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April 19, 2024

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CLIMATE CHANGE RESEARCH

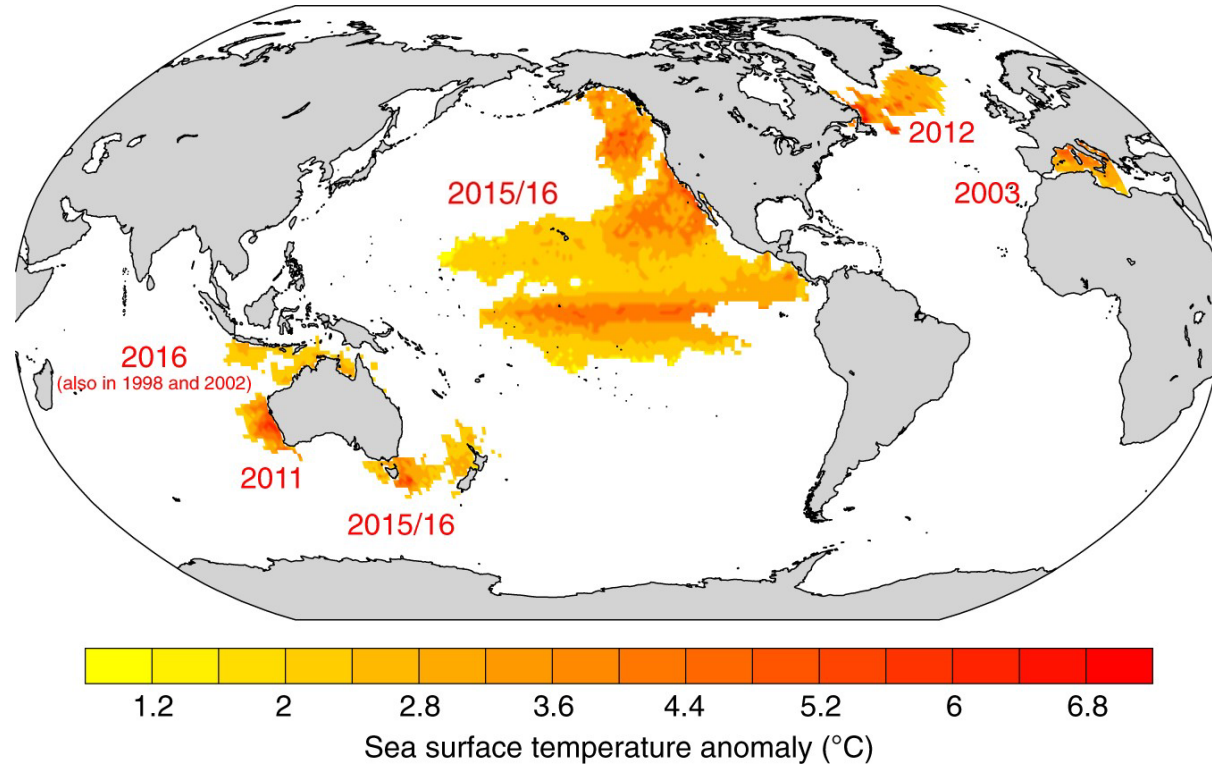


Extreme and compound events are key drivers of low pelagic fish biomass

Natacha Le Grix, Jakob Zscheischler, William Cheung, Gabriel Reygondeau and Thomas Frölicher

Motivation

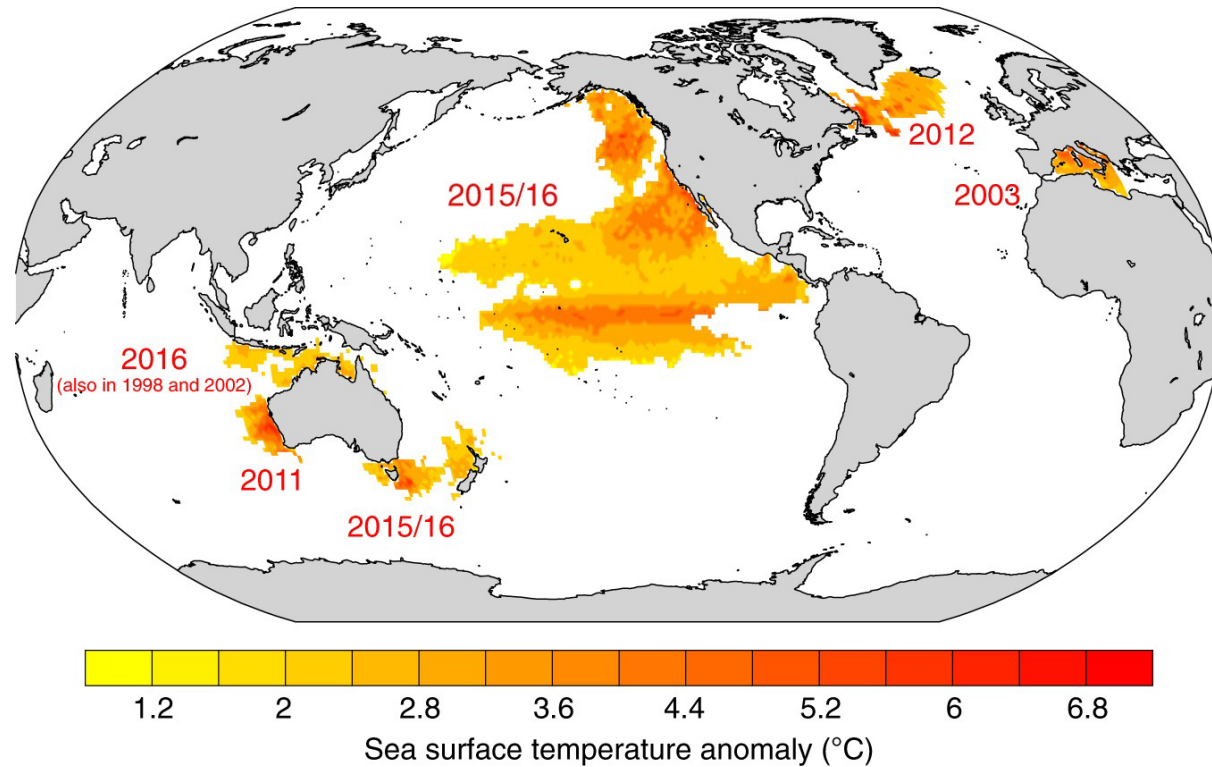
Motivation



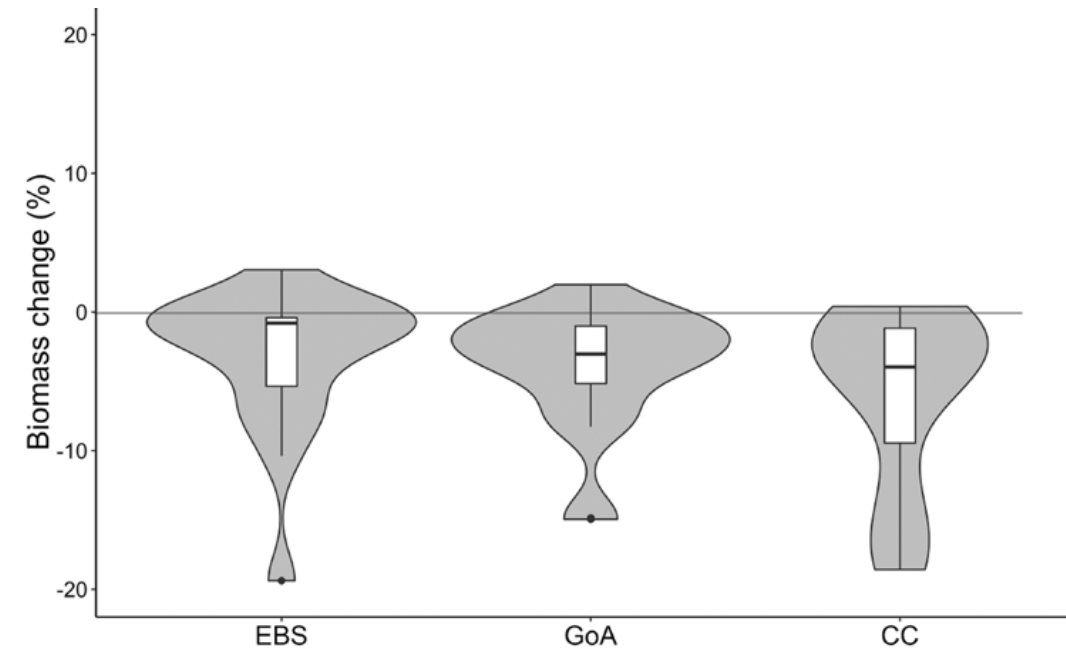
Frölicher and Laufkötter (2018)

Marine heatwaves have major impacts on marine life and human societies

Motivation



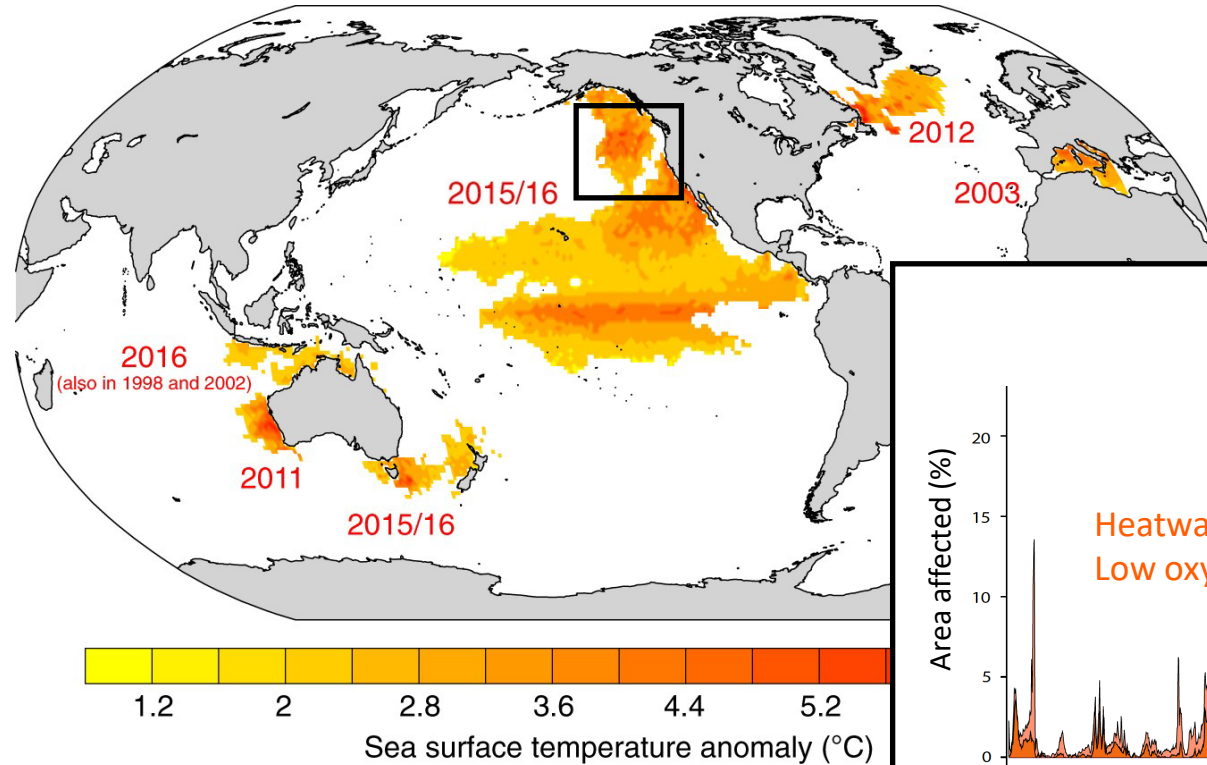
Frölicher and Laufkötter (2018)



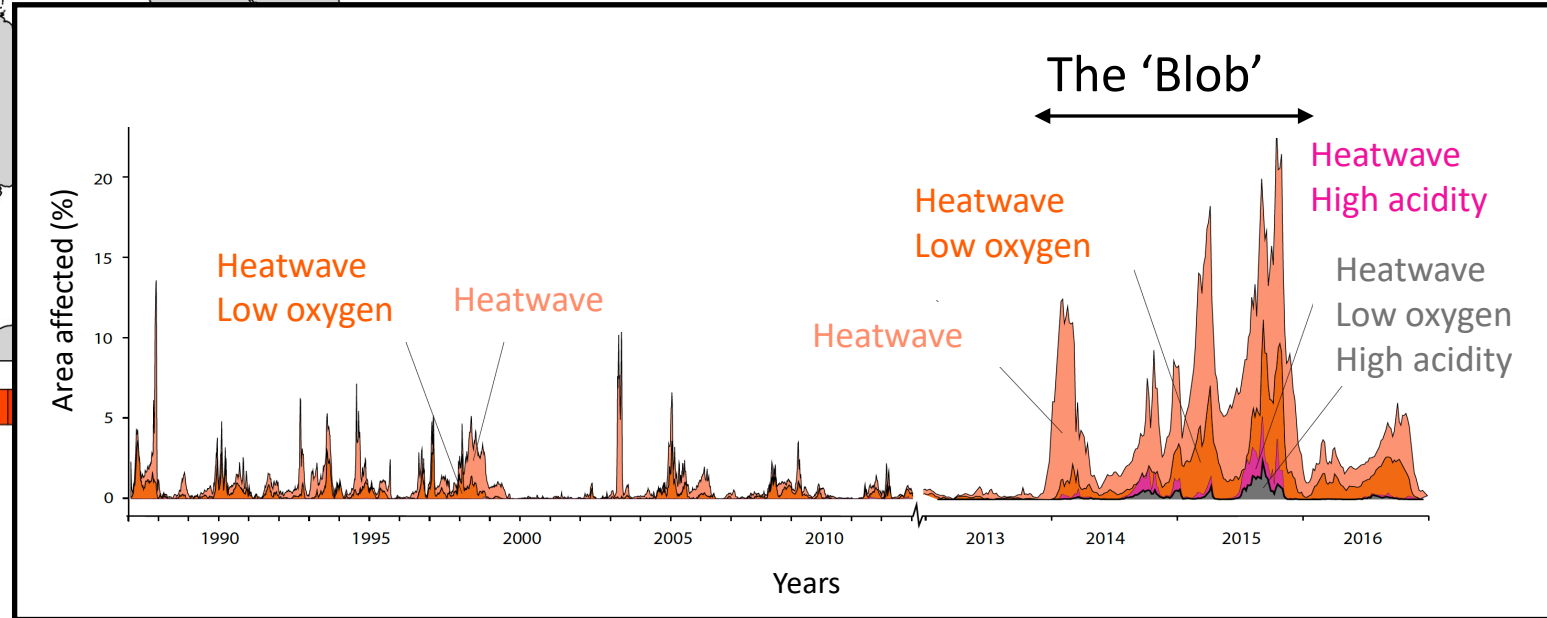
Cheung and Frölicher (2020)

Marine heatwaves have major impacts on marine life and human societies

Motivation



Frölicher and Laufkötter (2018)

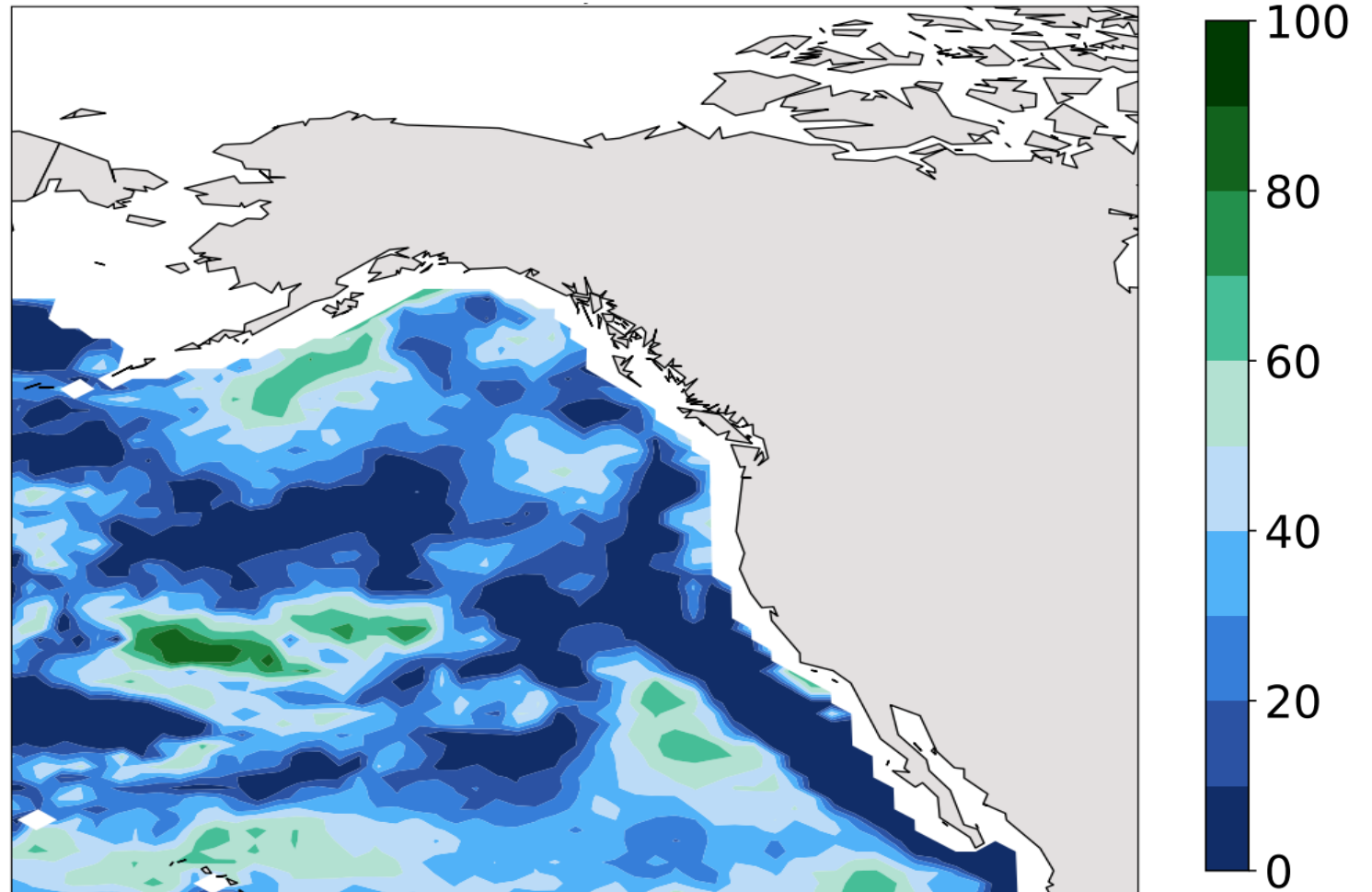


Gruber, Boyd, Frölicher, Vogt (2021)

Ocean **compound** events drive severe ecological impacts

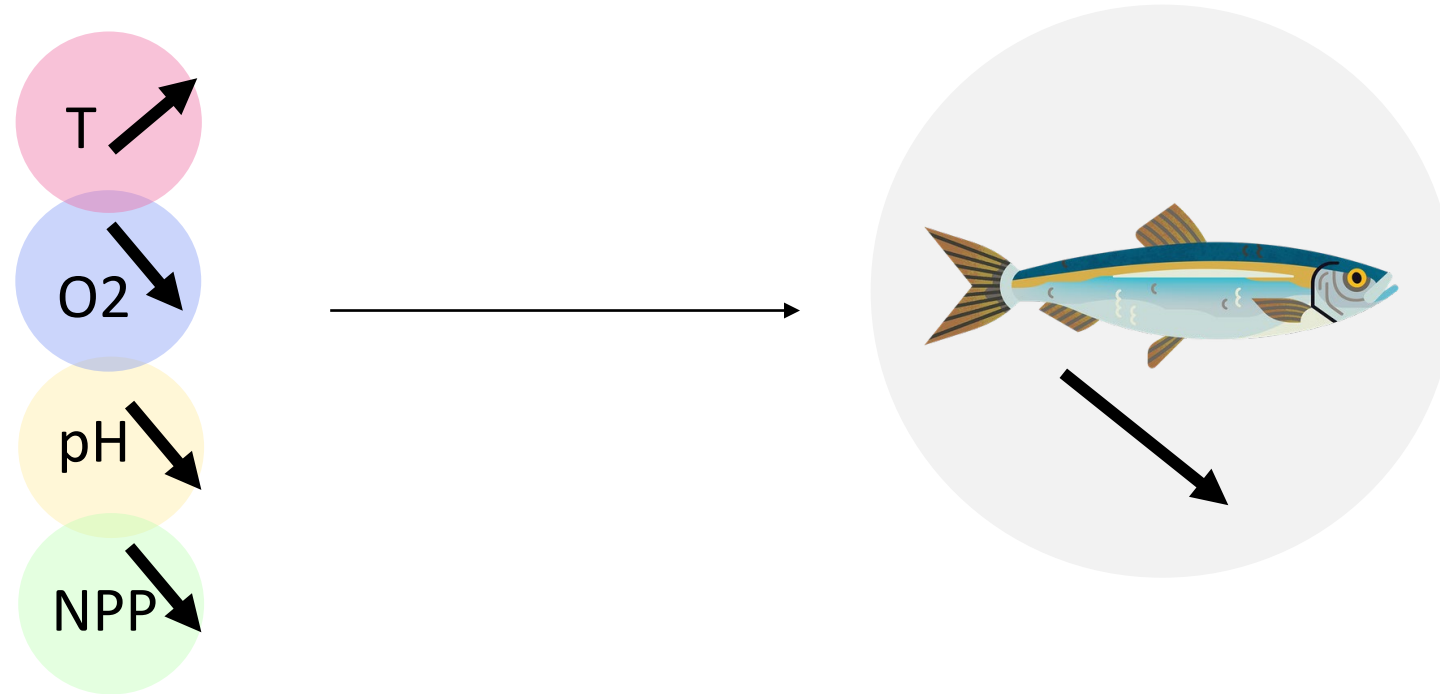
The 'Blob' = a compound marine heatwave (MHW) and low NPP (NPPX) event

Mean percentile of the NPP anomaly during the Blob



Motivation: Research question

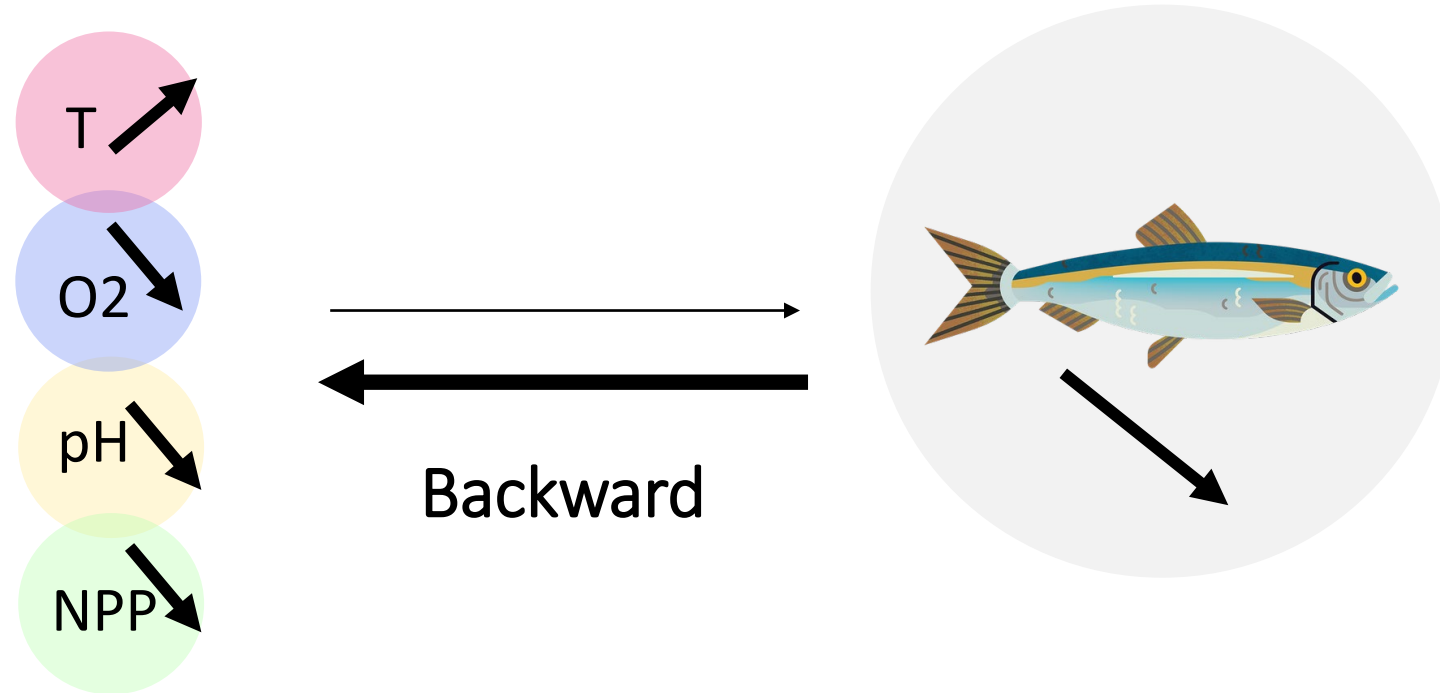
natacha.legrix@unibe.ch



What (combination of) (extreme) ocean conditions drive low biomass events?

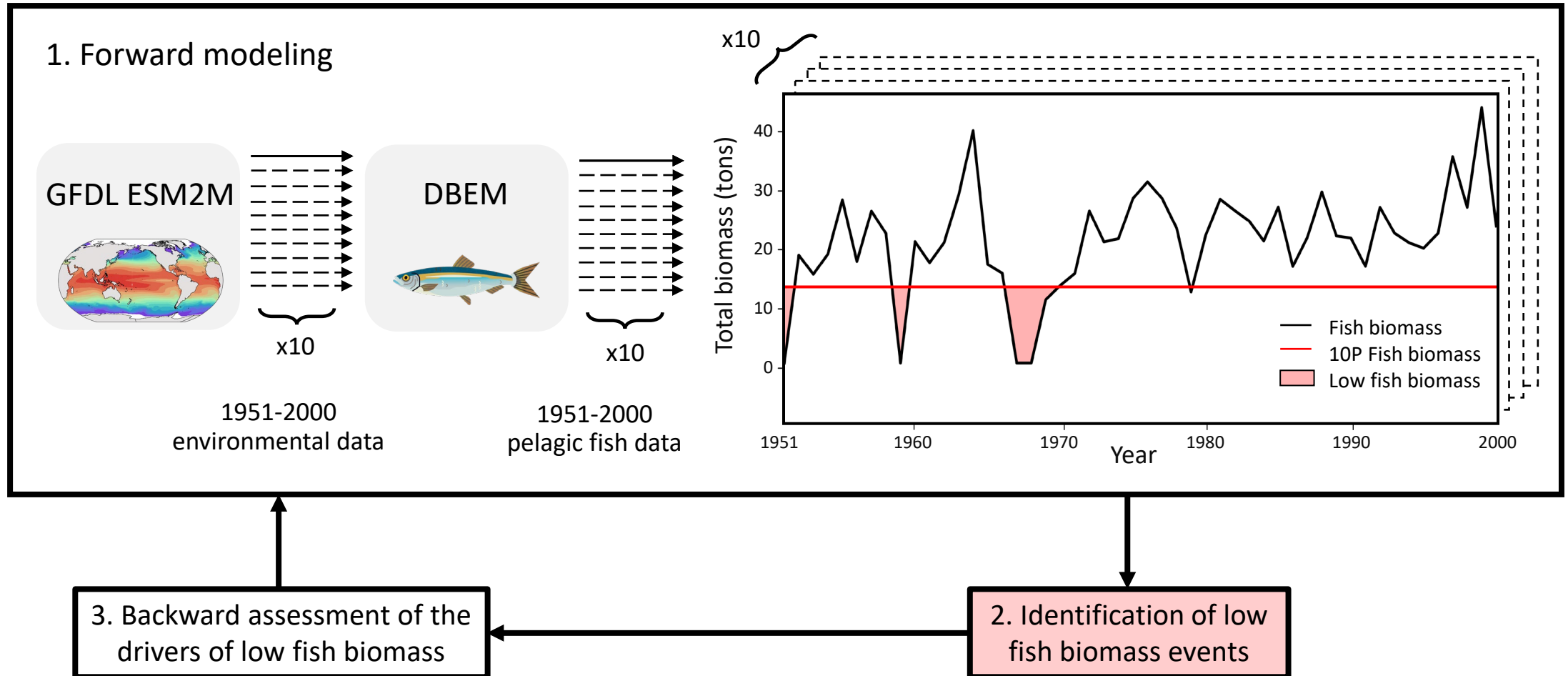
Motivation: Research question

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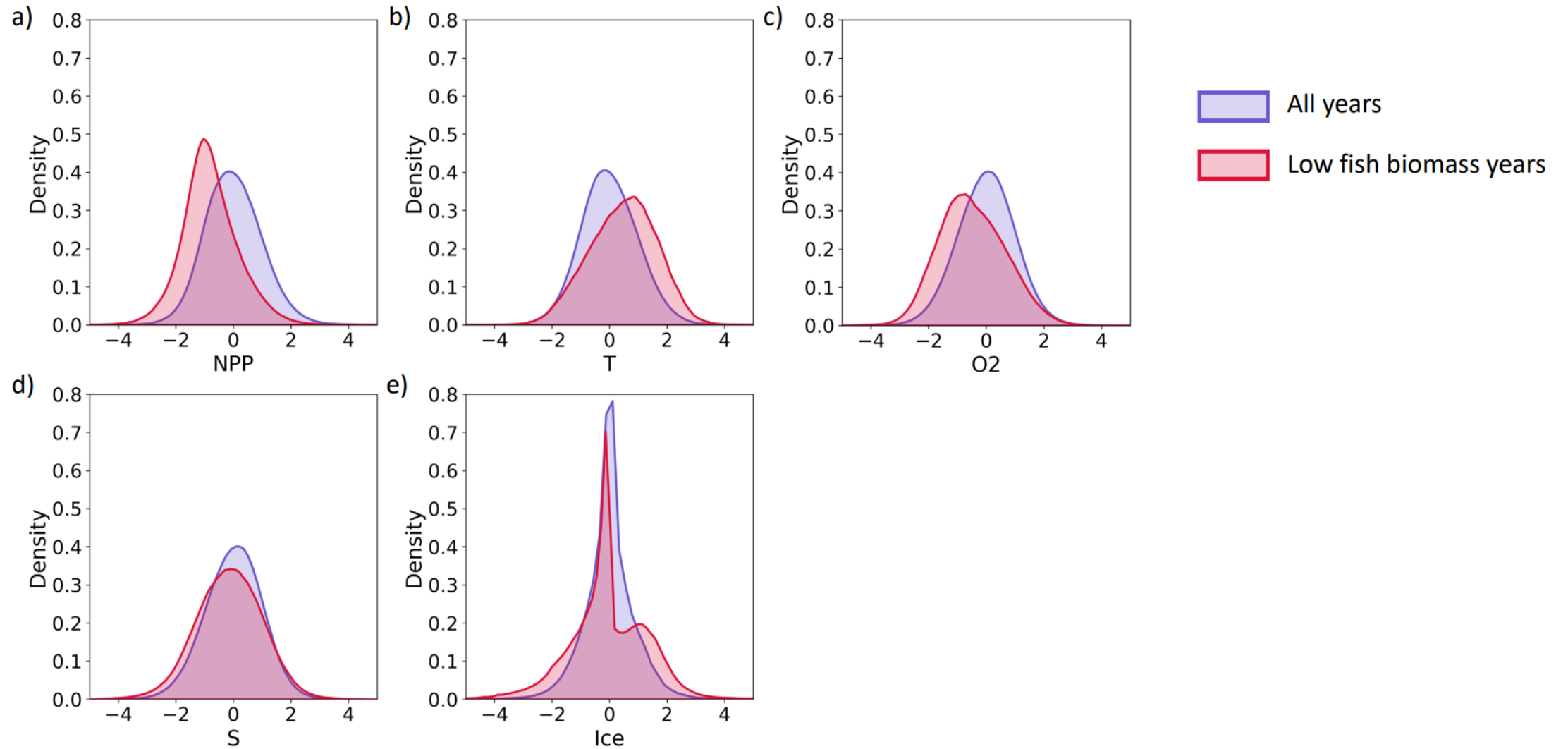
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Methods



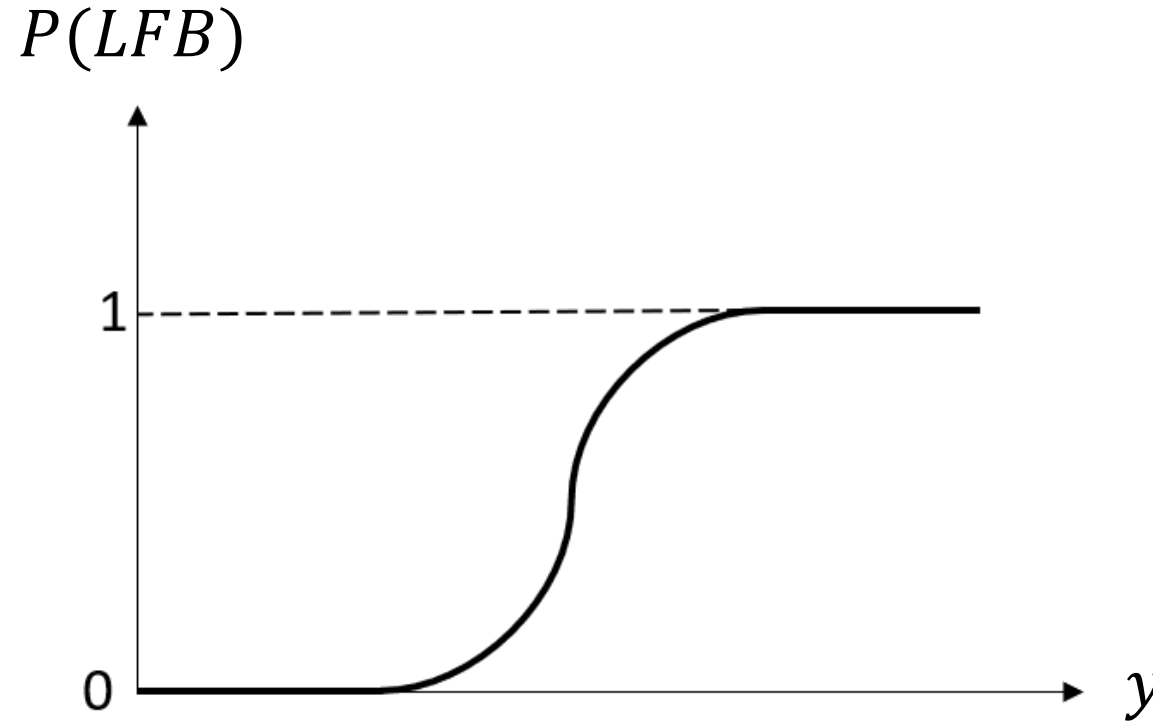
Methods

Low fish biomass is associated with a shift in ocean conditions.



We express the probability of low fish biomass (LFB) using logistic regression.

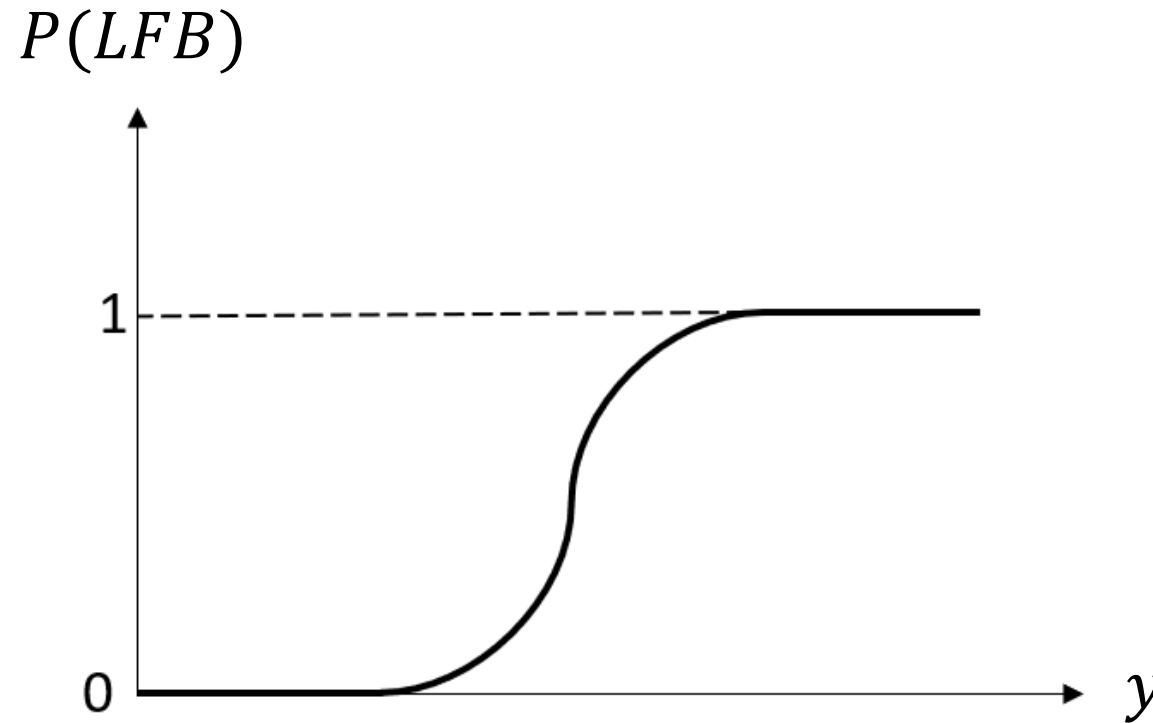
$$P(LFB) = \frac{1}{1 + e^{-y}}$$



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$$P(LFB) = \frac{1}{1 + e^{-y}}$$

$$y = \beta_0 + \beta_i X_i$$

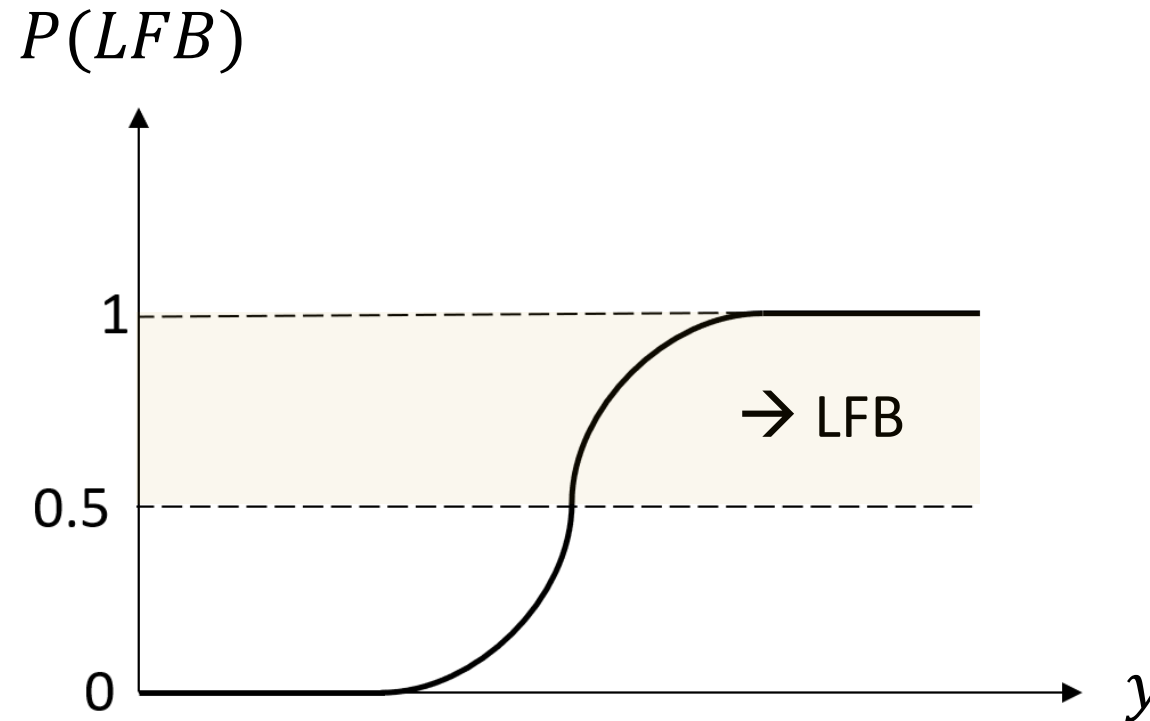


where $X_i \in [NPP, T, O_2, S, Ice]$ up to two years before the event.

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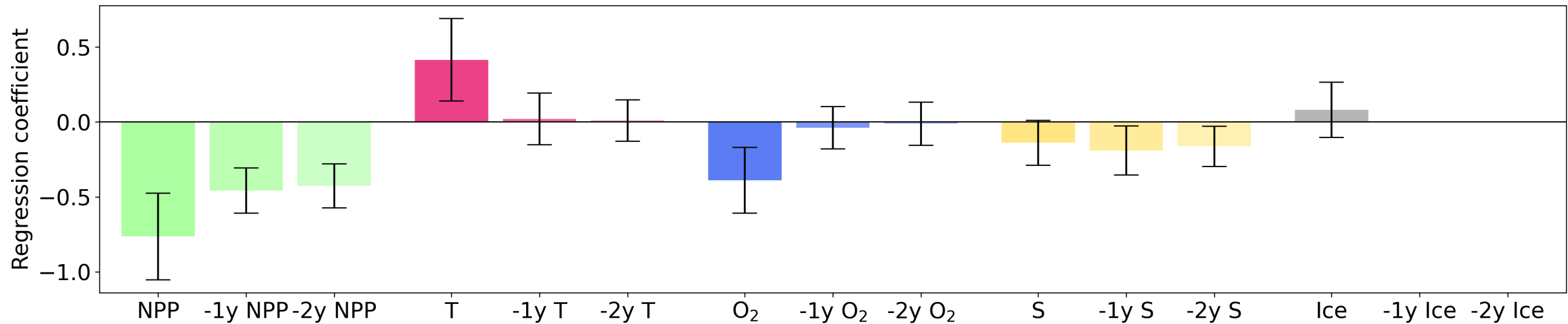


where $X_i \in [NPP, T, O_2, S, Ice]$ up to two years before the event.

Results

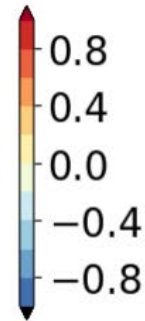
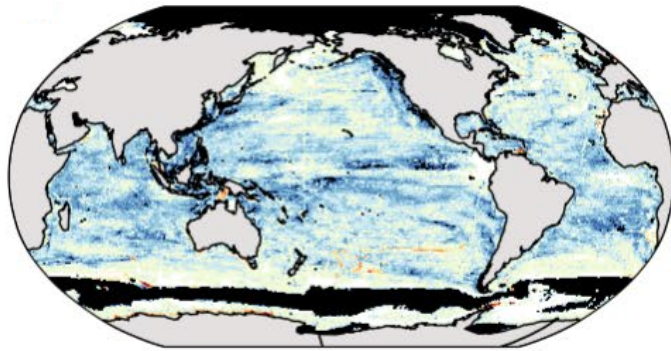
What ocean conditions drive the most severe impacts?

On average, **low NPP**, **high T**, **low O₂**, **low S** and high Ice increase the probability of low fish biomass.

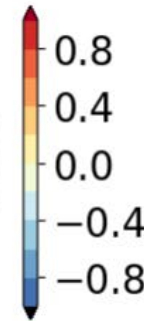
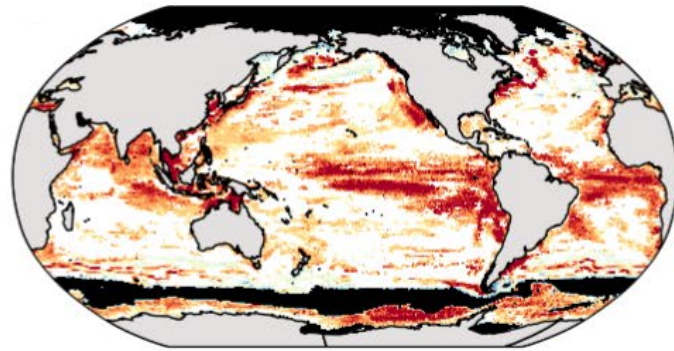


What ocean conditions drive the most severe impacts?

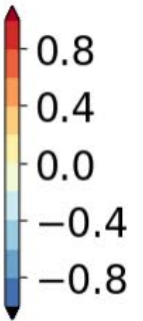
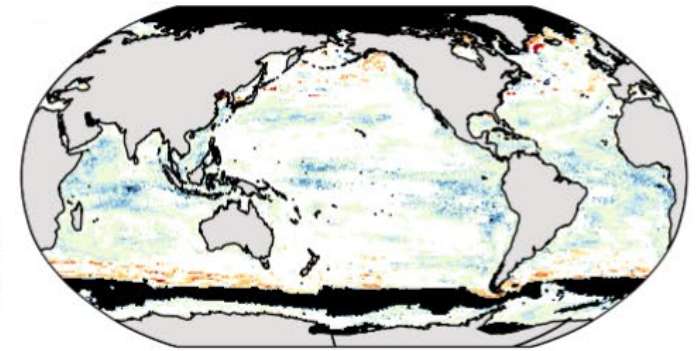
β_{NPP}



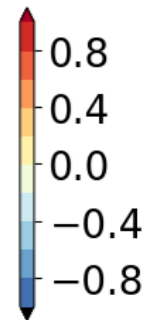
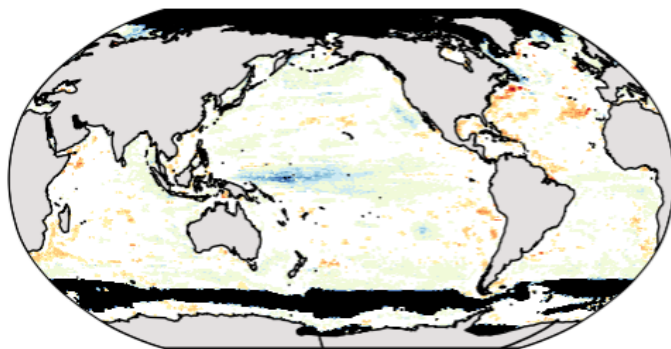
β_T



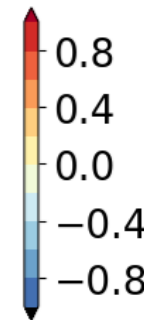
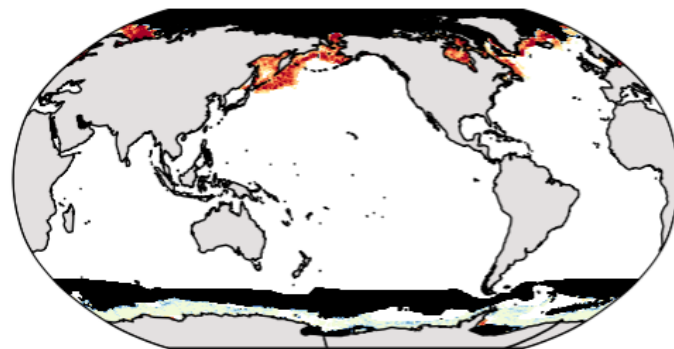
β_{O_2}



β_S

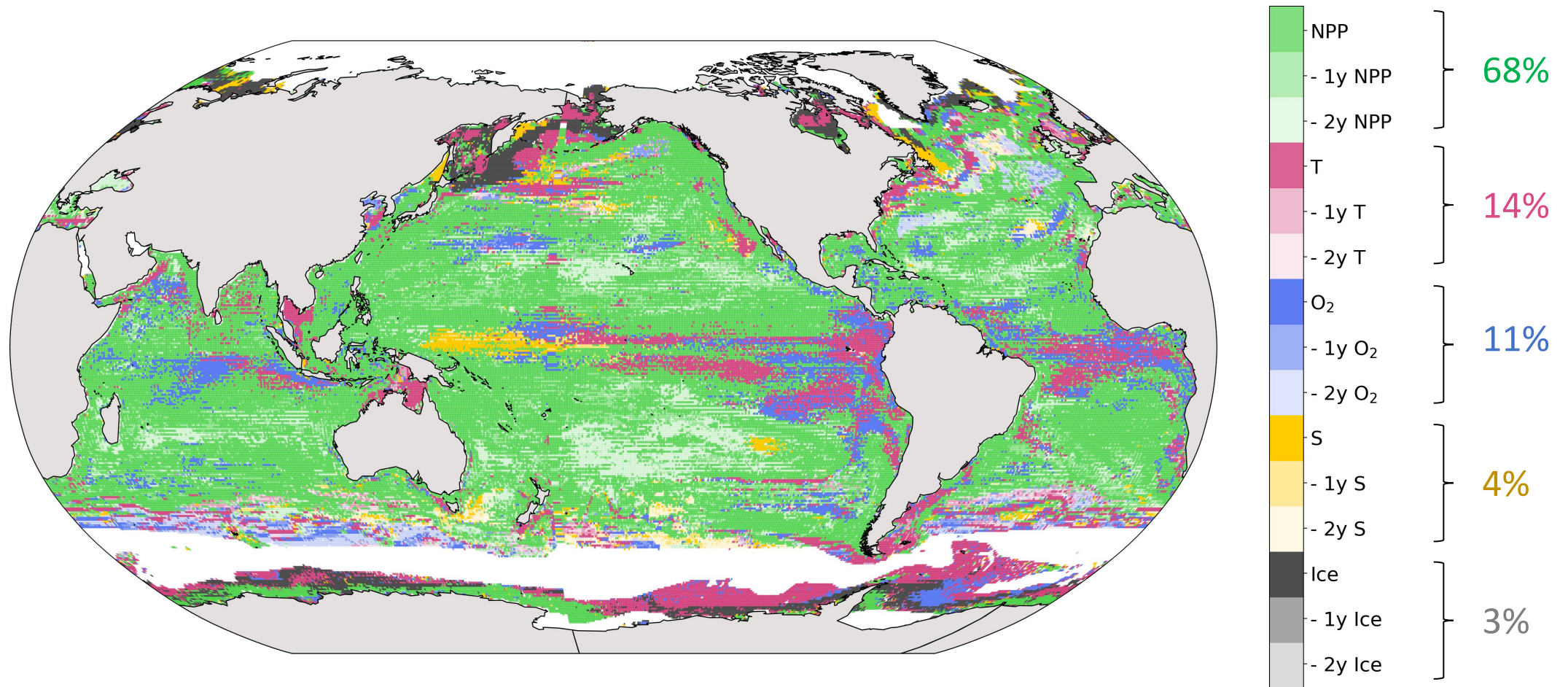


β_{Ice}



The probability of low fish biomass increases when the predictor is **low/high**

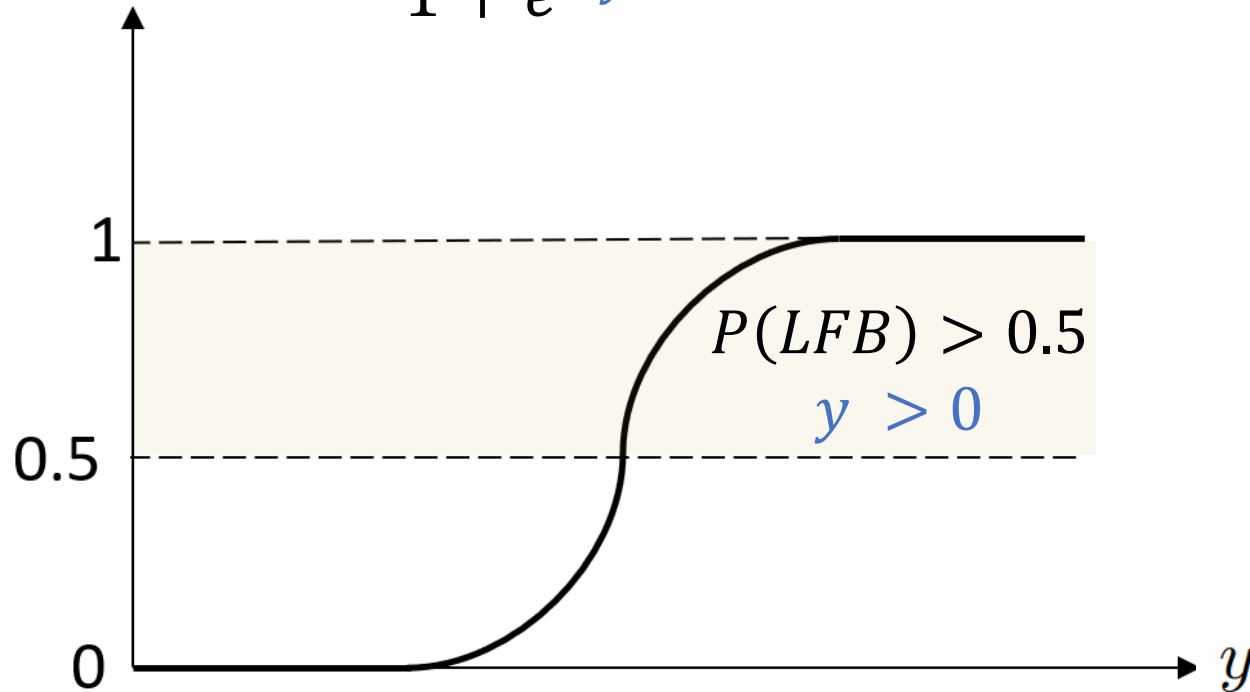
What ocean conditions drive the most severe impacts?



NPP is the main predictor of low fish biomass over most of the global ocean

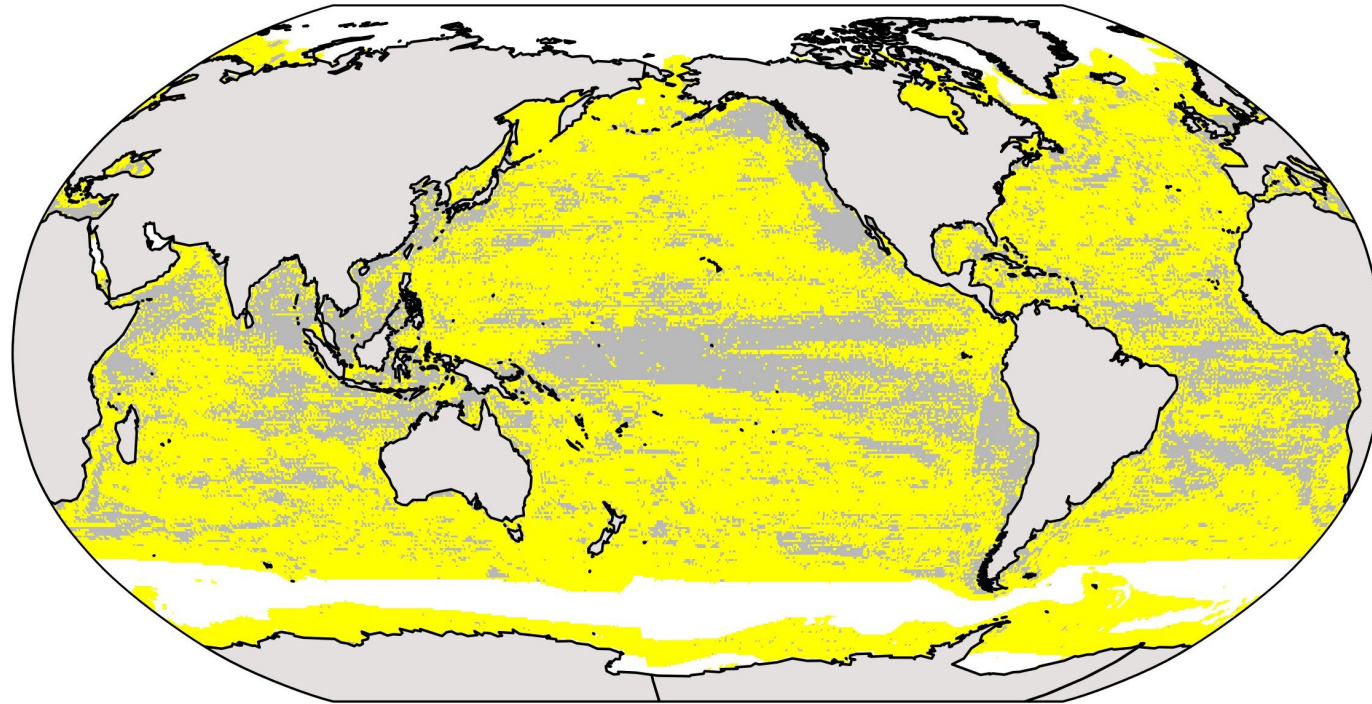
Are **extreme** events necessary to drive severe impacts?



$$P(LFB) = \frac{1}{1 + e^{-y}} \quad \text{with } y = \beta_0 + \beta_i X_i$$



“Can y be positive if all X_i are between their 10th or 90th percentiles?”

Are **extreme** events necessary to drive severe impacts?

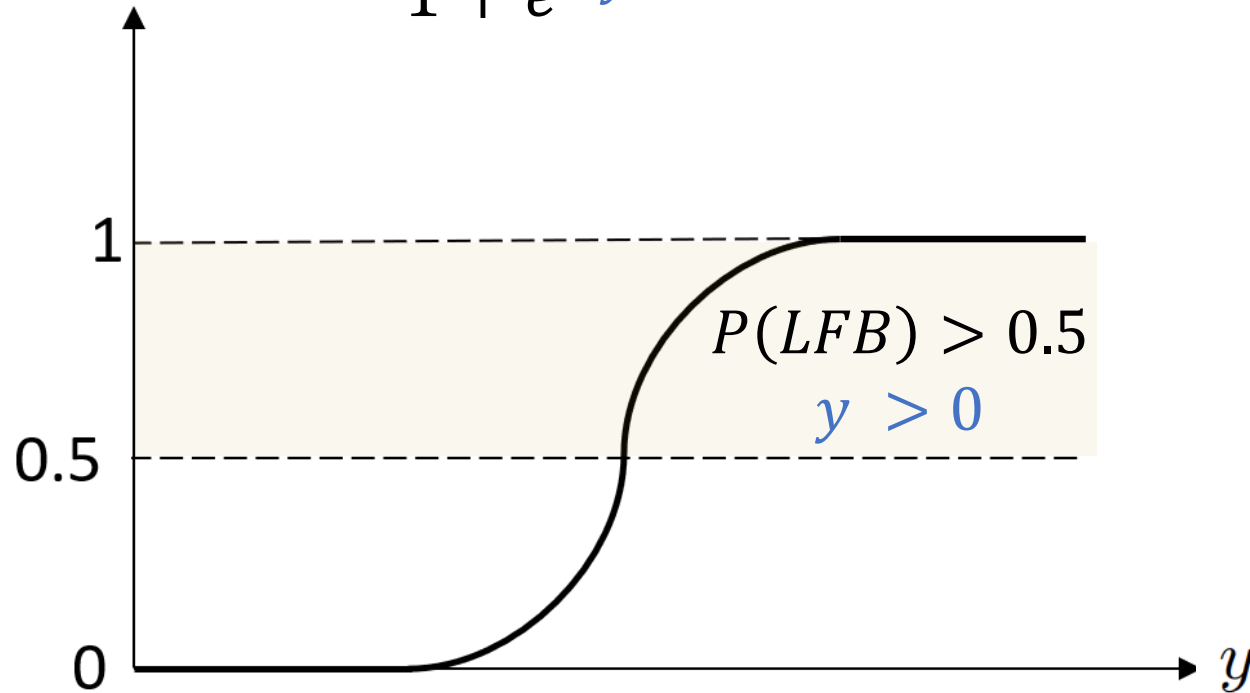


-  The driver can be a moderate event (30%)
-  The driver must be an extreme event (70%)

Over **70 %** of the global ocean, only extreme events can drive extremely low fish biomass.

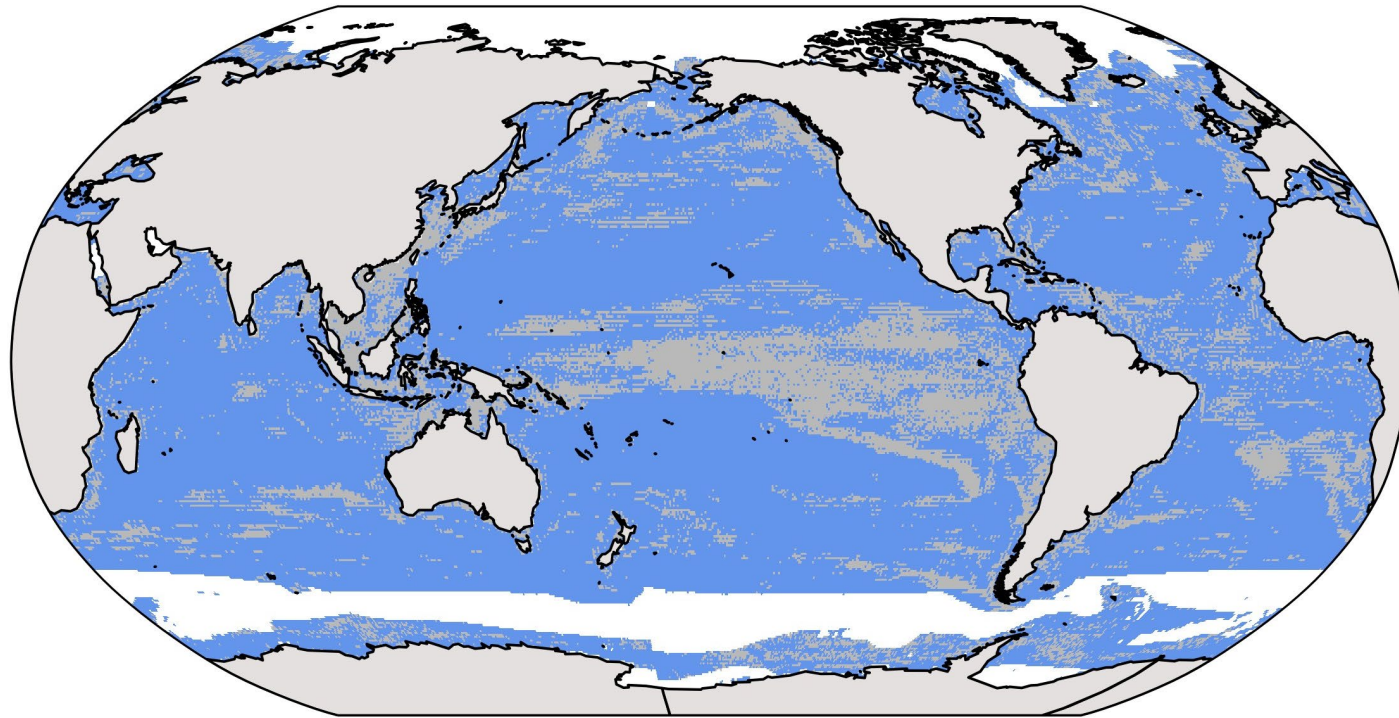
Are compound events necessary to drive severe impacts?



$$P(LFB) = \frac{1}{1 + e^{-y}} \quad \text{with } y = \beta_0 + \beta_i X_i$$



“Can y be positive if only one variable X_i (NPP, or T, or O₂, ...) is anomalous?”


Are **compound** events necessary to drive severe impacts?

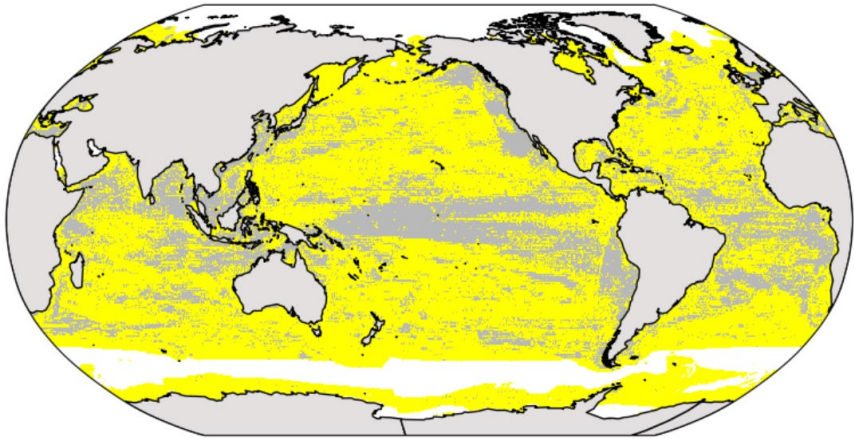



-  The driver can be a univariate event (22%)
-  The driver must be a compound event (78%)

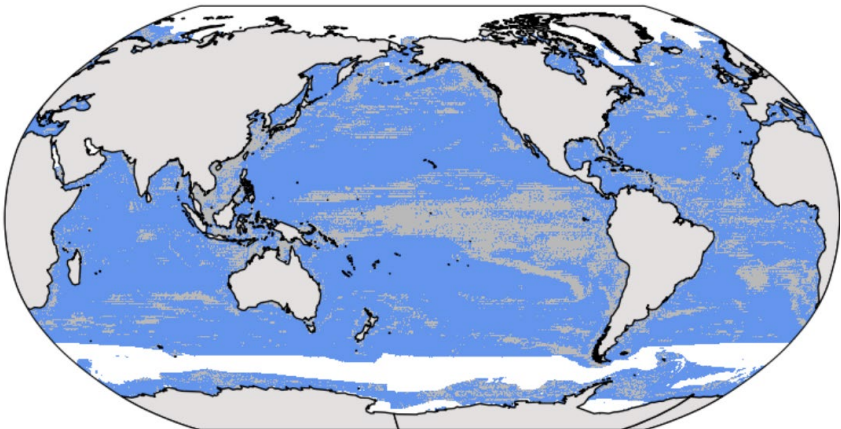
Over **78 % of the global ocean**, only compound events can drive extremely low fish biomass.

Are **compound extreme** events necessary to drive severe impacts?

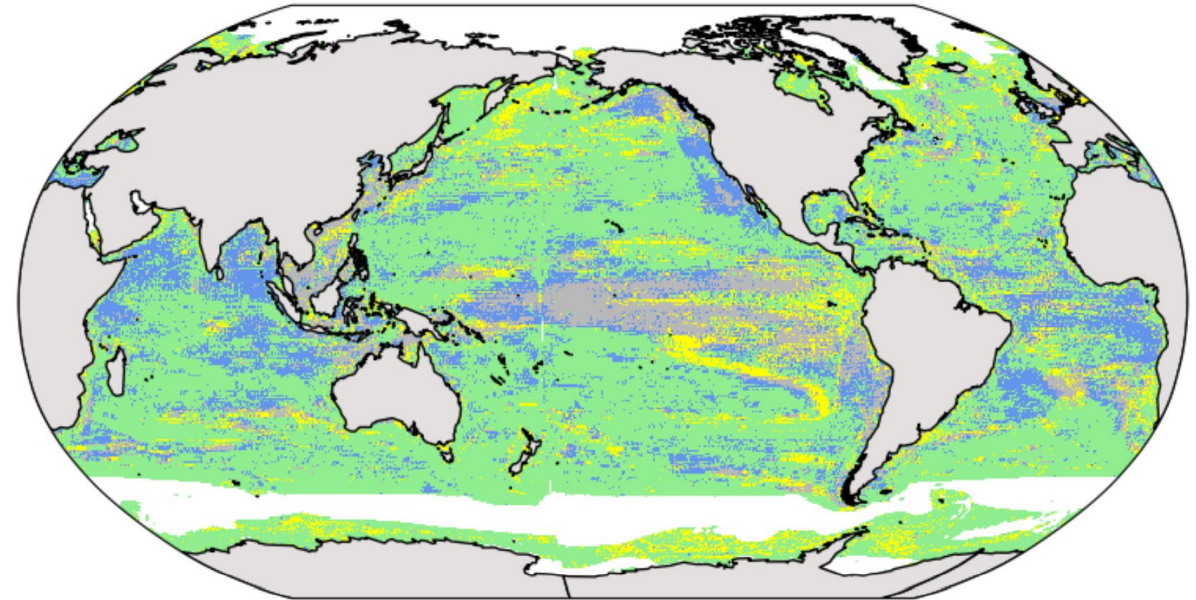
 The driver must be an **extreme** event (70%)



 The driver must be a **compound** event (78%)



 The driver must be a **compound extreme** event (61%)



Conclusions

Conclusions

- Low NPP, O, S and & high T and Ice increase the likelihood of low fish biomass.
- NPP is the main predictor of low fish biomass events
 - *Monitor NPP / NPP extremes to better predict low fish biomass*
- Low NPP increases the likelihood of low fish biomass for (at least) the two following years.
- Low fish biomass cannot be driven by a univariate moderate event. Over 61% of the ocean, it can only be driven by a compound extreme event.
 - *Monitor compound changes in ocean variables to better predict low fish biomass*
 - *Encourage the study of extreme/compound events in the ocean*

For more info:

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Global Change Biology

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Extreme and compound ocean events are key drivers of projected low pelagic fish biomass

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