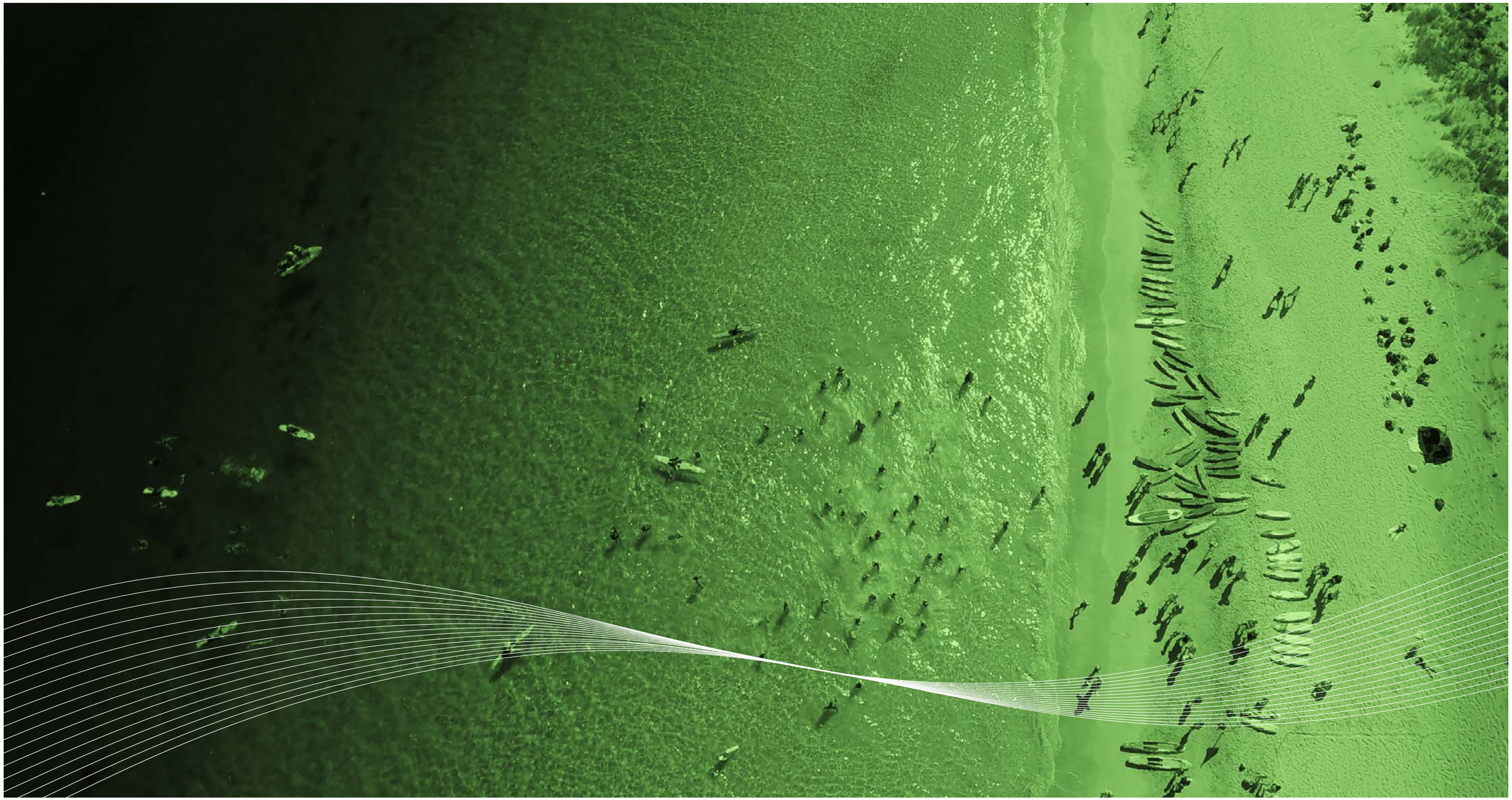
2018

STATE OF COCKBURN SOUND MARINE AREA REPORT



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Purpose of this report

The Cockburn Sound Management Council reports annually to the Minister for Environment and the community on the results of environmental monitoring of the Cockburn Sound marine area and the extent to which the monitoring results meet the environmental quality objectives and criteria set in the *State Environmental (Cockburn Sound) Policy 2015*. These reports are published on the Council's website at: csmc.dwer.wa.gov.au.

Every three years, the Council reports on the overall state of the Cockburn Sound marine area, including trends in water quality and associated environmental values. This report is the first of these reports and represents the Council's assessment of the overall state of the Cockburn Sound marine area in 2018.

Cockburn Sound

Cockburn Sound is a sheltered marine embayment located south of the Swan–Canning river mouth at Fremantle (Figure 1). The Sound is 22 kilometres (km) long and ranges from 15 km wide in the north to 9 km wide in the south, with an area of about 124 square kilometres (km^2). It has a relatively large, low-gradient, deep central basin (17–22 metres (m) in depth) flanked by the relatively steep slopes of the surrounding banks, shoals and shoreline to the north, south and west, with a lower gradient bank to the east. Garden Island extends along the western side of Cockburn Sound, providing protection from prevailing winds and ocean swells.

In terms of both its depth and degree of shelter from ocean swell, Cockburn Sound is unique along Perth's metropolitan coast and for several hundred kilometres to the north and south. These physical features are responsible for the regional significance of Cockburn Sound in ecological terms, including extensive areas of seagrass (*Posidonia* spp.) and organic-rich silts in the deeper basin. Cockburn Sound is also a major spawning ground and nursery area for pink snapper (*Pagrus auratus*), an important foraging area for little penguins (*Eudyptula minor*), and a nursery and feeding area for resident Indo-Pacific bottlenose dolphins (*Tursiops aduncus*).

Cockburn Sound is the most intensively used multiple-use marine embayment in Western Australia and considerable human alteration of Cockburn Sound has occurred since European settlement of the area during the 1800s.

The Sound provides a safe anchorage and maritime facilities adjacent to the State's major industrial complex at Kwinana and the HMAS *Stirling* naval base on Garden Island. It supports recreational and commercial fisheries and aquaculture operations. Cockburn Sound is also highly valued by the community for its ecological, recreational and aesthetic attributes (including dolphins, fishing, swimming, diving and boating) and is used extensively for tourism.

Cockburn Sound is of vital economic and social importance to the Western Australian community, as well as supporting significant environmental values. Ongoing protection of Cockburn Sound is an important priority for the State Government to ensure that it continues to support the multiple values for which it is renowned.

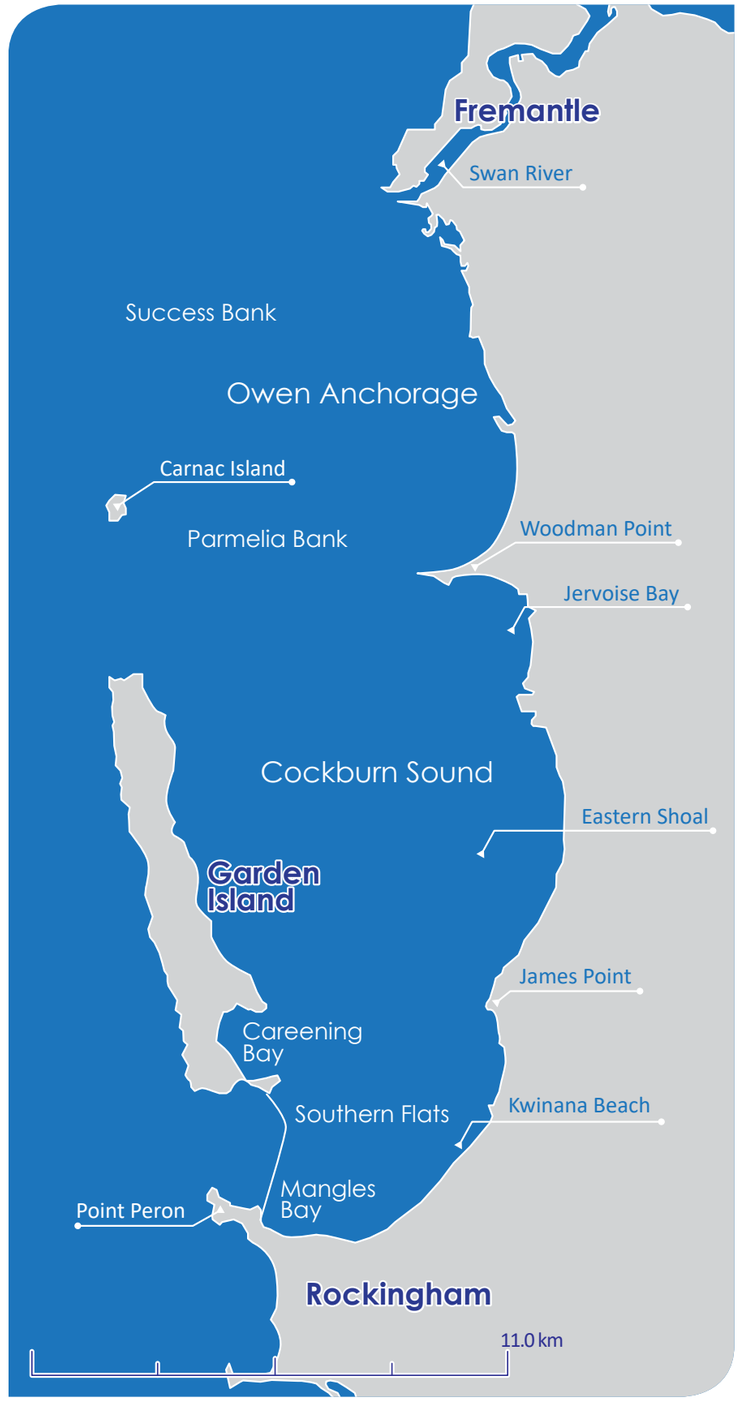


Figure 1: Cockburn Sound

History of development

Before 1954, Cockburn Sound was used primarily for recreational purposes, commercial fishing and for Australian Defence Force activities during both world wars[1]. The Kwinana Industrial Area was established in the early 1950s and an oil refinery was constructed at James Point in 1954. The Kwinana Industrial Area is now the State's largest industrial centre and includes a diverse range of industries from smaller service industries, such as fabrication and construction facilities, through to chemical and fertiliser production plants, a bulk grain terminal, power stations and heavy processing industries, including alumina and nickel refining/processing plants. Industrial development led to the construction of wharves, breakwaters and dredging for shipping channels across Parmelia Bank and the Eastern Shoal.

A wastewater treatment plant was commissioned in the 1960s at Woodman Point at the northern end of Cockburn Sound to treat wastewater from Perth's southern suburbs. Between 1966 and 1984, primary treated effluent was discharged into the Sound through an outlet off Woodman Point. In the late 1970s, the Cape Peron pipeline was built and treated wastewater is now discharged through the Sepia Depression Ocean Outlet Landline (SDOOL) to the Sepia Depression (a 20 m deep depression west of Garden Island). Since 2004, the SDOOL has also been used to dispose of industrial wastewater and water from the Jervoise Bay Groundwater Recovery Scheme, reducing industrial discharge to Cockburn Sound. In October 2005, fertiliser manufacturer CSBP diverted discharge from Cockburn Sound into the SDOOL.

At the southern end of Cockburn Sound, a 4.2 km long causeway was constructed in 1971–73 across the southern opening between the mainland and Garden Island to service the naval base at Careening Bay on Garden Island. The causeway comprises 3.3 km of solid rockfill wall and two trestle bridges at the southern and northern ends through which limited exchange of water with the ocean occurs.

The Australian Marine Complex, located on the shores of Jervoise Bay's northern and southern harbours in the north-east sector of Cockburn Sound, was opened in 2003. It provides manufacturing, fabrication, assembly, technology development, service and repair facilities for the marine, defence, mining and petroleum industries.

In 2006, the Perth Seawater Desalination Plant, located north of James Point, began operation. The plant produces around 18 per cent of Perth's water supply requirements annually, representing an important climate-independent water source for the population of Perth.

Development in Cockburn Sound is projected to increase with a number of potential new proposals.

1950

Development:
- Early 1950s Kwinana industrial area established
- Oil refinery constructed at James Point

Seagrass cover:
- 1954: 4200 ha

1960

Development:
- Wastewater treatment plant commissioned and between 1966 and 1984 primary treated effluent was discharged to Cockburn Sound
- Industrial wastewater discharged to Cockburn Sound

Seagrass cover:
- 1967: 2929 ha

1970

Development:
- Causeway constructed between the mainland and Garden Island
- Cape Peron pipeline constructed and treated wastewater discharged to the Sepia Depression

Seagrass cover:
- 1972: 1342 ha
- 1978: 900 ha

Environmental quality:
- Early 1970s first environmental studies
- 1976–79 *Cockburn Sound Environmental Study*

1980

Seagrass cover:
- 1981: 740 ha

Environmental quality:
- 1982/83 water quality monitoring program commenced

1990

Seagrass cover:
- 1994: 690 ha
- 1999: 721 ha

Environmental quality:
- 1991–94 *Southern Metropolitan Coastal Waters Study*
- 1998 Seagrass monitoring program commenced

2000

Development:
- Australian Marine Complex opened
- Industrial wastewater and water from the Jervoise Bay Groundwater Recovery Scheme discharged to the Sepia Depression
- Perth Seawater Desalination Plant began operation

Environmental quality:
- 2001 Pressure-State-Response assessment

2010

Seagrass cover:
- 2012: 925 ha
- 2017: 965 ha

Environmental quality:
- 2017 Drivers-Pressures-State-Impacts-Responses assessment

2020

1 D.A. Lord & Associates Pty Ltd (2001). *The State of Cockburn Sound: A Pressure-State-Response Report*. Report prepared for the Cockburn Sound Management Council; BMT (2018). *Cockburn Sound – Drivers, Pressures, State, Impacts, Responses Assessment 2017 Final Report.* Report prepared for Department of Water and Environmental Regulation, the Kwinana Industries Council, the City of Rockingham and the City of Kwinana on behalf of the Cockburn Sound Management Council.

Major studies and monitoring programs in Cockburn Sound

1950s to early 1970s

Development from the 1950s onwards resulted in the deterioration of environmental quality in Cockburn Sound and by the 1970s conflict with recreational users was an additional issue.

The first environmental studies in Cockburn Sound were carried out in the early 1970s. Two main environmental issues were identified:

- deteriorating water quality due to 'blooms' of phytoplankton
- widespread loss of seagrass due to shading caused by increased growth of epiphytic algae on the seagrass and increased growth of phytoplankton in the water column.

mid to late 1970s

From 1976 to 1979, the *Cockburn Sound Environmental Study*[2] was undertaken to provide information to underpin the management of the Sound for multi-purpose use. The main findings included:

- the loss of seagrass was related to an increase in nutrient inputs, including nitrogen, into Cockburn Sound
- the deterioration in water quality was due to phytoplankton blooms that were attributable to increased nutrient inputs
- some biota, sediments and inshore waters were contaminated by heavy metals or bacteria
- industrial discharges and sewage effluents were the sources of nutrients, heavy metals and bacteria in Cockburn Sound.

The study resulted in a number of recommendations to improve the water quality of Cockburn Sound. These included the implementation of process changes and in-plant treatment or removal of specific wastewater discharges from Cockburn Sound. In response to these recommendations, measures were implemented to remove nitrogen from industrial effluent and to divert wastewater out of Cockburn Sound.

2 Department of Environment and Conservation (1979). *Cockburn Sound Environmental Study 1976–1979*. Report No. 2, Department of Conservation and Environment, Perth, Western Australia.

1980s

To assess the impacts of reduced nitrogen loads into Cockburn Sound, a long-term monitoring program was implemented to monitor the physical, biological and chemical characteristics of the water column weekly in summer when, historically, phytoplankton blooms were most frequent[3].

Surveys undertaken in the 1980s found that while water quality in the early 1980s had improved compared with the late 1970s, mainly attributable to reduced nitrogen loads, there was a significant decline in water quality in the late 1980s. In 1989–90, water quality in Cockburn Sound was approaching the levels of the late 1970s.

3 Carey, JL, Simpson, CJ and Chase, S (1991). *Water Quality in Cockburn Sound. Results of the 1989/90 Summer Monitoring Programme. A Contribution to the Southern Metropolitan Coastal Waters Study (1991–1994)*. Technical Series No. 47, Environmental Protection Authority, Perth, Western Australia.

early to mid 1990s

The decline in water quality led to the 1991–94 *Southern Metropolitan Coastal Waters Study*[4]. The main findings included:

- water quality in Cockburn Sound in the early 1990s, as measured by chlorophyll *a* concentrations and light attenuation, was only slightly better than in the late 1970s
- seagrass loss had slowed considerably since the early 1970s, but losses were still occurring particularly in the southern end of the Sound, and there was no evidence of seagrass re-establishment
- contaminant inputs from industry (metals and organic contaminants) were less than in the late 1970s and concentrations in sediments and mussels were generally below environmental guidelines and food standards
- diffusion from contaminated groundwater had replaced industrial discharges as the main source of nitrogen input into the Sound
- there was widespread contamination of sediments and mussels with tributyltin (TBT) (from antifouling paint), with high concentrations reported near harbours, marinas and commercial and naval wharves
- most monitored beaches met human health guidelines for swimming and shellfish harvesting.

4 Department of Environmental Protection (1996). *Southern Metropolitan Coastal Waters Study (1991–1994)*. Final Report. Report 17, Department of Environmental Protection, Perth, Western Australia.

2001

A Pressure-State-Response (PSR) assessment of Cockburn Sound was undertaken[5]. The main findings included:

- overall water quality had improved slightly since the early 1990s, apart from in the Jervoise Bay Northern Harbour
- nutrient inputs from human activities had declined from an estimated 2000 tonnes/year in 1978 to about 300 tonnes/year in 2000, about 70 per cent of which was from groundwater
- large decreases in nitrogen inputs into Cockburn Sound had not been matched by a similar decrease in chlorophyll levels
- estimated amounts of metals and oil discharged by industry decreased due to improved waste treatment practices and, depending on the contaminant, were about 1/6th to 1/1000th of the concentrations discharged in 1978
- TBT levels in sediments were generally lower than in 1994, but were still high in Jervoise Bay Northern Harbour and in Careening Bay.

5 D.A. Lord & Associates Pty Ltd (2001). *The State of Cockburn Sound: A Pressure-State-Response Report*. Report prepared for the Cockburn Sound Management Council.

2017

A Drivers-Pressures-State-Impacts-Responses (DPSIR) assessment of Cockburn Sound was undertaken[6]. The main findings included:

- as a result of concerted effort by industry, government and the community, water quality in Cockburn Sound has improved to the extent that environmental guidelines are only rarely exceeded, although concerns about poor water quality remain in some areas
- coastal areas are highly modified, especially along the mainland coast, the Eastern Shelf and eastern portion of Parmelia Bank
- water quality for recreational and industrial use is typically excellent
- sediment quality is generally considered acceptable, although there is some evidence of localised contamination by TBT in the vicinity of jetties and wharves
- some commercial and recreational fisheries are in decline (for example, mussels, crabs, herring, garfish), while others are stable (for example, squid, octopus, snapper)
- the populations of dolphins and little penguins resident in Cockburn Sound appear stable.

6 BMT (2018). *Cockburn Sound – Drivers, Pressures, State, Impacts, Responses Assessment 2017 Final Report*. Report prepared for Department of Water and Environmental Regulation, the Kwinana Industries Council, the City of Rockingham and the City of Kwinana on behalf of the Cockburn Sound Management Council.

An environmental policy for Cockburn Sound

One of the main objectives of the *Southern Metropolitan Coastal Waters Study* was to design a coordinated management approach for the protection of Perth's coastal waters from pollution. This approach involved:

1. identification of environmental values for coastal waters
2. identification of environmental quality objectives to support these values and to determine where the objectives would apply
3. the development of environmental quality criteria to help ensure environmental quality objectives would be met.

In 2000, the Environmental Protection Authority (EPA) released a working document describing the environmental values and environmental quality objectives for Perth's coastal waters, including Cockburn Sound.

In 2005, the Government of Western Australia released the first State Environmental Policy for the protection of environmental quality in Cockburn Sound. An updated policy was released in 2015. The policy identifies five environmental values for the Cockburn Sound marine area:

1. ecosystem health
2. fishing and aquaculture
3. recreation and aesthetics
4. cultural and spiritual values
5. industrial water supply.

The policy also sets out the environmental quality objectives that are required to be met to ensure the protection and maintenance of these values. The overall objective of the policy is to ensure that water quality is maintained and, where possible, improved so that there is no further net loss and preferably a net gain in seagrass areas, and that other values and uses are maintained.

Ecosystem health environmental value: state and trends

Nutrient-related water quality in Cockburn Sound has been measured through summer (non river-flow) surveys of nutrient concentrations, chlorophyll *a* (as a measure of phytoplankton abundance) and light attenuation (as a measure of water clarity) since 1977[7].

A suite of other physical–chemical indicators (dissolved oxygen concentrations, salinity, temperature and pH) has also been routinely measured. Changes in these parameters beyond their normal range can have a deleterious impact on the plants and animals in Cockburn Sound.

To summarise the monitoring data and provide information on status and trends in the water quality of Cockburn Sound, a water quality index has been calculated from five indicators:

- Total Nitrogen concentration
- Total Phosphorus concentration
- chlorophyll *a* concentration
- light attenuation coefficient
- dissolved oxygen concentration in the water just above the seafloor.

The index is an overall water quality score for each of the five ecological protection areas in Cockburn Sound[8] (Figure 2) relative to water quality at a reference site in Warnbro Sound. For further information on how the index is calculated, refer to 'Calculation of the Cockburn Sound Water Quality Index' on page 7.

7 There have been a number of changes to the Cockburn Sound water quality monitoring program over the 40 years of the program. These include: (1) the inclusion of additional sites into the program and changes in the location of some sites, (2) changes in the frequency of monitoring (every one to three years to annually; monthly to approximately weekly), (3) changes in the sampling methodology (samples collected from surface, middle and bottom depths to depth-integrated samples), (4) changes in methods for measuring light attenuation, (5) changes in sample processing and analytical methods.

8 The State Environmental Policy describes three levels of ecological protection (high protection, moderate protection and low protection) that apply to Cockburn Sound and where they apply spatially so that overall ecological integrity can be maintained. Most of Cockburn Sound is designated as having a high level of ecological protection. Areas where societal uses preclude a high level of ecological protection have been designated as having a moderate level of ecological protection. A few small areas around outfalls (less than 1 per cent of the protected area) have been designated as having a low level of ecological protection.

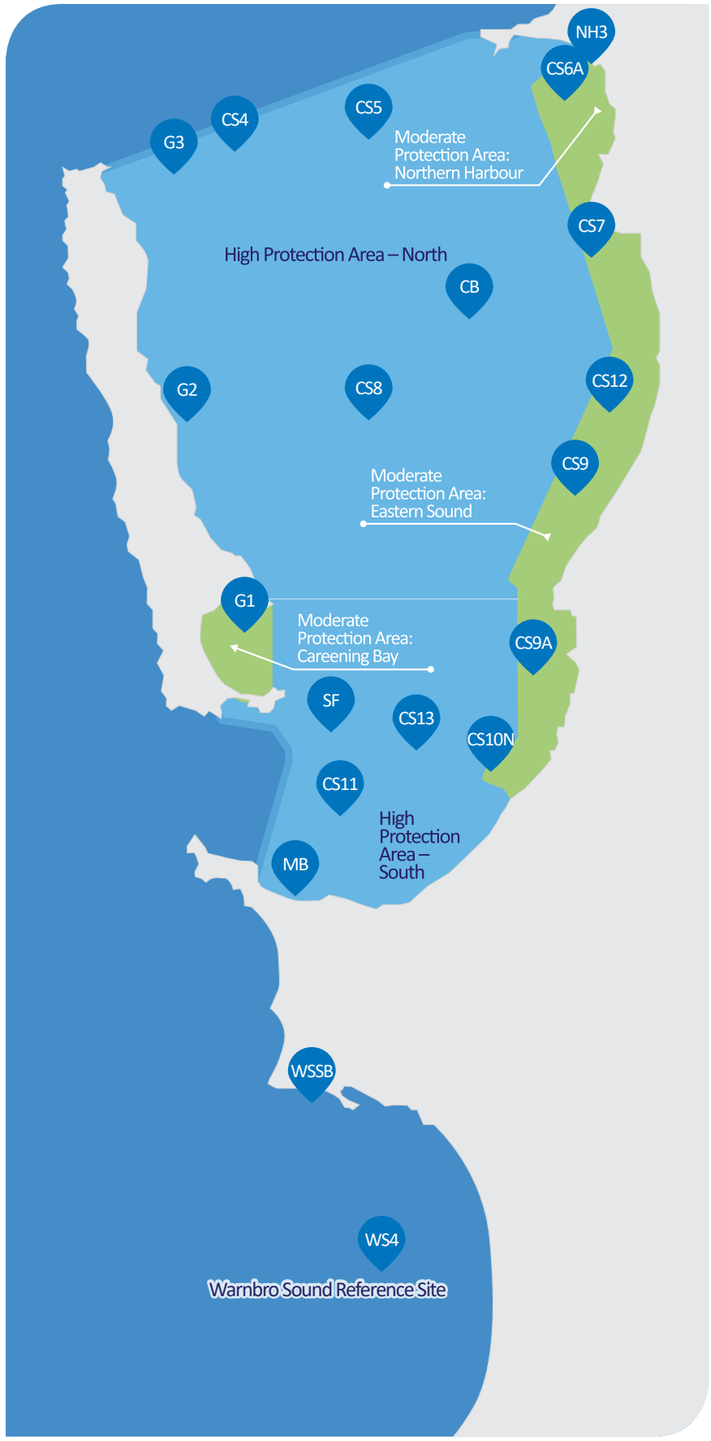


Figure 2: High and moderate ecological protection areas and the location of water quality monitoring sites in Cockburn Sound

Calculation of the Cockburn Sound Water Quality Index

	Indicators	Chlorophyll *a*	Light Attenuation Coefficient	Dissolved Oxygen	Total Nitrogen	Total Phosphorus	Score (%)	Grade
	Monitored	Approximately weekly over the non river-flow period (December to March) at18 sites in Cockburn Sound						
	Assessed against guideline values calculated from the Warnbro Sound reference site to determine the percentage of times each ecological protection area met the guideline	**High Protection Areas**						
		≤ 1.1 µg/L	≤ 0.096 $\log_{10} m^{-1}$	> 90% saturation	≤ 130 µg/L	≤ 14 µg/L		
		Moderate Protection Areas						
		≤ 1.8 µg/L	≤ 0.014 $\log_{10} m^{-1}$	> 80% saturation	≤ 140 µg/L	≤ 15 µg/L		
2016–17 results	High Protection Area North (6 sites)	85%	54%	81%	88%	70%	76%	B+
	High Protection Area South (4 sites)	48%	42%	55%	73%	25%	49%	C
	Moderate Protection Area Eastern Sound (6 sites)	85%	48%	90%	91%	51%	73%	B
	Moderate Protection Area Careening Bay (1 site)	94%	69%	100%	100%	63%	85%	A
	Moderate Protection Area Northern Harbour (1 site)	13%	0%	75%	0%	0%	18%	F+

The five indicator scores within each ecological protection area are averaged to give each ecological protection area Water Quality Index score and grade.

The Water Quality Index is reported for the 2016–17 monitoring period for each of the ecological protection areas in Cockburn Sound. Changes in the Water Quality Index are based on the past three years of available information presented as:

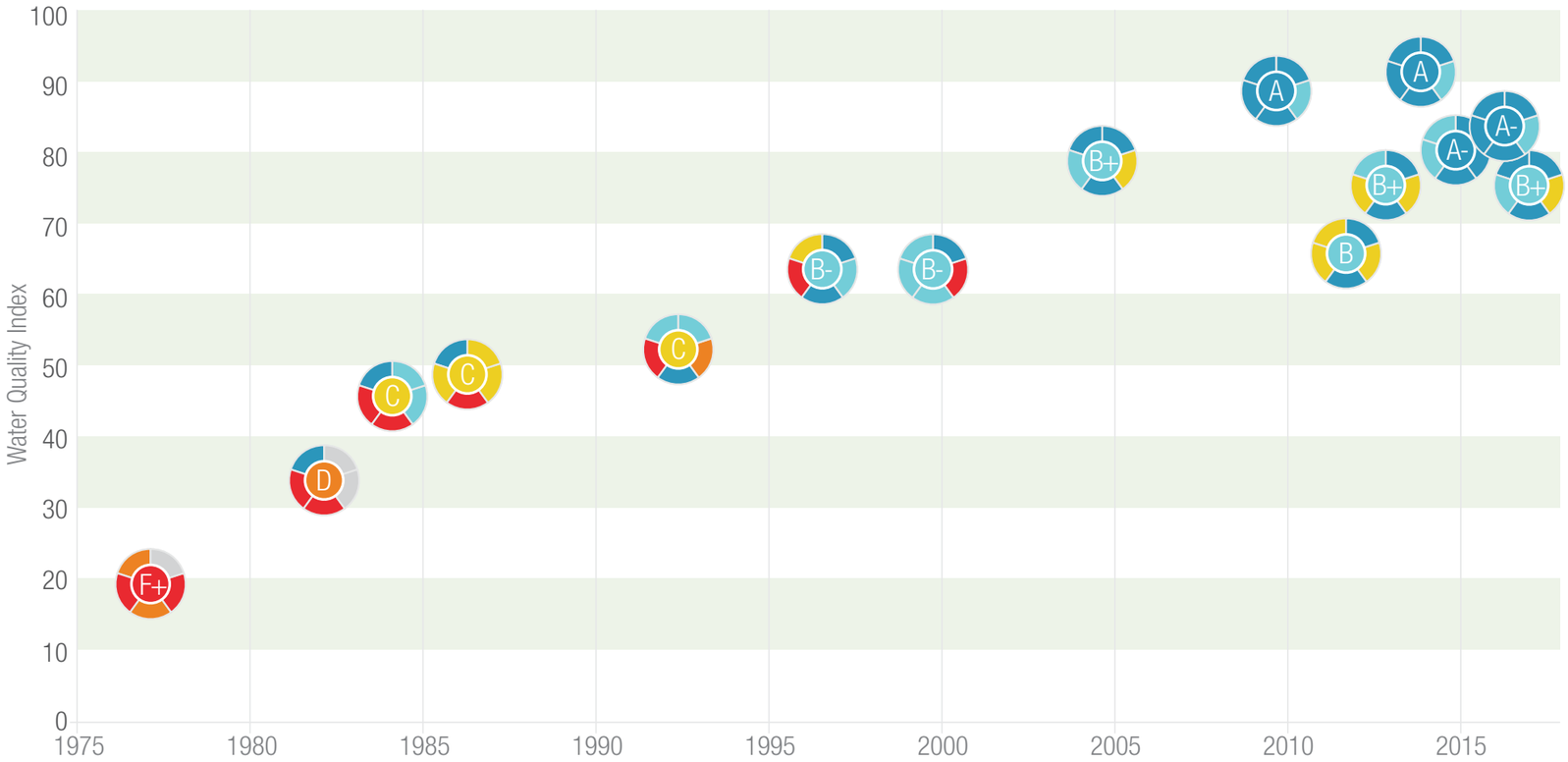
improving water quality is improving

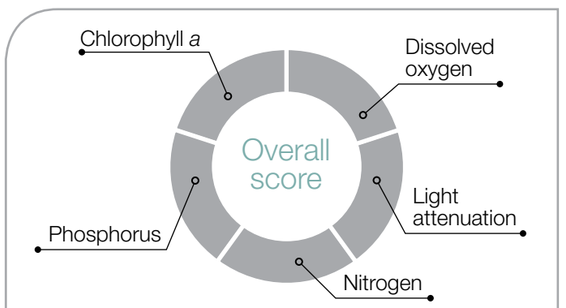
declining water quality is declining

unchanging water quality has not changed (it is not getting better or worse)

The graphs overleaf show the trend in Water Quality Index over time from when water quality information was first collected in each of the ecological protection areas with long-term trends in water quality also presented.

State and trends in water quality in the High Protection Area North





A	80–100%
B	60–79%
C	40–59%
D	20–39%
F	0–19%
	No data

Water Quality Index

A Water Quality Index between 'B' and 'A' indicates that all water quality indicators usually meet the desired levels.

Variability between years may be due to factors such as weather events (e.g. the wet summer in 2016–17[9]).

9 Cockburn Sound Management Council (2018). *Cockburn Sound Annual Environmental Monitoring Report 2016–17. Assessment against the environmental quality objectives and criteria set in the State Environmental (Cockburn Sound) Policy.*

Nutrients

There has been an improvement in water quality since the late 1970s/early 1980s, with significant decreases in nutrient concentrations (Total Nitrogen and Total Phosphorus) recorded at long-term monitoring sites (those sites for which there are data from the late 1970s/early 1980s).

Chlorophyll *a* / light attenuation

There have been no significant changes in either chlorophyll *a* concentrations or light attenuation coefficients at long-term monitoring sites since the late 1970s/early 1980s. While there is an indication of an improving trend in light attenuation coefficients at these sites, variability from year to year is high.

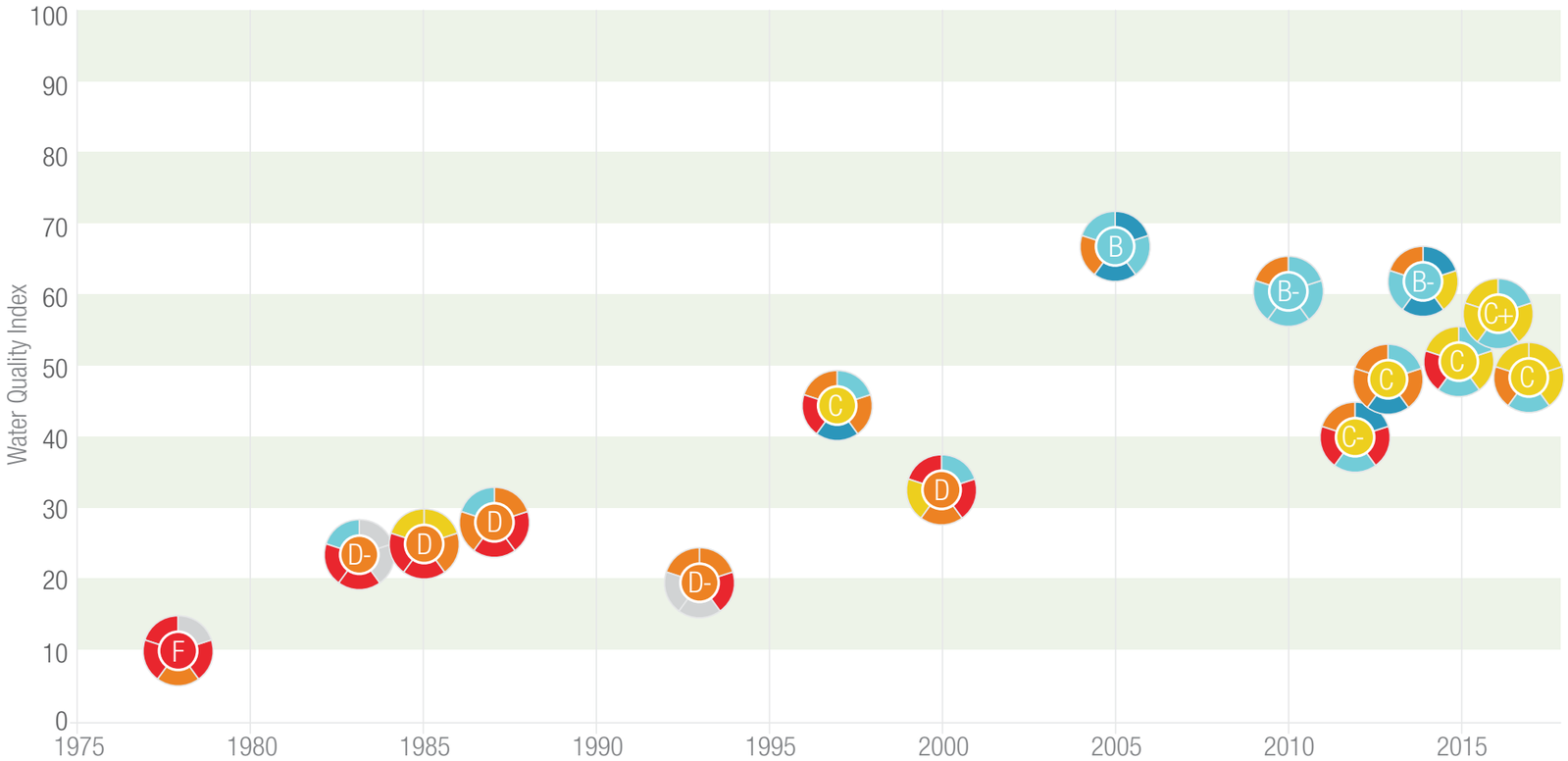
Phytoplankton biomass

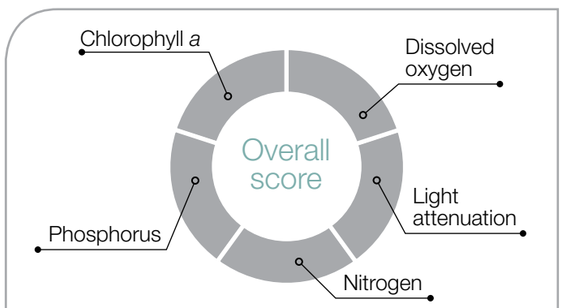
Phytoplankton biomass (which is an indication of phytoplankton blooms) has generally met the guideline since 2005–06.

Dissolved oxygen

The waters are generally well mixed and well oxygenated. There are periods, mostly during late summer and autumn, or associated with extreme weather events, when bottom waters become stratified and low dissolved oxygen concentrations may be experienced for short periods.

State and trends in water quality in the High Protection Area South





A	80–100%
B	60–79%
C	40–59%
D	20–39%
F	0–19%
	No data

Water Quality Index

A Water Quality Index between ‘C’ and ‘B’ indicates that some water quality indicators fail to meet the desired levels, signalling pressure on the ecosystem.

Variability between years may be due to factors such as weather events (e.g. the wet summer in 2016–17[9]).

Nutrients

There has been an improvement in water quality since the late 1970s/early 1980s, with significant decreases in nutrient (Total Nitrogen and Total Phosphorus) concentrations recorded at the long-term monitoring site (the site for which there is data from the late 1970s/early 1980s).

Chlorophyll *a* / light attenuation

There has been a significant decrease in light attenuation coefficients at the long-term monitoring site since the late 1970s/early 1980s.

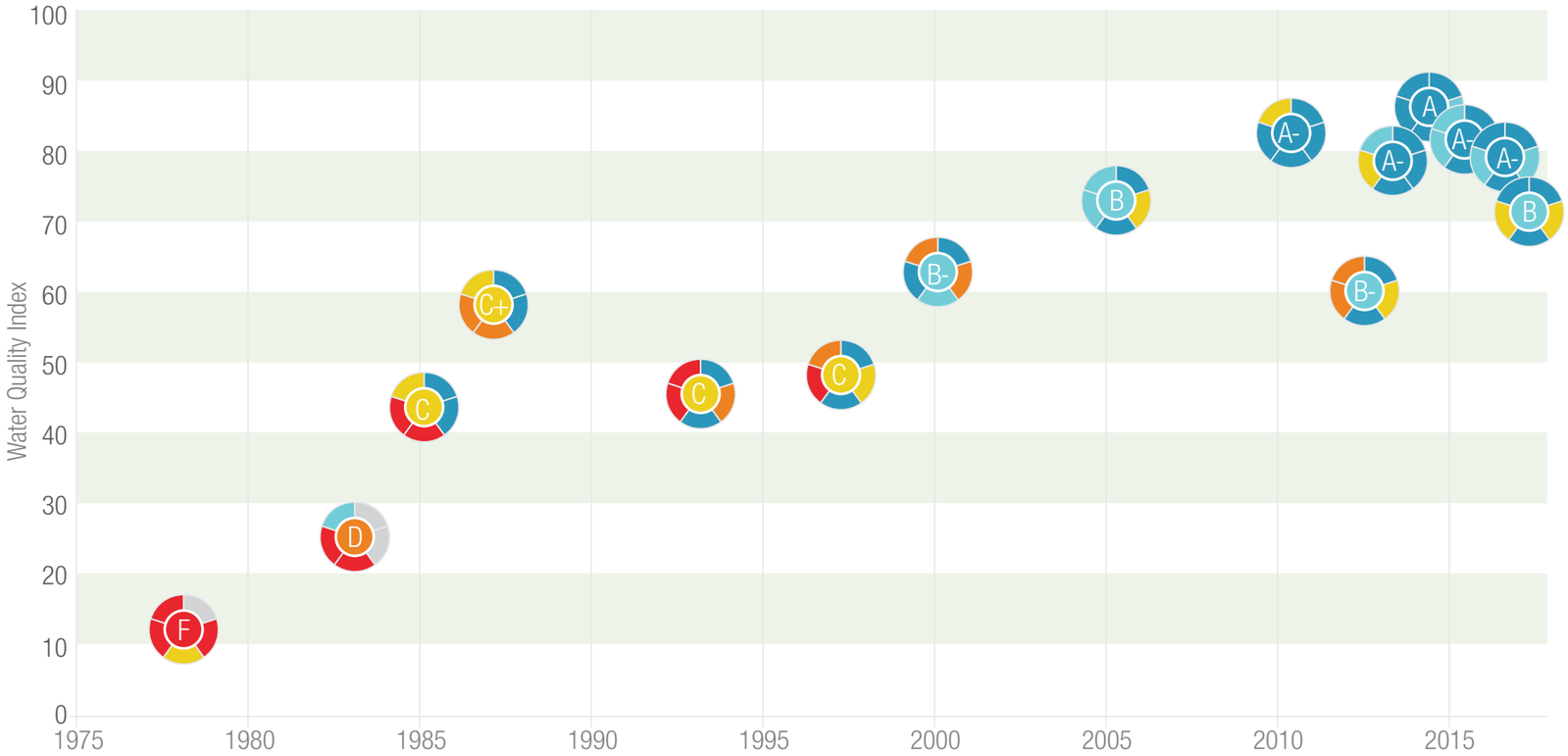
Phytoplankton biomass

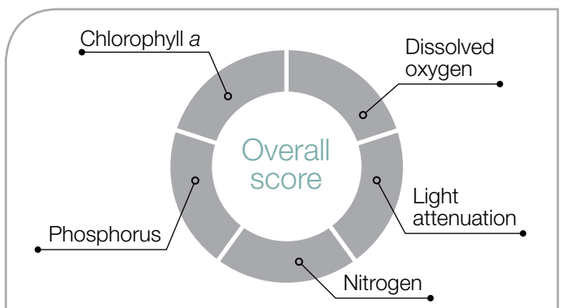
Phytoplankton biomass has met the guideline in about half of the years since 2005–06.

Dissolved oxygen

The waters are generally well mixed and well oxygenated. There are periods, mostly during late summer and autumn, or associated with extreme weather events, when bottom waters become stratified and low dissolved oxygen concentrations may be experienced for short periods particularly in the deeper waters at the southern end of Cockburn Sound.

State and trends in water quality in the Moderate Protection Area Eastern Sound





A	80–100%
B	60–79%
C	40–59%
D	20–39%
F	0–19%
	No data

Water Quality Index

A Water Quality Index between 'B' and 'A' indicates that all water quality indicators usually meet the desired levels.

Variability between years may be due to factors such as weather events (e.g. the wet summer in 2016–17[9]).

Nutrients

There has been an improvement in water quality since the late 1970s/early 1980s, with significant decreases in nutrient concentrations (Total Nitrogen and Total Phosphorus) recorded at long-term monitoring sites (those sites for which there are data from the late 1970s/early 1980s).

Chlorophyll *a* / light attenuation

There have been significant decreases in chlorophyll *a* concentrations and light attenuation coefficients at long-term monitoring sites since the late 1970s/early 1980s. Chlorophyll *a* concentrations at sites along the eastern shore were historically high; and higher than at sites in the middle of Cockburn Sound or on the western side of Cockburn Sound near Garden Island.

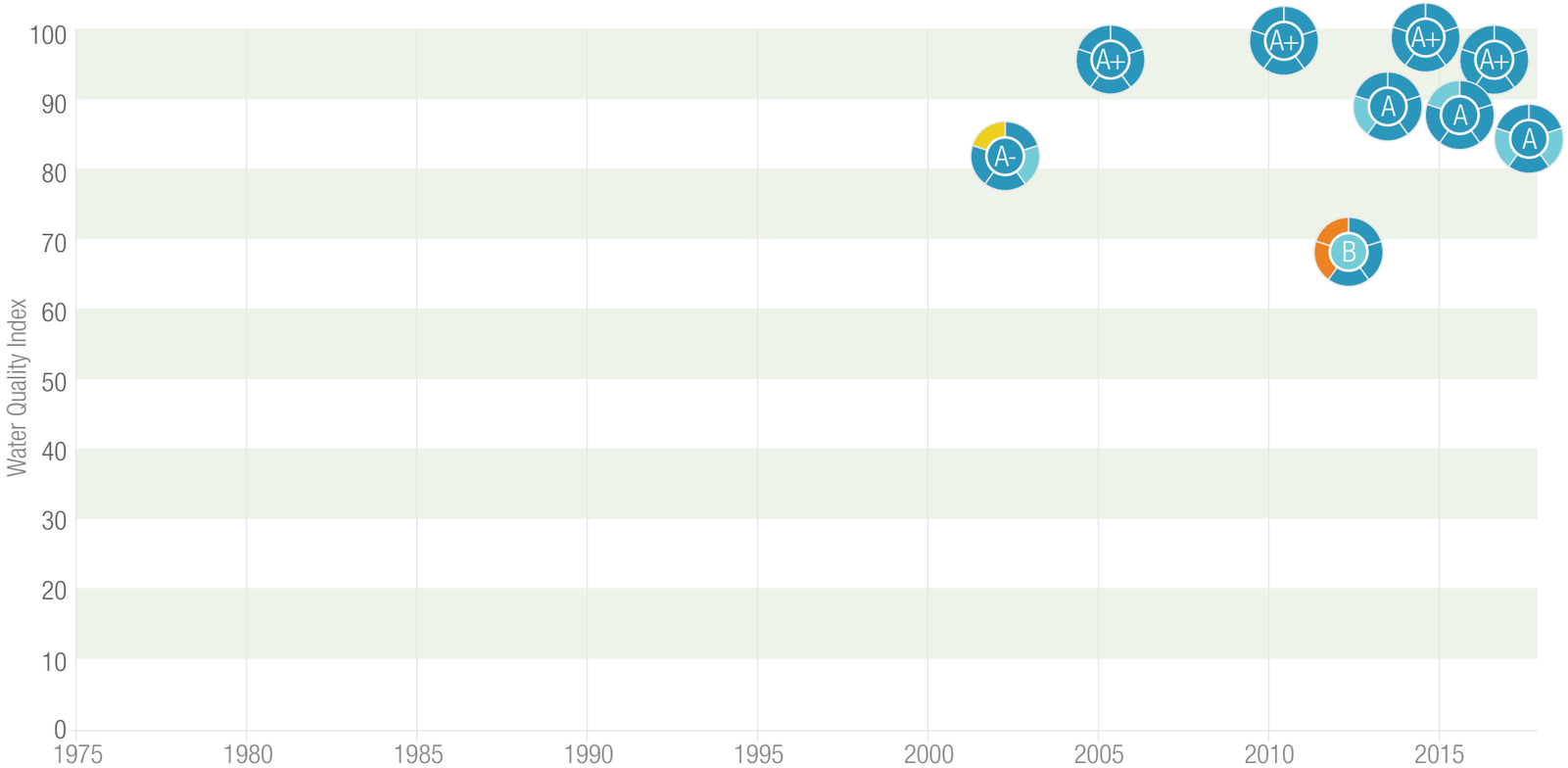
Phytoplankton biomass

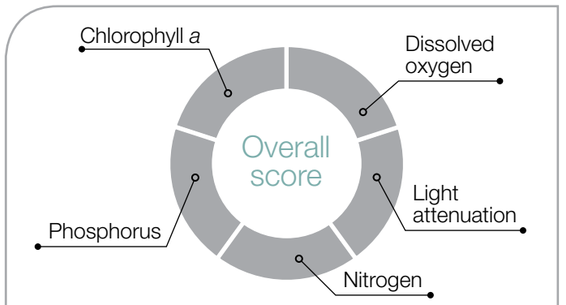
Phytoplankton biomass has met the guideline in most years since 2005–06.

Dissolved oxygen

The waters are generally well mixed and well oxygenated. There are periods, mostly during late summer and autumn, or associated with extreme weather events, when bottom waters become stratified and low dissolved oxygen concentrations may be experienced for short periods.

State and Trends in Water Quality in the Moderate Protection Area Careening Bay





A	80–100%
B	60–79%
C	40–59%
D	20–39%
F	0–19%
	No data

Water Quality Index

A Water Quality Index of 'A' indicates that all water quality indicators meet the desired levels.

Variability between years may be due to factors such as weather events (e.g. the wet summer in 2016–17[9]).

Nutrients

Monitoring in Careening Bay commenced in 2001–02 and water quality has been connsistently high since that time with no indication of significant trends in nutrient concentrations.

Chlorophyll *a* / light attenuation

Monitoring in Careening Bay commenced in 2001–02 and water quality has been consistently high since that time with no indication of significant trends in chlorophyll *a* concentrations or light attenuation coefficients.

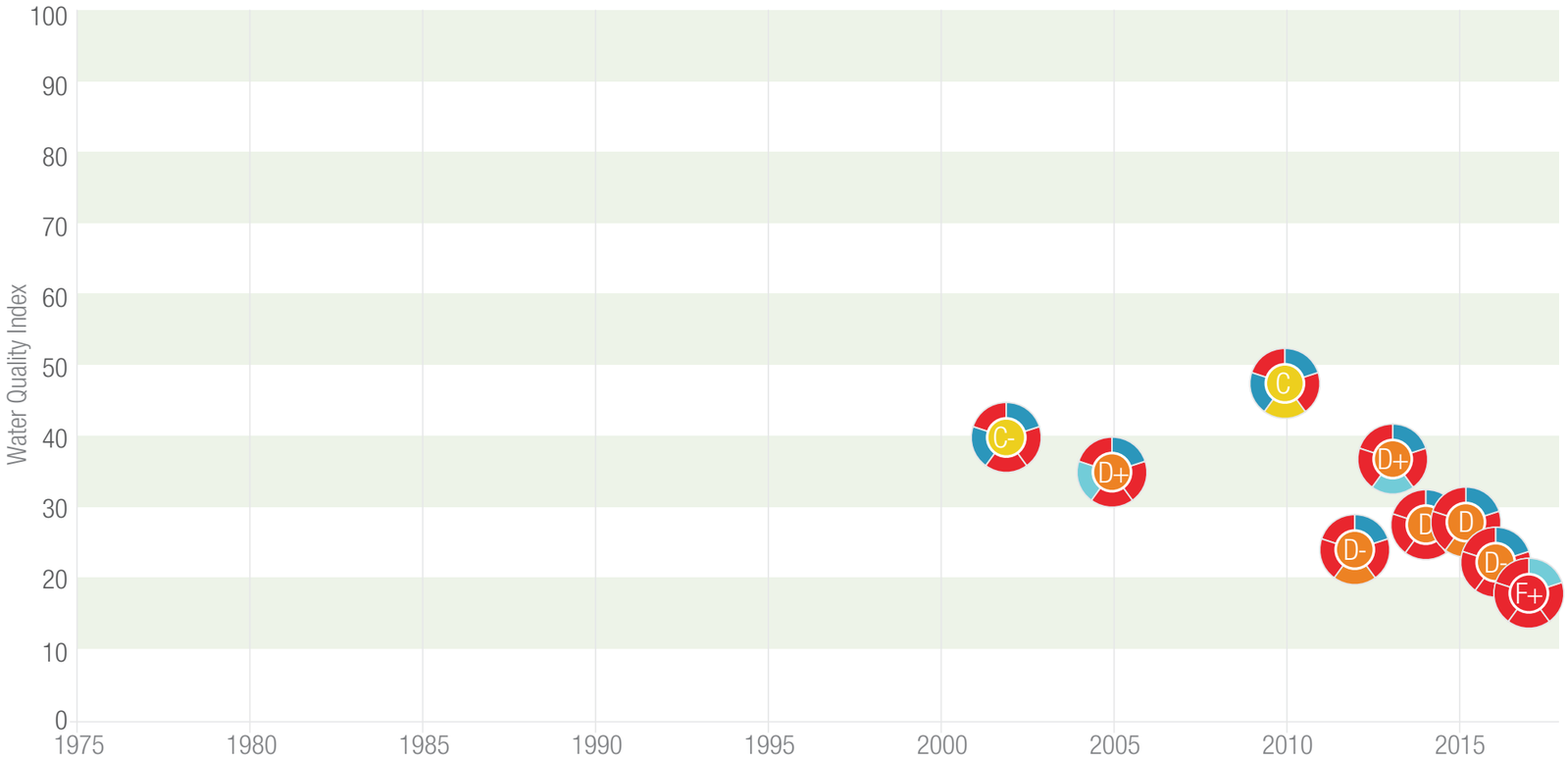
Phytoplankton biomass

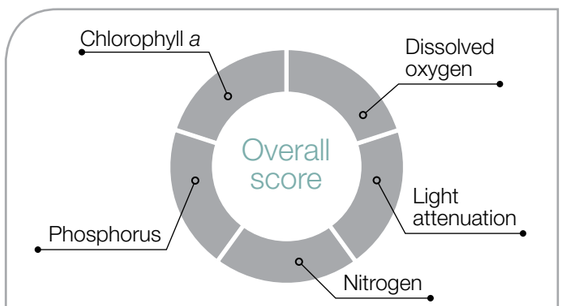
Phytoplankton biomass has met the guideline in all years since 2005–06.

Dissolved oxygen

The waters are generally well mixed and well oxygenated.

State and Trends in Water Quality in the Moderate Protection Area Northern Harbour





A	80–100%
B	60–79%
C	40–59%
D	20–39%
F	0–19%
	No data

Water Quality Index

A Water Quality Index between ‘D’ and ‘F’ indicates some persistently poor water quality indicators.

Variability between years may be due to factors such as weather events (e.g. the wet summer in 2016–17[9]).

Nutrients

Northern Harbour has a long history of poor water quality attributed to high levels of nitrogen in groundwater flowing into the harbour and the reduced flushing resulting from the construction of the northern breakwater in 1997. There has been a significant decrease in Total Nitrogen concentrations since 2001–02.

Clorophyll *a* / light attenuation

Monitoring in Northern Harbour commenced in 2001–02. Elevated chlorophyll *a* concentrations and light attenuation coefficients have been consistently reported.

Phytoplankton biomass

In 2016–17 the ‘Phytoplankton biomass’ guideline for Cockburn Sound was met for the first time since reporting began in 2003.

Dissolved oxygen

The waters are generally well mixed (vertically) and well oxygenated. There are periods, mostly during late summer and autumn, or associated with extreme weather events, when bottom waters become stratified and low dissolved oxygen concentrations may be experienced for short periods.

Seagrass in Cockburn Sound

Seagrass meadows are an important benthic (seafloor) habitat providing critical ecosystem functions and services in Cockburn Sound. Seagrasses provide habitat for fish and other aquatic organisms, contribute to improving water quality through nutrient recycling and sediment retention, and represent an important source of organic matter. Seagrasses respond rapidly to changes in environmental conditions, such as light and nutrient availability, making them good indicators of the state of the marine environment.

Historically, there have been large-scale losses of seagrass meadows in Cockburn Sound. Between 1954 and 1978, seagrass coverage declined from 4200 to 900 ha (a reduction of about 80 per cent), with most loss occurring between 1969 and 1975[10]. This loss was attributed to an increase in nutrients that stimulated the growth of phytoplankton and epiphytes, which in turn reduced the amount of light reaching the seagrass.

Seagrass mapping in Cockburn Sound in 2017 has shown that coverage increased from 721 ha in 1999 to 965 ha in 2017, a gain of 244 ha or about 30 per cent (Figure 3)[11]. This increase is primarily in the eastern and southern areas of Cockburn Sound, with coverage increasing in the Southern Flats area and offshore areas in eastern Cockburn Sound. There was a small increase (40 ha) between 2012 and 2017, mainly reflecting an increase in seagrass cover in the areas off the north-eastern coast of Garden Island. These increases in seagrass coverage coincide with reported improvements in water quality.

Annual monitoring of seagrass shoot density has been undertaken at sites in Cockburn Sound since 1998. Significant declining trends in shoot density have been reported at several of these sites over the past 11–15 years, indicating continued decline of meadows in areas at the northern end of Garden Island, Eastern Shoal and Mangles Bay. While mapping has shown an increase in seagrass coverage in these areas, as well as Cockburn Sound as a whole (indicating that the seagrass meadows are expanding at the edges), the decline in shoot density suggests thinning in parts of the meadows. Continued thinning of the meadows could lead to reduced resilience, potentially threatening the ecosystem functions of seagrasses in Cockburn Sound.

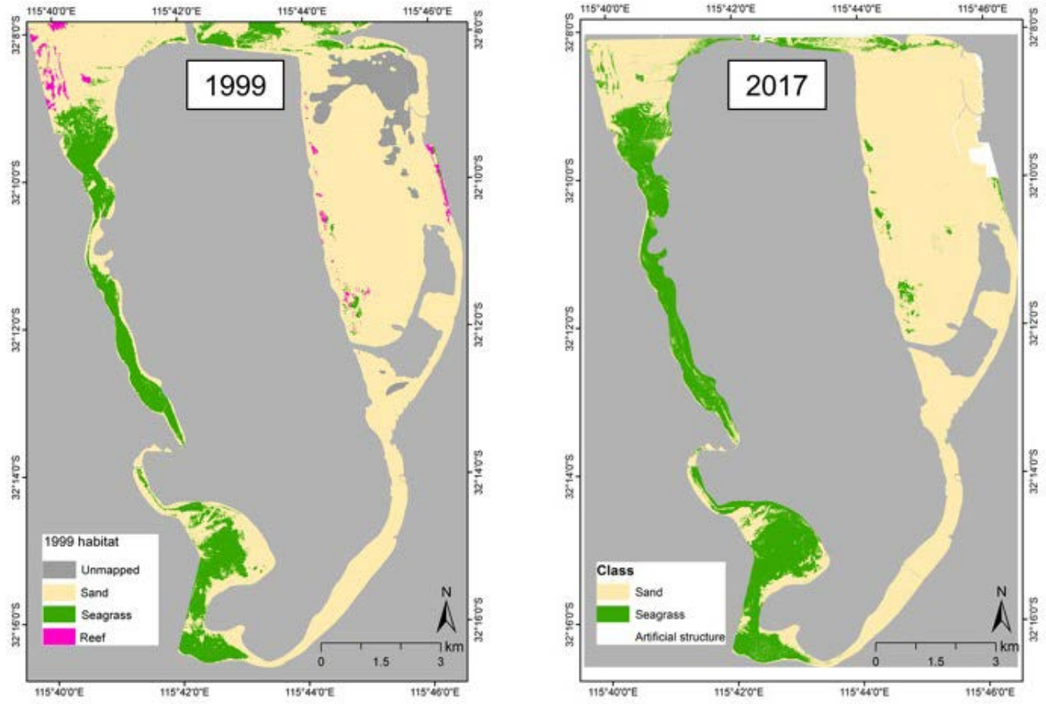


Figure 3: Distribution of seagrass in Cockburn Sound in 1999 and 2017[11]

10 Kendrick, GA, Aylward, MJ, Hegge, BJ, Cambridge, ML, Hillman, K, Wyllie, A and Lord, DA (2002). Changes in seagrass coverage in Cockburn Sound, Western Australia between 1967 and 1999. *Aquatic Botany* 73: 75–87.

11 Hovey, RK and Fraser, MW (2018). *Benthic Habitat Mapping of Cockburn Sound*. Report prepared for the Department of Water and Environmental Regulation and Fremantle Ports, Western Australia, on behalf of the Cockburn Sound Management Council, by the Oceans Institute and School of Biological Sciences, University of Western Australia.

Contaminants in marine waters and sediments

Marine waters

Monitoring of contaminants (for example, metals, organometallics, non-metallic inorganics, organics and pesticides) in marine waters is not routinely undertaken in Cockburn Sound. Concentrations of potential contaminants were last comprehensively assessed in 2008; some site-specific targeted surveys have been undertaken since that time.

Based on the available information, the marine waters of Cockburn Sound are generally of good quality. Contaminant concentrations were below the guidelines, below their respective detection limits or Limits of Reporting[12] where no guidelines are available, or present in low concentrations.[13] Contaminants at concentrations above the Limits of Reporting but with no guidelines were within accepted international standards where these are available.

Sediments

Concentrations of sediment contaminants in Cockburn Sound were last comprehensively assessed in 2006; some site-specific targeted surveys have been undertaken since that time.

Based on the available information, concentrations of most contaminants (metals, hydrocarbons, organochlorine pesticides) are generally below the guidelines where these are available or the analytical Limits of Reporting.[13] Concentrations of most metals (copper, zinc, aluminium, cobalt, lead, mercury, nickel) are generally higher in the southern area of Cockburn Sound. This is most likely due to the higher silt and clay content of the sediments (smaller particles have higher surface areas for adsorption of contaminants), rather than a local contaminant source.

Tributyltin (TBT) and its breakdown products (dibutyltin (DBT) and monobutyltin (MBT)) are consistently present in Cockburn Sound sediments particularly in localised areas around port infrastructure, jetties and boat mooring areas, suggesting recreational and commercial vessels historically as a major source.[13] Once in sediments, TBT is resilient and 'hot spots' of TBT contamination around infrastructure are expected to persist for some time, noting that new introductions of TBT would be expected to be non-existent or minimal.

Copper-based compounds have replaced organotins as the active ingredient in antifouling paints. Copper concentrations are occasionally elevated in sediments at individual sites around shipping-related infrastructure, with concentrations highly variable between sites.[13]

12 The lowest amount of a substance in a sample that can be determined with acceptable precision and accuracy under the stated analytical conditions.

13 BMT (2018). *Cockburn Sound – Drivers, Pressures, State, Impacts, Responses Assessment 2017 Final Report*. Report prepared for Department of Water and Environmental Regulation, the Kwinana Industries Council, the City of Rockingham and the City of Kwinana on behalf of the Cockburn Sound Management Council.

Marine pests in Cockburn Sound

The introduction and spread of new species into Western Australian waters poses a significant threat to the State's aquatic resources and can have widespread effects on both the economy and public health. A targeted surveillance program provides early detection of marine pest species within the Swan River and Cockburn Sound[14].

Table 1: Introduced and pest species detected in Cockburn Sound and Fremantle Port waters.

Common name	Scientific name	Type of organism	Pest status	Year first detected	Subsequent detection
	Alexandrium catanella	Dinoflagellate	Pest-like if in bloom	2012–13	N
	Alexandrium sp.	Dinoflagellate	Pest-like if in bloom	2014–15	N
Mediterranean fanworm	*Sabella spallanzanii*	Polychaete	Pest	2012–13	Y
Aeolid nudibranch	*Godiva quadricolor*	Mollusc	Introduced species	2013–14	Y
Scallop	*Scaeochlamys livida*	Mollusc	Introduced species	2012–13	Y
Asian green mussel	*Perna viridis**	Mollusc	Pest	2011–12*	Y*
Asian date mussel	*Arcuatula senhousia*	Mollusc	Pest	2012–13	Y
Ivory barnacle	*Balanus improvisus**	Barnacle	Pest	2013–14*	N
	*Balanus pulchellus**	Barnacle	Introduced species	2013–14*	N
	Amphibalanus amphitrite	Barnacle	Introduced species	2014–15	N
Asian paddle crab	*Charybdis japonica*	Crab	Pest	2013–14	N
Ciona	*Ciona intestinalis*	Ascidian	Introduced species	2013–14	Y
	Didemnum perlucidum	Ascidian	Introduced species, pest-like characteristics	2012–13	Y
Striped sandgoby	*Acentrogobius pflaumi*	Fish	Introduced species	2014–15	Y

Key

*	species detected on vessel and is not known to be established in the wild
Y/N	species previously detected in the region and detected again in recent surveillance (previous two years)

14 Source: Department of Primary Industries and Regional Development.

Ecosystem integrity

The overall objective of the environmental quality management framework for the waters of Cockburn Sound is to maintain a level of environmental quality that will protect the integrity of the marine ecosystem as well as current and future societal uses of the waters. Ecosystem Component Characterisation is a modelling approach that has been used to provide a contemporary estimate of the contribution of the various ecosystem components to the overall ecosystem integrity of Cockburn Sound and the changes since European habitation[15]. The detailed characterisation of each habitat type incorporates the attributes of structure (habitat complexity and the structure of the communities in each habitat in terms of biodiversity, biomass and abundance) and function (primary and secondary production, biogeochemical cycling) and is summarised in Table 2.

The overall ecosystem integrity of Cockburn Sound can be characterised as a marine ecosystem modified by historical nutrient enrichment (eutrophication) and seagrass loss.

Table 2: Contemporary estimate of the contribution of the various ecosystem components to ecosystem integrity in Cockburn Sound and estimated changes in ecosystem integrity since European habitation

Ecosystem component	Contemporary estimate of Cockburn Sound ecosystem integrity	Estimated changes in Cockburn Sound ecosystem integrity since European (pre-1944) habitation
Ecological structure		
Habitat complexity	• Seagrass *(Posidonia* spp.) dominant habitat in terms of contribution to overall habitat complexity (96%). • Small contributions to habitat complexity from dredge spoil, low relief reef and rock walls.	• Decreased by 96% since European habitation, mainly because of the widespread loss of seagrass habitat.
Benthic primary producer biomass	• Estimated 3264 tonnes dry weight. • Dominated by biomass of seagrass (almost 100%).	• Decreased by 92%, mainly due to the loss of seagrass.
Benthic secondary producer (infauna[16] and epifauna[17]) biomass	• Estimated 1339 tonnes (ash-free dry weight). • Infauna and epifauna in 'unvegetated sediment in > 10 m water depth' contributed 51% to overall secondary producer biomass. • Infauna and epifauna in 'unvegetated sediment in < 10 m water depth' and seagrass habitat contributed 30% and 13%, respectively.	• Decreased by 50%. • 'New' habitats created since European habitation (including 'unvegetated sediment in < 10 m water depth', dredge spoil, low relief reef and rock walls) support relatively high biomass of secondary producers, counterbalancing the loss of fauna associated with the loss of seagrass habitat.
Benthic secondary producer abundance	• Estimated 81 billion individual benthic invertebrates. • Greatest contribution (77%) from 'unvegetated sediment in > 10 m water depth' due to large area of this habitat and relatively high abundance of some infauna groups.	• Total abundance of benthic invertebrates decreased by 9% since European habitation. • Relatively small decline predominantly due to the maintenance of a high abundance of infauna within 'unvegetated sediments in < 10 m depth' where seagrass once grew. • Total benthic invertebrate diversity declined by 29%. • Majority of decline attributed to loss of epifauna species associated with the loss of seagrass cover and loss of infauna species within dredged areas.
Ecological function		
Total primary production	• Overall primary production rate estimated at 18,973 tonnes carbon/year. • Due to relatively high production rate and spatial coverage, seagrass dominant habitat (58%) in terms of benthic primary production. • Due to fast growth rates, phytoplankton primary production exceeded that of all benthic habitats, contributing 73% (13,718 tonnes carbon/year) of the total primary production in Cockburn Sound. • 1991–94 *Southern Metropolitan Coastal Waters Study* reported that primary productivity in Cockburn Sound was phytoplankton dominated. Annual primary productivity of phytoplankton estimated at 22,009 tonnes carbon/year. Given decreasing chlorophyll *a* concentrations since 1996, likely that annual primary productivity of phytoplankton has decreased since then.	• Benthic primary production declined by 92%, mainly due to the loss of seagrass. • Seagrass contribution to benthic primary production declined by 99% due to losses in cover and health. • Loss slightly offset by primary production of microphytobenthos across unvegetated sediments where seagrass once grew and by macroalgal production on new dredge spoil reef and rock walls.
Total secondary production	• 'Unvegetated sediment in > 10 m water depth' dominant habitat in terms of contribution towards secondary production from infauna and epifauna (33%), followed by the water column (zooplankton) (28%) and 'unvegetated sediment in < 10 m water depth' infauna and epifauna (23%).	• Benthic secondary production declined by 30% since European habitation, predominantly due to the loss of infauna and epifauna associated with seagrass habitat.
Total nitrogen turnover	• Overall nitrogen turnover rate of primary producers estimated at 1,560 tonnes nitrogen/year. • Phytoplankton dominated total nitrogen turnover (89%: 1,384 tonnes nitrogen/year) due to the fast growth rate and relatively high nitrogen content of phytoplankton.	• Nitrogen turnover rate in Cockburn Sound is estimated at about 5% higher than the pre-European habitation estimate due to the higher production rates of phytoplankton in the water column, in turn due to higher nutrient availability.

15 BMT (2018). *Cockburn Sound – Drivers, Pressures, State, Impacts, Responses Assessment 2017 Final Report.* Report prepared for Department of Water and Environmental Regulation, the Kwinana Industries Council, the City of Rockingham and the City of Kwinana on behalf of the Cockburn Sound Management Council.
16 Organisms that live in seafloor sediments.
17 Organisms that live on the surface of seafloor sediments or substrates, such as rocks, pilings and seagrass leaves.

Cockburn Sound fisheries

Cockburn Sound has historically been a popular area for both commercial and recreational fishing due to its proximity to the Perth metropolitan area. There are currently four managed fisheries operating in Cockburn Sound: Cockburn Sound Crab Fishery, Cockburn Sound Line and Pot Fishery (octopus), Cockburn Sound Fish Net Fishery and Cockburn Sound Mussel Fishery[18]. Thirty-five fishers are licensed to operate in one or more of these fisheries. Recreational fishers target some of the same resources as exploited by these commercial fisheries, as well as other species.

Cockburn Sound Crab Fishery

Commercial trap catches for blue swimmer crab (*Portunus armatus*) peaked in the late 1990s at over 350 tonnes and declined to 25 tonnes in 2014 (Figure 4). Due to low recruitment and stock levels, the Cockburn Sound Crab Fishery has been closed to commercial and recreational fishing since 2014.

In 2017, the annual standardised index of juvenile blue swimmer crabs in Cockburn Sound, which is a measure of juvenile crab abundance, had improved slightly over the past four years, but was still below the limit established in the preliminary harvest strategy.[19] In 2016, the annual egg production index had increased significantly from 2014 and 2015, and was at the preliminary harvest strategy threshold level. Despite this increase in egg production, the proportion of berried females was lower than historic levels, which may have contributed to the 2017 juvenile recruitment index remaining at a low level. The egg production index declined in 2017 and the effect of this on recruitment in 2018 is as yet unknown. As commercial monitoring catch rates also improved during 2016, the status of the stock was changed from 'environmentally limited' to 'recovering' for the 2017–18 season.[20]

The reasons for the stock decline include the combined effects of reduced levels of primary productivity (chlorophyll *a*) within Cockburn Sound, changes in water temperature, increased predation and the negative effects of density-dependent growth, which may have had an effect on the proportion of berried females. The recent declines in abundance are believed to be primarily attributable to environmental changes, rather than fishing. It is considered unlikely that crab stock levels will recover to historical levels while productivity in the system remains low.

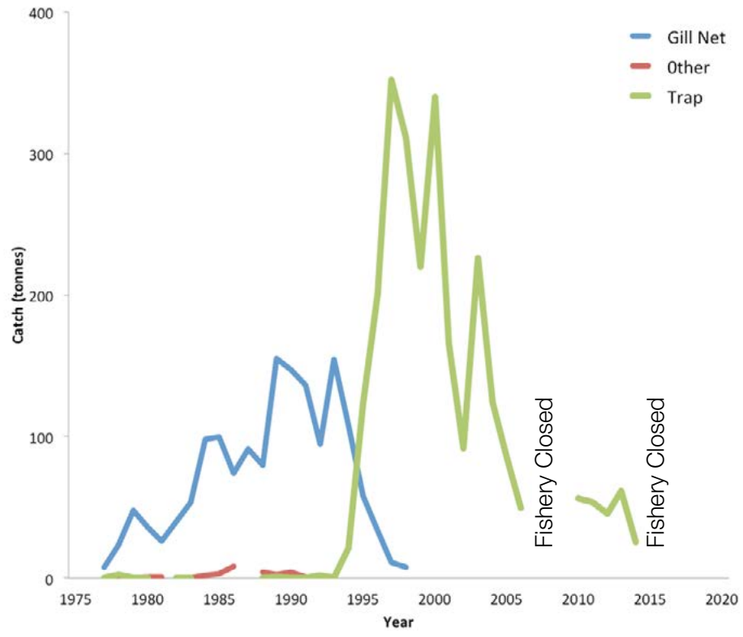


Figure 4: Annual commercial catch (tonnes) by season, for each fishing method in the Cockburn Sound Crab Fishery. The fishing season in Cockburn Sound runs from December to September inclusive. The fishery operated with gill nets from 1977–78, transitioning to traps from 1994–95 to 1998–99, after which it was a trap only fishery.

18 Source: Department of Primary Industries and Regional Development.

19 A harvest strategy is a formal document that supports the decision-making process required to ensure the management of a fishery resource is consistent with principles of Ecologically Sustainable Development. Harvest strategies outline the objectives, performance indicators, reference levels (limit, threshold, target) and harvest control rules for each resource and are used when preparing advice for the Minister for Fisheries.

20 Source: Johnston, D, Marks, R and O'Malley, J (2018). 'West Coast Blue Swimmer Crab Resource Status Report 2017'. In DJ Gaughan and K Santoro (eds), *Status Reports of the Fisheries and Aquatic Resources of Western Australia 2016/17: The State of the Fisheries*. Report prepared by the Department of Primary Industries and Regional Development, Western Australia.

Cockburn Sound fisheries

Cockburn Sound Octopus Fishery

The Cockburn Sound Line and Pot Fishery commenced in March 1995 and thirty-four of the thirty-five fishers are permitted to operate in this fishery. Since 2005, a total of 13 licence holders have been active within the fishery, although only a small number of these have focused on specifically capturing the gloomy octopus (*Octopus tetricus*). Fishing is allowed with both baited and unbaited pots; however, longline-set shelter pots have been the gear type historically used in the fishery. Octopus are also caught as by-product in rock lobster pots. A maximum of 47 tonnes of octopus was caught in 2013; since 2005, the catch has generally fluctuated between 20 and 30 tonnes[21].

While there is no evidence to suggest that over-exploitation has occurred, the potential for localised depletion of octopus in Cockburn Sound has resulted in a highly precautionary management approach. Historically, in addition to limited entry, effort was regulated through restrictions on vessel size. Effort has been further constrained since 2015 with the introduction of a fixed octopus entitlement of 13,000 shelter pots[21].

Cockburn Sound Mussel Fishery

Black mussels (*Mytilus* spp.) are aquacultured in the southern region of Cockburn Sound. Black mussel production in Cockburn Sound increased from its first year in the early 1990s of around 400 tonnes to over 700 tonnes in the early 2000s. Since this peak, production has fallen significantly to below 200 tonnes in recent years. Mussels are filter feeders and their growth rates are directly affected by the productivity of the ecosystem. The reported decline in aquaculture productivity may be attributed to a decline in phytoplankton primary productivity (chlorophyll *a*) and potentially an increase in snapper and crab predation.

21 Source: Hart, A, Murphy, D and Yerman, M (2018). 'West Coast Octopus Resource Status Report 2017'. In DJ Gaughan and K Santoro (eds), *Status reports of the Fisheries and Aquatic Resources of Western Australia 2016/17: The State of the Fisheries*. Report prepared by the Department of Primary Industries and Regional Development, Western Australia.

Cockburn Sound Finfish Fisheries

A range of finfish species is caught by commercial (Cockburn Sound Line and Pot Fishery, Cockburn Sound Fish Net Fishery) and recreational fishers in the waters of Cockburn Sound.

Cockburn Sound and the adjacent embayments of Owen Anchorage and Warnbro Sound are the only locations on the lower west coast where snapper (*Chrysophrys auratus*) aggregate to spawn. Annual fishing closures are in place to protect these aggregations during their spawning periods. Current management arrangements for snapper are designed to rebuild the west coast stock, following evidence of overfishing in the early 2000s. There is no evidence of any long-term negative effects of environmental changes on these aggregations and subsequent recruitment of juveniles into Cockburn Sound.

Cockburn Sound was historically the main commercial and recreational fishing area for southern garfish (*Hyporhamphus melanochir*) in Western Australia, and is regarded as a key location for this species. Garfish have declined in the Metropolitan Zone (area between Lancelin and north of Bunbury) since the late 1990s, due to a combination of overfishing and environmental factors. The 2011 marine heatwave accelerated stock decline[22]. A total fishing ban for southern garfish was implemented in the Metropolitan Zone in 2017 to allow recovery of the stock. Garfish are seagrass dependent for spawning and a decline in seagrass biomass is likely to negatively affect garfish.

The 2011 marine heatwave had major impacts on fish and fisheries along the west coast, including Cockburn Sound. There were marked changes in the composition of the fish fauna on the west coast after this event because of range shifts, increased mortality and recruitment failures.

22 Source: Smith, K, Holtz, M, Bunbury, E, O'Malley, J and Yerman, M (2018). 'West Coast Nearshore and Estuarine Finfish Resource Status Report 2017'. In DJ Gaughan and K Santoro (eds), *Status Reports of the Fisheries and Aquatic Resources of Western Australia 2016/17: The State of the Fisheries.* Report prepared by the Department of Primary Industries and Regional Development, Western Australia.

Social environmental values: state and trends

Assessment of the state and trends in the Cockburn Sound marine area for the four social environmental values identified for protection: 'Fishing and aquaculture', 'Recreation and aesthetics', 'Cultural and spiritual' and 'Industrial water supply.

Environmental value	Environmental quality objective	State in 2017	Trend	At a glance
Fishing and aquaculture	*Maintenance of seafood safe for human consumption*			Shellfish harvested from the 'approved' and 'conditionally approved' shellfish harvesting areas in southern Cockburn Sound are safe for human consumption. Limited information is available from other areas in Cockburn Sound or for wild shellfish or fish. Accredited quality assurance monitoring programs based on the requirements of the *Western Australia Shellfish Quality Assurance Program* (WASQAP) Operations Manual are currently conducted for 'approved' and 'conditionally approved' shellfish harvesting areas in southern Cockburn Sound where shellfish are grown commercially for the food market. The Department of Health recommends only eating shellfish harvested commercially under strict quality assurance monitoring programs[23].
	Maintenance of aquaculture			Based on the information available, physical–chemical conditions in the shellfish harvesting areas are generally good for growing shellfish. Physical and chemical parameters (dissolved oxygen concentrations, pH) and toxicant concentrations are suitable for maintaining aquaculture production in the shellfish harvesting areas in southern Cockburn Sound. The industry has nevertheless reported a decrease in peak mussel production in recent years from around 750 tonnes to 250 tonnes[24]. This decline is attributed to a reduction in nutrients, which has stunted mussel growth rates, reducing tonnage by up to 60% over the past decade. In addition, in recent years, snapper have been eating the mussels, in particular in the Southern Flats harvesting area. The industry estimated that in the 2016 season, snapper ate between 120 to 140 tonnes in a period of 2.5 weeks.
Recreation and aesthetics	*Maintenance of primary contact recreation*[25]	 		Provisional beach grade risk classification 'Good' at Jervoise Bay Boat Ramp, Rockingham Beach, Rockingham Jetty, Palm Beach Jetty and Palm Beach. Based on incomplete information available to date, bacterial water quality appears to be safe for swimming most of the time. Water quality results to date have been good on most occasions and there are few potential faecal contamination sources identified. Standard Department of Health warnings apply. Provisional beach grade risk classification 'Good'/'Fair' at Jervoise Bay Beach, Naval Base, Kwinana Beach and North Hymus. Based on incomplete information available to date: • bacterial water quality appears to be safe for swimming most of the time • elevated bacterial levels are likely to be due to animal pollutants (e.g. bird faeces) and from contaminants flushing into the water following rainfall. Standard Department of Health warnings apply[26].
	Maintenance of secondary contact recreation[27]			Based on the information available, water quality in Cockburn Sound is suitable for secondary contact recreation activities.
	Maintenance of aesthetic values			Records of visual indicators of aesthetic quality (including the presence of nuisance organisms, faunal deaths, water clarity, the presence of surface films and debris, and odours) are made over the summer (non river-flow) period and reported on annually. However, many of the guidelines for aesthetic quality are subjective and relate to the general appreciation and enjoyment of Cockburn Sound by the community as a whole. A workshop on aesthetic values was held by Cockburn Sound Management Council in 2001 to underpin the development of the aesthetic criteria for Cockburn Sound. However, there have been no direct measures made of the community's perceptions of the aesthetic values of Cockburn Sound to determine whether there has been a perceived loss or gain of value since then (e.g. through regular community surveys to establish trends in community perception of aesthetic values over time).
Cultural and spiritual	*Maintenance of Indigenous cultural and spiritual values*			Inclusion of this environmental value recognises the cultural and spiritual values of Cockburn Sound to the Indigenous peoples of the area. To date, no specific environmental quality criteria have been established for this value and there are no specific monitoring programs in place. Ensuring that the quality of the marine waters of Cockburn Sound is sufficient to protect ecosystem integrity, protect the quality of seafood, enable safe recreation and maintain aesthetic values may go some way towards maintaining cultural values[28]. It is difficult to define spiritual value in terms of environmental quality requirements.
Industrial water supply	*Maintenance of water quality for industrial use*			Minor exceedances of guidelines in the intake water for the Perth Seawater Desalination Plant reported for some parameters. No significant reduction in efficiency of the desalination process or significant increases in maintenance requirements reported[29].

23 Department of Health (2010). *Wild shellfish collection*. Environmental Health Directorate, Department of Health. [source: healthywa.wa.gov.au].
24 Source: Glenn Dibbin, Blue Lagoon Mussels.
25 Primary contact recreation includes all recreational activities where the participant comes into frequent contact with the water, either as part of the activity or accidentally (for example, swimming, water-skiing, wind surfing or diving).
26 Source: Department of Health (2018). Beach Grades for Perth metropolitan ocean sites (http://ww2.health.wa.gov.au/Articles/A_E/Beach-grades-for-Perth-metropolitan-ocean-sites).
27 Secondary contact recreation includes recreational activities in which the participant comes into direct contact with the water infrequently, either as part of the activity or accidentally (for example, boating, canoeing or fishing).
28 Source: Environmental Protection Authority (2017). *Environmental Quality Criteria Reference Document for Cockburn Sound. A supporting document to the State Environmental (Cockburn Sound) Policy 2015*.
29 Source: Water Corporation, Western Australia

Conclusions

State categories	Explanation
	For this environmental value, based on available environmental monitoring data, the state of the Cockburn Sound marine area is presently meeting all environmental quality criteria and the environmental quality objective is being achieved.
	For this environmental value, based on available environmental monitoring data, the state of the Cockburn Sound marine area is presently not meeting all the environmental quality criteria and there is a risk the environmental quality objective may not be being achieved.
	For this environmental value, based on available environmental monitoring data, the state of the Cockburn Sound marine area is presently meeting none or only a few of the environmental quality criteria, and the environmental quality objective is not being achieved.

Trend categories	Explanation
	Available information indicates that for this environmental value, the state of the Cockburn Sound marine area is improving.
	Available information indicates that for this environmental value, the state of the Cockburn Sound marine area is unchanging (it is not getting better or worse).
	Available information indicates that for this environmental value, the state of the Cockburn Sound marine area is declining.

Historical nutrient enrichment (eutrophication), contaminated groundwater inputs, physical alterations associated with infrastructure development, increasing urbanisation and increasing recreational boating and fishing have resulted in significant changes to the diversity and integrity (both structure and function) of Cockburn Sound's marine ecosystem. The most important changes have been the extensive loss of seagrass between the 1960s and the 1990s because of poor water quality and the shift in primary productivity in Cockburn Sound from seagrass to the water column.

Since the 1970s, the State Government, in partnership with industry, local government and the community has worked to improve the environmental health of Cockburn Sound through a range of collaborative management and mitigation efforts. Water quality has improved significantly since the 1980s, and seagrass coverage has increased between 1999 and 2017. However, there are ongoing concerns about poor water quality in some areas of Cockburn Sound, declines in seagrass shoot density at some sites, a decline in productivity of some commercial (including aquaculture) and recreational fisheries, as well as the emergence of new threats.

Based on the available information, the water quality in Cockburn Sound is such that the other values and uses – including recreational use, ensuring shellfish from the shellfish harvesting areas in southern Cockburn Sound are safe to eat, and industrial water supply – are being maintained.

There is no information available on whether aesthetic and Indigenous cultural and spiritual values are being maintained. Ensuring that the quality of the marine waters of Cockburn Sound is sufficient to protect ecosystem integrity, protect the quality of seafood, enable safe recreation and maintain aesthetic values may go some way towards maintaining the cultural values of the Sound.

Cockburn Sound is likely to experience further pressures in the future and particularly along the eastern shoreline from urbanisation and industrial and infrastructure development. There is currently limited understanding of the ecological resilience of Cockburn Sound's marine ecosystem to these pressures.

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Or visit the Cockburn Sound Management Council's website
csmc.dwer.wa.gov.au