6 Threats to ecological character

A number of factors at Towra Point Nature Reserve and in the surrounding catchment areas threaten to adversely alter the ecological character of Towra Point. Figure 56 outlines the key threats to Towra Point and is followed by a brief description of each threat.

![Diagram of Threats to Towra Point Nature Reserve Ramsar site]

Figure 56: Threats to Towra Point Nature Reserve Ramsar site

Adapted from Millennium Ecosystem Assessment (2003)

Figure 56: Threats to Towra Point Nature Reserve Ramsar site
6.1 Weeds

Along with pests, weeds are one of the biggest threats to Towra Point Nature Reserve and surrounding areas. Due to clearing of Towra Point for grazing and timber in the 1800s, weeds were able to colonise the area. Towra Point contains at least eight weeds listed under the *Noxious Weeds Act 1993*, four of which are weeds of national significance. As the landowner, DECCW is obliged to control weeds at Towra Point. A Weed Management Strategy has been prepared for 2007–2012 (WODEC 2007). Although a formal peninsula-wide strategy has not yet been developed, DECCW and Sutherland Shire Council are working closely with landowners to coordinate a holistic approach to management of weeds.

Towra Point is not accessible to visitors and this has helped prevent the spread of weeds. However, foxes, birds, horses, dogs, boats and vehicles can also disperse weed seeds (NPWS 2001a; WODEC 2007). Volunteer groups such as The Friends of Towra Point and Botany Bay Busy Bees, along with DECCW and NSW Maritime, are involved in bush regeneration in the area, which mainly involves weed control, which is a key activity in protecting the biodiversity of Towra Point. Volunteers from a weekend detention centre are trained in horticulture and undertake weed control and native plant propagation at Towra Point in conjunction with the Georges River Combined Council Committee (P. Annabel 2007, pers. comm.). Other groups involved in weed removal and native bush regeneration include Conservation Volunteers Australia, the Towra Team and corporate volunteers including Westpac and Toyota.

The biggest weed threats to the flora and fauna of Towra Point are bitou bush, lantana and caulerpa (*Caulerpa taxifolia*), and are described below. Other weeds of concern include spiny rush, blackberry (*Rubus* spp.), prickly pear (*Opuntia stricta*), pampas grass (*Cortaderia selloana*), African olive (*Olea africana*), African box-fern (*Lycium ferocissimum*) and asparagus fern (*Asparagus sprengeri*) (NPWS 2001a).

**Bitou bush**

Bitou bush is a key threatening process (TSC Act) and poses the biggest threat to coastal ecosystems in NSW, including Towra Point (DEC 2006b). This introduced species grows in dense shrubs and spreads rapidly, suffocating native plants, preventing native seed propagation and threatening biodiversity. Birds and foxes are the main vectors for dispersal, with wind and water the next most important mechanism (WODEC 2007).

Bitou bush is found throughout Towra Point with high density areas along Towra Beach, on the western side of Towra Point, along the southern shores of Quibray Bay near the horse stables and throughout the Kurnell dune forest (WODEC 2007). It is a major threat to the endangered ecological communities at Towra Point, including the small stand of littoral rainforest and Kurnell dune forest. Loss of native flora will have significant negative impacts on the native fauna of Towra Point due to loss of food and nesting areas and may lead to a loss of species. Some fauna may have adapted to the protection of bitou bush or use it as a food source in the absence of native flora and care must be taken when removing it and choosing native flora to replace it (DEC 2006b).

A State-wide threat abatement plan for bitou bush from 2006 to 2011 makes this species a top priority for management at Towra Point under the weed management strategy (WODEC 2007). DECCW is implementing this strategy and has prepared a bitou bush site management plan to assist the long-term eradication of bitou bush. Ground spraying of glyphosate has been used as a method of broad-scale weed control in conjunction with other control measures such as hand removal of weeds.
and bush regeneration (Figure 57). Similar control methods are being undertaken on Kurnell Peninsula by DECCW and Sutherland Shire Council.

**Lantana**

Lantana is a weed of national significance and forms dense growth that eliminates native plant species and threatens biodiversity. Spread mainly by birds and insects, it has infested over four million hectares in Australia and has been named one of the world’s worst weeds (ARMCANZ et al. 2000).

Lantana is widespread throughout Towra Point Nature Reserve, including the endangered ecological communities such as Kurnell dune forest and littoral rainforest (WODEC 2007). By 1990, almost 75% of vegetation at some parts of Towra Point was lantana, with a particularly bad infestation at Weedy Pond (SSEC 2004b). In 1996 the Friends of Towra Point Nature Reserve and other volunteer groups, funded by Coastcare, began lantana and other weed control strategies, and the work is ongoing. Much of the weed control technique has been removal by hand and with the use of herbicide (SSEC 2004b).

**Caulerpa**

Caulerpa is a seaweed native to warm, tropical waters including tropical Australia and the South Pacific. Caulerpa was first recorded in NSW in Port Hacking in April 2000 and has now been found in 13 NSW estuaries or coastal lakes, including Botany Bay (DPI 2007a). It is a Class 1 noxious species in NSW (FM Act) and it is illegal to possess or sell the species. Caulerpa has the potential to threaten other seagrasses by its invasive nature of forming dense meadows. A chemical produced by caulerpa prevents epiphytic algae growth which reduces available food for grazers (Street 2007).

Caulerpa uses light and nutrients for growth, as do other seagrasses. However, caulera increases in height under low light conditions thereby out-competing other seagrasses. Caulerpa may be able to use organic matter in the sediment for growth when the light is inadequate (Street 2007).

Figure 57: Bitou bush control

Photo: K. Brennan 2007
The initial introduction of caulerpa into NSW estuaries may have been the result of releasing aquarium contents into the waters and further transport is made possible by boats and fishing vessels. Caulerpa can survive out of water for up to 10 days and is a fast growing, highly adaptable species. In the surrounding waters of Towra Point Nature Reserve caulerpa grows in the seagrass meadows (Figure 58).

**Recommended actions for weeds**

A weed management strategy for Towra Point was prepared in 2007 (WODEC 2007). Implementation of this strategy will be followed by a review at the completion of the strategy. Ongoing weed management is critical in reducing the threat to biodiversity of the area and an integrated weed management strategy for Kurnell Peninsula, along with private landowner cooperation, is the next critical step of protection (WODEC 2007).

I&I NSW continues to monitor NSW estuaries, including Botany Bay, for the presence and distribution of caulerpa. A number of control methods have been tested, such as dredging, handpicking, smothering and salt application, the latter being the most effective. However, due to the scale of infestations, management focus has shifted to preventing further introduction of this species into new areas (DPI 2007a). Research is ongoing in several areas affected by caulerpa to further the understanding of the impacts of this invasive species on native seagrasses and habitats. Ongoing research is being undertaken in conjunction with education programs by I&I NSW to advise the community about how to prevent the spread of this invasive weed (M. Walker 2007, pers. comm.). As the surface temperature of the sea increases, temperate areas will become more favourable for growth of tropical seagrass species (Poloczanska 2006a), such as caulerpa, which may expand its distribution.

**6.2 Pests**

Pest animal species at Towra Point include introduced and native species, such as foxes, cats, ravens, rabbits, gulls, ants and the black rat. Foxes are the biggest threat to native birds and mammals. With Towra Point being so close to urban areas, cats also pose a threat, especially to species that use habitat fragments of urban areas to move between habitats. Ravens, gulls, rabbits, ants and rats are a threat to shorebird communities, in particular little tern and pied oystercatcher eggs and chicks (NPWS 2003).

Towra Point is listed as a high priority site for fox control due to predation on the little tern and pied oystercatcher (NPWS 2001b).

Some pest species are controlled by biological measures, such as by predation on rats, for example by swamp harriers and whistling kites. However, species-specific control measures, such as trapping and baiting to reduce numbers, are applied (NPWS 2003). A number of landowners across Kurnell Peninsula are developing an integrated weed and pest management strategy which will increase the effectiveness of control.

**Recommended actions for pests**

Habitat fragmentation may increase the impact of foxes due to their concentration in smaller areas. Control of foxes must be coupled with monitoring of native species and pest populations, since a reduction in foxes may increase the presence of other introduced predators such as rabbits or cats (NPWS 2001b). The most effective control measure for foxes is the use of the toxin sodium mono-fluoroacetate (1080) inside meat bait. Other control measures include trapping, shooting and den fumigation (NPWS 2001b).
Figure 58: Distribution of caulerpa in southern Botany Bay
As part of the NSW Fox Threat Abatement Plan, the Parks and Wildlife Group of DECCW conducts its fox baiting program in Kurnell Peninsula, including Towra Point, from September to March. The program is timed to coincide with the little tern and pied oystercatcher breeding seasons when foxes are the biggest threat. A proposed integrated weed and pest management strategy for the future will see DECCW, Sutherland Shire Council, other government agencies and private landowners using fox control measures throughout Kurnell Peninsula to increase the success of fox eradication (A. Bianchi 2007, pers. comm.).

During the little tern nesting period at Towra Spit Island between September and March additional control of threatening species is carried out. Species such as the Australian raven (*Corvus coronoides*) and ants are monitored and managed according to predation on eggs and chicks (NPWS 2003).

### 6.3 Altered hydrology

Any alteration of the natural hydrology over the entire catchment will have an effect on the ecological character of Towra Point as hydrology is a major ecosystem driver. Dredging, land reclamation, water harvesting and catchment land use will cause a change in how water moves through the system. In Towra Point Nature Reserve an analysis of the effect of the causeway through the main saltmarsh area on drainage and water flow is needed. The track was constructed in 1952 and removal or reconstruction of the track will likely change the hydrology at Towra Point and may influence other components and processes.

#### Dredging

Dredging in Botany Bay in the 1960s and 1970s caused ongoing detrimental effects to Towra Point by altering wave patterns. This increased the erosion rate at Towra Beach and changed sedimentation patterns. Future developments on Kurnell Peninsula have proposed dredging in Botany Bay which will alter the bay’s hydrology. There are two certain and immediate projects that involve dredging of Botany Bay: the first is a desalinated water distribution pipeline for Sydney Water and the second is two underground electricity cables for Energy Australia.

Dredging not only affects wave patterns, it changes the way in which water moves throughout the system, therefore changing the physicochemical processes and sedimentation patterns. A change in the seabed changes the benthic macro-invertebrates and plants, which affect higher trophic levels.

The seagrass meadows in Botany Bay are relatively large for the Sydney area and are sensitive to turbidity. They are a critical component of the Towra Point ecosystem as they protect the shoreline from erosion, provide shelter for juvenile fish and crustaceans and assist in nutrient and energy transfer. The proposed projects will affect this important habitat adjacent to Towra Point both directly, by dredging for the laying of pipeline and cables, and indirectly, by sediment plumes during construction and future maintenance. Sediment plumes have been modelled for the desalination plant pipeline (CLT 2007). Seagrasses stabilise the seabed and reduce the effects of waves, and a reduction in seagrass area could have a deleterious effect as the effects of waves on the area increase (Larkum 1976).

The environmental assessment for the Botany Bay cable project for Energy Australia states that 80 threatened species are within six kilometres of the cable site, one of which, the black cod, resides in the area. Therefore, dredging may cause loss or change of habitats and may lead to loss of species (MS 2007).
Inappropriate water use

Groundwater extraction, sandmining and water harvesting can be carried out sustainably. However, inappropriate water use is a major threat to Towra Point and surrounding areas.

Sandmining since the 1930s has exposed the southern part of Botany Sands Aquifer, increasing the risk of groundwater contamination and increasing the rate of evaporation of the groundwater. Groundwater-dependent wetlands throughout Kurnell Peninsula are now rare, possibly due to a lowering of the height of the water table. The loss of wetland habitats has reduced the biodiversity of the area, as wetlands are favourable to many bird, fish, and frog and turtle species.

Changes in the way water is extracted from the system, either by groundwater extraction or water harvesting, will alter the surrounding environment and threaten the organisms in the area.

Recommended actions for altered hydrology

Careful consideration and planning of proposals to change the hydrology of the Georges River and Botany Bay must be taken. Modelling the effects of future proposals gives an estimate of the extent of change and must not be underestimated. Where possible, alternative options to alteration of hydrological regimes should be investigated thoroughly.

6.4 Urban and industrial development

The Georges River and Botany Bay catchment area is home to approximately 1.5 million people with future growth predicted (Colman and Hopkins 2001). Urban expansion and industrial development poses a major threat to ecological communities, as it places pressure on all aspects of the natural environment. Development increases the area covered by hard surfaces, which increases runoff into the waterway. Loss of bushland and permeable surfaces affects natural hydrological regimes, such as groundwater recharge, and increases water flows, especially after rainfall. The loss of these areas prevents infiltration of runoff through the soil, which increases sediment, nutrient and contaminant load and volume of water into the waterway, thereby reducing water quality.

Clearing of land for urban and industrial development causes loss of habitat for native plants and animals which can have a significant detrimental effect on the many threatened species in the catchment, and fragmentation of bushland and reserves hinders movement of species and reduces genetic biodiversity. While some developers revegetate after clearing and building, if inappropriate plants are used, species may be lost.

Taren Point Shorebird Community is an endangered ecological community protected under the TSC Act. However, the adjacent lands are privately owned and are under pressure for residential development and construction of recreational facilities. The shorebird community is under severe threat if residential development is approved, as loss of habitat and increased disturbance is likely. The benthic fauna at Taren Point and Shell Point are unique to the area and are specific feeding habitats for a number of shorebird species (DECC 2005). Site managers are under pressure to remove an old jetty and barge; these structures are important roosting sites for a number of shorebirds. Loss or degradation of this habitat may result in loss of species, and increase competition for and pressure on habitat at Towra Point.


**Recommendations for urban and industrial development**

Best practice for development includes the maintenance of habitat corridors; prevention of habitat loss and revegetation of pre-development flora is critical in the protection of biodiversity. Water-sensitive urban design improves an ecosystem’s ability to cope with increasing population pressures. Sutherland Shire Council has applied a stormwater management development control plan to improve water quality for new and existing developments. The implementation of stormwater quality improvement devices throughout the catchment will reduce pollution entering the waterway. Other programs such as Sydney Water’s ‘SewerFix’ will increase the capacity of wastewater treatment plants and improve the quality of sewer overflows (SWC 2007a). Community education and awareness plays an important role in protecting the environment by increasing the value people place on natural areas and reducing some of the negative impacts they cause.

Suitable bird habitat away from disturbance should be established before the clearance of existing structures or development of sensitive areas. For example, if development along Taren Point were to occur, alternative habitat for birds may include high tide roost posts and structures in Woolooware Bay (P. Straw 2007, pers. comm.). Protection of existing mudflats and intertidal areas is critical for the biodiversity of the area as they support many species of fish, macro-invertebrates and birds.

### 6.5 Pollution

Towra Point Nature Reserve is in a severely impacted catchment (Heap et al. 2001). Although most of the catchment is bushland, parkland or rural, urban and industrial areas are located adjacent to the waterway, and the industries in the catchment, such as the Caltex oil refinery and Kurnell Landfill Company, are potential sources of major pollution. The permeable soils and shallow water table makes the Botany Sands Aquifer vulnerable to contamination which poses a threat to the ecological character of Towra Point. Surface water may be affected by hydrocarbon contamination of groundwater at the oil refinery and nutrient and metals contamination from the landfill site as well as from urban and industrial runoff. Pollution from the oil refinery and landfill are contained on site and strict monitoring and reporting measures are a requirement. However, the potential to affect Towra Point is high due to drainage patterns of the sub-catchment and proximity to the wetland.

Sydney Ports is located on the northern side of Botany Bay, east of Sydney Airport. In the 2006–07 financial year, more than 1,600 trading vessels, including at least 240 tankers, visited Botany Bay, the majority of which were container and bulk liquid carrying vessels (SPC 2007). These vessels have the potential to bring introduced or pest species into Botany Bay and increase the risk of an oil spill.

A wharf which extends one kilometre north-west from Silver Beach into Botany Bay was built in 1956 for the Caltex oil refinery to transport crude oil from ships to the refinery. About 50% of airline fuel required at Sydney Airport is transported from the wharf via an underground pipeline. Between 1957 and 1988, 31 spills of more than one barrel (169 litres) were recorded, including a spill of 95 tonnes (95 kilolitres) in 1979 (Figure 59) (McGuinness 1988). There is a risk of oil pollution at Towra Point from faulty pipes or spills from oil tankers. Due to the ecological importance of Towra Point and NSW regulations, contingency plans, adequate equipment, trained staff and an oil spill response atlas are provided in the event of an emergency (Caltex 2007). Sydney Ports Corporation is responsible for responding to oil and chemical spills in Botany Bay and NSW Maritime conducts training courses and maintains the database.
A fish kill is ‘any sudden and unexpected mass mortality of wild or cultured fish’ and can result from natural causes, such as disease or change in salinity, or by anthropogenic influences, such as a change in the physicochemical environment caused by pollution (Lugg 2000). There are three records of fish kills in Botany Bay before 1984 (McGuinness 1988) (DPI 2007b):

- in 1972, caused by an unknown source (it was presumed to be low temperature)
- in 1973, caused by a cyanide leak into the Cooks River
- in 1979, caused by a 95-tonne oil spill from the World Encouragement.

It is likely that there were other fish kills which were not recorded. Reporting of fish kills since 1984 has increased and the NSW Fisheries Fish Kill database has seven fish kills between 1998 and 2004 recorded. Causes of these kills are mostly unknown, however some were due to undersized by-catch dumped from fishing vessels or fish washed ashore by strong winds (DPI 2007b).

Other forms of pollution that are a risk to Towra Point include surface runoff from the catchment and sewer overflows. Excess nutrients and toxic chemicals have an influence on any ecosystem, including higher risk of algal blooms and eutrophication and poisoning of plants and animals from high levels of copper, zinc and lead. Towra Point is affected by runoff from urban and industrial areas which regularly exceed water quality guidelines for ammonia, total nitrogen, suspended solids, copper and lead (SSC 2002, 2004). The northern side of Botany Bay is heavily industrialised by polluting industries. However, due to the nature of the aquifer and the semi-diurnal tidal patterns, impacts on Towra Point have so far been minimal.

**Recommended actions for pollution**

Prevention of pollution is most effective at the source. Therefore, if industries and land owners in the catchment improve effluent and runoff quality, the threat of pollution will be reduced. Water-sensitive urban design and stormwater quality

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Figure 59: Oil spill from the *World Encouragement* in 1979

Source: Duke and Burns (1999)
improvement devices assist in filtering out sediments and pollutants from runoff. Sydney Water is improving wastewater treatment plants along the Georges River, and some councils are increasing the number of gross pollutant traps and water sensitive urban design features within their jurisdiction. Kurnell Landfill Company and Caltex oil refinery have strict regulations on effluent quality and must report results quarterly. In the event of an oil spill, contingency plans are in place to reduce the effect on the area and training exercises are organised and coordinated by NSW Maritime.

6.6 Inappropriate recreation

The Botany Bay area is a popular place for recreation, including fishing, swimming, boating, bird watching and bike riding (SPCC 1978b). Certain activities, such as destruction of habitat and disturbance of important bird habitat, have a negative effect on the biota at Towra Point (NPWS 2001a). Motorbike riding, boating, use of four-wheel drive vehicles, and horse-riding can damage native vegetation and spread weeds. Litter and fires are also a risk related to inappropriate recreation. There is only one area at Towra Point available for recreation which is located on the western side of Towra Point, where permanent buoys are located to allow boats to moor without damaging seagrasses due to anchoring. The rest of the nature reserve is accessible by permit only.

Shorebirds are particularly sensitive to disturbance, some more than others (Blumstein et al. 2003), and people, dogs, horses, vehicles and boats may cause the site to become unfavourable for these birds (NPWS 2003). Towra Spit Island is an important nesting site for little terns and a roosting site for other migratory shorebirds between September and April (NPWS 2003). Signage on the island and boat patrols by rangers and volunteers prevent disturbance of the site. Increasing urban and industrial development in the area threaten to change habitats and put pressure on shorelines. For areas around Taren Point and Shell Point, development and increased disturbance along the shoreline could risk the loss of large numbers of shorebirds which may not find other suitable habitat in Botany Bay (P. Straw 2007, pers. comm.).

Recommended actions for inappropriate recreation

Kurnell Peninsula has historically been used by heavy industries and many people, even within Sydney, do not know of Towra Point or of its international significance, which may have protected it from disturbance and inappropriate activities so far. Increased signage and education about the importance of Towra Point Nature Reserve are recommended, which may reduce the threat of inappropriate activities and place an increased value on the area.

Towra Spit Island is patrolled on weekends during the little tern breeding season by DECCW and the Towra Team to prevent public access and educate people about the importance of the site. It is recommended that the monitoring continues every year for the protection of shorebirds.

6.7 Mangrove encroachment

Aerial photographic records since 1942 have shown a change in mangrove and saltmarsh area in a number of estuaries in south-east Australia; there has been an increase in mangrove area and a decrease in saltmarsh area over this period in at least twenty-eight locations in south-east Australia including Towra Point (Figure 60). Mangrove encroachment has been described as the main cause of saltmarsh decline in south-east Australia (Saintilan and Williams 2000). From 1956 to 1999 at Towra Point, mangrove area increased by 34% and saltmarsh area decreased by 62%
There are three factors which may have the most influence on mangrove and saltmarsh distribution:

- sea level rise;
- sedimentation and subsidence; and
- nutrient and sediment loads.

**Sea-level rise**

As sea level rises, more areas will be inundated. The response of mangrove and saltmarsh communities to these changes will most likely be to move in a landward direction to maintain optimal ecological conditions (Mitchell and Adam 1989; Harty 2004). Saltmarshes have maintained a zone almost free of other wetland types due to the extremely saline environment that they tolerate. However, if there were increased tidal inundation, reduction of soil salinity and increase of soil moisture would favour the growth of mangroves which would out-compete saltmarshes for light (Clarke and Hannon 1971). Landward migration of saltmarshes will be prevented at Towra Point by urban and industrial development unless buffer zones are developed (Saintilan and Williams 1999; Wilton 2002; Harty 2004).

**Sedimentation and subsidence**

Mangroves stabilise and accumulate sediment, which increases habitat for them to colonise and allows them to increase their distribution. The effect of accumulation of sediment on surface elevation is dependent on rainfall, level of the water table and has been related to the ENSO cycle. An increase of sedimentation does not always relate to an increase in surface elevation. During periods of low rainfall, low plant productivity and a reduced water table the soil is likely to subside, and the effects of accretion will be reduced. ENSO correlates with periods of low rainfall and drought conditions which may influence mangrove encroachment due to subsidence of the soil (Rogers et al. 2006).

Figure 60: Mangroves in the saltmarsh zone (mixed habitat)
Nutrient and sediment loads

Since 1941 the Georges River and Botany Bay catchment has undergone intense growth in urban and industrial development. The replacement of native vegetation with hard surfaces has increased the amount of sediment and nutrients directly entering waterways. While Towra Point is at the lower end of the catchment and Botany Bay is well flushed, the increase in sediment loads from the catchment has an influence on the wetland. A study of 28 estuaries in south-east Australia showed a trend towards a higher level of mangrove encroachment in more modified urban and industrial catchments (Saintilan and Williams 2000). Growth of mangrove and saltmarsh species improves with increased nutrient concentration of the soil to a certain amount, with their optimum growth requirements higher than the average soil nutrient level (Clarke and Hannon 1970). Therefore an increase in dissolved nutrients provides optimum levels for growth for both species. However, mangroves out-compete saltmarsh for light, which may explain the encroachment of mangroves into the saltmarsh zone.

The influence of soil subsidence could be detrimental to saltmarsh communities if it corresponds with sea-level rise or increased runoff from the catchment, diluting soil salinity and elevating nutrient concentrations, favouring the growth of mangroves. Therefore it is most likely that a contribution of all three factors has influenced the landward migration of mangroves at the expense of saltmarsh (Saintilan and Williams 1999).

Recommended actions for mangrove encroachment

In order to prevent loss of saltmarsh species, the causes of mangrove encroachment at Towra Point need to be established and managed. Further study is needed and monitoring of management is critical in order to allow for natural variability. Management actions should not include the removal of mangroves, as the causes of their encroachment will persist and they will regrow. Examples of management actions include (Harty 2004):

- water-sensitive urban design for new developments
- construction of wetlands or ecological buffer zones between areas prone to erosion or high runoff
- implementation of stormwater quality improvement devices and gross pollution traps
- minimisation of paved surfaces to allow groundwater recharge and filtration of sediments and nutrients.

6.8 Climate change

The effect of greenhouse gas emissions has most likely influenced the warming of the Earth and changes in other parameters of climate over the past 50 years. Observed changes in climate include sea-level rise, temperature change, altered rainfall patterns, changes in atmospheric carbon dioxide and methane levels and decreased snow and ice cover (Solomon et al. 2007).

Changed climatic conditions may alter species distribution and abundance and threaten their survival. A loss of species at Towra Point would have a large negative impact on the diversity of the Sydney bioregion. The key threats of climate change at Towra Point include sea-level rise, temperature change, changed rainfall patterns, intensity and frequency of storms and changes in the physicochemical environment.
Sea-level rise
The height of Australian coastal waters has risen by approximately 1.2 millimetres per year from 1920 to 2000 (CSIRO and BoM 2007) and this increase is expected to continue at this rate until the middle of the century (Solomon et al. 2007). This rise can partly be attributed due to global warming and is related to the melting of ice caps and snow. Sea-level rise on a local scale is dependent on regional climate, tides, geomorphology and the ENSO cycle (Solomon et al. 2007).

Sea-level rise is a key threat to the low-lying Towra Point as it will alter tidal levels, will likely change the distribution and abundance of species and may result in habitat and species loss. Hydrology is a key driver for the ecological character of Towra Point and past altered hydrological regimes have had long-term detrimental effects on the ecosystem. The major influence of tides on critical components and processes at Towra Point has been outlined in section 5.3.1.

Under current conditions the saltmarsh zone is inundated by seawater only during spring tides and grows optimally under highly saline conditions (Clarke and Hannon 1970). Sea-level rise would cause more frequent tidal inundation in the current saltmarsh zone, consequently diluting the soil salinity. This would create less favourable conditions for saltmarsh and, more significantly, provide more favourable conditions for mangroves, which out-compete saltmarsh species for light. Mangrove encroachment into saltmarsh areas at Towra Point has been documented since the 1950s and may be partly due to sea-level rise (Saintilan and Williams 1999; Wilton 2002; Saintilan et al. 2009).

Water depth will increase as a result of sea-level rise, which will cause a shift in the distribution of seagrasses (Short and Neckles 1999). An increase in water depth will increase the tidal prism of the water body, which will change the way water moves through the system and may alter wave action or tidal currents. Loss of a relatively small area of seagrass could cause cumulative loss due to increased exposure to waves and tides (Larkum 1976) and would have negative implications for the ecological character of Towra Point.

Temperature change
Average air temperatures in Australia have risen by approximately 0.9°C since 1950 (Figure 61). The temperature in Sydney is projected to increase by approximately 0.9°C by 2030 and by approximately 1.6–3.0°C (low–high greenhouse gas emissions) by 2070. A significant increase in the number of days over 35°C is also projected (CSIRO and BoM 2007). The average rate of global warming since 1950 is almost double the rate of warming since 1900 (Solomon et al. 2007).

Since 1955 global ocean temperature has increased and this has been at least part of the cause of sea-level rise. In the oceans surrounding Australia, sea surface temperature has risen since 1920 and is expected to rise by approximately 0.3-0.6°C off the east coast by 2030. Some of the increase in ocean temperature may be due to the more southerly flow of the warm waters of the east Australian current. Air and ocean temperatures differ on a regional scale and are also influenced by the ENSO cycle. There is no evidence to suggest that the ENSO cycle has been influenced by climate change, however, the effects of El Niño and La Niña on other components influenced by climate change may be significant. Therefore, in south-eastern Australia, it is estimated that El Niño events will become drier and La Niña events will become wetter (CSIRO and BoM 2007; Solomon et al. 2007).

Mangrove distribution at Towra Point may increase with a rise in air temperature as mangroves favour tropical conditions (Clarke and Hannon 1967). The increase in distribution is likely to be supported by sea-level rise and will be at the expense of saltmarsh species (Saintilan et al. 2009). However, if annual average rainfall
decreases over Towra Point and surface temperature increases, soil salinity will increase, which will limit the distribution of mangroves.

The east Australian current is critical in replenishing fish stocks and helping to improve water quality. It has strengthened since the late 1970s and the warmer waters are travelling further south (CSIRO and BoM 2007). Seagrass distribution is likely to shift south-wards and tropical species are likely to move into more temperate areas (Poloczanska 2006a). There is a risk that the distribution of caulerpa in Botany Bay may increase.

Warmer sea temperatures will cause a shift in distribution and abundance of marine species, from phytoplankton, zooplankton and macro-invertebrates to fish and species higher in the food chain. Phytoplankton are critical primary producers in an ecosystem and a shift in their distribution will influence the distribution and abundance of higher order species. Sea temperature influences fish distribution and abundance due to both the presence of prey and physiological processes of individual species (Bell et al. 1984; Kunz and Richardson 2006; Okey 2006; Okey and Hobday 2006; Richardson and Kunz 2006).

The solubility of oxygen decreases as water temperature increases, and warmer temperatures can promote epiphytic algae growth (Short and Neckles 1999; Okey 2006). In low energy areas such as Woolooware, Quibray and Weeney bays the combination of less dissolved oxygen and increased algal growth may increase the risk of a eutrophic system.

Species adaptation to new conditions will be necessary with a change in temperature, which will affect distribution and abundance of both flora and fauna (Short and Neckles 1999); the adaptability of different species will be determined by the rate at which temperature changes.

![Graph showing annual mean temperatures for eastern Australia 1910–2007](image)

Source: BoM (2007b)

Figure 61: Annual mean temperatures for eastern Australia 1910–2007
**Changed precipitation patterns**

Hydrological components and processes are critical in an ecosystem and have a major influence on ecological character. In eastern Australia rainfall has declined since 1950 and is predicted to continue to decline, especially in winter. Rainfall in Sydney is expected to decline by three per cent by 2030 and by four to eight per cent by 2070 (CSIRO and BoM 2007).

A change in the hydrology in the Georges River and Botany Bay catchment will influence plant distribution and abundance. A decrease in annual average rainfall may disadvantage terrestrial and mangrove species and favour saltmarsh species due to an increase in soil salinity.

Although annual average rainfall is projected to decline in eastern Australia, the frequency and intensity of rain and storms is likely to increase (CSIRO and BoM 2007). This is likely to increase the rate of erosion, flooding and runoff entering the catchment, including sewer overflows and salt water which may inundate Towra Lagoon.

**Increased carbon dioxide and ocean acidification**

Oceans absorb atmospheric carbon dioxide which is used by seagrasses and mangroves for photosynthesis. As the amount of carbon dioxide in the atmosphere increases, so will the amount of carbon dioxide absorbed by the ocean increase, and this will make the surface water more acidic (Poloczanska 2006a; CSIRO and BoM 2007).

An increase in carbon dioxide in the air or dissolved in the oceans will favour the growth of terrestrial and marine plants. However, under acidic conditions, the production of calcium carbonate shells by some marine organisms such as molluscs will reduce. An increase in acidity will alter sediment composition and cause a shift in benthic organism distribution and abundance and will affect species higher in the food chain (Okey 2006; Poloczanska 2006a, 2006b; CSIRO and BoM 2007).
7  **Knowledge gaps and recommendations for monitoring**

A detailed understanding of a wetland is necessary in order to undertake sustainable holistic management. There are gaps in the knowledge base of some key components of Towra Point Nature Reserve, including some baseline data. Towra Point’s proximity to a major city and a number of research institutions increases the possibility of obtaining the required data. Recommended actions are based on knowledge gaps and critical threats and are listed according to the key components and processes (Table 22). These recommendations will assist management authorities in decision-making for future funding and management plans.

A summary of recommended actions are:

- that the Ramsar site be expanded to match the nature reserve to provide extra protection for areas such as Towra Spit Island and saltmarsh communities
- that the Ramsar site be extended to include the Towra Point Aquatic Reserve due to the importance of the seagrass and intertidal areas to the Ramsar site.
- an integrated weed and pest management strategy be implemented which would involve participation of landowners on Kurnell Peninsula
- a comprehensive flora and fauna study is required to collect baseline or follow-up information and to determine limits of acceptable change
- information on the location and ecological condition of the freshwater and brackish lagoons is needed, including salinity and nutrient measurements, and groundwater status
- a study to understand the influence groundwater has on the wetland and to collect baseline water quality data to determine limits of acceptable change
- predictive modelling to estimate the influence of the changes to geomorphology and hydrology of Botany Bay on the ecological character of Towra Point
- monitoring of the sedimentation patterns surrounding Towra Point to ensure that Towra Beach and Towra Spit Island are maintained
- that protection of Towra Spit Island for little tern and other shorebird habitat should continue, including habitat improvement and boat patrols
- that protection of Aboriginal sites continues
- that areas of mangrove and saltmarsh are monitored to ensure the loss of saltmarsh habitats does not occur; limits of acceptable change need to be established
- an increase in education and signage on the importance of Towra Point Nature Reserve to emphasise the value of the area and to protect it from threatening processes such as inappropriate recreation.
<table>
<thead>
<tr>
<th>Knowledge gaps</th>
<th>Recommendations for monitoring</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Geomorphology</strong></td>
<td></td>
</tr>
<tr>
<td>Condition of Towra Lagoon, Weedy Pond, Mirrormere and other freshwater lagoons</td>
<td>Information on the ecological condition of freshwater and brackish lagoons is needed, including salinity and nutrient measurements, and groundwater status</td>
</tr>
<tr>
<td>Changes in surface elevation, accretion and erosion patterns</td>
<td>Surface Elevation Table and Marker Horizon technique</td>
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<tr>
<td>Effects of changes in sediment loads at Towra Point</td>
<td>Monitoring of the sedimentation patterns surrounding Towra Point</td>
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<td>Hydrodynamic modelling</td>
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<td><strong>Hydrology</strong></td>
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<tr>
<td>Groundwater data for areas draining into Towra Point sub-catchment</td>
<td>A study to understand the influence groundwater has on the wetland and to collect baseline water quality data to determine limits of acceptable change</td>
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<tr>
<td></td>
<td>Continued monitoring and reporting of groundwater at Caltex oil refinery and Kurnell Landfill Company</td>
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<tr>
<td><strong>Water quality</strong></td>
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<tr>
<td>Turbidity levels</td>
<td>Turbidity measurements and response to turbidity by seagrasses</td>
</tr>
<tr>
<td>Ecological effects of changes in nutrient loads on the values of Towra Point Ramsar site</td>
<td>Biogeochemical modelling to show the effects of changes in nutrient loads</td>
</tr>
<tr>
<td><strong>Biota</strong></td>
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<tr>
<td>Limits of acceptable change for biodiversity</td>
<td>Comprehensive flora and fauna study is required to collect baseline or follow-up information</td>
</tr>
<tr>
<td>Extent of terrestrial vegetation</td>
<td>Map terrestrial vegetation and monitor its growth into saltmarsh areas</td>
</tr>
<tr>
<td>Macro-invertebrates</td>
<td>Survey macro-invertebrate species</td>
</tr>
<tr>
<td></td>
<td>Establish benchmarks and limits of change</td>
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<tr>
<td>Fish</td>
<td>Survey fish species</td>
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<td></td>
<td>Establish benchmarks and limits of change</td>
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<tr>
<td>Birds</td>
<td>Survey shorebirds annually in Ramsar site</td>
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<td></td>
<td>Continue monitoring of shorebirds in Botany Bay (e.g. through regular counts by Australasian Waders Study Group) and extend to Ramsar site</td>
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<td></td>
<td>Maintain database for migratory shorebird species</td>
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<td></td>
<td>Establish benchmarks and limits of change</td>
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<tr>
<td>Reptiles</td>
<td>Survey reptile species</td>
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<td>Establish benchmarks and limits of change</td>
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<tr>
<td>Amphibians</td>
<td>Survey amphibian species</td>
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<td></td>
<td>Establish benchmarks and limits of change</td>
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<tr>
<td>Mammals</td>
<td>Survey mammal species</td>
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<tr>
<td></td>
<td>Establish benchmarks and limits of change</td>
</tr>
<tr>
<td>Changes in the extent of seagrass area in Botany Bay</td>
<td>Aerial photography of Botany Bay and ground validation using a standard methodology that enables comparison over time</td>
</tr>
<tr>
<td>Changes in the extent of mangrove and saltmarsh areas within Towra Point Ramsar site</td>
<td>Areas of mangrove and saltmarsh are monitored to ensure the loss of saltmarsh habitats does not occur; limits of acceptable change need to be established</td>
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</tbody>
</table>

### 7.1 Important communication, education and public awareness messages

Towra Point Nature Reserve was listed as a Ramsar site due to the significant migratory bird habitat it supports. While it is still an important roosting, nesting and foraging site for both migratory and resident birds, there are other important reasons for its significance, including that:

- it is the last remaining wetland of its type in the Sydney area and the largest in the Sydney Basin bioregion
- it supports 60% of the remaining saltmarsh area and 40% of the remaining mangrove area in the Sydney region
- there are four nationally threatened species (EPBC Act) and 23 threatened species and five endangered ecological communities in NSW (TSC Act)
- various vegetation communities and habitats support a diverse range of fauna and biodiversity on a regional, national and international scale
- some of the habitats are the most extensive of anywhere in the Sydney area and may be the last remaining habitat for some fauna species, such as the white-fronted chat and little tern, in the biogeographic region
- it supports the last remaining nesting site for the endangered little tern (TSC Act) in the Sydney region and is the second most important little tern nesting site in NSW
- it is one of the four most important migratory shorebird habitats in NSW
• extensive seagrass meadows adjacent to the nature reserve provide an important fish nursery habitat and protect the shoreline from erosion

• approximately 25 species of fish found in the waters surrounding Towra Point are of economic or recreational importance and use Towra Point as a source of food and protection.

As Towra Point is located in the largest city in Australia and within the same catchment as a growing population, and is very close to Australia’s largest airport, crude oil importing port, oil refinery and container port in NSW, threats to the ecological character of Towra Point include:

• catchment land use, which will affect sediment and nutrient loads in the waterway and hydrology

• changes to the morphology of the catchment, which influences hydrology

• weeds and pests which threaten native flora, fauna and habitats

• pollution

• climate change which may cause sea level rise, temperature change, change in precipitation patterns and increased atmospheric carbon dioxide

• inappropriate recreation such as use of four-wheel drive vehicles, motorbike riding and boating in and adjacent to the reserve, which can destroy habitats and disturb fauna.