WATCH: How climate change is impacting Australia's Kelp Forests – https://www.youtube.com/watch?v=1jQH6ZG11zU

Source: Great Southern Reef

Climate change: Atmosphere and biosphere interactions

Anthropogenic climate change is placing increased stress on the Great Southern Reef and has caused significant kelp forest losses. Changes to kelp forest ecosystems attributed to a warming atmosphere include:

- **tropicalisation** and migration of herbivorous species of fish and urchins
- **kelp bleaching** reduces the ability of algae to photosynthesise and reproduce and makes them more susceptible to grazing by fish and other marine herbivores
- **marine heatwaves** bring temperatures that exceed the threshold for kelp to grow
- **ocean acidification** impacts organisms with shells or skeletons made from Calcium Carbonate e.g., lobsters. Shells dissolve in acidic water and organisms' ability to produce Calcium Carbonate structures is reduced. This can mean smaller creatures with thinner shells, slower growth and reproduction rates and repercussions for food chains and food webs.

BIOSPHERE AND ECOSYSTEM FUNCTIONING

'Kelp forests are the biological engine of the southern reef, producing as much as 65 tonnes of biomass per hectare per year, more than 16 times the yield from Australia's most fertile wheat fields.'

'This biological powerhouse provides both a habitat and a rich food source in our coastal ecosystems, critical for the energy and nutrient cycles supporting the rich marine life of the reef and the wider ocean beyond shelf waters.'

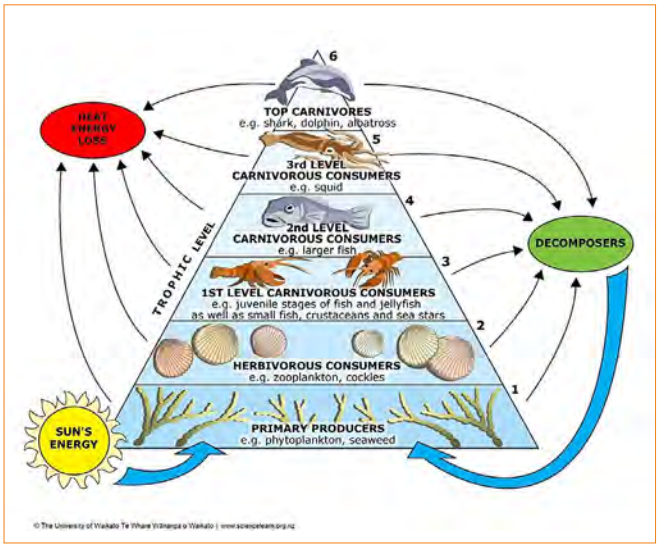
Source: https://theconversation.com/australias-other-reef-is-worth-more-than-10-billion-a-year-but-have-you-heard-of-it-45600

Food chains, food webs and energy flows

Kelp and microalgae (phytoplankton) are the **primary producers** of the Great Southern Reef. They are the primary biomass that captures the suns energy and creates food through photosynthesis. Organisms such as fish and urchins feed directly on kelp, others such as abalone, graze on *drift seaweed* (dislodged kelp or blades caught in cracks and crevices) and detritus or like sponges, organisms filter food floating in the water.

Consumers transfer energy through the trophic levels of the ecosystem. **Figures 10 and 11**

Figure 10: Trophic levels and energy transfer through a kelp forest ecosystem



Science Learning Hub – Pokapū Akoranga Pūtaiao, University of Waikato, Source: https://www.sciencelearn.org.nz/images/144-marine-trophic-pyramid

Kelps are **keystone species** and a **foundation species** because:

- without kelp the GSR ecosystem would not exist – when the kelp is lost the ecosystem collapses
- kelp creates 3D habitats for a large diversity of marine organisms.
- the physical structure of the reef and the biochemical properties of the seawater (oxygen, carbon dioxide, nutrients) that support life are largely determined by kelp.

The foundation species of the Great Southern Reef is the brown macroalgae known as Golden Kelp. Other large macroalgae include Crayweed, Giant Kelp and Bull Kelp growing on a reef.

WATCH this short video to learn more about Golden Kelp https://youtu.be/6gdeNgqGs5o

Recorded observations of Golden Kelp
Source: Atlas of Living Australia

Crayweed at centre are juveniles and adult plants on the right.
Image source: John Turnbull

The **high primary productivity** of kelp forests supports high levels of biodiversity across all trophic levels. Kelp also modifies the environment to create conditions that favour biodiversity. For example, kelp

- slows water movement providing a sheltered habitat on the sea floor
- shades the seabed for species needing low light
- creates an under-storey below the canopy
- provides habitat for mobile and sessile animals across all levels of the forest including within the holdfast.

Slowing water movement also catches drifting larvae making it easier for species such and rock lobster to reproduce and maintain their populations.

Great Southern Reef

The rocky reefs of the Great Southern Reef are home to some of the world's most pristine waters and diverse marine life.

Many of the species found on the Great Southern Reef make use of both the temperate rocky reef habitat itself as well as the adjoining inter-reef habitats such as the deeper water sponge gardens as well as shallow water seagrass meadows.

This week we are exploring the Great Southern Reef's vast networks of shallow water seagrass meadows.

Seagrasses differ to seaweeds as they are plants (unlike seaweeds which are algae). This means they have a root system, stems and leaves, and produce flowers and seeds. Like seaweeds, seagrasses are highly productive ecosystems and provide shelter and food to an incredibly diverse community of animals

GSR species visit many inter-reef habitats Source: Great Southern Reef Facebook Group for teachers . Posted Aug 30, 2021 – https://www.facebook.com/greatsouthernreef/

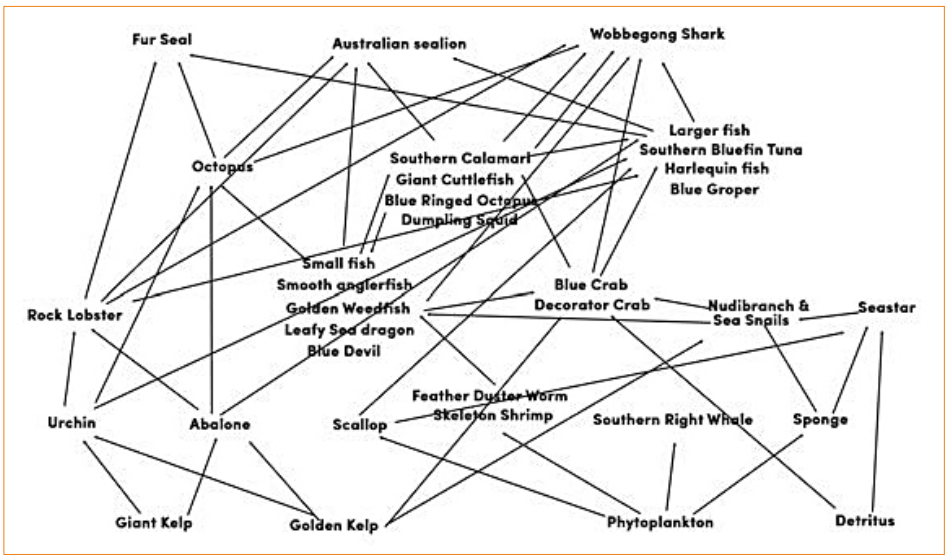
The GSR is a designated **global biodiversity hotspot** with species found nowhere else in the world and more **endemic species** than the Great barrier Reef. Of the three groups of algae (brown, green, and red) the Great Southern Reef has the greatest diversity of red algae in the world, more than 800 species with over 75% found nowhere else.

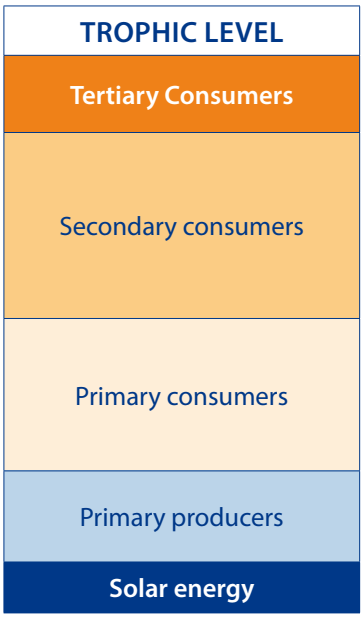
EXAMINE the biodiversity on the Great Southern Reef on the website https://greatsouthernreef.com/marine-life

COMPLETE a food chain and food web activity using the totem cards provided in the Great Southern Reef website. **Figure 12**

Figure 11: Kelp Forest food web

Note: Some species are on multiple trophic levels. For example, an omnivorous fish that eats seaweed and other fish is both a primary and secondary consumer.





Source: Great Southern Reef

Figure 12: Food chain / Food web activity

Totem Card Activity (Download totem cards **HERE**)

- Create a food web using the totem cards.
  1. Move around the room and find other on a similar trophic level. What do your species have in common?
  2. Move around the room and form a food chain by finding predator or prey species of your totem.
  3. Record the food chains of other groups and link them together to make a food web.
  4. Use your food web to predict the consequences if there were too many urchins, and not enough predators of urchins.
- Complete further research on species using this **worksheet** and the **marine life section of this website**

Source: Great Southern Reef Resources https://greatsouthernreef.com/resources

Nutrient cycling

Kelp plays an integral role in **nutrient cycles** including the carbon, oxygen, nitrogen and phosphorus cycles. They absorb carbon dioxide and release oxygen. The oxygen rich water supports consumer organisms that feed on the kelp and phytoplankton. Kelps absorb nutrients such as Nitrogen and Phosphorus directly from the water and transfer these nutrients to other consumer organisms through the food web. Nutrients and detritus from decomposed kelp support other consumer species such as sponges that feed by filtering water.

Beach wrack found on beaches adjacent to the Great Southern Reef consists of decomposing kelp and kelp forest organisms such as sponges and crustaceans that have been washed ashore. The decomposition of organic material recycles essential nutrients for both coastal and marine ecosystems. When it returns to the ocean decomposed wrack become another source of food in the kelp forest ecosystem. Many birds and terrestrial species also utilise wrack. For example, in South Australia, 40 species of birds use beach wrack for nesting, shelter and /or food.

Dynamic Equilibrium

There is a fine balance between producer and consumer organisms in the kelp forest ecosystem and unique and specialised relationships between organisms. This balance is easily upset by changes that cause as loss of species or reduced populations. Natural events such as storms and floods or human modifications such as pollution, sedimentation, overharvesting, introduced species and anthropogenic climate change. Kelp forests become **barrens** or are replaced by **algal turfs** cause imbalances.

'Research published today into the state of kelp forests around the world shows they are being degraded into flat seascapes carpeted by short, unwanted turf-algae – and the Western Australian coastline is one of the worst-affected areas.'

"Most worryingly, these critical transitions can be very difficult to halt or reverse because climate change is pushing more and more kelp forests over the tipping point for collapse."

Source: The rise of turfs—flattening of global kelp forests. University of Western Australia. 2018 – https://phys.org/news/2018-01-turfsflattening-global-kelp-forests.html

Kelp is a stationary species that cannot move to avoid a stress event. Once kelp is decimated or lost, reforestation is difficult without sufficient adult population. When a **tipping point** is passed kelp forests and the species they support will not recover naturally. Examples of kelp forest losses on the Great Southern Reef include Crayweed forests in Sydney, Giant kelp forests in Tasmania and Golden Kelp in Western Australia.

See Illustrative Examples

A Pygmy leatherjacket clings onto a stalked ascidian (sea squirt)
Source: Great Southern Reef Resources https://greatsouthernreef.com/resources

Spotted Handfish

The unique Spotted Handfish in Tasmania was impacted by the overfishing of scallops, the invasion of North Pacific Seastar and loss of the ascidians the fish need for reproduction. This story illustrates how **disequilibrium** has consequences for species.

WATCH: Spotted Handfish – https://www.youtube.com/watch?v=mWXpbmgDbE8

Endangered & Invasive Species – Teacher Guide **HERE**

Great Southern Reef
26 August at 21:21 ·

Many herbivorous fish that live on the Great Southern Reef such as the silver drummer (Kyphosus sydneyanus) feed on brown algae such as the golden kelp.

Mild herbivory on kelp forests is normal for a healthy kelp forest. But in recent years tropical herbivorous fish have moved further south into the Great Southern Reef on both the East and West coast.

A similar fish species, the grey drummer (Kyphosus bigibbus) is a tropical herbivore and usually feeds on tropical algae such as Sargassum and Turbinaria. With climate change increasing warming southern waters and increasing the range of tropical species, kelp forests have get a double whammy of stress.

"First you have the acute temperature stress then, at the same time, the warming temperatures bring in all of these tropical fish that like to eat seaweeds," explained Dr Thomas Wernberg.

Tropicalisation of species changes the dynamic equilibrium. Source: Great Southern Reef Facebook Group for teachers . Posted Aug 27, 2021 – https://www.facebook.com/greatsouthernreef/

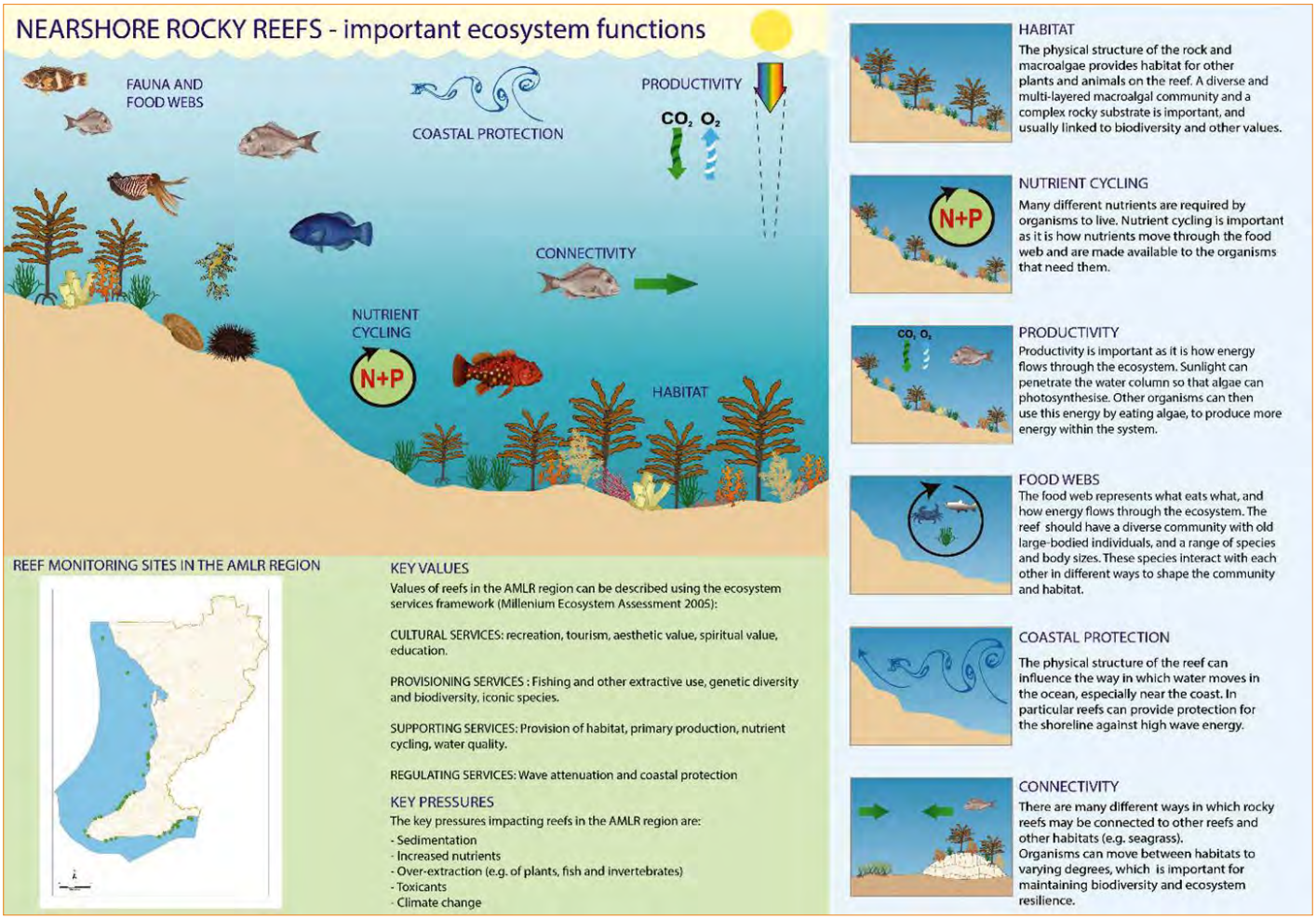
Spotted Handfish and egg mass on ceramic ASH
Photo credit Alex Horrmann and IMAS.

CONCLUSION: KELP FOREST ECOSYSTEM FUNCTIONING

Figure 13 summarises the ecosystem processes and functions of kelp forest ecosystems on the Great Southern Reef in South Australia and is representative of the functioning of kelp forest ecosystems across the entire reef.

See 'IMPORTANCE OF MANAGEMENT AND PROTECTION' on page 29 for more about the values of the GSR kelp forest ecosystem.

Figure 13: Conceptual model – Nearshore Rocky Reefs



Source: Imgraben, S., Peters, K. and Brock, D. (2019). Conceptual models of nearshore reefs in the Adelaide and Mount Lofty Ranges region. DEW Technical note DEW-TER-2018-10, Government of South Australia, Department for Environment and Water, Adelaide - https://data.environment.sa.gov.au/Coast-and-Marine/Ecosystems/Pages/home.aspx

Ecosystem functioning concepts for the Great Southern Reef

upwelling	biodiversity hotspot	oxygenation	turbidity
urchin barren	carbon sink	primary productivity	detritus
dynamic equilibrium	herbivory	trophic level	zonation
temperate	substrate	rocky reef	macroalgae
continental shelf	subtidal	marine heatwave	wrack
keystone species	microalgae	endemism	acidification
algal turf	habitat	biogenic habitat	tropicalisation

KEY: Atmosphere Lithosphere Biosphere Hydrosphere