Centre for Environment Fisheries & Aquaculture Science

Cefas

World Class Science for the Marine and Freshwater Environment

UK marine ecosystem impacts under future warming pathways

Climate projection summary

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UK marine climate projections

Climate change models for UK seas are downscaled from global climate models using additional information about local processes. The most recent and detailed UK marine climate models tend to use the high emission scenario (RCP8.5), and to a lesser extent, the moderate mitigation emissions scenario (RCP4.5).

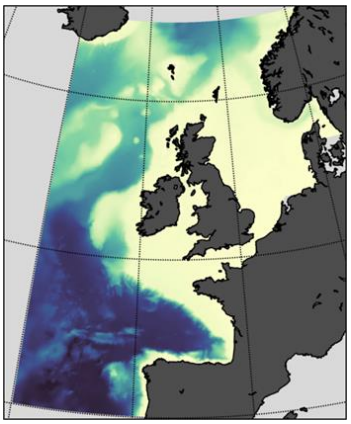
The climate model projections, or outcomes (i.e. projected sea temperature increase), that are available for UK seas vary depending on: the climate scenario behind the model; the global model simulation/s used; the local or downscaled models and simulations used; and the number of ensemble members. The differences between the climate model simulations that have been run provide an indication of uncertainty. Table 1 summarises the most recent downscaled climate models that we identified in our review, that are available for UK marine ecosystem studies. A more detailed description for each is available in Appendix 1.

Climate models include a wide range of physical and biogeochemical variables that can be used to project ecosystem impacts of climate change. The most commonly used variables are temperature, salinity, currents, phytoplankton and pH as these are available in some or many climate models. Other variables are captured in climate models and can be used as appropriate and on request, where climate modellers can provide these. Variable selection depends on the species or habitats under study and how much species variation is explained by the variable.

Table 1. Summary details of recent and available climate models available for UK seas (see Appendix 1 for further details). SST – sea surface temperature; SSS – sea surface salinity; NBT – near bed temperature; DFT – difference in temperature between the surface and bed; PEA – potential Energy anomaly; MLD – Mixed Layer Depth; DOC – dissolved organic carbon; POC – particulate organic carbon; DIC – dissolved inorganic carbon.

Climate scenarios	Model name	Variables modelled	Are there any other variables in your model that may be of interest for species/ecosystem modellers.	Number of ensemble members	Baseline period for climate projection	Time period of projections and are they continuous	Spatial extent	Spatial scale	Vertical resolution
RCP8.5	AMM7-ROAM-HADGEM RCP8.5 NEMO-ERSEM	3D temperature, salinity, currents, phytoplankton, pH	Primary production, phytoplankton, zooplankton, bacteria, nutrients, oxygen, DIC	1 member	1980-2009	1980-2100, continuous	20W-13E, 40N - 65N	7km	32 terrain-following levels
RCP 8.5	AMM7-RECICLE-IPSL RCP8.5	3D temperature, salinity, currents, phytoplankton, pH	Primary production, Zooplankton, DOC, POC, benthic variables, nutrients	1 member	1990-2005	1990-2099, continuous	20W-13E, 40N - 65N	~ 7km	51 terrain following s-levels
RCP 8.5	AMM7-RECICLE-GFDL RCP8.5	3D temperature, salinity, currents, phytoplankton, pH	Primary production, Zooplankton, DOC, POC, benthic variables, nutrients	1 member	1990-2005	1990-2099, continuous	20W-13E, 40N - 65N	~7km	51 terrain following s-levels
RCP4.5 and 8.5	AMM7-C3S	3D temperature, salinity, currents, phytoplankton, pH	Primary production, PEA, Zooplankton, DOC, POC, benthic variables, nutrients	1 member per scenario	1990-2005	1990-2050, continuous	20W-13E, 40N - 65N	~ 7km	51 terrain following s-levels
RCP4.5 and 8.5	POLCOMS-ERSEM-C3SP5	3D temperature, salinity, currents, phytoplankton, pH	Primary production, Zooplankton, DOC, POC, benthic variables, nutrients	1 member per scenario	1990-2005	1990-2099, continuous	20E-35E, 15N - 65 N	~11km	43 terrain following s-levels
RCP4.5 and 8.5	MPIOM-HAMOCC	3D physics and biogeochemistry	Unknown	3	1961-2005	2006-2100	global	<10km on the shelf	30 standard levels
RCP8.5	AMM7 NWSPPE RCP8.5	Temperature (SST, NBT, DFT), Salinity, Currents	Stratification (PEA), water column structure (MLD)	12 member Perturbed Parameter Ensemble	2000-2019	(1980-)1990-2098, continuous	20W-13E, 40N - 65N	7km	51 terrain following s-levels
RCP8.5	FVCOM	Physics only (likely currents, temperature, salinity)	Unknown	Unknown	climatology for present day	climatology for period 2038-2062	13W-13E, 48N-63N	Variable from 500m to 20km	Unknown
RCP4.5 and 8.5	RisesAM-NEA-clim	Wave height	Unknown	Unknown	1970-2006	2005-2100	20W-13E, 40N - 65N	12km	Spectral wave model
RCP8.5	AMM7-NEMO	3D temperature, salinity, currents, stratification	No	11 members forced by 11 global models	1983–2012	1983-2095, continuous	20W-13E, 40N - 65N	7km	51 terrain-following s-levels

Appendix 1 - Description of the selected climate simulations



AMM7-ROAM-HADGEM

NEMO-ERSEM

Domain: AMM7 (40N to 65N; 20W to 13E)

Scenario: high emission scenario (RCP8.5)

Period: 1990-2099

CMIP model used: HadGEM2-ES

Model: NEMO (3.2) – ERSEM (15.06)

Resolution: 7km

Ensemble: 1 member

Variables: 3D physics and biogeochemistry (daily and monthly)

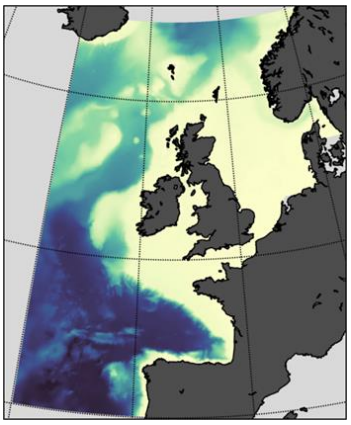
Availability: Data available on request from Plymouth Marine Laboratory published here: https://doi.org/10.1016/j.pocean.2020.102400

Narrative:

This model is driven by a CMIP model with a high sensitivity to greenhouse gas emissions, and therefore the impact of climate change is on the higher end of the variability for this scenario. The sea surface temperature is projected to increase by about 2-4 degrees by the end of the century and the surface salinity is projected to decrease between 1 and 2PSU, with much stronger freshening projected in the Norwegian Trench (up to -4PSU).

By the end of the century, the total net influx of North Atlantic water into the North Sea is projected to decrease by 100%.

AMM7-RECICLE-IPSL RCP8.5



Domain: AMM7 (40N to 65N; 20W to 13E)

Scenario: high emission scenario (RCP8.5)

Period: 1990-2099

CMIP model used: IPSL-CM5A-MR

Model: NEMO (3.6) – ERSEM (20.09)

Resolution: 7km

Ensemble: 1 member

Variables: 3D physics and biogeochemistry (daily and monthly)

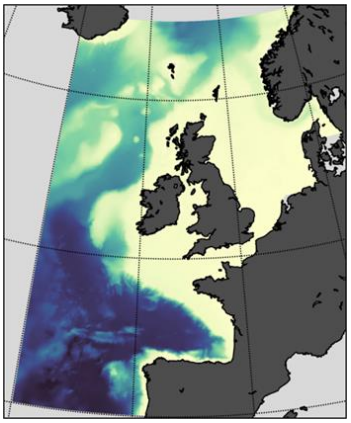
Availability: Data available on request from Plymouth Marine Laboratory, published here: https://doi.org/10.5194/bg-21-2143-2024.

Narrative:

This model is driven by a CMIP model that is quite sensitive to GHG emissions, and therefore the impact of climate change is on the higher end of the variability for this scenario. The sea surface temperature is projected to increase by about 1-3 degrees by the end of the century and the surface salinity is projected to decrease by about 1PSU in most of the domain, with much stronger freshening projected in the Norwegian Trench (up to -4PSU).

By the end of the century, the influx of North Atlantic water into the North Sea is projected to decrease by 70%.

AMM7-RECICLE-GFDL RCP8.5



Domain: AMM7 (40N to 65N; 20W to 13E)

Scenario: high emission scenario (RCP8.5)

Period: 1990-2099

CMIP model used: GFDL-ESM2G

Model: NEMO (3.6) – ERSEM (20.09)

Resolution: 7km

Ensemble: 1 member

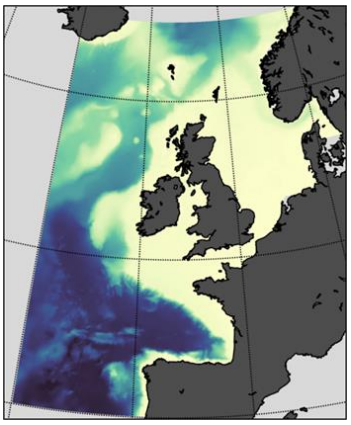
Variables: 3D physics and biogeochemistry (daily and monthly)

Availability: Data available on request from Plymouth Marine Laboratory, published here: https://doi.org/10.5194/bg-21-2143-2024.

Narrative:

This model is driven by a CMIP model with a low sensitivity to GHG emissions, and therefore the impact of climate change is on the lower end of the variability for this scenario. The sea surface temperature is projected to increase by about 1-2 degrees by the end of the century and the surface salinity is projected to decrease by less than 0.5PSU in most of the domain. No significant change in the influx from North Atlantic water into the North Sea is projected.

AMM7-C3S RCP4.5 and 8.5



Domain: AMM7 (40N to 65N; 20W to 13E)

Scenario: high emissions scenario (RCP8.5)

mid-range mitigation scenario (RCP4.5)

Period: 1990-2049

CMIP model used: HadGEM2-ES (downscaled atmosphere)

Model: NEMO (3.6) – ERSEM (20.09)

Resolution: 7km

Ensemble: 1 member

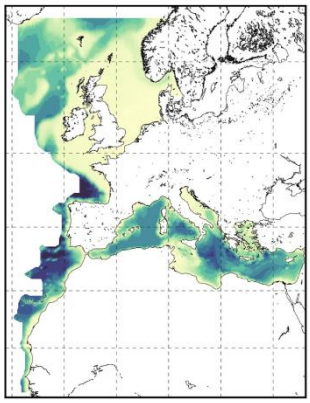
Variables: 3D physics and biogeochemistry (daily and monthly)

Availability: Data available on request from Plymouth Marine Laboratory

Narrative:

This model is driven by a CMIP model with a high sensitivity to GHG emissions, and therefore the impact of climate change is on the higher end of the variability for this scenario. The sea surface temperature is projected to increase between 0.5 and 1.5 degrees by 2050 with surface salinity decreases of less than 0.5 PSU.

POLCOMS-ERSEM-C3S RCP4.5 and 8.5



Domain: Pan European seas

Scenario: high emissions scenario (RCP8.5)

mid-range mitigation scenario (RCP4.5)

Period: 1990-2099

CMIP model used: MPI-ESM-LR (downscaled atmosphere)

Model: POLCOMS-ERSEM

Resolution: 7km

Ensemble: 1 member

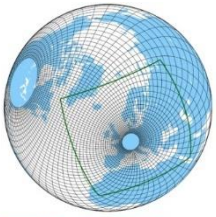
Variables: surface and depth averaged physics and biogeochemistry (daily and monthly)

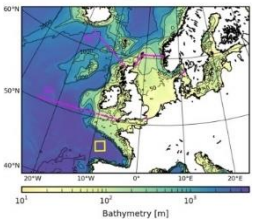
Availability: Data available on request from Plymouth Marine Laboratory

Narrative:

This model is driven by a CMIP model with intermediate sensitivity to GHG emissions, and therefore the intensity of climate change can be considered close to the average for this scenario. The sea surface temperature is projected to increase between 1 and 4 degrees by the end of the century and a freshening of the Atlantic waters between 0.7PSU in open waters and 2-3PSU in Atlantic coastal waters. In contrast, the Mediterranean Sea is projected to increase its salinity up to 1PSU in its Eastern part.

MPIOM-HAMOCC RCP4.5 and 8.5





Domain: global (with focus on North-Western European Shelf)

Scenario: high emission scenario (RCP8.5)

mid-range mitigation scenario (RCP4.5)

Period: 1920-2099

CMIP model used: MPI-ESM-LR

Model: MPIOM-HAMOCC

Resolution: variable, 5-10 km on the shelf, 20 km in the North Atlantic

Ensemble: 3 members (of CMIP model)

Variables: 3D physics and biogeochemistry (monthly)

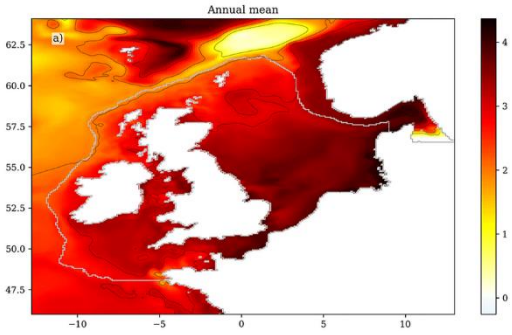
Availability: Data available here: https://www.wdc-climate.de/, published here: https://www.sciencedirect.com/science/article/abs/pii/S0924796318300198?via%3Dihub

Narrative:

This model is driven by a CMIP model with intermediate sensitivity to GHG emissions, and therefore the intensity of climate change can be considered close to the average for this scenario. The sea surface temperature in North-Western European Shelf is projected to increase by about 1.5-2.5 degrees by the end of the century and the surface salinity is projected to decrease by about 0.5 PSU, with a stronger freshening projected in the Norwegian Trench (up to -1.5PSU).

This simulation uses three different ensemble members of the original CMIP model, to explore how the uncertainty of the CMIP model translates in the finer resolution model.

AMM7 NWSPPE RCP8.5



Domain: AMM7 (40°N to 65°N; 20°W to 13°E)

Scenario: high emission scenario (RCP8.5)

Period: 1990-2099

CMIP model used: HadGEM3 GC3.05

Model: NEMO (4.0.4)

Resolution: 7km

Ensemble: 12 members (of the downscaling model)

Variables: 3D physics (daily and monthly)

Availability: Available from https://catalogue.ceda.ac.uk/uuid/7d6c30d625664d4d805e26b385e65964/ with higher frequency data available to collaborators on request from Met Office. Publication available here: OS - Twenty-first century marine climate projections for the NW European shelf seas based on a perturbed parameter ensemble

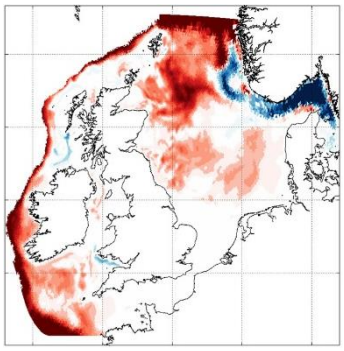
Narrative:

This model is driven by a CMIP model with a high sensitivity to GHG emissions, and therefore the impact of climate change is on the higher end of the variability for this scenario. The sea surface temperature is projected to increase between 2 and 5 degrees by the end of the century and the surface salinity is projected to decrease between 1 and 2 PSU.

This is a 12 members parameter perturbation ensemble, i.e. the driving CMIP model (HadGEM3 GC3.05) has been run 12 times with different values for some parameters to explore the uncertainty linked to the parameters of the model itself. Each of the 12 CMIP simulations as been downscaled with the downscaling model (NEMO 4.0.4) to show how this uncertainty is expressed within the seas around the UK.

These projections are consistent with the UKCP18 climate projections, allowing these marine climate projection data to be used with consistent projected changes in the atmosphere, and land surface.

FVCOM RCP8.5



Domain: NW European Shelf

Scenario: high emissions scenario (RCP8.5)

Period: present day and 2050 climatologies

CMIP model used: HadGEM2-ES (downscaled atmosphere)

Model: FVCOM

Resolution: variable (from 500m near the coast to 20 km)

Ensemble: 1 member

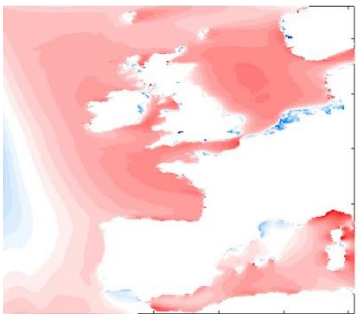
Variables: 3D physics

Availability: Published here: https://doi.org/10.1029/2018jc013832

Narrative:

This model is driven by a CMIP model with intermediate sensitivity to GHG emissions, and therefore the intensity of climate change can be considered close to the average for this scenario. The model projects a warming and freshening of the North Sea although this is not quantified.

RisesAM-NEA-clim RCP4.5 and 8.5



Domain: Pan European seas (focus on NW European Shelf)

Scenario: high emission scenario (RCP 8.5)

mid-range mitigation scenario (RCP4.5)

Period: present day to 2100

CMIP model used: EC-Earth (downscaled)

Model: Wave Watch III

Resolution: 12km

Ensemble: 1 member

Variables: significant wave height and other wave related statistics

Availability: Published here:
https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2018JC013866

Narrative:

This model is driven by a CMIP model with intermediate sensitivity to GHG emissions, and therefore the intensity of climate change can be considered close to the average for this scenario. The model projects that by the end of the century, the significant wave height will decrease by up to 0.2m, with significant spatial and temporal variability (e.g. winter significant wave height increasing, up to 0.1m, in the Celtic Sea, the English Channel and the southern coast of the North Sea). An increase in intensity of rare high wave is projected, although uncertain.

About us

We are the Government's marine and freshwater science experts. We help keep our seas, oceans and rivers healthy and productive and our seafood safe and sustainable by providing data and advice to the UK Government and our overseas partners.

We are passionate about what we do because our work helps tackle the serious global problems of climate change, marine litter, over-fishing and pollution in support of the UK's commitments to a better future (for example the UN Sustainable Development Goals and Defra's 25 year Environment Plan).

We work in partnership with our colleagues in Defra and across UK government, and with international governments, business, maritime and fishing industry, non-governmental organisations, research institutes, universities, civil society and schools to collate and share knowledge.

Together we can understand and value our seas to secure a sustainable blue future for us all, and help create a greater place for living.

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• enable food security
• support marine economies.

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