ULTRAMARINE SPECIAL ISSUE EBOOK

DoubleHelix

Turtles in trouble

Mysterious wonky holes

SOLAR-POWERED SEA SLUG

CSIRO

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MINDEROO FOUNDATION

DIVE INTO THE *science* BENEATH OUR *oceans*

This special edition ***Double Helix*** eBook is part of ***Cosmos*** Magazine's Ultramarine project.

Ultramarine publishes the latest research, innovations and news from our ocean and marine environments for anyone aged 14 and above.

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ON THE COVER

Take a dive under the sea with the *Double Helix* Ultramarine e-book! Explore the mysteries of the wonky holes that dot the reef (page 18), and learn about the challenges that face our sea turtles (page 10). Or meet a solar-powered sea slug (page 16)! If you're more into tech, read about the undersea cables that power the internet (page 12).

We've got plenty of experiments for budding marine scientists. Study ocean currents (page 23), and discover an ancient diving reflex hidden in your brain (page 26). Plus, we've got instructions for drawing a life-sized blue whale – it's REALLY big (page 24).

ULTRAMARINE

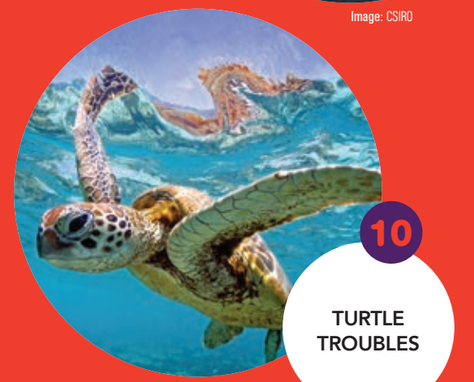
Double Helix is pleased to be part of the Ultramarine project. The project is a partnership between CSIRO's science magazine for older readers – *Cosmos* and the Mindaroo Foundation. Ultramarine is all about sharing the science of our oceans, lakes, rivers and wetlands with all kinds of people from across Australia and the world.

FEATURES

REGULARS

ACTIVITIES

Image: CSIRO



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RECORD-BREAKING BIRD!

Look up in the air. It's a bird – it's a plane – it's… actually, it IS a bird! A world-record-breaking bird.

A young bar-tailed godwit recently flew a record 13,560 kilometres from Alaska to Tasmania without stopping. The five-month-old bird took 11 days and one hour to complete the epic journey. It beat the previous record held by an adult male of the same species.

Scientists tracked the bird through a satellite tag on its back. Birds of this endangered species migrate each year from their breeding grounds in Alaska. The bar-tailed godwit headed southwest to Hawaii, continued over open ocean, and flew over the Pacific Islands before continuing between Australia's east coast and New Zealand.

"The bird would have fuelled up on worms and water bugs to prepare for the flight," says Birdlife Australia's Sean Dooley.

To survive their long-distance journey, bar-tailed godwits shrink their organs — so they can eat and store more food for energy!

– By Heather Gallagher

These small birds fly nonstop between Alaska and Australia

Image: Wikimedia/ Wayne Butterworth CC BY 4.0

Image: ©iStock.com/Sami Sert

Scientists just found a way to turn plastic into vanilla flavouring!

A SWEET SOLUTION TO POLLUTION

With less than 10 per cent of all plastic being recycled, scientists have developed a way of transforming a waste 'problem' into a deliciously sweet 'solution'.

Researchers from Scotland's University of Edinburgh have repurposed plastic waste into vanillin – the primary component of the vanilla flavour. The team used genetically engineered *E. coli* bacteria to convert terephthalic acid, which is a key chemical that can be extracted from plastic bottles, into high-quality vanillin.

It's a great new way to reduce plastic waste, but that's not the only benefit. Most artificial vanillin is made from wood or from petrochemicals. So this new method of recycling is a more environmentally friendly alternative. Imagine a world where your favourite vanilla-flavoured ice-cream, cakes and fragrances are sourced sustainably from recycled plastics!

– By Brody Hannan

SEAWEED SANITISER

Migrating humpback whales are a familiar sight along the Australian coast in winter. At this time, people sometimes see humpbacks rolling around in seaweed on the ocean's surface.

Researchers at Griffith University on the Gold Coast think the whales may be using seaweed as a sanitiser – just like we use a tube of ointment bought from the chemist! They also think that this behaviour may be more common than originally thought.

The researchers used drones to watch whale behaviour near Australia's coast. They also studied social media posts in which people described their encounters with humpback whales.

It turns out that humpback whales around the world use seaweed in a similar way. They most often rubbed the top of their rostrum (nose) with the seaweed. This behaviour may be playful, but it could also help to remove parasites and treat skin conditions, because seaweed slime has antibacterial properties.

– By Alastair Freeman and Amanda Freeman

Humpback whales use seaweed to scrub themselves clean

Image: ©iStock.com/rockwyn

This spiky egg case once held a skate fish!

Image: ©iStock.com/suriya silsaksom

AN EGG-CITING DISCOVERY

A newly observed skate nursery is helping scientists understand important habitat for Southern Ocean skates – fish that are closely related to stingrays.

Like rays, skates have flat bodies, wing-like pectoral fins, long tails and many other similarities. But they differ in how they reproduce. While other rays give birth to live young, skates lay egg cases onto the seafloor. The egg cases are rectangular, leathery, and have four horns – one on each corner.

Early last year, scientists discovered a skate nursery in the Ross Sea near Antarctica. It's only the second-known nursery in the entire Southern Ocean. Using deepwater video imaging, scientists counted 337 skate egg cases. Judging by their colour, most of the egg cases were freshly laid.

"Locating skate nurseries is critical for fisheries and conservation management," says CSIRO scientist Will White. "It gives us information on critical habitat types or areas."

These habitats need protection to make sure skates survive into the future.

– By Emily Gumina

Image: CSIRO

A CSIRO marine biologist scoops up eDNA

eDNA IS EVERYWHERE

What if a simple scoop of seawater could tell you what's living in the ocean nearby?

Like a teacher marking the roll, environmental DNA – or eDNA – allows scientists to check off a list of marine life quickly.

DNA is found in almost every cell of every living thing. It's also in lots of tiny stuff living things leave behind, such as skin cells . But how tiny is tiny? And who leaves what size particles behind?

Haylea Power, a CSIRO scientist, set out to answer these questions. Haylea's team put seawater through a series of filters, separating particles by size. The largest particles were about the thickness of a sheet of paper, and the tiniest were about ten times thinner than gold plating on jewellery.

Each filter caught very different particles from very different creatures. The experiment showed eDNA can be free pieces of DNA or even clumps of tissue. It also showed different sized filters work better for detecting different creatures, like fish versus shellfish.

"If you choose the wrong size filter, you can accidentally filter out what you are trying to find," says Haylea.

Her research will help scientists choose the right filters to find the species they're looking for.

– By Ariel Marcy

STAYING ALIVE

Somewhere below the seabed
beneath its silica-sand,
trapped in a layer of silt-mud
lives something rather grand.

We've found some sleeping microbes
that awoke when they were fed.
Bacteria so ancient,
you'd think they should be dead.

With scarce food for survival,
just hibernation's pause,
have microbes here been staying alive
since the Age of Dinosaurs?

– By Celia Berrell

These microbes might be 100 million years old!

Image: JAMSTEC

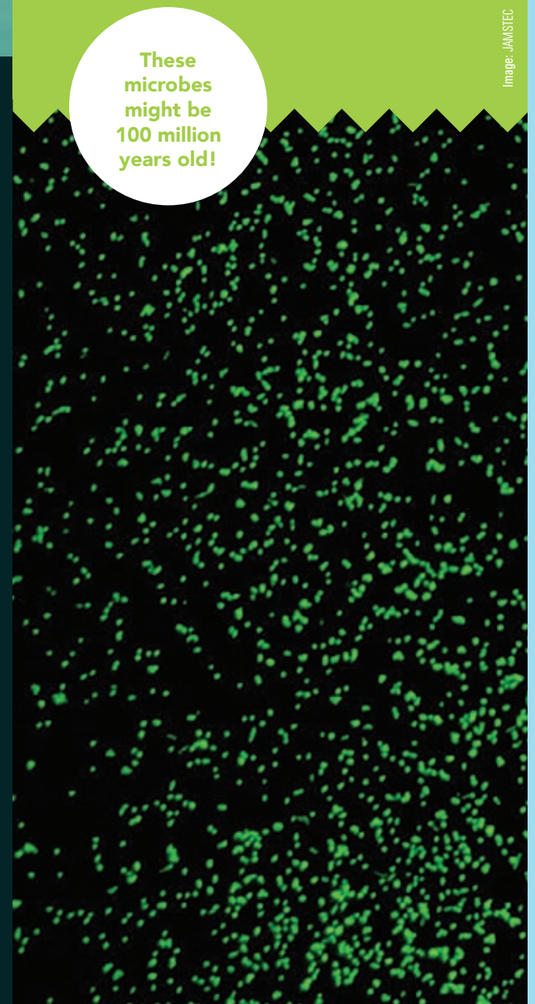


Image: Carlos Gauna/The Malibu Artist

This is the first-ever photo of a newborn great white shark (probably)

BABY SHARK!

Did you know that great white sharks give birth to live young, just like whales and people? But no one has seen a living, newborn great white…until now!

Last year, filmmaker Carlos Gauna teamed up with marine biologist Phillip Sternes to look for sharks off the coast of California. There, Carlos' drone camera picked up something exciting: an all-white shark about 1.5 metres long.

"We enlarged the images, put them in slow motion, and realised the white layer was being shed from the body as it was swimming," says Phillip.

Great white sharks are usually grey on top. But before they are born, their mothers produce a thick, milky liquid to feed them. Phillip believes that leftover layers of this milky liquid made the newborn shark look all white.

The team admits that a skin disease could also explain their sighting. But Carlos points out that no such condition has ever been reported for these sharks.

So enjoy this cute photo of the world's deadliest baby!

– By Ariel Marcy

BY THE NUMBERS: WHALE SHARKS

– By Louise Molloy

1.5

Whale sharks can have mouths this many metres wide. All the better to hoover up plankton, krill, crabs, small fish – but not humans! They are filter feeders, but…

…in their mouths are this many rows of tiny, hooked teeth.

300

20

The number of filter pads whale sharks have to separate food from water. When they sometimes 'cough', it's thought they're clearing the bits stuck in their filter pads.

The length in metres of the largest whale shark accurately measured to date. They're the largest fish living in our oceans, but they've been tricky to measure and study!

18.8

46

The number of whale sharks tagged by CSIRO researchers at Ningaloo Reef in Western Australia. The data collected showed that after visiting the reef, some swam nonstop for four weeks, at two to four kilometres per hour. Most stayed within 400 kilometres of the reef. There's still a lot we don't know about these enormous sharks.

Whale sharks are the biggest fish on Earth!

Image: ©iStock.com/indianoceanimagery

Would you ever expect this fish to sing?

Image: iNaturalist Australia/Jens SommerKnudsen CC-BY-NC 4.0

FISHY SEA SONGS

Researchers are investigating a musical mystery – which fish are singing in the ocean off Western Australia?

We might imagine the ocean as a tranquil environment. But when the sun goes down, plenty of sounds fill the water. Fish buzz, burble, squawk and pop. And when many fish do it at once, the sound can be heard kilometres away! These are called fish choruses.

The researchers wanted to find out which fish were singing what part of the chorus. First, they put underwater acoustic recorders and video cameras in the water off the coast of Bremer Bay. Next, they tried to map how the chorus changed over the seasons, when different fish were more common.

They found that in spring, the singing was likely from large groups of red snapper and deep sea perch. Further research is looking at what happens at other times of the year.

– By Jacinta Bowler

UNDERWATER HOTSPOT

Would you brave 10-metre waves to map the seafloor near Antarctica? Scientists aboard CSIRO research vessel, RV *Investigator*, did just that – and it paid off!

"To our delight, we've discovered a spectacular chain of ancient seamounts," says CSIRO geophysicist Chris Yule. "Eight long-dormant volcanoes with peaks up to 1,500 metres high!"

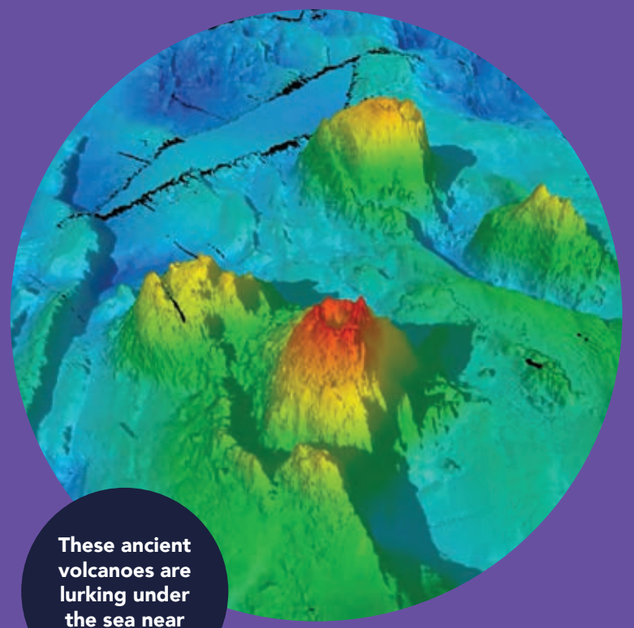
These underwater volcanoes formed around 20 million years ago, thanks to a hotspot. Hotspots are super-heated pockets of mantle – the layer of hot rock beneath Earth's rocky crust. The hot mantle in this spot melts the crust, and this melted rock then erupts to form a volcano.

Over time, Earth's crust drifts over the stationary hotspot, so different parts of the crust get melted. Eventually, this creates a chain of volcanoes.

Chris's team mapped the newly discovered chain of volcanoes using a multibeam echosounder. This cutting-edge technology uses sound waves to precisely measure underwater peaks and valleys.

The team hopes that their detailed seafloor map will help us understand ocean currents around Antarctica.

– By Ariel Marcy



These ancient volcanoes are lurking under the sea near Antarctica

Image: CSIRO

A WHALEY LONG WAY

Image: ©iStock.com/Olena Chystova

SOMETIMES THE BEST WAY TO FIGURE SOMETHING OUT IS TO GRAB A SCRAP OF PAPER AND DO A QUICK CALCULATION. SCIENTISTS CALL THESE 'BACK OF THE ENVELOPE' CALCULATIONS. GET YOUR ENVELOPE READY!

QUESTION

HOW FAR CAN A WHALE SONG TRAVEL?

ANSWER

Sperm whales are the loudest animals on the planet. They can produce clicks with the incredible intensity of about 133 kilowatts per square metre (kW/m^2). That intensity is similar to a thunderclap! But just like thunder, a whale's click will turn into a distorted rumble over long distances.

Rather than clicks, we're going to look at whale songs. Whales sing to communicate, find prey and navigate over huge distances. Humpback whale songs measure about 0.033 watts per square metre (W/m^2). This might not sound like much compared with the sperm whale click, but if the song was in air, it would be similar to a live rock concert.

Let's try to work out the distance at which one whale could hear another. It's a bit tricky to give a whale a hearing test, so we don't have much information on their hearing. But researchers think that some whales can hear volumes of just 0.000,000,000,000,033 W/m^2. This sounds ridiculously tiny, but is actually pretty similar to the limits of human hearing too.

To make a first guess at how far away a whale can be heard, we can assume that the sound travels out in all directions – forwards, backwards, left, right and even up and down. This means that at any particular time, the sound will be spread over a sphere. Over time, the sphere gets bigger and bigger, and the sound at any one point on the sphere will get weaker and weaker.

We can work out how far the sound will travel by the time it gets to the threshold of whale hearing by knowing that the intensity at the source (given at one metre from our singing whale) will be the same as the sound over the whole sphere that contains our listening whale. We can write this as:

Area of 1 m^2 sphere x humpback whale song intensity = area of final sphere x hearing threshold

$4\pi \times 1^2 \times 0.033 = 4\pi \times r^2 \times 0.000,000,000,000,033$
$0.033 = r^2 \times 0.000,000,000,000,033$
$r^2 = 0.033 \div 0.000,000,000,000,033$
$r = \sqrt{(0.033 \div 0.000,000,000,000,033)}$

Which gives us a distance of…1,000 kilometres! That actually sounds pretty believable.

To get a better answer, we could consider lots more things. First, as sound moves through water, some of the energy gets lost as heat. This would shorten the distance at which whales could be heard. On the other hand, changes in water density at the surface and near the sea floor can guide sound waves onwards.

Sound also travels at different speeds depending on the temperature of the water – very low, deep sounds travel much better than high notes. Researchers think that whales use all these tricks to communicate over thousands of kilometres. I bet they're having a whaley good chat!

TURTLE TROUBLES

By Alysha Huxley

Sea turtles have lived in the oceans for 110 million years

Image: iStock.com/Nautilus Creative

Image: iStock.com/goc

Sea turtles are at risk from plastic pollution, which we can easily see. But what about the risks we can't see?

ANCIENT OCEAN LOVERS

Sea turtles have been swimming through our oceans for the last 110 million years. They spend almost all their life in the ocean – in fact, males only ever touch land when they hatch. Female sea turtles return to land occasionally to lay their eggs during nesting season.

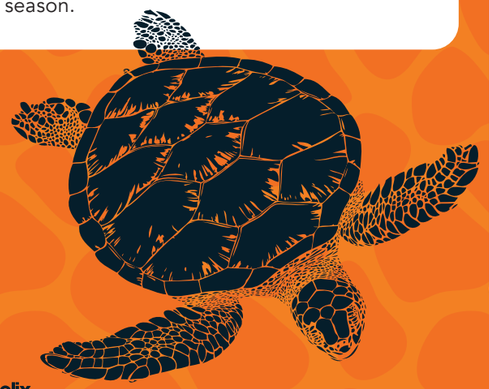


Image: ©iStock.com/mv

HOT SANDS

When a sea turtle lays her eggs, she buries them deep in the sand. This has a very important role in shaping the baby sea turtle's life, because the sand's temperature determines whether it will be male or female.

If the sand temperature is warmer, above 31 degrees Celsius, a female sea turtle will hatch. If the sand temperature is below 27.7 degrees Celsius, the sea turtle will be male. And eggs that are laid in sand between 27.7 and 31 degrees Celsius hatch a mix of both females and males.

Sand temperatures are rising due to climate change, making scientists worry that sea turtle populations may start having too many females and not enough males. This will make it hard for a female to find a mate. If female sea turtles aren't finding mates, then they are unable to lay eggs, and the population is at risk of falling.

But there may be another problem, too.

WHAT A WASTE

A team of researchers led by Arthur Barraza recently studied green sea turtles on Heron Island, off the coast of Queensland. They found that a type of pollution known as chemical contamination may also affect the biological sex of sea turtles.

Chemical contamination ends up in the ocean from human activities, such as factories, mining, run-off from farms and general household waste. Once in the ocean, the chemicals can be absorbed by plants and animals. Over time, larger animals such as sea turtles can absorb a lot of these contaminants.

Arthur explains that certain contaminants, such as heavy metals, have been found in the sea turtles at Heron Island.

"Our new research shows that contaminant metals, such as cadmium and antimony, can mimic the female sex hormone, oestrogen (EES-troh-jen)," he says. "By mimicking the hormone, this may send a false signal that the sea turtle is female."

These kinds of false hormone signals may be happening inside unhatched sea turtle eggs while they are buried in the sand.

The new research suggests that sand temperatures might not be the only factor causing more sea turtles to be female, but scientists need to do further studies to be sure.

Arthur Barraza has been studying the green sea turtles of Heron Island

Image: Dr Arthur Barraza

Heron Island is beautiful but there is still some pollution about

Image: ©iStock.com/Image Source

Image: ©iStock.com/mv

HELPING SEA TURTLES

With all seven species of sea turtles listed as vulnerable, endangered or critically endangered, they could really use our help.

We can all help sea turtles by being aware about what we put into the ocean and reducing pollution. Many ideas can also be put into action through policies (plans) from governments and organisations.

"Better policies across the world to reduce ocean pollution are essential," says Arthur.

BRIDGING CONTINENTS

THE CABLES CONNECTING OUR PLANET

BY JACINTA BOWLER

Image: flickr.com/derlandsknecht CC BY-SA 2.0

For many of us, the internet just happens – letting us do our homework or play videogames with friends. But video chatting with someone on the other side of the world requires most of the trip to be through cables, with some deep under the sea.

BIG STEEL CABLES PROTECT THE TINY OPTICAL FIBRES IN THE MIDDLE

Image: ©iStock.com/Christoph Burgstedt

THIS SHIP LAYS UNDERSEA CABLES!

CRISSCROSSING THE OCEANS

Undersea cables are hose-sized tubes that can span thousands of kilometres across the ocean. They hopscotch from coast to coast, with data flowing near the speed of light to transfer everything from a funny video to top-secret documents.

The undersea cables are a key part of connecting the internet, but the ocean can be a dangerous place. So companies invest plenty of money to try and stop them being damaged.

"The most common cause [of damage] is fishing: trawls and vessel anchors are the main threats," says Nicolò Boschetti from Cornell University. Nicolò is an expert in internet infrastructure – the physical equipment and structures that make up the internet.

Earthquakes, submarines and underwater eruptions can all destroy undersea cables.

"Sometimes, even sharks and other marine animals have been filmed biting them," Nicolò adds.

CABLE CORE

In the very middle of the cable is an optical fibre that transmits data at around 70 per cent the speed of light. Layers of steel wire and plastic protect the optical fibre from breaking. The outer layer is then surrounded by a gel to prevent water getting inside.

"If a section of cable is placed at low depths, it will be particularly heavy duty, and often buried in the seabed to withstand ships' anchors or fish bites," explains Nicolò.

THIS MACHINE MAKES OPTICAL FIBRE, WHICH CAN CARRY DATA AT 70 PER CENT THE SPEED OF LIGHT

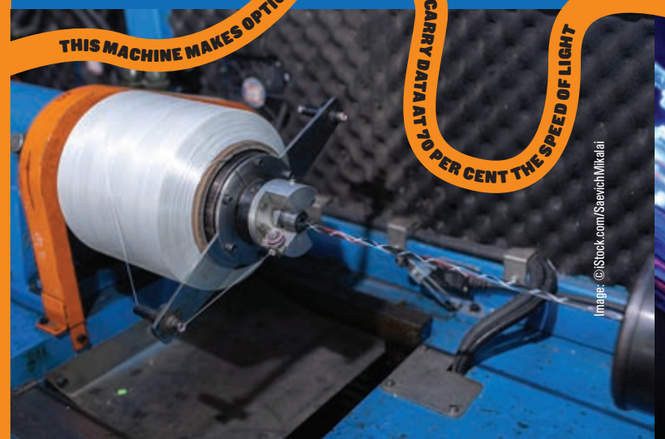


Image: ©iStock.com/SaevichMikalai

UNDERSEA COMMUNICATION CABLES CRISSCROSS THE GLOBE, REPRESENTED BY COLOURED LINES

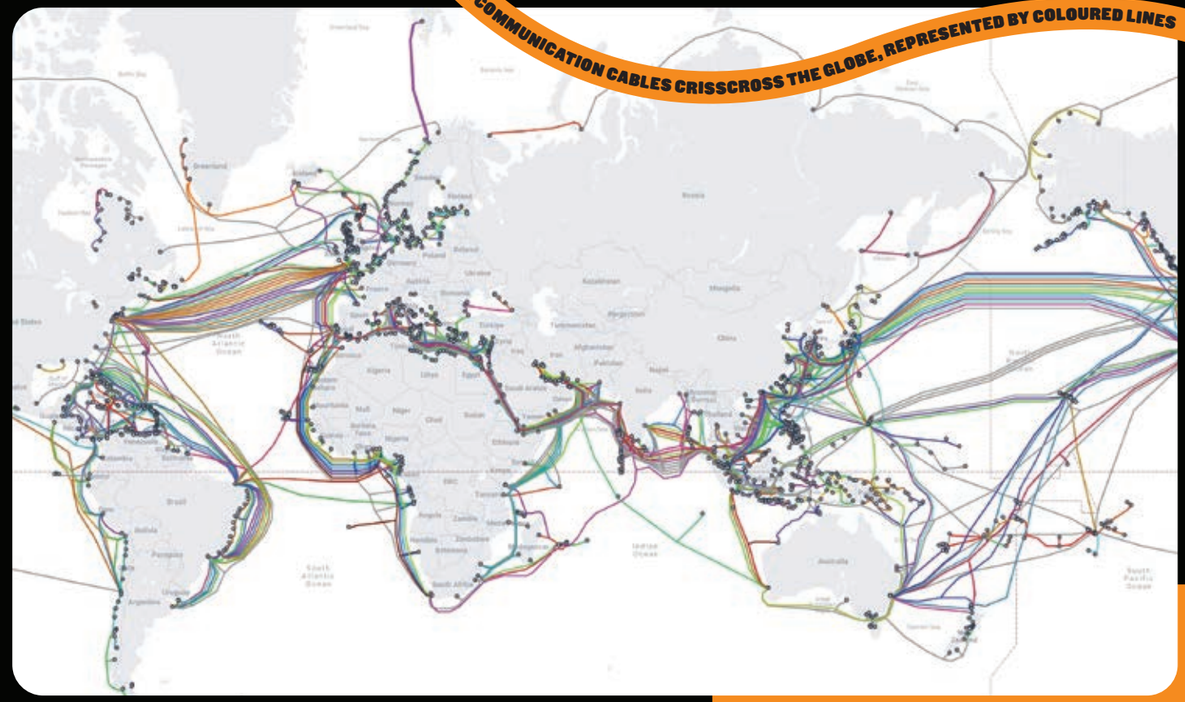


Image: TeleGeography's Submarine Cable Map (CC BY-SA 4.0)

SPANNING THE GLOBE

The Submarine Cable Map shows all the undersea cables around the world. Some areas – such as between Europe and North America – have dozens of cables going through almost the same place. In the Pacific, many of the cables travel through the same spot too – a tiny island called Guam.

The whole population of Guam is just less than Darwin's, and it might seem like a surprising undersea cable hub, but it has a trick up its sleeve – it's a territory of the United States.

"Guam's strategic location in the Western Pacific makes it the perfect bridge between Asia and the Americas," says Nicolò. Because it's a United States territory, American companies want to use it more. And Nicolò says that once you have one cable, it's easier to put in more.

LIGHT TRAVELS THROUGH OPTICAL FIBRE

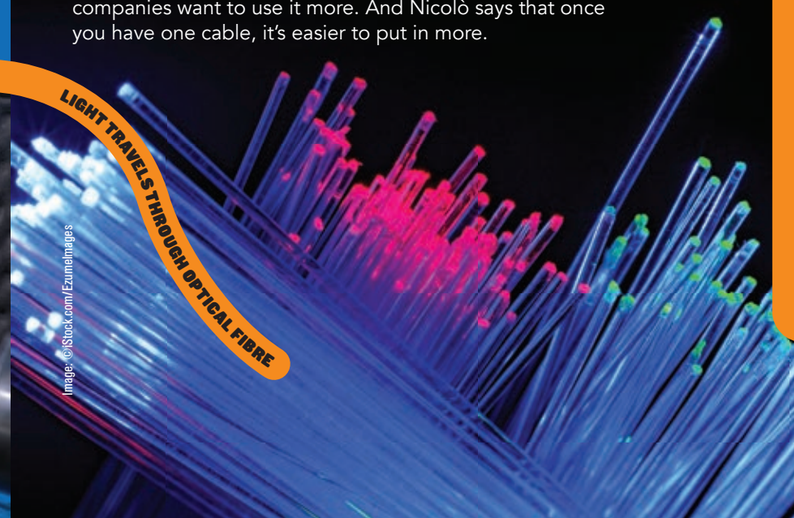


Image: ©iStock.com/EzumeImages

CLOSER TO HOME

Australia has many undersea cables connecting us to the rest of the world. Some island nations with smaller populations, such as Tonga, only have one. If something was to go wrong with that cable, the whole island would lose internet access!

If Australia was to lose one of our cables, we wouldn't lose all access – but it wouldn't be all smooth sailing, either.

"Data is usually rerouted through alternative paths, preventing a total internet shutdown, but possibly causing slower speeds and higher latency," says Nicolò.

"Sometimes, other cables nearby can offer some of their spare capacity, or satellites can be used for some essential services.

"To get back to normal, you have to wait for a ship to locate the fault, reach it, and repair or replace the cable: a long and cumbersome process!"

SEALS, HUMANS, BATS AND MAPS!

BY LOUISE MOLLOY

Seals, humans, bats and maps – what's the link? But before we tell you, where are we? Antarctica! And more precisely – the deep ocean off the coast of the icy continent.

Image: Clive McMahon | IMOS and SIMS

SEALS LIKE THIS ONE DISCOVERED A HUGE UNDERWATER CANYON!

DEEP DIVERS

Exploring the deep sea off Antarctica was difficult for humans. That is until seals gave us a hand – or a flipper! Since 2004, scientists have collected data from satellite-linked devices attached to the heads of around 300 southern elephant seals and Weddell seals.

When these deep divers surface, their dive data is transmitted back to base in Hobart – the Institute for Marine and Antarctic Studies at the University of Tasmania. The data includes ocean temperature, depth and salinity.

Data from about 500,000 individual dives has recently helped scientists map the ocean floor under the ice shelf off East Antarctica. And some surprises were in store! For instance, the seafloor in one area is 1,000 metres deeper than previously thought. The data also revealed more information on troughs and a deep-sea canyon.

This is important research for predicting the effects of climate change.

"The observations we collect from the seals help us better understand the shape of the ocean floor," says scientist Clive McMahon. "Especially where there are channels for warm water to access ice shelf cavities. This knowledge is essential for scientists trying to measure ice sheet melt rates."

ECHOLOCATORS

Come aboard the *RSV Nuyina* (noy-YEE-nah). It's an icebreaker that travels between Hobart and Antarctica, taking crews and supplies to research stations.

Although the ship doesn't look like a bat, it does use deep-sea bat technology – a multibeam echosounder! Like a bat using echoes to 'see' in the dark, RSV *Nuyina* maps the seafloor by sending out pings and waiting for their reflections. The scientists onboard who do this mapping are called acousticians (acoustic means relating to sound).

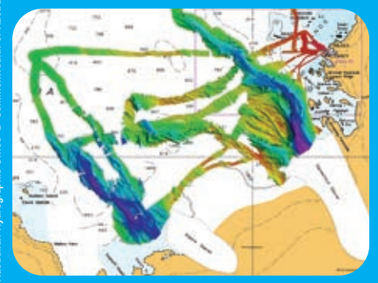


Image: AAD/hydrographic material reproduced with permission of The Australian Hydrographic Office © Commonwealth of Australia 2024

NUYINA'S ECHOSOUNDER MAKES A RAINBOW MAP OF THE SEABED

"I always find it fun, and almost mesmerising, to make a rainbow road of the seabed ping by ping," says senior acoustician, Alison Herbert. Why rainbow, you may ask? Different depths pinged below the ship show as different colours on the maps.

In January this year, *RSV Nuyina's* researchers mapped an unknown underwater canyon off Antarctica. It was huge: 2,100 metres deep, 9 kilometres wide and more than 46 kilometres long!

Remember that other deep-sea canyon the seals helped humans find? The *RSV Nuyina* pinged that too, and mapped it in more detail. It's now been named the Mirounga–Nuyina Canyon, in honour of the ship and the scientific name of the elephant seals that discovered it (genus *Mirounga*).

Image: Pete Harmsen/AAD

ACOUSTICIANS FLOYD HOWARD, JILL BROUWER AND ALISON HERBERT ON BOARD RSV NUYINA

RSV NUYINA IS DESIGNED TO SAIL THROUGH THE ICY SEAS AROUND ANTARCTICA

Image: Pete Harmsen

INVESTIGATORS

Now let's head halfway between Tasmania and Antarctica onboard CSIRO research vessel, the RV *Investigator*, where an international team of scientists are studying the Antarctic Circumpolar Current. It's the strongest ocean current on our blue planet.

"The Antarctic Circumpolar Current flows around the icy continent from west to east," says CSIRO's Benoit Legresy, the chief scientist onboard. "It acts as our safety belt so that the warm water doesn't reach the Antarctic and melt the ice."

Using an echosounder, the team mapped 20,000 square kilometres of ocean floor. One of their discoveries was an ancient underwater mountain range with dormant volcanoes. Meanwhile, gliders, floats, buoys and even a satellite were studying the ocean itself.

By mapping not just the seafloor, but the ocean currents and changing sea levels too, the scientists can investigate how and where warmer water is making its way to Antarctica. This will help us understand the impact of climate change on the icy continent.

Image: CSIRO

RV INVESTIGATOR MAPPED 20,000 SQUARE KILOMETRES OF THE OCEAN FLOOR!

This cute, little critter is a solar-powered sea slug!

The sea slug eats tiny plants called algae. But instead of digesting the whole plant, the sea slug does something clever. It can steal the algae's chloroplasts – the parts of the plant that turn sunlight into food. The slug then keeps the chloroplasts inside its own body, giving it a sun-powered feed and turning it green!

DoubleHelix CSIRO

www.doublehelix.csiro.au

WONKY HOLES

BY MITCHELL JEFFREY

A NORTH QUEENSLAND FISHING YARN TELLS OF MYSTERIOUS, GIANT VENTS OF FRESH WATER ON THE OCEAN FLOOR, WHERE THE FISH ALWAYS BITE. SCIENTISTS SAID THIS WAS TOO STRANGE TO BE TRUE – BUT WE STILL DON'T REALLY KNOW WHAT'S DOWN THERE.

WHAT'S A WONKY HOLE?

Wonky holes lie about 20 metres underneath the ocean, in many places between Cape York and K'gari (formerly known as Fraser Island). They're found on the continental shelf – land that was flooded by rising seas at the end of the last ice age. Found up to 60 kilometres from today's shoreline, wonky holes can be 30 metres wide and 10 metres deep. Fishing enthusiasts say the holes can be full of fish, prawns or crayfish.

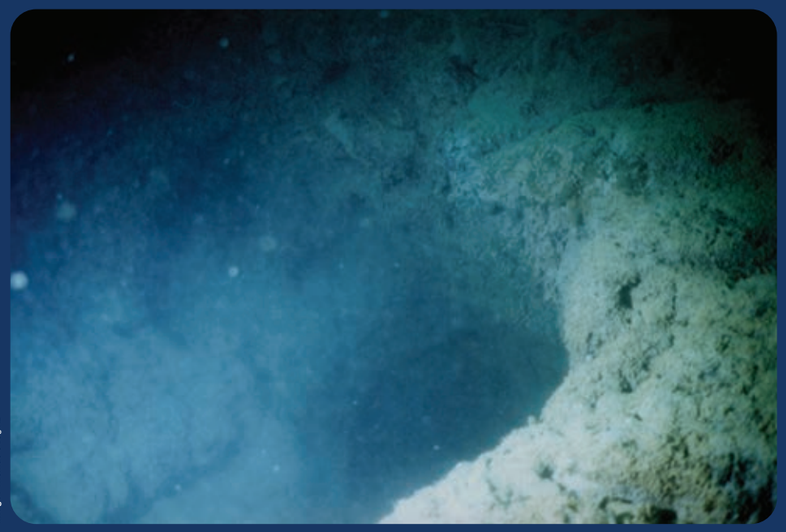


Image: Thomas Stieglitz

This wonky hole is about 30 metres below the waves

TANGLED NETS & FISHING YARNS

Sam Pagano, a fisherman from Innisfail was the first person to suggest scientists take a closer look at wonky holes.

"We thought the idea was complete hogwash," says Thomas Stieglitz, who was then working at James Cook University and the Australian Institute of Marine Science. Thomas thought he should go talk to some experts.

"Prawn trawlers know everything about the seabed," he says. Brett Shorthouse is one such prawn trawler, and he confirmed that wonky holes were real.

"The boards at the mouth of the trawl net can get tangled in a wonky hole, and it takes hours to untangle them," says Brett. "We had to know where wonky holes were and avoid them. Each wet season, new ones would pop up."

Brett once dived to the bottom of a wonky hole.

"It had beautiful, cool, stunningly clean water," he describes. "So I tasted it, and it was fresh – not salty like the ocean."

Image: flickr.com/bhn

Prawn trawlers know a lot about the ocean floor

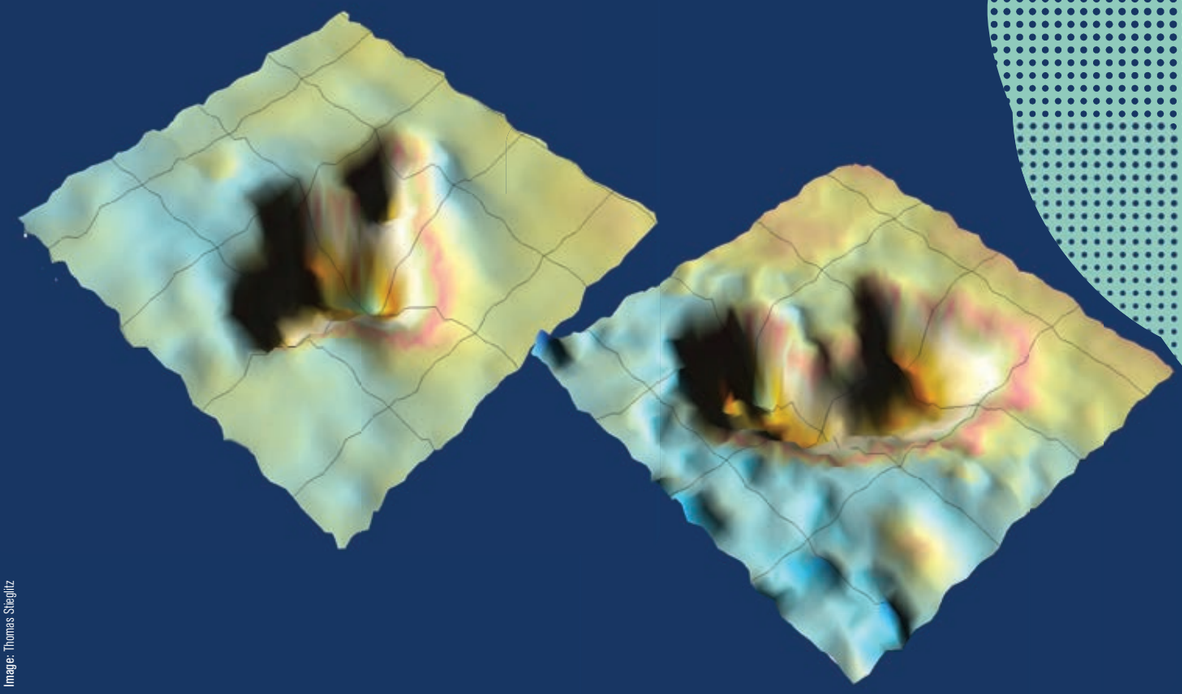


Image: Thomas Stieglitz

Scientists scanned these wonky holes from the surface with sonar!

PALEOCHANNEL CONNECTIONS

Thomas hasn't measured fresh water flowing from a wonky hole, but he doesn't doubt the stories from people such as Brett.

"Based on the holes' shape, I can't see them being made by anything other than fluid flow," he admits.

Thomas found that wonky holes are always connected to paleochannels under the seabed. Paleochannels are ancient rivers that filled with rocks, gravel and sand as sea levels rose. But they still carry fresh water from today's major rivers. This might explain whether wonky holes have periods of dormancy, like volcanoes do, or how new wonky holes appear after rain.

Even more mysteriously, Thomas says divers found tunnels in the walls of wonky holes.

"They went a few metres into these tunnels and just stopped – it was too spooky," he says. "They came back with sea snakes wrapped around their legs. So we don't know how long the tunnels are or where they go. But their shape isn't consistent with fluid flow, so I guess they were dug by fish or animals."

Thomas thinks marine life is attracted to wonky holes – mostly for shelter. Elsewhere, researchers studying fresh water coming from the ocean floor have found it can carry nutrients or pollution from land.

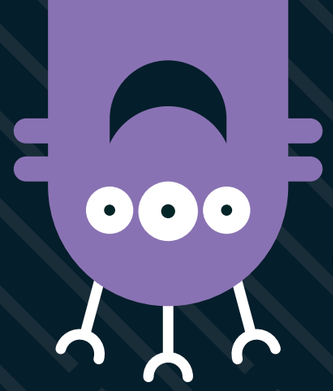
"It's frustrating we couldn't find water flowing from a wonky hole during our research," he says. "But it triggered this idea that we need to look at the groundwater–ocean connection, and I've been investigating this all over the world ever since."

DIVERS EXPLORED THE TUNNELS IN A WONKY HOLE AND CAME BACK WITH SEA SNAKES WRAPPED AROUND THEIR LEGS!

Wonky holes attract lots of fish

Image: Chris Bolton Fishing

KEEPING PACE WITH EARTH'S AIR AND OCEANS



GAIL LEXY HERE, WITH NEWS FOR RESIDENTS OF THE THIRD ROCK FROM THE SUN. YES, THAT'S YOU, EARTHLINGS.

Image: NASA GSFC

The PACE satellite searches for microscopic ocean algae, from up in space!

NASA is adding to the fleet of satellites monitoring the health of your home planet with a spacecraft called PACE. The name stands for Plankton, Aerosol, Cloud, ocean Ecosystem, and it will measure phytoplankton (microscopic algae) in the sea and aerosols in the air.

"Phytoplankton are the base of the food chain," says PACE project scientist, Jeremy Werdell. "They feed fisheries and support our economy."

Just like land plants, phytoplankton convert carbon dioxide into sugar and oxygen during photosynthesis. In this way, these tiny algae draw carbon dioxide out of Earth's atmosphere. But that's not all they do.

"Phytoplankton also release gases that make aerosols," says Jeremy. Aerosols are microscopic particles in the air, such as sea salt, pollen and ash.

"Aerosols affect the climate because they reflect sunlight back to space, cooling Earth," says atmospheric scientist Otto Hasekamp.

Aerosols also function as seeds for clouds to form. They affect whether clouds have a lot of tiny droplets that reflect sunlight, or become heavier, darker clouds that absorb the sun's energy.

"What aerosols are made of, their size, shape, and where they are in the atmosphere, has a huge impact on the kinds of clouds that form," explains Karen St. Germain, PACE mission director. "And their role is a big source of uncertainty in predicting climate change."

So how will the PACE mission measure such tiny plants and particles from space?

"By monitoring reflected sunlight," says Jeremy.

The main sensor onboard the spacecraft is the ocean colour instrument, which measures the colour of light reaching PACE from the ocean. Since sunlight is reflected and scattered by particles in the ocean and atmosphere, this will tell scientists the amount of phytoplankton and aerosols.

"With PACE, we'll be able to collect these measurements on a global scale because of our vantage point in space," says Karen.

This global perspective will help scientists understand how phytoplankton and aerosols interact to affect Earth's climate – and make better climate change predictions.

SPACE-AGE SAILS

200 years ago, sailing ships carried cargo around the world without burning any fuel. Now, sailing ships are coming back!

Image: Oceanbird

▲ This ship has sails shaped like airplane wings!

NOW

Rotor ships sound absolutely ridiculous. Huge, rotating poles are built on top of a cargo ship. The ship's engines spin the poles, and the poles push against the wind and move the ship.

The key ingredient is the Magnus effect, which turns the spin into a pushing force. It's the same effect that makes spinning balls curve through the air.

Surprisingly, cargo ships with rotors are already sailing the seas! Danish shipping company, Maersk, estimates that their rotor ship *Pelican* uses 8.2 per cent less fuel because of its rotors.

SOON

The higher in the air you go, the faster the wind blows. That's one reason why old sailing ships had such tall masts. But the fastest air is hundreds of metres above the ocean's surface – far too tall for a ship mast.

So, how do you get a sail up into that fast air? Fly it there!

Airseas is a new company that's building giant kites for cargo ships. Known as seawings, the kites cover 1,000 square metres and fly to heights of 300 metres. They're not powerful enough to pull the ship by themselves, but they can cut fuel use by about 20 per cent.

EVENTUALLY

If you want a fully sail-powered ship, you need lots of sails. But they don't need to be made from old-fashioned squares of fabric.

Swedish company Oceanbird's Wing 560 sail looks a bit like an airplane wing, or a wind turbine blade. The high-tech shape generates a lot of lift, but since the wing points up and down, that lift pulls the ship forwards, instead of upwards.

When ships need to go under bridges, the Wing 560 has another trick up its sleeve. It's mounted on a hinge, so the whole thing can lie down flat on the roof of the ship!

JUST IMAGINE

"The wind is shifting again," Matthew called out. "Are you sure this is going to work?"

"It's bound to." Bungaree was adamant. "The turbine can spin 360 degrees – it'll pick up the wind from any direction."

Matthew looked unimpressed, but the turbine slowly turned to face the front of the ship, where the wind was coming from.

"See!" Bungaree crowed. "It's generating heaps of power. And that's all going to the propeller, pushing us forwards."

"And that wind against the turbine is pushing us backwards," Matthew muttered under his breath, but he kept an eye on the GPS.

The two sailors stood and watched as the ship slowly moved forwards. After a few minutes, Bungaree turned to Matthew, saying: "Honestly, I'm almost as surprised as you are!"

AI GENERATED IMAGE

Image: Midjourney

OUT OF SIGHT, OUT OF MIND

"Can I really go with you?" Emily grabbed her safety pack and ran for the submersible hatch.

She and her dad had been stuck on the underwater mining base for weeks. She was getting so bored. They didn't let teenagers do anything on this stupid base!

"Yep, I'm just on my way down to check out the site," said Dad. "Final review before the miners get to it."

"And I can come?"

"Sure, there'll be nothing left after, so I want you to see it. Once they start, centuries of seabed and animal colonies just vanish in a big mud cloud."

Dad pulled the hatch shut behind them and started flicking switches.

Emily was quiet for a while. "But...?"

"But we get metals for batteries and modern technology? Sure." Dad didn't sound impressed.

The submersible descended through the deep. Its headlights picked up glittering particles and the occasional startled fish eye out of the gloom. The pair watched the seabed slip beneath them. Large markers were already in place identifying the edges of the first mining strip.

As they rounded a rocky outcrop, three small, brightly coloured squid circled the main porthole.

"Oh, wow!" Emily yelled. "Look!"

"Very cool," her dad said. "Say, why don't you get some pictures? Maybe someone back at school can identify them."

Emily glanced at her dad, who seemed unusually helpful.

"You haven't seen them before?"

He ignored her question and muttered, "I just find this stuff interesting." Then he looked up. "Did you know it takes months to sign off for a deep-sea mining venture like this? All sorts of safety and environmental checks."

Emily wasn't paying attention anymore. The squid were so beautiful. She took some pictures and posted them to the school net: "Can ayone find out whathese arE?" she typed quickly. The images began transmitting and she looked back out the submersible.

They'd spent another hour in the deep, chasing a school of fish then following a trail of iridescent vegetation into the mud, when a message light began to blink on the submersible console. Dad pressed play and the head of mining operations appeared on the screen, her hair dishevelled, as though she'd just woken up.

"Hey, I've got a bunch of calls from head office: people talking about some…rare squid? Get back here asap, because legal is getting worked up and now there's environmental groups yelling down my neck. I'm delaying the operations until we figure this out."

The message ended and Dad looked at Emily.

"Wow!" he said, although it was clear he wasn't surprised. "Maybe those squid were important after all. Funny, no one ever seemed to care when I put them in my reports. Lucky you were here. I guess the school thought they were interesting and started asking about them?"

"Yeah," Emily replied. "No one would've even known they were down here." She narrowed her eyes. "Lucky for those squid I was here, at the exact right time, just before they all got dug up."

"So lucky," Dad said. He started to pilot the submersible back to base.

TIE-DYE CURRENTS

BY ARIEL MARCY

CREATE OCEAN-INSPIRED ART WITH COLOURED WATER.

Safety: This activity involves boiling water. Ask an adult to help.

YOU WILL NEED

- Measuring cup, ideally with a spout
- Warm and cold tap water
- Blue and red food colouring
- Spoon
- Large, see-through rectangular container

WHAT TO DO

1. Fill the measuring cup with cold tap water and stir in 1–2 drops of blue food colouring.
2. Put the cup of blue water in the fridge for 30 minutes.

2

Image: CSIRO/Ariel Marcy

3. Half-fill the rectangular container with warm tap water.
4. Add just one drop of red food colouring and stir. The water should take on a light pink colour.

5. Put one cup of water into the kettle. If that's not enough water to reach the minimum mark, fill it up to the minimum.
6. Boil the kettle and pour about 1 cup of hot water into the container of pink water.
7. Now it's time for tie-dye! Get the cool, blue water out of the fridge. Pour a small amount into one corner of the container of warm, pink water.

7

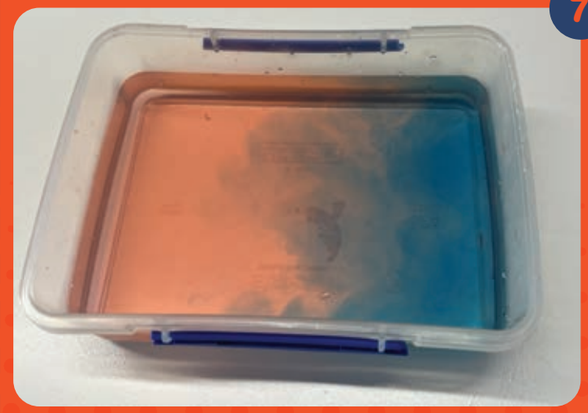


Image: CSIRO/Ariel Marcy

8. Watch what happens, both from above and from the side. What patterns do you notice?
9. When you've finished, mop up any spills you made!

WHAT'S HAPPENING?

Our oceans are connected by a huge network of currents that move water all over Earth. This network is called the global conveyor belt. If you followed one molecule of water around the network, it would take about 1,000 years for it to complete the loop.

Did you notice that the cool, blue water sank to the bottom of the container? This is because cold water is more dense than hot water. In the global conveyor belt, cool, dense water forms deep currents that move from the poles towards the equator. At the equator, the Sun heats the water, creating warm, shallow currents that move towards the poles. This loop plays many important roles, from spreading heat and nutrients around the oceans to regulating the climate.

Did you also notice circular patterns forming as the pink and blue water mixed? When these patterns form in the ocean, scientists call them eddies. Eddies form where cold and warm water mix, and often break away from larger currents.

Ocean eddies can be small, like the ones in this activity, but they can also be much, much bigger. Some eddies are hundreds of kilometres across, and can last for months or even years. In some places, scientists give big eddies names – just like how they name tropical cyclones!

DRAW A BLUE WHALE

BY DAVID SHAW

Image: ©iStock.com/ecn2drew

IT'S HARD TO IMAGINE THE SIZE OF A BLUE WHALE – THE BIGGEST ANIMAL THAT HAS EVER LIVED ON EARTH. BUT YOU WON'T NEED TO IMAGINE AFTER YOU'VE DRAWN A FULL-SIZED PICTURE OF ONE!

Safety: When outdoors, be sun smart with a hat and sunscreen. If there's any chance that you will encounter cars, ask an adult to come with you.

YOU WILL NEED

- A big, safe asphalt or concreted area
- A hat and sunscreen
- Lots of chalk
- Long tape measure, trundle measuring wheel or phone with a measuring app

WHAT TO DO

1. Before you start, be safe. Make sure everyone's sun smart, and set a lookout if cars ever drive through the area.
2. Draw a big chalk mark where you want the front of the whale to go.
3. Measure back 30 metres from this mark to make sure you have enough space.

Image: CSIRO/David Shaw

4. One final check – measure about 15 metres back from the starting mark and make sure you have at least 5 metres of space top-to-bottom.
5. Look at the whale diagram on the next page. You need to scale it up so that each square is 1 metre long and 1 metre high. The darker lines appear every 5 metres.
6. Start drawing! Here are a list of features to get you started:
   - 0 metres – front of the whale
   - 5 metres – end of the mouth
   - 7 metres – eye. A blue whale's eyeballs are only about 15 centimetres wide!
   - 8.5 metres – start of the front fins
   - 10 metres – tallest point. The whale is about 5 metres tall from its belly to its spine.
   - 20 metres – the body is about 3 metres high here.
   - 21 metres – tiny dorsal fin
   - 26.5 metres – start of the tail
   - 28 metres – end of the whale's body

Image: CSIRO/David Shaw

Image: CSIRO/David Shaw

WHALE TAILS GO OUT TO THE SIDES OF THEIR BODIES, WHILE FISH TAILS STAND VERTICALLY. A BLUE WHALE'S TAIL CAN REACH 7.5 METRES WIDE!

WHAT'S HAPPENING?

Blue whales are the largest animals on the planet. And as far as we know, they're the largest animals to have ever lived! They're bigger than every dinosaur, every megalodon, every plesiosaur and every mammoth that's ever been discovered.

Blue whales are truly humongous, weighing up to about 200 tonnes – about the same as the average house! Their tongues weigh as much as an entire elephant, and their hearts are the size of small cars. And yet, they feed on some of the smallest animals in the sea – tiny shrimp called krill.

Known as ram feeders, blue whales swim quickly up to a swarm of krill and open their mouths wide, collecting up to 50 tonnes of sea water. Then they slowly filter the water out of their mouths, keeping the tasty krill inside to eat. Blue whales are a very different shape when their mouths are full, so don't worry if your whale drawing looks a bit lumpy or weird!

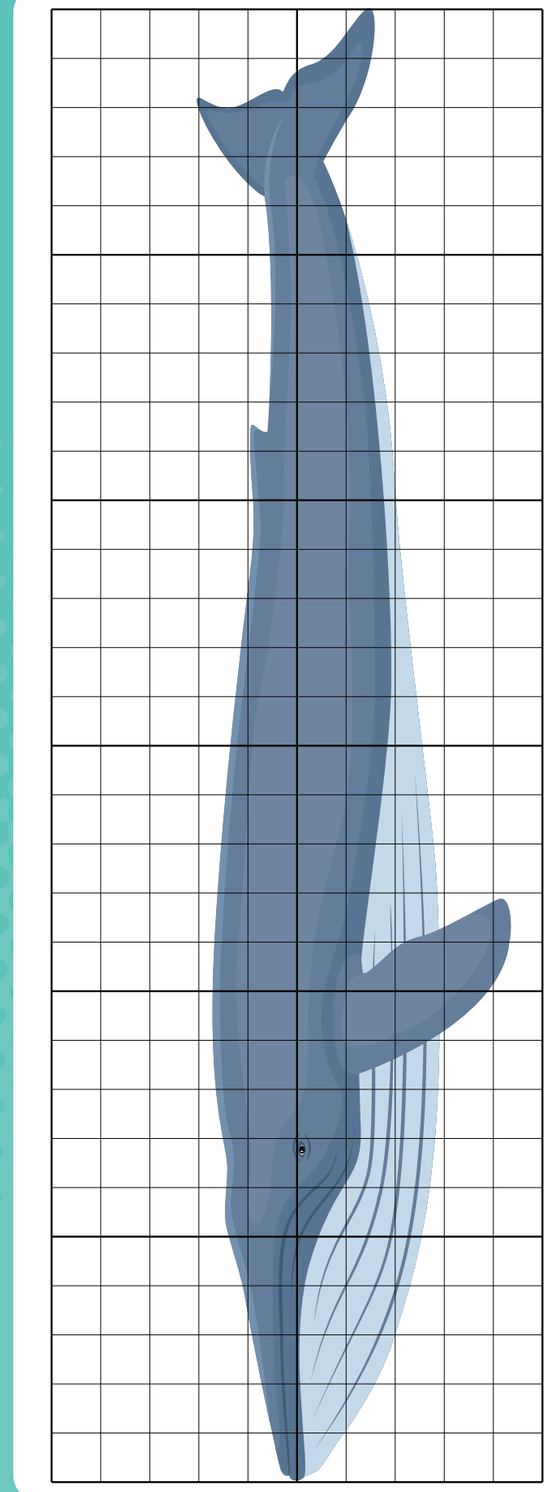


Image: ©iStock.com/Zhenyakot

DIVE REFLEX CHALLENGE

BY ARIEL MARCY

READY, SET, SPLASH! IN THIS CHALLENGE, BRAVE A FACEFUL OF WATER TO UNLOCK YOUR DIVING REFLEX! THIS AUTOMATIC RESPONSE WILL SLOW YOUR HEART RATE SO YOU CAN SURVIVE YOUR 'DIVE.'

Image: ©iStock.com/Imgorthand

Safety: Getting water poured on your face can be very scary. It is important that you pour the water on your own face – don't let anyone else do it. If it's too scary, you can stop pouring the water and restart your breath at any time.

YOU WILL NEED

- Tall plastic or paper cup
- Cold water
- Friend or family member
- Bathroom or spot outside where you can spill some water
- Timer

WHAT TO DO

1. Fill the cup full of cold water – the colder the better.
2. Take the cup and a friend and go stand in a shower or outside.
3. Ask your friend to take your 'before' heart rate. To do this, have them place their index and middle fingers on the part of your wrist underneath your thumb. Ask them to count how many beats happen in 30 seconds.

Image: CSIRO/Ariel Marcy

4. Write your heart rate down, multiply the number by 2 and label the result 'before – beats per minute'.
5. Ask your friend to find your pulse again, because here comes the challenge! Get ready to perform the next three steps in quick succession.
6. Close your eyes, hold your breath, and tilt your head back slightly.
7. Pour the cup of water on your face, aiming for your eyes and cheekbones. Speed-wise, try counting to three in your head as you pour.

Image: CSIRO/Ariel Marcy

8. As soon as you finish pouring, your friend should start counting your heart beats for 30 seconds. You can stop holding your breath at any time.
9. Write the new number down, multiply it by 2 and label the result 'after – beats per minute'.
10. Compare the before and after numbers. Did your heart rate change? What else did you feel?

WHAT'S HAPPENING?

Imagine you're running from a bear. All of a sudden, your path dead ends at a cliff. There's nothing but ocean below and no time to waste! You jump! Water rushes up your nose as you sink into the depths.

Humans can't survive underwater. We simply can't get the oxygen we need. Fortunately, our bodies have evolved to handle surprise dunkings. When you become submerged in water, your body automatically conserves oxygen by:

- slowing your heart rate
- slowing the signals to breathe
- channelling your blood away from muscles and towards your brain.

Together, these changes are called the mammalian dive reflex.

Like other reflexes, the dive reflex is automatic and quick, and it only happens when just the right things happen to you. The triggers are water on your face and breath holding, just like you did in this activity. Did your heart rate slow down as expected?

Interestingly, the dive reflex seems to be stronger in young people. Why not challenge an older family member to test their dive reflex and find out?

MAMMAL EVOLUTION

True to its name, the mammalian dive reflex is found in all mammals, from platypuses and humans to cats and whales. Because so many mammals show the reflex when submerged in water, biologists think it is a very ancient adaptation. Whales, dolphins and seals have highly developed dive reflexes that allow them to hold their breath and conserve oxygen for long periods of time.

Sperm whales can dive for 1,000 metres on a single breath of air!

Image: ©iStock.com/Sergio Hanquet

FROM SURVIVAL TO MEDICINE

Remember that bear? To outrun it, you'd need a faster heartbeat, faster breathing, and blood in your muscles. These anxiety-driven changes are all opposite from the mammalian dive reflex! Because of this, scientists are really interested in using the dive reflex to help people with chronic anxiety or those who experience panic attacks.

Image: ©iStock.com/melapompa

The dive reflex might help control anxiety

MAPPING MAYHEM

DIFFICULTY: FUN

Can you divide this map into triangles? Each island must only be on one triangle. The dots show the corners of the triangles.

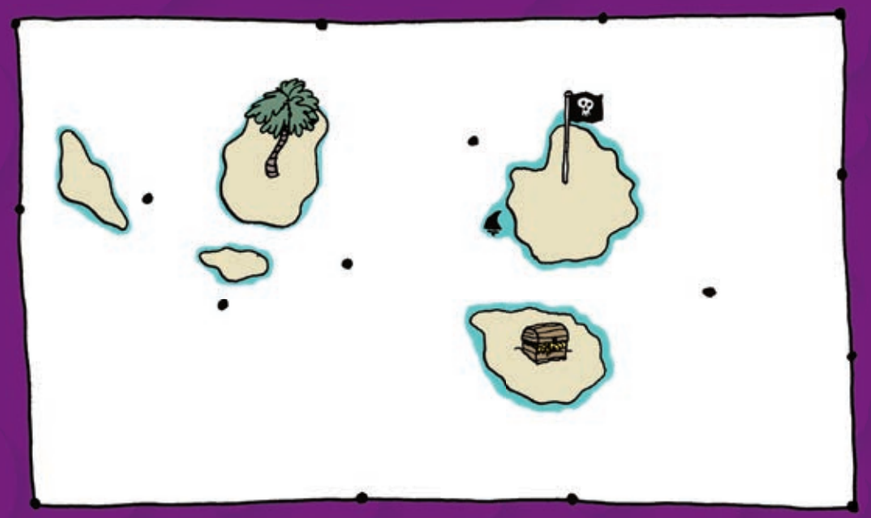


Image: Alex Hallatt

CONFUSING CABLES

DIFFICULTY: TRICKY

Three undersea cables are wending their way through this grid. Each square of the grid is covered by just one of the cables, and the tops and sides give the numbers of squares each cable covers in that row or column. Can you draw the cables in between the start and stop marks according to the numbers on the grid? Note that cables cannot travel diagonally.

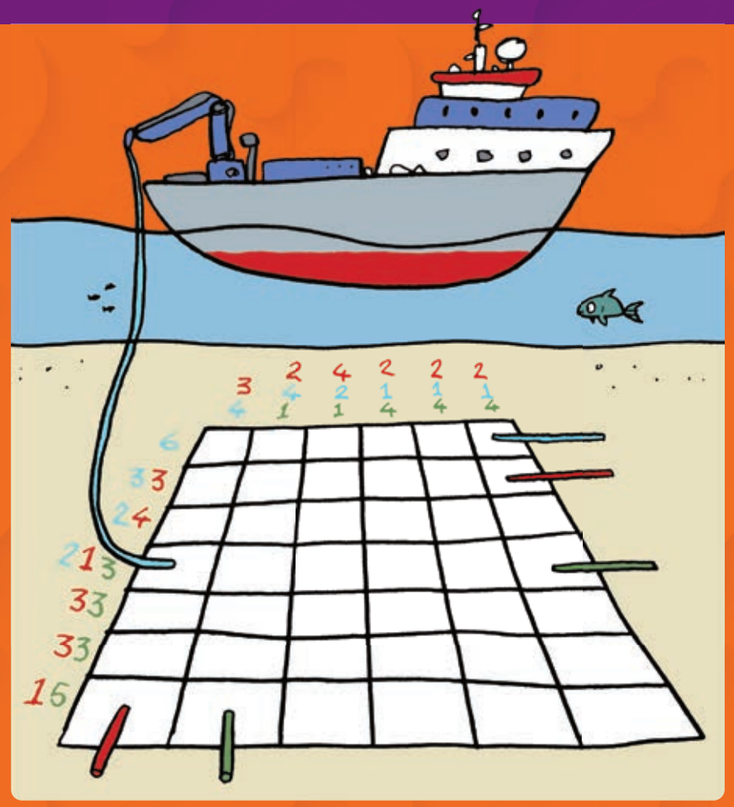


Image: Alex Hallatt

SCUBA SET

DIFFICULTY: FUN

Three scuba divers all want to have air tanks that add up to 20 litres. How can they share out these tanks so that each diver has exactly 20 litres? Each scuba diver can carry three sets of tanks, and they can't leave any behind.

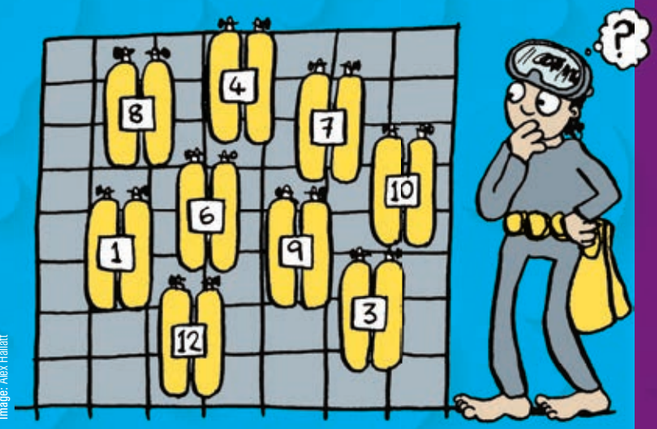
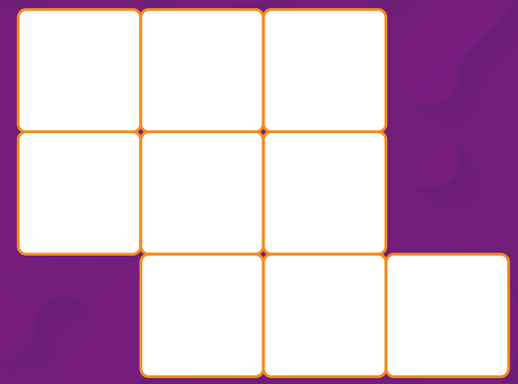


Image: Alex Hallatt

NUMBER NUDGE

DIFFICULTY: TRICKY

Arjun has completed a massive survey of a reef. He found 33 sharks, 413 crabs, 311 turtles, 343 clownfish, 313 eels and 335 snapper. How can he write all these numbers into this number grid? Numbers can go left to right or top to bottom.



QUICK QUIZ

DIFFICULTY: FUN

1. What is the scientific name for flippered animals such as seals and sea lions? Is it a) pinniped, b) milliped or c) biped?
2. Where would you find the Mariana Trench? Is it in the a) Southern Ocean, b) Dead Sea, c) Pacific Ocean or d) Coral Sea?
3. True or false? Ambergris, a whale product that often smells of poo, is used in expensive perfumes.
4. Which is the biggest ocean? Is it the a) Atlantic, b) Pacific or c) Indian?
5. What are baby sharks called? Is it a) calves, b) pups, c) squabs or d) fry?

BRAIN TEASER

DIFFICULTY: EXTREME!

Simi has 1,024 kilograms of ice on her truck, and it's melting. Every hour, the amount of ice on her truck halves.

When Simi gets home at the end of the day, only 1 kilogram of ice is left on the truck.

If she got home two hours earlier, how much ice would have been left on her truck?

JUST FOR LAUGHS

Q: What do sea monsters eat?
A: Fish and ships

Q: Which are the strongest creatures in the ocean?
A: Mussels

Q: Which part of a fish weighs the most?
A: The scales

Q: Which fish is the most famous?
A: The star fish

Q: What's that gooey stuff in between a shark's teeth?
A: Slow swimmers!

MESSAGE IN A BOTTLE

DIFFICULTY: EXTREME!

This message in a bottle was found floating out to sea, but it's all in code! Can you help us to decipher this cryptogram?

The cryptogram is a Caesar cipher. Each letter has been replaced by a different letter, and there's a simple but clever pattern to the swap. We've started decoding by giving you the word 'MESSAGE'. Can you decode the rest? Good luck!

Hint: To decode this MESSAGE IN A BOTTLE, the key is the number 3.

B r x i r x q g p b p h v v d j h l q d e r w w o h!

_ _ _ _ _ _ _ _ _ _ **M E S S A G E** _ _ _ _ _ _ _ _ _!

L d p d v f l h q w l v w d q g w k l v e r w w o h l v

_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

d q h a s h u l p h q w. L g u r s s h g l w r i i d

_ _ _ _ _ _ _ _ _ _ _ _. _ _ _ _ _ _ _ _ _ _ _ _ _

e r d w q h d u K d z d l l. Z k h q b r x i l q g

_ _ _ _ _ _ _ _ _ _ _ _ _ _. _ _ _ _ _ _ _ _ _ _ _

w k l v, s o h d v h o h w p h n q r z z k h u h

_ _ _ _’ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

b r x i r x q g l w!

_ _ _ _ _ _ _ _ _ _!

Image: © iStock.com/gio_banfi

TURN THE PAGE UPSIDE DOWN TO READ THE...

ANSWERS

QUICK QUIZ

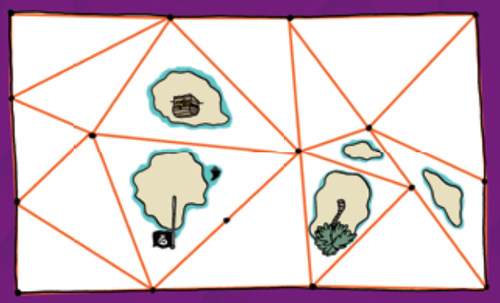
1. a) Pinniped means 'fin foot' and is used to describe seals, sea lions and walruses. **2.** c) The Mariana trench stretches for 2,550 km just below Japan in the western Pacific Ocean. Reaching 10,984 m deep, it's the deepest part of the ocean we've found. **3.** True. Ambergris is used in fancy perfumes to prevent the fragrance from evaporating, and it's very rare and expensive! **4.** b) The Pacific Ocean covers almost one-third of Earth's entire surface! **5.** b) The term pup is used for baby sharks, as well baby bats, dogs, armadillos, stingrays and seals.

BRAINTEASER

For every hour that passes, the ice on the truck halves. So for every hour earlier that Simi gets home, the opposite happens – the amount of ice left doubles.
If she were home one hour earlier, she would have 2 kilograms of ice left.
If she got home two hours earlier, she would have 4 kilograms of ice left.

CONFUSING CABLES

One answer is:



MAPPING MAYHEM

One answer is:

SCUBA SET

Set 1: 12, 7 and 1 L.
Set 2: 10, 6 and 4 L.
Set 3: 9, 8 and 3 L.

NUMBER NUDGE

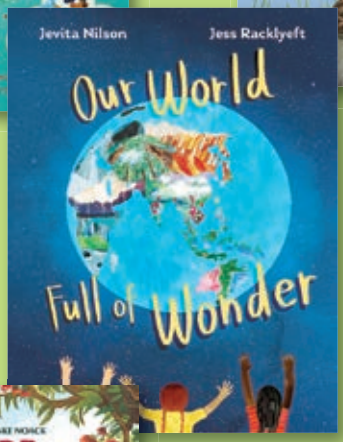
3	3	5
3	1	1
3	4	3

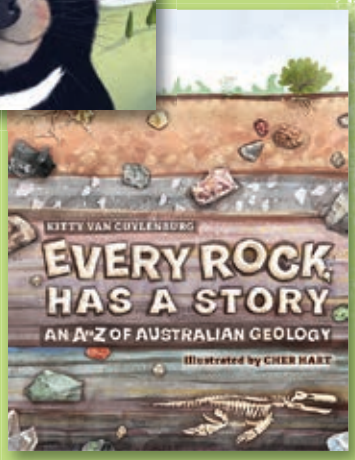
MESSAGE IN A BOTTLE

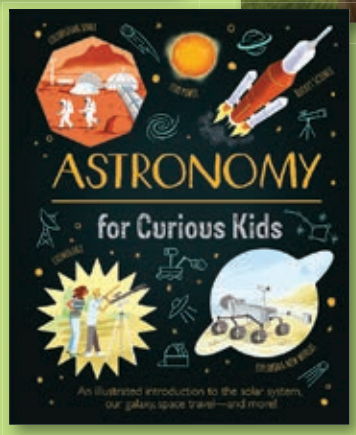
Plain A B C D E F G H I J K L M N O P Q R S T U V W X Y Z
Cipher D E F G H I J K L M N O P Q R S T U V W X Y Z A B C

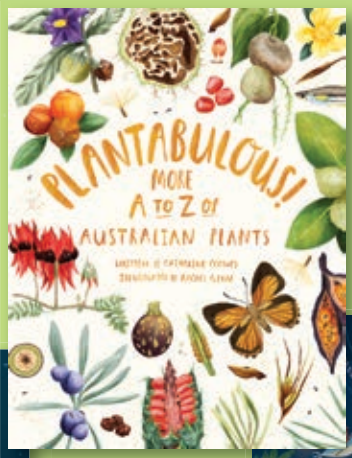
You found my message in a bottle!
I am a scientist and this bottle is an experiment. I dropped it off a boat near Hawaii. When you find this, please let me know where you found it!

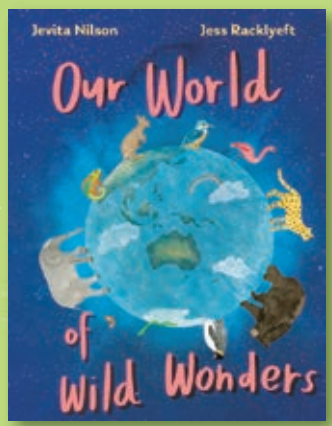
INSPIRING BOOKS FOR CURIOUS KIDS!











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