Land2Sea

Aquatic Ecosystem Services in a Changing World

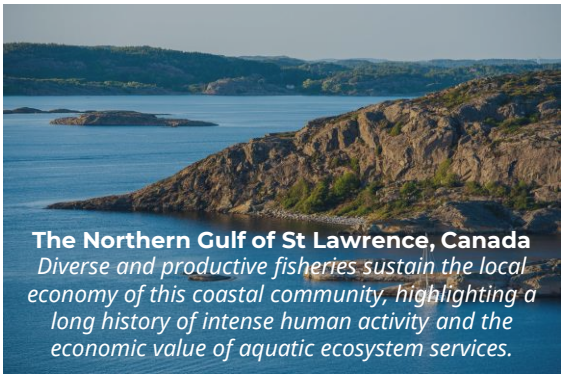
Newsletter #1, Autumn 2021

Land2Sea (2019-2022) aims to (a) clarify impacts of multiple climatic and terrestrial stressors on freshwater and marine ecosystems and their economic, societal and cultural contributions to people and (b) produce models and tools to inform policy and management. It involves researchers and stakeholders from Ireland, Germany, Sweden, Canada and the USA and work in four case study areas.

This Newsletter provides a brief update on some of our activities. Contact the project coordinator Prof Tasman Crowe or visit land2sea.ucd.ie for more information.

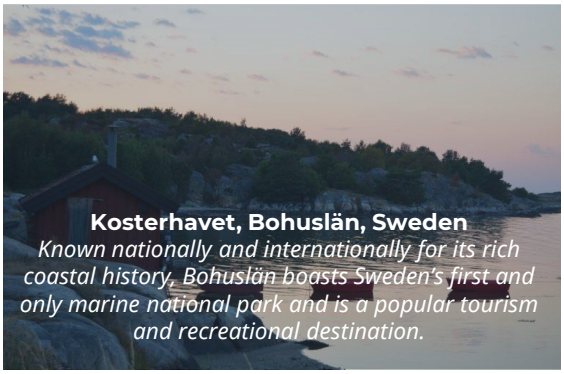
CASE STUDY AREAS

The River Liffey and Dublin Bay, Ireland
Set in the heart of the densely inhabited Irish capital city, Dublin Bay is the centre point for a wide range of recreational, commercial and cultural activities.



The Northern Gulf of St Lawrence, Canada
Diverse and productive fisheries sustain the local economy of this coastal community, highlighting a long history of intense human activity and the economic value of aquatic ecosystem services.

The Tidal Elbe, Germany
Characterized by a rich cultural landscape and strong place attachment in local communities, the River Elbe comprises many valuable habitats for protected species as well as being heavily managed as an essential shipping route.



Kosterhavet, Bohuslän, Sweden
Known nationally and internationally for its rich coastal history, Bohuslän boasts Sweden's first and only marine national park and is a popular tourism and recreational destination.

A DIGITAL TWIN OF KOSTERHAVETS NATIONAL PARK: SOCIO-ECOLOGICAL SIMULATIONS

Matthias Obst, University of Gothenburg, Sweden

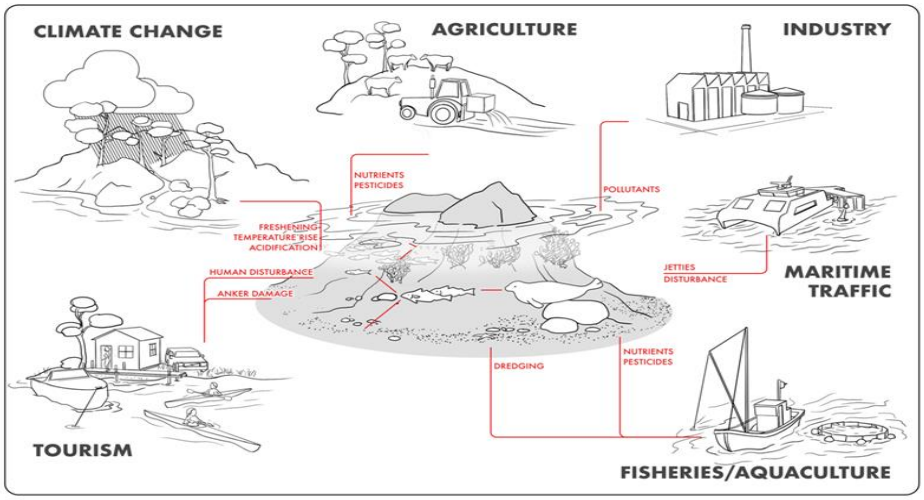
Although life in our oceans remains largely unexplored, we do know that marine organisms and the habitats they live in offer an invaluable number of goods and services upon we as humans critically depend. Hence, strategies for a sustainable future need to find a balance between the maintenance of biodiversity and the socio-economic development of human populations. This is especially important in coastal areas, in which the human population is growing disproportionally fast.

One of study sites chosen by the Land2Sea project is Kosterhavets National Park on the Swedish West coast. The Park offers an ideal 'model place' given its legal status as a national park and the fact it is a hotspot of marine biodiversity. The Park is home to 12,000 species and covers an area of 400 km^2, encompassing a fjord and an archipelago. There are few if any coastal ecosystems as well studied, accessible and under active management as the Kosterhavet National Park, which also boasts one of Europe's finest marine research stations.

In Land2Sea we developed an entirely new modelling approach to specifically study the interplay between environmental factors (such as temperature and ocean currents) with key biological components (such as eelgrass meadows and shrimp stocks), as well as human activities (such as tourism and trawling for shrimps) in the Kosterhavet National Park.

A digital ecosystem of Kosterhavets National Park.

We believe that the interaction between different human activities causes a great deal of uncertainty in current management strategies, and we plan to use the Koster model for predicting and comparing the impact of alternative management and climate scenarios on both humans and nature. For example, how will eel grass meadows be affected if the number of tourists doubles within 10 years? Or how will the rare and protected species in the park be affected by future climate change scenarios or if trawling were banned completely from the area? Such questions are essential in our attempt to build up a truly symbiotic relationship between humans and nature in coastal areas.



Can we study how human activities together affect both the biology of the ecosystem and in turn the local human population in the National Park?

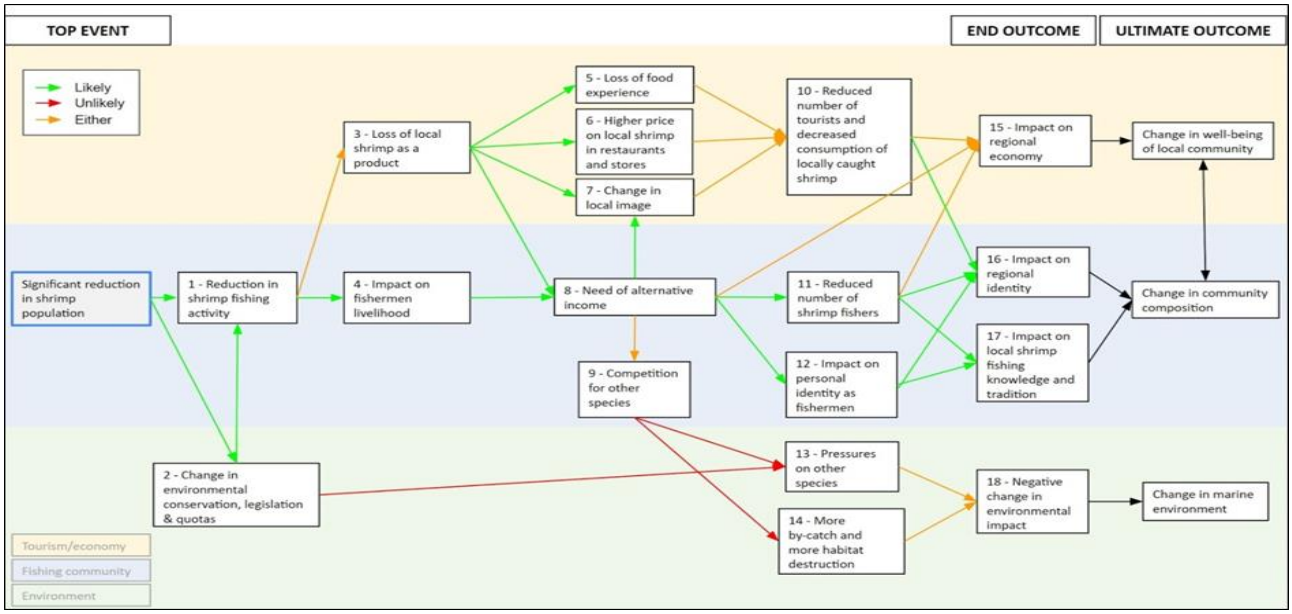
SOCIO-ECONOMIC AND SOCIO-CULTURAL ANALYSIS

Nicklas Lindroth and Sebastian Packalén, Department of Marine Sciences, University of Gothenburg, Sweden

During our MSc studies over the last year, we have worked on the socio-economic and socio-cultural consequences of global change and human pressures in Kosterhavet, Sweden. The aim of the work was, through stakeholder interviews and workshops, to "determine consequences of changes in freshwater and marine ecosystems for delivery of nature's contributions to people, including ecosystem services". During our work we have talked to a wide range of stakeholders ranging from shrimp fishers in the Bohus archipelago to local restaurant owners and representatives from the Kosterhavet National Park.

By gathering quantitative data in a traditionally qualitative field of research we have managed to conclude how an ecological event - a significant reduction in shrimp population - impacts socio-economic and socio-cultural aspects of the local communities, as seen in the figure below.

By joining the Land2Sea project, we gained experience of transdisciplinary work in an international context, as well as insight into what challenges coastal communities might face in the future. We believe that these experiences will be of great use to us in our future careers and we hope that our contribution to the project will lead to a better understanding of how global change and human pressures affect our coastal communities.



TIPPING POINTS IN THE CONTEXT OF MULTIPLE STRESSORS: A FRESHWATER EXPERIMENT CONDUCTED AT LAVAL UNIVERSITY

Charlotte Carrier-Belleau, Laval University, Canada

Under pressure from human activities, ecosystems sometimes tip from one state to another, e.g. from a system dominated by plants, to a system dominated by invertebrates. One of the aims of Land2Sea was to test whether such tipping points can be detected experimentally in freshwater ecosystems by imposing gradients of stress and also to determine whether a tipping point associated with one stressor can be altered by a second stressor.

We used a laboratory experiment to identify the impact of a saltwater intrusion on a simplified freshwater benthic community exposed to a nutrient enrichment gradient. We focused on freshwater zebra mussels, *Dreissena polymorpha*, as well as periphyton and microbial communities.

Our results show that the presence of multiple stressors can decrease the tolerance of an ecosystem and advance a tipping point, such that the system tips more rapidly into another state. For instance, we identified a threshold at 70 g of nutrient pellets along the environmental gradient where mean mortality in *D. polymorpha* suddenly increased. When combined with saltwater intrusion, this threshold shifted to a lower level along the nutrient enrichment gradient - at 14 g of nutrient pellets. We also identified a switch in stressor interactions along the environmental gradient created through nutrient enrichment. Nutrient enrichment and saltwater intrusion interacted synergistically before reaching the tipping point. Beyond this point, stressors did not interact or interacted antagonistically.

Ultimately, our results, combined with other work done within Land2Sea will allow us to better understand and predict the consequences of combined environmental stressors generated by human activities in aquatic ecosystems.

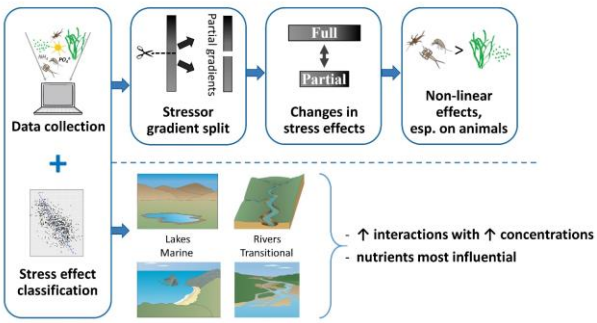
META-ANALYSES OF MULTIPLE STRESSOR EFFECTS

Camino Fernández de la Hoz, University College Dublin, Ireland & IH Cantabria, Spain
Leoni Mack, University of Duisburg-Essen, Germany

To examine how the influence of multiple stressors can vary, two analyses were conducted on multiple stressor effect-relationships in different surface waters worldwide. We collected 351 studies of effects of paired land use and climate change related stressors affecting fresh- and saltwater organisms and modelled stressor-effect relationships for each case. Stressors included thermal stress, nutrients, toxins, hydrological changes, invasive species, light, dissolved oxygen, pH and salinity.

In the first study, we examined how multiple stressor effects change along gradients of stress by splitting the data for the stress gradients in half and analysing each half separately. We found that stressor effects on plants were relatively stable along the stressor gradients, while effects on animals changed to a high degree. We conclude that the combined effects of multiple stressors can vary along stressor gradients, particularly for animals.

In the second study, we compared multiple stressor effects across freshwater, transitional and marine domains. We found a consistent frequency of effect types across all domains, although they were exposed to very different stressors. From experiments, we found that one stressor often dominated the impact, while in observational field studies, stressors were more likely to interact and cause antagonistic or synergistic effects. Nutrient enrichment was the most influential stressor in all domains; in transitional waters, thermal stress also had a strong influence.



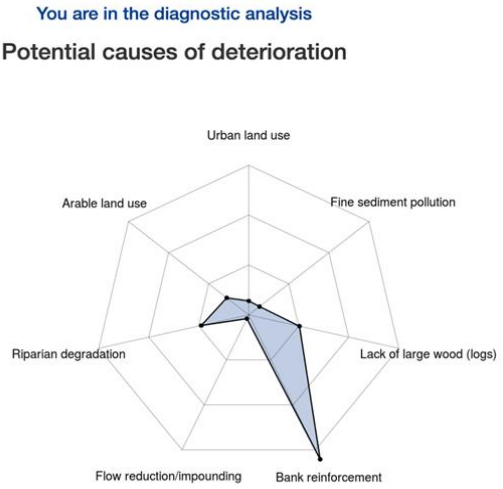
THE RIVER DOCTOR

Christian Feld and Katharina Rettig, University of Duisburg-Essen, Germany

Too little shade? Too many nutrients from adjacent fields? Overexploited river banks? If a river or stream is not doing well from an ecological point of view, there are many possible causes. But they are sometimes difficult to identify. In Germany, we have developed a method that connects causes of ecosystem impairment with biological symptoms.

Our tool works much like a doctor's visit, where we are asked “What's wrong?”. Instead of looking at the aches and pains of the human body, however, biologists look at the biological symptoms of a body of water that is "sick," such as the insects, small crustaceans and mussels present. This is because each species has different requirements. The biological diversity can therefore be used to deduce information about water temperature, oxygen content, flow or the condition of the stream bed. But the tool also works in the opposite direction and then can help water and ecosystem managers to estimate likely effects of environmental change on ecosystems biodiversity and services. Such tools are currently being further developed in the Land2Sea project.

The tools have recently been presented to a regional water board in Germany to illustrate the progress that science has made in recent years to better integrate environmental diagnostics into ecosystem management. This integration, among other outcomes, may result in interactive Decision Support Tools. Such tools, among other products, will be provided also by the Land2Sea project.



Read more about the tools background and rationale in a recent scientific publication:

Feld, C. K., Saeedghalati, M. & Hering, D. (2020): 'A framework to diagnose the causes of river ecosystem deterioration using biological symptoms'. Journal of Applied Ecology. (DOI: 10.1111/1365-2664.13733)

Example tools are available online at www.freshwaterplatform.eu/index.php/mars-diagnostic-tools.html

Land2Sea is a collaboration between natural scientists, social scientists, economists and humanities researchers from University College Dublin (Ireland), Trinity College Dublin (Ireland), University of Gothenburg (Sweden), University of Duisburg-Essen (Germany), Helmholz-Zentrum Hereon (Germany), University of Colorado (USA) and Laval University (Canada).

The project is part of the BiodivScen programme, jointly supported and managed by Belmont Forum, Biodiversa and the European Commission, with national funding for partners provided by the Environmental Protection Agency (Ireland), the Marine Institute (Ireland), Deutsche Forschungsgemeinschaft (Germany), DLR Projektträger (Germany), Formas (Sweden), National Science Foundation (USA), NSERC (Canada), Fonds de recherche, Nature et technologies Québec (Canada).

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