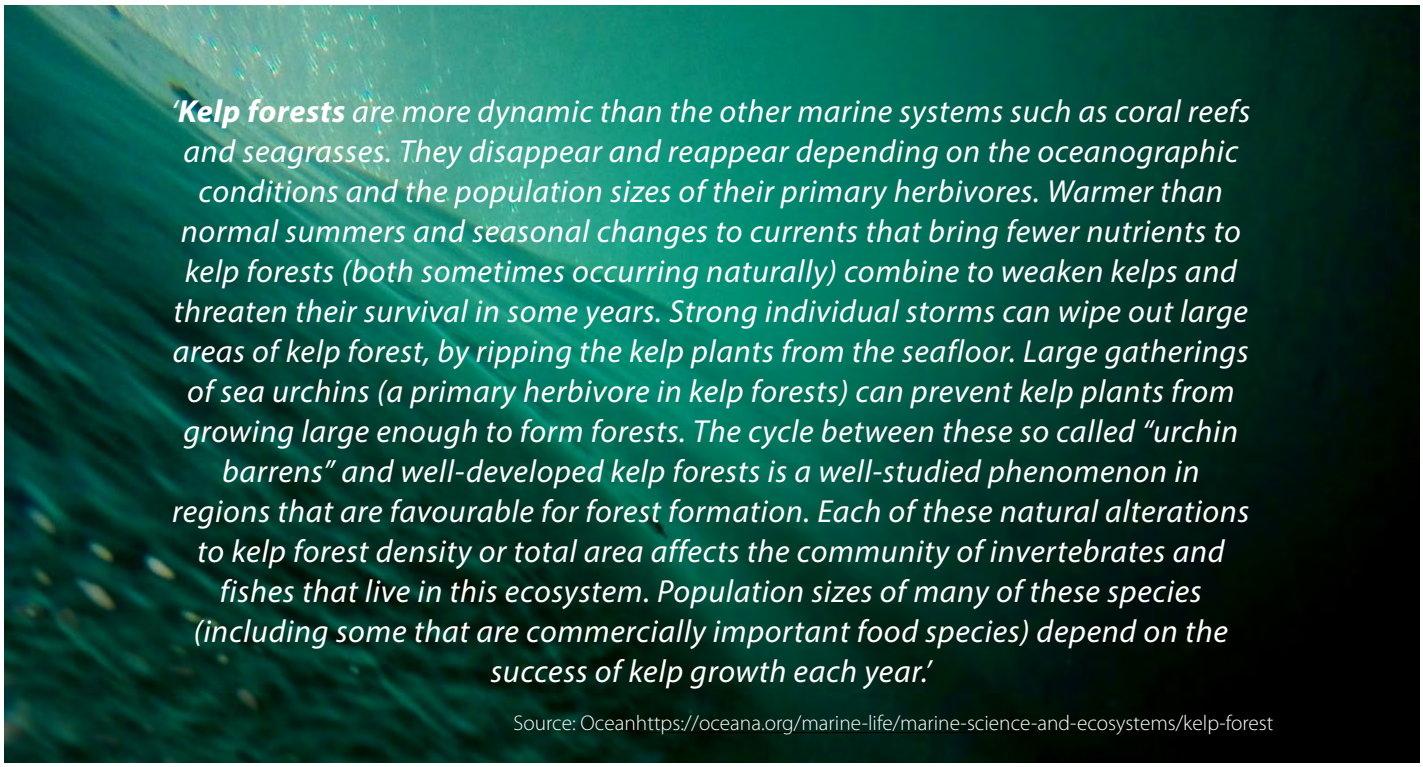
VULNERABILITY AND RESILIENCE

Marine ecosystems such as the Great Southern Reef continuously adjust to stresses caused by changes to their environment. This balancing act is known as **dynamic equilibrium**.



*'**Kelp forests** are more dynamic than the other marine systems such as coral reefs and seagrasses. They disappear and reappear depending on the oceanographic conditions and the population sizes of their primary herbivores. Warmer than normal summers and seasonal changes to currents that bring fewer nutrients to kelp forests (both sometimes occurring naturally) combine to weaken kelps and threaten their survival in some years. Strong individual storms can wipe out large areas of kelp forest, by ripping the kelp plants from the seafloor. Large gatherings of sea urchins (a primary herbivore in kelp forests) can prevent kelp plants from growing large enough to form forests. The cycle between these so called "urchin barrens" and well-developed kelp forests is a well-studied phenomenon in regions that are favourable for forest formation. Each of these natural alterations to kelp forest density or total area affects the community of invertebrates and fishes that live in this ecosystem. Population sizes of many of these species (including some that are commercially important food species) depend on the success of kelp growth each year.'*

Source: Oceanhttps://oceana.org/marine-life/marine-science-and-ecosystems/kelp-forest

RESILIENCE

The ability to adapt to a changing environment is called **resilience**. Kelp forests on the GSR display a high level of natural resilience within the biosphere. For example:

- flexible stipes allow kelp to bend and adjust to changes in wave energy caused by variations in weather conditions.
- high spore production allows for fast propagation and re-establishment on rock surfaces deforested by storm waves.
- rapid growth rates under optimal conditions speed recovery from change
- storage of nutrients enables species to survive periods of poorer water quality and low nutrients such as during floods or ocean warming events.
- natural predators keep herbivore populations in check
- high primary productivity supports complex food webs and connections between organisms. More complex food webs are more resilient to loss of organisms.

There is a low level of resilience to changes in the atmosphere and hydrosphere such as temperature and water quality.

VULNERABILITY

Kelp forests are extremely **vulnerable** to natural and human induced stresses. Kelp is the ***keystone species*** and principal ***primary producer*** for the Great Southern Reef kelp forest ecosystem**.** The loss or decimation of kelp can cause a ***trophic cascade*** of change that can result in a kelp forest ecosystem replaced by an urchin barren or algal turf.

Factors causing vulnerability include biodiversity, extent, location, and linkages. Figure

Biodiversity. Complex ecosystems with high levels of biodiversity have greater resilience. If one species is lost or suffers reduced population, the ecosystem can still function… unless it is the primary producer of the ecosystem.

Extent. Extent refers to dimensions including area, shape and continuity. Large, compact and continuous ecosystems are less vulnerable than smaller, fragmented and / or elongated areas where edge effects have greater impact.

Location. The location of an ecosystem determines the vulnerability to natural and human stresses including climate variability, extreme weather events, urban development, resource exploitation and pollution.

Marine ecosystems at all latitudes are vulnerable to global warming and marine heatwaves, although some locations, including the GSR, are experiencing a greater magnitude and rate of change.

Linkages. Connections within and between ecosystems are essential to ecosystem functioning. When linkages are broken or altered the dynamic equilibrium is disturbed. All ecosystems are linked to the atmosphere and hydrosphere and are increasingly vulnerable to changes in these systems.

Climate change and increasing vulnerability

'Due to their low capacity to relocate and high sensitivity to warming, kelp forests are projected to experience higher frequency of mass mortality events as the exposure to extreme temperature rises (very high confidence). Moreover, changes in ocean currents have facilitated the entry of tropical herbivorous fish into temperate kelp forests decreasing their distribution and abundance (medium confidence). More evidence from model projections in the 21st century supports this observed range contraction of kelp forests at the warm end of their distributional margins and expansion at the poleward end with the rate being faster for high emission scenarios (high confidence).'

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The frequency and intensity of extreme weather events is predicted to increase. The events that will increase the vulnerability of the Great Southern Reef include:

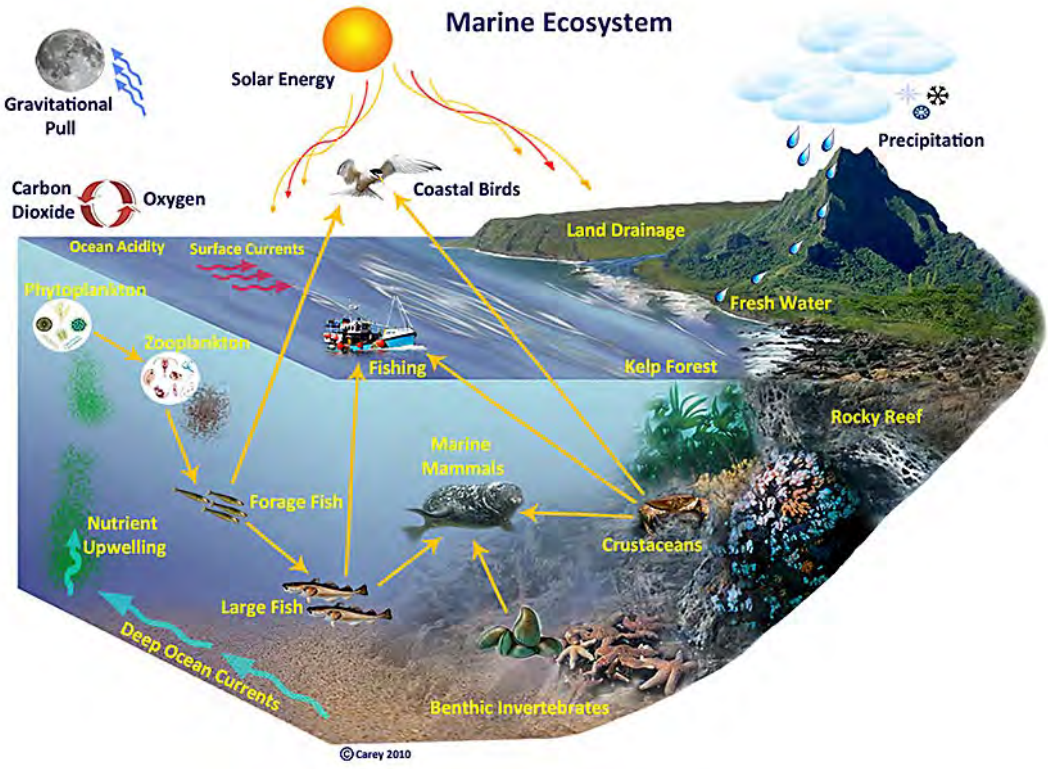
- longer, more intensity and more frequent heatwaves
- more intense and frequent extreme rainfall events and flooding
- higher sea levels

Management: Building resilience

Management is aimed at reducing vulnerability and maintaining or building resilience by:

- protecting vulnerable species and habitats to maintain biodiversity
- conserving and protecting current kelp forests and restoring lost forests
- maintaining populations of native species or removing threatening species
- managing stresses at specific locations by controlling human activities such as fishing

At a global scale, action on climate change is essential to minimising future kelp losses



Source: https://www.flickr.com/photos/xbordercurrents/5228770307

VULNERABILITY: GREAT SOUTHERN REEF

BIODIVERSITY

The Great Southern Reef has high levels of ***genetic***, ***species*** and ***ecosystem*** (habitat) diversity that reduce its vulnerability to stress. For example: in Western Australia, ***genetic resilience*** is attributed to Golden Kelp that was not decimated by a marine heatwave in 2010 –11. This find gives hope to kelp forest restoration efforts. Illustrative example – Green Gravel.

Golden Kelp has proven more resilient than Crayweed and Giant Kelp to changing environmental conditions and has survived in places where other species have been lost. See Illustrative examples – Super Kelp and Operation Crayweed

The Great Southern reef has a large ***diversity of interconnected habitats*** such as kelp, sponges, and seagrasses. Organisms move between habitats for food, breeding and shelter.

NOTE: Kelp habitat, the foundation of the GSR, is the most vulnerable to change.

EXTENT

The Great Southern Reef has a large latitudinal extent and covers 8000 km of coastline. However, it is comprised of many ***discontinuous smaller reefs*** with rocky outcrops often separated by large distances. These reefs occupy a ***narrow band of subtidal continental shelf*** where kelp grows to depths that light can penetrate. These environmental constraints make kelp forest ecosystems particularly vulnerable to changes in hydrologic and atmospheric conditions.

NOTE: There is little potential for kelp forests to extend seaward or coastward in the short term because of the limiting environmental conditions kelp requires. Over a longer timeframe however, adaptation, invasion and succession into different environments is possible if the rate of environmental change is slow.

LOCATION

Sections of the Great Southern Reef are adjacent to large populations and some of the fastest urban growth regions in Australia. All southern capital cities are coastal and put stresses on the GSR through pollution, harvesting resources, fishing, and recreation. See Illustrative Example- Operation Crayweed. Agricultural catchments increase the vulnerability of the GSR to pollutants and sedimentation.

Fortunately, large areas of the coast bordering the Great Southern Reef are protected in National and State Parks and reserves. These areas are often remote so much of the GSR in these locations is in good condition.

NOTE: No location along the GSR however can escape global warming and marine heatwaves. Increased herbivory and the disappearance of kelp is happening all along the GSR as a result of ocean warming. Sections of the GSR, such as eastern Tasmania are experiencing a greater magnitude and rate of warming.

LINKAGES

Kelp forest food web connections are easily broken by changes to biotic and abiotic conditions. Increased runoff from urban and agricultural landuse delivers sediment and pollutants that reduce kelp productivity. Declining populations of species due to overharvesting causes explosions in herbivore populations that overgraze kelp. Kelp loss has repercussions for food webs and biodiversity.

The Great Southern Reef is ecologically linked to adjacent ecosystems such as seagrasses, rock platforms and beaches and the deeper ocean. Changes to adjacent ecosystems and/or a loss of species has repercussions for kelp forests. For example, without coastal mangroves and seagrasses, kelp forests face increasing coastal sediment loads and turbidity and reduced biodiversity.