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 are now included in the revised version of the manuscript.

Notably, we followed 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 modifications made to the manuscript. I indicated the line numbers of the Revised Manuscript with the Track Changes version.

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 have been amended as the figures' captioning and formatting. We agree with your opinion about the introduction and discussion, and we have expanded 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	Thank you for the insights, we have included these aspects in the introduction from line 45 in a new paragraph as 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

how organisms respond to this (see DOI: 10.1126/science.1163156), as well as the fact that temperatures may be more likely to exceed critical thresholds during MHWs (see DOI: 10.1016/j.tree.2021.09.003).	certain upper and lower temperature limits within which they can survive (Pörtner et Farrell, 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 have checked and corrected the 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.	Thank you, we have revised the figure caption and the paragraph in the manuscript as follows: 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 (line438-445) "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 have incorporated this idea from line 810: "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 for α (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 have added these sentences (lines 698-701) to discuss these points: "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?	We have rewritten the sentence as follows (line 781) "To be cautious, we considered various loss rate scenarios to obtain a complete range of responses from marine ecosystems." to enhance clarity
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 have included 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 have rewritten the conclusion as follows: "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 have addressed 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.	

Reviewer 2 :

Comment to the authors:	**Responses to comments**
Summary In this research article, the authors performed global hindcast simulations with the EcoTroph-Dyn numerical model to estimate the distinct impacts of marine heat waves (MHWs) on the trophodynamics of marine ecosystems. They found that MHWs generally lead to a decrease in biomass, with the decrease being stronger and longer lasting for higher trophic levels. They conclude that in the future, ecosystems may not be able to recover between successive MHW events, which may disrupt trends associated with long-term climate change.	
General comments Overall, the manuscript is coherently written and provides novel insights into an important and timely topic. However, the introduction is quite short and should be expanded to provide a better overview and deeper understanding of the topic (see specific comments). Several minor	Dear RC2, thank you for your positive general comment on the manuscript: Through the revised manuscript, grammatical errors have been amended. We agree with your opinion about the introduction, and we have expanded some of the sections as proposed. Furthermore, we have clarified the minor points in the

points should also be added or clarified in the Material and Methods, Results, and Discussion sections, which are nevertheless well written and understandable. The conclusions are quite short but precise; however, I think it should at least be specified which repercussions of MHWs were identified in the current study.	Material and Methods, Results, and Discussion sections.
Linguistically, the manuscript contains some minor grammatical, typographical, and formatting issues, especially in the references, that need to be addressed. I have listed the issues I found in "Technical corrections" and also made some suggestions to improve clarity and readability.	Thank you very much for pointing out these issues; we have addressed them in the revised manuscript.
Specific comments	
Comment1: L. 33-48: A clear, quantitative definition of heatwaves would help this paragraph, especially since you give quantitative changes in heatwave duration, frequency etc.	Thank you for the suggestion. We have specified the definition of MHW on line 34 as follows "Over the last century, marine heatwaves (MHWs) - defined as more than 5 days period of anomalously warm sea surface temperatures (SSTs) exceeding a specific threshold, typically determined by natural climatological variations - have increased in frequency, duration, and intensity (Frölicher et al., 2018; Hobday et al., 2016)."
Comment2: L. 49-60: This paragraph should introduce more MHW-related ecosystem modeling studies to put the current study into a broader context. Specifically, it should be made clear to the reader what has been done already and what is new about the current study. I would also recommend to place this paragraph before the last paragraph of the introduction (i.e., between l. 66 and l. 67) to create a nice transition to the description of the current study.	We agree, moving this paragraph before the last paragraph of the introduction is better for transition. We also have added, from line 71, more MHW-related ecosystem modelling studies to put the current study into a broader context. "Previous studies assessed MHWs impacts through numerical modelling approaches. For example, Cheung et al., (2021) and Cheung & Frölicher, (2020) employed climate-fish-fisheries models to investigate MHW implications for biomass and potential catches of exploited marine species and their implication for fisheries. They found that MHWs may cause biomass decreases and shifts in the biogeography of fish stocks that are faster and bigger in magnitude than the effects of decadal-scale mean changes. They projected a doubling of impact levels by 2050 amongst the most important fisheries species over previous assessments that focus only on long-term climate change. Gomes et al. (2024) use the Ecopath with Ecosim (EwE) modelling approach to assess the ecological impacts of 'the Blob' MHW. They highlighted the alteration of trophic interactions and energy flux following the MHWs

	which might have profound consequences for the specific ecosystem structure and function. However, there is a gap in applying ecosystem modelling framework to study global impacts of MHWs on ecosystem structure and functions.
Comment3: L. 51-52: It is not clear which method(s) Carneiro et al. used.	We have rewritten this part (line 67) to enhance clarity as follows : "For example, Carneiro et al., (2020) assessed the evolution of physiological and biochemical parameters and survival rates of the clam *Anomalocardia flexuosa* in response to simulated MHWs. Under laboratory conditions, *Anomalocardia flexuosa* was allowed to adapt to a stable control condition before being exposed to simulated conditions of MHWs occurrence lasting up to 21 days by warming the tank water by 3°C above the control temperature."
Comment4: L. 62-63: Could you elaborate on this further and explain the processes behind?	We have elaborated on this part (from line 84) as follows: "Trophic dynamics of marine ecosystems are affected by ocean temperature (Eddy et al., 2021; du Pontavice et al., 2019). In particular, ocean warming is expected to increase the speed of energy transfer through the food web, i.e., flow kinetic (du Pontavice et al., 2020). Faster flow kinetic under ocean warming represents the increasing dominance of short-lived species so that each unit of biomass spends less time at a given TL and, on average, across all TLs, ultimately leading to a decrease in total biomass (Gascuel et al., 2008). Simultaneously, ocean warming is expected to induce a decrease in biomass transfer efficiency, altering both consumer production and biomass due to larger energy losses between each TL (du Pontavice et al., 2019). Therefore, ocean warming alters both the amount and speed of matter and energy transfer within the food web, potentially leading to a decline in consumer biomass through independent and cumulative effects (du Pontavice et al., 2021; Guibourd de Luzinais et al., 2023)."
Comment5: L. 78: I would leave out "proceeding their occurrences", it makes the sentence difficult to understand.	Yes, we agree, we have removed this part of the sentence.
Comment6: L. 89: Is there a specific reason for using TL width = 0.1?	Previous studies applying EcoTroph employed a TL width of 0.1, primarily because of computational efficiency while maintaining a good representation of food web structure and functions. We have mentioned this in the revised manuscript (from line 119) as follows: "Practically, each biomass trophic spectrum with

	TL above 1 is split into small trophic classes bounded by pre-defined lower and upper trophic levels (with conventionally TL width = 0.1 - primarily because of computational efficiency while maintaining a good representation of food web structure and functions - in the steady-state version of EcoTroph."
Comment7: L. 92-93: Why is the biomass transfer in lower TLs faster?	It is due to the shorter life expectancy from low TL individuals. We have modified the sentence as follows (see lines 126-127): "The time needed for the biomass to flow from one to the next trophic class varies along the food chain, with biomass transfers generally faster in lower TLs (as species generally have short life-expectancy) than in the higher ones.".
Comment8: L. 97: biomass flows between(?) the trophic biomass spectra	No, the correct term is "in" and not "between" as with EcoTroph-Dyn, we analyse biomass flow changes in each trophic biomass spectrum. By "each trophic biomass spectrum," we refer to the trophic biomass spectrum represented in each 1° × 1° longitude-latitude ocean cell.
Comment9: L. 118: I don't understand what you mean by "the trophic level of each TL classes j.". Do you mean the trophic level of the j TL class?	Yes, we meant that, we have modified the sentence in the revised manuscript (see line 157).
Comment10: L. 119-120: Is this assumption based on observations/experiments? Give appropriate references.	We have modified the sentence as follows (line 158): "MHWs cause marine organism mortality, impacting their life expectancy (Smith et al., 2023). In EcoTroph-Dyn, these changes in life expectancy are reflected in the loss rate within the biomass spectrum, representing the proportion of biomass that neither persists nor progresses through the food web (du Pontavice et al., 2021; Gascuel et al., 2008, Guibourd de Luzinais et al., 2024). Therefore, according to equations used in the steady-state version of EcoTroph, the flow kinetics during MHWs is increased as follows:"
Comment11: L. 125-126: "Biomass spectra in EcoTroph-Dyn are split into trophic classes with variable widths of trophic levels." – I don't really understand this sentence. Do you mean: "Biomass spectra in EcoTroph-Dyn are split into trophic classes of variable width."?	Yes, we meant that, we have modified the sentence in the revised manuscript (see line 167).
Comment12: L. 164-165: "lasting 15 days of the fortnight" − something must be wrong here.	Sorry it's a misuse of language. We ran the EcoTroph-Dyn model at a half month time step, and the expression seems to be a fortnight? We define a fortnight for our study as 1/24 of a year in line 219. To avoid confusion, we have changed

	the term “fortnight” to “15 days” throughout the manuscript.
Comment13: L. 168: I don’t understand this sentence. Do you mean: “We used an alpha of 0.2 in our simulations.”?	Yes, we meant that, we have modified the sentence in the revised manuscript (line 213).
Comment14: Figure 1: How do you derive transfer efficiency, MHW mortality, and flow kinetic from satellite data?	To derive transfer efficiency, MHW mortality, and flow kinetic from satellite data, we used empirical equations where satellite data (SST) intervenes
Comment15: L. 193-194: Why did you use a single threshold and not one for each month, for example? Which impact may the use of only one threshold have on your results?	The objective of the study was to assess the impact of MHWs, to do so we preferably detect the ones where species are undergoing a thermal stress which occurs mostly during summer period. We have clarified the framework of the study by defining MHWs in the introduction as follows (see line 99): “This study aimed to disentangle the additional or synergistic consequences of MHWs occurring during the year's warmest month, when species are undergoing a thermal stress, with the effects of the slow-onset climate changes in marine ecosystems.” Furthermore, we have incorporated the following paragraph after line 735 in the discussion. “Here, we focused solely on the direct impacts of MHWs occurring during the year's warmest month via thermal stress, resulting in species mortality (Oliver et al., 2021; Smith et al., 2023). However, MHWs in other seasons can also have consequences on populations by affecting a specific stage of the life cycle of certain species (Crickenberger & Wethey, 2018; Oliver et al., 2021; Smith & Thatje, 2013). For example, MHWs that stress adult breeders can lead to a decrease in reproductive investment and, consequently, fewer, smaller, and lower quality gametes (e.g., Shanks et al., 2020), resulting in a loss of abundance and biomass of some species (Johansen et al., 2021). While taking seasonality into account will increase the number of detected extreme events, some may not have ecological consequences (Oliver et al., 2021; Smith et al., 2023). Thus, our approach can be seen as conservative and may underestimate the impact of MHWs. Nevertheless, we detected MHWs with potentially significant ecological impacts. Studying MHWs occurring in seasons other than summer would involve considering the phenological effects of MHWs. However,

	since the EcoTroph-Dyn model does not directly represent this phenological aspect of marine organisms, future studies can apply other approaches that explicitly represent seasonal processes such as spawning and migration to elucidate the effects of phenology"
Comment16: L.215: How can a day with Yt < Tt + St be an MHW day? Can you explain this in more detail?	In our study, we can have a MHW day with Yt < Tt + St. This comes from the use of an annual threshold value to detect MHW events (see appendix figure S5 just before April month). We have rewritten this part for greater clarity as follow (see line 263): "In our study, we can have a MHW day declared even though Yt<Tt + St. This specific situation is rare (less than 0.5% of time series) and occurs because of the use of an annual threshold value to detect MHW events that mainly occurred during the year's warmest months. (See appendix figure S5 just before April month for schematic visualisation. The time series created using this algorithm is referred here as 'without MHW'."
Comment17: L. 224-229: Could you further explain the EPPLEY-VGM method? Not all readers may be familiar with this method nor the VGM method, so I think especially basic information would be helpful. For example, what is the general concept of these methods and what is Pb_opt?	Yes, we have added these details. We developed the idea line 277 as follows: "The EPPLEY-VGPM method is a hybrid model that employs the basic model structure and parameterisation of the standard VGPM (Vertically Generalized Production Model) computation. This model estimates net primary production (NPP) based on chlorophyll concentration, incorporating the vertical distribution of primary production. The specificity of the EPPLEY-VGPM method is that the polynomial description of the maximum daily net primary production found within a given water column (Pb_opt, expressed in units of mg carbon fixed per mg chlorophyll per hour) is replaced by the exponential relationship described by Morel (1991), based on the curvature of the temperature-dependent growth function described by Eppley (1972)."
Comment18: L. 230-235: This should at least be mentioned in the Discussion (somewhere in the paragraph l. 656-675).	We have added these sentences from line 767: "Secondly, in this study, in order to propose a suitable representation of the world ocean, we use an interpolation method to reconstruct an incomplete NPP time series. The interpolation was constrained by the minimum and maximum satellite data values of the NPP observed over their respective time series to ensure reliable interpolation and reduce potential bias."

Comment19: L. 236-237: Which biases may be introduced by this duplication? This should also be included into Sect. 5.3.	We have added these sentences from line 770: "Thirdly and lastly, in this study, we duplicated NPP monthly value to able the EcoTroph-Dyn to run at a 15 days basis. This duplication may have smoothed marine ecosystem response to the historical changes in marine environment; However, it has not changed trends and conclusions of our results."
Comment20: L. 285-287: "Furthermore, more days with MHWs with lower intensity were identified for low latitude regions (23°N - 6°S) (Figure 3c) compared to MHWs identified in higher latitude regions (> 23°N and 25°S)." This sentence is not really clear. Do you mean that the intensity of MHWs was generally lower in high latitude regions?	Yes, see response to comment4 of reviewer RC1.
Comment21: Figure 3: The figure caption seems to be mixed up. The description for c) seems to match panel d), while the description for d) does not match any panel. Thus, panel c) has no fitting description.	Please, see response to comment4 of reviewer RC1.
Comment22: L. 304: "effects of the short-term impacts of MHWs on the long-term changes" This part seems a bit confusing and contradictory, I would leave out the "short-term impacts".	Yes, we agree, we have removed this part of the sentence (see line 372).
Comment23: L. 320: Even if explained in the caption of Fig. 4, I would also define the three biomes in the text since the figure may be placed somewhere else in the typeset paper.	Ok, we have added the biomes definition in the main text as follows (line 382):"While total consumer biomass was projected to decrease slightly across the three biomes (temperate, tropical, and upwelling biomes represented in Figures 4b, c, and d, respectively)".
Comment24: L. 337: Using numbers for biomass increase for both scenarios would make it easier to compare the results, i.e., "a biomass ~~decrease~~increase was projected to occur in ~~76%~~24% of the global ocean"	We agree, we have modified the sentence in the revised manuscript, see line 420.
Comment25: L. 358: Maybe it would be useful to give the number for global biomass loss without MHWs again for direct comparison.	We agree, we have added the percentage in the revised manuscript and modified the sentence as follows (line 422): "Under the 'with MHWs' scenario, this proportion decreased and a biomass decrease was projected to occur in 76% of the global ocean, with a projected global biomass decrease of 4.8% by 2015-2021 relative to 1998-2009 compared to an only 2.4% biomass loss under 'without MHW' scenario."
Comment26: L. 365: What do you mean with "expected"? You already analyzed the differential impact of MHWs on trophic levels in Sect. 4.2.2, didn't you?	Yes, we have changed the wording "were expected" by "are projected", see line 429.

Comment27: L. 377: Can you explain what an ANOVA is?	Sure, we proposed to add an explanation in the Material & Methods section line 218: "We performed a three-way ANOVA, that is a statistical test we used to analyse the effects of trophic levels, biomes, and α value on biomass change."
Comment28: L. 383: greatest instead of greater?	No, the correct word is greater.
Comment29: L. 403: Why do you use different reference periods to define temperature anomalies? In this way, the anomalies are not consistent. I would suggest to choose one of both periods. Did you use the same reference periods to calculate the temperature anomalies shown in Fig. 8? If yes, these should be corrected as well.	We always used the reference period 1982-2011 to define temperature anomalies. We have rephrased the sentence (line 467) as follows "Temperature anomalies were on average >=4 °C (between 2013 to 2016) and up to 8 °C in 2015 relative to 1982-2011." to enhance clarity
Comment30: L. 430-431: This part is difficult to understand. Do you mean: "Considering the influence of MHWs from 2013 to 2016 using the 'with MHWs' scenario and alpha=0.2 resistance capacity"?	We agree, we have modified the sentence in the revised manuscript, see line 495.
Comment31: L. 456-459: This sentence is difficult to understand. Maybe replace with something like: "In this study, we accounted for MHWs in the last four decades using hindcast simulations and showed the potential of synergic impacts of MHWs (pulses) and long-term climate change (presses) on bio-mass and trophodynamics of ecosystems.".	We agree, we have modified the sentence in the revised manuscript, see line 521.
Comment32: l. 494-495: This explanation of TE would be helpful in the methods section.	We agree, and have moved it to the method section, see lines 145-150.
Comment33: L. 521: metabolic efficiency or transfer efficiency? Shouldn't the ratio between ingested and stored energy be high, i.e., only a small part of the ingested energy is stored and the rest is lost?	Thank you for pointing out this mistake, we have modified the sentence line 591 as follows: "Tropical ecosystems are composed of species with low transfer efficiency (TE) (low ratio between stored energy and ingested energy), with significant energy losses that increase with temperature (Brown et al., 2004; du Pontavice et al., 2020; Schramski et al., 2015).
Comment34: L.529-530: Why is the mortality higher in low TLs?	We have added on line 600 "as low TLs tend to have lower thermal limit than high TLs" to enhance clarity.
Comment35: L. 534: If the increase is 1% I wouldn't use the word "sharp".	We agree and have removed the word sharp in the revised manuscript (see line 604).
Comment36: L. 561-562: I don't understand part (ii), could you explain this further?	We have modified this part as follows (line 632-637): "(ii) the specific functioning of these ecosystems with cool water rising from depth to the surface, tends to reduce the number of MHW days compared to their adjacent open ocean (Varela et al., 2021). More generally, it

	has been highlighted that ocean warming does not affect coastal regions with upwelling in the same way as the open ocean (Varela et al., 2021).”
Comment37: L. 585-587: The structure of this sentence seems odd and makes it difficult to understand. Please check and revise.	Thank you, we have revised the sentence as follows (see line 660): “In contrast, in the California Current biogeochemical region, the MHW was associated with a substantial increase in the abundance of pyrosomes which implied a limitation of energy flow moving toward higher trophic levels has been observed (Gomes et al., 2024)”
Comment38: L. 599-600: What defines the models in this family? What do they have in common?	We have rephrased the sentence (see line 676) to enhance clarity as “Despite its apparent simplicity and the reduced number of parameters, EcoTroph-Dyn is part of the family of "complete ecosystem models and dynamic system models" (Plagányi, 2007) as it represents all trophic levels, from primary producers to top predators.”
Comment39: L. 607-608: What are biomass density values?	Mistake in the wording, it is simply biomass: we have deleted density (see line 683) .
Comment40: L. 615: The word “projection” usually refers to simulations/estimates for the future. Since you performed hindcast simulations, I would use a different word here to avoid confusion. Please also check the rest of the manuscript.	We have changed it to “historical simulation”, see line 693.
Comment41: L. 629-632: Can you quantitatively compare your results to those of Arimitsu et al. (2021)?	We can only compare qualitatively our results with those of Arimitsu et al., 2021, as in their study they work at the species level and did not account for species of the entire food-web/model, while in our study we used a trophic level-based approach.
Comment42: L. 640: The reference Cheung et al. (2020) does not exist in your reference list. Do you mean Cheung & Frölicher (2020)?	Yes, thank you for pointing out this mistake.
Comment43: L. 647-448: This part is difficult to understand. Maybe replace with “It would therefore have been valuable to test EcoTroph-Dyn against other MHWs in the world ocean”.	Yes, your proposition is simpler, we havel changed it, see line 725.
Comment44: L. 681: What do you mean by “dismiss any possibility”?	We have rewritten the sentence (line 781) as follows: “To be cautious, we considered various loss rate scenarios to obtain a complete range of responses from marine ecosystems.”
Comment45: L. 684-688: This sentence is quite complex and difficult to understand. Maybe replace with something like: “Even though the global impact of MHWs is negative, species-explicit modelling could improve our understanding of how various impacts of climate	We agree and have made changes to the revised version of the manuscript (see lines 787-790).

change and species-level responses will affect trophodynamics and ecosystem structure and function.”.	
Comment46: Sect. 5.4: You could highlight here how future work can build on your study in particular. For example, what analyses should your model be used for in the future? Should your model be modified/extended, and if so, how?	Yes EcoTroph-Dyn model can be used to project the impacts of hypothetical future MHWs at global and local scales. Please, see the response to reviewer RC1 comment5.
Technical corrections	
Throughout the manuscript, there are some issues with reference formatting (i.e., the use of parentheses, commas, and semicolons). I have already included a few examples below. • L. 11: are becoming have become • L. 20: (NPP) data • L. 21: observations • L. 22: by trophic levels • L. 25: specific MHW-induced decline in biomass of 8.7% ± 1.0 (standard error) in the region from 2013 to 2016. • L. 27: than in lower • L. 36: resulting in more than a doubling of the number of MHWs days • L. 37: a space is missing before the reference • L. 43: have caused a decrease • L. 50: simulationnumerical modelling • L. 51: Don’t use a comma for in-text citations: Carneiro et al., (2020) • L. 66: function globally have not yet been clearly understood on a global scale	Thank you for pointing out these technical corrections line by line. We have addressed them through the revised version of the manuscript and make a full check of the manuscript for others.

• L. 68: climate changes • L. 69 and l. 70: Since this is an article with multiple authors, I would use “we” consistently. • L. 70: MHWs (see (Guibourd de Luzinais et al., 2024) • L. 77: occurred in on the • L. 79: Material and methods • L. 83: from by primary producers • L. 85: food webs • L. 87: TLs, i.e., • L. 88: trophic spectra spectrum • L. 90: the whole consumers biomass • L. 92: generally being faster • L. 94-95: the references should be put into parentheses • L. 96: ecosystems biomass • L. 102: MHWs occurrence. EcoTroph-Dyn's algorithms’ details • L 112: TL. year-1 • L. 114: trophic level, using • L. 131: within the TL class [τ,τ+Δτ[. It], is expressed as • L. 144: depenant dependent • L. 147: flow kinetic (K)) and where • L. 149: 3.2 MHW loss rate algorithm computation	

• L. 152: loss rate algorithm computation • L. 153: into EcoTroph-Dyn • L. 154: period (period 1982-2011) • L. 156: Matching historical MHWs' historical distributions and characteristics with species distribution • L. 158: Estimation bBased on this percentage estimation of an additional loss rate • L. 159-160: Finally, through loss rate (ηi) mathematical expression, we assumed in the mathe-matical expression of loss rate ηi that species arewere continuously challenged by MHW in-creased MHW intensity, which is expressed as: • L. 164-165: with β rangesranging from β=0; (no MHW), to β=1; (MHW lasting 15 days of the fortnight) • L. 165: MHWcat,i corresponds to an MHW intensity index • L. 169: to community resistance capacity to MHW by testing • L. 184: without MHWs • L. 189: every MHWs day • L. 207: seasonal component (St), is then • L. 208: estimation of (St) on the trend-adjusted series	

• L. 212-213: without MHWs • L. 215: component, i.e., • L. 215: For MHW days with Yt below ($Tt + St$) or not an MHW daynon-MHW-days, we keep • L. 217: referred to here as • L. 218: match adapt • L. 222: when an MHW lasts for an entire fortnight. • L. 225: is a hybrid model • L. 239-240: under for the scenarios • L. 246: of simulating 12 years • L. 254: past MHWs events • L. 267: by in the period 2015-2021 • L. 268: NPP changes were was observed • L. 268: Notably In particular • L. 270, 272: in the period 2015-2021 • L. 273: warmed up warming by 1°C during over • L. 277: relative to the average between and the average of • L. 292: Evolution of the spatial extent • L. 292-293: Evolution of MHWs averaged duration categorised by their intensity • L. 299: on average, by 0.07 ± 0.02%	

• L. 317: S2 for biomes spatial definition • L. 321: with MHWs', the declines • L. 332, L. 339, L. 358, L. 375: by in the period 2015-2021 • L. 335 and Fig. 5 caption: For the trophic level classes, the second opening parenthesis needs to be a losing parenthesis • L. 336-337: notably with the tropical and upwelling biomes being notably more impacted. • Fig. 5: Change in trophic groups biomass (y-axis) • L. 345-346: Projected changes in consumer biomass by trophic levels and biomes under the 'without MHW' and 'with MHWs' scenarios relative to the 1998-2009 average between 1998-2009. • L. 362: off the coast of Papua New Guinea Coast • L. 389: by trophic levels • L. 392: 75th quantiles • L. 395: the response of low TLs response • L. 402: in the biomass spectrum • L. 403: relative to the 2016 average • L. 416: exhibited a significant total consumer biomass decrease	

• L. 417: the scenarios with and without MHWs • L. 420: the most • L. 420-421: However, uUnder • L. 425: provinces were the most affected by the MHW • L. 426: biomass decreases of 5% and 3.8% 'with MHWs' relative to the 'without MHW' scenario • L. 429: lower TLs • L. 433: as of by 2021 • L. 443: change in the 'without MHW' and 'with MHWs' scenarios • L. 444: indicates the duration of 'the Blob' duration. • L. 451: 0.2, while • L. 452: by in the period 2013-2016 • L. 457-458: longterm long-term • L. 466, 468: Be careful with the use of past tense. The suggestions of your study have not expired, so use "suggest" instead of "suggested" in L. 466. Similar cases appear throughout the manuscript • L. 470: ecosystems, which is congruent with studies by Arimitsu et al., (2021);, Gomes et al., (2024);, and Smith et al., (2023) studies.	

• L. 373: ecosystems perturbations • L. 475: of the perturbation in ecosystem functioning perturbation • L. 476-477: intensity and duration of MHWs characteristics have continuously increased • L. 478: hindcast period hindcast • L. 482: recover to pre-perturbed • L. 484: upwelling biomes, where the hindcast biomass of high TLs consistently • L. 488: may, therefore, be • L. 490: continuing continued • L. 514: , which is used • L. 551: These MHWs • L. 564: through our modelling approach in our simulations • L. 566: in the California Ocean • L. 568: with anthe increase • L. 570: differently differentially • L. 575: Differences in exposure to the intensity • L. 577: subjected • L. 592-595: For example, communities in the Gulf of Alaskan Gulf are more efficient than those in the Californian Current (du Pontavice et al., 2020), and	

the energy entering the food web was less disrupted than in the Californian Current, which may explain the greater impact of the MHW on the Californian Current. • L. 598: MHWs hindcast • L. 602: by their trophic levels • L. 632-634: It is worth noting that projections obtained fromusing a smaller (larger) α led to an underestimation (overestimation) of biomass losses and changes in biomass flow parame-ters relative to the estimates of Cheung & Frölicher, (2020) and Gomes et al., (2024) esti-mates. • L. 640-641: Grey violin plots correspond to results from Cheung et al., (2020), while the red ones corresponds to our hindcasted EcoTroph-Dyn simulation with α=0.2 scenario. • L. 656: Furthermore, uncertainties aboutin our results arise from EcoTroph-Dyn the environmental drivers of EcoTroph-Dyn. • L. 657: EcoTroph-Dyn has been was driven	

• L. 660: In this study, we did not consider the 'with' and 'without' MHWs scenarios for NPP. • L. 663: couldmay have overestimated MHWs impacts • L. 666: Why do you capitalize marine ecosystem models? • L. 681-682: Running the aforementionedthese five MHW-induced loss rate-induced scenarios • L. 683-684: with a worsening an increasing biomass loss over marine ecosystems with de-creasing resistance capacities decreasing (increasing α increasing). • L. 690: From In our study • L. 693: anomalously low wind, an anomalously weak Ekman transports • L. 694: north, and, coupled with anomalously low air-sea heat exchanges • L. 696: have already contributed • L. 700: better understand better	