GEOGRAPHY BULLETIN

CASE STUDIES for Stage 6

The Geography Teachers Association of New South Wales Inc.

Special Edition 2020

IN THIS ISSUE:

PROFESSIONAL INTEREST

The emergence of modern geography, Plymouth, the Pacific and Prussia?

Geography Effect

YEAR 11: GLOBAL CHALLENGES

Population 'boom or 'bust' (The challenge of predicting future demographic trends)

SKILLS ACTIVITIES: POPULATION

World population may shrink by 2100

One billion face displacement by 2050

Nearly 80 million displaced worldwide

YEAR 11: GLOBAL CHALLENGES

Case Study: Rare Earth Elements

Visualising the importance of environmental management in mining

SKILLS ACTIVITIES: NATURAL RESOURCES

China may weaponise rare earths

Environmental Management in mining

SELECTING CASE STUDIES

Broken Hill: A case study option

YEAR 12: URBAN PLACES

Urban Dynamics of Change in Sydney Olympic Park, Newington, Rhodes and The Waterfront

YEAR 12: PEOPLE AND ECONOMIC ACTIVITY

Aquaculture

YEAR 12: ECOSYSTEMS AT RISK

Ningaloo Reef

Oregon Dunes

PROJECTS • REPORTS • RESOURCES • ARTICLES • REVIEWS

GEOGRAPHY BULLETIN

Editor
Lorraine Chaffer

Articles and letters should be sent to the Editor:
Lorraine Chaffer
Email: lchaffer@tpg.com.au

Design and layout:
Jill Sillar, Professional Teachers' Council NSW
jill.sillar@ptc.nsw.edu.au

ISSN 0156-9236

The Geography Teachers Association of NSW & ACT Inc.

OFFICE OF THE GEOGRAPHY TEACHERS' ASSOCIATION OF NEW SOUTH WALES

ABN 59246850128
Address: 67–71 St Hilliers Rd, Auburn NSW 2141
Postal Address: PO Box 699 Lidcombe NSW 1825, Australia
Telephone: (02) 9716 0378, Fax: (02) 9564 2342
Email: gta.admin@ptc.nsw.edu.au
Website: www.gtansw.org.au

ANNUAL MEMBERSHIP (Subscriptions include GST)

Personal membership $90.00
Corporate membership (school, department or business) $200.00
Concessional membership (retiree, part-time teacher or student) $40.00
Primary corporate membership & pre-service teachers free

Front Cover: Farmer collecting seaweed at a farm in Nusa Penida, Indonesia. Source: Shutterstock

Back cover: Farming seaweed, Jungut Batu Nusa Lembonga. Source: https://commons.wikimedia.org/wiki/File:Lembongan_2.JPG

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.

GEOGRAPHY BULLETIN

Volume 52 Special Edition 2020
EDITOR: Lorraine Chaffer

CONTENTS

EDITORIAL 2

PROFESSIONAL INTEREST
- The emergence of modern geography, Plymouth, the Pacific and Prussia? 5
- Geography Effect: Two decades of change 15

YEAR 11: GLOBAL CHALLENGES
- Population 'boom or 'bust' (The challenge of predicting future demographic trends) 20

STAGE 6 SKILLS: POPULATION
- World population may shrink by 2100 23
- One billion face displacement by 2050 24
- Nearly 80 million displaced worldwide 25

YEAR 11: GLOBAL CHALLENGES
- Case Study: Rare Earth Elements (REE) 26
- Visualising the importance of environmental management in mining 29

STAGE 6 SKILLS: NATURAL RESOURCES
- China may weaponise rare earths 31
- Environmental Management in Mining 32

STAGE 6 FIELDWORK
- Fieldwork with Observatory Hill EEC 33

SELECTING CASE STUDIES
- Broken Hill: A Case Study option 37

YEAR 12: URBAN PLACES
- Urban Dynamics of Change in Sydney Olympic Park, Newington, Rhodes and The Waterfront 42

YEAR 12: PEOPLE AND ECONOMIC ACTIVITY
- Aquaculture 47

YEAR 12: ECOSYSTEMS AT RISK
- Ningaloo Reef 69
- Oregon Dunes 79

ADVICE TO CONTRIBUTORS 85

EDITORIAL

EDITORIAL: SPECIAL HSC EDITION

Welcome to this Special Edition of the Geography Bulletin. The focus is on Stage 6 Case Studies for both years 11 and 12 with some interesting professional reading about Geography, past and future.

Stage 6 Geography is being taught by many teachers for the first time while more experienced Stage 6 teachers have voiced a desire to develop new case studies for different topics. This conversation is taking place amid the frustration of waiting for a new Stage 6 Geography Syllabus to be finalised and released, and delays caused by the NSW and Australian Curriculum Reviews. The Draft Stage 6 Syllabus released for consultation in 2019 contained some existing stage 6 Geography topic content. Whilst that does not mean this will be the case in the new syllabus when it is released, teachers voiced approval during the consultation process, and it is expected that decisions about the final syllabus would take into account feedback from that consultation process.

The case studies integrated in this edition were selected based on an expectation that new material may be adapted to a future syllabus while at the same time providing an opportunity to refresh teaching programs and provide ideas beyond the textbook for those new to teaching Stage 6 Geography.

Our thanks go to the following authors for the material they have provided for this edition.

For your professional reading and discussion, Nick Hutchinson, *The emergence of modern geography, Plymouth, the Pacific and Prussia?* and Martin Pluss, *The Geography Effect: The end of Geography?* provide much food for thought and a chance to reflect on the nature of Geography over time and where it is heading as a Stage 6 subject in NSW Schools.

For Year 11 Global Challenges there are short case studies for Population and Natural Resources.

- Grant Kleeman: *Population boom or bust (The challenge of predicting future demographic trends)*
- Lorraine Chaffer: *Rare Earth Elements*
- Visual Capitalist*: Visualizing the Importance of Environmental Management in Mining*

To support these studies, as Editor, I have created a selection of skills activities using infographics from Graphic News and Visual Capitalist

- *World population may shrink by 2100 (*Graphic News)
- *One billion face displacement by 2050* (Graphic News)
- *Nearly 80 million displaced worldwide* (Graphic News)
- *China may weaponise rare earths* (Graphic News)
- *Environmental Management in Mining* (Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development)

In *Broken Hill: A Case study option* David Proctor has shown how a single location, especially a local one, can be used to develop case studies for many topics across Stage 6, in this case Broken Hill.

During 2020, NSW Environmental Education Centres have developed wonderful Virtual Fieldwork resources and opportunities to assist teachers in meeting their fieldwork obligations during COVID-19 constraints. In this edition *Observatory Hill EEC* has provided details for their virtual and real fieldwork programs to support Stage 6.

Lorraine Chaffer, Editor

EDITORIAL

The following case studies are for the three Year 12 topics: Urban Places, People and Economic Activity and Ecosystems at Risk.

In *Urban Dynamics of Change in Sydney Olympic Park, Newington, Rhodes and The Waterfront* Jaye Dunn illustrates the use of local suburbs to investigate the urban dynamics of change operating in a large city in the developed world (Sydney).

In *Aquaculture* I (Lorraine Chaffer) have provided a detailed set of notes under syllabus headings, with links to other contemporary resources that can be used as a starting point for deeper investigation and to inform the selection of a local enterprise.

David Latimer has provided a foundational case study for Ecosystems at Risk for those wanting to study a marine ecosystem that is not the Great Barrier Reef. The case study is on *Ningaloo Reef* , Western Australia. This study might suit students who are keen to study coral reefs but may be overwhelmed by the large amount of material on management of the Great Barrier Reef.

If you study coasts in years 7–11 or live on the coast you may find coastal dunes an interesting case study for Ecosystems at Risk and one you can support with local fieldwork. *Oregon Dunes*, in the USA is a fascinating study with a management twist that makes it somewhat different to coastal dune management in Australia and other parts of the world. In this case study I have provided links to many informative resources and am grateful to Save the Dunes in Oregon for freely sharing their resources to benefit teachers in NSW.

Finally, success in Stage 6 begins with strong foundations in Geography 7–10. The GTA E-Learning courses can assist teachers, particularly those untrained in Geography, to build those foundations. See pages 35 and 36 for more information.

Lorraine Chaffer

Vice President GTANSW & ACT

Editor.

Source: Restoring Oregon Dunes, Oregon Dunes Restoration Collaborative.


GTA
GTA NSW & ACT Annual Conference 2021
THE GEOGRAPHY LEARNING JOURNEY: Shaping futures
SAVE THE DATE:
Thurs 6 & Fri 7 May 2021
Venue to be advised


PLAN for 2021
Digital Professional Learning Package
REGISTER NOW


THE ACTIVE GEOGRAPHER
AGTA 2021
HOBART TASMANIA • 29 SEPT – 1 OCT
REGISTER YOUR INTEREST – https://tinyurl.com/y5d8v85a

Captain James Cook, 1728–79, oil on canvas by William Hodges. Source: Wikimedia Commons

The emergence of modern geography, Plymouth, the Pacific and Prussia?

Nick Hutchinson, GTANSW & ACT Lifetime Member

In May, 1768, Lieutenant Cook left Plymouth and sailed to Brazil and around Cape Horn, reaching Tahiti in April 1769, he touched the coast of New Holland in 1770. Arguably, The Pacific arena witnessed the birth of modern geography, with Prussian scholars at the soul the story. The origins of modern geography are very opaque, but some scholars consider that the long Enlightenment was time when the world was made modern, conventionally from 1685 to 1815 (Withers, 2007, p. 1). It was described an intellectual movement, centred as far as geography was concerned on Konigsberg and Berlin, based on the power of reason, an imperative that could improve the human condition. Stoddart articulated a convincing, but somewhat controversial, claim that a revitalised modern geography developed during the short period of time at the end of the eighteenth century and beginning of the nineteenth century. However, it was an amorphous geography that gradually metamorphosed from geography 'as description' to a much more emancipated and scientifically-oriented geography that permeated the intellectual currents of the European Enlightenment.

Stoddart (1987, pp. 32-5) regards geography as a distinctively objective study, a science that developed during the Age of Reason. This idea is examined in the context of Cook's voyages through the Pacific, particularly by reference to the journey along the coast of New Holland in the autumn and winter seasons of 1770. Geography's faithfulness to rationality and reason is tempered by further changes in the geographical experiment, seen as a movement away from the priorities of navigation and exploration towards a more affective geography. But also, more ominously towards imperialistic tropes and an all too often complicit engagement with racism. Many of geography's progenitors comply with the notion that revitalised modern geography may indeed be coincident with Cook's voyages into the Pacific but perhaps an emphasis on the 'great men' of historical geography tends to cloak rich, complex and more impervious geographies. Further attention to the discourses of geography may lead to improved elucidation and understanding.

The origins of modern geography

Europe had long engaged in extensive maritime trade and exploration from the fourteenth and fifteenth centuries onwards, accumulating map data and knowledge in ever increasing amounts but there was little purpose to this undertaking. Dissatisfied with this state of affairs there arose a point of view that the knowledge ought to be used to test certain assumptions about the links between people and environments (Hubbard, Kitchin, Bartly & Fuller, 2002, p. 24), and the power of reason and rationality would uncover those links (Johnston & Sidaway, 2004, p. 394).

Stoddart (1987, pp. 28-40) refers to a revitalised modern geography that developed over a comparatively short period of time at the end of the eighteenth century and beginning of the nineteenth century. He termed it a European science, an intellectual project based on a set of attitudes, methods, techniques and questions that set geography apart from other branches of knowledge. In Europe, up to the end of the eighteenth century, geography was essentially descriptive, an accessible body of work that began to emerge in England by the 1620s (Cormack, 1997, p.157). Broad in its scope, it aimed to describe the earth creating a unified, true, comprehensive, and complete picture of the entire surface of the planet, or selected parts of the world (Godlewska, 1999, p.2). Its modus operandi depended on mathematical, graphic and literary devices and its aim in presenting a complete representation of the earth was to expand knowledge. For some, geography was a servant to well-to-do class interests and the power of the church (Mayhew, 2000, p. 9); English Tudor undergraduates, at Christ Church, Oxford, drawn from

urban merchant backgrounds, aimed to be better equipped for mercantile careers, diplomatic journeys to Europe and imperial ambitions (Cormack, 1999, p. 45) Those who practised geography appealed to the general curiosity of the reading public and were more interested in presenting the location of phenomena rather than understanding them. Godlewska (1999, p. 3), referring this time to geography in France, explained that 'It is difficult to conceive today of just how nonexplanatory geography then was'.

However, geography 'as description' was also regarded as a science in pre-Enlightenment Europe. It was, admittedly, an 'easy and pleasant' science (Mayhew, 2000, p. 29), science as knowledge as opposed to science as 'certainty grounded on demonstration' (p. 30). It was a science about the situation of places on the earth and the make-up of those places in natural and human terms (p. 30) rather than science in the pursuit of truth (Unwin, 1992, p. 20). Then there is another view of geography prevalent in popular parlance, a traditional starting point for geography as the art of the mappable (Holt-Jensen, 2008).

> 'Cook's mission was at once geographical in its mapping of the Pacific islands, scientific in its attention to natural history, anthropological in its detailed accounts of island customs, and political in its alertness to the possibility of British imperial claims' (Wolff, p.20).

Geography, debatably, now embraces all of Cook's attributes, and much more besides.

The argument, presented here, seeks to examine the change from a sixteenth and seventeenth century geography that was taught at British universities, geographical works that were read by merchants, courtiers, and country gentlemen as well as investors and explorers, (Cormack, 1994, p. 19), a geography whose relationships with cosmography, astronomy, chorography and topography helped determine its nature until the end of the eighteenth century (Mayhew, 2000, p. 27), a geography that was primarily a textual practice rather than one that entertained the notion of fieldwork (p. 27–8) to the emergence of a new form of modern geography, a change in its discipline, what contemporaries held the subject to be, and, in geography as a discourse, the practices through which people came to know the world (Withers, 2007, p. 12).

Gregory (1994, p.11) explained that the discourses of geography percolate through the social practices of the wider community: seen, for example, through seventeenth century maps, Royal courts, Cook's cabin, commandeered by Banks and his retinue of gentlemen, 'the wide-open airy spaces of the field' and the 'stuffed displays of the museum' (Livingstone, 2003, p. 17): practices that involved 'observing, mapping, collecting, comparing, writing, sketching, classifying, reading, and so on' (Withers, 2007, p. 12). Such practices were not confined to any one discipline and they are not expressed in specific geographic vocabularies but use, for example, the languages of cartography, anthropology, botany, zoology and geology (Livingstone, 2003, pp. 9-10) to present the South Pacific as a comprehensible geographic entity.

Stoddart's argument is illustrated by reference to a number of personalities, an inclination towards the 'great men' of history who enlightened the world. And, so the story unfolds, – while Cook was developing his astronomical, surveying and cartographic skills in the cold Atlantic waters off Canada, Enlightenment philosopher Immanuel Kant had commenced long sequence of lectures on physical geography (1756-96) at the university of Konigsberg, East Prussia. When another Prussian, polymath geographer, naturalist and explorer, Alexander von Humboldt, was born in 1769, lieutenant Cook first observed the Pacific Ocean. He was then a skilled seaman with almost twenty years-service in the merchant and royal navies. When he was killed in Hawaii, in 1779, German geographer Carl Ritter was born.

Humboldt and Ritter are regarded by most geographers as the founders of modern geography (Buttimer, 1993, p. 59, Gade, 2011, p. 201, Gregory, 1994, p. 40, Waitt, McGuirk, Dunn, Hartig, & Burnley, 2000, p. 171). Humboldt's synthetic thinking 'seeking laws concerning interrelationships of the physical the biological, and even the human' (Buttimer, 2001, p. 107), his innovative use of maps, insistence on accuracy, his constant search for answers to critical questions and scepticism for past theories, was pivotal to the development of scientific geography. Ritter was another synthetic thinker developing his compendious 19 volume *Erdkunde* a generalised world geography with the earth as the home of humanity. His analysis, that covered only Asia and Africa at the time of his death, was, however, suffused with the author's Christian worldview. Furthermore, Kant gave geography a theoretical justification. He argued that both geography and history, as sciences, extend over the entire span of human knowledge with geography concerned with space and history with time. In dealing with space, geography provides humanity with access to the ordering and categorising of the world (Elden, 2011, p. 11). His popular geography lectures, on physical geography, broad enough to include much of what we would now understand as human geography (Elden, 2011, p. 5), aimed 'to civilise young students to become citizens of the world' (Wilson, 2006, p. 8). They provided

empirical grounding for his philosophical ideas, to guide students in their moral and practical lives (Elden, 2011, p. 3). In short, the lectures provided a propaedeutic, a preliminary instruction, for practical reason (p. 3).

The theoretical justification for Stoddart's argument is predicated upon the development of geography as a distinctly objective science, centred on quantification, concerned with realism in description, systematic classification in collection and comparative method in explanation (Gregory, 1994, p. 19, Stoddart, 1987, pp. 32-5, Withers & Livingstone, 1999, p.1). It was also a geography of social concern, unified by an ecological understanding (Mayhew, 2000, p. 8). It was a geography codified as a discipline through the efforts of Humboldt and his brother Wilhelm in the early nineteenth century, when modern geography was taught at German universities, and degrees and doctorates awarded. Geography then spread across Europe and North American universities in the later nineteenth century (Mayhew, 2011, p. 27).

Implicit in Stoddart's geography is not only accurate mapping that depended on increasingly sophisticated quantification, but also the direct observation of phenomena in the field, thinking about these observations and then through classification and comparison seeking some kind of explanation (Gregory, 1978, p. 16). The aim of the new sciences, such as anthropology, geology, chemistry and sociology, was the explanation of selected aspects of the earth's (or its inhabitants) functioning. To some extent geography was left out of these accomplishments. Explorers such as La Perouse, Cook and Bougainville turned to the findings of other explorers, and the views of the wider scientific community, rather than the obsolete and scarcely interesting world of 'cabinet-bound' descriptively-inclined geographers (Godlewska, 1999, pp. 5-6). Empiricism alone was insufficient in the age of reason. It was Humboldt, according to Bowen (1981), that moved geography from a preoccupation with naïve empiricism towards an integrated study of physical and human phenomena. This notion together with an awareness of the geographer's social responsibilities (Mayhew, 2000, pp. 8-9) were powerful new conceptions. Humboldt believed, for example, that there were no superior nor inferior races throughout the world (Wulf, 2015, p. 108).

Stoddart's objective science must be seen in a wider context, i.e. the philosophical milieu of the Enlightenment: with the power of reason to change human society, to question religious dogma and political authority, and, of science to elucidate understanding of the world (Livingstone, & Withers, 1999, p. 6). It also presaged a more universal change in the nature of sciences, to what Foucault described as a shift from the Classical era [circa 1650-1800] to the Modern era [circa 1800+] (Flynn, 2007, p. 60). The Modern era was the period where geography moved away from naïve empiricism, 'the nature of the life, earth and human sciences shifted from description to explanation and from a focus on surficial phenomena to the theoretical exploration of interior structures' (Godlewska, 1999, p. 236). In short, with the right questions most problems could be addressed and 'enlightenment' would proceed. Such 'enlightenment' was based on an unshakable penchant for exploration and from far-reaching collection and classification of information and specimens (p. 238). Withers (2007, p. 5) recognised an emerging zeitgeist,

> 'People in the eighteenth century understood their world to be changing as a fact of geography, and as a result of processes of geographical inquiry – in the shape and dimension of continents, for example, in the types of human cultures making up mankind, in the reasons plants, animals, and humans were located as they were'.

Notwithstanding these observations, the argument that Cook's voyages through the Pacific revitalised modern geography is more difficult to make than the notion that his voyages were coincidental with the development of modern geography, as seen through the scholarly works of Kant, Humboldt and Ritter. Nevertheless, the former argument is presented here.

Cook and a revitalised modern geography

Firstly, the perception of realism in description is apparent in new developments in artistic representation during Cook's voyages. Secondly, realism and a reliance on accurate measurement is examined in the context of Cook's 1770 chart of Botany Bay.

Cook employed professionally trained artists on all three of his voyages. These individuals learned to shift their emphasis from more traditional styles of British landscape painting to a more empirical approach to nature. They worked side-by-side with scientific illustrators to change their ways of seeing towards a more literal portrayal of the world from a metaphorical one, to embrace a search for 'a scientific language, the advancement of empiricism, and the spread of naturalism' (Livingstone, 1992, p. 133). Attention to detail was paramount. Stoddart (1987, p. 34) explained that, 'The botanical illustrations of Parkinson, and later the depiction of shells, birds and minerals with minute accuracy became characteristic'. Artists, like Parkinson, were also influenced by the emergence of the new

sciences, particularly, the sciences of visible nature: anthropology, geology, botany and zoology (Gregory, 1994, p. 23) in their 'European vision of the South Pacific' (Smith,1985, cited in Livingstone, 1992, p. 130).

Superficially, map making had changed from a preoccupation with creativity and imagination towards direct experience and precise measurement. Cook's charts were designed to act as accurate guides to assist navigators, to ensure their survival at sea. All the same, the most factual of maps, ones that embodied empirical truths were also replete with ambiguity and ideology (Edney, 1999, p. 169). They were also fit for purpose, omitting salient geographical detail. Cook's chart of Botany Bay titled 'A sketch of Botany Bay in New South Wales: latitude 34°00' S' (Cook, J., & New South Wales. Government Printing Office, 1893) was allied with Admiralty regulations and instructions to record new coasts visited and to produce charts.

The sketch map of Botany Bay was a realistic depiction obtained through painstakingly accurate land-based triangulation surveying, sightings from the Endeavour, from ship to shore and from small boats offshore. Soundings were also taken and rocks, shoals and sand deposits recorded. The resultant chart, later redrawn at the British hydrographic office, shows a remarkable degree of verisimilitude, with hachures indicating the steep inclines offshore, stippling indicating shoals off Point Sutherland and the presence of freshwater sources at six location. But there are also some rhetorical flourishes on the chart with an inset sketch of the Endeavour inside the compass rose and another depiction of the ship situated to the north of the aforementioned shoals. Vegetation on land was represented as a highly stylised open savanna. The sketch map is clearly designed as a chart for sailors but was also a contrived 'picture' of the landscape, much more than a realistic replication of a small portion of the world, or, an abstraction of reality.

None of the rich variety of terrestrial vegetation is recorded neither is the presence of Indigenous people. Reconstructions of the vegetation communities surrounding Kamay/Botany Bay undertaken to correlate the collections made by Banks and his fellow workers, in the eight days the crew spent in the area, indicate that the specimens were taken from a wide variety of communities (Benson & Eldershaw, 2007), from Swamp Sclerophyll Forest to Littoral Rainforest communities, from heaths to the Turpentine-Ironbark Forest. In all, over this short period of time, some 130 species of plants were collected, eventually giving rise to 94 coloured sketches (Benshaw & Howell, & Royal Botanic Gardens, Sydney, 1990, p. 28), but none are recorded on Cook's chart.

Stoddart's inclusion in his set of criteria lists systemic classification in collection. This best applies to Banks and his party rather than to Cook. Following the Linnaean tradition their classification was concerned with visible and external features of plants but it was also a theory-based description, focused the reproductive function (Godlewska, 1999, p. 13). On board the Endeavour was an extensive library of natural history texts and all manner of devices for snaring and preserving animals. According to Cook's biographer, Beaglehole (Cook, 1955, p. cxxxvi, cited in Gregory, 1994, p. 18) 'No people ever went to sea better fitted for the purpose of Natural History'.

Cook was involved in a more pervasive and persistent geographic tradition: the descriptive one, and an empirical one at that, 'In this Chart I have laide down no land not figur'd out any shore but what I saw my self, and thus far the Chart may be depended upon' (Cook, 1955, p. 52, cited in Carter, 1987, p. 22). But it was also a descriptive tradition with a wider purpose. His maps and charts, according to Carter (2010), were designed to record exact information, they left traces of 'particular encounters and the memories of particular experiences' (Gregory, 1994, p. 25). Cook was an 'explorer of horizons, and not a discoverer of countries, his realm of competence was confined to a coastal swath bounded by the visible horizon' (Carter, 1987, p. 27). Along that coastal swath he named particular prominent features: Pigeon House Mountain or Mount Dromedary, and on the N.E. Australian coast 'where the Lords of the Admiralty flitted from cape to cape' (Cook, 1955, p. cciv), but the names were vulgar mnemonics (Seddon. 1998, p. 42) for geographical coordinates. In fact, meridians of longitude spread out from Greenwich, the nerve centre of the British Admiralty. 'Every place named by Cook was also plotted by him on this grid, knitted into the fabric woven by the world's then greatest naval power and thus tied to the Britain which he served' (p. 42). Cook's descriptions had an ulterior purpose. The spatial history of Australia was consolidated when the European 'discoverers', explorers and settlers were 'choosing directions, applying names, imagining goals, inhabiting the country' (Carter, 1987, p. xxi).

Byangee Walls and Pidgeon House Mountain NSW, looking east. Source: Wikimedia Commons

The third element in Stoddart's reconstruction of the beginning of modern geography, comparative method in explanation, that analyses data seeking common patterns and distinctions, could be seen in embryonic form in the Endeavour crew's expeditions around Botany Bay. On May 3, 1770, Cook, Solander and Munkhouse boarded the pinnace to reach the head of the bay where Cook described a more productive environment than the sandy shores beyond the first watering place near Point Sutherland, 'instead of sand I found in many places a deep black Soil which we thought was capable of produceing any kind of grain at present it produceth besides timber as fine meadow as ever was seen' (Cook n.d. & South Seas, 2004, Manuscript 1, p. 230). The three gentlemen may have been comparing podsolised sands near Point Sutherland with those of swamp forests in the Cooks River estuary or locations further upriver at Kogarah Bay where the Turpentine-Ironbark Forest community flourished on a Wianamatta Shale ridge.

According to Stoddart (1987, p. 34) comparative method in explanation was seen most explicitly during Cook's second voyage when Rheinhold Forster tried to explain the existence of uplifted coral reefs in the Pacific in relation to the perceived emergence of the land from the sea in Scandinavia. When George Forster, his son, published an account of Cook's second voyage he insisted that a naturalist's task was much more than to bring back a collection of butterflies and dried plants it was rather to make sense of nature, of showing how the different facets of terraqueous globe were interrelated and interdependent (Gascoigne, 2007, p. 147). It was George Forster who so inspired Humboldt with his stories of a new era of scientific travel that had begun with Cook's expedition, a venture into 'comparative anthropology and geography' (Buttimer, 2001, p. 107).

The comparative method in explanation was most apparent in geography's engagement with anthropology. Gregory (1994, p. 5) believed that modern human geography had been defined by 'a series of encounters with anthropology in the eighteenth century', encounters that possibly date back as far as 1502 when Amerigo Vespucci recorded in his South American journal 'everything from the childbirth practices to the religious customs of the peoples he encountered' (Livingstone, 1992, p. 46). Anthropology sought to understand people in their own social and cultural context rather than see them from afar as alien, exotic, primitive, savage or barbarous (Wolff & Cipolloni, 2007, p. xii).

Cook's forays into anthropology and ethnography progressed from his initial descriptions of native people living on the Bay of Good Success, Tierra del Fuego, on Jan 15, 1769, where he attempted to relate the apparently harsh environment of the Haush to their resilience in the face of adversity (Thomas, 2018, p. 50), to his emergence 'as an ethnographer of no small talent' (Livingstone, 1992, p. 127). He observed the apparently strange burial customs and tattooing practices across the Pacific and reflected on adolescent female sexuality in Tahiti. Cook's observations on the natives of New Holland after the ship departed from Possession Island that 'ranged over physique, hair, ornament, body paint and piercing, canoes, subsistence and houses' (Thomas, 2018, p. 128) were another case in point. But more revealing was his quite astounding, and very enlightened, philosophical pronouncement about the natives of New Holland that 'live in a Tranquillity which is not disturb'd by the Inequality of Condition: The Earth and sea of their own accord furnishes them with all things necessary for life; they covet not Magnificent Houses, Houshold-stuff &C[a]'. (Cook, & South Seas, 2004. Manuscript 1. p. 299).

The geographical experiment at *Waalumbal Biri*

The 'geographical experiment' (Livingstone, 1992, p. 177), seen through the monumental efforts of Ritter and Humboldt, sought to combine nature and culture under the same umbrella (Bonnet, 2008, p. 87). The relationship between people and environment in the Enlightenment was complex. Firstly, there was a powerful divine or theistic tradition expressed in 'man's' dominion over the fish in the sea and the fowl in the air (Porter, 1999, p. 421) combined with a rationalist assumption emanating from Enlightenment natural philosophy that nature may be mastered, managed, and used by humanity (p. 425). Such notions shed some light on people-environment relations when Cook's voyagers entered *Waalumbal Biri*, Endeavour River, in June 1770, in order to repair their ship. Put bluntly, 'They came to exploit the natural and social environment with no sense of obligation to replenish what they exhausted or to feel the consequences of the changes they caused' (Dening, 1980, p. 23, cited in Nugent, 2005, p. 33). The fishermen and foragers were particularly successful in these terms. 'So much fish was taken, that each man had two pounds and a half; and plenty of greens were gathered, which boiled with the pease, their fare was deemed excellent' (Rhys, 1999/1906, p. 79).

However, the incident that best illustrates the gulf between the duties, rights and entitlements of the strangers and Bama (rainforest Aboriginal people) was the refusal of the ship's officers to share turtles with

Guugu Yimithirr. On July 19, 1770, the Endeavour was visited by ten Bama, armed with spears, who 'were very desirous of having some of our turtle' (Cook & South Seas, 2004, manuscript1, p. 267) which were 'probably as great a dainty to them as to us' (Hawkesworth, 1773, & South Seas, 2004, pp. 580-584). Bama attempted to move two of the turtles to the side of the ship, to the gangway, near to where their canoe was moored, but the sailors reclaimed them. Several more attempts were made until the warriors paddled off in their canoes. Apparently infuriated and perplexed by the incident, one Bama took up a handful of dry grass and lit the bundle from a fire under a kettle of pitch and 'in an Instant the whole place was in flames' (Cook, & South Seas, 2004, manuscript1, p. 267) and the Endeavour's precious fishing net was nearly destroyed. Cook was 'obliged to fire a musquet load[ed] with small shott at one of the ri[n]g leaders which sent them off' (p. 267).

As far as Bama were concerned the turtles belonged to them. According to Molony (2012, p.6), 'They were treasured as an item of food but a large part of the year had to pass before they were caught when they came ashore to lay their eggs'. The Endeavour had arrived during the season of *Guumbamu,* just before the beginning of turtle hunting season, when sea urchins and crabs were fat and ***wukay***, a type of yam, ready to eat (Hornsby, 2012, pp. 8-9).

Apparently, Cook did not understand that, 'these 'Indian' peoples practiced reciprocal food sharing and expected it of others, nor that they might consider turtles to be the produce of their own estate, which could not be stolen by strangers, white or black' (MacCallum, 2012, p.11). The Captain, who was also the ship's purser, assumed the turtles were his to keep or give away. Thomas (2018, p. 122) questioned this perception believing the Cook would have known all too well who owned the trout, hare, pheasant, deer and other game that roamed estates in his native Yorkshire. On the other hand, it would be wrong to project current environmental ideals upon the Endeavour's company. It would be an overreaching act to suggest that Cook, with his rural background, would have realised that Europeans had managed and mastered nature for centuries, 'clearing forests, embanking, ploughing, planting, mining' (Porter, 1999, p. 425)?

The ancients and the moderns

Stoddart (1987, p. 28) eschews more typical histories of geography that proclaim the roles of Eratosthenes, Strabo and Ptolemy, followed by Hakluyt, Purchas, and Varienius. But there are some continuities that are worth examining. The 'ancients' were as concerned with describing the earth at various scales in the form of ***topos*** as the study of place***, choros*** as the study of a region***,*** and ***geos*** as the study of the entire face of the earth (Barnes, 2011, p. 382, Mayhew, 2011, p. 29) as were geographers in the sixteenth, seventeenth and eighteenth centuries. Strabo's endeavour to describe every detail of the Greek world of the 7th century BCE 'based on both his own travels and also on authoritative sources and other travellers' accounts' (Cormack, 1999, p. 131) can be compared with Hakluyt's. Described as an academic, diplomat, spy and churchman (Cormack, 1994, p. 21), in the sixteenth century he lectured on cosmology at Oxford, a term that best encompassed what was later to become geography (Unwin, 1992, p. 62).

There are strong currents involving mathematical and astronomical interests based on measurement of the dimensions of the Earth, its place in the cosmos, and the production of maps, that stream through geography's history. Additionally, there are a number of philosophical concerns centred on an interest in the relations between of humanity with the natural world (Holt-Jensen, 2009, p. 35). Varenius' *Geographia generalis* (1650) explicitly drew from Ptolemy as far as the former is concerned but was also influenced by Reformation theologian, mathematician and astronomer Keckermann's *Systema Geographicum* (1611). Some contemporary geographers regard Varenius' work as marking an intellectual divide that separated ancient and medieval geography from modern geography, in effect a transition from Renaissance to Enlightenment geography (Livingstone, 1992 p. 86, Mayhew, 2011, p. 26, Smith, 1992, p. 263, Unwin, 1992, p. 67). Smith (1992, p. 263) maintains that 'The separation of geography from cosmology and astronomy, philosophy and mathematics was a historical process and Kant like Varenius was regarded as a watershed figure' James Cook would have appreciated a section in *Geographia generalis* that focused on the needs of mariners, on navigation, on latitude and longitude of places in comparison with each other.

Furthermore, geography as navigation, continued to be important. Morrill's (1840) *Geographical manual for teachers* maintained that school geography should be divided into three parts: mathematical, civil or political and physical geography (Morrill, 1840, p. 1). Cook had had obviously developed a deep understanding what came to be understood as mathematical geography. An extended list of instructions had been drawn up by the Admiralty for sailors who were about to embark on long sea voyages. They included:

> To observe the declination of the compass, or its variation from the meridian of the place, frequently

> marking with all the latitude and longitude of the place . . . To make plots and draughts of the prospect of considerable coasts, promontories, islands and ports, marking the bearings and distances as near as they can. . . . To take exact care, to observe the trade winds, about which degree of latitude and longitude they first begin, where and when they cease, or grow stronger or weaker' (National Museum Australia, 2012, transcript, para. 4).

According to Robson (2012, p. 1) 'For James Cook, the production of a new chart was his principal reason for going to sea', and as Haggett (1990, p. 7) argues the map is a diagnostic touchstone used to determine whether a text is truly geographical.

The development of geography as exploration also shifted over time. Some earlier explorers were very honest about their endeavours. 'Bernal Diaz, frankest of conquistadores, wrote that he and his like went to the Indies 'to serve God and his Majesty, to give light to those who were in darkness and to grow rich, as all men do" (Parry, 2010/1963, p. 33) but geography changes course as society changes. The more deliberately scientifically oriented exploration, enhanced by new navigation and cartographic techniques together with substantial capital injection from powerful European maritime powers (Heffernan, 2009, p. 6) assisted in this regard.

Joseph Conrad's 1924 National Geographic essay, 'Geography and some explorers' (Conrad, 1924, 10–17) saw Cook's voyages as typifying *Geography Militant*, seen as a thorough quest for certainty about the geography of the world, a world where there were open spaces to explore and a society that espoused an absolute faith in science (Driver, 1996, 340–1). This commitment underpinned the European Enlightenment, involving the power of human reason to change society (Livingstone & Withers, 1999, p. 3) and to seek a better society (Slater, 1997, p.56). Geography as exploration is exemplified in Forster's account of Cook's second voyage in chapter headings that still resonate with many school geographies today: 1. The earth and its strata, 2. Water and the ocean, 3. The atmosphere, 4. The changes of the globe, 5. Organic bodies, and 6. The human species (Stoddart, 1996, p. 469).

There was also an affective component to geography as exploration, an attachment to the accounts in the form of journals, popular fiction and poetry. Dampier's,1697, *New Voyage round the world* was 'simply but vividly written' (Spate, 1988, p. 25) and 'Dampier provided raw material for eight of Defoe's novels and for Swift's Gulliver's Travels; while Coleridge's Ancient mariner was drawn from a mate of Shelvocke's [a disreputable privateer]' (p. 25). This tradition was enhanced by the presence of professional artists on the Endeavour, commencing a long commitment to the geography of vision (Cosgrove, 2008), offering other ways of seeing, imagining and representing the world. Geography as exploration can be evocative, '. . . you feel the dust in your eyes, the sand between your toes, the salt spray on your face' (Stoddart, 1996, 471). Moreover, geography as exploration still survives in the lavishly illustrated pages of the National Geographic magazine. It still persists in the geographer's partiality for fieldwork

Nonetheless, Conrad's *Geography Militant* also suggests another trope: imperialism, which in its starkest guise has been described as including 'territorial acquisition, economic exploitation, militarism, and the practice of class and race domination (Hudson, 1977, p. 12, cited in Peet, 1998, p. 12). Carter (2010) argues that Cook's practice of naming places on the east coast allowed colonisation and dispossession to be set in train, making the landscape familiar to future colonisers and alien to native inhabitants (Gregory, 1994, pp. 171–2). Smith (1985, p.2) contends that ships like the Endeavor combined the values of a fortress and a travelling laboratory, bringing together more precisely one implication of Conrad's title, *Geography Militant*. Enlightenment philosophy has been seen by some as a seedbed for modern racism (Appiah, 2019, p. 6, Kobayashi, 2003, p. 544–6), and Anderson observed that Enlightenment ideas posed a conundrum for Banks who mused over the apparent contradiction, of human presence and uncultivated land on the east coast, arguing, 'that because there was no cultivation along that coast, either the inland of the continent must be unpeopled or the coastal Aborigines must be akin to monkeys' (Anderson, 2005, p. 9).

Geographers divided

There is a plethora of geographers from a variety of inclinations and professional interests that indicate that revitalised modern geography may indeed be coincident with Cook's voyages into the Pacific. Stoddart's arguments come from a geographer steeped in natural history. Similarly, Bowen, (1981), who surveyed geographical scholarship from Bacon to Humboldt, shared his ecological visions of geography, to laud Humboldt's vision of early nineteenth century science (Livingstone, 1992, p. 7). Those with an inclination towards regional geography such as Hartshorne (1961/1939, pp. 48–54) or Dickinson (1969, pp. 22, 277–8, cited in Livingstone, 1992, p. 6) emphasise the contributions of Humboldt and Ritter towards the

regional concept. Buttimer, coming from a humanistic tradition, sees Humboldt's *Cosmos* imbued with the humanist spirit, (1993, p. 59) but Schaefer (1953, p. 228), a champion of the quantitative tradition, maintained that Humboldt and Ritter recognised that their major concern was the manner in which natural phenomena, including people, were distributed in space. Crang (1998, p. 18), a cultural geographer, would see Humboldt's ideas expressed in the notion that geography is the art of seeing how land and life differs across space, and Cresswell (2013, pp. 40–1), another geographer from the cultural tradition, sees Ritter as more interested in the human world than Humboldt, with a focus on comprehending the interconnections between people and nature.

Other geographers seek recourse to geography in Ancient Greece or pre-Enlightenment times, in their search for the birth of modern geography whether they are writing from the tradition of historical geography (Mayhew, 2011, pp. 21–38) or spatial analysis (Barnes, 2011, pp. 381–4). Some are more cautious about the timing of the emergence of modern geography thought, seeing it as emerging- certainly not fully formed – in the Enlightenment. (Godlewska, 1999, p. 2).

Some see Enlightenment geographies as an impediment to the development of contemporary critical geographies. Harvey, regards Kant's adherence to absolute space, rather than see space as simultaneously absolute, relative and relational (2007, p. 45), as a constraint on the development human geography. Geography was unable to address grander, more difficult questions when it was later caught in the 'dead science of spatial ordering' (p. 46).

Whose geographies?

This account has referred to those who profess to be geographers, for all, or parts of their lives. There are others referred to who write about geography and there are those scholars who are co-opted into the geographic enterprise (Unwin, 1992, pp 45–6). Contemporary geographers tend focus on discourses of geography rather than the discipline of geography. They tend to repudiate geographies seen through the lives and works of a series of eminent gentlemen, or through plotting the progress of geography from 'an unenlightened past to a glorious present' (Livingstone, 1992, p. 5).

Stoddart sought to present a contextual history of geography that focused on objective science. He concentrated on a small corpus of 'great men' and his enthusiastic account is permeated with the spirit of adventure. Another reading would examine the development of modern geography from within a 'map' of the intellectual landscape (Gregory, 1994, p. 5), a chart of its emergence together with other disciplines in the life, earth and human sciences. Stoddart goes further to argue the modern geography diverged from other disciplines, that scientific methods of observation, classification and comparison to peoples and societies made geography distinctive from other branches of knowledge but in reality, geography gained from its engagement with anthropology, cartography, geology, botany and zoology. An affective component was prominent in the emergence modern geography, one made more eloquent in Humboldt's writings, 'where fresh data from geographical explorations were exciting popular imaginations' (Buttimer, 2001, p. 106) and from Ritter where the gift of reason meant that, for the Earth's inhabitants it 'is not merely the place where they may stand, the cradle where they may sleep, the home where they may live, it is the school where they may be trained' (Ritter, 1865, p xvi).

The Age of Reconnaissance (Driver, 1992, Parry, 2010/1963), that preceded the Age of Reason, was undergirded by mercantilist or militaristic rather than scientific ideologies (Edney, 1999, p. 168) but insidious geographies of race and imperialism also emerged during the Enlightenment. Whether continuity played a bigger role, than pivotal change over the comparatively short period of time at the end of the eighteenth century and beginning of the nineteenth century, on the development of modern geography is debatable. Using the geographic concept, scale, to hone in on the passage of the Endeavour along the coastline of New Holland in 1770, and, to examine the kinds of scientific geography that it engendered may focus too much on the particular rather than those ideas that emanate from the longer historical view?

References

Appiah, K.A. (2019). Dialectic of Enlightenment. *The New York Review of Books*, May, (pp. 1–6). Retrieved from https://www.nybooks.com/articles/2019/05/09/irrationality-dialectics-enlightenment/

Anderson, K. (2005). 'Griffith Taylor Lecture, Geographical Society of New South Wales, 2004: Australia and the 'State of Nature/Native. *Australian Geographer*, 36(3), 267–282.

Barnes, T.J. (2011). Spatial analysis. In J. Agnew & D. Livingstone (Eds.), *The SAGE handbook of geographical knowledge*. pp. 381–392. London: SAGE.

Benson, D., & Eldershaw, G. (2007). Backdrop to encounter: the 1770 landscape of Botany Bay, the plants collected by Banks and Solander and rehabilitation of natural vegetation at Kurnell. *Cunninghamia*, 10 (1), 113–137.

Benson, D. H. & Howell, J. & Royal Botanic Gardens (Sydney, N.S.W.) (1990). *Taken for granted: The bushland of Sydney*

and its suburbs. Sydney, Kenthurst, N.S.W.: Kangaroo Press in association with the Royal Botanic Gardens Sydney.

Bonnett, A. (2008). *What is geography?* London: SAGE.

Bowen, M. (1981). *Empiricism and geographical thought: From Francis Bacon to Alexander von Humboldt.* Cambridge: Cambridge University Press.

Buttimer, A. (2001). Beyond Humboldtian science and Goethe's way of science: Challenges of Alexander von Humboldt's geography. *Erdkunde*, 55, 105–120.

Buttimer, A. (1993). *Geography and the human spirit.* Baltimore: The John Hopkins University Press.

Carter, P. (1987). *The road to Botany Bay: An essay in spatial history.* London: Faber.

Carter, P. (2010). *The road to Botany Bay: An exploration of landscape and history* (2nd ed.). [Kindle]. Retrieved from amazon.com.au.

Cook, J. & New South Wales. Government Printing Office. (1893). *A sketch of Botany Bay in New South Wales latitude 34°00′S.* Retrieved from http://nla.gov.au/nla.obj-231834491.

Cook, J. (1955). *The Journals of Captain James Cook on his voyages of discovery.* In J.C. Beaglehole, A.R. Skelton, & the Hakluyt Society (Eds.), Cambridge: Published for the Hakluyt Society at the Cambridge University Press.

Cook & South Seas, 2004, manuscript1, p. 267. Retrieved from http://nla.gov.au/nla.cs-ss-jrnl-cook-17700719

Cook n.d. & South Seas, 2004, Manuscript 1, p. 299. Retrieved from http://nla.gov.au/nla.cs-ss-jrnl-cook_remarks-092

Cook n.d. & South Seas, 2004, Manuscript 1, p. 230. Retrieved from http://nla.gov.au/nla.cs-ss-jrnl-cook-17700503.

Conrad, J. (1924). Geography and some explorers. *National Geographic*, March. Published in R. Curle (Ed.), (1926). *Last essays*, (pp. 10–17). London: J.M. Dent.

Cormack, L.B. (1999). *Charting an empire: Geography at the English universities 1580–1620.* London: University of Chicago Press.

Cormack, L.B. (1994). The fashioning of an empire: Geography and the state of Elizabethan England. In A. Godlewska, & N. Smith, (Eds.), *Geography and empire*, (pp. 15–30). Oxford: Blackwell.

Cosgrove, D. (2008). *Geography & Vision: Seeing, Imagining and Representing the World.* London: I.B. Tauris.

Crang, M. (1998). *Cultural geography.* London: Routledge.

Cresswell, T. (2013). *Geographic thought: A critical introduction.* Chichester: Wiley-Blackwell.

Dening, G. (1980). *Islands and Beaches: Discourse on a Silent Land, Marquesas, 1774–1880*, Melbourne: Melbourne University Press.

Dickinson, R. E. (1969). *The makers of modern geography.* London: Routledge and Kegan Paul.

Driver, F. (1996). Geography's empire: Histories of geographical knowledge. In S. Daniels & R. Lee (Eds.), *Exploring human geography*, (pp. 340–358). London: Arnold.

Edney, M.H. (1999). Reconsidering Enlightenment geography and map-making: Reconnaissance, mapping, archive. In D. Livingstone, & C. Withers (Eds.), *Geography and the Enlightenment*, (pp. 165–198). Chicago: The University of Chicago Press.

Elden, S. (2011). Reintroducing Kant's geography. In Elden, & E. Mendieta (Eds.), *Reading Kant's geography*, pp. 1–15. Albany, NY: State University of New York Press. Retrieved from https://www.sunypress.edu/pdf/62189.pdf .

Flynn, T. (2007). Foucault among the geographers. In S. Elden, & E. Mendieta (Eds.), *Foucault and geography*, (pp. 59–66). Albany: State University of New York Press.

Gade, D.W. (2011). *Curiosity, inquiry, and the geographical imagination.* New York: Peter Lang.

Gascoigne, J. (2007). The German Enlightenment and the Pacific. In L. Wolff, & M. Cipolloni (Eds.), *The Anthropology of the Enlightenment*, (pp. 141–171). Stanford: Stanford University Press.

Godlewska, A. (1999). *Geography Unbound: French Geographic Science from Cassini to Humboldt.* Chicago: University of Chicago Press.

Gregory, D. (1994). *Geographical imaginations.* Oxford: Blackwell.

Gregory, D. (1978). *Ideology, science and human geography.* London: Hutchinson & Co.

Haggett, P. (1990). *The geographer's art.* Oxford: Basil Blackwell.

Hartshorne, R. (1961/1939). *The nature of geography: A critical survey of current thought in the light of the past.* (7th imprint). Lancaster: The Science Press Printing Company and The Association of American Geographers.

Harvey, D. (2007). The Kantian roots of Foucault's dilemmas. In J. Crampton, & S. Elden (Eds.), *Space, knowledge and power: Foucault and geography.* Aldershot: Ashgate.

Hawkesworth, J. (1773) & South Seas (2004). *An account of the voyages undertaken by the order of his present majesty for making discoveries of the southern hemisphere.* London: Strahan & Cadell. National Library of Australia, 2004, (II-III), 580-84. Retrieved from http://nla.gov.au/nla.cs-ss-jrnl-hv23-580

Heffernan, M. (2009). Histories of geography. In N. Clifford, S. Holloway, S. Rice & G. Valentine (Eds.), *Key concepts in geography*, (2nd ed.), (pp. 3–20). London: SAGE.

Holt-Jensen, A. (2009). *Geography history and concepts: A student's guide.* (4th ed.) London: SAGE.

Holt-Jensen, A. (2008). The art of the mappable. *Norsk Geografisk Tidsskrift-Norwegian Journal of Geography* 45, 173–181.

Hornsby, A. (2012). *Dispelling the Myths, Oral history through the Guugu Yimithir people of contact with Cook and his crew.* Cook's treasures seminar, National Library of Australia. Retrieved from https://www.nla.gov.au/events/cooks-treasures/papers/Alberta-Hornsby-national-library.pdf

Hubbard, P., Kitchin, R., Bartley, B, & Fuller, D. (2002). *Thinking geographically: Space, theory and contemporary human geography.* London: Continuum.

Hudson, B. (1977). The new geography and the new imperialism 1870–1918. *Antipode*, 9, 12–19.

Johnston, R.J., & Sidaway, J.D. (2004). *Geography & geographers: Anglo-American human geography since 1945.* (6th ed.). London: Arnold.

Kobayashi, A. (2003). The construction of geographical knowledge – racialisation, spatialization. In K. Anderson, M. Domosh, S. Pile & N. Thrift (Eds.), *Handbook of cultural geography,* (pp. 544-56). London: SAGE.

Livingstone, D. (2003). *Putting Science in Its Place: Geographies of Scientific Knowledge.* Chicago: The University of Chicago Press.

Livingstone, D. (1992). *The geographical tradition: episodes in the history of a contested enterprise.* Oxford: Blackwell.

Livingstone, D., & Withers, C. (Eds.), (1999). *Geography and the Enlightenment.* Chicago: The University of Chicago Press.

McCalman, I. (2012). *Turtle power: Captain Cook's environmental crisis on the Great Barrier Reef.* Cook's treasures seminar, National Library of Australia. Retrieved from https://www.nla.gov.au/events/cooks-treasures/papers/Iain-McCalman-Turtlepower-NLACook.pdf

Mayhew, R.J. (2011). Geography's genealogies. In J. Agnew, & D. Livingstone (Eds.), *The SAGE handbook of geographical knowledge*, (pp. 22–38). London: SAGE.

Mayhew, R. J. (2000). *Enlightenment geography: The political languages of British geography, 1650-1850.* Basingstoke: Macmillan.

Molony, J. (2010). *James Cook and the Endeavour at Botany Bay and Cooktown.* Cook's treasures seminar, National Library of Australia. Retrieved from https://www.nla.gov.au/events/cooks-treasures/papers/John-Molony-Cook-Botany-Bay-Cooktown.pdf .

Morrill, C. (1840). *Geographical manual for teachers, on the classification system, also to be used as a reference.* Concord: Morrill, Silsby & Co.

National Museum of Australia (2012). *Letter readings from the voyages of discovery.* (Audio transcript). Retrieved from https://www.nma.gov.au/audio/audio/uncategorised/letter-readings-from-the-voyages-of-discovery/transcripts/letter-readings-from-the-voyages

Nugent, M. (2005). *A contextual history Botany Bay National Park (Kurnell Section),* Sydney: Department of Environment and Conservation (NSW).

Parry, J.H. (2010/1963). *The age of Reconnaissance: discovery, exploration and settlement, 1450–1650.* London: Orion Books.

Peet, R. (1998). *Modern geographical thought.* Oxford: Blackwell Publishing.

Porter, R. (1999). Afterword. In D. Livingstone, & C. Withers, (Eds.), (pp. 415-431). *Geography and the Enlightenment.* Chicago: The University of Chicago Press.

Rhys, E. (Ed.). (1999/1906). *The voyages of Captain Cook.* Ware: Wordsworth Editions Limited.

Ritter, C. (1865). *Comparative geography.* (Translated for the use of schools and colleges, by W.L. Gage). Philadelphia: J.P. Lippincott & Co.

Robson, J. (2012). *Cook the map maker.* Cook's treasures seminar, National Library. Retrieved from https://www.nla.gov.au/events/cooks-treasures/papers/John-Robson-canberra-paper.pdf

Schaefer, F.K. (1953) Exceptionalism in Geography: A Methodological Examination, *Annals of the Association of American Geographers,* 43(3), 226–249.

Seddon, G. (1998). On the road to Botany Bay. In G. Seddon, *Landprints: reflections on place and landscape,* (pp. 35–48). Melbourne: Cambridge University Press.

Slater, D. (1997). On borders of social theory: learning from other regions. In T. Barnes & D. Gregory (Eds.), *Reading human geography: The poetics and politics of inquiry,* (pp 48–69). London: Arnold.

Smith, B. (1985). *European vision and the South Pacific* (2nd ed.) New Haven: Yale University Press.

Smith, N. (1992). History and philosophy of geography: Real wars, theory wars. *Progress in Human Geography.* 16(2), 257–71.

Spate, O. (1988). The literature of Cook's voyages. *The Latrobe Journal.* 41, 25–29.

Stoddart, D. (1996). To claim the high ground: Geography for the end of the century. In S. Daniels & R. Lee (Eds.), *Exploring human geography: A reader,* (pp. 466–479). London: Arnold.

Stoddart, D. R. (1987). *On geography: and its history.* Oxford: Blackwell,

Thomas, N. (2018). *Discoveries: the voyages of Captain Cook.* (2nd ed.). [Kindle]. Retrieved from amazon.com.au.

Unwin, T. (1992). *The place of geography.* Harlow: Longman Scientific & Technical.

Waitt, G., McGuirk, P., Dunn, K., Hartig, K. & Burnley, I. (2000). *Introducing human geography: globalisation, difference and inequality.* Frenchs Forest: Pearson Education Australia.

Wilson, H. (2006). *Kant's pragmatic anthropology: Its origin, meaning and critical significance.* Albany: State University of New York Press.

Withers, C. (2007). *Placing the Enlightenment: Thinking geographically about the Age of Reason.* Chicago: The University of Chicago Press.

Wolff, L. (2007). Discovering cultural perspective: The intellectual history of anthropological thought in the age of Enlightenment. In L. Wolff, & M. Cipolloni, (eds.) *The Anthropology of the Enlightenment,* (pp. 3–32). Stanford: Stanford University Press.

Wolff, L. & Cipolloni, M. (Eds.) (2007). *The Anthropology of the Enlightenment.* Stanford: Stanford University Press.

Wulf, A. (2015). *The invention of nature: The adventures of Alexander von Humboldt: The last hero of science.* London: John Murray.

Geography Effect: Two decades of change

Martin Pluss
GTA NSW & ACT Councillor

Introduction

The number of students studying HSC Geography has declined over the past two decades, and although there has been a levelling off in numbers, they are nothing like the glory days. What has happened? Are we seeing the end of Geography as we know it?

When I confront an issue like this my starting point is one of self-reflection. What could I have done?

One of my regrets in my involvement in professional Geography between 1995 and 2001, when the review for the HSC was undertaken, was my lack of awareness of the consequences of decisions made at the time.

I had been teaching for 9 years when the Professor Barry McGraw HSC review started, was in my second school, had only been back in Sydney since 1991 and had just joined the GTA NSW and Geographical Society of NSW Councils.

I was sufficiently professionally connected through the writing of articles for Geography teachers since the mid 1980s to get an invitation to be part of the team to set up the HSC Online. This involved a trip to Charles Sturt University Bathurst campus where we set up and populated the online resource for the New HSC in Geography.

In the GTA NSW we were working hard and strategically to represent Geography. I was too in-experienced to be effectively involved and nor could I get the time off school to attend the key meetings, where the decisions were being discussed.

Hindsight makes you wiser than you are at the time decisions are made. However, 25 years of experience and observation of NESA data has made it possible for me to reflect and see what has happened since then.

This is what I am going to try and do in this paper. Maybe it is to atone for my failure to successfully represent Geography.

I have lots of unanswered questions which you may be able help myself and each other with suggested answers. Is there an ongoing decline of students studying Geography, or have we reached an equilibrium in the numbers studying Geography? What role has the absence of the School Certificate had on Geography numbers and development of skills and knowledge of geography? Is there a mismatch between HSC and University geography or can they help each other? Is there an overemphasis in skills, GIS, perhaps even fieldwork and the SGP in Preliminary Geography? What impact does this have on retention of students into the HSC year?

In addition, to these issues within Geography, what is the impact of overcrowded curriculum, changes in all syllabuses, teachers not trained in geography and high-level political decisions, for example, to drop three unit study, or the removal of the School Certificate? Of course, most recently, there are the findings of the Curriculum Review to consider.

Does Geography have a crisis of identity and suffer from the ills of conflicting agendas and multiple stakeholders? Is there dilution of its core through engaging with new trends such as the agenda of activists, alignment to certain political ideologies and the adoption of new initiatives?

It appears here that I have made a series of blanket generalisations through these questions, which would be a fair reflection. My plan is to take a deep dive into most of these issues and seek input from membership in the coming writings and podcasts.

This article is only the starting point. It will look into the evidence of the changing participation in Geography over the past 25 years through an investigation of publicly available data on the NESA website.

The data

Now let's look at the NESA data.

Let's see if these generalisations about the decline of Geography are indicated in the data. NESA, and the Board of Studies at the time, has provided data for the number of students enrolled in subjects since 1995. The year 1995 was the year that Professor Barry McGraw initiated the HSC review which was implemented in 2001.

In this period, we transitioned from the School Certificate, implemented the new syllabus for Stages 4 and 5 Geography and Three Unit Geography was removed as a course of study with the implementation of the New HSC in 2001.

Firstly, we have the course enrolment data figures for students studying Geography in the HSC (Figures 1 and 2) and the Preliminary years (Figure 3).

Figure 1
1995-2000 2 Unit HSC Geography

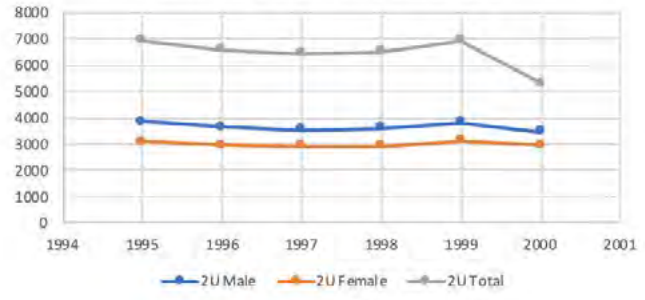


Figure 2
HSC Geography 2001 - 2019

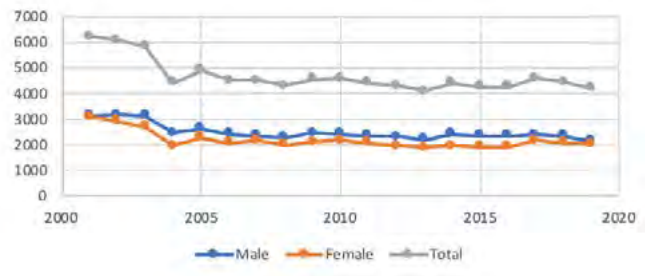


Figure 3
Preliminary Geography 2006-2019

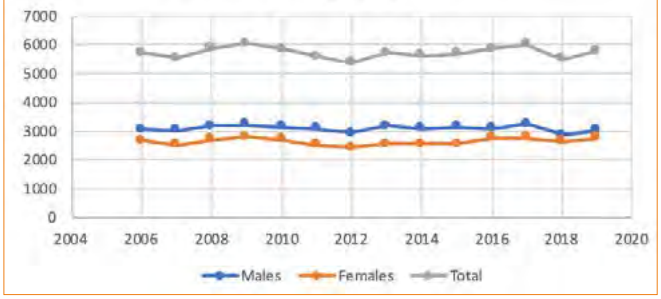
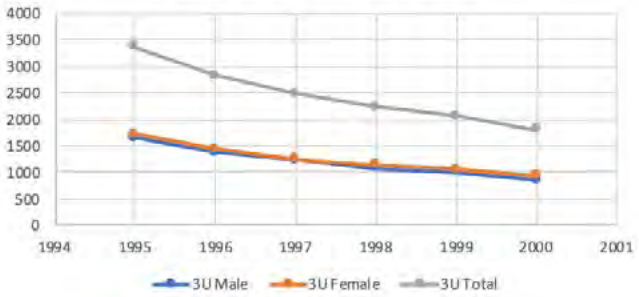


Figure 4
Geography 3 Unit 1995-2000



Prior to the New HSC in 2001, (1995 to 2000) Geography was studied by students with the option of two units and three units of courses (Figure 4).

The number of students that studied Two Unit Geography range from 5287 in 2000 up to 6932 in 1995. In addition, the number of Three Unit students ranged from 1803 through to 3366 once again between 2000 and 1995 respectively.

It needs to be noted that the students studying Three Unit are included in the Two Unit enrolment numbers. When Two Unit and Three Unit students are combined the total number of students studying Geography was 10,298 in 1995 compared to 7090 in 2000, before the start of the New HSC. One comment can be made is that the decline in students studying in geography was trending down from 1995 six years prior to the new HSC.

Now let's see what the impact of New HSC implementation, if any, on the number of student's studying Geography.

In 2000, the total number of students studying geography (2 Unit) was 5287 and in 2001 increased to 6223. However, the number of total students studying geography was reduced substantially with the removal of Three Unit Geography.

In 2002, there were 6090 students studying Geography and in 2003 there were 5835 students. After this the number of students studying Geography stayed in the 4000 bracket all the way through to 2019. In 2005 there

was a slight peak at 4913 and the lowest point was in 2019 with 4189. What does this suggest?

For the Geography Life Skills course (Figure 5) the NESA HSC data exists for 2013 to 2019. The total number of students studying the course range from 77 up 240 students each year.

The NESA website also has the figures for students studying Geography in the Preliminary course. The students studying Preliminary Life Skills between 2012 and 2019 had enrolments with troughs and peaks of 102 students in 2013 up to 169 students in 2016. The numbers also drop off into the HSC year.

A comparison of the numbers of students studying Geography in Year 11 Preliminary course and Year 12 the HSC course makes for an interesting comparison (Figure 6).

Figure 5
Geography Life Skills 2013-2019

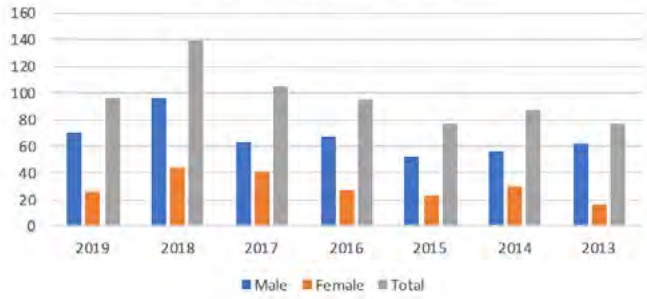
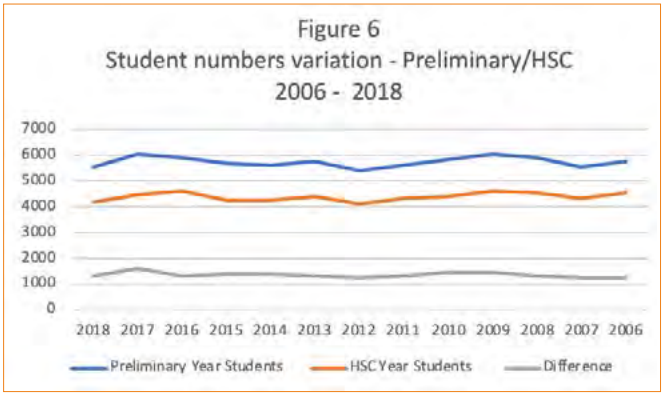


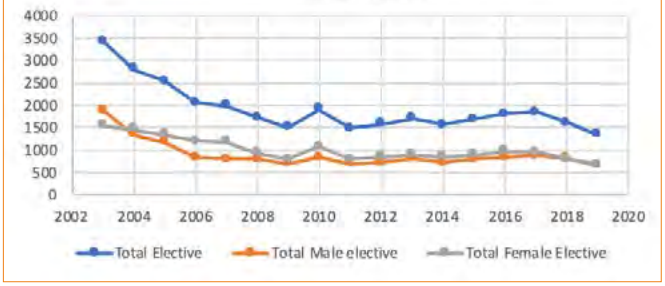
Figure 6
Student numbers variation - Preliminary/HSC
2006 - 2018



In short, we are able to see how many students dropped Geography after the Preliminary year by looking at the NESA data. For example, the 2018 student numbers can be compared to the Preliminary course data for the 2017 students. This can be applied to NESA data available between 2006 and 2018 – it's just a matter of aligning the spreadsheets.

In summary, in each year of a transition between Year 11–12, there is drop in the number of students studying Geography between 20–25%. The smallest decline being 21.1% 2006 (1211 students) and largest 26.28% 2017 (1580 students).

Figure 7
Stage 5/School Certificate Elective Geography
2003- 2019



The NESA data also provides a breakdown of the number of students studying elective geography in the School Certificate era and the Stage Five era of the Geography (Figure 7).

It is a little bit tricky to compare the elective data prior to 2001 because there is a substantial decline in the number of students studying elective geography.

Why? It seems the elective students are separated from the total number of students studying Geography after 2001 but not before 2001. For example, there was 15,770 students studying geography in 2001 and then the elective units had 2814 students in 2002, so there must be a variation in the collection of data.

However, the data does show that in 2002 there were 2814 students studying both 100 and 200 hours of Elective Geography and this number stayed around this level through to 2007. After this it varied between 900 and 800 students studying Geography through to 2017. The numbers declined again to 788 students in 2018 and dropped further to 676 students in 2019.

The data also provides information into the gender of students who study geography (Figures 1–3). In the HSC and the Preliminary course for every year between 2001 in 2019 there are more males studying geography than females. For the period 1995 to 2000, the pre-New HSC geography era of courses for Two Unit, also had more males than females studying geography.

In relation to Three Unit Geography between 1995 and 2000 the number of female students were greater male students studying the extension Three Unit course.

In relation to the Life Skills courses for both the Preliminary and the HSC year there were more male students studying Life Skills for the period where data is available between 2012 2019.

Where does Geography fit in to all the subjects taught in the HSC year?

The number of students studying the HSC has grown by about 14,000 students from 1995 to 2019, that is, from

61,551 to 75,006 in 2019 (Figure 8). However, the highest number of students studying the HSC was 77,433 in 2015. Geography made up 6% of this total 2010–2019, 7% 2004–2007, 9% 2002–2003 and 10% in 2001.

Figure 8 HSC and Geography Candiditure Comparison

Year	HSC Students	Geography Students	Percentage
2019	75006	4189	6
2018	76732	4432	6
2017	77150	4589	6
2016	77163	4283	6
2015	77433	4276	6
2014	76669	4418	6
2013	74168	4109	6
2012	73397	4297	6
2011	72391	4409	6
2010	71310	4600	6
2009	69261	4556	7
2008	67931	4299	6
2007	67189	4528	7
2006	66185	4504	7
2005	65888	4913	7
2004	66279	4408	7
2003	65311	5835	9
2002	64805	6090	9
2001	62751	6213	10
2000	62883	7090	11
1999	66768	8999	13
1998	65667	8737	13
1997	63038	8901	14
1996	63000	9409	15
1995	61551	10298	17

In the Pre-New HSC era (1995 to 2001) the percentage of students studying Geography compared to the total number of students doing the HSC steadily declined 17% 1995, 15% 1996, 14% 1997, 13% 1998, 13% 1999 and to 11% in 2000.

This percentage drop in the study of Geography is also reflected in comparing the top 30 subjects in 2019 to the top 30 subjects in 2000, the year before New HSC (Figures 9 and 10). In 2000 Geography was ranked 16th and, in comparison to other related HSIE subjects, was ahead of all but one subject with Ancient History at 28th, Economics 21st, Legal Studies 17th, Modern History 18th and Business Studies 5th.

In 2019 Geography was ranked 26th and substantially dropped below similar HSIE subjects such as Economics 22nd, Ancient History 17th, Legal Studies 9th, Modern History 8th and Business Study holding solid at 5th place.

In short, Geography was on the last run of the ladder in relation to HSIE subjects in 2019 compared to second on the same ladder in 2000.

Figure 9 2000 HSC Subject Enrolment Ranks

Rank	Subject	Male	Female	Total
1	English (General)	12866	16635	29501
2	Mathematics in Society	12058	15435	27493
3	Mathematics	11459	11026	22485
4	Contemporary English	11939	9418	21357
5	Business Studies	8667	7777	16444
6	Biology	5075	9731	14806
7	General Studies	5445	6128	11573
8	Chemistry	5273	4877	10150
9	Visual Arts	3132	6765	9897
10	Mathematics	5446	4030	9476
11	PDHPE	4192	5185	9377
12	Physics	6480	2588	9068
13	Computing Studies	6196	2670	8866
14	Studies of Religion	3915	4711	8626
15	English	2729	5567	8296
16	**Geography**	**4291**	**3849**	**8140**
17	Legal Studies	2922	5163	8085
18	Modern History	2952	4207	7159
19	Computing Studies (General)	3171	3268	6439
20	Mathematics in Practice	2465	3586	6051
21	Economics	3541	2290	5831
22	Design and Technology	2687	1739	4426
23	Ancient History	1557	2706	4263
24	Drama	1042	3064	4106
25	Life Management Studies	571	3424	3995
26	Music Course 1	1775	1800	3575
27	Visual Arts	918	2573	3491
28	Ancient History	1259	1953	3212
29	Food Technology	595	2581	3176
30	Business Studies 3U	1617	1468	3085

Figure 10 2019 HSC Subject Enrolment Ranks

Rank	Subject	Male	Female	Total
1	English Standard	14861	15372	30233
2	Mathematics Standard 2	14219	15440	29659
3	English Advanced	10472	14779	25251
4	Biology	6799	11869	18668
5	Business Studies	9481	8105	17586
6	Mathematics	9030	8281	17311
7	PDHPE	6868	8678	15546
8	Modern History	5471	5858	11329
9	Legal Studies	3827	6689	10516
10	Chemistry	5436	4842	10278
11	Mathematics E1	5123	3707	8830
12	Visual Arts	2279	6247	8526
13	Studies of Religion I	3832	4643	8475
14	CAFS	786	7622	8408
15	Physics	6500	1906	8406
16	English Studies	4963	3390	8353
17	Ancient History	3008	4225	7233
18	Hospitality	2048	4505	6553
19	Studies of Religion II	2163	3883	6046
20	Industrial Technology	4812	891	5703
21	Catholic Studies	3132	2024	5156
22	Economics	3372	1728	5100
23	Mathematics Standard 1	2967	2129	5096
24	Society and Culture	869	3901	4770
25	Music 1	2348	2329	4677
26	**Geography**	**2155**	**2034**	**4189**
27	SLRS	2951	1154	4105
28	Drama	1428	2652	4080
29	English E 1	1036	2454	3490
30	Design and Technology	1841	1380	3221

Using the data

So, what can we do with all this data?

Firstly, it starts with personal reflection. For me personally, I reflect on my failure to do more to help Geography when I instinctively saw the signals, while I was professionally in position to do more with the changing of syllabuses, School Certificate and the New HSC. There was always going to be an impact on the number of students studying Geography.

The government of the day had declared interest in History rather than Geography as an extension subject in the New HSC. The adoption of new courses introduced increased choice for students and in the case of Geography moving some of those students across to other subjects.

In my involvement with the GTA NSW in this period we were aware of these implications, and efforts were made to address our concerns, but on reflection we could have done more but I don't know what.

Secondly, in hindsight there are little trends there which we should've picked up earlier, but I guess it's difficult to do unless you have 20 years of data which we have now to interrogate.

We need to further investigate the pinch points where there were meso and micro declines in the number students studying Geography. We could look into the lead in role of elective geography for Stage 6 geography. Should we investigate why female students are consistently under-represented in the study of geography compared to male students, especially since the removal of Three Unit Geography.

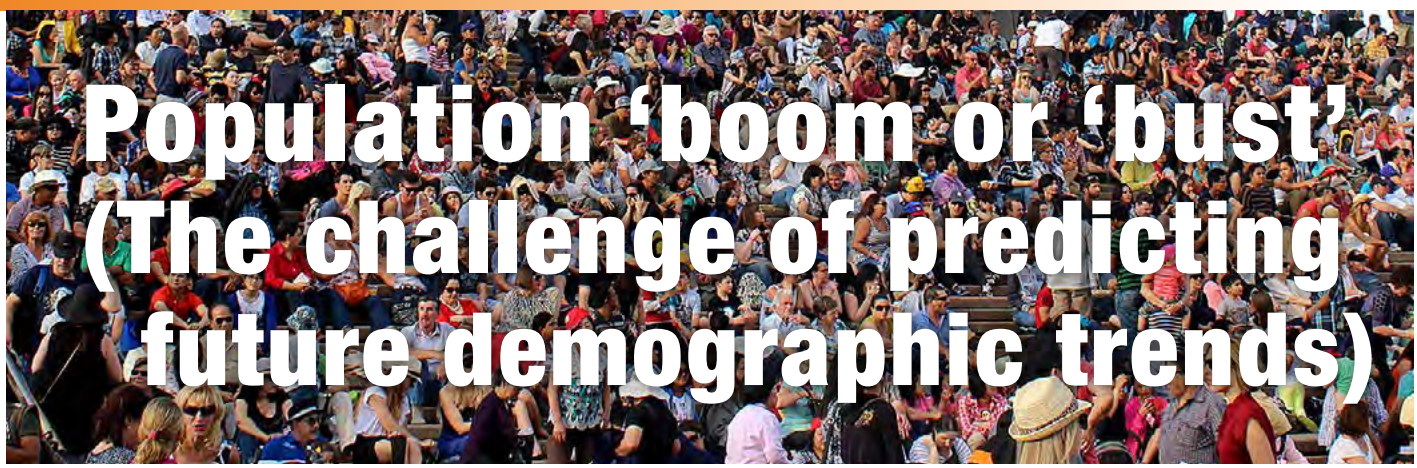
Of significance I feel we need to see what we can do with the substantial reduction in the number of students studying Geography between the Preliminary in the HSC years. By substantial I mean, since 2006, the decline is between 20% and 25% each year. We need to strategically build an approach to improve the retention of students between Years 11 and 12.

Thirdly, I hope this data can be used by you in discussion with your teaching staff and middle leadership to develop a strategy to hopefully arrest the decline of Geography. Or, if this is the new norm, how do we move forward?

I have a spreadsheet of all this data, should you wish to have the spreadsheet. So please let me know if you would like a copy and I will forward it to you. You can contact me via martinpluss@gmail.com or twitter.com/plu.

GTA NSW & ACT resource sharing platforms

- **GTA NSW & ACT Website – www.gtansw.org.au**
- **GTA NSW & ACT Scoop.it – https://www.scoop.it/topic/year-9-geographies-of-interconnections**
- **GTA NSW & ACT Facebook page – https://www.facebook.com/GTA.NSW/**
- **GTA NSW & ACT Twitter – @ GTANSWACT**



Population 'boom' or 'bust' (The challenge of predicting future demographic trends)

Grant Kleeman

In July 2020, Peter Hartcher, The Sydney Morning Herald's Political and International Editor, wrote an article analysing the disparity in the population projections made by the world's three leading sources of demographic data. In this article, we take a closer look at these population projections and the assumptions that underpin them.

In 2011, the world's population reached 7 billion. Today it stands at an estimated 7.8 billion. That's quite a fast rate of growth! But what of the future? While we often rely on the UN's Population Division as the principal source of global demographic data, it's important to remember that it's not the only authoritative source such data. The other globally recognised population forecasting institutions are Austria's Wittgenstein Centre for Demography and Global Human Capital and the University of Washington's Institute for Health Metrics and Evaluation.

All three institutions reject the notion that the world's population will just continue to grow indefinitely, and they all project a peak later this century and then a steady decline this is where the agreement ends. Estimates of when the peak will be achieved and projections about the rate of decline vary considerably.

The UN's projections

The UN states that the world's population will continue to grow, albeit at a slower pace than at any time since 1950, from an estimated 7.7 billion people in 2019 to around 8.5 billion in 2030, 9.7 billion in 2050, and 10.9 billion in 2100. This is the UN's 'medium-variant' projection which assumes a decline of fertility for countries where large families are still the norm, a slight increase of fertility in countries where women have fewer than two live births on average over their lifetime, and continued reductions in mortality.

Much of the projected increase will be driven by current age structures and would occur even if fertility rates were to fall to around two births per woman in those countries still experiencing high fertility rates. This is because of the large population of children and young people who will reach reproductive age over the next few decades and begin to have children of their own.

Continued rapid population growth presents challenges for sustainable development. The 47 least developed countries are among the world's fastest-growing – many are projected to double in population between 2019 and 2050 – putting pressure on already strained resources. Angola, Benin, and Niger are, for example, expected to see their population increase by 150 per cent or more in the period 2020–2050.

At the other end of the population growth continuum are those countries projected to experience declining populations. The UN concludes that 91 countries and territories have total fertility rates below the replacement level (2.1). These include Brazil, China and the USA. Thirty-eight countries and territories are projected to have a smaller population in 2050 than in 2020.

Despite such projections, the UN concedes that there is inherent uncertainty in population projections. At the global level that uncertainty depends on the range of plausible future trends in fertility, mortality and international migration, which have been assessed for each country or area using demographic and statistical methods. Given these parameters, the UN claims, with 95 per cent certainty that the earth's population will reach between 9.4 and 12.7 billion in 2100.

Figure 1: UN World population, actual and projected 2020–2100

Region	2020	2050	2100
World	7.79 billion	9.74 billion	10.88 billion
Asia	4.63 billion	5.29 billion	4.72 billion
Africa	1.34 billion	2.49 billion	4.28 billion
Europe	748 million	711 million	630 million
Latin America & Caribbean	651 million	762 million	680 million
North America	369 million	425 million	491 million
Oceania	43 million	57 million	75 million

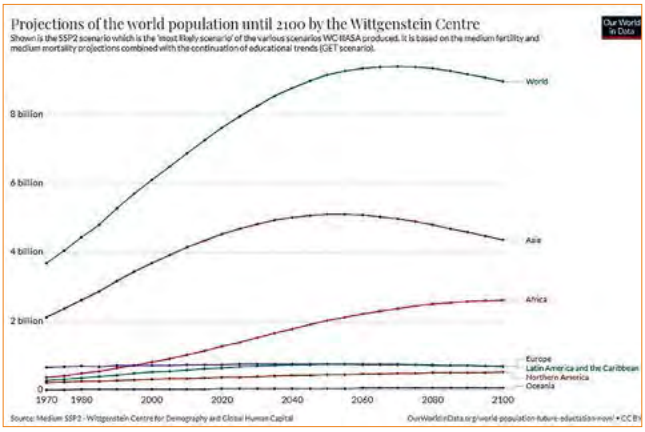
Austria's Wittgenstein Centre for Demography and Global Human Capital projections

The second of the three institutions, Austria's Wittgenstein Centre for Demography and Global Human Capital, rejects the UN's claim that the world's population will exceed 10 billion in 2100. Wittgenstein's demographers estimate that the population will peak at 9.4 billion around 2070 and then begin to decline. By the end of the century, there will be fewer than 9 billion people on Earth, 1.9 billion fewer than the UN estimates. The Wittgenstein 'most likely scenario' estimates are based on medium fertility and medium mortality projections combined with a continuation of educational trends.

The trend by region provides several interesting insights. According to the Wittgenstein Centre, Asia's population is projected to peak around 2050 at 5.11 billion before declining to 4.36 by the end of the century. Europe's population will peak in 2060 at 262.2 billion before declining to 702.24 billion in 2100. Africa, North America and Oceania are the only regions where the population is projected to keep growing, with Africa reaching 2.62 billion by the end of the century (up from 1.27 billion in 2020); North America experiencing an increase from 371.37 million to 520.48 million in 2100; and Oceania projected to experience an increase from 41.9 million to 65.93 million. See figures 2 and 3.

Figure 2: Projections of the world population until 2100

The Wittgenstein Centre's projections of the world population until 2100, by region.



Source: https://ourworldindata.org/grapher/projections-of-the-world-population-until-2100-by-the-wittgenstein-centre

Figure 3: World population, actual and projected 2020–2100

The Wittgenstein Centre's world population projections, actual and projected 2020–2100

Region	2020	2050	2100
World	7.61 billion	9.14 billion	8.95 billion
Asia	4.53 billion	5.11 billion	4.36 billion
Africa	1.27 billion	2.02 billion	2.62 billion
Europe	748.06 million	754.42 million	702.24 million
Latin America & Caribbean	650.96 million	757.88 million	683.88 million
North America	371.37 million	447.32 million	520.48 million
Oceania	41.90 million	56.92 million	65.93 million

Source: Wittgenstein Centre for Demography and Global Human Capital

University of Washington, Institute for Health Metrics and Evaluation

The third organisation providing world population projections is the University of Washington's Institute for Health Metrics and Evaluation. The Seattle-based institute predicts that human numbers will peak around 2064 at around 9.73 billion and fall to 8.79 billion by the end of the century.

The Institute's population projections for the five largest countries in 2100 are India (1·09 billion), Nigeria (791 million), China (732 million), the USA (336 million) and Pakistan (248 million).

The Institute also draws attention to the shifting age structure in many parts of the world, with a projected 2·37 billion (27%) of individuals older than 65 years and just 1·70 billion (19.34 %) of the population younger than 20 years. The current population mix is 9.1 per cent over the age of 65 years and 21 per cent younger than 20 years of age.

By 2050, the Institute estimates that 183 countries were forecasted to have a fertility rate lower than replacement by 2100. Of these, 23 countries, including Japan, Thailand, Italy and Spain, are forecasted to have population declines greater than 50 per cent.

Japan's population is expected to contract from 126 million in 2020 to 53 million. In Europe, Italy, Spain and Portugal are also expected to lose half their populations. In Asia, the populations of Thailand and South Korea is also projected to decline by a half. China's population will peak at about 1.6 billion before declining to 732 million.

Dramatic declines in working age-populations are predicted in countries such as India and China. This, in turn, will hamper their economic growth and lead to shifts in global powers. China's population was forecasted to decline by 48 per cent and while China's economy is forecast to be the world's largest economy by 2035, the USA is projected to once again claim the title of the largest economy by 2098.

The institute also projects that if the world meets the UN's Sustainable Development Goal targets for education and contraception, the global population will have declined to 6·29 billion by 2100.

Population boom or bust?

In his article Peter Hartcher cites the work of Canadians Darrell Bricker and John Ibbitson. In their book, *Empty Planet: The Shock of Global Population Decline*, Bricker and Ibbitson argue that the earth does not face the problem of a 'population bomb' but rather a 'population bust'. – 'a relentless, generation-after-generation culling of the human herd unlike anything that has ever happened before'.

While it's difficult to predict what fertility rates will be in 40-50 years there is now a growing consensus (as noted above) that the world's population will peak sometime in the second half of this century and then start declining. The main driver of this decline is likely to be a fall in fertility rates. In 1950 the average woman had 4.7 children in the course of her life. Today, the global average is, according to the UN's 2020 World Population Data Sheet, about 2.3. Improvements in access to modern contraception and the education of girls and women are the principal drivers of this decline.

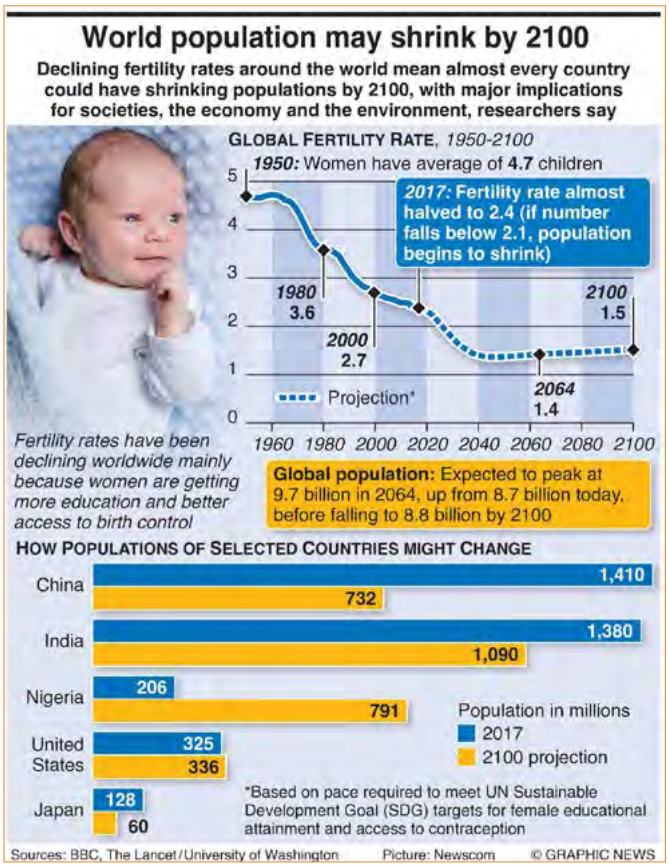
The fertility rate required to keep the population constant (referred to as the 'replacement rate') is about 2.1 children. The University of Washington's, Institute for Health Metrics and Evaluation estimates that the global average will fall below 1.7 by 2100. In other words, the fertility rate will have fallen below the rate required to sustain the world's population. Anything below 2.1 children per women results in decline in human numbers.

Such declines will help mitigate some of the challenges facing humanity including climate change, environmental degradation and food supply. There are, however, several negative consequences for labour forces, economic growth and social support systems.

From the Editor: A related media report posted in the Guardian in November 2020

Japan to help cover IVF costs in attempt to avert demographic crisis –
https://www.theguardian.com/world/2020/nov/06/japan-to-help-cover-ivf-costs-in-attempt-to-avert-demographic-crisis?fbclid=IwAR25ADzt3i5FJKNUpxfcMn8T4IQjonooMkMD2tF0O81bK9FtBHgalRjqxQ0

POPULATION GROWTH RATES



A study, published in The Lancet, says 183 out of 195 countries will not be able to maintain current populations by the end of the century.

23 countries, including Japan, Thailand and Spain, are expected to see their populations halve by 2100. Another 34 would lose between a quarter and a half of their citizens. China is expected to lose 48 percent of its population.

More women in education and work, as well as greater access to contraception, is leading to fewer children being born.

If the fertility rate – the average number of children a woman gives birth to – falls below 2.1, the size of the population begins to decline. The global fertility rate is projected to fall below 1.7 resulting in the world's population peaking at 9.7 billion in 2064 before falling to 8.8 billion by the end of the century.

While declining populations are good news for the environment, reduce stress on food production systems and lower carbon emissions, most countries outside of Africa will see shrinking workforces and inverting population pyramids with negative consequences on the economies.

GRAPHIC NEWS 16/07/2020

ACTIVITIES

1. Define the concepts – fertility rate, population projection, population pyramid.
2. Calculate the proportional change in population between 1980 and that projected for 2064. (calculate as a %)
3. Calculate the proportional change in population in China between 2017 and the projection for 2100
4. Complete a PQE analysis for each graph
5. What explanations are used for the trends shown in the graphs?
5. Why is Nigeria predicted to have a different experience to other countries?
6. Challenge question: Assess the economic significance of an inverted population pyramid referred to in the text.
7. List three key ideas from the media report *Japan to help cover IVF costs in attempt to avert demographic crisis* at https://www.theguardian.com/world/2020/nov/06/japan-to-help-cover-ivf-costs-in-attempt-to-avert-demographic-crisis?fbclid=IwAR25ADzt3i5FJKNUpxfcMn8T4IQjonooMkMD2tF0O81bK9FtBHgalRjqxQ0

Skills activities created by Lorraine Chaffer using Graphic News infographics.

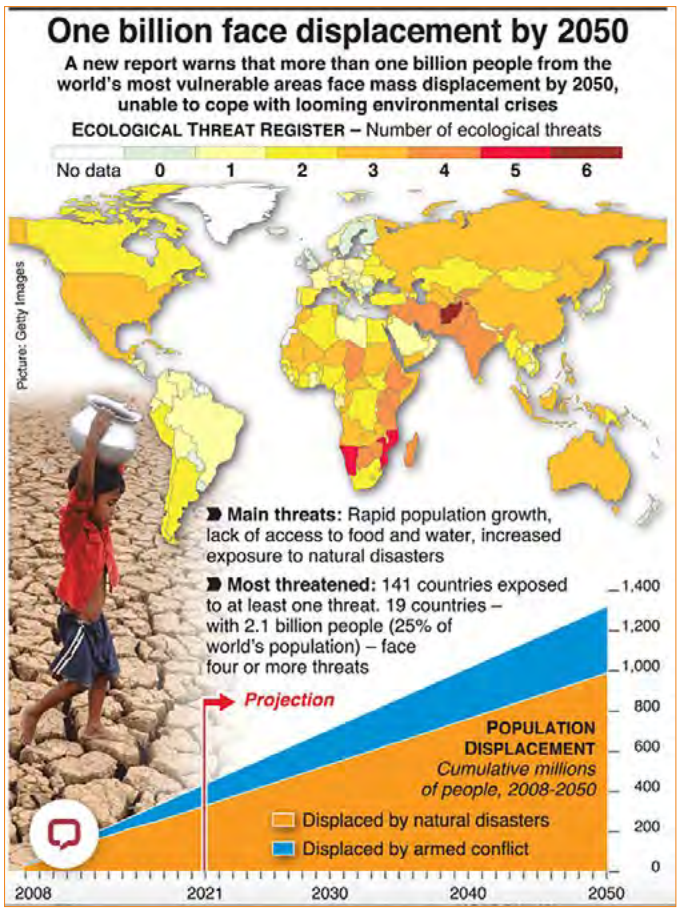
PQE Method

Pattern: Give a general overview of any patterns you may identify. Look for things that stand out or form patterns.

Quantify: Add specific and accurate information to define and explain the patterns. Use statistics (quantities) such as amounts, sizes and locations to give specific details.

Exceptions: Identify everything that does not fit your patterns

POPULATION MOVEMENTS: Ecological threats



A new report warns that more than one billion people from the world's most vulnerable areas face mass displacement by 2050, unable to cope with looming environmental crises.

Compiled by the Institute for Economics and Peace (IEP), the Ecological Threat Register uses data from the United Nations and other sources to assess eight ecological threats – including rapid population growth, lack of access to food and water, and increased exposure to natural disasters.

With the world's population forecast to rise to nearly 10 billion by 2050, intensifying the scramble for resources and fuelling conflict, the research shows as many as 1.2 billion people living in vulnerable areas of sub-Saharan Africa, Central Asia and the Middle East may be forced to migrate by 2050.

The report has also found that nineteen of countries with the highest number of ecological threats are among the world's 40 least peaceful countries, including Afghanistan, Syria, Iraq, Chad, India and Pakistan.

The IEP said it hoped the register, which may become an annual analysis, would shape aid and development policies, with more emphasis and funding going towards climate-related impacts.

GRAPHIC NEWS 2020

ACTIVITIES

Refer to the infographic and text

1. Define displacement, ecological threat
2. What is the source of data used to create the infographic?
3. Why might you consider this data valid and reliable?
4. Describe the trends and patterns in population displacement shown in the graph.
5. Identify the main ecological threats that cause population displacement.
6. Describe the spatial distribution of ecological threats by completing a PQE for the choropleth map.

Ecological Threat Register 2020 – http://visionofhumanity.org/app/uploads/2020/09/ETR_2020_web-1.pdf

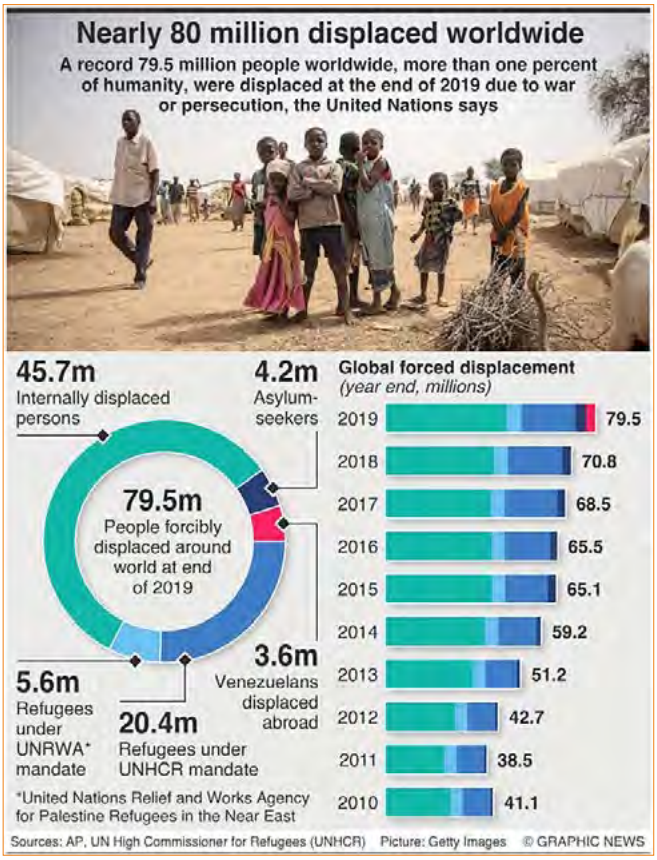
Group activity: Refer to pages 4 and 5 of the Ecological Threat Register. List 10 additional findings you consider to be of greatest concern to human wellbeing. Rank these using a ranking diamond. Contribute to a class discussion in which you justify your choices and rankings.

Diamond Ranking Template – https://www.globaleducation.edu.au/verve/_resources/diamond_ranking-1.pdf

Online Diamond Ranking Template – https://online.visual-paradigm.com/diagrams/features/diamond-ranking-template/

Skills activities created by Lorraine Chaffer using Graphic News infographics.

POPULATION MOVEMENTS: Conflict and persecution



ACTIVITIES

1. Differentiate between internally displaced people, asylum seekers and refugees.
2. Calculate the % of forcibly displaced people in 2019 who were refugees.
3. Decribe the changes in global forced displacement between 2015 and 2020. Use statistics in your answer.
4. Identify the specific countries that account for much of the increase in displacement since 2010.
5. Suggest reasons why poorer countries contributed most to the 'newly displaced' category of displaced people.
6. Refer to pages 2, 3 and 4 of UNHCR Global Trends. Forced Displacement 2019. List ten additional facts about displacement not identified in the infographic.

More than one percent of humanity forcibly displaced: UN

June 18, 2020 - A record 79.5 million people worldwide – or more than one percent of all humanity – were displaced at the end of 2019 as a result of conflict or persecution, according to the United Nations refugee agency.

The UN High Commissioner for Refugees (UNHCR) said in its annual "Global Trends" report that the number of asylum-seekers, internally displaced people and refugees shot up by nearly nine million from a year earlier – the biggest rise in its records.

UNHCR says the surge is due to a new way of counting people displaced from Venezuela and a "worrying" new displacement in the persistent trouble spots of Congo, the Sahel region of Africa, Yemen and Syria, which alone accounted for more than 13 million people on the move.

While the total figure of people facing forced displacement rose from 70.8 million at the end of 2018, some 11 million people were "newly displaced" last year, with poorer countries among those most affected.

UNHCR says forced displacement has nearly doubled from 41 million people in 2010, and five countries – Syria, Venezuela, Afghanistan, South Sudan and Myanmar – are the source of nearly two-thirds of people displaced abroad.

Graphic News 18/06/2020

UNHCR: Global Trends. Forced displacement 2019 – https://www.unhcr.org/5ee200e37.pdf

Skills activities created by Lorraine Chaffer using Graphic News infographics.

CASE STUDY: RARE EARTH ELEMENTS (REES)

Lorraine Chaffer, Vice President GTA NSW & ACT

Source: Shutterstock

'If you have a phone, a camera or an electric car, chances are that each of these devices is wholly dependent on key minerals that, at the moment, are processed only in China.'

Source: https://www.smh.com.au/world/asia/australia-s-race-against-china-s-rare-earths-weapon-20200825-p55p8s.html

Syllabus: Natural Resource Use

- the nature of natural resources
- spatial patterns and consequences of the distribution and consumption of natural resources at a global scale
- economic and political issues related to the use of natural resources, their ownership and management
- environmental and social issues related to the use of natural resources such as ecologically sustainable development, and the impacts on, and responses of, indigenous peoples

Nature of Rare Earth Elements (REE)

The rare earth elements (REE) are a unique group of 17 chemically similar elements - scandium, yttrium, and 15 lanthanides (cerium, dysprosium, erbium, europium, gadolinium, holmium, lanthanum, lutetium, neodymium, praseodymium, samarium, terbium, thorium, thulium, ytterbium).

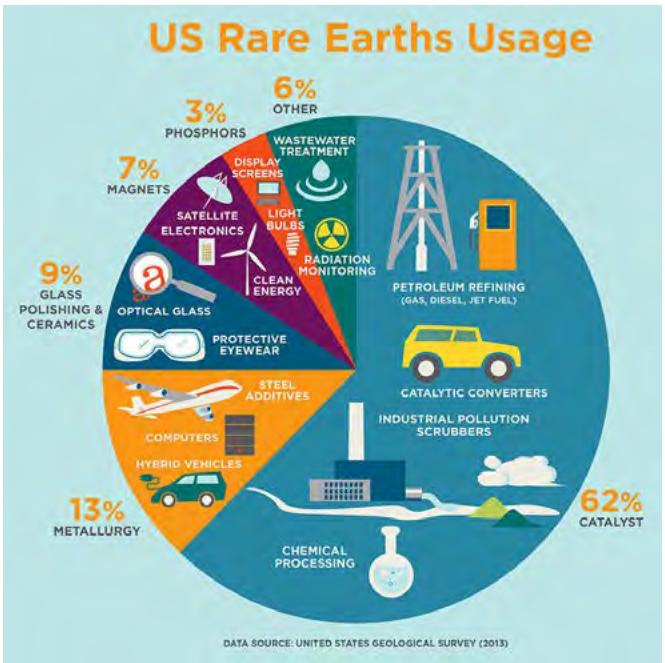
REE have many very specific uses, See Figure 1. The minerals from which REE's are extracted are difficult and costly to mine. Cheaper substitutes are considered inferior or no substitutes have yet been found.

Technological advances have increased the importance of REE in domestic, medical, industrial and strategic applications because of their unique properties. Uses of REE include the production of magnets, motors, electronic and computing equipment, batteries, petroleum, medical images, glass and ceramics (colouring agents) and lasers. In recent decades these uses have multiplied e.g. phone touchscreens and camera lenses, wind turbines, LED lights and electric cars. One electric car for example, uses 16kg of rare earths.

'As the world's appetite for technology increases, as we move towards electric vehicles and as every individual owns several handheld digital devices, the need for rare earths increases.'

Source: https://www.intheblack.com/articles/2019/08/01/extracting-truth-about-rare-earths

Figure 1: Rare Earth Usage in the USA



US Geological Survey. Source: https://www.jics.tennessee.edu/files/images/rare-earths-infographic-rev.jpg

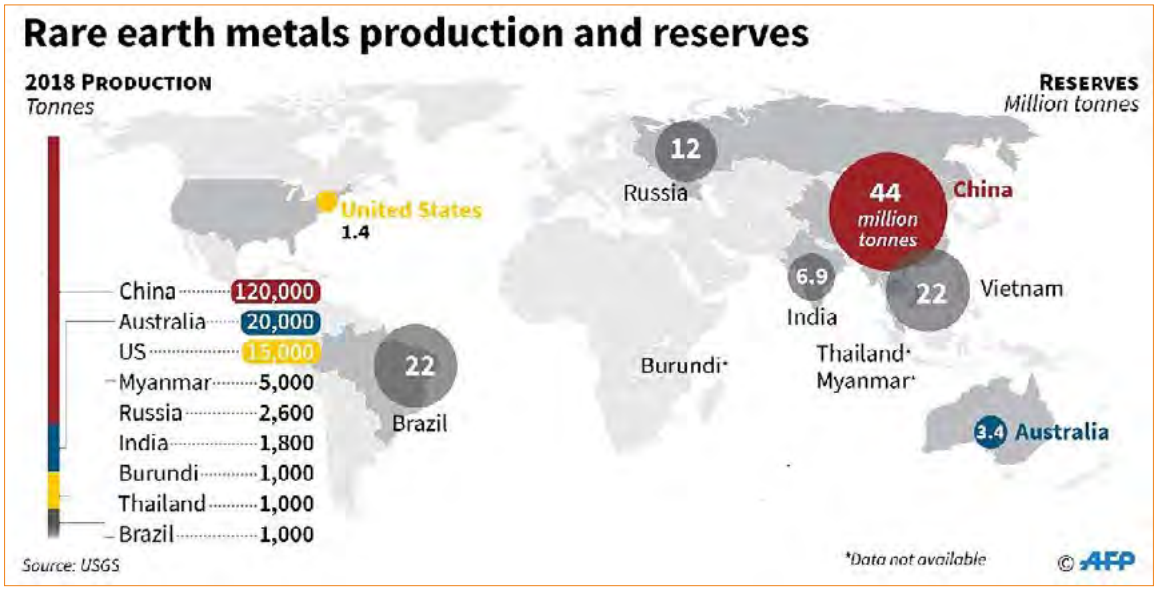
Spatial patterns, distribution and consumption

Rare earths are generally very abundant with global reserves greater than those of silver, similar to those of copper and lead and in the case of thulium and lutetium (two of the least abundant earths) 200 times more common than gold. See Figure 2

China's controls of 95 percent of the world's supply of rare earth metals but it is not the only country with large reserves. However, very little is produced elsewhere because of environmental and economic costs – mining creates large amounts of toxic waste and production costs are high. China's poorer environmental regulations and lower production costs have contributed to it becoming the world's leading producer.

The United States Geological Survey estimated that in 2018 there were 120 million tonnes of deposits worldwide including 44 million in China and 22 million in both Brazil and Vietnam. See Figure 2

Figure 2: Reserves of rare earth metals, by country and annual production in 2018.



Source: USGS https://scx2.b-cdn.net/gfx/news/2019/rareearthmet.jpg

Issues related to the use of natural resources, their ownership and management

Economic and political issues

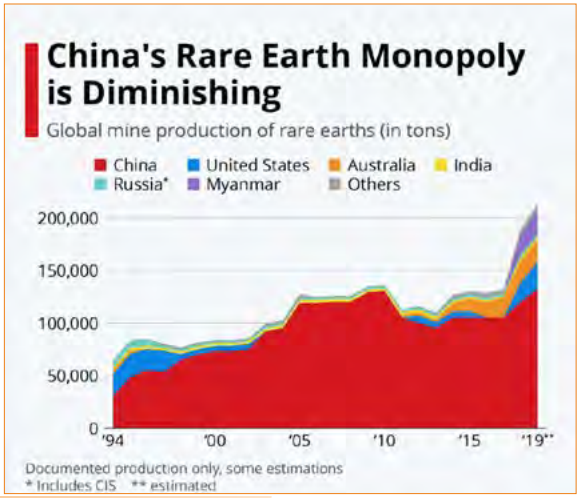
Rare Earths have been used as political instruments by China in disputes with other countries. When the USA banned the export to China of technology containing rare earths from China, the Chinese government threatened to stop supplying them. China also threatened to interrupt supplies of rare earths to other western markets. In 2010 supplies of REE to Japan were disrupted amid a dispute over the sovereignty of uninhabited islands. China also cut general export quotas in 2010 to preserve supplies for its own industry, forcing global prices to increase astronomically.

'In 2018, Beijing was accused of dumping products that undermine the security of US-based rare earth metal productions. In doing so, China undoubtedly lowered the price of materials, thereby undercutting producers in other countries and driving them out of business.'

https://www.futuredirections.org.au/publication/countering-chinas-grip-on-rare-earth-commodities/

Despite challenges created by actions of the Chinese government, production in other countries has grown since 2010, a trend predicted to increase and over time reduce China's monopoly. See Figure 3

Figure 3: Rare Earth production over time



Source: Statistica https://www.statista.com/chart/18278/global-rare-earth-production/

Ecological and social issues

Extracting rare earth elements from host rocks is chemically complex and expensive, requiring large quantities of energy, water and acid, often leaving radioactive waste.

Environmental problems are caused by the two main extraction methods

- Removing the topsoil, transporting it to a leaching pond, and adding chemicals to separate out the metals. These chemicals can create air and groundwater pollution and cause erosion.
- Drilling holes into the earth, inserting pipes and hoses, pumping in chemicals to flush out earth in a slurry that is pumped into ponds to separate out the REE. The chemicals used create similar problems to the topsoil removal process with the added impact of pipes and equipment littering the environment.

Chemicals continue to leach into groundwater and waterways from abandoned mines.

Rare earth elements often have a radioactive element — thorium in small concentrations that could affect the environment and the people – not enough ids known yet about this potential threat.

Villagers have lost their farming lands and are forced to work in contaminated, poorly regulated mines for low wages. The chemicals used cause health issues such as causing tooth and bone decay. Food production has been impacted by polluted soil and water.

> *"The results are jarring: In mineral-rich regions of China, poisoned water and soil have caused abnormal disease rates in "cancer villages" from which impoverished residents cannot afford to move. Crops and animals have died around a crusty lake of radioactive black sludge formed from mining waste near a major mining site in Baotou, Inner Mongolia. It's so large that it is visible by satellite."*
>
> Source: https://www.latimes.com/world-nation/story/2019-07-28/china-rare-earth-tech-pollution-supply-chain-trade

The Future

The nature, production and consumption of REEs in the future will be influenced by several important processes

- Finding more sustainable options for extraction. Rare-earth metal extraction has the potential to be done without environmental harm. One method from Harvard University proposes using mild acidic solutions to separate metals from the earth.
- Finding alternatives to rare earths and developing products that rely less on rare-earth metals. Honda is reportedly developing hybrid cars that are mostly free of rare-earth metals.
- Using diplomacy to incentivise reform of China's lax environmental regulations and improve standards for environmental protection.
- Research and production for sustainable REE production at a global scale to reduce China's monopoly.

LEARN MORE ABOUT RARE EARTHS: MEDIA REPORTS

- Extracting the truth about rare earths (Includes a podcast) – https://www.intheblack.com/articles/2019/08/01/extracting-truth-about-rare-earths
- The hidden costs of China's rare-earth trade – https://www.latimes.com/world-nation/story/2019-07-28/china-rare-earth-tech-pollution-supply-chain-trade
- What are rare earth elements and why are they so important? – https://www.euronews.com/2019/08/15/what-are-rare-earth-elements-and-why-are-they-so-important-in-the-us-china-trade-war
- US-China trade war: China may use rare earth dominance to strike back – https://www.straitstimes.com/world/united-states/china-may-use-rare-earth-dominance-to-strike-back (Includes an infographic)
- Global Times: Ensuring rare-earth dominance crucial in trade war – https://www.globaltimes.cn/content/1171149.shtml
- China Wrestles with the Toxic Aftermath of Rare Earth Mining – https://e360.yale.edu/features/china-wrestles-with-the-toxic-aftermath-of-rare-earth-mining
- Boom in Mining Rare Earths Poses Mounting Toxic Risks – https://e360.yale.edu/features/boom_in_mining_rare_earths_poses_mounting_toxic_risks
- How Rare-Earth Mining Has Devastated China's Environment – https://earth.org/rare-earth-mining-has-devastated-chinas-environment/
- Countering China's Grip on Rare Earth Commodities – https://www.futuredirections.org.au/publication/countering-chinas-grip-on-rare-earth-commodities/
- The story of rare earth elements (REEs): occurrences, global distribution, genesis, geology, mineralogy and global production – https://www.researchgate.net/publication/340468310_The_story_of_rare_earth_elements_REEs_occurrences_global_distribution_genesis_geology_mineralogy_and_global_production
- Rare Earths: Outlook to 2030 – https://roskill.com/market-report/rare-earths/

Visualising the Importance of Environmental Management in Mining

Published in Visual Capitalist on September 22, 2020

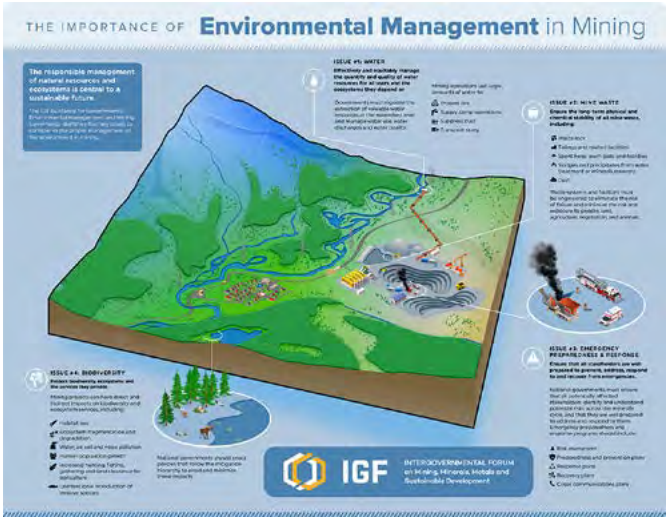
The Importance of Environmental Management in Mining

A mine will always impact the environment, but the question is to what degree? The responsible management of natural resources and ecosystems such as soils, plants, animals, water and air, and the services they provide, is central to the efforts of any society seeking to become more sustainable.

The Intergovernmental Forum on Mining "IGF" has identified four issues that governments could effectively manage to reach sustainability goals.

1. Water Management
2. Biodiversity and Ecosystem Services
3. Mine Waste Management
4. Emergency Preparedness

These four key issues are critical for governments and communities to consider – to ensure mining and the environment can coexist for the benefit of all.



See page 32 and PPT for a larger version of this diagram.

Source: https://www.visualcapitalist.com/environmental-and-mining/

Issue 1: Water Management

According to the IGF, U.S. mining operations used 5,526 million cubic meters of water, amounting to 1% of the country's total water use in 2015. Mining is a very water intensive industry. In mineral processing, slurry transport, dust suppression, and to meet the water needs of employees, large-scale mining operations use significant amounts of groundwater and surface water across the mine life cycle. Mining operations need water to process ore and run camp operations. Mines also need to manage water that comes in contact with operations, through rainfalls and runoff.

The protection of water resources applies to both surface and groundwater, and these water resources are increasingly under strain due to:

- Climate change
- Variable precipitation
- Growing populations, increased industrial and agricultural activity

Competing demands for water resources from the mining sector, agriculture, households, from other industries and sectors, and for conservation and leisure—ensure that governments will always play a critical role in water management throughout the life of a mine, not only at the site itself but across watersheds and beyond national borders.

Issue 2: Biodiversity and Ecosystem Services

Mining projects have the potential to impact biodiversity and ecosystem services throughout their lifecycle. Understanding how mining can impact biodiversity is vital to mitigate the harmful impacts of mining on the biodiversity and ecosystem. Biodiversity delivers many benefits to their surrounding communities known as ecosystem services—and a mining project has direct and indirect impacts before, during and after mining operations on these services.

Direct Impacts:

- Habitat loss
- Ecosystem fragmentation and degradation
- Water, air, soil and noise pollution

Indirect Impacts:

- Human migration seeking opportunities
- Increased hunting, fishing, gathering and land clearance for agriculture
- Unintentional introduction of invasive species to an ecosystem

Governments, when considering the merits of a proposed mining project, will have to weigh the economic and development needs of the country and the local community against its conservation and environmental goals.

Issue 3: Mine Waste Management

Mining moves and processes large amounts of materials to extract metals. The excess material is known as mine waste. Mine wastes can contain minerals that are reactive which could be released from the rock when it is mined, crushed, and exposed to air and water. Mine waste makes up the largest amount of material that is mined. The strip ratio defines how much waste rock there is compared to valuable ore. For example, a 2:1 strip ratio means that mining one tonne of ore will require mining two tonnes of waste rock.

Waste management in mining is complex and incorporates a range of disciplines, including geology, geochemistry, civil engineering, and geotechnical engineering. Waste rock storage facilities, leach pads, and tailings storage facilities are large structures that must be carefully engineered to ensure they are stable over time and the safety of workers and the public.

Governments should set international standards within their own jurisdictions to ensure the proper construction and maintenance of waste rock facilities.

Issue 4: Emergency Preparedness

Emergency preparedness involves understanding the likelihood of an emergency situation and its potential consequences, taking proactive action to prevent the hazard, preparing to mitigate emergency effects, responding appropriately, communicating effectively, and recovering afterwards. This relates to:

- Industrial emergencies
- Natural and climate-related disasters
- Health emergencies
- Political and security risk

Governments have a strong role to play in emergency preparedness, ensuring that responses are swift, organised and coordinated, and that all relevant stakeholders, from local communities to staff, are safe and protected.

Dry bed of the tailings dam,Brukunga Pyrite Mine, South Australia. Source: http://www.scienceimage.csiro.au/image/4507

Resources and Communities

Mineable deposits occur in both convenient and inconvenient places, close to or distant from communities, close to or distant from water sources, and close or distant from farmland or ecologically sensitive areas.

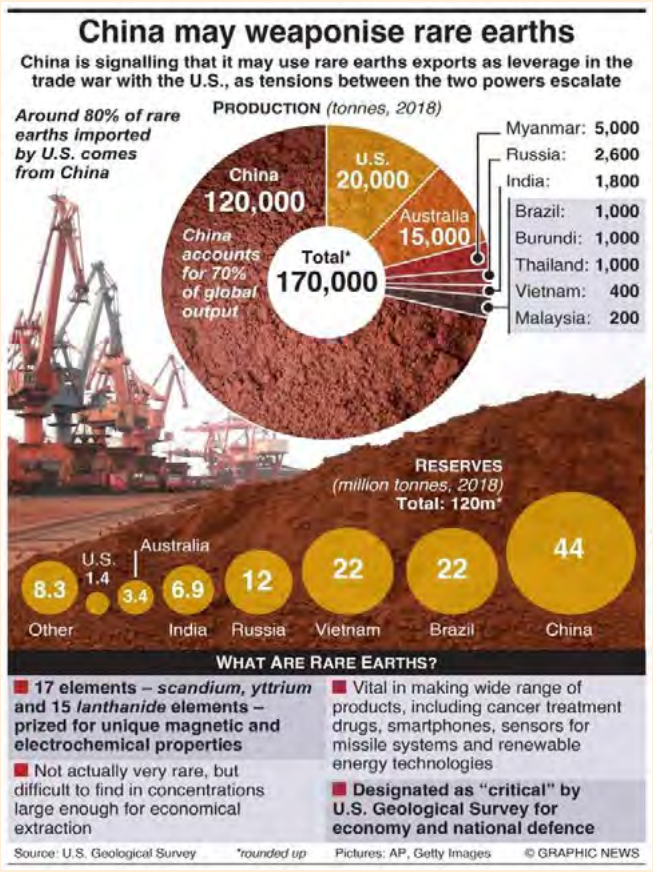
Mining will always have an impact. The active and sustainable management of these natural resources before, during, and after mining will help to avoid negative impacts where possible and could even mean excluding mining.

A failure to manage the four issues of mining on the environment can threaten the viability of operations but can also undermine the relationships between a mining company, affected communities, and all levels of government.

The Intergovernmental Forum on Mining "IGF" is creating the policy framework to address the importance of environmental management in mining.

Elevated aerial panorama over deep excavation at an open cut coal mine in the Hunter Valley. Source: Shutterstock

CHINA MAY WEAPONISE RARE EARTHS



China may weaponise rare earths in trade war with U.S.

China is signalling that it may use rare earths exports as leverage in the trade war with the U.S., as tensions between the two powers escalate.

Rare earths, a group of 17 metals with a variety of high-tech applications, used in magnets, instrument displays and other strategic applications, are the one raw material where China dominates global supply.

Around 80% of the rare earths imported by the U.S. comes from China, according to US government data.

The official newspaper of the ruling Communist Party, People's Daily, said in an editorial Wednesday that the U.S. is a major buyer of China's rare earth materials and is "highly dependent" on such resources.

Last year, the US Geological Survey designated these minerals critical to the economy and national defence.

Graphic News 30/05/2019

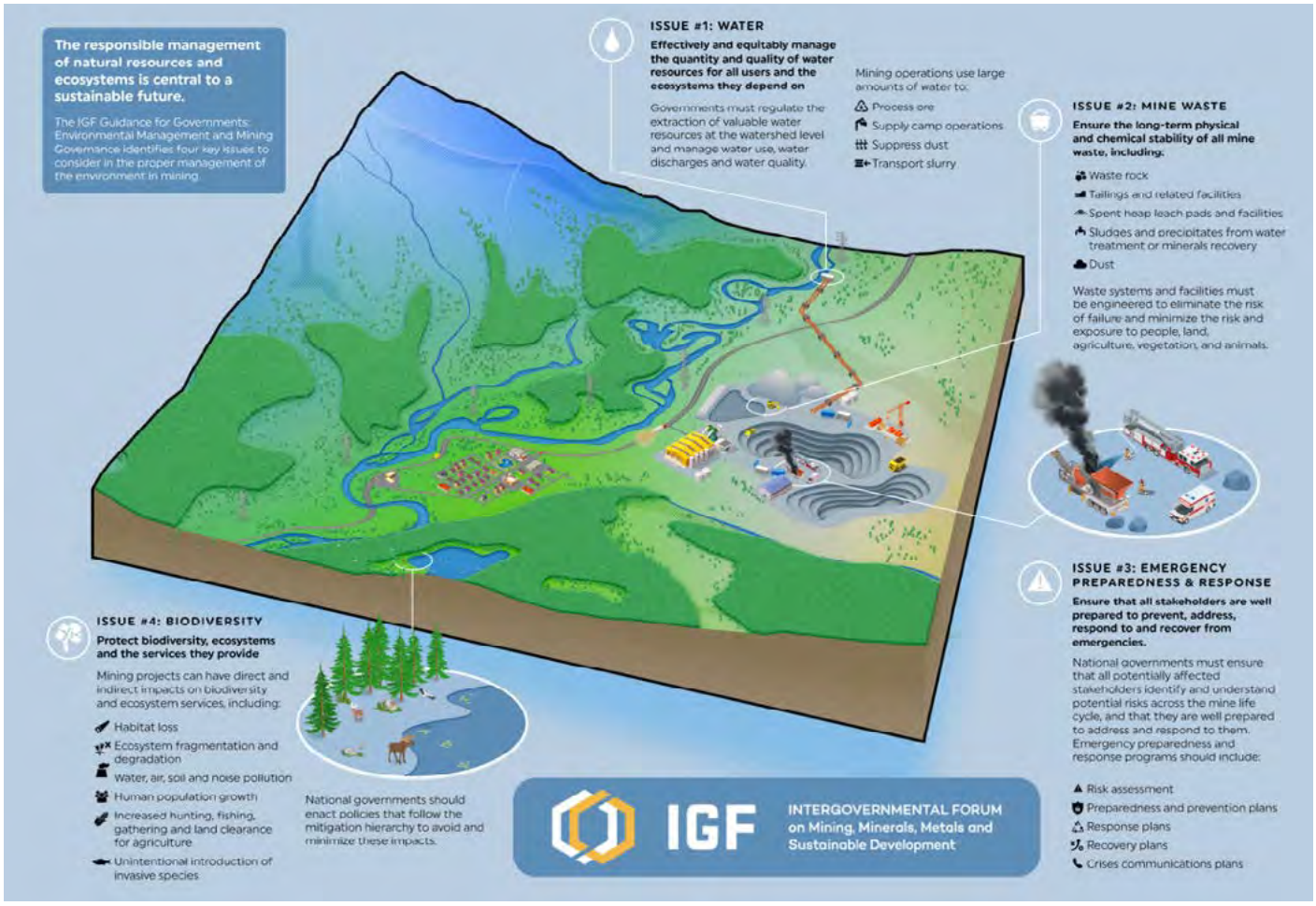
ACTIVITIES

Refer to the article *'Rare Earth Elements'* AND the infographic *'China may weaponise rare earths'* to complete the following activities.

1. Calculate Myanmar's proportion (%) of total Rare Earth production.
2. Calculate Vietnam's share of global Rare Earth reserves as a %
3. Calculate the total % of REE production based in Asia.
4. China, USA and Japan are the major consumers of REE. Suggest reasons for this pattern of consumption. HINT: Consider the uses of REES.
5. Describe the spatial distribution of REE production and consumption on a global scale.
6. Create an infographic that incorporates information from the article Case Study: Rare Earth Elements. Choose your own digital tool. Include a map, photograph, graph and fact boxes in your infographic.

Skills activities created by Lorraine Chaffer using Graphic News infographics.

ENVIRONMENTAL MANAGEMENT IN MINING



Source: Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development

ACTIVITIES

Refer to '*Visualizing the Importance of Environmental Management in Mining', the infographic above* and the case study: *Rare Earth Elements.*

1. Identify the four sustainability in mining goals set by the Intergovernmental Forum on Mining (IGF).
2. Create a table with 2 rows and 3 columns. Create 3 headings, one in each column - use the first three sustainability goals identified in the infographic.
3. Using your knowledge about the production and consumption of Rare Earth Elements in China to add comments about sustainability in the table under each heading.
4. Write a concluding statement about the sustainability of mining REE in China based on the content of your table. Identify the criteria you used to make judgements about sustainability in your answer.
5. Name three emergency events that could impact on REE mines across the world.
6. Create a priority list of four actions for the Chinese government to implement achieve sustainable production in its REE mines.

Skills activities created by Lorraine Chaffer using the IGF infographic from Visual Capitalist (Permission to use granted by IGF).

STAGE 6: FIELDWORK

Observatory Hill Environmental Education Centre is developing a number of **virtual fieldwork stand-alone case studies** that can be used to support the S6 geography syllabus.

Completed case studies include:

- Urban Dynamics - Urban consolidation in Waitara – https://sites.google.com/education.nsw.gov.au/urbandynamics-waitara/home
- Urban Dynamics – Urban Consolidation and Renewal in Pyrmont – https://sites.google.com/education.nsw.gov.au/urban-dynamics-pyrmont/home
- Economic activity - Sydney Harbour YHA, a case study of an economic enterprise at a local scale https://sites.google.com/education.nsw.gov.au/sydneyharbouryha/home

The following case studies will be coming soon:

- Economic Activity – Taronga Western Plains Zoo Dubbo case study
- Ecosystems at Risk – Rainforests of NSW
- Ecosystems at Risk – Kelp ecosystems of eastern Australia

In addition, the Centre already offers case study support websites for a number of S6 topics, which can support and supplement actual fieldwork with the Centre, or virtual fieldwork lessons provided by the Centre. These websites include pre and post program quizzes, pre fieldwork or virtual fieldwork (webinar) tasks, Google Tours and updated resources such as video clips, latest news, maps and more.

Case studies **include:**

- **People and Economic Activity** Tourism – Taronga Zoo case study – https://sites.google.com/education.nsw.gov.au/obhill-pea-tourism/home
- **Urban Places** – Urban renewal and consolidation in Pyrmont – https://sites.google.com/education.nsw.gov.au/obhill-urbanplaces-pyrmont/home
- **Urban Places** – Urban renewal and consolidation in Green Square – https://sites.google.com/education.nsw.gov.au/obhill-urbanplaces-greensquare/home
- **Urban Places** – Urban renewal and consolidation in Barangaroo and Millers Point – https://sites.google.com/education.nsw.gov.au/obhill-urbanplaces-barangaroo/home

Virtual fieldwork presentations can be delivered to your class by the Centre's trained geography teachers covering the topics above, as well as selected S4 and S5 topics. The virtual presentations explore each case study in depth, including related syllabus content. Webinar worksheets are provided and students have the opportunity to ask questions.

Feedback from teachers is overwhelmingly positive with comments such as; *"That was fantastic, thank you for your time today. Heaps of information for the students to take in but very clear and structured with an examination focus, the students really appreciated it."* Kogarah HS

Examples of Observatory Hill EEC fieldwork / webinar case studies

People and Economic Activity – Tourism

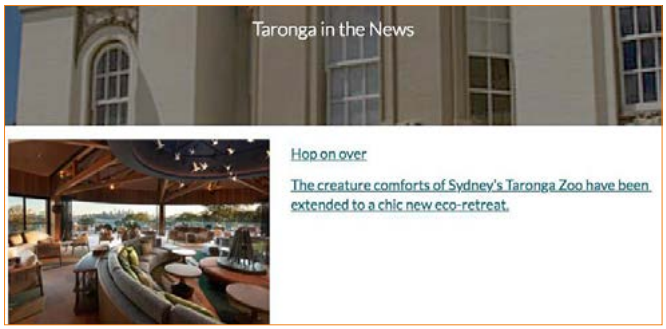
Taronga Zoo Sydney local case study

Observatory Hill EEC, in partnership with Taronga Zoo Sydney, offers fieldwork or a virtual fieldwork webinar on the global tourism industry, and Taronga Zoo Sydney as a local case study of a tourism enterprise. Schools that attend Taronga Zoo, participate in two presentations that address the *People and Economic Activity* syllabus dot points, including the local case study, and tour the zoo. Alternatively, students can attend a webinar that walks them through the *People and Economic Activity* syllabus dot points (with a tourism focus) and the Taronga Zoo Sydney local case study. In lieu of actual fieldwork a virtual tour is available on the support website. The fieldwork and presentations are delivered by DoE environmental education / geography teachers, and Taronga Zoo Sydney teachers.

Schools also have the option to conduct fieldwork at Taronga Western Plains Zoo Dubbo TWPZ and a supporting TWPZ case study website will also be available.

A virtual tour linked to the supporting website allows students to experience the zoo in their own time and at their own pace – https://poly.google.com/u/0/view/49HsXUuPJ29

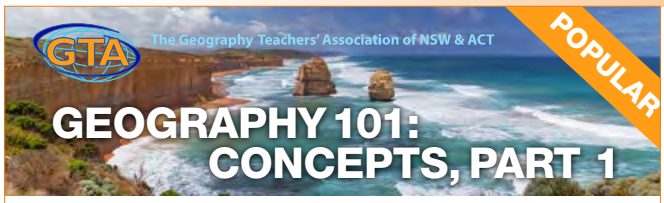
The supporting websites contains updated resource materials including information on global tourism and the impacts of Covid-19 on Taronga Zoo Sydney's operations.



Urban Dynamics – Green Square

Observatory Hill EEC specialises in urban geography and conducts urban dynamics fieldwork at Pyrmont, Barangaroo and Green Square. The Green Square fieldwork focusses on the urban dynamics of urban renewal and consolidation. Teachers have the option to attend actual fieldwork or participate in a comprehensive virtual fieldwork webinar which covers the syllabus dot points (or both). During fieldwork, City of Sydney Town Planners involved with the development, discuss Green Square in detail. Students then visit the precinct to observe and record aspects of the urban dynamics at play. All students are provided with an iPad to collect data so they can create digital maps of their fieldwork A supporting website allows student to revisit the site and offers a virtual tour, quizzes and updated resources about Green Square.

A virtual tour linked to the supporting website allows students to learn more about Green Square in their own time and pace – https://poly.google.com/view/8UBpBRi0rhJ



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

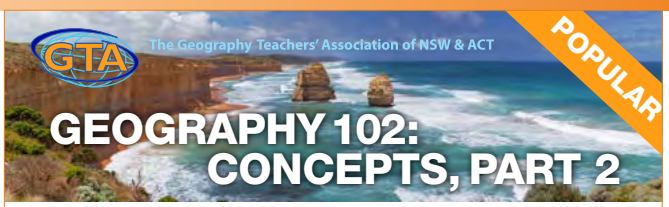
PARTICIPANT FEEDBACK:

"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."

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 September 2020 – 1 November 2021** 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.

www.gtansw.org.au • gta.admin@ptc.nsw.edu.au • 02 9716 0378



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 four of 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),
- participating in learning to update knowledge and practice targeted to professional needs and system priorities (NESA Standard 6.2.2) 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/geography102/
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."
"Another great course. Such a valuable learning opportunity."
"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."

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 102: Concepts, Part 2**, on **29 September 2020 – 1 November 2021** will contribute **5 Hours** of NSW Education Standards Authority (NESA) Registered PD addressing 2.1.2; 6.2.2; 6.3.2 from the Australian Professional Standards for Teachers towards maintaining Proficient Teacher Accreditation in NSW.

www.gtansw.org.au • gta.admin@ptc.nsw.edu.au • 02 9716 0378

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

Geographical tools and skills are an important part of teaching Geography.

This professional development course, created by Dr. Paul Batten on behalf of the GTA NSW & ACT, introduces the maps and map skills that teachers should share with students within the 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),
- applying knowledge and understanding of effective teaching strategies to support students' literacy and numeracy achievement (NESA Standard 2.5.2) 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. 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 for future participants to review.

Cost: $90 – Register at www.openlearning.com/ptc-nsw/courses/geography110/
For further information about this course contact – gta.elearning@gmail.com

PARTICIPANT FEEDBACK:

"This is an accessible and easy way to learn and improve classroom practice."
"I really enjoyed doing this course. Strong explanations of each skill were given with relevant activities provided to consolidate understanding, plus some really good resources."
"A valuable professional learning activity for those wanting to validate their mapping skills, e.g. primary teachers or those new to teaching Geography."

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 110: Intro to Maps** on **29 October 2020 – 29 October 2021** will contribute **3 Hours** of NSW Education Standards Authority (NESA) Registered PD addressing **2.1.2; 2.5.2; 6.3.2** from the Australian Professional Standards for Teachers towards maintaining Proficient Teacher Accreditation in NSW.

www.gtansw.org.au • gta.admin@ptc.nsw.edu.au • 02 9716 0378

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

Topographic mapping is an important aspect of teaching Geography in NSW.

This professional development course, created by Dr Paul Batten and Katerina Stojanovski behalf of GTA NSW & ACT, examines the use of these tools for teaching in the NESA Geography Syllabus K–10.

The course explores skills, for example those related to elevation, aspect and gradient, using spatial technologies as appropriate.

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),
- creating questions to assess student learning (NESA Standard 5.1.2) and,
- contributing to collegial discussions to improve professional knowledge and practice (NESA Standard 6.3.2).

The course is designed for flexible delivery, where participants can start, progress and finish at times convenient to them. The collaboration is in a 'pay it forward' style, where participants engage with previous contributions and contribute themselves – learning in the process, but also adding to the galleries of exemplars and case studies for future participants to review.

COST: $90 for each GTA online course, with discounts available on multiple registrations.

COURSE REGISTRATION: Available at –
www.openlearning.com/ptc-nsw/courses/geography111

For further information about the GTA online courses contact gta.elearning@gmail.com

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 111: Intro to Topographical Mapping** on **1 November 2020 – 1 November 2021** will contribute **3 Hours** of NSW Education Standards Authority (NESA) Registered PD addressing **2.1.2; 5.1.2; 6.3.2** from the Australian Professional Standards for Teachers towards maintaining Proficient Teacher Accreditation in NSW.

www.gtansw.org.au • gta.admin@ptc.nsw.edu.au • 02 9716 0378

Professional Learning

GTA NSW&ACT is continuing to offer its acclaimed online learning opportunities through the Open Learning platform. These flexible, anywhere, anytime courses are NESA-accredited for 3–5 hours. The last year has seen an exciting expansion of course offerings to support new and experienced Geography teachers:

Geography 101: Concepts, Part 1 (5hr)

Geography 102: Concepts, Part 2 (5 hr)

Geography 110: Intro to Maps (3hr)

Geography 111: Intro to Topographic Map Skills (3hr)

Geography 141: Teaching Place and Liveability – for teachers new to the unit (3hr)

Geography 241: Teaching Place and Liveability – for experienced teachers (3hr)

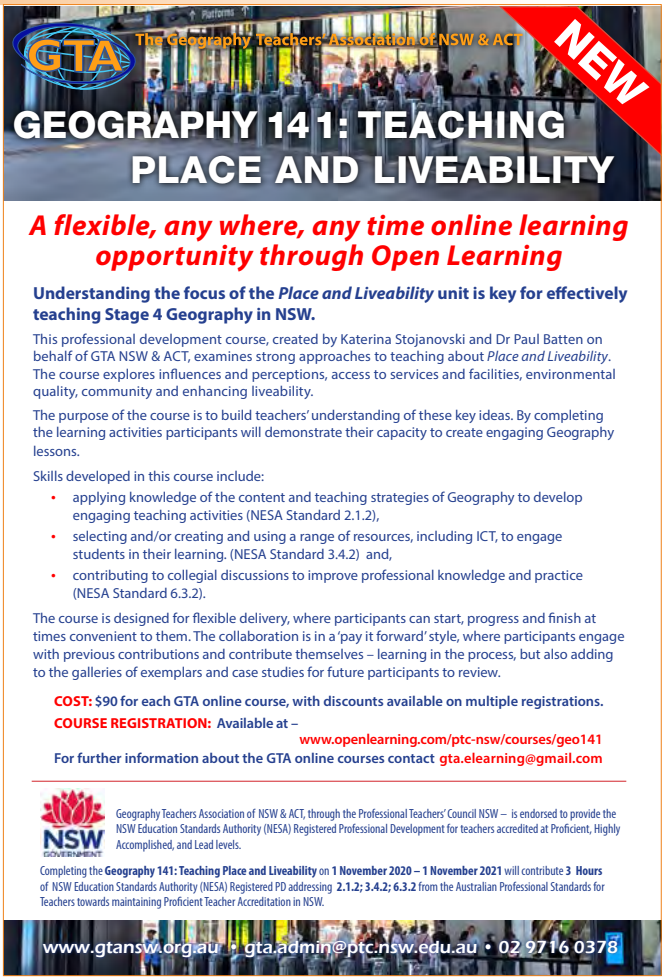
Geography 142: Teaching Landscapes and Landforms (3hr)

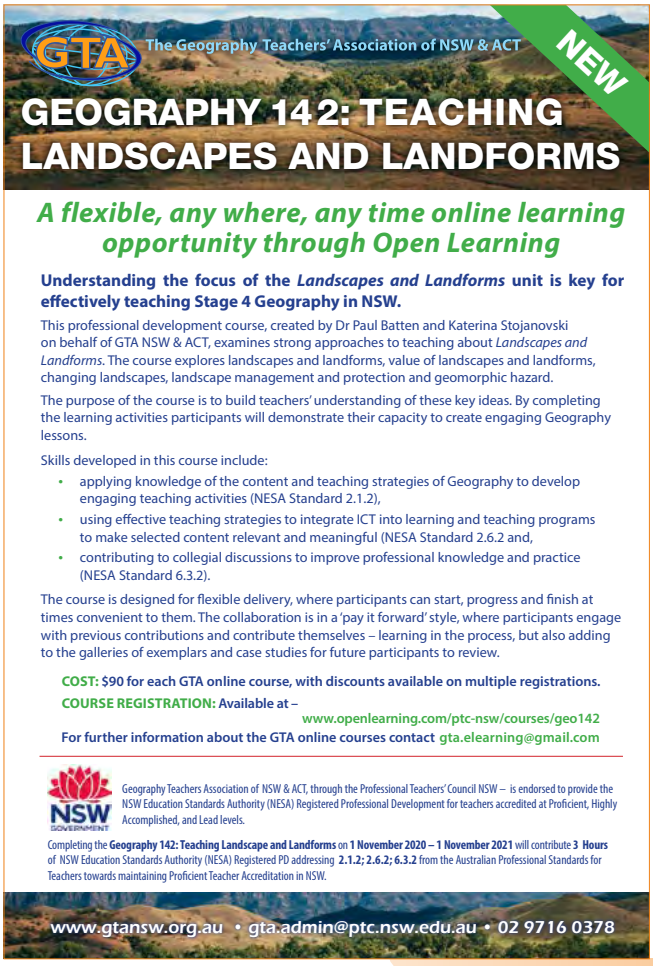
These courses, written and facilitated by Dr Paul Batten and Katerina Stojanovski, have been rated very positively by participants.

For more information about our online learning courses, please contact the GTA NSW & ACT Online Learning Coordinator at gta.elearning@gmail.com.

Dr Paul Batten, GTA NSW & ACT Councillor

Katerina Stojanovski, GTA NSW & ACT Councillor





BROKEN HILL: A case study option

David Proctor, Head Teacher HSIE, Willyama High School

The diverse nature of our continent including our vibrant cities, sometimes overshadows the hidden gems of the rural locations we have on offer to help inform our studies.

Here's a shout out to one rural town that is going through a population decline and how you could use Broken Hill in Wilyakali country throughout the HSC course as a unique case study.

ECOSYSTEMS AT RISK – ARID ZONES

About the ecosystem

The bioregion in which Broken Hill sits is known as the Barrier Range and is characterised by its low average rainfall of 259mm. It is often a hostile location, however in 2020 has seen major downpours causing vegetation levels to spike and usually dry riverbeds to flow again. The arid nature of the Barrier Range region means that decomposition and nutrient cycling is slow, however is aided by large predator birds such as the wedge-tailed eagle and rain events as well.

Many of the dominant native vegetations in this area are known to be endangered or vulnerable, while the invasive species are classed as destructive to natural ecosystems. There are recorded to be 195 bird species, 58 reptile species and 37 species of mammals including the yellow-footed rock-wallaby.

Management and protection

A 2,400-ha conservation area known as the Living Desert was created in 1994 to help with conservation efforts with protection of the native flora and fauna and also provide an area for passive recreation. This area includes spaces for walking tracks which highlight natural vegetation, some fauna and the Living Desert sculptures as a major tourist drawcard to the region.

Reserves also encircle the township to aid in mitigating the impacts of mining and grazing. Regeneration – mostly using saltbush – helps to reduce the large amounts of dust that blow through the town which are eroded from the local sand dunes.

Stresses on the Barrier Ranges

Human impacts centre around the goat and sheep grazing which has over the years caused many of the native species to contract. Saltbush dominates the landscape around the town and means there is a lowering of diversity in many areas around Broken Hill of native species. Predator birds are similarly affected by human activity with hot spots of easy prey found on the sides of roads. This means their range and function throughout the local ecosystem has been skewed to coincide with human activities.

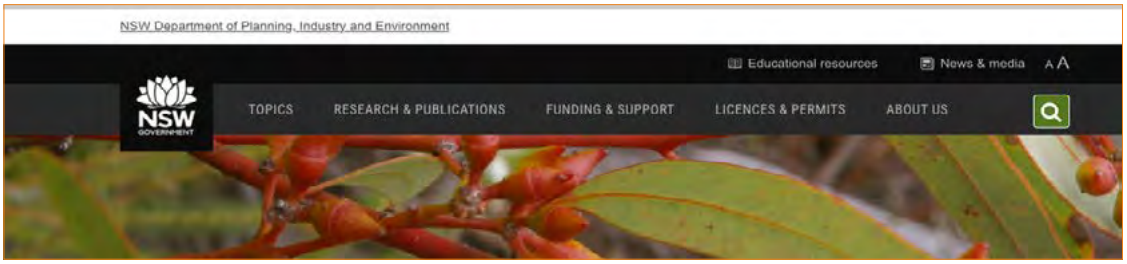
Environment / ecosystem characteristics

Typical arid vegetation communities

Source: Shutterstock

Source: Shutterstock

Information on the Broken Hill Bioregion can be found on the NSW Dept of Infrastructure and Planning website.https://www.environment.nsw.gov.au/bioregions/BrokenHillComplex-RegionalHistory.htm



Natural environment / natural history and Aboriginal heritage

Source: https://destinationbrokenhill.com.au/broken-hill/history/

Dust storm approaching

Source: David Proctor

Arid ecosystem

Source: David Proctor

URBAN PLACES – URBAN DECAY

Urban history

The city of Broken Hill has been placed on the National Heritage List due to its significant contribution to the history of Australia. It was formed as a mining town and has remained so for its entire life, with expansion into other industries. The architecture of the town reflects the history and administration, with many nods to the close ties the city has to South Australia. The houses resemble the style found in many rural areas of SA, while other large buildings have a Sydney/Melbourne colonial feel about them. Many of the original buildings are made from the local rocks and help with the extremes in weather.

Newer dwellings have followed the style of the original, however, made use of modern materials such as iron and other metal cladding being the most popular.

View down the main street

Source: Shutterstock

Causes and effects of decay

Broken Hill continued to see a boom in mining over the years leading to an associated peak in the population in the 1970s, when the town had the largest High School in the southern hemisphere at the time. This led to an expansion of the town and its facilities. This was not the trend for the population after the 70s. Many of the mines have since scaled back on their operations and miners who follow the work have left town. Houses were left vacant and savvy locals were able to snap up homes for as little as $12,000.

Trades Hall building

Source: David Proctor

Decay and traditional colours

New motel built in similar style to nearly buildings

Source: David Proctor

The decline of the population was also mirrored in the quality of housing stock in the city with decay setting in for homes across the city without regular maintenance over the years. Many homes have since been left to rot with salt damp a major issue. The lack of attention to some homes has seen them sit for sale for years, with no one interested in buying them, or even empty lots which dot the city's landscape. The population today of Broken Hill is around 17,000 and this has a chance of bouncing with the announcement of future mines opening.

The positive note is that where there is renewal in Broken Hill it is done with sympathy. Many of the stores, pubs and motels are done up with the heritage architecture and colours kept in mind.

Population change, Broken Hill

Annual change in Estimated Resident Population (ERP)									
	Broken Hill City			**New South Wales**			**Australia**		
Year (ending June 30)	Number	Change in number	Change in percent	Number	Change in number	Change in percent	Number	Change in number	Change in percent
2019	17,479	-236	-1.33	8,089,817	+109,649	+1.37	25,365,571	+382,883	+1.53
2018	17,715	-168	-0.94	7,980,168	+112,232	+1.43	24,982,688	+380,828	+1.55
2017	17,883	-231	-1.28	7,867,936	+135,078	+1.75	24,601,860	+410,953	+1.70
2016	18,114	-246	-1.34	7,732,858	+105,440	+1.38	24,190,907	+340,123	+1.43
2015	18,360	-267	-1.43	7,627,418	+110,223	+1.47	23,850,784	+346,646	+1.47
2014	18,627	-175	-0.93	7,517,195	+108,113	+1.46	23,504,138	+358,237	+1.55
2013	18,802	-183	-0.96	7,409,082	+100,877	+1.38	23,145,901	+403,426	+1.77
2012	18,985	-166	-0.87	7,308,205	+89,676	+1.24	22,742,475	+402,451	+1.80
2011	19,151	-116	-0.60	7,218,529	+74,237	+1.04	22,340,024	+308,274	+1.40
2010	19,267	-154	-0.79	7,144,292	+90,537	+1.28	22,031,750	+340,097	+1.57
2009	19,421			7,053,755			21,691,653		

Source: .id the population experts https://economy.id.com.au/broken-hill/population/

Powered by .id - the population experts for Broken Hill City

PEOPLE AND ECONOMIC ACTIVITY – MINING/TOURISM

Mining

Broken Hill has a rich history in its mining, and it is no surprise the BHP is where it all began. Lead, zinc and silver ore are the main minerals and metals found in Broken Hill. BHP has been replaced by other operations in the city with two new operations recently being announced this year. An effect of this has been many homes for sale suddenly being taken off the market with buyers eager to snap up a bargain before prices rise.

$100 billion of wealth is said to have been generated from Broken Hill so far and it looks as if this is to continue if mining operators continue to see viability. Currently exploration occurs and blasting is felt daily. Depending on how deep the blasting occurs you can feel the ground (and often your house) shake at 6:45am and pm. Another bit of mining trivia: there are more traffic lights underground than above in Broken Hill.

The town has certainly come to life because of mining and is one of the major employers in town (about 10% of the workforce). However, there are efforts being made in areas of tourism and entertainment to see that it doesn't die if mining does. One of the big impacts of the decline in the mining workforce over the years has been the number of older people who have remained in the city in retirement. This, along with other factors, has led to a greater need for social and medical support services.

Line of Lode dominating the city skyline

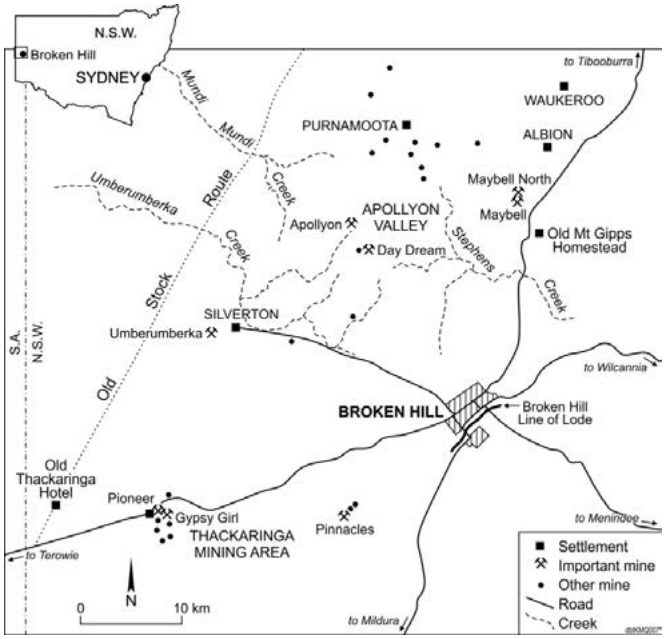
Source: David Proctor

Tourism

COVID-19 has hurt towns like Broken Hill. There has always been a greater affinity with Adelaide (distance and sharing the same time zone) and the border restrictions with South Australia and the only other major centre nearby, Mildura in Victoria, have seen visitor numbers decrease this year. The relaxing of the borders has seen a change though in town in recent weeks, along with the recent NSW school holidays seeing a major boost to tourism. Sadly, festivals and celebrations have much like other locations been called off including the famous Broken Heel festival which attracts people from around Australia to celebrate LGBTQ+ people.

The influx of tourists has seen stronger trade in all sectors of the tourism and hospitality economy in the last few weeks according to local business owners, many of whom had staff on job keeper payments and no prospects of a bright future. The droughts which frequently hit Broken Hill and the decline in mining, have also played a role in the decline in local tourism and spending in town.

Location of Broken Hill in NSW and historical mine map



Source: Mcqueen, Kenneth. (2016). 'Tackaringa': First step to Broken Hill. Journal of Australasian Mining History. 14. 77–98.

Mad Max Museum

Source: Shutterstock

Line of Lode Miners Memorial

Source: Shutterstock

The strategic plan for tourism has some highlights that show a strong focus on tourism as revenue stream for the city and wider outback with a focus on promotion, use of technology including apps and prizes(buried silver bars), and encouraging filming in town – the latest is a mini-series based on the Royal Flying Doctors service which has been filming throughout the last few months in town.

Popular tourist destinations include natural and cultural places of interest including Living Desert Sculptures, Living Desert Flora and Fauna Sanctuary, Mutawintji National Park, Mundi Mundi Plains, Outback Astronomy, Original Silverton Hotel and Mad Max Museum.

Living Desert sculpture and surrounding plains

Source: David Proctor

Story poles in the Living Desert

Urban Dynamics of Change in Sydney Olympic Park, Newington, Rhodes and The Waterfront

Jaye Dunn, Epping Boys High School

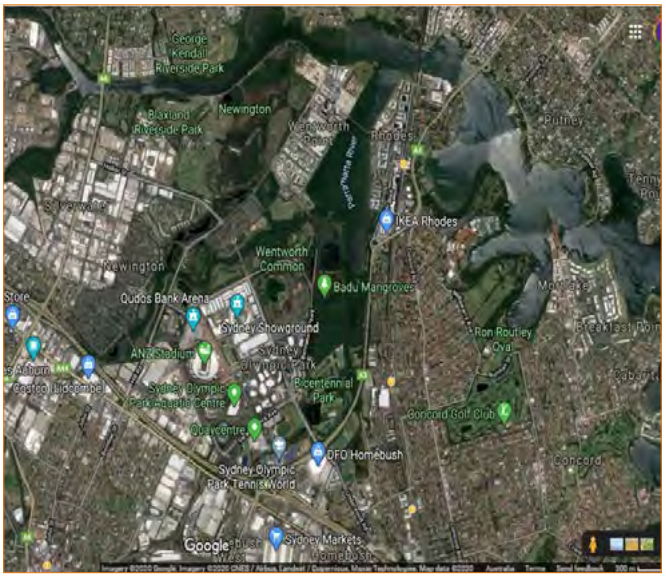
Syllabus Content

The urban dynamics of change: suburbanisation, exurbanisation, counterurbanisation, decentralisation, consolidation, urban decay, urban renewal, urban village, spatial exclusion

A case study showing one of the urban dynamics listed above, operating in a country town or suburb.

The concept of *urban dynamics* refers to the constant change and development of urban areas by any or all of the key processes; suburbanisation, exurbanisation, counterurbanisation, decentralisation, consolidation, urban decay and renewal, urban village creation or spatial exclusion. Population growth has led to an increasing need to accommodate people in urban places, particularly in Sydney. The inner western suburbs of Sydney Olympic Park, Newington, Rhodes and the relatively new inclusion of Wentworth Point are examples of areas undergoing continual and dynamic change.

Figure 1: The suburbs of Sydney Olympic Park, Newington, Rhodes and Wentworth Point are located approximately 13km from the Central Business District of Sydney. This makes them prime locations for residential and retail.



Source: Google maps

The area was once heavily focused on industry. The Sydney Olympic Park site, for example, has been home to an abattoir, armory, brick pit and assorted factories over the last one hundred years. At the turn of the century, a booming population gave rise to the need for increased industrial activity to provide resources for building homes, particularly bricks. Plastic production and chemical manufacturing emerged between the 1940s and 1960s. As a result, the adjoining Homebush Bay was thought to be the fourth most polluted waterway in the world, due to chemical and organic run-off. The high levels of pollution were especially problematic for the adjacent Badu Wetlands, a crucial home for several native species and an essential location for birds and juvenile fish. This can be covered in detail in the *Ecosystems at Risk* topic.

Source: National Library of Australia

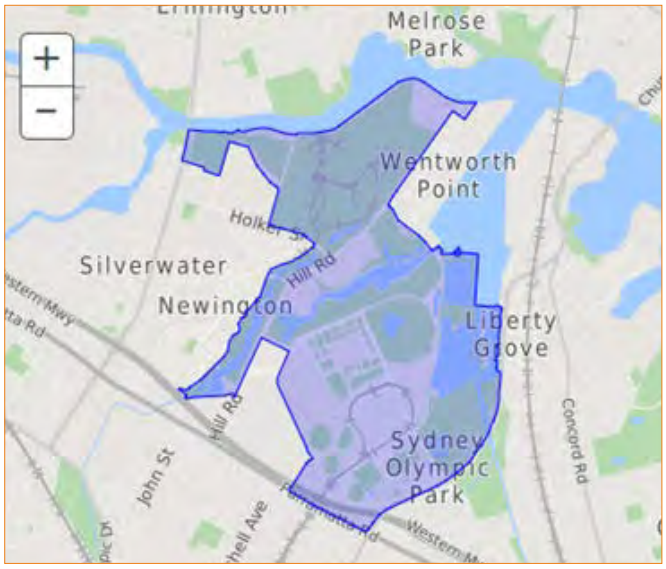
The severe ecological damage to the precinct started to attract more attention during the 1970s and 1980s, in tandem with a greater appreciation of its potential use for future population growth. As such, a goal of remediation was planned. The first part of

the plan was the development of Bicentennial Park in the early 1980s for the 1988 Australian Bicentenary. Construction began in 1983 with the aim to create 100 hectares of parkland to be used for the personal enjoyment of locals and tourists. The core principles were *sustainability* and longevity of the area to improve *liveability*, protect *biodiversity* and increase *air quality* by creating large areas of green space. Additionally, the area would eventually include residential, employment, conservation and recreation.

When Sydney won the 2000 Olympic Games in 1993, the site was chosen for the Games due to its proximity to the CBD and the area in its current form lacked purpose and clear vision. Thereafter, full scale remediation and development became the priority. In addition, the plan aspired to create a space that would continue to grow and evolve well after the Games had moved on, unlike many other locations of past Olympic Games.

The Games came and went, and the vision to see the area remain a vibrant urban space was followed through with vigour. This led to the development of Sydney Olympic Park as an official suburb (in 2009) to include employment, housing and greenspace for its residents and visitors. Sydney Olympic Park is 640 hectares in size, including 430 hectares of urban parkland. The Australian Bureau of Statistics cites 100% apartment living (as pictured), with a population at the 2016 census of 1,736. Additionally, the median weekly household income was $1,768 and the median age of residents was 31.

Figure 2



Source: MapData Services

Urban renewal, adaptive reuse, urban consolidation and sustainability were paramount focus areas in the development of Sydney Olympic Park as a "go-to" location. The remediation and rezoning of the location are ideal examples of urban renewal. The area had suffered significant decay during and after the closure of industrial activity in the mid-20th century. The consolidation of unused and dilapidated areas by converting them into residential, economy and recreation was effective and led to the development of the new Sydney Olympic Park suburb. Whilst a lot of the new buildings possess a modern feel, the historic *"culture of place"* has been maintained by repurposing original heritage buildings through the process of *adaptive reuse*. For example, the main abattoir administration building is now used as the headquarters of Paralympics Australia (pictured). Similarly, what was once a naval armory is now the highly popular Blaxland Riverside Park and Arts and Culture Precinct. A final example is the adaptation of the former brickpit site into the Ring Walk (pictured). The area acts as a place of leisure, along with having significant conservational importance as vital habitat for the endangered green bell frog, along with being a catchment for water run-off.

LEFT: High-rise development, Sydney Olympic Park

FAR LEFT: Abattoir heritage precinct, Sydney Olympic Park. Source: Wikimedia

Brickpit Ring Walk

Principles of sustainability have been given high priority in the design of Sydney Olympic Park. Effective examples of environmentally sound practices are scattered all over the location and often without being obvious. Examples include:

Specialised building designs – the Lion building incorporates solar panels and principles of energy efficiency, earning it a five-star sustainability rating. Similarly, the Sydney Olympic Park train station's leaf-shaped roof (pictured) maximises run-off and the entry of sunlight. The Qudos Bank Arena's roof is insulated with used phone books, demonstrating a novel and unique form of recycling.

Sydney Olympic Park station entrance. Source: Wikimedia Commons

Infrastructure designs – many areas around the precinct have been designed to maximise run-off to the purpose-built on-site Water Reclamation Plant. Collected run-off is recycled and reused throughout Sydney Olympic Park, Newington and Wentworth Point. Design features include sloped pavement toward the centre of Olympic Boulevard (pictured), gutter breaks to allow water to flow into the drains with ease and permeable pavement (pictured) around deciduous trees to allow temperature regulation in the restaurant zone.

RIGHT: Sydney Olympic Park lighting and landscaping. Source: Wikimedia Commons

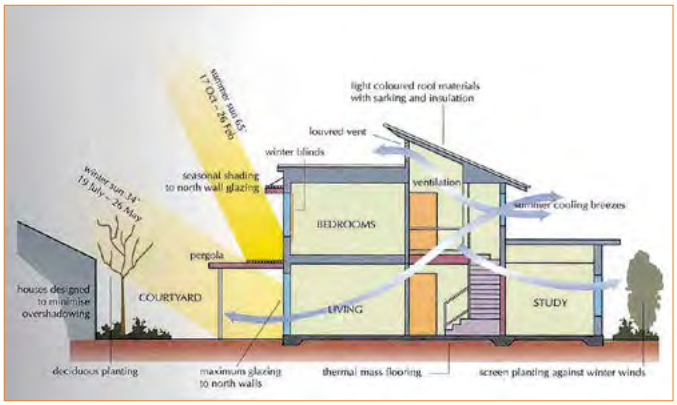
Blaxland Riverside Park and Arts and Culture Precinct

Olympic Boulevard pavement and tree planting

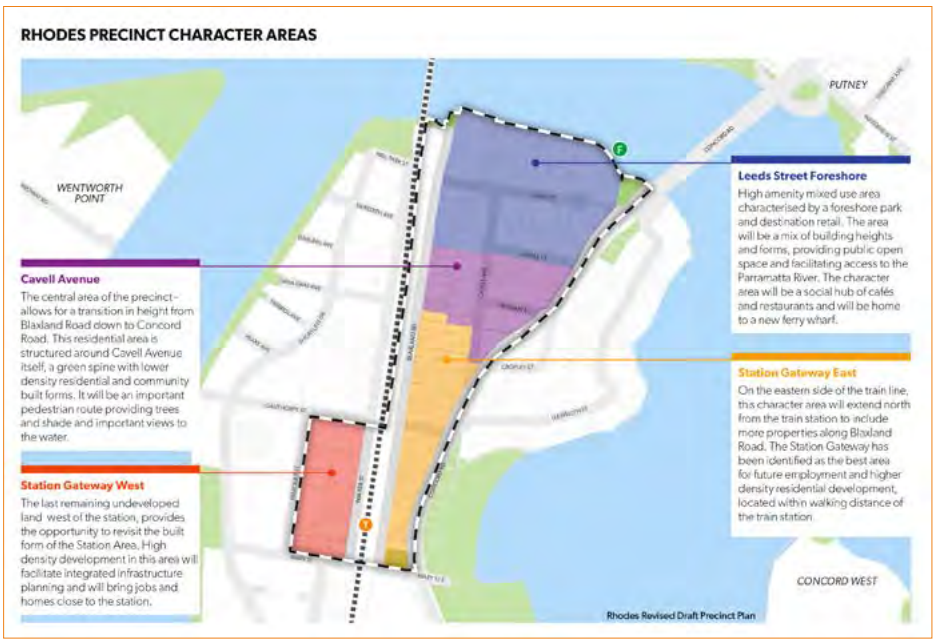
The ***Sydney Olympic Park 2030 Master Plan*** is the key document focusing on the ***future directions*** and plans for the precinct. This prospectus outlines the ambition to continue the development of Sydney Olympic Park as a key location for lifestyle, employment, recreation and environmental sustainability. The location of SOP, a short distance from the commercial centre of Parramatta, means that it is a sensible choice for residential and economic development. The Plan aims to make SOP a go-to location by building 10,000 new homes for 23,500 new residents, to cater for 34,000 new jobs and 100,000m2 of retail space. This will be pursued with high standards of liveability and economic growth in mind. The SOP Authority wants to stand true to the goal of ensuring the longevity of the location long after the Games, and also be a leader in the development of urban places that offer an attractive lifestyle, as well as the necessary amenities for everyday life.

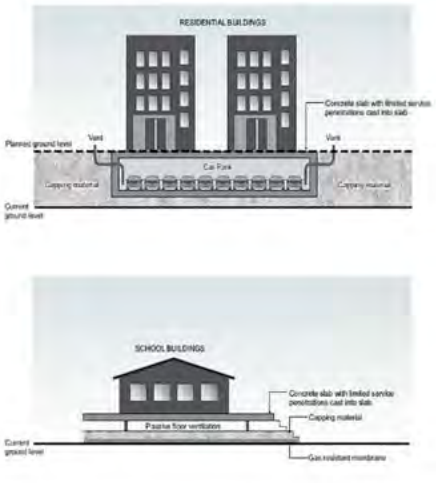
Neighbouring suburbs

The suburb o***f Newington*** was the home of the athletes during the Sydney Olympic Games. Whilst originally designed for the Games, there was always an aim to sell the residential facilities and create a suburb that thrived long after the year 2000. Central to its design were principles of sustainability and liveability for residents. It was built to include the use of recycled water from the SOP Water Reclamation Plant, and a focus on solar energy with a move away from air conditioning. Also, Newington was created under Community Title, one of the first such developments in Australia, and as such has very strict rules regarding the use of space and the architectural design of the suburb. Mixed density residential was a priority and houses were specially designed to make use of natural ventilation, access to sunlight (diagram pictured) and the surrounding greenspace. There is widespread use of natural gas within homes, and during construction effort was taken to minimise construction waste. Newington has continued to grow since the Games and is now home to 5,802 people, almost double the population in 2001 when the suburb first welcomed private residents. Newington now supports thriving Chinese and Korean populations, creating a sense of community for newer Australians and a distinct *culture of place*.



Another nearby location, ***Rhodes***, is a example of urban renewal. The area was once a place to manufacture cast iron pipes for gas and city water reticulation purposes, however, redevelopment in the 2000s has led to the creation of a highly popular mixed use precinct. Major remediation was required to make the site habitable, and now includes an abundance of employment and economic land nestled between surrounding parklands and Homebush Bay. Rhodes covers only one square kilometre but has a population of 11,906 (an increase of 10,000 from 2006) with a median weekly household income of $1693 as per the 2016 census. The original design principles limited residential buildings to no more than five storeys in height, ensuring residents did not feel overcrowded while maintaining the general aesthetic of the area. However, changes to this plan have led to higher density developments, increasing the population and the demand for services, particularly transport infrastructure. The Bennelong Bridge opened in 2016 to increase pedestrian access to the SOP and surrounding parklands, while simultaneously providing residents of Wentworth Point easier access to train services. Future plans for Rhodes include more greenspace, increasing density and the creation of more mixed use areas, as pictured. Whilst the skyline of the area will change dramatically, there is an emphasis on maintaining the character of the area and a focus on environmental sustainability.





Source: https://www.planning.nsw.gov.au/-/media/Files/DPE/Plans-and-policies/Rhodes/rhodes-revised-draft-precinct-plan-part-2-2018-12-07.pdf

Finally, a quick look at the nearby ***Wentworth Point,*** with a population of 6,994 and a median weekly household income of $1,877, as a prime example of ***urban renewal and consolidation***. What was once a site for industry has quickly become a thriving example of urban consolidation.

Since 2014, warehouses and manufacturing infrastructure have made way for a mixed-use urban activation precinct. The plan is still in motion but thus far has incorporated several key design features, such as:

- Plenty of open space, utilising the nearby SOP and the creation of a new Peninsula Park;
- Community facilities including the expansion of the existing community centre and the shared use of parks and fields with the newly created Wentworth Point Public School;
- Building essential infrastructure such as transport and education, including the Bennelong Bridge and increasing ferry access to SOP. There is also new cycle and pedestrian walkways to encourage non-car related travel;
- Affordable housing is being considered with Housing NSW aiming to take ownership of an allocated number of dwellings;
- Improved retail access as part of the mixed-use design to encourage the development of a unique 'culture of place' as a location of nightlife and cafes; and
- Sustainable design principles such as permeable surfaces, recycled water from the SOP Water Reclamation Plant and restricted building height to reduce shadow and improve liveability. Furthermore, buildings have been designed to maximise natural air flow and ventilation, as shown in the image. Site decontamination and remediation was required prior to construction due to increased sulfate and acid levels.

To conclude, the suburbs of Sydney Olympic Park, Newington, Rhodes and Wentworth Point were developed to maximise the use of existing land and create more residential and mixed-use opportunities to curb the ever growing issue of urban sprawl in Sydney. All are effective examples of urban dynamics and the constant change of urban morphology. Sydney Olympic Park runs several excursions and the Stage 6 Urban Places Excursion is highly recommended and is an excellent way to see all these processes in action.

Sanctuary Apartments, Wentworth Point

Bennelong Bridge, linking SOP & Wentworth Pt. Source: Wikimedia Commons

AQUACULTURE

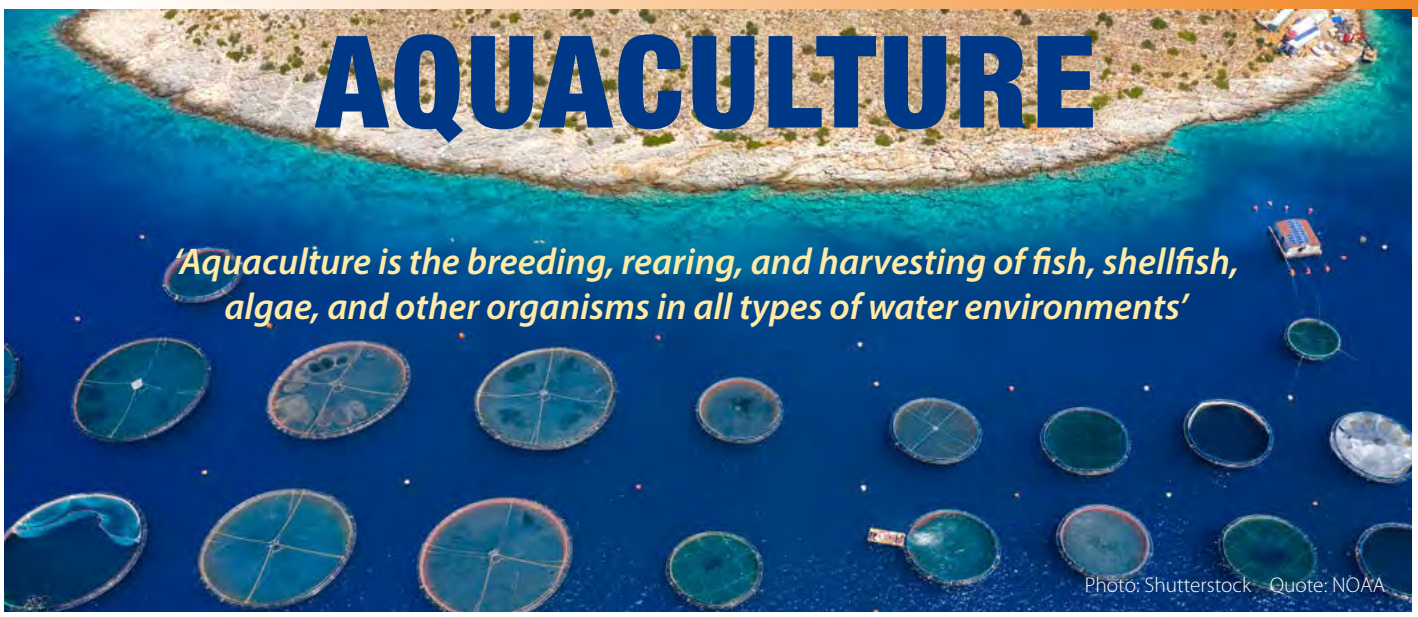


Photo: Shutterstock Quote: NOAA

Lorraine Chaffer, Vice President GTA NSW & ACT

APPROACH 1: Economic Activity (global) – AQUACULTURE
Economic Enterprise (local) – e.g. a salmon, oyster, prawn farm or business

Note: This would suit schools who have a local aquaculture venture e.g. oyster farm they could visit for fieldwork but there may not be sufficient material to focus on that single activity at a global scale.

APPROACH 2: Economic Activity (global) – SALMON AQUACULTURE (or other species)
Economic Enterprise (local) – e.g. a salmon farming business

THE NATURE OF AQUACULTURE

'We must plant the sea and herd its animals, using the sea as farmers instead of hunters'.

Jacques Cousteau

ENGAGE

- Conversation starter: ***Why is aquaculture viewed as both an ecological saviour and an ecological villain of global seafood production?***
- Stimulus: Deep Sea Fish Farming with Geodesic Domes (10 minutes) https://www.youtube.com/watch?v=NSZV_Ikrg0s

  Farms under the sea could feed the world in 2050 (6 minutes) https://www.youtube.com/watch?v=Pm58yVMT3MY

INVESTIGATE

a. Key characteristics

- Aquaculture is the *farming* of fish, crustaceans, molluscs, aquatic plants, algae, and other organisms. It involves cultivating freshwater and saltwater species under controlled conditions, in contrast with *capture fisheries*, that harvest wild populations. Farming implies intervention or control over elements of production such as breeding, feeding, containment and protection from predators.
- Aquaculture is one of the world's fastest growing economic activities which, along with capture fisheries, provides *food* to global markets. Aquaculture also provides *feed, fibre, medicinal, cosmetic and consumer products* eg. nutritional supplements and is used to rebuild stocks of species that have been overhunted or harvested.
- Aquaculture has a *long history*, having been practiced for around 4000 years. The Romans (c. 2500 BC), the Chinese (c. 3500 BC) and indigenous peoples in the Americas and Australia all practiced aquaculture.
- Methods of production range from *traditional to scientific and technologically advanced* such as ocean cages with remote feeding systems; scientifically developed fish foods that optimise nutrients and reduce waste; and sophisticated climate controlled indoor facilities.
- *Ownership* of aquaculture ventures varies from small family farms to large Transnational Corporations (TNCs), a feature expected to increase in the future.

b. Diversity

As well as farming a large number of different species in a variety of environments, aquaculture is a diverse activity. It can be:

- *extensive* or *intensive*.
- *subsistence* or *commercial*
- *fresh water* or *saltwater*
- *inland* or *ocean / estuary* (mariculture)
- *'in-situ'* (in bays, estuaries and rivers) or *"ex-situ"* (in tanks, ponds and fish runs).

***Extensive*:** low management, low investment or operating costs e.g. Nile Perch in Lake Victoria

***Intensive*:** human manipulation is prominent and outdoor sites are confined to distinct areas e.g. pearling in Broome, salmon in Tasmania.

***Subsistence*:** exclusively for consumption by the producer or for barter in a local community e.g. fish raised in Asian rice paddies.

***Commercial*:** exclusively for sale e.g. salmon farming in Canada, seaweed farming in Indonesia.

***Freshwater*:** inland rivers and waterways. e.g. carp, eels, trout.

***Mariculture*:** marine plants and animals e.g. prawns, oysters, mussels, seaweed

c. Production

'The Ocean is not a grocery store; we can't continue to take like this without some serious results'
Brian Skerry for the World Economic Forum

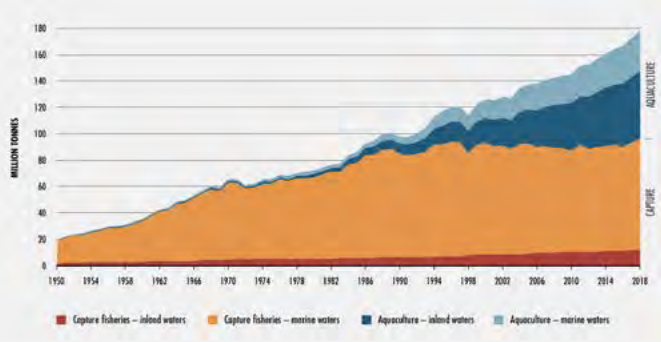
Is our world ready for a blue revolution? A view on fishing and aquaculture from 2009 that still rings true today. TED TALK https://www.youtube.com/watch?v=uk2g9t0KdO4

As human populations and seafood consumption have risen, the global abundance of wild fish has not. Wild harvests have plateaued for over 30 years while aquaculture production has increased globally to meet demand – by 5.3% between 2001 and 2018. (Figure 1). Asia produced 89% of global aquaculture output over the last two decades. Most aquaculture production is finfish (Figure 2) and freshwater aquaculture contributes more than mariculture. Mariculture dominates in Japan compared to China where production is mostly freshwater, however mariculture is increasing e.g. shrimp farming. Other major producers are Egypt, Chile, India, Indonesia, Vietnam, Bangladesh and Norway. (Figure 3)

In Australia the production volume of aquaculture increased by 4% in 2017 – 2018, accounting for 36% of total fisheries and aquaculture production - up from 26% in 2008. The gross value of production (GVP) of aquaculture increased by 5% to $1.42 billion in 2017–18 – the fourth consecutive rise since 2013–14. (Figure 4).

Aquaculture production is projected to reach 109 million tonnes in 2030, an increase of 32 percent over 2018. China's Thirteenth Five-Year Plan (2016–2020) will continue to see a transition from extensive to intensive aquaculture.

Figure 1: World capture fisheries and aquaculture product ion 2018



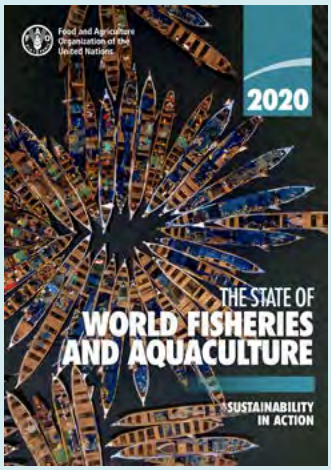
Source: FAO State of World Fisheries and Aquaculture Report 2020 http://www.fao.org/publications/sofia/en/

Figure 2: Finfish

Finfish is the term used to describe a group of fishes, sometimes called true fishes, to distinguish them from other aquatic life whose common names also end in "fish", including molluscs (e.g., cuttlefish), crustaceans (e.g., crayfish), echinoderms (e.g., starfish), and other animals (e.g., jellyfish); or any other aquatic life harvested in fisheries or aquaculture (e.g. shellfish).

Text: https://iss-foundation.org/glossary/finfish/
Image: https://e360.yale.edu/features/can-deepwater-aquaculture-avoid-the-pitfalls-of-coastal-fish-farms

Figure 3: Global aquaculture production



'World aquaculture production attained another all-time record high of 114.5 million tonnes in live weight in 2018, with a total farmgate sale value of USD 263.6 billion. The total production consisted of 82.1 million tonnes of aquatic animals, 32.4 million tonnes of aquatic algae and 26 000 tonnes of ornamental seashells and pearls. The farming of aquatic animals in 2018 was dominated by finfish (54.3 million tonnes).

The farming of aquatic animals in 2018 was dominated by finfish (54.3 million tonnes, USD 139.7 billion), harvested from inland aquaculture (47 million tonnes, USD 104.3 billion) as well as marine and coastal aquaculture (7.3 million tonnes, USD 35.4 billion). Following finfish were molluscs (17.7 million tonnes, USD 34.6 billion) – mainly bivalves – crustaceans (9.4 million tonnes, USD 69.3 billion), marine invertebrates (435 400 tonnes, USD 2 billion), aquatic turtles (370 000 tonnes, USD 3.5 billion), and frogs (131 300 tonnes, USD 997 million).

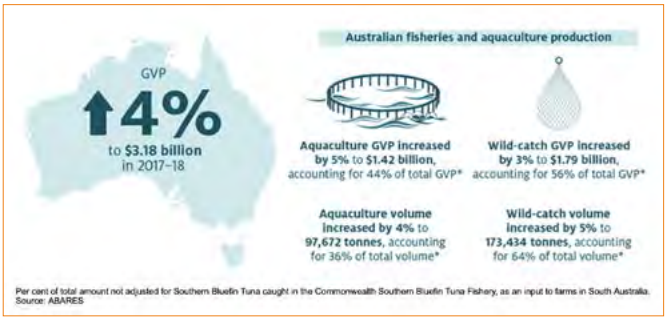
World aquaculture production of farmed aquatic animals grew on average at 5.3 percent per year in the period 2001–2018, whereas the growth was only 4 percent in 2017 and 3.2 percent in 2018. The recent low growth rate was caused by the slowdown in China, the largest producer.

In 2018, inland aquaculture produced 51.3 million tonnes of aquatic animals, accounting for 62.5 percent of the world's farmed food fish production, as compared with 57.9 percent in 2000. Mariculture and coastal aquaculture collectively produced 30.8 million tonnes of aquatic animals in 2018.

Despite technological developments in marine finfish aquaculture, marine and coastal aquaculture produce currently many more molluscs than finfish and crustaceans. World aquaculture production of farmed aquatic animals has been dominated by Asia, with an 89 percent share in the last two decades or so. Among major producing countries, Egypt, Chile, India, Indonesia, Vietnam, Bangladesh and Norway have consolidated their share in regional or world production to varying degree over the past two decades.'

Source: The State of World Fisheries and Aquaculture 2020

Figure 4: Australian aquaculture production 2018



Source: ABARES https://www.agriculture.gov.au/abares/research-topics/fisheries/fisheries-and-aquaculture-statistics/production-2018#gvp-increases-by-4-in-201718-to-318-billion

d. Consumption

As many parts of the world's oceans face *overfishing by capture fisheries* and popular species become severely depleted, aquaculture has grown increasingly important.

Demand for fish and other aquatic products has risen rapidly over the past 30 years. Australians for example are now consuming 13.5kg of seafood per head per annum (ABARES) compared with 3kg in the 1950's. Seafood prices have risen rapidly as well with increased demand.

Increasing demand for seafood can be attributed to:

- Rising incomes worldwide
- Greater wealth in western countries is increasing the demand for luxury items such as prawns, oysters, crayfish, caviar and crabs
- Newly acquired tastes for fashionable items such as smoked salmon and sashimi and other exotic seafood
- Multicultural influences introducing new tastes for meats such as calamari and sea urchin
- Healthy lifestyles resulting from improved dietary knowledge and demand for fish that is high in protein and essential oils and good fats e.g. Omega 3
- Environmental concerns associated with the production of livestock eg methane emissions, land clearing and climate change

Trade

Seafood is one of the most traded food commodities in the world. Recent increases in seafood trade (4% in 2019) have been mainly driven by farmed species, particularly high-value crustaceans and marine species and lower-value whitefish species traded from Southeast Asia to western countries – a trend expected to continue.

Trade dynamics and routes are likely to change in the future with increasing protectionism, uncertainties in trade relations among trading partners (e.g. Brexit, US-China), the growing aquaculture sector in different parts of the world using new technologies (e.g. land-based and offshore farms), and biological challenges.

COVID-19 has impacted global trade and production in 2020. Projections for the future are based on an assumption of significant disruption in the short run for production, consumption and trade, with a recovery in late 2020 or early 2021.

See Huon Aquaculture illustrative example.

SPATIAL PATTERNS

Aquaculture is a global activity, occurring in almost every country, with Asian countries dominating global production and China dominating in Asia. Generally, higher production occurs in countries with a long history of aquaculture e.g. China and diets incorporating aquatic species e.g. Norway. There is generally less aquaculture production in countries and regions that have large wild catch fisheries e.g. Oceania.

Spatial patterns vary by species, continents and countries due to cultural preferences, biophysical conditions or both. Norway and Chile are renowned for salmon farming that takes advantage of an abundance of cold, high quality water in bays and fjords while shrimp farming is dominated by countries with warmer, shallow bays and inlets such as China, Indonesia and Vietnam.

Other examples of species farmed in different countries

- China: seaweeds and carp and shrimp predominate.
- Japan: yellow tail, bream, salmon, tuna, prawns, oysters, scallops, abalone, algae.
- Russia: sturgeon, salmon, carp, roe.
- North America: catfish, salmon, trout, oysters, prawns (shrimp),
- Europe: catfish, salmon, oysters, mussels, eels.
- Australia: salmon, snapper, oysters, tuna, prawns, pearls, abalone.

See illustrative examples: Seaweed Aquaculture and Huon Aquaculture (Salmon)

For graphs on production, consumption and future projections see:

State of the World's fisheries and Aquaculture 2020 (Document and interactive)
http://www.fao.org/publications/sofia/en/

Prospects for aquaculture by 2030
http://www.eurofish.dk/att/presentations/04-Adrienne.pdf

GTA Bulletin – Vol 52, Special Edition PPT


Source: https://commons.wikimedia.org/wiki/File:Aquaculture_Western_Greece_2004.jpg

FACTORS INFLUENCING THE NATURE, SPATIAL PATTERNS AND FUTURE DIRECTIONS OF AQUACULTURE

BIOPHYSICAL FACTORS

i) Species requirements (Hydrosphere and Atmosphere)

Different species used in aquaculture production require a particular set of *environmental conditions*. Localities that best meet these requirements will have a *competitive advantage*. These conditions will determine where that activity can be located.

The production of *South Sea Pearls* requires sheltered shallow bays with clear warm water. Broome in Western Australia has the ideal biophysical conditions making it the most important pearling centre in Australia. The production of *salmon* requires cold, clean waters, both fresh and salt. Tasmania provides these conditions. When Australia is in drought and Tasmania faces warmer summers production declines. Some aquaculture species require *fresh water*, e.g. yabbies. Others such as shrimp and abalone require salt water. Some like salmon require both environments – the fish hatch in fresh water and grow in brackish water, maturing in saltwater.

Technology is making the impact of biophysical factors less important for some species with production in indoor facilities where computers control environmental conditions and *climate change* is impacting on the viability of some aquaculture activities, especially those in shallow coastal waters.

ii) Water quality

Water quality is one of the most important requirements for successful aquaculture. Pollution can seriously effect production and aquaculture can cause a serious deterioration of water quality. In many areas of the world aquaculture ventures have failed because they have not been ecologically sustainable i.e., they have not maintained the water quality necessary for their survival and have had a disastrous environmental impact and explosion in aquatic diseases. In the past white shrimp farms in China collapsed after they polluted the very water they needed to operate successfully.

iii) Landforms (Lithosphere)

The ideal sites for many maritime activities are flat coastal lands that flood easily or sheltered bays and river estuaries. Figure 5 Inland freshwater lakes and farm dams or village ponds are ideal sites for freshwater species, e.g. Lake Victoria in Egypt and village ponds in China and Japan. Many aquaculture ventures are therefore established in coastal locations or existing lakes and dams.

See illustrative examples: Seaweed Aquaculture and Huon Aquaculture (Salmon)

Figure 5: Coastal bays, inlets and estuaries suit marine aquaculture production

Shutterstock: Salmon farming cages in a coastal estuary

iv) Conflicting water uses

In Asia and South America areas suited to aquaculture are often sites of subsistence rice farming or mangrove forests utilized for resources such as timber and fish. This has resulted in the displacement of traditional farmers and clearing of wetlands.

In coastal areas in the developed world there is also increasing conflict for suitable aquaculture sites with residential, recreational, farming and capture fishing activities. In the Huon Valley estuary in Tasmania landowners claim that salmon aquaculture cages are reducing their property values and sailing clubs are upset about the reduction in the areas within the bays where they can hold regattas.

> 'There are serious constraints on aquaculture's growth. For one, fish farming requires both land and water - two resources in short supply in many areas. In Thailand both these resources have been diverted in recent years to fuel the growth of the aquaculture industry. For example, nearly half the land now used for shrimp ponds in Thailand was formerly used for rice paddies: in addition, water diversion for shrimp ponds has lowered ground water levels in some coastal areas. In China, the concern over loss of arable land has led to restrictions on any further conversion of farmland to aquaculture ponds'
>
> World Resources Institute

ECONOMIC FACTORS

Economic factors are associated with money and capital. As global demand for seafood currently outweighs supply, aquaculture is seen as an economically viable activity for the future as prices are high and supplies are low. This varies on a regional and national scale. Australia imports large amounts of fish to satisfy demand, however, Australia still exports some products such as salmon, pearls and Western Rock lobsters. Peru and Chile are major exporters of seafood.

i) High incomes and profits

There are opportunities to earn high incomes e.g. abalone earns up to $70 per kilogram. Western Rock lobsters can fetch $90 per kilogram and seahorses $1200 per kilogram in the Asian market. For this reason, aquaculture is said to have a very positive economic outlook for the future.

ii) Capital-intensive operations

Set up costs for some ventures are very high e.g. seahorse farms in Tasmania require indoor, climate-controlled facilities and computer monitoring as well as continued research and development. Salmon farms in Tasmania require hatcheries, sea cages and computer-controlled feeding mechanisms. Pearling involves scientific implantation of seeds into oysters – which is carried out in laboratories.

See illustrative example: Huon Aquaculture

On the other hand, yabbies are raised in farm dams in Australia and fish are raised in paddy fields in China. Neither requires huge capital outlays or equipment.

The need for capital equipment affects the spatial pattern of many aquaculture ventures. Europe has the most technologically advanced aquaculture farms because of the level of development means there is capital to invest. In the Pacific Islands aquaculture ventures are largely subsistence activities due to a low level of economic development and lack of investment capital. South Sea pearls are less perfect than "cultured" pearls grown in Australia's northwest around Broome because they involve low levels of technology.

The nature of aquaculture in different parts of the world is a reflection of economic factors. In Asia a significant amount of aquaculture takes place in ponds and dams using ancient techniques such as polyculture. In Australia and Europe, many aquaculture farms use expensive tanks often indoors using capital-intensive equipment and software to maintain temperatures, water flows and filtering.

iii) Exchange rates.

The value of a country's currency can affect the economic viability of aquaculture by affecting demand in other countries. In 2001 the Australian dollar was worth than less than 50 US cents. This meant Australian products were cheaper overseas, so demand increased. In 2012 the Australian dollar rose to over $1.00 US cents to the Australian dollar. This reduced demand for Australian products. In 2020, the Australian dollar fluctuated around 65 – 70 cents to the US dollar.

iv) Economic trade-off in poorer countries

There are some unfortunate *social consequences* of the high value of seafood on global markets.

These include:

- *Poorer countries* have been taking advantage of the high value of seafood by selling it overseas. Unfortunately, countries are often selling one of their main sources of protein and their own population suffer from malnutrition as a result. Many African countries suffer from the commercialisation of traditional fisheries.
- In some *coastal countries* such as Ecuador and the Philippines land has been sold to large TNC's for shrimp farms. Traditional farmers are no longer able to farm rice and huge areas of mangroves have been lost. The consequences have been social as well as environmental (see later notes on environmental factors and sustainability).

v) Economic benefits

The development of aquaculture can have a positive economic impact on a community, a region and a country. In developing countries aquaculture is seen as a means of providing *employment* and important *foreign exchange*. Unfortunately, this often comes at both a social and environmental cost – in Ecuador for example, the environment and indigenous communities were devastated by shrimp farming. In developed countries aquaculture is both a source of employment and a means of satisfying local markets and earning foreign exchange.

Government economic policies such as trade agreements, tariffs and subsidies can impact on the viability of aquaculture activities. Many European Union countries apply tariffs to imported seafood. This means Australian produce cannot compete with locally produced seafoods. This reduces the size of the market available to Australian producers.

ECOLOGICAL FACTORS

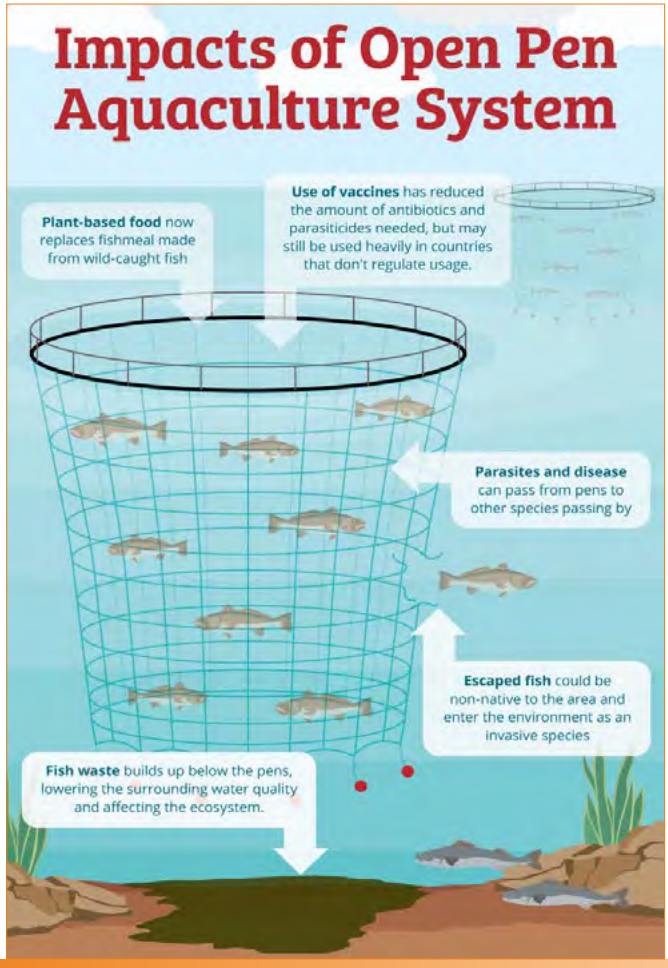
i) Sustainability

The principle behind ecologically sustainable economic activities is that we should use resources to meet the needs of the present without compromising the ability of future generations to meet their needs. The farmers should work with nature rather than against it to ensure the basic ecological processes are not disturbed to the extent that they cannot function in the future.

In the case of aquaculture, the hydrosphere and its maintenance are crucial. The quality and quantity of water must be maintained to ensure the activity itself can be sustained as well as ensuring the survival of any aquatic ecosystems.

A failure to remain ecologically sustainable will impact on the future of the activity, destroying the biophysical environment in the process. Currently, the farming of many species is not environmentally sustainable. Criticisms of aquaculture being ecologically unsustainable have grown in recent years and include the removal of mangrove ecosystems; the use of fish meal (farming the seas to feed the fish); the susceptibility of monocultures to diseases and impacts of escaped species on ecosystems (Figure 6).

Figure 6: Environmental impacts



LEFT: Environmental impacts of fish farming https://www.fix.com/blog/breaking-down-fish-farming/

Salmon cages, Norway. Source: Wikimedia Commons

There are many examples of failed aquaculture ventures because the environment was destroyed.

- White shrimp farms in China. Effluent pollution from these farms destroyed the aquatic environments of the bays and estuaries in which the farms were located. Water quality deteriorated, disease affected the shrimp and production continued to decline resulting in eventual failure. A focus on more sustainable practices is seeing a slow recovery.
- Sea cage farming of salmon has been widely criticised for the amount of nutrients added to the waters around the farms. It takes 100 tonnes of food pellets to produce 50 tonnes of salmon but 20% of the feed falls to the sea floor along with fish faeces.
- Some enterprises use live fish feed or fishmeal harvested from the ocean…not a sustainable practice in our already overfished oceans.

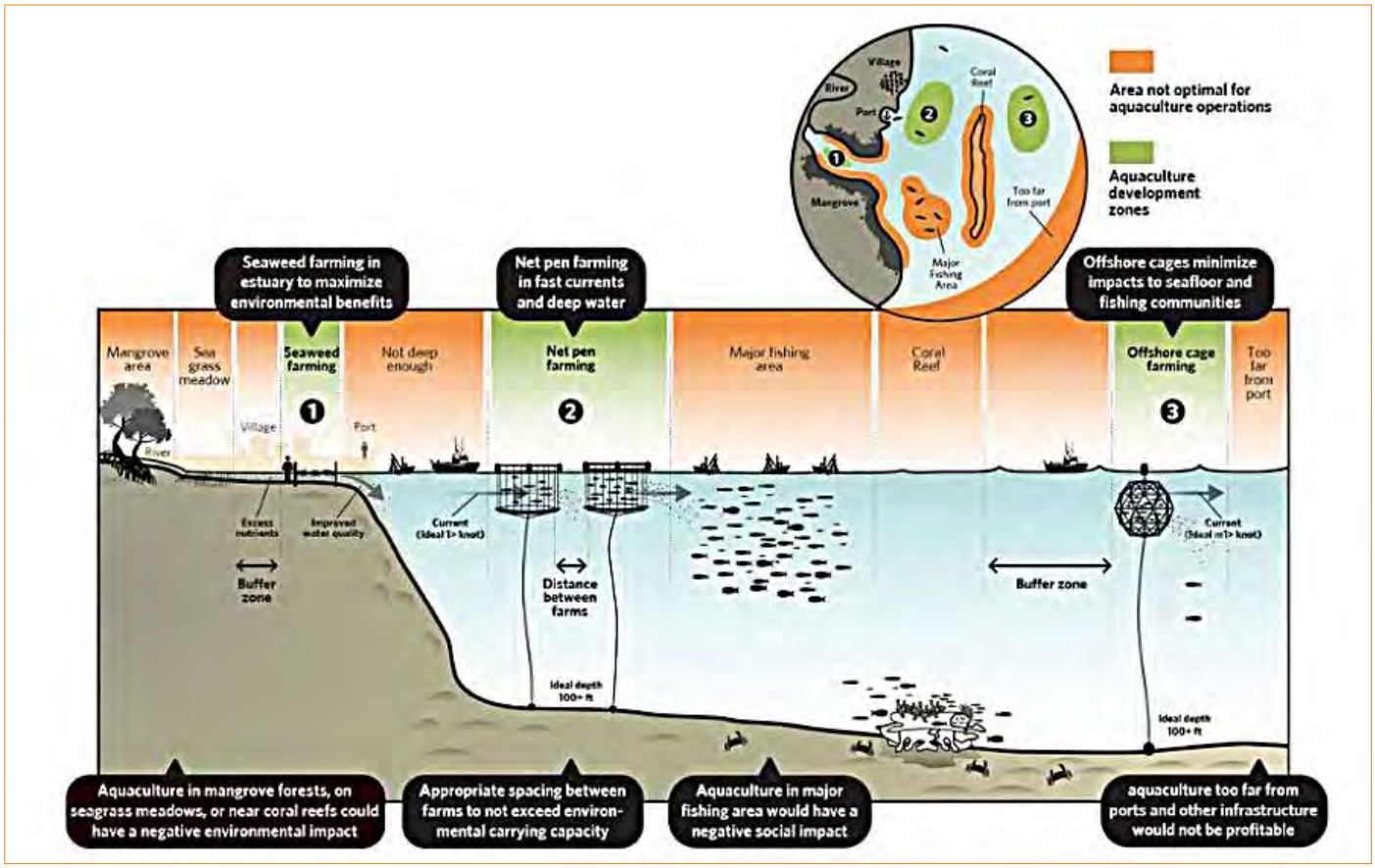
ii) Improving sustainability

There is increasing pressure for aquaculture to be ecologically sustainable and environmentally friendly. People want to know that the seafood they are eating has come from clean waters. Sustainability is not a single technique or practice but encompasses a range of techniques and technologies which vary according to the species farmed. (Figure 7)

Common principles that need to be followed include:

- Determining the carrying capacity of the environment.
- Using techniques that have little effect on the environment.
- Planning for the long-term gain instead of short-term profit.
- Site selection should focus on areas of little biodiversity or less ecosystem importance e.g. mud flats instead of mangrove forests.
- Using settling ponds where waste and nutrients are collected and filtered before water is discharged into the environment.
- Sensible stocking levels.

Figure 7: Aquaculture site considerations for sustainability



Smart Growth in Aquaculture

Siting of aquaculture operations is the first and most critical consideration to minimse negative impacts of aquaculture operations. It is also a critical factor in determining the profitability of an aquaculture operation. To protect the environment and ensure economic growth, aquaculture operations should be sited in optimal locations based on environmental, economic, and social factors.

Source: The Aquaculture Opportunity– https://www.nature.org/en-us/what-we-do/our-insights/perspectives/the-aquaculture-opportunity/
SMART GROWTH IN AQUACULTURE © The Nature Conservancy

Monoculture (one species) is not as sustainable as polyculture e.g. Chinese polyculture pond farming had carried on for centuries using the same ponds because the system includes species that recycle nutrients and reduce wastes.

Many current aquaculture ventures are not sustainable for a variety of reasons the most prominent being over exploitation of the natural environment beyond its' carrying capacity e.g. trying to make large profits quickly by over stocking. Creating sustainable farms is more expensive but with current technology it is possible.

Examples of more sustainable practices include 3D farming, the use of shellfish and seaweeds species to filter wastes, (Figure 8), Integrated Multi-trophic aquaculture (Figure 9) and offshore farming.

Huon Aquaculture in Tasmania is moving to offshore cages to reduce impacts on coastal communities and environments, a move that involves significant investment in infrastructure and technology.

See Huon Aquaculture Illustrative example.

Farming underwater: 3D solutions for land and sea Earthrise (Good animation) https://www.youtube.com/watch?v=yi97si_Wueg

Figure 8: Scallops as water filters

Giant Japanese scallops thrive on fish waste off Canada's Vancouver Island. The farm also uses sea cucumbers and kelp to consume excretions from nearby pens of native sablefish.

Source: National Geographic https://www.nationalgeographic.com/foodfeatures/aquaculture/

SOCIAL / CULTURAL FACTORS

These include features of a society that influence production and consumption of farmed seafood.

i) ***Traditional diets*** like the Japanese rely on seafood as a major source of protein. They are finding it difficult to meet demand from capture fisheries and are relying more on aquaculture and imported seafood. The high incomes mean the Japanese are willing to pay top prices for imported seafood and to invest in aquaculture ventures in other countries.

ii) ***Diet consciousness*** (especially in western cultures) has seen an increased emphasis on low fat and high protein fish diets and a growth in people following 'pescatarian' diets. Increasing knowledge of the benefits of Omega 3 oils in reducing health problems is leading to increased demand for seafood rich in these oils e.g. salmon. Many nations of the developed world are also demanding pollutant free seafood as a part of their increasing health consciousness. Australia's image as a country able to produce "clean and green" seafood has opened markets in Japan.

iii) ***Multiculturalism*** has led to an increased demand for the non-traditional seafoods in many parts of the world. Australia today produces eels, yabbies and seaweeds to satisfy this demand. We are also exporting to parts of the world where these are traditional foods.

iv) ***Socio-economic status.*** In rich countries there is a demand for lobster and caviar. As income levels grow there is increased demand for luxury products. This affects the global spatial pattern as new ventures develop to satisfy the growing demand e.g. Lobster and crayfish farms in Australia.

v) ***Traditional vs modern production methods.*** In China farmers use polyculture to raise several fish species in one pond whereas in Australia and European countries aquaculture ventures tend to be monocultures e.g. a barramundi farm. In the Pacific Islands methods of pearl farming are based on traditional practices where divers free dive to collect oysters grown on lines whereas in Broome, Western Australia methods are much more modern and scientific e.g. scuba.

LEFT: Barramundi farming, Cardwell Qld.. Source: Wikimedia Commons, https://www.fix.com/blog/breaking-down-fish-farming/

TECHNOLOGICAL FACTORS

The use of technology has:

- Made new aquaculture ventures possible.
- Allowed new species to be developed for farming.
- Improved exporting and importing by improving transport.
- Created new employment opportunities and education courses.
- Reduced the importance of the biophysical environment to the location of farms.
- Improved environmental monitoring to ensure the ecological sustainability.

Modern research techniques, new equipment and the ability to create artificial environments in laboratories and indoor facilities has meant an increase in the number of different species of organisms that can be farmed and changed the way they are farmed, e.g. Red Sea Bream in Japan.

The fish are raised from spawn in land-based tanks and hand fed. Eventually they are set free in the ocean. A tower in the ocean emits a feeding signal and food is released through a chute. Nets are then cast after a signal is given making harvesting easy. The fish are fed scientifically formulated food – krill and shrimp – to give them the red colour favourable to consumers.

Technological innovation

3D and Integrated Multi Trophic aquaculture is a modern form of polyculture - with different species farmed down a water column such as below salmon farming cages. Here, species that feed on fish waste eg mussels, are farmed while contributing to improved sustainability of cage aquaculture. These systems are likely to increase in order to promote sustainable practice into the future. (Figure 9)

Progress in *biotechnology* has led to the development of new species through genetic engineering, e.g. At Port Stephens Fisheries Research Centre scientists developed the Sydney Rock Oyster with three chromosomes as opposed to two. This new species cannot reproduce so they concentrate on growth, as a result the oysters reach market size six month earlier and are 27% larger.

Transport technology has opened new global markets e.g. Yabbies' are transported from Western Australia to Europe, and salmon from Tasmania to Japan by chilling and use of refrigerated transport. Products no longer need to be frozen. They can be chilled and arrive fresh to global markets.

The use of technology had reduced the importance of the biophysical factors for many aquaculture activities. Conditions can be reproduced in indoor facilities where conditions such as air and water temperatures and nutrients are computer controlled e.g. Seahorse farms in Tasmania.

The use of technology has increased the demand for highly trained workers such as laboratory technicians and scientists. There is also demand for new research and development with many educational institutions now offering aquaculture courses

Commercial seahorse farming. Source: Wikimedia Commons,

Figure 9: Integrated Multi Trophic Aquaculture (or 3D aquaculture)

Conceptual model for an integrated multi-trophic aquaculture (IMTA) system

The integrated multi-trophic aquaculture (IMTA) system represents a promising new approach to sustainable fish and seafood production. This farming system combines species from multiple levels of the food chain, taking advantage of the fact that wastes from one organism can be a food source for another.

Source: http://www.joycehuiart.com/featured02.php
https://www.dfo-mpo.gc.ca/aquaculture/sci-res/imta-amti/imta-amti-eng.htm

ORGANISATIONAL FACTORS

These factors include the ownership, decision-making and control of aquaculture ventures as well as the structure of organisations. The prospect of huge profits has attracted both large and small entrepreneurs with TNC's often involved. For example, a Thai company, using a major Saudi construction company started a prawn-farming venture in Malaysia.

An *agribusiness* is a single corporation involved in farming, processing and distribution of farmed products. For example, General Foods and Coca Cola have been prominent investors in Ecuador's prawn farming. The aquaculture industry is subject to a lot of bankruptcies, mergers and takeovers often giving a lot of control to one corporation.

Many larger aquaculture companies are vertically and horizontally integrated. *Vertical integration* means the company is involved in many different aspects of the venture, not just farming. e.g. They own processing plants, transport companies, marketing organisations and research facilities. Huon Aquaculture in Tasmania owns its hatcheries and processing plants.

Horizontal integration means they will be involved in other similar farming ventures eg shrimp and salmon farming e.g. Tassal Ltd in Tasmania is both vertically and horizontally integrated company.

These factors influence the spatial pattern of aquaculture through things such as land zoning and licensing of aquaculture farmers. They affect the growth and success of ventures through:

- Tariffs and subsidies
- Import and export licenses
- Research
- Funding / joint ventures
- Environmental restrictions and regulations

In Australia governments are heavily involved at the state level through the fisheries organisations such as the *NSW Fisheries Research Centres* at Port Stephens and Narrandera. At national level they are involved though the work of the CSIRO. Environmental Impact Studies must be carried out before any productive activity can take place. Legislation such as *The Clean Waters Act* required the monitoring of activities that might affect water quality. At a local level Council *land zoning* and *development application* requirements affect present and potential sites for aquaculture.

Government regulations have been enacted to control the taking of brood stock from the wild and their replacement from the stock reared on farms e.g. abalone and bream are raised from wild stock.

'Future mapped out for Tasmania's salmon industry' reports that most of the coastline will be made off-limits to salmon farmers through government zoning but more development is encouraged in high-energy sites. This will impact the nature and location of salmon aquaculture in the state. https://www.fishfarmingexpert.com/article/future-mapped-out-for-tasmania-s-salmon-industry/

Governments across the world are encouraging aquaculture ventures because of the perceived economic benefits. In some cases, they are *partners in aquaculture ventures* e.g. in Tasmania the first salmon hatchery was a joint venture with the Tasmanian government. In Australia the CSIRO is involved in research into potential new species, disease control, environmental monitoring and the development of fish feed. Legislation in Ecuador prohibited the clearing of mangroves for shrimp farming.

SOCIAL, ECONOMIC AND ENVIRONMENTAL IMPACTS

Aquaculture can have a very positive impact on local populations by providing a readily available, high protein food source; employment and improvements in infrastructure.

Negative environmental impacts are the greatest challenges to aquaculture and those receiving the most publicity. Pollution, escaped species and farming the oceans to feed the fish are common complaints

Positive:

- Reducing global demand on capture fisheries
- Satisfying increasing national and global demand for seafood.
- Benefits communities through job creation and businesses supplying goods and services. In 2018 – 20.53 million were engaged in aquaculture.
- Brings tourists – further stimulating the local economies.
- Increasing exports and improve national balance of payments.
- Improving water quality and coastal defenses to natural hazards.

See illustrative examples: Seaweed Aquaculture and Huon Salmon Aquaculture

Figure 10 Benefits of aquaculture for coastal communities

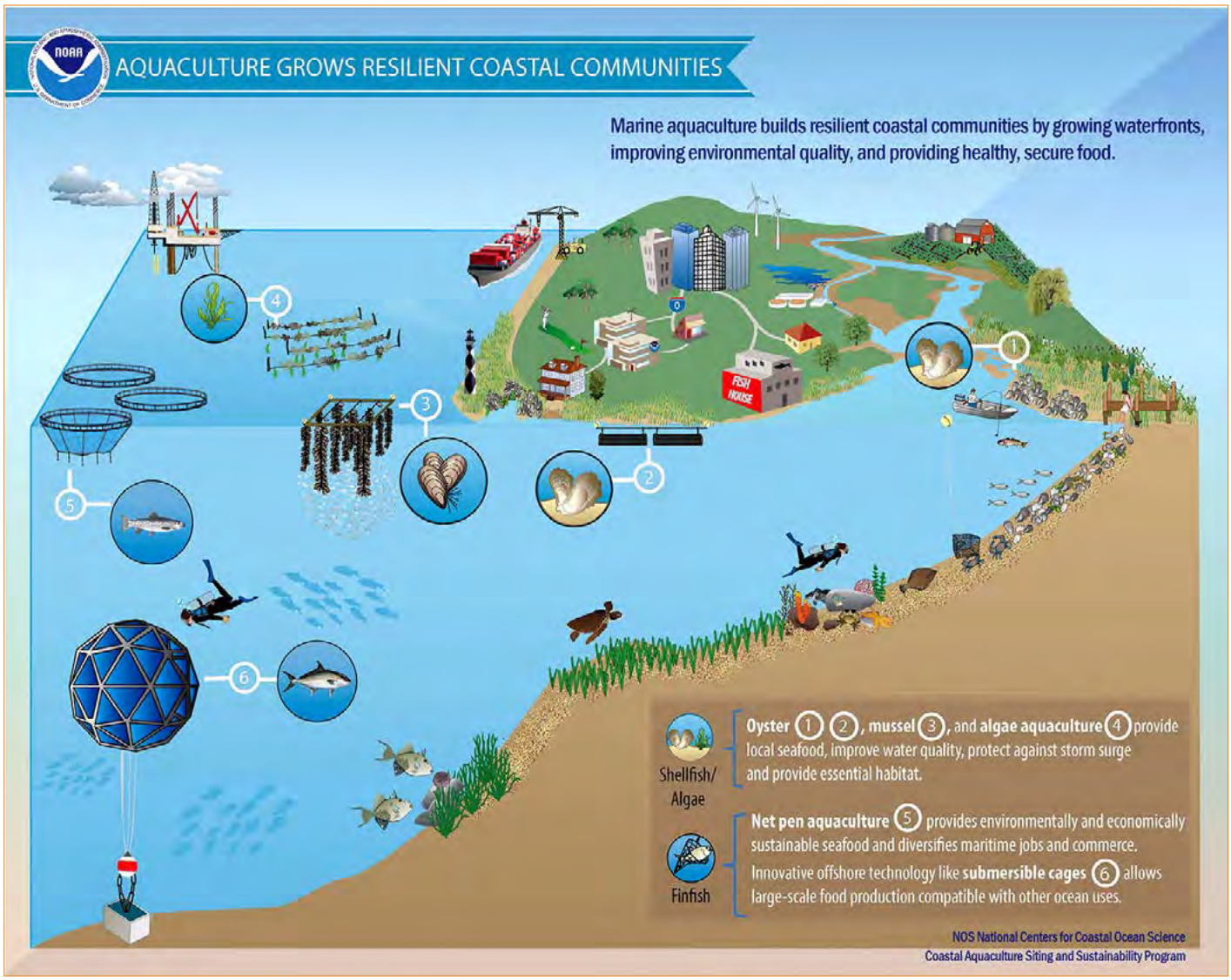


Illustration by Joyce Hui. Source: NOAA https://www.noaa.gov/stories/story-map-farming-in-water

Negative.

- Environmental impacts on coastal ecosystems and species, reduced water quality, noise and poor visual amenity.
- Social upheaval where locals are displaced to make way for fishponds.
- Sale of protein source by people in developing countries. The income is used to buy more carbohydrates increasing malnutrition.
- Can reduce land values in surrounding areas due to operating noise and visual pollution.
- Competes with other economic and social activities eg. Farming and recreation.

The new "blue revolution," which has delivered cheap, vacuum-packed shrimp, salmon, and tilapia to grocery freezers, has brought with it many of the warts of agriculture on land: habitat destruction, water pollution, and food-safety scares. During the 1980s vast swaths of tropical mangroves were bulldozed to build farms that now produce a sizable portion of the world's shrimp. Aquacultural pollution—a putrid cocktail of nitrogen, phosphorus, and dead fish—is now a widespread hazard in Asia, where 90 percent of farmed fish are located. To keep fish alive in densely stocked pens, some Asian farmers resort to antibiotics and pesticides that are banned for use in the United States, Europe, and Japan.

National Geographic: How to farm a better fish – https://www.nationalgeographic.com/foodfeatures/aquaculture/

Globally, expansion into offshore locations is seen as a solution to water quality issues in estuaries and negative impacts on coastal communities at the same time as increasing production and creating employment.

See Huon Aquaculture illustrative example

Source: Shutterstock

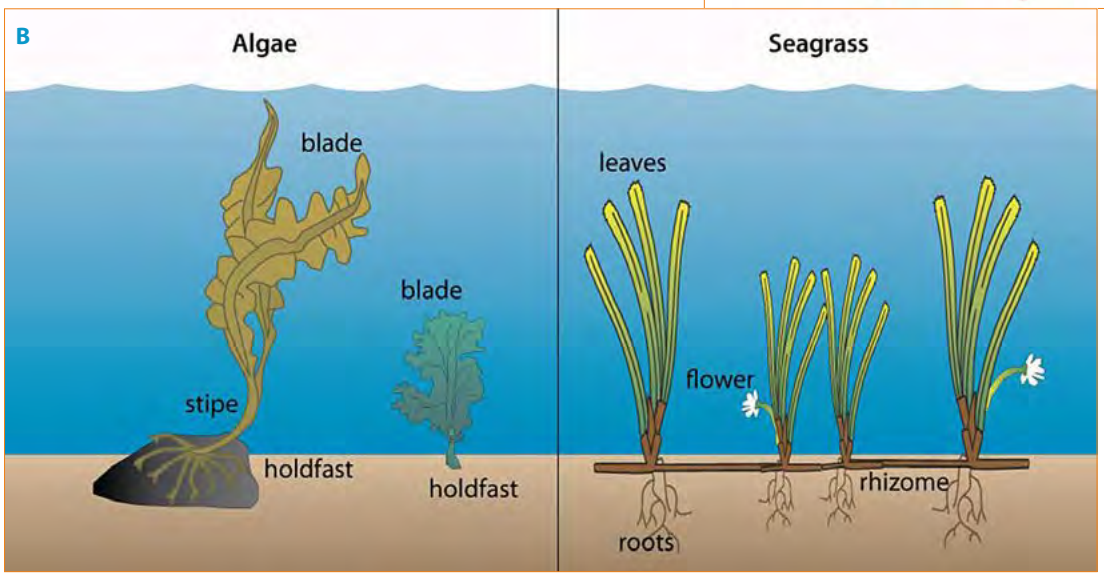
ILLUSTRATIVE EXAMPLE 1: GLOBAL SEAWEED AQUACULTURE

ENGAGE

- Conversation starter:
  Is kelp a socially, economically and ecologically sustainable product of aquaculture?
- Stimulus:
  - YouTube: Kelp Its what's for dinner (6 minutes) https://www.youtube.com/watch?v=0BHfHkOoDGA
  - Belize: Villagers farming seaweed to prevent overfishing https://www.youtube.com/watch?v=lFWiHt0tkng
  - Figure 1: What is seaweed / kelp?
    i. Seaweed is not seagrass.
    ii. Seaweed is algae.

'Algae are classified into three groups: red, brown, and green algae. While some algae have root-like structures called holdfasts, algae do not have true roots or leaves. Like plants, they do photosynthesis, but unlike plants, they are single-celled. These single cells may exist individually or in colonies.'

Figure 1: What is seaweed / kelp?



A: What is seagrass? – https://www.thoughtco.com/what-is-seaweed-2291912

B: Algae vs seagrass – https://ocean.si.edu/holding-tank/images-hide/algae-vs-seagrass

INVESTIGATE

Seaweed aquaculture

Macroalgae have played an important role in coastal communities for centuries with the earliest written record of use in China, about1700 years ago. For centuries, coastal populations harvested seaweeds for food, feed, medicine and industrial uses.

Globally, seaweed is now a highly valued marine resource with an estimated worth in 2019 of around US$9 billion a year. Most seaweed consumption is still for food, with the remainder used for industrial (cosmetics, fertiliser and agars) or feed purposes (such as animal and fish feed).

Seaweed production comes from the harvesting of natural seaweed communities and seaweed aquaculture beds (SAB's). SABs are artificial systems in which seaweeds are attached as germlings to cultivation lines attached to buoys or poles and then allowed to grow until they are of harvestable size.

Spatial patterns of production and consumption

The seaweed industry is undergoing rapid global expansion and currently accounts for ~ 49% of total mariculture production. Exponential growth in the last 50 years has resulted in the increasing value of the industry and growth in employment, particularly in developing and emerging economies.

At a global scale seaweed harvesting and production occurs in a diversity of climates and regions across about 50 countries, dominated by Europe and Asia. Between 2000 and 2014 95% of global seaweed production was in Asian countries. Seaweed aquaculture beds cover extensive shallow coastal areas, particularly in the Asia-Pacific region. The future of seaweed aquaculture is likely to see an increase in the total harvest production following an increase in the number of cultivation areas around the world. In 2019, China was the largest importer of seaweed and the Republic of Korea the largest exporter.

In Australia seaweed imports have increased due to increasing demand for seaweed products. Imports increased by 10,550 tonnes between 2000 and 2017 while exports remain steady. Compared to other countries where seaweed production has developed from a traditional base to commercial production, Australia's industry is in early stages of development and has a mix of harvesting and farming ventures. On the west coast of Western Australia marine algae are produced by aquaculture for beta-carotene and in Tasmania, almost 2,000 tonnes of Undaria or 'wakame' (a delicacy in Japan and the Republic of Korea) was harvested in 2017–2018.

Future directions

Natural seaweed communities and seaweed aquaculture beds (SAB's) have utility and environmental values and are increasingly considered a solution to increasing demands on Earth's natural resources and declining natural environments. The sequestration of CO2, the provision of food and supply of useful chemicals will drive increased demand in the future.

One challenge to the future of seaweed production is climate change. Elevated levels of CO2 and ocean acidification, increased temperatures and rising levels of UVB, affect the performance of seaweeds with impacts varying between species. SAB are considered a valuable contributor to blue carbon, helping to ameliorate increasing anthropogenic CO2 emissions' by increasing the drawdown of CO2. Seaweed is an important component of new initiatives that involve the farming of many species within a column of sea water because of the environmental benefits that increase sustainability.

'Regenerative ocean farming' is another concept linked to seaweed farming. 'It involves growing seaweed and several kinds of shellfish — not just to feed people but to heal the oceans and fight climate change. He said the aim is "going beyond sustainability and using our crops to breathe life back into ecosystems."

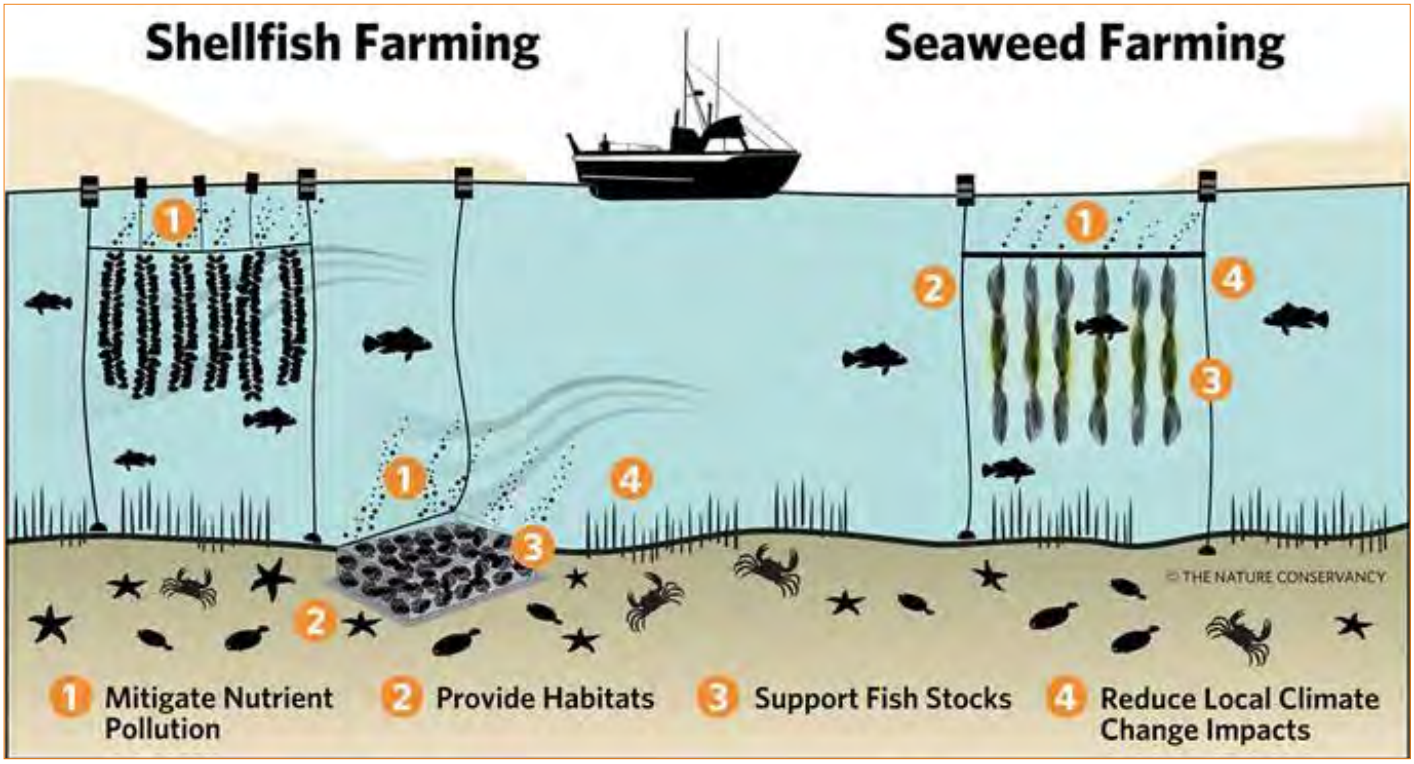
Seaweeds have experienced a renaissance in popularity, prompted in part by the media's take on their applications as 'superfood', with newspapers asking: 'Is seaweed the new kale?', or 'the next superfood?'.

Source: https://www.tandfonline.com/doi/full/10.1080/09670262.2017.1365273

Other challenges to future production include pathogens; epibionts (barnacles, leeches and other marine life that live on the seaweed); grazers and the need to maintain the genetic diversity of seaweeds used in aquaculture.

Seaweed farming, Lembongan. Source: Wikimedia Commons

Figure 2: Seaweed and Bivalve Aquaculture Systems © The Nature Conservancy



Seaweed can contribute to sustainable aquaculture that benefits the environment. Source: Catalysing the Blue Revolution: How Investors Can Turn the Tide on Aquaculture, NATURE – https://www.nature.org/en-us/what-we-do/our-insights/perspectives/how-investors-can-turn-the-tide-on-aquaculture/

Figure 3: 3D Ocean farming

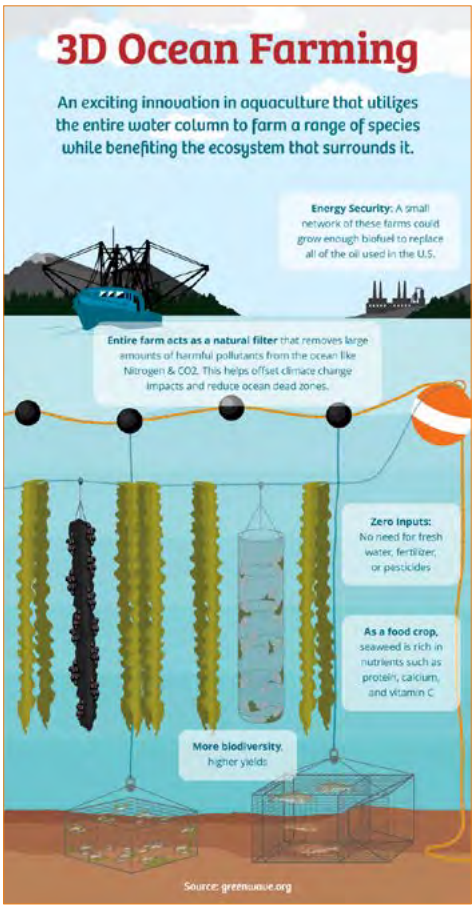
3D Ocean farming

One exciting and new aquaculture method being pioneered right now has been dubbed 3D ocean farming. In these farms, the entire water column is used to grow kelp, scallops, muscles, and oysters, all of which work together to clean our oceans. The farms absorb carbon dioxide and nitrogen from the water, filter out toxins, and could be used as valuable tools to help mitigate the effects of climate change. These farms can be used to grow local food, organic fertiliser, biofuel, and more.

Source: https://www.fix.com/blog/breaking-down-fish-farming/

Figure 4: Low technology, shallow water red seaweed farming in Zanzibar

As the seaweed industry booms, how can we farm seaweed more sustainably?
Credit Leyo /Wikimedia Commons/CC BY-SA 2.5 CH Source: THE WORLD https://www.pri.org/stories/2016-09-24/seaweed-industry-booms-how-can-we-farm-seaweed-more-sustainably



The Environmental Impact of Fish Farming https://www.fix.com/blog/breaking-down-fish-farming/

Figure 5: Satellite view of extensive seaweed farms around Sisan Island, South Korea.

The patchwork of small squares are entire fields of seaweed that are held in place with ropes and buoys to keep the plants near the surface during high tide but off the seafloor in low tide.

Source: NASA Earth Observatory Goddard Space Flight Centre on Flickr – https://www.flickr.com/photos/gsfc/17320902662/in/photolist-soA9UN-soKEa6-KrobV4-hk6iTB-hk4UPe-JTgTpB-hk5o5Y-2iXzsa7-rYNYkz-2c2tDu1-hk6ihr-2c2tJ8E-DLpkBL-s5wdic

ILLUSTRATIVE EXAMPLE 2: HUON SALMON AQUACULTURE (Tasmania)

Huon Aquaculture can be used as an illustrative example of the Economic Activity: Aquaculture, particularly in relation to offshore farming, technological innovation and sustainability OR as a local Economic Enterprise.

There are many layers in the Huon Aquaculture website. This summary is a guide to assist you in finding information quickly

Image source: Shutterstock

Huon Aquaculture began in 1986 when a farming family decided to diversify their Tasmanian cattle and sheep farming enterprises. Salmon are grown in three marine regions: Huon's traditional home – the Huon and D'Entrecasteaux Channel; the unique Macquarie Harbour; and offshore in Bruny Island's Storm Bay. Figure 1

The business has grown into a successful, vertically integrated farming activity that produced nearly 19,000 tonnes of fish (salmon and trout) in the FY2019 and employed over 760 multi-skilled staff (January 2020) located in most states of Australia. Figure 2 Huon employees include biologists, welders, divers, factory hands, accountants, analysts and industry sales and marketers. Huon Aquaculture is recognised globally as a premium producer of fresh and smoked salmon products.

Today, Huon is the only company in Tasmania farming salmon offshore. Prior to ocean farming in Storm Bay, the company closed shallow inshore sites in the Huon River, to reduce the impact of farming operations on neighbours, to improve navigation and safety and reduce environmental impacts.

The following video clips show Huon Aquaculture's operations and directions

YouTube: Get to know Huon (3 minutes, 2015) https://www.youtube.com/watch?time_continue=3&v=17Zfhr8dmGM&feature=emb_logo

LANDLINE: Fish Profit Slump: Managing risks during COVID-19 https://www.abc.net.au/landline/fish-profit-slump:-managing-risks-during-covid-19/12659752?fbclid=IwAR0sK4ePcSNi3kcoD-Ze6eEgZGCeoPMar53NbNOb-U4TeyFwDPDt3IMGNtk

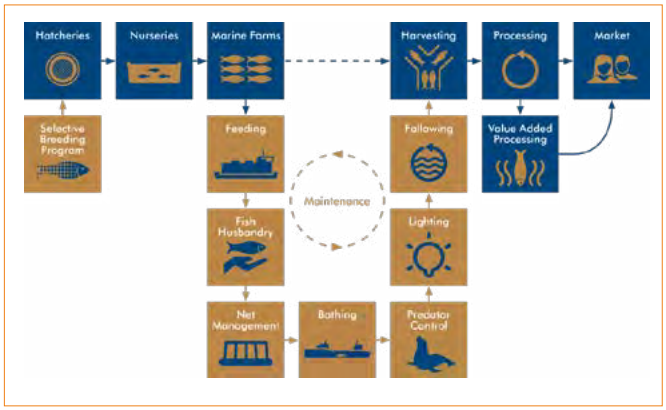
RIGHT: Huon aquaculture https://www.huonaqua.com.au/about/operations/

Figure 1: Huon's marine farm, hatchery and processing facilities

Source: Huon aquaculture https://www.huonaqua.com.au/about/operations/

Figure 2: A Vertically integrated company

Huon Aquaculture does everything from selectively breeding brood stock for egg production, to processing salmon ready for the consumer plate.



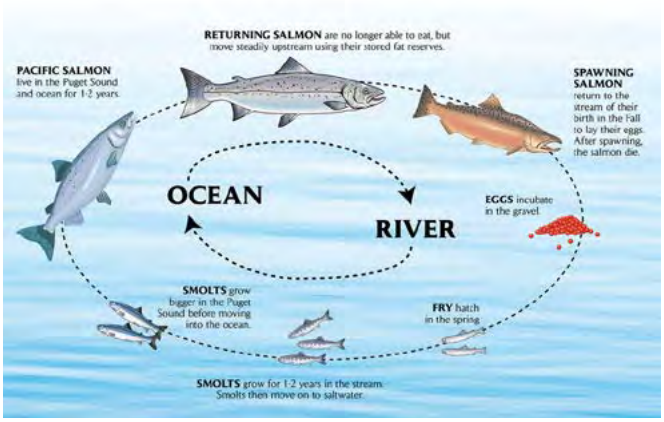
SEE THINK WONDER about wild salmon

Refer to Figure 3 and the YouTube clip about the salmon life cycle.

What are the environmental conditions that need to be replicated to farm salmon?

Figure 3: Salmon life cycle

Atlantic salmon and spend their juvenile phase in rivers before migrating to sea to grow and mature. To complete their life cycle salmon must return to their river of origin to spawn.



Source: http://www.wfpa.org/fish-wildlife/native-fish-amphibians/

YouTube The Life Cycle of the Atlantic Salmon animation (5 minutes) – https://www.youtube.com/watch?v=2fGLzEvWuYA

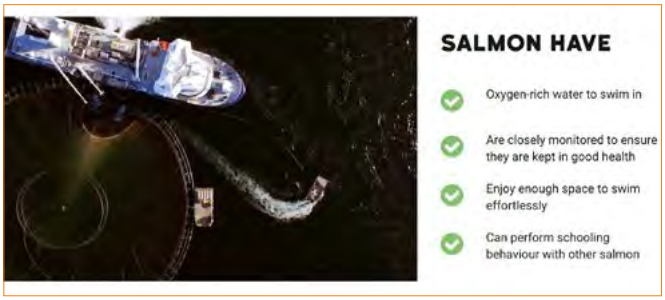
OR

Life cycle of the salmon (6 minutes) – https://www.youtube.com/watch?v=nlSoUXfJEeQ

FARMING OPERATIONS

General introduction and approach to operating including fish welfare – https://www.huonaqua.com.au/our-approach/our-operations/

RSPCA approval – https://rspcaapproved.org.au/rspca-approved-products/farmed-atlantic-salmon



Freshwater Operations

Read about Huon Aquacultures freshwater facilities here – https://www.huonaqua.com.au/our-hatcheries/

Read how a problem led to diversification: Huon caviar – https://www.youtube.com/watch?v=sWBFXbKuYG0

Selective breeding – https://issuu.com/huonaqua/docs/the_huon_story_-_edition_four/s/10345224

Figure 4: Freshwater operations comprise inland hatcheries

Aerial view of the Huon Aquaculture hatchery. Source: https://issuu.com/huonaqua/docs/the_huon_story_-_edition_four/s/10345224

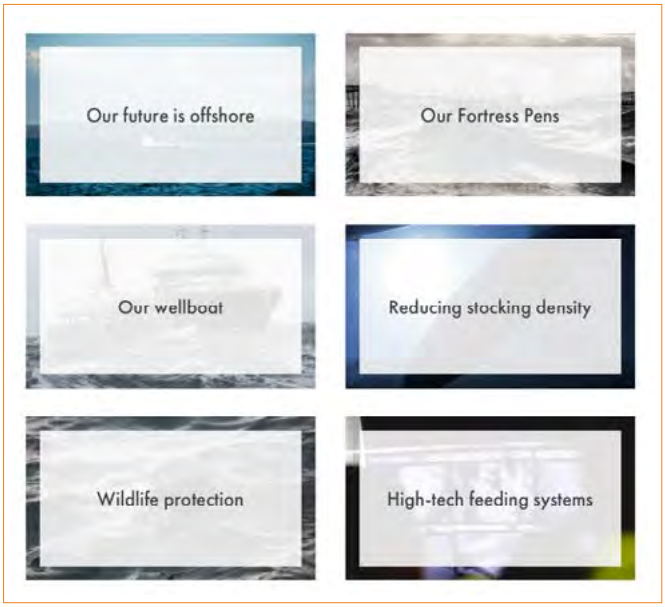
Huon Aquaculture inside a hatchery. Source: https://www.huonaqua.com.au/our-hatcheries/

Offshore operations

Read about different aspects of Huon Aquaculture on the website. Requirements and benefits of offshore sites and how they are selected – https://www.huonaqua.com.au/our-approach/future-fish-farming/offshore-farming/

Aspects of offshore operations

Figure 5: Offshore operations



Screen capture: Huon Aquaculture https://www.huonaqua.com.au/our-approach/future-fish-farming/

YouTube: Offshore operations – https://www.huonaqua.com.au/our-approach/future-fish-farming/

The website contains considerable information on offshore operations including the technology used (fortress pens and wellboats) and link to sustainability.

Sustainability and technology

Huon has a Controlled Growth Strategy (CGS) under which the business has expanded to meet demand and invested in improved freshwater, marine operations and processing. The CGS is guided by six basic principles to achieve sustainability:

- Increasing production to meet growing customer demand responsibly and safely while increasing efficiency of farming practices and improving already high quality of fish
- Improving the health and welfare of fish (RSPCA Approval)
- Improving safety for Huon workers;
- Reducing the company's environmental footprint;
- Continuing to positively participate in the community; and
- Producing world-class salmon products in Tasmania.

Learn more about sustainable freshwater use here: https://www.huonaqua.com.au/our-approach/approach/our-freshwater-use/

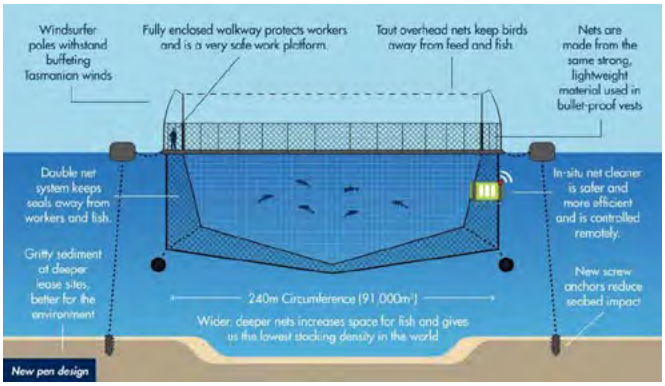
Watch video clips relevant to sustainability

- Large cages to keep stocking density low
- Reducing seafloor waste
- Human and wildlife safety

These clips also demonstrate the application of technology https://www.huonaqua.com.au/our-approach/

To operate on a larger scale and in areas not previously farmed in Tasmania, Huon has used cutting edge technology to innovate and incorporate engineered solutions to enhance production offshore.

Figure 6: Pen design



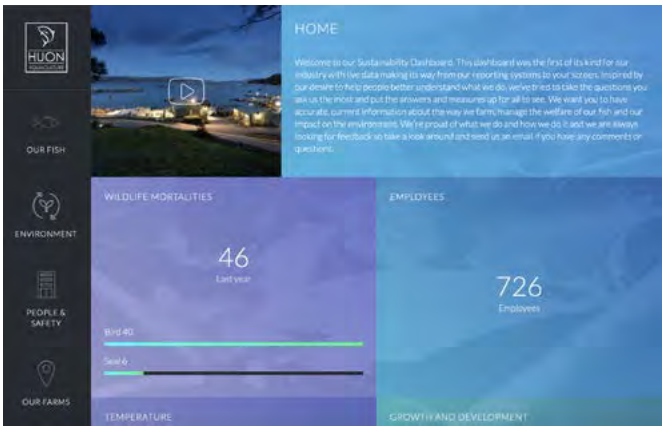
The new pens are a world first in seal and sea-bird protection that will deliver unparalleled safety improvements – for farm workers, for seals, for sea birds, and for the salmon they protect. Read more at https://www.huonaqua.com.au/about/

Figure 7: From the PDF The future of Fish Farming – this image illustrates the importance of technology in meeting production, sustainability and safety targets

Sustainability Dashboard

This online platform shares information about farming operations with the community and public in general in an effort to be more transparent about their business. Data on the Dashboard includes wildlife interactions, temperature and dissolved oxygen data, underwater footage, employee figures, and research spend and more.

Figure 8: Sustainability Dashboard



https://www.huonaqua.com.au/wp-content/uploads/2016/09/Huon-Aquaculture-Future-of-Fish-Farming.pdf

Investigate the interactive sustainability dashboard here: https://www.huonaqua.com.au/our-approach/approach/ethical-farming/sustainability-dashboard/

The future

The future is in offshore farming and the application of technology to remain productive and sustainable.

Read more about the future on the website and linked PDF – https://www.huonaqua.com.au/our-approach/future-fish-farming/

The future mapped out for Tasmania's salmon industry (Political influences) – https://www.fishfarmingexpert.com/article/future-mapped-out-for-tasmania-s-salmon-industry/

The sustainability principles set by Huon Aquaculture are supported through their actions to protest in court government decisions to allow increased operations by rival companies in Macquarie Harbour - on the grounds of environmental impact and carrying capacity.

Several media reports illustrate this story:

Huon Aquaculture takes Tasmanian Government to court over salmon farming in Macquarie Harbour – https://www.abc.net.au/news/2017-02-06/huon-aquaculture-lawsuit-tasmania-government-macquarie-harbour/8244330

Huon Aquaculture loses legal battle against Tasmanian rivals over Macquarie Harbour – http://www.abc.net.au/news/2018-07-06/huon-aquaculture-loses-court-battle-over-macquarie-harbour/9949520.html

All is not perfect

Huon aquaculture do not have a perfect record with fines for breaches of environmental laws in the past.

Huon Aquaculture Convicted of Environmental Breaches – https://tasmaniantimes.com/2020/05/huon-acquaculture-convicted-environmental-breaches/

Escaped Salmon Silence Further Evidence of Self-Regulated Industry – https://tasmps.greens.org.au/media-release/escaped-salmon-silence-further

FACT SHEETS

These Fact Sheets provide more detailed information on many aspects of Huon Aquaculture operations. https://www.huonaqua.com.au/our-approach/fact-sheets/

AQUACULTURE RESOURCES

State of the World's fisheries and Aquaculture 2020 (Document) – http://www.fao.org/publications/sofia/en/

State of the World's fisheries and Aquaculture 2020 (Interactive) – http://www.fao.org/state-of-fisheries-aquaculture

Farming in water: Story map NOAA – https://www.noaa.gov/stories/story-map-farming-in-water

Global aquaculture Alliance – https://www.aquaculturealliance.org/blog/what-is-aquaculture-why-do-we-need-it/

Ocean Matters: The Blue Revolution | Brian Skerry – https://www.youtube.com/watch?v=Zh6VP0AxxxI

ABARES – https://www.agriculture.gov.au/abares/research-topics/fisheries/fisheries-and-aquaculture-statistics/seafood-consumption-2018

Diversity in species and production

Indigenous aquaculture site Budj Bim added to World Heritage List – https://watersource.awa.asn.au/environment/built-environment/indigenous-aquaculture-site-budj-bim-added-to-world-heritage-list/

Shrimp farming in Australia – https://www.youtube.com/watch?v=n_LEYz_5c4U

Shrimp farm in Japan – https://www.youtube.com/watch?v=9xXANblxqQ0

Feeding 1.4 billion: China's floating fish farms – https://www.youtube.com/watch?v=B4kszhlfvFw

Breeding crayfish under solar panels – https://www.youtube.com/watch?v=byepgkpqjOE

Farm raised Bluefin Tuna – https://www.youtube.com/watch?v=m4r9XC6Ta-s

Aquaculture - the Velella Project - Next Generation Mariculture in Hawaii (6 minutes) – https://www.youtube.com/watch?v=-5GnPGuUhm8

Open-ocean fish farmer: Future of food (6 minutes) – https://www.youtube.com/watch?v=BBbB27698Ug

Sustainability and technology

Introductory Video: Sustainable aquaculture (animation) – https://www.youtube.com/watch?v=fu5wvD9iDyU

The future of seafood. A fascinating look at offshore sea cages seven stories high. – https://www.youtube.com/watch?v=eff-Z0NdwzY

Negative and Positive Environmental Impacts of Aquaculture – https://greentumble.com/environmental-impacts-of-aquaculture/

Ocean farming series – https://oceantoday.noaa.gov/every-full-moon/episode16-oceanfarming/welcome.html

National Geographic: How to farm a better fish – https://www.nationalgeographic.com/foodfeatures/aquaculture/

The Future of Ocean Farming: Innovations in Aquaculture – https://www.youtube.com/watch?v=OXOXn_5PtNI

The Aquaculture Opportunity – https://www.nature.org/en-us/what-we-do/our-insights/perspectives/the-aquaculture-opportunity/

Finally! Healthy fish farming in the deep sea – https://www.youtube.com/watch?v=iWIUM1cnnTE

Farming underwater: 3D solutions for land and sea | Earthrise – https://www.youtube.com/watch?v=yi97si_Wueg&t=551s

The Environmental Impact of Fish Farming – https://www.fix.com/blog/breaking-down-fish-farming/

All About Aquaculture: Environmental Risks and Benefits – https://www.talkingfish.org/2012/did-you-know/all-about-aquaculture-environmental-risks-and-benefits

Seafood Watch – https://www.seafoodwatch.org/ocean-issues/aquaculture

ILLUSTRATIVE EXAMPLE: SEAWEED AQUACULTURE

FAO The global status of seaweed production, trade and utiliSation pdf – http://www.fao.org/in-action/globefish/publications/details-publication/en/c/1154074/

The future of seaweed aquaculture in a rapidly changing world. Retrieved from – https://www.tandfonline.com/doi/full/10.1080/09670262.2017.1359678

Seaweed production: overview of the global state of exploitation, farming and emerging research activity. Retrieved from https://www.tandfonline.com/doi/full/10.1080/09670262.2017.1365175

Australian Department of Agriculture, water and environment – https://www.agriculture.gov.au/abares/research-topics/fisheries/fisheries-and-aquaculture-statistics/australian-seaweed-production

A New Leaf. Seaweed could be a miracle food—if we can figure out how to make it taste good. – https://www.newyorker.com/magazine/2015/11/02/a-new-leaf

Kelp farming is a win-win when it comes to healing the ocean – https://www.penbaypilot.com/article/kelp-farming-win-win-when-it-comes-healing-ocean/65129

The power of Kelp – https://wsg.washington.edu/community-outreach/kelp-aquaculture/

Kelp farming shown to boost marine biodiversity – https://thefishsite.com/articles/kelp-farming-shown-to-boost-marine-biodiversity

Seaweed Farming: Transforming Fishing into Aquaculture – https://www.energyseek.co.uk/2016/09/04/seaweed-farming-transforming-fishing-to-aquaculture/

Fascinating Satellite Photos of Seaweed Farms in South Korea – https://www.thisiscolossal.com/2015/04/fascinating-satellite-photos-of-seaweed-farms-in-south-korea/

Is algae the food of the future? – https://www.youtube.com/watch?v=tAdrNQNP8ew

Seaweed farming at another level – https://www.youtube.com/watch?v=235gbdhaLOE

Is seaweed America's next cash crop? – https://www.youtube.com/watch?v=geziHoX9GWI

Alaska Sea Kelp Farming – https://videos.fisheries.noaa.gov/detail/videos/aquaculture/video/6095673526001/alaska-kelp-farming:-a-new-sustainable-seafood-opportunity?autoStart=true

ILLUSTRATIVE EXAMPLE: HUON AQUACULTURE

Huon Aquaculture – https://www.huonaqua.com.au/our-approach/

The HUON STORY company magazine contains interesting articles that build deeper understanding of Huon's operations and internal and external linkages, including community involvement and connections. –https://www.huonaqua.com.au/the-huon-story-edition-four/

Edition 1 – The use of baseline surveys to assess seabed flora and fauna at potential offshore sites.

Edition 3 – Technology and trialling the integration of kelp into farming operations

Edition 4 – Antibiotic use, innovation and engaging with education providers

Facebook – https://www.facebook.com/huonaquaculture

ASX Media Release for 2019 – https://www.asx.com.au/asxpdf/20190222/pdf/442vnbkp1rpz36.pdf

Tasmanian salmon farm takes to open, wild water in 'fortress pens' built for millions at Storm Bay – https://www.abc.net.au/news/rural/2019-09-04/millions-of-salmon-make-move-to-open-water-in-southern-tasmania/11432492

Huon Aquaculture. Image source: shutterstock_228638236.jpg

LANDLINE: Fish Profit Slump: Managing risks during COVID-19 – https://www.abc.net.au/landline/fish-profit-slump:-managing-risks-during-covid-19/12659752?fbclid=IwAR0sK4ePcSNi3kcoD-Ze6eEgZGCeoPMar53NbNOb-U4TeyFwDPDt3IMGNtk

ABC news: Huon Aquaculture's revenue grew, but the salmon grower still took a hit due to COVID-19 – https://www.abc.net.au/news/2020-09-01/huon-aquaculture-nets-millions-in-capital-in-tough-conditions/12617384

JUST RELEASED

Australian Seaweed Industry Blueprint

"A seaweed industry offers Australia a sustainable, high-tech and high-value new economic opportunity. By investing and fostering seaweed production, we have the opportunity to improve the health of our bays, oceans and reefs, provide jobs in regional coastal areas, produce high-value products for domestic and export markets, and even make significant progress on mitigating Australia's carbon emissions. Development of a seaweed industry will also assist achievement of the National Aquaculture Strategy's target to increase the current value of Australia's aquaculture industry to $2 billion by 2027.

Source: https://www.agrifutures.com.au/wpcontent/uploads/2020/09/20-072.pdf

NINGALOO REEF

David Latimer
Head of HSIE, MLC School


Photo: Shutterstock

This study provides an introductory framework for using Ningaloo Reef as a case study for Ecosystems at Risk. A list of resource links is provided for filling in the detail needed to fully investigate each syllabus point.

The Ningaloo Coast is an interaction between coral reef and limestone karst geology seen in this image. Although the Great Barrier Reef tends to gain most of the nations' focus, Australia's "other reef" is no less spectacular. The Ningaloo Coast is placed at great risk by global changes to climate and ocean chemistry. However, its relatively low visitor numbers and remote location mean that it is in quite pristine condition which contributes to a high level of resilience. Potential threats arise periodically when plans for resource development, particularly oil / gas and ports to the north are proposed.

SPATIAL PATTERNS AND DIMENSIONS

Location and Altitude

Ningaloo Coast is located 1200km North of Perth on the Western Australian Coast, in the NW quadrant of Australia and bounded by the Indian Ocean. The reef's latitude ranges from 21°42'14"S - 24° 1'52"S (one of the highest for reefs) and the longitude between 113°25'E - 114° 15'E. The reef is found between shallow waters 0 and 30 metres below mean sea level and oceanic waters to a depth of 500 metres.

GIS maps on Google Earth can be found here http://ningaloo-atlas.org.au/content/explore/maps

Figure 1: General location map

Source: https://hotgetaways.com.au/tour/sight-seeing/ningaloo-reef-humpback-whale-adventure/

Size and shape

As a fringing reef, Ningaloo is narrow and extends for 290 km along the West Australian coastline. It is the longest fringing reef in the world and one of only two on the west coast of a continent. The Ningaloo Reef area is a marine environment with Cape Range National Park on the adjacent coast. See Figure 1.

The Ningaloo Marine Park is 4587 km2 in size, consisting of 2326 km2 of commonwealth waters and 2261km2 of

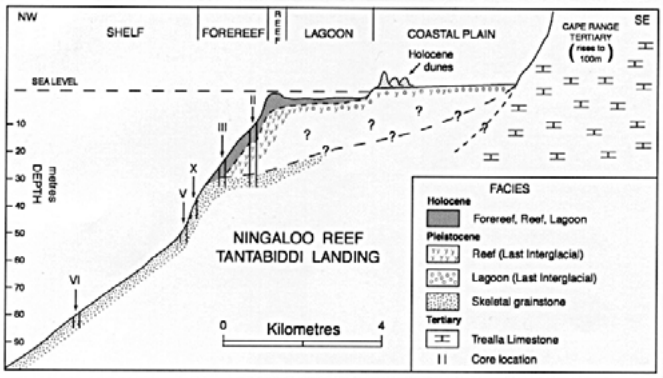
state waters. The World heritage site is 604 500 ha (6045 km 2) of marine and terrestrial environments - demonstrating the integrated nature of the ecosystems.

Continuity

The fringing reef is quite young, at only about 7- 8000 years old. The karst landscape adjacent to the reef owes its geological origin to previous reef activity and sea level change. See Figure 2.

Uplifted wave-cut terraces and fossil reefs fringe the Exmouth Peninsula and submerged fossil reef terraces form the substrate of the developing modern reef. These features contribute to the region's outstanding heritage value. Figure 2 shows the structure of the coastline where Ningaloo reef is building on a foundation laid by previous reefs. The source of this diagram can be used to further investigate the past geological history of the area.

Figure 2: Idealised northwest-southeast cross-section of northern Ningaloo Reef based on transect core and seismic data.



Sources: Collins, Lindsay & Zhu, Z. & Wyroll, K. & Eisenhauer, Anton. (2002). Geological evolution of the northern Ningaloo Reef System during the late Quaternary. 1. Ningaloo Marine Park – Reef Morphology and Growth History (WAMSI) – https://www.wamsi.org.au/sites/wamsi.org.au/files/Node%203.4.1%20Reef%20Morphology%20and%20Growth%20History.pdf

Further reading

The following article provides a deeper insight into the continuity of coral reef formation along this section of the Western Australian coast. 'Travels in Geology: Twin coral reefs separated in time in Western Australia' https://www.earthmagazine.org/article/travels-geology-twin-coral-reefs-separated-time-western-australia

BIOPHYSICAL INTERACTIONS

Dynamics of weather and climate

Ningaloo has a hot and arid climate with an average annual temperature of 24.8°C and precipitation of 260 mm. This climate results in low run-off of very high, water quality for coral reef building. See Figure 3.

The area is subject to regular tropical cyclones with events expected every 2–3 years (BOM). The most severe storm on Australian record was tropical cyclone Vance which struck Exmouth in 1999. Cyclones cause strong destructive winds in excess of 100km/h and high levels of precipitation.

Figure 3: Climate statistics and sea temperatures for Coral Bay

CORAL BAY	
Month	Sea Water Temperature °C
January	24
February	26
March	26
April	26
May	26
June	24
July	23
August	22
September	22
October	22
November	23
December	23

CORAL BAY (5 meters)				
Month	Average low (°C)	Average high (°C)	Precip. (mm)	Precip. days
January	23	38	26	
February	24	37	40	
March	23	36	40	
April	20	33	15	
May	16	28	41	
June	13	24	40	
July	11	24	22	
August	12	26	11	
September	14	29	2	
October	16	32	2	
November	18	34	2	
December	20	36	5	
YEAR			246	

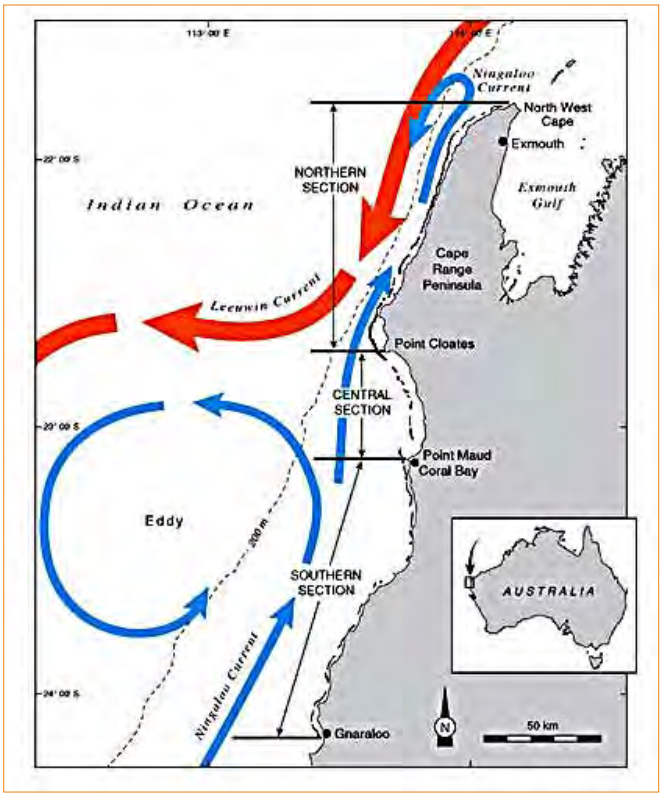
Source: https://www.travelguide-en.org/coral-bay-climate/#

Geomorphic and Hydromorphic Interactions

The Leeuwin and Ningaloo Currents are a major determinant in Ningaloo Reef's location. The Leeuwin Current draws warmer water from the north allowing Ningaloo's reef-building corals to flourish. Most reef building coral species grow optimally in water temperatures between 23°–29°Celsius (NOAA).

However, the Ningaloo current also brings cooler water from the south which combines with the latitude of the area to place it on an ecotone, between tropical and temperate waters. This results in the Ningaloo Coast hosting an unusual diversity of marine species. See Figure 4

Figure 4: Ocean currents on the Ningaloo Coast



The Leeuwin Current brings warm waters south allowing for coral growth. The Northward Ningaloo Current comes closer to the Leeuwin Current between March and July creating an eddy of upwelling. This brings an abundance of zooplankton which attracts whale shark feeding congregation

Source: https://www.latitudegeography.org/ningaloo-reef.html

The arid climate is beneficial for coral. Most reef-building corals require very saline water ranging from 32 to 42 parts per thousand and water with very low turbidity to allow the maximum amount of light to penetrate. The average annual rainfall of 260mm supports these requirements. See Figure 3.

The main terrestrial feature of the Ningaloo Coast is the extensive karst system which is the product of millions of years of marine fauna skeletons that were deposited in what is now ancient regressed seas, uplifted terrain and network of underground caves and water courses of the Cape Range. The karst system includes hundreds of separate features such as sinkholes, caves, dolines and subterranean water bodies and supports a rich diversity of highly specialised subterranean species (UNESCO).

Sediment formation on the Ningaloo coast is also highly biological as broken coral pieces are further eroded by wave action, Parrotfish "chew" coral and deliver fine sediment in their faces and mollusc shell pieces are eroded.

Biogeographical Interactions

The Ningaloo Coast is notable for its very high biodiversity. Over 300 documented coral species of coral are present on the Ningaloo Coast. Reef building corals are the keystone species as they provide the habitat for all other species in the ecosystem. Coral polyps have a symbiotic relationship with algae **zooxanthellae**.

Over 700 reef fish species, roughly 650 mollusc species, as well as around 600 crustacean species and more than 1,000 species of marine algae all live within the reef. The high numbers of 155 sponge species and 25 new species of echinoderms add to the significance of the area (UNESCO).

Ningaloo Reef has high levels of biodiversity. Source: Shutterstock

The flora and fauna of the Ningaloo Coast have developed a range of adaptations to inhabit ecological niches. These physiological and behavioural adaptations include camouflage, symbiosis, territoriality and distinct breeding patters. An example of this is the annual coral spawning that occurs approximately 10 days after the full moon in March or April. Predator relationships, such as the Drupella snail are thought to have a positive effect on the diversity of their prey by pruning faster growing corals.

Ningaloo also forms the habitat for several high value species including marine mammals such as dugongs, whale sharks (Rhincodon typus), manta rays, many species of turtle (including Loggerhead and Green turtles).

The whale shark is known to migrate globally making Ningaloo an important site ecologically. Whale sharks congregate at Ningaloo between March and July. While the exact purpose of these congregations are unknown, it is believed to be a feeding event (Tourism Western Australia).

Whale sharks are a major tourism attraction.Source: Shutterstock.

Image source: Wikimedia Commons

Further reading

The following article is about research in 2020 that discovered previously unknown species on the reef:

'Rare pictures uncover diverse marine life at Ningaloo Reef'

https://www.news.uwa.edu.au/20190910116O2/research/rare-pictures-uncover-diverse-marine-life-ningaloo-reef

THE NATURE AND RATE OF CHANGE and ECOSYSTEM FUNCTIONING

Tropical cyclones are a key natural stress for the Ningaloo coast. The strong winds and waves damage coral structures and the high rainfall can result in freshwater pooling. In response the outskirts of reefs tend to grow less delicate branching corals. Areas that have been destroyed are also able to be recolonised by neighbouring coral and the annual coral spawn.

Corals thrive in locations that also happen to be near their physiological limits, making them sensitive to stresses caused by sea temperature anomalies resulting in the phenomenon known as coral bleaching (AIMS). When stressed by high temperatures the symbiotic relationship between coral polyps and the zooxanthellae algae breaks down and is expelled resulting in bleaching events. This is not necessarily lethal for the coral; however, repair may take 10–20 years and greater frequencies of coral bleaching will result in the death or the decline of the coral cover.

Predator-Prey dynamics are common factors affecting coral reefs globally. Ningaloo's reefs are not heavily affected by the crown of thorns starfish. However, outbreaks of Drupella (a type of snail) have drastically reduced coral cover, destroying 90% of corals in parts of the northern reef at Ningaloo Reef in 1997. More on Drupella snail outbreaks.

The nature and rate of change which affects ecosystem functioning

Coral polyps are a finely tuned species with a very narrow range of tolerance. This makes them quite vulnerable.

There are a wide variety of changes which affect the ecosystem. These might be natural or man-made and might be very gradual or rapid and catastrophic.

Rapid Changes

i. Tides:

- Tides affect the vertical extent of the coral.
- Tides are a response to the sun and moon's gravitational pull on the earth's water.

ii. Weather:

- Weather changes daily and the Ningaloo area is prone to heat waves in summer months.
- Heat stress causes the coral to exclude the zooxanthellae algae which can result in coral bleaching.
- Increased bleaching will cause starvation, killing the coral.

iii. Tropical cyclones:

- Tropical cyclones cause extreme wind and wave action and potentially, storm surges.
- This violent action can damage the reef structure.
- Fresh water pooling can also cause stress on coral.

Medium Changes

i. Climate change:

- The issue of the climate change of significant for marine park and World Heritage management of the reef. The key issues for Ningaloo are likely to be coral bleaching, increased storminess, increased sea-level and ocean acidification.
- As with the Great Barrier Reef, Ningaloo can be aided to be more resilient to climate change impacts by ensuring that local impacts from mining and tourism don't create too much strain.

ii. Ocean acidification:

- Ocean water naturally has a pH of 7.5 – 8.5. Coral polyps exude an exoskeleton of limestone. The coral skeleton forms the structure of the reef which many other organisms use as their habitat.
- Ocean pH is subject to change as it forms a dynamic equilibrium with atmospheric CO2 (increasing acidification is a threat to coral survival)

ii. Sea surface temperatures:

- Ocean/Atmospheric exchanges (La Niña/El Niño). Strong La Niña events push water south from Indonesia creating far higher temperatures than the seasonal average and a very large coral bleaching event resulted.

Slow Changes

- Sea level change

Further reading

Scientists Pinpoint How Ocean Acidification Weakens Coral Skeletons – https://www.whoi.edu/press-room/news-release/scientists-identify-how-ocean acidification-weakens-coral-skeletons/

Human Impacts

Tourism puts pressure on preservation of the reef while mineral exploration places the extraction of resources at higher value.

As most people know little about Ningaloo Reef, its anonymity and distant location benefit it.

i. Development (-ve)

- Proposed development of "Maud's Landing" was highly controversial as it threatened to disturb loggerhead turtle breeding areas. Although it did not proceed it was partly responsible for the World Heritage listing.
- Any development of the region places additional pressure on numerous aspects of local ecology:
  - The water cycle is disturbed, and wastewater / sewage are generated
  - Construction and dredging activities generate turbidity.
  - Additional human activity is generated and pushed into remote areas
  - Animal breading habits may be disturbed.
- In 2012 Tony Abbott made an election promise to "develop the north" and encourage future development in the region. This approach was favoured by both sides of politics. Colin Barnett the Western Australian Premier has also long held a pro development stance. The Gascoyne Development Commission is a Western Australian Government statutory authority dedicated to the economic and social development of the region.
- In 2020 a proposed oil and gas pipeline fabrication facility (Subsea 7) and towing operation in the nearby Exmouth Gulf was out on hold until June 2021.

Further reading

Pipeline near WA's Ningaloo put on hold – https://www.canberratimes.com.au/story/6900650/pipeline-near-was-ningaloo-put-on-hold/

ii. Tourism (-ve/+ve)

- Tourism is the number one economic driver in Gascoyne region, followed by fishing, retail, mining, horticulture and pastoral industries.
- Tourism in the area is primarily self-drive and there is limited air access.
- The reef is rarely more than a few kilometres offshore and in many places is directly off the beach - possible for tourists to wade out to.
- Ningaloo's pristine environment ironically attracts people which has a damaging effect on the reef. Snorkelling and fishing are the main tourist activities, and both can be highly sustainable if managed well. The remoteness of Ningaloo reef tends to attract a nature loving type of tourist.

iii. Military Activity (-ve)

- Learmonth Air Weapons Range Facility covers about 18,954 hectares is used for military exercises and as a bombing range.
- It was one of Australia's most active bombing ranges until around 1990. Exmouth also has a significant history of US naval presence. The Federal

Government's 2016 Defence White Paper allocates an investment of over $400 million into Exmouth to develop missile defence and space capabilities; including the relocation of a space surveillance telescope to be set up near the Harold E Holt Naval Communication Station and the Learmonth RAAF Base.

- Future bombing activities on the Learmonth Air Weapons range may pose a potential threat, in particular to the Bundera sinkhole which is located on Defence land. A 2009 review of Department of Defence ranges recommended its continued use in the future.
- Although Defence land within the heritage site is subject to the EPBC Act, the act may be countermanded if this is "in the interests of Australia's defence or security, or in relation to a national emergency".

iv. Mining (-ve)

- Both BP and Royal Dutch Shell have bid to conduct test drills for hydrocarbon resources as close at 48 kilometres from the Commonwealth marine park boundary.
- Shell was given approval for exploration 50km west of Ningaloo in July 2011 and Fortescue Metals submitted an application to explore for minerals along a 500km stretch of WA coastline but later recalled the application.
- In addition to the increased risk of oil spills the seismic vibrations impact on sea turtles, fish and whales that frequent the area.
- Hydrocarbon mining also bring an increased frequency of shipping activity which raises the risk from oil spills and exotic introductions from ballast water.
- The Exmouth gulf has also faced plans for a salt mining operation. This has been protested by WWF and a group called Halt the Salt! - primarily on the grounds of damage to associated ecosystems like mangroves forests.
- As with the GBR, there is now an interesting debate about whether Australia should be developing hydrocarbon industries. Global carbon pricing may result in the creation of "stranded assets" and prevent Australia from transitioning to other industries in a timely manner. Students can use this to explore opportunity cost.

v. Fishing, Snorkelling and other water activities (-ve)

- The Ningaloo Marine Reserve is multi use zone with many commercial activities, such as fishing not permitted. However, multiple small-scale operators can also have an impact.
- Anchor drop is a major impact that results from fishing, diving and snorkelling vessels and can result in significant damage to coral structures. Cruise ship anchor activity has significantly larger impacts. This damage is easily avoided with mooring buoys.
- Reef walking and snorkelling are both highly ranked tourism experiences, but both are high impact activities.
- Tourism activities disturb breading patterns, although strict behaviour is required when encountering animals such as Whale Sharks. See Figure 8

vi. Feral Animals

- Weeds, cats and foxes are all common feral species on the Ningaloo coastline. They reduce vegetation which lowers water quality and affect various trophic levels.
- Exotic predation places stress on species unaccustomed to predators.
- Foxes are a significant problem for turtle hatching and the area is also likely to be within the distribution of can toads in the future.

vii. Climate change and Sea level rise (-ve).

See Figure 5

- Probably the biggest threat to the reef
- Extreme heat bleaches coral. See Figure 6
- Climate temperature rises enhance the frequency and severity of tropical cyclones
- Greater stress makes coral more susceptible to pest out breaks like Crown of Thorns
- Sea level rises mean coral cannot adapt quickly enough
- Ocean acidification (changes negatively from around 8) mean that coral cannot build its limestone structures and prevents growth and repair.

viii. Environmental Management (+ve)

- The scientific management of ecosystems is improving, and Ningaloo coast's isolation meant there were fewer visitors in the era of poorly behaved tourism. Tourists and development now face stricter controls.
- The Ningaloo Collaboration Cluster is a major research project that commenced in the region in 2007.
  - The project involves researchers from the CSIRO, Sustainable Tourism Cooperative Research Centre and a range of Australian Universities including Uni of Western Australia, ANU and Uni of Queensland.

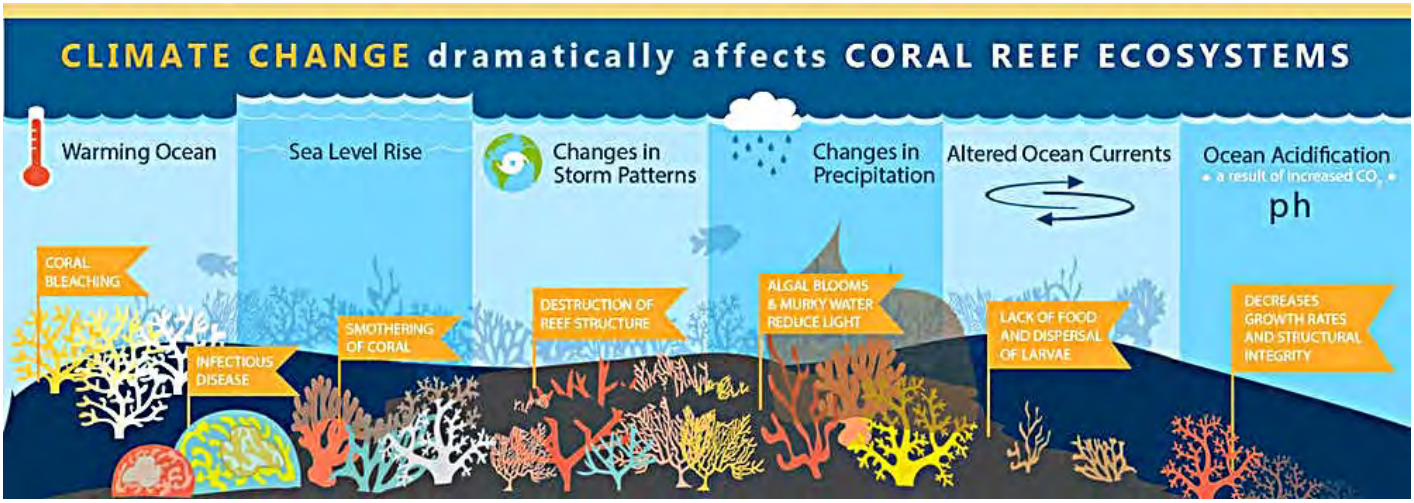
– The project will deliver a dynamic model of Ningaloo incorporating socioeconomic and environmental load implications of human activity in the region that can be integrated with an ecological model of the region with the aim of developing planning tools and management models to ensure sustainable use of the region.

ix. World Heritage Listing (+ve)

- Inscribed in 2011
- World heritage status places international pressure on government to protect the area.

Source:http://www.ningalooreefboathireexmouth.com.au/gallery.html

Figure 5: Impacts of Climate Change



Source: https://reefci.com/2017/10/20/climate-change-and-coral-reefs-2/

MANAGEMENT STRATEGIES

Traditional Management

- Aboriginal occupation of area evident for 32 000 years through middens, fish traps and burial grounds.
- Jinigudira people occupied most of Ningaloo Coast from Northern tip. Baiyungu people occupied the southern portion of the reef coast.
- Under traditional law, Aboriginal people are responsible for, and obliged to protect, preserve and manage areas, sites and objects of Aboriginal significance associated with their country.
- Traditional management includes protection and preservation of physical sites and objects as well as the traditional knowledge and practices pertaining to them.
- The "meaning" of the land is also important as it reveals the record of creation and the history (The events of Dreamtime).
- These responsibilities and obligations are of continuing importance to Aboriginal people, particularly with respect to teaching cultural heritage to the young.

Figure 6: Coral Bleaching

Source:https://climatechange.lta.org/climate-impacts/coral-reef-degradation/

- The Gnulli Native Title claim (represented by the Yamatji Land and Sea Council) may also see this land management continued.
- Hunting of dugong and turtle are an example of finding a balance between contemporary and traditional management practices

- Coral Coastal Park demonstrates cooperation between Gnulli Working Group, Baiyungu traditional owners and CALM to facilitate Aboriginal involvement in management of the Ningaloo Marine Park and the Cape Range National Park.
- A Draft plan of management for Ningaloo Coast Reserves that include part of the marine park was released for consultation in 2019.

Further reading

For insight into Aboriginal cultural heritage, managing traditional values and the contribution of traditional owners to the planning for the *Nyinggulu* (Ningaloo) coastal reserves by the WA Department of Biodiversity, Conservation and Attractions read:

Nyinggulu (Ningaloo) coastal reserves, Red Bluff to Winderabandi, Draft Joint Management Plan. (Pages 9–23) https://www.dpaw.wa.gov.au/images/documents/conservation-management/managementplans/Ningaloo%20coastal%20reserves%20draft%20joint%20management%20plan%202019.pdf

Contemporary Management

Maps showing management zones can be found here http://ningaloo-atlas.org.au/node/215

- The Ningaloo coast is managed jointly by WA (along shoreline) CALM and the Commonwealth (over deeper waters) Department of Environment
- Management uses multiple reserve zones and restricted use areas. See Figure 10
- Area is managed for conservation and recreation and management plans have been developed to protect environmental, social and economic values.
- There are numerous State/Commonwealth legislation governing Ningaloo reef:
  - Wildlife Conservation Act (1950),
  - Environmental Protection Act (1986),
  - The Aboriginal Heritage Act (1972) and the Conservation and Land Management Act (exception: pastoral leaseholds) (1984).
  - The entire marine component is subject to the Fish Resources Management Act (1994).
- World Heritage Listing in 2011 provides additional pressures on Governments to protect the reef.
- Designation as a Hope Spot by Mission Blue. See Figure 7
- Research and scientific investigation are utilised to ensure management plans are effective. Plans are redrawn as needed. The Ningaloo Collaboration Cluster is a major CSIRO research project.
- Technology aids ecological management
  - Robot sensors used to scan sea floor
  - Tourist photos of whales and sharks to create a movement database
  - remote underwater stereo-video (stereo-BRUV)
  - Lidar photography (bathymetry)
- Visitors to the area are educated through signs and guides. Such as rules for whale shark and whale watching. See Figure 8
- Activism: Interest Groups such as Protect Ningaloo advocate for protection and seek community support to oppose proposed developments such as Subsea 7. See Figure 9

Figure 7: Hope Spot naming

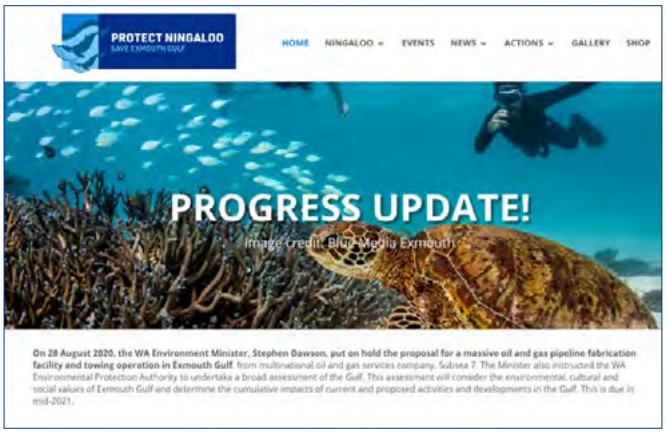
The world heritage-listed Ningaloo Reef and adjacent Exmouth Gulf were together named a Hope Spot by international marine science organisation Mission Blue, which is run by legendary oceanographer Dr Sylvia Earle. Hope Spots are natural environments which contain significant marine ecological values that are threatened, and it was decided the coastline around Exmouth met the criteria on the back of a scientific review released by Dr Ben Fitzpatrick in July. Dr Fitzpatrick said a Hope Spot listing would help to achieve broader recognition of the ecological values and better protection of the area.

Source: https://www.pilbaranews.com.au/news/pilbara-news/ningaloo-reef-exmouth-gulf-named-global-hope-spots-ng-b881289003z

Figure 8: Rules for wildlife tourists

Whale shark management in WA
Source: https://www.dpaw.wa.gov.au/plants-and-animals/animals/whale-sharks?showall=&start=2

Figure 9: Activism: Protect Ningaloo



Source: https://www.protectningaloo.org.au/stop-subsea-7/

Evaluation of management

- Traditional Management has proven extremely sustainable. However, it is no longer possible and relies on extremely detailed ecological knowledge being woven into every aspect of culture.
- Contemporary management is only as effective as the will to protect the ecosystem. As with other ecosystems, this may require the utility values from tourism and ecosystem biological values to achieve higher value than is being derived from mineral extraction in order for protection and management of the reef to be taken seriously.
- International involvement, such as the World Heritage listing, places additional requirements on Governments to protect the coastline. However, international threats also pose the greatest risk to the ecosystem and it is most threatened by climate change, which is beyond the control of Australian governments. The Coalition government has taken little direct action to address climate change.

The verdict: The Ningaloo coast is one of the best-preserved reef systems in the world however sustainability in not ensured. Sustainability requires continued valuing by the Australian community and businesses operating within or near the reef such as Live Ningaloo. Global forces such as climate change and ocean acidification are major threats that are beyond local control.

Read an interesting commentary of the management of Ningaloo over time from author Tim Winton here: 'Saving Ningaloo Again' https://www.themonthly.com.au/issue/2018/december/1543582800/tim-winton/saving-ningaloo-again#mtr

Figure 10: Marine Park Management Zoning

Ningaloo Marine Park Sanctuary Zones and Muiron Islands Marine Management Areas (Screen capture) Source: http://ningaloo-atlas.org.au/sites/default/files/Ningaloo%20Marine%20Park%20(State%20Waters)%20brochure.pdf

Resources

- TED: Ningaloo Reef and why it is important (Natural resource exploitation threats) https://www.youtube.com/watch?v=CtcGIr7utTM
- Ningaloo reef is unique (CSIRO) https://research.csiro.au/ningaloo/
- Ningaloo Atlas http://ningaloo-atlas.org.au/
- Ningaloo Marine Park https://parksaustralia.gov.au/marine/parks/north-west/ningaloo/
- Ningaloo Marine Park https://www.marineconservation.org.au/ningaloo-marine-park/
- Ningaloo Coast World Heritage Area https://www.dbca.wa.gov.au/parks-and-wildlife-service/world-heritage-areas/ningaloo-coast-world-heritage-area
- Map: Ningaloo Coast World Heritage Area https://www.environment.gov.au/system/files/pages/31a9e336-d04a-48cb-810b-76a2b53751ac/files/ningaloocoastmap.pdf
- Guidelines for interacting with wildlife (whale sharks, whales, manta rays, dugong) http://ningaloo-atlas.org.au/sites/default/files/Ningaloo%20Marine%20Park%20(Commonwealth%20Waters)%20visitors%20guide.pdf
- Backgrounder: Climate change and the tropical marine environment http://www.aims.gov.au/docs/research/climate-change/position-paper.html
- NOAA Ocean Services (Infographics) https://oceanservice.noaa.gov/facts/coralreef-climate.html
- CSIRO: Ningaloo Outlook https://research.csiro.au/ningaloo/outlook/

- Ningaloo Reef could be wiped in 30 years https://thewest.com.au/news/environment/ningaloo-reef-could-be-wiped-in-30-years-warns-intergovernmental-panel-on-climate-change-ng-b88984088z
- Dive into Ningaloo on Streetview, 2020 https://australia.googleblog.com/2020/06/dive-into-ningaloo-on-google-street-view.html
- Ningaloo Marine Park – Reef Morphology and Growth History Final Report https://www.wamsi.org.au/sites/wamsi.org.au/files/Node%203.4.1%20Reef%20Morphology%20and%20Growth%20History.pdf
- Travels in Geology: Twin coral reefs separated in time in Western Australia https://www.earthmagazine.org/article/travels-geology-twin-coral-reefs-separated-time-western-australia
- Ningaloo Reef, Exmouth Gulf named global Hope Spots https://www.pilbaranews.com.au/news/pilbara-news/ningaloo-reef-exmouth-gulf-named-global-hope-spots-ng-b881289003z
- Coral bleaching and reef degradation https://climatechange.lta.org/climate-impacts/coral-reef-degradation/
- Whale shark management (Government of WA) https://www.dpaw.wa.gov.au/plants-and-animals/animals/whale-sharks?showall=&start=2
- Ningaloo survey finds deep treasures worth protecting National Science Environment Program: Marine Biodiversity Hub. https://www.nespmarine.edu.au/news/ningaloo-survey-finds-deep-treasures-worth-protecting
- Rare pictures uncover diverse marine life at Ningaloo Reef (University of WA) https://www.news.uwa.edu.au/2019091011602/research/rare-pictures-uncover-diverse-marine-life-ningaloo-reef
- Natural history magazine https://www.naturalhistorymag.com/htmlsite/master.html?https://www.naturalhistorymag.com/htmlsite/0406/0406_feature.html
- Has been bleaching and loss of biodiversity https://www.youtube.com/watch?v=4sfqzUI1p9o
- Scientists Pinpoint How Ocean Acidification Weakens Coral Skeletons https://www.whoi.edu/press-room/news-release/scientists-identify-how-ocean-acidification-weakens-coral-skeletons/
- Ocean acidification https://www.youtube.com/watch?v=6SMWGV-DBnk
- How does ocean acidification affect coral reefs? https://www.youtube.com/watch?v=ccYvlbcBlTY
- Coral reefs and climate change https://www.youtube.com/watch?v=BgFS5f_MUMg
- Rising Ocean Temperatures are "Cooking" Coral Reefs (National Geographic) https://www.youtube.com/watch?v=mQ10xBl8XMQ
- A 'chapter' of the short documentary, Western Australia's Ocean Environment – A Voyage of Discovery. Coral bay expedition https://www.youtube.com/watch?v=BwFKQx14-qg (WAMSI)
- Biodiversity: Science to inform conservation Marine Park https://www.youtube.com/watch?v=C9ygNABphlA
- Watch coral bleaching happen (National Geographic) https://www.youtube.com/watch?v=bFdPmiwZzVE
- Imagining a greener future for Ningaloo (ECOS) http://www.ecosmagazine.com/?paper=EC12276
- Ningaloo Coast: Conservation Outlook (IUCN) https://worldheritageoutlook.iucn.org/explore-sites/wdpaid/555542338
- What is the Western Australian Marine Science Institute (WAMSI) https://www.youtube.com/watch?v=Df_yvCN4bBc
- Ningaloo Reef: Researchers find low amounts of rubbish and waste at World Heritage listed marine park (ABC) https://www.abc.net.au/news/2018-06-18/ningaloo-reef-researchers-report-very-low-levels-ocean-debris/9866568
- Ningaloo Reef could be wiped in 30 years, warns Intergovernmental Panel on Climate Change (West Australian) https://thewest.com.au/news/environment/ningaloo-reef-could-be-wiped-in-30-years-warns-intergovernmental-panel-on-climate-change-ng-b88984088z
- Nyinggulu (Ningaloo) coastal reserves, Red Bluff to Winderabandi, Draft Joint Management Plan. (Pages 9 – 23) https://www.dpaw.wa.gov.au/images/documents/conservation-management/managementplans/Ningaloo%20coastal%20reserves%20draft%20joint%20management%20plan%202019.pdf
- Ningaloo Marine Park Management Plan https://www.environment.gov.au/system/files/resources/303362ea-8cc3-4410-874c-de424d050172/files/ningaloo-plan.pdf

CASE STUDY TASTER: OREGON DUNES

Lorraine Chaffer
Vice President, GTA NSW & ACT

The Oregon Dunes, Florence. Source: Wikimedia Commons

The images below show the Oregon Dunes but only one represents a threat to the survival of the Oregon Dunes ecosystem. Which image would you choose and why?

The Oregon Dunes can be used as a Case Study OR an illustrative example for Ecosystems at Risk. There is detailed information available to cover all syllabus requirements for this topic.

This article is a taster, an introduction to the Oregon Dunes as an Ecosystem at Risk.

A document containing information about the Oregon Dunes for all syllabus dot points will accompany this edition of the Geography Bulletin on the GTA NSW & ACT website

Open dunes are a popular tourist attraction Shutterstock

European Beachgrass on the foredune L Chaffer

OREGON DUNES – AN OVERVIEW

'Our hike through the Oregon Dunes was a lesson in how man can screw up nature, wrecking perfectly functioning ecosystems, probably beyond repair.'

Judy Nichols - Hiking the Oregon Dunes: A lesson in ecosystem destruction (2019) https://www.newamericannomads.com/blog/hiking-the-oregon-dunes-a-lesson-in-ecosystem-destruction/

Watch this short video clip for a 'big picture' summary of change over time to the Oregon Dunes and attempts to protect this unique ecosystem.

https://www.youtube.com/watch?time_continue=428&v=ZVx2dNTjywA&feature=emb_logo

Spatial patterns and dimensions

Location: Altitude: Latitude: Size: Shape: Continuity

The Oregon Dunes stretch 87 km along the Pacific Coast of the US state of Oregon, stretching in a continuous band from Heceta Head north of Florence (44° N, 124 ° W) to Cape Arago south of Coos Bay (43° N Longitude: 124° W). The eastern boundary extends up to 4 kilometres inland. The dunes cover 162 square kilometres (40,000 acres /16,200 hectares) making them the largest dune system on the West Coast of North America (spatial continuity) and one of the largest temperate dunes systems in the world.

The dune system is over 100,000 years old with the youngest dunes nearest the shore forming in the last seven thousand years. The oldest and highest dunes further inland to the east, are up to 150 metres in altitude and formed between 20,000 years ago and 100,000 years ago (temporal continuity). The primary source of sand for these dunes are the Cascade and Coast Mountains and the Umpqua River, Siuslaw River and other smaller rivers flowing to the west.

Source: https://www.mercurynews.com/2016/11/17/an-oregon-coast-getaway-waves-gems-and-plenty-of-charm/

Figure 1: General location map

Figure 2: The Oregon Dunes morphology

The dunes: Nearest the beach the foredune is a 7 to 8 metre vegetated ridge running almost continuously along the shoreline. Inland lies a deflation plain, a low-lying area with seasonal ponds and low transverse dunes. Farther inland, oblique dunes shaped by prevailing winds in winter, stand 60 metres above sea level.

BIOPHYSICAL INTERACTIONS

Coastal dunes are dynamic aeolian landforms created by interactions between the atmosphere, hydrosphere and lithosphere. These biophysical interactions create the abiotic conditions for dune formation and continuity across time and space. In their natural state, the sands of the Oregon Dunes move continuously from day to day, storm to storm, and season to season, and life on the dunes (the biosphere) has evolved to cope with these changes.

Lithosphere, atmosphere and hydrosphere (Abiotic interactions)

In order for coastal dunes to form there must be:

- adequate sediment availability (sand 0.2 –2.0mm in size)
- wind energy capable of transporting sand landward

Over 45 million years ago tectonic plate movements created the Cascade and Coast mountain Ranges. Weathered and eroded sediment was transported to the coast over thousands of years via the Siuslaw, Siltcoos, Tahkenitch, Umpqua, and Coos rivers. Sand accumulated on Oregon's broad continental shelf and a low coastal terrace of sedimentary rock. When sea levels fell, dry sand was moved by wind and when sea levels rose waves transported sand onto the coast. The flat coastal topography was the foundation on which the dunes were built and shaped by tides, wind and waves.

The Oregon Dunes contain many lakes such as the Siltcoos, Tahkenitch, and Tenmile Lakes formed when moving dunes dammed streams flowing from the mountains. Today, some of these lakes drain through creeks to the Pacific Ocean while inter-dune lakes such Lily Lake and Horsfall Lakes are intermittent and rely on seasonal rainfall.

Biosphere (Biotic interactions)

After the initial formation of the dune field, a positive sediment budget meant that sand continued to accumulate. Finally, the dunes were stabilised by groundwater (wet sand is not moved by wind) and the growth of vegetation that trapped the sand and stabilized the ground. A vegetation succession developed across the dunes. Pioneer species facilitated the establishment of other native species and biodiversity increased. There is a diversity of ecoregions within the Oregon Dunes including areas of moving sand, wetlands, bushland, woodland and forest – each adapted to the environment of a location. Figure 2 illustrates the changing topography and vegetation succession found in the Oregon Dunes today.

Much of the flora and fauna that has colonised the dunes over time has adapted to the shifting sands and ever-changing abiotic environment. Complex food webs and food chains transfer energy and nutrients and support high levels of biodiversity. Plant species are highly dependent on moving sand and wildlife feed in different areas of the dunes. The Western Snowy Plover forage for insects in the wrack (ocean debris) and dunes and Lupine, Wild Pea, and Sand Verbena grow in close proximity. When sand stops moving, some plant communities become permanent, however other native species disappear from the ecosystem. Native species impacted by changes to the lithosphere can be seen in Figure 3.

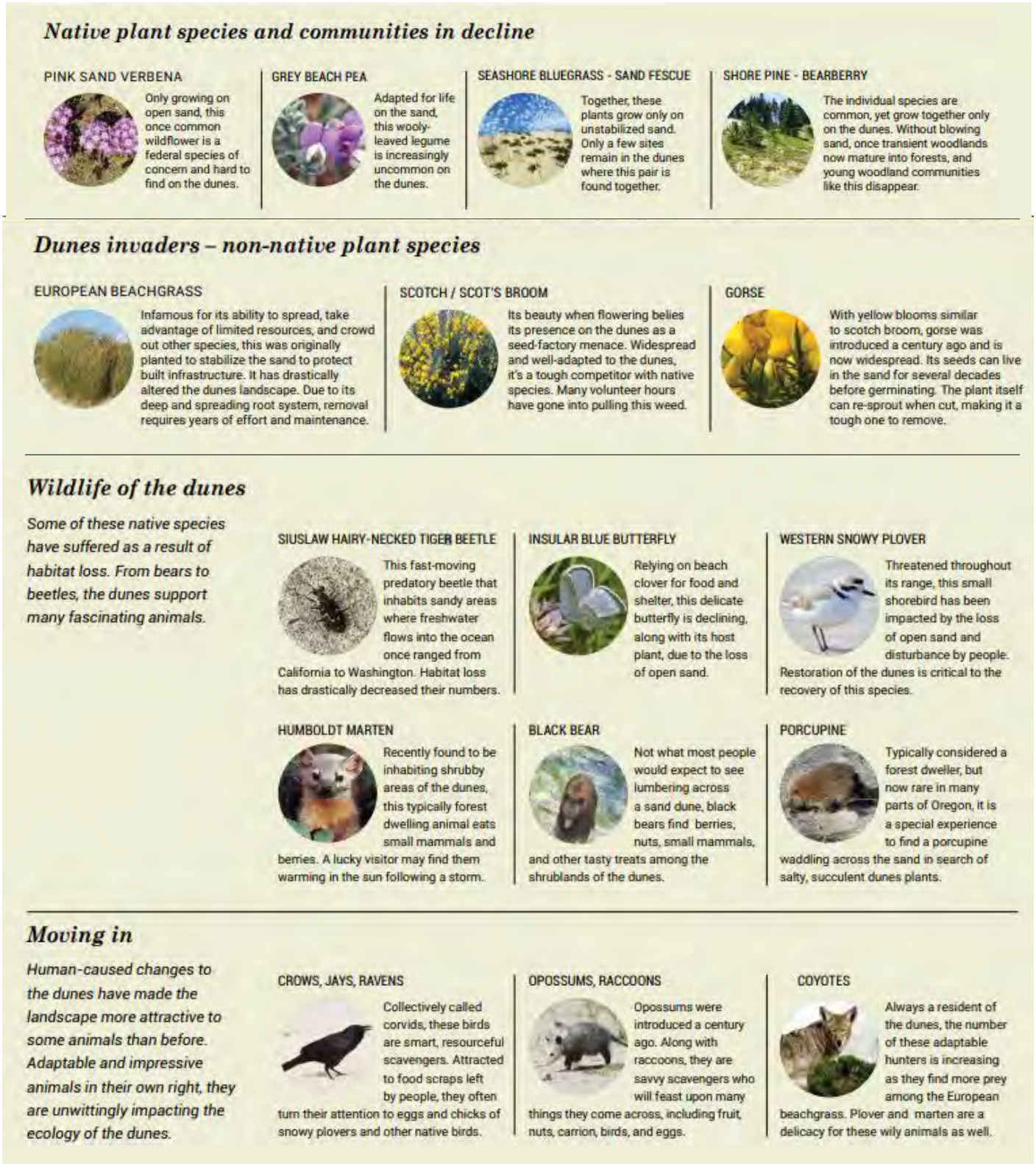
A unique ecosystem at risk of disappearing forever.

The Oregon Dunes are quite different today than they were 100 years ago. The introduction of European Beachgrass has changed the dune morphology and ecosystem dramatically. The loss of sand for dune formation and invasion of exotic species of plants and animals has caused irreversible change to much of the ecosystem … as far inland as the forests on the highest dunes. Only a few places exhibit features of the original ecosystem.

> *'There are few places where humanity's hand is as evident as it is on the dunes ecosystem. We have a responsibility to preserve what is left and restore what we can so the amazing natural processes and unique plants and wildlife of the dunes can thrive there once more.'*
>
> Chandra LeGue, Oregon Dunes Restoration Collaborative

The introduced European Beachgrass seen in the opening image of this article threatens the survival of the entire Oregon Dunes ecosystem. The beachgrass forms dense mats and hummocks with roots as deep as 10 metres extending to the groundwater below and rhizomes that spread long distances across the dunes. The dense grass prevents the seasonal movements of sand and has created a large stable foredune that blocks the wind, preventing the inland transfer of sand needed to replenish the dunes. Behind the vegetated foredune a large deflation plain, robbed of sand and no longer replenished by new supplies is now a wetland dominated by non-native bushland species and shrubs. See Figure 3 It has been calculated that 5 metres of dunes are being lost each year as these species take over and hundreds of metres of dunes have been lost over the last 80 years.

Figure 3: Biodiversity and change



See these images in greater detail and read a concise summary of the Oregon Dunes ecosystem at risk in the PDF document titled 'Restoring Oregon's Dunes' at https://www.saveoregondunes.org/wp-content/uploads/2019/06/Siuslaw_Dunes-Restoration-Strategy_WEB.pdf

The ecological changes to the Oregon Dunes are destroying the very features that attract locals and tourists to the dunes each year. The loss of intrinsic, heritage and utility values of the dunes is significant. See Figure 4.

> *'Without sand moving across the open landscape, plants that have evolved with blowing sand disappear, and plants that require an unmoving surface, moisture, and soil invade the dunes and a new succession of non- native species has taken hold'.*
>
> *'If the foredune was mobile the open sand would cover the naturally occurring deflation plains and move inward and the natural processes would work as they should'.*

Figure 3: Human induced change

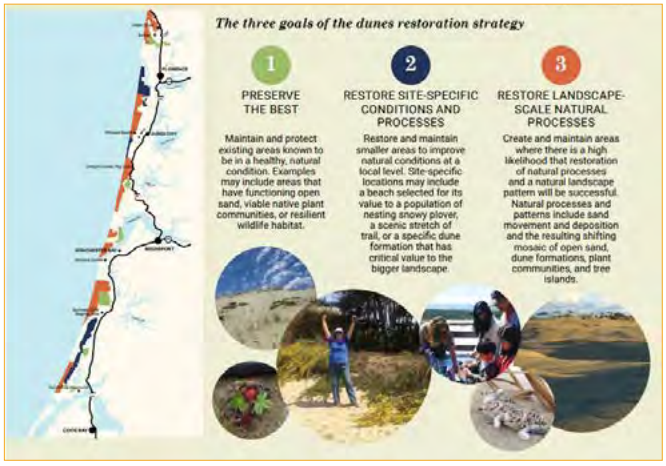
Foredune with European Beachgrass and other exotic species

Deflation plain and wetland behind the foredune

Photos L Chaffer

It has been accepted that most of the change to the Oregon Dunes ecosystem is irreversible. Management is now focused on maintaining the values of the existing dune ecosystems for people and the environment and efforts to restore the original ecosystem and its unique biodiversity to areas in the healthiest natural condition. See Figure 5

Figure 5: Goals of dune restoration



Map source: https://www.saveoregondunes.org/wp-content/uploads/2019/06/Siuslaw_Dunes-Restoration-Strategy_WEB.pdf

Figure 4: Ecological change

'Over the course of the last century, people who love the dunes began to see a shift – first subtle, later more pronounced – in the palette of this special place. The expanse of sand – the speckled tan, the pink-purple-yellow – was fading to grey-green, beachgrass green. And over time, an unusual succession was taking place. Where once the wind-driven sand kept the landscape, and the vegetation, in constant flux, the movement had stopped or slowed, and permanent wetlands and woodlands were taking the place of what had once been open sand.

Life on the dunes felt this shift as well. Snowy plovers were finding fewer and narrower areas of open sand to raise their young. Predators like coyote were finding it easier to catch dinner on the dunes, the dense vegetation providing cover for them as they hunted and more habitat for their prey; their numbers increased. Wetlands emerged and persisted as larger grass-covered dunes altered how wind touched the land, changing the very structure of the landscape. And new forests cropped up as beachgrass-covered sand provided a new solid foundation on which trees could take hold. Once transient and minor features of the landscape were now prominent, the mosaic altered and now static.

An early resident or settler of the Oregon dunes, visiting today, would find a vastly changed landscape, one where the delicate balance of wind, sand, plants, and animals has been thrown of kilter, where the motion of the dunes has been replaced by the march of beachgrass across the landscape, the unintended consequence of a century-old decision.'

Restoring Oregon Dunes. The bid to save a national treasure. https://www.saveoregondunes.org/wp-content/uploads/2018/02/Dunes-Restoration-Strategy.pdf

New wetland vegetation community on the deflation plain Photo: L Chaffer

Educational signs explain the changes happening to the dunes. Photo: L Chaffer

Management of the Oregon Dunes includes controlling tourist access and use as well as protecting breeding sites for endangered species such as the plover. L Chaffer

OREGON DUNES RESOURCES

- Save Oregon Dunes (PDF) https://www.saveoregondunes.org/wp-content/uploads/2018/02/Dunes-Restoration-Strategy.pdf
- Save Oregon Dunes website https://www.saveoregondunes.org
- Pavlis, *Dina. Secrets of the Oregon Dunes*. Florence, Ore: Windy Acres Enterprises, 2008. Book review http://alottasand.com/als-home.aspx
- Saving One of Oregon's Most Unique Landscapes https://www.coastexplorermagazine.com/features/saving-oregon-dunes-national-recreation-area
- The Secret World of Sand https://oregoncoastmagazine.com/2015/11/15/the-secret-world-of-sand/
- Oregon Dunes https://oregonencyclopedia.org/articles/oregon_dunes/#.XaBoSi1L1N3
- Oregon Dunes National Recreation Area https://en.m.wikipedia.org/wiki/Oregon_Dunes_National_Recreation_Area
- Oregon Dunes Restoration https://www.outdoorproject.com/articles/oregon-dunes-restoration
- Geology of the dunes https://www.fs.usda.gov/detailfull/siuslaw/learning/nature-science/?cid=fsbdev7_007155
- Oregon State Parks https://www.stateparks.com/oregon_dunes_national_recreation_area_in_oregon.html YouTube: Buggies in the dunes (Tourism) https://www.youtube.com/watch?v=aqnivVjb3gw

A DOCUMENT SUMMARISING KEY INFORMATION ABOUT THE OREGON DUNES TO COVER ALL SYLLABUS DOT POINTS WILL ACCOMPANY THIS EDITION ON THE GTA NSW & ACT WEBSITE

ADVICE TO CONTRIBUTORS

Geography Bulletin guidelines

1. ***Objective:*** The Geography Bulletin is the quarterly journal of The Geography Teachers' Association of NSW & ACT 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 NSW & ACT 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: Please try to limit the number of images 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 NSW & ACT Inc accepts responsibility for statements or opinions expressed herein.

Books for review should be sent to:

The GTA NSW & ACT Council
PO Box 699
Lidcombe NSW 1825

Editions

There are four bulletins each year – two published each semester. Special Editions are created on need.

Notice to Advertisers

'Geography Bulletin' welcomes advertisements concerning publications, resources, workshops, etc. relevant to geography education.

FULL PAGE (26 x 18cm) – $368.50
Special issues $649.00

HALF PAGE (18 x 13cm or 26 x 8.5cm) – $214.50
Special Issues $382.80

QUARTER PAGE (13 x 8.5cm or 18 x 6.5cm) – $132.00
Special issues $242.00

All prices include GST

Advertising bookings should be directed to:

GTA NSW & ACT Office
Telephone: (02) 9716 0378
Fax: (02) 9564 2342
Email: gta.admin@ptc.nsw.edu.au

The Geography Teachers Association of New South Wales Inc.