How will warming oceans affect invasive Pacific Oysters in the UK?

Summary

- The Pacific oyster is one of the most important commercial shellfish in the UK, but over the past decades they have become a growing threat to native marine ecosystems in the UK.
- Sea surface temperature is a major controlling factor in Pacific oyster growth and expansion.
- Met Office have partnered with Kent and Ulster Wildlife Trusts to analyse and understand how climate change may impact on Pacific oyster numbers by analysing future changes in sea surface temperatures at Thanet, Kent and Strangford Lough, Ulster under a high emissions scenario.
- By 2050, there will be more breeding opportunities due to a longer spawning season at Thanet, warmer waters year-round meaning greater survival of juvenile oysters at both sites with the greatest rise in spawning days seen at Strangford Lough.
- By 2050 sea surface temperatures in Strangford Lough will be similar to Thanet in 2000s.

Why do pacific oysters matter?

Invasive Pacific oysters are threatening marine ecosystems in the UK

The Pacific oyster is one of the most important commercial shellfish in the UK but has become progressively more invasive since the 1990s, after its introduction into UK aquaculture in the 1960s. Initially, UK waters were believed to be too cold for its survival outside of aquaculture, but over the past decades Pacific oyster populations have boomed, primarily driven by warming sea temperatures due to climate change[1].

An adult Pacific Oyster.
Photo credit: Sherece Thompson, Kent Wildlife Trust.

The growth in Pacific oyster numbers will have a positive impact on the economies of some areas, but it will also have complex implications on ecosystems[2] and native species. Many of the UK's estuaries are protected for nature as they harbour mudflats and soft muddy shores that are vital habitats for native wading birds and fish. In the last decade, Pacific oysters have rapidly colonised these habitats and created large oyster reefs which block native wildlife and can injure people, dogs and boats[3].

Two of the places which have experienced a large increase in Pacific oyster numbers are Thanet, in Kent and Strangford Lough in Northern Ireland. Pacific oysters are now commonly recorded in Strangford Lough since they were first observed in the 1990s outside of licensed aquaculture sites and Wildlife Trust volunteers in Thanet regularly exercise control measures due to the rapidly expanding oyster reefs in the intertidal zones.

Volunteers exercising control measures on Pacific Oysters in Walpole Bay, Kent. Photo credit: Sherece Thompson, Kent Wildlife Trust.

The Met Office in collaboration with Ulster Wildlife Trust and Kent Wildlife Trust applied known temperature thresholds for the Pacific oyster to analyse and understand how the frequency and length of spawning, and growth into adults may change by 2050 in Strangford Lough and Thanet[a] (Figure 1).

Our results were calculated using marine climate projections for the NW European Shelf Seas based on the UK Climate Projections 2018, for 'high emissions' RCP8.5 scenario where no attempt at reducing greenhouse gas emissions is made[4]. Under this scenario, there will be more breeding opportunities for Pacific oysters by 2050 at both sites, with an extended spawning season in Thanet. By 2050, sea surface temperatures in Strangford Lough will be similar to Thanet in 2000s.

[a] For more details of technical methodology, please refer to the accompanying technical reference document

Figure 1. Map of the UK showing the study locations.

What controls the spread of Pacific oysters?

Sea temperature is a critical factor in the Pacific oyster lifecycle and is the dominant environmental influence on the establishment of wild populations[5] and can be used to estimate how wild oyster populations may change in the future[1,b].

Temperature thresholds for pacific oysters

Pacific oyster adults require cumulative heat exposure of at least 600 degree days above a 10.55°C threshold to spawn[c] and begin spawning when water temperatures reach over 18°C which typically happens between June and September in the UK[1]). Development of the larvae and settling requires at least 825 degree days above 10.55°C. Adult oysters reach sexual maturity in 3 years and live for an average of 20 years.

What has happened so far?

Sea temperatures in both Thanet, Kent and Strangford Lough, Ulster are already warm enough for adult oysters to spawn and for their larvae survive to adulthood (Figure 2). Historically in Northern Ireland, only some years reached the temperature threshold for larvae survival but recently (early 2020s), average sea temperatures became warm enough that the average year will surpass the threshold required for larval survival and settlement which means Northern Ireland is likely to see a growing population of Pacific oysters in the coming decades.

What will happen in the future?

Warmer summer sea surface temperatures will lead to more reproductively mature oysters[6] as warmer waters allow for more recruitment, faster maturation and larger established populations of Pacific Oysters[7].

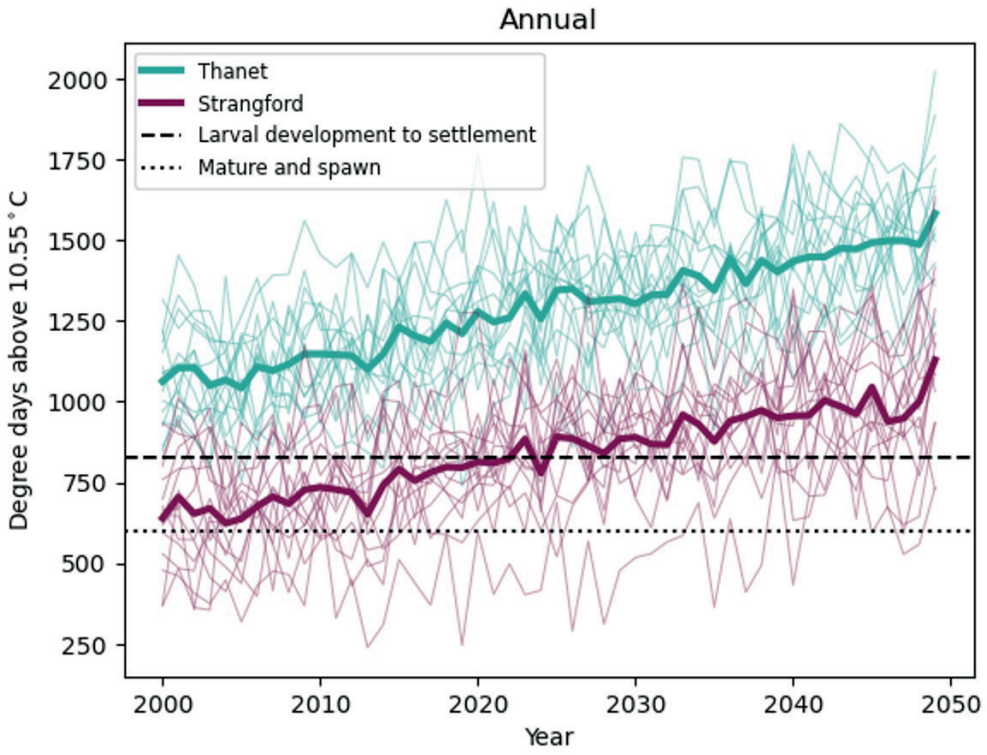

Figure 2. Number of days required for **survival into adult oysters** represented by the number of degree days above 10.55°C in Thanet (teal lines) and Strangford Lough (mauve lines) where the bold line represents an average of 12 plausible climate 'futures' called ensemble members under a 'high emissions' climate change scenario[d]. Average sea temperatures will be warm enough for Pacific oysters to mature and spawn when the bold lines for Thanet and Strangford pass the black dotted line (representing 600 degree days above 10.55°C) and warm enough for Pacific oysters' larvae to develop and settle when the black dashed line (representing 825 degree days above 10.55°C) is surpassed.

[b] Other environmental, physiological and biological factors such as salinity, water pH, habitat, food, predation and disease also influence oyster population dynamics but these were not considered in this small study.

[c] Degree Days: Day by day sum of degrees by which the temperature exceeds the baseline temperature using the minimum, mean and maximum recorded temperatures for that day (in this case 600 days above 10.55°C). Warmer locations such as Thanet, Kent will accumulate a higher number of degree days, which will lead to an earlier spawning date. Colder locations such as Ulster, Northern Ireland will have lower rates of degree day accumulation so spawning will be later.

[d] A 'high emissions' scenario refers to RCP8.5. More details in the technical summary doc.

The number of days suitable for Pacific Oyster breeding will rise significantly, with the greatest rises seen in Strangford Lough. Under a high-emissions greenhouse gas scenario, the number of days where spawning could occur in summer[e] will rise by ~47% in Thanet (range ~30-61%) and~126% (range ~55%-266%) in Strangford Lough[f] by 2050.

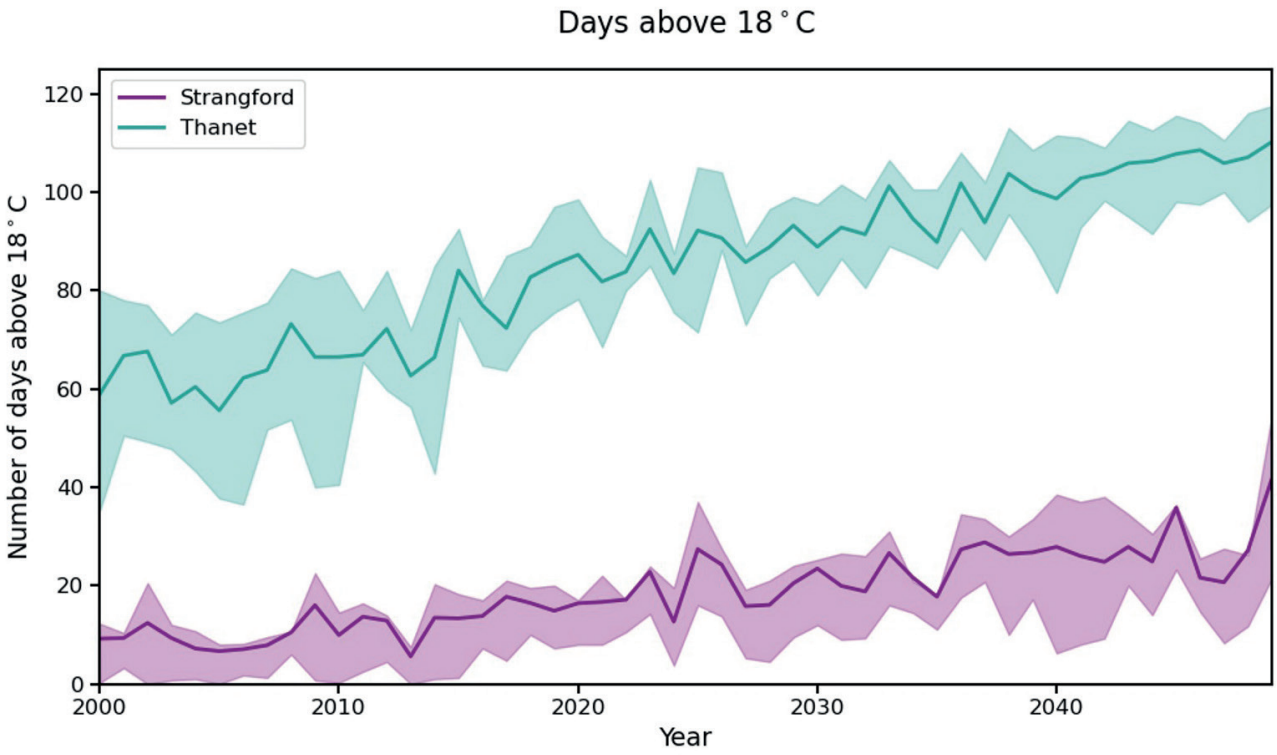

Figure 3. **Frequency of spawning** represented by the number of days per year above the spawning threshold calculated by averaging the number of days above an 18°C threshold. The bold lines indicate the average projected number of days for Strangford and Thanet, whilst the shaded area around the lines indicate the interquartile range across the ensemble.

The spawning season (June-September) is likely to lengthen by 2050 leading to greater recruitment opportunities for Pacific oyster larvae, particularly in Thanet. The spawning season (typically from June-September when water temperatures are warmer), will last ~40% longer in Thanet by 2050 (Figure 4), but there is less certainty as to whether the season will lengthen in Strangford Lough as there is greater variability in the data.

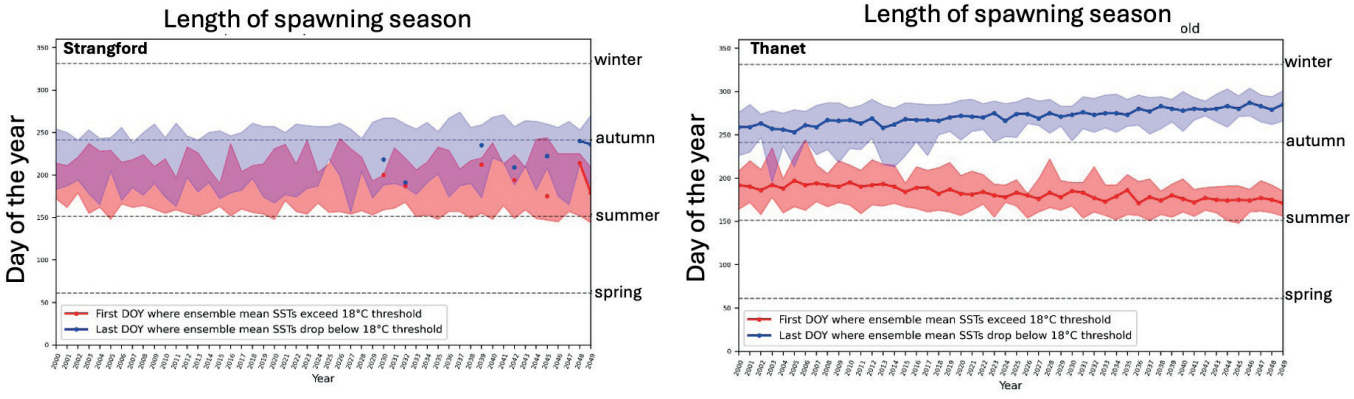

Figure 4. Length of spawning season defined by the first day of the year sea surface temperatures exceed 18°C threshold. The shaded areas represent the ensemble spread, whereas the solid line represents the ensemble average. Note there is no solid line for Strangford as only a few ensembles exceeded the 18°C threshold.

[e] Defined as the number of days in excess of 18°C between June-September each year.

[f] Relative to a 2000-2019 baseline.

What does this mean?

- **Greater likelihood of survival into adult oysters:** By 2050, sea temperatures will be warmer year-round in both Thanet and Strangford Lough allowing better survival chances for juvenile oysters until reproductively mature.
- **Rise in the frequency of spawning:** Strangford Lough may experience a larger rise in Pacific oysters due to a larger rise in days suitable for spawning compared to Thanet, but overall both sites will experience a greater number of spawning days by 2050.
- **Longer spawning season:** The spawning season will lengthen by 2050 particularly at Thanet.
- By 2050 sea surface temperatures in Strangford Lough will be similar to Thanet in 2000s.

What are the limitations and next steps?

- **More biological counts and coordination of oyster frequency data are required** to fully comprehend the direct impact of rising sea surface temperatures on their numbers through e.g. species distribution modelling.
- **More sea temperature data from the intertidal zones would be beneficial to validate model results.** Expected sea temperatures are likely to be more variable than modelled because the climate data used in this study does not capture the much more variable sea temperatures in the intertidal zone where Pacific oysters colonise.
- **Rising numbers of marine heatwaves could boost recruitment of Pacific oysters**[7]. More research into how marine heatwaves may change around the UK coastline could earmark future hotspots of Pacific oyster proliferation.
- **Pacific oysters are already on the edge of their salinity tolerance in UK waters.** More investigation into how climate change affects future salinity would show whether the oyster's threshold is exceeded.

References

[1] Wilson, R.J., Kay, S., Ciabatta, St., 2024. Partitioning climate uncertainty in ecological projections: Pacific oysters in a hotter Europe, Ecological Informatics, 80, https://doi.org/10.1016/j.ecoinf.2024.102537

[2] Herbert, R.J.H.., Humphreys, J., Davies, C.J., Roberts, C., Fletcher, S., Crowe, T.P., 2016. Ecological impacts of non-native Pacific oysters (Crassostrea gigas) and management measures for protected areas in Europe, Biodiversity and Conservation, 25, 2835-2865, https://doi.org/10.1007/s10531-016-1209-4

[3] 'Pacific oyster expansion threatens Devon and Cornwall estuaries', 4th November 2021: https://www.bbc.co.uk/news/uk-england-cornwall-58739570

[4] Tinker, J. (2023): Physical Marine Climate Projections for the North West European Shelf Seas based on the UKCP18 Perturbed Parameter Ensemble.. NERC EDS Centre for Environmental Data Analysis, 17th September 2024. http://catalogue.ceda.ac.uk/uuid/8326776183704457f9e0a85da021c1312/

[5] Alves, M.T., Taylor, N.G.H., Tidbury, H.J., 2021. Understanding drivers of wild oyster population persistence. doi: 10.1038/s41598-021-87418-1

[6] Crandall, G., Thompson, R.E., Eudeline, B., Vadopalas, Br., Timmins-Schiffman, E., Roberts, S., 2022. Proteomic response of early juvenile Pacific oysters (Crassostrea gigas) to temperature. PeerJ, 10, doi: 10.7717/peerj.14158

[7] Beck, E.L., Ruesink, J., Troyer, S., Behrens, M., 2024. Wild populations of Pacific oysters (Magallana gigas) emerge during the blob heatwave in south Puget Sound, Washington USA, Frontiers in Marine Science, 11, https://doi.org/10.3389/fmars.2024.1292062

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