Narrative CV from 2018-2023.

Karline Soetaert, 01 june 2023.

1. Introduction

This narrative CV is based on a self-evaluation, written by myself (Prof. Dr. Karline Soetaert), of my chair focusing on Marine Ecosystem Modelling, at Utrecht University (UU). This chair was erected to substantiate the link, and deepen interactions, between the NIOZ Royal Netherlands Institute for Sea Research and Utrecht University, as well as to complement expertise not yet available at Utrecht University. The chair is embedded in the Department of Earth Sciences, Faculty of Geosciences at UU, and linked to the research programme Climate and Environment and the Master's Degree Programmes Marine Sciences and Earth, Life & Climate.

This self-evaluation is ornamented with self-citations, where the references refer to work that I have performed in the last 5-6 years (see reference list at the end).

2. Research in the period 2018-2023.

My work is situated at the interface of physics, (biogeo)chemistry, biology and ecology and involves acquisition of field- or experimental data, as well as mechanistic or statistical modelling, and the combination of all of these. Part of my work is fundamental, part of the work is applied. In the past, I contributed to research in the general field of marine biogeochemical modelling, with a focus on marine ecosystem and food-web modelling, physical-biological coupling and data assimilation techniques. I have further developed and maintained these research lines, but extending it towards anthropogenic pressures.

2.1 Environmental studies

Marine sciences and oceanography cover the interrelated physical, geological, chemical, ecological and microbiological aspects of the ocean and adjacent systems such as estuaries, lagoons and deltas. I study marine ecosystems by quantifying and modeling their physical dynamics (light and temperature distribution, transport), sediment dynamics (settling, accumulation, erosion, resuspension, dissolution and bioturbation), chemical conditions (organic matter, nutrients) and the biological actors (from microbes to plants and animals) and their activities and interactions.

I am interested both in dynamics occurring in sediments, in the water column, and the exchanges between these two components.

Sediment work.

My long-lasting research on sediment ecology and biogeochemistry led to two reviews on the topic resulting from workshops (refs [1, 2]). Although initiated either from the biological ([1]) or biogeochemical ([2]) point of view, both reviews pointed, amongst other things, to the lack of coherence between biological and biogeochemical approaches in sedimentary studies and modelling, as confirmed by us ([18]). My recent work on this topic has focused on how sediment biogeochemistry is affected by and affects biological life and ecosystem functioning ([1, 10, 34, 37, 53]), and how human impacts affect sediment functioning ([8, 38]). I also participated in many studies where we looked at the sediment ecology and biogeochemistry in estuarine ([15, 17, 29, 61, 63]) and delta systems ([36]), in temperate coastal regions ([35, 37, 62]) , but also in polar ([6]) and tropical coastal areas ([7]). In an ongoing UU-funded project, we investigate the effect of the microphytobenthos on biogeochemistry in the intertidal, where we also measure and model the physical conditions in these systems.

My research on sediments has been extended towards sediment geomorphology, where I studied the impact of sediment composition ([20]) and benthic life ([49]) on the development of geomorphological features ([5]), how the geomorphological dynamics impact the transient storage of fines (mud, silt) in coastal sediments ([60]), the non-linear effects that suspended sediments induce on estuarine dynamics ([11]), and their impact on water-column biogeochemistry ([69]).

The physical and chemical conditions of a system provide the boundary conditions for ecosystem functioning. However, the presence and activities of organisms can also impact the chemical and physical conditions ([68]). The activity of so-called ecosystem engineers is so pervasive that they also change the functioning of ecosystems. Building on my previous work on deep-water corals, we have studied the trophic structures of deep-water corals ([3]), how these reef building organisms are affected by their environment ([25, 52]) and, via spatial self-organisation locally alter the ambient physical conditions ([28, 51]) and thus the structure of the ecosystem ([45, 51, 56]), but also how they affect ([45]) and are affected by the water-column properties ([71]).

Pelagic work

Pelagic work has focused on the characterization ([16, 47, 64, 66, 67]) and modelling ([32, 44]) of foodwebs, and nutrient and carbon cycling in e.g. deep-water sponges ([33]).

In an ongoing project (Footprint), we are currently working on characterizing the foodwebs (sediment and water column), in and outside of offshore windfarms. In a newly acquired project (OrElse), we will look at the combined impacts of turbidity and turbulence on zooplankton dynamics and primary production, both from an experimental and modelling point of view.

2.2 Human impacts and extreme environmental stressors.

The oceans and seas provide many key services to society, by storing heat and carbon; by providing food (fisheries and aquaculture), transport routes, non-renewable resources, space for infrastructure (e.g., offshore windfarms, OWFs). But there are limits to these services, and our marine systems are in addition also subject to global warming, acidification, de-oxygenation, eutrophication, etc... Many of these pressures are linked or interact (e.g. warming and eutrophication both impact oxygen levels) and an integrated understanding of ecosystem functioning and dynamics is thus required.

In the past 6 years, I have worked on the impact of anthropogenic (eutrophication ([70]), OWFs, fisheries, aquaculture) and natural stressors (storms, floods), on the marine environment.

Fishing

We have performed a number of *in situ* and on-board fishing experiments to assess the effects of bottom trawling on sediment ecosystem ([22, 23]) and biogeochemical functioning ([8, 48]), and their interactions ([55]). With respect to biogeochemistry, these data were upscaled to larger areas by means of diagenetic modelling ([38]), for which we adapted our early diageneses models to include catastrophic human impacts. While this initial model roughly parameterized the ecological components, we are now working towards representing the effects on *ecosystems* in our models and how this links with biogeochemistry. In the frame of an NWO-funded project (BFIAT), and in cooperation with the ICES working group WG-FBIT (dealing with trawling impacts) and the EU-funded EMODnet biology project, we are creating an ecosystem-based assessment tool where we combine trait-based ecological models with fishing data.

In a number of recently acquired projects, we will further extend and apply these instruments to assess bottom disturbing effects such as sand extraction (project OrElse), deep-water mining (OCEAN-ICU) and benthic fishing (NECCTON, OCEAN-ICU).

Offshore windfarms (OWFs)

In a number of Belgian funded projects, I studied the impact of OWFs on the ecosystem level and on biogeochemistry ([65]). Upscaling the OWF effects on biogeochemistry to the scale of the southern part of the North Sea was done by coupled hydrodynamic-biogeochemical modeling ([30, 41, 42]). Results from these projects also served to point out how interdisciplinary science can support management ([14]).

Aquaculture

The possible impact of macro-algal (seaweed) aquacultures on ecosystem functioning was assessed in a series of modeling papers tuned at the scale of the Oosterschelde (a marine bay in S Netherlands). We first developed a hydrodynamic model for the area ([9, 12, 19]), and added an ecosystem model ([26]) to this. This coupled model was then used to investigate plausible impacts of macro-algal cultures on ecosystem functioning ([58]) and system-wide carrying capacity ([54]).

The physiologically-based seaweed model that was applied to aquaculture, will now serve in the NECCTON project which aims, a.o. at modelling the growth and impact of wild populations of seaweed.

Extreme events

Storms, floods, heatwaves, and other extreme events also have large impact on ecosystems. My improved biogeochemical models, originally intended to be used for estimating impacts of human perturbations (fishing, sand extraction) also serve to estimate the impacts of flood events ([57]). For our studies on tidal flats, we made a (physical) model that describes the heat balance in intertidal sediments and that will be linked to our diagenetic models. In addition, we also measured the impact of a severe summer storm on sediment resuspension and water-column oxygenation in a deep region of the North Sea (in prep).

3. Valorisation and impact

Open source tools

I have always been committed to open source data and software. In the period 2009-2014, I wrote about 20 open source packages in the R-software that still need (a bit of) maintenance. While I was not so active in software development during the last 5-6 years, this activity has recently been rejuvenated with our work on early diagenetic modeling, on trait-based approaches in ecology, and on ecosystem-based assessment of human impacts. A new set of R-packages has been created, but are still in the development or testing phase. For instance, one R-package contains the model and the interactive tool (serious game) to assess the effects of bottom trawling on ecosystem functions and services. Also, I created an R-package in support of the reaction transport modelling course that I teach in Utrecht (see below).

While some argue that making available (and properly documenting + maintaining) open source software is too time-consuming and gives away carefully built expertise, I do not share this view. I believe that my open source software has strongly increased the impact of my work, which extends far beyond the oceanographic community (see appendix on the use of my R-packages, which now amounts to ~ 8500 downloads per day). Also, although I typically do not require co-authorship for small expert help on my software, sometimes this leads to an unforeseen cooperation [(31, 39, 43, 46)].

In addition to open source software, I also endorse freely downloadable data. We compiled and made available a number of open source data sets ([13, 24]), and contributed to works that make use of such datasets ([26]).

Ecosystem-based assessments

Environmental, coastal and marine management strategies and environmental assessments are increasingly based on an ecosystem approach and on scenarios coming from ecosystem models. I have been improving our existing (e.g. biogeochemical) and have been developing new (e.g. trait-based) modelling tools that serve such ecosystem-based assessment. As my research integrates fundamental knowledge from chemistry, biology, and physics, it is well positioned to make generalizations on the (combined) impacts of these stressors.

Some of my work the past 5 years is usable for sustainable environmental management questions. For instance, we developed modelling tools to assess impacts of (future?) seaweed farming on carrying capacity in the Oosterschelde. Other models were used to forecast effects of offshore windfarms (OWFs) on ecosystem functioning, and the footprint it has on the area surrounding these OWFs (see above).

While marine ecosystem models are the best tool to bridge the scale from field observation to system-wide estimates such as carrying capacity, or to attribute environmental changes to key drivers, there is more and more demand for tools that are faster, are easy to apply and give (management) solutions in real-time. Such tools can be based on emulation of complex model output, or on large data sets, or even on a combination of these information sources. The tool is often based on a “digital twin” of the environment, a computer-representation of the real world, akin to the computer simulations used in engineering.

Several new projects that I am involved in comprise development of a digital twin technology of the marine environment, including NECCTON and OCEAN-ICU (EU projects), and Or-Else (NWO-funded), aiming at the development of digital twins of human impacts in the Black Sea, in global oceans, and in the Northsea respectively.

Another project, LTER-LIFE, aims at developing a research infrastructure to host digital twins of marine and terrestrial ecosystems.

Policy advise

I have been active (together with Dick van Oevelen) to set up new observational platforms in the North Sea, as part of the MONS initiative (RWS) ([R1]). In the coming years, the Netherlands will deploy buoys and floats for increased (real-time) temporal resolution in water column measurements, while ferry boxes will provide increased spatial resolution. Initial monitoring will focus on process measurements of community or bulk rates (e.g. photosynthesis), but also on the zooplankton distribution.

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Report

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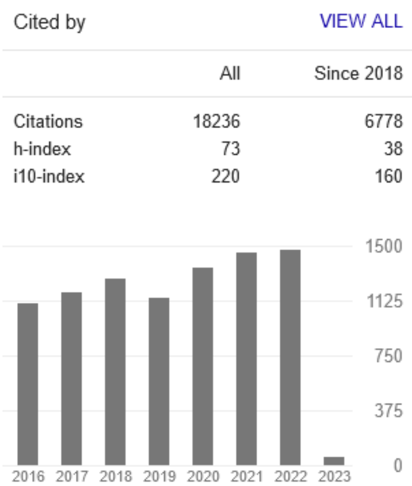

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