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ATOM
AUSTRALIAN TEACHERS OF MEDIA

A STUDY GUIDE BY
DAVE CREWE

Synopsis

Young marine scientist Anna Cresswell, aboard mini-submersible Odyssea, embarks on a remarkable voyage into the labyrinth of Western Australia's iconic Ningaloo Reef in search of its key to life.

Framing Australia's remote Cape Range Peninsula and growing close along its shoreline, Ningaloo Reef is one of the longest fringing reefs on the planet. It is also listed as a World Heritage Site for its beauty and environmental significance; therefore its conservation is paramount.

Travelling with Anna and Odyssea deep into this underwater wonderland is like floating through an exquisite dream – one filled with unearthly coral formations and exotic marine life. Ningaloo has one of the most diverse and complex ecosystems ever discovered – every species has a place in the food chain and a role to play in maintaining the balance of life on the reef.

Anna's mission is to witness the annual, synchronised, mass coral spawning. Governed by the lunar cycle, this is one of the natural world's most mysterious and spectacular reproductive events. For Anna, studying this phenomenon may provide answers to the threat of climate change faced by coral reefs around the world.

The annual mass coral spawning heralds the arrival of one of the largest aggregations of the world's biggest fish. Whale sharks, the 'gentle giants of the sea', come to feed on krill. The krill, tiny shrimp-like crustaceans, swarm to feast on blooming microscopic plant life, fertilised by the large amounts of organic matter left in the water after the spawning.

On Ningaloo everything is interconnected in a web of life woven through the reef. The annual mass coral spawning Anna has come to witness is the foundation of this world and the place where life on the reef begins.

CONTENT HYPERLINKS

Background

» Ningaloo Reef

STRETCHING UP TO 300 KILOMETRES ALONG THE WESTERN COAST OF AUSTRALIA, NINGALOO REEF IS ONE OF THE WORLD'S LONGEST FRINGING REEFS AND HOME TO AN EXTRAORDINARY DIVERSITY OF LIFE. PART OF THE WORLD HERITAGE-LISTED NINGALOO COAST, NINGALOO REEF IS HOME TO OVER 500 SPECIES OF FISH AND MORE THAN 340 SPECIES OF CORAL. IT IS ALSO FAMOUS FOR ITS ANNUAL MASS GATHERING OF THE LARGEST FISH IN THE SEA – THE WHALE SHARK.

THE ARRIVAL OF THESE 'GENTLE GIANTS' IN MARCH EACH YEAR COINCIDES WITH ONE OF NATURE'S MOST SPECTACULAR EVENTS: MASS CORAL SPAWNING. GOVERNED BY THE MOON, MILLIONS OF INDIVIDUAL CORAL POLYPS SPAWN TOGETHER ALONG THE ENTIRE LENGTH OF THE REEF AT EXACTLY THE SAME TIME. THE SUCCESS OF THIS ANNUAL REPRODUCTIVE PHENOMENON IS CRUCIAL FOR THE HEALTH AND REGENERATION OF NINGALOO REEF. IN THE FUTURE, IT MAY ALSO HELP SCIENTISTS PROTECT CORAL REEFS AROUND THE WORLD AGAINST THE RAVAGES OF CLIMATE CHANGE.

» Odyssea

ODYSSEA IS A SPECIALIST-DESIGNED SUBMERSIBLE THAT ENABLES A PILOT AND ONE PASSENGER TO DESCEND BELOW THE OCEAN'S SURFACE TO THE MAXIMUM DEPTH OF 200 METRES. IT IS 5 METRES IN LENGTH, 2.5 METRES IN HEIGHT, AND 3.2 TONNES IN WEIGHT. ODYSSEA OFFERS A UNIQUE OPPORTUNITY TO VIEW FROM A 250-DEGREE PERSPECTIVE AND CAPTURE THE MARINE WORLD WITH ITS 200-DEGREE 4K CAMERAS AS RARELY SEEN BEFORE. THE THICK, ACRYLIC, DOMED CABIN CREATES A SAFE, 1-ATMOSPHERE ENVIRONMENT. THE CABIN OPENS AS A CLAMSHELL AND ALLOWS FOR EASY ENTRY AND EXIT FOR THE OCCUPANTS. ODYSSEA HAS A MAXIMUM MISSION-DIVE TIME OF EIGHT HOURS AND A LIFE-SUPPORT SYSTEM OF UP TO SEVENTY-TWO HOURS.

» Anna Creswell, MARINE BIOLOGIST

Tasmanian born, 27-year-old Anna is a final-year PhD scholar at the University of Western Australia. As part of the BHP-CSIRO Ningaloo Outlook Project, Anna studies the fish and coral of Ningaloo Reef and how they respond to climatic and other disturbances. Anna graduated from the University of Tasmania with a Bachelor of Science in Applied Mathematics and Zoology, with Honours in Marine Science, and has received an impressive list of accolades to date.

These include three scholarships to support her studies so far, four listings on the University of Tasmania Dean's Roll of Excellence and two recent student presentation awards at conferences, including for her presentation on the Ningaloo Marine Park at the 2018 Australian Coral Reef Society Conference, held in Exmouth, WA.

Anna's substantial field experience and skills in mathematical modelling, along with her lifelong love of the ocean, has earned Anna recognition within the Australian marine science field. Anna came aboard mini-submersible Odyssea in 2018 as the marine scientist for Prospero Productions' daring voyage into the labyrinth of Ningaloo Reef.

» Luke Hewitt, NARRATOR

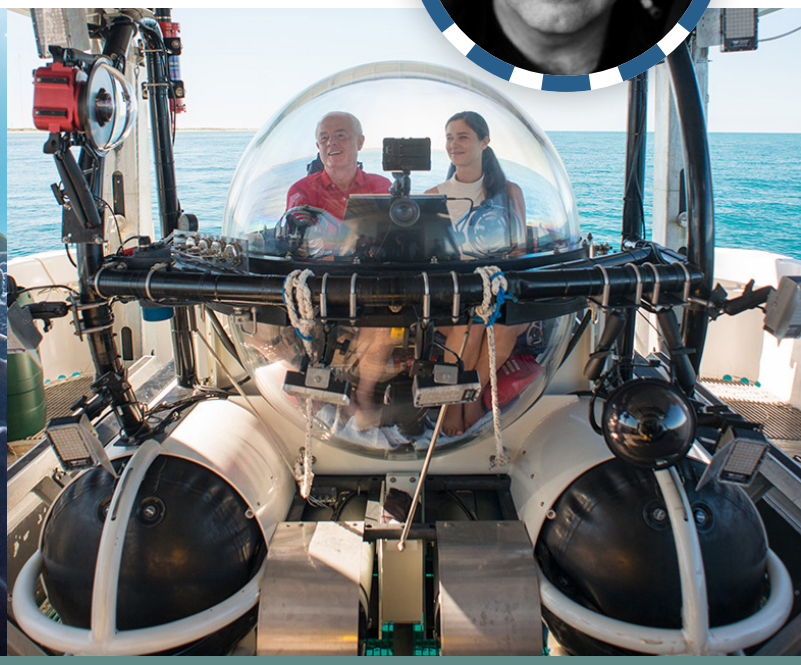
Winner of the Perth Theatre Trust / Equity Guild Award for Best Actor in both 2008 and 2009, and nominated again in 2010 and 2013, Luke has been acting professionally in Perth for more than twenty years.

Luke made his debut in *1959 Pink Thunderbird Convertible* (Eureka! Productions) at Swy Theatre in 1993. Since then Luke has gone on to work with the majority of theatre companies in Perth and toured around Australia and internationally.

Recent credits include *Taking Liberty* and a three-month national tour of *Krakouer!* (Deckchair Theatre), *Boundary Street*, *A Midsummer Night's Dream*, *12th Night*, *Much Ado About Nothing* (Black Swan State Theatre Company), *Cyrano de Bergerac* (BSSTC and Happy Dagger), *An Oak Tree*, *Speed the Plow* (Perth Theatre Company), *Wonderlands* (Deckchair Theatre), *Love Me Tender* (Thin Ice / Griffin Theatre, Sydney) and he played Jerry Hall's husband, Mr Robinson, in *The Graduate* at His Majesty's Theatre.

Luke has had roles in feature films *Two Fists, One Heart*, *Stone Bros*, and *Crush*. Many may also recognise Luke from kids' TV series *Street Smart*, *Parallax* and *Wormwood*, along with commercials for Lotterywest and Booze Buses.

Luke has also had a successful career as a voice-over artist for many years, lending his talents to countless programs including *Serangoon Road* (Series ABC / HBO Asia), *The War That Changed Us* (Series ABC), Australia's *Outback Truckers* Series 1–3 (7mate), *Cloudstreet* mini-series, ABC's *Constructing Australia: Pipe Dreams*, *Streetsmartz*, *Parallax*, *Wormwood*, *Bush Patrol* and *Ship to Shore*.



» Russell Vines, DIRECTOR

Russell Vines is a producer, director and writer. Over the last twenty years he has worked across documentary, drama and various other factual formats.

Recent work includes producing, writing and directing the four-part factual format Shaun Micallef's *Stairway to Heaven* (Artemis International) for SBS-TV and producing *Railroad Australia* (Prospero Productions), a thirteen-part documentary series for Discovery Channel.

Other highlights include producing the critically acclaimed blockbuster telemovie *The Great Mint Swindle*; directing the AACTA award-winning documentary series *Search for Warriors* (Prospero Productions) about Australia's special forces SAS regiment; and producing National Geographic's *Life On The Edge* (Prospero Productions), a series on the circumnavigation of Australia by land, sea and submarine.

Russell directed the feature-length dramatised documentary *The Waler, Australia's Great War Horse* (Margo Films) about the horses and men of the famous Australian Light Horse Units during World War I. He has also directed numerous instalments of *Who Do You Think You Are?* (Artemis International) including episodes about Geoffrey Rush and John Butler.

Curriculum Links

Ningaloo: Australia's Other Great Reef is suitable for students undertaking

- **Science (Years 6–10, with applications in Senior Science courses);**
- **Geography (Years 7–10);**
- **Design and Technologies (Years 7–10);**
- **Media Arts (Years 7–10);**

with further links to Mathematics (Year 10) and the cross-curricular priority of Sustainability.

The sub-activities found under the 'Coral Reefs' heading centre largely on Science and Geography curriculum links, though elements of these curricula can be found in other sub-activities in this study guide.

As a curriculum resource in Science, *Ningaloo: Australia's Other Great Reef* is primarily relevant to the biological sciences content of Science Understanding, with applications in Earth and space science content. Investigations and observations suggested by the program allow students to develop their Science Inquiry skills, while connections to questions of sustainability and conservation ensures that this resource is also applicable to the Science as a Human Endeavour strand.

As a curriculum resource in Geography, *Ningaloo: Australia's Other Great Reef* is primarily relevant to the strand of Geographical Knowledge and Understanding, with specific links to unit 'Water in the World' in Year 7 and unit 'Environmental Change and Management' in Year 10. The questions of conservation and human intervention also present students with the opportunity to demonstrate the qualities described in the geographical inquiry and skills descriptor of this subject.

The sub-activities found under the 'Submersibles' and 'Filming Underwater' headings centre largely on Design and Technologies and Media Arts curriculum links, though also incorporate some Science descriptors.

As a curriculum resource in Design and Technologies, *Ningaloo: Australia's Other Great Reef* is relevant to the Knowledge and Understanding strand. In Media Arts, the program provides the opportunity for students to explore technical and symbolic elements in the context of fulldome documentary. Note that while most sub-activities can be commenced after viewing the film, 'Storyboarding for Fulldome' is best introduced beforehand.

Teachers are advised to consult the Australian Curriculum online at <https://www.australiancurriculum.edu.au> and curriculum outlines relevant to their state or territory for further information.

RELEVANT CONTENT DESCRIPTORS FOR MEDIA ARTS

	CONTENT DESCRIPTIONS
Years 7–8	Experiment with the organisation of ideas to structure stories through media conventions and genres to create points of view in images, sounds and text. ACAMAM066
	Analyse how technical and symbolic elements are used in media artworks to create representations influenced by story, genre, values and points of view of particular audiences. ACAMAR071
	Identify specific features and purposes of media artworks from contemporary and past times to explore viewpoints and enrich their media arts making, starting with Australian media artworks including of Aboriginal and Torres Strait Islander media artworks. ACAMAR072
Years 9–10	Experiment with ideas and stories that manipulate media conventions and genres to construct new and alternative points of view through images, sounds and text. ACAMAM073
	Evaluate how technical and symbolic elements are manipulated in media artworks to create and challenge representations framed by media conventions, social beliefs and values for a range of audiences. ACAMAR078
	Analyse a range of media artworks from contemporary and past times to explore differing viewpoints and enrich their media arts making, starting with Australian media artworks, including media artworks of Aboriginal and Torres Strait Islander Peoples, and international media artworks. ACAMAR079

RELEVANT CONTENT DESCRIPTORS FOR SCIENCE

SCIENCE UNDERSTANDING	
Year 6	**Biological sciences:** The growth and survival of living things are affected by physical conditions of their environment. ACSSU094
	Earth and space science: Sudden geological changes and extreme weather events can affect Earth's surface. ACSSU096
Year 7	**Biological sciences:** Interactions between organisms, including the effects of human activities can be represented by food chains and food webs. ACSSU112
	Earth and space science: Some of Earth's resources are renewable, including water that cycles through the environment, but others are non-renewable. ACSSU116
Year 9	**Biological sciences:** Ecosystems consist of communities of interdependent organisms and abiotic components of the environment; matter and energy flow through these systems. ACSSU176
Year 10	**Earth and space sciences:** Global systems, including the carbon cycle, rely on interactions involving the biosphere, lithosphere, hydrosphere and atmosphere. ACSSU189

SCIENCE AS A HUMAN ENDEAVOUR	
Year 6	**Use and influence of science:** Scientific knowledge is used to solve problems and inform personal and community decisions. ACSHE100
Year 7	**Use and influence of science:** Solutions to contemporary issues that are found using science and technology, may impact on other areas of society and may involve ethical considerations. ACSHE120
Year 9	**Use and influence of science:** Values and needs of contemporary society can influence the focus of scientific research. ACSHE228
Year 10	**Use and influence of science:** Values and needs of contemporary society can influence the focus of scientific research. ACSHE230

SCIENCE INQUIRY SKILLS	
Year 6	**Communicating:** Communicate ideas, explanations and processes using scientific representations in a variety of ways, including multi-modal textsACSIS110
Year 7	**Communicating:** Communicate ideas, findings and evidence based solutions to problems using scientific language, and representations, using digital technologies as appropriateACSIS133
Year 9	**Evaluating:** Critically analyse the validity of information in primary and secondary sources and evaluate the approaches used to solve problemsACSIS172
	Communicating: Communicate scientific ideas and information for a particular purpose, including constructing evidence-based arguments and using appropriate scientific language, conventions and representationsACSIS174
Year 10	**Evaluating:** Critically analyse the validity of information in primary and secondary sources and evaluate the approaches used to solve problemsACSIS206
	Communicating: Communicate scientific ideas and information for a particular purpose, including constructing evidence-based arguments and using appropriate scientific language, conventions and representationsACSIS208

KNOWLEDGE AND UNDERSTANDING	
Years 7–8	Investigate the ways in which products, services and environments evolve locally, regionally and globally and how competing factors including social, ethical and sustainability considerations are prioritised in the development of technologies and designed solutions for preferred futures. ACTDEK029
	Analyse how motion, force and energy are used to manipulate and control electromechanical systems when designing simple, engineered solutions. ACTDEK031
Years 9–10	Investigate and make judgments on how the characteristics and properties of materials are combined with force, motion and energy to create engineered solutions. ACTDEK043
	Investigate and make judgments, within a range of technologies specialisations, on how technologies can be combined to create designed solutions. ACTDEK047

RELEVANT CONTENT DESCRIPTORS FOR GEOGRAPHY

	KNOWLEDGE AND UNDERSTANDING
Year 7	Classification of environmental resources and the forms that water takes as a resource. ACHGK037
	Economic, cultural, spiritual and aesthetic value of water for people, including Aboriginal and Torres Strait Islander Peoples and peoples of the Asia region. ACHGK041
	Causes, impacts and responses to an atmospheric or hydrological hazard. ACHGK042
Year 10	Human-induced environmental changes that challenge sustainability. ACHGK070
	Environmental world views of people and their implications for environmental management. ACHGK071
	The application of systems thinking to understanding the causes and likely consequences of the environmental change being investigated. ACHGK073
	The application of geographical concepts and methods to the management of the environmental change being investigated. ACHGK074

	GEOGRAPHICAL INQUIRY AND SKILLS
Year 7	**Collecting, recording, evaluating and representing:** Represent spatial distribution of different types of geographical phenomena by constructing appropriate maps at different scales that conform to cartographic conventions, using spatial technologies as appropriate. ACHGS050
	Communicating: Present findings, arguments and ideas in a range of communication forms selected to suit a particular audience and purpose; using geographical terminology and digital technologies as appropriate. ACHGS053
	Reflecting and responding: Reflect on their learning to propose individual and collective action in response to a contemporary geographical challenge, taking account of environmental, economic and social considerations, and predict the expected outcomes of their proposal. ACHGS054
Year 10	**Collecting, recording, evaluating and representing:** Represent spatial distribution of geographical phenomena by constructing special purpose maps that conform to cartographic conventions, using spatial technologies as appropriate. ACHGS075
	Communicating: Present findings, arguments and explanations in a range of appropriate communication forms, selected for their effectiveness and to suit audience and purpose; using relevant geographical terminology, and digital technologies as appropriate. ACHGS079
	Reflecting and responding: Reflect on and evaluate findings of an inquiry to propose individual and collective action in response to a contemporary geographical challenge, taking account of environmental, economic, political and social considerations; and explain the predicted outcomes and consequences of their proposal. ACHGS080

RELEVANT CONTENT DESCRIPTORS FOR MATHEMATICS

	CONTENT DESCRIPTIONS
Year 10	**Linear and non-linear relationships:** Apply understanding of polynomials to sketch a range of curves and describe the features of these curves from their equation. ACMNA268
	Pythagoras and trigonometry: Use the unit circle to define trigonometric functions, and graph them with and without the use of digital technologies. ACMMG274]
	Pythagoras and trigonometry: Solve simple trigonometric equations. ACMMG275

CROSS-CURRICULAR PRIORITIES UNDER THE SUSTAINABILITY HEADING

- The biosphere is a dynamic system providing conditions that sustain life on Earth.
- All life forms, including human life, are connected through ecosystems on which they depend for their wellbeing and survival.
- Sustainable patterns of living rely on the interdependence of healthy social, economic and ecological systems.
- World views that recognise the dependence of living things on healthy ecosystems, and value diversity and social justice, are essential for achieving sustainability.
- World views are formed by experiences at personal, local, national and global levels, and are linked to individual and community actions for sustainability.
- The sustainability of ecological, social and economic systems is achieved through informed individual and community action that values local and global equity and fairness across generations into the future.
- Actions for a more sustainable future reflect values of care, respect and responsibility, and require us to explore and understand environments.
- Designing action for sustainability requires an evaluation of past practices, the assessment of scientific and technological developments, and balanced judgements based on projected future economic, social and environmental impacts.
- Sustainable futures result from actions designed to preserve and/or restore the quality and uniqueness of environments.

Coral Reefs

» The Other Great Reef

As the subtitle of *Ningaloo: Australia's Other Great Reef* suggests, Ningaloo Reef plays second fiddle to the beacon of Australian natural wonder – the Great Barrier Reef. But this comparison should do nothing to dull the majesty of Ningaloo. As explained by narrator Luke Hewitt, 'World Heritage Listed, Ningaloo is considered one of the most outstanding natural places ever discovered.'

THE IMPORTANCE OF NINGALOO REEF

As a group, prepare a presentation identifying the importance of the Ningaloo Reef to some or all of the following. You may wish to assign different topics to each group member.

- **The health of the surrounding ocean region**
- **The condition of nearby coastlines**
- **The atmosphere**
- **Australia's fishing industry**
- **Australia's tourism industry**

There are plentiful resources online about how coral reefs protect coastlines; this website is a useful starting point: <https://web.stanford.edu/group/microdocs/howreefs.html>.

Mapping the Reef

Ningaloo Reef is described as 'one of the largest fringing reefs on the planet.' What is a fringing reef? Draw a map of the Ningaloo Reef, identifying its key geographical features.

HERITAGE LISTING

The Ningaloo Reef was bestowed with World Heritage listing status on 24 June 2011, thanks to its 'natural beauty and biological diversity.'

- What does it mean for a location to be included on the World Heritage List?
- What other prominent places in Australia are World Heritage-listed?
- What qualifies a location to join the World Heritage List? Research the criteria required and the process involved in nominating a location.

As explained at <http://ningaloo-atlas.org.au/node/200/>, the Ningaloo Reef was nominated for World Heritage listing based on the following three criteria:

CRITERION (VII) to contain superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance. **CRITERION (VIII)** to be outstanding examples representing major stages of earth's history, including the record of life, significant on-going geological processes in the development of landforms, or significant geomorphic or physiographic features. **CRITERION (X)** to contain the most important and significant natural habitats for in-situ conservation of biological diversity, including those containing threatened species of outstanding universal value from the point of view of science or conservation.

Choose one of these three criteria and write a one-page letter directed to the World Heritage List committee explaining how Ningaloo Reef meets this criterion, including properly sourced evidence and full justification.

Marine mammals	Birds	Marine turtles	Crocodile
Sea snakes	Sharks	Rays	Echinoderms
Crustaceans	Molluscs	Hard coral	Soft coral
Sea anemones	Jellyfish	Sponges	Fishes

(Adapted from <http://www.gbrmpa.gov.au/about-the-reef/animals/>)

» Reef Dwellers

Ningaloo: Australia's Other Great Reef **asserts that 'Coral reefs are home to more species of life than all of Earth's rainforests combined', and while that might be a touch contentious, the biodiversity of every rainforest on Earth combined likely eclipses a single coral reef – coral reefs certainly boast the highest biodiversity of any ecosystem on the planet. According to WiseOcean, <https://www.wiseoceans.com/seasense/coral/>, '32 of the 34 recognised animal Phyla are found on coral reefs compared to only 9 Phyla in tropical rainforests.'**

BIODIVERSITY

During Anna Cresswell's dive into the Ningaloo Reef, she encounters a small sample of the diverse animals found in the region: whale sharks ('the biggest fish in the sea'), humpback whales, sea cucumbers, lionfish and manta rays ('the angels of the sea'), among others.

Research the Ningaloo Reef (or coral reefs in general) to develop an understanding of the biodiversity of the reef; in other words, the number of different species that live in and around the reef. The following resources may prove useful:

- https://coral.org/coral-reefs-101/coral-reef-ecology/coral-reef-biodiversity/
- https://www.coral-reef-info.com/coral-reef-plants.html
- https://www.mirg.org.au/Docs/Sample-of-Part3-Life%20on%20the%20Reef-4pp.pdf

How many species are estimated to live on the Ningaloo Reef? How does this compare to other coral reefs around the world?

Create a poster or presentation featuring the different species found on the Ningaloo Reef. You may wish to use the categories (top of this page, right) as a guide.

THE NINGALOO ECOSYSTEM

Everything is playing a role here on the reef, so it all fits together in a complex ecosystem. Like this rough-back stingray. Looking for food, they also churn up sediment, which resupplies the water with nutrients. – Anna Creswell

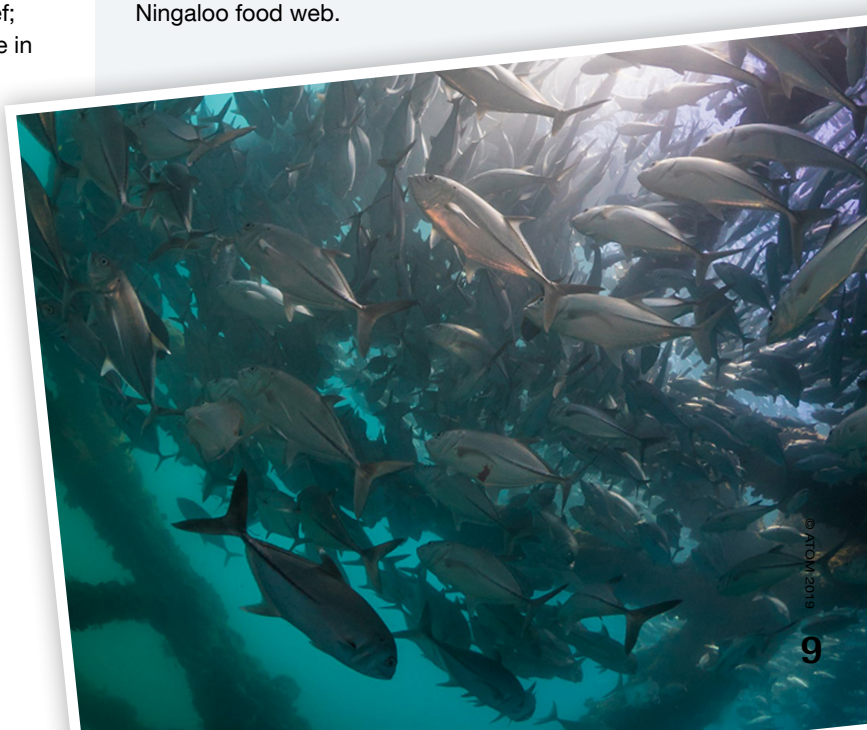
Having completed the 'Biodiversity' sub-activity, identify some key interactions between these species and the ecosystem they exist within. How do these organisms rely on one another for their survival?

This resource may assist: <https://www.livingoceansfoundation.org/science/coral-ecology/>

Complete the National Geographic activity at <https://www.nationalgeographic.org/media/coral-reef-food-web/> to identify the following in a coral reef like Ningaloo:

- **The primary producers**
- **First-order consumers**
- **Intermediate predators**
- **Top predators**
- **Decomposers**

Use this information to produce a visual representation – drawn by hand or using graphical software – of the Ningaloo food web.



» The Coral Life Cycle

Anna Cresswell describes corals as 'like alien life forms,' explaining that while 'they look like plants, [they] are in fact lots of tiny animals living together called polyps.' Corals are certainly fascinating organisms, from their individual features to their lunar life cycles, and worthy of further study.

CORAL FEATURES

Enter the definition of the key terminologies associated with coral in the table below. Use or reference a dictionary as necessary:

polyp	
algae	
digest	
calcium carbonate	
veneer	
symbiont	
photosynthesise	

Having completed the table, produce a diagram or write a short paragraph in your own words explaining the relationship between the 'colonial' cells that make up a coral.

This is an example of 'symbiosis' – a mutually beneficial interaction between two organisms. Research another example of a symbiotic relationship between organisms. You may find this *Cosmos Magazine* article helpful: <https://cosmosmagazine.com/social-sciences/symbiosis-when-living-together-win-win/>

CORAL SPAWNING

In *Ningaloo: Australia's Other Great Reef,* Anna Cresswell describes coral spawning as 'one of nature's greatest events.'

Research the phenomenon of coral spawning in order to answer the following questions:

- Why do corals collectively spawn at the same time?
- How do the seasons of the moon and tides affect coral reproduction?
- How reliably can coral spawning be predicted?
- Research when the last coral spawning occurred on the Ningaloo Reef, and use this information to predict when the next coral spawning will occur.
- Corals are hermaphroditic. What does 'hermaphroditic' mean, and what might be the reproductive advantages associated with hermaphroditic species?

Useful links:

- http://www.gbrmpa.gov.au/about-the-reef/corals/coral-reproduction/
- https://oceanservice.noaa.gov/facts/coralmadeof.html
- https://www.australiangeographic.com.au/topics/wildlife/2017/11/coral-spawning-a-rare-natural-wonder/
- https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4878369/

You can use tide data for the Ningaloo Reef by referring to the data for Exmouth at the Australian Government Bureau of Meteorology Tide Tables website (<http://www.bom.gov.au/oceanography/projects/ntc/wa_tide_tables.shtml>).

CORAL BLEACHING

As chronicled in *Ningaloo: Australia's Other Great Reef*, coral is far from immune to the ecological challenges brought on by climate change. We bear witness to a field of dying coral, bleached white.

Use this National Oceanic and Atmospheric Administration (NOAA) resource – <https://oceanservice.noaa.gov/facts/coral_bleach.html> – along with the section of *Ningaloo: Australia's Other Great Reef* focusing on coral bleaching to answer the following questions:

- What is coral bleaching?
- Why does bleached coral lose its colour?
- What is mesentery, and what role does it play in coral bleaching?
- Is a bleached coral dead?
- Coral bleaching is typically caused by higher temperature. Can anything else trigger bleaching?

'A heat wave caused the coral to shed the algae, which provide it with important nutrients. And once this happens, most coral will slowly die. And then, once dead, all the life it supported will either leave or die, too.' – Anna Creswell

Write a report measuring the impact of coral bleaching in Ningaloo Reef on the surrounding ecosystem, and extrapolate this to consider the effects – both in terms of the health of the wider ocean ecosystem and the Australian economy.

Useful links:

- https://www.carbonbrief.org/great-barrier-reef-at-unprecedented-risk-of-collapse-after-major-bleaching-event/
- https://cmsdata.iucn.org/downloads/fact_sheet_red_list_staghorn_corals.pdf
- https://news.nationalgeographic.com/2018/01/coral-bleaching-reefs-climate-change-el-nino-environment/

» Protecting Ningaloo

'There is no doubt that the world's coral reefs are facing a crisis because of climate change. I want to help save them.' That bold mission statement comes from Anna Cresswell, demonstrating both her commitment to preserving the Ningaloo reef habitat and the magnitude of the danger facing Ningaloo Reef and similar coral reefs as climate change continues to impact the world.

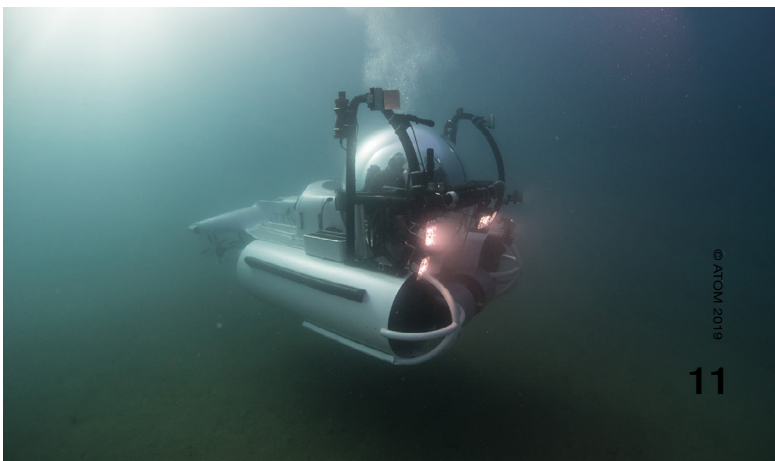
CORAL DISINTEGRATION

Write a fully referenced report detailing the degradation of the Ningaloo Reef, including sourced statistics to demonstrate the rate of bleaching and damage over the past decade.

Extension activity: Compare the damage to the Ningaloo Reef to equivalent coral reef(s) around the world. Is the rate of bleaching comparable across these reefs? Can you account for any discrepancies?

Teachers would likely want to set this task for students without provided sources; however, if you wish to scaffold the task, the following sources are a good starting point for chronicling the damage done to the Ningaloo Reef and related impacts in recent years:

- https://www.theguardian.com/environment/2017/nov/04/coral-bleaching-badly-affected-reefs-of-kimberley-study-finds/
- http://ningaloo-atlas.org.au/node/193/
- https://www.watoday.com.au/national/western-australia/ningaloo-s-world-heritage-coral-won-t-keep-pace-with-sea-rise-study-20180613-p4zlap.html
- https://www.coralcoe.org.au/media-releases/research-examines-impact-of-coral-bleaching-on-western-australias-coastline/
- http://www.news.uwa.edu.au/201703169472/international/scientists-examine-widespread-impact-bleaching-australian-reefs/



SAVING THE REEF

Ningaloo: Australia's Other Great Reef asserts that 'the successful reproduction of coral is going to be essential in regenerating damaged reefs.' But that's easier said than done. With climate change bringing oceanic heat waves and increasingly damaging reefs' sustainability, the future of Australia's coral reefs – and those around the world – is precarious at best.

Some of the possible options proposed to protect our reefs include:

- 'Super-coral' (<https://www.australiangeographic.com.au/topics/science-environment/2017/07/what-exactly-are-super-corals/>)
- Coral conditioning (<https://www.washingtonpost.com/national/health-science/creating-corals-that-can-survive-climate-change/2015/10/19/ca0464fe-62fc-11e5-9757-e49273f05f65_story.html?noredirect=on&utm_term=.226e3303a2cd/>)
- The reduction of potentially damaging dredging (<https://theconversation.com/what-can-we-say-for-certain-about-dredging-and-the-great-barrier-reef-39181/>)
- Broader strategies to reduce humanity's carbon footprint and prevent and/or mitigate future climate change

Choose one of these options and identify its strengths and weaknesses as a method of protecting and salvaging Ningaloo Reef, or coral reefs in general.

Marine Biologist

Produce a poster or pamphlet explaining:

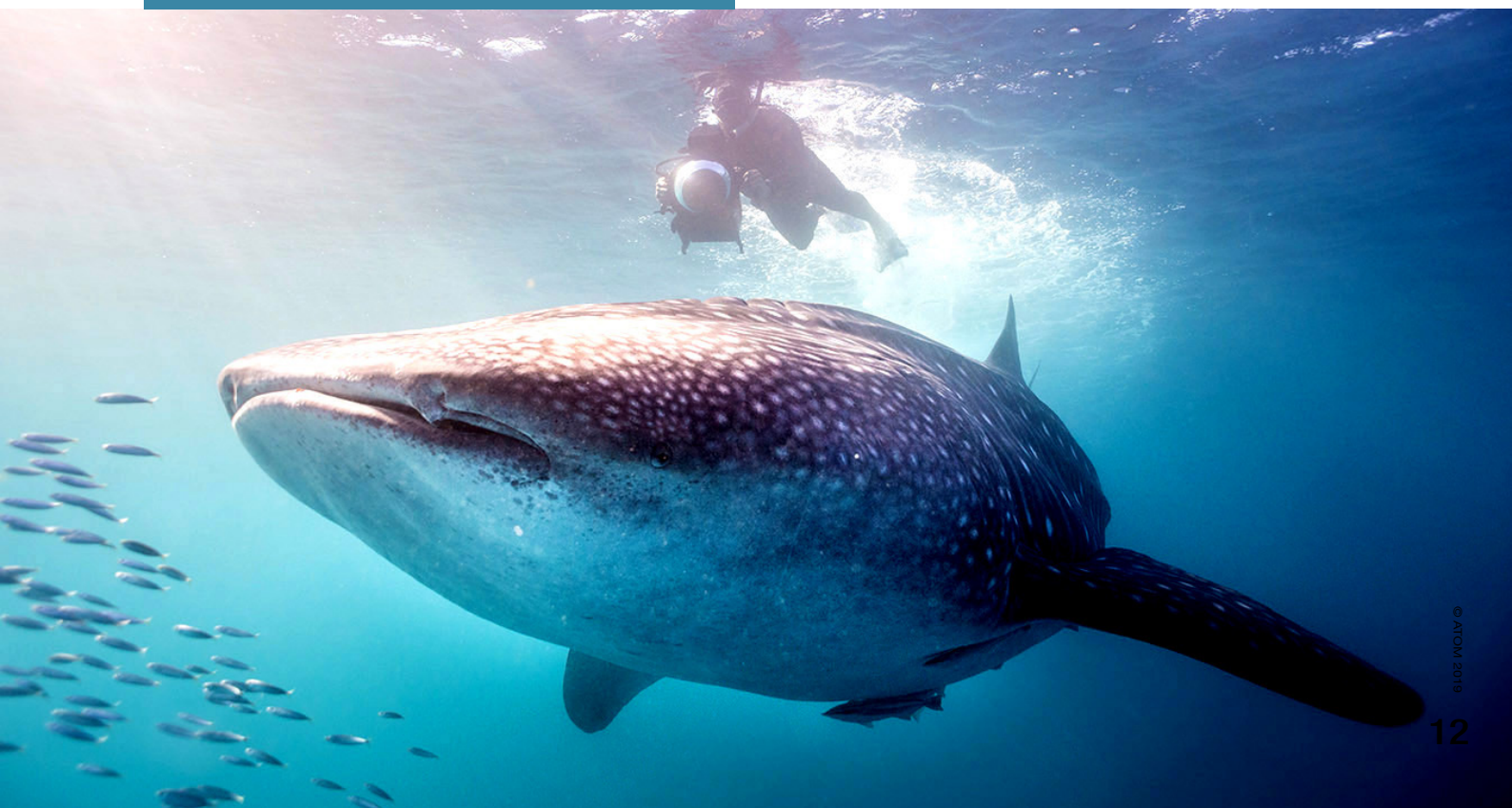
- the prerequisite skills and study required to become a marine biologist;
- the relevance of a marine biologist to wider society;
- what a day in the life of a marine biologist might look like.

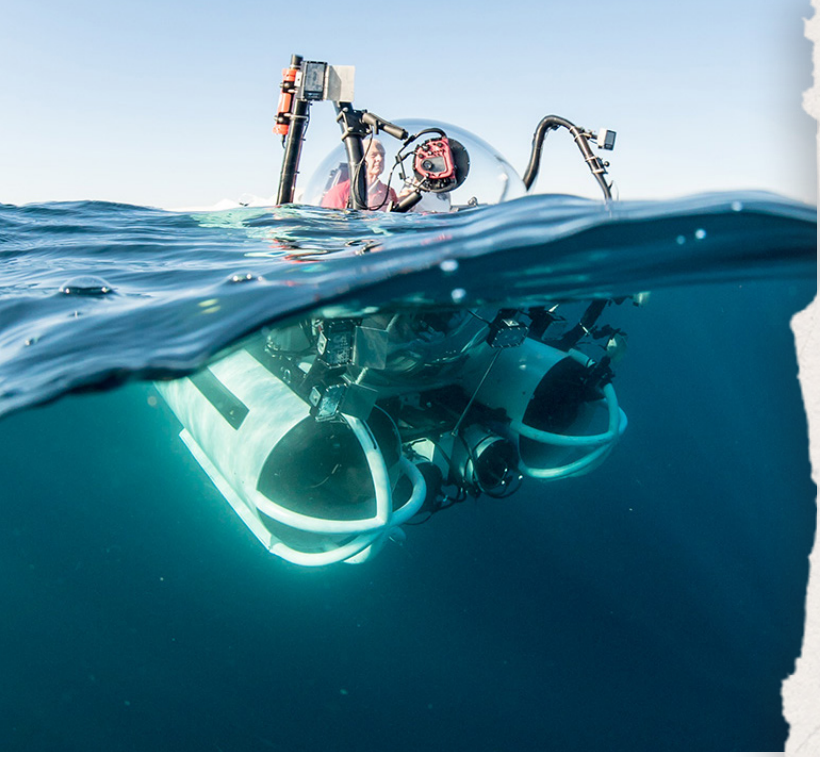
Such interventions are often politically controversial, particularly when considered in the context of Australia's Great Barrier Reef. For example:

'Millions of dollars of commonwealth money is being handed to tourism-linked groups for Great Barrier Reef protection, despite official advice recommending against the projects, or repeatedly finding them to be failing.' – Michael Slezak, *The Guardian,* <https://www.theguardian.com/environment/2018/jan/21/millions-spent-on-great-barrier-reef-projects-against-expert-advice/>, 21 January 2018.

'[T]he politicisation of reef science, and particularly the Great Barrier Reef itself, is not new. It has a long history, stretching back to the time when the British empire was at its most powerful.' – Rohan James Lloyd, *The Conversation,* <https://theconversation.com/politicised-science-on-the-great-barrier-reef-its-been-that-way-for-more-than-a-century-101815/>, 22 August 2018.

- Do the same controversies and political challenges that surround the Great Barrier Reef affect Ningaloo Reef? Why or why not?
- Is this likely to be beneficial or detrimental for biologists like Anna Cresswell striving to protect and preserve the reef?
- What other social considerations might affect the interventions considered to sustain the health of Ningaloo?





Submersibles

» Odyssea

Odyssea enables the entire running time of *Ningaloo: Australia's Other Great Reef.* A modern, innovative submersible, it provides a 250-degree view of its marine environment, allowing for careful study of the surrounds by marine biologists like Anna, and can dive as deep as 200 metres under the sea.

The specifications for Odyssea can be found in this study guide in the 'Background' section on ***page 3***. Use these specifications and the vision of the submersible in *Ningaloo* to produce a labelled diagram of the ship and its key features.

- The Odyssea boasts a 'safe, 1 atmosphere environment'. What does 1 atmosphere mean, and why is this considered safe?
- What water pressure would you expect to encounter 200 metres beneath the surface of the sea?
- Approximate the kind of force the Odyssea would need to sustain at the depth of 200 metres.
- What design challenges are associated with creating a submersible with such a wide view of its surrounds?
- Could you redesign Odyssea to safely travel deeper into the ocean? What changes would need to be made?

» Build Your Own Sub

There are numerous options open to the enterprising inventor wishing to make a miniature submarine for their own household. Make Magazine have shared easily understandable instructions for developing a self-propelled soft drink bottle submarine at <https://makezine.com/projects/soda-bottle-submarine/>, while more enterprising design students might want to create their own RC (Remote Control) with the assistance of resources such as this ThoughtCo website: <https://www.thoughtco.com/what-do-you-need-to-build-an-rc-submarine-2863059/>.

DESIGNING YOUR OWN SUBMARINE

For this activity, we'll be focusing on designing our own simple film-canister submarine, using an activity adapted from https://www.nsta.org/publications/news/story.aspx?id=40867.

AIM: Make your own miniature submarine. Your submarine should sink to the bottom of the provided water container, then rise back to the surface.

MATERIALS:

- **Film canister with hole in lid (or similar sealed, watertight container)**
- **2-litre soft drink bottle with top removed**
- **Coins**
- **Baking powder**
- **Baking soda**
- **Citric acid**
- **Effervescent antacid tablets**

PROCEDURE: Working in a group, design and construct different submarines using different materials. Record the process used to build each submarine, then decide upon your most effective submarine based on your observations.

DATA: Record the mass and volume of chosen submarine after it rises to the top, along with any other observations.

QUESTIONS:

- Describe what causes your sub to sink, then float.
- What was the density of your sub after it rose to the top?
- How much buoyant force was required to make the sub rise?
- How much **mass** must the sub initially have to sink? What **weight** must the sub have to sink?
- What is the **mass** of the sub while floating? What **weight** does the sub have while floating?
- Explain which three substances or combinations of substances were successful.
- Link the results of this experiment to the operation of real submarines.

Further teacher notes to contextualise the science associated with this experiment can be found at the above link from which this activity is adapted.

Filming Underwater

» Optics

Ningaloo: Australia's Other Great Reef is not only a showcase for the wonders of the natural world – it also showcases modern camera technology through its immersive fulldome photography.

FULLDOME PHOTOGRAPHY

Fulldome is a video-projection format that, as suggested by its name, is displayed in a dome format. It is an excellent showcase for non-narrative films that allow the viewer to explore and be immersed by their environment: whether expansive wilderness, infinite space or – as in *Ningaloo: Australia's Other Great Reef* – the dark depths of the ocean.

Research the history and technical qualities of fulldome photography to answer the following questions:

- When and where did fulldome photography first originate?
- What sort of fulldome films are shown at the venue where you viewed *Ningaloo: Australia's Other Great Reef?*
- How does fulldome projection operate?
- What are the advantages of single-projector fulldome systems as opposed to multiple-projector fulldome systems?

This program was filmed using the 200-degree, 4K digital camera is mounted externally on the Odyssea submersible, and the 8 K RED camera is operated by an underwater camera man.

- What challenges are associated with designing, producing and filming with such a wide lens?
- How do the laws of reflection apply to a 200-degree lens? Where would its focal centre be located?

STORYBOARDING FOR FULLDOME

Fulldome presents a unique challenge for filmmakers in that the audience is given free rein to look wherever they wish, rather than being restricted to a flat, finite screen. While this facilitates an immersive atmosphere, it also risks the audience missing crucial information.

While watching *Ningaloo: Australia's Other Great Reef,* take careful note of how director Russell Vines controls the audience's attention. At what points are your eyes drawn to the natural focus at the front of the dome? When do you find your attention wandering to the outskirts of the dome? Is this intentional or incidental?

The following is an excerpt of the documentary's script. Draw a storyboard of this scene, indicating clearly where you expect the audience's attention to be drawn and how that will be achieved. Think carefully about how you might represent a three-dimensional space in two-dimensional storyboards.

Further out to sea, one of the 'gentle giants of the ocean', has also set a course for the reef – the largest fish in the sea – a whale shark.

Nearing the end of a long journey, it's one of over five hundred that come to Ningaloo at this time, every year.

Odyssea moves toward the reef. If the coral spawning is tonight, Anna needs to be in position by sundown. She has three hours.

Up ahead - the first challenge.

ANNA: *So we're coming into the reef now and you start to see the wall it's forming. This is what we call the outer reef slope.*

Odyssea must find a way through the reef's towering outer wall. Rising as much as thirty-five metres from the ocean floor.

ED: *Talasea, this is Odyssea…we've reached the outer wall, we're now searching for a way in… out.*

ANNA: *All of this structure here has built up over thousands of years. On the top are living corals. And underneath we've got centuries of the skeletons of dead corals. That's how coral reefs grow into something as mammoth as this.*

ED: *Oh, look at that!*

ANNA: [Intake of breath] *That's a humpback! You see lots of them here. They're migrating up and down the coast.*

Odyssea pauses.

ED: *Talasea, this is Odyssea. We've found an opening. Visibility is good. Entering now. Out.*

Virtual Reality

The principles behind filming footage for virtual reality (VR) are similar to the principles underpinning fulldome footage. What specific factors would a director need to consider when filming footage for a VR program? How do these differ to the requirements associated with fulldome films?

AUSTRALIAN TEACHERS OF MEDIA

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