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Potential impact of tidal power plants and future sea-level rise on the dynamics of the European Shelf

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Tidal power is a potential renewable energy source internationally, although financial and technical limitations to tidal power have been addressed. There is also a dynamical aspect of the extraction of tidal energy from shallow shelf seas: what will happen with the tidal dynamics on the shelf if energy is extracted at point sources? The tidal currents and the dissipation of tidal energy control the location of shelf sea fronts and thereby the seasonal stratification. Any change in the tides may thus have far-reaching implications for the biogeochemical and physical systems on the shelf, e.g. primary production, draw-down of atmospheric CO2, and sediment transport. Here we suggest ways to implement tidal power plants in dynamic tidal models, and we investigate how the tidal dynamics of the European shelf changes if we extract large amounts of tidal energy during both present and future climate-change scenarios. With a 1 m future sea-level rise the results show significantly modified tidal amplitudes with up to 20% in certain areas, and the effects may reach the global ocean. These changes are attributed to modifications of the resonant properties of the ocean, which induce a shift in the location of the amphidromic points. During present day conditions the addition of a large-scale Severn barrage induces amplitude changes of 10-20% of the regional tide in several locations. Significant changes can be found at locations far from the barrage itself, i.e. on the Northwest coast of Scotland and in the English Channel, again due to movement of the amphidromic points. However, the back effects on the open ocean tides from tidal power plants are negligible. The combination of a 1 m sea-level rise and a Severn barrage show even larger modifications with effects at large distances from the shelf and the power plant itself. The conclusion is that care must be taken in the implementation of tidal power plants to ensure that the full impact of the power extraction is understood and quantified.