ANNUAL REPORT 2013

ROYAL NETHERLANDS INSTITUTE FOR SEA RESEARCH

With interviews
on pages 28 to 31

DELTA

RV Stern

INTERTIDAL

COASTAL

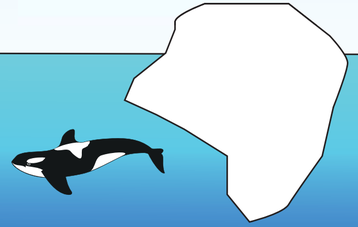
RV Navicula

TROPICS

OPEN OCEAN

RV Pelagia

POLAR



In memoriam Carlo Heip

On 15 February, our former director Carlo Heip (1945-2013) passed away after a prolonged illness. Carlo Heip studied biology at Ghent University, where he graduated on a study of the ecology and population dynamics of meiobenthos, small organisms living in the sediment. His study site was a small brackish-water pond but his **main** interest was the open ocean and his peers were international colleagues. He founded a research team on marine biology at Ghent University that still persists. At this time he wrote a seminal paper on the ecology of marine nematodes, focused on the functional role and ecophysiology of meiobenthos and developed the use of meiobenthic diversity as a tool in biomonitoring. As the chairman of ICES' benthic ecology working group, he organized the large North Sea Benthos Survey in 1986.

When he became director of the Delta Institute of Hydrobiological Research in Yerseke, The Netherlands, in 1987, he re-oriented the institute from a regional initiative to an international player in the study of the ecology of estuaries and coastal seas. In 1992 the Delta Institute became part of the Netherlands Institute of Ecology (NIOO-KNAW). Carlo founded and led a research group that focused on the interaction between species and their biogeochemical and physical environment. The research had a strong modelling component. It resulted in a few well-known reviews on estuarine processes, new model developments especially for benthic processes and the development of new biogeochemical methods for the study of estuarine ecology. In contrast to most studies in biogeochemistry, it kept a strong focus on biology and species.

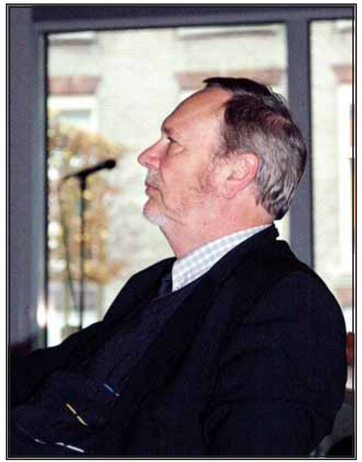
From the early 1990's onwards, he was very active as a Projectleader and coordinator of European research projects in Land-Ocean Interaction studies. Within the scientific study of global change, he had the strong feeling that biodiversity issues were underrepresented and that the field was splintered. For this reason he actively engaged in several initiatives to bring together the relevant partners. This resulted in several initiatives, of which the European Network of Excellence MARBEF (Marine Biodiversity and Ecosystem Function) was the most important one. MARBEF united ecologists and taxonomists on a European scale in a joint effort to provide the protection of the biodiversity of marine life with a sound scientific basis. This European project also stimulated world-wide initiatives to better understand and describe the diversity of marine ecosystems.

In 2006, Carlo Heip became director of NIOZ at Texel, where he remained until his retirement in 2011. As director he managed to lead the institute to an excellent peer review in 2011. He also prepared the merger of the Centre for Estuarine and Marine Ecology of NIOO-KNAW in Yerseke with NIOZ, thus bringing together the two Dutch institutions to which he had devoted his professional life under the umbrella of the Netherlands Organization for Scientific Research (NWO).

Carlo Heip had the leadership and vision that made him an excellent organizer, both as a director and as a coordinator of the numerous international initiatives he was involved with. He had an innovative and creative mind and a special gift for summarizing the essence of a scientific field or debate. He was, above all, a people manager. He stimulated his collaborators by giving them respect, trust and strategic guidance.

Carlo had a drive for nature. He was keen on bringing scientific knowledge to the policy and management level and to improve coastal and marine management. He was involved in local and regional estuarine management, as well as in European and worldwide programs for the protection of biodiversity. And above all, he was a warm personality with a good sense of humour, who enjoyed all good things in life.

Peter Herman



From the directorate

Gaining insight in the complex and dynamic marine ecosystems and environments is of vital importance for modern society and at the heart of the mission of Royal NIOZ. Our activities, our mission, our multidisciplinary research, including frontier applied studies, our modern research facilities, labs, and research vessels, are all dedicated to this task. Furthermore, NIOZ supports academic and applied marine and maritime research with know-how and infrastructure in the Netherlands and abroad, and we continued to do so in 2013.

Research at NIOZ continued to focus on marine environments globally, in estuaries and deltaic settings, from polar regions via temperate zones to tropical coral reefs, and into the depths of the oceans. NIOZ was and is a respected and trusted partner in a multitude of national and international efforts to improve our understanding of the changing oceans, and for paving the way to improved and sustainable use of them in terms of global food, energy and other natural resources for broad scientific and societal benefit.

In the year 2013, NIOZ scientific productivity reached an all time high with over 263 peer reviewed publications, including 59 open access papers, 11 PhD theses, more than 220 professional papers and well over 600 outreach and media contributions. It was also the year where NIOZ was very successful in the various national NWO/STW 'topsector' calls, and where the Principal scientists of our biogeochemistry department prof. Jaap Sinninghe Damsté and prof. Stefan Schouten, as leading members of two national research consortia, were awarded the prestigious NWO/OCW 'Zwaartekracht' grants from the Netherlands Organisation for Scientific Research (NWO) and the Ministry of Education, Culture and Science (OCW); the largest research grant of its kind in The Netherlands. Moreover, prof. Stefan Schouten received an advanced ERC grant as well. Kees Camphuijsen won The Academic Year Price 2013.

The year 2013 was in many respects a difficult year for the institute. The sad and too early demise of prof. Carlo Heip, just retired from his long standing general directorship of Royal NIOZ, left us all impressed and speechless. He will be remembered as an excellent, world-leading scientist in the field of Biodiversity, and a nationally and internationally highly respected leader of the institute. More mundane, issues arose as well, linked to the global economic crisis, the general political environment, and financial management. As a consequence, the institute was, is, and will be facing serious budgetary reductions in 2014 and the years to come. Yet, also in these troublesome times we will have to face them and move forward.

Henk Brinkhuis
Herman Ridderinkhof

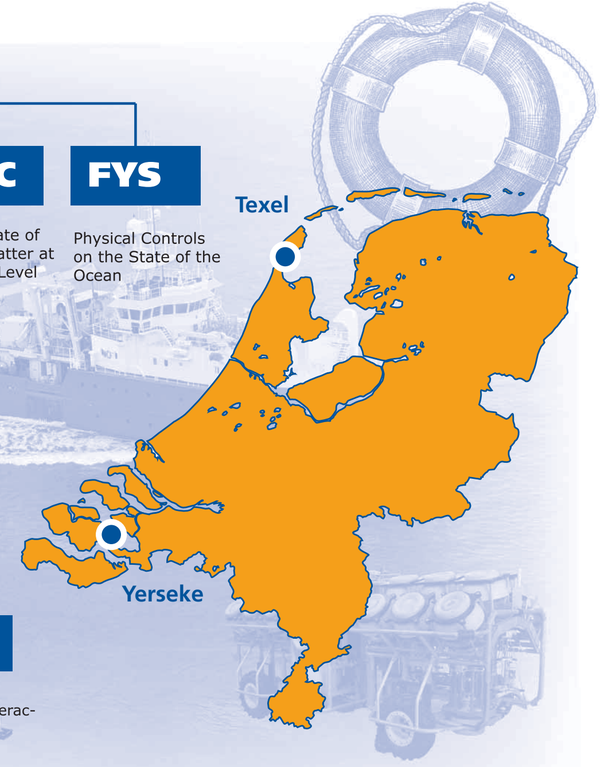
More information is available on-line via www.nioz.nl

NIOZ TX

- **BIO** — Microbial Food Web & Biogeochemical Cycles
- **MEE** — Structure & Dynamics of Marine Populations
- **GEO** — Sedimentary Systems & Climate Reconstruction
- **BGC** — Origin & Fate of Organic Matter at Molecular Level
- **FYS** — Physical Controls on the State of the Ocean

NIOZ YE

- **YES** — Ecology & Biogeochemistry
- **YMM** — Microbial Ecophysiology
- **MON** — Benthic Communities as Environmental Indicators
- **YRE** — Organism-Landscape Interactions



From the board

On 15 February 2013 NIOZ was shocked by the sad loss of prof. Carlo Heip after a relatively short period of fatal illness. Carlo Heip will be remembered by the Board not only as an eminent scientist and director of NIOZ but also as a good colleague, friend and amiable person. Carlo Heip was appointed as part-time director of NIOZ on 1 October 2006 in conjunction with his directorship of CEME in Yerseke. After a highly fruitful five-year period of growth, improved governance and strongly increasing scientific achievements of NIOZ, Carlo Heip retired as general director on 1 October 2011, just before the successful merger of NIOZ-Texel and what is now known as NIOZ-Yerseke was formally concluded.

Prof. dr. M. Vincx was appointed by the Board of NWO on 1 January 2013. Prof. dr. T.M. Elzenga (University of Groningen, CEES) left the board on 1 November 2013. In 2013 Board and directors convened six times, on 28 February (Yerseke), 17 May (Texel), 9 July (Utrecht), 22 August (Texel), 25 October (Utrecht) and 28 November (Texel). Moreover, during the Board meetings of 17 May and 28 November the chairman and members of the Board conferred with the Works Council of NIOZ.
Board meetings were attended by prof. dr. W.P.M. de Ruijter (IMAU, Utrecht University) on behalf of the NIOZ Science Committee, as well as by drs. R.M.L. Schorno on behalf on the general director of NWO.

On 5 March the annual bilateral consultation between the Board of NWO and the Board of NIOZ took place. On 20 November the Board of NWO consulted with the chairmen of all NWO research institutes. Discussions during these meetings mainly focussed on the financial constraints of NIOZ Texel in conjunction with NIOZ Yerseke, the renewal of the NIOZ Science and Strategic Planning, the developments concerning the renovation and commercial exploitation of the NIOZ harbour, the structural deficit of the exploitation costs of R.V. Pelagia, and the establishment of the Caribbean Netherlands Science Institute (CNSI).

The chairman of the NIOZ board met several times with the chairman of the Board and the director of NWO to discuss the long term role and funding of Pelagia and ocean research. Van der Kamp and Elzenga, as members of the Audit Committee, had several meetings with the NIOZ controller and the external accountants of KPMG. Koster attended meetings of the steering committee of CNSI.

During 2013 research retained its excellent standard. Several NIOZ research groups are working at the forefront of their field internationally and their research has an important impact in the field. Leading scientists obtained substantial research grants in a highly competitive national and international granting framework. In scientific and professional reviews and in public media NIOZ research has been recognized as scientifically leading and highly relevant for society.

Discussions continued with the Division of Earth and Life Sciences of NWO as well as with the General Board of NWO with respect to the financial contribution to the maintenance and operation of the R.V. Pelagia. A new business plan for the Pelagia has been presented, stressing the international importance of the ship for the high level of marine research by the Netherlands scientific community. Initial steps towards a 'national marine board' have been taken in cooperation with other scientific and commercial partners in the marine field. Its task will be to formulate a 'national marine vision for marine infrastructure in The Netherlands'. Good progress has been achieved in the establishment of a NIOZ Holding structure including the NIOZ-Harbour private limited liability company (NIOZ Haven B.V.).

During the year severe financial deficits came to light in the annual accounts of 2012 and 2013. These were partly due to the transition to a different accounting system, but also caused by somewhat optimistic estimates of revenues from overhead and profits from a multitude of scientific and commercial projects and a decrease in the annual funding of NIOZ by NWO.

Pier Vellinga
Chairman of the Board

As per 31 December 2013, the Board consisted of the following members:

- prof. dr. E.A. Koster: Utrecht University, Faculty of Geosciences
- prof. dr. M. Vincx: Ghent University, Faculty of Sciences, Marine Biology Research Group
- ir. A. Lubbes: Fugro, Leidschendam
- prof. dr. ir. P. Vellinga (chairman): Wageningen University and Research Centre
- mr. G.F.C. van der Kamp: Bussum
- prof. dr. J.L. Olsen: University of Groningen, Centre for Ecological and Evolutionary Studies (CEES) (not present when picture was taken).

Ecology and Physics, a world apart?

A labyrint pattern in a mussel bed

Is fundamental physics relevant for ecology? Do ecologists have to read Einstein? Yes, is the answer! It turns out that the movement and aggregation of mussels during the formation of mussel beds is a process that has well-known counterparts in physics. Mussels move a lot while alone or in dense crowds, but move less when encountering a clump of the right – intermediate – size. In this way, they form regularly spaced clumps. Similar density-dependent movement is also essential for the formation of alloys of for instance iron and steel, which separate out to form similar patterns. While aggregating into dense clumps, their movement becomes increasingly similar to random Brownian motion, due to collisions with other mussels. Here, mussel movement is shaped by the same mechanism as Einstein proposed for Brownian motion in atoms and molecules in solutions: collisions. It seems that even in the 21st century, we can identify universal principles that cut across the various disciplines of the natural sciences.

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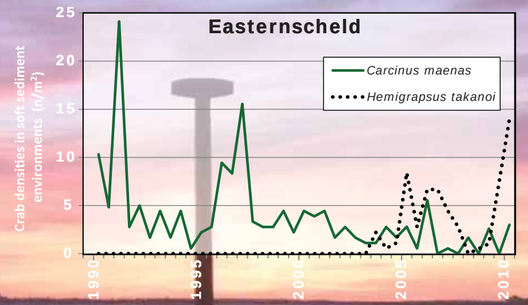
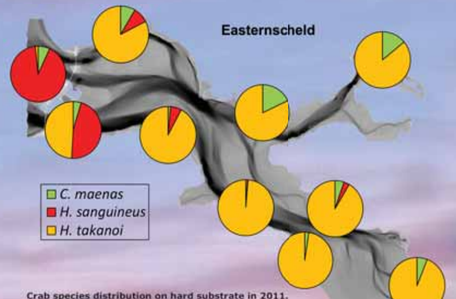
Competition between Asian and European shore crabs





Crab species distribution on hard substrate in 2011.
Study in cooperation with Anneke van den Brink (IMARES)

Exotic species are often mentioned as the reason for the decline of species that originally live in our waters. This was also the case when two Asian shore crab species (*Hemigrapsus takanoi* & *Hemigrapsus sanguineus*) were co-incidentally introduced in our waters and the formerly abundant European shore crab (*Carcinus maenas*) was getting rarer. The Asian species were successfully expanding all over the Delta region and behaved more aggressive than their European counterparts. However, from the long-term monitoring data series of the Monitor Taskforce it became clear that European shore crab populations were already declining far before the arrival of the exotic species in 1999 and their appearance in the samples from soft sediment environments in 2004. A similar pattern was observed in the other Dutch delta waters with European shore crab numbers already declining for decades and Asian shore crabs not abundant until recently. When both present, Asian shore crabs do nowadays expel young European shore crabs from their preferred shelter places into the open sandy bottom areas, where risks of being eaten are much higher. Competition of Asian shore crabs is not the initial cause of the decline of the European shore crab populations, but is definitely an additional problem.

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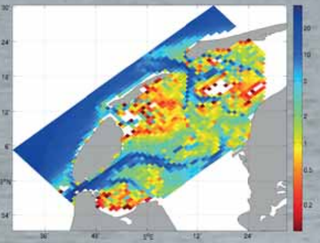
Any time, any where: a new model for fine scale ecosystem dynamics



New computer model for ecosystem dynamics in the Wadden Sea showing the depth in 1 km grid points (coloured squares). All biological processes are calculated in each grid point; the coupled water flow model calculates the rates of transport between the grid points.

Merging a model of the physical aspects of the western Wadden Sea (GETM) with an ecosystem model developed for European regional seas (ERSEM) resulted in a new improved model. This model describes algal growth and production at the basis of the food web in reaction to available nutrients, grazing on the algae by animal plankton and shellfish, and mineralization by bacteria. It includes both the deeper parts of the western Wadden Sea remaining permanently submerged as well as the tidal flats emerging during low-tide. Using the model, physical, chemical and biological variables can be simulated throughout the seasonal cycle and at places where they have not been measured. Entirely new for any model is the inclusion of algae which live attached to the surface of the sea floor. These benthic algae are responsible for 10-20% of the total algal production in the Wadden Sea; an aspect which has been largely neglected until now in modelling.

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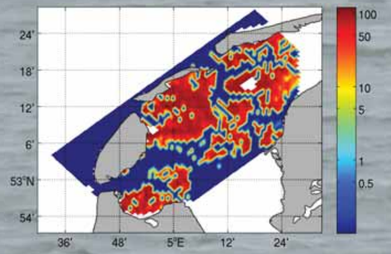
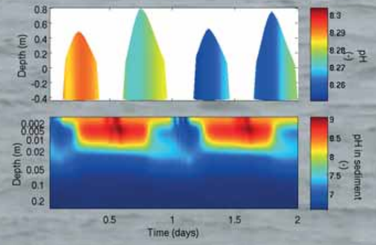
Link to running model video's http://www.nioz.nl/ersem-getm

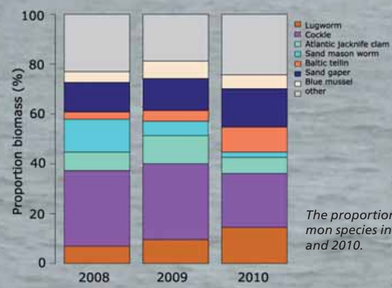


Algal growth (mg C m^{-2} d^{-1}) on Wadden Sea floor. Production by these algae is responsible for 10-20% of the total algal production in the Wadden Sea.



Model of pH in an intertidal grid-point. Dynamics in the water column are controlled by the tide. Dynamics in the sea floor are controlled by light availability. During the day, algae use CO_2 and cause a pH increase. During the night, algae and bacteria produce CO_2 and decrease the pH.

SIBES: large Wadden Sea sampling program



The proportion (%) of biomass contributed by common species in the Dutch Wadden Sea for 2008, 2009 and 2010.

The Wadden Sea is a large expansive tidal flat area that is key for migratory shorebirds and North Sea fishes due to its high biomass of communities of organisms which live in and on the tidal flats (macrobenthic communities). Based on appearances this area might be mistaken as a homogenous habitat. Instead, steep environmental gradients and heterogeneous sediments dominate this area. The data from the Synoptic Intertidal benthic surveys (SIBES), a large tidal flat sampling program, identified differences in species composition from west to east and in the Dollard region. For example, bivalve species like sand gapers are found more in the western Wadden Sea while common cockles are more abundant in the eastern Wadden Sea. Consistent with these differences, a model integrating environment and species data identified that the Wadden Sea is a heterogeneous ecosystem that supports a wide variety of macrobenthic communities.

Henk van der Veer, Marine Ecology
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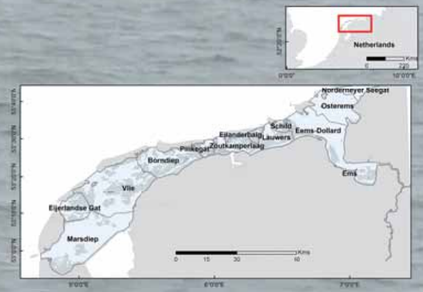
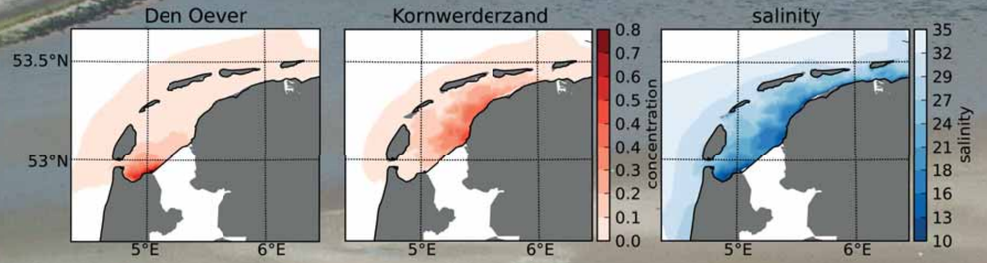


Points sampled across the Dutch Wadden Sea during the SIBES monitoring program. Tidal basins and boundaries are shown.

Pathways of fresh water in the Wadden Sea



Simulation of the spread of tracers (mimicking freshwater) from the sluices of Den Oever (left) and Kornwerderzand (middle).

The two sluices in the Afsluitdijk are the principal source of fresh water in the Dutch Wadden Sea, but it has been a long-standing question how it spreads and where it leaves the Wadden Sea. On the basis of sparse measurements, it was commonly thought the major inlets Marsdiep and Vlie would also form the main exit for the fresh water. On the basis of high-resolution model results, we now get for the first time a detailed spatial and temporal view of the way the fresh water traverses the Wadden Sea. As expected, the Marsdiep plays a key role. But, surprisingly, the other major inlet, the Vlie, turns out to be much less significant: the tidal movement, involving huge amounts of water pushed back and forth through the inlet, does not, in the end, result in a large net exit of fresh water. Instead, the fresh water travels eastward, crossing the watershed south of Terschelling, and further. An example is shown in the figure. The significance of this finding goes beyond the fate of fresh water alone; it shows that transects with relatively small tidal prisms, like the watershed south of Terschelling, can be disproportionally important for the net exchange of water and any of its constituents (sediment, pollutants etc).

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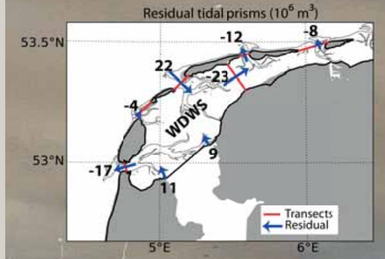
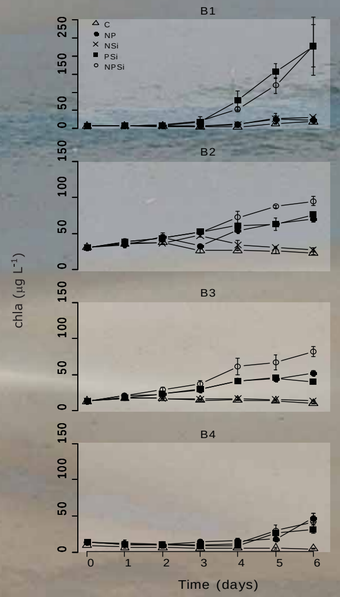


Long-term residual flows (per tidal period) in the western Dutch Wadden Sea, calculated from model results (GETM).



The effect of a combination of different nutrients during four 1-week bioassays (B1-B4) in April 2010. The depletion of Si in the water of the Marsdiep led to the disappearance of diatoms and to the rise of the nuisance algae Phaeocystis, responsible for the foaming of the water in this period of the year.

Phosphate limits the growth of phytoplankton

The Wadden Sea is a unique coastal area with large intertidal areas separated from the North Sea by barrier islands. It is an important area for waders and is part of the north east Atlantic flyway. The ecosystem in the Wadden Sea is changing as a result of anthropogenic and climate induced factors. Since the mid '80-ies the inorganic N and P loads are decreasing, and this has affected the ecosystem foodweb and potential carrying capacity. Is the phytoplankton P-limited? The literature is conflicting on this topic and the ZKO projects P-reduce and IN-PLACE set out to determine the limiting factors for phytoplankton production. Using different approaches we clearly demonstrated that the phytoplankton is P-limited during the spring bloom, but diatoms show a short period of P-silicate co-limitation. The P-limitation affected the foodweb structure and decreased the dominance of diatoms.

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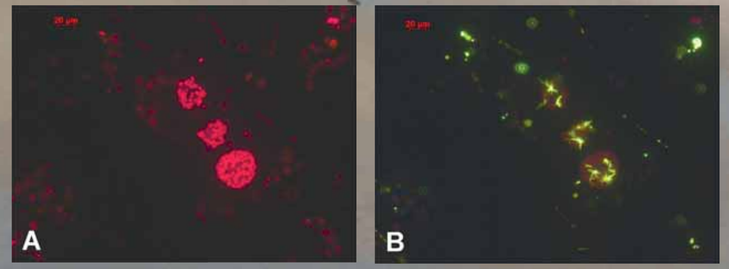

The pictures show the expression of the enzyme alkaline phosphatase (AP), visible as green fluorescence using the molecular probe ELF® (B), whereas the autofluorescence by the chloroplasts is visible as red fluorescence (A). Despite the fact that organic-P was apparently utilized by the algae, not all organic-P seems biological available. This needs further research.

Ballast water treatment: favouring the fast and the furious

To stop the further spreading of aquatic invasive species, ships' ballast water needs to be disinfected according to international standards that require the enumeration of viable microorganisms. NIOZ developed and maintains the facilities to test whether ballast water treatment systems are effective. For such a test, the microbial community composition in sea water was treated with hydrogen peroxide and compared to untreated water using a rigorous qualitative analysis based on molecular biology. Ballast water treatment did not affect the microbial community randomly, but completely wiped out certain groups of organisms and favoured the abundance of opportunistic, fast growing bacteria. Among these were members of the genera Vibrio and Pseudoalteromonas which are capable of producing antibiotic substances that prevent other bacteria from growing. As a result, the diversity of the microbial community was drastically reduced after ballast water treatment.

Judith van Bleijswijk, Biological Oceanography
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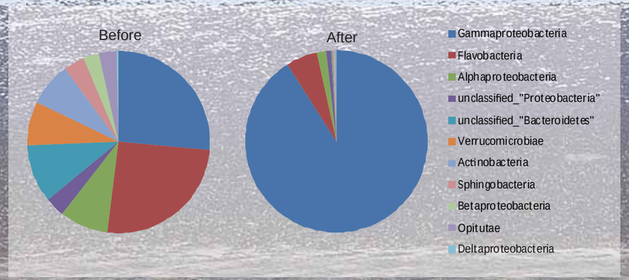
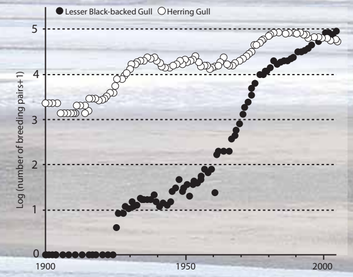
Ballast water test facility in the NIOZ harbour.

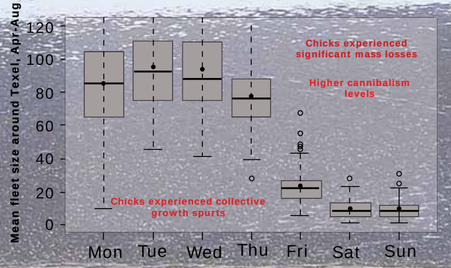


Bacteria in ballast water before treatment and 5 days after treatment with hydrogen peroxide: fast growing gammaproteobacteria benefit from treatment and become dominant.

A weekly cycle in cannibalism: killing the chicks on Sunday



Trends in numbers of breeding pairs of Herring Gulls and Lesser-Black-backed Gulls in The Netherlands in the 20th century. Lesser-Black-backed Gulls started breeding from 1926 onwards.



Number of fishing boats around Texel, Apr–Aug.

Gull breeding populations reached unprecedented levels in the late 20th century. However, Herring Gull numbers declined after the peak in the 1980s and Lesser Black-backed Gulls declined after the peak in 2005. From a comparative study of their foraging ecology, demography, and population dynamics at Texel, it appeared that Herring Gulls were mostly affected by low annual survival rates in winter. Wintering survival was high in Lesser Black-backed Gulls, but the reproductive success was low as a result of high levels of cannibalism. GPS tracking studies suggested that commercial fisheries were of importance for these gulls, but that discards appeared to be the major food source as was clearly observed in the cyclic fluctuations in chick growth (spurts on weekdays, mass losses in weekends) and peaks in cannibalism in weekends. This pattern perfectly matches the weekly rhythm in fishing effort. The breeding populations of the two species are currently not flourishing, but both have profited from anthropogenic (unnatural) resources and population numbers were therefore unnaturally high.

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Extinction of Australian megafauna: vegetation change and forest fires

Intense crown fire in a Eucalyptus dominated wet sclerophyll forest, Kilmore area, Victoria, February 2nd, 2009.
© Richard Alder AFSM, National Aerial Firefighting Centre.

NIOZ researchers reconstructed past climate conditions as well as vegetation for South East Australia, home for a large part of the Australian fauna. This revealed an extensive period (68,000-31,000 years) of generally high C_4 (e.g. grasses) plant abundance that was punctuated by an abrupt increase in C_3 (e.g. trees) vegetation at ~43,000 years. This sharp increase directly followed the period in which the large animals in Australia became extinct. The cause for the vegetation change was not climate change as no evidence was found for any abrupt, strong changes in temperature or precipitation. Instead, the extinction of the megafauna allowed the expansion of C_3 vegetation such as shrubs and trees, which were normally consumed by these large animals. The researchers also found specific molecules which indicated that large parts of the vegetation were burned at this time. These fires were likely engendered by humans and aided by the fact that the C_3 vegetation is more prone to fire than C_4 vegetation.

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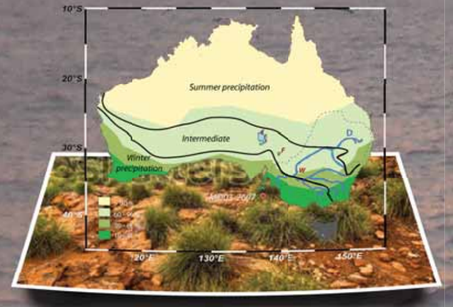
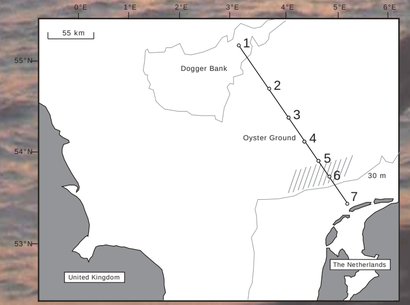


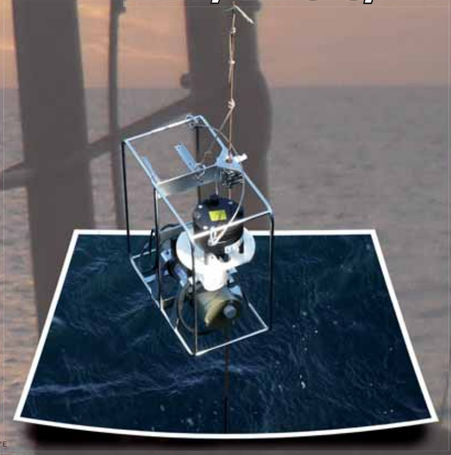
Map of Australia illustrating the modern distribution of C_4 grass relative to C_3 grass and seasonality of precipitation. Red dot indicates the location of core MD03-2607 offshore of the mouth of the River Murray. The blue lines show the River Murray (M) and Darling River (D) and their major tributaries.

Photo showing the 32m long core returned on the deck of the French research vessel Marion Dufresne. The grey mud stuck to the metal tube shows that it penetrated the pile of sediments below the sea floor, representing, in this case, over 250,000 years of sedimentation.



Map of the southern North Sea showing the study site. Stations are labeled 1–7. Approximate bathometry at 30m illustrated with gray line and approximate area of the Frisian Front indicated with hatched area. Adapted from map in Weston et al. (2008) Mar. Environ. Res. 65, 235–249.

The marine nitrogen cycle: who, where, when, why?



Nitrogen is an essential element for marine life. In the oceans and seas one form of nitrogen available to life is ammonia, which is used by phytoplankton but also by microbes such as the Thaumarchaeota which utilize ammonia as a source of energy. In this study we examined the importance of Thaumarchaeota in the North Sea. Thaumarchaeota were found in both the water as well as in the sediment floor. We found more Thaumarchaeota in the water in winter than in summer, but this was not the case in the sediment where Thaumarchaeota were most abundant in spring and summer. Their abundance in the surface waters was mainly dependent on the different water masses present in the southern North Sea. In the bottom waters the abundance of Thaumarchaeota was determined by particles or ammonia derived from the underlying sediment.

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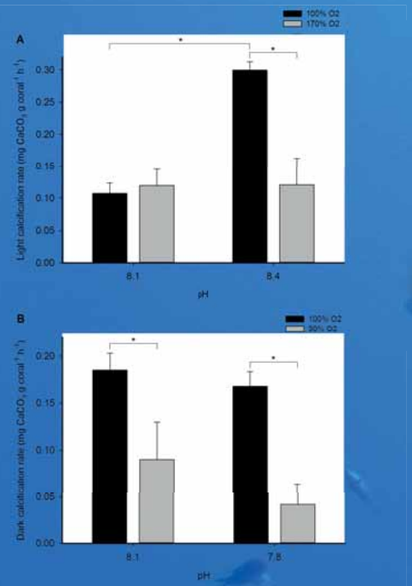
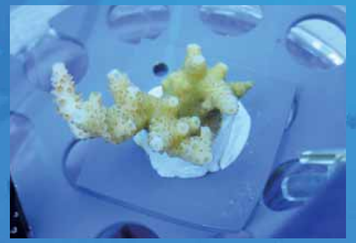


(A) Light calcification rate of Acropora millepora at a pH of 8.1 and 8.4, and 100 and 170% oxygen saturation.

(B) Dark calcification rate of A. millepora at a pH of 8.1 and 7.8, and 100 and 30% oxygen saturation. Values are means + S.E. (N=4). Asterisks indicate significant differences (P<0.05).

Oxygen concentration affects coral calcification

Laboratory setup for coral calcification measurements. Oxygen, pH and temperature probes allow a tight control over environmental conditions. © T. Wijgerde - Wageningen UR).



Close-up of a fragment of the coral Acropora millepora, a major reef building species from the Indo-Pacific region that was used in the cooperative laboratory study.

In a natural reef, corals have to cope with daily fluctuations of pH and oxygen (pH 7.8-8.7 and 27-241% O_2 saturation). The fluctuations are a result of the light/dark regime with higher pH and O_2 saturation values under light conditions. The effect of pH and oxygen fluctuations on the calcification rate of the reef-building coral *Acropora millepora* was investigated during a cooperative laboratory study between NIOZ and Wageningen UR. Under light conditions, calcification rates were enhanced three-fold solely by increasing pH. However, when the oxygen saturation was simultaneously increased, the pH effect was completely neutralized. Under dark conditions, pH had no effect on calcification, whereas low oxygen saturation resulted in significantly lower calcification rates. The results suggest that oxygen has a considerable control over *A. millepora* calcification, under both light and dark conditions. These results have implications for reef formation since the predicted higher water temperatures and coastal eutrophication are accompanied by a decrease in seawater oxygen saturation.

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Close up of a sponge that is living on the coral reef. The thin threads of fluffy brownish material is detritus released by the sponge.

Large tubular sponges that are characteristic of Caribbean coral reefs.

Surviving in a marine desert

Ever since Darwin's early descriptions of tropical coral reefs, scientists have debated how one of the world's most productive and diverse ecosystems can thrive in the marine equivalent of a desert. It is an enigma how the flux of dissolved organic matter (DOM), the largest food source produced on reefs, is transferred to higher tropic levels. We discovered that sponges make DOM available to the reef fauna by rapidly expelling filter cells as waste which in turn is consumed by corals and other reef fauna. This "sponge loop" on the coral reef was confirmed in experiments, using DOM enriched in ^{13}C- and ^{15}N isotopes. The DOM-sponge-fauna pathway explains why biological hotspots such as coral reefs can survive in nutrient-poor tropical sea and hereby, provides an explanation for Darwin's reef paradox.

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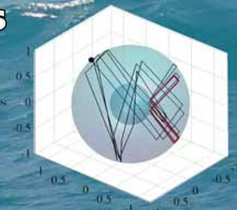
Experiment in progress. The white cotton cloth prevented water exchange for a few hours between a coral cavity and the surrounding reef water so that the fate of dissolved organic matter could be traced. Coral cavities are covered with thin sponges in their interiors and where therefore selected in this study.

OPEN OCEAN

Jupiter and Earth comparison. Internal waves are a universal phenomenon in all kinds of density stratified and/or rotating fluids, from the ocean to the atmosphere, from fluid planets to stars to planet's cores. The mechanisms illustrated here possess the same level of universality, and might play a role in our laboratory tanks as well as in Jupiter inner dynamics. Fotocredits: NASA.

Internal waves and Equatorial dynamics



The three dimensional (3D) spherical cavity represents a global ocean: no continents are present in this idealized model, the whole planet is covered with water with the same density and rotating at a fix rate around its vertical axis. The black line is tracing the 3D energy trajectory of an internal wave, caused by a local perturbation of the rotation rate. After few bounces, a so called "internal wave attractor" (in red) arises, trapping the energy in the equatorial region, triggering hot spots for vertical mixing.

The equatorial ocean plays a fundamental role in our global climate system, as a connection between the two hemispheres and as the principal region of heat exchange between the oceans and the atmosphere. However, despite its importance, many aspects of the deep equatorial ocean still remain unexplained. One reason for this is the peculiar location of the low latitude belt: the equatorial ocean surface is actually aligned to the Earth's rotation axis, and thus common approximations, used to mathematically describe waves and currents in the mid-latitude ocean, break down. In this study, some intriguing aspects of geo-physical (and astro-physical) waves propagating in the interior of a water mass ("internal waves") have been explored in a fully enclosed basin, unveiling a mechanism of energy focusing that may be of relevance for the interpretation of equatorial features such as deep current jets or anomalous internal wave activity. Both can be very important for vertical mixing processes in the ocean.

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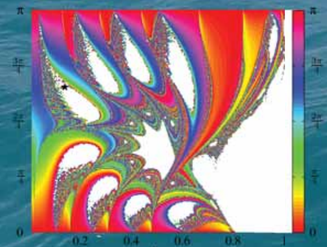
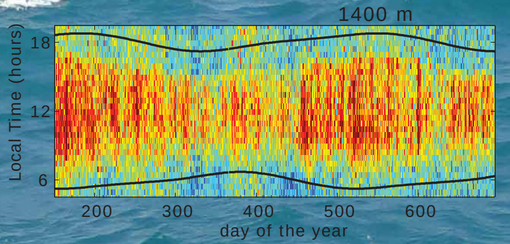


Here, many perturbations at a specific frequency are excited at the surface of the ocean (a storm?). This is done at different locations (horizontal axis) and in different initial directions (vertical axis). In white, energy is not focused on any specific location. In colours, energy gets eventually focused onto "internal wave attractors" and is distributed at different longitudes according to the colour scale on the right.

Daily vertical migration in deep sea plankton is finely tuned to north-south position and day length



One-and-a-half years of daily acoustic variations. DVM follows day length variation with a change in season at all depths, here 1400 m, at 22.5°N. The black lines denote times of local sunrise and sunset.

Daily vertical migration (DVM) is an ubiquitous phenomenon in marine plankton communities. Plankton migrate to surface waters at dusk and return to deeper waters at dawn. Up until recently, it was thought that DVM was triggered by a relative change in visible light intensity. However, evidence has shown that DVM also occurs in the deep sea where no sunlight penetrates. To identify whether such DVM is associated with north-south position and seasonal daylight variation, one and a half years of eight acoustic data records, a measure of zooplankton abundance and movement, were examined from the NE-Atlantic Ocean.

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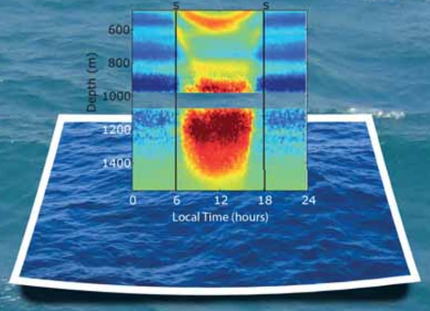
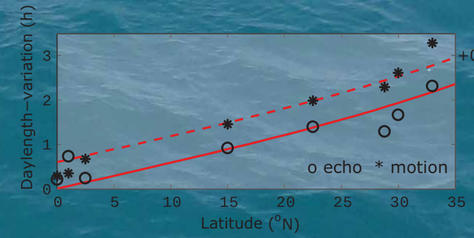


One-day composite of acoustic observations (red=high values), a measure of zooplankton abundance and movement. DVM followed the rhythm of local sunrise and sunset (s) precisely between 500 and 650 m (maximum sunlight penetration), but plankton shortened their time at depth by up to 63%, at 1600 m. This suggests light was no longer a cue for DVM. This trend stayed consistent both across latitudes and between the different seasons. It is hypothesized that another mechanism, viz. a precise biochemical clock, maintains deep-sea plankton motions. In accordance with this hypothesis, the deepest plankton were consistently the first to migrate upwards.



DVM follows day length variation with a change in latitude at all depths, here ~1000 m where the average acoustics data residual is 77% (9.3 hours) of the sun's day length. The full red line indicates the theoretical sun's variation in day length.

OPEN OCEAN

Blowing in the wind ...

Every year about 200 million tons of Saharan dust blow over the Atlantic Ocean. Together with dust derived from other arid regions in the world, it has the potential to modify global climate by influencing the radiative balance of the atmosphere as well as by supplying iron and other essential limiting micronutrients to phytoplankton in the ocean. As part of a multidisciplinary effort to improve our understanding of the links between desert dust and ocean productivity and climate, three autonomous dust-collecting buoys were engineered by the NIOZ-MTEC department. These have been deployed along the path of the northern trade winds across the Atlantic. The buoys are equipped with meteo sensors to check weather- and sea state, and with a dust collecting device to take samples of atmospheric dust at regular time intervals, in sync with submarine sediment traps that sample dust settling through the water column to the ocean floor. Updates of the buoys' positions and performances are transmitted via satellite links to land twice a day, whilst the sampling time and duration can be manipulated from home via return signal. These buoys are unique in the world and they provide exclusive samples and data that are of vital importance for many scientific disciplines including geology, meteorology, remote sensing, climatology, and biology.

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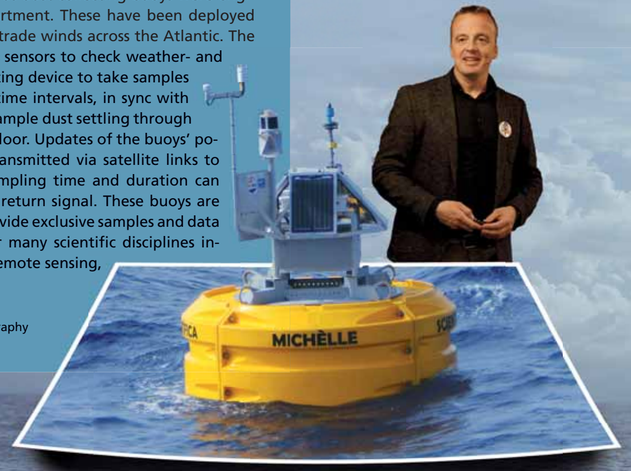

Reconstruction of salt content from algal lipids

Sea water in the oceans contains about 3.5% salt with higher concentrations in the tropics and lower concentrations in the polar regions. These differences in salt concentration form an important driver of the water mass circulation in the present day ocean and therefore of our climate. Salt concentrations have likely varied in the (geological) past, but at this moment we lack the tools to test this hypothesis. Currently, at NIOZ we are developing such a tool based on lipid molecules of so-called haptophyte algae. These lipid molecules contain many hydrogen atoms and only a small amount of these is in a 'heavy' form, as deuterium. Culture experiments showed that the amount of 'heavy' hydrogen in the algal molecules is depending on the salt concentration of the water in which the algae grow. In water with high salinity the molecules contain more 'heavy' hydrogen than in water with low salinity. Since the molecules are found in ancient marine sediments that are up to 55 million years old, analysis of their 'heavy' hydrogen content opens the possibility to reconstruct salt concentrations of ancient sea water.

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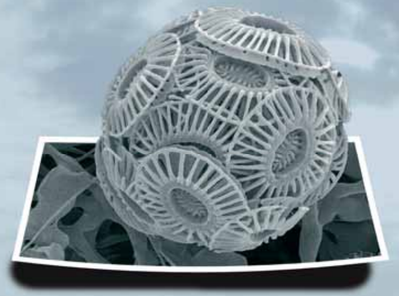
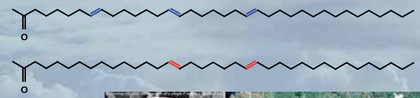


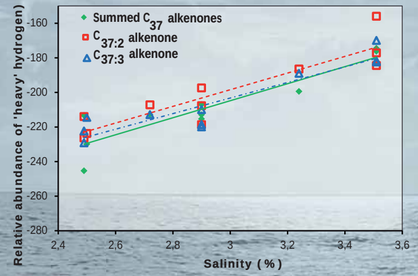
Electron microscopy picture of a haptophyte alga: Emiliania huxleyi. © Jeremy Young palaeontology, Dept. The Natural History Museum London



Long chain organic compounds produced by phytoplankton (alkenones): chemical fossils for haptophyte algae.

Satellite picture of a massive Emiliania huxleyi bloom off the coast of south England .
© NASA

In cultures of Emiliania huxleyi their lipid molecules contain more heavy hydrogen (deuterium) in water with high salinity than in water with low salinity. This graph shows that the alkenones $C_{37:2}$ and $C_{37:3}$ do not have to be separated to reconstruct salt concentrations, the three lines are nearly identical and can be represented by one summed C_{37}.



Rapid shift in Arctic ecosystem due to global warming

Melosira arctica filaments at the underside of multiyear sea ice.

Strands of Melosira arctica recovered from the Arctic deep sea floor. © Science.

In the summer of 2012, NIOZ scientists joined an international expedition to the Arctic sea with the German ship Polarstern. Previous investigations of the underside thick multiyear-sea-ice found that the diatom *Melisora arctica* grows meter-long filaments. Extreme melting of Arctic sea ice due to general global warming has led to the observed major loss of the thick multiyear sea ice. This melting resulted in subsequent massive sinking of these algae filaments to the seafloor. Decomposition of the dead algae by bacteria rapidly consumed most of the oxygen in a large area on the sea floor. The preceding consensus was that it would take a considerable amount of time before changes in the climate would affect the conditions on the seafloor. However, the expedition scientists observed that the ecosystem of the Arctic Sea, both at the sea surface by loss of sea-ice and on the deep sea floor is rapidly affected by increasing temperatures. These findings were reported in Science (Boetius et al., Science 339, 1430; 2013)

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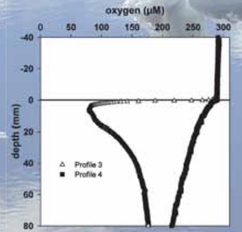

In situ measurements of oxygen concentration in Arctic deep sea floor show decrease in oxygen at places with ice-algal deposits (profile 3) compared to places without algal deposits (profile 4).

Scientists investigate physics and biology of, in and under the sea ice on an expedition with RV Polarstern in the high Arctic during the sea ice minimum in summer 2012.

Understanding the past sea-level changes

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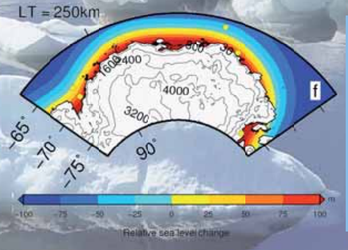
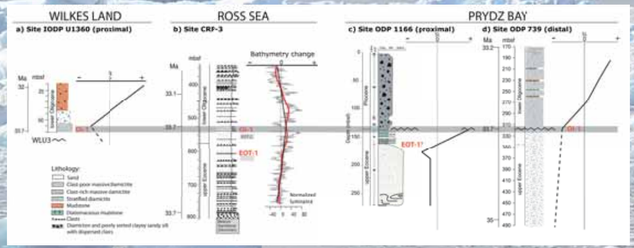
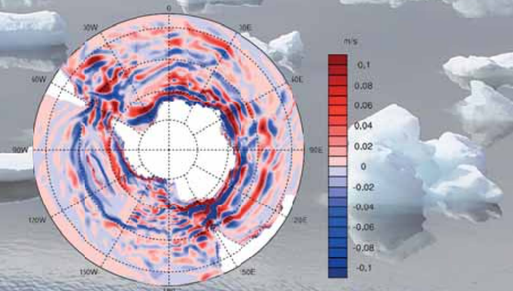
Several low-latitude sea-level indicators of geological origin are found nowadays above the present mean sea level. They witness major relative sea-level (rsl) drops caused by past climate-related expansions of high-latitude continental ice sheets. We can use these data to quantify the global ice sheets volumes through time.



Theoretical predictions are able to reproduce the observed pattern of rsl change at the near-field sites. Hence, near- and far-field rsl sites can be used together to fully constrain the computation of the first Antarctic glaciation as well as any other ice-sheets fluctuation throughout the history of Earth.



Conversely to the low-latitude far-field rsl sites, sediments cores from the inner continental shelf of East Antarctica witness a large rsl rise during the first Antarctic glaciation (~34 million years ago). The observed deepening stems from the combination of crustal subsidence under the load of the ice sheet and from the gravitational attraction exerted by the growing Antarctic ice sheet on the ocean water.



Bathymetric variations induced by the first Antarctic glaciation significantly affected the ocean circulation in the Southern Ocean. The ocean flow variations alone likely impacted local nutrient variability, erosion and sedimentation rates and also ocean heat transport.

Cascading effects of losing predators around the globe

Jan van Gils

"Being a true globetrotter, the Red Knot may be a very good indicator species for the global biodiversity crisis". Jan van Gils talks passionately about the shorebird species *Calidris canutus canutus* that connects the Arctic tundra via the tidal flats of the Wadden Sea with the tropical mudflats of West-Africa. With a VIDI research grant van Gils tries to understand the role of this shellfish-eating bird for benthic communities in the Dutch Wadden Sea and the Banc d' Arguin in Mauritania, West-Africa.

"Our research within the Department of Marine Ecology has societal relevance", emphasizes van Gils. He worries about the drastic biodiversity decline caused by mankind. "For example, fishing activities (notably shellfish) in the Dutch Wadden Sea have greatly diminished the food supply for shorebirds in the past", he says. "Currently there are additional threats of gas- and salt-extraction".

Most likely these fishery activities in the Dutch Wadden Sea have led to a smaller population of Red Knots in Africa. That led to a reduced predation pressure on African shellfish. As a result the total number of shellfish increased, but with a few species dominating over the rest. Van Gils: "Possibly, therefore Banc d' Arguin is nowadays overcrowded with a toxic shellfish species. A species that a Red Knot cannot eat too much of, otherwise the bird gets diarrhea".

A migrant predator like the Red Knot illustrates how a pristine tropical tidal flat area in Africa is affected by the situation in the Dutch Wadden Sea. "The steering role of predators on ecosystems is often underestimated", says van Gils. His research is aimed at filling that knowledge gap. "As more and more predators disappear, the consequences for biodiversity will be tremendous".

In a parallel project, van Gils also examines the indirect role of crab plovers on the seagrass beds and their inhabitants in Barr al Hikman, Oman. "There, the system seems sufficiently intact to investigate the community impact of crab plovers". Van Gils stresses that he feels obliged as a researcher to find out what the effects are of this rapid decline in biodiversity. What are the consequences for the functioning of ecosystems worldwide that are connected by migratory birds? In the coming years van Gils is dedicated to answer those questions with his sophisticated experiments. "Nature is so beautiful; we simply cannot allow that to be destroyed by mankind".

Valuable expeditions in the North-Atlantic Ocean

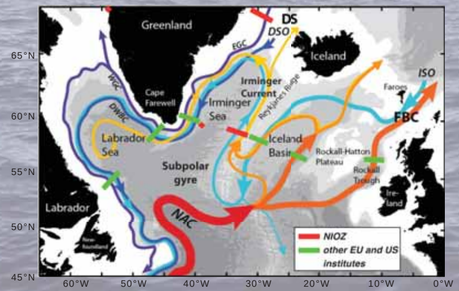
Laura de Steur

"It takes a long time, it's expensive and it requires a lot of coordination". Laura de Steur outlines in one sentence three important features of her research on ocean currents in the sub-polar North Atlantic. "I want to know more precisely about the processes that determine these currents, their relation with atmospheric forcing and their role in Earth's climate", she says.

Within the Physical Oceanography department, de Steur focuses on different aspects involved in the large-scale ocean currents of the Arctic and North Atlantic. "For example, I investigate variations in density due to temperature and salinity changes or variability due to atmospheric forcing such as winds", de Steur says. "My present research focuses on the cold and fresh Arctic current southwards and a northward branch of warm Atlantic water. I want to unravel the physical properties of both currents that are indicated with blue and yellow lines on the map".

But how to measure ocean currents? With hand gestures de Steur explains the characteristics of a mooring, an anchored installation rising upwards from the ocean floor. A long steel cable is kept upright by a buoy and is anchored to the bottom by a heavy weight. Instruments placed at different depths on the cable measure temperature, salinity and current velocities. "That's how we obtain continuous physical measurements in the ocean", explains de Steur.

These measurements are time-consuming and expensive since her research is aimed at the long-term. De Steur explains that the moorings are often left in place for one to five years or even more. "But we have to go back each year to get the data from the instruments and service the moorings". That involves a research vessel, like our NIOZ flagship RV Pelagia, and technical staff from the NIOZ. Costly research, therefore de Steur has to be patient before the first data become available for analysis.



These data are processed and analyzed at the NIOZ. "That is extremely important", says de Steur. "You first have to know the fundamental part of the story before you can think of application in future ocean or climate scenarios". Integration of data obtained at other European institutes that, like the research of de Steur, are part of NACLIM (North Atlantic CLIMate Program) is done to obtain the "big picture". Ultimately these results are also used to validate and improve climate models. "Sea going expeditions are so expensive that cooperation with other research institutes is an absolute necessity" ends de Steur. A new research project OSNAP (Overturning in the Subpolar North Atlantic Program), with American, German, British and Canadian colleagues, starts in 2014 and will further strengthen the global partnerships of research institutes to which the NIOZ belongs.

INTERVIEWS

Lipids and DNA to learn more from wonderful microorganisms

Laura Villanueva

'Thaumas' means wonder in Greek. Studying Thaumarchaeota, microorganisms that live in the oceans, must therefore be exciting research. Analysis of the organic components of Thaumarchaeota and other small organisms can provide insights into past climates. "We collect water column samples and sediment, searching for lipids which we use to track the presence of Thaumarchaeota in both the present and the past", says Laura Villanueva, scientist at the department of Marine Organic Biogeochemistry (BGC).

Thaumarchaeota have some very specific lipids, the main component of their membranes, that are not found in any other organism in the ocean. The BGC department developed a paleothermometer called TetraEther indeX of lipids with 86 carbons (TEX_{86}) that is used to reconstruct past sea surface temperatures. "Thaumarchaeota living in warmer temperatures adapt their membrane by increasing the number of rings in their lipids, which is reflected in the TEX_{86} value. TEX_{86} values can thus be translated into the temperature at which past Thaumarchaeota were living. In order to understand how these microorganisms behaved in the past and which environmental factors affected them, we also need to study them in present oceans", says Villanueva.

Futhermore, Thaumarchaeota are a key component of the carbon and nitrogen cycle in the marine environment. They oxidize ammonia into nitrite and they use bicarbonate as a carbon source. Villanueva: "Once we know how abundant and active Thaumarchaeota are under certain conditions, we are then able to predict their role in the marine carbon and nitrogen cycles". That is important information because life on earth depends on both these elements.

The specific lipids of Thaumarchaeota are excellent tools to track their presence as they can be preserved in marine sediments for millions of years, which makes them ideal for past climate reconstruction. But in order to know if Thaumarchaeota are living and active, Villanueva makes use of molecular tools based on DNA and RNA. "These molecules degrade much faster than lipids and in the case of RNA, it is only produced if the organism is active", she says. "For that analysis I make use of the molecular laboratory facilities of the Biological Oceanography department".

Villanueva started her scientific career working with lipids. After her graduation she became involved in genetics. Now she combines both paths. "I do what I always wanted to do", says Villanueva. "It is exciting to fill the gap between two disciplines. Together with the extremely helpful people working at the NIOZ I'm always learning new things".

The ocean in 5 millimeters of sand

Henk Bolhuis

A green patina on the beach. Only a few millimeters thick. Microbiologist Henk Bolhuis describes the first impression of a microbial mat. "Despite its plane appearance, a microbial mat is like a tiny model of the ocean", he says. "The whole vertical stratification of the ocean is hidden in its minute layers". Bolhuis is a senior scientist at the Department of Marine Microbiology in Yerseke where he investigates the diversity of microorganisms and their role in the structure and function of marine coastal ecosystems.

Bolhuis talks contagiously about cyanobacteria, the primary producers and conductors of a microbial mat. "Just like us, they also have a biological clock that determines their day-night rhythm. Cyanobacteria are phototrophic organisms that produce oxygen, sugars and nitrogen containing compounds. Other microorganisms depend on these products and in that way an unprecedented microbial diversity is supported in only a few milli meters".

The dynamics of sand and water, light and dark, oxic and anoxic, fresh and salt water make the microbial mats an ideal model system for studying ecological issues. "Many oceanic processes, such as the sulfur and carbon cycle, are represented in a microbial mat", says Bolhuis. "Using a multidisciplinary systems biology approach, we can study and model all facets of these mats, ranging from spatial patterns, geochemical processes, species interactions and of course evolutionary processes related to diversity and adaptation".

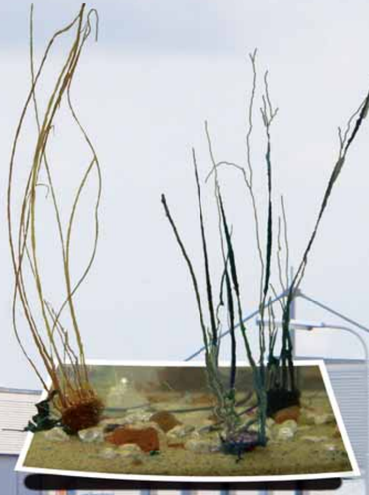
In Yerseke, Bolhuis and his colleagues maintain a unique culture collection of cyanobacteria and unicellular algae. With the Culture Collection Yerseke (CCY), NIOZ facilitates researchers all over the world.

The interaction with people, the different nationalities and working at the frontiers of knowledge are all important personal motivations for Bolhuis, which allow him to work each day with passion and enthusiasm. Bolhuis: "Within our department we combine fieldwork with state-of-the-art molecular techniques. My goal is to develop a large artificial microbial mat in the laboratory where researchers from all over the world can collaborate to study all facets of the system".

Bolhuis explains the societal importance of his work in terms of natural coastal defense. "We can create a starter culture to add to the bare sand and initiate the development of a microbial mat". "For example at the North Sea coast of Schiermonnikoog", he emphasizes. "There microbial mats turned the beach into a unique salt marsh. An important process given the expected sea level rise". In the photo Bolhuis presents a bottle of extreme halophiles, another passion of his. The only square microorganisms that exist. "I was the first to isolate them and sequence the genome", he proudly says.

OUTREACH

open house Yerseke



2 Wetenschap

NRC Weekend zaterdag 22 juni & zondag 30 juni 2013

Toch niet minder algen in de oceanen

Jonge mosselen.

natuurdagboek 24 april 2013

Mosselbanken

Trouw 4 juli 2013

Netvormige structuur maakt mosselbed zo sterk als staal

Het netvormige patroon van een mosselbed.

NRC HANDELSBLAD

Nederlands lab op Antarctica open

Nederlands Dagblad 21-6-'13

HANS HOPMAN nd.nl/binnenland BEELD JUDY SHAMOUN-BARANES

Zondagsrust leidt tot kuikenmoord

...Als meeuwen hun kuikens opvreten heeft dat alles te maken met de zondagsrust.

...Onderzoeker Kees Camphuysen, die vandaag promoveert op het gedrag van meeuwen, denkt dat te weten.

Heeuwendeskundige Kees Camphuysen bevestigt een van zonnecellen voorziene data-logger met gps op de rug van een kleine mantelmeeuw. Op die manier kan

'Kwal richt wél schade aan'

ND 14-01-2013

PRIZES, AWARDS & GRANTS

Jaap Sinninghe Damsté, Stefan Schouten en Laura Villanueva won the NWO/OCW 'Zwaartekracht' grants from the Netherlands Organisation for Scientific Research (NWO) and the Ministry of Education, Culture and Science (OCW)

The research team including Kees Camphuijsen won the Academic Year Price 2013 for their research into the behaviour of birds and their response to their environment.

Stefan Schouten won an ERC grant for his research on long chain diols as novel organic proxies for paleoclimate reconstructions.

SUSTAINABILITY

As the NIOZ mission is to gain and communicate scientific knowledge on seas and oceans for the understanding and sustainability of our planet, the NIOZ respects the environment and is working in a sustainable way. On the one hand the NIOZ is striving to optimize its daily working processes and to deploy the most sustainable solutions. On the other hand sustainable management of resources and dealing responsibly with our environment, and the seas, oceans and coastal zones in particular, is the scope of a substantial part of our research.

Tangible steps which have been made in 2013 include:

- Composition of a Procedure Invasive Species and the arrangement of a special climate room with facilities for experiments with potential invasive species to reduce risks of coincidentally releasing potential invasive species.

- Introduction of the NIOZ instruction movie 'In the workplace' with instructions how to operate in a sustainable and safe way at the NIOZ and in the laboratories in particular.

- A Risk Inventory Evaluation was held in 2013 and it was concluded that the personnel is well-educated to work with potentially environmentally hazardous substances. Another finding is that there is still room for indoor climate control optimization to counter unnecessary energy use. As a result the indoor climate control will be computed and adjusted in 2014.

Examples of research projects with important sustainability aspects for 2013 are:

- The involvement of the NIOZ in 'Building with Nature' projects in The Netherlands and around the world. For example the research on the optimization of the recolonization perspectives for sand excavation sites in the North Sea. Several other projects involve research on natural coastal defense using sand motors, sand suppletions and oyster reefs, but also the sustainable removal of problematic exotic oyster reefs at recreational sites. Research on 'natural' sedimentation and erosion processes in amongst others the Wadden Sea and the Eastern Scheld are of importance to maintain and restore intertidal flats with rich benthic communities (as well as shallow subtidal and undisturbed supratidal areas) important as feeding and breeding grounds for birds and fish. This is of increasing importance with the expected sea level rise in the 21st century. Other research on ecosystem restoration includes seagrass and marsh vegetation restoration and in the tropics mangrove forests and coral reef restoration. These are all of importance for the reduction of energy of waves reaching shorelines. Besides restoration one can think of sustainable exploitation of marine resources and minimization of impacts, amongst others investigated in relation to deep sea mining, to fisheries and the effectiveness of the closure of areas for certain activities.

- Several NIOZ projects involve European networking and adjustment initiatives, with the aim that common strategies will lead to progress in the adaptation of sustainable marine policy and management. Examples are the leading role of the NIOZ in the installation of a pan-European Marine Biodiversity Observatory System and a role of the NIOZ in the optimization of present and potential sensors for Coastal Observation. Other relevant projects towards sustainable European management comprise the development of innovative tools and indicators for quality assessments and management evaluations.

- In 2013 the NIOZ seaweed centre has been built on Texel, which will be officially opened in 2014. The centre aims to investigate the potentials of sustainable production of seaweed biomass for food, energy and pharmacy in the coastal systems in the future. Electricity for the centre is generated by solar panels, wastewater is treated using a seaweed biofilter, and seaweed incubation tanks are heated/cooled using an earth heat-cold system. In relation to microalgae the NIOZ runs a demonstration project in Yerseke for an integrated and sustainable enclosed raceway and photobioreactor for algal cultivation and biodiesel production.

- The NIOZ has signed the Chain agreement Plastics Recycling in November 2013. The agreement aims at the prevention of plastic wastes in the environment including worlds' oceans. Innovative cooperation should close the plastic cycle to prevent consequences of amongst others marine litter on flora and fauna, shipping, fisheries and food - and water quality.

- The NIOZ research on ballast water treatment installations helps manufacturers to design and build better installations to prevent exotic and potentially invasive species introductions and exchange. As one of the laboratories carrying out land-based tests for ballast water treatment systems, NIOZ plays an important role in tests for type approval of these instruments. The development of small hand-held test instruments will allow port authorities to check the performance of treatment systems on board of ships within the hour.

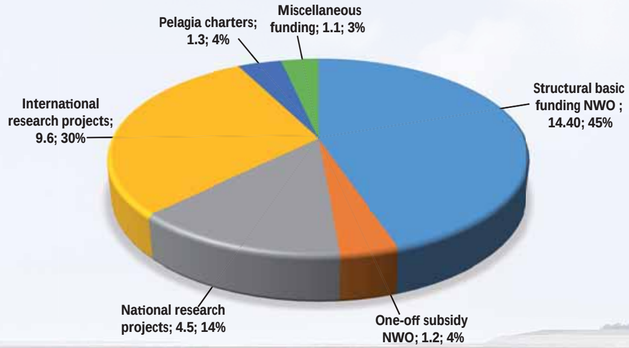
This is just a small sampling of our research initiatives in 2013 directly related to sustainability issues. Screening our projects will show that sustainability is in our genes.

FACTS & FIGURES

Budget

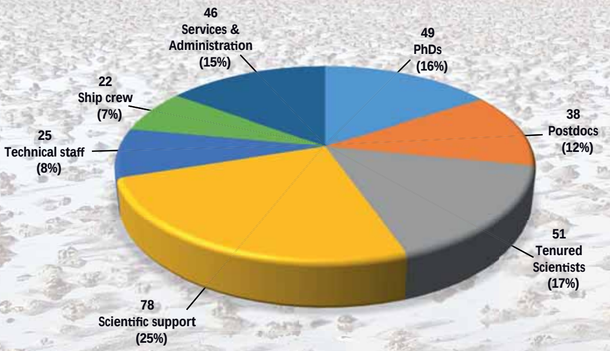
The overall budget for 2013 amounted to 32.1 M€. NWO contributed 14.4 M€ (equivalent to 45% of the total budget) as basic structural funding and 1.2 M€ (4%) as a one-off subsidy. Project related additional funding was received through national (4.5 M€; 14%) and international (9.6 M€; 30%) projects acquired in competition. Chartering of RV Pelagia to third parties yielded a net revenue of 1.3 M€ (4%). Miscellaneous and ad hoc funding amounted to 1.1 M€ (3%).

In 2013, spending surpassed income, resulting in a net loss. The development of a strategy to close this gap has the highest priority for the management and the board in 2014. A more detailed budget overview is presented online at www.nioz.nl/annual-report-2013.



Staff

On 31 December 2013, NIOZ employed a staff of 309 FTE's, equivalent to 344 employees. Of these, 79 employees were of foreign nationality, representing 19 countries. The numbers and relative distribution (in %) of personnel over the different staff categories remained fairly constant. In comparison to the end of 2012, total staff decreased by 9.5 FTE's. Scientific staff, including tenured senior scientists, postdocs and PhD students accounted for 45% of the total staff, scientific support staff 25%, and technical staff, ship crew, and services & administration accounted for 30%.

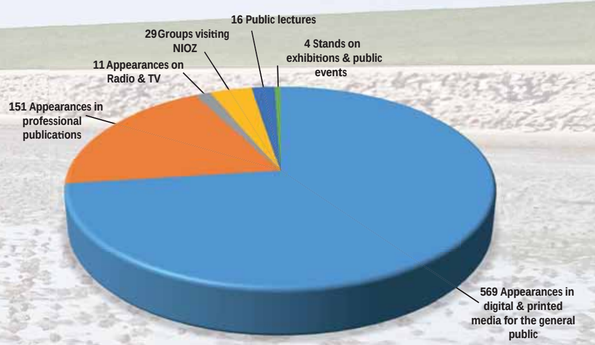


Scientific output

NIOZ scientists authored 263 peer-reviewed publications, of which 59 publications appeared in open access journals. Eleven PhD students received their degrees at the University of Groningen (4), Utrecht University (2), Vrije Universiteit Amsterdam (2), the Radboud University Nijmegen (1), the University of Bremen (1) and the University of Las Palmas (1). Moreover, 2 monographs, 9 book chapters as well as 51 non-refereed publications and 13 NIOZ reports have been written. More than 236 oral presentations and 88 posters were presented at symposia, workshops and the weekly NIOZ colloquium series covered 50 lectures.

Public outreach

NIOZ research was discussed 569 times in digital and printed media for the general public and 151 times in media with a professional readership. Many of the news highlights are presented in this annual report. NIOZ scientists appeared 11 times on Radio and TV and gave 16 public lectures outside NIOZ. At NIOZ Texel, a lecture series was organized on 8 June, being declared as 'World Oceans Day' by the United Nations. NIOZ had a stand on 4 exhibitions.



Marine Research Facilities (MRF)

NIOZ research vessel Pelagia sailed for 280 days in 16 cruises, 2 of which were charter cruises funded by third parties, 9 were funded by NWO-ALW or EU/ESF/ERC, and 5 were NIOZ projects. In support of the start of the Caribbean Netherlands Science Institute (CNSI) on St. Eustatius Pelagia visited the island at the end of the year, the ship's first-ever visit to the Caribbean. RV Luctor sailed for 147 days in 8 research and charter projects on the Scheldt estuary, Eastern Scheldt and Lake Grevelingen. RV Navicula sailed in the Wadden Sea for 163 days for 5 student courses, 20 research cruises and a chartered bird survey for marine research institute IMARES along the Dutch coast. In May, Navicula went to Yerseke to take over the normal Luctor programme while Luctor was carrying out a charter cruise for IMARES.


RV Pelagia


RV Navicula


RV Luctor

NIOZ Royal Netherlands Institute for Sea Research, located on Texel and in Yerseke, is an institute of the Netherlands Organization for Scientific Research (NWO).

www.nioz.nl

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The annual report can be ordered free of charge, by preference on an exchange base, from the library of NIOZ Royal Netherlands Institute for Sea Research. It is also available at the NIOZ website www.nioz.nl/annual-report-2013

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The mission of NIOZ is to gain and to communicate scientific knowledge on seas and oceans for a better understanding and sustainable use of our planet, to manage the national facilities for sea research and to support research and education in the Netherlands and in Europe.