Press Release

GEOMAR
Helmholtz Centre for Ocean Research Kiel

41/2023 – **Under embargo until 20 July 2023, 16:00 British Summer Time**

How eelgrass spread around the world

An international research team led by GEOMAR reconstructs the worldwide colonisation history of the most widespread marine plant

20.07.2023/Kiel/Groningen. **Seagrasses are the only fully submerged, marine flowering plants to have conquered coastal habitats around the world. Eelgrass has captured the northern hemisphere, spanning latitudes from 35° to 70° North – from warm-temperate shores to frozen Arctic coasts. An international group of researchers coordinated by Professor Thorsten Reusch, marine biologist at GEOMAR Helmholtz Centre for Ocean Research Kiel, reconstructed the colonisation history of the eelgrass *Zostera marina* from its origin in the Northwest Pacific Ocean to the Pacific, Atlantic and the Mediterranean. In addition, they found a reduction in genetic diversity, which raises concerns how well eelgrass is able to adapt to a changing climate.**

Seagrasses evolved from freshwater plants and use sunlight and carbon dioxide (CO_2) for photosynthesis and are able to thrive in depths down to 50 metres. In contrast to algae, they possess roots and rhizomes that grow in sandy to muddy sediments. The grass-like, leaf-shoots produce flowers and complete their life cycle entirely underwater. Seeds are negatively buoyant but seed-bearing shoots can raft, thus greatly enhancing dispersal distances at oceanic scale.

As a foundational species, eelgrass provides critical shallow-water habitats for diverse biotas and also provides numerous ecosystem services including carbon uptake. Seagrasses have recently been recognised as one of the important nature-based contributions to store carbon in the ocean. The sediment below seagrass meadows can sequester between 30 and 50 times more carbon annually that the roots of forests on land. Unfortunately, the continuing loss of seagrass beds worldwide – including eelgrass – is of acute concern.

An international group of researchers coordinated by Professor Thorsten Reusch, Head of the Research Division Marine Ecology at GEOMAR Helmholtz Centre for Ocean Research Kiel, used complete nuclear and chloroplast genomes from 200 individuals and 16 locations to reconstruct and date the colonisation history of the eelgrass *Zostera marina* from its origin in the Northwest Pacific Ocean to the Pacific, Atlantic and the Mediterranean. The findings described in a peer-reviewed publication and a Research Briefing published today in the scientific journal *Nature Plants* beg the question, "How well will eelgrass adapt to our new, rapidly changing climate?"

Using a phylogenomic approach the scientists were able to determine that eelgrass plants first crossed the Pacific from west to east in at least two colonization events, probably supported by the North Pacific Current. The scientists then applied two DNA "molecular clocks" – one based on the nuclear genome and one based on the chloroplast genome – to deduce the time when eelgrass populations diverged into new ones. The DNA mutation rate was calculated and calibrated against an ancient, whole genome duplication that occurred in eelgrass.

Both nuclear and chloroplast genomes revealed that eelgrass dispersed to the Atlantic through the Canadian Arctic about 243 thousand years ago. This arrival is far more recent than expected – thousands of years versus millions of years, as is the case with most Atlantic immigrant species during the Great Arctic Exchange some 3.5 million years ago. Reusch explains: "We thus have to assume that there were no eelgrass-based ecosystems – hotspots of biodiversity and carbon storage – in the Atlantic before that time. Recency was also mirrored in an analysis of the associated faunal community, which features many fewer specialised animals in the Atlantic as compared to the Pacific eelgrass meadows. This suggests that there was less time for animal-plant co-evolution to occur", said Reusch. Mediterranean populations were founded from the Atlantic about 44 thousand years ago and survived the Last Glacial Maximum. By contrast, today's populations found along the western and eastern Atlantic shores only (re)expanded from refugia after the Last Glacial Maximum, about 19 thousand years ago – and mainly from the American east coast with help from the Gulf Stream.

In addition, the researchers further confirmed the huge difference in genomic diversity between the Pacific and Atlantic, including latitudinal gradients of reduced genetic diversity in northern populations. "Both Atlantic compared to Pacific populations, and northern versus southern ones are less diverse on a genetic level than their ancestors by a factor of 35 among the most and least diverse one", summarised postdoctoral scientist Dr. Lei Yu, first author of the publication which was a chapter in his doctoral thesis. "This is due to bottlenecks arising from past ice ages, which raises concerns as to how well Atlantic eelgrass, will be able to adapt to climate change and other environmental stressors based on its genetic capacity."

"Warming oceans have already caused losses of seagrass meadows at the southern range limits, in particular North Carolina and southern Portugal. In addition, heat waves have also caused losses in shallow waters in some the northern parts of the distribution," noted Reusch. "This is not good news because seagrass meadows form diverse and productive ecosystems, and no other species is able to take on the role of eelgrass if meadows cannot persist under future conditions."

"One possibility for restoration might be to borrow some genetic diversity from Pacific eelgrass to fortify diversity in the Atlantic. Our next step is to interrogate the eelgrass pangenome. A new reference genome from Pacific eelgrass is currently under development and should tell us more about the adaptive ecotypic capacity across its global range of habitats," said Prof. Jeanine Olsen, emeritus professor from the University of Groningen who initiated the study and coordinated the work between the Joint Genome Institute (JGI) and the research team. Thus, the verdict on rapid adaptation is out but there's reason for optimism.

Original publications:

Yu, L. et al (2023): Ocean current patterns drive the worldwide colonization of eelgrass (Zostera marina. Nature Plants, doi: 10.1038/s41477-023-01464-3. The publication will become available after the embargo lifts on 20 July 2023 at 16:00 (British Summer Time).
Reusch, T.B.H., Olsen, J.L. (2023): Reconstructing the worldwide colonization history of the world's most widespread marine plant. Nature Plants Research Briefing; doi and link pending

Project funding:

The study was supported by the United States Department of Energy Joint Genome Institute Community Sequencing Program and a PhD scholarship from the China Scholarship Council. Field sampling was supported by the National Science Foundation.

Links:

https://www.rug.nl/research/gelifes/?lang=en Groningen Institute for Evolutionary Life Sciences
https://jgi.doe.gov Joint Genome Institute (JGI)
https://www.nature.com/articles/nature16548 Olsen, J., Rouzé, P., Verhelst, B. et al. (2016): The genome of the seagrass *Zostera marina* reveals angiosperm adaptation to the sea. Nature, https://doi.org/10.1038/nature16548

Images:

Images are available for download at http://www.geomar.de/n9043-e

Contact:

Maike Nicolai (GEOMAR, Communication & Media), media@geomar.de