



SCIENTIFIC FINAL REPORT – RESEARCH NETWORKS

Registration number, Östersjöstiftelsen: 21-RN-0003

Project manager: Anushree Sanyal

Project title: *A coordinated effort to understand genomic changes in revived diatom and phytoplankton populations from Baltic Sea sediments in light of environmental change*

1. Purpose of the research network

Recently, drastic changes in biodiversity affecting the stability and function of marine ecosystems have been observed. The Baltic Sea has become one of the most polluted and the largest hypoxic region in the world (Carstensen et al. 2014) due to increased human activities. We need to understand the changes that have occurred over long timescales in oceans to understand marine phytoplankton evolution to formulate sustainable goals of management and conservation of nature.

The sediments are the natural archives which have records of the past changes in the environment and biota (Ellegaard et al. 2020). DNA preserved in the viable resting stages of diatoms and phytoplankton and bulk sediments can provide answers to changes in biota over long timescales (Sanyal et al. 2021). Our aim was to examine the role of the resting stages in the persistence of the species over long timescales and also the changes in their genomic signatures in sediment revived resting spores in the adaptation of marine phytoplankton to changes in climate and anthropogenic activities.

2. A description of the research network's activities funded by Östersjöstiftelsen

We had a two-day scientific meeting in Stockholm and a lab visit where international and Swedish researchers presented their work on questions and answers obtained from examining the role of the sediment revived resting spores in species persistence and adaptation by looking at changes in the genotype and the phenotype of the different phytoplankton species.

3. The output from the research network, for example applications for research funding

Three projects and three manuscripts are being produced as an outcome of this research network grant. We applied and got funding for two grants from Södertörn University to build up on our ideas of growth experiments and single cell genomics during the meeting. We also applied for a grant from Södertörn University and will apply for VR and FORMAS grants for a project on the resurrection of diatom species in sediment cores collected from Hanö Bay to examine the changes in the species composition of diatoms over long timescales. We will submit a grant next year to FORMAS to examine the effect of changing temperatures on diatom species under the genera *Chaetoceros* and *Skeletonema* based on the ideas we came up during our meeting from this grant and the preliminary results of the grants which we got from Södertörn University for furthering our questions on the response of *Chaetoceros* and *Skeletonema* spp. to changing temperatures.

During the Phytorev meeting Cönnny Sjöqvist from Abo Akademi in Finland and Anushree Sanyal planned on writing grants for their ideas on single cell genomics and growth



experiments to see the effect of temperature on resurrected resting spores of *Chaetoceros muelleri*. Anushree Sanyal wrote two grants in collaboration with Conny Sjöqvist and others for furthering these collaborations which were funded by Södertörn University in 2021 and 2022. Our findings showed that there were differences in the response of the resurrected populations of *Chaetoceros muelleri* to high and low temperatures from two time periods (recent and approx. 20-year-old sediments). Growth rate and cell count measurements were done by students at Södertörn Univ. (Ana Vilaplana Burgos and Ainara German Perez).

A manuscript which was envisioned during the Phytorev meeting examining resting stage occurrences: '**Resting stages as tools for survival and species persistence over long timescales**' has been written up and will be finalized next month and submitted soon after.

A doctoral student Mohanad Abdelgadir at Södertörn University and researcher Anushree Sanyal at Södertörn University have finalized a manuscript titled '**Tracing diatoms over space and time: a view from species distribution modelling**'. Mohanad worked on this project and presented this work at the meeting in Stockholm. This manuscript will be submitted next month. We will also submit a grant to FORMAS based on our findings.

Anushree Sanyal and two students (Emelia Ceballos Notman and Ashoke Weerakoon) at Södertörn University are working on another project '**Tracing the trajectory of *Chaetoceros* species in the Baltic Sea over long timescales.**' This study examined the changes in *Chaetoceros* populations and showed that meaningful information can be obtained for 69 of these species based on availability or paucity of data in the Baltic Sea. The examination of the correlation with environmental data is ongoing with data from several publicly available databases. The results of this study has been written up for a grant application and will be submitted to FORMAS and Östersjöstiftelsen next year.

4. The research network's contribution to research and/or doctoral studies at Södertörn University

Anushree Sanyal from Södertörn University, Conny Sjöqvist from Abo Akademi in Finland and Nisha Motwani from Södertörn University had applied for two grants based on ideas generated during the Phytorev meeting to work on single-cell genomics and growth experiments to see the effect of temperature on resurrected resting spores of *Chaetoceros muelleri*. Two grants were funded by Södertörn University in 2021 and 2022. Our results showed differences in the response of the resurrected populations of *Chaetoceros muelleri* to high and low temperatures in resurrected populations from two time periods (recent and approx. 20-year-old sediments). Growth curves were measured, and cell counts were done by students at Södertörn University (Ana Vilaplana Burgos and Ainara German Perez). We also got a breakthrough result with amplification of DNA from single cells from resurrected resting spores of the diatom *Chaetoceros muelleri*. Anushree Sanyal from Södertörn Univ., Conny Sjöqvist from Abo Akademi, Giannina Hattich from Univ of Turku and Claudia Bergin from Uppsala Univ. were involved in this project.

Doctoral students and researchers from Södertörn University participated in the research network activities. A project titled 'Tracing diatoms over space and time' was formulated by Anushree Sanyal and a doctoral student Mohanad Abdelgadir where he examined the effect of the different environmental variables on six diatom species in the Baltic Sea. A manuscript on the findings will be submitted to the journal 'Water Research' next week.

Researchers at Södertörn University; Anushree Sanyal and Elinor Andren are working on another project (**Resting stages as tools for survival and species persistence over long timescales**) examine the survival strategies of diatoms by examining the presence or absence of resting spores, resting cells, resting stages in approx. 1300 diatom species and the



ecological data of the diatom species to understand the mechanisms underlying the persistence of diatom species over long timescales. (Nakov et al. 2018).

Anushree Sanyal and two students at Södertörn University (Emelia Ceballos Notman and Ashoke Weerakoon) worked on a project (Tracing the trajectory of *Chaetoceros* sp. in the Baltic Sea over long timescales). A research proposal for a grant has been written up.

5. The contribution of the research network to the knowledge of the Baltic Sea Region and Eastern Europe

Anushree Sanyal from Södertörn University and Conny Sjöqvist's from Abo Akademi Finland and other collaborators have started to work on a single-cell genomics and growth experiments after the meeting with funds from Södertörn University to see the effect of temperature, salinity, and light on resurrected resting spores of *Chaetoceros muelleri* from the Baltic Sea. We found differences in the response of the resurrected populations of *C. muelleri* to high and low temperatures in resurrected populations from two time periods (recent and approx. 20-year-old sediments). Growth rate and cell counts were measured by students at Södertörn University (Ana Vilaplana Burgos and Ainara German Perez).

A project titled 'Tracing diatoms over space and time' was formulated by Anushree Sanyal and a doctoral student at Södertörn University Mohanad Abdelgadir has been working on the project where he examined the effect of the different environmental variables on six diatom species in the Baltic Sea. This project showed that silica and temperature were the main drivers of the distribution of diatom species in the Baltic Sea.

Researchers at Södertörn University; Anushree Sanyal and Elinor Andren are working on another project (**Resting stages as tools for survival and species persistence over long timescales**) on the survival strategies of diatoms by examining the presence or absence of resting spores, resting cells, resting stages in approx. 1300 diatom species in a phylogenetic, ecological and evolutionary context. The presence and absence of resting stages were mapped onto a diatom phylogeny (Nakov et al. 2018) wherever possible. The ecology of the species (Marine, freshwater and brackish) of all the species were also mapped on the phylogeny. This study showed us that the resting stages were absent in a great proportion of freshwater species when compared with the marine and brackish water species. This was an interesting study showcasing the role of the resting stages as survival strategy in different ecological conditions. A doctoral student Rickard Stenow has been involved largely in collecting data for this study and involves contributions from researchers from Sweden, Germany, Finland, Estonia, Belgium, and Denmark. A manuscript has been drafted, and the plan is to submit it Communications Biology in the coming months. The findings are relevant to the happenings in the Baltic Sea and beyond.

Anushree Sanyal and two students (Emelia Ceballos Notman and Ashoke Weerakoon) at Södertörn University are working on another project (Tracing the trajectory of *Chaetoceros* sp. in the Baltic Sea over long timescales). This study examined the changes in all *Chaetoceros* sp. in the Baltic Sea and showed that meaningful data could be obtained for 69 *Chaetoceros* sp. from databases. The examination of the correlation with environmental data is ongoing with extraction of data from several publicly available databases. This study helped us to understand the effect of environmental variables of several *Chaetoceros* species in the Baltic Sea. It also provided us insight into the availability or the paucity of the data and the recordings in the different databases and the challenges which we need to address moving forward with respect to biodiversity studies in the Baltic Sea and beyond.