# ASSESSMENT OF THE SOUTHERN INLETS

2024 INTERIM REPORT

**THE CLIMATE CENTRE**

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# THE INAUGURAL ASSESSMENT OF THE SOUTHERN INLETS REPORT

I am honoured to introduce the inaugural Assessment of the Southern Inlets Report. This critical report by The Climate Centre, focuses on the health and future of the iconic and vital Nornalup, Wilson, and Irwin inlets located in Western Australia's beautiful Great Southern region. These remarkable natural features not only define the region's breathtaking coastline, but underpin a vibrant ecosystem, support recreational activities, and Indigenous heritage. And yet these pristine natural areas, with a low population density and being located in remote areas of the country, are often overlooked by scientific studies by both academic researchers and government policy makers.

Our research fills a gap in the scientific assessment of the Great Southern's estuarine environmental health, and in doing so paints an alarming picture. Based on current greenhouse gas emission trajectories, there is a projected mean sea level increase in this region of the world by 0.54 – 0.74 meters by the year 2100. Such a rise would be catastrophic for these low-lying estuarine inlets, which provide critical nursery habitat for fish and crustaceans while supporting local ecosystems, communities, and economies.

These inlets are environmental and economic treasures for the Great Southern. Their loss would be devastating – both locally through impacts on industries like fishing and tourism, and globally as biodiversity hotspots are drowned by the rising seas. Increased sea levels translate to increased coastal erosion, threatening the integrity of beaches and dunes. Increased inundation from storm surges and high tides can disrupt delicate ecological balances within the inlets.

I urgently call on all levels of government, industry, and the community to take comprehensive action to mitigate and adapt to sea level rise. We must aggressively reduce emissions while investing in coastal protection, habitat restoration, and long-term resilience planning. The science is unequivocal. Further delay will render the consequences potentially beyond our control. It is incumbent upon us to act decisively and ambitiously to safeguard the ecological wonders and economic future of Western Australia's treasured Southern Inlets. By working together – scientists, policymakers, and the community – can ensure the continued health and vitality of the Great Southern's inlets for generations to come.

**Ben Goodsell**
Principal Scientist

## A commitment to social and environmental equity

The Climate Centre is committed to advocacy for the betterment of the environment, for reducing humanity's negative impact on the climate system, and the socio-culture damage that has been caused by human activities. By developing sustainable practices, we can move towards a future where the impact of society is to uplift all peoples and living things, and work towards a future defined by a healthy planet. We reject the cultural norms that have allowed the destruction of the environment and society to take place. We acknowledge the wisdom in us to improve our way of life, and we acknowledge the wisdom of Indigenous cultures past, present and future in respecting the planet on which we rely.

# NORNALUP INLET

## Geographic and hydrologic setting

The Nornalup Inlet is a coastal inlet system located in the south-western region of Western Australia, approximately 420 km south of Perth. It is situated between the towns of Walpole and Denmark and encompasses an area of approximately 27 $km^2$. The inlet consists of a main basin, measuring 10 km in length and 2 km in width at its broadest point, connected to the Southern Ocean via a narrow entrance channel. It is a bar-built estuary, formed by the buildup of a sandbar across the mouth of the Deep River and the Frankland River, which serve as the primary sources of freshwater input (Hodgkin & Hesp, 1998). It is located south of the smaller Walpole Inlet.

## Ecological significance

The Nornalup Inlet is recognized for its high ecological and conservation values, supporting a diverse range of flora and fauna. It provides important habitat for various waterbird species, including migratory shorebirds such as the Red-necked Stint and the Sharp-tailed Sandpiper (Ramsar, 1990). The inlet's waters and surrounding vegetation also support significant populations of fish species, such as the Black Bream and the Western Trout Gudgeon, as well as several threatened plant species, including the Swamp Honeymyrtle (Melaleuca teneraeramulosa) (Chubb et al., 1998).

**Figure 1 – Satellite view of Nornalup Inlet (Bing Maps, 2024).**

## Geomorphic characteristics of adjacent coastline

The coastline surrounding the Nornalup Inlet entrance is characterized by sandy beaches, dune systems, and rocky outcrops. The inlet's entrance channel is flanked by mobile sand dunes, which are subject to ongoing erosion and accretion processes influenced by wind, waves, and longshore currents (Eliot et al., 2011). To the west of the entrance, the coastline transitions into a series of rocky headlands and cliffs composed of Precambrian granite and gneiss formations. These rugged coastal features are interspersed with small bays and coves, providing shelter from the prevailing swells and enabling the formation of pocket beaches. Offshore, submerged reefs and shoals contribute to the complex nearshore bathymetry, influencing local hydrodynamics and sediment transport patterns. The below figure, taken from CoastAdapt, shows these sections classified as coastline dominated by hard rock (green), and sand (purple), corresponding to low and high erodibility, respectively. The coastline to the east of Nornlaup Inlet is dominated by sandy beaches, such as Bellanger Beach, which will erode with rising sea levels. Other sandy beaches that will experience erosion into the future that are not identified in this figure, include Circus and Shelly, which are located to the west of the Inlet entrance.

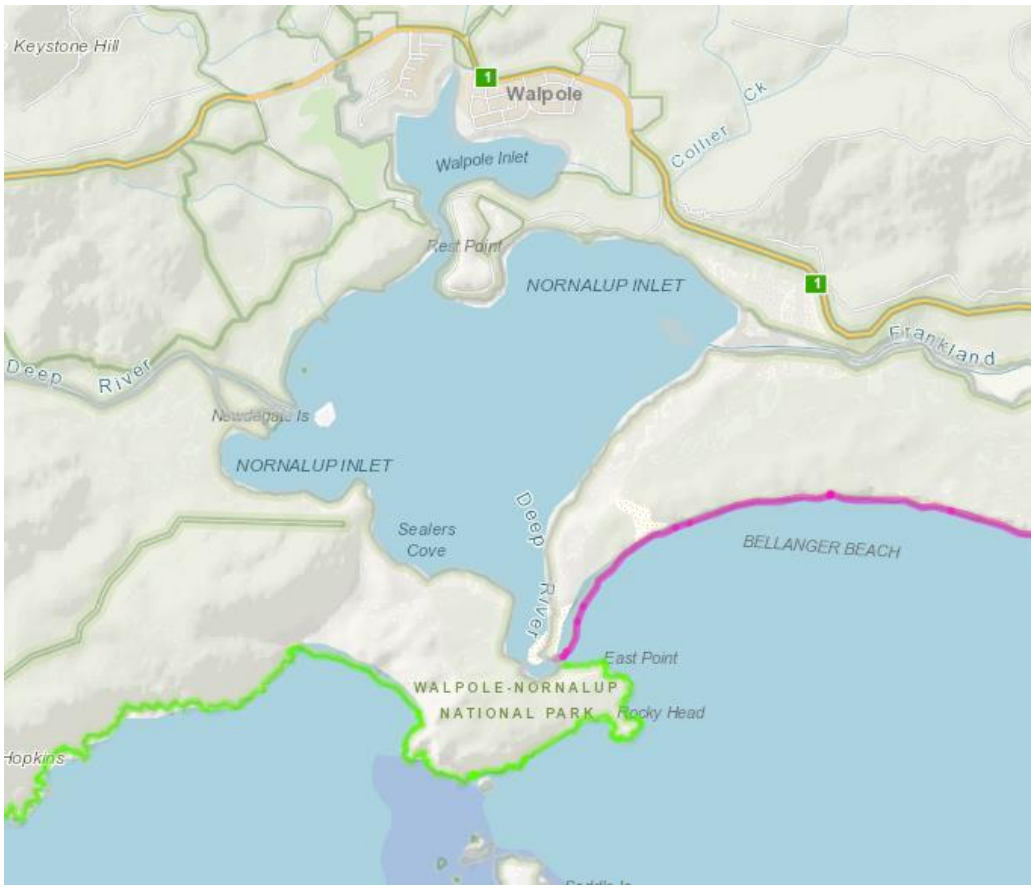



**Figure 2 – Geomorphic characteristics of the coastline adjacent to the Nornalup Inlet (CoastAdapt, 2024).**

## Coastal erosion

The coastline adjacent to the entrance of the Nornalup Inlet has experienced significant erosion issues in recent decades. The sandy beaches and dune systems near the inlet's mouth have been impacted by shoreline retreat and the loss of vegetated dunes (Damara WA, 2012). This erosion has been attributed to factors such as rising sea levels, storm surge events, and changes in longshore sediment transport patterns. This erosion may pose a hazard to recreational activities, such as four-

wheel driving. Concurrently, the buildup of sediment within the inlet's entrance is likely exacerbated by the erosion of the adjacent beaches, which contribute to the sediment load entering the channel.


**Figure 3 – Sea-level changes along sections of sandy coastline adjacent to and within the entrance to the Nornalup Inlet (DEA, 2024).**

## Intertidal zones

The Nornalup and Walpole inlets are relatively deep, allowing mature marine ecosystems to develop. Some western areas feature intertidal areas that are regularly exposed during low tide, which provide crucial feeding and roosting habitats for migratory and resident shorebirds, such as the Red-necked Avocet and the Banded Stilt (Lane et al., 2007). The saltmarshes, dominated by species like samphire (Sarcocornia spp.) and seablite (Suaeda spp.), play a vital role in nutrient cycling, sediment trapping, and providing nursery habitats for various fish and crustacean species.

**Figure 4 – Intertidal areas of the Nornalup Inlet (DEA, 2024).**

# IRWIN INLET

## Geographic and hydrologic setting

The Irwin Inlet is a coastal inlet system located within the Shire of Denmark, but is located closer to the town of Walpole than that of Denmark. The inlet stretches approximately 8 km in length and covers an area of around 14 $km^2$. It is a bar-built estuary, formed by the buildup of a sandbar across the mouth of the Irwin River, which serves as the primary source of freshwater input (Brearley, 2005).

## Ecological significance

The Irwin Inlet is recognized as a wetland of international importance under the Ramsar Convention, owing to its rich biodiversity and ecological values. It provides crucial habitat for various waterbird species, including migratory shorebirds, and supports significant populations of threatened species such as the Australasian Bittern and the Western Ringed Plover (Ramsar, 2002). The inlet's waters and surrounding vegetation also support a diverse array of fish, crustaceans, and plant life, making it an important ecosystem in the region.

**Figure 5 – Satellite view of Irwin Inlet (Bing Maps, 2024).**

## Geomorphic characteristics of adjacent coastline

The coastline adjacent to the Irwin Inlet is characterized by a mix of sandy beaches, dune systems, and rocky outcrops. The inlet's entrance is flanked by mobile sand dunes, which are subject to ongoing erosion and accretion processes driven by wind and wave action (Eliot et al., 2011). The below figure, taken from CoastAdapt, shows these sections classified as coastline dominated by hard rock (green), and sand (purple), corresponding to low and high erodibility, respectively. The coastline adjacent to the Irwin Inlet is dominated by sandy beaches, which will erode with rising sea levels.

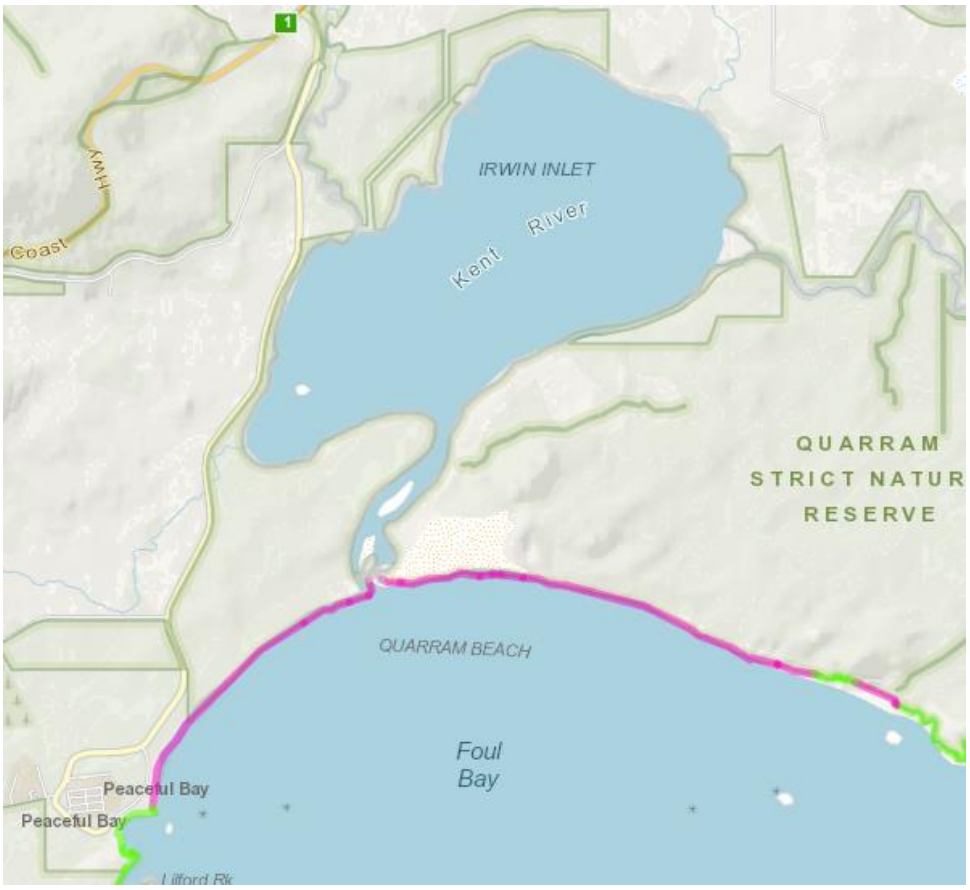



**Figure 6 – Geomorphic characteristics of the coastline adjacent to the Irwin Inlet (CoastAdapt, 2024).**

## Coastal erosion

The Irwin Inlet and its surrounding coastline have experienced significant erosion issues in recent years. The dune systems adjacent to the inlet's entrance have been affected by erosion, leading to the loss of vegetated dunes and the exposure of underlying limestone formations (Eliot et al., 2011). While the coastline immediately adjacent to the entrance of Irwin Inlet has experienced moderate erosion, coastal properties and infrastructure in the nearby town of Peaceful Bay have been impacted by erosion, prompting the implementation of coastal protection measures. Changes to the sedimentation in and around the entrance to Irwin Inlet causes sand bards to form and dissipate with time.


**Figure 7 – Sea-level changes along sections of sandy coastline adjacent to and within the entrance to the Irwin Inlet (DEA, 2024).**

## Intertidal zones

The Irwin Inlet features extensive intertidal zones, including mudflats, sandflats, and saltmarshes, which are exposed during low tide. These areas provide important feeding and roosting habitats for migratory and resident shorebirds, as well as nursery grounds for various fish and crustacean species (Ramsar, 2002). The saltmarshes, dominated by species such as samphire (Sarcocornia spp.) and seablite (Suaeda spp.), play a crucial role in nutrient cycling and sediment trapping within the inlet system.

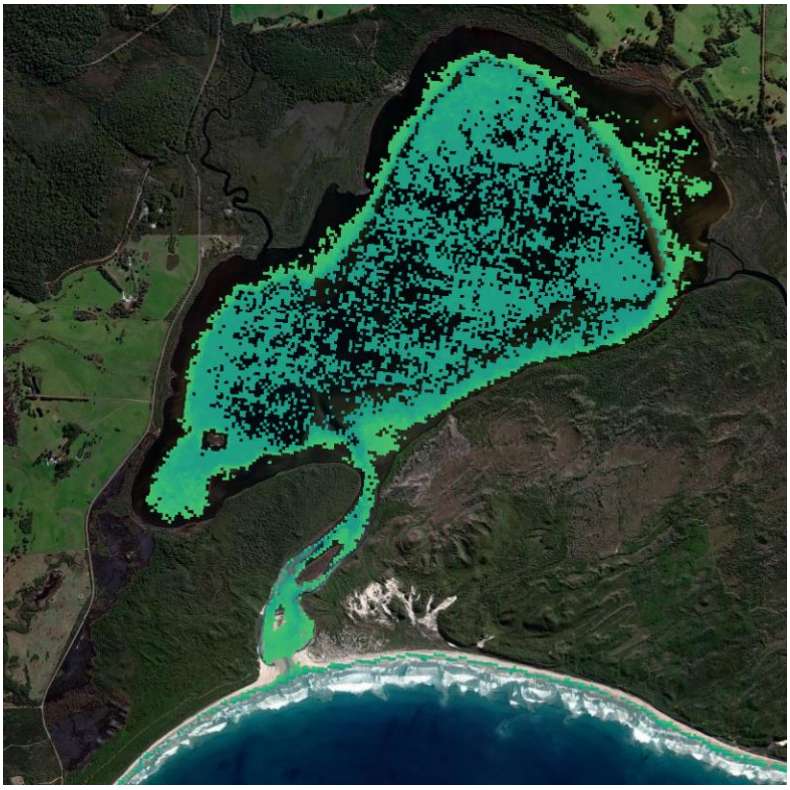


**Figure 8 – Intertidal areas of the Irwin Inlet (DEA, 2024).**

# WILSON INLET

## Geographic and hydrologic setting

The Wilson Inlet is a coastal inlet system located close to the town of Denmark and is part of the Wilson Inlet Catchment Area. The inlet covers an area of around 48 $km^2$ and has a maximum depth of 5 meters. It is a bar-built estuary, formed by the buildup of a sandbar across the mouth of the Denmark River and Hay River, which serve as the primary sources of freshwater input (Brearley, 2005).

## Ecological significance

The Wilson Inlet is recognized as a wetland of international importance under the Ramsar Convention, owing to its rich biodiversity and ecological values. It provides crucial habitat for various waterbird species, including migratory shorebirds such as the Red-necked Stint, and supports significant populations of threatened species like the Australasian Bittern and the Western Ringed Plover (Ramsar, 1990). The inlet's waters and surrounding vegetation also support a diverse array of fish, crustaceans, and plant life, making it an important ecosystem in the region.

**Figure 9 – Satellite view of Wilson Inlet (Bing Maps, 2024).**

## Geomorphic characteristics of adjacent coastline

The coastline adjacent to the Wilson Inlet is characterized by a mix of sandy beaches, dune systems, and rocky outcrops. The inlet's entrance is flanked by mobile sand dunes, which are subject to ongoing erosion and accretion processes driven by wind and wave action (Eliot et al., 2011). West of the entrance, the coastline is dominated by granite outcrops and headlands, while to the east, a series of small bays and pocket beaches are found, interspersed with rocky cliffs. The below figure, taken from CoastAdapt, shows these sections classified as coastline dominated by hard rock (green), and sand (purple), corresponding to low and high erodibility, respectively.

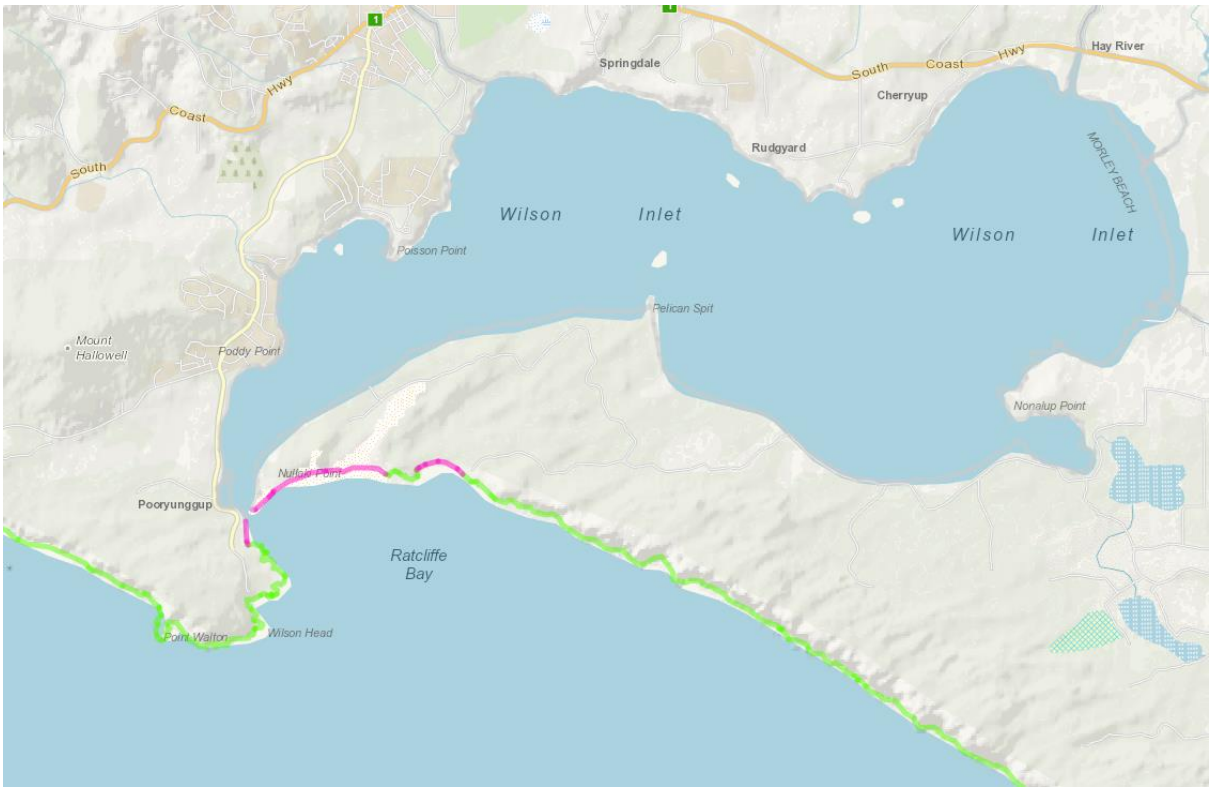



**Figure 10 – Geomorphic characteristics of the coastline adjacent to the Wilson Inlet (CoastAdapt, 2024).**

## Coastal erosion

The Wilson Inlet and its surrounding coastline have experienced significant erosion issues in recent years. The dune systems adjacent to the inlet's entrance have been affected by erosion, leading to the loss of vegetated dunes and the exposure of underlying limestone formations (Eliot et al., 2011). Additionally, several coastal properties and infrastructure in the nearby town of Ocean Beach have been impacted by erosion, prompting the implementation of coastal protection measures such as seawalls and groynes.


**Figure 11 – Sea-level changes along sections of sandy coastline adjacent to and within the entrance to the Wilson Inlet (DEA, 2024).**

## Intertidal zones

The Wilson Inlet features extensive intertidal zones, including mudflats, sandflats, and saltmarshes, which are exposed during low tide. These areas provide important feeding and roosting habitats for migratory and resident shorebirds, as well as nursery grounds for various fish and crustacean species (Ramsar, 1990). The saltmarshes, dominated by species such as samphire (Sarcocornia spp.) and seablite (Suaeda spp.), play a crucial role in nutrient cycling and sediment trapping within the inlet system.

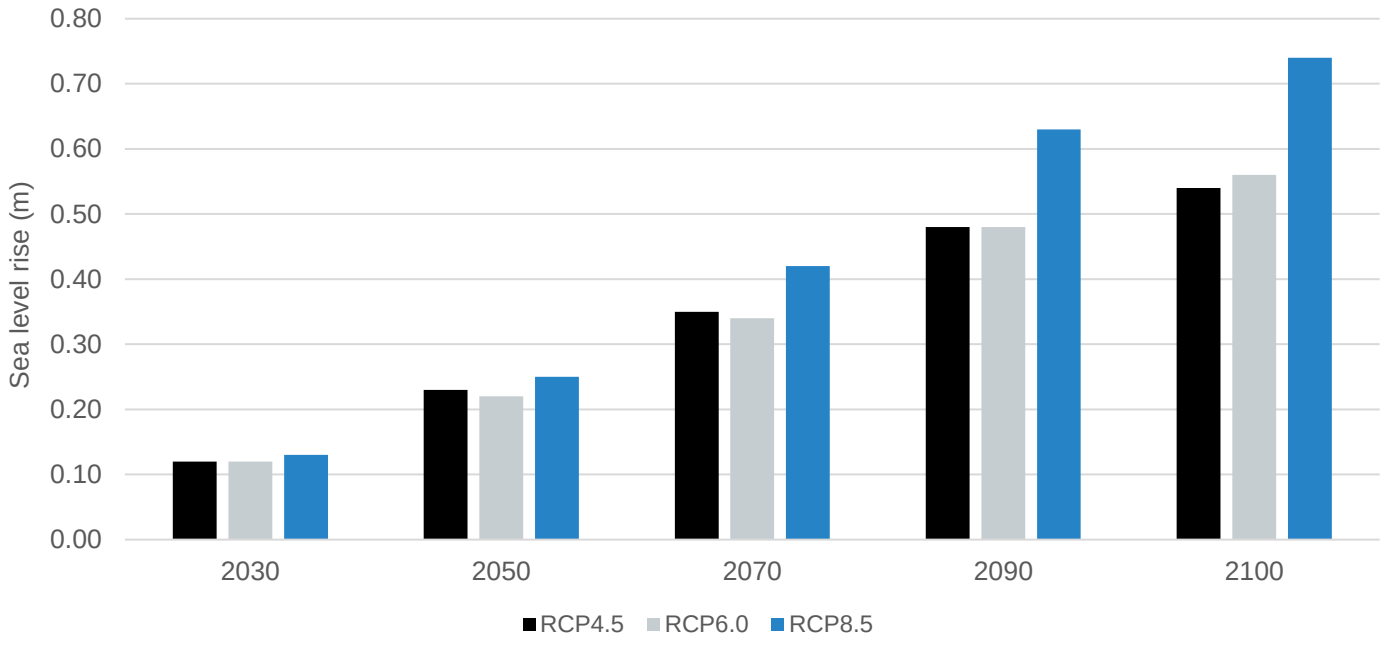
**Figure 12 – Intertidal areas of the Wilson Inlet (DEA, 2024).**

# LOOKING FORWARD

This report presents the environmental condition and management challenges faced by the coastal inlet systems of the Great Southern region. This report's significance lies in its ability to provide a baseline understanding of these vital ecosystems, paving the way for more detailed environmental assessments and targeted conservation strategies. With support from government agencies, research institutions, and industry stakeholders, there is potential to expand the scope of this report to encompass other critical waterways and wetlands in the region.

The threat of coastal erosion due to rising sea levels poses a significant challenge to the coastlines surrounding the southern inlets of Western Australia. As global temperatures continue to rise, the melting of glaciers and the thermal expansion of ocean waters are contributing to an overall increase in sea levels. While current projections estimate a minimum sea level rise of 0.5 meters by the end of the century, there is considerable uncertainty surrounding the potential impact of accelerated glacier melt, which could exacerbate this issue. The southern inlets of Western Australia, including the Nornalup, Irwin, and Wilson Inlets, represent pristine and ecologically significant natural environments that warrant careful preservation. Concerted efforts from government agencies, conservation organizations, and local communities are necessary to implement effective management strategies, promote environmental education, and ensure the long-term protection of these invaluable natural assets for future generations.

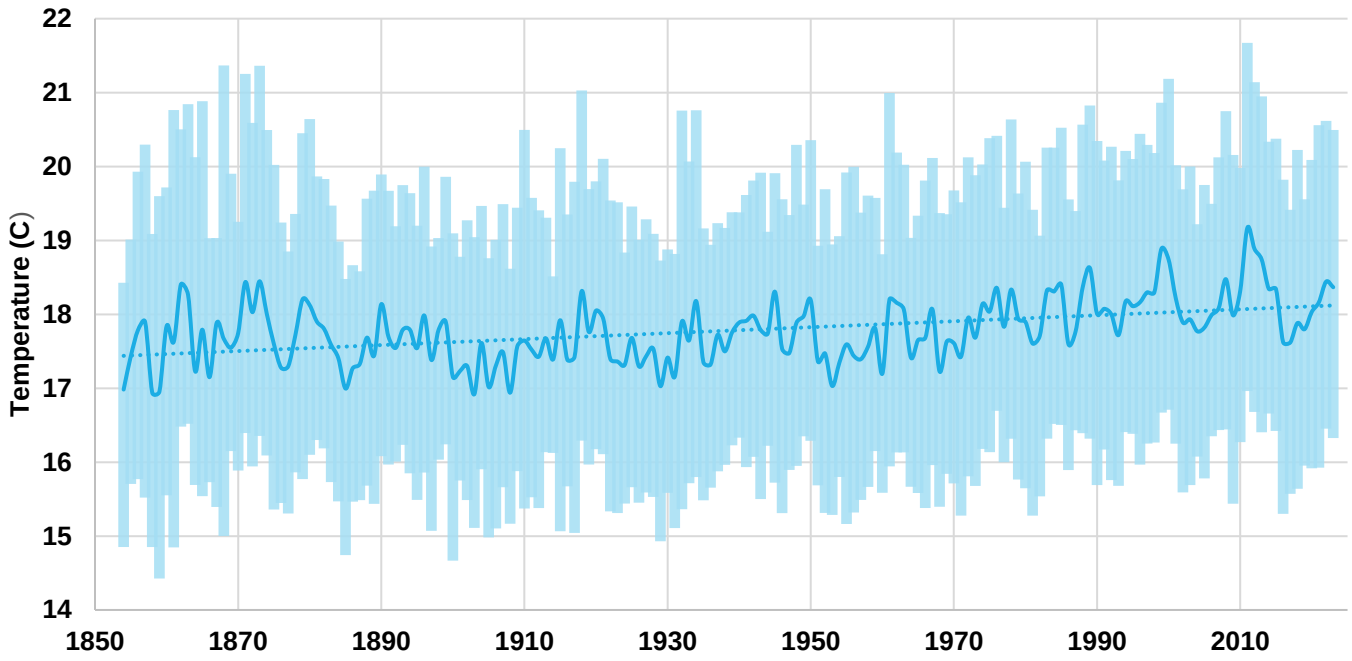
| Scenario | 2030 | 2050 | 2070 | 2090 | 2100 Average |
|---|---|---|---|---|---|
| RCP4.5 | 0.12 (0.08-0.17) | 0.23 (0.15-0.31) | 0.35 (0.22-0.48) | 0.48 (0.30-0.66) | 0.54 |
| RCP6.0 | 0.12 (0.07-0.17) | 0.22 (0.14-0.30) | 0.34 (0.21-0.46) | 0.48 (0.31-0.67) | 0.56 |
| RCP8.5 | 0.13 (0.09-0.18) | 0.25 (0.17-0.34) | 0.42 (0.28-0.57) | 0.63 (0.42-0.86) | 0.74 |



## Sea surface temperatures

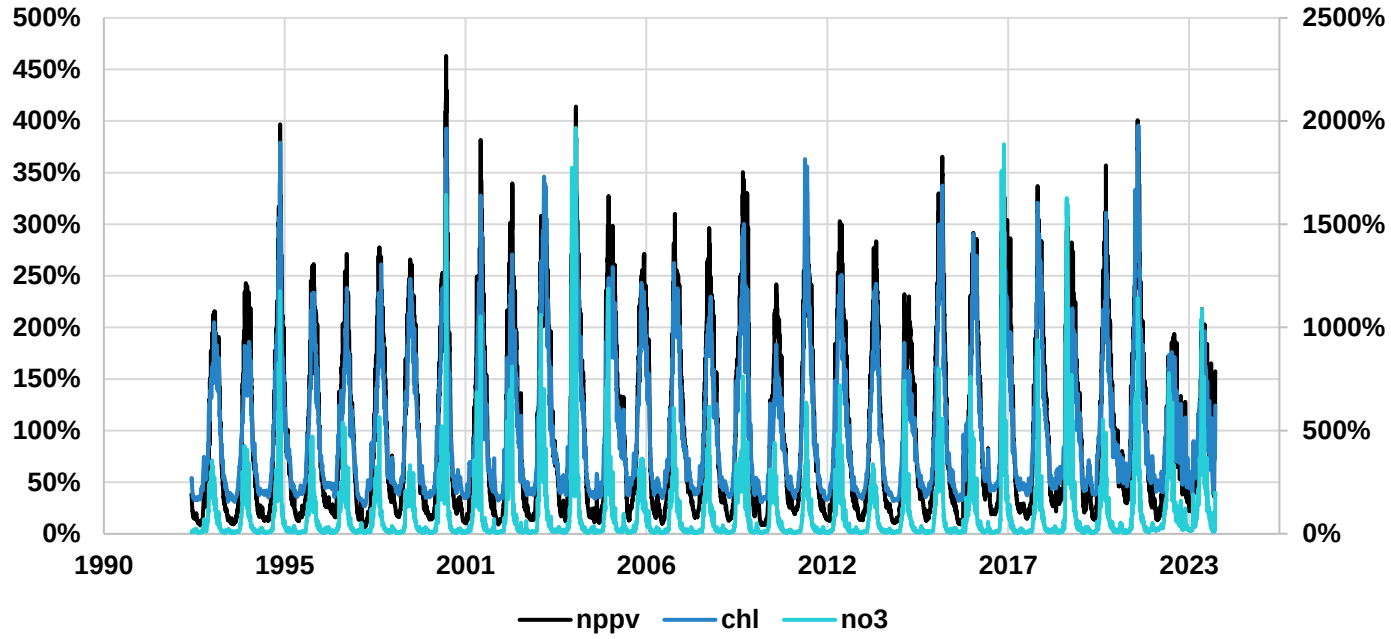
In addition to sea level rise, the ocean waters off the coastlines adjacent to the Nornalup, Irwin and Wilson Inlets are also warming due to global warming caused by climate change. The average per decade increase since 1850 has been approximately 0.04 C, which is slightly below the global average of 0.06 C (Lindsay and Dahlman 2024). This increase has accelerated in recent decades, with a per decade rate of 0.17 C over the period 1985 to 2023, and 0.24 C over the period 2002 to 2023, based on sea surface temperature data from the Extended Reconstructed SST, Coral Reef Watch, and Group for High Resolution Sea Surface Temperature (GHRSST) datasets. The accelerated warming trend has been a global phenomenon which has caused concern amongst climate and environmental scientists and is likely to increase into the future as carbon emissions continue (Copernicus 2023).

The consequences of this warming are far-reaching. Changes in water temperature can disrupt marine ecosystems, impacting fish populations and the delicate balance of underwater life. Scientists have observed a shift in species distribution, with warm-water adapted creatures moving further south. This can disrupt food chains and put stress on existing habitats. Understanding the causes and effects of warming waters entering these Inlets is crucial. By monitoring these changes, we can develop strategies to mitigate the impact on this precious marine environment.

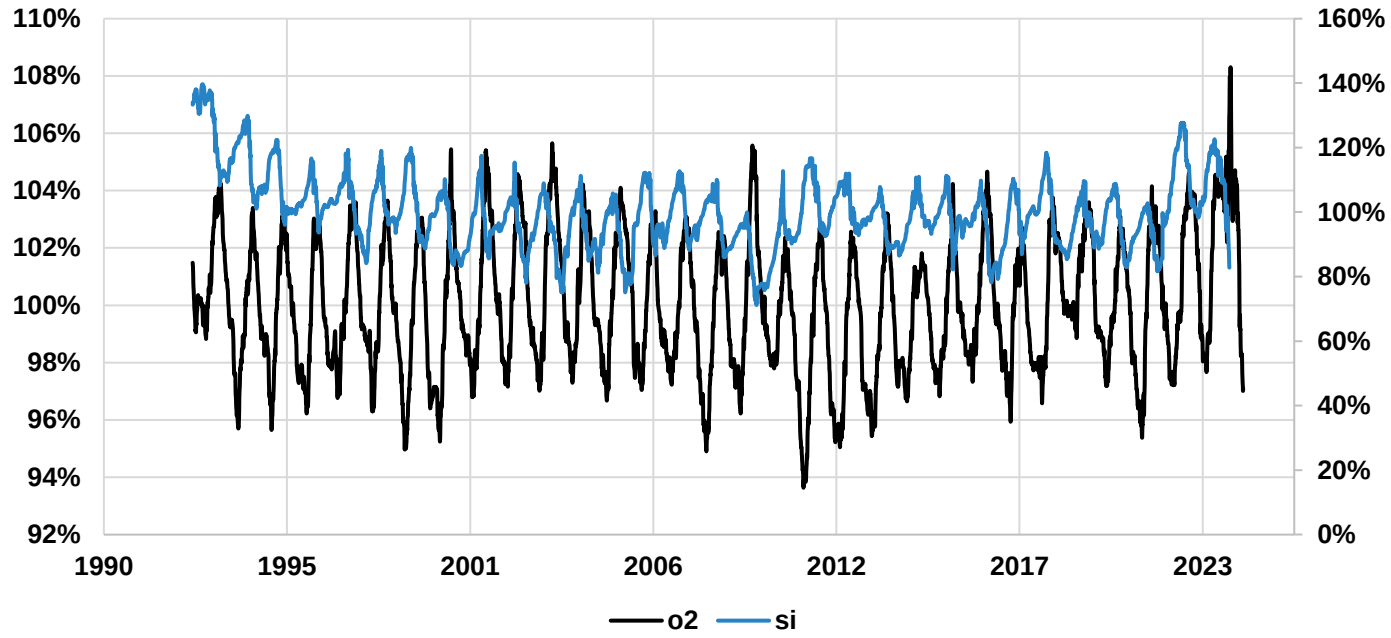



## Sea surface biochemistry

The ocean waters off the coastlines adjacent to the Nornalup, Irwin and Wilson Inlets experience fluctuations in biochemistry on a seasonal cycle primarily due to upwelling. This phenomenon is caused by prevailing winds which cause cooler, nutrient-rich waters from deeper layers to rise towards the surface. These deeper waters are rich in silicate, nitrate, phosphate and dissolved carbon dioxide (NOAA 2023). The spike in these levels off the southern coast of Western Australia occur during the austral spring and can rise to several times (nppv and chl) if not more than an order of magnitude (no3) above their long term averages, before declining to near-zero during the austral summer and autumn.




The upwelling that occurs during the austral winter and spring brings these nutrients into the euphotic zone and is then converted by phytoplankton into oxygen through photosynthesis, hence rises in oxygen slightly lag the increase in other available nutrients. Unlike levels of carbon (nppv), chlorophyll, and nitrate, however, oxygen and silicate are always present in the sea surface.



# REFERENCES


Brearley, A. (2005). Ernest Hodgkin's Swanland: Estuaries and Coastal Lagoons of South-western Australia.

Chubb, C. F., Jaensch, R. P., & Lane, J. A. (1998). Marine and estuarine waders of conservation concern. Wetlands International.

Copernicus. (2023). July 2023: Global air and ocean temperatures reach new record highs. https://climate.copernicus.eu/july-2023-global-air-and-ocean-temperatures-reach-new-record-highs

Damara WA. (2012). Coastal Hazard Mapping for Economic Analysis of Coastal Vulnerability.

Eliot, M., Nutt, C., Gozzard, B., Higgins, M., Buckley, E., & Bowyer, J. (2011). CoastWA: Coastal Compartment Study for the City of Albany.

Hodgkin, E. P., & Hesp, P. (1998). Estuaries to salt lakes: Holocene transformation of the estuarine ecosystems of south-western Australia.

Lane, J. A., Clarke, A. G., & Jaensch, R. P. (2007). Shorebird conservation in Westernport. Parks Victoria.

Lindsay, R. & Dahlman L. (2024). Climate Change: Global Temperature. https://www.climate.gov/news-features/understanding-climate/climate-change-global-temperature

NOAA. (2023). What is upwelling? https://oceanservice.noaa.gov/facts/upwelling.html

Ramsar Convention on Wetlands. (2002). Irwin Inlet Ramsar Site Information.

Ramsar Convention on Wetlands. (1990). Nornalup Inlet Ramsar Site Information.

Ramsar Convention on Wetlands. (1990). Wilson Inlet Ramsar Site Information.