Summary

This manuscript describes the impacts of marine heatwaves on different regions of the Salish Sea. It examines the relationships between the Northeast Pacific marine heatwave (NEP-MHV; 2014–2017) and larger-scale climate signals such as the SOI and the NPGO. The study investigates the effects of temperature anomalies during these heatwave events on regional ecosystems, highlighting cascading effects across different phytoplankton and zooplankton groups. The results show that both the drivers of these perturbations and their ecological impacts vary among regions. The study combines modeling and observations, a comprehensive and relevant approach that supports the validity of the SalishSeaCast model, which performs well when compared with observations.

Overall, this work contributes meaningfully to our understanding of ecosystem perturbations associated with extreme climate events, an issue of growing importance as marine heatwaves are becoming more frequent and intense under ongoing global warming.

My main concern with the manuscript relates to the interpretation of the results. The processes underlying the contrasted responses observed across regions are complex but crucial to understand and to highlight. In its current form, these processes are not sufficiently interpreted or discussed, and the manuscript would benefit from a more thorough discussion of the mechanisms behind the observed patterns. The manuscript is well structured, clearly written, and highly relevant to the scope of the journal, provided that the following comments are addressed.

General comments

The manuscript does not include a dedicated Discussion section; elements of discussion are integrated in the Results section. However, interpretation of the impacts of the different marine heatwaves on biogeochemistry and lower trophic levels should be addressed in a dedicated section. It is essential to discuss the processes linking large-scale climate signals and local MHWs, as well as the relationships between temperature and nitrate anomalies and phytoplankton and zooplankton responses, including differences among the functional groups or the model.

The Discussion should address the following specific points:

- Why are temperature anomalies in different regions more strongly correlated with certain large-scale climate signals than others (SOI, NPGO). The manuscript would benefit from presenting hypotheses, supported by relevant literature, to interpret these correlations.

- For both sites (JdF and SoG), the manuscript should explain the cascading processes by which temperature and nitrate anomalies propagate through the food web, from phytoplankton to zooplankton, and discuss why/how these pathways differ between sites.

- Interpretation and discussion of the zooplankton results presented in Section 3.3.2 (see related comment below).

Specific comments

Section 2.2 Study Period

- Throughout the manuscript, you refer to extended time periods associated with well-known large-scale climate signals, such as the NEP-MHV (2014–2017), SOI and El Niño events (e.g., 2010, 2015), and NPGO years (post-2014). However, these periods are described using different expressions, which may be confusing for the reader (e.g., L246: "*post-2014 period (i.e., during negative or warm-phase NPGO years)";* L382, L453: "*negative NPGO years*"; L565: "*NPGO negative (warm) years*").
  To improve clarity and consistency, it would be helpful to explicitly describe these climate events when they are first introduced in section 2.2, and to define a clear terminology that is then used throughout the manuscript. This approach is already well implemented for the NEP-MHV period (L103), and a similar treatment for the other climate signals would greatly enhance readability. For example: *"Monthly values for the NPGO index indicated a shift to the negative (warm) phase in October 2013 (Fig. 2). Hereafter, we refer to the post-2014 period as the 'negative NPGO years'."*

- In several sections, key statements are supported almost exclusively by self-citations and are not sufficiently placed within the broader literature. For instance, in Section 2.2 (L108–108), relationships between NPGO/SOI and physical and biological conditions in the Salish Sea are referenced primarily through the authors' previous work, and in Section 3.1 (L274), relationships between temperature and large-scale climate indices in the Strait of Georgia are supported in a similar way. While these references are clearly relevant, including additional independent studies would strengthen the manuscript by better situating the results within the broader scientific context.

Section 2.3 SalishSeaCast Model

- L152: *"Functional light dependence was switched to a potential energy curve but tuned to match the old response closely"*.
  What do you mean by *"tuned"*? Please elaborate.

- L174-187: Could you briefly describe the trophic interactions among the different model components (diatoms, nanophytoplankton, Z1, Z2)? This information would be useful for interpreting the cascading effects observed during marine heatwaves.

Section 2.4 Model Data

- L195: "*We focus our discussion mainly on the surface (0-50m) as this depth layer is most relevant to both phytoplankton and zooplankton.*", and L202: "*Model output for phytoplankton (diatoms and nanoflagellates) and zooplankton (Z1 and Z2) biomass were depth-averaged over the 0-50 m depth range to capture the full extent of the euphotic zone across regions (mmol N m-3)"*.
  The manuscript would benefit from including information on the vertical structure and migratory behavior of zooplankton in the different regions of the Salish Sea. First, this would support the assumption that a 0–50 m layer is appropriate for representing zooplankton. In addition, such information would be valuable for interpreting the results on the impacts of marine heatwaves on lower trophic levels (cf. my comment on Section 3.3.2).

- L204: "*the extent to which temperature dependence and light/nutrient limitation was limiting to growth was calculated based on the phototrophic growth rate equations in the model*".
  Could you please elaborate on the methodology of this diagnostic?

Section 3.1.1 Temperature

- L271: "*indicating a longer-term warming signal than **can** be explained by the NEP-MHW alone".* Can or can't ?

- L275: "*In contrast, surface temperature anomalies in the JdF region were significantly correlated to the SOI ($r = -0.44$, $p < 0.001$), but not to the NPGO ($r = -0.11$, $p = 0.12$; Table 1).*" Could you provide an interpretation of this result, or propose hypotheses to explain it? See the general comment regarding the need for a dedicated Discussion section.

Section 3.3.1. Phytoplankton

- L411: "*slightly less light limitation*".
  Please consider providing a metric or quantitative indicator to better support the interpretation of Figure 9. Moreover, why was this analysis/diagnostic performed only for diatoms? Applying a similar diagnostic to all four model components (diatoms, Z1, Z2) would help to interpret the processes underlying the variation patterns observed across the different trophic levels studied.

- L426: "*Also evident was that diatoms during the post-2014 period (i.e., during negative or warm-phase NPGO years) peaked earlier, and for shorter durations, before switching to nanoflagellate dominance compared to the 2007 to 2014 period (Fig. 8b, Supp. Fig. S6a).* »
  Unclear, please clarify or rephrase. In particular, what is meant by *"peaked earlier"*, earlier relative to what?

Section 3.3.2. Zooplankton

- In the JdF region, the marine heatwave has been described as being linked to the NEP-MHV and SOI, with the end of positive temperature anomalies and negative nitrate anomalies around 2020. From 2020 to 2022, negative temperature anomalies reappear, along with positive nitrate anomalies. A similar shift is observed for both nanophytoplankton and diatoms, with predominantly negative anomalies over the 2020–2022 period. Consequently, negative anomalies are also observed for Z1, but we do not observe the same response of Z2 (except for a peak in 2022). How can these contrasting responses between Z1 and Z2 be explained?
  More generally, providing information and relevant literature on the trophic structure and/or taxonomic composition in the different regions studied would greatly help to interpret these results. In particular, differences between the SoG and JdF sites, as well as communities' changes across the different periods within each site, should be discussed. Overall, this part of the results would benefit from being accompanied by interpretation in the Discussion section.

Section 3.3.4. Model and Observation Comparisons

- L467*: "model zooplankton (Z1 and Z2 combined) values were always within the range of observed values".*
  Figure 10c shows that the model does not capture the maximum observed zooplankton values. Please clarify.

- L470: *"Both model nitrate and chlorophyll a showed better agreement with the observed values in the Central SoG"*.
  Computing a comparison metric, such as the RMSE, for all variables in the observation–model comparison would help support this statement. This is not obvious for chlorophyll-a

- L486: Please reconsider the scale of Figure 11c, using a range of approximately 0–300 mg C m^{-3}. This range differs from the zooplankton values at JdF shown in Figure 10c; this difference can be noted in the figure legend.

- L507*: "(F(2, 13) = 4.59, p < 0.05)"*.
  Please provide more details about this metric, either here when it is first mentioned or in the Materials and Methods section.

- L528: "*while the results presented here show similar patterns between model and observation data for certain parameters, these results varied depending on the depth ranges considered."*
  The analysis underlying this statement should be clarified, with an explicit reference to the supporting figure or table.

- Figures 12 and 13: Calculating this p-value over the periods pairwise (i.e., pre-NEP-MHW vs. NEP-MHW, and NEP-MHW vs. post-NEP-MHW) would have allowed quantification of the shifts between regimes. It is possible that in cases where the p-values over the entire period are not significant, a pairwise-period-specific p-value corresponding to a regime shift could have been significant.

Minor comments

- L47: The acronym SST (sea surface temperature) is defined later in the manuscript (L114). Please define it at its first occurrence (L47).
- L86: Please correct "JDF" to "JdF."
- L100: In the legend of Figure 1, a punctuation mark is missing between "boxes" and "Bathymetry." Please revise accordingly (i.e., "blue boxes. Bathymetry").
- L109: Punctuation "Suchy et al. ,2022 »
- You may use the acronym NEP-MHV that you previously introduced in the figure legends instead of spelling out "the Northeast Pacific marine heatwave" (e.g., L120: Figure 2; L256: Figure 3; L336: Figure 6), for consistency with the terminology used in the main text.
- L414: Fig. 9b, not 9c.