As well as providing renewable energy, wave farms can help protect coasts against erosion by reducing the force of waves. However, it remains unknown whether they can provide this complementary service under future climate change when sea levels will be higher. A new study, based upon computer simulations, concludes that a wave farm off the south coast of Spain could indeed protect the coastline under higher sea levels, and cause the local beach to grow in size after storms.

Future sea-level rise threatens coasts across the world by increasing the risk of coastal erosion and flooding. Coasts near river deltas are particularly affected, as they are often home to places with high economic, social and environmental value. Although primarily built to supply energy, wave farms can also protect coasts by softening the impact of waves as they roll towards the shore.

This EU-funded study is the first to explore how wave farms could affect coastlines under future sea-level rise. The researchers considered the effects of a hypothetical wave farm 500–750 metres off the coast of Playa Granada, a three-km-long beach in southern Spain. This gravelly beach has suffered shoreline retreat and terminal erosion in recent years. It experiences Atlantic cyclones and Mediterranean storms, during which significant wave heights typically exceed three metres.

Using two computer models, the researchers simulated the wave farm’s effects on wave heights and sediment movement under three scenarios:

1. **Present-day sea levels**;
2. **Optimistic future sea levels in 2100** — assuming climate change will develop as per scenario RCP4.5, under which global warming stabilises thanks to major reductions in carbon emissions;
3. **Pessimistic future sea levels in 2100** — assuming the business-as-usual, high-emission climate change scenario of RCP8.5, which projects continued global warming.

The researchers assumed the hypothetical wave farm to comprise 11 wave energy converters arranged in two rows placed 500–750 metres out to sea, each of which stretched to around 1300 metres in length. These ‘V’ shaped converters float on the surface of the water. They are moored to a single point on the seabed using an anchoring system that allows them to turn towards the incoming wave direction. The researchers modelled both easterly and westerly storms: the two prevailing wave directions at the site.

The model indicates that the wave farm would reduce wave heights during storms under all three scenarios. The results are expressed as the ratio between wave heights with and without the wave farm. Wave height reduction is most significant in the case of easterly storms, with the average wave-height ratio across all three scenarios during easterly storms being 0.79–0.8: i.e. waves are around 20% smaller, on average, in the presence of the wave farm.

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Wave farms could help prevent coastal erosion under future sea-level rise

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The farm’s effects on wave height are actually greater with higher sea levels. For example, the minimum wave height ratio is 0.63 during easterly storms under both optimistic and pessimistic scenarios, compared with 0.65 under present-day conditions.

These changes in wave height affect the way that coastal sediment moves and builds up on the shore. This varies according to the section of the beach, with some small sections experiencing erosion but the rest experiencing sediment build-up. The overall effect along the beach is positive.

Without the farm, the beach area would shrink by 90.15 m$^2$, 42.83 m$^2$ and 51.66 m$^2$ after 48 hours of a westerly storm under the present-day, optimistic and pessimistic scenarios, respectively. With the wave farm, however, the beach area would grow by 2.31 m$^2$, 28.76 m$^2$ and 8.14 m$^2$ respectively.

The researchers call for long-term studies to better characterise these effects, but suggest that such a wave farm could be more effective at protecting coasts under sea-level rise than traditional hard-engineering solutions such as seawalls or groynes (banks or walls that stretch out to sea from the beach). While the research team has not analysed the possible impacts – notably environmental – of enlarging beaches and changing the flow of sediments, it plans to explore the ecological effects of the wave farm in the near future.