It's Not Just About Sea Surface Temperature: Synthesizing Information to Communicate Climate Change Projections for European Seas

Susan Kay[1]

[1]Plymouth Marine Laboratory

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Abstract

Environmental change in coastal and shelf seas provides a challenge to fisheries and aquaculture worldwide. Coupled physical-biogeochemical models can be used to create projections of environmental conditions under different climate scenarios, but models of this type produce a wealth of information covering multiple environmental variables and a range of timescales. It is challenging to synthesize that information into a form which can be quickly and effectively conveyed to stakeholders. I describe how a range of approaches has been used to analyse projections of environmental conditions in European seas, created using a regional model with a resolution of 0.1 degrees. The projections run from the present-day to 2099 and include temperature, primary production, plankton biomass, pH and nutrient and oxygen concentrations for moderate and high carbon concentration scenarios. A range of formats that convey the scale and extent of projected change in the North East Atlantic, the North Sea and the Mediterranean, are included, aiming for simple, visual communication that goes beyond maps of changing sea surface temperature. Colour-coded tables show at a glance which variables are projected to show significant change at a range of locations. Time series and maps are used together to give complementary information. Contours show geographical shifts in conditions. In each case the content can be adjusted to fit the interests of different stakeholder groups: examples from fisheries and aquaculture are included here.

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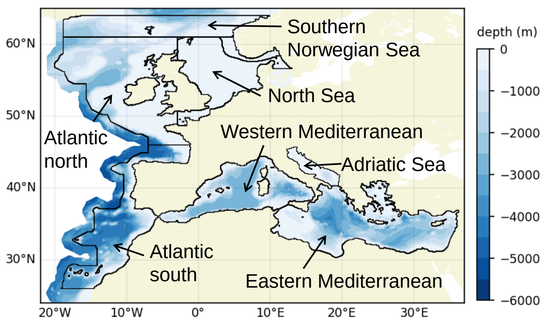
Susan Kay,
Plymouth Marine Laboratory
suka@pml.ac.uk

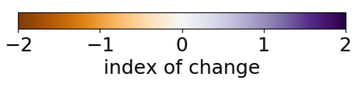
Users of climate model data often use maps of sea surface temperature as a quick way into the data. But outputs from regional climate models with a biogeochemical component contain a wealth of data of interest to stakeholders. How can we convey more information quickly and effectively?

RCP 8.5	SST	SBT	surface salinity	MLD	net PP	euphotic layer chl	phytoplankton	zooplankton	bottom O_2	surface pH	surface N	surface P	surface Si
Southern Norwegian Sea	0.9	0.1	-0.35	-29.4	-0	0.098	1	-8	-91.0	-0.078	-1.27	-0.09	-2.94
Atlantic north of 46°N	1.1	0.0	-0.59	-9.8	-7	-0.014	-78	3	-41.1	-0.038	-1.65	-0.13	-3.36
North Sea	1.7	1.5	-0.68	-1.9	-5	-0.033	-146	-43	-13.0	-0.025	-0.31	-0.12	-3.81
Atlantic south of 46°N	1.8	0.4	-0.43	-4.1	-76	-0.056	-329	-186	-12.2	-0.022	-0.18	-0.07	0.11
Western Mediterranean	2.3	2.0	0.03	-2.6	45	0.063	113	125	-29.2	-0.041	0.03	0.12	-0.45
Adriatic Sea	2.3	2.1	0.44	-1.0	39	0.036	48	95	-15.7	-0.057	0.09	0.27	-0.32
Eastern Mediterranean	2.5	2.0	0.49	-1.4	11	0.030	8	48	-19.8	-0.057	0.01	0.17	-0.35

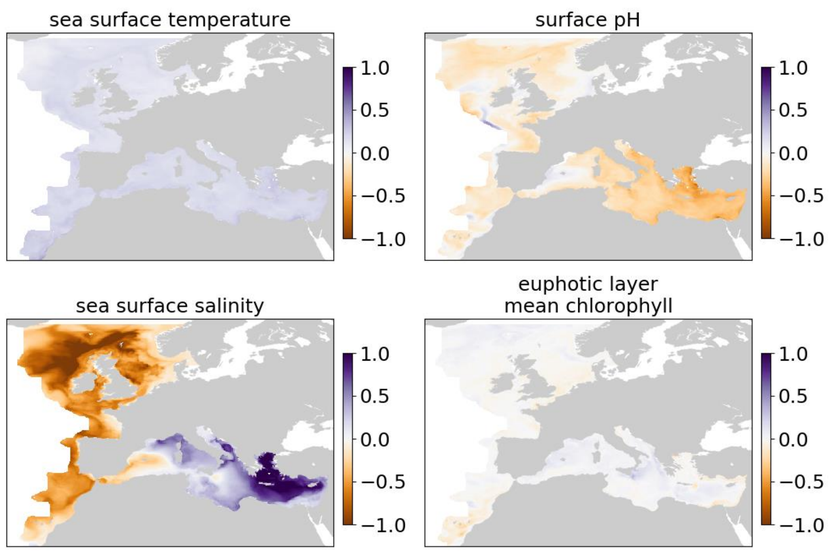


I have used outputs from a coupled physical-biogeochemical model for European seas to demonstrate some ideas. More details about the model are given at the bottom of this poster. The plot to the left shows the model domain and regions.

RCP 4.5													
Southern Norwegian Sea	0.4	-0.1	-0.23	-9.1	-0	0.056	0	-4	-73.1	-0.058	-0.47	-0.04	-1.93
Atlantic north of 46°N	0.4	-0.1	-0.50	-4.4	-5	-0.006	-70	22	-42.4	-0.047	-0.82	-0.07	-2.96
North Sea	0.7	0.5	-0.53	-1.0	-13	-0.039	-116	-39	-4.7	-0.027	-1.09	-0.09	-3.90
Atlantic south of 46°N	0.9	0.3	-0.34	-1.6	-37	-0.037	-182	-40	-6.7	-0.029	-0.08	-0.04	0.43
Western Mediterranean	1.0	1.1	0.17	-1.1	54	0.085	169	140	-10.7	-0.037	0.10	0.15	0.17
Adriatic Sea	1.0	0.8	0.37	-0.2	35	0.045	112	106	-6.3	-0.049	0.14	0.26	-0.16
Eastern Mediterranean	0.9	1.2	0.33	-0.2	31	0.086	169	123	-9.7	-0.043	0.08	0.19	-0.21



SST: sea surface temperature (ºC); SBT: sea bottom temperature (ºC); surface salinity (psu); MLD: mixed layer depth (m); netPP: column total net primary production (mg C m^{-2} day^{-1}); euphotic layer chl: chlorophyll concentration averaged over the euphotic depth (mg m^{-3}); phytoplankton: column total (mg C m^{-2}); zooplankton: column total (mg C m^{-2}); bottom O2: bottom level dissolved oxygen concentration (mmol m^{-3}); surface N: surface nitrate concentration (mmol m^{-3}); surface P: surface phosphate concentration (mmol m^{-3}); surface Si: surface silicate concentration (mmol m^{-3})



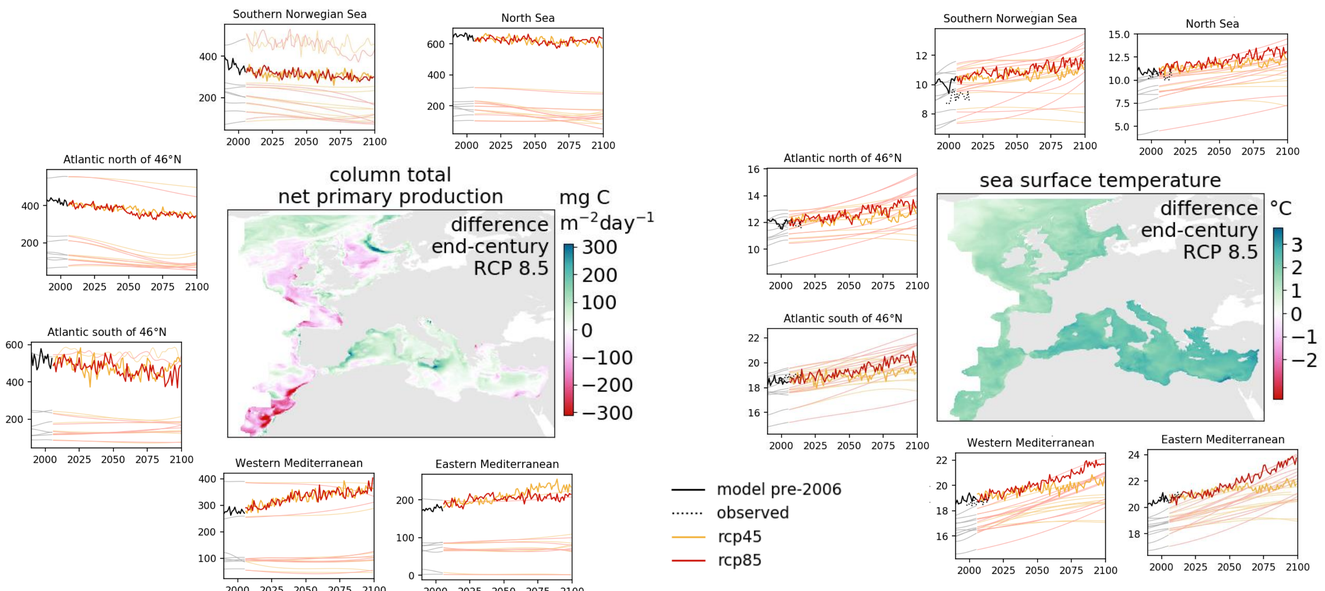
Scaled plots showing projected change at the end of the century under RCP 8.5; see the paragraph to the right for a description of the scaling method. The variables shown are key for the shellfish aquaculture industry.

Scale the change in different variables using the present-day range

The table above shows projected change in multiple variables. The numbers give the change from the first 20 years of this century to the last 20 years. The colour shows the change divided by the difference between the maximum and minimum monthly values for 2000-2019. If the change is not significantly different compared to the present-day range the number is shown in grey. This method enables multiple variables to be compared and gives a sense of how the change compares to present-day variability. It can also be used to scale spatial plots (right).

Times series and maps show complementary information

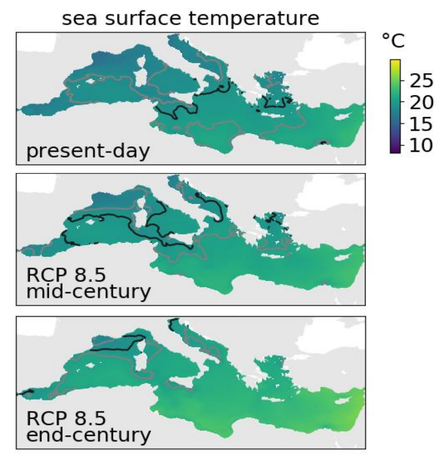
Use them together, for multiple variables and multiple models.



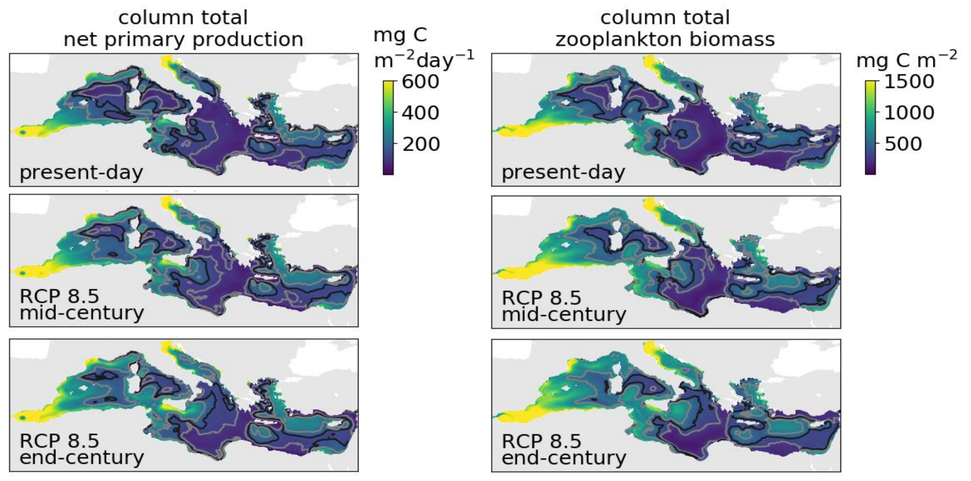
Contours show changing distribution

These plots show contours at the values of the present-day median (black) and lower and upper quartiles (grey) overlaid on the spatial distributions for the present-day, mid-century and end-century.

For sea surface temperature, the northward shift is clear:

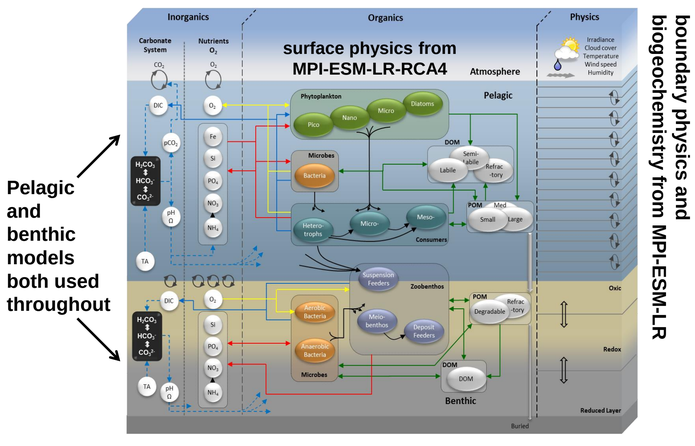


But fisheries-relevant biological variables don't show such clear patterns:



Model information

- Physical model POLCOMS[1]: baroclinic B-grid model suitable for shelf seas and deep water areas.
- Biogeochemical model ERSEM[2]: four phytoplankton functional types, three zooplankton, bacterial loop, independent tracking of C, N,P, Si, separate benthic model.
- Horizontal resolution 0.1º x 0.1º, 40 vertical levels, modified sigma distribution.
- Surface forcing from the global CMIP5 model MPI-ESM-LR[3] downscaled by the regional model RCA4.
- Open ocean boundary conditions from the global model MPI-ESM-LR.
- River flow, N and P from the hydrological model E-HYPE, also driven by MPI-ESM-LR.



Pelagic and benthic models both used throughout

boundary physics and biogeochemistry from MPI-ESM-LR

The model outputs are available from the Copernicus Climate Data Store: cds.climate.copernicus.eu dataset sis-marine-properties

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References

1. Butenschön, M., et al., 2016. ERSEM 15.06: a generic model for marine biogeochemistry and the ecosystem dynamics of the lower trophic levels. Geosci Model Dev 9, 1293–1339. 2. Holt, J.T., James, I.D., 2001. An s coordinate density evolving model of the northwest European continental shelf 1, Model description and density structure. J. Geophys. Res. 106, 14015–14,034. 3. http://www.mpimet.mpg.de/en/science/models/mpi-esm.html
Further information about the model can be found in Kay et al. 2018. Projections of physical and biogeochemical parameters and habitat indicators for European seas, including synthesis of Sea Level Rise and storminess. https://cordis.europa.eu/project/id/678193/results

Contact us: PML,Prospect Place, The Hoe, Plymouth, PL1 3DH, United Kingdom T +44(0)1752 633100 W www.pml.ac.uk E forinfo@pml.ac.uk