# Supplementary Information for

# High trophic level feedbacks on global ocean carbon uptake and marine ecosystem dynamics under climate change

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Supplementary text
Figs. S1 to S8
Table S1

## Supporting Information Text

## DIC change

Figure S1 shows the spatial distribution of DIC changes under the RCP8.5 scenario relative to the first 20 years of the historical period, in both the OW and TW simulation. Both simulations exhibit a decrease in the total inventory of DIC and very similar patterns.

## Active export

**Methods.** Active export is computed via a mass-conservation equation through the 200m-depth plane. We assume that what migrant organisms have lost under the 200-depth plane is equal to what they have actively brought down via diel vertical migration. Thus $ActiveExport = \int_{200-1000m}(grazing + egestion + excretion)$

**Change in active export.** Figures S2 and S3 show the spatial differences in active export response to climate change in the TW simulation. The general pattern is that the tropics exhibit a decrease in active export while the high latitudes show an increase in active export.

## Biomasses

Figures S4 and S5 show the biomass anomalies distribution at the global scale and Table S1 summarizes the global changes between the RCP8.5 scenario and the historical time period (1851-2005) for all the organisms in PISCES and APECOSM. Figure S6 shows the change in biomass per degree of warming at the global scale. Figure S7 shows the changes in trophic relationships between HTL and LTL organisms in OW and TW simulations.

## Size-spectrum

Supplementary figure S8 illustrates the effect of climate change on the size-spectrum of fish biomass in the two model configurations. This would have to be combined to fishing effects, that mostly reduce fish biomass at large size classes, to have a better picture of the anthropogenic pressures on the marine fish community.

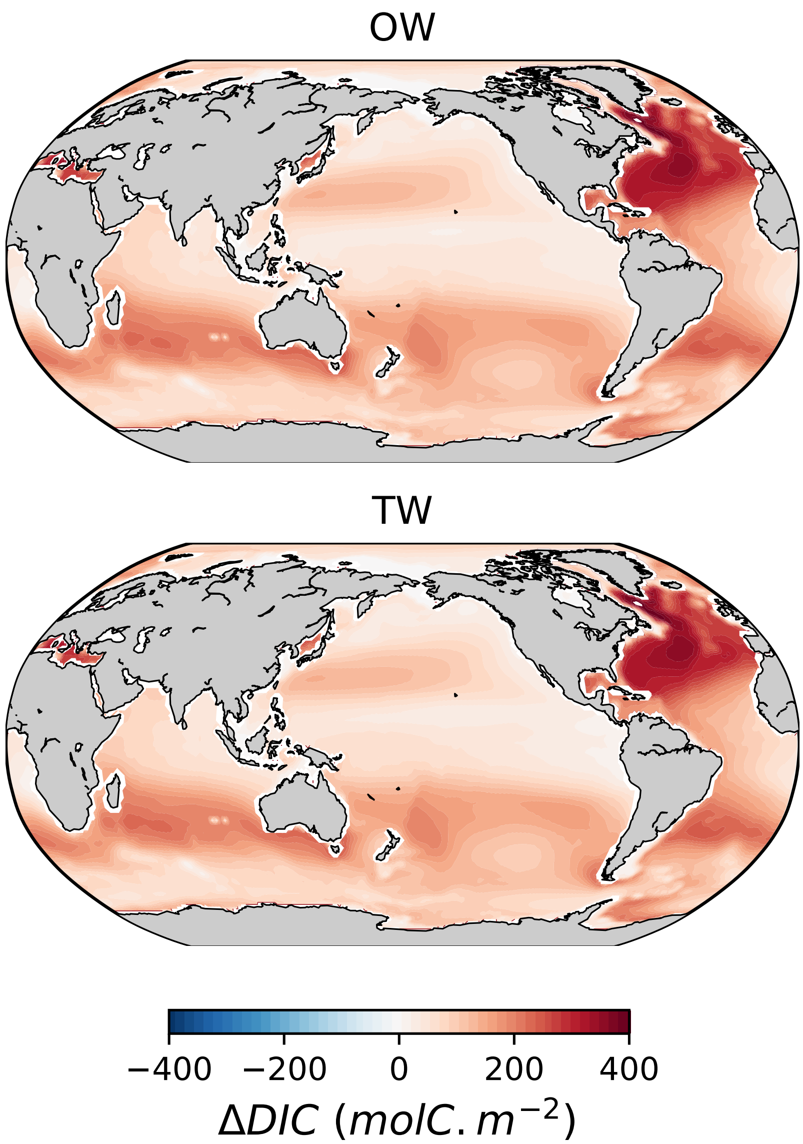


**Fig. S1.** Change in DIC, integrated over the whole water column, between the last 20 years of the future time period (RCP8.5, 2080-2100) and the first 20 years of the historical time period (1851-1870), in a) the OW simulation and b) the TW simulation.

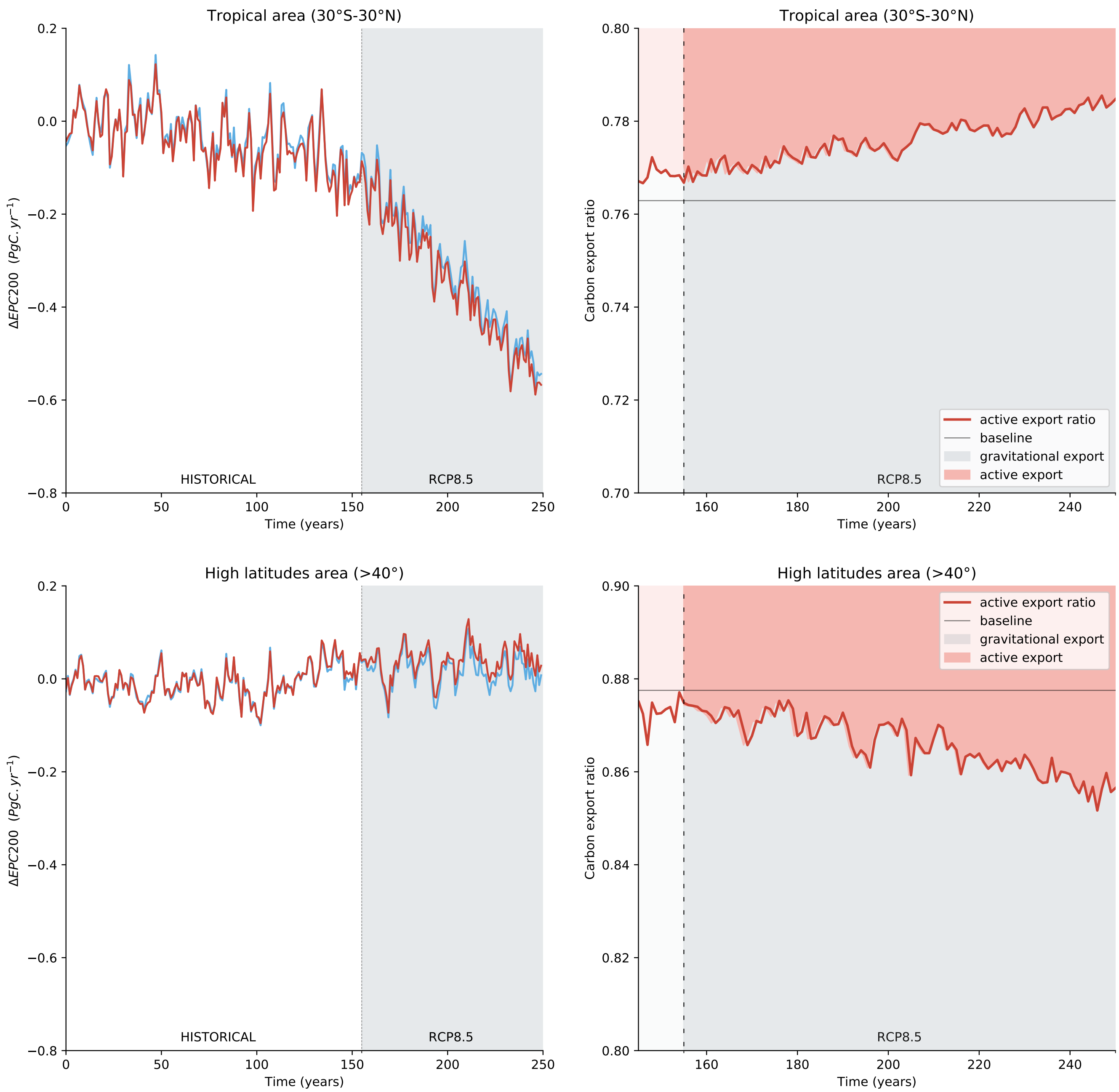


**Fig. S2.** Regional analysis of the export at 200m-depth in terms of active and passive export in response to climate change using the RCP8.5 scenario in the TW simulation. The grey and red areas represent the proportion of passive and active export, respectively, to the total carbon export. The red line represents the distinction between passive and active export in time. The grey line, named baseline, is the averaged contribution of passive vs active export during the historical time period.

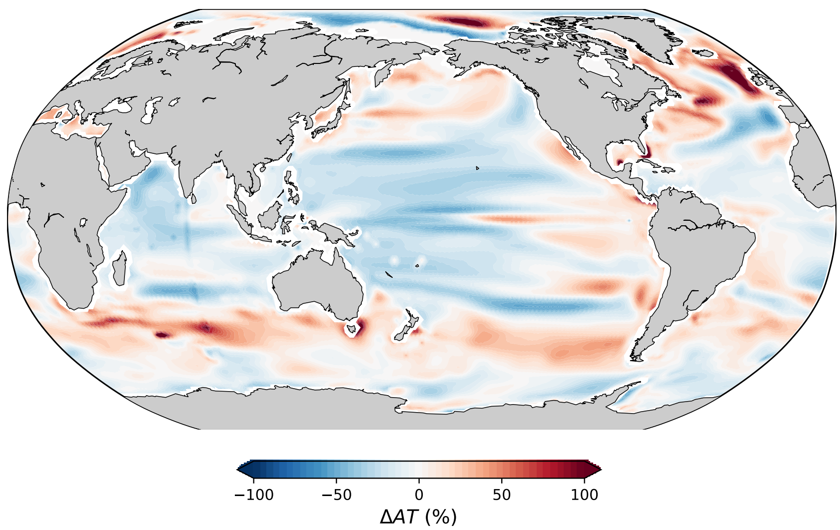


**Fig. S3.** Map of the change in active export in response to climate change (2080-2100, RCP8.5 scenario) in the TW simulation relative to the first 20 years of the historical time period.

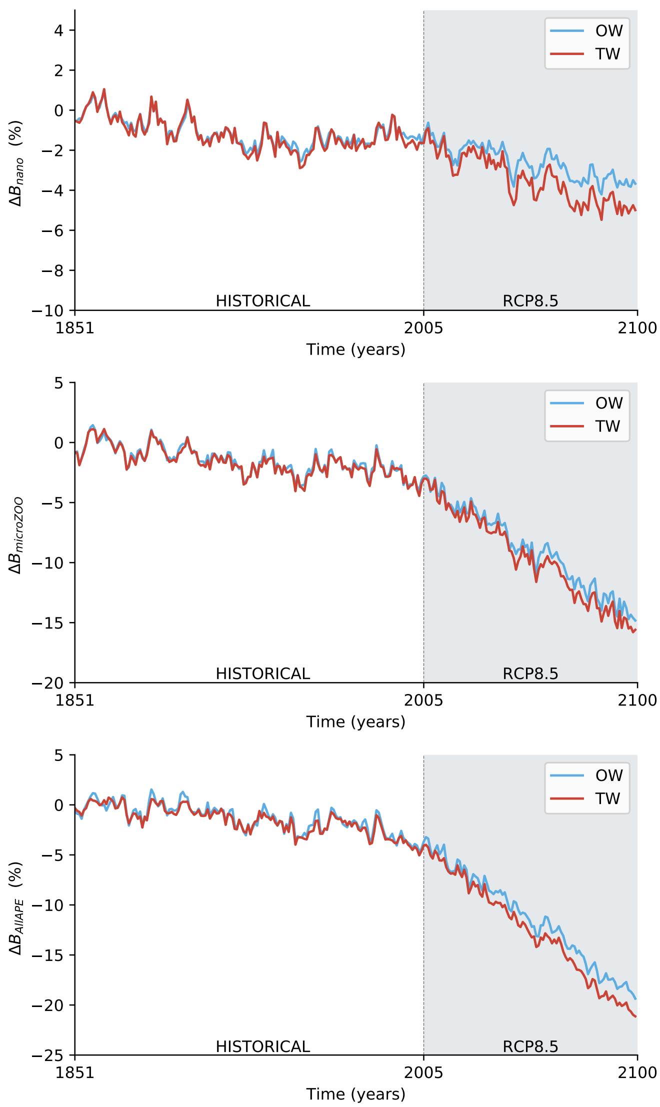


**Fig. S4.** LTL and HTL (all and small size classes) biomass anomalies (%) as a function of time in the OW and TW. Anomalies are computed relative to the 20 first years of the historical period (1850-1870).

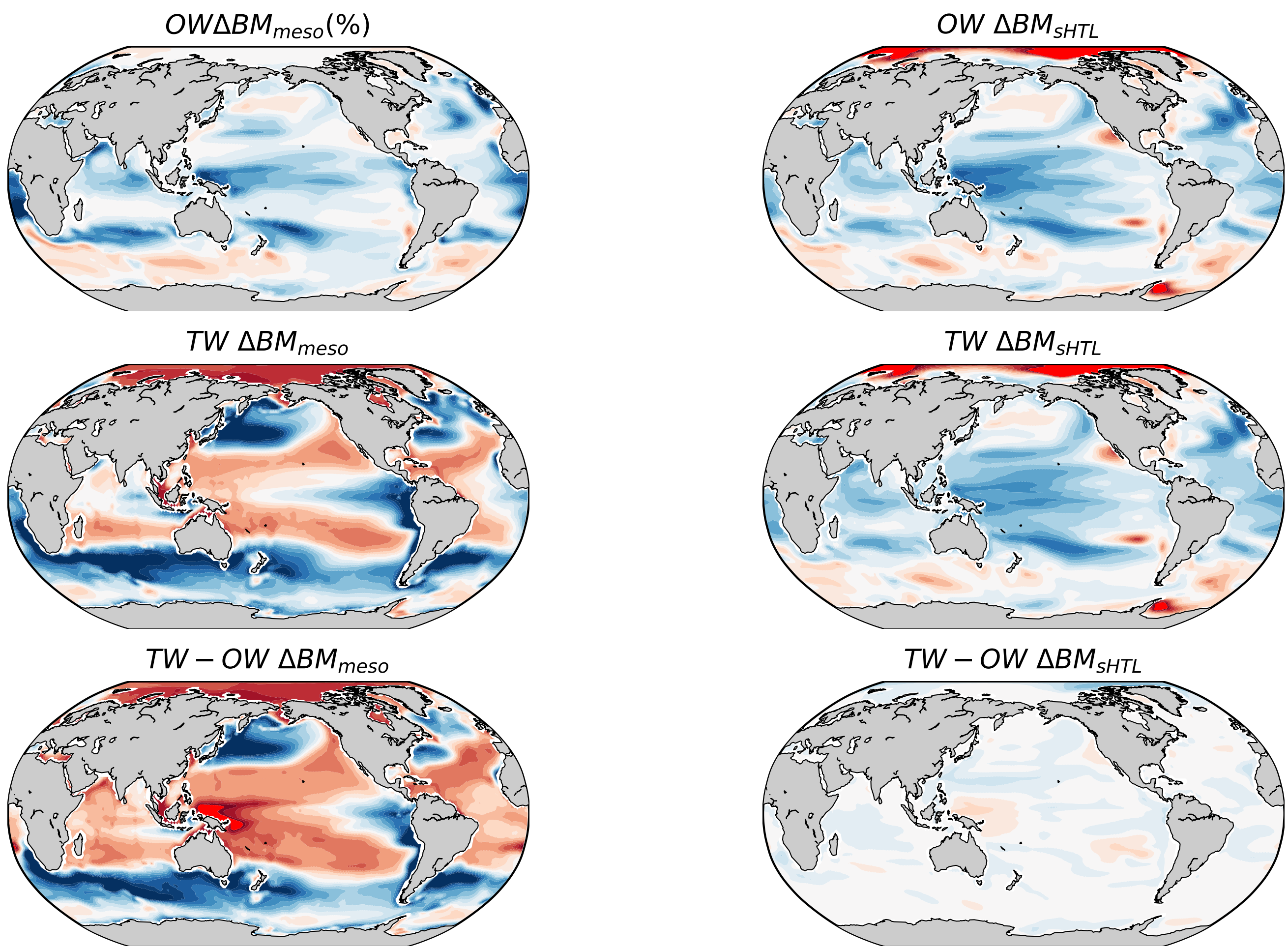


**Fig. S5.** Small HTL (1mm-2cm) and PISCES mesozooplankton biomass anomaly (%, (RCP8.5-historical)*100/historical) in the OW and TW simulations and the intermodal difference (TW-OW, third row).

**Table S1.** **Biomass change (%), total biomass difference ($10^{-2} GtC$) between the RCP8.5 (2080-2099) and the historical (1980-2005) time periods, and slopes of the linear regression between biomass changes and temperature changes, relative to the historical time period, in the RCP8.5 time period, in both the OW and the TW simulation.**

| | PISCES | | | | | | APECOSM | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Phytoplankton | | | Zooplankton | | | Zooplankton | | Fish | | | | |
| **Organism** | Nano | Diatom | Nano +Diatom | Micro | Meso (0.2-1mm) | Micro + Meso | Meso (1-2mm) | Macro (2mm-2cm) | Small HTL (1mm-2cm) | <10cm | 10-30cm | >30cm | All HTL (>2cm) |
| **OW (%)** | -2.5 | -16.4 | -6.3 | -12.0 | -15.1 | -14.0 | -15.0 | -15.0 | -15.0 | -14.1 | -19.1 | -18.0 | -17.2 |
| **TW (%)** | -3.6 | -17.4 | -7.3 | -12.9 | -13.2 | -13.1 | -16.8 | -16.8 | -16.8 | -15.4 | -19.9 | -20.6 | -18.9 |
| **OW ($10^{-2} GtC$)** | -1.3 | -3.3 | -4.6 | -3.2 | -7.4 | -10.7 | -5.1 | -11.3 | -16.5 | -6.6 | -5.0 | -11.3 | -25.0 |
| **TW ($10^{-2} GtC$)** | -2.0 | -3.7 | -5.7 | -2.8 | -6.9 | -9.6 | -4.4 | -9.9 | -14.3 | -6.2 | -3.7 | -8.2 | -20.0 |

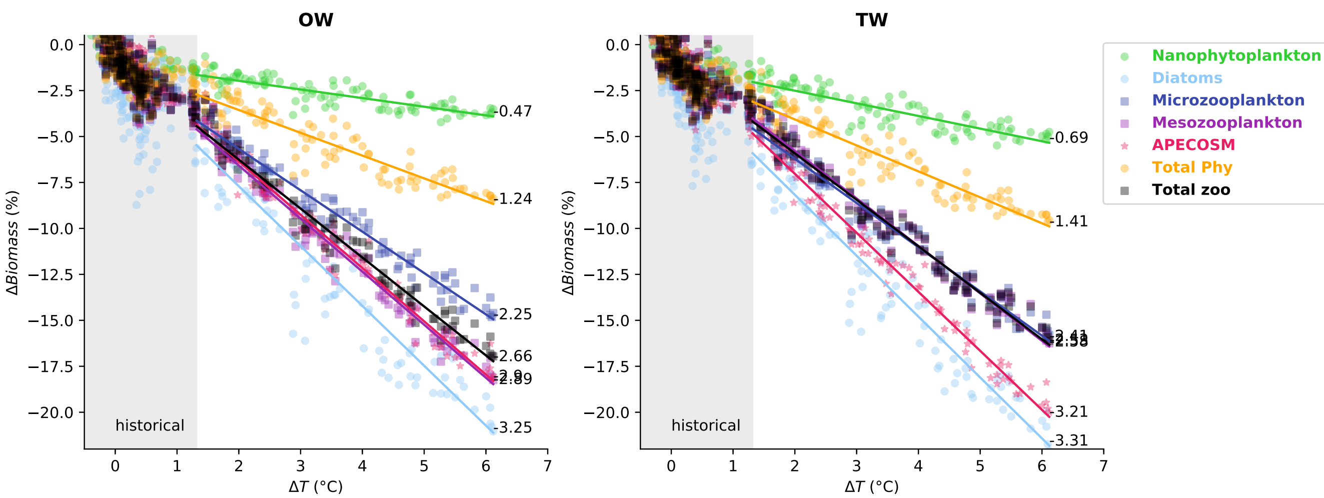


**Fig. S6.** Biomass change per degree of warming for nanophytoplankton, diatoms, total phytoplankton, microzooplankton, mesozooplankton, total zooplankton and all high trophic levels biomass, for the OW framework (left) and the TW framework (right). Anomalies are computed as the relative difference between the last 20 years of the future time period and the first 20 years of the historical time period. The linear regressions are computed over the RCP8.5 period.

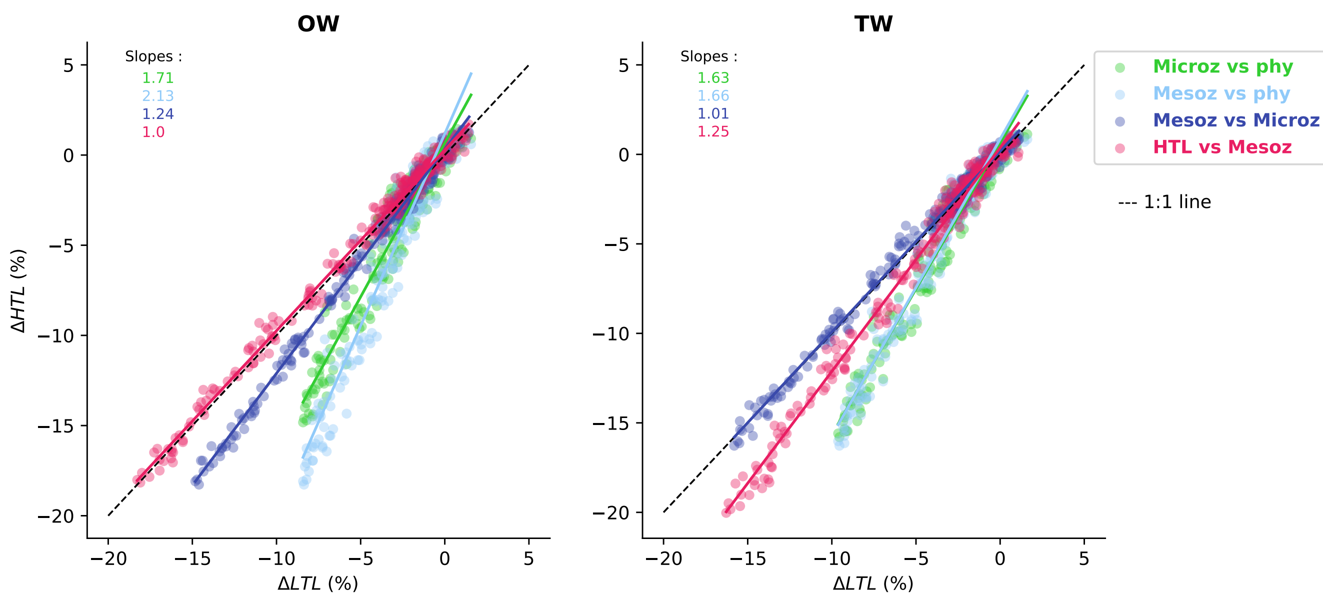


**Fig. S7.** Relationship between HTL biomass change (%) and LTL biomass change (%) relative to the first 20 years of the historical time period, in the OW and TW framework (left and right, respectively). The average slopes are given in the corresponding colors on the plots. The 1:1 line is represented in a dashed black line.

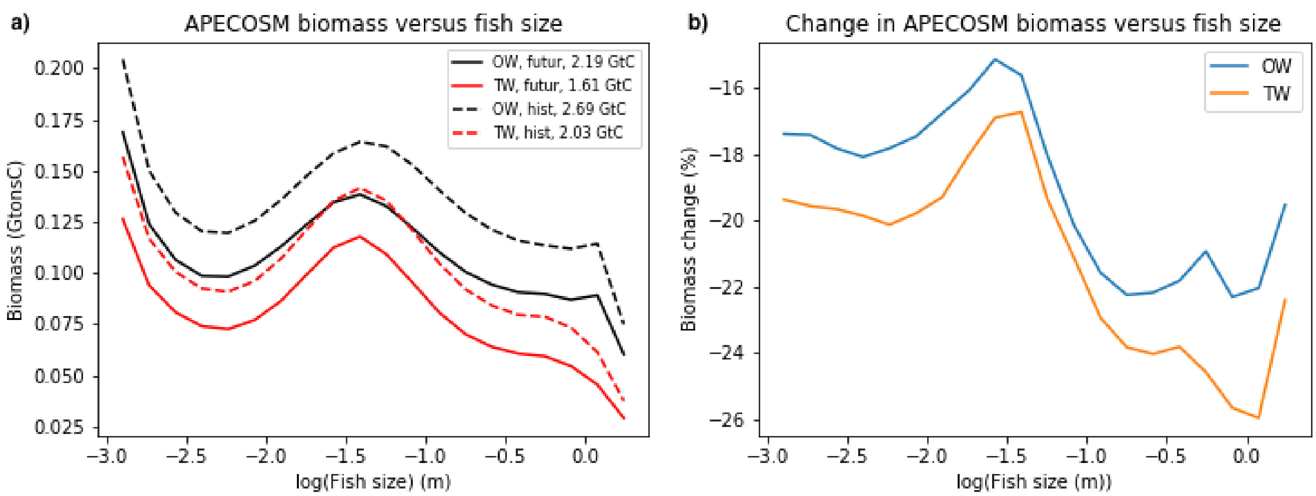


**Fig. S8.** (a) HTL biomass as a function of HTL size in the OW and TW simulations averaged over the first 20 years of the historical time period (1851-1870) and over the last 20 years of the RCP8.5 period (2080-2100), and (b) the relative biomass change between the two time time periods in the OW and TW simulations. The values in GtC given in panel (a) are the total biomass in each simulation averaged over the relative time periods.