
NIOZ
Royal Netherlands Institute for Sea Research
ANNUAL REPORT 2015

Our seas and oceans are in trouble. The combined and cumulative effects of increasing human activities, including global warming, overfishing and pollution, superimposed on 'natural change' have become important topics on the international policy agendas (cf Paris climate conference, 2015). At the same time, 'blue space' is increasingly employed for global solutions in terms of energy, resources, food, transportation and the like, at sea, and at ever greater depths in the open oceans. It is in this context that an institute like Royal NIOZ has an ever more important and increasing role: activities in the 'blue arena' require knowledge and insight in the complex, partly unknown and ever changing marine ecosystems and environments from the deep oceans to the shallow delta areas.

NIOZ in 2015: Winds of change, and the path to NIOZ 2.0

Henk Brinkhuis &
Harry Baayen

Our mission, activities, multidisciplinary research, including frontier applied studies, our modern research facilities, labs, and research vessels, and our network of cooperating national and international universities and institutes 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.

Our largely blue planet is in trouble; sound knowledge of our oceans and seas is indispensable to solve the major problems. Photo: shutterstock.com ©Digital Storm.

In 2015, research at Royal NIOZ continued to focus on marine environments globally, in estuaries and deltaic settings, from polar regions via temperate zones to tropical coral reefs and sea-grass fields, and into the depths of the oceans. Royal NIOZ is a respected and trusted partner in a multitude of national and international efforts to improve our understanding of the changing seas and oceans, and for paving the way to improved and sustainable use of them in terms of coastal protection ('building with nature'), global food, energy and other natural resources for broad scientific and societal benefit and 'Blue Growth'.

2015 was again a dynamic year for the institute under difficult conditions. In terms of the necessary changes in the organisation, we moved forward with the 2014 plan *A new course for NIOZ*, towards 'NIOZ 2.0'. A key element in

INTRO

The NIOZ building in Yerseke (below left) on the border of the Eastern Scheldt. ©Flying Focus BV

NWO chairman Jos Engelen, President of the Executive Board of Utrecht University Marjan Oudeman, and chairman of the NIOZ board Harry Baayen signed the trilateral cooperation agreement on 13 January.

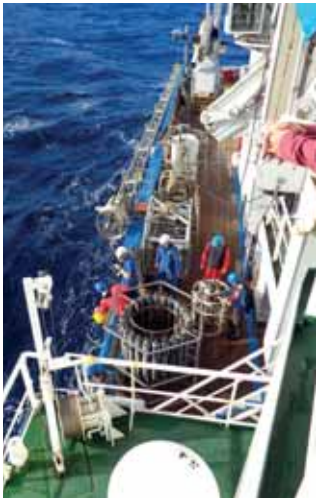
the new course is the 10 year agreement between NIOZ, our mother organisation, the Netherlands Organisation for Scientific Research (NWO), and Utrecht University that was signed on 13 January. This intensified new collaboration and co-affiliation with Utrecht University allows significant new investments in fundamental marine sciences for the coming decade, while our national role and cooperation with other Dutch universities remain unchanged. After the key decisions by the general board of NWO in July, implying definitive acceptance of the new plan and vision, the reorganisation took further shape.

It was decided that NIOZ Yerseke will remain; it will be transformed into the scientific department of Estuarine & Delta Systems. We will strive for an increasing cooperation with regional partners in research, education and policy in the province of Zeeland. Other elements of the plan are an improved financial control and transparency and avenues to secure NIOZ's research vessels and other sea going national marine research facilities.

2015 was a transitional year, paving the way to the future, with preparation and adaptation of the organisation. In solid cooperative spirit, NIOZ management, the works council (OR), and the unions succeeded to push the complex process ahead, eventually giving the green light for NIOZ 2.0 starting February 1st 2016. Meanwhile, despite the transition, NIOZ science performed admirably with scientific output in 2015 lying just below the record high of 2014 with 268 peer reviewed publications, of which 153 (57%) were open access papers. Twelve PhD theses were successfully defended at five Dutch universities. Allert Bijleveld defended his thesis on the behaviour of individual waders 'cum laude' and he received the annual Waddenacademie award for the year's best Wadden Sea related PhD thesis.

Several 2015 highlights of our research are presented in this annual report. Furthermore, we compliment the NIOZ personnel for engaging in a wide array of outreach events, ranging from school presentations and teaching, various public talks, and interviews in the media. NIOZ issued 25 press releases on scientific highlights, and our results were mentioned 137 times in national and regional newspapers, as well as 447 times on the internet. NIOZ scientists appeared 63 times on national radio or on TV. NIOZ was also represented at the Hannover Messe in April and at the famous 'Mussel day' in Yerseke in September. Besides the home of NIOZ, Yerseke is also the capital of the Dutch mussel and oyster fishery. On Texel, our female scientists presented a series of six public lectures.

It was also a year in which NIOZ was again successful in the various national and international calls, and increasingly involved in public-private (pps) collaborative efforts, the national economic 'Top Sectors', and contributions to the 'national scientific agenda' (NWA) that was launched in 2015.



Many sorts of equipment were used during the expeditions.

Other notable achievements in 2015 were the successful Treasure and JPI-Oceans cruises associated with the NWO-STW Top Sector maritime deep sea efforts, the Blue-Tec Tidal Energy project, an assessment study for the intended flooding of the Hedwige Polder bordering the Western Scheldt, polar cruises in collaboration with the German Alfred Wegener Institute for Polar and Marine Research (AWI), and an impressive employment of our RV Pelagia, essentially covering large parts of the Mediterranean, and the Atlantic and Indian oceans. The latter with special thanks to a Dutch Marines unit who accompanied our crew offshore NE Africa.

The RV 'Polarstern' with the NIOZ TransArc-II research team reached the geographical North Pole. Standing from left to right: Hans Slagter, Loes Gerringa, Micha Rijkenberg, Libby Jones (RUG) en Sven Ober. Sitting in front: Jan van Ooijen.

NIOZ hosted the symposium 'Wild Clocks' on the influence of internal biological clocks in organisms on processes in nature, a Summer School of the EU project MaCuMBA (Marine Microorganisms-Cultivation Methods for Improving their Biotechnological Applications) and a PhD course on Organic Biogeochemistry of the virtual Netherlands Earth System Science Centre (NESSC), of which NIOZ is one of the partner institutes.

The NIOZ harbour on Texel was officially reopened on 17 September after extensive renovation. The large 'Pelagia quay' was completely renewed and is now 50 m longer, 1 m wider and 0.5 m higher, this with an eye on the expected sea level rise. The pontoon of the Navicula jetty is also new and other parts were renovated. It is now operated as a Limited Liability Company (in Dutch: BV) under the NIOZ holding. The harbour has become a public seaport with the new name 'Seaport Texel'. It is accessible for all parties, provided that their activities do not harm the environment.

Official opening of the renovated NIOZ harbour, now 'Seaport Texel'. From left to right: Eric Hercules, alderman of the municipality of Texel, Jaap Bond, representative of the province North-Holland, and Thomas de Greef, managing director of 'Seaport Texel'.

INTRO

Indeed, 2015 may be characterised as a productive, and a transient year, preparing for the step from NIOZ 1.0 to 2.0. We compliment all of NIOZ with the continuous efforts of everybody involved in keeping NIOZ top-notch, viable and vivid. We may now look ahead to clear skies, calm seas and clearer waters; may the wind be in our back in 2016.

Prof. Dr. Henk Brinkhuis, director Royal NIOZ
Ir Harry Baayen, chair of the board

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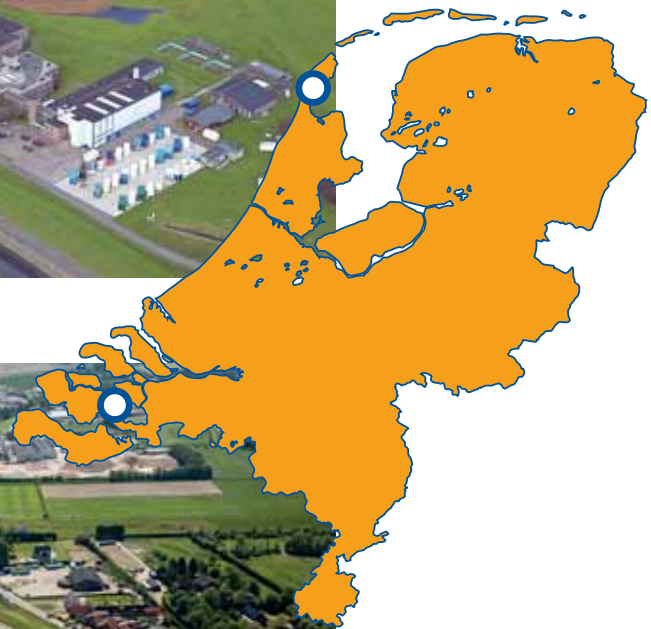
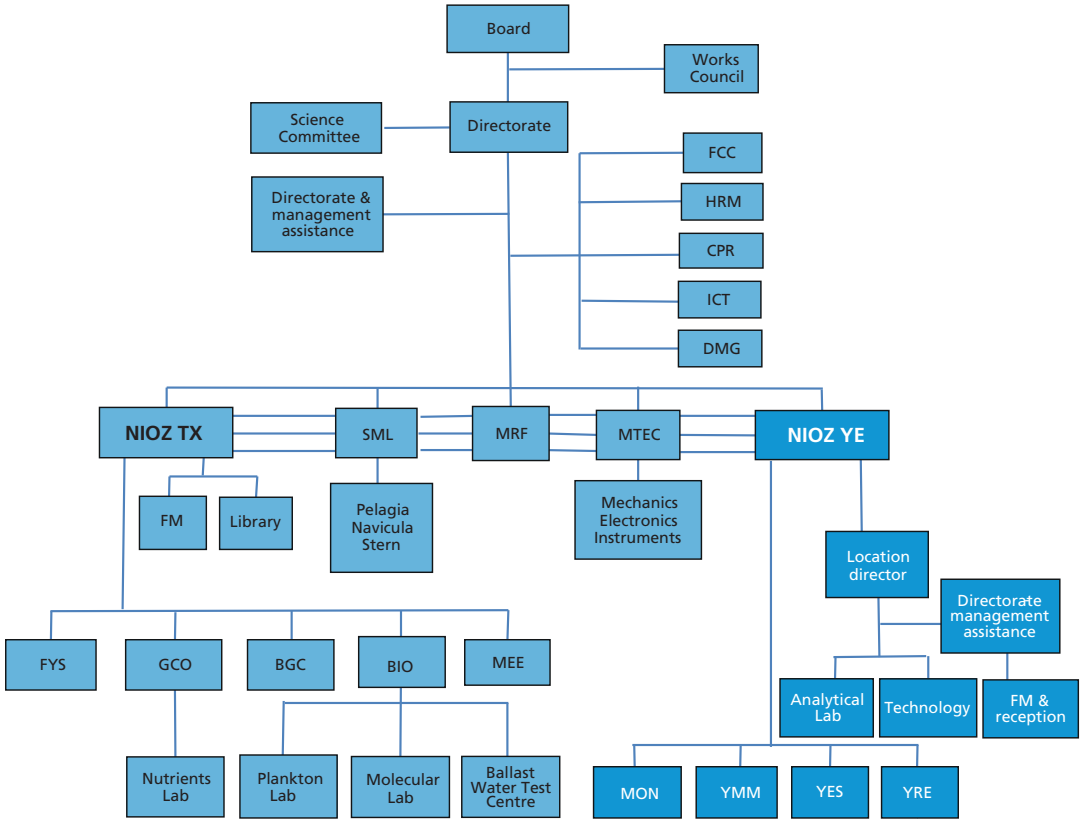




FCC = Finance, Control & Contracts
HRM = Human Resource Management
CPR = Communication & Public Relations
ICT = Information & Communication Technique
DMG = Data Management Group
FM = Facility Management
SML = Ship Management & Logistics
MRF = Marine Research Facilities
MTEC = Marine Technology
FYS = Physical Oceanography
GCO = Marine Geology & Chemical Oceanography
BGC = Marine Organic Biogeochemistry
BIO = Biological Oceanography
MEE = Marine Ecology
MON = Monitoring Task Group
YMM = Marine Microbiology
YES = Ecosystem Studies
YRE = Spatial Ecology

Man has discovered an unexpected ally in combatting toxic sulfide gases in oxygen-depleted coastal waters: a bacterium that uses electricity to mobilise iron deposits and build 'ferrous firewalls'. As a result, the smell of rotten eggs is captured inside the sea floor, and marine life is protected.

How bacteria use electricity to protect our coasts from toxic nightmares

Filip Meysman

Silvia Hidalgo Martinez shows a sediment core which has just been taken in Lake Grevelingen.

Oxygen depletion in coastal waters can lead to the mass release of foul-smelling sulfides that are extremely toxic to most marine life. But in practice, this rarely happens. Why? Because there are brave little bacteria that prevent it. A team including Prof. Filip Meysman and PhD student Dorina Seitaj found out how, by studying the phenomenon in Lake Grevelingen.

Detail of a sediment core. The black part contains the sulfides.

It turns out there are little-known filamentous microbes called cable bacteria active that can send electric currents down their bodies for distances up to a centimeter - a long way, for a microbe. The electricity causes migration of dissolved iron from deep in the seabed to the ocean floor, where it forms an orange crust, trapping the sulfides in the sediments below.

Every spring, the bacteria are present, to form a firewall against sulfides. This is good news indeed for the oyster colonies in Lake Grevelingen - and those who harvest them. Without the cable bacteria, there would be mass oyster mortality due to oxygen insufficiencies.

The phenomenon is not restricted to Lake Grevelingen. Recently, the research team has established that the cable bacteria are abundant in many other coastal systems threatened by oxygen depletion during summer months. There too the bacteria are ready to play their part in protecting life.

Nature shows how to speed salt marsh recovery

Brian Silliman &
Johan van de Koppel

Natural growth of marsh grass in the Western Scheldt.

Traditionally, man has planted marsh grasses in carefully spaced geometric grids when trying to accelerate salt marsh recovery from disruptions. Why? To minimise competition for light and nutrients. But recent research shows this thinking could be misguided, and that nature's way could be better.

DELTA

Comparison of the old planting method (above) and the new method of planting in clumps.

Salt marshes need grasses to hold them together, and after severe storms the planting of new grasses can accelerate the recovery of wetland and marsh vegetation. The straight rows of such grasses on dunes and in marshes are tell-tale signs of man responding to storms in the not-so-distant past.

But recent research by NIOZ and Duke University, done in the wetlands of Florida and the Netherlands, springs some surprises.

It turns out that planting the grasses in clumps does not only produce a more natural look, but also a significant acceleration in plant growth. The research team measured plant growth increases over 200%, and an average doubling of recovery rates when the plants were placed close together in clumps - much as they normally would grow in nature.

The explanation is that the benefits of so-called facilitation between neighbouring plants, a much researched topic in recent years, are much greater than those of exclusivity to nutrients and light would be for plants spaced further apart. It is almost as if the plants enjoy each other's company.

NIOZ's Prof. Johan van de Koppel is confident that the findings can be put to immediate use in restoring the vegetation of salt flats ravaged by either nature or man. And in this case, it was nature who showed us how.

Brian Silliman received funding from the KNAW Visiting Professors Programme to work as a guest scientist at NIOZ.

Flocks of wading birds over the Wadden Sea mudflats tend to look uniform. But looks can deceive. In reality, flocks contain birds that differ vastly in their body size, dietary patterns, fat reserves and, as Allert Bijleveld discovered, personalities.

Some wading birds are stick-in-the-muds

Allert Bijleveld

Allert Bijleveld (centre) defended his PhD thesis at the University of Groningen and got a cum laude.

Allert's experiments show: some birds are eager to travel from one place to another, while others prefer to stay in the same place. Such differences in conduct, measured in NIOZ's experimental shorebird facility on Texel, correspond remarkably well with differences in the wild: upon release, the knots that had been identified as keen travellers headed for foreign mudflats, while the stick-in-the-mud knots remained where they were, in the Dutch Wadden Sea. Interestingly, these differences are linked to body size and dietary patterns. Knots that are keen to travel are smaller, slimmer, and prefer high-quality prey. The stick-in-the-muds are fatter, eat low-quality prey and are less mobile. Interestingly, both approaches lead to equal survival. But they inspire different forms of cockle predation.

It has been established that the fewer cockles there are in a bank, the fatter they become: the result of less competition for food. The travel-eager birds tend to avoid the cockle-rich flats, preferring to seek out the less densely populated areas with fat, high-quality cockles.

And so, in developing Wadden Sea conservation policies, it may not only be the cockle-rich areas that need our protection as food sources for migratory birds.

Experiment in progress in the Experimental Shorebird Facility at NIOZ on Texel.

At first glance, all these knots look the same, but they differ in body size, diet, fat reserve, and personality. Photo: Jan van de Kam.

Coral reefs under threat from not-so-boring sponges

Benjamin Mueller &
Fleur van Duyl

The destructive action of boring sponges in a coral colony.

Boring sponges such as *Cliona celata* are common inhabitants of coral reefs. But, they have a darker side that becomes apparent if too many of these sponges colonize the reef.

COAST

Benjamin Mueller and a colleague in action on a coral reef on Curaçao.

In past decennia, pollution, climate change and overfishing have conspired to increase the presence of algae on coral reefs; algae that produce more soluble organic material (e.g. sugars) than corals. NIOZ PhD Benjamin Mueller found that this organic matter release by algae (turf algae) is even exacerbated by nutrient pollution. Micro-organisms and various open reef sponges are more than happy to absorb this dissolved organic matter (DOM), and then pass on this carbon further up the food chain. Mueller found that boring sponges also feed on DOM; more than 70% of their diet consists of it. And because these sponges appear to feed on a diet consisting mainly of algal derived DOM, the hypothesized chain of events goes like this: more algae means more DOM, leading to more sponges, including the boring varieties. These boring sponges drill holes (hence the 'boring') in the stony skeleton of corals both living and dead, and in the process weaken the reef structure. In the end, the corals could succumb, and lose the competition for space to algae and sponges.

Expanding activity of boring sponges is one of nature's many examples of previously unimagined causes of coral reef decline.

Cover of Journal of Plankton Research number 1, 2015, featuring an aerial photo of the NIOZ fish fyke.

Jellyfish in a warming Wadden Sea

Lodewijk van Walraven & Henk van der Veer

As the Wadden Sea warms, jellyfish increasingly appear early in the season. And that's not all we learned from 50 years of data gathering.

Many scientists believe that the increasing number of mass jellyfish occurrences is caused, at least in part, by man. Overfishing and climate change are probable causes. But robust proof can be hard to find, because the global science community has simply not measured jellyfish abundance for long enough periods.

An exception is, perhaps, to be found in the Wadden Sea. Here, researchers have been studying jellyfish systematically for half a century, using a special fyke placed near NIOZ headquarters. Every day during spring and autumn, the entire catch is meticulously identified, counted, measured and recorded, species by species. The result: a unique long-term database.

And the data are clear. The most abundant species, the moon jellyfish (*Aurelia aurita*) and barrel jellyfish (*Rhizostoma octopus*), are showing up earlier in the year than they did in the past. A clear relationship to seawater temperature has been established, and an underlying cause suggested: warmer water means more juvenile fish, on which the jellyfish feed.

Overall jellyfish catches decreased, but in recent years a newcomer has appeared on the scene: the comb jellyfish *Mnemiopsis leidyi* or sea walnut. Their presence is not always appreciated: the fyke fishermen complain that they clog the nets and thus cause smaller fish catches. The study by NIOZ researchers Lodewijk van Walraven and Henk van der Veer was featured in a fascinating cover story in the Journal of Plankton Research.

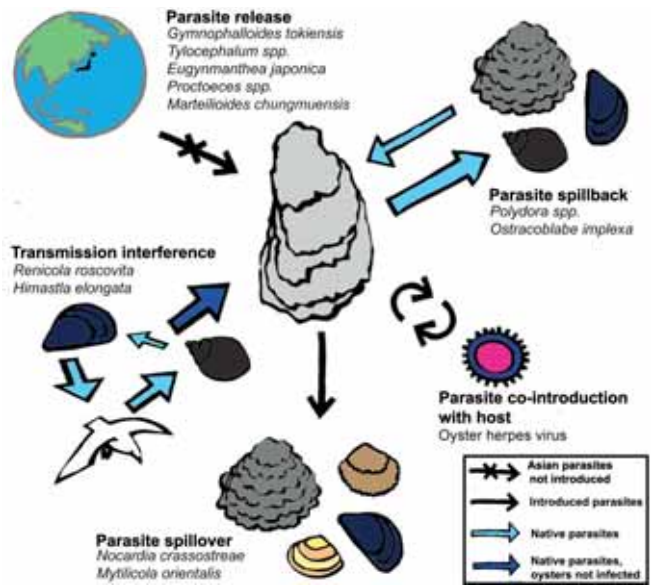
Species occurring in the Wadden Sea. From left to right: the comb jellyfish Mnemiopsis leidyi, the moon jellyfish Aurelia aurita and the barrel jellyfish Rhizostoma octopus. Photo barrel jellyfish: Shutterstock.com©Art Wittingen.

NIOZ

COAST

Invasive oysters affect disease risk of native species

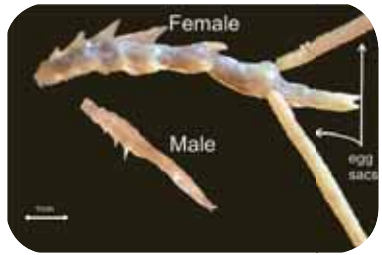
The impact of invasive species can include a multitude of effects on parasites and pathogens which ultimately affect disease risk of native species. This is the result of a bilateral project with German partners, focusing on Pacific oysters.



Although Pacific oysters (Crassostrea gigas) have lost many parasites from their native range during invasion, they still affect many parasites and pathogens (in italics) in the invaded region via various mechanisms.

Anouk Goedknegt & David Thieltges

Invasive species are of increasing concern in global coastal waters as they can dramatically impact on native ecosystems. Less known is that such invasive species can also affect parasite and pathogen dynamics in invaded regions.



The parasitic copepod Mytilicola orientalis was co-introduced with Pacific oysters and now infects the intestine of various native bivalve species.

Sampling Pacific oysters in the Wadden Sea.

Working with colleagues from the Alfred Wegner Institute in Germany, a team of NIOZ scientists investigated the impact of invasive Pacific oysters on disease risks for native species in the Wadden Sea.

They found that Pacific oysters lost parasites from their native regions during the invasion process, which may have given them a head start during establishment in the Wadden Sea. However, the oysters later became infected with native parasites which were then able to spill back to native hosts, increasing their infection levels. Oysters also co-introduced parasites, some of which only infect Pacific oysters. Others like the copepod *Mytilicola orientalis* have already spilled over to native bivalve species, with negative effects on these new hosts.

However, oysters can also have positive effects on native species, by interfering with the transmission of infective stages and thus reducing infection levels in native hosts. For example, oysters can filter free-living parasite stages out of the water column before they can infect a native host.

This research suggests that biological invasions can have very complex effects on disease risks in ecosystems, and that such effects should be included in impact assessments.

Deep-sea corals live in an environment with very little food. And so it is advantageous for them to recycle 'waste' material. NIOZ researchers, working alongside scientists from the German GEOMAR centre and colleagues from the Universities of Utrecht and Gothenburg are beginning to understand how they do this. And the keyword is: efficiency.

Lessons in efficient recycling

Dick van Oevelen

Deep-sea corals form reefs that are oases of life in the deep sea. Photo: Solvin Zankl @GEOMAR.

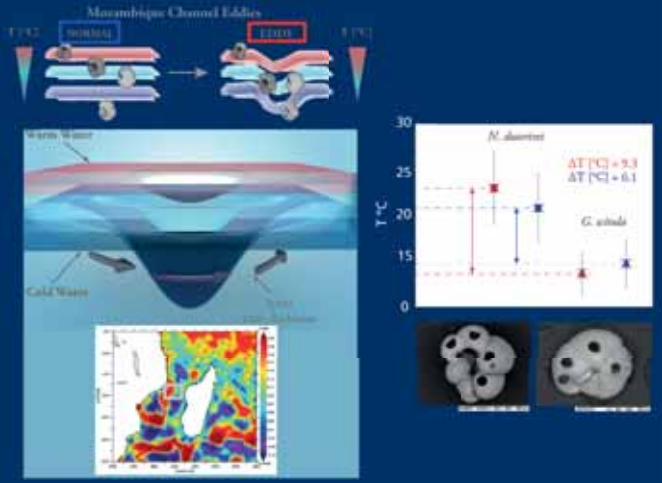
Detail of the dominant coral species Lophelia pertusa. On the right the head of the worm Eunice norvegica sticks out. This worm lives inside the calcareous skeleton of Lophelia. Photo: Solvin Zankl @GEOMAR.

Tropical corals obtain their energy from symbiotic algae that use energy from the sun to convert carbon dioxide into biomass. In contrast, deep-sea corals live in pitch darkness. And so: no such photosynthesis. These corals rely on the scarce supply of food that sinks all the way down from the surface ocean. A recent, fascinating laboratory experiment shows that they therefore efficiently recycle 'waste' products.

Corals were collected from a depth of some three hundred metres in the seas of Norway, and kept alive under controlled laboratory conditions. The first thing the scientists discovered was that bacteria living on the coral use the energy from the waste product ammonium to convert inorganic carbon into biomass - and do so in total darkness. In effect, these bacteria fulfil a functional role that is similar to the one played by symbiotic algae in tropical corals. But there is more. Working as a symbiotic team, the bacteria and corals convert nitrogen gas into biological forms of nitrogen - and do so within the incredibly short time of 24 hours. An unexpected result, for such an energy-intensive process, and one that should inspire further research - possibly within the context of Netherlands Earth System Science Centre (NESCC).

Using plankton to measure ocean perturbation

Juliane Steinhardt



Sea level anomalies in the Mozambique Channel (red colour indicates positive sea level anomalies caused by the passing of an anticyclonic eddy). The passing of an eddy causes warmer surface waters to be pushed into deeper layers (see top right). This temperature signal is recorded by planktonic foraminifera living at the base of the mixed layer. Ultimately, the reconstructed temperature differences between foraminiferal species living in the mixed water layer and those living in deeper waters is greater during the passage of an eddy (see left).

Juliane Steinhardt and Theo Hillebrand on-board of the South African ship FS Algoa, retrieving the sediment traps (large white 'funnels' on the left) deployed in the Mozambique Channel.

Past hydrographic changes in the upper waters of the Mozambique Channel have been identified by studying the geochemical composition of planktonic foraminifera (or short 'forams'). By determining the composition of the forams' 'shell' (the calcite test), scientists can identify and interpret recent changes in water temperatures as deep as 200 metres. Such changes were the result of passing eddies.

Several different species of planktonic foraminifera - single cell organisms living in the oceans of the world, in this case the notoriously turbulent Mozambique Channel - were obtained from sediment traps by scientists working on board the South African research vessel Algoa. Using high-resolution laser ablation techniques on the miniscule calcite shells and their individual chambers, they were able to establish that each shell contains information about ambient temperatures of the water in which it was calcified. Comparing different foram species from various depth habitats, temperature changes at different depths within the water column were reconstructed. These temperature changes proved to be directly related to the passing of individual eddies along the Channel.

These results open new perspectives on reconstructing a larger scale climate history of the area in terms of past eddy intensity and frequency. If this geochemical method can be further refined and validated, a promising new tool to this end may be in the making...

OCEAN

Marine viruses may endanger future fish populations

Marine viruses are an increasingly important cause of death for bacteria and algae in the Northeast Atlantic, as water temperatures rise. This could be bad news for fish populations. That's what Kristina Moijca discovered on board RV Pelagia during her PhD research.

She already knew there are more viruses in the oceans than any other kind of life. And viruses are parasites, infecting organisms - bacteria, algae - in order to replicate, killing their hosts in the process. Marine viruses are currently responsible for half the microbial mortality in the Northeastern Atlantic, the other half being a result of predation/grazing. And the ratio between these two causes of death is changing...

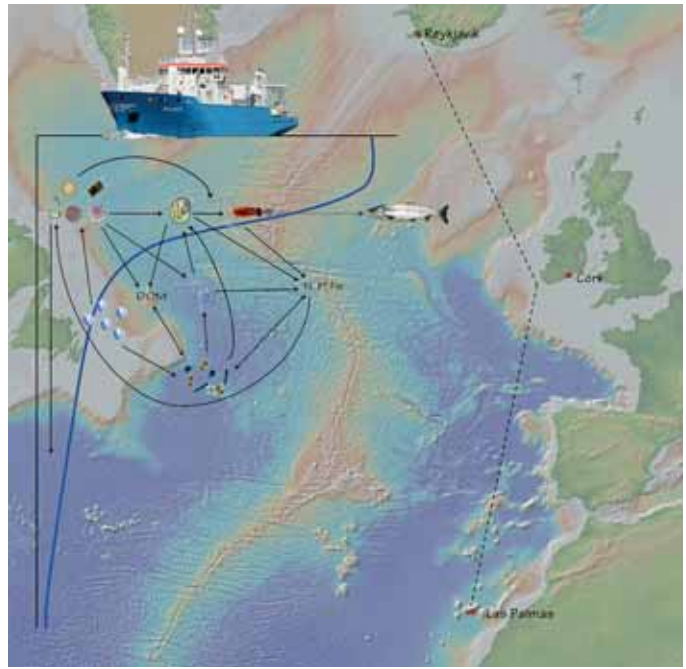
Kristina Mojica & Corina Brussaard

Kristina Mojica working in a container lab on board RV Pelagia.

The warmer areas of the ocean are lower on nutrients, and here the relatively high incidence of viral lysis as a cause of death, a death in which the microbe is effectively destroyed rather than eaten, is proving of importance.

Crucially, viral lysis diverts cellular carbon away from fish, birds and mammals, instead retaining it in the sea as dissolved organic matter. And the effect is significant. In the southern part of the Atlantic area researched, such recycling within the pool of dissolved organic matter is more than double that at higher, colder, nutrient-rich latitudes.

This is a major finding when viewed in the context of global warming, because it suggests that as the ocean warms up, viral lysis will increasingly outstrip predation as a cause of microbial mortality, causing increased carbon recycling within the dissolved organic pool. The result: less food for fish.



Cruise track and schematic view of the food web in the North Atlantic. The blue line represents the water temperature and illustrates the vertical stratification of the upper water column.

How the Mediterranean vanished - and then, reappeared

Five million years ago, the Mediterranean Sea dried up to become a huge, salty land basin. A quarter of a million years later, the waters returned. And now, we know why.

It took a multidisciplinary team including NIOZ's Paolo Stocchi to solve a mystery that has been dividing scientists ever since what has become known as the Messinian Salinity Crisis (MSC) was first postulated.

Stocchi's team discovered, by examining no less than sixty drill cores from around the edge of Antarctica, that continental ice was on the increase in the lead up to MSC, causing water levels to lower. Using state-of-the-art computer models to simulate such Antarctic ice growth, they next discovered that such a freeze would have caused gravitational and rotational effects affecting the entire planet. The result: deformations in the Earth's crust, in particular around the Straits of Gibraltar, where the pressure of water on the crust would have diminished, allowing the crust to rise. Suddenly, the already shallow sea was landlocked, and consequently evaporated, leaving behind huge salt flats.

Late Miocene palaeogeographic map of the Mediterranean region during the Messinian salinity crisis. Credits: Ron C. Blakey, Colorado Plateau Geosystems, Arizona, USA.

Paolo Stocchi

A quarter of a million years later, sea levels were rising. Not by very much, but just enough to wash over (and consequently deepen) the thin land bridge between the pillars of Hercules, and to refill the Mediterranean basin in a huge deluge known as the Zanclean flooding event.

It is an example that illustrates how sea-level changes can have non-linear effects: worth noting in any future climate change scenario.

Harvesting the energy of the tides

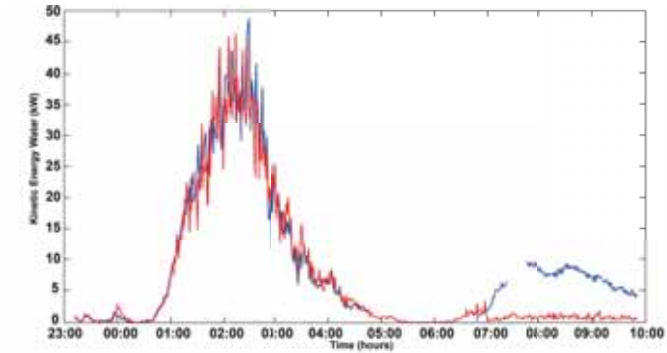
Collecting energy from the tidal currents has long been a dream. Nowadays for NIOZ, having previously established the best location and the best attainable results, it's a reality.

Introducing BlueTEC, the world's first floating tidal energy power plant! A surface platform in the Marsdiep inlet just south of NIOZ headquarters that is both a demonstration as well as a production unit. A tidal stream turbine beneath the platform provides the muscle. A multi-purpose cable connects the tidal turbine to the island of Texel, where it helps to lower NIOZ's electricity bill and fuel our green ambitions.

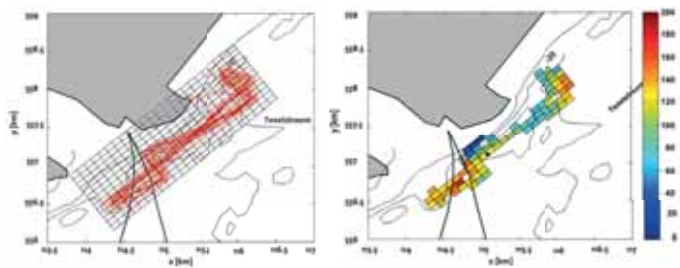
Janine Nauw

Prior to tethering, dedicated research was carried out aboard our own research vessel Navicula in finding the optimal location for BlueTec. The challenge: staying away from navigational channels, avoiding the high frequency island ferry and achieving maximum power output. Our calculations showed tides could, in theory, produce at most 90 MWh per year, and in practice the turbine is currently already churning out up to 40% of that.

Current meters are mounted beneath the platform to measure differences in flow velocities before and after the turbine. Besides that, an additional instrument is placed on the adjacent sea floor to measure wave height, direction and frequency, which will allow the evaluation of turbine efficiency under various current, wave and wind conditions - including extreme ones. Don't you just love it, when science and economics come together in a good plan?



Kinetic energy of the tidal current before and after the turbine that was used in a test phase of the project. Before 7:00, the turbine was not operating. Between 7:00 and 10:00, the blue line indicates the undisturbed flow and the red line the kinetic energy in the flow after extraction of the energy by the turbine.



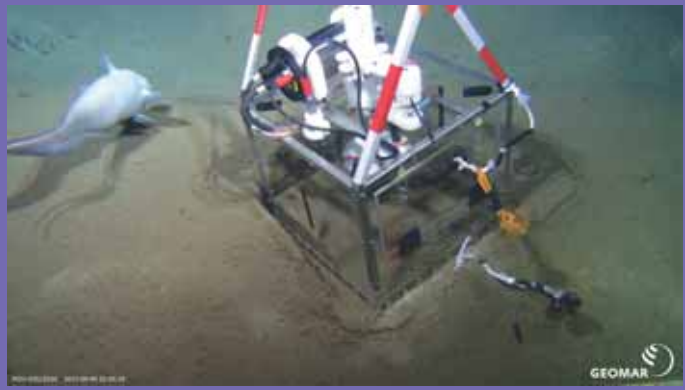
Left: Track of the Navicula during survey for determining the optimal location. Right: Kinetic energy of the current during one tidal cycle (kWh). Black dot: optimal location outside the navigational channel and the envelope of the ferry tracks.

Deep-sea mining: today's treasure, or tomorrow's tragedy?

Henko de Stigter &
Dick van Oevelen

The seabed is home to large metal deposits including copper, nickel, cobalt, gold, silver and rarer trace metals vital to the electronics industries. With modern technology and under UN supervision, mining these deposits is viable. But is it desirable?

To find out, a variety of deep-sea experiments have been carried out over the past decades. The aim: to establish and monitor the impact of mining on vulnerable marine ecosystems. In such experiments, the seabed would typically be artificially disturbed to simulate the effect of deep-sea mining. Later, the impact of this intervention on local ecosystems and their recovery would be assessed.



Picture of the CUBE with a sea cucumber inside, at the sea floor at 4 km depth with fish alongside.

Bottom currents measured by the BOBO (BOttom BOundary) lander are used in model predictions of the dispersion of sediment plumes generated by mining.

In 2015, one such experiment initiated way back in 1989 at more than 4 km depth in the Pacific Ocean off Peru, was revisited. An international team of scientists returned to the scene, as part of the European project 'Ecological aspects of deep-sea mining'. The team included three NIOZ scientists, specifically investigating deep-sea current dynamics, and measuring biological activity in both disturbed and pristine areas of seabed. Preliminary results show that, even after 26 years, the traces of the original disturbance are still clearly visible. More worryingly, at least some of the affected deep-sea life forms have still not recovered from man's intervention, despite a quarter of a century of non-interference. These findings suggest that industrial activities in and on the seabed could have far-reaching consequences for some of the least understood ecosystems on the planet: those hidden deep in our oceans.

2015 brought new and exciting events for the NIOZ flagship RV Pelagia. Highlights were a successful multibeam survey and thermistor string deployment in the 8500m deep Puerto Rico Trench and the deployment of the 5000m Canadian ROPOS ROV in the SW Indian Ocean East of Reunion Island.

Recovery of ROV ROPOS after one of its 12 dives to the southern Central Indian Ridge during the BGR cruise. During the dives, ROPOS spent up to 8 hours on the sea floor at a depth of up to 3400m and collected rocks, sediments and biological samples from active vent sites. www.ropos.com

RV Pelagia in 2015: Moorings and more!

Erica Koning

The 2015 cruise program was once again a mix of science cruises, barters (exchange cruises with our European OFEG research partners) and charters (semi-commercial cruises). It started in the Cape Verde Islands, with the third annual cruise for the EU project Dust/Traffic that monitors transport of Saharan dust over the Atlantic Ocean. The vessel then performed a multibeam survey cruise along the Surinam and Guyana coasts, followed by a 'deep-sea mining' cruise to the Mid-Atlantic Ridge. From mid-June to early August, Pelagia serviced the OSNAP-East moorings, with US, UK, German and Dutch partners on board. A total of 21 deep-sea moorings were recovered and redeployed.

To guarantee the safety of ship and crew on the transits through the Piracy High Risk Area along the Somali coast, Pelagia was supported by Vessel Protection Detachments provided by the Dutch Royal Navy.

On August 11, Pelagia left her home port of Texel for a 7-months voyage, visiting Istanbul before heading for the Black Sea as part of the VICI grant to Caroline Slomp, Utrecht University. Next, Pelagia passed the Suez Canal and made her way towards Reunion Island for a 63-day charter for the German 'Bundesdienst für Geowissenschaften und Rohstoffe' (BGR).

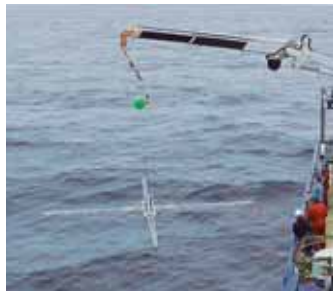
The year ended with Pelagia sailing North, arriving in Egypt on New Year's day.

Cruise track for RV Pelagia. Symbols along the track show part of the mooring stations visited in 2015.

Technology development for innovative marine science

Often our scientists want to carry out innovative measurements which require novel equipment. In such cases our marine technologists join them. Some highlights:

3-dimensional thermistor string
Turbulent water motion in the deep sea is responsible for deep vertical mixing. This is driven by internal waves, which can be registered by differences in water temperature over time at different depths. NIOZ scientists and technicians launched a 3D mooring from RV Pelagia, holding 475 sensitive temperature sensors on five parallel lines just 4 m apart and 100 m long onto the slopes of a large undersea mount southwest of Lisbon. Three months later a rich data set revealed the details of 3-dimensional internal waves causing turbulent overturning.



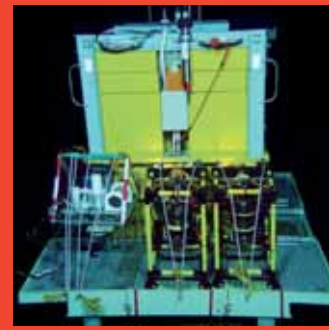
The unfolding of the five-line 3D mooring.

Marck Smit

The Pristine water bottle; MK-II
A light-tight version of our 'Pristine' ultra clean water sampler was produced. This 'MK-II' version is now ideal for both the measurement of ultra-low levels of trace metals and for biological activity measurements, because growth of autotrophic organisms in the upper water layer is prevented. A complete titanium frame with 24 of such bottles is currently under production for our fellow marine research institute KIOST in the Republic of Korea.

Recovery of the Ultra Clean water sampling system in the Arctic.

The CUBE
These acrylic inCUBEation chambers allow the measurement of the biological activity of enclosed larger organisms on the deep sea floor. The grazing activity of sea cucumbers, the cows of the deep sea, was measured at 4 km water depth at the bottom of the Pacific Ocean, both in control areas and in areas where large-scale disturbances had been induced previously. Such differences indicate the length of time required by the seafloor community to recover.



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SUPPORT

Jan Boon

The presence of NIOZ at public events and in popular articles explaining the importance of the oceans and seas, is becoming increasingly important in relation to the main research themes 'Changing Ocean systems' and 'Adaptability of marine ecosystems in a changing world'.

To increase 'Ocean literacy' in an attractive and accessible way, we produced several video clips which can be viewed via our own YouTube channel 'NIOZclips'. Highlights are:

- 'The colours of the Sea' on how dissolved compounds, algae and suspended particles in the water can change its perceived colour,
- 'How mussel beds change the landscape' in intertidal areas like the Delta and the Wadden Sea,
- 'Thinking like a bird' on the challenges that migrating birds face on their journeys between breeding and wintering areas,
- 'Go with the flow' on research on the currents in the subpolar North-Atlantic, and
- 'Wadden Sea fish decline', on the results of our 50 years of fish catches with the NIOZ fish fyke at Texel.

Citizen science: Dr. Marcel Wernand holds the palette of 21 water colours of the Forel-Ule scale. The new 'EyeOnWater' App allows everybody with a smartphone to take a picture of a water body and choose the colour that fits their picture best. All results are collected in a central data base.

In September and October, six NIOZ scientists presented their personal expertise to an audience in the public library in Den Burg, Texel in a weekly series.

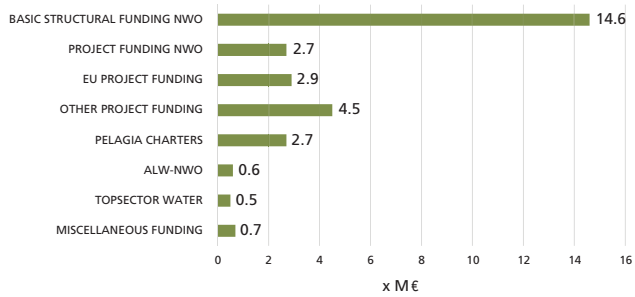
NIOZ presence at the NWO stand in the Holland House at the Hannover Messe; the largest technology exhibition in the world (April).

Yerseke is the heart of the mussel and oyster food industry in the Netherlands. This role was highlighted by organising a 'Mussel Day' on 14 August.

OUTREACH

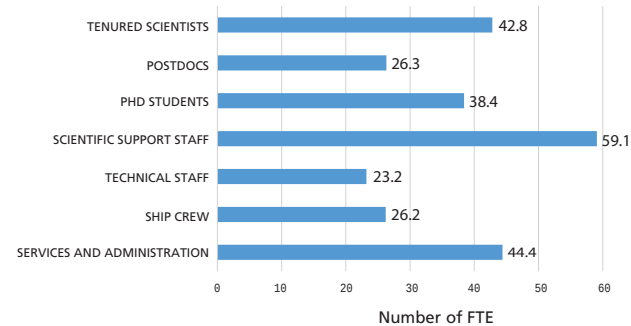
Budget

The overall budget for 2015 amounted to 29.2 M€. NWO contributed 14.6 M€ as basic structural funding (equivalent to 50% of the total budget) and 2.7 M€ project funding (9%). Other project-related additional funding was received through EU projects (2.9 M€; 10%) and other national and international projects acquired in competition (4.5 M€; 15%). Chartering of RV Pelagia to third parties yielded a revenue of 2.7 M€ (9%). Other shipping funding was received from ALW-NWO (0.6 M€; 2%) and the 'Topsector Water' (0.5 M€; 2%). Miscellaneous and ad hoc funding amounted to 0.7 M€ (2%).

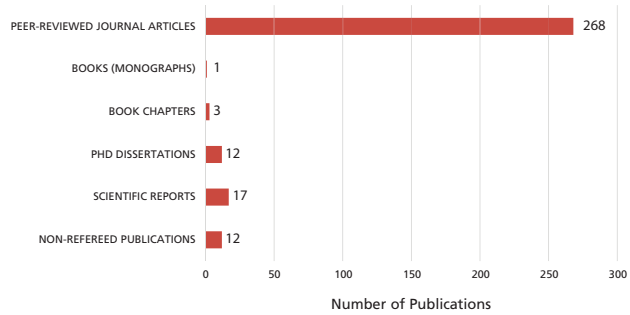


Staff

As of 31 December 2015, NIOZ employed a full-time equivalent (FTE) of 260, with a total headcount of 302 employees. Of this total, 54 employees were of foreign nationality, representing 21 different countries. Total staff decreased by 28 FTE from 2014. The relative distribution in % of personnel over the different staff categories remained fairly constant. Scientific staff, including tenured senior scientists, postdocs and PhD students accounted for 41% (2014: 43%) of the total staff, scientific support staff 23% (2014: 23%), and technical staff, ship crew, and services & administration accounted for 36% (2014: 33%).

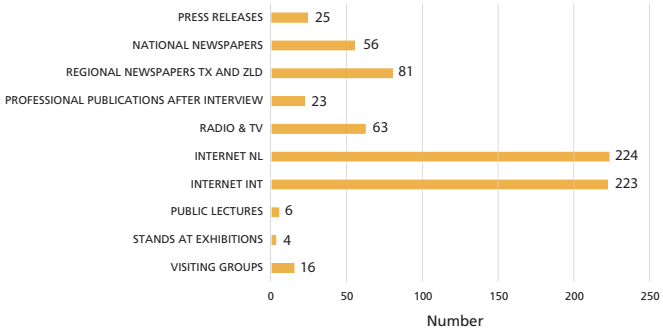


Scientific output



NIOZ scientists authored or co-authored 268 peer-reviewed journal articles, 1 book (monograph), 3 chapters in books, 12 non-refereed publications and 17 scientific reports. Out of the total of 268 peer-reviewed journal articles, 153 or 57% appeared as open access publications. Twelve PhD students received their degrees; from Utrecht University (5), the University of Groningen (3), the University of Amsterdam (2), VU University Amsterdam (1) and the Technical University Delft (1). 28 presentations were given by NIOZ scientists and guests in our colloquium series, either on Texel or in Yerseke.

Public outreach



NIOZ issued 25 press releases on scientific highlights and was mentioned 56 and 81 times in national and regional newspapers, and 224 and 223 times on national and international websites, respectively (data: Meltwater News Database). 23 publications were written by journalists in professional journals following interviews with NIOZ scientists. Our scientists appeared 63 times on radio or TV and gave 6 public lectures in a series in the library in Den Burg. In order to increase Ocean Literacy in an easily accessible way, we made several video clips on specific scientific items (www.youtube.com/NIOZclips). Exhibitions: NIOZ was present at the Hannover Messe in Germany at the NWO stand, at the 'Mussel Day' in Yerseke, the 'Aardwetenschappelijke Loopbaandag´ in Amsterdam and contributed to the 'Andre Kuipers lecture tour' in Zeeland. 16 Groups visited NIOZ.


Mission B
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Building NIOZ 2.0 on existing foundations

Henk Brinkhuis, head of NIOZ since October 2011, does not mince his words. He starts the interview by stating: 'Shortly after I took over, we discovered to our surprise the place was effectively bankrupt, without any prior indications. There was simply nothing left in the coffers.'

He continues in this vein in discussing the role of NIOZ. 'We always thought of ourselves as a prominent institute. In fact, we are world famous here on Texel and have a good reputation among colleague institutes around the world. A handful of Dutch academics in our line of business know who we are. But beyond that: few folk out there have a real clue who we are or what we do.' Brinkhuis is not the man to accept such a situation. 'In the past, our performance was judged once every six years, purely on academic merit and research quality. Now, we need to reach out and demonstrate our relevance to society, and take steps to ensure continuity in our existence.'

Henk Brinkhuis

NIOZ can look back on a turbulent 2015. In 2016, the venerable 140 year old institute cuts back its number of research departments from nine to just four. Three are located on Texel: Ocean Systems, Coastal Systems and Marine Microbiology & Biogeochemistry. A fourth, Estuarine Delta Systems, operates out of Yerseke, in the Dutch Delta. All departments now embrace a multidisciplinary approach in which biologists, physicists, chemists and geologists no longer each occupy their own little island, but work in unison towards common goals.

Closing down the Yerseke location was only narrowly avoided, and some staff members were relocated - sometimes in organisational terms, sometimes physically. A ten percent slimming down operation could not be avoided. 'We had to take painful measures. There was simply no alternative', explains Brinkhuis. He adds that the new approach has also led to the creation of new jobs, some currently still unfulfilled.

The financial side of what he consistently calls NIOZ 2.0 was redesigned. A major success was the cooperation agreement with Utrecht University, signed early in 2015, that guarantees an annual investment of €2.4 million by the University. A substantial funding, intended for long term strengtening of NIOZ's scientific excellence. 'NWO provides us with €16 million per annum, but €10 million of that goes on maintenance of ships and buildings, support staff salaries and other basic needs. The Utrecht contribution means we can expand our research activities by about a third. The close cooperation with Utrecht does not mean our hands are tied. There is no closed shop vis-a-vis Utrecht, we are free to welcome other partners.'

The threat to the future of the NIOZ fleet was parried, and more: 'Our sea-bound activities are central to operations in the years to come. Our research does not just require laboratories: we need suitably equipped vessels. Our future is at sea.'

Brinkhuis' further plans include a national support centre for marine science students in search of internships, and more intensive marketing/PR, targeting marine business sectors. The crucial role in all this is that of NIOZ associates: 'There's a lot of change going on. We need to embrace our staff and involve them on this journey, challenging them to identify their own positions against a new backdrop. We have said goodbye to the old NIOZ, retaining just the foundations. That is now our building site, in the exciting times to come.'

Faith in the new multidisciplinary approach

'I realise that for some, it feels unfamiliar, but I believe the new research division structure is an improvement. Yes, I am all for the multidisciplinary approach. That's how science works. The reorganisation has propelled us into the 21st century.'

Gert-Jan Reichart, by 2016 head of Ocean Systems at NIOZ, is adamant. He and his associates focus on research 'at full sea', as he succinctly puts it. It is a pretty large area that includes the water column itself as well as the sea floor underneath - plus all that lives within either. 'The scale of such research automatically brings together scientists representing different disciplines.'

Gert-Jan Reichart

Fascinating is the word for deep sea research, the ocean below 500 metres depth, where darkness rules and algae are absent. 'Most of the ocean floor is barren, with occasional hotspots in the form of cold water coral reefs and sponge colonies. Why? We know it has to do with redistribution effects. Food particles float down from higher water strata where sunlight still penetrates, and locally creates environments for these life forms. To understand why the nutrients land just there, you need to understand ocean currents. That means biologists teaming up with physicists.'

A better understanding of climate change is vital to society. An important role is played by single-cell algae and foraminifera (forams) that like many sea creatures build skeletons of calcium carbonate. When they die, they drop to the ocean floor; that's been happening for hundreds of millions of years. By recovering the sedimentary layers in which they are piled-up, we can find clues to past climate history: water temperatures, salinity, etc. 'By adding such information to what we already knew, we can attempt explanations of contemporary climate changes.'

Of all CO2 (the number one greenhouse gas) man has produced since the industrial revolution, 30% ended up in the sea. 'Most gets transported to the depths of the North Atlantic. An interesting question is whether this process will continue now polar icecaps are melting. Sudden changes, known as tipping points, are eminently feasible. The result could be that current climate protocols can be condemned to the scrapheap from one moment to the next.'

Central in departmental operations is 'going to sea'. 'Our own ship, Pelagia, is at sea 300 days every year in the North Atlantic, the Mediterranean, the Indian Ocean, the Baltic Sea. In addition, we work together with all NIOZ departments in a North Sea Task Force.'

To do all this to the best of his ability, Reichart is looking for reinforcements. 'We have just one physicist; we need three. And half a marine chemist rather than the ideal two and a half. We need to fill these vacancies this year, and due to international competition, that's tough. Luckily, we get our share of Utrecht University's investment in NIOZ. We use it to get the best people we can. Ultimately, it will be their task to ensure the interesting research projects for, and in, the future.'

Gaining insight from large scale research

He calls himself 'NIOZ-made', because he has spent nearly forty years at the institute where he has learned so much about marine research. 'Not just the cruises, but also the coffee machine chin-wags. I soon learned that here it is all about open doors, not about hierarchy. A very pleasant working environment.'

Nevertheless, his extended stay was never a foregone conclusion. 'I always kept an antenna for the outside world. And I had some offers. But I never left. And the decision to stay was always a positive one.'

Van der Veer headed the Marine Ecology department for eight years, and is now in charge of Coastal Systems. This new department focuses strongly on the Wadden Sea and other wadden systems (and cooperates with other departments in addressing North Sea issues as well). In doing so, it perpetuates a tradition originally started by the Zoological Station, the NIOZ precursor founded in 1876. 'Initially, the research was all qualitative: describing and localising occurrences of flora and fauna. Since the sixties, the focus has switched to quantitative studies. That allows comparisons over time, and hence: improved insight.'

Henk van der Veer

For instance, every year NIOZ employees take bottom samples throughout the Dutch Wadden Sea intertidal area. Every 500 metres, a 6-inch core sample is taken to collect the benthic fauna to establish which forms of life are present, and in what numbers. 'Many of these benthic species eat algae before becoming prey to birds and fish. We map their occurrence and abundance including depth and sediment data. Ultimately, we are able to establish the food landscape for individual birds, which can then be compared with actual numbers per location.'

The long-term tradition of the research offers an important bonus. It protects from impulsive pleas for change. A case in point was a proposal to dump controlled amounts of phosphates in the sea. The rationale behind it was that the sea is now cleaner with less nutrients than it used to have, thanks to stringent measures, and that this means less potential for plants and animal life - unless you add phosphates. 'You have to be blinkered to believe that this is really the solution. In the war, the entire area was covered with fykes. They had to be emptied twice daily to avoid breakage in the supporting poles. In those days, there were very few man-made phosphates around. The same was true a thousand years earlier, when the sea was bursting with fish. Only five percent or so of those populations are around today. Adding phosphates could get the number up to eight percent. Which would not alter the fact that the whole area has virtually gone belly-up. Our own fykes used to collect fifty kilos of samples per day. Now, it's more like five.'

Van der Veer is careful not to lay all the blame on overfishing. 'Climate change can equally be playing a role. Or sand extraction and beach nourishment, which effectively destroy the fish nurseries just off the coast every couple of years, and maybe increase the import of sand into the Wadden Sea. To learn more about this, research in the Danish part of the Wadden Sea might be an option, where beach nourishment does not take place. The point is, that the more you know, the better your judgments and measures are going to be.' Which measures? 'That is for society to decide', says van der Veer. We supply the facts, try to provide the total picture. Then, it is up to the politicians to decide what is best.'

Putting nature to work in the delta

For a while, it looked like the Yerseke location, having joined NIOZ only four years previously, would have to close down in 2016. But in the summer of 2015, NWO decided that the small town in Zeeland would be host to a whole new department, Estuarine & Delta Systems – a department that would harmoniously bring together physicists, ecologists, biologists, chemists and other scientists.

Departmental head Klaas Timmermans applauds the decision: 'I cannot deny we had some hard times, and there is no joy in saying farewell to people who have served you well for many years. But the new approach offers scope for growth, and room for new forms of collaboration. We are currently in a year of transition. But we can already see an increase in employee enthusiasm.'

'Deltas have long been of interest', Timmermans explains. 'They don't simply form a frontier between land and sea at the end of a river. They have also always been places of human settlement, of agriculture and fishery, and hubs of transportation. The negative has always been security: deltas are prone to flooding.'

Klaas Timmermans

Physically, chemically and biologically, the delta fascinates. Timmermans cites molluscs like oysters and mussels as examples. 'They don't just lie around waiting for something to happen. They form banks that impact on their environment. They slow down tides, decrease wave size, increase sedimentation. And us humans can turn all this to our advantage. As an alternative for protection derived from bulldozers, concrete, basalt and everything else needed to raise up a dyke, all involving high costs and intensive maintenance, we can try to entice mussels and oysters to perform their magic. It may be enough to allow more modest construction works. We call it 'Building with Nature'. Other contemporary subjects subject to the scrutiny of Timmermans and his researchers include the potential of seaweed as a source of human food, and future energy; the consequences on ecosystems of allowing water in and out through the Grevelingen dam; the potential of such a dam in generating sustainable energy, and the effects of a rise in sea levels on life, both local and remote. For such projects, NIOZ is not the initiator, but rather an essential link in the chain. 'We understand the area in which such projects take place. We can prepare informed prediction and measure consequences.'

Estuarine & Delta Systems employs twelve scientists and nine analysts. Including PhD students, postdoctoral researchers and other intermittent staff, the head count is over sixty. Interfacing with other NIOZ units, the department also indulges in North Sea research. And in deciding to keep Yerseke open, one of NWO's conditions was that they should collaborate closely with other partners in the Delta. Currently, that includes the University of Applied Sciences Zeeland and the provincial government. A good thing, according to Timmermans. 'Marine research is quite a small field. Our professional standard is very high, but for the institute to be viable, we need to extend our research volume.'

INTERVIEW

Finding good new people is vital

His department, Marine Microbiology & Biogeochemistry, is the largest at NIOZ. 'We currently have quite some vacancies for permanent scientists. Within a year or so there will be 70-80 associates, including fifteen fully employed scientists, fifteen technicians and a plethora of post docs, PhD students and other temporary employees.'

Departmental head Jaap Sinninghe Damsté faces a huge challenge. There is no shortage of interesting work, including two so-called Gravity Projects, supported on behalf of Dutch government by NWO. Both bring in 0.5 million Euro's annually and will span a decade. Two Advanced Grants from the European Research Council ('they are like a European NWO') help fund fundamental research, to the tune of 2.5 million over a five year period for Sinninghe Damsté and his colleague Stefan Schouten. 'Fifteen years down the road, we would like to still have such projects. That's why it is so important to attract good young scientists. Their job will be to attract funding in their specific areas of expertise.'

Jaap Sinninghe Damsté

Sinninghe Damsté alone is on the lookout for 7 scientists. 'A huge expansion in our scientific staffing. And they are not easy to find. For many of them, Texel seems like the end of the world.' Sinninghe Damsté can offer candidates a high level of independence. 'I won't be telling them what to do. The NIOZ mission is to perform excellent marine research. To achieve that, you need to give people loose reins in satisfying their curiosity.'

Marine Microbiology & Biogeochemistry came into being when two departments, Marine Organic Biogeochemistry and Biological Oceanography, merged with the task force for Marine Microbiology. Biologists, chemists and earth scientists cooperate closely in the new department. 'It's true to say that microbiologists are becoming more and more important. Just think of their role in the purification of waste water, the production of food and in medicine.' The new NIOZ department is particularly interested in the water column processes. 'We understand processes at the ocean surface quite well. But much of what goes on in the deep, remains a mystery.'

Sinninghe Damsté and his associates are also heavily involved in reconstructing past climates. They do so by studying archaea, micro-organisms that adapt the chemical structure of their cellular membranes to the ambient water temperatures. These chemicals can be well preserved in deeper lying strata, and so offer strong indications of ocean temperatures, going back millions of years to pre-human times.

Other researchers study the occurrence of various microorganisms in the ocean and try to establish what they actually 'do'. Here, the departmental head sees many benefits in the liaison with the University of Utrecht and using their high-throughput DNA sequencing facilities. 'In analysing the genetic material of microorganisms, huge amounts of data are involved. Making sense of it all is too big a job for us alone, but together with bioinformaticians at Utrecht University we can make rapid progress. It's a kind of research that we expect to stimulate in years to come. Otherwise, we could find ourselves lagging behind what is happening elsewhere in the world. So it's time to roll up our sleeves. Our chances of success will depend on the degree to which we manage to attract the right scientists: those with an excellent pedigree and innovative ideas.'

Supplier to science, and department of promise

National Marine Research Facilities (NMF) is the name of a brand new NIOZ department that incorporates an instrument factory, workshop, electronics section, coordination function for data management and shipping. Her mission: to support NIOZ scientists - and possibly others - in doing their job.

Departmental head Thomas de Greef cuts an optimistic and ambitious picture. A former sea-going captain and entrepreneur running a network of his own self-built logistic centres, he sold up five years ago and joined NIOZ, taking charge of shipping and logistics. Since then, the job has grown considerably. 'I am responsible for everything that takes to the sea, including maintenance and management', he summarises. And that means: a department full of promise. 'We are suppliers to science. Our growth depends on science. And I expect the field to widen. We have worked in our current format since January 1st. And already, we can witness increasing demand, from institutes and universities. That's why we selected the name we currently use. Our image should convey a role of national importance.'

Thomas de Greef

NMF employs 45 associates that can be intelligently deployed in their new context. 'In the past, we were in trouble as soon as the ships stayed ashore. Now, we can utilise capacities efficiently, in maintenance for example.'

The fleet consists of three vessels: the compact Stern, designed for research in the Western Wadden Sea; the Navicula for all Dutch coastal waters, and the flagship Pelagia that is at home on all the world's oceans. Pelagia in particular is in high demand, spending seven months per year on NIOZ-related research voyages, and four months on charter to foreign research teams. 'In turn, our researchers may be found on the ships of our European sister organisations. There is a voyage exchange programme called Ocean Facilities Exchange Group, where facilities are traded, without financial adjustments wherever that is feasible.' In a more commercial vein, Pelagia may spend a couple of weeks per year working for international maritime businesses.

To improve service levels and increase efficiency, NIOZ recently entered into an agreement with the national shipping agency that operates some 150 vessels. 'We agreed to utilise each other's craft and to share data. The result is improved coordination of activities.'

The home port on Texel was refurbished last year. 'We added length, height and width to the quay and built new bridges, pontoons and scaffolds. The fifty-year old port is now ready for at least another fifty.'

NIOZ is proud of her in-house instrument workshop. 'We manufacture hi-tech equipment, e.g measuring tools that are accurate to 1/100th of a degree even at great depth.' Such equipment is in great demand. 'We recently supplied high-pressure samplers to India, for measuring micro-organism activities on the ocean floor. Our ultra-clean pristine water scoops are attracting interest in South Korea.'

NIOZ looks after NWO's national pool of ocean-going equipment available for research purposes. 'Not a huge number of pieces, but some very intricate and valuable machinery.' An interesting case is that of an advanced data logger designed by NIOZ. 'The first deliveries cost something around 150,000 euro's. Now we can make them for 5 or 6 grand. That opens up new avenues of use, and possibly even commercial exploitation.'

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

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The annual report can be ordered free of charge from the library of NIOZ Royal Netherlands Institute for Sea Research. It is also available at the NIOZ website www.nioz.nl/annual-report

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NIOZ

AR 2015

As the national oceanographic institute, NWO-NIOZ Royal Netherlands Institute for Sea Research performs academically excellent multidisciplinary research, both fundamental and frontier applied. In so doing, important scientific and societal questions regarding the functioning of oceans and seas are addressed. In addition, NIOZ serves as national marine research facilitator for the scientific community in the Netherlands. Also, NIOZ stimulates and supports multidisciplinary marine research programmes (both fundamental and frontier applied), as well as serving education and marine policy development in both national and international contexts.