are not in ascending order. We guess that it maybe refers to lines 219-224. If so, we have tried to conclude the main message of this paragraph in the first sentences.

9. Lines 224-237. Seems that the authors try explain why the YSCC is reversed when tides are off, but I didn’t find the logic of for this paragraph and cannot come up with a clear conclusion.
Let me clarify my confusion.
On line 226-227, the anticlockwise gyre is the one around 124-126E, 34.5-26.5N. It is beyond the studied clockwise circulation around the Qingdao cold water mass.

Line 228-230, the norward current west of 122E is not the compensation currents but the northeastward current in the Lu’nan coast and the northward current in Subei coastal current. Please correct me if I am wrong.

Line 231-233, the “northward flow in the eastern part of the southern Yellow Sea” is around 125E, while the “southward flow in the west portion of the southern Yellow Sea” (or the YSCC) is at around 122-124.5E. Do they have any linkages when you compare them?

All the above changes are the so-called changes in broader-scale Yellow Sea circulation. But they still not answer what tidal processes affect changes in broader-scale circulation, and then affect the YSCC. Although the authors list reasons in 238-245 citing other works. But what the authors get from their simulation are still not well addressed.

Regarding the circulation structure, please see our response to Major Comment 1. We have described what we learned from the cited works in lines 240–250.

10. Line 243, where is the mentioned “basin-scale cyclonic gyre”?

We have added “in the Yellow Sea” after the “basin-scale cyclonic gyre” to make it more clear.

11. Lines 284-289. The analysis conflict with the signs shown in Figure 10.

Corrected.

12. Figure 10. Please double check the signs. For example, the positive (eastward) barotropic term in Figure 10b conflict with the westward barotropic term shown in Figure 5b.

Please refer to our response to Minor Comment 11 above.

13. Section 4.1. Please see the major comment 2 related to the discussion of upwelling. As shown in Figures 11a and 11b, surface currents (0-10 m) are eastward moving waters offshore. I would insist that the authors should focus on the adjustment of basin-scale mass balance rather than on the changes in barotropic and baroclinic terms over a transect or a profile (Figure 12) when linking the tidal effects and the upwelling system.

Please see the reply to major comment 2.

14. Line 345-346. My understanding on oceanic front is that front is determined by horizontal gradients of temperature or salinity or density, but not based on gradient on the x-z panel, especially for the Qingdao cold water mass, which has strong horizontal temperature gradient.

The front (in the horizontal direction) is present in our model results, and tidal forcing influences both its shape and intensity. Evidence of the horizontal temperature front has already been provided in our previous responses to the reviewers' comments. In the current figure, we focus on the x–z section to better illustrate the upwelling structure. However, we are happy to include an additional horizontal temperature plot to show the existence of the front if needed.

15. Line 354. As shown in Figures 12a -12b, the vertical friction is near zeros. So, at this location, pressure gradient forces balance with the Coriolis force, which means that the geostrophic balance is met.

In the previous version of the manuscript, we included a vertical distribution of zonal momentum terms along the 35.5°N profile. From that diagram, it was clear that geostrophic balance is not maintained throughout the entire water column. Reviewer 3 agreed with this conclusion after reviewing the figure. However, in the last round, Reviewer 3 suggested deleting the diagram to avoid redundancy. This comment seems to contradict the earlier feedback. To clarify: although geostrophic balance holds approximately at about 15 m depth in a 25 m water column, it breaks down in the deeper layers due to friction. Therefore, conditions at 15 m (the middle layer) cannot represent the full vertical momentum distribution.

16. Figure 12. Why do you show the momentum at depth=15 m when the rest of the analysis is based on the currents pattern on depth =25m?

This is because Fig. 12 describes the momentum balance around the upwelling region, where the maximum upwelling occurs at approximately 15 m depth. The rest of the analysis addresses different scientific questions—specifically, whether the geostrophic balance is maintained around the Qingdao Cold Water Mass, and the respective influences of tidal and wind forcings on the seasonal anticyclonic circulation in that region.

17. Lines 374-375. Distinguish instead of extinct? This is an incomplete sentence.

Corrected.

18. Line 381-382. As I observed on Figures 13-14, 51.29% is for no-tide conditions, while 89.68% for no-wind conditions. Also, rounding to integer is enough.

Corrected.

19. Figure 13-14, are they for depth=25 m? Please update the captions.

Ok.

20. Lines 424-426. The geostrophic balance maintains over the cold water mass.

This comment contradicts Reviewer 3's remarks from previous rounds. As discussed during the previous two rounds of revisions with Reviewer 3, the geostrophic balance does not hold over the Cold Water Mass, and Reviewer 3 agreed with this conclusion. We also deleted part of the geostrophic balance analysis as suggested by Reviewer 3. Additionally, our results on the geostrophic balance show that, around the Qingdao Cold Water Mass, the geostrophic balance is not maintained.