**Poster Session abstracts National Ocean Science Conference**

**Anouk van Boxtel** – NIOZ

Dust-associated production and export of phytoplankton biomarkers in Ionian Sea sediment traps

Dust deposition can trigger phytoplankton growth in oligotrophic parts of the ocean by temporarily relieving nutrient limitation. Additionally, ballasting by dust particles can enhance carbon export to the deep ocean, increasing the strength of the biological pump. In the Mediterranean Sea, some, but not all, dust events are followed by increased primary production. Hence, the exact relationships between dust deposition, phytoplankton response, and carbon export remain unresolved. To identify these relationships, we analyzed lipid biomarkers of higher plants, phytoplankton, and bacteria in sinking particles collected by sediment traps in Bannock Basin, eastern Mediterranean from 1999-2011 with 10-21 day resolution. Traps positioned at different water depths allow us to distinguish dust-induced productivity from ballasting effects. Some dust events are associated with enhanced fluxes of phytoplankton and bacterial biomarkers in the upper trap, although the response is not consistent among phytoplankton groups. Moreover, not all dust-related productivity events recorded by the upper trap resulted in increased export to the deeper traps. This suggests that Saharan dust deposition can have fertilizing and ballasting effects, but the exact response depends on confounding factors such as dust source area, deposition mode, and timing. These potentially influence the functioning of the biological carbon pump in the oligotrophic Mediterranean Sea.

**Daan Reijnders** - Utrecht University

Tracing Ocean Transport: From Plastics to Carbon

The ocean transports all sorts of things around the globe: heat, salt, life, carbon and plastic. My PhD research focuses on tracing transport pathways using numerical simulations. I develop new methods to do so, critically assess current approaches, and put methods into practice, for example to better understand the carbon cycle. My poster highlights my last two projects, on tracing carbon variations along ocean pathways, and on difficulties in tracing the origins of floating material backward in time. In my applied project, I look at how carbon concentrations change as water gets transported into, within and out of North Atlantic Subtropical Mode Water (NASTMW). This is a relatively thick and homogeneous water mass. Lying underneath the ocean surface, it comes into contact with the atmosphere during winter, when the surface layer is vigorously mixed due to strong winds, causing the mixed layer to connect with NASTMW. This way, it is a conduit for carbon to penetrate beneath the ocean's upper mixed layer, with the potential to sequester it. We study NASTMW from the viewpoint of a parcel of water that moves with the currents and how carbon concentrations in the water parcels change along different NASTMW pathways. For each pathway, the carbon concentration changes due to an interplay of vertical mixing and biogeochemical processes, for example related to plankton growth and decay. These processes can unfold over different timescales and may counteract or enhance themselves or one another. The largest change in carbon concentration is found when a parcel moves from the upper ocean mixed layer into NASTMW, mostly due to vertical mixing. The method that we developed for this study can also be used in other contexts, for example in assessing the efficacy of marine carbon

dioxide removal (mCDR). The other project is about backtracking the origins of floating material that is found at a certain location. Think about plastic or sargassum. A typical approach is to run a 'Lagrangian' pathway simulation backwards in time. But there is a catch. The ocean is full of upwelling and downwelling regions. Floating material tends to move away from upwelling regions quickly, as these are unstable, while downwelling regions function as attractors. Backwards in time, the reverse is true: downwelling regions become unstable, while the upwelling regions become attractors. When mapping probable origin locations, this causes backtracking studies to underestimate downwelling zones as origins, while upwelling zones are overestimated. The error that backtracking studies make depends on the timescales of the problem at hand. If forward and backward tracking significantly disagree, only forward approaches are warranted.

**Darshika Manral** - Utrecht University
Transport of Sargassum seaweed in the Tropical Atlantic

The floating rafts of Sargassum seaweed in the tropical Atlantic Ocean play a crucial ecological role, providing habitat to marine species, producing oxygen, and sequestering carbon when they sink to the bottom at the end of their lifecycle. However, when Sargassum arrives at coastal regions in excessive quantities, it can lead to hypoxic conditions, adversely affecting coastal species, fisheries, and tourism. To address this issue, the Weeds of Change project aims to conduct a month-long expedition (June-July 2024) in the tropical Atlantic Ocean, studying the growth, export, and transport of Sargassum. Drifter systems built to move with the Sargassum rafts will be deployed at each station. The data obtained from these on-board experiments will be used to improve Sargassum transport modeling, assisting in the mitigation of the negative effects of excessive landings and contributing to the sustainable management of this marine phenomenon.

**Elsa Girard** - Naturalis Biodiversity Center
Watching out for coral reefs with forams

Coral reefs are hotspots of biodiversity in shallow marine environments. Yet, they are under great anthropogenic pressures; their state as we know it may not persist into the future. Finding ways to monitor their health and preserve them despite their "urbanisation" is of utmost importance. Overlooked organisms, often due to their small size, have the potential to provide essential information about the reef condition, such as large benthic foraminifera. These tiny shells are calcifying unicellular organisms. They thrive on the seafloor of coral reefs because of their symbiosis with microalgae, just like corals, but have a much faster community turnover rate, compared to corals. These traits make large benthic foraminifera sensitive to the water quality and habitat variable. Hence, they are good bioindicators of environmental conditions of the coral reefs. We studied the spatial distribution of large benthic foraminifera in the turbid coral reef system of the Spermonde Archipelago to understand how they are impacted by local and regional eutrophication and turbidity in reefs. Our results show that the shallower communities are more impacted by eutrophication, whereas deeper communities are more affected by water transparency. This fundamental knowledge is essential in assessing and correctly interpreting signals we extract from the shift in large benthic foraminifera communities over time and space in coral reefs.

**Emma Daniëls** - Utrecht University
Virtual oceanography fieldwork: The Virtual Ship educational tool

I would like to showcase our educational tool Virtual Ship Parcels: a python notebook “simulation” that revolves around planning and conducting research at sea and thereby mimics fieldwork of an oceanographic research expedition. Fieldwork is an essential component of many education programs, but traditional marine science fieldwork can be cost-prohibitive, time-consuming, logistically challenging, and often has a large carbon footprint. We therefore design a digital learning experience that mirrors the complexities of at-sea research expeditions, suitable for students, early-career scientist and newly aquired staff. Over the last year we have developed Virtual Ship Parcels and the accompanying lesson material to allow students to virtually plan expeditions and perform measurements as if they were on a research vessel. Students formulate a research question, plan and prepare for the cruise, and virtually measure ocean fields. The data is generated from a climate model and includes measurement noise, allowing students to work with and interpret realistic information and data files. The current version of the Virtual Ship includes ADCP, CTD and underway data measurements and the option to deploy argo floats and/or drifters. The next version of the tool is currently being developed and will also include biological and geological measurement options to increase the usability for a larger audience of marine scientists. In addition a module to learn how to pilot gliders will be added. The Virtual Ship has been tested in 2 MSc courses at Utrecht University and surveys and interviews show the students were very enthausiastic and more engaged than in regular tutorials. We will futher investigate the achievement of the learning outcomes, the students’ engagement and self-efficacy through a Scholarship of Teaching and Learning (SoTL) research and show some preliminary results.

**Felix Dols** – Deltaris
European Digital Twin Ocean (EDITO) and application of Deltares software on the EDITO platform

The EDITO project is aiming to develop the next generation of ocean and coastal models, combining artificial intelligence and high-performance computing, to be integrated into the EDITO public infrastructure, providing access to Focus applications and what-if scenarios. The improved core model suite together with automated model builders and downscaling tools, as well as high-resolution data sources from both numerical simulations and machine learning approaches will be published in an interactive manner on the EDITO platform. In an interactive demonstration we showcase the capabilities of the European Digital Twin Ocean in two of the so-called Focus Applications, designed for intermediate users and what-if scenarios, designed for ocean and coastal policy makers. The Applications and scenarios cover three areas in line with the EU Mission "Restore our Ocean and Waters": Biodiversity, Zero Carbon and Zero Pollution. The applications that Deltares contributes to most explicitly are: (1) Biodiversity: Optimizing Marine Protected Areas by simulating biodiversity indicators and habitat suitability in the Wadden Sea (2) Multi-use in marine spatial planning to achieve Zero Carbon Emissions: the impact of aquaculture on the carbon cycle in the North Sea. By developing these Applications and deploying them in the EDITO public infrastructure, the Deltares and the EDITO Model Lab consortium hope to stress the added value of integrating the next generation of ocean models (Digital Twin Ocean Engine) with the Digital Twin Ocean Data Lake, containing data from CMEMS, EMODnet and other

sources. Moreover contribute to a fruitful discussion with intermediate- and end users around observing, simulating, forecasting and projecting coastal and ocean processes.

**Isabel van Waveren** - Naturalis Biodiversity Center
The Carbon Cycle revisited - A reconstruction of the Keeling curve using net chemical pollutant production.

When comparing the calculation of the atmospheric growth of Ballantyne et al. (2015) to the calculation of the yearly increase in atmospheric CO2 at Moana Loa minus the yearly decrease, it appears the two are equal. This allows us to expect that for the Global Carbon Equation (GCE) the yearly emitted industrial CO2 minus the yearly ocean and land CO2 sinks is equal to the yearly increase in CO2 at Mauna Loa minus the yearly decrease. Yet, when making a box chart if the GCE expressed in this new way, the GCE is not in equilibrium, for the Northern hemisphere. Considering the present day atmospheric CO2 concentration is aberrant, a new hypothesis is developed where pollutants drive global warming, especially in the Northern hemisphere. This hypothesis is elaborated as six functions, two related to seasonality, and three proportional to pollutant emission, one telated to the biological drawdown if CO2, two having influence in the troposphere of the Northern hemisphere and one having influence on the ozone depletion in the stratosphere. The sum of the six function has a determination coefficient of 0,99 and a probability of 0 (!) in comparison to the montly averages of the atmospheric CO2 concentrations in the Keeling curve.

**Jackie Ashkin** - Leiden University

Relationship between evaluation practices and knowledge production in marine science through an ethnographic lens

**Kim Darbouze** – KITLV
Healing Haunting Matters: Material, eco-geopolitical wounding and extractions of afterlives and colonialism across the Atlantic

This re/search focuses on weaving as a material and metaphorical means of revealing the frays, tears, wounding, and trauma of colonialism imposed upon the West Indies, Africa, and South-East Asia via European and North American domination. This multi-sited re/search includes an artist embodied analysis (dance/poetry/visual arts), eco-geopolitical, psycho-anthropological-scope, invites unlearning, and re-learning beyond the dominant, erosive, and continued colonial oppression. I address these matters by assessing interlinked relationship between oceans, lands, soil, and seeds tied to bodies and materials that are affected by capital commodity and colonial demands of the regions of Curacao, Suriname, and Indonesia. This embodied queering of methods addresses the harvesting of strange fruits that grows out of worn, torn, bombed, displaced, and re-rooted bodies and lands via colonial powers. This re/search examines, addresses, and re-dresses the colonial frays impacting ecological, material erosion, economic insecurity which creates issues of belonging, citizenship, erasures/lack of appreciation for Indigenous/non-western ways of knowing, and embodied colonial ideologies. By weaving in these

various modes of analysis between the West Indies, Africa, and South-East Asia allows for a reconsideration that queers Indigenous knowledges between oceans, lands, bodies, and ecosystems made separate. Weaving unhinged from colonial fragments reminds us of the powerfully significant and inextricably tied impact of land, species, and natural resources on presents and futures. Weaving holds on to memory to mapping and worldly tracing towards collective care for futures yet to come. This blending of methods leads towards the significant material impact erased and it's haunting terrains that allows us to remember what was there before. It reshapes how we engage, remember, and work through futures of healing. The material world is immersed with multiple ways of knowing (McKittrick, 2006), learning, and relearning. My re/search works towards collective healing starting with radical imaginations.

**Lisette Mekkes** - Naturalis Biodiversity Center
Contrasting calcification patterns between juvenile and adult pteropods across the Atlantic

Shelled pteropods are key calcifying plankton in the global ocean. They are expected to be the first calcifiers affected by ocean acidification due to their delicate aragonite shells. However, there are still large uncertainties in global carbon cycle models, attributed to an incomplete understanding of calcium carbonate formation and dissolution, particularly of aragonite. Most studies on the effects of ocean acidification on pteropod calcification focus on species from polar regions. Therefore, in this study, we focus on globally the most abundant pteropod species, Heliconoides inflatus, inhabiting different habitats from temperate to (sub)tropical regions. We assessed variability in juvenile and adult H. inflatuscalcification along natural ocean gradients along a meridional Atlantic transect. Net calcification was quantified using 3D models acquired through Micro-CT scanning of 221 shells collected at 21 stations. Our results show that juvenile calcification is positively correlated with the carbonate system, where higher pH and aragonite correlate with thicker shells. Conversely, adult shell thickness does not vary along the transect but larger shells are associated with higher chlorophyll a (a proxy for food). This indicates that juveniles are probably more vulnerable than adults to ocean acidification and would be the most suitable as bio-indicators. This research shows that there are different drivers affecting calcification depending on the life stage of pteropods. Hence, future studies need to take into account life stage and food availability as important drivers of calcification responses to a changing ocean. The rapidly changing ocean due to climate change, with predicted lower pH and food availability, is expected to negatively impact aragonitic calcifiers.

**Marjolein van Vulpen** - The Ocean Cleanup
Assessing the Environmental and Social Benefits of The Ocean Cleanup's Technologies.

Ocean plastic pollution is a pressing environmental challenge. The cleanup of legacy plastic pollution may reduce risks to marine ecosystems. The Environmental & Social Affairs (ESA) team of The Ocean Cleanup tries to ensure the net positive environmental and social impact of The Ocean Cleanup's operations by investigating the risks and benefits of cleaning up plastic pollution in rivers and on the high seas. We continually seek to have a greater understanding of the relationship between our technology and the natural and social environment with the goal of maximizing the net positive effect of our impact. In addition, we conduct scientific research to better understand the adverse impacts of plastic pollution on

marine ecosystems and how cleanups can help mitigate them. By researching, among others, neuston in the North Pacific Garbage Patch, ingestion of plastics by fish and turtles, and the impact of plastics on mangroves in and around rivers, the knowledge generated is used to assess the net benefit of cleanups on nature and society. Ultimately, this research contributes to a better understanding of plastic pollution impacts on marine environments.

**Marleen Vintges** - The Ocean Cleanup
Plastic ingestion in marine fish from the Great Pacific Garbage Patch

Plastics in the marine environment pose a threat to marine ecosystems in various ways, one of which is ingestion by marine, often by fish. While plastics ingested by fish can often pass through the digestive tract without harm, they can also result in internal injuries, blockages of the tract, lowered reproductive performance, decreased predatory efficiency, malnutrition, starvation, and death. The North Pacific Garbage Patch (NPGP), located in the eastern part of the North Pacific subtropical gyre, represents a high plastic ingestion risk area due to its high plastic concentrations. However, due to its remoteness, little is known about the extent and characteristics of plastic ingestion in the NPGP. Here, we studied the ingestion of plastic in fish species captured in the NPGP as incidental bycatch during cleanup operations by The Ocean Cleanup. Gastrointestinal tracts from each fish were dissected and microscopic analysis was used for the recovery of plastic debris. Subsequently, the plastic particles were counted and classified by type, size, and colour, and weight. Plastic polymer types were analysed using ATR-FTIR. Even though not all fish plastic were found to ingest plastic the recovered plastics in the GIT of pygmy and cookie cutter sharks were mostly fishing line and net. Ultimately, this research contributes to a better understanding of plastic pollution impacts on the high seas particularly in oceanic gyres like the NPGP.

**Niels van Helmond** - Radboud University Nijmegen
Variable effects of ecosystem restoration in a eutrophic coastal lagoon: reoxygenation by increasing water exchange

Increased anthropogenic activities are affecting water quality, e.g. leading to eutrophication and deoxygenation, culminating in biodiversity loss in coastal ecosystems globally. In the Southwest Delta in the Netherlands, large scale engineering to protect coastal areas against storm surges has turned several tidal inlets and estuaries into coastal lagoons and (marine) lakes. The water quality in these ecosystems has strongly deteriorated as a result of stagnation of bottom waters in combination with eutrophication. One such ecosystem, Lake Veere, showed signs of recovery after restoration of water exchange with the adjacent tidal marine Eastern Scheldt in 2004. In recent years, regular water monitoring has revealed the return of low-oxygen conditions, however, along with other signs of worsening water quality such as fish kills and jellyfish blooms. Here, we assess the role of the sediments in the (re)occurrence of low-oxygen conditions in Lake Veere. During two sampling campaigns in 2022, water column and sediment samples were collected. Geochemical analysis, including direct in-situ flux measurements with a benthic lander, revealed an increasing sedimentary oxygen demand (SOD) from the western (sea-side) part of the lake to the east, from ~10 to >100 mmol $O_2$ $m^{-2}$ $d^{-1}$. This gradient in SOD opposes the observed trend in water column deoxygenation, with low-oxygen conditions predominantly prevailing in the central and western part of the lake and not in the east. This indicates that, despite restoration efforts, large parts of the lake

are still highly sensitive to deoxygenation. Sediment analyses show the near-absence of iron-oxides, hence little capacity to buffer toxic hydrogen sulfide, which indeed accumulated in pore waters, reaching concentrations of up to 10 mmol L-1. In the central part of the lake, hydrogen sulfide even accumulated in the bottom waters, pointing towards its potential involvement in the observed fish kills in the region. Our results illustrate the difficulty of improving water quality through changes in water exchange alone because of strong legacy effects of eutrophication and deoxygenation in the sediment.

**Pieter Hovenkamp** - NIOZ / Utrecht University
An image of contrasts - automated image analysis to understand the role of zooplankton in a changing ocean

Plankton comes from a Greek word meaning ‘to wander, to drift’ and refers to all pelagic organisms in the sea that are unable to swim against currents. Zooplankton are the animal-like groups therein and they play a vital role in the marine pelagic food web, as they are the link between primary production from algae and higher organism such as fish, sea birds and mammals. However, zooplankton is particularly sensitive to changing environmental conditions: due to ocean warming, some species distributions have shifted northwards with 200 kms per decade, and such changes have been linked to major shifts in fish stocks. It is therefore vital to closely monitor zooplankton communities, and to understand how these communities are linked to possible changes in primary production and in environmental conditions. Over the past decases, though, little work has been done on zooplankton in the Dutch North Sea. A main reason for this is that monitoring of zooplankton with traditional net sampling is a time-consuming, and therefore costly effort. In this PhD project, we work with recently developed underwater microscopes that take in situ photos of zooplankton. We developed machine learning techniques that can identify and count plankton species from such images automatically. For this we make use of Convolutional Neural Networks, a form of deep-learning that has become very popular over the past decade for all kinds of image recognition applications, and we are now able to classifiy observed zooplankton groups with an accuracy of around 90%. An additional benefit of these in situ imaging instruments, is that we can obtain fine-grained data on zooplankton abundance in time and space, and we can link these data to seawater conditions that we measure simultaneously. This way, we can discover patterns that would be impossible to find with traditional net sampling methods, since these are limited in their temporal and spatial resolution. Over the past years, with these novel techiques we conducted studies in various parts of the North Sea and in Greenland in order to better understand the role of zooplankton in a changing pelagic ecosystem. The combination of imaging instruments and machine learning facilitates future monitoring of zooplankton in the North Sea, and eventually, in the less observed oceans throughout the world.

**Samuel Lu** - Utrecht University
Governance marine biodiversity in areas beyond national jurisdiction: Institutional interaction as a catalyst for cooperation and coordination

Oceans contribute to many important aspects of humankind. However, the rise of anthropogenic activities causes harm to the oceans' health from increasing marine pollution to overfishing. The small island developing States, which majorly rely on the oceans, are susceptible to the harm done to the ocean. This raises the alarm of the necessity of conserving the marine biodiversity in the oceans, particularly in the areas beyond national jurisdiction (ABNJ).The ABNJ is governed by various institutions that were tasked with a specific mandate such as fisheries, deep seabed mining, and shipping, all of which create the ad hoc and fragmented institutional landscape in the area. None of these institutions are specifically tasked with the objective of protecting marine biodiversity, nor are they obliged to take into account measures adopted by other institutions which are not related to their mandates. A Particularly Sensitive Sea Area (PSSA) that specifically focuses on protecting the marine environment from shipping activities, for example, would not intertwine with fishing measures, and vice versa. It is under this context that the Agreement under the United Nations Convention on the Law of the Sea on the Conservation and Sustainable Use of Marine Biodiversity of Areas beyond National Jurisdiction (The Agreement) was adopted in 2023. In the already clustered and fragmented area, the biggest challenge presented to the Agreement is how it could enhance cooperation and coordination between existing institutions to promote more effective protection of marine biodiversity. The thesis argues that the BBNJ Agreement hosts a range of measures for institutional interactions, which in turn creates a catalysing effect for cooperation and coordination in ABNJ. The institutional interactions can take place between existing institutions through the centralisation of information concerning all ABNJ activities to the Clearing-House Mechanism; ensuring public participation and transparency in decision-making; identifying the best available science and best available information; developing standards and guidelines to provide a unifying approach, particularly in conducting environmental impact assessment; and making recommendations to adopt measures provided by other institutions. Second, institutional interactions can also manifest between the BBNJ Agreement and other institutions. This includes making arrangements and consultations with other institutions; adopting compatible conservation measures and filling gaps left by existing institutions; and requesting advisory opinions with judicial bodies that can clarify and develop the obligations concerning cooperation and coordination between institutions in ABNJ. The Agreement itself is a product of compromise and package deal. State parties and other existing institutions are not willing to be undermined by the newly adopted BBNJ Agreement. Thus, instead of conducting direct intervention, the range of methods provided by the BBNJ Agreement is to catalyse the interactions to enhance cooperation and coordination. Whether institutional interactions are adequate to govern the marine biodiversity in ABNJ remains an elusive question. The answers may be rooted in the structure of contemporary international legal order that may not be solved by simply adopting a new treaty.

**Shirin Rahman** - Utrecht University
Geochemistry of whale teeth: indicators for modern and ancient ecology

Since whales are integral to marine ecosystems globally, developing effective policies for their conservation is essential. However, these policies must be informed by accurate assessments of population baselines, in order to track changes in their habitats. Due to their long life spans and some whale species being migratory, these ecological baselines are harder to establish, especially for historic populations. Since whales are integral to marine ecosystems globally, developing effective policies for their conservation is essential. However, these policies must be informed by accurate assessments of

population baselines, in order to track changes in their habitats. Due to their long life spans and some whale species being migratory, these ecological baselines are harder to establish, especially for historic populations. However, it is possible to gain insight into their ecology and environment by analyzing biological remains, such as teeth. Teeth are chemically stable and often well preserved, even in the fossil record. Whales keep their teeth throughout their lives, thus they can also preserve long-term environmental information on diet, migration routes or environmental temperatures. By comparing the information recorded in modern to subfossil teeth, I want to gain insight into human impact on whales throughout the last few millennia. For my PhD project, I am sampling teeth from harbor porpoises (Phocoena phocoena) and sperm whales (Physeter macrocephalus) from the North Sea. Both species represent very contrasting ecologies and are thus differently affected by anthropogenic impacts. Modern teeth are acquired from stranded whales on the Dutch coast through the Faculty of Veterinary Medicine at Utrecht University. Subfossil material is collected from European museums. In order to gain more insight into the growth dynamics of each individual, the growth layer groups in each tooth were imaged and counted. These layers are very recognizable in whale teeth, thus allowing for age estimations and insights into growth dynamics. The modern and subfossil teeth were then compared to each other in their chemical, elemental and crystallographic structure. This step is necessary to quantify for post mortem changes due to a process known as diagenesis, since these changes can influence the applicability of proxies used to determine the ecological niches of the whales. Diagenetic alterations can be identified using Raman spectroscopy, a method which provides insight into the mineral composition and thus also enables the characterization of different mineralized biological tissues (dentine, enamel and cementum). Correcting for diagenesis, before applying suitable proxies to modern and subfossil teeth, is the first step to reconstructing the ecological niches of past and present whale populations. By understanding the habitat changes caused by anthropogenic impact, more specific conservation policies could be implemented in the future, to ensure the survival of vulnerable whale species.

**Sonia Heye** – Deltaris
Environmental effects of oyster restoration in the North Sea under different climate change scenarios

The North Sea is currently an impoverished system, in terms of biodiversity. North Sea wide efforts aim to restore habitat-forming species, such as the European flat oyster (Ostrea edulis). Within the EU project FutureMARES, we used a state-of-the-art numerical model to investigate the restoration potential of different areas in the North Sea for this species under a range of climate scenarios. We found that in most of the large areas that used to host big oyster populations, their growth rate is insufficient for rapid restoration. Only a few areas in the North Sea appear to have suitable habitat conditions as well as sufficiently rapid growth rates.

**Titus Kruijssen** - Wageningen University & Research
Hydrogeological pressures on coral reef ecosystems around Curaçao

Fringing coral reef ecosystems face a variety of environmental pressures, ranging from global ocean warming to local nutrient and pollutant inputs. Local stressors receive increasing attention from academia, but most reef ecosystem studies still only generally consider terrestrial processes that govern inputs from land. Nutrients and pollutants from land enter marine ecosystems via multiple hydrological

pathways, including surface runoff and submarine groundwater discharge fluxes. Hence, a thorough quantitative understanding of an area's hydro(geo)logical system is essential to predict and characterize terrestrial inputs to sea and assess their impact on reef ecosystems. We extensively studied the hydrogeology of the tropical semi-arid island of Curaçao, located in the Caribbean Leeward Antilles Island range. Multiple methods were applied and combined in the field to assess both the quantity and water-quality of terrestrial inputs. We monitored groundwater level and salinity in over 100 wells across the island to grasp the seasonal variation in groundwater discharge fluxes to sea. Ground- and surface water samples were collected and analyzed to assess the nutrient and pollutant loads of the island's various terrestrial water sources. In sea, electrical conductivity surveying was combined with Radon sampling to detect and quantify land-derived freshwater inputs into the island's inland bays. The field data are currently used as inputs for hydrogeological model simulations to further quantify land-derived fluxes to the island's marine ecosystems. We herein present a combination of our preliminary results that provide essential insights in the location and timing of seaward surface and groundwater discharge towards the island's fringing reefs. These results will later be used by other researchers in the SEALINK research project, aiming to quantify local impacts of terrestrial inputs on coral reef ecosystems.

**Vesna Bertoncelj** - NIOZ / Utrecht University

Simulating residence times of nutrients and pollutants around coral reef communities on Curaçao

Functioning and growth of shallow-water ecosystems, such as coral reef communities, are highly dependent on the local water quality. The availability of nutrients, minerals and pollutants is dynamic and depends on the local sources of these substances, biogeochemical processes that affect them, as well as the offshore and nearshore hydrodynamics and their connectivity. One of the key factors in determining the influence of ocean- and land-derived substances on coral reef communities is the seawater residence time at the nearshore reefs. Our research is a part of a larger interdisciplinary program where we quantify the role of ocean hydrodynamic processes in linking the land-to-ocean continuum in the Dutch Caribbean, particularly focusing on the nearshore coral reefs of the island of Curaçao. We present results from a Lagrangian connectivity analysis in a novel regional 3D hydrodynamical model of the Southern Caribbean Sea surrounding Curaçao. The model configuration is forced by oceanic boundary conditions from the CMEMS global ocean eddy-resolving reanalysis GLORYS12V1, and the ERA5 atmospheric reanalysis produced by the ECMWF. A Lagrangian simulation using the Parcels framework is then used to predict the pathways of neutrally buoyant particles coming from both the open ocean and the land. The residence times of particles passing the nearshore coral reef areas are used to identify hot spots, i.e. the areas with high residence times relative to the other areas. Results show the shadowing of the current by the island shape and bathymetry, resulting in longer residence times in the North-West of the island. The combination of 3D hydrodynamical model and Lagrangian model serves as the basis for further analysis on the influence of land-derived nutrients, pollutants and suspended matter on coral reef health.

**Virginia Sánchez Barranco** – NIOZ

The island effect on the biogeochemistry of tropical coastal waters: A case study from Curaçao (Caribbean Sea)

Water quality is a critical factor for coral reef health and growth. Yet, the effect of land-derived substances on reefs structure and biodiversity is not fully understood. As part of the SEALINK project, this research aimed to 1) examine the spatial distribution of (in) organic nutrients along the coast of Curaçao and their relation to human activities or other sources and 2) assess the effect of bays on the water column biochemistry and nearby reefs. Sampling included a large collection of water samples (DIC, TA, Si, NH4, PO4, NO2, NO3, SPOM) and environmental parameters along the south coast of Curaçao as well as sediment and suspended matter around two bays (Sint Michiel and Piscadera Bay). Nutrient results indicate a relatively homogenous biogeochemical signature (i.e. no significant differences in the concentrations) along the coast and offshore of the island. However, we found distinctly higher concentration of nutrients close to Piscadera Bay and the west part of the island. In addition, when zooming in into small scale variations around the 2 studied bays we found spatial differences: water surrounding reefs that are more exposed to the bay flow showed higher nutrient concentrations compared to the reefs upstream. Fluxes of suspended matter and their distribution around these bays were also mainly determined by local hydrodynamics and tides. These results match the more degraded state observed in the reefs more exposed to the bays effect. Together, these findings suggest that rather than population density or coastal development, general water circulation and channeling of land-derived matter by bays are governing the near-shore water column chemistry. This is of especial relevance as the south coast of Curaçao contains many bays and understanding how these processes affect reefs close by might be key to develop effective management practices.