Dear Editor and reviewer,

Thank you for allowing us to submit a revised version of our manuscript entitled: “Marine heatwaves deeply alter marine food web structure and function”. Below, we provided a detailed response regarding the concerns of the reviewers and we listed the improvements made to the manuscript.

These changes will be included in the revised version of the manuscript.

Notably, we follow the guidance from the reviewers to expand the introduction and improve the discussion of our study’s findings.

Sincerely,

Vianney GUIBOURD DE LUZINAIS on behalf of the coauthors,

NB: the text in blue indicates the proposed modifications to the manuscript.

Reviewer 1 :

Comment to the authors:	**Responses to comments**
General comments This article describes the application of an ecosystem dynamics model to a global sea temperature and NPP dataset to assess the occurrence of marine heatwaves and model the impacts of these heatwaves on ecosystems. The article is concisely written and coherent overall, though there are minor grammatical errors throughout that should be amended to improve the readability and flow of the article. There are also a couple of errors with figure captioning and formatting. Some sections within the introduction and discussion could be further expanded, as described below.	Dear RC1, thank you for your positive general comment on the manuscript. Through the revised manuscript, grammatical errors will be amended as the figures' captioning and formatting. We agree with your opinion about the introduction and discussion, and we will expand some of the sections as proposed.
Specific comments	
Comment1: The abstract is effective.	Thank you very much for your comment.
Comment2: The introduction section is quite short, and could be expanded with more examples and some deeper explanations, but provides a concise and generally effective overview of the topic. In general, it would be helpful to give more information about why MHWs have such sizable ecological consequences. For example, you could discuss why changes in temperature cause stress and how organisms respond to this (see DOI: 10.1126/science.1163156), as well as the fact	Thank you for the insights, we will integer these aspects in the introduction from line 41 in a new paragraph and propose the following: “Marine ectotherms' physiological functions are directly affected by ocean temperature changes that are closely related to their body temperature (Pörtner et Farrell, 2008, Guibourd de Luzinais et al., 2024). These species are adapted to perform optimally at a range of body temperature, with certain upper and lower temperature limits within which they can survive (Pörtner et Farrell,

that temperatures may be more likely to exceed critical thresholds during MHWs (see DOI: 10.1016/j.tree.2021.09.003).	2008). When environmental temperatures exceed this temperature range, e.g., during MHWs, the organism is stressed, leading to functional constraints and declines in performance (Pörtner et Farrell, 2008). Particularly, abnormally high temperatures during MHWs often exceed organisms' thermal limits, impacting their distribution, growth and survival (Smale et al., 2019; Smith et al., 2023, Guibourd de Luzinais et al., 2024). Moreover, impacts of MHWs at population level have cascading effects at community and ecosystems level. For example, MHW-induced declines in phytoplankton biomass and diversity have led to significant changes in zooplankton and other marine invertebrate diversity and biomass (Cavole et al., 2016). MHWs cause coral bleaching that also impacts coral reef ecosystems (Garrabou et al., 2009, 2022; Pearce et al., 2011). Range shifts driven by MHWs result in "tropicalization" of fish communities (Wernberg et al., 2016). Ultimately, MHWs imply mass mortality of fish and invertebrates modifying ecosystem functioning (Cannell et al., 2019; Cavole et al., 2016; Collins et al., 2019). However, these ecological impacts of MHWs are not ubiquitous and vary largely between MHW events, species and ecosystems (Fredston et al., 2023; Oliver et al., 2021; Pershing et al., 2018; Smale et al., 2019; Smith et al., 2023).".
Comment3: The Material and Method and Results sections are generally well-written. See below for grammatical corrections.	Thank you, we will check and correct grammatical errors.
Comment4: Figure 3 - the caption needs to be more specific about what each panel represents. For Figure 3a, the caption should specify how the spatial extent of MHWs was defined. Is this the percentage of the oceans' total surface area that experienced a MHW during each year? Or the average spatial extent of each individual MHW event? The figure keys state that Figure 3c depicts the average number of MHW days in each cell and Figure 3d depicts the average intensity of MHWs, but the figure caption states the opposite. It is also unclear whether Figure 3c depicts the average duration of each individual MHW event in days, or the total number of MHW days per year in each cell.	We acknowledge the paragraph corresponding to fig 3 and fig 3 caption needs to be clarified. We propose these modifications: For the figure: Fig 3C legend ~~"Average of MHW days"~~ "Average MHWs duration in days" Caption: "**Figure 3: Temporal and spatial characteristics of MHWs identified for the period 1998 to 2021.** (a) Changes in the percentage of the oceans' total surface area with MHW in each year categorised by their intensity, (b) Changes in MHWs averaged duration categorised by their intensity, and (c) Average duration of each MHW event in days that occurred over the period 2015-2021. (d) Average intensity of each MHW event over the period 2015-2021."

	For the paragraph "Under the 'with MHWs' scenario, MHWs occurring during the year's warmest month increased in intensity, duration, and surface extent from 1998 to 2021 (Figures 3a, b) with large spatial variability (Figures 3c, d). MHWs with intensity lower than 3°C above the climatology were identified on average in 28.5 % of the ocean surface (Figures 3a). These MHWs lasted, on average, more than 40 days (Figures 3b). In contrast, MHWs characterised as higher intensity (≥3°C above climatology) were identified in <20% of the ocean surface area (Figures 3a). These relatively more intensive MHWs lasted, on average, 32 days (Figures 3b). Furthermore, more MHW days of lower intensity were identified for low latitude regions (23°N - 6°S) (Figure 3c, 3d) compared to MHW days identified in higher latitude regions (> 23°N and 25°S). ~~In addition, the intensity of MHWs was higher in higher latitude regions in the northern hemisphere relative to those in the southern hemisphere (Figure 3d).~~"
Comment5: The discussion is generally well-written and explains the findings and implications of this work with an appropriate level of detail. It would be interesting to include some recommendations for future development and use of the EcoTroph-Dyn model. For example, do you think the model could be used to predict the impacts of hypothetical future MHWs at global and local scales, and how much caution should be used when interpreting these findings?	Yes, EcoTroph-Dyn model can be used to project the impacts of MHWs at global and local scales under future scenarios. We propose to add this idea from line 705: "The EcoTroph Dyn model is a tool to understand the ecological consequences of MHWs at global and local scales, and to project their impacts under future scenarios. However, the model focuses on aggregated energy flows between trophic groups while ecological responses to MHWs between species within each group may vary substantially. Some species may acclimatize or adapt to MHWs. Consideration of the potential acclimatization/adaptation in the model requires the development of specific adaptation scenarios and model settings in addition to the model settings presented here.".
Comment6: Line 622 - do you have any ideas of why the model might have underestimated ecosystem responses to MHWs? Do you have any recommendations for how people using this model could account for this uncertainty?	Yes, the choice of the parameter values forα (representing marine communities' resistance capacity to MHW) strongly affect the sensitivity of the simulated ecosystem responses to MHWs. In this study, we used a range of α values (0.2, 0.5, and 1) and showed that an α value of 0.2 underestimates ecosystem response to 'the Blob" MHW, while an α value of 0.5 overestimates ecosystem response. To account for this uncertainty, we recommend that future study can calibrate α values for each ocean regions/ marine ecosystems based of

	historical MHWs impacts on marine ecosystems' biomass. We propose to add after line 622, "The underestimation of ecological responses to MHWs is likely caused by the choice of a lower α value that lowers the sensitivity of the ecosystem to MHWs. To reduce the uncertainty over the α value, future studies could calibrate it for specific region using observational data of MHWs impacts on marine ecosystems' biomass."
Comment7: Line 676 - Do you think it would be possible to design a species-specific or ecosystem-specific version of the EcoTroph-Dyn model that could more precisely predict the impacts of MHWs on specified regions or ecosystem types?	The power of the EcoTroph-Dyn model lies in its ability to represent the functioning of ecosystems in a general way at the trophic level scale. As mentioned in this paragraph, in order to obtain more accurate projections of the response of specific species or ecosystems, the use of more complex models operating at the species level and/or integrating more fully the physical changes in the environment during MHWs with the inclusion of other environmental variables such as O^2, salinity and pH would be necessary.
Comment8: Line 681 - Dismiss any possibility of what?	The sentence should be rewritten as "To be cautious, we considered various loss rate scenarios to obtain a complete range of responses from marine ecosystems."
Comment9: The conclusion section is very short. It might be useful to include a brief summary of your findings regarding the accuracy of the EcoTroph-Dyn when model compared to real-world data from 'the Blob'.	We agree and will include a brief summary of our findings regarding the accuracy of the EcoTroph-Dyn when the model is compared to real-world data from 'the Blob' into the conclusion. We propose this new conclusion: "Utilising the EcoTroph-Dyn trophodynamic framework for MHWs, we highlighted substantial and latent repercussions of MHWs, notably biomass loss and biomass flow alteration, which are particularly consequential for higher TLs. As a result, the recovery/restoration time can extend over several years, if not decades. EcoTroph-Dyn model demonstrates its capacity to characterize the impacts of MHWs on ecosystem structure and functions, with a slight underestimation of the magnitude of the impacts when the model is applied to examine 'the Blob' MHW. However, considering the dynamics and characteristics of current and future MHWs, it can be anticipated that ecosystems might not be afforded the necessary temporal window to recover between successive MHW events, which can significantly

	disrupt long-term trends associated with climate change.”
Comment10: Technical and grammatical corrections	Thank you for pointing out these grammatical corrections line by line and issues with the figures captions/ format. We will address them through the revised version of the manuscript.
Line 11-12 - This sentence mixes present and past tense in a way that doesn’t completely make sense; “have become longer” might sound better. ● Line 46 - Verb tenses are inconsistent; “are not ubiquitous and have varied largely” would sound more consistent. Additionally, it could be informative to provide more specific details about how ecological impacts have varied between different MHW events. ● Line 69 - This sentence begins with “I used” while the rest of this paragraph uses “We” - it would be better to change this to “We used” for consistency. ● Line 70 - There are two opening brackets in this sentence, but only one is needed. Also, MHWs rather than MHW. ● Line 90 - “the total biomass of all consumers” is clearer than “whole consumers biomass” ● Line 94-95 - The list of examples should be enclosed in brackets. ● Line 118 - “each TL class”.	

• Line 130 - “represents” rather than “representing” • Line 222 - “MHWs last” or “MHW conditions last” • Line 225 - “is a hybrid model” • Line 267 - “large spatial variability was observed in NPP changes” is grammatically clearer • Line 403 - this line should use the ≥ (greater than or equal to) symbol • Line 426 - “the ‘without MHW’ scenario” • Line 430 - “the ‘with MHWs’ scenario” • Line 470 - “congruent with the findings of…” would be grammatically clearer • Line 471 - “ecosystem functions” • Line 473 - “ecosystem perturbations” • Line 476 - “the intensity and duration of MHWs have continuously increased” • Line 482-483 - “high TL biomass experienced greater impacts from MHWs, and was not able to recover to pre-perturbation levels as effectively as the low and medium TL biomass” • Line 585-587 - This sentence is unclear - I assume that what you mean is “the MHW was associated with a substantial	

increase in the abundance of pyrosomes limiting/stopping energy flow moving toward higher trophic levels (Gomes et al., 2024).", but the grammatical structure of the sentence as written makes it somewhat difficult to follow. ● Figure 9 - the category labels on the X-axis are not vertically aligned with the violin plots.	