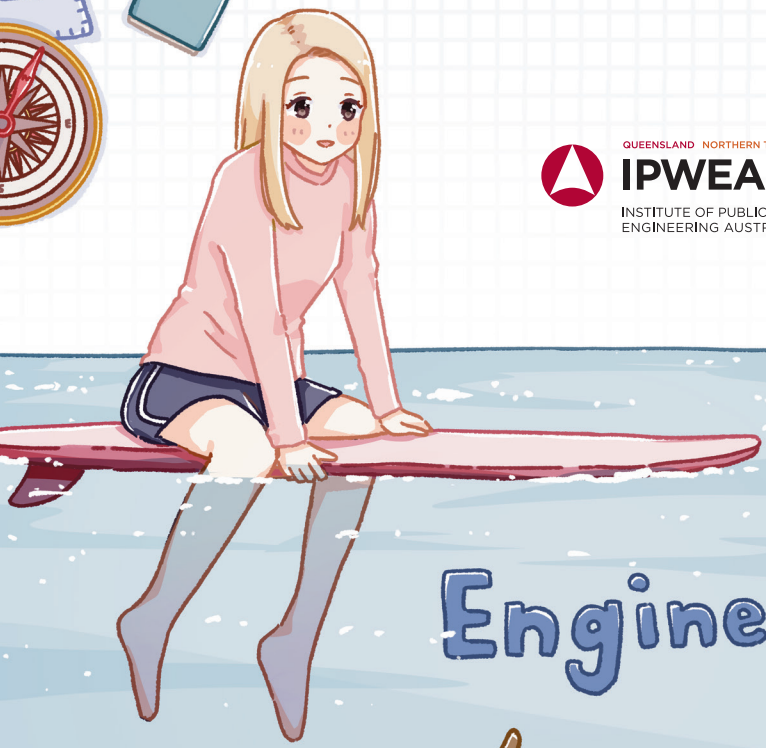
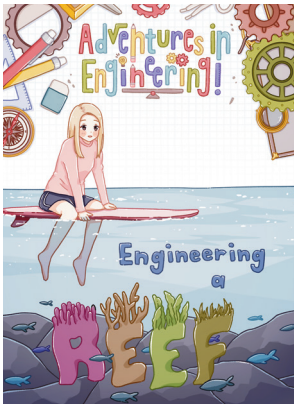
Adventures in Engineering!

QUEENSLAND NORTHERN TERRITORY
IPWEA
INSTITUTE OF PUBLIC WORKS ENGINEERING AUSTRALASIA



Engineering a REEF



Adventures in Engineering:
Engineering a Reef

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Our thanks to our featured public works engineer, Zoe Elliott-Perkins for sharing her engineering project.

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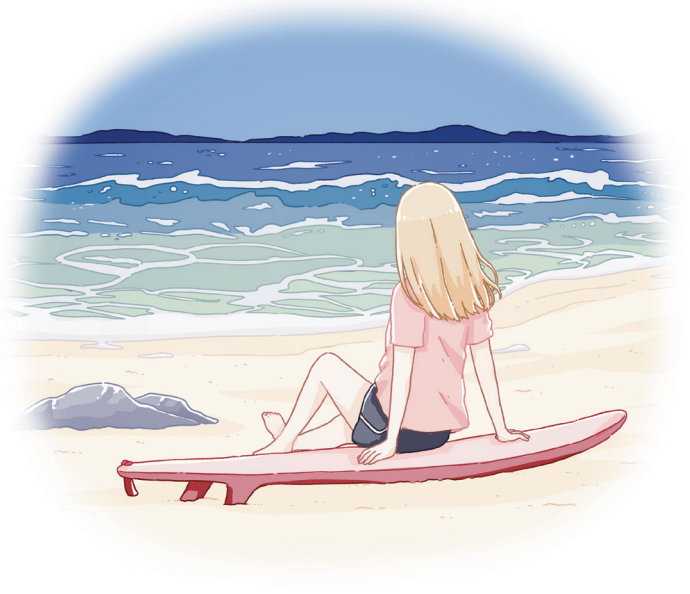
Engineering a Reef

First Edition

With thanks to the National Careers Institute

Chapter 1

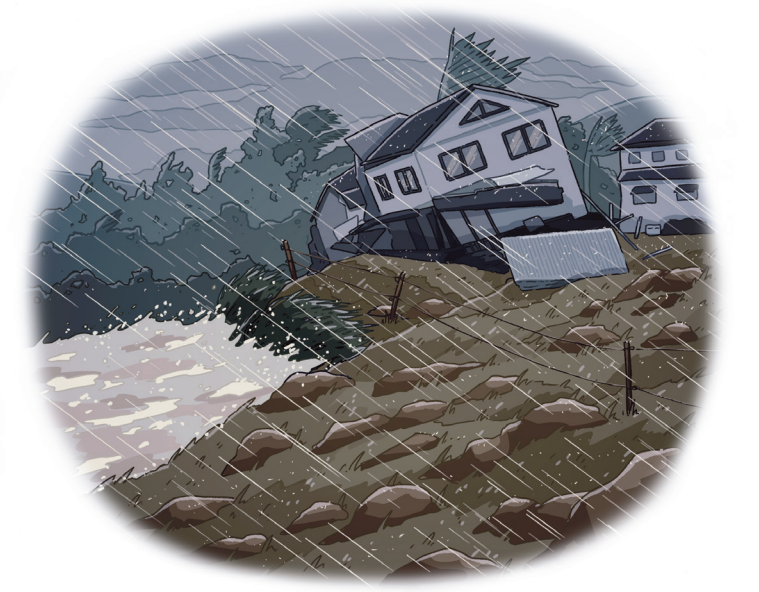
Zoe was always at the beach. Before school, after school, on weekends. Her Dad taught her to understand beach conditions and to surf. She couldn't imagine what it would be like for those people who had never seen, heard, smelt, or swum in the ocean. Imagine never building a sandcastle or riding a wave!



Even when she wasn't at the beach, Zoe would enjoy listening to her parents talk about the beaches along the Gold Coast, where they had lived for many years.

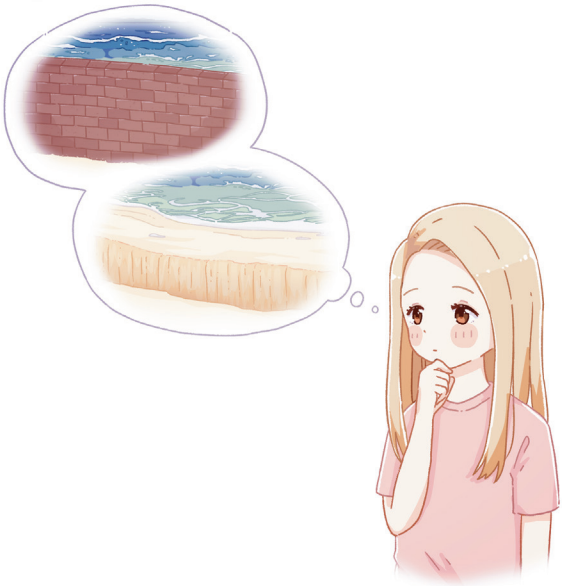
Zoe's parents told her about the powerful cyclones that had **lashed** the coastline in 1967. It wasn't just one or two storms that year - seven storms damaged the Gold Coast, tearing away sand from the beaches and leaving the coastline unrecognisable.

One of the worst was Tropical Cyclone Dinah. This Category 4 cyclone was so strong that the wind and high tides caused the waves to erode the dunes and part of the esplanade at Surfers Paradise collapsed! Then, when Tropical Cyclone Glenda hit later that year, the patio of one of the Surf Life Saving clubs fell into the ocean when the sand underneath it was washed away. Zoe's parents even said that two houses had been washed out to sea in one of the storms. It was wild to think that so much damage could be caused.



Following these conversations, Zoe would try to work out how to protect the beaches and nearby buildings from this kind of damage. Cyclonic winds and big storms were very powerful, and it would take something very large to get between the weather and the beach to keep it protected.

Would a big high wall work? You'd have to dig it in deep or the wind would just blow it over. Not to mention that it would block the view of the ocean – and she knew a lot of people came to the Gold Coast to look at the ocean.



A big moat, like those that surrounded castles? No, that probably wouldn't work either. Zoe was a very experienced sandcastle builder and knew the waves would eventually push the sand back into the hole.

Somebody somewhere must have a solution to these problems. After all, beaches hadn't yet disappeared!

Little did Zoe know at the time that one day she would be part of a team that created a unique beach protection structure—an artificial reef made of tens of thousands of tonnes of big rock boulders.

Chapter 2

Zoe surfed every morning before school. Heading to the beach early one day to catch some waves, Zoe was shocked to see big mechanical diggers on the beach scooping up sand and pouring it into the back of what looked like tip-trucks. Her usually peaceful beach was a work site! Why would anyone want to dig up a beach? Where were they taking the sand? Would she be able to swim and surf here ever again? Concerned, Zoe hurried to the fenced off area in search of someone who could tell her what was going on.

Reaching the temporary fencing, Zoe saw a man wearing a hard hat, high-vis vest and lace up boots. Well, he certainly isn't here to swim or surf, thought Zoe. As he walked past, Zoe called out to get his attention.

'Excuse me, why is the beach being dug up?' she asked the man with the clipboard.

‘Oh, we’re not digging it up. Not forever. We’re building a seawall’.

‘A seawall?’ asked Zoe. She’d thought of building a wall but hadn’t thought it was a good idea. ‘How is building a big high wall going to stop the large storm waves from causing lots of damage like it did in 1967? Won’t it block out the view?’

The man laughed good-naturedly. ‘It won’t be a tall wall,’ he said. ‘It’s an underground wall. You won’t even see it when we’re finished’.

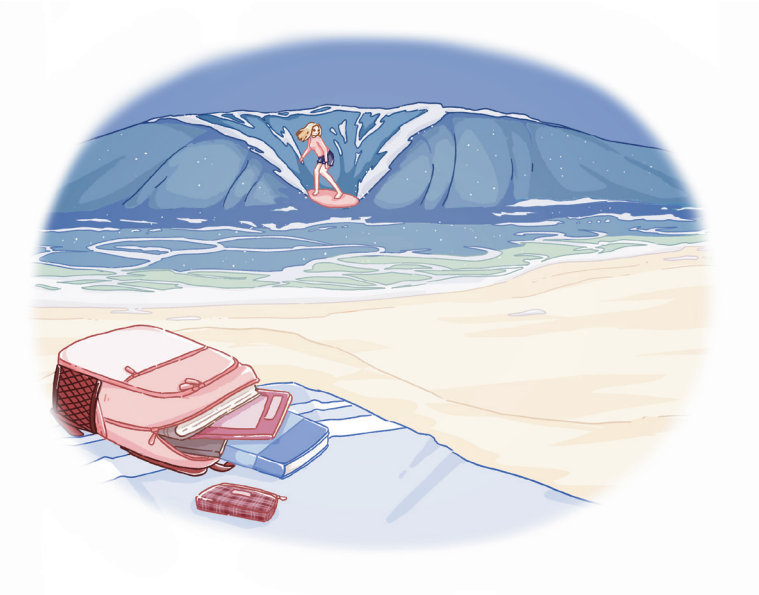
‘How do you know that, though?’ asked Zoe. ‘If we can’t see it then how will it stop the waves from destroying all the roads and houses behind the beach?’

‘I know because I’m a coastal engineer. I have been studying **erosion** along our beaches for a long time. The council has been building seawalls for years and years. See all the way along here,’ said the man, pointing up the beach at the sand dunes. ‘There are seawalls under those sand dunes. And, as you can see, the park and roads and houses behind the beach haven’t been washed away.’

This was a lot for Zoe to take in. Hidden seawalls? Coastal engineer? Someone did know how to protect the beaches … they were called coastal engineers. And, thought Zoe to herself, that sounds like a pretty good job for me.

Chapter 3

Zoe worked hard at high school and university, especially in Maths and Physics lessons, to become a coastal engineer. It wasn't all hard work though, as she could count time at the beach, surfing and relaxing, as time studying!



Through her engineering course, Zoe had a much better understanding of beaches and how they are always changing due to natural coastal processes and changing weather patterns.

Since that time at the beach, the council had built many more kilometres of seawalls, and she'd even worked on some of these projects, but still more needed to be done. Zoe was lucky enough to work for the City of Gold Coast (close to home, by the beach, early morning surfing before work started). Together

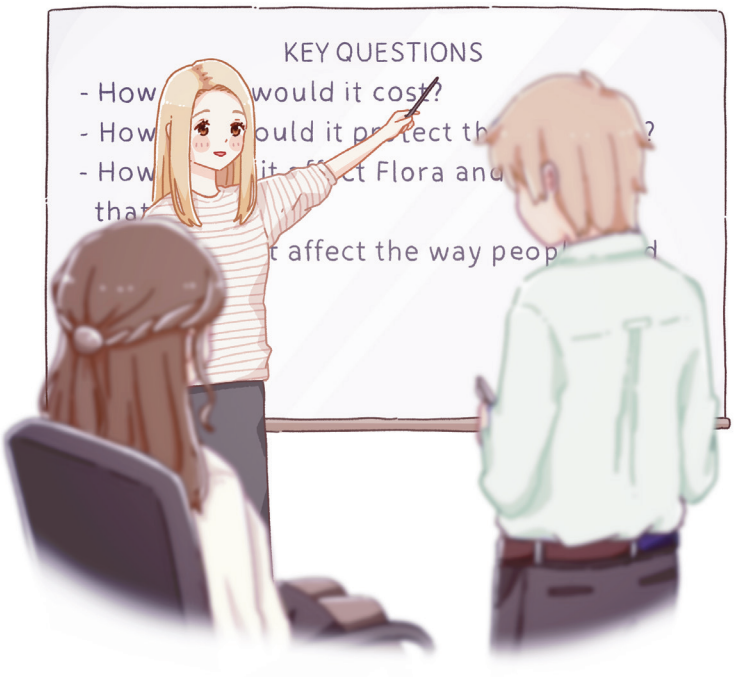
with a team of other engineers, she researched how to best protect the beaches and the beachfront properties, parks and roads close to the beach. Just like when she was young, she and her workmates came up with ideas they thought would work. Sometimes their research and investigations showed that their ideas wouldn't be very helpful or practical. Although disappointing, it was still useful to rule out the bad ideas so they could focus on creating better ones.

The seawalls had been a good idea and were very effective. Even though they protected the esplanade and the buildings along the coast, sand was still being eroded from time to time and sometimes needed a helping hand from the team of coastal engineers.

Chapter 4

One of Zoe's favourite places on the Gold Coast was Palm Beach. With Tallebudgera Creek on one side and Currumbin Creek on the other, it felt like a slice of paradise. However, Palm Beach was also one of the most eroded areas of the Gold Coast. This sometimes meant people couldn't use the beach because there wasn't enough sand. That also put the buildings along the foreshore at risk. She didn't want anything like what happened to the coastline in 1967 to happen again.

The council was also very concerned, so they assembled a team of experts – coastal engineers and scientists – to work together to come up with the best solution to help protect Palm Beach. Zoe was glad that she was a part of this team and looked forward to using all her coastal engineering knowledge and skills to protect this part of the Gold Coast.



One of the first steps to come up with a solution was to work out exactly what the project needed to do. The team came up with a list of questions:

• How much would it cost?

• How well would it protect the coastline?

• How would it affect the **fauna** and **flora** in that area?

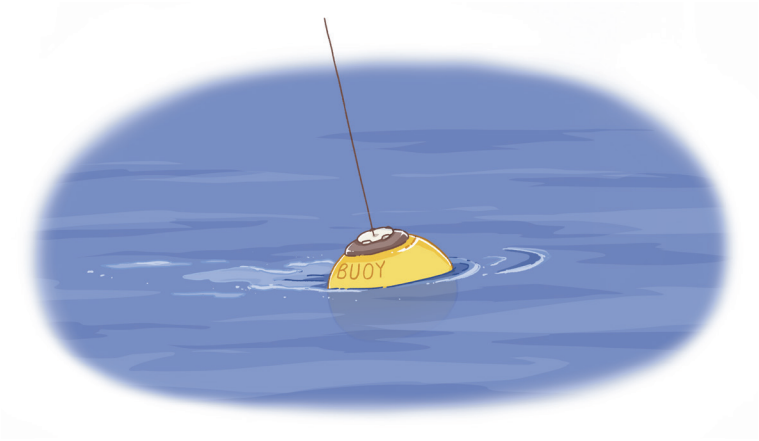
• How would it affect the way people used the beach?

Eventually, after brainstorming many ideas, Zoe and the expert team narrowed down their list of possible solutions to 18. 'Goodness,' thought Zoe, 'That is a lot of ideas. We'll need to do a lot more investigating to work out which of all these is the best one'.

Chapter 5

Zoe liked working in a team of experts. She knew that different people were good at different things, and in a team, it wasn't up to one person to come up with a solution. Some people knew a lot about waves, others knew a lot about sand dunes, others were great at researching, conducting experiments or using technology. Working together, the team had to find the best possible solution from the list. And it would take more than a simple internet search.

The team decided to use two methods of researching to find the best solution and a third one to help make sure that solution was perfect.

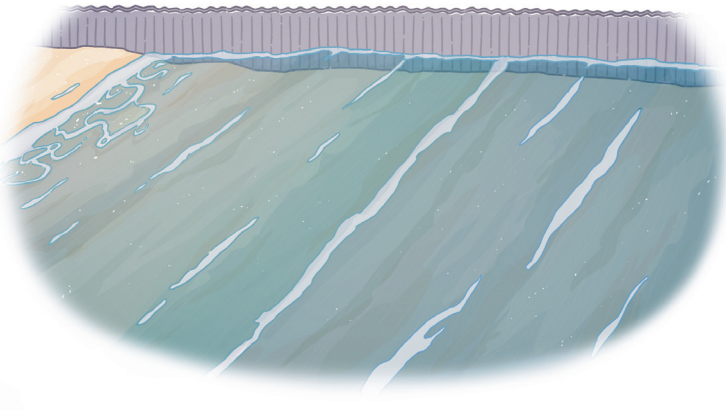


The first method was observation. This involved measuring the waves using wave buoys, mapping the shape of the beach, how it changed over time, and collecting lots of photographs. This was useful because the scientists could see and measure what was really happening on Palm Beach. However, this

method could only look at what had happened in the past. The team needed to predict what might happen to the beach in the future as well.

To gather this information, the team used a computer program that predicted what the beach might do as it continued to be hit by storms - a process called numerical **modelling**.

The team entered information about Palm Beach into the program, including a map of the Palm Beach coastline, **tide** levels and wave heights. The program was then able to calculate what might happen to the beach in the future in different kinds of weather and tidal situations. Zoe thought that predicting the future like this was pretty amazing.



The most interesting research method of all was the physical **modelling**. As part of a team, Zoe got to make a miniature version of Palm Beach in a big wave tank. Using a wave paddle, she created miniature waves to test different weather conditions and how it would impact the beach. Zoe loved building the miniature model of Palm Beach and watching the wave machine at work!

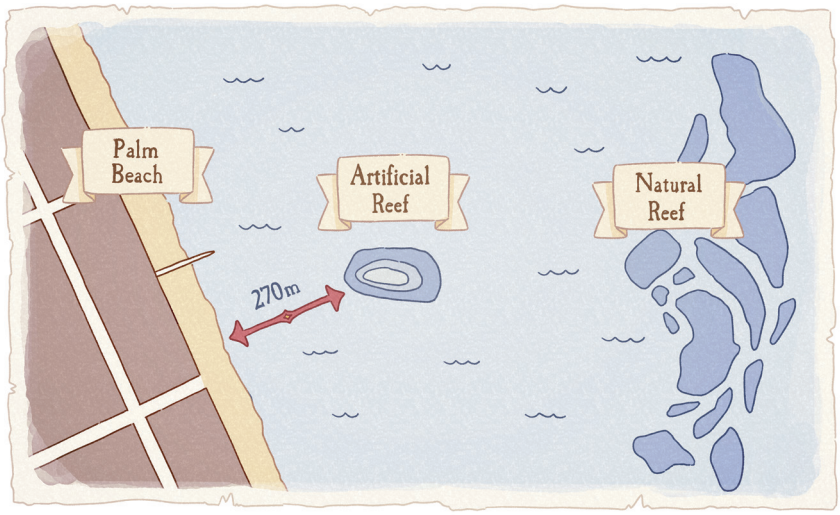
Chapter 6

Once the team looked at the data from the three research methods, they were sure they had the best option to protect Palm Beach from **erosion**, but it would require two steps.

First, lots of extra sand had to be pumped onto the seabed along the beach. And when the team said a lot of sand, they meant a lot of sand. 470,000 cubic metres - the equivalent of 188 Olympic-size swimming pools!

The second step was to build an artificial reef. Palm Beach already had a natural reef. By building their own reef, between the natural reef and the shoreline, it would change the waves and currents near the underwater structure to help sand stay at Palm Beach for longer. This would mean there would be plenty of sand for people to walk and play on, and enough to buffer the beach from big powerful storm waves. Council liked the team's solutions because it used natural materials and was hidden under the water - the Gold Coast residents and visitors would still enjoy the same views of their beloved beach.

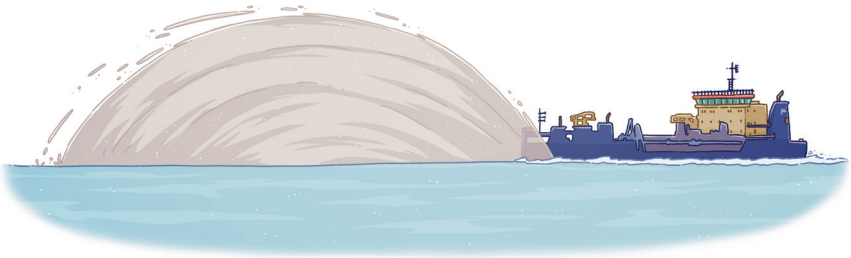
Zoe knew that although a big part of the overall project had been completed, the most challenging part was still to come, making the plans a reality. This would involve many more people and a lot more machinery and technology.



'This will be fun,' thought Zoe. 'What a great project for a coastal engineer to be involved in.'

Chapter 7

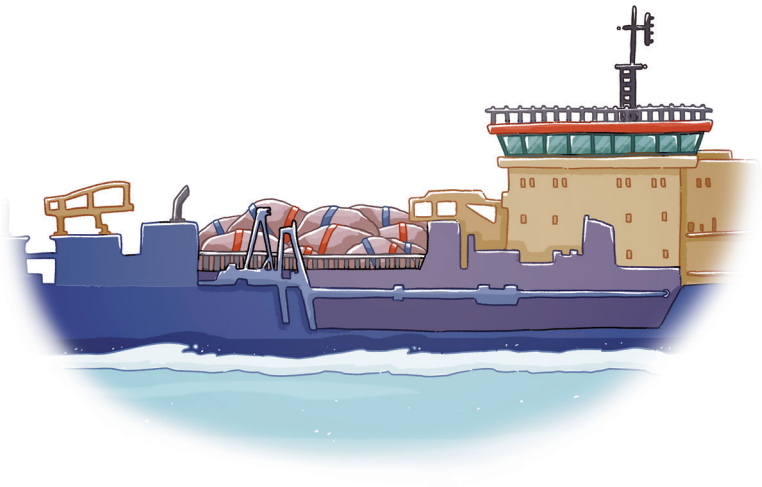
The first part of the project, or 'phase one', was certainly big in scale. The scientific name was 'sand nourishment'. Just like people are nourished and made healthy when they eat food and drink water, Palm Beach would be made healthy by being fed more sand. Standing on the beach, Zoe looked out to sea at a big boat named the *Balder R*.



Technically, it was called a trailing suction hopper dredger. This meant that the dredge was able to suck sand from deep out at sea, carry it on board, and then distribute it closer to shore. Sometimes Zoe could see sand being sprayed out of a large hose, in a process called rainbowing. The sand came out in a big arc like how a sprinkler spurts water. The other process was called 'bottom dumping' where the dredge dropped the sand out of the bottom of its **hull** in one big pile. The *Balder R* did this across different areas of Palm Beach so that the whole area could benefit.

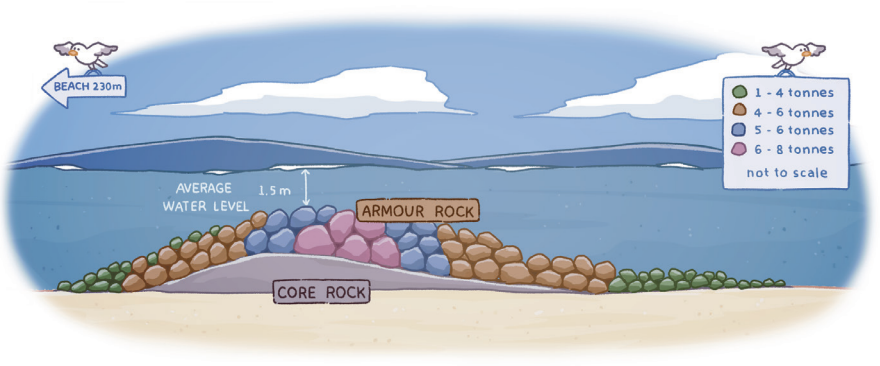
Chapter 8

Now, it was time to commence phase two, building the artificial reef. As a member of the expert team, Zoe had seen the design for the artificial reef. It would be built out of rocks and would be 160 metres long and 80 metres wide and high enough to sit 1.5 metres under the average water level. 'If we thought that moving 470,000 cubic metres of sand was challenging,' thought Zoe, 'Then 60,000 tonnes of rock needed to build the artificial reef is going to be much more difficult.' But, like many engineers, Zoe enjoyed finding solutions for big problems the most. She knew that the team would find a way.



And find a way they did! The team chose a combination of basalt and greenstone rock to build it with. The rocks had to be dug up from quarries in South East Queensland, transported by trucks, loaded onto boats at the Port of Brisbane and sailed south to Palm Beach. By road this would take about an hour

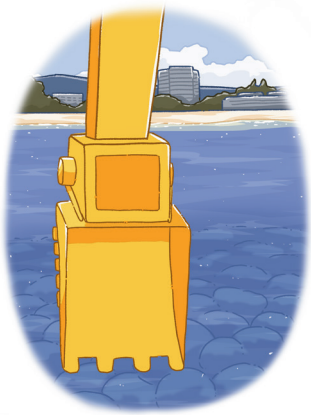
and a half. By sea this took many more hours! No wonder it was so tricky to build.



The design of the reef meant that they had to sort the rocks out into four different sizes: core rock, which weighed between 300 - 1000 kilograms each, and armour rocks, weighing from 1 tonne to 8 tonne each. Zoe knew that her car, a standard average-sized one, weighed almost 2 tonnes, so each of the largest rocks weighed almost 4 times as much as her own car! How she enjoyed being part of this amazing project!

Chapter 9

The best days for Zoe on this unusual engineering project were when she was able to work at sea at the site of the artificial reef. She could see the tug boats pulling the split hopper barges into position right above the artificial reef site, then, at the direction of the captain, the **hull** of the barge opened, and the cargo of rocks tumbled out onto the seafloor, near to where the expert team wanted them.



Then a big marine excavator, called a backhoe dredger, would pick up the rocks and move them into their exact position using **GPS** technology – this uses satellites in the sky to pinpoint exact locations in real time. This was very clever as the dredge operator was able to see the seafloor level and the artificial reef design levels on a screen to shift the 8 tonne of rocks exactly where they had to go. Zoe was really pleased that this project involved so many different people with so many different skills. There was no way that one person could think up all these solutions to this **erosion** problem.

Chapter 10

Finally, after many months, the artificial reef was finished. Zoe calculated that by the time it was complete, the artificial reef was almost as big as the nearby AFL football stadium, and that venue had enough room for a football oval and 40,000 people. If Zoe could get people to imagine what the stadium would look like full of rocks, then she could get them to understand just how big the artificial reef was and how much teamwork, research, designing and building it took to create.

Zoe enjoyed the official opening of the artificial reef, which was recognised with a plaque at Nineteenth Avenue. She was proud of having worked with a team of such talented scientists, engineers, barge and dredge machine operators, and the many other experts who worked together to build the reef. Zoe was happier still when she was given a role of monitoring the artificial reef. She knew that it was very important when building a big structure like an artificial reef to make sure that it did what it was designed to do and to check it wasn't causing any damage to the environment.

Chapter 11

Zoe knew that she would have to use technology to monitor the reef, just as they used it to build the reef. Although Zoe really loved spending time at the beach, she couldn't just check the reef by diving or snorkelling around it. It may have been useful in some ways, but the Council couldn't just rely on her describing what the reef looked like. Very slowly, over time, the rocks would move tiny amounts as they settled into place. There was no way Zoe could spend enough time in the water to see if any of the 60,000 tonnes of rock had shifted. She had to find other options.

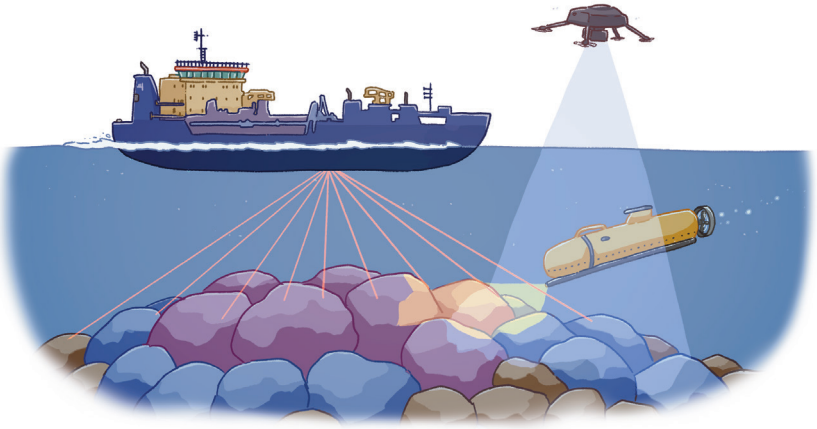
Working with some of the same experts who had built the reef, Zoe and the team decided that three forms of technology would be very useful in monitoring it:

1) An airborne drone

2) An underwater remote-operated vehicle, and

3) Multi-beam **hydrographic survey** data.

From the air, the drone was able to inspect the reef from the top down, looking at how the waves broke over the artificial reef and ensuring no rocks had moved. The underwater vehicle could get a closer look where the drone could not see. Finally, the multi-beam **survey** data could measure the levels of the rock and compare it with the design, to check for any rock movements with even more precision. Using these three together ensured that the team would always be confident the structure was safe and sound.

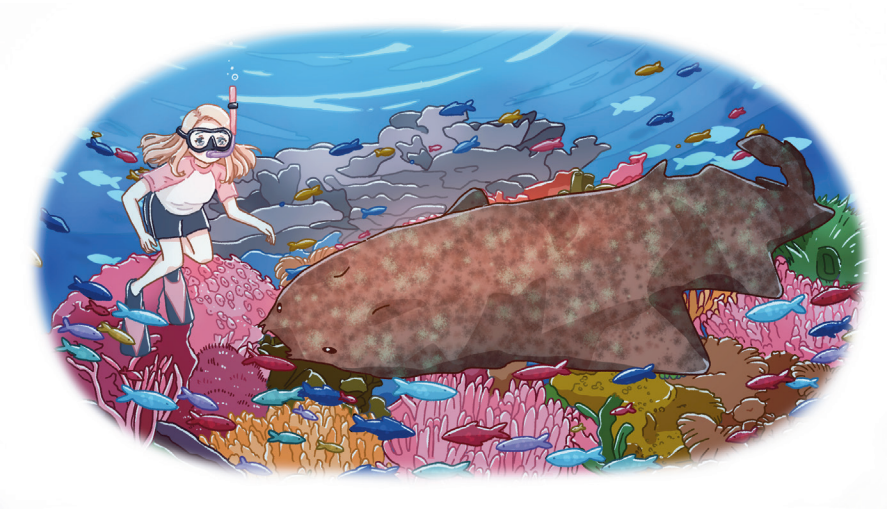


Working with the local university, Zoe and her team were also able to measure how well the artificial reef was protecting the coast, how the reef affected how people used the beach and whether it made it more or less safe to swim. Zoe was very relieved that the first report on the data found that the coastline was more protected than before. It was rewarding to see beach users continuing to enjoy the beach. Zoe was really pleased that the surfers found the waves to be even better to ride than before.

This feedback was so interesting that the council sought even more research on the waves by using remote camera technology. Zoe thought that Palm Beach might soon be the most monitored and researched beach on the Gold Coast, or Queensland, or even the world! She was pleased that all this researching and investigation would help to make sure that Palm Beach was more protected, but also that scientists and coastal engineers around the world would be able to use the information that they created to protect their own beaches.

Chapter 12

One day, many months after the artificial reef was completed, Zoe went out to visit it. She loved snorkelling, and decided it was a good time to swim around the reef. Zoe remembered all the rocks that she saw on the boats before they were dropped into the reef zone. It was even more exciting for Zoe to see that instead of bare rock, the reef was now covered in many kinds of marine plants, which helped to feed and house the thousands of small fish that now lived there. Zoe even saw a crab peering out from under a boulder and caught a glimpse of a wobbegong shark as it swam past her.



As Zoe snorkelled around the reef, she was delighted that she had become a coastal engineer. Beaches were still her absolute favourite place to be, and she was pleased and proud to have a job where she could help to protect them.

Glossary

erosion	(n) the process by which the surface of something is gradually destroyed through the action of wind, rain, etc.
fauna	(n) all the animals living in an area or in a particular period of history
flora	(n) the plants of a particular area, type of environment or period of time
GPS	(n) Global Positioning System. A system by which signals are sent from satellites to a special device, used to show the position of a person or thing on the surface of the earth very accurately
hull	(n) the main, bottom part of a ship, that goes in the water
hydrographic	(adj) of or relating to the features of bodies of water
lashed	(v past tense) to hit something forcefully
modelling	(n) the work of making a simple description of a system or a process that can be used to explain it
survey	(n) the act of examining and recording the measurements, features, etc., of an area of land or sea in order to make a map or plan of it
tide	(n) a regular rise and fall in the level of the sea, caused by the pull of the moon and the sun; the flow of water that happens as the sea rises and falls

Glossary definitions sourced from
https://www.oxfordlearnersdictionaries.com/

Activities

Chapter 1

The author used the word '**lashed**' to describe the cyclones of 1967. Why might '**lashed**' be a good description of a cyclone? Write 3 – 5 other verbs that might be a good description of what a cyclone does?

Chapter 2

Why do you think the idea of becoming a coastal engineer appealed to Zoe?

Chapter 5

According to the author, it is best to work in a team with people who are good at different things. Do you agree with the author? Why or why not?

Chapter 11

In what ways did Zoe know that building the reef had been a success?

Discuss

What kind of tasks did Zoe perform in her job as a coastal engineer?

What kind of skills did Zoe use to help solve the problem?

Are there any aspects of Zoe's job you think you would like to do?

Queensland beaches are the best, but what can be done when large waves and tides put the beach and coastal towns at risk? What can Zoe do to slow the erosion of a Gold Coast beach?

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