

Comparative effects of climate change and tidal stream energy extraction in the NW European continental shelf

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Environmental Interactions of Marine Renewable Energy Technologies (EIMR)

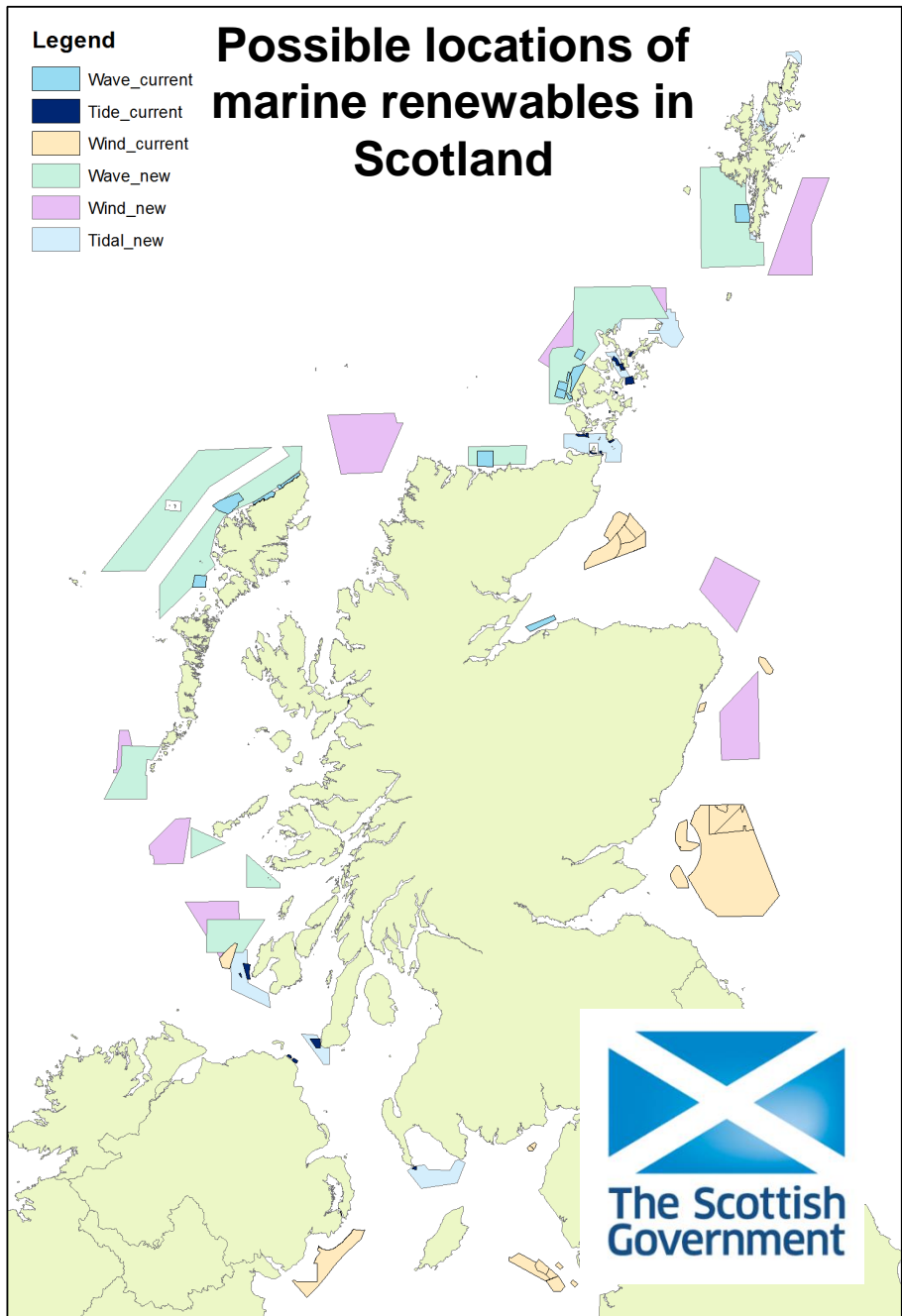
Kirkwall, Orkney, 24-27 April 2018



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ENVIRONMENT

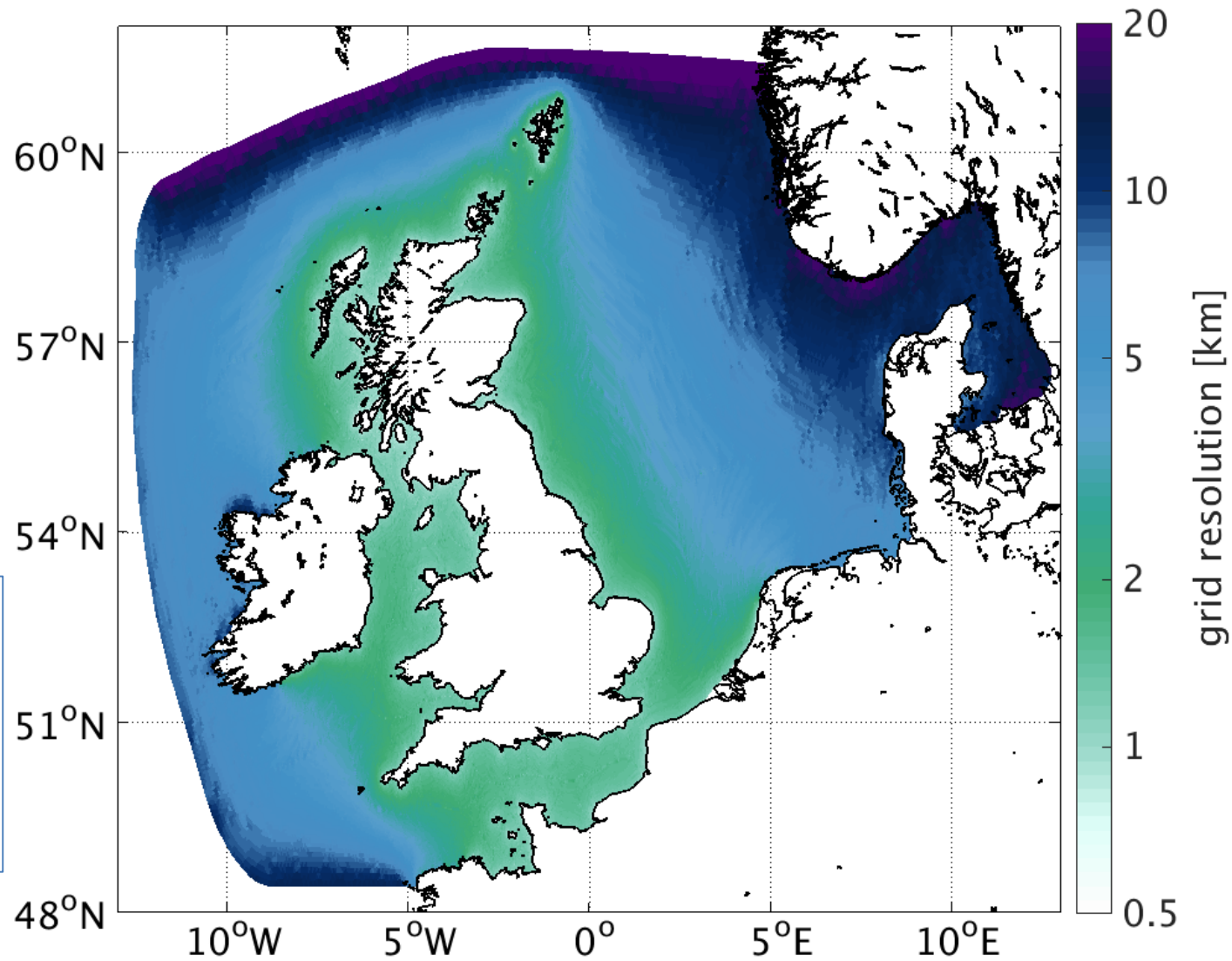


EcoWatt2050

How can marine energy developments affect ocean hydrodynamics, and consequently modify ecosystem habitats and animals' behaviour?

Are there ways in which the deployment of marine renewables may ameliorate or exacerbate the predicted effects of climate change?

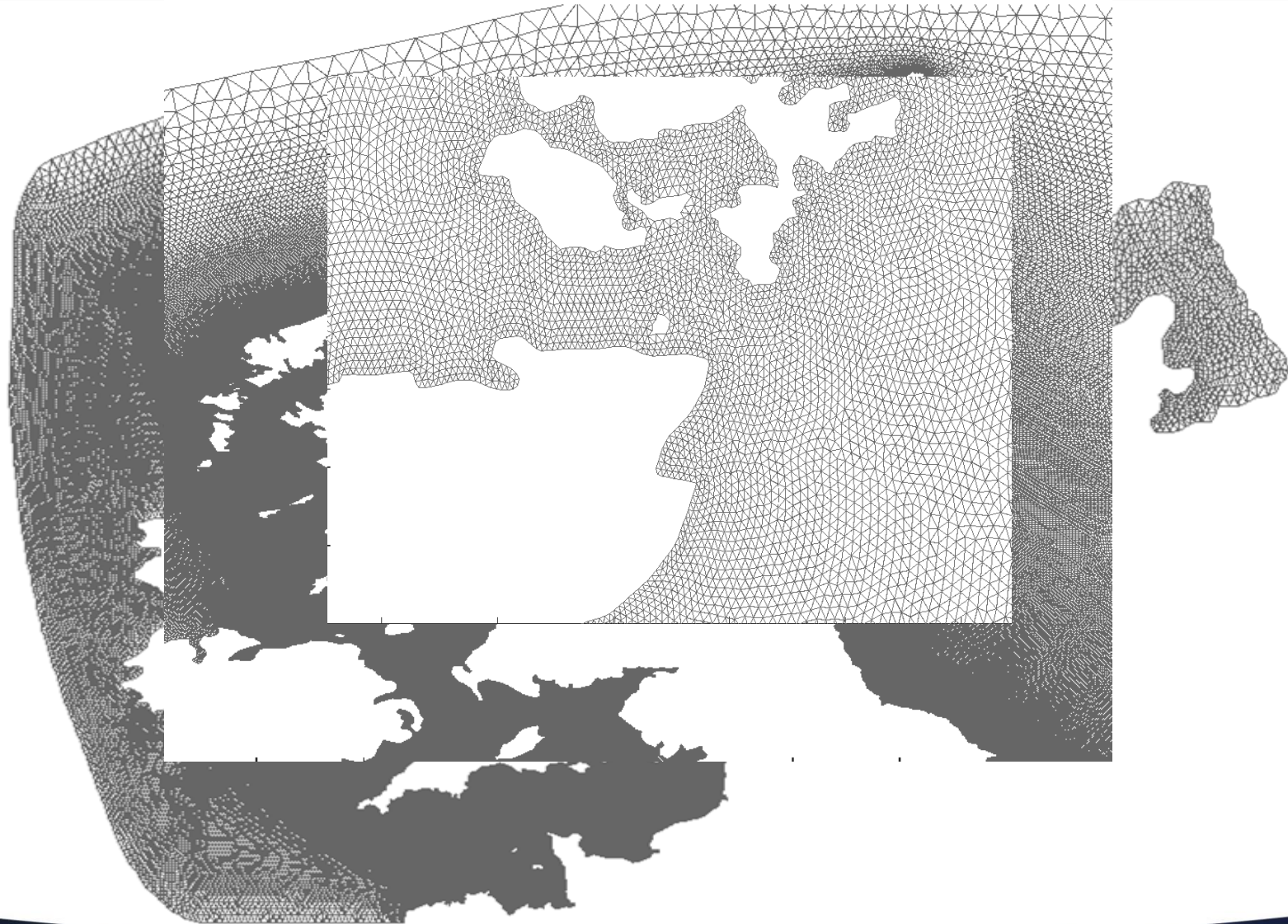
Scottish Shelf Model



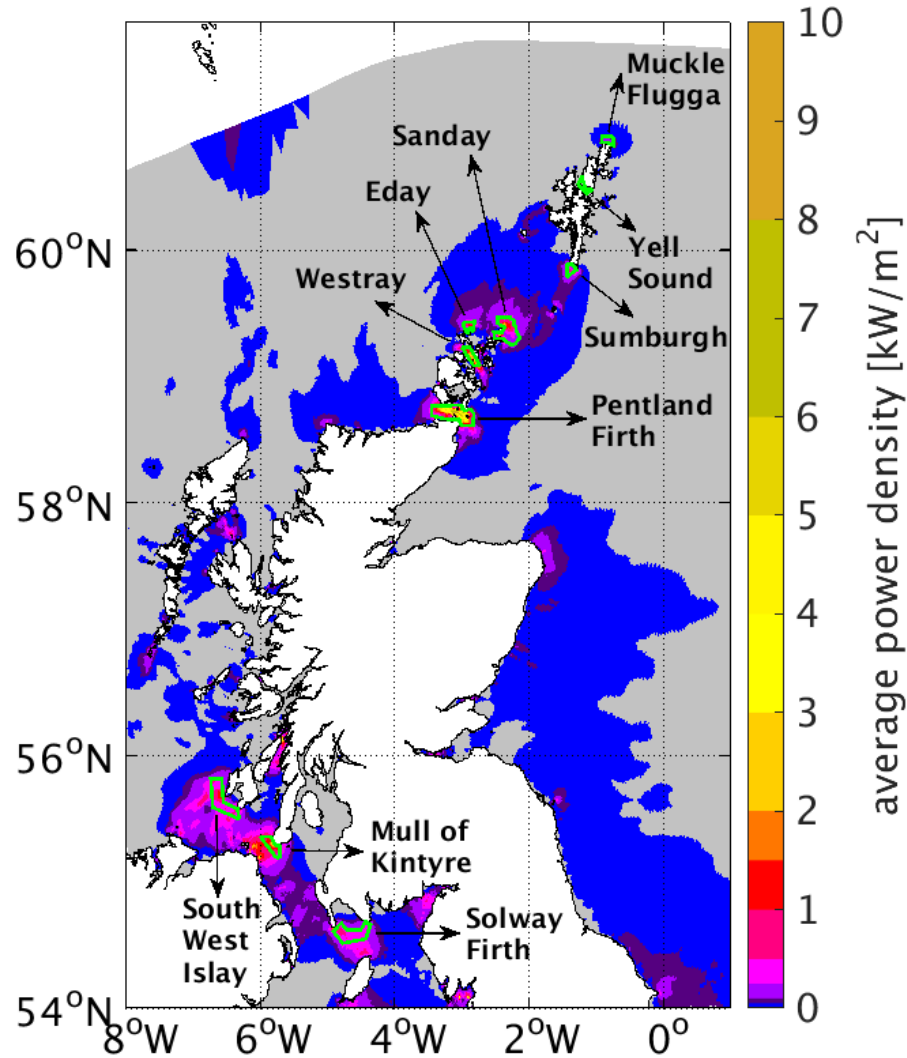
**Unstructured 3D FVCOM
Finite
Volume
Community
Ocean
Model**



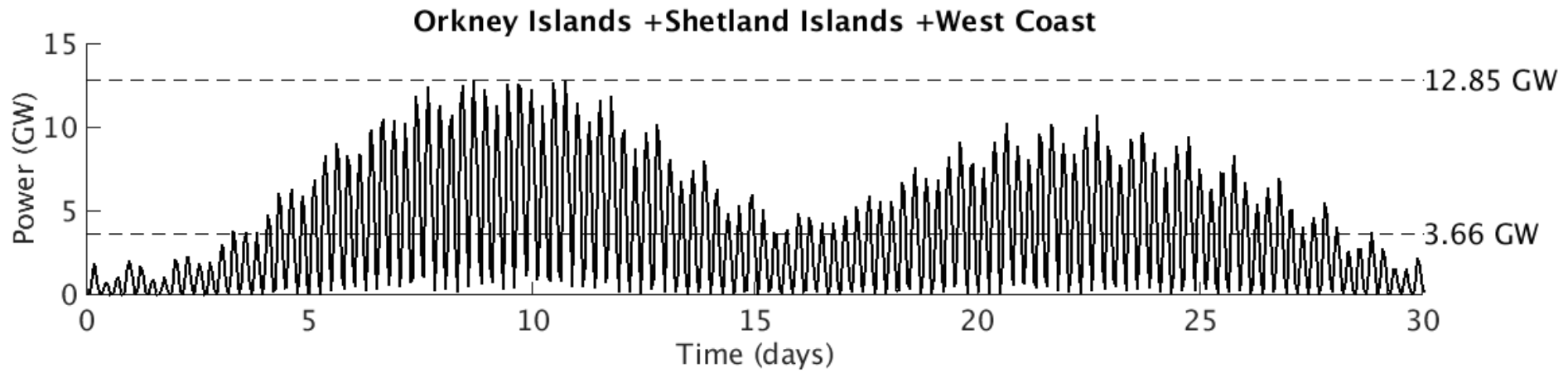
Scottish Shelf Model



Available tidal stream energy in Scottish Waters



Tidal stream turbine array	Average instantaneous power [GW]	
	present	future
Pentland Firth	1.67	1.68
Eday	0.45	0.46
Sanday	0.31	0.32
Westray	0.06	0.06
Mull of Kintyre	0.7	0.7
South West Islay	0.34	0.34
Solway Firth	0.14	0.14
Sumburgh	0.08	0.09
Yell Sound	0.02	0.03
Muckle Flugga	0.003	0.003



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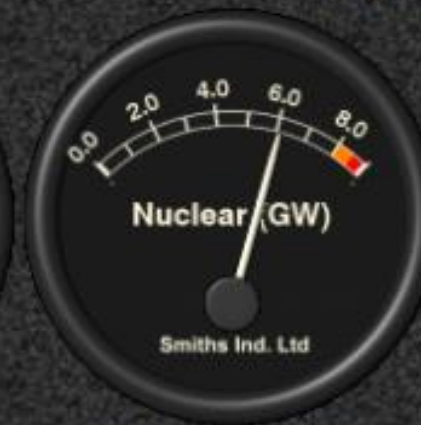
Links

Info

Stats

G.B. National Grid Status

Data courtesy of Elexon portal and Sheffield University



Demand 43.73GW

Frequency 50.077Hz

**Coal 6.04GW
(13.81%)**

**Nuclear 6.14GW
(14.04%)**

**CCGT 22.34GW
(51.09%)**

**Wind 1.50GW
(3.43%)**

34.55 GW is the yearly (2015) average instantaneous electricity consumption (Source: DUKES - www.gov.uk)

Data last recorded on Friday the 9th. of March, 2018 at 11:25 GMT

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Four scenarios



- **Present climate**



- **Present climate & tidal stream energy extraction**



- **Projected future climate in 2050 (RCP8.5 - very high GHG emissions)**

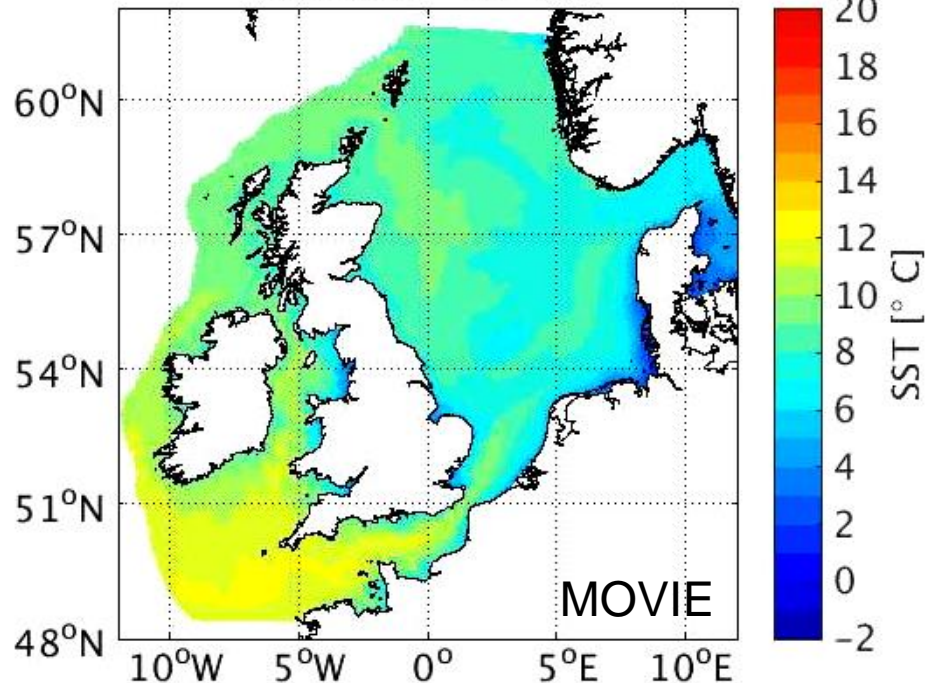


- **Projected future climate in 2050 & tidal stream energy extraction**

Present climate

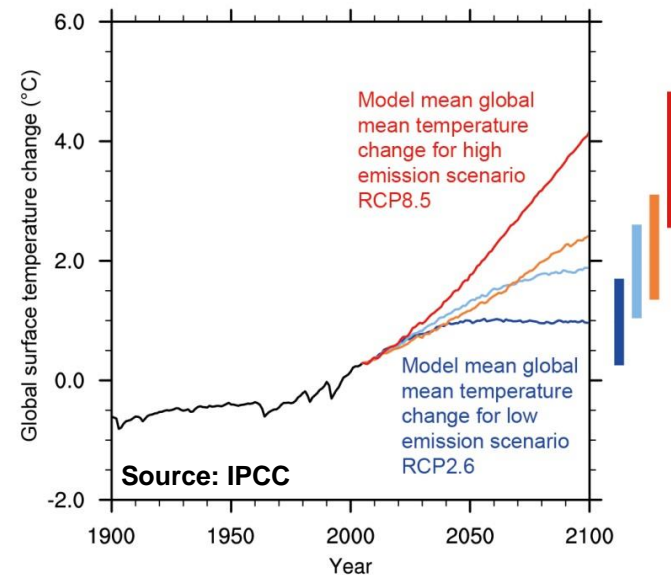
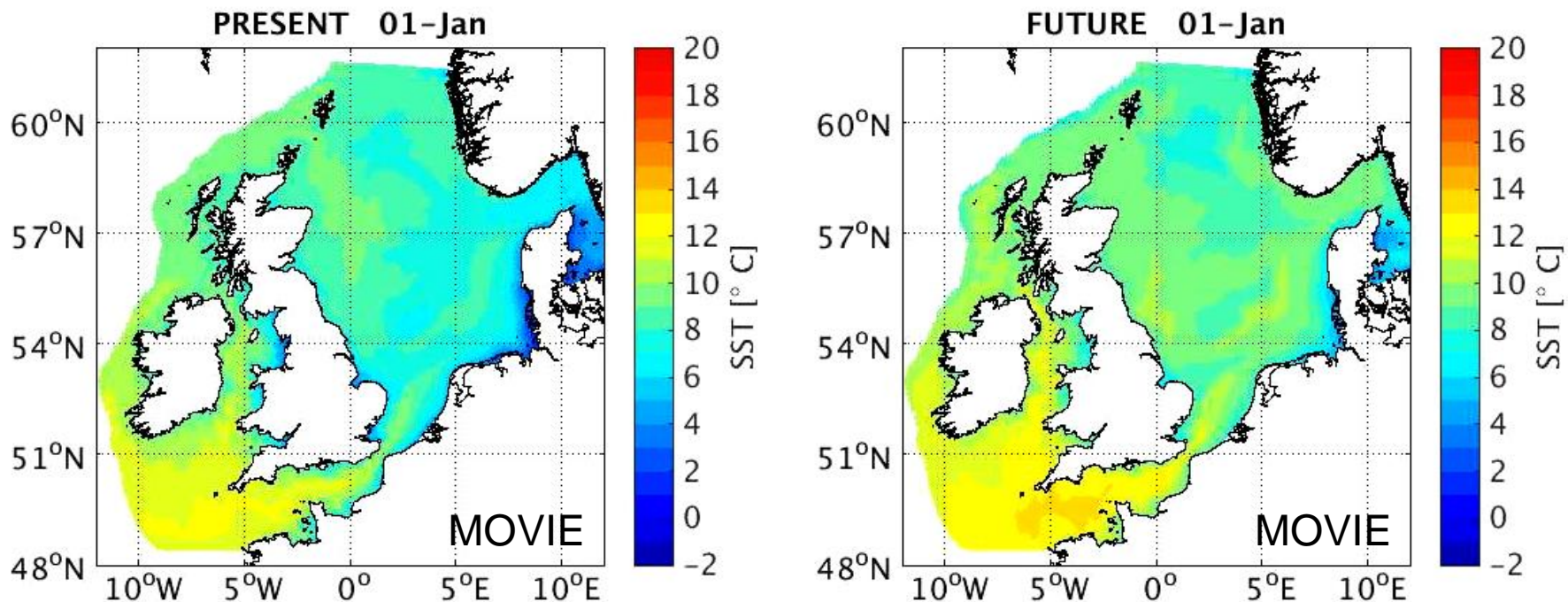
A typical annual cycle of the present NW European Shelf hydrodynamics was reproduced by the Scottish Shelf Model and compared with output for the same period of time perturbed by tidal stream energy extraction.

PRESENT 01-Jan



Projected future climate in 2050

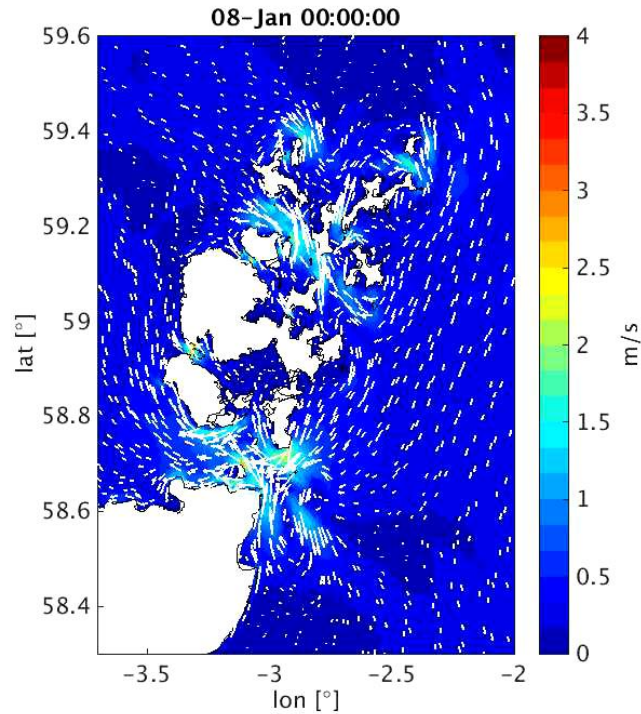
One single, physically plausible, representation of the future hydrodynamic conditions in 2050 was reproduced by the Scottish Shelf Model and compared with a run perturbed by tidal stream energy extraction.



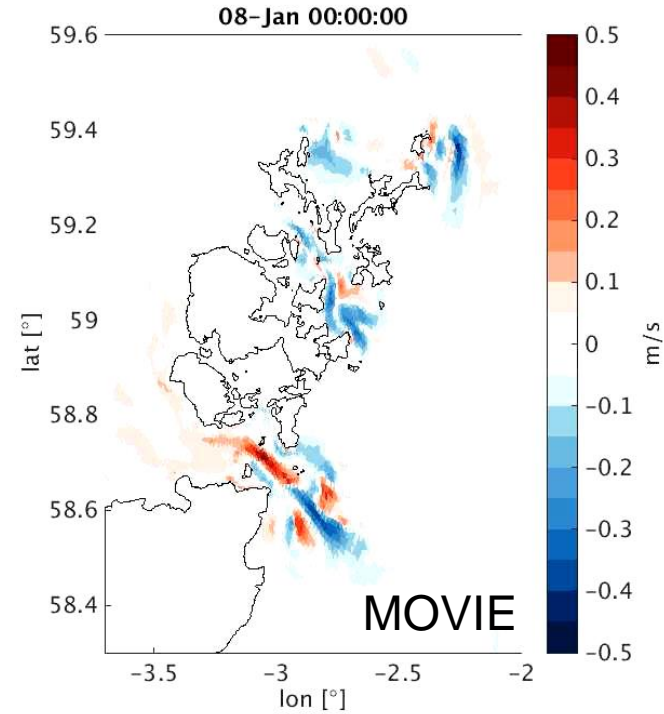
The present climatological forcing is based on the ERA Interim re-analysis, while the future forcing was built using a “delta-change” approach based on ERA-Interim and Hadgem2-ES global climate model outputs.

Impact on Currents – Orkney Islands

Present climate



Change due to tidal stream energy

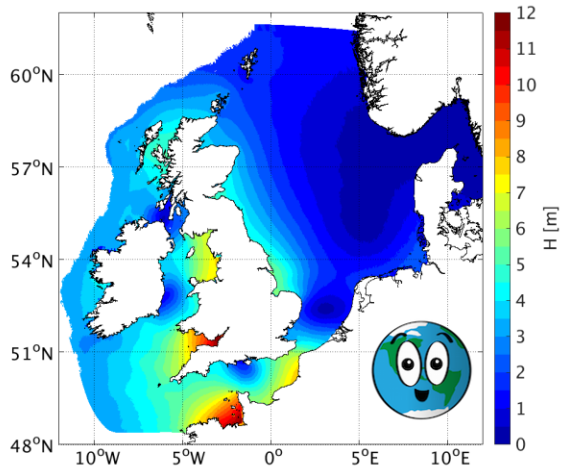


Instantaneous model output

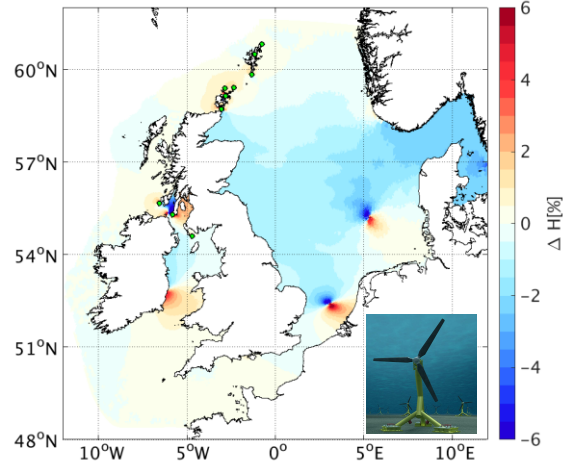
Impacts on tidal dynamics

Spring peak tidal range

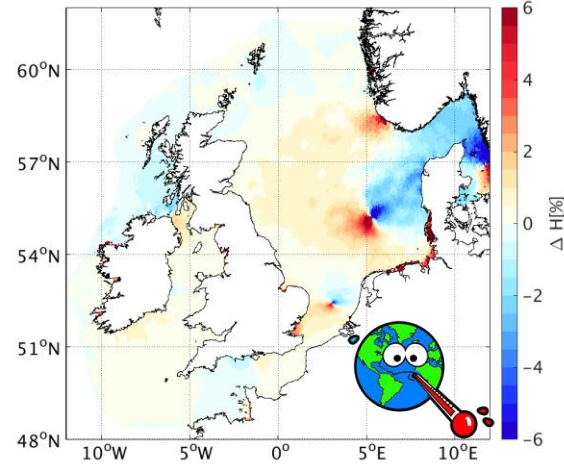
Present climate



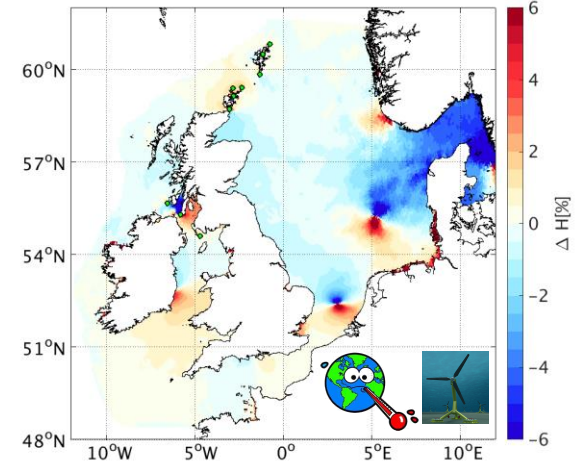
Change due to tidal stream energy



Change due to future climate



Change due to future climate & tidal stream energy

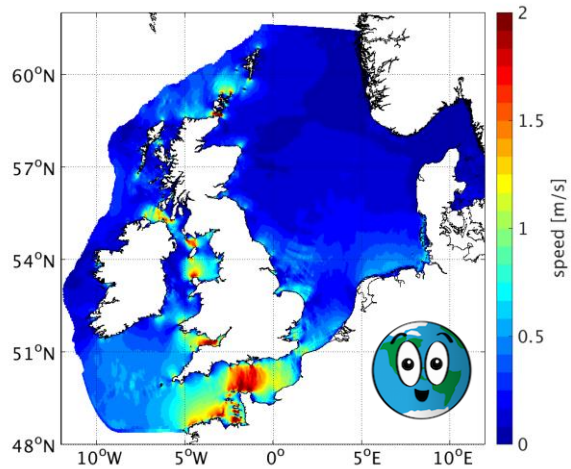


Combined M2 and S2 tidal harmonics

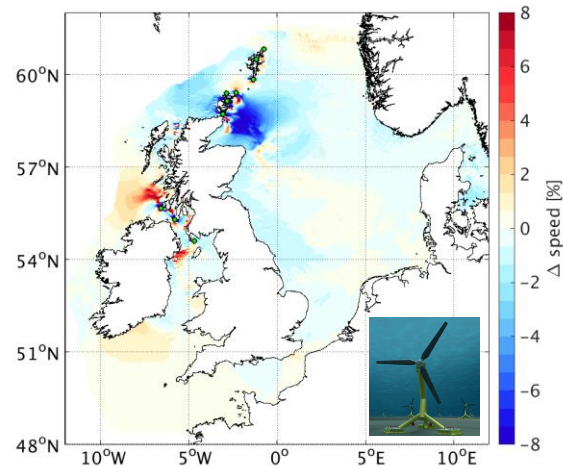
Impacts on tidal dynamics

Spring peak tidal currents

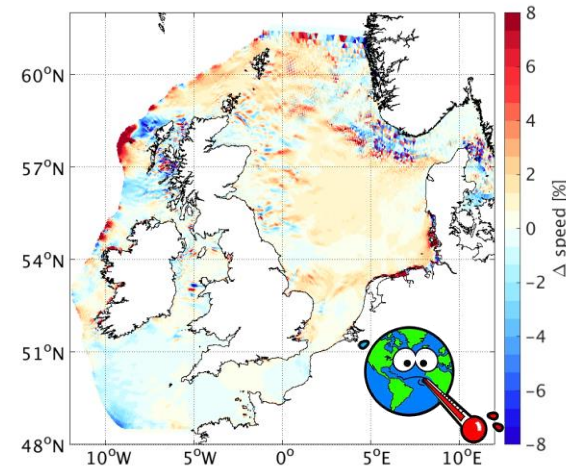
Present climate



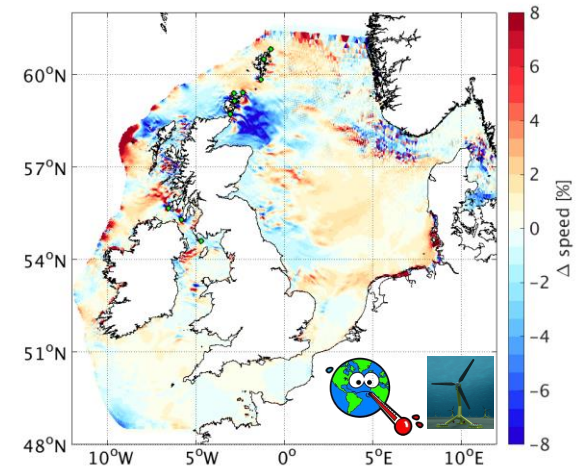
Change due to tidal stream energy



Change due to future climate



Change due to future climate & tidal stream energy

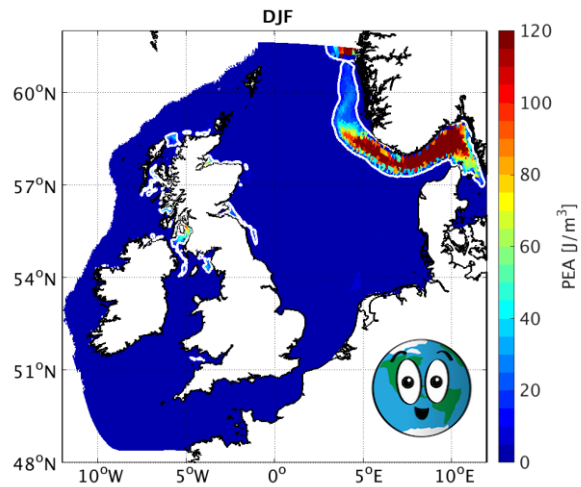


Combined M2 and S2 tidal harmonics

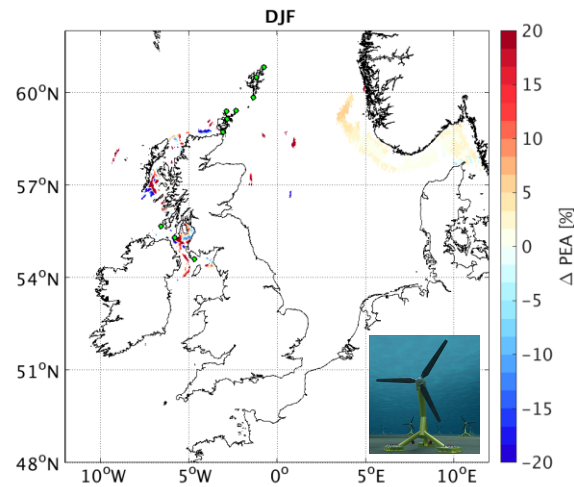
Impacts on stratification

WINTER Potential Energy Anomaly

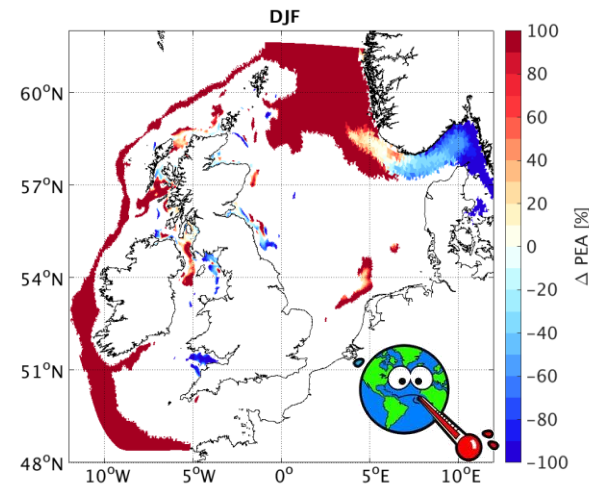
Present climate



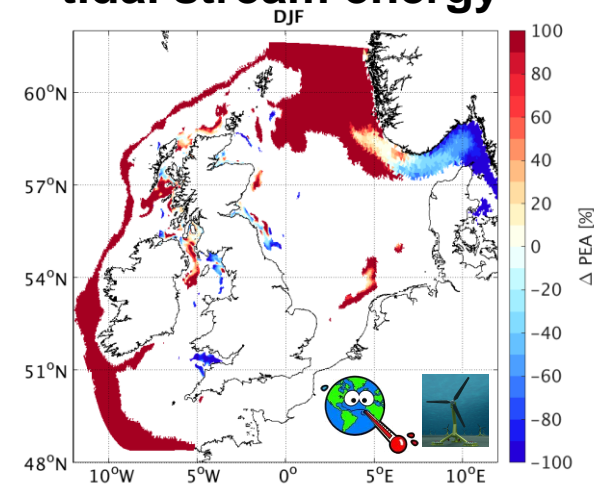
Change due to tidal stream energy



Change due to future climate



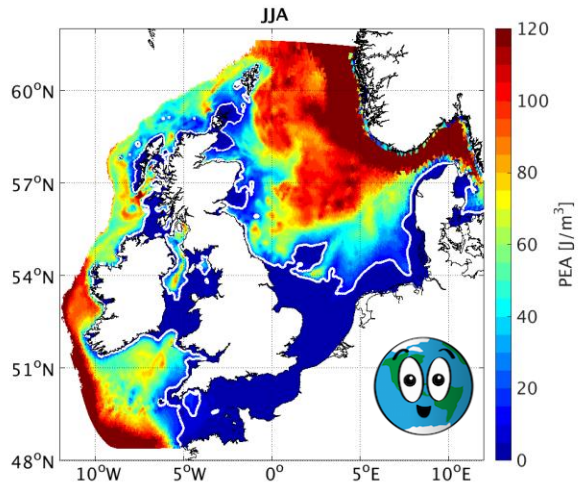
Change due to future climate & tidal stream energy



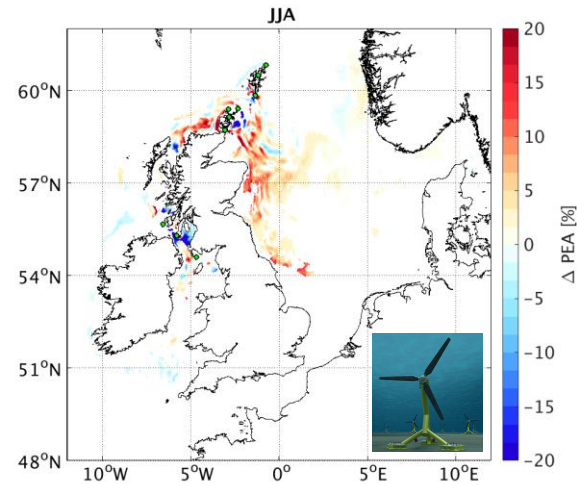
Impacts on stratification

SUMMER Potential Energy Anomaly

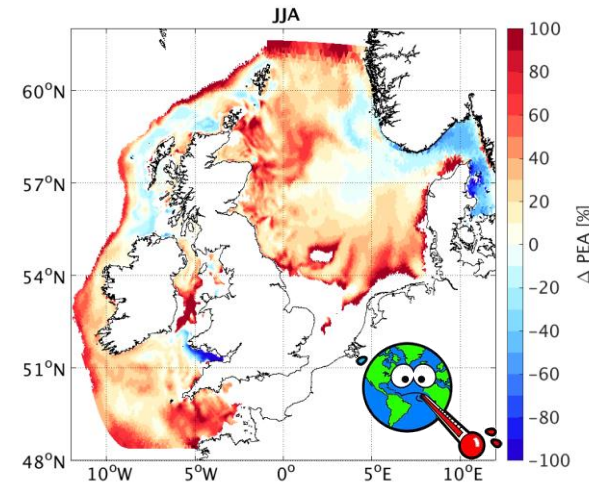
Present climate



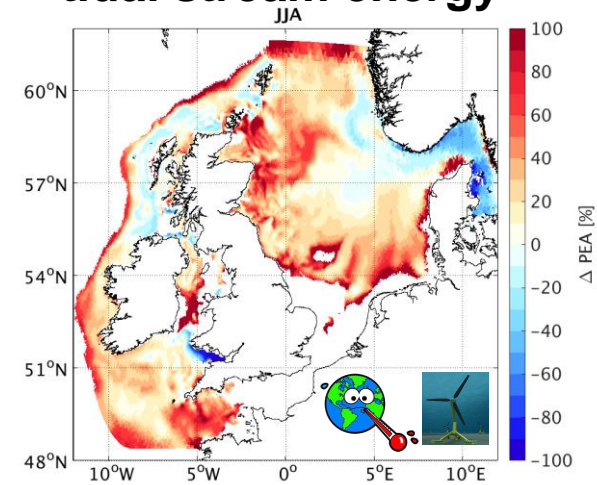
Change due to tidal stream energy



Change due to future climate



Change due to future climate & tidal stream energy



Summary & Conclusions

- **A plausible future projection!**
- **The available tidal energy does not reduce under future climate conditions**
- **Tidal energy extraction could ameliorate the undesirable effects of rising mean sea level in some locations**
- **The future increase in water column stratification, driven by the global warming, is ten times larger and over a much wider area than the one generated by tidal stream energy extraction**
- **How does the ocean response translate into impacts on ecosystem habitats and animals' behaviour?**



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**De Dominicis, M., Wolf, J., O'Hara Murray, R.
Comparative effects of climate change and tidal stream energy extraction in a shelf sea.
JGR-Oceans, 2018**

Acknowledgements

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