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EDITOR'S NOTE

SCIENCE ALL AROUND US

This final issue of Quest for 2017 takes us on a science trip around our world. Starting at sea, we take a look at how the new *SA Agulhas II* is contributing to educating postgraduate students and inspiring another generation of ocean scientists. The SEAmester programme takes students from across South Africa and offers a unique experience aboard this national facility. But the *SA Agulhas II* is not only there for educational programmes. Local and international scientists use this world-class facility to carry out research projects, one of which is examining exactly what happens to the literally tons of plastics that are produced each year. A frighteningly large amount of this plastic waste lands up in our seas, polluting the oceans and damaging marine life. The ocean itself is also the subject of much research, particularly in the face of climate change, warming seas and resultant changing ocean currents and scientists working from *SA Agulhas II* are making major contributions to our knowledge about these systems.

Quantum physics is the science of the incredibly small and understanding the physics behind the random motion of tiny particles is leading to advances in many fields, from an insight into the process of photosynthesis, to quantum computing.

And now to the unimaginably large and long ago – deep space and deep time. The Hubble Space Telescope has been quietly sending back images for some decades now and this issue of *Quest* features some of the more spectacular images – not just pretty pictures – but vital to our understanding of the evolution of the Universe and all that is present in it – literally looking back in time.

Science provides us with an explanation of the unknown, gives meaning to the world around us and offers a counter to myth and superstition. Enjoy your reading.

Bridget Farham
Editor – QUEST:
Science for South Africa

ON THE COVER SEAMESTER

A plague of plastics

A sample of diverse plankton life from the bongo net occasionally includes a piece of micro plastic – the bright green shard in the background. *Morgan Trimble*

What happens to the tons of plastic we produce each year? Research during SEAmester 2017 gives us some idea and it isn't pretty. By Morgan Trimble with contributions from Katherine Hutchinson.

A crane hoists a small, buoyed net from the deck of the *SA Agulhas II* research vessel and lowers it to the ocean at starboard. The net bobs at the ocean surface as the ship slowly steams ahead. Seawater filters through the fine mesh, but the net captures anything bigger than a quarter of a millimeter. After fifteen minutes, the ship's crew hoist the net back on board. Vonica Perold, SEAmester 2017 lecturer and researcher working with Prof. Peter Ryan at the University of Cape Town, stands by to examine the catch. But this net isn't for fishing, it's for sampling plastics afloat at sea.

A GROWING PROBLEM

Humanity produces 300 million tons of plastic each year – that's 40 kg of plastic for each of the 7.4 billion people on Earth. Mass production of plastics took off in the 1940s and 50s, and society loved the material. Plastic is cheap, durable, and lightweight. But these very properties make plastic a disaster for the environment. In nature, plastic doesn't break down easily because of the chemical bonds that give plastic its strength.

The microbes that decompose your banana peels and newspapers won't touch plastic. Chucked out after a single use, everyday items like plastic bags and drink bottles will linger for hundreds

Students working on SEAmester II conduct an assignment on microplastics. The goal was to sample plastic in sand from Muizenberg beach. The students add water to the sand, stir vigorously, then allow the sample to settle. Plastic particles mixed in with the sand float to the surface of the water, where they can be collected and further analysed. *Morgan Trimble* to thousands of years. Today, besides the enormous annual production of new plastics, we're struggling with the mass of more than half a century of trash. The plastic problem is growing.

When the crew aboard the *SA Agulhas II* hoist the plastic-sampling net back on deck, Vonica takes the sample back to the ship's onboard lab for a preliminary look. Students and other scientists crowd around for a peek at the catch. They gasp in amazement and disgust. Here, in the middle of the South Atlantic Ocean, more than 1 000 km from Cape Town in a seemingly pristine ocean wilderness, a net dipped briefly in the surface waters has scooped up a palm full of plastic fragments.

PLASTIC AT SEA

Each year, 5 - 12 million tons of plastic enters the oceans. Some are bigger pieces – plastic sheets, buckets, buoys, and fishing equipment. Much is consumer waste – bottles, bags, takeout containers, straws – that finds a way into rivers and stormwater runoff and eventually flows to sea. A surprising amount comes from microscopic by-products of modern life – plastic microfibres that wash out of synthetic fabrics like fleece jackets and nylon athletic wear and the 'microbeads' that have become popular additives in cosmetics.

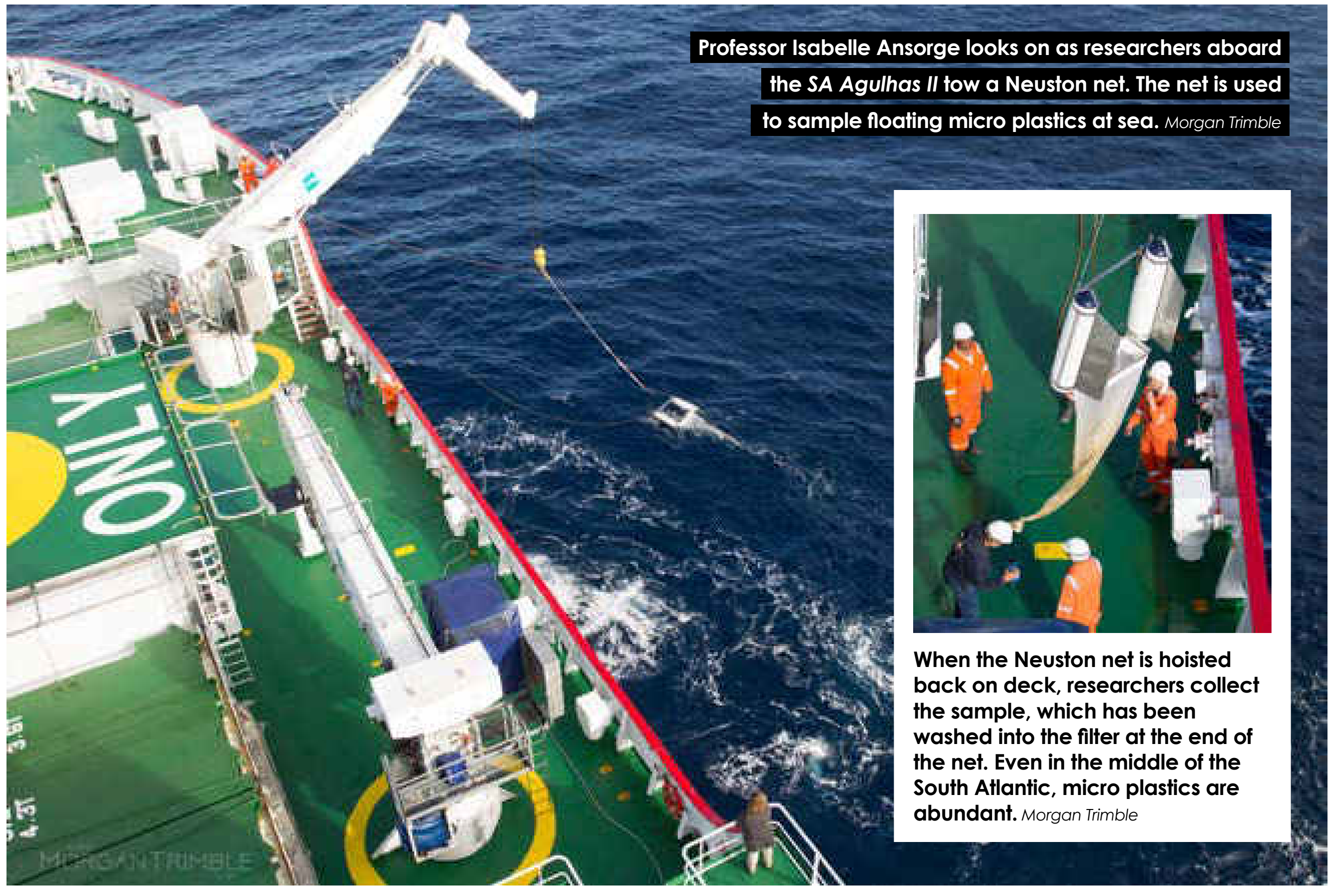
Plastic rubbish is, of course, an eyesore, but the problem is much more significant than aesthetics. At sea, plastic becomes an accidental snack for marine animals, from the tiniest plankton to the largest whales, and all the fish, turtles, seabirds, and marine mammals in between. Many mistake plastic for food – a floating bag looks like a tasty jellyfish to a sea turtle – but filter feeders who scoop up huge mouthfuls of seawater to collect miniature morsels of food can't avoid plastic bycatch.

Plastic kills marine animals in a variety of ways, from entanglement to clogged-up digestive tracts, but less visible and more terrifying is plastic's toxicity. Besides the potentially dangerous chemicals in the plastic itself, plastic in the sea acts like a magnet for other toxins, which can amplify in the food chain. Tiny fish eat plastic particles and absorb the toxins, bigger fish eat many tiny fish and absorb many toxins, even bigger fish eat those fish, absorbing even more toxins, and eventually, a fisherman might catch that big fish and serve it to his family.

In recent years, we've become aware of huge garbage patches at sea. The most famous is in the North Pacific, but given the dynamics of the ocean, garbage patches form in each of the large-scale swirling systems of currents called gyres. These gyres trap floating debris. These garbage patches are often described as plastic islands, but they're more like plastic soup. Under harsh conditions at sea, exposed to the sun and waves, bigger pieces of plastic become brittle and break up into smaller and smaller pieces. From satellite images or aerial flyovers or even from the deck of the *SA Agulhas II*, it's hard to see the full scale of the plastic problem.

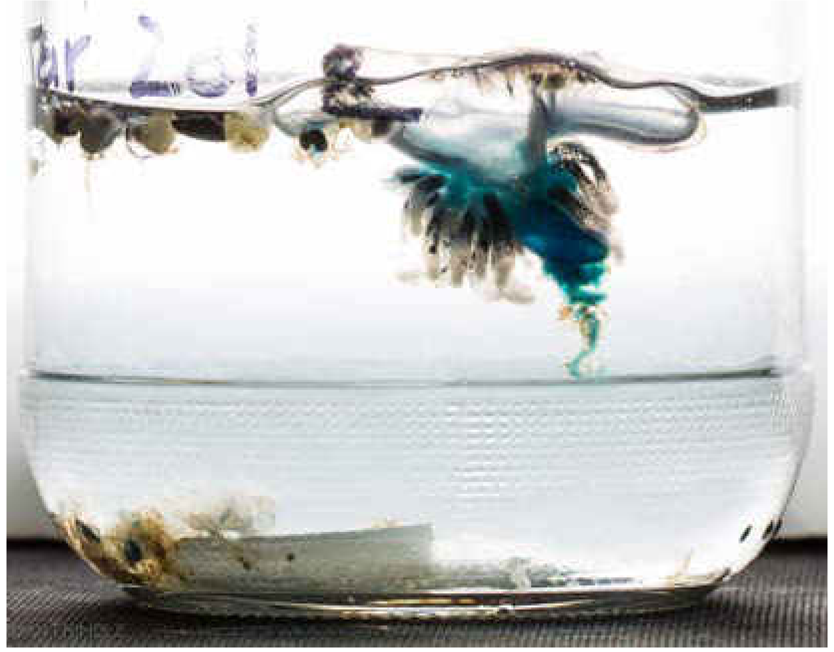
SOLVING THE PLASTIC PROBLEM

This is where the standardised sampling protocols like the net tows aboard the *SA Agulhas II* are important. As humanity grapples with the plastic problem, we still don't fully understand it. For example, although 5 - 12 million tonnes of plastic waste ends up in the sea each year, studies from around the world (similar to the plastic sampling done on board the *SA Agulhas II*) suggest that only 250 000 tonnes of plastic is



Professor Isabelle Ansorge looks on as researchers aboard the *SA Agulhas II* tow a Neuston net. The net is used to sample floating micro plastics at sea. *Morgan Trimble*

When the Neuston net is hoisted back on deck, researchers collect the sample, which has been washed into the filter at the end of the net. Even in the middle of the South Atlantic, micro plastics are abundant. *Morgan Trimble*



A sample from the Neuston net tow includes organic life like a bluebottle, but also microplastics. The plastic beads floating to the left of the bluebottle are known as mermaid's tears or nurdles – factories melt them to cast plastic products, but some spill into the sea during shipping or improper handling. *Morgan Trimble*

floating on the ocean surface. Where is the rest? Floating somewhere below the surface? On the sea floor? In organisms? Only further research will tell.

In the meantime, all who witnessed the disturbing amount of plastic pulled from the middle of nowhere in the South Atlantic were inspired to think about solutions to the plastic plague (and hopefully everyone who reads this article will be too). While the global-scale problem is mindboggling, on a personal level, there are many ways to help.

South Africa ranks 11th worst among 192 coastal nations for mismanaged plastic waste, which might end up in the ocean. Once plastic at sea breaks into tiny fragments, it becomes impossible to clean up, so the solution is to prevent plastic from getting there in the first place. We need to use less plastic and dispose of it responsibly. How can you help? Avoid products with microbeads. Reject single-use plastics like straws, plastic bags, and unnecessary packaging. Buy in bulk instead of individually wrapped portions. Chose reusable products wherever possible – think reusable mugs, drink bottles, and shopping bags. Dispose of rubbish appropriately. Recycle. Join a clean-up effort in your neighbourhood or at your local beach, and pick up litter before it washes or blows into the ocean. Finally, tell a friend; help spread the word.

SEAmester is funded by the Department of Science and Technology. The Department of Environmental Affairs provides access to the *SA Agulhas II.*

Dr Morgan Trimble is an ecologist and science writer and lectured scientific communication aboard this year's SEAmester voyage. Katherine Hutchinson, PhD student at UCT affiliated with the South African Environmental Observations Network (SAEON), helped report this article and lectured ocean dynamics on SEAmester.

UCT researcher Vonica Perold pulls a bucket full of seawater to the deck of the *SA Agulhas II*. She later filters the sample to look for microfibers—tiny plastic threads that wash out of synthetic textiles and end up in the sea. *Morgan Trimble*

LANGUAGE TRANSLATION

A plague of plastics - inkinga kaplastiki

The microbes that decompose your banana peels and newspapers won't touch plastic. Chucked out after a single use, everyday items like plastic bags and drink bottles will linger for hundreds to thousands of years. Today, besides the enormous annual production of new plastics, we're struggling with the mass of more than half a century of trash. The plastic problem is growing – every year, 5 to 12 million tons of plastic enters the oceans. While the global-scale problem is mindboggling, on a personal level, there are many ways that you can help.

► Amagciwane enza ukuthi amakhasi kabhanana nephephandaba kubole, kodwa angeke kuwubolise uplastiki,uma usulahliwe emva kokusetshenziswa kanye nje. Izinto zikaplastiki ezifana nezikhwama nomabhodlela okuphuza zizohlala zingashabalali emva kokulahlwa iminyaka engaba izinkulugwane. kulezinsiku, ngaphandle kokukhiqizwa kwamaplastiki amasha amaningi,sibhekene nenkinga yemfucuza yeminyaka engaphezuldlwana kweminyaka engamashumi amahlanu. Inkinga kaplastiki iyakhula njalo ngonyaka, amathani angamamillion amahlanu (5) kuya kwayishumi nambili (12) kaplastiki angena olwandle. Kuyawuhlukumeza umqondo ukucabanga ngobukhulu balenkinga umhlaba wonke. Umuntu ngamunye zikhona izindlela angazisebenzisa ukusiza ukuxazulula lenkinga.

CURRICULUM CORNER

GEOGRAPHY GRADE 7
Natural resources and conservation

LIFE SCIENCES GRADE 10-12
Human impact and the environment

SEAMESTER SOUTH AFRICA'S UNIVERSITY AFLOAT

Now in its second year, the SEAmester postgraduate education programme inspires another generation of ocean scientists. By Morgan Trimble with contributions from Katherine Hutchinson.

Students look out over Cape Town from the helicopter deck of the *SA Agulhas II* as it departs for SEAmester II. *Morgan Trimble*

A turn of the microscope's focus knob snaps the backlit picture into clarity. Dancing and shimmying through drops of seawater, an unexplored world springs to life. Many of the organisms are completely transparent, but occasional flashes of orange, turquoise, and pink draw attention to the gaudier individuals. Some keep still, trying to evade detection as predators of the plankton world hunt their prey under my gaze. It's a galaxy in a petri dish.

The ocean's universe of creatures is an alien world to the SEAmester students and me, but it's familiar territory for Dr Paula Pattrick and Dr Eleonora Puccinelli, lecturers aboard SEAmester. Exotic names roll off the marine biologists' tongues and land in enthusiastic student ears. Pattrick and Puccinelli point out isopods, salps, copepods, amphipods, pteropods, forams and more. We find miniature versions of familiar creatures, the larval stages of squids, eels, fish, crabs, and lobsters. I can't believe the diversity of life hiding in a sample of sea water.

What we're looking at is plankton—the collective group of organisms that float in sea water, drifting with the currents with little ability to choose their course. In both description and diversity, this little bowl of plankton is a good analogy for SEAmester, a gathering of students and lecturers from incredibly diverse backgrounds and disciplines brought together aboard the *SA Agulhas II* research vessel. For 11 days, we go with the flow, bound to the ship's trajectory, with the singular goal of learning as much as possible about our oceans.

Students working on SEAmester II scan the horizon for whales. Finn, humpback and sei whales were among the marine mammals spotted during the cruise. *Morgan Trimble*

Students look out over Cape Town from the deck of the *SA Agulhas II* as it departs for SEAmester II. *Morgan Trimble*

THE SEAMESTER PROGRAMME

This year marks the second annual SEAmester cruise, building on the inaugural 2016 voyage's success. SEAmester is the brainchild of Prof. Isabelle Ansorge, Head of the Oceanography Department at the University of Cape Town.

'SEAmester was something I first thought about four years ago,' says Prof. Ansorge, explaining that while students at the University of Cape Town (UCT) tend to get opportunities to go to sea aboard the *SA Agulhas II* through various research programmes, students at other institutions are often not so lucky. 'There are plenty of students studying oceans or earth sciences, whether they're in Pretoria or Bloemfontein or KwaZulu-Natal, that have no chance to go to sea, particularly on this vessel, unless they're attached to the South African National Antarctic Programme. But the *SA Agulhas II* is a national facility. It's world class. It's probably one of the best research vessels in the world.'

Prof. Ansorge's solution was to create SEAmester as an educational programme for postgraduate students. The idea was to combine the programme with research cruises that the *SA Agulhas II* would be undertaking anyway. While a given oceanographic cruise might involve just 20 scientists, the ship has space for about 100 passengers. Prof. Ansorge saw those extra berths as an opportunity to provide first-hand experience at sea for students eager to learn.

'We put out an open call to all the postgraduate students at all the universities to apply for SEAmester,' explains Prof. Ansorge. 'We're providing access to this research vessel and the research we do to previously disadvantaged universities, to universities and technical institutes that have no traditional connection to the Southern Ocean, that have no traditional connection to the *SA Agulhas II*.' Without SEAmester, it would be challenging for these students to get experience on the ship. SEAmester requires a great deal of logistical and scientific planning, and for this Tahlia Henry, a former Cape Peninsula University of Technology (CPUT) student and current UCT/Nelson Mandela Metropolitan University (NMU) MSc student, is the lead coordinator.

The educational programme on SEAmester is intense. Students from diverse backgrounds join a comprehensive lecture programme, complete with practical components and mini research projects. All students enjoy learning the basics of oceanography and ocean dynamics, but they choose one of two focus areas: Oceans in a Changing Climate or Tools of the Trade. The former centres on marine biology, nutrient cycles, and human impacts on the oceans while the latter focuses on physical oceanography, the equipment and techniques oceanographers use and the instrumentation aboard the ship.

SEAmester also features more relaxed evening lectures about general-interest topics. Aboard this year's cruise, Prof. Pierre Cilliers from the South African

Students pose for a photo while on an engine tour of the *SA Agulhas II* where state-of-the-art equipment keeps the amazing ship on course. *Morgan Trimble*

Professor Ken Findlay explains distance sampling, a technique to estimate abundance of marine mammals like whales and dolphins. *Morgan Trimble*

National Space Agency lectured on the aurora phenomenon and the effect of space weather, like solar flares, on our technology. I presented tips for communicating science. Dr Greg Hofmeyr from the Port Elizabeth Museum and Prof. David Walker, lecturer at CPUT, spoke about their experiences in the South African Antarctic research programme. Prof. Ken Findlay of CPUT explained our ocean economy. Several students also took the opportunity to share their own projects from their home institutions.

RESEARCH AT SEA

Because SEAmester takes place during a research cruise, students also get to learn about, and help with, the research programme on board. In 2016, the SEAmester cruise coincided with a trip to the ocean region of offshore Port Elizabeth to service the Agulhas System Current Array (ASCA) that measures the speed and direction of the Agulhas Current. The array consists of a series of moorings – instruments strung along a line extending up through the water column from an anchor at the sea floor.

This year, we sail west out of Cape Town to the Prime Meridian at 0° of longitude to service a set of instruments that measure currents and temperature in the South Atlantic. This collection of instruments is called SAMBA, the South Atlantic Meridional Overturning Circulation Basin-wide Array. Its purpose is to monitor changes in the important ocean conveyor belt that regulates our climate.

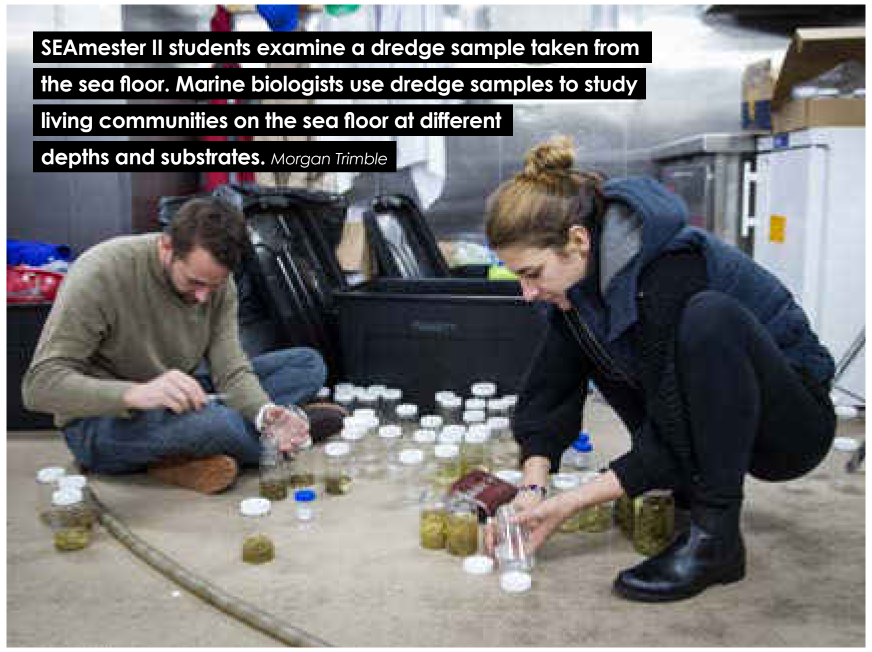
In addition to the work on the SAMBA array and traditional oceanographic profiling, SEAmester lecturers and scientists conduct research on a wide variety of topics including microbiology, plastic pollution, meteorology, plankton communities, nutrient levels, and atmospheric particles. Marine mammal and bird observers joined SEAmester to record sightings of whales and dolphins, and oceanic birds such as albatrosses, petrels, and shearwaters. Given the expense of surveying at sea and the threats to ocean wildlife, all research cruises are an opportunity to collect invaluable data. With the quantity and diversity of research work going on around the clock, SEAmester students never have a dull moment.

THE *SA AGULHAS II*

SEAmester lecturer Prof. Rosemary Dorrington from Rhodes University surveyed the microbial communities of the South Atlantic during the 2017 cruise. Her thoughts on the research vessel mirror many of the other scientists' opinions: 'The SA *Agulhas* II is the most awesome, cutting-edge research vessel on the planet. It's a huge privilege to be on the ship. She's got fantastic research laboratories, a crew that are specialised – the best trained for what they do, and a captain that is here to support the research. It's no wonder we're doing world-class research.'

The five-year-old *SA Agulhas II's* research facilities are excellent, but so too is the rest of the ship. Passengers sleep in comfortable cabins and enjoy access to a gym, sauna, library, business centre, dining hall, lounges, table tennis, and plenty of deck space to appreciate the ocean views. The ship is a research laboratory and a hotel rolled into one. From top to bottom, the ship is equivalent in height to a 15-storey building, and it's longer than a rugby field.

Early in the cruise, Prof. Ansorge explains to the students that being confined to the ship is one of the greatest benefits of SEAmester. Students have full access to the scientists and lecturers on board to get to know them in a friendly environment, network, ask advice on their current projects and future studies, and potentially even connect with a future supervisor or collaborator.



SEAmester II students examine a dredge sample taken from the sea floor. Marine biologists use dredge samples to study living communities on the sea floor at different depths and substrates. *Morgan Trimble*

A student examines a type of hermit crab found in a dredge sample from the sea floor. *Morgan Trimble*

A planktonic creature seen under magnification. Marine biologists used bongo net tows to sample plankton near the ocean surface. *Morgan Trimble*

While still above the continental shelf, Cape fur seals were a frequent sighting alongside the *SA Agulhas II*. *Morgan Trimble*

WHY STUDY OUR OCEANS?

Peering through the microscope at the life squeezed inside a single drop of seawater is awe-inspiring. But discovery for discovery's sake is not the only reason to study our oceans. Each of us, even those who have never been to the sea, depends on the oceans every day.

The oceans cover two-thirds of the planet, and they control our climate and weather. They absorb most of the energy from the sunlight that hits Earth. Oceans are by far our biggest storage space for carbon. The ocean's own version of oxygen-creating forests – photosynthesising phytoplankton – produce half of the oxygen we breathe. Furthermore, nearly a fifth of the animal protein humans eat comes from the sea.

With South Africa's extensive coastline, our oceans also provide important economic opportunities, from fisheries to shipping to tourism. One of the three projects in the government's programme to fast-track their national development plan, Operation Phakisa (which means 'hurry up' in Sesotho), focuses on the ocean's economy. It seeks to create 1 million jobs and contribute R177 billion to the gross domestic product by 2033. Such rapid development calls for a new generation of ocean scientists to keep track of the health of the system and the sustainable use of its resources. SEAmester aims to fill this gap by inspiring young researchers to pursue careers in marine science.

Marc de Vos, who was on board the 2017 cruise to lecture meteorology and perform observations for the South African Weather Services, says, 'Natural sciences have such an impact on people's lives worldwide, yet they're not always front of mind when people think about what to study. SEAmester provides a condensed look into the world of natural science as it happens day to day. To have so many professionals from so many broad avenues of natural science, in one place at one time, all doing their thing for the students and teaching them around the clock is really special.'

The selection process for SEAmester students is highly competitive. This year, just one student was accepted for every six that applied. But students who were unable to attend this year will get another opportunity – plans for the 2018 SEAmester voyage are already underway. Prof. Ansorge says, 'We're looking for quality, motivated students who want to learn everything that is available on board. The students who attended the past two SEAmester courses can be proud of themselves to have been selected.'

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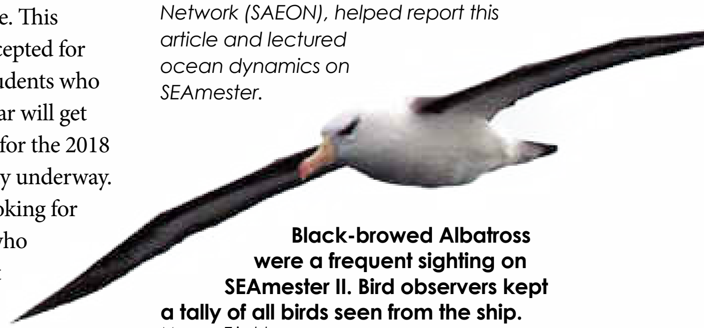
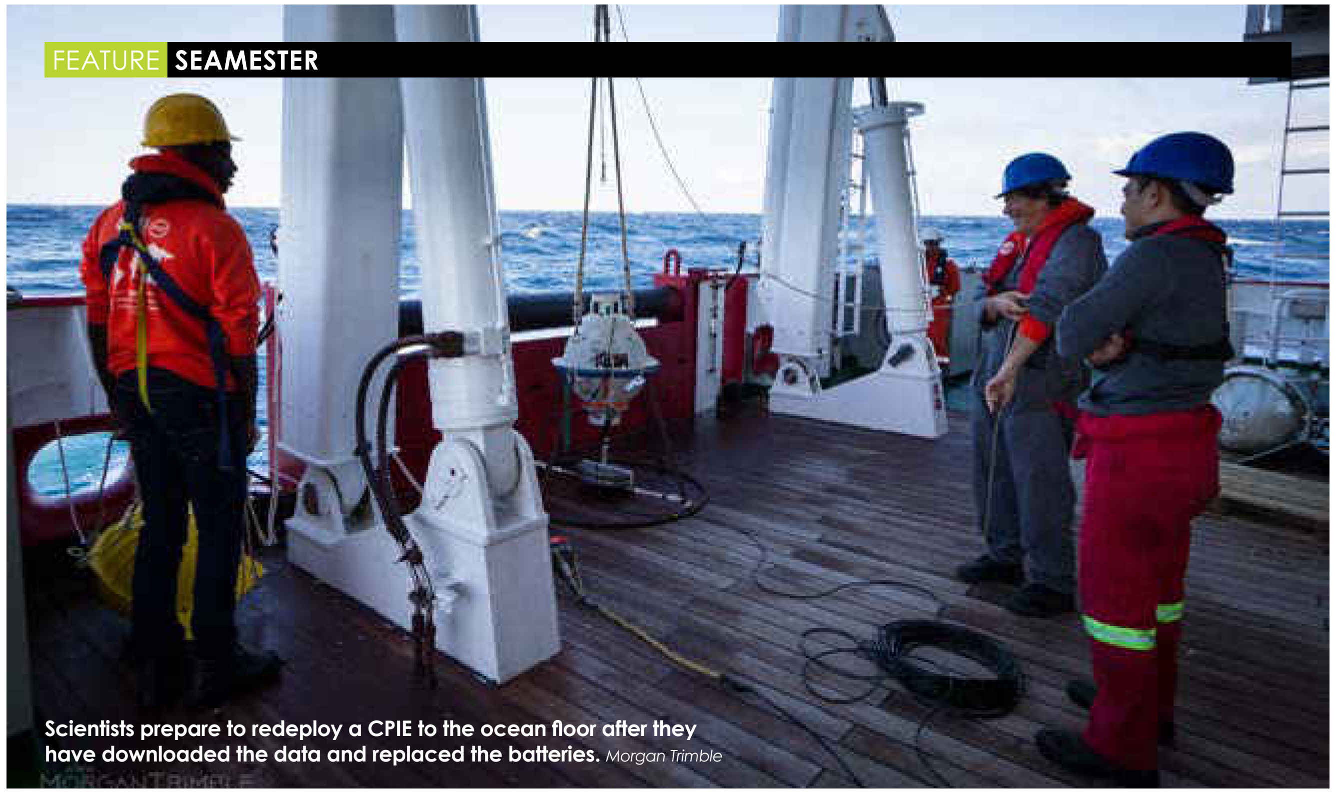


Black-browed Albatross were a frequent sighting on SEAmester II. Bird observers kept a tally of all birds seen from the ship. *Morgan Trimble*

UCT post-doc Eleonora Puccinelli leads SEAmester students in sorting and cataloging dredge samples taken on a previous SA Agulhas II research voyage to Marion Island. *Morgan Trimble*



Scientists prepare to redeploy a CPIE to the ocean floor after they have downloaded the data and replaced the batteries. *Morgan Trimble*

SCIENCE AT SEA

From the air we breathe to the food we eat and the climate we experience, oceans play a major role in defining life on Earth. Here's a taste of what we learned during SEAmester 2017. By Morgan Trimble with contributions from Katherine Hutchinson.

DOING THE SAMBA FOR OCEAN DYNAMICS

If you could label a drop of water in the middle of the ocean and come back later to check on it, where would you find that drop in a week? A month? A year? A thousand years? The dynamics of water in the oceans are critical for controlling Earth's weather and climate and crucial to sea life. Understandably, oceanographers put a lot of effort into understanding ocean dynamics.

Intuitively, we know the oceans' surface waters aren't static. Throw a message in a bottle into the sea off the coast of South Africa, and there's a chance it will wash up on the shores of Brazil in less than a year (as proved by a student on SEAmester 2016, when a Brazilian man found and replied to a message she dispatched into the Agulhas Current). Ocean currents aren't limited to the surface layers. Deep water moves too. Ocean waters are constantly in motion, driven by the physics of energy reaching us from the sun and interrelated factors like wind, freshwater inputs from rain and rivers, gravity, and the influence of our spinning planet.

THE OCEAN CONVEYOR BELT

Although the physics is complicated, the notion is relatively simple – scientists use a giant conveyor belt as an analogy

Researchers aboard the *SA Agulhas II* send an acoustic signal to release the ADCP from the sea floor. Once sighted, the ship's crew will hook and haul up the instrument so scientists can download the data and redeploy it. *Morgan Trimble*

The ADCP surfaces amid Cape fur seals and seabirds. *Morgan Trimble*

to visualise how water moves within and between our interconnected ocean basins.

Let's start in the North Atlantic. Here frigid, polar surface waters become extra salty because of the combined effect of wind-driven evaporation and the salt rejection that takes place as sea ice forms. This cold, saline water is dense, and thus heavy. It sinks rapidly, like a waterfall, to the bottom of the Atlantic. More sinking water pushes it from behind, so it flows along the sea floor southwards, towards Antarctica. When the water gets to the Southern Ocean, it meets the Antarctic Circumpolar Current, which carries it eastwards to the Indian and Pacific Ocean basins.

In these basins, the deep water slowly warms, becomes less dense and eventually rises upwards towards the sea surface. Surface water, in turn, needs to balance the huge volume of water sinking in the North Atlantic. So, surface water from the Indian Ocean moves southwest around South Africa – the famous Agulhas Current – and eventually heads north to the North Atlantic to start the cycle once more.

The Atlantic is the only basin that links the two poles. The shallow Bering Strait limits circulation between the Pacific Ocean and the Arctic, and the Asian land mass closes off the Indian basin in the north. Therefore, the north–south (meridional) exchange of water that takes place in the Atlantic is critical for global ocean circulation. This meridional overturning is of great interest to scientists.

MONITORING THE MERIDIONAL OVERTURNING CIRCULATION IN THE ATLANTIC

The ocean conveyor belt represents a delicate balance. Scientists are concerned that subtle changes in temperature or melting polar ice could disrupt ocean dynamics as we know them, with potentially disastrous consequences for life on land. Western Europe, for example, could freeze over without the influence of the warm tropical surface waters that flow towards the North Atlantic.

To monitor the Atlantic section of the meridional overturning circulation in detail, an international team of researchers have deployed two lines of instruments. In the north, scientists from the UK and USA installed sensors along the 26.5°N line of latitude and called it the RAPID array. In the south, South Africa is working with other nations to install and maintain a line of monitoring instruments at 34.5°S. This line is called SAMBA – South Atlantic Meridional Overturning Current Basin-wide Array.

These CPIEs – current-sensing pressure-equipped inverted echo-sounders — have been collecting data on current velocity and ocean temperature along the SAMBA line for four years. This information helps researchers understand how water moves in the Atlantic and whether climate change is affecting the process. Scientists aboard the *SA Agulhas II* collected the data and serviced the instruments, which they subsequently redeployed to the ocean floor. *Morgan Trimble*

SERVICING THE SAMBA LINE

The 2017 SEAmester voyage, an 11-day floating university for ocean sciences, coincided with a research cruise aboard the *SA Agulhas II* to service the instruments along the eastern section of the SAMBA line.

The eastern section consists of seven CPIES – current-sensing pressure-equipped inverted echo-sounders – moored to the sea floor. These capsules have multiple sensors to measure different physical aspects of the ocean. A current sensor measures current speed and direction just above the sea floor. A pressure sensor calculates how deep the ocean is. The inverted echo-sounder sends an acoustic signal up to the surface and waits for the echo that bounces off the interface between the surface of the ocean and the air. The time it takes for the echo to return is an indication of the average temperature of the water column, because sound moves faster through warmer water.

The array also features two bottom-moored ADCPs – acoustic Doppler current profilers. These instruments send sound signals too, but they measure both the time it takes for the echo to return, an indication of distance travelled, and the frequency shift of the echo, which indicates current speed and direction based on the Doppler effect. To measure current velocity at various depths, the ADCPs send 'pings' and listen for echoes that bounce off particles throughout the water column.

The CPIES and ADCPs of the eastern SAMBA line were installed in 2013, and ever since, they have been collecting

Thierry Terre, a research collaborator on SAMBA from Laboratoire de Physique des Océans, in France, joined SEAmester II to work with the instruments. *Morgan Trimble*

The *SA Agulhas II*'s crew has successfully hauled in a CPIE that has been collecting data at the sea floor for four years. *Morgan Trimble*

Students aboard *SA Agulhas II* throw a message-in-a-bottle into the South Atlantic. This activity is a mini experiment to test surface currents. A student on SEAmester I was eventually contacted by a man in Brazil, who found her message-in-a-bottle nine months after she threw it into the Agulhas Current. *Morgan Trimble*

data, pinging the water column and recording its temperature and the velocities of its currents. The data are stored in the devices, patiently waiting for scientists to call the devices back to the surface and download this precious information. Our job on the SEAmester 2017 cruise was to do just this.

The first step in recovering an instrument is to navigate to its known coordinates. Then, to call the devices to the surface, scientists use a hydrophone – a specialised underwater speaker that transmits a unique code embedded in sound waves. When the CPIES and ADCPs hear their special instructions, they send an electric current through a wire attaching the main body of the instrument to its anchor, which holds it to the sea floor. The electric current moving through the wire exposed to salty seawater causes immediate corrosion. Within minutes, the wire breaks, releasing the instrument to float to the surface.

From the ship, observers spot the instrument, the crew uses a hook to catch and haul in the device, and the scientists set about excitedly downloading four years of data. Scientists then clean up and replace the batteries of the instruments before sending them back down to the sea floor to resume data-collection duties.

The value of the SAMBA line lies in the power of long-term observations to expose subtle environmental changes. Currently, researchers are measuring a baseline for the meridional overturning circulation and its natural variability so that they will be able to detect possible alterations in the future. The goal is to detect changes in the chemical and physical properties of the circulation and investigate how these changes are influenced by and in turn influence global climate.

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Dr Morgan Trimble is an ecologist and science writer and lectured scientific communication aboard this year's SEAmester voyage. Katherine Hutchinson, a PhD student at UCT affiliated with the South African Environmental Observations Network (SAEON), helped report this article and lectured ocean dynamics on SEAmester.

LANGUAGE TRANSLATION

Science at Sea -ubuchwepheshe obusolwandle

Throw a message in a bottle into the sea off the coast of South Africa, and there's a chance it will wash up on the shores of Brazil in less than a year! The dynamics of water in the oceans are critical for controlling Earth's weather and climate and crucial to sea life. Lines of monitoring equipment moored to the sea bed are used to monitor everything about the ocean and how it changes.

► faka umlayezo ebhodleleni, uwufake olwandle olusogwini leningizimu ne afrika, kunamathuba okuthi lingagcina seliqhamuka ogwini lase Brazil kungakapheli unyaka! Ukushintsha kwamanzi olwandle kubalulekile ukulawula isimo sezulu ezweni,kanti futhi nakukho konke okuphila olwandle. Izintambo zemishini yokuqapha ezifakwe ngaphansi kolwandle sisetshenziswa ukubheka yonke into emayelana nolwandle nokushintsha kwalo.

CURRICULUM CORNER

GEOGRAPHY GRADE 10-11
The world's oceans

LIFE SCIENCES GRADE 10-12
Human impact on the environment

QUANTUM WALKS

Bereneice Sephton, Angela Dudley and Andrew Forbes explain the importance of random motion.

Consider the path of tiny dust particles as they float in still air or the motion of those small specs of matter just visible in your glass of water. These are examples of random motion. It is an integral part of how the world operates and facilitates many of the fundamental processes that maintain the Earth, such as heat transport in materials and the transport of gases like oxygen, which are crucial to survival. It can even go so far as to describe the way animals forage and aspects of finances.

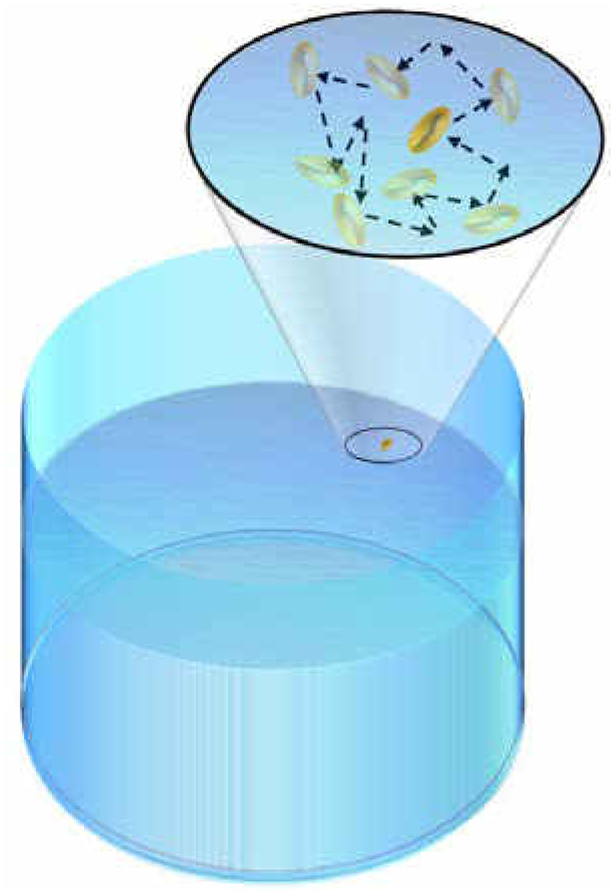

Figure 1. Robert Brown noted the stochastic, random movements of pollen floating on water, which resulted in the concept of random motion. The black arrows show the random path taken by the pollen grain where the overall path results in no net displacement.

RANDOM MOTION

So, what exactly is random motion? The answer can be dated back to 1827 when a botanist, Robert Brown, noted the movement of pollen floating on water (Fig. 1). He saw that the tiny bits of pollen moved in many random directions, but did not actually go anywhere – they had no overall displacement.

This tied in with the study of atoms and this movement was eventually shown to come from the random motion of fast-moving molecules that hit the pollen grains from all sides. However, different sides of the pollen experienced slightly greater forces than others, which resulted in the random movement of the pollen itself. Soon after this, in 1905, Einstein provided the mathematical foundation for this phenomenon, consolidating random motion as a foundation in many scientific studies today.

Understanding and being able to predict such motion lies in our ability to simulate it. However, how do you do this when the basic feature of something that is random is that there is no definable pattern and thus should not be predictable? The answer lies in the concept of the random walk.

RANDOM WALKS

Consider for a moment the idea of using the flip of a coin to make a decision. An example would be – shall I move left or right? To do this, you make each side of the coin indicate a direction, for example, heads to right and tails to left. By flipping the coin and moving in that direction, you are moving randomly. If you flip the coin again and move according to the outcome, another random movement is carried out. If you do this over and over again, you are creating random motion, or more specifically a random walk (see Figure 3(a) in Box 3). It follows that by assigning particular values to the available options and then randomly generating those assigned values, 'randomness' can be simulated by simply acting upon the randomly generated values. Associated outcomes can then be predicted.

The result of such a simulation is a Gaussian distribution (see Box 1) where the most probable outcome, and thus the option that will happen most often, is found at the starting position. This is exactly what Robert Brown noted for the pollen.

Being able to predict random motion has allowed scientists