

Supplementary Material

1 Sensitivity of results to model assumptions in the EwE model

1.1 Impact of vulnerability parameter cod-sprat

Primary production increase results in increased biomass flow to sprat through increased zooplankton production in the Ecopath with Ecosim (EwE) model. The flow control parameter of the adult cod-adult sprat and adult cod-juvenile sprat interactions ($v_{c,s}$) modulates how much of the resulting sprat production can potentially be channelled to adult cod. When the flow control parameter is set to a low value ($v_{c,s}=1$) compared to the default ($v_{c,s}>100$), it constrains the biomass flow between the two species (Walters et al. 1997, Walters 2014). Thus, it has a major influence on the response of adult cod and sprat biomass to increasing P/B (Fig. S1.1). Therefore, when repeating the simulations varying P/B and OxAr under $v=1$, the biomass increase of adult cod under increasing P/B is reduced to approximately half compared to the default setting (Fig. S1.1a) while adult sprat biomass increases to a larger extent (Fig. S1.1b).

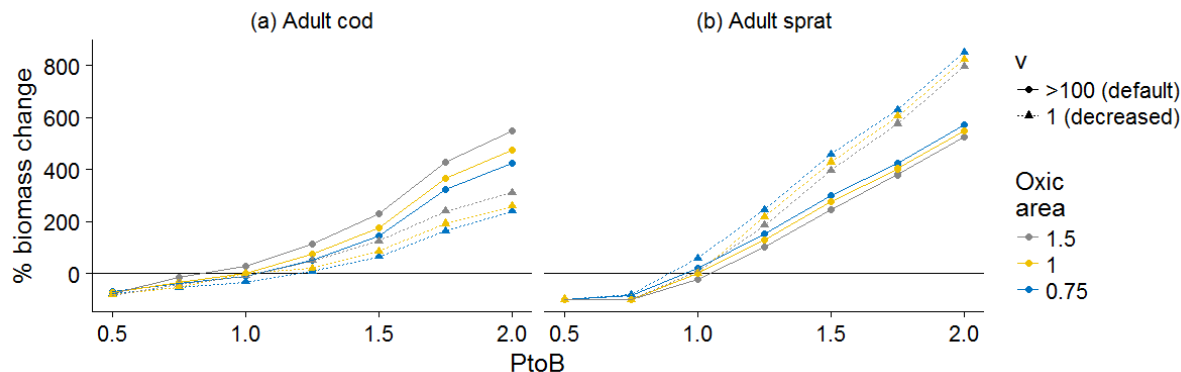


Figure S1.1 Change in biomass of adult cod (a) and adult sprat (b) as a function of relative changes in P/B and OxAr under two different flow control parameter setting for the adult cod-adult sprat interaction ($v_{c,s}$). Circles and solid lines indicate simulations when v was at its default value (repeated from Fig. 3a,d for easier comparison). Triangles and dashed lines indicate simulations with v decreased to 1. All forcing functions except of P/B and OxAr were set to 1. Biomass change is relative to baseline equilibrium value. Horizontal line means no change.

1.2 Impact of vulnerability parameter herring and flounder

We repeated the simulations varying P/B and OxAr under a high value (100) of the flow control parameters of adult herring and adult flounder predation on all prey ($v_{h,f}$) to test if the smaller biomass response of these two groups to forcing compared to other fish (Fig. 2b,c) is due to the relatively low $v_{h,f}$ values (at default set to 2, except for the adult herring- mysids, adult zooplankton, Temora sp. interactions where they were 1). The results of these simulations (Fig. S1.2) showed that this was not the case, as the magnitude of biomass response was not largely affected by the increased

$v_{h,f}$. However, in contrast to adult cod and sprat, where changing $v_{c,s}$ only changed the magnitude of their biomass response to P/B and OxAr forcing but not its shape, changing $v_{h,f}$ affected the shape of the cumulative effect of P/B and OxAr on adult herring and flounder biomasses. Nevertheless, the effects of changing forcing, especially for herring, remained generally low compared to the other fish groups (see Figs. S2.1-S2.3).

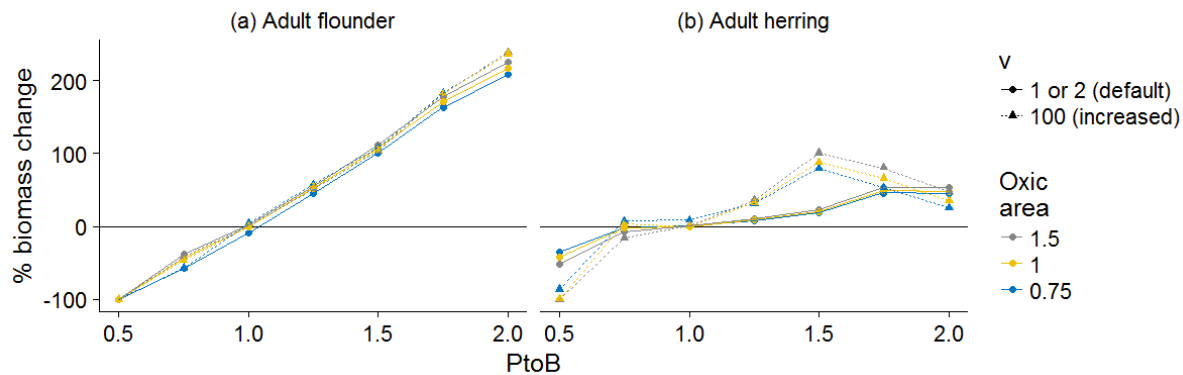


Figure S1.2 % change in biomass of adult flounder (a) and adult herring (b) as a function of P/B forcing at 3 different levels of OxAr under two different flow control (v) parameter setting for adult herring- all prey and adult flounder- all prey interactions. Circles and solid lines indicate simulations when v was at its default value, 2 or 1 depending on the interaction (repeated from Fig. 3b,c for easier comparison). Triangles and dashed lines indicate simulations with v increased to 100. All forcing functions except of P/B and OxAr were set to 1. Biomass change is relative to equilibrium biomass value when all forcing functions are set to 1. Horizontal line means no change.

2 All biomass responses – EwE model

For clarity, only a subset of the simulation results are shown in the main manuscript. This supplement shows the effects of all tested combinations of environmental forcing levels on the biomasses of all studied functional groups in the Ecopath with Ecosim (EwE) model.

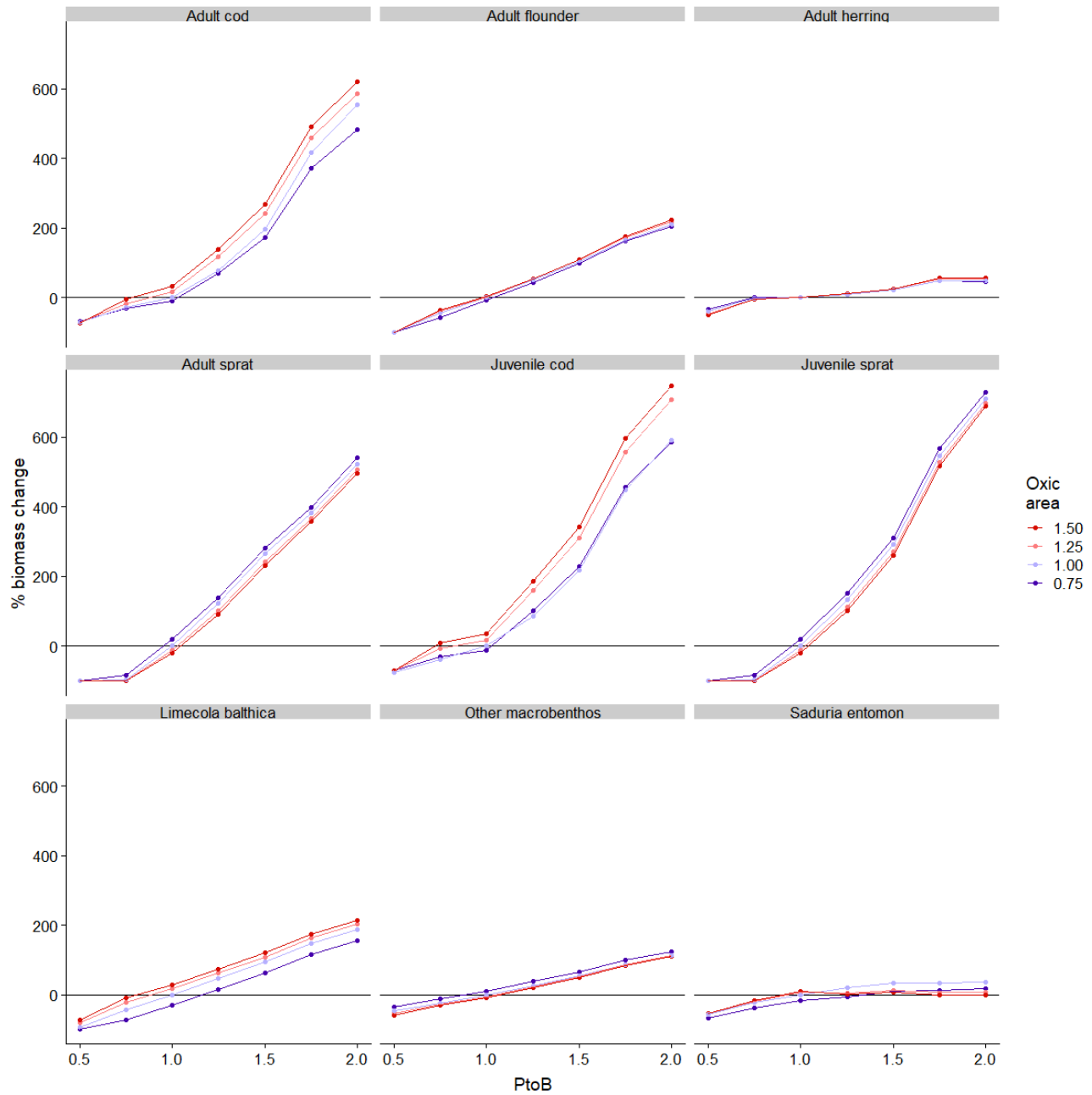


Figure S2.1 Change in biomass of all studied functional groups as a function of relative changes in P/B and OxAr, where 1 denotes baseline forcing. Biomass change is relative to baseline equilibrium value. Horizontal line means no change.

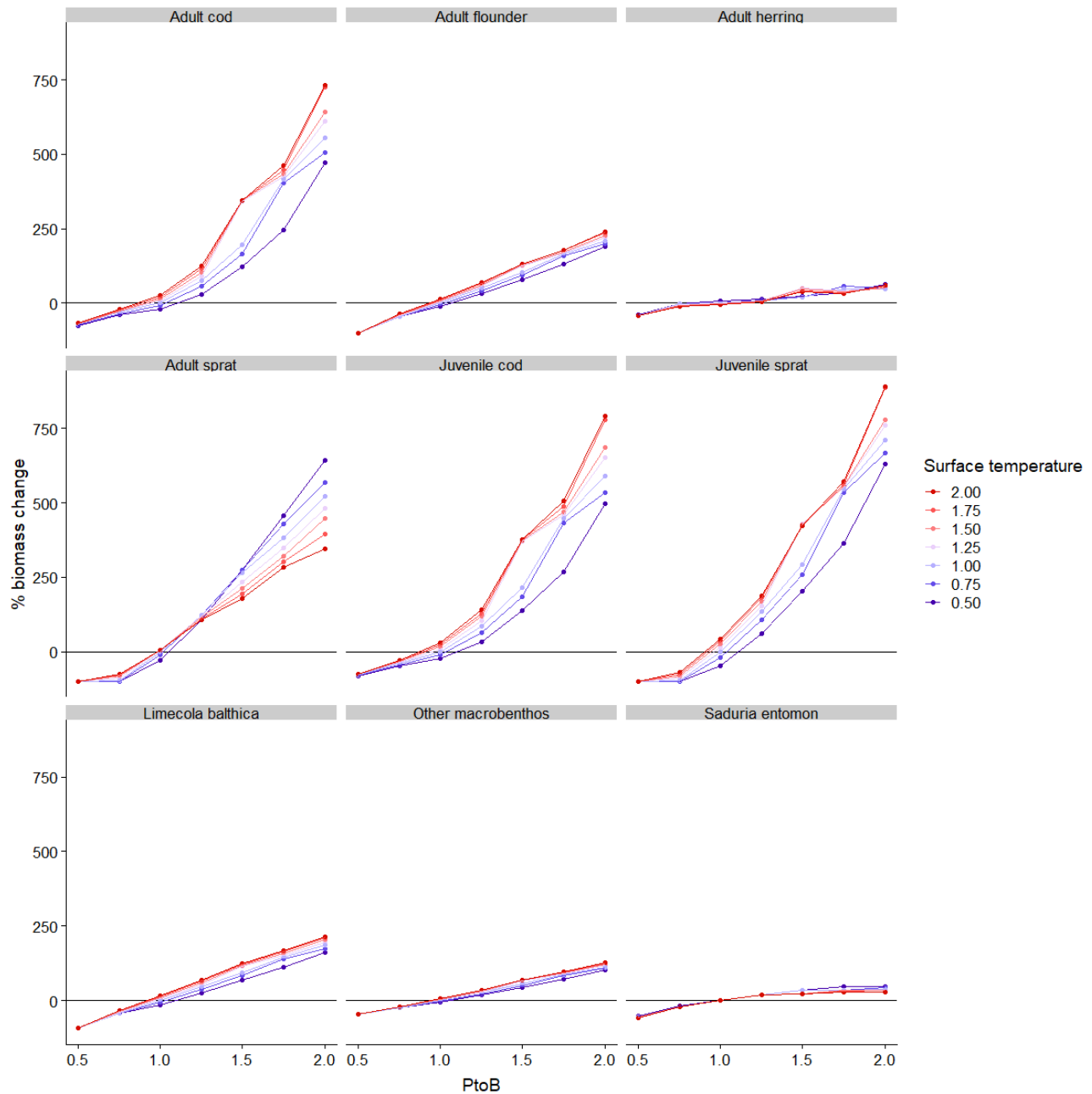


Figure S 2.2 Change in biomass of all studied functional groups as a function of relative changes in P/B and T_{Surf}, where 1 denotes baseline forcing. Biomass change is relative to baseline equilibrium value. Horizontal line means no change.

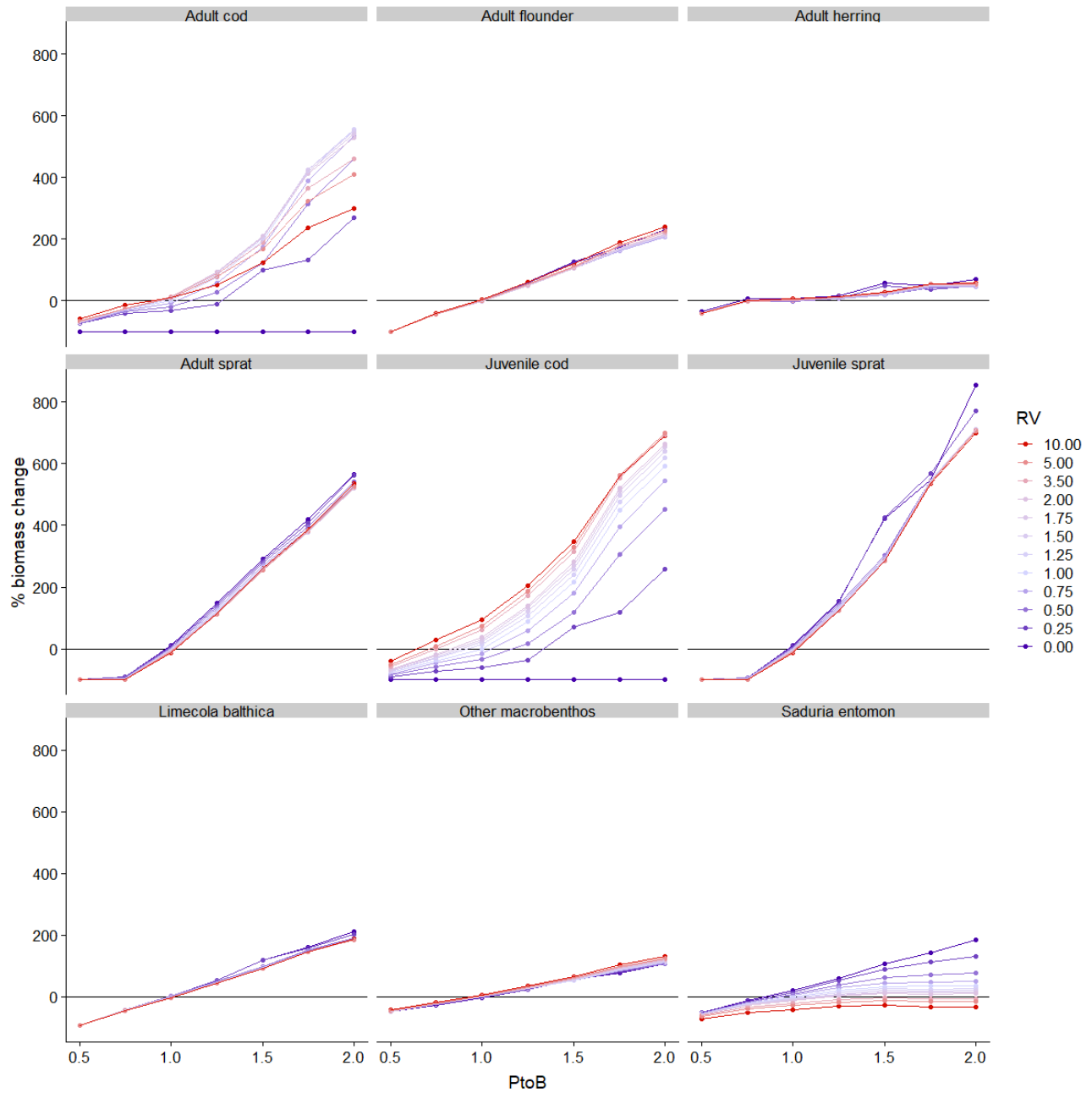


Figure S2.3 Change in biomass of all studied functional groups as a function of relative changes in P/B and CodRV, where 1 denotes baseline forcing. Biomass change is relative to baseline equilibrium value. Horizontal line means no change.

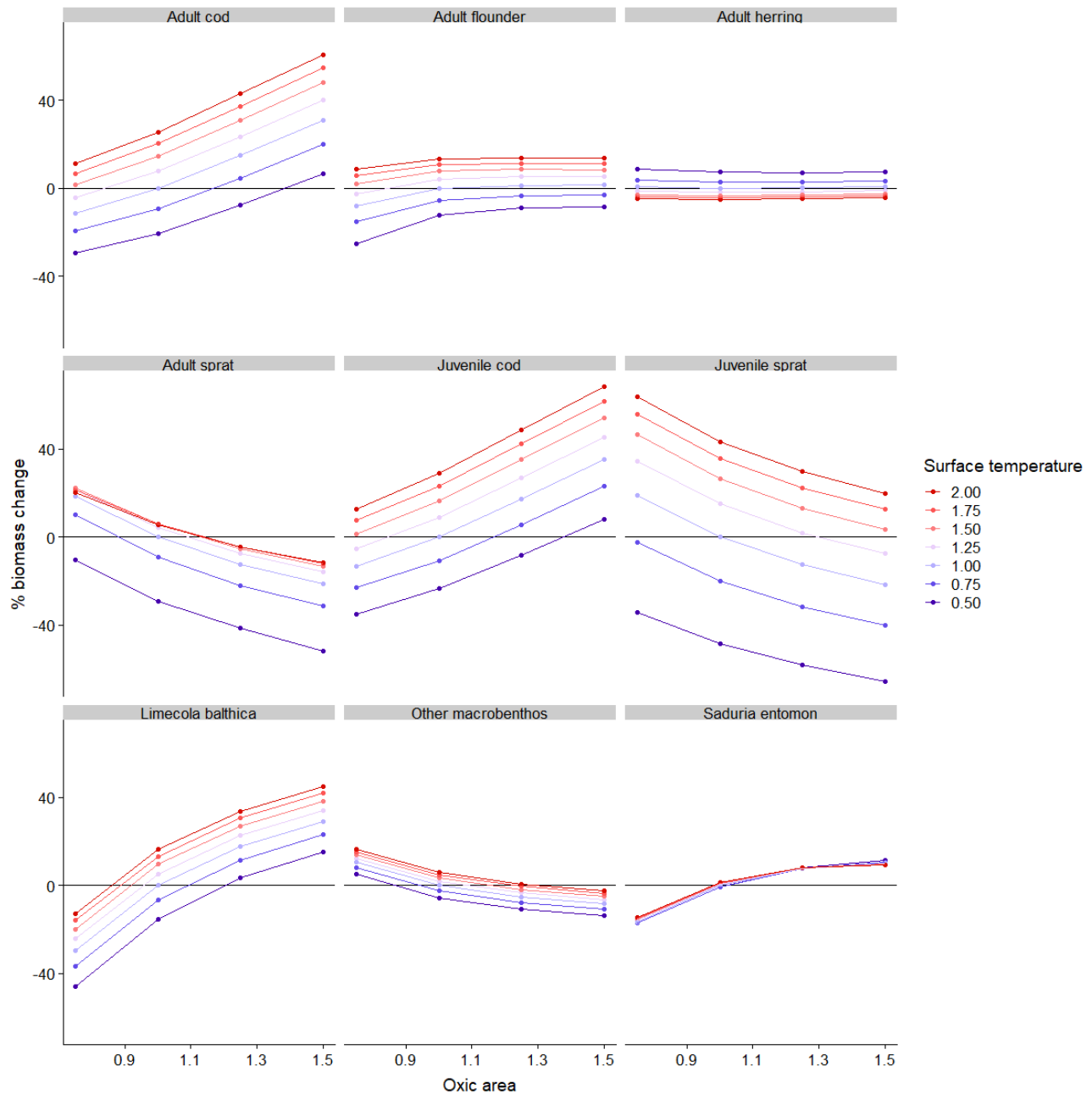


Figure S2.4 Change in biomass of all studied functional groups as a function of relative changes in OxAr and TSurf, where 1 denotes baseline forcing. Biomass change is relative to baseline equilibrium value. Horizontal line means no change.

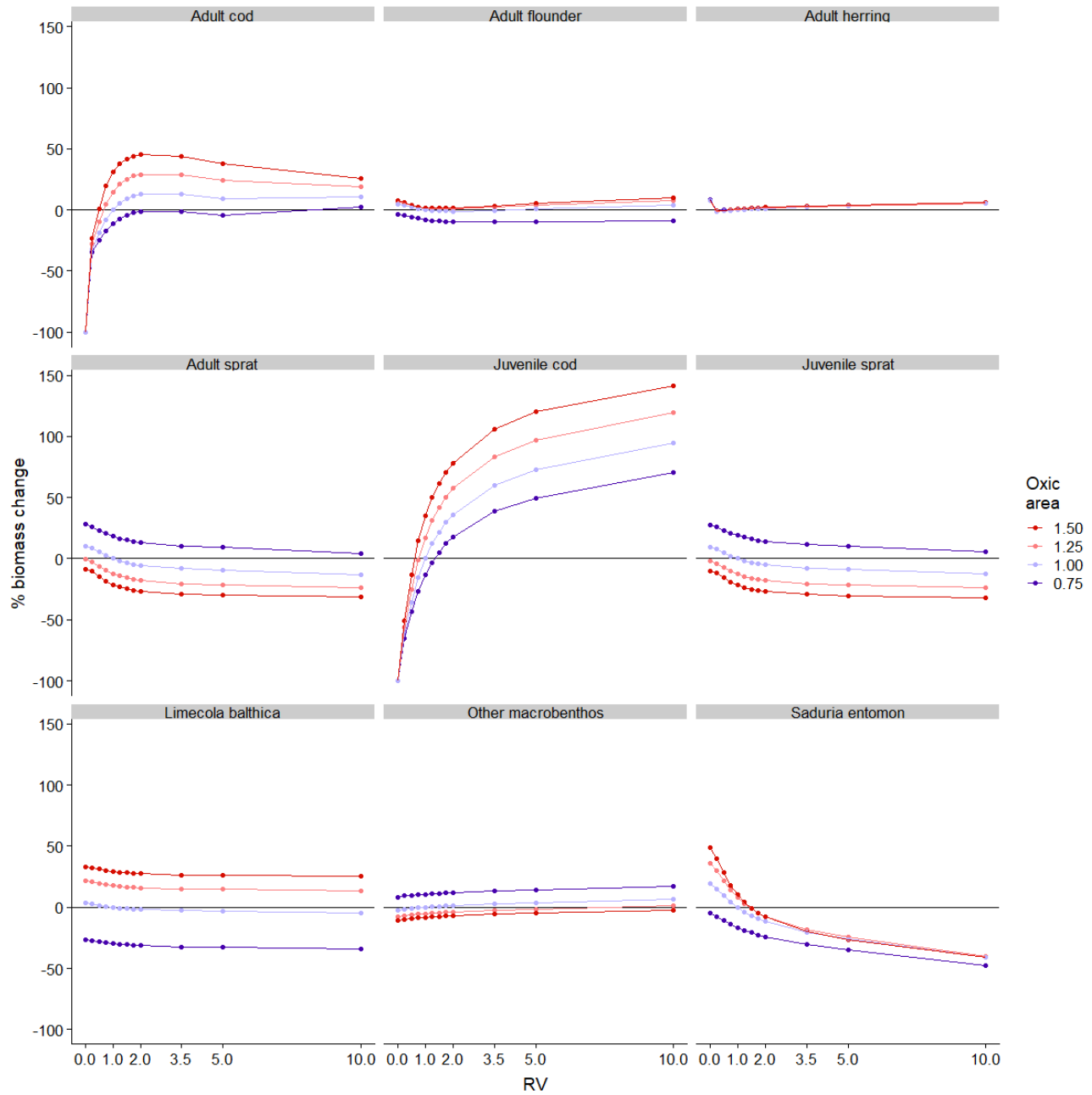


Figure S2.5 Change in biomass of all studied functional groups as a function of relative changes in CodRV and OxAr, where 1 denotes baseline forcing. Biomass change is relative to baseline equilibrium value. Horizontal line means no change.

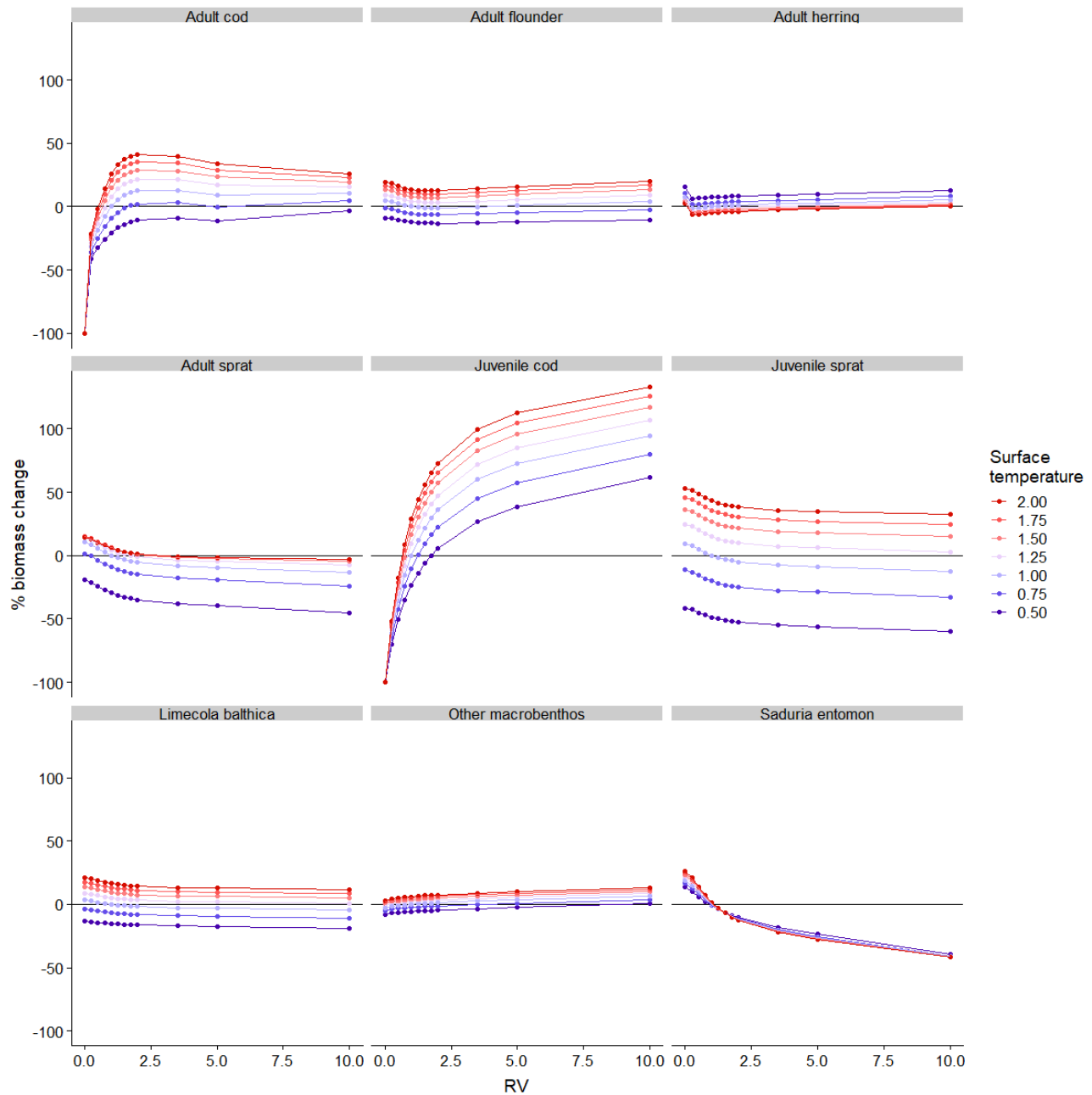


Figure S2.6 Change in biomass of all studied functional groups as a function of relative changes in CodRV and TSurf, where 1 denotes baseline forcing. Biomass change is relative to baseline equilibrium value. Horizontal line means no change.

3 All biomass responses – BM model

For clarity, only a subset of the simulation results are shown in the main manuscript. This supplement shows the effects of all tested combinations of environmental forcing levels on the biomasses of all studied functional groups in the Benthic Macrofauna (BM) model.

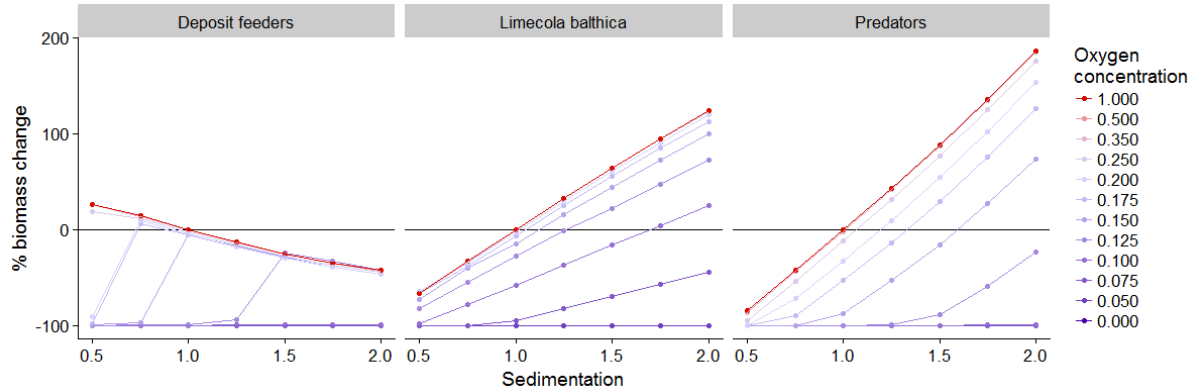


Figure S3.1 Change in biomass of all studied functional groups as a function of relative changes in Sed and O2Conc, where 1 denotes baseline forcing. Biomass change is relative to baseline equilibrium value. Horizontal line means no change.

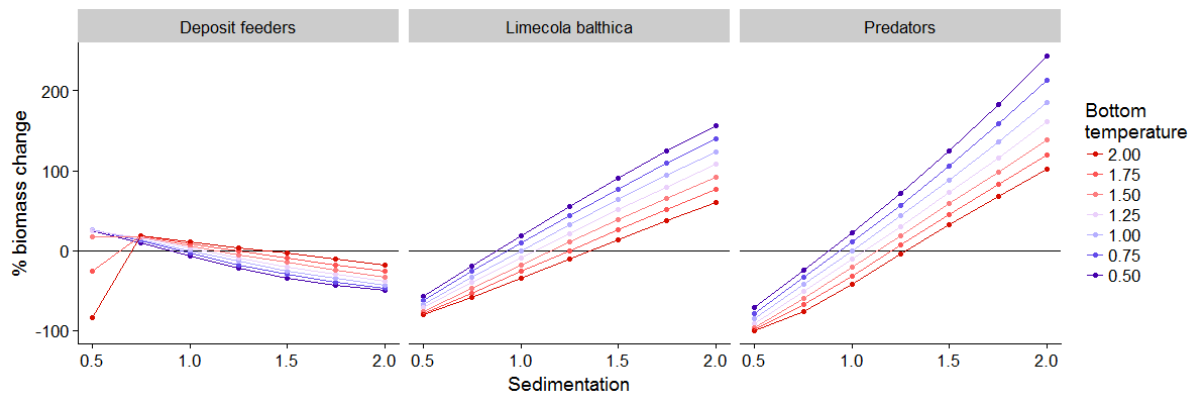


Figure S 3.2 Change in biomass of all studied functional groups as a function of relative changes in Sed and TBot, where 1 denotes baseline forcing. Biomass change is relative to baseline equilibrium value. Horizontal line means no change.

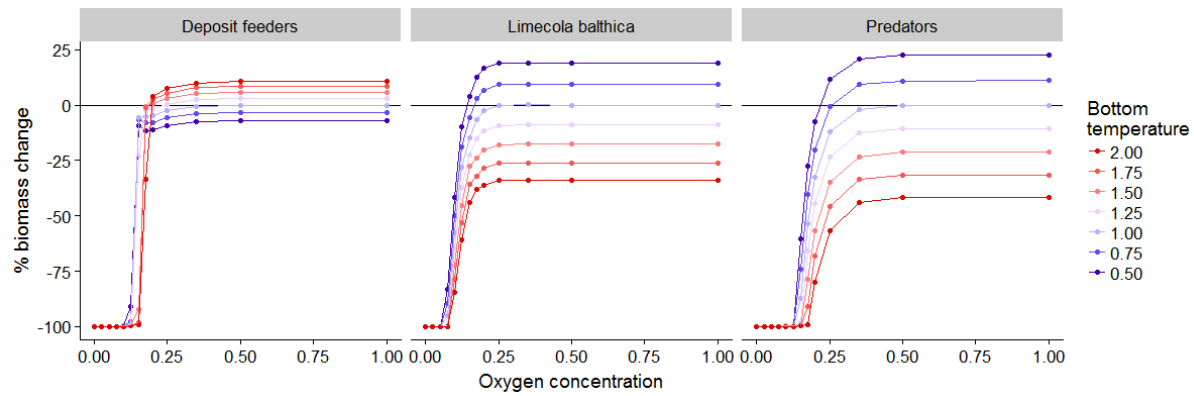


Figure S3.3 Change in biomass of all studied functional groups as a function of relative changes in O2Conc and TBot, where 1 denotes baseline forcing. Biomass change is relative to baseline equilibrium value. Horizontal line means no change.