Cavan et al. 2018 – Supplementary Material

Supplementary Methods

Sensitivity analyses

The entire MTE model was reran with two other export efficiency algorithms (Supplementary Fig 1) (Arteaga *et al.*, 2018), firstly from Laws *et al.* (2000, 2011):

$$e - ratio = 0.05 * \ (\left(0.78 - \frac{0.43 * SST}{30}\right) * \left(PP * \frac{1000}{30.42}\right)^{0.31}) \qquad \text{(Equation S1)}$$

And then Britten *et al.* (2017):

$$e - ratio = \left(3.72 + (-0.16 * SST) + (-0.04 * [Si])\right) * (\mathrm{PP} \ * \ 1000/30.42/12)^{-0.55} \qquad \text{(Equation S2)}$$

where [Si] is silicate concentration downloaded from the WOA. We also reran the analysis using a different primary production algorithm (Supplementary Fig 2), the Carbon-based Productivity Model (CbPM, also downloaded from the Ocean Productivity site) and all three export algorithms (Supplementary Fig 3). All of these sensitivity analyses are presented in Table S2 and the supplementary material. Finally, we reran our MTE (Henson) model but varied the temperature term (*T*) by 0.5 and then 3.5 C.

Supplementary Results

Sensitivity analysis

Changing the mass term by changing the magnitude of export (by changing the primary productivity and the e-ratio) did not change the total decline in export by 2100 (Table 1), even though the CbPM estimated one third more ‘present-day’ primary production at 69 Gt C yr^{-1}. The Laws e-ratio algorithm had the highest global mean e-ratio of 31 % compared to 9 % for Henson and 8 % for Britten. The high Laws e-ratio resulted in higher export at 100 m of 17.9 Gt C yr^{-1}, compared to 3.0 and 1.9 Gt C yr^{-1} for Henson and Britten respectively. As the only change between the beginning and end of the century was the change in temperature, changing the input mass term still resulted in a decline in export of 12 % (Supplementary Table 1).

Table S1. Models used in this analysis. Control, historical and forced runs (RCP8.5) were downloaded from the IPCC CMIP5 archive (http://pcmdi9.llnl.gov/).

Modeling Center (or Group)	**Institute ID**	**Model Name(s)**	**Biogeochemical model**	**Reference**
Max Plank Institute	MPI	MPI-MR MPI-LR	HAMOCC	Jungclaus *et al.*, 2013
NOAA Geophysical Fluid Dynamics Laboratory	NOAA GFDL	GFDL-ESM2G GFDL-ESM2M	TOPAZ2	Dunne et al. 2013
Met Office Hadley Centre (additional HadGEM2-ES realizations contributed by Instituto Nacional de Pesquisas Espaciais)	MOHC (additional realizations by INPE)	HadGEM2-CC HadGEM2-ES	diat-HadOCC	Collins et al. 2011
Institut Pierre-Simon Laplace	IPSL	IPSL-CM5A-LR IPSL-CM5A-MR	PISCES	Seferian et al. 2013

Table S2. Reduction in export between 2003 and 2100 according to MTE using different primary production and export efficiency algorithms; VGPM and CBPM are the primary productivity models and Hen (Henson *et al.*, 2012), Laws (Laws *et al.*, 2000, 2011) and Brit (Britten *et al.*, 2017) the export efficiency algorithms. The final column shows the results of temperature sensitivity runs using VGPM, Hen and the median change in temperature projected by 2100 + (Large) and – (Small) the standard deviation of the historical and future temperature from the 8 CMIP5 models.

		VGPM			**CBPM**			**Temperature**	
		Hen	**Laws**	**Brit**	**Hen**	**Laws**	**Brit**	**Small**	**Large**
Export ($GtC\ yr^{-1}$)	2003	2.9	17.9	1.9	3.1	21.6	2.0	3	3
	2100	2.6	15.5	1.6	2.7	19.0	1.8	2.4	1.1
Change in … 2003 - 2100 (%)	PP	10.5	10.5	10.5	10	10	10	11	11
	R	22.5	22.5	22.5	22	22	22	29	71
	Export (R - PP)	12	12	12	12	12	12	18	60

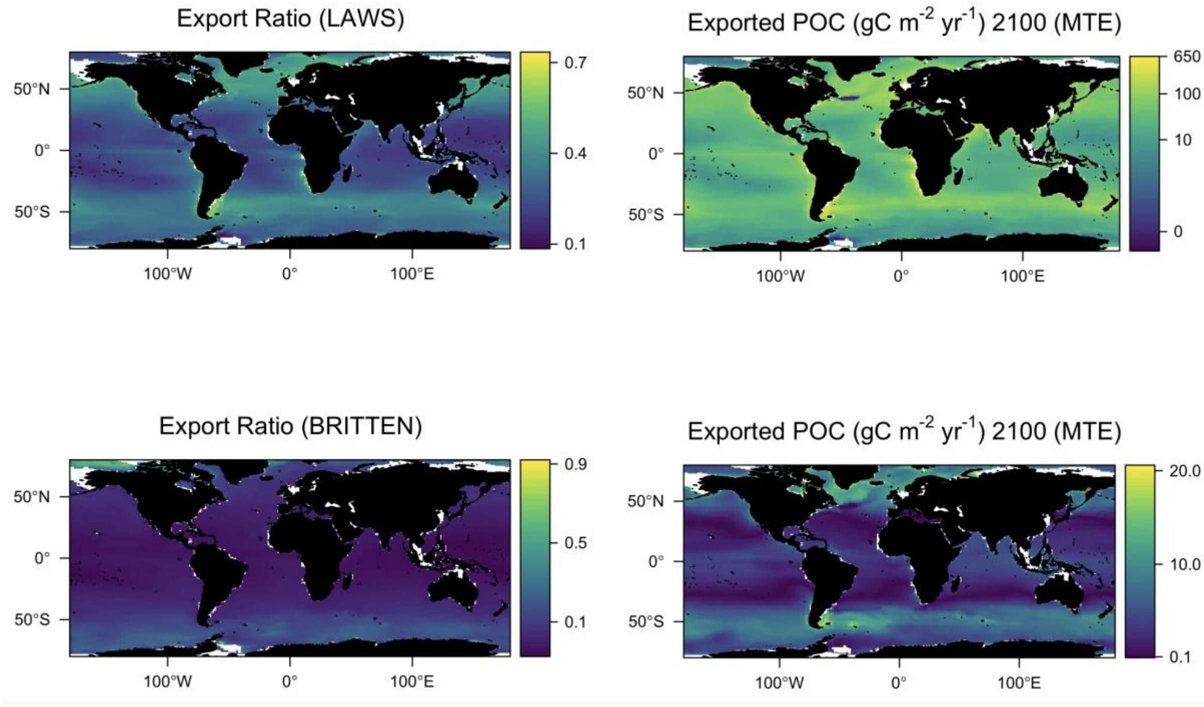

Fig. S1. E-ratio and exported POC in 2100 according to MTE using Laws and Britten algorithms.

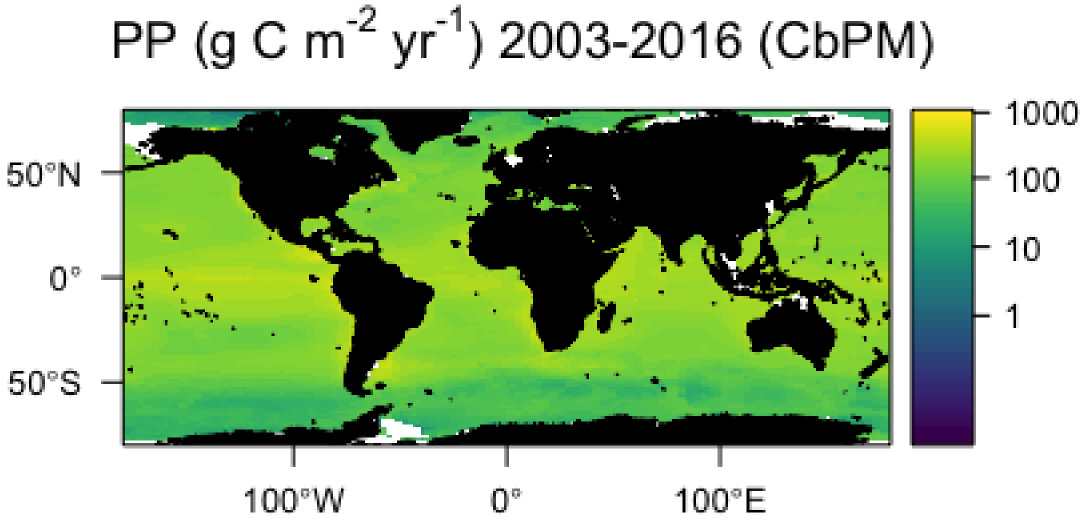

Fig. S2. Climatology of primary production (2003 – 2016) according to the CbPm algorithm used in the sensitivity analyses (Table S2).

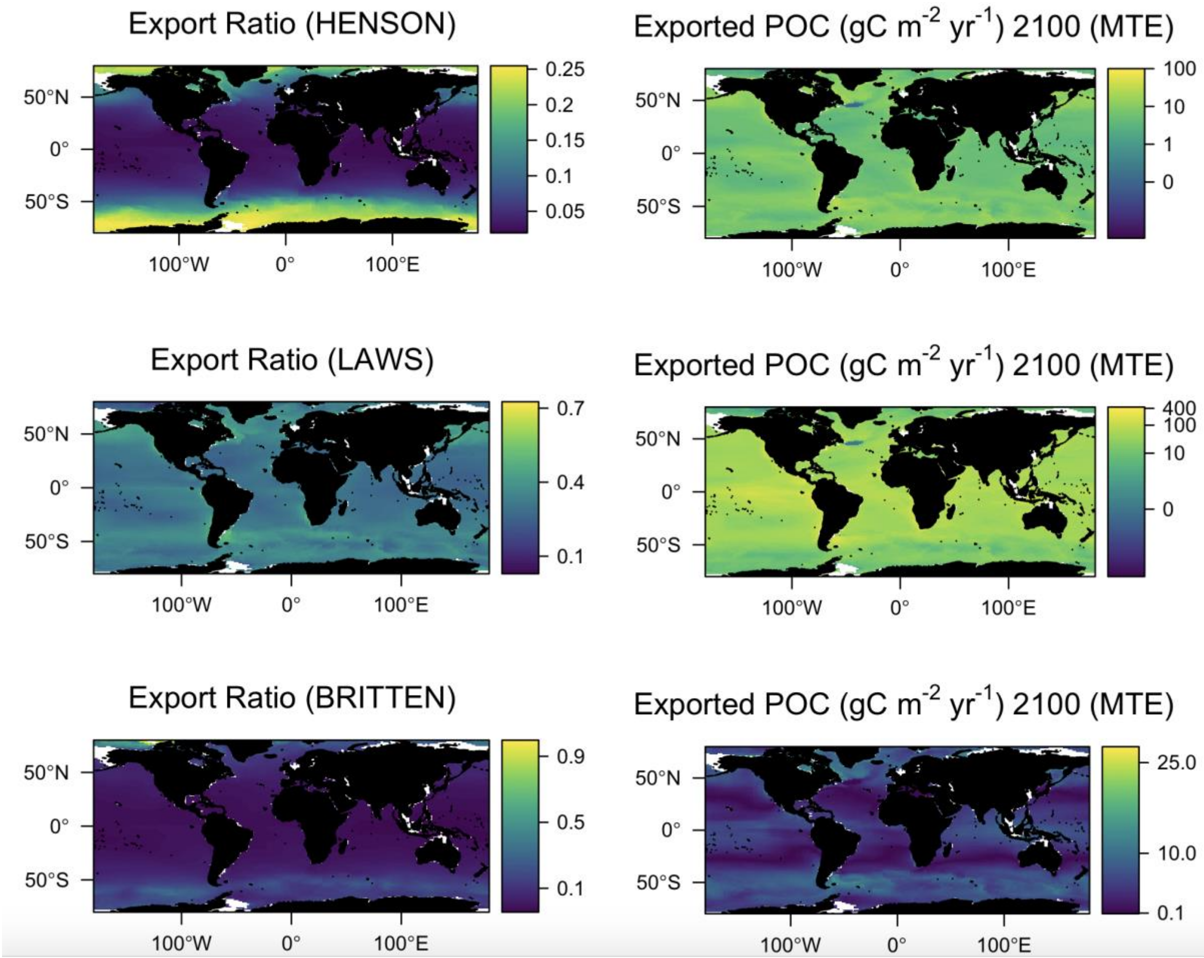

Fig. S3 export ratio and POC exported in 2100 using CbPM for primary production and Henson, laws and britten algorithms.