GEOGRAPHY BULLETIN

ENVIRONMENTAL CHANGE AND MANAGEMENT

The Geography Teachers Association of NSW & ACT Inc.

Volume 50 No 4 2018

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REPORTS • RESOURCES • ARTICLES • REVIEWS

EXECUTIVE 2018

GEOGRAPHY BULLETIN

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Lorraine Chaffer

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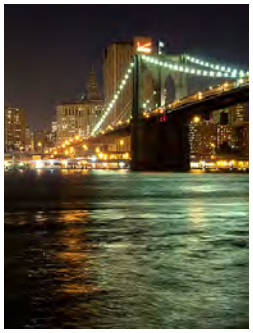

Front cover: Lights on Manhatten Bridge
Back cover: Brooklyn Bridge at night with Lower Manhatten skyline
Image source: Wikimedia Commons

The Geography Bulletin is a quarterly journal of The Geography Teachers' Association of New South Wales. The 'Bulletin' embraces those natural and human phenomena which fashion the character of the Earth's surface. In addition to this it sees Geography as incorporating 'issues' which confront the discipline and its students. The Geography Bulletin is designed to serve teachers and students of Geography. The journal has a specific role in providing material to help meet the requirements of the Geography syllabuses. As an evolving journal the Geography Bulletin attempts to satisfy the requirements of a broad readership and in so doing improve its service to teachers. Those individuals wishing to contribute to the publication are directed to the 'Advice to contributors' inside the back cover. Articles are submitted to two referees. Any decisions as to the applicability to secondary and/or tertiary education are made by the referees. Authors, it is suggested, should direct articles according to editorial policy.

GEOGRAPHY BULLETIN

Volume 50, No4 2018
EDITOR: Lorraine Chaffer

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EDITORIAL

Welcome to the final edition of the Geography Bulletin for 2018 with a focus on the Stage 5 topic Environmental Change and Management.

Many thanks to the following contributors and authors

- *12 Emerging Global Trends That Bring Hope for 2018* from The Nature Conservancy
- *Environmental Change: Marine Environments* from The Conversation

Assessment Task

- *Coastal Environments: Assessment Task* by Karen Bowden

Feature articles

- *Coral Reefs: Environmental Change and Management* by Louise Swanson
- *Sydney Harbour Estuary: Environmental Change and Management* by Lorraine Chaffer
- *New York Harbour Comparative Study* by Lorraine Chaffer

AGM Documents

- *Presidents Annual Report* by Lorraine Chaffer
- *Financial Papers*

Professional Learning for 2019

GTANSW Planning Day for 2019 Professional Learning and the AGM was held on October 22nd. Dates will be released soon for the first events for 2019 including the 2019 Annual Conference and Term 1 Webinars.

Reminders

The Arthur Phillip Fieldwork Competition is open for entries up to November 23rd

Nominate a great Geography teacher for the Brock Rowe Award for excellence in teaching Geography in schools. Click on the flyer to see what is required.

Enter the members Photo Competition in 2019. Click on the flyer to see what is required and upload your best holiday shots.

Resources available on the GTA website include:

- *A Guide to Geography Bulletin Resources* is a document hyperlinking directly to individual *Geography Bulletin* articles.
- Past and present *Geography Bulletins* (Whole editions and individual articles)
- Recordings of Webinars
- Past conference presentations and recordings
- *Primary Geography Alive* – fully resourced units of work for primary school Geography Teachers.

Membership

Renew or join as a new member in early November to get 12 months access to new and existing resources and discounted and earlybird offers to new events.

Individual members receive direct emails re new events and resources and can become members of the GTA NSW Council.

Lorraine Chaffer, Editor

Follow Us ...

GTANSW Facebook Page is used for major events and the general promotion of Geography at https://www.facebook.com/GTA.NSW/

GTANSW has two specific support groups:

- **GTANSW Teachers of Senior Geography Group https://www.facebook.com/groups/841307156040600/**
- **GTANSW Primary Geography Teachers Group https://www.facebook.com/search/top/?q=gtansw%20primary%20geography%20teachers%20group**

Admission to these groups is on request and requires questions to be answered before approval is given.

Reviews

It is important for the future of Geography that members have input into curriculum reviews. Have your say on the NSW Curriculum Review. See https://www.educationstandards.nsw.edu.au/wps/portal/nesa/about/initiatives/curriculum-review

Contribute to the Geography Bulletin

The first edition of the Geography Bulletin in 2019 will be on Biomes. Writing an article or contributing a resource or task for the Geography Bulletin is great professional development.

Editor
Lorraine Chaffer

EDITORIAL

A GUIDE TO GEOGRAPHY BULLETIN RESOURCES

Lorraine Chaffer
President GTA NSW & ACT, Editor Geography Bulletin

The following table is a record of some of the most recent GTANSW Bulletin articles that support the NSW Geography 7-10 Syllabus topics. Follow the links to directly access the article you want. You will need to login first. For other articles and links access the full document on the GTA website homepage at https://www.gtansw.org.au/index.php

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ARTICLE AND AUTHOR	EDITION / YEAR
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Geomorphic Hazards: Earthquakes in Haiti and Chile *Dr Susan Bliss*	Volume 50, No 1, 2018
Illustrative study: A natural disaster. Whose fault? Port-au-Prince, Haiti *Dr John Buchannan*	Volume 50, No 1, 2018
Introducing landforms and Landscapes *David Alchin*	Volume 50, No 1, 2018
Mongolia: Grassland landscape and biome *Dr Susan Bliss*	Volume 48, No 1, 2016
Canada, beautiful, liveable but vulnerable **Part 1: Landscapes, landforms, geomorphic processes and hazards** *Lorraine Chaffer*	Volume 47, No 4, 2015
Canada, beautiful, liveable but vulnerable **Part 2: Selected landscapes, landforms, values and protection** *Lorraine Chaffer*	Volume 47, No 4, 2015
Incredible journeys across earth: Biodiversity *Dr Susan Bliss*	Volume 45, No 1, 2013
Hazards: Year 7 & Year 8 *Dr Susan Bliss*	Volume 45, No 3, 2013
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Place and Liveability Part 1: Some teaching ideas *Lorraine Chaffer*	Volume 49, No 2, 2017
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New Zealand: Perceptions of liveability *Nick Hutchinson*	Volume 46, No 2, 2014
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Canada, beautiful, liveable but vulnerable **Part 4: Stimulus based inquiry activities / Bow River** *Lorraine Chaffer*	Volume 48, No 3, 2016
Year 7 and Year 8 (Hydrologic & atmospheric hazards) *Dr Susan Bliss*	Volume 45, No 3, 2013
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Three Gorges Dam *Dr Susan Bliss*	Volume 45, No 4, 2013
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Coffee Interconnections *Dr Susan Bliss*	Volume 49, No 4, 2017
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Chocolate *Dr Susan Bliss*	Volume 49, No 1, 2017
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China: Surfing connections — The Legend of the Magic Wind *Milton Brown*	Volume 48, No 4, 2016
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Canada, beautiful, liveable but vulnerable **Part 1: Canada's biomes and climate zones** *Lorraine Chaffer*	Volume 47, No 4, 2015

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Sydney Harbour Estuary: Environmental Change and management. Includes fact sheets and activities. *Lorraine Chaffer* (To be linked after publication)	Volume 50, No 3, 2018
Comparative Study: New York Harbour Estuary *Lorraine Chaffer* (To be linked after publication)	Volume 50, No 3, 2018
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Aboriginal Australia Series Part 4: Threats to Aboriginal Land *Jens Korff*	Volume 50, No 3, 2018

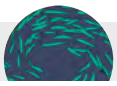
2018 Editions

12 Emerging Global Trends That Bring Hope for 2018

The Nature Conservancy

Many of this year's outlook stories paint a grim picture, particularly for our environment. And yet, as we look deeper into some of the challenges ahead, we see new solutions emerging. Without minimizing the task ahead, we want to point to some trends that are unlocking investment for nature and offering hope for a sustainable future.

For press inquiries on any of these topics, contact media@tnc.org.
A deeper dive on all these trends is available on ***TNC's Global Solutions*** *platform at https://www.nature.org/2018emergingtrends.*



1. HIGH TIME FOR THE HIGH SEAS

Could the biggest thing to happen for the environment in decades be in the middle of the ocean? An unprecedented UN resolution calls for protection of the high seas, which have long suffered from pollution and illegal and unregulated fishing.

"This could be the most important step I have seen in my 30 years working on the ocean. We need a strong treaty that represents biodiversity and the ocean—this process could open the way to create a Paris Agreement for the ocean."

— Maria Damanaki, Managing Director for Global Oceans

2. A NEW PRESCRIPTION FOR PUBLIC HEALTH

A tree a day keeps the doctor away? A shift in public health practices is underway as policymakers and healthcare providers alike focus on the connections between nature and human health across the globe.

"More people are breaking out of their traditional lanes of conservation, health and development to find new solutions. It's time to realize that we won't achieve better health for growing populations unless we attend to the health of the planet, too."

– Heather Tallis, Global Managing Director and Lead Scientist for Strategy Innovation

3. FOLLOWING THE MONEY TO GLOBAL IMPACT

Ten years since the term "impact investment" was coined, the sector is scaling in a new way—maybe enough to start closing the $300-400 billion gap (€240-325 billion) for global conservation funding.

"We're seeing a real focus on bringing impact investments to the scale of the global challenges we face. If enough private capital is directed in the right ways, it can provide the needed push on top of public finance to meet the SDGs and Paris Agreement targets."

– Marc Diaz, Managing Director of NatureVest

4. NEW FACES TACKLING CLIMATE CHANGE

Who will step up on this generation's main stage? New leaders — in both the public and the private sector, and from the national to the local level—are emerging to lead on climate action.

"This year's Global Climate Action Summit is just one more sign of the unstoppable momentum we've been building since the Paris climate talks. Despite last year's setbacks, we are seeing more leaders, from China to U.S. state governments to major companies, stepping up to fill the void and lead on climate action."

— Will McGoldrick, Director of Climate Strategy

5. NATURAL CLIMATE SOLUTIONS: THE YEAR'S TOP CARBON TECHNOLOGY

Solving for future carbon emissions is one thing; removing carbon dioxide already in the atmosphere is another. Nature itself may be our most game-ready carbon storage technology—and one of the most important ways to begin reaching international climate goals now.

"We have proven the potential of nature to be a climate solution, but the science tells us we have no time to waste. This is a critical year where we need more 'nature for climate'. And we're seeing initiatives in both the public and the private sector beginning to unify these fragmented efforts."

– Justin Adams, Managing Director for Global Lands

6. SOIL — BELIEVE IT OR NOT — IS A HOT TOPIC

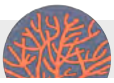
Here's the dirt: this year, soil is on trend. In fact, soil management may be the single most dynamic sustainability solution, with benefits for food security, water quality and climate mitigation.

"We are finally appreciating soil's critical role in not only providing food and water but also stabilizing the climate, and I believe we will see significantly more action on this issue in 2018."

– Deborah Bossio, Lead Scientist for Soil Sciences

12 Emerging Global Trends That Bring Hope for 2018

The Nature Conservancy



7. ENGINEERING OUR WAY OUT OF CRISIS — WITH NATURE'S HELP

The trillion-pound (£) elephant in the room? Infrastructure. The changing climate is prompting communities around the world to invest in nature as part of their infrastructure planning.

"More people—from governments to engineering firms to insurance companies—are waking up to the fact that major investment in nature is a key part of a new era of infrastructure solutions."

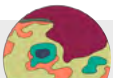
— Lynn Scarlett, Co-Chief External Affairs Officer

8. BIG DATA AND THE DAWN OF A CONSERVATION REVOLUTION

A welcome disruption? The tech industry is setting its sights on a new sector: conservation. Big data solutions are leading the way, and new funding ventures could accelerate progress.

"Technologies that have revolutionized so many sectors of the economy have the potential to transform the way we do conservation. We're at the front end of a new 'nature-tech' revolution and nature stands to win big from it."

– Brian McPeek, Chief Conservation Officer



9. MORE COMPANIES ARE GETTING SERIOUS ABOUT GLOBAL GREEN GOALS

What to do with SDGs and two degrees? The private sector's increasing alignment with global agreements like the Paris Climate Accord and the UN Sustainable Development Goals signals an important commitment to addressing some of the world's most urgent environmental challenges.

"Investing in nature is smart business. Companies understand that incorporating biodiversity conservation and ecosystem services into their sustainability strategies is an important move that will position them better in the future."

— Glenn Prickett, Chief External Affairs Officer

10. CLEAN ENERGY IS POWERING THE FUTURE — NOW WHERE TO PUT IT?

Our clean energy future is arriving faster than we thought. That's great news—but siting energy presents its own challenges. Large-scale planning will be key to balancing goals for energy production, development and conservation.

"We can win the battle for clean energy—but the challenge for the future will be figuring out where to put energy installations. We have to think bigger, moving from piecemeal planning to whole-system planning."

– Joe Kiesecker, Senior Scientist for Global Lands

11. TO REDEFINE GREEN DESIGN, CITIES ARE THINKING BIGGER — *AND* SMALLER

Green cities are striving for LEED buildings, light rail—and a better experience walking down the block. Ideas about sustainable urban planning are shifting to include a greater emphasis on resilience, inclusivity and human-nature interaction.

"Too often we've been designing cities for cars instead of the people who live there. Nature can be a catalyst for flourishing neighborhoods —but it's crucial we do it equitably, so all communities have access to green spaces and the benefits they bring."

– Pascal Mittermaier, Managing Director for Global Cities

12. OH, AND ONE MORE THING — MORE

More investment, more research, more accountability, more heroes. The year 2020 will likely be time of stocktaking, and while we're seeing positive trends, we still have a long way to go on global targets like the SDGs. Meeting those targets will require more accountability, scientific research, innovation and real-world solutions.

"It is increasingly clear that it is impossible to separate environmental concerns from global advancement and that addressing both will require us to fundamentally rethink and resize our solutions."

– Giulio Boccaletti, Chief Strategy Officer and Managing Director for Global Water

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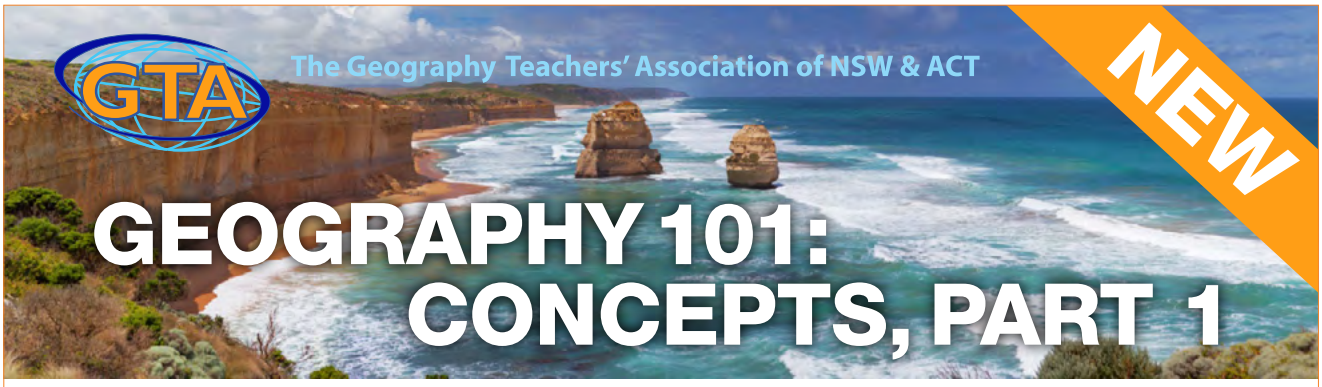

A flexible, any where, any time online learning opportunity through Open Learning

Geographical concepts are a foundation for teaching Geography in NSW.

This professional development course, created by Dr. Paul Batten on behalf of the GTA NSW & ACT, examines the seven key concepts from the Australian Curriculum Geography and NESA Geography Syllabus K–10.

Skills developed in this course include:

- applying knowledge of the content and teaching strategies of Geography to develop engaging teaching activities (NESA Standard 2.1.2),
- providing opportunities for ATSI respect and understanding (NESA Standard 2.4.2) and,
- contributing to collegial discussions... to improve professional knowledge and practice (NESA Standard 6.3.2).

The course is designed for flexible delivery. Participants can start, progress and finish at times convenient to them. The focus of the course are text and image posts. Participants collaborate in a 'pay it forward' style with other teachers, engaging with previous contributions and creating their own posts, adding to the galleries of exemplars and case studies for future participants to review.

Cost: $90 – Register at https://www.openlearning.com/ptc-nsw/courses/geography-101/
For further information about this course contact – gta.elearning@gmail.com

PARTICIPANT FEEDBACK:

"This is an accessible and easy way to learn and to improve classroom practices."

"Geo 101 is relevant and practical and will definitely add value to student learning."

"The course covers key geographical concepts, incorporates interesting activities that you could easily use in your own classroom, and has the added bonus of learning from your colleagues."

NSW GOVERNMENT

Geography Teachers Association of NSW & ACT, through the Professional Teachers' Council NSW – is endorsed to provide the NSW Education Standards Authority (NESA) Registered Professional Development for teachers accredited at Proficient, Highly Accomplished, and Lead levels.

Completing the **Geography 101: Concepts, Part 1**, on **29 October 2018 – 29 October 2019** will contribute **3 Hours** of NSW Education Standards Authority (NESA) Registered PD addressing 2.1.2; 2.4.2; 6.3.2 from the Australian Professional Standards for Teachers towards maintaining Proficient Teacher Accreditation in NSW.

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MARINE ENVIRONMENTS

Editors comments

These two articles, originally published in The Conversation, provide some valuable insights into changes impacting on marine environments.

The first, *'Climate change could alter ocean food chains, leading to far fewer fish in the sea'*, looks at the impact of climate change on important marine environmental processes.

The second, *'Seagrass is a marine powerhouse, so why isn't it on the world's conservation agenda?'* explains the global loss of marine seagrass ecosystems and the need for greater management.

Further reading

'Loss of marine habitats is threatening the global fishing industry – new research', examines the interconnection between healthy marine environments, particularly seagrasses, and global food security. This article can be found at https://theconversation.com/loss-of-marine-habitats-is-threatening-the-global-fishing-industry-new-research-96561

THE CONVERSATION

CLIMATE CHANGE COULD ALTER OCEAN FOOD CHAINS, LEADING TO FAR FEWER FISH IN THE SEA

Author: Jefferson Keith Moore (Professor of Earth System Science, University of California, Irvine)

Source: This article was originally published on April 19, 2018 http://theconversation.com, https://theconversation.com/climate-change-could-alter-ocean-food-chains-leading-to-far-fewer-fish-in-the-sea-93114

Climate change is rapidly warming the Earth and altering ecosystems on land and at sea that produce our food. In the oceans, most added heat from climate warming is still near the surface and will take centuries to work down into deeper waters. But as this happens, it will change ocean circulation patterns and make ocean food chains less productive.

In a recent study, I worked with colleagues from five universities and laboratories to examine how climate warming out to the year 2300 could affect marine ecosystems and global fisheries. We wanted to know how sustained warming would change the supply of key nutrients that support tiny plankton, which in turn are food for fish.

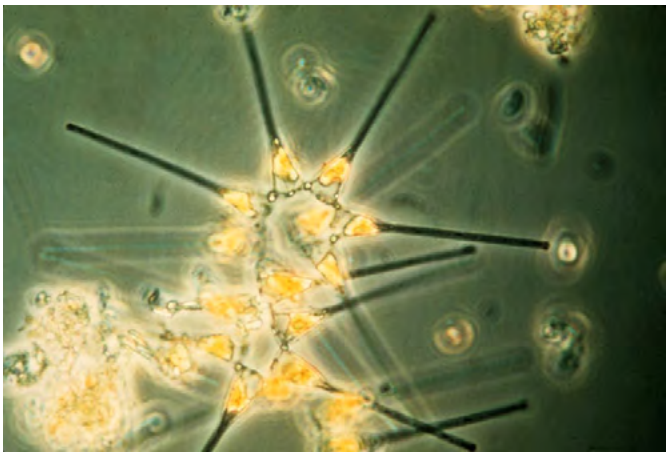
We found that warming on this scale would alter key factors that drive marine ecosystems, including winds, water temperatures, sea ice cover and ocean circulation. The resulting disruptions would transfer nutrients from surface waters down into the deep ocean, leaving less at the surface to support plankton growth.

As marine ecosystems become increasingly nutrient-starved over time, we estimate global fish catch could be reduced 20 percent by 2300, and by nearly 60 percent across the North Atlantic. This would be an enormous reduction in a key food source for millions of people.

Ocean food production and the biological pump

Marine food production starts when the sun shines on the ocean's surface. Single-celled, mostly microscopic organisms called phytoplankton – the plants of the oceans – use sunlight to photosynthesize and grow in a process called net primary production. They can only do this in the sunlit surface layer of the ocean, down

to about 100 meters (330 feet). But they also need nutrients to grow, particularly nitrogen and phosphorus, which can be scarce in surface waters.



Phytoplankton, the plants of the ocean. NOAA

Phytoplankton are consumed by zooplankton (tiny animals), which in turn provide food for small fish, and so on all the way up the food chain to top predators like dolphins and sharks. Unconsumed phytoplankton and other organic matter, such as dead zooplankton and fish, decompose in surface waters, releasing nutrients that support new phytoplankton growth.

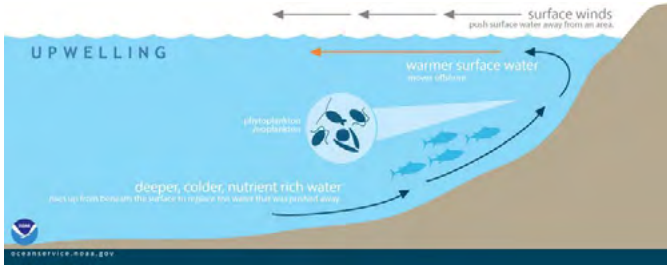
Some of this material sinks down into the deeper ocean, providing food for deep sea ecosystems. Carbon, nitrogen, phosphorus and other nutrients in this sinking organic matter ultimately are decomposed and released at depth.

This process, which is known as the biological pump, continually removes nutrients from surface waters and transfers them to the deeper ocean. Under normal conditions, winds and currents cause mixing that eventually brings nutrients back up to the sunlit surface waters. If this did not happen, the phytoplankton eventually would completely run out of nutrients, which would affect the entire ocean food chain.

Sea ice, winds and nutrient upwelling

Nutrients that sink to the deep ocean eventually return to the surface mainly in the Southern Ocean around Antarctica. North of Antarctica, strong westerly winds push surface waters away from Antarctica. As this happens, deep ocean waters that are rich in nutrients rise up to the surface all around Antarctica, replacing the waters that are being pushed away. The zone where this upwelling occurs is called the Antarctic Divergence.

Today there isn't a lot of phytoplankton growth in the Southern Ocean. Heavy sea ice cover prevents much sunlight from reaching the oceans. Concentrations of iron (another key nutrient) in the water are low, and cold water temperatures limit plankton growth rates. As a result, most nitrogen and phosphorus that upwells in this area flows northwards in surface waters. Eventually, when these nutrients reach warmer waters throughout the lower latitudes, they support plankton growth over most of the Pacific, Indian and Atlantic oceans.



When winds displace surface ocean waters, nutrient-rich colder waters well up from below. NOAA

Trapping nutrients in the deep ocean

Our study demonstrated that sustained, multicentury global warming could short-circuit this process, leaving all ocean areas to the north of this Antarctic zone increasingly starved for nitrogen and phosphorus.

We used a climate model simulation that assumed nations continued to use fossil fuels until global reserves were exhausted. This climate path would raise mean surface air temperature by 9.6 degrees Celsius (17.2 degrees Fahrenheit) by 2300 – nearly 10 times the warming beyond pre-industrial levels recorded up to the present. Scientists already know that the poles are warming faster than the rest of the planet, and in this scenario, that pattern continues. Eventually the oceans would no longer freeze over near the poles, even in winter.

Warmer ocean waters without sea ice, aided by shifts in winds that are also driven by strong climate warming, would greatly improve growth conditions around Antarctica for phytoplankton. This increased growth would trap nutrients that well up near Antarctica, preventing them from flowing northwards and supporting low-latitude ecosystems worldwide.

In our simulation, these trapped nutrients eventually mix back to the deep ocean and accumulate there. Nitrogen and phosphorus concentrations in the upper 1,000 meters (3,300 feet) of the ocean steadily decrease. In the deep ocean, below 2,000 meters, they steadily increase.

Far fewer fish

As marine ecosystems become increasingly nutrient-starved, phytoplankton growth and net primary production throughout most of the world's oceans would decline. We estimate that as these impacts ripple up the food chain, global fish catches could be reduced 20 percent by 2300, with decreases of more than 50

percent across the North Atlantic and several other regions. Moreover, at the end of our simulation net transfer of nutrients to the deep ocean was still taking place, which suggests that ecosystem productivity and potential fisheries catch would decline even further beyond 2300.

Eventually, after more than a thousand years, most of the carbon dioxide that human activities have added to the atmosphere will be absorbed by the oceans, and the Earth's climate will cool back down. Sea ice will return to polar oceans, suppressing phytoplankton growth around Antarctica and allowing more upwelled nutrients to flow north once again to lower latitudes. But even then, it will take centuries more for ocean circulation to fully replenish nutrients in the upper ocean.

Ocean resources are already stressed today. About 90 percent of the world's marine fisheries are fully fished or overfished. World population is projected to increase from 7.3 billion in 2015 to 11 billion in 2100. The impacts that we found in our study would have serious implications for global food security. Expanding aquaculture, or even more drastic steps such as directly fertilizing the oceans to spur plankton growth, would not even come close to making up for the loss of nutrients to the deep ocean driven by sustained global warming.

Our simulation was based on a strong climate warming scenario. More research is needed to explore just how warm the climate has to get to melt sea ice and initiate Southern Ocean nutrient trapping. But clearly this is a tipping point that we don't want to cross.

Source: https://www.youtube.com/watch?v=H7sACT0Dx0Q

Phytoplankton are critical to life on Earth. Climate change is interfering with ocean mixing processes that promote phytoplankton growth.

THE CONVERSATION

SEAGRASS IS A MARINE POWERHOUSE, SO WHY ISN'T IT ON THE WORLD'S CONSERVATION AGENDA?

Authors

Richard K.F. Unsworth Research Officer (Marine Ecology), Swansea University
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Source: This article was originally published in http://theconversation.com on October 11, 2016
https://theconversation.com/seagrass-is-a-marine-powerhouse-so-why-isnt-it-on-the-worlds-conservation-agenda-66503

Seagrass meadows are often overlooked by the public but vital to the ocean ecosystem. Source: Ben Jones, Author provided

Seagrass has been around since dinosaurs roamed the earth, it is responsible for keeping the world's coastlines clean and healthy, and supports many different species of animal, including humans. And yet, it is often overlooked, regarded as merely an innocuous feature of the ocean.

But the fact is that this plant is vital – and it is for that reason that the World Seagrass Association has issued a consensus statement, signed by 115 scientists from 25 countries, stating that these important ecosystems can no longer be ignored on the conservation agenda. Seagrass is part of a marginalised ecosystem that must be increasingly managed, protected and monitored – and needs urgent attention now.

Seagrass meadows are of fundamental importance to human life. They exist on the coastal fringes of almost every continent on earth, where seagrass and its associated biodiversity supports fisheries' productivity. These flowering plants are the powerhouses of the sea, creating life in otherwise unproductive muddy environments. The meadows they form stabilise sediments, filter vast quantities of nutrients and provide one of the planet's most efficient oceanic stores of carbon.

But the habitat seagrasses create is suffering due to the impact of humans: poor water quality, coastal development, boating and destructive fishing are all resulting in seagrass loss and degradation. This leads in turn to the loss of most of the fish and invertebrate populations that the meadows support. The green turtle, dugong and species of seahorse, for example, all rely on seagrass for food and shelter, and loss endangers their viability. The plants are important fish nurseries and key fishing grounds. Losing them puts the livelihoods of hundreds of millions of people at risk too, and exposes them to increasing levels of poverty.

Rapid loss

There is clear, extensive evidence of the rapid loss of seagrass. Growing historic, recent and current records show degradation and fragmentation of the plant around the world. In Biscayne Bay, Florida, for example, 2.6km^2 of seagrass disappeared between 1938 and 2009. Up to 38% of the seagrass in a lagoon in the south of France may have been lost since the 1920s. The nearshore waters of Singapore has lost some 45% over the past 50 years. Similar examples have been reported in Canada, the British Isles and the Caribbean too.

Even the Great Barrier Reef Marine Park has suffered periods of widespread decline and loss of seagrass over the past decade, particularly along its central and southern developed coasts; a consequence of multiple years of above average rainfall, poor water quality, and climate-related impacts followed by extreme weather events. The most recent published monitoring surveys show that the majority of inshore seagrass meadows across the reef – which cover some 3,063 km^2 – remain in a vulnerable state, with weak resistance, low abundance and a low capacity to recover.

Human impact

As the human population grows and the world economy expands, there will be increasing pressure on our coastal zone. And it must be ensured that this doesn't negatively influence seagrass meadows. It is already recognised that poor water quality, specifically elevated nutrients, is the biggest threat to seagrasses; these problems are particularly acute in many developing nations with rapidly growing economies, such as Indonesia, where municipal infrastructure is often limited and environmental legislation is largely weak.

Coastal development is a competition for finite space: boating, tourism, aquaculture, ports, energy projects and housing are all placing pressures on seagrass survival. These threats exist with a backdrop of the impacts of environmental change and sea level rise too. Humans must reduce their local-scale impact on seagrass so that it can remain resilient to longer term environmental stressors.

There can be a bright future for this oceanic plant, however. Across the world, communities, NGOs and governments are beginning to embrace the monitoring of meadows. As knowledge of the plants' ecology improves, conservationists are learning more about how to successfully restore seagrass meadows: Tampa Bay in Florida and Virginia's bays, for example, have seen genuine large scale recovery. We also now have greater appreciation for the value of seagrass in the global carbon cycle, and governments are more willing to include its conservation in ways to mitigate carbon emissions. Though commendable, these are just the first steps on a course of targeted strategic action.

As the WSA statement calls, seagrass meadows must be put at the forefront of marine conservation today. We need to increase its resilience by improving coastal water quality, prevent damage from destructive fishing practices and boating, include seagrasses in Marine Protected Areas and ensure that fisheries aren't over exploited. Seagrasses also need to be managed effectively during coastal developments, and steps taken to ensure recovery and restoration in areas where losses have occurred.

The scientific community must be more united, not only in its work, but in engaging more actively with the general public, coastal managers and conservation agencies too. Seagrass ecosystems must fully pervade policy around the globe too, as well as the consciousness of our global coastal communities. For the sake of future generations we need to work together to ensure the survival of the world's seagrass meadows now.

Assessment Task: Coastal environments

Karen Bowden, GTANSW Councillor

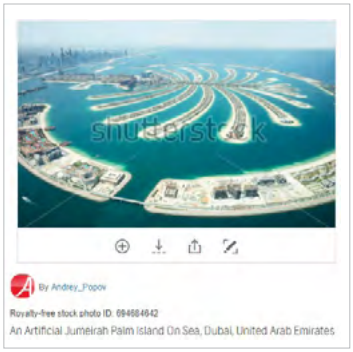
Around the world changes to coastlines occur due to natural and human environmental forces. Examples of these changes may include erosion as a result of tsunamis and severe storms, or the development of coastlands for tourism, industry, recreation and power generation.

As we experience more extreme weather patterns, communities are being forced to manage coastal environment changes more sustainably. Australians can learn from experiences and strategies being trialled in other countries.

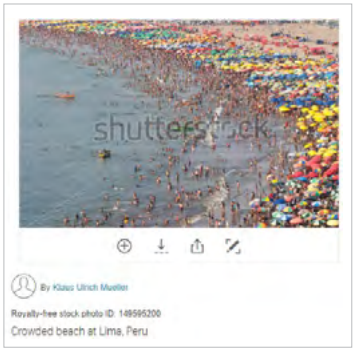
ECO-COAST is a new field study business that hopes to encourage a greater appreciation of coastal environments. They plan to deliver field trips for Australian Year 10 Geography students in countries overseas.

For example:

UAE – Land reclamation



PERU – Tourism



USA – Nuclear power plant

TASK OUTLINE:

Investigation Report

- Using your recent field work experience to Long-Reef / Collaroy as an example, students are required to investigate **Environmental Change and Management** in a coastal environment outside of Australia.
- Students are to present their findings in an information report format OR website using the headings provided.

Propose ONE coastal environment (in a country outside of Australia) and develop an information report (OR website) for this coastal site.

The site selected **must**:

- ✓ be located in a coastal environment.
- ✓ be located in a country outside of Australia.
- ✓ have experienced environmental change over time.
- ✓ be suitable for a one-day field trip experience to investigate coastal processes and management strategies.
- ✓ please check your choice with your teacher.

Information to include in your field trip report/ website:

The aim of **ECO-COAST** will be to offer coastal environment field trips that:

- Investigate the biophysical processes essential to the functioning of the coastal environment
- Investigate the causes, extent and consequences of the environmental change
- Investigate the management of the environmental change.

SOURCE: Geography 7–10 Syllabus

HEADINGS

a. Area Description (4 marks)

- Brief introduction to the study area.
- Location of the study site within a country outside of Australia.
- Details of how the Australian study group would travel to this study site (from Sydney).

b. Historical Land Use (4 marks)

- Prepare a timeline to highlight the major land use changes to the area.
- Consider - Indigenous occupation of the area and how the coast is viewed by the local culture.
- Include an outline of current human use.

c. Study Area (5 marks)

- Prepare **no more** than two maps to:

  Show the extent of this coastal environment.

  Locate and annotate the areas of focus for the proposed field trip- (BOLTSS)

d. Design a Focus Question (2 marks)

- Suggest an appropriate focus question for your field trip.
- Why have you chosen this focus question?

e. Coastal Landforms / Biophysical processes (4 marks)

- Suggest a Primary data field activity that will enable students to understand the natural processes operating.
- Provide at least one reason for your choice of activity at this beach.

f. Evidence of Coastal Environmental Change (6 marks)

- Research and prepare between 5 and 7 resources, to demonstrate that environmental change has taken place at the field study site.
- Carefully label and present each resource and suggest one way each resource could be used to demonstrate Environmental Change to Australian Geography students.
- Examples may include: media news, satellite images, video, photographs, etc
- All sources must be referenced using Harvard style

g. Coastal Management (6 marks)

- Identify between 3 and 7 stakeholders in this investigative study.
- For example: local indigenous, local residents, local council, tourists, property developers, shopkeepers etc
- Explain the perspective of each group on the management of environmental change at this site.

h. Conclusion - Sustainable Coastlines (5 marks)

- What lessons can be learnt by Australians about sustainable coastal management strategies practised in the country studied for this investigation?
- Detail specific strategies used in your study area or challenges faced that may provide useful guidance to decision makers in Australia's coastal areas.

i. Bibliography + overall presentation (4 marks)

- Use of the Harvard style bibliography
- Use of headings provided.
- All images and maps are clearly labelled and referred to in your paragraphs.
- All images and maps are correctly referenced.

Need some ideas to get started?

Coastal resource materials:

BENOA BAY: (BALI)

Cassrels, D 2016, 'The businessman who aims to turn Bali into the new Palm Islands', *Financial Review*, 9 September 2016, accessed 10 June 2018, http://www.afr.com/lifestyle/anguish-bali-tourist-development--and-the-enigmatic-tomy-winata-20160829-gr3v4r.

Glenn, J 2017, 'Refugees in paradise:A humanitarian crisis on Bali's Serangan Island', *Coconuts Bali*, 31 January 2017, accessed 10 June 2018, https://coconuts.co/bali/features/refugees-paradise-humanitarian-crisis-balis-serangan-island/.

Topsfield, J 2016, '$3 billion islands project for Bali's Benoa Bay has locals up in arms', *Sydney Morning Herald*, 29 February 2016, accessed 10 June 2018, https://www.smh.com.au/world/3-billion-islands-project-for-balis-benoa-bay-has-locals-up-in-arms-20160228-gn5m1p.html.

PALM ISLAND: (DUBAI)

'Dubai's coastline changing: Study' 2016, *Khaleej Times*, 7 April 2016, accessed 10 June 2018, https://www.khaleejtimes.com/nation/general/dubais-changing-coastline.

'Dubai's Palm Island' 2010, television program, *Megastructures*, National Geographic, 21 October 2010.

MANAGEMENT STRATEGIES: MAYA BAY (THAILALND)

Smith, O 2018, 'The idyllic cove from The Beach is closing due to overtourism.', *The Telegraph*, 31 May 2018, accessed 10 June 2018, https://www.telegraph.co.uk/travel/destinations/asia/thailand/articles/the-idyllic-cove-from-the-beach-is-closing-due-to-overtourism/.

Maya Bay on Koh Phi Phi Le, an island of the Phi Phi archipelago, in the Krabi province of Thailand

NORTHHOLM GRAMMAR SCHOOL

Assessment Task Notification

Environmental Change and Management Investigation and Report

Due: Week 10 | Friday 6 April

Total: 40 marks (marking guidelines are outlined below)

Weighting: 25%

Length: Maximum length 1,500 words (excluding bibliography, headings, subheadings, and diagrams). You must be no more than 10% over this length to avoid a penalty.

Overview:

- Students are required to investigate Environmental Change and Management in a coastal environment outside of Australia.
- Students are to present their findings in a report format OR website using the scaffold provided.
- Students will be allocated a limited amount of class time to work on this take-home task, as directed by the teacher.
- Students need to upload their report (size 12 Arial or Calibri font) or Website Link to CANVAS by the due date and time, to avoid penalty.

Outcomes:

On completion of the task, students will have developed understanding and skills related to:

GE5-2: *explains processes and influences that form and transform places and environments*

GE5-3: *analyses the effect of interactions and connections between people, places and environments*

GE5-4: *accounts for perspectives of people and organisations on a range of geographical issues*

GE5-5: *assesses management strategies for places and environments for their sustainability*

GE5-7: *acquires and processes geographical information by selecting and using appropriate and relevant geographical tools for inquiry*

GE5-8: *communicates geographical information to a range of audiences using a variety of strategies*

(SOURCE: Geography 7–10 Syllabus)

NORTHHOLM GRAMMAR SCHOOL

Student Name .....

Year 10 Geography – Assessment Task 1
Marking Guidelines

a. **Area Description**		
- Informative and well researched introduction to the study area and outline of human forces (operating in a coastal environment located outside Australia) provided. - Details provided of the study area location, in relation to Sydney.	3–4	
- Introduction and /or outline of human forces operating is provided. - Some evidence of research about the study site and travel to the chosen country.	1–2	
Comments:		

b. **Historical Land Use**		
- An informative and well researched summary of major land use changes in the selected coastal environment. - A well-researched reference to coastal use by the local indigenous cultures and/ or community. - Land use changes over time are clearly presented in a time-line format.	3–4	
- A summary of major land use changes and/ or how the coast is perceived. - Attempt made to order the major changes over time.	1–2	
Comments:		

c. **Study Area**		
- Introduction to the Study area and the extent of the coastal environment using no more than 2 clearly annotated maps. - The coastal fieldtrip focus area is clearly indicated using BOLTSS and clear labels.	5	
- The extent of the coastal environment is clearly indicated in less than/ more than 2 maps - The coastal fieldtrip focus are is clearly indicated using BOLTSS	3–4	
- The coastal environment is partially indicated using maps and/ or the coastal field work site is indicated	1–2	
Comments:		

d. **Design a Focus Question**		
- The suggested focus question is clearly communicated, appropriate for the selected study site and justified.	2	
- The suggested question requires greater detail and / or not appropriate for the selected study site.	1	
Comments:		

Marking Guidelines

e. **Coastal Landforms / Biophysical Processes**		
- A well designed primary data field activity designed to enable students to deeply understand the natural processes operating at the selected site. - A clear justification for this activity is presented.	3–4	
- A primary data field activity designed to enable students to understand the natural processes operating at the selected site and a justification for this activity is presented. OR- a general reference to the coastal processes that may operate at the beach.	1–2	
Comments:		
f. **Environmental Change**		
- Clearly communicated and high quality evidence of environmental change at the selected field study site AND the intended use of the resources is clearly presented. - Two or more source types (e.g. personal images, media news, satellite images, video, photographs etc) used effectively to demonstrate environmental change in a selected coastal environment. - Between 5 and 7 resources demonstrating environmental change at the selected site clearly introduced, and referenced correctly using Harvard Style referencing.	5–6	
- Evidence of environmental change at the selected field study site presented - Use of only one source type - Less than 5 or more than 7 resources used - A reasonable attempt made to reference the sources using Harvard Style referencing	3–4	
- A number of sources used to in an attempt to demonstrate evidence of environmental change. - Harvard style referencing may be included.	1–2	
Comments:		
g. **Coastal Environment Management**		
- The coastal management perspectives of between 3 and 7 stakeholders clearly communicated - Presentation of stakeholder perspectives appropriate to the site selected	5–6	
- The perspectives of between 3 and 7 stakeholders communicated - Presentation of stakeholder perspectives may be appropriate to the site selected	3–4	
- Less than 3 or more than 7 perspectives presented and/ or - Presentation of stakeholder perspectives with reference to the site selected	1–2	
Comments:		

Marking Guidelines

h. **Conclusion – Sustainable Coastlines**		
- Clear evidence of research about management strategies practised in the country studied for the investigation. - Clear communication of lessons to be learnt by Australians about one sustainable coastal management strategy.	5	
- Evidence of research about management strategies practised in the country studied for the investigation. - Lessons to be learnt by Australians about one sustainable coastal management strategy may be presented.	3–4	
- Management strategies practised in the country studied for the investigation outlined and/ or limited evidence of lessons learnt about sustainable coastal management strategies presented.	1–2	
Comments:		
i. **Bibliography + Overall presentation**		
- Presents a logical response using suggested report structure. - All images and maps are labelled and referred to in the text. - Each section is consistent with others; includes a bibliography; appropriate length - Correct use of Harvard style bibliography to acknowledge information sources - Evidence of a creative and thorough approach to this task.	3–4	
- Presents a logical response mostly using report format and some geographical terminology. - Reasonable attempt made to prepare a Harvard style bibliography	1–2	
Comments:		

Waikiki Beach, Hawaii, USA. Photo: L. Chaffer

CORAL REEFS

Environmental Change and Management

Louise Swanson, Vice President GTANSW

Investigating change

Pre-lesson class questions

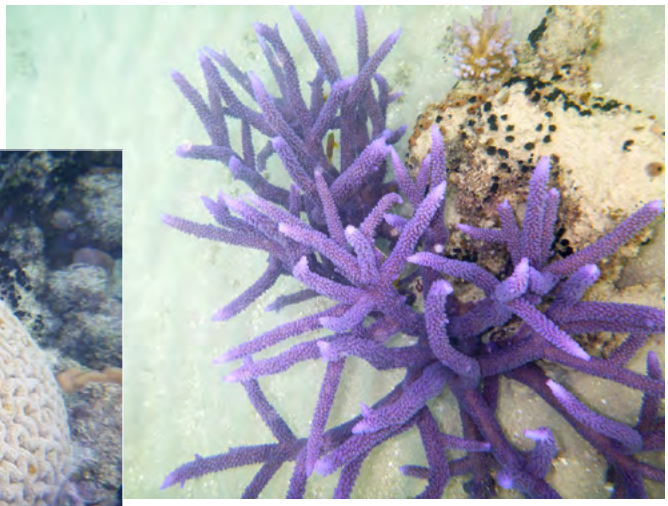
- What do you already know about types of environments and how they function?
- What are some local environments?
- What environments have you visited on your holidays?
- Are all types of environmental change negative?
- What do you already know about coral reefs?
- Have you ever visited any areas of coral reefs?
- What changes to coral reefs have you heard about in the news?

Examples of types of environments

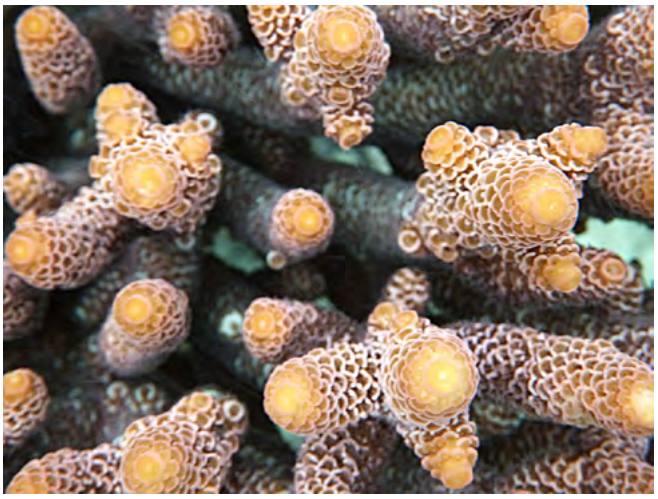
- Coral reefs
- Coasts
- Deserts
- Grasslands
- Wetlands
- Mountains
- Polar lands
- Rainforests
- Rivers
- Tundra

Lesson activities

- Brainstorm features of the environment and processes that relate to the four spheres (lithosphere, hydrosphere, atmosphere and biosphere).
- Create a mind map of causes of environmental change.
- Create a digital portfolio on environmental change. Include three articles about environmental change at each of: local, regional and national/global scale. Write a one paragraph analysis on each article addressing:
  - What is the cause of the change?
  - What are the positive and negative impacts of the change?
  - How do these changes impact on how the environment functions?



Photographs: Louise Swanson



Overview – Coral reefs

In this investigative study you need to compare environmental change in Australia with at least one other country. Throughout the activities you will compare change to coral reefs in Australia with change in countries such as Indonesia, Malaysia, Papua New Guinea, Philippines, Solomon Islands and Timor-Leste. Explore ArcGIS – location of coral reefs. https://www.arcgis.com/home/webmap/viewer.html?useExisting=1&layers=97071c96008d4ea6b0aabe4ed125661f

- With reference to ArcGIS, describe the location of coral reefs in: Australia, Indonesia, Malaysia, Papua New Guinea, Philippines, Solomon Islands, Timor Leste

Glossary

Adaptation – when behaviour, structural form or biology of an organism change over many generations.

Coral bleaching – when microscopic algae in coral tissues are expelled when there are changes in water chemistry including changes to temperature, salinity and pH.

Coral spawning – when clouds of coral eggs and sperm are released in large quantities and float around. Eventually the egg and sperm meet and larvae settle on the old reef to grow.

Ocean acidification – the ongoing decrease in pH of oceans caused by absorbing Co2.

Resilience – the ability to recover from a negative event.

Symbiosis – a very close relationship between two organisms

Upwelling – when cool nutrient-rich water is pushed to the ocean surface.

Zooplankton – very small animals that rely on water currents to move around

Biophysical processes

Climate and weather

Coral growth and functioning requires specific climatic and weather conditions. Average temperatures of around 26 degrees and clear water are essential for growth. If the temperature is too low the coral can't produce limestone, while if it is too high the coral will expel the zooxanthellae. Zooxanthellae are plant-like organisms that live in corals.

Corals can be damaged by extreme weather events. Heavy rainfall and floods can result in increased run-off and large amounts of sedimentation from mainland areas. These can suffocate corals and lead to algal blooms. During extreme events, wind and waves can break corals. Tropical cyclones can result in heavy rainfall (increased freshwater), increased river flow (sedimentation entering the ocean) and increased wind (coral breakage).

Symbiotic relationships

Symbiosis is a long term relationship between two organisms. There are three types of symbiotic relationship: mutualism (where both organisms benefit), commensalism (where one species benefits, but there is no benefit or harm to the other species), and parasitism (where one organism benefits tot he detriment of the other). There are many examples of symbiosis on coral reefs.

Clownfish and anemones

The Sea Anemones have tentacles with stinging cells. These stinging cells kill many organisms and it is in this way the anemones get their food. Clownfish hide in amongst the tentacles of the Sea Anemone, but are not harmed by them. In this way the clownfish are protected from other predators. Occasionally the Clownfish will catch food for the Sea Anemone.

Corals and zoozanthallae

The relationship between the corals and the zoozanthallae is beneficial to both. Corals provide the zoozanthallae with an environment suitable for survival. It is moist and the coral's waste gives energy to the zoozanthallae. Through the process of photosynthesis the zoozanthallae produce compounds that the coral use for food.

Sharks and Remoras

Sharks sometimes get parasites which live on the external surface of the shark. Remoras are cleaner fish, and they attach themselves to the shark and kill the parasites. When the shark feeds the Remora are able to eat the scraps from the feed.

Using Streetview to investigate coral diversity

Overview

Street View enables you to explore places with the full 360 degrees.

Click Explore, Choose a location, and click the Google Cardboard icon. You do really feel like you are part of the place. This could be valuable in helping students develop an appreciate of the places you are studying, and to get a better understanding of what those places are actually like.

How to…

Search for a location.

The location of the various options will show on the map.Select one of the options by scrolling down and clicking on your choice.

Students can maneuver around the reef. By scrolling to the right or left for a 360o view or by moving the forward or back arrows.

If students have access to a virtual reality head set they can click the headset icon to view it in a more immersive way.

Virtual reality lesson activity

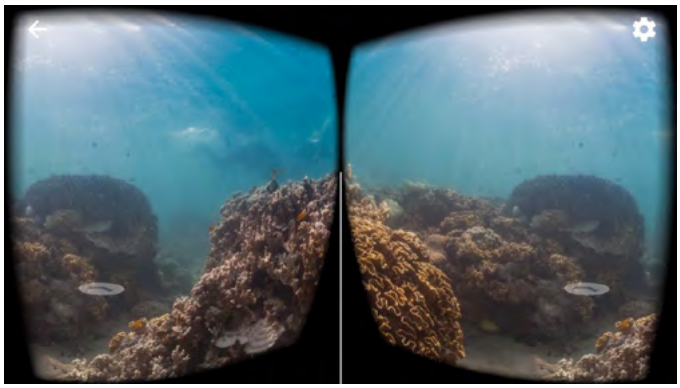
Use Google Streetview to examine a range of sites around the Great Barrier Reef and Coral Triangle. Choose specific sites, eg, several locations around Lizard Island, or Kimbe Bay. Compare the two main virtual field sites.

Make judgements about the quality of the corals, the colours of the corals, etc.

Try to identify specific types of coral. You will need to refer to a coral identification site.

Compare the complexity and biodiversity or the two sites.

Find two secondary sources that support your findings.



Causes of change to coral reefs

Climate change

Reefs are highly vulnerable to climate change. Increasing temperatures can result in slowed growth, loss of hard corals, crumbling of reef structures and widespread bleaching. Climate change is associated with sea level rise, increased ocean temperatures, ocean acidification, increased occurrence of extreme weather events such as cyclones, and movement of species.

Population pressure

Increased population pressures on mainland North Queensland have resulted in increased levels of pollution and physical activities related to tourism on the reef area.

Tourism

The outstanding beauty of the reef attracts millions of tourists each year. The pressure placed on the reef as a result of tourism includes developments on the shoreline (and associated sewage, rubbish) increase boating activity (including oil spills, coral breakage as a result of boat propellers), and tourist activities (breaking corals while snorkelling, walking on reefs, accessing sensitive areas).

Agriculture (particularly sugar cane farming)

Agriculture, including sugar cane farming, has resulted in increased sediment and fertiliser run-off from cane farms. Sugar cane farmers apply fertilisers containing Nitrogen (N) and Phosphorous (P). Many put on extra fertiliser in case of heavy rain (so it is not all washed away). Of all fertilisers applied, only a third is absorbed by the crops. The rest is either evaporated, enters groundwater or runs off into nearby rivers or canals.

Land clearing and deforestation

Clearing of forests for farming, livestock and urban development increases runoff and the sediment it carries with it. Erosion has accelerated due to clearing of land (less tree to stabilise soil), including the erosion of river banks. Due to erosion the river can erode into paddocks. In Australia, there is believed to be four times more sediment reaching the coast than prior to European settlement, and in some places it is closer to 40 times. Indonesia is one of the world's highest deforesters, and is also home to some of the most diverse coral reefs in the world. Indonesia clears 1.1 million hectares of forest every year.

Fishing

Recreational and commercial fishing have had major impacts on the reef. Commercial prawn fishing accounts of a large proportion of Queensland's Fisheries output. Approximately 6 million kgs of prawns area harvested in a good year. Recreational fishing in the General Use

zones of the Great Barrier Reef Marine Park (GBRMP) accounts for 75% of the fin fish taken from the reef each year. Commercial fishing includes fishing for crayfish, finfish, reef fish, barramundi and tuna.

Dredging

Dredging is removing sediment from the bottom of a river bed, harbour, etc and placing it elsewhere.

Coral bleaching

The changes in temperature and associated bleaching are resulting in a different mix of species on the reef. This will impact reefs in the long term.

Loss of species

Fish, whales, dolphins, sharks, rays and the many other organisms found in reefs rely on the complexity of the ecosystem for survival. Some fish rely on the colour of the corals for camoflauge and the structure of the coral for hiding. Many organisms are unable to carry out normal functions and processes as a result of the increased ocean acidification associated with climate change. Shellfish are less able to create their shells due to increased pH. Slow growing corals will take 100-200 years to recover, meaning that the reef will not exist in the form that we have known it in the past.

Dispersal of spawn

Ocean warming impacts on the dispersal or coral spawn (eggs). Increased ocean temperatures result in a decline in the dispersal distance of coral spawn from the origin (parent coral) to the destination site. This change in dispersal patterns can impact on species' distribution, abundance or corals in particular areas and genetic diversity across reefs. Changes to dispersal patterns can also impact on the connectivity (interconnections) between different areas of the reef by limiting the areas of reef that particular coral species are located.

Poleward shift of species

Ocean warming can also result in a poleward shift of species from tropical zones to more temperate zones. Warmer waters are found further from the tropics and species are able to take advantage by increasing their range.

In Western Australia, a species of wrasse - cheorodon rebuscens has started to shift its range with displacement of recruits south of its usual habitat. There is evidence of high recruitment at the temperate edge and no recruitment at the tropical edge. The range shift provides limited expansion opportunities, reducing resilience of the species.

Irukandji are migrating further south on the Great Barrier Reef as a result of warmer waters and are also having longer seasons in other areas. There have been anecdotal reports of increases in reports of stinging and hospitalisations on islands within the Great Barrier Reef (e.g Fitzroy Island) and snorkellers are being strongly advised to wear stinger suits outside of usual peak Irukandji seasons. Irukandji and associated stingings have also been reported on western side of the southern tip of Frazer Island where they haven't previously been found.

Symbiotic relationships

Following bleaching events or even natural disasters, corals can become overgrown with algae, making it difficult for coral recruits to settle and grow. The mix species on a reef can impact on how resilient that particular reefs is. The scale of the bleaching on GBR makes it unlikely that natural processes will have much of an impact on recovery in the short to medium term.

Using twitter to investigate coral changes

Overview

Social media is a tool that students are very familiar with and use for a variety of personal and social purposes. If we can tap into students' enthusiasm for and ability to use social media we can easily harness it to enhance student learning. Recent coral bleaching events have been discussed widely on twitter by experts and organisations that study and work to protect coral reefs.

Who to follow…

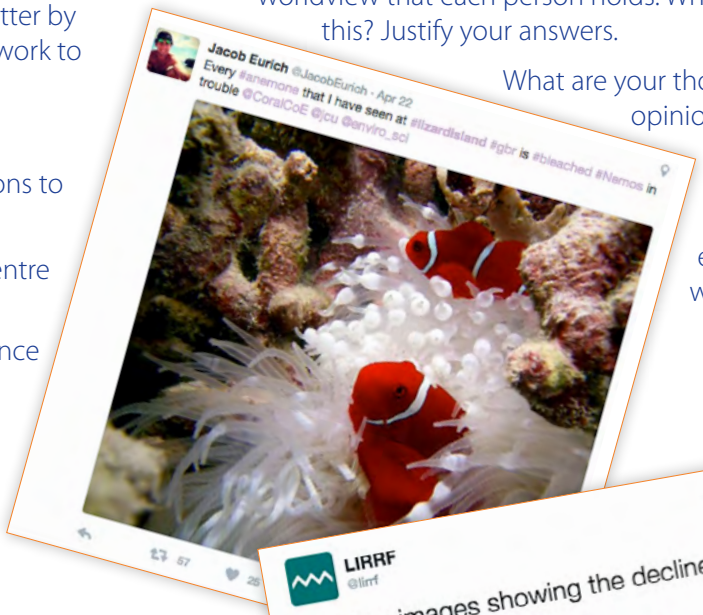
Some examples of experts and organisations to follow on twitter:

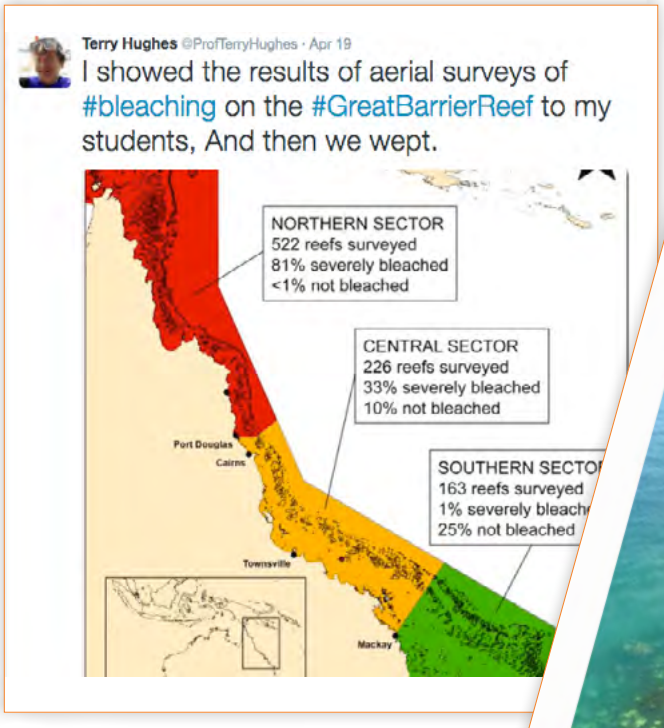
- @ProfTerryHughes – Director of ARC Centre of excellence
- @CoralCoE – The ARC Centre of Execllence for Coral Reef Studies
- @jpGattuso – CNRS Research Professor
- @AllisonPaley & @GraceEFrank – Research Assistant with Coral Ecophysiology Lab
- @jcu – James Cook University
- @AustCoralReefs – Australian Coral Reef Society

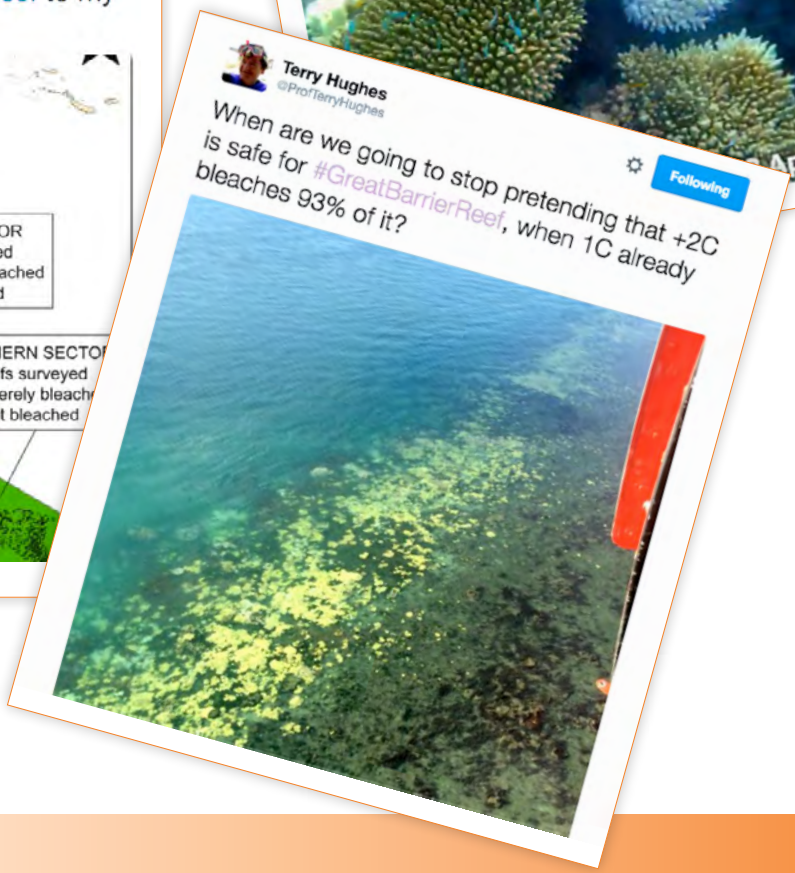
Twitter lesson activity

Investigate the differences in people's views about the causes of environmental issues such as coral bleaching and ocean acidification. Take screenshots of a range of different views about this issue. Refer to the information about environmental worldviews from previous lessons. Make an inference about the environmental worldview that each person holds. Why do you think this? Justify your answers.

What are your thoughts and opinions about this issue? How do your thoughts reflect your own environmental worldview?







Investigating changes using GIS

In this activity you will use Reef GIS to investigate factors causing change in coral reef cover and health.

Visit Reef GIS

http://reefgis.reefbase.org

Before you begin the activity, explore the menus on the left hand side of the screen. You have three options: Maps, Layer and Legends.

Maps allows you to select from different map themes.

Layers allows to select the type of information that shows on your map.

Legends allows you to see the colours or symbols used on the map and a label to explain what they mean.

Some of the map themes you can choose from include: Location of coral reefs, Coral diseases, Coral bleaching and Sea Surface Temperatures, Reefs At Risk, Solomon's Post-disaster and Marine Protected Areas.

Begin by exploring the Location of Coral Reefs. Click the option from the Maps list.

You can view this information at a global scale or zoom in the look more closely at individual countries, by selecting the country name from the drop down list.

When you click on the Layers tab you are able to click the types (or layers) of information that you want to view. In this case, you can view reefs by type, geomorphology or depth. Each category of information is shaded in a different colour to help you see the information.

The Legend provides the colour and category of information shown by the colour, but you can also see this information in the Layers tab.

Comparative study: Australia and Indonesia, Malaysia or Papua New Guinea

Choose an issue/factor affecting coral reefs from the themes in the Maps section. Examine the data shown in the map. Write an information report including the following:

- Describe the issue/factor causing change in coral reef environments globally (comment on spatial distribution, scale, etc). Propose an explanation for the spatial patterns/trends you can see.
- Conduct secondary research to identify the causes of this change in Australia and at least one of the listed countries.
- For both Australia and one other country, describe the extent of the change shown in the Reef GIS map.
- Describe how Geographical Information Systems (like Reef GIS) might be used to analyse geographical information, make predictions and suggest management strategies.
- Reflect on the information you have gathered. Propose individual, community or government actions that could be taken to address the issue/factor affecting coral reefs.

Using Within to examine environmental change

Within is a virtual reality app that provides a range of educational programs, one of these is Valen's Reef, created by Conservation International: the Click Effect.

Open the Within app, select Valen's Reef.

This presentation follows a local fisherman explaining the pressures on him and his local reef.

A narrative is provided over the footage of the reef and the island. Students can maneuver around the scene to access 360° views. Students will feel immersed in the scene and the story.

Valen's reef lesson

Virtual reality lesson – Valen's Reef

Students view Valen's Reef, using the Within app.
A couple of quick questions:

- What were some of the threats to coral reefs in Raja Ampat?
- What was the role of Conservation International?
- Assess whether the strategies being implementedare successful? What indicator suggest success?
- The narrator refers to continued "outside pressures". What is he referring to?
- What evidence is there throughout the experience of traditional worldviews or management structures/ strategies?

Change and management

Worldviews

Environmental worldviews are the viewpoints that people hold about how the world works and where people fit into the world. The worldview that someone holds will form the assumptions and values that guide an individual's actions towards the environment.

Egocentric: where people see themselves and their needs as the most important factor to consider.

Anthropocentric: acknowledges that humans have a variety of needs and wants that often must be placed above the desire to protect environments.

Stewardship: recognises that although humans need to make use of environments for survival and development, they have a responsibility

Biocentric: recognises the significant role that the Earth and its environments play in sustaining life, including human life. It strives to minimise the impact of human activities on environments and species.

Ecocentric: a worldview that places the preservation of environments above all other needs and wants.

The implications of different worldviews are that the competing demands for and uses of coral reefs result in varied and sometimes opposing management of the marine environment (coral reefs).

Management strategies

- Government Policy
- Legislation
- World Heritage Sites
- Marine Parks
- Zoning
- International agreements
- Government cooperation
- Traditional use
- Climate change strategies
- Low intensity fishing techniques
- Equipment restraints
- Artificial lagoons
- Reef restoration
- Species protection
- Ecotourism
- Yield constraints
- Education
- Research
- Species monitoring
- Taboos
- Reef and lagoon tenure.

Lesson activities

- Create a dot point summary about the cause of change to coral reefs.
- Develop a blog or use a twitter hashtag to compile evidence of coral bleaching globally.
- Groupwork: Coral bleaching. Investigate coral bleaching in a location other than Australia. Prepare a one minute lecture and interactive presentation to present to the class.
- Create a board game about coral bleaching.
- Write newspaper/magazine articles about the different ways that corals can be managed, and compile them into a class magazine to be published on the school website or Facebook page.
- Create a series of podcasts about coral reefs and their management. Conduct peer reviews of other groups' podcasts and provide feedback.
- Create an infographic using picktochart or a similar program. Your infographic should be on the topic of the causes and consequences of environmental change in coral reefs. It could include themes such as pollution, runoff, coral bleaching,the impact of land clearing, or coastal development.
- Identify your own worldview. Organise yourselves into groups with likeminded people, undertake research about Adani coal mine and establish your point of view about the development.
  Develop two opposing groups in the class, and hold a debate on: *The benefits of the Adani coal mine will outweigh the disadvantages.*

Using Storify to investigate management

Create a Storify that shows the progress of discussions, research, campaigns and decisions related to the management of a coral reef. Use the tweets and the links contained in them as a starting point for a geographical inquiry. This may help you to pose questions, planning an investigation, collecting secondary information.In doing so, consider:

- Have you represented a range of viewpoints?
- Is there evidence of reliable geographic or scientific research?
- Where can you take your inquiry from here?

Summarise the key points from your storify. This will provide the context for a geographical inquiry.

Stage 5 Environmental Change and Management

Lorraine Chaffer, President GTANSW

SYLLABUS LINKS

STAGE 5: Environmental Change and Management

Environments
Students investigate the role and importance of natural environments

Environmental change
Students investigate human-induced environmental changes across a range of scales

Environmental management
Students investigate environmental management, including different worldviews and the management approaches of Aboriginal and Torres Strait Islander Peoples

Select ONE type of environment in Australia as the context for a comparative study with at least ONE other country.

Students:

- investigate the biophysical processes essential to the functioning of the selected environment
- investigate the causes, extent and consequences of the environmental change
- investigate the management of the environmental change

Key Inquiry Questions

- **How does the Sydney Harbour estuary function?**
- **How do people's worldviews affect their attitudes to and use of Sydney Harbour?**
- **What are the causes and consequences of change in the Sydney Harbour estuary and how can this change be managed?**
- **Why is an understanding of environmental processes and interconnections essential for sustainable management of the Sydney Harbour Estuary environment?**

Aerial view of the Middle Harbour, located north of Sydney central business district - https://upload.wikimedia.org/wikipedia/commons/f/f8/Parramatta_River_From_above_%288450764898%29.jpg

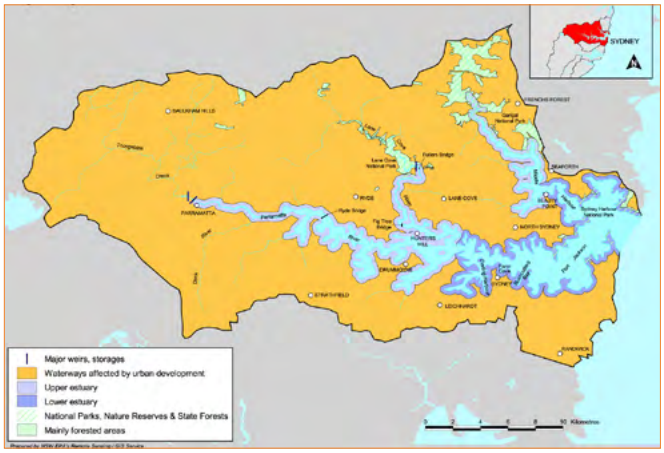
SYDNEY HARBOUR ESTUARY

Sydney Harbour, one of the largest estuaries in the world, is a drowned river valley with a wide, open mouth, and many bays and inlets. The structure of the harbour creates a wide variety of habitats that support a high level of biodiversity compared to comparable estuaries around the world. Until the 1950's very little was known about what was below the surface of Sydney Harbour, today that is changing as research scientists investigate the marine environment to better understand its features, functioning and threats.

"Over centuries, Sydney Harbour has figured as an invisible ecosystem, traditional country, an industrial underwater, and a place of myth and fantasy. It represents such a large part of the city of Sydney, yet it continues to be hidden in history, and invisible to citizens going about their daily lives."

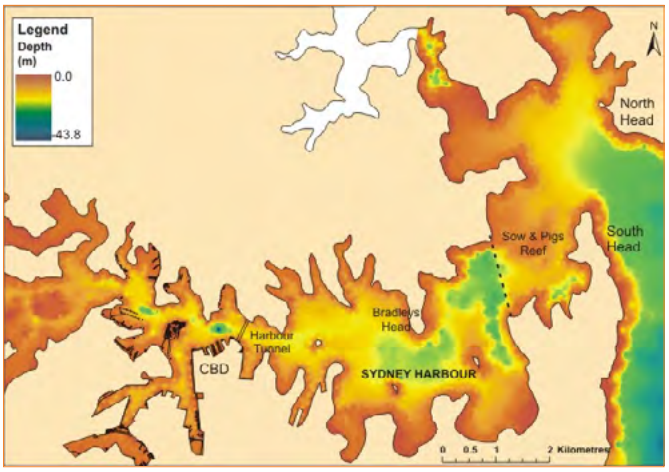
Source: Blog - The Floor of Sydney Harbour – Ann Elias's new research project February 2018 http://sydney.edu.au/environment-institute/blog/floor-sydney-harbour/

Map 1: Sydney Harbour Estuary and catchment



Source: Environment NSW https://www.environment.nsw.gov.au/ieo/SydneyHarbour/maplg.htm

Map 2: Natural bathymetry of Sydney Harbour



Source: Ozcoasts – http://www.ozcoasts.gov.au/geom_geol/case_studies/sydney_final_report.jsp

Note: A map showing submarine contours can be found on the Port Authority of NSW website at https://www.portauthoritynsw.com.au/sydney-harbour/pilotage-navigation/pilotage-harbour-masters-directions/port-passage-plan/

Activate prior knowledge

Activity Worksheet 1: Healthy aquatic environments

Activity Worksheet 2: Sydney Harbour Quiz

GEOGRAPHICAL FACTS

- Extent – 30 km west to Parramatta
- Surface area approx. 50 km^2 with a total catchment of 500 km^2
- 3 km wide at the heads – up to 30 m deep
- Major components
  - Port Jackson (Sydney Harbour)
  - Middle Harbour
  - Parramatta and Lane Cove Rivers (main tributaries)
- The natural beauty attributed to the complex shoreline and topography
- 90% of the catchment is urbanised or industrialised
- 50% of the foreshore is armoured
- The surrounding population is 5 million people
- The seabed is heavily contaminated from Sydney's industrial past

Source: Sydney Institute of Marine Science http://sims.org.au

ENVIRONMENTAL PROCESSES AND FUNCTIONING

A number of related processes create conditions for a diversity of habitats and species within the harbour. These include:

- Estuarine processes – tides and river flow
- Weather and climate
- Currents eg East Australian Current

Sydney Harbour is a tide-dominated estuary that extends inland to the Parramatta weir where the tidal influence ends. Before the river valley drowned as the sea level rose, the coastline was 3 to 5 km east of where it is today. The flooding of the river valley and subsequent sedimentation, erosion, deposition and human activity have created a complex estuarine environment. The underwater topography (bathymetry) of the harbour has an average depth of 13 metres, with deep channels and shallow areas from 3 to 5 metres deep. Some shipping channels are 28 to 45 metres. There are large, shallow bays between headlands and intertidal zones that are exposed at low tide and submerged at high tide.

Parramatta River, Parramatta - https://commons.wikimedia.org/wiki/File:Parramatta_River_-_Parramatta,_NSW_(7834157948).jpg

Estuarine processes

Estuarine processes result in the mixing of salt water and fresh water and the supply of sand (marine sediment) and silt / mud (fluvial or river sediment) that settles on the floor and shoreline.

Variations in salinity and sediment contribute to the different habitats found in the harbour. The estuary can be divided into different units based on the dominant sediment.

- The entrance and lower seaward estuary (sands)
- The central estuary (muddy sands)
- The upper estuary, off-channel bays & intertidal zones (muds)

Salinity varies with the inflow of freshwater and saltwater – this is determined by precipitation, infiltration, runoff and evaporation in the catchment, daily tidal ranges, prevailing winds and extreme weather events such as East Coast Lows.

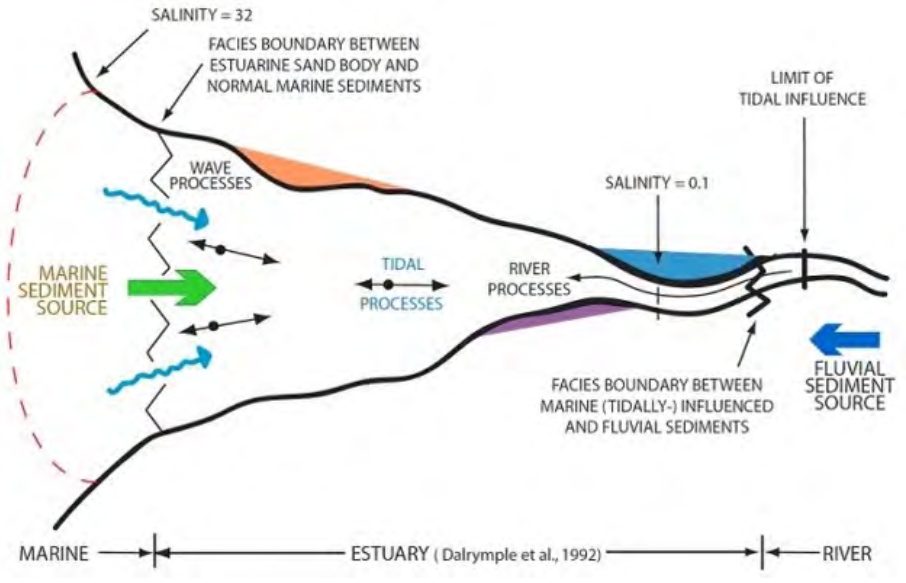
The main Sydney Harbour catchments are Parramatta, Lane Cove and Middle Harbour, however runoff also comes from small creeks and stormwater outlets. The tidal range is considered to be small at 2.1 metres. The Sydney Harbour catchment has been described as dry with periodic high precipitation events, a feature that limits freshwater flushing in many bays and inlets.

To learn more about estuaries see:

- FACT SHEET 1: What is an estuary?
- What's an Estuary? Now you know – https://youtu.be/XLumSN4G5P4

The East Australian Current brings warm nutrient poor water down the east coast of Australia (pushed to the western edge of the ocean by the rotation of the Earth). Current speeds off Sydney can be up to 1.5 m/s. Over time, this current has strengthened making Sydney and eastern Australia climate change "hotspots" and impacting on marine habitats and species. An increasing

Diagram 1: Estuarine processes result in the mixing of salt and fresh water and the supply of sand (marine sediment) and silt (Fluvial or river sediment).



Where would Paramatta be on this diagram?

What is the difference between marine and fluvial sediment?

Why is this important?

Source: Nature – https://www.nature.com/scitable/knowledge/library/estuaries-where-the-river-meets-the-sea-102734157
Bianchi, T. S. (2013) Estuaries: *Where the River Meets the Sea.* Nature Education Knowledge 4(4):12

number of tropical species are being found within the estuary, some now 'wintering', meaning they can survive further south all year round. The story of NEMO is a reality.

Can you identify features of the lithosphere, hydrosphere and atmosphere in the Sydney Harbour Estuarine environment?

THE NATURAL HABITATS OF SYDNEY HARBOUR

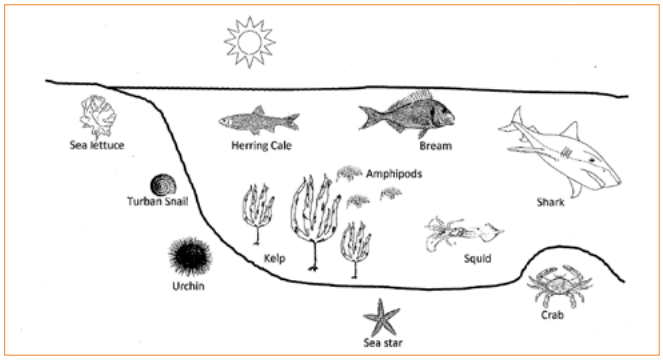
The topographic and hydrologic variations within Sydney Harbour created a diversity of habitats that support a large number of species diversity. These habitats have distinct characteristics, yet are interconnected through the movement of water, nutrients, sediments and organisms within the entire estuarine environment.

Subtidal rocky reefs occur where the harbour bottom dips from the shoreline to deep channels such as Dobroyd Head and Middle Head. In this habitat native kelp beds support high levels of biodiversity including sea-urchins, sponges, algae, seahorses and fishes. There are 45 species of wrasses, 32 species of gobies and 26 species of damselfishes as well as endemic species such as the Sydney Scorpionfish. Compared to other urban estuaries such as Melbourne's Port Phillip Bay, Sydney Harbour rocky reefs have high levels of fish biodiversity at 25–25 species per 500 m2.

Photo 1: Subtidal rocky reefs and rocky intertidal shore habitats

Source: https://www.localliving.com.au/manly/beaches-off-the-beaten-track/reef-beach/

Diagram 2: Kelp is the main habitat forming organism for species on subtidal rocky reefs.

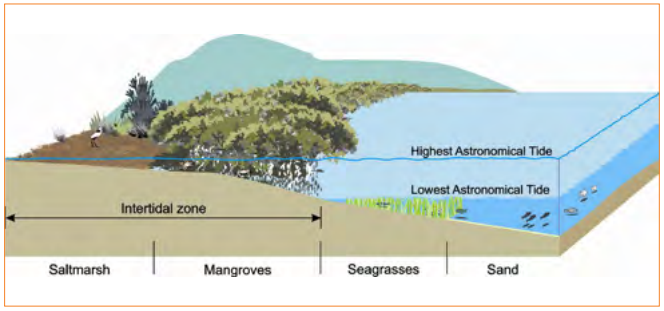


Source: Sydney institute of marine science

Rocky intertidal shores include fragmented areas of natural shoreline ranging from flat or gently sloping sandstone shelves to vertical walls. Habitat forming species such as oysters and algal beds are found in patches that support high levels of biodiversity. Much of this habitat in Sydney Harbour has been replaced by human structures such as seawalls.

Soft bottoms and beaches support seagrass, mangrove and saltmarsh vegetation communities. Mangroves (mainly Grey Mangrove and River Mangrove) are the basis for detritus-based (decaying plant matter) food webs that support a variety of species including algae, barnacles, molluscs and fish. Saltmarsh found landward of the mangroves, and seagrasses (submerged plants), which once dominated places with soft sediment, have largely been cleared. Estimates state that seagrasses now occupy less than half the area (51.7 ha) they did in 1943 while mangroves have increased in that time.

Diagram 3. Habitats on soft harbour bottoms and beaches



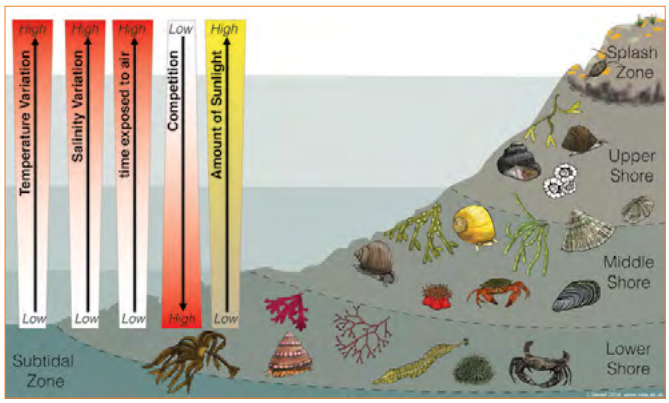
Source: https://www.ces.vic.gov.au/sotb/chapter/mangroves-saltmarsh

Open waters support plankton-based food webs. The deeper water in this zone transports dissolved and suspended material from upstream to other habitats and supports the migration of fishes and mammals between the estuary and the ocean, including annual migrations of humpback and Southern Right whales (May–September). A Little Penguin colony found between Manly and North Head spends the day at sea, up to 20km off the coast, feeding on small fish, squid and krill. They return to their land-based colonies after dark.

The importance of understanding the Sydney harbour environment.

With over 3000 marine species, Sydney Harbour is a biodiverse waterway because of the variety of habitats, varying types of sediment, water depth, and vegetation. Aquatic organisms require different light, salinity, temperature, air exposure conditions. Changing conditions such as the East Coast Current can impact on biodiversity. Understanding these environmental limits is important for environmental management.

Diagram 4: Different species require different environmental conditions on an intertidal rocky headland.



Source: The Marine Biological Association http://www.mba.ac.uk/fact-sheet-rocky-shore

Using Diagram 4:

Can you identify plants and animals found in the Middle Shore zone of a rocky headland and describe the environmental conditions they prefer? (A search of 'intertidal zone creatures' might help your identification)

How might environmental conditions change in the upper shore zone with a rise in sea level and how might plants and animals react?

Activity Worksheet 3: A Sydney Harbour Food Web

Activity Worksheet 4: Identify Sydney Harbour estuarine habitats.

KEY HABITAT FORMING ORGANISMS IN SYDNEY HARBOUR

There are certain species within the different habitat types in the Sydney Harbour that have significant environmental values including filtering water, stabilising and protecting shorelines and supporting high levels of terrestrial and aquatic biodiversity through food chains and food webs. The species include:

- Mangroves and saltmarshes
- Oysters
- Kelp

Photo 4. Mangroves are often known as 'nurseries of the sea' for the role they play in supporting small fish and other marine creatures.

Source: UNESCO https://es.unesco.org/node/293694

Human activities in and around the harbour have severely reduced populations of these organisms and in doing so impacted on water quality and biodiversity in the estuary. Habitat restoration efforts to restore some of these habitats have increased in recent years.

Activity Worksheet 5: Can oysters save Sydney Harbour? A Geographical Inquiry

Photo 2.: In sheltered bays, Sydney rock oyster reefs provide a haven for invertebrates and fish.

Source: The surprising benefits of oysters. – http://theleadsouthaustralia.com.au/environment/surprising-benefits-oysters-no-not-thinking/

Photo 3. *Ecklonia radiata*, the most common kelp found in Sydney Harbour, provides food and shelter to many animals in the ecosystem.

Source: John Turnbull, Creative Commons https://www.flickr.com/photos/johnwturnbull/14545258891/

ENVIRONMENTAL USE, CHANGE AND MANAGEMENT

1. Significance of the Sydney Harbour Estuary for Aboriginal Australians

It is estimated that over 1500 Aboriginal people from several different clans lived around the Sydney Harbour Estuary before 1788. These clans included the Gadigal, Wangal, Wallumedegal, Boromedegal, Gamaragal, Borogegal, Birrabirragal and Gayamaygal. Archaeological evidence from rock engravings, shell middens and artefacts as well as historical artworks show that fish were an important source of food for groups living around Port Jackson and Parramatta and Georges Rivers.

* Shell middens are the location of campsites and 'dinner-time' camps, and the shells are principally the remains of past meals

Textbox 1: Dictionary of Sydney

'People lived on the south-eastern edge of Australia well before the sea started rising around 11,000 ago. Humans witnessed the inundation, albeit over generations, and adapted to the changing environments. Ultimately, they retreated to occupy the foreshores that were created when the waters finally stopped rising some 6,000 years ago. By then what had been a river valley was a complex harbour of many coves, headlands and points, with three estuarine arms to the immediate north, north-west and west.

At some time before or after the water stabilized, these people established territories around the waterway based upon family groups. By the 1700s, there were at least eight clans occupying specific parts of the harbour foreshores. These were 'saltwater people' who gathered much of their food from the waterway and for whom the meaning of place was all-important. The land, shore, and probably the harbour itself, were imbued with social and spiritual significance. Headlands, points and coves were named from Boree (North Head) along to Parramatta, at the end of the Harbour's western estuary, and back around to Tar-ral-be (South Head).

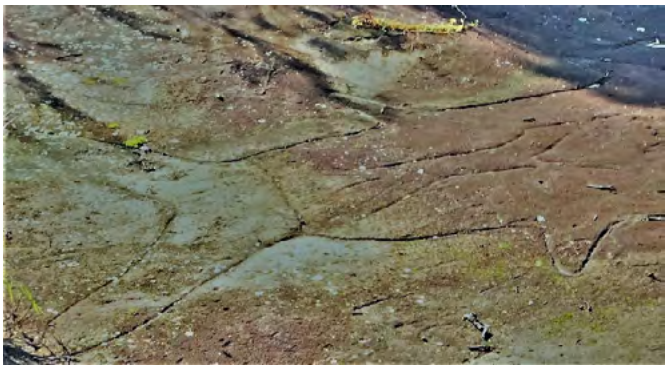
The local sandstone was ideal for engraving, so on rock platforms along the waterway, the harbour's first people carved images of the animals they saw and hunted and to which they may have attached totemic significance.

Source: https://dictionaryofsydney.org/entry/sydney_harbour_a_cultural_landscape. Information on the site based on the following publication.– Val Attenbrow, *Sydney's Aboriginal Past: Investigating the Historical Records*, second edition, University of NSW Press, Sydney, 2010

Artwork 1. Aboriginal people using bark canoes, spear-fishing, diving, swimming, and returning to shore

Source: ***Lycett, Joseph: Fishing [Port Jackson], 1817.***National Library of Australia http://nla.gov.au/nla.pic-an2962715-s17

Photo 5: An ancient engraving of a whale carved on a headland by the Cammeraygal people.



Source: Coal Loader Centre for Sustainability, in Waverton. https://www.atlasobscura.com/places/aboriginal-carving-whale

2. Urbanisation and population growth

Artwork 2: Dictionary of Sydney- 'The City of Sydney', drawn by M.S. Hill in 1888, shows an aerial view of the city

Source: City of Sydney Archives. https://historycouncilnsw.org.au/new-home-dictionary-of-sydney/

Use Google Earth to take a screen capture of this view of Sydney today and compare the differences.

Create a sketch map and label places you recognise around the harbour.

3. Anthropogenic change: Human impact on the Sydney Harbour Estuary since 1788

1. Nutrients have increased.
2. Intertidal habitats have been modified by artificial structures.
3. The water cycle has changed - water diversion and hard urban surfaces have altered freshwater runoff, sediment and nutrient flows.
4. Aquatic species have been overexploited or reduced by habitat destruction through land reclamation and building seawalls to replace the natural shoreline.
5. Industry has caused high concentrations of contaminants in harbour sediments and water.
6. Introduced species are altering habitats and food webs, threatening native species, and reducing commercially important species.
7. Climate change is impacting on habitats and biodiversity.

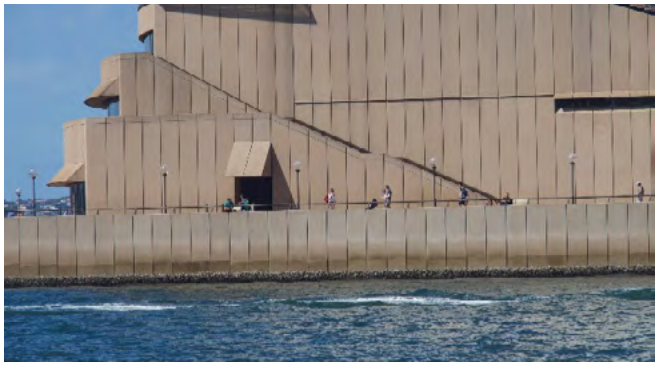
Activity Worksheet 6: Investigating threats to estuaries using conceptual models

4. What's wrong with Sydney Harbour today?

'A common perception is that cities, and their associated ecological impacts end at the waterline. However, coastal cities such as Sydney are also highly modified underwater. Below the waterline in Sydney Harbour there is a dense network of coastal infrastructure, the sediments hold a legacy of chemical contamination and shipping activities contribute further stress through antifouling biocides and invasive species.'

Source: Sydney Marine Science – http://engonet-sims.azurewebsites.net/directory/59/putting-sydney-harbour-into-marine-rehab&sa=D&ust=1542237211549000&usg=AFQjCNEOZbXhspCDsBdLKwWUnfXbObSWdQ

Images 6–11 of Sydney Harbour foreshore today show the heavily armoured shoreline that has replaced natural habitats, particularly east of the Anzac Bridge.



Photos by Lorraine Chaffer

The *cumulative impacts* of human activities on Sydney Harbour today include

1. Water pollution (nutrients, chemicals, bacteria and pathogens, dioxins, litter, plastics and microplastics)
2. Interference with natural habitats and processes - the water cycle, food chains and nutrient cycles and alien species
3. Artificial structures and habitat modification – seawalls, land reclamation, dredging, boating and fishing.
4. Climate change

Pollution in the harbour is caused by poor waste management, Sydney's industrial past industry and stormwater runoff. Although industrial waste disposal to Sydney Harbour is now regulated, past pollutants remain in the sediments on the harbour floor where they can be injested by organisms and enter food chains. Warnings about eating fish caught west of the Sydney Harbour bridge are evidence of this pollution. More recently, plastics (including microplastics) and cosmetic products (microbeads) have become issues in relation to water quality. Plastic container deposit schemes, plastic bag and microbead bans and education programs about microplastics are recent efforts to reduce these pollutants.

Stormwater runoff adds to this pollution preventing habitats such as oysters from recovering to a level where they can improve sediment and water quality through natural filtering. Restoration projects include creating oyster reefs and tiling seawalls to attract habitat forming species with water filtration powers. Living seawalls are now seen as the 'rooftop gardens' of the harbour.

Nutrients including nitrogen, phosphorus and carbon are recycled through harbour food chains and keep habitats functioning healthily. Excess nutrients from human sources such as fertilisers and sewage can cause problems such as eutrophication (where excess nutrients lead to the growth of algae that increase turbidity). This in turn interrupts food chains by reducing the sunlight available for photosynthesis by aquatic plants such as Kelp and seagrasses. Education and effort to intercept and treat stormwater runoff to remove nutrients are ways of addressing this issue.

Ships, boating and fishing

Recreational boats, ferries and cruise ships along with fishing activities and infrastructure such as moorings and marinas have multiple inpacts including:

- removing large fish from aquatic food webs
- causing propeller damage, wash, noise and pollution from antifouling paints and oil spills.
- Reducing biodiversity through animal strikes, sediment resuspension, anchor drag, and transporting introduced species that can compete with native species for food and habitat

Establishing marine parks and designing and building fish friendly moorings, piers and jetties are efforts to manage these issues.

'Urban sprawl beneath the waves provides shelter to marine invaders that have hitchhiked into our harbour on travelling ships. Harbour-dwellers that thrive in the crevices of pilings and pontoons are often invasive species hostile to Sydney's natural ecosystem and include sea squirts and bristle worms which spread across habitats, driving indigenous marine life away.'

Marine ecologist Dr Katherine Dafforn, 'It's war down there: Sydney Harbour a marine battleground between invasive and local species' https://www.smh.com.au/national/its-war-down-there-sydney-harbour-a-marine-battleground-between-invasive-and-local-species-20140807-101dt1.html

'In Sydney Harbour, recreational boat density has increased at a rate of approximately 2 per cent per year, with additional moorings needed to secure boats when not in use. Almost 22,400 registered recreational vessels are expected for the harbour by 2021. Moorings affect the seabed because their attached chains scour the sediment, often disturbing seagrass and sediment infauna. Seagrass-friendly moorings (those without chains to disturb the seabed) have been installed at some locations...'

State of the environment Report 2016. https://soe.environment.gov.au/theme/coasts/topic/2016/coastal-waters

Climate change is a growing concern. Rising temperatures are causing changes to water temperatures and impacting on the distribution of aquatic species, their growth and reproduction. Tropical fish are now commonly found in Sydney Harbour, with some surviving through winter. The impact on of tropical grazing fish on sea grasses and kelp beds is already being seen off the coast. Predicted sea levels rises will impact on intertidal habitats.

'By 2050 sea levels are predicted to rise by up to 40cm from 1990 levels, and by 90cm by 2100. According to a recent report by the NSW Department of Climate Change, one centimetre of sea level rise could potentially result in one metre of erosion.

Rising sea levels will eat away at habitats, particularly in low-lying areas like mangroves or marshes. Combine the rising sea levels with an increase of climate-related storm surges and marine habitats take a belting.'

Source Cool Australia https://www.coolaustralia.org/sydney-harbour-secondary/

Student activities:

- Analyse quantitative and qualitative data such as graphs and sea level modelling maps (GIS) to draw conclusions about the impact of climate change on Sydney Harbour. Ozcoasts maps show modelling under different scenarios for different sections of the harbour. See https://ozcoasts.org.au/maps-data/
- Examine and discuss media reports such as:

  Sydney Harbour's corals are bleaching https://www.mq.edu.au/newsroom/2016/04/19/sydney-harbours-corals-are-bleaching/

  Sydney's waters could be tropical in decades, here's the bad news… https://theconversation.com/sydneys-waters-could-be-tropical-in-decades-heres-the-bad-news-31523

  - Note the key points
  - Assess the material and ideas for validity, reliability, usefulness
  - Find evidence to support the claims
  - Create a media evidence file

Artificial structures and shoreline modification

Sydney Harbour is one of the most modified harbours in the world. While under water impacts are invisible to most people, the extent of urban development and modifications to the shoreline are the most dominant and visible change. Today, 90% of the catchment is urbanised or industrialised and 50% of the foreshore armoured.

Structures include seawalls, marinas, jetties and pontoons

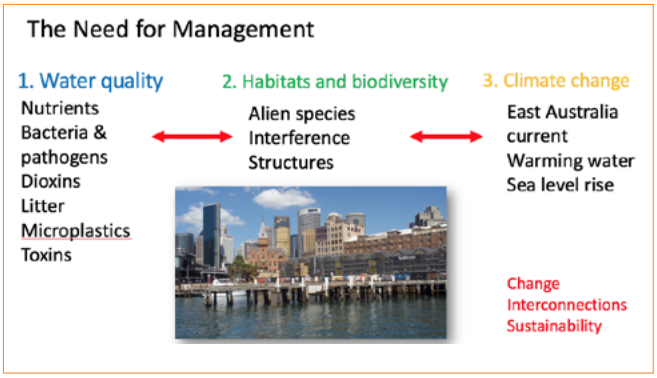
Reasons for structures:

- Reclamation
- Protection
- Recreation
- Economy (trade, tourism)
- Community

Photo 12: Shoreline modifications at Chowder Bay

MANAGEMENT OPTIONS

Screen capture: Sydney Harbour Presentation GTANSW Annual Conference 2018



Source: L Chaffer

1. Managing water quality

Inquiry questions

- How can the quality of water entering Sydney Harbour be improved?
- Where is this being implemented and by whom?
- Are strategies effective?
- What criteria are used to make this judgement?

Catchment management & Water Sensitive Urban Design can significantly improve Sydney Harbour water quality. Water Sensitive Urban Design (WSUD) uses better urban planning and design to reuse stormwater, stopping it from reaching our waterways by mimicking the natural water cycle as closely as possible.

Some examples of WSUD include:

- Raingardens
- Grassed swales & porous paving
- Constructed / artificial wetlands
- Onsite capture & storage – rainwater tanks
- Maintaining & replanting riparian revegetation
- the 'Naturalisation' of waterways through local government planning and projects

Photo 13: Raingarden

Source: *Pollution Removal Performance of Laboratory Simulations of Sydney's Street Stormwater Biofilters* James Macnamara and Chris Derry, Western Sydney University

2. Managing habitats and biodiversity

Inquiry question

- How can the biodiverse habitats and species in Sydney harbour be protected and enhanced?

Strategies for restoring and protecting habitats and biodiversity:

- Shoreline and habitats restoration
- Retrofit for habitats / mimic natural complexity e.g. flowerpots, tiles, artificial reefs
- Eco- engineering – living walls, fish friendly structures, reefs, piers & wharves
- Protected areas (National Park, Marine reserve)
- Urban Development guidelines & legislation

See Fact Sheet 2:
Strategies to enhance biodiversity

3. Protected areas

The aim of marine protected areas is to:

- conserve marine and shoreline plant and animal biodiversity
- protect fish habitats
- facilitate educational activities & scientific research.

1. Sydney Harbour National Park

   The *management plan* for the park includes management of the foreshore area that impacts on the aquatic environment

2. NSW Marine protected areas /North Harbour Marine Reserve

   The reserve features a variety of habitats and species including sheltered coves that contain seagrass habitats: nearshore reefs that support kelp habitats used by species such as seahorses and sea dragons: rocky reefs and kelp beds that support invertebrates and fish and boulder habitats in deeper water support sponges and corals. In summer, tropical fish arrive by the East Australian Current (EAC) are common. Critical habitat for the little penguin is in the reserve.

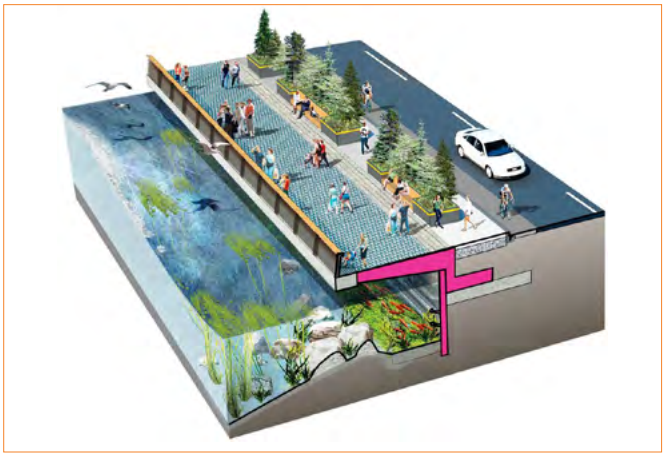
Photo 14: Barrangaroo Headland

Source: http://www.barangaroo.com.au/the-project/news/awards-keep-coming-for-barangaroo-reserve/

4. Urban renewal project design: Can it be harbour friendly?

The opportunity exists for urban renewal projects on Sydney Harbour to incorporate features that create habitats that will encourage a diversity of habitats and species. At Barrangaroo Headland a rocky shore was created using sandstone blocks. Other sites around Sydney Harbour earmarked for redevelopment / renewal such as the Bays Precinct will be interesting to watch to see if the designs incorporate Water Sensitive Urban Design features and biodiversity friendly infrastructure.

Diagram 5: An example of a biodiversity friendly harbour infrastructure in Seattle



Source: https://www.eopugetsound.org/magazine/seawall

Read about future plans for the Bays Precinct

'Providing a mix of green shorelines and living sea walls' http://thebayssydney.nsw.gov.au/destinations/bays-waterfront-promenade/

The transformation Plan https://thebayssydney.nsw.gov.au/assets/Document-Library/Reports-and-Plans-2014-/2015-Transformation-Plan.pdf

Artwork 3: An artist's impression of the Glebe Island White Bay Power Station and foreshore redevelopment.

Source: http://www.abc.net.au/news/2015-10-22/sydney-harbour-foreshore-redeveloped-global-tech-hub-government/6876784

Satellite image: The harbour front area known as the Bays precinct

Source: https://thebayssydney.nsw.gov.au/destinations/bays-waterfront-promenade/

See Activity 7: Design Project

THE FUTURE

The future health of the Sydney Harbour Estuary will be influenced by actions taken by individuals, groups, businesses, governments and non-government organisations.

Research will provide scientific data on which to make management decisions. Sydney's universities and the Sydney Institute of Marine Science (SIMS) have several research projects underway and are trialing innovative solutions to enhance marine biodiversity in the harbour. SIMS scientists study a range of impacts resulting from urbanisation including heavy metal pollution and the invasion of degraded habitats by marine pests. The World Harbour Project was initiated by the Sydney Institute of Marine Science with the aim of the of linking, facilitating, and enhancing programs of research and management across major urban harbours of the world.

Watch this video about the work being done at SIMS https://www.youtube.com/watch?v=8TVGceFEa50.

Learn about Sydney's newest Living Seawall https://www.youtube.com/watch?v=MgwuxPfCMhw

Technological innovation will underpin new harbour friendly urban design and infrastructure development

Sustainable Design principles already exist for developers to follow when undertaking urban projects that could impact on the harbour. See *'Guiding principles for marine foreshore development'* https://thebayssydney.nsw.gov.au/assets/Document-Library/Precinct-Wide-Technical-Studies-Underway-2015-/2016-Guiding-Principles-for-Marine-Foreshore-Developments.pdf

Legislation to improve water quality and protect biodiversity and habitats and create new protected areas will remain important and must respond to threats in a timely manner. Organisations with waterfront developments such as Taronga Zoo need a licence to release water into Sydney Harbour and are required to publish pollution monitoring results each year. The 2018 report from Taronga Zoo can be found here. https://taronga.org.au/conservation-and-science/sustainability/water

Conclusion: Worldviews

Activities

- Examine different environmental world views
- Summarise attitudes to Sydney Harbour environments at different periods of time eg 1700, 1788, 1888, 1988, 2018
- Discuss how and why worldviews about the Harbour changed over time
- Propose ways individuals can contribute to the sustainable management of Sydney Harbour?

FIELDWORK OPPORTUNITIES

Visit sites around Sydney Harbour or catchment

- Examine stormwater outlets / discuss stormwater vs sewer system water.

  Note: *This can be anywhere in the catchments of Sydney Harbour with the added task of tracing the path of stormwater in a suburb to the harbour.
- Do water quality testing (e.g. Measure - turbidity, nutrients, Dissolved Oxygen, microplastics)
- Observe species / habitats / (e.g. dip – netting, observation, photographs, tally)
- Visit sites to investigate strategies to minimise pollution from stormwater and waste e.g. Taronga Zoo, Darling Harbour, Circular Quay, local stormwater drains or a public place
- Visit artificial structures to assess the impact

Use a dedicated fieldwork provider such as:

- Observatory Hill Environmental Education Centre (Barrangaroo, Bays Precinct and Sydney Harbour studies)
- Sydney Institute of Marine Studies (Marine environments and research)
- Bicentennial Park (Wetland studies)
- Taronga Zoo (Sustainability)
- Tribal warriors (Indigenous studies & harbour cruise)

Monitor temporal change at new urban renewal project sites.

Students in future years could make data comparisons.

Collect media files over time – these could be useful if sites cannot be visited in the future.

This resource is to support the PPT presentation on Sydney Harbour from the 2018 GTANSW Annual Conference.

There are two PPT presentations accessible to members on the GTANSW website.

Many thanks to Alana Rooney (SIMS) and Mariana Mayer Pinto (UNSW) for guidance and resources

There is also a PPT presentation on New York Harbour as a comparative study.

RESOURCE LIST

Significant resources used in the development of this unit resource. Other references are included throughout the article, Activity sheets and Fact sheets.

NSW Geography Syllabus K–10 https://syllabus.nesa.nsw.edu.au/hsie/geography-k10/

Office of Environment & Heritage – Estuaries of NSW http://www.environment.nsw.gov.au/estuaries/index.htm

Ozcoasts (Estuarine models) http://www.ozcoasts.gov.au/conceptual_mods/index.jsp

SIMS (Sydney Institute of Marine Science) http://sims.org.au

Sydney Harbour: Beautiful, diverse, valuable and pressured. Regional Studies in Marine Science Vol 8 Part 2 2016 (paywall) J. Banks, L.H. Hedge, C. Hoisington, E.M. Strain, P.D. Steinberg, E.L. Johnston. https://www.sciencedirect.com/science/journal/23524855

Pollution in Sydney Harbour: sewage, toxic chemicals and microplastics Briefing paper No 03/2015 https://www.parliament.nsw.gov.au/researchpapers/Pages/pollution-in-sydney-harbour-sewage-toxic-chemica.aspx (Free download)

Our harbour; Our Asset (Free download) https://www.sims.org.au/page/20/publications

Building 'blue': An eco-engineering framework for foreshore developments Journal of Environmental Management Vol 189, 2017 (paywall) Mayer-Pinto, M; Johnston, E. L; Bugnot, A. B; Glasby, T. M; Airoldi, L; Mitchell, A & Dafforn, K.A.

Sydney Harbour: a review of anthropogenic impacts on the biodiversity and ecosystem function of one of the world's largest natural harbours Marine and Freshwater Research. 66. 1088–1105. Mayer-Pinto, M; Johnston, E. L; Hutchings, P A; Marzinelli, E. M; Ahyong, S. T; Birch, G; Booth, D. J; Creese, R. G; Doblin, M. A; Figueira, W; Gribben, P. E; Pritchard, T; Roughan, M; Steinberg, P. D; Hedge, L. H. 2015.

Guiding principles for marine foreshore development. https://thebayssydney.nsw.gov.au/assets/Document-Library/Precinct-Wide-Technical-Studies-Underway-2015-/2016-Guiding-Principles-for-Marine-Foreshore-Developments.pdf

Sydney Harbour: enhancing seawall sustainability. https://www.fishhabitatnetwork.com.au/userfiles/files/CASE%20STUDY%20-%20Enhancing%20Seawall%20Sustainability%20Sydney%20Harbour.pdf

Department of planning and environment coastal plans http://www.planning.nsw.gov.au/Policy-and-Legislation/Coastal-Reforms/Marine-estate-reform

World Harbour Project http://www.worldharbourproject.org

NSW Dep't Primary Industries – Marine Protected Areas https://www.dpi.nsw.gov.au/fishing/marine-protected-areas/aquatic-reserves/north-harbour-aquatic-reserve

Know your microplastics http://www.waterkeeper.ca/cases-microplastics/

Sydney Opera House Sustainability Plan https://www.sydneyoperahouse.com/content/dam/pdfs/environment/ESP_2017-19.pdf

Image source: Shutterstock

ACTIVITY 1:
HEALTHY AQUATIC ENVIRONMENTS

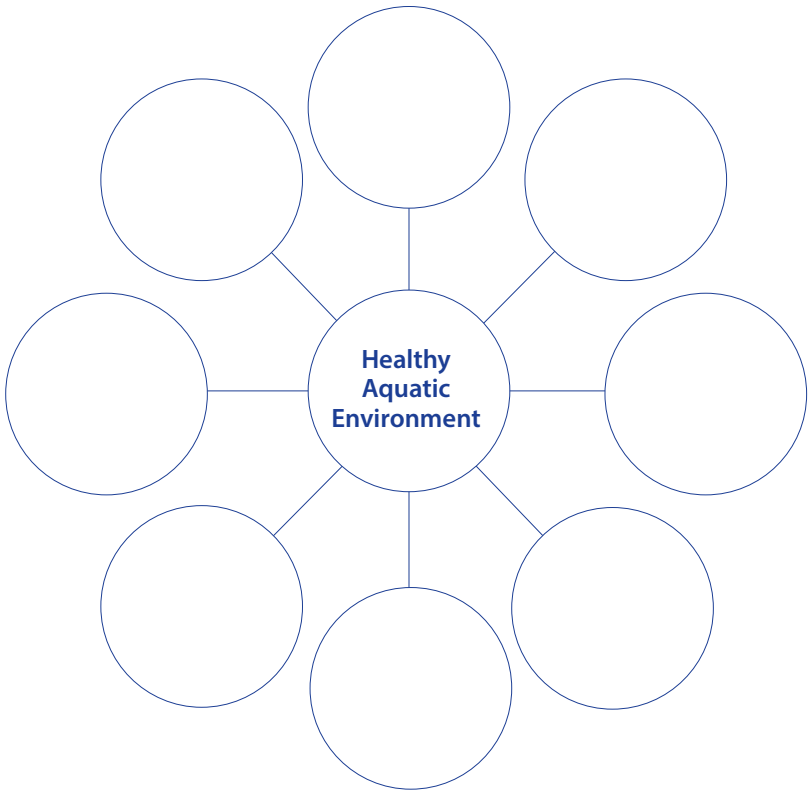
1. THINK, PAIR, SHARE

a. Distinguish between aquatic and terrestrial environments

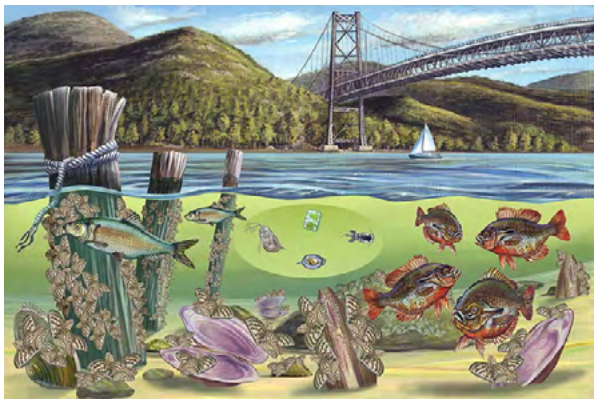
b. Identify some aquatic environments you know

2. SEE SAW

Work in pairs to add features of a healthy aquatic environment to the following mind map.
See-Saw so each student contributes in turn – do not progress until your partner has contributed an idea.
After 5 minutes – study the images on the following page.
See-Saw again to confirm or change the ideas on the mind map.



Source: https://water.usgs.gov/nawqa/ecology/pubs/cir-1391/images/NaturalStream.pdf



Source: https://www.amnh.org/education/resources/rfl/web/riverecology/explore.html

Source: https://pxhere.com/en/photo/1372124
The image is released free of copyrights under Creative Commons CC0

You might also like to visit this interactive diagram of Oyster Harbour, WA – https://rei.dwer.wa.gov.au/estuary/oyster-harbour/estuary/

INQUIRY QUESTION

Do you think Sydney Harbour is a healthy aquatic environment? YES NO
Justify your answer

ACTIVITY 2: SYDNEY HARBOUR QUIZ

1. The city of Sydney is very young.
   How old is the harbour on which it was built?
   a) 25 Million Years
   b) 10 Million Years
   c) 100 000 years
   d) 10 000 years

2. Tidal ranges vary hugely around Australia from less than 1m at Portland, Victoria to more than 10m at Derby, Western Australia. Being connected to the open ocean Sydney Harbour is also subjected to tidal changes. What is the maximum difference between the high and low tide in Sydney Harbour?
   a) 0.5m
   b) 2.1m
   c) 5.3m

3. Seagrass beds provide important nursery grounds for baby fish. How many species of seagrass occur in Sydney Harbour?
   a) 3
   b) 15
   c) 30

4. The Eastern blue groper is one of the most charismatic fish in the Harbour. They can grow up to 120 cm, but how long can they live?
   a) 5 years
   b) 10 years
   c) > 30 years

5. The East Australian Current flows southward from the Great Barrier Reef along the coast of NSW. In the film 'Finding Nemo' Nemo's dad Marlin travelled southward in the EAC from the GBR to Sydney. Is this realistic? Do we find tropical fish in Sydney Harbour?
   a) Yes
   b) No

6. If you answered yes, how many days do you think it takes for a fish to arrive in Sydney Harbour if it came from Heron Island (approximately 1500km north of Sydney), assuming the EAC flows at 1 m/s?
   a) 17 days
   b) Two months
   c) Half a year

7. Sydney Harbour can be a busy waterway! Approximately how many boats were registered in Sydney Harbour in 2014?
   a) 5000
   b) 9 000
   c) 20 000
   d) 50 000

8. One Sydharb is an official Australian unit of measurement. It is used to measure volume and is equivalent to the volume of water in Sydney Harbour.
   A Sydharb of water equals?
   a) 250 gigalitres
   b) 500 gigalitres
   c) 750 gigalitres
   d) 1000 gigalitres

9. There are more species of fish in Sydney Harbour than along the coast of the United Kingdom. How many fish species are in Sydney Harbour?
   a) Fewer than 380
   b) 480
   c) 580
   d) Over 580

10. How much of the 322km long Sydney Harbour shoreline is reclaimed land?
    a) 25%
    b) 30%
    c) 40%
    d) Over 50%

Can you add ONE extra thing you know about Sydney Harbour?

Source of Quiz Questions: Sydney Institute of Marine Science. Answers on Page 53.

ACTIVITY 3: BIODIVERSITY

1. CREATE A SYDNEY HARBOUR FOOD WEB

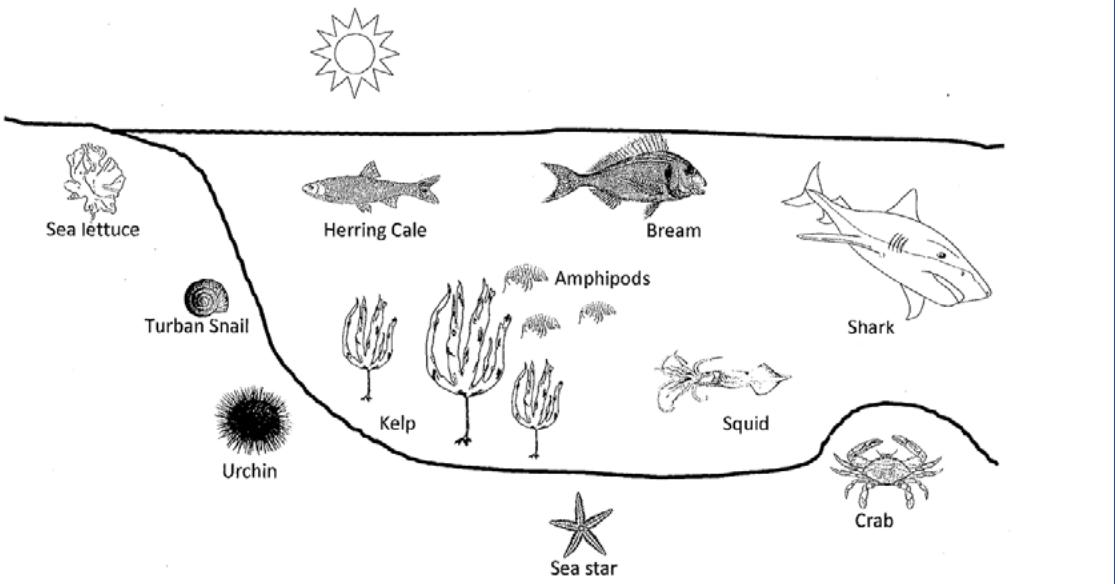
The following diagram illustrates common species found in a Subtidal Rocky Reef habitat.

Large algae (kelp) are the main habitat forming organisms in the subtidal rocky reefs. ***Ecklonia radiata*** is the most common type of kelp found in Sydney Harbour and it creates large underwater forests, providing food and shelter to many animals in the ecosystem.

A food web consists of all the food chains in an ecosystem. Each living thing in an ecosystem is part of multiple food chains. The sun provides the energy for plants to produce food. This is the beginning of every food chain.

Start with an arrow beginning at the sun, then show the flow of energy through the producers and consumers to the top predators. Can you draw a possible subtidal food web?

Natural Subtidal Rocky Reef Food Web



Source: Sydney Institute of Marine Science

2. SOFT BOTTOM AND BEACH SPECIES

Undertake a geographical inquiry to identify a variety of species that occupy mangrove, seagrass and saltmarsh habitats in NSW estuaries (including Sydney Harbour Estuary).

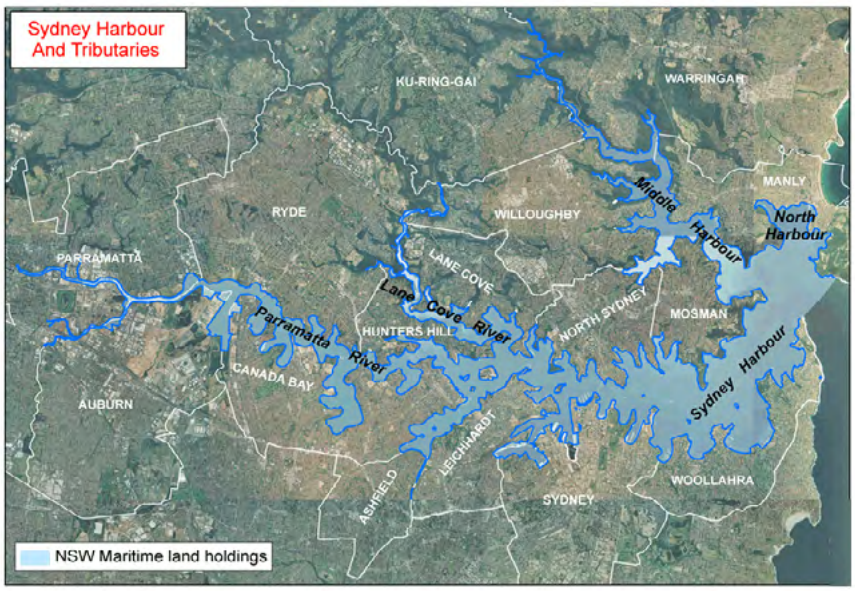
ACTIVITY 4:
IDENTIFYING SYDNEY HARBOUR HABITATS

Use Google Earth (or alternative source of satellite images) to fly over and zoom in on sections of Sydney Harbour Estuary between North Head and Parramatta.

For each of the habitats in the boxes below find 2 locations where that habitat is observed. Use arrows to show these locations and add place names to the habitat box.

Subtidal rocky reef habitats

Rocky intertidal habitats



Source: NSW Road and Maritime Services - http://www.rms.nsw.gov.au/images/maritime/property-planning/leasing/sydney-aerial-lg.gif

Soft bottom and beach habitats

Open water habitats

Paste a photograph (digitally) or complete a photo-sketch of one location or species found at one of the locations you have identified.

ACTIVITY 5:
CAN OYSTERS SAVE SYDNEY HARBOUR?

Inquiry Questions

What is a habitat forming species?

Why have populations of oysters in Sydney Harbour declined?

Why are recent management strategies for Sydney Harbour focused on restoring key species such as oysters?

Investigation

Research each of the following areas:

1. The environmental importance of oyster reefs
2. Human uses and impact on oyster habitats in Sydney Harbour since 1788
3. Management strategies to restore oyster habitats in Sydney Harbour
4. How the environment of Sydney harbour will benefit from oyster restoration.
5. Global trends in oyster habitats distribution
6. Strategies used in another country to restore or protect oyster habitats.

Answer the question 'Can oysters save Sydney Harbour?'

Create an infographic summarising your key research findings.

Use the images and websites below to inspire your research.

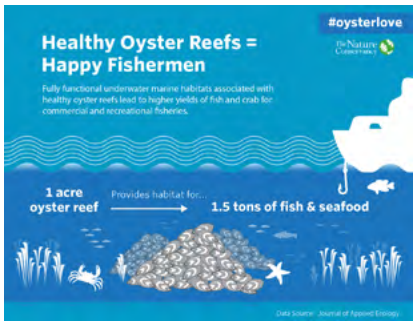
Weblinks

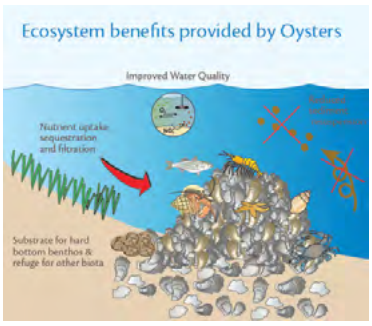
The surprising benefits of oysters – and no, it's not what you are thinking
https://theconversation.com/the-surprising-benefits-of-oysters-and-no-its-not-what-youre-thinking-90697

Oysters: Ecological superheroes with a dark past
https://www.adelaide.edu.au/environment/marine-biology/research/oyster-reefs/oysters/

Restoring shellfish reefs https://www.youtube.com/watch?time_continue=1&v=Dn8dZrWK7fM

SIMS Sydney Harbour Research Program. Habitat restoration
http://engonet-sims.azurewebsites.net/page/115/habitat-restoration





Sources for images

For the love of Oysters – https://blog.nature.org/science/2016/02/11/love-oysters-seafood-water-oceans/
Living Seawalls in Sydney Harbour – https://www.sims.org.au/news/30/volvo-partners-with-sims
NOAA Office – http://chesapeakebay.noaa.gov/oysters/oyster-reefs

ACTIVITY 6: THREATS TO ESTUARIES

Sydney Harbour faces the same environmental threats as other estuaries around the world.

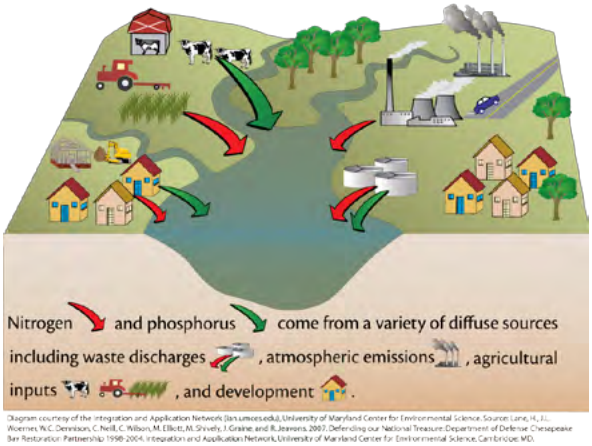
Inquiry Questions

What are the main threats to estuarine environments such as Sydney Harbour?
What has been the cumulative impact of these threats on the Sydney Harbour estuary?
Is Sydney Harbour a healthy, well-functioning environment?

Class discussion

Examine the conceptual diagram / model here and on the next page:

- Identify the purpose of this type of diagram or model
- assess the value of conceptual models for learning about environmental change and management
- look up terminology you do not know eg. benthic, eutrophic



Source: Integration and Application Network (IAN

Group task

Each group will use ONE conceptual model from the Ozcoasts website to investigate threats to an estuarine environment such as Sydney Harbour. https://ozcoasts.org.au/conceptual-diagrams/stressors/

1. Choose ONE of the following conceptual models
   - Toxicants
   - Pest species
   - Bacteria / pathogens
   - Litter (including plastics / microplastics)
   - Habitat removal / disturbance
   - Nutrients
   - Biota removal /disturbance (Loss of biodiversity)
2. Examine the model to determine
   - The cause or source of the threat to the estuary
   - The impacts of the threat on the environment and people living around that estuary.

   Summarise this information into a table
3. Develop a hypothesis based on the degree to which this threat is impacting on Sydney Harbour
4. Research evidence for the impact you are investigating for Sydney Harbour

   Be specific in your search e.g. Microplastics / toxic substances in Sydney Harbour.

ACTIVITY 6: THREATS TO ESTUARIES

Class plenary

Contribute to a class discussion of the cumulative impacts of a range of different threats on the Sydney Harbour environment.

1. Record the key ideas from each group on a mind map.
2. Create several flow diagrams to show the cause and effect of different threats.
3. Answer the following questions in short paragraphs.

Inquiry Questions

What are the main threats to estuarine environments such as Sydney Harbour?

What has been the cumulative impact of these threats on the Sydney Harbour estuary?

Is Sydney Harbour a healthy, well-functioning environment?

Extension

Create a hand drawn or digital conceptual model summarising the key threats to Sydney Harbour.

Explain your model to TWO other students. Ask for feedback. Revise your model.

Source: http://ian.umces.edu/blog/2016/10/11/conceptual-diagrams-turning-science-into-graphic-art/

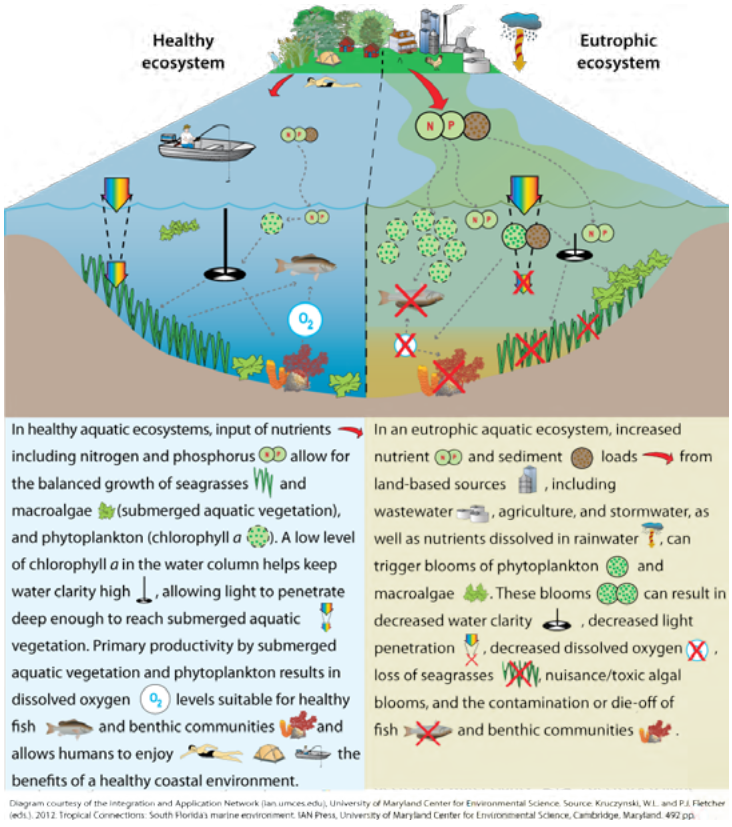


Diagram courtesy of the Integration and Application Network (ian.umces.edu), University of Maryland Center for Environmental Science. Source: Kruczynski, W.L. and P.J. Fletcher (eds.). 2012. Tropical Connections: South Florida's marine environment. IAN Press, University of Maryland Center for Environmental Science, Cambridge, Maryland. 492 pp.

Conceptual diagram comparing a healthy system with no or low eutrophic condition to an unhealthy system exhibiting eutrophic symptoms. From Bricker et al., 2007.

ACTIVITY 7:
DESIGN A NEW HARBOUR SHORELINE

INSTRUCTIONS

Choose a location on Sydney Harbour where the shoreline has been replaced by infrastructure such as at Farm Cove where the Botanic Gardens meet the harbour.

Develop Inquiry Questions (Examples)

- What's wrong with Farm Cove?
- What are some future threats to the environment at Farm Cove?
- How might Farm Cove be made more sustainable for the benefit of the Sydney Harbour environment?

Conduct a site visit if possible. For example, at Farm Cove walk from the Opera to Mrs Macquarie's Chair making observations, taking measurements and taking photographs to record the current state of the shoreline.

Use secondary sources to provide background information e.g. current and historical maps and photographs, diagrams

Use Google Earth to locate and draw elevation profiles of the site

Discuss what is wrong with the location. Consider questions such as - Is it environmentally sustainable? Is it fish friendly? Are there any habitats and living organisms present? What criteria might be used to assess sustainability?

Study the Design Brief and template provided.

Work in pairs to create a proposal to enhance the sustainability of the selected shoreline

Present and justify the proposal to the class and invited community members.

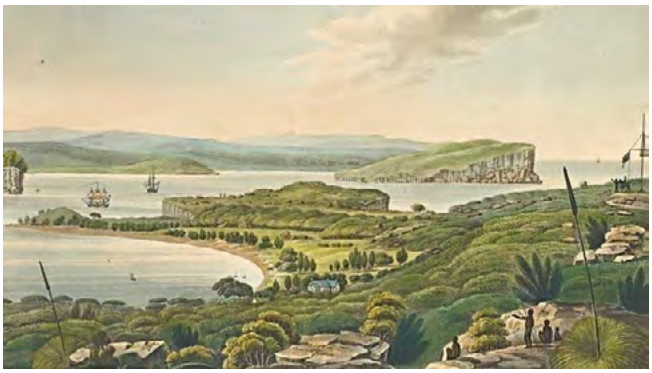
Examples based on Farm Cove

Source: https://en.wikipedia.org/wiki/Royal_Botanic_Garden,_Sydney

Source: Google Earth screen capture L Chaffer

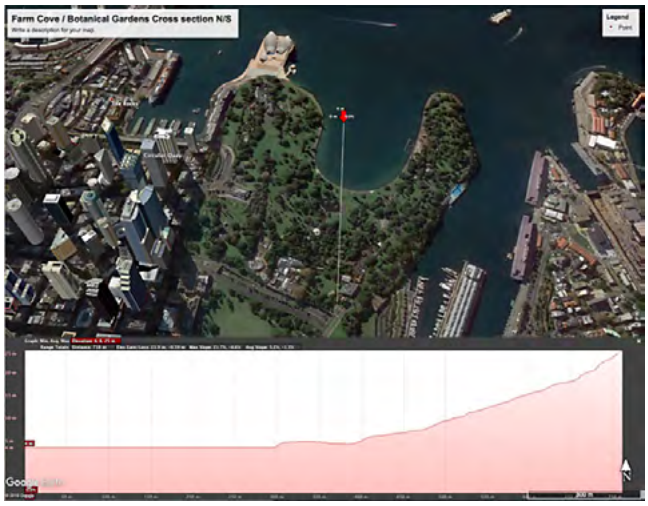
ACTIVITY 7: DESIGN A NEW HARBOUR SHORELINE

What was Farm Cove like? Then and now maps.



LEFT: Convict Sydney - https://sydneylivingmuseums.com.au/convict-sydney/governors-domain#gallery-1

RIGHT: Joseph Lycett 'View of the Heads, at the entrance to Port Jackson, New South Wales', 1825 https://www.theaustralian.com.au/arts/seeing-was-believing-in-the-early-days-of-australias-white-settlement/news-story/d757a4ce5b40b1c98b3794896d09d109?sv=5d53c7579440cd6b10c89d4bd29f3cc8



LEFT: Google Earth digital elevation profile

RIGHT: Climate Change Model Source: http://www.abc.net.au/news/2017-05-23/coastal-areas-at-risk-new-climate-study-reveals/8549934

LEFT: Topographic Map
Screen capture from six maps
Parramatta Map

Photographs of seawall and footpath. Source: L Chaffer

Note: Farm Cove has heritage status and the wall cannot be altered. This is a hypothetical.

Create a New Harbour Shoreline: Design brief

Brief	**Options**	**Justification**	**Sustainability** **How does your plan achieve sustainability?** **Environmental, Economic, Social**
You have an opportunity to change the Sydney Harbour foreshore at one location What would you do to enhance the sustainability of Sydney Harbour at this location? What area will you include in your design? The aim is to promote biodiversity and harbour health while meeting the social, environmental and economic demands on the site	REPLACE e.g. Living shoreline,		
	RETROFIT e.g. Eco-engineering: Living seawall		
	RETHINK e.g. Offshore reef		
	REDESIGN Your unique idea		

MY PROPOSAL DRAFT

DESIGN DRAWING	DESIGN EXPLANATION

See what a masterplan might look like at
https://www.smh.com.au/national/nsw/fivestar-150room-hotel-blooms-in-radical-botanic-gardens-and-domain-revamp-20140405-365qo.html

ACTIVITY 2: Answers

1d Sydney Harbour was formed just over 10 000 years ago. As the sea level rose, the ocean flooded into a valley hilly river system. Sydney Harbour is known as a ria (drowned river valley).

2b Sydney is known as 'micro-tidal' and experiences a maximum 'tidal range' just over 2.1 m. The Harbour is a tide dominated estuary. The tides determine water level, salinity, current strength and direction and aquatic species throughout the whole harbour. Estuarine environments are among the most species rich on Earth.

3a Several species of seagrass have been recorded but seagrass beds are dominated by 3 taxa. Sea grasses are habitat forming and important for biodiversity.

4c. Blue gropers can live in excess of 35 years!

5a Yes … on the increase!

6a. Note: Time = Distance divided by speed (T = D/S)

7c. As of 2009 there were 20,000 boats registered in Sydney Harbour. Most of these were between 4–6 meters in size.

8b. 500 gigalitres (1 Gigalitre is 1,000,000,000 litres)

9c. Over 586 species of fish are found in Sydney Harbour…. rich estuarine biodiversity. There are over 3000 marine species in the harbour.

10a. 77km of the shoreline is reclaimed land (about 25%) – but 50% is armoured by seawalls for reclamation as well as protection of property. Sydney Harbour is one of the world's most modified harbours.

Photo: L Chaffer

FACT SHEET 1: WHAT IS AN ESTUARY?

'Estuaries are partially enclosed bodies of water along coastlines where fresh water and salt water meet and mix. They act as a transition zone between oceans and continents. An estuary has a free connection with the ocean. Fresh water input from land sources (usually rivers) dilutes the estuary's salt content'[1].

Estuary functioning (processes)

Most estuaries were formed approximately 12,000 years ago when rising sea levels flooded river valleys while others formed due to glaciation (erosion) and tectonic forces (crustal movements).

Rivers carry sand, silt and plant matter downstream where it is deposited on floodplains or in estuaries to create a nutrient rich environment. Daily tides and climatic events result in a mix of saltwater and freshwater – salinity decreases moving upstream in the estuary. Precipitation, river discharge, tide sizes and the topography of an estuary will determine its unique characteristics.

'It's the transport of nutrients and biological matter washed from land to sea and back that makes an estuary so productive'[2].

The importance of estuarine environments

1. ***Habitats*** for a diversity of marine species that thrive in a protected environment with abundant food. The life cycle of many commercial fish species is linked to estuaries while birds, including migratory species, and mammals, rely on them for food and nesting or nurseries sites.

   'A healthy estuary produces between 4 and 10 times as much organic matter as a cornfield of the same size'[3].

2. ***Vegetation communities*** such as intertidal salt marshes and habitat forming marine species such as oysters filter sediment and pollutants from the water as it moves from land to sea. These communities also act as buffers against climate and tidal stresses such as tidal surges.
3. ***Estuaries*** are economically important. Coastal activities, commercial and recreational fishing, boating, and tourism provide 28 million jobs and generate more than 20 billion dollars of income each year.
4. ***Estuaries*** are a popular recreational destination. In 1993 more than 180 million Americans (about 70% of the population) visited ocean and bay beaches. Rhode Island has more than 85 marinas, 28 yacht clubs, 16 boat builders, 9 sailing schools, 100 public launching sites and swimming at more than 100 beaches.
5. ***Cultural significance***. People have always used estuaries for food and transportation. For indigenous communities there is a cultural link to the land and sea within and around estuaries.

1. Estuarine Science http://omp.gso.uri.edu/ompweb/doee/science/descript/whats.htm
2. How do estuaries work? https://www.howitworksdaily.com/how-do-estuaries-work/
3. Estuarine Science http://omp.gso.uri.edu/ompweb/doee/science/descript/whats.htm

FACT SHEET 1: WHAT IS AN ESTUARY?

Threats to Estuaries[4]

Urban development, agriculture and aquatic Industries, over-fishing, habitat loss, boating, structures, erosion, sedimentation and pollution, dams and power stations, litter.

> *'Estuaries have become part of our history and our heritage. They will be a part of our future if we can find sustainable ways to use them and preserve their health[5].*

Diagram 1: Important linkages between physical (e.g., tidal currents, river discharge, and groundwater) and biological (e.g., fish migrations, larval transport) processes in estuaries[6]

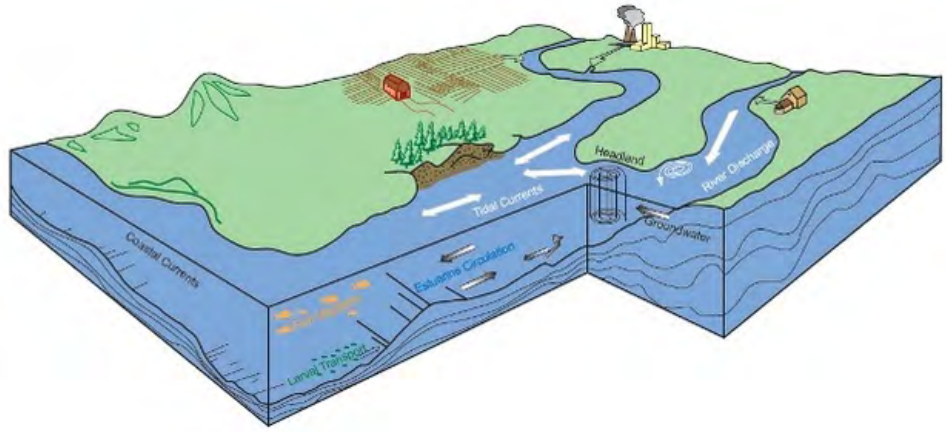
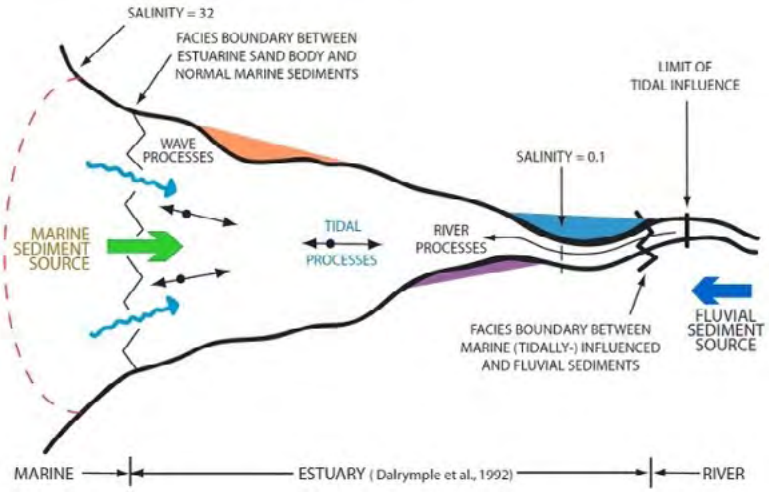


Diagram 2: Typical zones in an estuary moving from inland, where fluvial (freshwater /river) processes dominate, to the mid- and mouth regions where tidal and wave processes are the dominant controlling physical forces[7].



4. Biome: Estuaries https://biome-estuaries.weebly.com/threats-to-estuaries.html
5. Estuarine Science http://omp.gso.uri.edu/ompweb/doee/science/descript/whats.htm
6. Estuaries: Where the river meets the sea https://www.nature.com/scitable/knowledge/library/estuaries-where-the-river-meets-the-sea-102734157
7. Estuaries: Where the river meets the sea https://www.nature.com/scitable/knowledge/library/estuaries-where-the-river-meets-the-sea-102734157

FACT SHEET 2: ARTIFICIAL STRUCTURES AND SHORELINE MODIFICATION

CHANGING THE SHORELINE

Sydney Harbour is one of the most modified harbours in the world with 50% of the harbour armoured with sea walls. These walls were constructed:

- when foreshore land was reclaimed for development, transport or recreation
- to facilitate infrastructure such as Circular Quay jetties and the opera house
- to protect property from flooding or storm damage.

The walls effectively replaced natural sloping, soft sediment shorelines and habitats with a straight hard surface. Piers and jetties allow water movement but create shady habitats preferred by many invasive species.

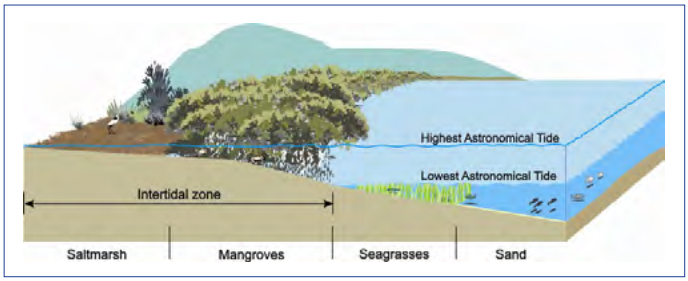


Diagram 1: On a natural shoreline, tidal changes create habitats and microhabitats in the intertidal zone that support marine plants and animals e.g. sponges, algae, molluscs, crustaceans and fish communities.

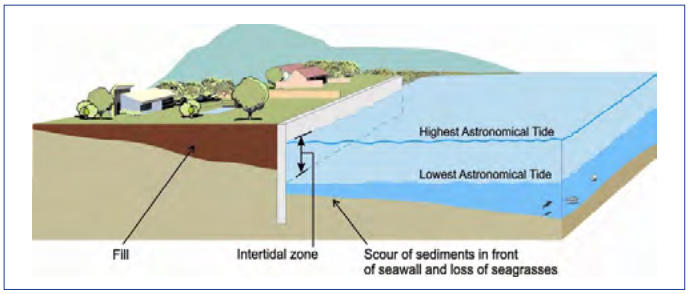
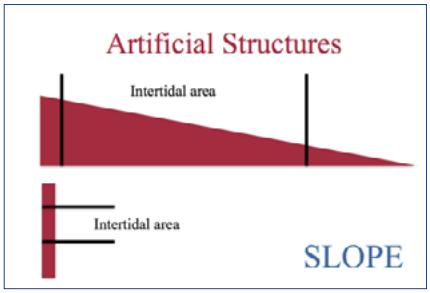


Diagram 2: Modified shorelines restrict natural tidal fluctuations and only those organisms that can survive on near vertical surfaces remain.

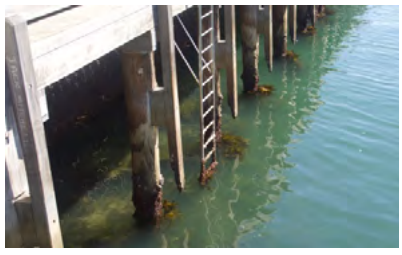
Diagrams from Office of Environment and Heritage via Fish Habitat Network – https://www.fishhabitatnetwork.com.au/projects/environmentally-friendly-seawalls-fish-friendly-marine-infrastructure



Source: Alana Rooney SIMS

Diagram 3 (left): Changing the shoreline from sloped to vertical

Photos: Examples of harbour modification



Source: L Chaffer

FACT SHEET 2: ARTIFICIAL STRUCTURES AND SHORELINE MODIFICATION

MANAGEMENT OPTIONS

Eco- engineering – new shoreline design or 'blue' design

Planners and developers are rethinking shorelines to more closely mimic natural foreshores. The most recent example is the Headland Park in Barangaroo Reserve where the design was based on ecological principles. Sandstone blocks of different sizes replicated natural sandstone headlands and were stepped to decrease slope and create rock pools.

Designing seawalls that incorporate ecological principles. For example:

- decreasing vertical slopes
- incorporating shallow habitats
- increasing the complexity of surfaces to create habitats
- adding 'skylights' into walkways or jetties to reduce shading effects

Retrofitting for biodiversity: Creating living walls

Attaching *concrete 'flowerpots'* that mimic some of the functions of natural rockpools (such as retaining water at low tide) onto existing seawalls. Examples include the Glebe foreshore & Botanic Gardens seawall. In less than a year the pots had 40% more algal species and 39% more immobile animals & 118% more mobile species than other seawalls. This benefited species such as fish by providing increased habitat and food supply.

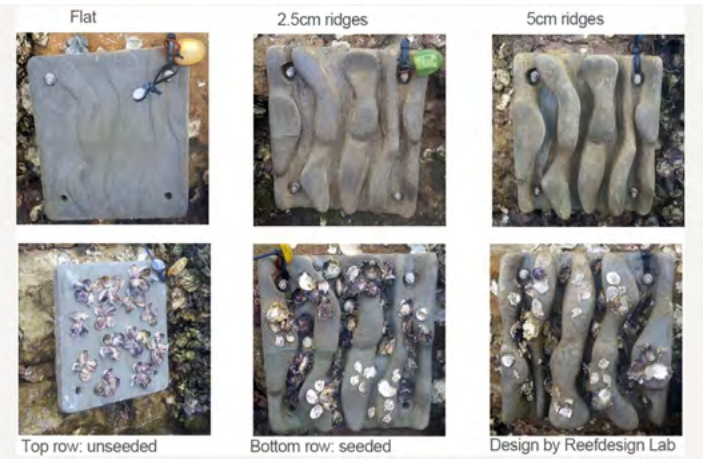
Photo: Flowerpot attached to seawall

Source: http://www.abc.net.au/catalyst/stories/2936248.htm

Read more:
Flowerpots tackle Sydney Harbour's aquatic housing crisis
http://www.abc.net.au/radionational/programs/offtrack/flowerpots-tackle-sydney-harbours-aquatic-housing-crisis/6148966

Environmentally Friendly Seawalls: A Guide to Improving the Environmental Value of Seawalls and Seawall-lined Foreshores in Estuaries
https://www.environment.nsw.gov.au/research-and-publications/publications-search/environmentally-friendly-seawalls

Photo: World Harbour Project



Attaching *3D-printed concrete tiles* to add complex surfaces that can be seeded with key habitat forming species (the Sydney rock oyster, and the calcareous red algae) and attached to seawalls. Over a year experimental sites showed that these features attracted significant marine life such as seaweeds, crabs and fish.

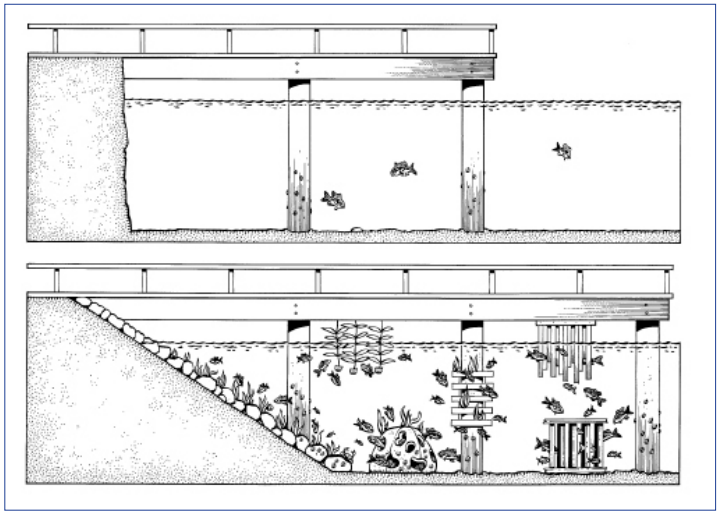
Source: http://www.worldharbourproject.org/workgroups/green-engineering/

Fish friendly infrastructure

Infrastructure suited to design and construction for fish friendliness includes small boat harbours and marinas, jetties, pontoons, boat ramps, boardwalks, mooring buoys and fishing platforms.
The aim is to create structures that:

- cause minimal disturbance to the existing environment
- incorporate features that provide habitats in which native fish can live.
- allow recreational and commercial activities to exist in balance with nature

Diagram of a fish friendly jetty



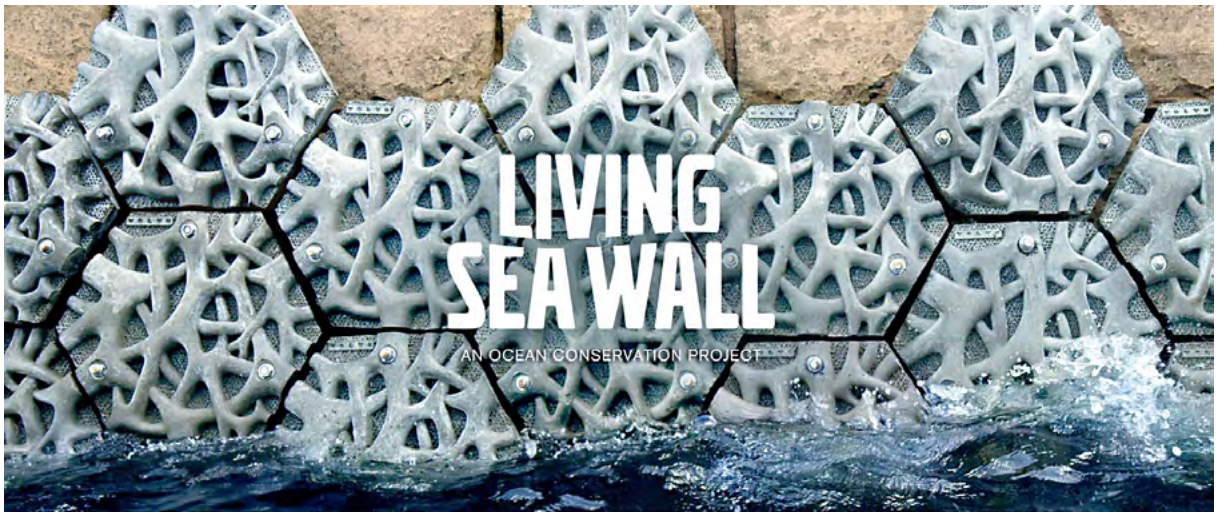
Source: https://www.daf.qld.gov.au/business-priorities/fisheries/habitats/policies-and-guidelines/fish-habitat-factsheets/what-are-fish-friendly-structures

Artificial reefs are being created to encourage habitat forming species in places where infrastructure has significantly reduced habitat such as around the Sydney Opera House and beneath large areas of infrastructure such as ferry wharves.

How a new Opera House reef project will breathe life into Sydney Harbour
https://www.sydneyoperahouse.com/backstage/backstage-articles/a-healthier-harbour.html

Photo and information, Sydney Opera House Trust

Screen capture from Sydney's newest living sea wall



Learn more at:

One of the worlds largest living seawalls – https://www.facebook.com/7newssydney/videos/one-of-the-worlds-largest-living-seawalls-has-been-launched-in-sydney-harbour-to/345909836163615/

Volvo Living Seawall – https://www.volvocars.com/au/about/australia/living-seawall

NEW YORK HARBOUR ESTUARY

A Comparative Study

Lorraine Chaffer, President GTANSW

New York New Jersey Harbour Source: Wikipedia Commons

Aerial view of Throgs Neck Brige. Source: Wikipedia Commons

SYLLABUS LINK

Stage 5: Environmental change and management

Investigative study

Select ONE type of environment in Australia as the context for a comparative study with at least ONE other country.

Students:

- investigate the biophysical processes essential to the functioning of the selected environment
- investigate the causes, extent and consequences of the environmental change
- investigate the management of the environmental change

The following Case Study has been developed to support the use of the New York Harbour Estuary in the USA as a comparative study to Sydney Harbour Estuary.

A PowerPoint presentation provides detailed information, ideas and resources for teaching this case study. For members, this resource is available on the GTANSW website at https://www.gtansw.org.au in the dropdown menu – Resources – Presentations - 2018

Introduction

'New York Harbour is a large, iconic and complex body of water that has been extensively modified to support the development of a megacity. These modifications have affected the shorelines, waterflow, water quality, habitats and living resources of the harbour.

Changes in topography and bathymetry have altered the landscapes and seascapes of the region, largely to support an active shipping port and intense human settlement. New York Harbor has been transformed from a region dominated by marshy shorelines and extensive submerged oyster beds to the present-day harbour with hardened shorelines, dredged shipping channels and remnant oysters that are unsafe to consume…'

New York Harbor: Resilience in the face of four centuries of development [1]

Brooklyn & Manhatten Bridges, New York Harbour Source: Wikipedia Commons

NEW YORK HARBOUR ESTUARY: ACTIVITY GUIDE

Key inquiry questions

How are the environmental changes to New York Harbour and Sydney Harbour similar or different?*

Can the changes to Sydney and New York Harbour estuaries be managed using the same strategies to create healthy environments in the future?

ACTIVITIES

- Create an e-portfolio to record your responses to the following activities.
- Use the links and resources as well as your own research.

* Note: New York Harbour is also called New York New Jersey Estuary, New York Raritan Estuary and Hudson River Estuary. Harbour is spelt 'harbor' in the USA.

Location and spatial dimensions

1. Locate New York Harbour (USA) and Sydney Harbour (Australia) on a map or satellite image of each country.
   - For each place record the latitude, longitude and adjacent ocean. (This could be done using Google Earth, Google Maps or ArcGIS)
2. Using Google Earth.
   - Make screen captures of each estuary. Include a scale with each image. Label environmental features of New York Harbour and surrounds on the image throughout this investigation e.g. Manhattan, Staten Island, Statue of Liberty, Hudson River, New Jersey
   - Create digital terrain profiles (cross sections) at locations across each estuary. Save two contrasting images. See examples Images 1 and 2
   - Compare the size and shape of the two estuaries.
   - Compare the topography (landforms) and settlement around each estuary.
   - Record comparisons in a table of similarities and differences.
3. Study Map 1 of New York Harbour estuary.
   - Read Fact box 1.
   - Add to your table of similarities and differences to **Sydney Harbour Estuary**.

Indigenous past and early settlement

4. Research historical images of New York Harbour from the 1500's to the present. Illustrations1and 2 are examples.
   - Create a collage of images to show change over time including any that refer to the indigenous peoples.
   - Below your collage insert a text box - comment on any similarities or differences between the settlement and use of New York Harbour and Sydney Harbour over time.

Environmental features and processes

5. Examine Diagram 1, Fact box 2 and the Wildlife Poster[2]
   - Briefly outline the important natural processes that occur in estuaries.
   - Explain why New York Harbour supports a large diversity of wildlife

Environmental Change and management

6. Explore New York Harbour using AIRPANO at http://www.airpano.com
   - Select Grand tour of Manhattan
   - Select view 1 (financial District) and use the tools to explore NY Harbour
   - Identify Places e.g. Brooklyn, New Jersey, Staten Island, Manhattan, Statue of Liberty (Use the map to assist with this activity); natural areas and port facilities.
   - Investigate other views of NY/NJ Harbour (e.g. views 4, 5 or 10)
   - Estimate the % of armoured shoreline (seawalls)
   - Identify points of difference to Sydney Harbour

This activity could also be undertaken using Google Earth or other spatial technologies.

7. Work in Groups to examine the Look inside New York Harbour[3] poster and State of the Estuary Fact Sheet (See resources attached).
   - Create two mind maps
     a. One to illustrate the original features of the New York Estuary
     b. One to illustrate environmental changes resulting from human activities

8. Investigate the impacts of ports and shipping OR industrial pollution on the harbour environments.
9. Assess the potential impact of climate change
   - In pairs watch one of the following video clips. Share key ideas with another pair.

     Rising sea levels put New York City at risk https://www.youtube.com/watch?v=-xLokKVdk7I

     How Climate Change Could Drown New York City https://www.youtube.com/watch?v=_zK6Grhp5Zk&t=90s
   - Compare Map 2 (vulnerability to sea level rise) to a similar Sydney Harbour map.
   - Investigate Hurricane Sandy and proposals to reduce the impact of future storms.
   - Write a statement about the climate change future of New York City and harbour
10. Revise the three main environmental issues facing Sydney Harbour Estuary.

    Can the environmental changes to New York Harbour be categorised this way?
11. Case Study: The Oysters of New York Harbour: an example of habitat restoration.

    Investigate the historical distribution, use, abuse and re-establishment of oyster habitats in New York Harbour Estuary. Start with *The Incredible Oyster Reef*[4] and *Oyster-tecture*[5] podcast resources. Research the *Billion Oyster Project*[6].
12 Investigate one other initiative to improve the environmental quality and functioning of the New York Harbour Estuary. Examples include living shorelines, storm barriers, stormwater and waste management, education programs, community action.

Analysis

Work in groups to develop responses to the two inquiry questions. Share ideas with the class.

Communication

Work in pairs to develop a short 3-minute oral presentation titled *Our plan to restore and protect the New York Harbour Estuary*.

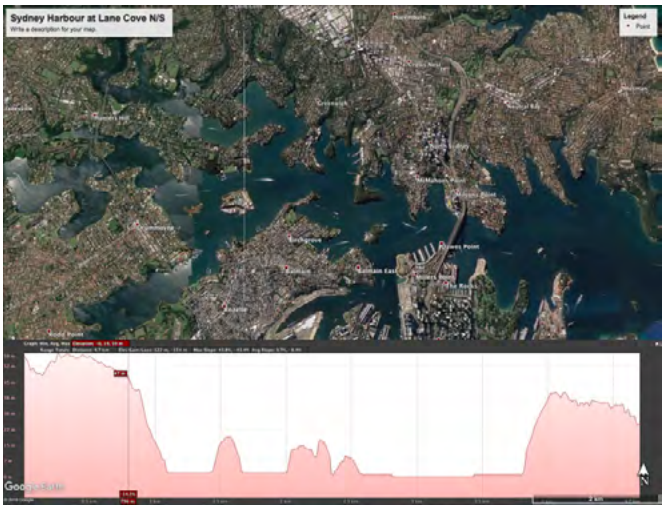
Endnotes

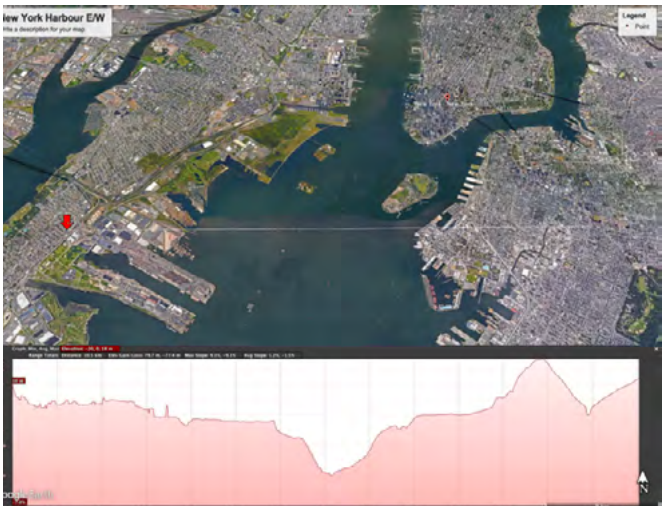
1. New York Harbor: Resilience in the face of four centuries of development. Judith M. O'Neil , Dylan Taillie, Brianne Walsh, William C. Dennison, Elisa K. Bone, David J. Reid , Robert Newton, David L. Strayer, Kate Boicourt, Lauren B. Birney, Sam Janis, Pete Malinowski, Murray Fisher.

   Retrieved from Regional Studies in Marine Science 8 (2016) 274–286 on October 28th 2018 https://www.sciencedirect.com/search?qs=New+York+Harbor%3A+Resilience+in+the+face+of+four+centuries+of+development&authors=&pub=&volume=&issue=&page=&origin=home&zone=qSearch
2. Wildlife of the New York New Jersey Harbor Estuary retrieved on October 28th 2018 from http://www.harborestuary.org/educationalmaterials.htm
3. A look inside New York Harbour retrieved on October 28th 2018 from https://vizziesvote.skild.com/entries/a-look-inside-new-york-harbor
4. The incredible Oyster Reef (YouTube) – https://www.youtube.com/watch?v=9V3yjCplc44
5. 'Oyster-tecture' (Living Breakwaters) https://99percentinvisible.org/episode/oyster-tecture/
6. Billion Oyster project – https://billionoysterproject.org

COMPARATIVE STUDY RESOURCES

Images 1 and 2. Sample digital elevation profiles for Sydney Harbour and New York Harbour





Created by L Chaffer using Google Earth Pro

Map 1: New York New Jersey Estuary

Source: State of the Estuary Report 2012 Page 3 http://www.harborestuary.org/pdf/StateOfTheEstuary2012/SOE_Rprt.pdf

Illustration 1: Port of New York.

Retrieved from https://minimalgoods.co/free-downloads-of-large-old-new-york-city-maps/

Illustration 2: The "bird's eye" view of New York City shown below is a drawing made around 1884. The Brooklyn Bridge is visible on the right, crossing over the East River. New Jersey is across the Hudson River to the left.

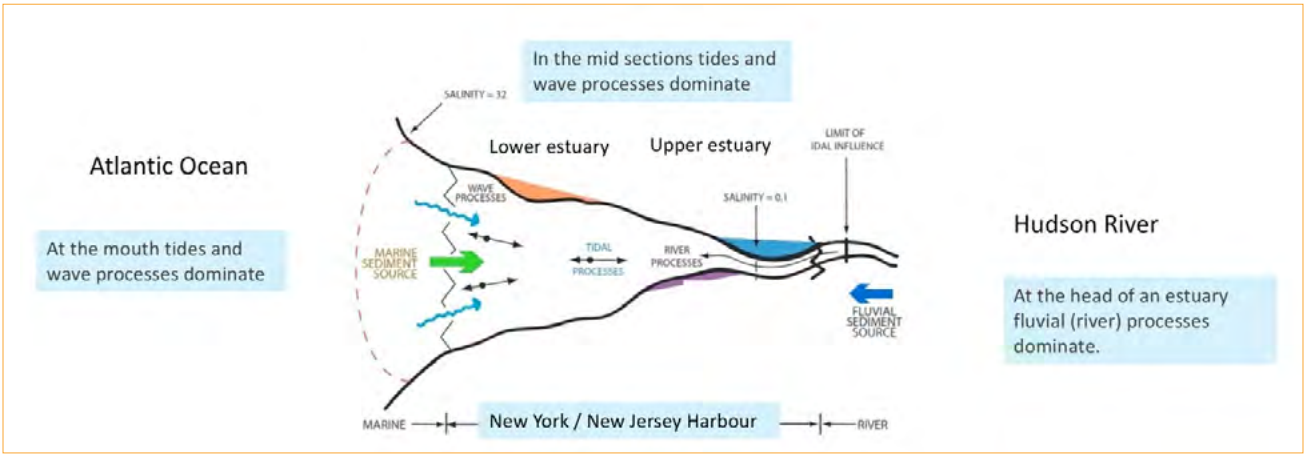
Source: http://www.fasttrackteaching.com/ffap/Unit_4_Cities/U4_Growing_Cities.html

FACT BOX 1: A Drowned valley and tidal estuary

New York Harbour is one of the largest natural harbours in the world, and like Sydney Harbour, is very modified. The estuary is located at the mouth of the Hudson River where it empties into New York Bay, then the Atlantic Ocean. It is a drowned River valley but unlike Sydney, the original valley was broad and flat.

Fresh water from the Hudson, Hackensack, Passaic, Rahway and Raritan Rivers meets salt water from the Atlantic Ocean, flowing north on the 'in' tide, and south on the 'out' tide. Native Americans named the Hudson, "Muhheakantuck", meaning, "the river that flows two ways". The tidal influence reaches Troy, 250 km upstream. At Statten Island, and in the lower estuary, the tidal range can be 1–2 metres. Intertidal zones contain a diversity of habitats that are rich in biodiversity including over 500 species of birds and fish.

Diagram 1: Simplified New York Estuary diagram.

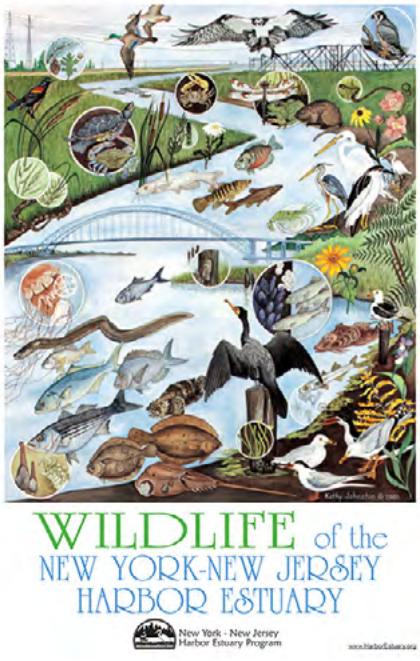


Adapted image. Source - Nature https://www.nature.com/scitable/knowledge/library/estuaries-where-the-river-meets-the-sea-102734157

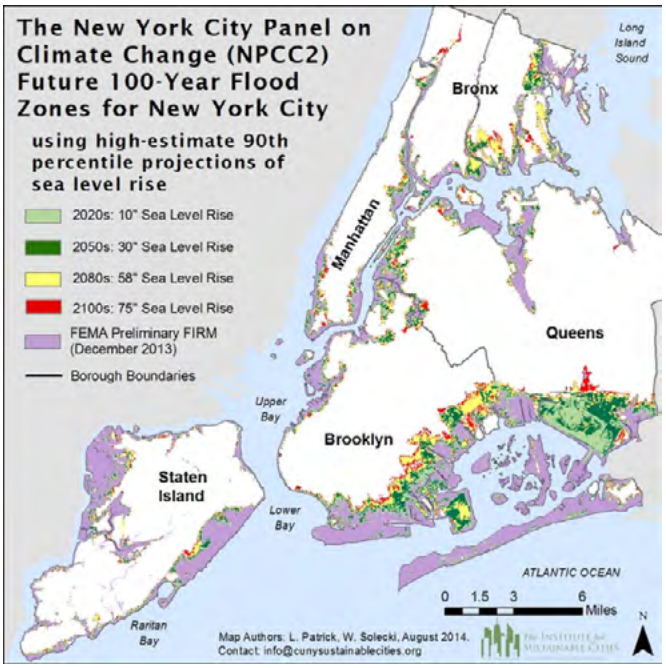
FACT BOX 2: Habitats and biodiversity in New York Harbour

- *Shallow mudflats*
  - habitat for algae, crabs, clams & invertebrates,
  - food for fishes, e.g. striped bass and bluefish
- *Wetlands*
  - habitat for resident birds, mussels, fiddler crabs and fish
  - overwintering areas (migratory birds) and breeding grounds
- *68 islands*
  - nesting populations e.g. herons
- *Tributaries*
  - provide a gradient of unique habitats from saltwater to freshwater
  - over 100 fish species
  - for 16 species it is essential habitat

Source: New York Harbor: Resilience in the face of four centuries of development Regional Studies in Marine Science 8 (2016) 274–286



Map 2: Projected impacts of climate change



Source: https://theconversation.com/building-climate-resilience-in-cities-lessons-from-new-york-52363

Image 3 (below): The Port of New York and New Jersey is third largest port in the USA and the largest port on the Atlantic seaboard handling 3.7 million containers, 500,000 automobiles, and other goods coming in and out each year. Container ships, barges, oil tankers, cargo vessels, tugboats, and other merchant ships operate in the estuary.

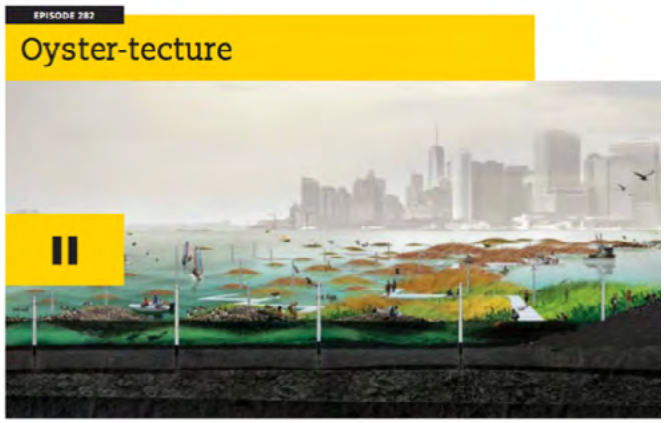
Retrieved from State of the Estuary report http://www.harborestuary.org/pdf/StateOfTheEstuary2012/SOE_Rprt_HiRes.pdf

YouTube: A video about Chesapeake Bay oysters

A similar story occurred in New York. Start at 1 minute 10 seconds. Screen capture obtained 29/10/2018

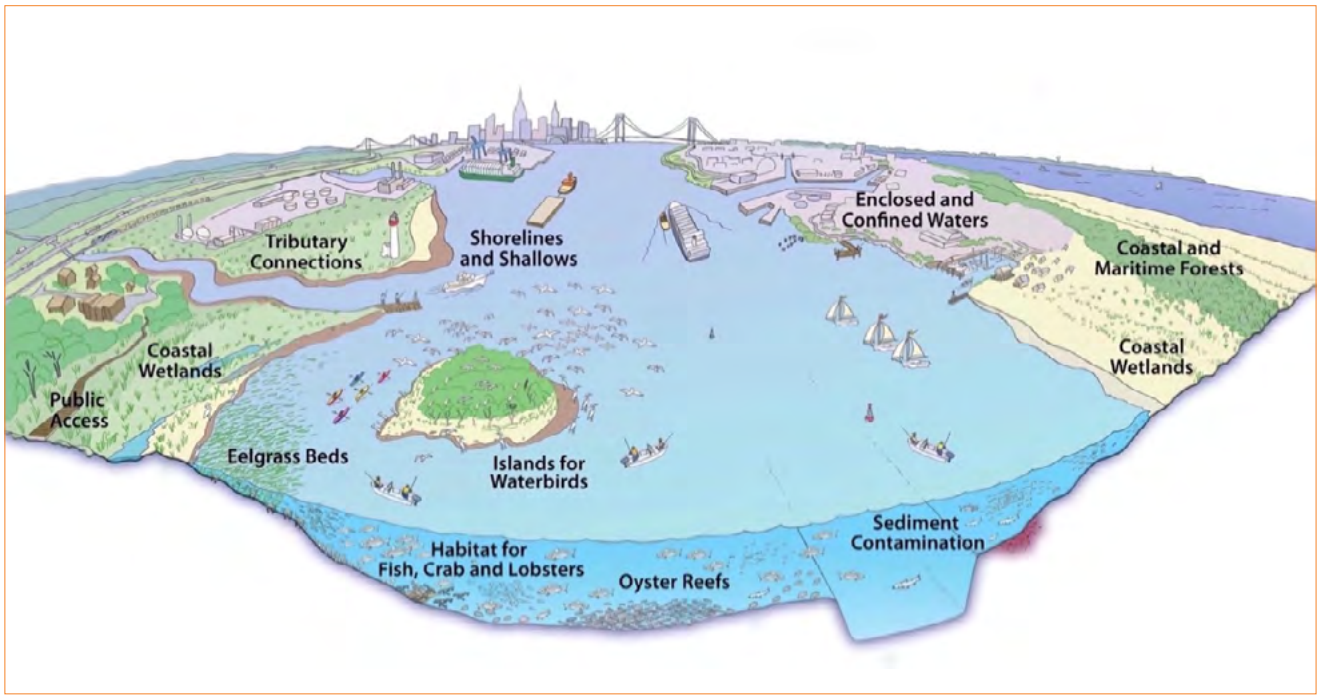
Source: https://www.youtube.com/watch?v=9V3yjCplc44

Podcast: 30-minute audio podcast Post Sandy to address climate change by suggestion options for the future



Source: https://99percentinvisible.org/episode/oyster-tecture/ Screen capture obtained 29 / 10/ 2018

Diagram 2: Restoring the New York New Jersey Harbor Estuary



Retrieved from http://www.harborestuary.org/watersweshare/resources.htm#crp

The Comprehensive Restoration Plan (CRP) for the Hudson-Raritan Estuary (HRE) is a master plan to guide ecosystem restoration efforts throughout the estuary. It is intended to be used by all stakeholders (environmental and community groups, government agencies, and others), thereby allowing the whole region to work toward a series of shared restoration goals providing benefits to the estuary.

Image 4: Creating or recreating living shorelines

Retrieved 29/10/18 from https://www.estuaries.org/first-national-report-on-living-shorelines-institutional-barriers-released

A LOOK INSIDE NEW YORK HARBOR

NEW YORK HARBOR IS A LARGE, ICONIC, COMPLEX BODY OF WATER

The harbor is an important part of New York City and its millions of residents. Throughout history, New York Harbor has been massively changed and impacted by human activities. These changes have altered the shorelines, water flow, plants, and animals of the harbor. Historically, New York Harbor had marshy shorelines, oyster reefs, sand bars, and rocky reefs which were hazards to ships. The present day harbor created hardened shorelines (seawalls and riprap rocks), dredged channels for shipping, and a few, scattered remaining oysters that are unsafe to eat. However, improvements in water quality, largely by upgrading sewage treatment combined with the natural flushing by tides are helping to restore the harbor. These illustrations of New York Harbor help explain what is happening below the water surface—a look inside.

The New York Harbor region includes the five boroughs of New York City (Manhattan, Bronx, Queens, Brooklyn, Staten Island), Westchester County, New York, Nassau County on Long Island, New York and extensive regions of Northeast New Jersey. The complex waterways include the Hudson River and several New Jersey Rivers (Hackensack, Passaic, Rahway and Raritan Rivers) which all empty into New York Harbor. There are six bays that are contiguous with New York Harbor: Newark, Raritan, Sandy Hook, Lower New York, Upper New York and Jamaica Bays. There are two entrances into New York Harbor; Long Island Sound via the East River, and the Atlantic Ocean via the entrance between Rockaway Point and Sandy Hook.

Four parallel east–west transects were established to provide insights into the natural and man-made features of New York Harbor. From north to south, these transects were the following: **T1**—George Washington Bridge transect, **T2**—Midtown Manhattan transect, **T3**—Statue of Liberty transect, and **T4**—Verrazano Bridge transect.

This poster is a product of the Curriculum and Community Enterprise for Restoration Science (CCERS), a National Science Foundation (NSF) funded project, with a diversity of partner institutions denoted by the logos.

GEORGE WASHINGTON BRIDGE TRANSECT

Hudson River is deep and turbid (poor water clarity) with hardened shorelines (riprap and seawalls) and toxic sediments (e.g., PCBs). It is spanned by the George Washington Bridge.

Harlem River is shallow (<16') and turbid.

Eastchester Bay is a shallow embayment (<7') in the Western Narrows of the deeper Long Island Sound (100'+).

The deep bottom waters of Long Island Sound are hypoxic (low oxygen) due to excess nutrients from stormwater runoff, sewage treatment effluent, and contaminated groundwater.

MIDTOWN MANHATTAN TRANSECT

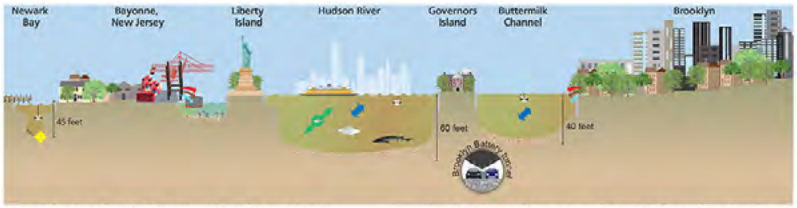
The New Jersey Palisades form a high bluff above a landfill created for port development.

The turbid Hudson River is deep (60') and serves as a fish migration corridor (e.g., sturgeon). The Lincoln Tunnel is below the river (100' deep).

Landfill along the hardened Manhattan shoreline has removed salt marshes and created space for roadways and development. Stormwater runoff and sewage treatment effluent lead to excess nutrients, but turbidity prevents algal growth.

The East River is 40' deep and is flushed by tides from Long Island Sound and New York Harbor, with the Queens–Midtown Tunnel (opened in 1940) underneath (100' deep).

STATUE OF LIBERTY TRANSECT



Newark Bay is shallow (<9') apart from a deep shipping channel (45') with muddy sediments containing toxins.

Liberty Bay is a shallow embayment of New York Harbor once filled with oyster reefs. Liberty Island, where the Statue of Liberty stands, is supported by landfill and hardened shorelines to 12' above sea level.

Upper New York Bay at the mouth of the Hudson River has variable depths and is transited by passenger ferries, water taxis, and commercial shipping.

Buttermilk Channel is relatively deep compared with historical accounts of being able to move cattle across at low tide, and separates Governors Island from Brooklyn. The Brooklyn Battery Tunnel runs underneath at a depth of 140'.

VERRAZANO BRIDGE TRANSECT

Arthur Kill, separating New Jersey from Staten Island, is maintained as a dredged shipping channel (35' deep) with poor flushing.

The Verrazano Narrows is very deep (228') and separates the Upper and Lower New York Harbor with vigorous tidal flushing. It is spanned by the Verrazano Bridge (4,260' long, opened in 1964).

Jamaica Bay is historically very shallow, but dredging has created some deep regions (50'+), especially near JFK International Airport. Jamaica Bay is managed by the National Park Service as part of Gateway National Recreational Area (established in 1972).

Stormwater runoff and sewage treatment effluent from Brooklyn and Queens degrade water quality of Jamaica Bay.

Habitat characteristics
- Water clarity
- Sandy bottom
- Muddy bottom
- Landfill
- Fish habitat
- Fish migration corridor

Key Issues
- Nutrients
- Sediment
- Stormwater runoff
- Hardened shoreline
- Toxins

Physical Processes
- Tidal flushing
- Riverine flow with tidal flushing

New York - New Jersey
Harbor & Estuary Program
www.harborestuary.org

FACT SHEET

STATE OF THE ESTUARY 2012

The New York-New Jersey Harbor Estuary is home to a complex ecological system in the midst of a heavily developed metropolitan area.

Increasing environmental degradation brought about a public outcry, legislation, and numerous actions to bring the estuary back from the brink. Today, our estuary's health is much better than it was 30 years ago, but many problems remain.

This fact sheet summarizes a few aspects of the "state of the estuary" including pollution, wildlife, and natural areas. A full report and related resources are available at *www.harborestuary.org*.

LIVING RESOURCES

Estuaries are areas where rivers meet the sea, creating habitats for countless plants and animals. These rich ecosystems provide essential benefits, including nourishment, clean water, protection from floods and erosion, and recreational opportunities.

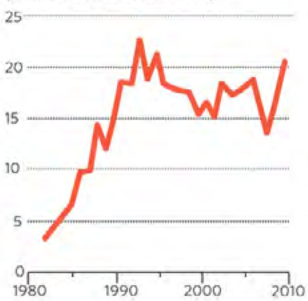
Urbanization and other human activities have profoundly changed our estuary. Many natural areas have been degraded or lost, but remaining habitats still provide invaluable resources and are in serious need of protection and restoration. While some species in the estuary are in poor condition, the success stories are encouraging.

Habitat: Although threats to remaining habitats persist in our region, loss and degradation have generally slowed in recent decades. There is growing recognition of the enormous value we derive from healthy ecosystems and the need to preserve and improve them. In 2009, a group that included many HEP partners drafted a Comprehensive Restoration Plan (CRP) for our estuary. This master plan is meant to guide conservation and restoration efforts in our region, leading to healthier habitats, cleaner air and water, aesthetic value, and recreational opportunities. This will translate into more livable and desirable communities, healthier families, and stronger local economies.

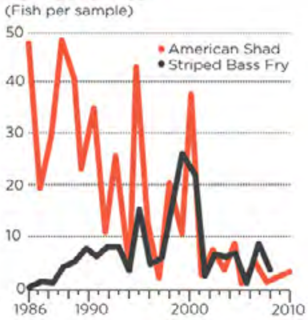
Harbor Herons (a group of wading birds) had disappeared from our estuary by the late 19th century. Improved environmental conditions and protection from hunting have contributed to their return. Their populations are now relatively stable.

Fishes: In the Hudson River, striped bass declined because of overfishing, but populations have recovered after the implementation of fishing restrictions. American shad populations are at historic lows and it is hoped that recent fisheries closures will aid its recovery.

HARBOR HERONS
(Number of nests, hundreds)



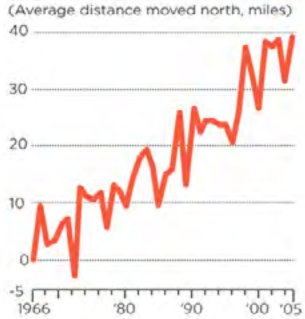
FISH ABUNDANCE
(Fish per sample)



CLIMATE CHANGE

Scientists agree that the earth's temperature is rising and that this is very likely the result of human activities, primarily the increasing use of fossil fuels such as coal and oil. The consequences of climate change could be catastrophic. Locally, we can expect more frequent and intense heat waves, rising sea levels, and intense rainstorms with more frequent flooding. These events may worsen many of the problems that currently affect our estuary, and create new ones. Among other negative effects, climate change may damage our homes, wastewater treatment plants, and other key infrastructure; and affect our health, transportation options, and the provision of electricity. Our estuary's ecosystem will suffer as wetlands are damaged and lost, shellfish growth slows, wildlife are driven away in search of cooler climates, and pests and invasive species spread more easily. We are already starting to experience some of these effects, and changes will be much worse if we fail to act. The task is daunting, but numerous efforts to mitigate and adapt to climate change are ongoing, and we as individuals can each make a contribution by working to conserve energy.

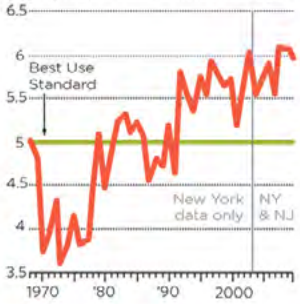
BIRD MIGRATION SHIFT IN N. AMERICA
(Average distance moved north, miles)



FACT SHEET

POLLUTION

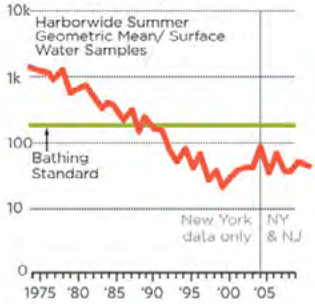
DISSOLVED O_2 IN BOTTOM WATERS
(mg/L) Harborwide, summer averages



Nutrients and Dissolved Oxygen:

Excessive nutrients in our waters enable microorganisms to grow and consume dissolved oxygen, stressing or even killing valuable aquatic wildlife. Nutrient pollution in our estuary has decreased, thanks to investments in better wastewater treatment. While green infrastructure will help, nutrients are very difficult to remove, and further reductions will likely require complex and expensive improvements.

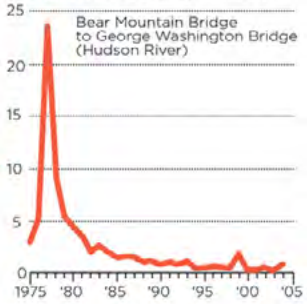
FECAL COLIFORM BACTERIA
(Bacteria per 100mL)



Pathogens:

Pathogens are disease-causing microorganisms. Pathogen pollution is commonly the result of contamination by human or other animal feces. Pathogens enter waterways mainly from combined sewer overflows, which discharge a mixture of stormwater and sewage when rainstorms overwhelm wastewater treatment plants. Pathogen pollution affects our ability to swim and enjoy our waterways, and also contaminates shellfish, making them unsafe to eat. Improvements in our wastewater treatment infrastructure have generally resulted in cleaner waters. Progress in areas of our estuary that do not have good tidal flushing will likely be slower and more expensive. But ongoing and planned efforts are expected to bring us closer to the ultimate goal of a healthy estuary that can be enjoyed safely by all at any time.

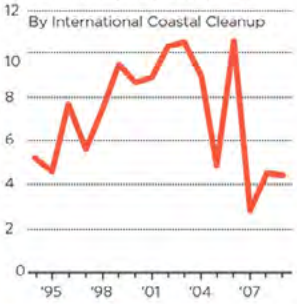
POLYCHLORINATED BIPHENYLS (PCBs)
IN STRIPED BASS (parts per million)



Toxic Chemicals:

Toxic pollution is one of the most serious problems in our estuary, threatening wildlife, limiting the safe consumption of local fish and shellfish, and increasing the cost of port operations. Many toxic chemicals entered our estuary as a result of past industrial activities and have persisted in sediments, accumulating in the tissues of fish and other wildlife. The concentrations of several toxic chemicals have been decreasing slowly, but it is necessary to address past contamination to achieve further reductions faster. Recently, cleanup was initiated at two of the most notorious contaminated sites in our estuary: the Hudson River PCBs and Passaic River Diamond Alkali Superfund sites. These are significant steps, but much more work is necessary at these and other sites.

DEBRIS COLLECTED IN 8
NY COUNTIES (100 pounds/mile)



Floatable Debris:

Litter and decaying structures such as piers and abandoned boats are the main sources of floatable debris on our beaches, shorelines, and waterways. Debris is not only an eyesore, it can harm people and wildlife, and cause damage to boats. Many groups are working to address this problem, and we can all do our part by generating less waste and disposing of trash properly. Floatable debris in our estuary may already be decreasing, but continued monitoring is needed to confirm whether this trend is real.

Little Blue Heron

Black-Crowned Night Heron

New York - New Jersey Harbor & Estuary Program
www.harborestuary.org

NEIWPCC
New England Interstate Water Pollution Control Commission

For more information on the State of the Estuary and for ideas on how you can help, visit *www.harborestuary.org*. We all need to do our part so that we can live, work, swim, travel, fish, canoe, bird-watch, learn, enjoy and preserve the wonderful treasure that is our estuary for generations to come.

NEW YORK HARBOUR ESTUARY STUDY

RECOMMENDED RESOURCES

Presentations

Lorraine Chaffer PowerPoint presentation: New York Harbour at GTANSW website https://www.gtansw.org.au Dropdown menu – Resources – Presentations – 2018

- *Slides 1–5* Introduction
- *Slides 6–9* Place Geography
- *Slides 10–20* Environmental processes and Functioning
- *Slides 20– 40* Environmental change and management

World Harbour Project: WEBINAR: New York Harbour (Register to view then go to Part 2) https://register.gotowebinar.com/recording/8363243159295259907

Academic paper

New York Harbor: Resilience in the face of four centuries of development

Judith M. O'Neil, Dylan Taillie, Brianne Walsh, William C. Dennison, Elisa K. Bone, David J. Reid , Robert Newton, David L. Strayer, Kate Boicourt, Lauren B. Birney , Sam Janis , Pete Malinowski , Murray Fisher

Retrieved from Regional Studies in Marine Science 8 (2016) 274–286 on October 28th 2018 https://www.sciencedirect.com/search?qs=New+York+Harbor%3A+Resilience+in+the+face+of+four+centuries+of+development&authors=&pub=&volume=&issue=&page=&origin=home&zone=qSearch

Reports

State of the Estuary report http://www.harborestuary.org/pdf/StateOfTheEstuary2012/SOE_Rprt_HiRes.pdf

State of the Estuary 2012 Fact Sheet http://www.harborestuary.org/pdf/StateOfTheEstuary2012/Factsheet_English.pdf

Restoring the New York New Jersey Harbor Estuary Page 1 http://www.harborestuary.org/watersweshare/resources.htm#crp

Restore, Adapt, Mitigate from Restore Americas Estuaries https://www.estuaries.org/images/stories/RAE_Restore-Adapt-Mitigate_Climate-Chg-Report.pdf

Websites

New York New Jersey Harbour Estuary Program http://www.harborestuary.org/RaritanBayConf2015.htm

Hudson River Estuary https://www.dec.ny.gov/lands/4923.html

Port of New Jersey New York http://www.panynj.gov/port/

Summary of restoration plans http://www.nan.usace.army.mil/Media/News-Stories/Story-Article-View/Article/496506/us-army-corps-of-engineers-meet-with-stakeholders-and-discuss-progress-and-plan/

Posters

Wildlife poster: *Wildlife of the New York New Jersey Harbor Estuary* http://www.harborestuary.org/educationalmaterials.htm

A Look Inside New York Harbour https://vizziesvote.skild.com/entries/a-look-inside-new-york-harbor

Oysters

New York New Jersey Harbour Estuary Program / Habitat: Oyster Reefs http://www.harborestuary.org/aboutestuary-habitats-oyster.htm

'Oyster-tecture' (Living Breakwaters) https://99percentinvisible.org/episode/oyster-tecture/

Billion Oyster project https://billionoysterproject.org

Why New York Schoolchildren Want to Grow a Billion Oysters https://www.smithsonianmag.com/smart-news/why-new-york-schoolchildren-want-grow-billionoysters-180963085/#UpV4BTlzumkAsHaK.99

The incredible Oyster Reef (YouTube) https://www.youtube.com/watch?v=9V3yjCplc44

GTANSW
President Report, AGM 2018

Lorraine Chaffer

President GTA NSW & ACT, October 2017 – October 2018

The Geography Teacher's Association of NSW (GTANSW) has had another highly successful year providing professional support for Geography teachers and students across NSW and the ACT. GTANSW professional learning events have been inclusive of all sectors and continue to actively promote Geography across all stages. Professional Learning activities are open to members and non-members.

MEMBERSHIP has grown from 375 to 431 as of October 1, 2018. Most memberships are corporate, covering all faculty members within a school. Fees for non-members remain higher to encourage membership.

GTANSW COUNCIL

On October 22nd before the 2018 AGM the GTANSW Council had 18 elected councilors (including a president and four Vice Presidents) and five co-opted members. There are five regional representatives from Wagga (1), Canberra (1) and Newcastle (3). Until recently GTANSW also had a North Coast representative who has recently moved to Queensland. GTANSW would like to thank Melinda Rowe for her contributions to GTANSW over the past year, particularly at the Annual Conference and assistance organising the Tweed Regional Conference. Over recent years the number of councilors from outside Sydney has increased. Council meetings are a mix of members attending in person and online (through Adobe Connect and recently trialing ZOOM). This has successfully allowed the full involvement of councillors unable to attend in person.

GTANSW outsources administrative, financial, publishing and organisational tasks to the Professional Teachers' Council NSW and rents office space within the PTC NSW premises.

2018 PROGRAM

2018 was an extremely busy year as we expanded the professional learning opportunities and resources for our members. None of this would be possible without a team of dedicated council members who contribute what time and circumstances allow throughout the year. Thank you. I will name individuals as I run through our 2018 achievements.

I have a few other people to thank before I report on the 2018 program.

- Sharon McLean for facilitating our online meeting forum through Skype, Adobe and more recently Zoom
- Milton Brown (and others including John Lewis and Susan Caldis) who took meeting minutes in his absence.
- Grant Kleeman for financial management as the ongoing GTANSW treasurer.

For office administration thanks go to all of the PTC NSW staff but in particular

- Julie Pham for event management. Whatever the event, Julie makes us all look good and has added a level of calm and sophistication to everything we do.
- Jill Sillar for her publishing skills to satisfy our constant demand for flyers and other promotional materials and of course the publication of the *Geography Bulletin*.

Lastly to Rob Berry for continued service to keeping the website current – even when he is on holidays overseas.

GTANSW President Report, AGM 2018

A. PROFESSIONAL LEARNING EVENTS

- Two-day ***Annual Conference*** in April. This involved 41 sessions (masterclasses, presentations or workshops) attended by over 220 teachers each day. Additionally, there were 32 exhibitors, over 30 presenters and 15 GTA councilors present.

  The focus for 2018 was on pedagogy, literacy and skills with content-focused workshops and presentations making up the remainder.

  2018 was the second year with sponsorship allowing the awarding of scholarships and bursaries to teachers in more rural or remote to attend and offsetting other costs.
- Two one-day ***Regional Conferences*** at Tweed Heads (South) and Canberra (NW)
- Six ***Webinars***

  Thank you to Sharon McLean for your organisation of these important events to service our city, rural and regional colleagues.
- Two ***Skills Workshops***

  Thank you to Grant Kleeman organise events desperately needed to meet the high demand for training in skills but those untrained in or new to teaching Geography.
- Two ***ESRI GIS in Schools*** events
- ***Senior Geography Teachers Conference*** (Now an annual event in November)

B. OTHER EVENTS

- ***HSC Exam Preparation Lectures*** to assist HSC exam preparation.

  Thank you to Catherine Donnelly and those who became MC's and presenters at these events.
- ***Arthur Phillip Fieldwork Awards Competition*** and ceremony – competition to promote geographical inquiry through fieldwork.
- ***Top HSC Achiever Awards Ceremony*** – Top 10 HSC students AND their teachers recognised in the Awards Ceremony during Annual Conference.

  Thank you to Grace Larobina for organising the collection and marking of the competition entries and organising the Award Ceremony at the Annual Conference. Thanks also to those of you who assisted Grace with these two activities, they could not run without a team effort.
- Many of you also represented GTANSW at several events throughout the year, particularly by visiting schools who had requested assistance.

  To Alexandria Lucas, Grace Larobina, David Latimer, Louise Swanson, Lorraine Chaffer and Susan Caldis thank you, and my apologies if I have missed someone in the process.
- GTA NSW and maintains a close relationship with the Geographical Society of NSW.

  Thank you to Martin Pluss and Susan Caldis for maintaining links and keeping us informed.
- Most recently GTANSW has submitted responses to NESA Review of the Stage 6 Syllabus and Draft Directions Paper. Many of you attended events and gave feedback that informed GTA's submission to NESA. This is an ongoing process.

  Thank you to Sharon Mclean for being the GTA representative on the Board Curriculum Committee for Stage 6.

GTANSW President Report, AGM 2018

C. PUBLICATIONS

- The ***Geography Bulletin*** remains the key publication with four digital editions for K–12 teachers and two special editions for senior Geography.
- ***Primary Geography Alive –*** an online resource of teaching units with integrated resources published on the GTANSW website with free access to primary teachers. Units continue to be added.

  Thanks go to Lorraine Chaffer as editor of the Geography Bulletin and Grant Kleeman as coordinator and developer of the primary resource.
- GTANSW maintains its ***Facebook Page*** for official notifications and general interest items, two ***Facebook Support Groups*** for HSC Teachers and Primary teachers and Twitter for conference events.

It is anticipated that all of these programs will continue into 2019. Discussions on the delivery of Professional Learning to ***primary teachers*** will continue with a potential focus on the use of webinars, twilight functions held in schools, and further ahead, online courses.

NEW INITIATIVES FOR 2019

- ***Assessment packages*** based on each of the 7–10 NSW Geography Syllabus Topics but applicable to all jurisdictions. The packages will contain a stimulus booklet and a range of different assessment activities, marking guidelines and suggested answers. These will be available for purchase. The first unit is in development now.
- ***Online Professional Learning*** through Open Learning and developed under the umbrella of a PTC NSW initiative involving other Subject Associations. The first course is in development now with a number of proposals submitted for approval.

GTANSW remains a hard-working team of volunteers with a passion for supporting Geography teachers in NSW and for that I am extremely grateful and proud of what we have achieved in 2018.

We anticipate the development of a new Stage 6 Syllabus in 2019, based on the Australian Senior Curriculum.

Lorraine Chaffer
President GTANSW

The Geography Teachers Association of NSW & ACT Inc.

NOTE: From November 2018 GTANSW will be known as the Geography Teachers Association of NSW and ACT

GTANSW Financial Statements 2018

THE GEOGRAPHY TEACHERS ASSOCIATION OF NEW SOUTH WALES INCORPORATED

INCOME AND EXPENDITURE STATEMENT FOR THE YEAR ENDED 30 JUNE, 2018

	2018 $	2017 $
Income		
Membership subscriptions	55,595	58,406
Grants received	1,000	3,568
Sponsorship	20,891	18,409
Attendance fees	133,688	97,646
Workshops and lectures	74,000	–
Expense Reimbursements	–	10,827
Copyright	5,425	3,369
Sales	22,758	10,896
Miscellaneous income	1,401	1,620
Interest received	298	290
Total income	315,056	205,031
Expenses		
Audit	2,072	1,399
Bank charges	752	671
Bookkeeping	8,781	6,125
Capitation	3,800	9,056
Conferences	70,208	82,794
Consultants	–	1,300
Courier	204	335
Depreciation	387	387
Filing fees	20	88
Gifts	1,438	423
Graphic design	24,196	17,550
Insurance	569	569
Meeting expenses	4,027	–
Membership and subscriptions	6,056	–

THE GEOGRAPHY TEACHERS ASSOCIATION OF NEW SOUTH WALES INCORPORATED

INCOME AND EXPENDITURE STATEMENT FOR THE YEAR ENDED 30 JUNE, 2018

	2018 $	2017 $
Postage	4,546	2,211
Printing & stationery	3,117	8,248
Removalist	-	1,965
Rent	15,413	14,715
Secretariat	35,365	19,166
Stock purchased	46,021	15,837
Telephone and internet	96	66
Travel and accommodation	4,120	7,640
Website	5,434	5,308
Workshops and lectures	79,733	–
Total expenses	316,355	195,853
Operating (Deficiency)/Surplus from Ordinary Activities	1,299	9,178
Retained earnings at the beginning of the financial year	313,737	304,559
Retained earnings at the end of the financial year	312,438	313,737

The accompanying notes form part of these financial statements.

THE GEOGRAPHY TEACHERS ASSOCIATION OF NEW SOUTH WALES INCORPORATED

BALANCE SHEET
AS AT 30 JUNE, 2018

	Note	2018 $	2017 $
CURRENT ASSETS			
Cash at Bank	2	303,460	291,650
Receivables	3	6,814	-
Inventory	4	7,302	22,712
TOTAL CURRENT ASSETS		317,576	314,362
NON CURRENT ASSETS			
Office Equipment	5	251	638
TOTAL NON CURRENT ASSETS		251	638
TOTAL ASSETS		317,827	315,000
CURRENT LIABILITIES			
Payables	6	5,389	1,263
TOTAL LIABILITIES		5,389	1,263
NET ASSETS		312,438	313,737
MEMBERS' FUNDS			
Accumulated surplus		312,438	313,737
TOTAL MEMBERS' FUNDS		312,438	313,737

The accompanying notes form part of these financial statements.

INDEPENDENT AUDIT REPORT TO THE MEMBERS OF THE GEOGRAPHY TEACHERS ASSOCIATION OF NEW SOUTH WALES INCORPORATED

Scope

We have audited the financial statements of the Geography Teachers Association of New South Wales Incorporated for the year ended 30 June, 2018. The committee is responsible for the preparation and presentation of the financial statements in order to express an opinion on them to the members.

Our audit has been conducted in accordance with Australian Auditing Standards to provide reasonable assurance as to whether the financial statements are free of material misstatement. Our procedures included examination, on a test basis, of evidence supporting the amounts and other disclosures in the financial statements, and the evaluation of accounting policies and significant accounting estimates. These procedures have been undertaken to form an opinion as to whether, in all material respects, the financial statements are presented fairly in accordance with Australian Accounting Standards so as to present a view of the association which is consistent with our understanding of its financial position and the result of its operations and cash flows.

The audit opinion expressed in this report has been formed on the above basis.

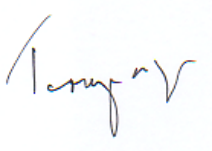
Qualified Audit Opinion

As is common for organisations of this type, it is not practicable for Geography Teachers Association of New South Wales Incorporated to maintain an effective system of internal control over donations, subscriptions and other fund raising activities until their initial entry in the accounting records. Accordingly, our audit in relation to fund raising was limited to amounts recorded.

Audit Opinion

In our opinion, except for the effects of such adjustments mentioned in the above qualification, the financial report presents fairly in accordance with the cash basis of accounting, as described above, the payments and receipts of Geography Teachers Association of New South Wales Incorporated for the year ended 30 June, 2018 and its cash and bank balances as at that date.

Date: 11th October, 2018



5th Floor, 20–24 Wentworth Street
PARRAMATTA NSW 2150

TERRENCE E. GIBBS
Registered Company Auditor – 3311

ADVICE TO CONTRIBUTORS

Geography Bulletin guidelines

1. *Objective:* The Geography Bulletin is the quarterly journal of the New South Wales Geography Teachers' Association, Inc. The role of the Geography Bulletin is to disseminate up-to-date geographical information and to widen access to new geographic teaching ideas, methods and content. Articles of interest to teachers and students of geography in both secondary and tertiary institutions are invited, and contributions of factually correct, informed analyses, and case studies suitable for use in secondary schools are particularly welcomed.
2. *Content:* Articles, not normally exceeding 5000 words, should be submitted to the GTA Office by email gta.admin@ptc.nsw.edu.au

   Submissions can also be sent directly to the editors: Lorraine Chaffer (lchaffer@tpg.com.au)

   Articles are welcomed from tertiary and secondary teachers, students, business and government representatives. Articles may also be solicited from time to time. Articles submitted will be evaluated according to their ability to meet the objectives outlined above.
3. *Format:* Digital submission in Word format.

- Tables should be on separate pages, one per page, and figures should be clearly drawn, one per page, in black on opaque coloured background, suitable for reproduction.
- Photographs should be in high resolution digital format. An indication should be given in the text of approximate location of tables, figures and photographs.
- Every illustration needs a caption.
- Photographs, tables and illustrations sourced from the internet must acknowledge the source and have a URL link to the original context.

Note: Try to limit the number of images (Table, map, graph, photograph, diagram etc) per page to facilitate ease of reproduction by teachers.

Diagrams created using templates should be saved as an image for ease of incorporation into the bulletin.

All assessment or skills tasks should have an introduction explaining links to syllabus content and outcomes. A Marking Guideline for this type of article is encouraged.

4. *Title:* The title should be short, yet clear and descriptive. The author's name should appear in full, together with a full title of position held and location of employment.
5. *Covering Letter:* As email with submitted articles. If the manuscript has been submitted to another journal, this should be stated clearly.
6. *Photo of Contributor:* Contributors may enclose a passport-type photograph and a brief biographical statement as part of their article.
7. *References:* References should follow the conventional author-date format:

   Abbott, B. K. (1980) ***The Historical and Geographical Development of Muswellbrook*** Newcastle: Hunter Valley Press.

   Harrison, T. L. (1973a) ***Railway to Jugiong*** Adelaide: The Rosebud Press. ***(2nd Ed.)***

Refereeing

All suitable manuscripts submitted to the Geography Bulletin are subject to the process of review. The authors and contributors alone are responsible for the opinions expressed in their articles and while reasonable checks are made to ensure the accuracy of all statements, neither the editor nor the Geography Teachers' Association of New South Wales Inc accepts responsibility for statements or opinions expressed herein.

Books for review should be sent to:

The GTA NSW Council
PO Box 577
Leichhardt NSW 2040

Editions

There are four bulletins each year – two published each semester.

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