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Cameron Sargent

From: John Newton <jnewton@newtricious.com.au>
Sent: Tuesday, 2 June 2015 3:32 PM
To: Cameron Sargent; office@stokes.minister.nsw.gov.au
Cc: Ben Eveleigh
Subject: Marina over development

As a resident of Alexandra Road, Glebe, I want to register my strong objection to the proposed marina and boat storage The Sydney Superyacht Marina opposite Jubilee park on Rozelle Bay.

The so-called super yacht – monstrous gas guzzling environmental disasters – were given temporary residence on the bay for the period of the Sydney Olympics in 2000.

Fifteen years later it is to take over the entire north side of the bay.

This monstrous over development is opposed by all residents, and has nothing to do with residents.

It will create noise which will affect all of us on this side of the bay.

I strongly oppose it.

John Newton
15 Alexandra Road Glebe 2037
(02) 9571 8513
0402 788 513

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Cameron Sargent

From: Deirdre Mason <msdeirdremason@gmail.com>
Sent: Tuesday, 2 June 2015 6:00 PM
To: Cameron Sargent
Cc: Jenni Neary
Subject: Sydney Super Yacht Club modifications

To: "Ben.Eveleigh@planning.nsw.gov.au"

Dear Mr Eveleigh,

RE: MP09_0165 MOD 1 - Section 75W Modification – Sydney Super Yacht
Marina, Rozelle Bay - submissions due June 5th

We object to the application for the proposed “modifications” as they are in fact major expansions of buildings and therefore intensification of use, specifically commercial use. The proposed consolidation of approvals for water & land use would have deleterious effects on the public domain, the environment as well as on current and future residents. The “modifications” we refer to include: greatly increased storage – from 24 to 43 boats – and the 36 tenders to support primary vessels, plus a huge increase in car parking from about 200 to 300 vehicles.

The proposed expanded project has been assessed without regard to the neighbouring precinct plans for the Bays Precinct, the White Bay power station and the future of Glebe Island Bridge.

The public interest for the use of Crown land adjacent to the foreshore is being ignored by allowing private interests to develop this land as a car park and boat park. Although we are members of the Sydney Super Yacht Club, we have not been consulted about the proposal.

We are objecting on three major grounds: noise, lack of consideration of consistency with the future development of the whole precinct, and the retention of Glebe Island Bridge as an integral part of Sydney's historical landscape and a continuing transport access corridor.

NOISE ASSESSMENT AND IMPACTS

The noise assessment did not consider the impact of the mix of proposed outdoor seating, the implications of the service of alcohol and the fact that the site is poorly serviced by public transport.

The assessment asserts rather than assesses the proposed changes. We believe for example that allowing for 36 tenders (for boats on a marina!) rather than the current zero, would be a substantial change to the noise levels of the area. The effect on other recreational, non-motorised boating users – kayakers, rowers and dragon boaters – is not considered.

The proposal for live music venues and restaurants would create noise and amenity problems for local areas as noise echoes across water and would impact on the residential areas of Glebe, Balmain, Annandale and Pyrmont.

Amplification of music or announcements will detract from amenity – not merely only after 10pm as suggested for Noise Mitigation and the approval of opening balconies nullifies that proposal since this would allow more transmission of noise.

The noise mitigation measures proposed are inadequate to protect the amenity of existing and future residences in Glebe, Balmain, Pyrmont and Annandale. These noise conditions must be subject to review and tied to a complaints mechanism.

GLEBE ISLAND BRIDGE

Pymont Bridge demonstrates the value of providing pedestrian and cycling access to the CBD. Hardy cyclists tackle the longer journey across the Anzac Bridge, but CBD access could be far easier. The Glebe Island Bridge could be trialled as a thoroughfare, initially during peak hours. As the Bays precinct becomes further developed with residences, the Bridge would play a useful role in easing congestion.

THE PROPOSED INTENSIFICATION IS NOT IN THE PUBLIC INTEREST

This area has been designated for marine uses, however intensive non-marine use such as car parking and entertainment run counter to the public interest in accessing Sydney's foreshore. Across the water the Jubilee Park to Bridge Road path/cycle way demonstrates effective development of the foreshore with minimal environmental impact and maximum public access. Already the land on the western side is partly alienated from the public. This proposal consolidates this alienation and does not serve the public good as required by the Sydney Harbour Sydney Regional Environmental Plan (Sydney Harbour Catchment) 2005. To protect our foreshores for the current and future residents of Sydney, public good must take precedence over private interests.

For these reasons, we strongly object to the proposed "modifications" outlined in the proposal.

Deirdre Mason
Jennifer Neary AM
2/501 Glebe Point Road
Glebe 2037

0296609211

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Cameron Sargent

From: Kemble Walker <kemble.walker@gmail.com>
Sent: Wednesday, 3 June 2015 9:08 AM
To: Cameron Sargent
Attachments: the fifth sacred thing.jpg

Thanks Cameron,

I would like Sydney to be a powerful world city. But this development is just unhealthy... polluting, tacky and supporting meaningless sex and alcoholism. Those things make us weaker, don't you see...

We young generation are scratching our heads how to get the message across.... you're hurting your own people and your own city.... We're on the same team, you know... we all live in Sydney, we all want this city to be great.

But please..... not another violence hotspot attracting wealthy, unpleasant people who don't give a rat's arse about the well-being of Sydney.

You know what would really make us powerful?

To make that space into a urban forest permaculture garden showcasing the most very advanced sustainability techniques. Make it a global flagship. Australia is already famous world-wide for inventing permaculture. There is a shitload of money, fame and the power to do good here...

Now we.. the internet generation.. have to learn how to talk to you...
in a way that makes sense to both of us.

I am totally certain that the proposed entertainment precinct is old news. It's not interesting to clever people. It's interesting to tacky, depressed nouveaux riches who want to drown their sorrows every night.

Not a good thing. It'll have to be demolished if anyone's actually dumb enough to build it.

What's the feel about all this?

Regards,

Kemble Dawson Walker etc.

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earthnet.us

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Cameron Sargent

From: gretchen gamble <gretchengamble@hotmail.com>
Sent: Sunday, 31 May 2015 2:17 PM
To: Cameron Sargent
Subject: FW: Submission Re:Appln 09_0165MOD1 Superyacht Marina, Rozelle Bay
Attachments: History of Contaminated Sites Sydney by Prof G Birch Syd Uni.pdf; Roz bat pollution Knott.pdf; Submission—Modification Sydney Superyacht Marina.docx

Attn Cameron Sargent

Having rec'd an "out of office" response I'm now sending, as it, stated to you.

Thank you

Gretchen Gamble

From: gretchengamble@hotmail.com
To: ben.eveleigh@planning.nsw.gov.au; information@planning.nsw.gov.au
CC: jamie.parker@parliament.nsw.gov.au; rporteous@lmc.nsw.gov.au; lkelly@lmc.nsw.gov.au; dkogoy@lmc.nsw.gov.au; vhannaford@lmc.nsw.gov.au; ianc@theplanet.net.au
Subject: Submission Re:Appln 09_0165MOD1 Superyacht Marina, Rozelle Bay
Date: Sun, 31 May 2015 03:48:09 +0000

Dear Mr Eveleigh,

Please accept the attached as my submission to the above DA.

In addition I've included pollution studies done by Knott and Prof Birch on the waters and severely contaminated sediment of Rozelle Bay for your consideration when making your determination on this DA.

I also declare--as per your on-line submission format--that:

I'm not marking this as "confidential", I'm not a planner and I've made no political donations.

regards

Gretchen Gamble

Submission—Modification Sydney Superyacht Marina, Rozelle Bay

(Part Lots 32 and 33 D P1151746)

We object to the above for the following reasons:

Rozelle Bay is a small area with poor tidal flow and is extremely badly polluted. (see attached the Prof. Birch report) Having such large motorized craft utilize these waters stirs up these toxic sediments, in a Bay that is used for recreational purposes, especially rowers.

24 extremely large motorized craft with "tenders" already exceeds an appropriate number of such craft in this relatively low tidal flow bay, so to increase the number to 43 is irresponsible and negligent.

The movement of such large craft in this bay creates a dangerous situation to other users of these waters, especially the rowers (a history of over 100 years of use in this bay).

The increase will result in nearly a doubling of the bay's surface area being occupied by these craft, which, when combined with that of the Catamaran Marina (another blight on the bay) and large craft which anchor in its middle, leaves very little open water for others!

The area of the building, as approved, is already too great, so to add to this—inclusion of another floor level and terrace area—is beyond what is reasonable. It will add to the effect of creating a continuous wall of buildings along the Bay's foreshore. The current monstrosity, known as the Boat Storage "racks", has obliterated the vista across the bay from both the City West Link and the southern side of the Rozelle Bay. It's an eyesore, devoid of any aesthetics and should never have received building approval. To enlarge the Superyacht Marina will just add to this lack of planning mess.

There'll be negative, intrusive noise and light impact to residents on the Glebe foreshore.

Expanding the car park will further alienate publicly owned land from the public! To build this to a height of even 4 levels is not acceptable, let alone to 5!

The public's access to this foreshore is currently fenced off to those who own it, us, and this should not be permitted. It's clearly not necessary as the public can access the foreshore of marinas elsewhere in the harbour.

Increasing the size to double will result in greater traffic flow and congestion at the already overloaded intersection of CWL and James Craig Rd.

Both the land and sea components should remain as separate so that each is required to make applications for any changes.

We make the following comments too.

This particular site was "approved" with no public consultation prior to the 2000 Olympics. When enquiries were made we were informed that it would go after 2000, but somehow it remained and then began to noticeably expand. Looking at some of the documents it's interesting to note that the current development was approved under Part 3A which the current

State Government said it agreed was a negative in the planning process, yet is now proceeding to assess DA's in precisely the same manner.

The original application—in 2002—has no signature or date lodged details, and no DA modification no. from the Dept. of Planning. Approval was given for "restaurant and construction of a temporary structure " and DA approval 24-6-02.

Then follows modifications

23-6-04

10-6-05

21-7-06

10-7-07

9-7-08

14-4-09

Then amended conditions to extend "approvals" by 18 mths from 24-9-10 until 24-3-12!

(at this point I couldn't spend more time trawling documents to ascertain under what "approvals" the marina has been operating since!) An interesting history!

What an embarrassing planning mess the state governments have made of this site of publicly owned land in the last 17 years, and which the current state govt. seems to have no objections to continue in this same shameful manner. The community has had its input at times, when "invited"—mostly non existent—and then been ignored.

Perhaps on this occasion the interests of the local and broader community will carry greater weight than will those of big business and developers?

This DA needs rejection for all the aforementioned reasons.

Apologies for this being a week late, but I've been interstate and was not aware of its existence until this week.

Regards

Gretchen Gamble

92 Nelson St

Annandale

2038

0427440654

- effect on floods and droughts in Australia', *Climatic change*, vol. 25, pp. 289–317.
- Wilby R L, 2005. 'Uncertainty in water resource model parameters used for climate change impact assessment', *Hydrological Processes*, vol. 19, pp. 3201–3219.
- Young P, 2003. 'Top-down and data-based mechanistic modelling of rainfall-flow dynamics at the catchment scale', *Hydrological Processes*, vol. 17, pp. 2195–2217.
- Young W, Brandis K & Kingsford R, 2006. 'Modelling monthly streamflows in two Australian dryland rivers: matching model complexity to spatial scale and data availability', *Journal of Hydrology*, vol. 331, pp. 242–256.
- Zhang L, Dawes W R & Walker G R, 2001. 'Response of mean annual evapotranspiration to vegetation changes a catchment scale', *Water Resources Research*, vol. 37, pp. 701–708.
- Zhang L, Walker G R & Fleming M, 2002. 'Surface water balance for recharge estimation', CSIRO publishing, Collingwood, Victoria.

A short geological and environmental history of the Sydney estuary, Australia

Gavin Birch

Abstract

Sydney is blessed with one of the most beautiful harbours in the world. However, like many large, capital ports world-wide, this environment has been exposed to relentless stress due to a rapidly increasing population density and extensive residential, commercial and industrial expansion. In this chapter, we explain why the coastal zone is such an important environment, especially for the people of Australia, and describe changes to the Sydney estuary as an example of environmental transformation due to anthropogenic pressure. The geologic development of the Sydney estuary is briefly traced, showing how the feature was eroded into the Hawkesbury Sandstone, mainly during low sea levels of the glacial periods. The estuary and its catchment changed soon after Captain Philip landed in Sydney Cove. Early land clearing increased sedimentation in the waterway and rapid industrial growth, located mainly on the waterfront, resulted in increasing contamination of the estuary. At the University of Sydney, a novel collaboration between urban geographers working on changes in historical cadastral records of the city and environmental chemists studying estuarine sediments, have shown that as urbanisation and industrialisation spread through the catchment, so did the level and spatial extent of contamination in the estuary. The area of the estuary has been reduced by 22 per cent over 220 years of almost constant reclamation, resulting in ecological modification and possible additional contamination. The present contaminant status of the waterway is described in the concluding part

of the chapter and a plea is made for a new effort for remediation and restoration of this iconic environment.

Introduction

Much of the character, and indeed the beauty, of Sydney can be attributed to its estuaries. Four deeply-incised, flooded valleys dissect the raised coastal margin of the region producing one of the longest coastlines of any capital city in the world. These beautiful waterways have 'injected' a maritime character deep into the heartland of suburban Sydney and have provided an extensive shoreline along which many beautiful historic homesteads have been built. These attributes have been vital in the development of Sydney into one of the most beautiful cities in the world.

These waterways have also provided excellent harbours for international trade and thus the city is at the intersection of domestic and international transport. Because of its locality, Sydney has attracted people and industry from many far off lands. The population of Sydney has grown rapidly since the Second World War and now exceeds four million – almost one quarter of the total population of Australia. The waterways have provided easy access for raw materials and export of produce and have supplied coolant for machinery, but they have also acted as a convenient receptacle for waste. All sewage and industrial waste was discharged directly into the estuaries until 1898 when three major coastal outfalls were constructed to discharge effluent directly into the surf zone offshore from Sydney. Only in 1972 was discharge into the estuaries controlled by the Clean Waterways Act and, since 1990, sewage has been dispersed into the sea about four kilometres from the coast in approximately 80 metres of water (Birch 2000).

Australian population

Australia is a vast island continent with an area of almost 6 million km² and a population of just 21 million. This extremely low average population density is deceptive as vast areas of internal desert and bushland are virtually uninhabited and over 85 per cent of the population live in the coastal zone (Zann 1996). Moreover, Australia is one of the most urbanised countries in the world with 67 per cent of the

national population living in one of the eight state and territory capital cities, all of which, except for Canberra, are located on the coast (Phillips, et al 1992). Even the 'coastal zone', which is defined as a section of land three kilometres wide running parallel to the coastline, has an extremely uneven population distribution: 82 per cent of the coastal fringe population live in just 1170 km, or 3.9 per cent, of coastline with 72 per cent of coast having zero population (McDonald et al 1993).

Australian estuaries

Coastal ecosystems support a variety of vital biological, economic and cultural functions; however, these systems are under considerable and increasing stress due to rapid urban and industrial development. Estuaries, in particular, are being threatened from increasing human intervention due to changes in water circulation, sedimentation, habitat loss, decline in native species and contamination by heavy metals, organochlorine compounds and polycyclic aromatic hydrocarbons. Environmental degradation appears to be an inevitable consequence of urbanisation and industrialisation.

Port Jackson

The waterway has a complicated geological and human history and even the naming of the estuary is difficult. Roy (1981) includes Middle Harbour, Port Jackson, and the Lane Cove and Parramatta Rivers in the definition of 'Sydney Harbour', whereas others confine the meaning to the central harbour area, including Circular Quay, Darling Harbour and White, Rozelle and Blackwattle Bays (McLoughlin 2000). 'Sydney estuary' will be used in the present text to include all of the above locations, including Duck River, and tributaries up to the fresh water limit and to the weirs on the Duck and Parramatta Rivers.

Port Jackson is one of 80 recognised harbours and 970 estuaries on the Australian seaboard (NSLWA 2002). The estuary is approximately 30 km long, 2 km wide and occupies about 50 km², whereas the total catchment is about ten times the surface area of the estuary (500 km²). Eighty-six per cent of the Port Jackson catchment is urbanised and/or industrialised. Sensitivity to environmental harm is given by the

relationship between the area of the estuary and that of the catchment. The Sydney estuary should have a low sensitivity to anthropogenic effect, however that is overwhelmed by the huge proportion of the catchment that is urbanised (86%), as will be seen in the following discourse.

The central east coast of Australia is micro-tidal and Port Jackson experiences a maximum 2.1 metre tidal range. Flushing times increase from three to seven days in the lower harbour to seven to ten days in the upper estuary. With such a small catchment, only a small quantity of fresh water enters the estuary under normal conditions and Port Jackson is almost completely saline. However, during heavy rainfall, large volumes of fresh water are delivered to the estuary quickly due to the short length of rivers. At these times, water in the harbour becomes stratified with a one to two metre thick layer of turbid, buoyant, fresh water at the surface and salty water below. These conditions for low- and high-rainfall periods are unusual for estuaries, which are typically more mixed with fresh and saline water.

Geological history

Permo-Triassic era

Port Jackson is located in the Sydney Basin which is Permian to Triassic age (300–220 million years). The most distinctive feature of the Port Jackson catchment is the beautiful outcrops of Hawkesbury Sandstone into which the estuary is dissected. Most of the high land in the outer catchment is comprised of Ashfield Shale which overlies the Hawkesbury Sandstone. The configuration of Port Jackson drainage system, the orientation of bays and shoreline are all controlled by underlying geological structures.

The Sydney estuary is a drowned river valley, which is eroded up to 85 metres into the Hawkesbury Sandstone. However, the origin and evolution of such a large river valley compared to its small catchment area has always been difficult to explain. Possibly the Paramatta River was once considerably larger than it is today and extended westwards to be connected to the Nepean River. Perhaps the Nepean River was later

'captured' by the Hawkesbury River leaving the Paramatta River considerably reduced in size (Liu 1989). This history may explain the unusually deep erosion associated with what is currently a small catchment.

The ancient river, which is now Port Jackson, was an old, mature river that meandered across a flat plain 80 million years ago. During periods of uplift, the river eroded down into the elevated coastal plain forming steep-sided banks and at times cut through some of the meanders. During interglacial periods, sea level rises and the 'river' is flooded, leaving the breached meanders as islands, of which there are 14 under present sea level conditions. The great depth to bedrock in Port Jackson is attributed to the incision by the rejuvenated paleo-Port Jackson stream associated with uplift during and related to sea floor spreading when the Australian plate moved away from the Lord Howe Rise Plate (Liu 1989). Sediment, which accumulated in the valley bed during high sea level stands, was repeatedly eroded and flushed from the floor of Port Jackson valley during sea level lows. The present-day absence of sediment in depression in the Port Jackson channel is maintained by high water velocities and scouring by turbulent currents moving around headlands protruding into the estuary.

Quaternary period

Oscillations of sea level from 5 m above to 120 m below the present day position occurred every 100,000 to 150,000 years during the Quaternary due to global climate change and by glaciation. The penultimate glaciation ended about 135,000 years ago with the succeeding interglacial extending to about 80,000 years before the present. Sediments which accumulated in estuaries in this region during interglacials were eroded during intervening glacial periods. However, for the majority of the last 135,000 years, sea level was 20 to 70 m below the present and therefore erosion of estuaries was more pronounced than deposition during this period (Roy 1998).

Holocene epoch

The world started to come out of the grip of the last glacial period about 17,000 years ago and sea level started to rise quickly (Thom & Roy 1985). At this time the coast was about 25 to 30 km east of its present position, but, with a slope of considerably less than one degree, small increases in sea level advanced the coastline thousands of metres. By 10,000 years before the present, sea level had risen to 25 metres below today's sea level and only 3–5 km off the present coastline. The sea reached its present position about 6000 years ago (Roy et al 1997).

Since the Australian Aborigines have inhabited the continent for more than 40,000 years, they would have experienced this rapid change in climate and rapidly advancing coastline. It is hard to visualise how they coped with such a rapidly fluctuating coastline which would have been highly unstable even over decadal periods. As the sea advanced across the continental shelf, it probably 'swept' ahead of it large quantities of sand that had accumulated on the shelf from rivers which disgorged sediment as the rivers flattened out and lost their energy. This sand was pushed into embayments and now form the beautiful golden sands which occupy the many beaches along the east coast of Australia. Some of this sand was transported by wave energy into the mouth of Port Jackson as a tidal delta. Meanwhile, as the sea advanced into the now drowned river valley, sediment transported by rivers started to be deposited in the upper parts of the estuary as a fluvial delta. Fine-grained sediments, carried mostly in suspension after floods, are deposited in the middle of the estuary between the tidal and fluvial deltas.

The present-day estuary comprises five sedimentological units. Shallow off-channel embayments of the central harbour are covered in thick mud, as is the 30-metre deep basin in Middle Harbour. The main channel of the upper harbour is moderately deep, and also mantled in mainly muddy sand, but in the central harbour, the main channel is deeply scoured. The sand content of bottom sediment increases gradually downstream and the main part of the lower harbour seaward of the Sydney Harbour Bridge is mantled in sandy sediment.

Environmental history

Early European occupation 1788–1800

Although the Aborigines had occupied the Port Jackson estuary area for ten thousands of years, evidence of their presence is hard to find. However, after the arrival of the Europeans in 1788, the environment changed rapidly. Soon after settlement the Europeans embarked on extensive land clearing, but because of the poor soils around Port Jackson, cultivation soon moved westwards to the Nepean and Hawkesbury Rivers. Clearing and poor land practices promoted erosion, and sedimentation rates increased more than ten times pre-European levels in the estuary.

The First Fleet, which had departed Portsmouth on 13 May 1787, landed in Botany Bay under the command of Captain Arthur Phillip between 18 and 20 January 1788. Captain Phillip quickly realised that the land in the Botany Bay area was not fertile enough to support the 1000-strong party of the First Fleet and decided to move to Port Jackson — 'the finest harbour in the world'. On 26 January 1788 Captain Phillip laid anchor in a wonderful cove with 'spring water' which he called Sydney Cove. The next day Captain Phillip established the colony and took possession of New South Wales, while the convicts began cutting down trees. The Second and Third Fleets arrived in June 1790 and July–August 1791 respectively and the colony spread rapidly. More fertile land to the west around Paramatta and further away in the Hawkesbury and Nepean Rivers was cultivated and settled (McLoughlin 2000).

Industrialisation and urbanization 1800–1854

Industries began to take shape on the banks of Darling Harbour in about 1800 and soon spread to nearby Cockle, Rozelle and Blackwattle Bays close to the present-day Sydney central business district (CBD). Metal foundries were the first to be established and the number of these industries increased from three to 14 between 1831 and 1851 (Taylor, Birch & Links 2004; Walsh 1963). Tanneries started operation in 1803 in the same area and were soon joined by other small industries. By 1828, metal foundries, copper-smiths and paint manufacturers were established adjacent to Blackwattle Bay due to readily available water supply and

proximity to the city (MacDonnell 1975). The region south and west of the city grew rapidly during the 1820s and the Darling Harbour – Rozelle Bay area was by this time fully developed. By 1848 this environment had become so degraded that legislation was passed to remove all tanneries and polluting industries out of the city to Botany, Willoughby and Parramatta.

Period 1854–1889

Prior to 1870, effectively all industrial activity in the Sydney region was located close to the present-day CBD, but steam power led to considerable growth in Sydney after this time. Metal working, engineering, building materials, clothing and textiles became major industries between 1861 and 1890. The introduction of tramways, railways and major bridges in the late 1880s prompted rapid urban expansion. Industrial activity in the Iron Cove catchment in 1870 consisted of only one blacksmith shop, but by 1891 the number had increased to 10 (Links 1998; Taylor, Birch & Links 2004). Also at this time, chemical industries, metal working, boat building, dye use, electrical and glass manufacturing, as well as horse-drawn vehicle building had taken root in the Iron Cove catchment. Land adjacent to Homebush Bay has been used for industrial purposes, including a naval armament store and brickworks, since the 1880s (Homebush Bay Corporation 1994; Suh, Birch & Hughes 2004; Suh, Birch & Hughes 2004; Suh, Brown & Birch 2003; Taylor, Birch & Links 2004).

Period 1889–1922

Sydney spread rapidly westwards between 1889 and 1922 and Iron Cove, Hen and Chicken and Homebush Bays became urbanised and industrialised. Detailed land use mapping (Jolly 2005) shows Iron Cove catchment changed from a suburb supporting predominantly large estates (30–40% of the total area) to one of mainly small residential blocks (57% of land use) in the period 1905 to 1930. In 1916 major abattoirs were relocated from Rozelle Bay to Homebush Bay. A large base metal foundry and a smelter commenced operations on the shores of Hen and Chicken Bay during the early 1900s.

Industry replaced agriculture in the Parramatta River region (Powell 1987) and because the movement of imported goods and manufactured items required proximity to waterways, almost all waterfront on the shores of lower Parramatta River was occupied by industry by the end of the 19th century.

1922 to the present

Factories manufacturing heavy electrical equipment, large oil refineries and power supply stations were constructed close to the estuary between the First and Second World Wars. Many heavy industries situated in the inner, mixed residential/industrial areas of the city were relocated outside the Port Jackson catchment after the Second World War (Links 1998; Taylor, Birch & Links 2004). However, these industries were soon replaced with light industry, wholesalers and transport companies. Further decentralisation of industry occurred in Sydney after the Second World War due to a movement of people to the outer suburbs and a change in transportation, mainly toward trucking and containerisation (Webber & Daly 1971). Hen and Chicken Bay catchment remained predominantly agricultural until after the Second World War when it changed to medium-density housing.

Extensive parts of the Homebush Bay shoreline were reclaimed. The western shore was completely remodified prior to 1955, whereas the Rhodes Peninsula, on the eastern shore, was reclaimed later, between 1956 and 1975, creating opportunities for housing, industrial, commercial and recreational redevelopments. However, many of these industries have moved away from this region in recent times.

Foreshore development and reclamation in the harbour

Port Jackson has been extensively modified by reclamation over the last 200 years, especially in the upper and central estuary. Approximately 77 km of the 322 km of original shoreline has been lost due to reclamation and infilling of intertidal areas (Pitblado, 1978). Reclaimed areas are used mainly for industrial, recreational and residential uses and cover a total 11.35 km² of the total 50 km² or 23% of the estuary (Birch & Murray 2007; Murray 2003). Natural foreshores of mud flats and mangroves have given way to sea walls, wharves and buildings. The head of many

embayments have been enclosed by sandstone walls and intertidal areas reclaimed by infilling. Reclamation has resulted in a loss of almost 9 million cubic metres of water on each tidal cycle, which has resulted in large changes in water movement, water quality, sedimentation and ecology of the upper harbour (Liu 1989). Sea walls have changed a ramp foreshore to a vertical shoreline altering the hydrology and ecology of the estuary. The following history of reclamation is mainly from the work of Murray (2003).

Period 1788–1854

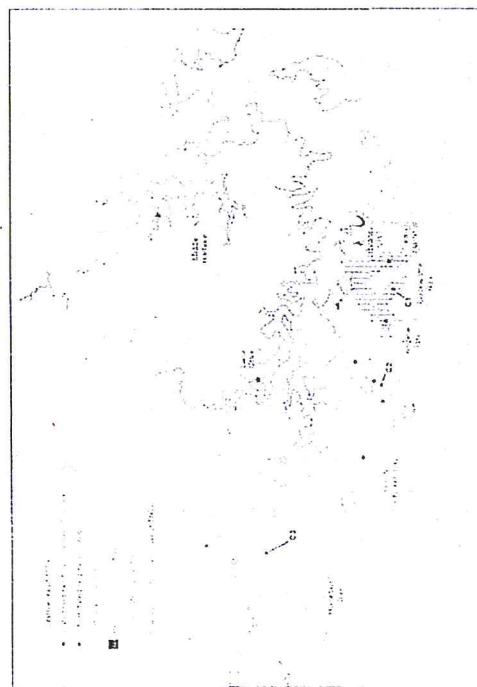


Figure 7.1 Only the central area of Sydney was urbanised by 1860 and foreshore reclamation was confined to Sydney and Farm Coves. The intensity of industrial activity can be judged by the number of ships in a photograph of Sydney Cove taken about this date (Figure 7.3). Sediment mounding Darling Harbour, Blackwattle Bay and Rozelle Bay began to show signs of heavy metal contamination by this time.

The first change in the foreshore occurred when large allotments were given out to the military, civilian administration, wealthy merchants and the clergy and by 1830 minor reclamation had started for wharfage and farming (Godden Mackay Pty Ltd 1991; Liu 1989). The first major reclamation project in the harbour occurred in the period 1855–1854 when the head of Sydney Cove was remodelled into a semi-circular sandstone quay with the Tank Stream channelled and buried. Mort and Walsh Bays were infilled and the opening of the Australian Gas Light Company transformed Darling Harbour (Godden Mackay Pty Ltd 1991, 1993).

Period 1854–1889

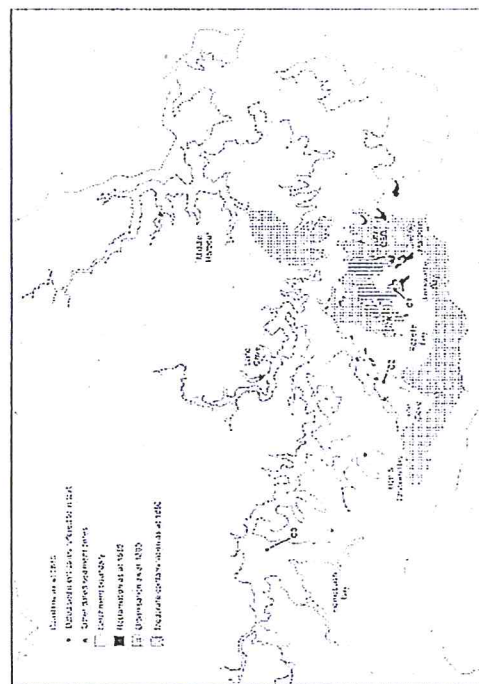


Figure 7.2 By 1880, urbanisation had spread to Iron Cove and most of the bay heads in the south, central part of the estuary had been reclaimed. At this time, sediments of Darling Harbour, Blackwattle Bay and Rozelle Bay had become moderately contaminated with heavy metals.

The introduction of trams and trains lead to a boom in development and an increased need for residential, industrial and recreational space. This resulted in reclamation of embayments close to central Sydney, that is Sydney Cove, Blackwattle Bay, Pyrmont Bay, Darling Harbour, Woolloomooloo Bay and Rushcutters Bay (Fitzgerald & Golder, 1994; Godden Mackay Pty Ltd 1991, 1993; Shore 1981; Stephensen, 1966). A photograph taken of Sydney Cove in the late 1850s shows numerous ships and intense industrial activity in this area during these times (Figure 7.3). In the second half of the 18th century, domestic waste, sewerage, offal and dead animals were discarded into foreshore areas considered dumping grounds for unwanted waste (Stringer 1984). It was believed that disease was communicated by noxious vapours emanating from damp areas where faecal waste accumulated, and odours and the fear of disease emitted from these wetlands contributed greatly to reclamation during this period (Solling & Reynolds 1977).

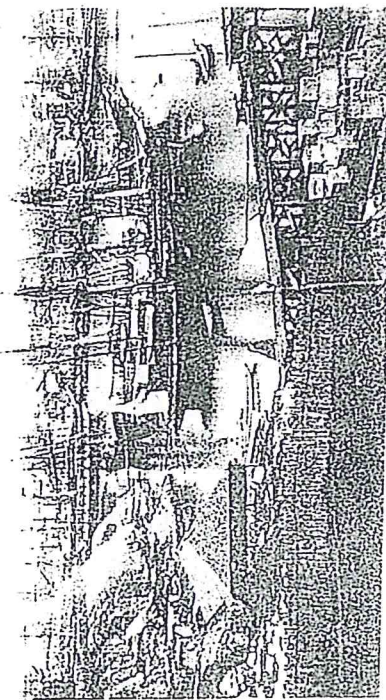


Figure 7.3 An early photograph of Sydney Cove taken in the late 1850s by an unknown photographer. The number of ships in the cove demonstrates the intensity of activity in this part of the harbour at this time. The period portrayed in this photograph correlates well with date of onset of contamination as indicated in a core taken from nearby Darling Harbour shown in Figure 7.6. The photograph is from the Macarthur Album titled "Sydney – The 1850s, the Lost Collections", by

Barry Groom and Warren Wickman from the Historic Photograph Collection, the University of Sydney.

Period 1889–1922

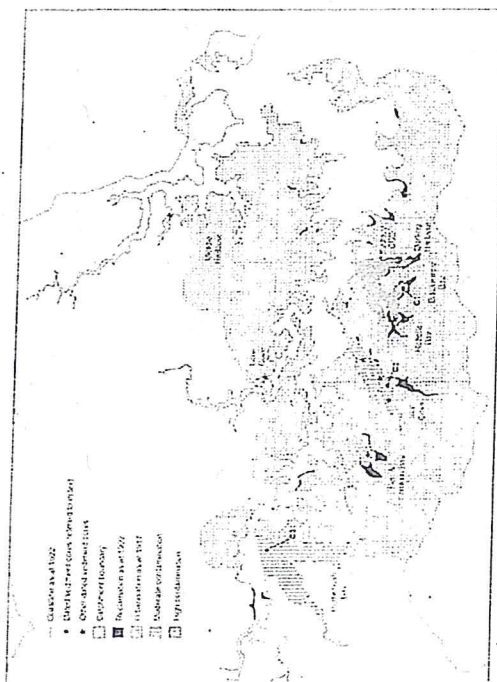


Figure 7.4 South of the harbour, urbanisation had spread from the estuary mouth to Homebush Bay by 1917, and the southern part of North Shore had become residential. Most of the upper ends of bays on the southern shores of the estuary had been reclaimed by 1922. Sediments in Darling Harbour, Blackwattle Bay and Rozelle Bay had become highly contaminated with heavy metals and Iron Cove, Hen and Chicken Bay and Homebush Bay sediments were moderately contaminated by 1917.

The continued widespread disposal of garbage in intertidal swamps (Coward 1988) to form industrial areas and parks (DEP 1986) was a major contributing factor to rat infestation and the outbreak of bubonic plague in 1898/99. The Sydney Harbour Trust (SHT) was formed under powers given by an Act of Parliament in 1900 to resume private

enterprises and modernise dilapidated foreshores in Walsh Bay and Darling Harbour, which sheltered infestations of rats (Emery 1965; MSB 1974). Increased demand for accessible waterside land for port and industrial functions resulted in extensive reclamation in Canada Bay, Kings Bay, Hen and Chicken Bay, Iron Cove (Hawthorne Canal), White Bay, Rozelle Bay and Rose Bay.

Period 1922–2002

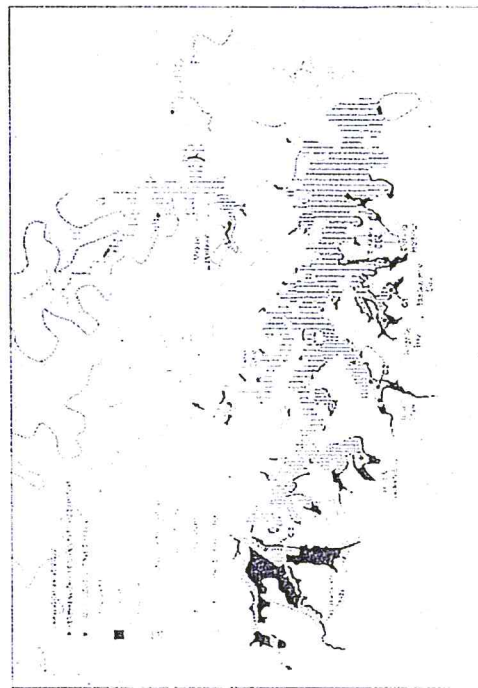


Figure 7.5 Urbanisation of the catchment is now almost complete, except for areas set aside for recreation and bush land reserves and foreshore reclamation has all but ceased. Sediments in the upper parts of bays, especially along the southern shores of the harbour, are highly contaminated with heavy metals and minor contamination is present in most sediment of the upper and central harbour, as well as in Middle Harbour and Lane Cove.

The most active period of reclamation took place in Port Jackson between 1922 and 1955 when about 5.7 km² of land was created adjacent to Parramatta River at Silverwater, Homebush Peninsula, Garden Island, Exile Bay, Kings Bay, Iron Cove, Glebe Island and Darling Harbour.

Between 1955 and 1978 reclamation was mainly by the use of landfill, including industrial wastes (Coward 1988) in low-lying areas adjacent to Middle Harbour, Parramatta River and Lane Cove River (McLoughlin, 1985). The last major reclamation period was from 1964 to 1981 when extensive foreshore areas were constructed to accommodate the new 'roll-on, roll-off' container shipping (Anglin & Associates 1990; Budin 1990; Fraser 1989; Proudfoot 1996).

Reclamation as a source of pollution

The total mass of material used to undertake 11.35 km² of reclamation in Port Jackson has been estimated at over 100 million tonnes (McLoughlin 2000). The most common method used to undertake this reclamation was to construct a sea wall and infill behind the barrier using garbage, industrial waste and sediments removed from the floor of the adjacent estuary. The composition of material used as infill varied with location and date of reclamation and although few records were made, the composition of one site is well known. The nature and extent of waste in the Homebush Bay area is well documented due to clean-up operations associated with the Sydney 2000 Olympic Games.

Prior to European settlement, this area comprised extensive tidal wetlands and thick woodlands, which were cleared and reclaimed from the early 1800s for farming. The region was used as a racecourse, brickworks, armaments depot and an abattoir between the mid-1880s and 1969. Unauthorised filling was commonplace from the late 1960s to the late 1970s. During this period over nine million cubic metres of commercial, domestic and industrial waste was dumped in the area (Suh et al 2004). A 25 metre-high engineered landfill rose above the southern bank of Haslams Creek and only 30 per cent of the Homebush Bay site retained its natural top soil and remnant vegetation. By 1970 Wentworth Bay ceased to exist and most of the low-lying land had been filled by 1978. Final filling along the north and south banks of Haslams Creek

took place between 1979 and 1988. The significant ecological damage had been recognized by 1975 when licensing of landfills became law, but a further five years lapsed before regulations became fully enforced. A total of \$137 million was allocated for clean-up of the site in one of the largest remediation projects carried out in Australia (Suh, Birch & Hughes 2004; Suh, Birch, Matthai et al 2004). Waste comprised putrescible, building, chemical and garbage municipal waste, construction debris, household garbage, demolition waste, ash fill and dredged sediment containing heavy metals, asbestos, a range of hydrocarbons, including dioxins, benzene, toluene, ethylbenzene and xylene (BTEX) compounds and polycyclic aromatic hydrocarbons, as well as organochlorine pesticides. A total of 400 tonnes of hazardous waste comprising dioxins, furans and other organochlorine compounds was classified as Scheduled Chemical Waste which had to be destroyed by a thermal/catalytic treatment under NSW REPA license (Birch, et al, 2007). In one of the largest surveys of its kind, 4531 soil samples were collected by coring through the infill for chemical analysis (Suh, Birch & Hughes 2004; Suh, Birch, Matthai et al 2004). Areas infilled with estuarine sediment from the adjacent bay contained elevated concentrations of heavy metals and in some areas soil metal concentrations were considered high enough to pose a threat to groundwater. This soil was removed and consolidated into small manageable areas capped with impermeable clay and surrounded by leachate drains to protect surrounding aquifers. To date, monitoring of the leachate drains indicate contaminant concentrations are at acceptable levels.

In a project specially designed to test leachate production in reclaimed lands due to rainwater filtration and tidal action, Suh, Brown & Birch (2003a, 2003b) placed six boreholes through infill at Bicentennial Park adjacent to Rozelle Bay. The Park (1.01 ha) was reclaimed between 1972 and 1980 by removal of approximately 31,000 m³ of material from the adjacent bay, primarily to attain navigation depths. In addition to the marine sediments, the fill comprised demolition waste, construction materials and industrial and domestic waste. Results of the experiment showed that during dry periods when water tables recede, oxygen ingress may lead to decreasing acidity (pH) and an associated increase in the concentrations of some heavy metals (copper, lead, zinc, arsenic and

chrome). The results of the field study were tested under controlled conditions in the laboratory by percolating fresh and saline water through columns containing soil material from the park (Suh, Brown & Birch 2003a, 2003b). Although the parallel field studies had considerably higher concentrations of metals than that produced in the laboratory experiment, concentrations were orders of magnitude greater than natural sea water. It was concluded that elevated concentrations of heavy metals probably enter the estuary by tidal action and during periods of rainfall.

Although it has been demonstrated in the field and in controlled laboratory studies that the material used for infilling is a source of heavy metals to the estuary, the process has not yet been quantified. The juxtaposition of high contaminant concentrations in sediments at the heads of most estuary embayments and extensive reclamation in adjacent lands has obvious implications. However, stormwater canals also discharge to the estuary at these locations (Barry, Taylor & Birch 1999, 2001; Birch et al 1999) and differentiating the relative magnitude of each source is complex and has not yet been attempted. The extraordinary masses of materials dredged from the estuary floor for infilling and reclamation around Port Jackson gives an idea of the potential magnitude of this possible source. Almost a million tonnes of contaminated sediment from Iron Cove was used for reclamation at the mouths of Hawthorne and Iron Cove Creeks; 4.6 Mt in Homebush Bay and another 2.8 Mt on the banks of the Parramatta River (McLoughlin 2000).

Ecological effects of reclamation

It is not surprising that, with 23 per cent of the area of Port Jackson lost to reclamation, approximately 50 per cent of the shore is composed of retaining seawalls or other built habitats (Chapman & Bulleri 2003). Altered shorelines, particularly the construction of long stretches of seawalls, have major ecological impacts. The Centre for Research on Ecological Impacts of Coastal Cities at the University of Sydney is doing some excellent work on understanding the ecological role that seawalls and other intertidal structures have on urbanised estuaries (Blockley, Chapman in press; Chapman & Bulleri 2003). Seawalls differ from natural rocky shores because they are usually steep and they have fewer

reeves and overhangs than rocky shores and some habitats (e.g. rock pools) are absent. Also, vertical seawalls have a compressed intertidal area (1–2 m) in contrast to natural shores with lower gradients (10s of metres). These factors affect the distribution and abundance of intertidal organisms. At mid- and high-shore levels there are frequent differences between assemblages on natural shores and seawalls, but, at lower levels, differences between assemblages are considerably smaller.

The longest seawalls in Port Jackson have been constructed to support reclamation activities at the heads of embayments, for example Farm Cove, Worimbondoo Bay and Iron Cove. These areas were once muddy, mangrove and saltmarsh wetlands with gentle slopes. The marked change in habitat in these areas has resulted in major alteration to ecological function, not to mention the reduction in biological productivity and changes in hydrology and physio-chemical attributes of the intertidal zone.

Historic effect of urbanisation and industrialisation on the Port Jackson estuary

The historic effect of increasing anthropogenic activity in the Port Jackson catchment on the adjacent estuarine environment has been established through an unusual collaboration by students and staff in urban geography and environmental chemistry in the Environmental Geology Group in the School of Geosciences at the University of Sydney (Birch & Murray 2007; Jolley 2005; Links 1998; Murray 2003; Taylor, Birch & Links 2004).

Studies of changing land use, development of industry and reclamation in Port Jackson, were undertaken by the School of Geosciences at the University of Sydney to determine potential adverse effects on the estuary by human activity in the adjacent catchment (Jolley 2005; Links 1998; Murray 2003; Taylor, Birch & Links 2004). Bottom sediments were used to determine possible effects on the estuary and to establish whether temporal changes in the catchment could be recorded in subsurface sediment in the estuary (Taylor, Birch & Links 2004). Sediment adsorbs contaminants from the overlying water column and thus has the ability to time integrate and to record the influx of contaminants into a water body. Because sediments are deposited layer-

by-layer in a regular chronologic sequence, this sediment 'memory' can be used as an historic record of contaminant flux, which in turn reflects anthropogenic changes in the adjacent catchment (Taylor 2000). To test this concept in Port Jackson, 12 sedimentary cores were taken in nine highly contaminated embayments and down-hole samples were analysed for contaminants and dated using radioisotopes lead 210 and caesium 137 (Taylor 2000; Taylor, Birch & Links 2004).

Three of the 12 cores, one each from Blackwattle Bay (Core 1), Iron Cove (Core 2) and Homebush Bay (Core 3) are reproduced in Figure 7.6. These bays are all manded in highly contaminated sediment and are located with increasing distance from central Sydney, that is, approximately 2, 5 and 12 km, respectively. All three cores show low concentration of heavy metals (copper, lead and zinc) at the bottom of the core and at some depth concentrations increase markedly. In some cases concentrations towards the top of the core remain constant, continue to increase, or begin to decrease. The depth at which concentrations begin to increase is the point, or time, where contaminants start to be discharged from the catchment, that is, the onset of contamination is faithfully recorded in the sediment. Contamination commenced in about 1860 in Blackwattle Bay (Core 1) and in approximately 1910 in Iron Cove (Core 2). Core 3 from Homebush Bay records adverse effects of human activity beginning at about 1925. The spread of urbanization and the development of industry outwards from central Sydney (Figures 1, 2, 4 and 5) are reflected in the expansion of contaminated sediment in the adjacent estuary.

The date of onset of contamination, as depicted in the cores, shows approximately the same timing as that of urbanisation and industrialisation in the adjacent catchments. Moreover, the severity of contamination in the sediment profile also decreases away from central Sydney with decreasing urban intensity. For example, zinc in sediment from the core taken closest to central Sydney (Core 1) in Blackwattle Bay is at a maximum of about 2000 $\mu\text{g/g}$ and for the core taken in Iron Cove (Core 2) it is approximately 1500 $\mu\text{g/g}$, whereas in Homebush Bay the maximum zinc concentration in the sediment is approximately 1000 $\mu\text{g/g}$.

The data provided here are for heavy metals, but the same trend is evident for organic contaminants as well (Taylor, Birch & Links 2004). Organochlorine compounds are entirely artificial insecticides and herbicides and these chemicals came into use in Australia after the Second World War. The onset of these organic contaminants in the core profiles are dated at 1945, almost precisely when they were introduced into the catchment.

These results provide confidence in the methodology and the science of the current approach. Although similar results have been obtained for individual, site-specific studies, this is the only catchment-wide demonstration of this approach.

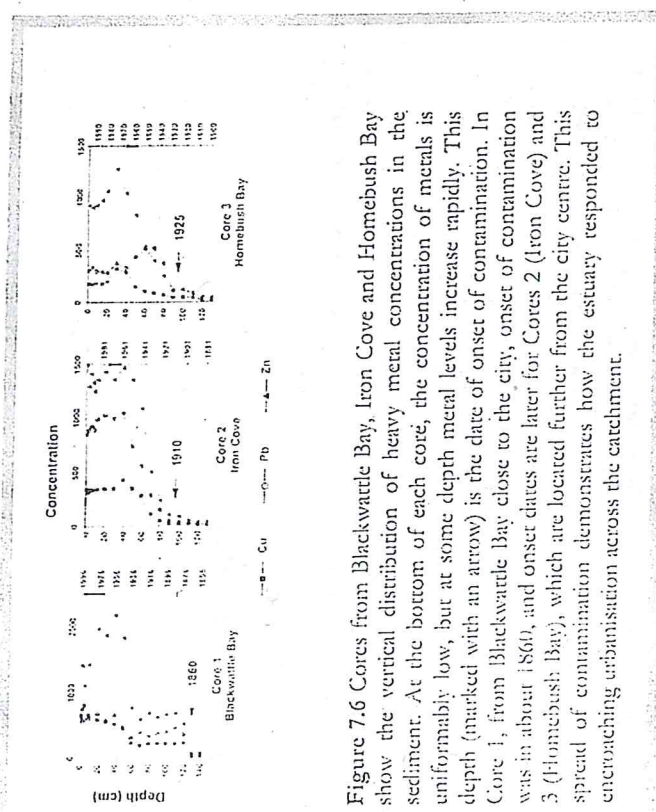


Figure 7.6 Cores from Blackwattle Bay, Iron Cove and Homebush Bay show the vertical distribution of heavy metal concentrations in the sediment. At the bottom of each core, the concentration of metals is uniformly low, but at some depth metal levels increase rapidly. This depth (marked with an arrow) is the date of onset of contamination. In Core 1, from Blackwattle Bay close to the city, onset of contamination was in about 1860, and onset dates are later for Cores 2 (Iron Cove) and 3 (Homebush Bay), which are located further from the city centre. This spread of contamination demonstrates how the estuary responded to encroaching urbanisation across the catchment.

Recent environmental history

More historic information can be gleaned from cores such as these. It is evident from Core 1 that zinc concentrations attained a maximum in the sediment in about 1955 and concentrations have been generally decreasing since that time. In fact, concentrations are almost half the maximum at present, whereas copper continues to increase in sediments at this location. There is evidence from the core profile that the concentration of lead has started to decline in recent times in Blackwattle Bay. There appears to have been two phases of contamination in this bay: a period of moderate contamination from 1875 to 1910, followed by a period of high contamination from 1910 to the present. In Iron Cove (Core 2), zinc concentrations reached a maximum in approximately 1960 and have remained high to the present day. Copper and lead also attained a maximum in Iron Cove at this time, but while lead appears to be decreasing slightly, copper concentrations have remained high and constant. Core 3 from Homebush Bay shows contamination reaching maximum concentrations in about 1970 for zinc and copper, but the maximum lead concentration occurred earlier in the 1940s, perhaps due to the introduction of industry manufacturing lead-based products on the shores of the bay. Increasing copper concentrations in recent times is commonly observed in sediments of Sydney Harbour, perhaps due to the continued use of copper-based antifouling boat paints, whereas declining lead over the last 15 years has been attributed to the introduction of unleaded petrol. The main source of zinc is vehicular emissions and component wear and is transported to the estuary by storm water.

Regional trends in contamination have been investigated by the Environmental Geology Group in the School of Geosciences at the University of Sydney using a considerably larger core database in conjunction with several vintages of surface sediment metal concentrations from about the mid-1970s to the present. Data from the cores and surficial sediments show that, in general, concentrations of metals in bottom sediment have been declining in the upper parts of the estuary, west of the Sydney Harbour Bridge, but have been increasing in the lower harbour, in Lane Cove and Middle Harbour over the last 25 years (Birch & Taylor 2004). The decrease in metal concentrations since the late 1970s is consistent with the introduction of the *Clean Waters Act*

which required industry to discharge waste into the sewerage system and to reduce waste generation. A decision by industry to relocate out of the Sydney Harbour catchment over the last 25 years has also contributed to reduction of metal flux to the harbour. Relocating industry away from high-land value real estate on the water front with high-density housing has undoubtedly also reduced contaminant loads discharged directly to the estuary. The move has also changed appreciation of the harbour from former working class suburbs to high-value, middle class areas, for example Balmain and Woolwich.

Increased metals concentration over the same 25-year period in sediments of Lane Cove and Middle Harbour have been attributed to a rapid expansion of residential and commercial property, as well as increased transport services in the Chatswood and North Ryde areas (Taylor, Birch & Links 2004). High concentrations of metals in sediments of rivers and creeks draining these areas support this view (Birch & Taylor 2004).

Present status of Port Jackson

Sediment in some parts of Port Jackson is the most contaminated of any harbour worldwide. Sediments mantling the estuary contain high concentrations of a wide range of contaminants over extensive areas, including heavy metals, organochlorine pesticides, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), polychlorinated dibenzo-*p*-dioxins and dibenzofurans (Birch & Taylor, 1999, 2000; Birch et al 2006; Irvine & Birch, 1998; McCready et al 2000). The origin of these substances can be broadly grouped as related to industrial activities, past and current stormwater discharge and leachates from reclaimed land. The industrial source is due largely to historical poor practices, whereas stormwater and leachate sources are past and contemporary. Early industry was located on the shoreline of the port for convenience and cheap delivery of raw materials, as well as for reducing haulage costs for coal to power stations. Export of heavy, bulky manufactured goods was also easy and inexpensive for shore-based industries. Contamination of adjacent sediment by waste associated with the movement of goods, and from cheap disposal of waste directly into the harbour, accounts for most of past industrially-sourced contamination.

Sampling of rivers and creeks discharging to Port Jackson has shown that stormwater continues to provide large quantities of contaminants, mainly heavy metals to the receiving basin. Although it is known that contaminants are being sourced from waste material contained within reclaimed lands surrounding the harbour, the magnitude of this supply remains unquantified, as with other diffuse sources, such as atmospheric deposition.

The majority of these contaminants are associated with the particulate phase, but the processes whereby these particle-bound contaminants are transported within the estuary and the effects of these materials on flora and fauna are poorly known and are the subject of current studies. Recent large ecotoxicological studies (McCready et al 2004; McCready et al 2005; McCready, Birch & Long 2006; McCready et al 2006a 2006b, 2006c) have shown that sediment in high impact areas of the harbour are toxic to some benthic animals, as was predicted by earlier investigations of sediment quality (Birch & Taylor, 2002a, 2002b, 2002c). To date little work has been done on the transfer of contaminants in the water column and bottom sediment to benthic and pelagic animals, termed 'bioaccumulation', or on the movement of these materials up the food chain, called 'biomagnification'.

Early studies detected high total PCB concentrations in mullet caught in Port Jackson (Woollard & Settle 1978), but mean values appear to have decreased since then (Richardson 1985). In a more recent study of chlorinated hydrocarbons in the tissue of seven fish types, concentrations exceeded National Food Authority Maximum Residue Limits for two species in Duck River, Homebush Bay and Iron Cove and one species in Parramatta River (Roach & Runcie 1998). High concentrations of polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans in sediment in Homebush Bay have resulted in unacceptably high tissue concentration in fin fish. In 1989 fin fishing was banned in the bay and in the following year the ban was expanded to include the whole upper third of the harbour. More recent monitoring saw the NSW Food Authority posing a 3-month ban on commercial fin fishing in the whole harbour in December, 2005, which in January the following year was extended to include prawn trawling,

These bans were made permanent in February 2006. Blood tests of prawn fishermen showed one individual with four-times the average dioxin concentrations and his son with seven times average levels. One grandfather had concentrations 10 times average values. However, these levels were not deemed detrimental to human health. Studies continue to determine the extent of the problem and how best to reduce bottom sediment concentrations to levels where fish and prawn tissue levels decline to acceptable values.

The appropriate and successful governance of this estuary requires high-quality, science-based information. The current challenges for scientists are to identify and quantify sources; understand the mechanisms controlling the fate of contaminants; determine the effects of these substances on living resources and construct management tools based on robust science. Modelling the source, fate and effects of these contaminants in Port Jackson will enable managers and planners to make decisions on such issues as stormwater remediation options, relaxation times (natural cleanup), and the amount of dredging required to reduce tissue concentrations to acceptable limits and to set maximum daily loading for creeks entering the water way. In recent times, considerable effort has resulted in reduced industrial waste entering Port Jackson. Now is an appropriate time to initiate a new concerted environmental effort to install second generation remedial devices to reduce current stormwater contaminant inputs. It is also time to undertake appropriate remedial work in the catchment and in the estuary to restore the harbour to a condition in which it can support a complete and healthy ecological community.

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References

- Anglin and Associates, 1990. *Sydney Harbour: Maritime Services Board Heritage and Conservation Register: History, vol 1*, Anglin Associates, Sydney.
- Barry S C, Taylor S E & Birch G F, 1999. 'Heavy metals in urban stormwater canals entering Port Jackson, Australia and their impact on the estuarine environment', *Proceedings of the Eighth International Conference on Urban Storm Drainage*, Sydney, Jolliffe & Ball J E (eds.), August, vol. 4, pp. 1825-1832.
- Barry S C, Taylor S E & Birch G F, 2001. 'Heavy metal supply to the Port Jackson Estuary, Australia by stormwater', *Australian Journal of Water Resources*, vol. 4, no. 2, pp. 147-154.
- Birch G F, Scollen A, Snowden R & Suh J, 1999. 'Sources of heavy metals in stormwater draining into Port Jackson, Australia', *Proceedings of the Eighth International Conference on Urban Storm Drainage*, Sydney, Jolliffe & Ball J E (eds.), August, vol. 4, pp. 2202-2209.
- Birch G F & Taylor S E, 1999. 'Source of heavy metals in sediments of Port Jackson estuary, Australia', *The Science of the Total Environment*, vol. 227, pp. 123-138.
- Birch G F, 2000. 'Marine pollution in Australia, with special emphasis on central New South Wales estuaries and adjacent continental margin', *International Journal of Environmental Pollution*, vol. 13, pp. 1-6 & 411-423.
- Birch G F & Taylor S E, 2000. 'The distribution and possible sources of organochlorine residues in sediments of a large urban estuary, Port Jackson, Sydney', *Australian Journal of Earth Sciences*, vol. 47, pp. 749-756.
- Birch G F & Taylor S E, 2002a. 'Possible biological significance of contaminated sediments in Port Jackson, Sydney, Australia', *Environmental Monitoring and Assessment*, vol. 77, pp. 179-190.
- Birch G F & Taylor S E, 2002b. 'Application of sediment quality guidelines in the assessment of contaminated surficial sediments in Port Jackson (Sydney Harbour), Australia', *Environmental Management*, vol. 29, no. 6, pp. 860-870.

- Birch G F & Taylor S E, 2002c. 'Assessment of possible sediment toxicity of contaminated sediments in Port Jackson estuary, Sydney, Australia', *Hydrobiologia*, vol. 472, pp. 19–27.
- Birch G F & Taylor S E, 2004. *Sydney Harbour and catchment: contaminant status of Sydney Harbour sediments: a handbook for the public and professionals*. Geological Society of Australia, Environmental, Engineering and Hydrogeology Specialist Group.
- Birch G F, Harrington G, Symons R K & Hunt J W, 2006. 'The source and distribution of polychlorinated dibenzo-p-dioxin and polychlorinated dibenzofurans in sediments of Port Jackson, Australia', *Marine Pollution Bulletin*, no. 54, pp. 295–308.
- Birch G F & Murray O A, 2007. Reclamation in Sydney Harbour, 1788–2002, *Australian Geographer*.
- Blockley D J & Chapman M G, (in press). 'Exposure of seawalls to waves within an urban estuary: effects on intertidal assemblages', *Austral Ecology*.
- Budin W H, 1990. Change in the use of portside lands in Sydney Harbour, MURP thesis, University of Sydney, Sydney.
- Chapman M G & F Bulleri, 2003. 'Intertidal seawalls: new features of landscape in intertidal environments. landscape and urban planning', vol. 62, pp. 159–172.
- Coward D, 1988. 'Out of Sight: Sydney's environmental history 1851–1981', Department of Economic History, Research School of Social Sciences, Australian National University, ACT.
- DEP, 1986. Parramatta River Regional Environmental Study: open space and recreation: Heritage Study, Department of Environment and Planning, Sydney.
- Limery J S, 1965. Port of Sydney, 1788–1945: a geographical study of development with particular emphasis on the influence of trade, MA thesis, University of Sydney, Sydney.
- Pitzgerald S & Golder H, 1994. *Pymont and Ultimo*, Hale and Iremonger, Sydney.
- Fraser D, 1989. *Sydney, from settlement to city: an engineering history of Sydney*. Engineers Australia Pty Ltd.
- Goddien Mackay Pty Ltd, 1991. *Sydney and Middle Harbours Heritage Study: Final report*. Report prepared for the NSW Department of Planning, Goddien Mackay Pty Ltd, Sydney.
- Goddien Mackay Pty Ltd, Conybeare Morrison & Partners, 1993. *North Shore Heritage Study Review*, part 1, vol 1, main report.
- Homebush Bay Corporation, 1994. *Briefing document on site contamination and environmental investigations at Homebush Bay*, Homebush Bay Corporation, NSW.
- Irvine I & Birch G F, 1998. 'Distribution of heavy metals in surficial sediments of Port Jackson, Sydney, Australia' *Australian Journal of Earth Science*, vol. 45, no. 1, pp. 169–174.
- Jolley R, 2005. Onset and flux of Cu, Pb and Zn loads in runoff in relation to historical changes in land-use, Iron Cove, Port Jackson, Australia 1885–1996.
- Links I, 1998. Assessment of catchment control on the contaminant characteristics of receiving basin sediments. A study of Sydney Harbour, Australia, BSc Hons thesis, University of Sydney, Sydney.
- Liu K, 1989. Evolution of the sedimentation in Sydney Harbour, MSc. Thesis, University of Sydney, Sydney.
- MacDonnell, 1975. *The Glebe: Portraits and Places*, Ure Smith, Sydney.
- Marine Services Board, 1974. *The Sydney Harbour Water-side Zoning Plan*, The Maritime Services Board of NSW, Sydney.
- McCready S, Slee D, Birch G F & Taylor S E, 2000. 'The distribution of polycyclic aromatic hydrocarbons in surficial sediments of Sydney Harbour, Australia', *Marine Pollution Bulletin*, vol. 40, no. 11, pp. 999–1006.
- McCready S, Spyrikis G, Greely C R, Birch G F & Long E R, 2004. 'Toxicity of surficial sediments from Sydney Harbour and vicinity', *Australia. Environmental Monitoring and Assessment*, no. 96, pp. 53–83.
- McCready S, Greely C R, Hynes R V, Birch G F & Long E R, 2005. 'Sensitivity of an indigenous amphipod, *Corophium* sp. to chemical contaminants in laboratory toxicity tests conducted with field collected sediment from Sydney Harbour, Australia and vicinity', *Environmental Toxicology and Chemistry*, vol. 24, no. 10, pp. 2545–2552.
- McCready S, Birch G F and Long E R, 2006a. Metallic and organic contaminants in sediments of Sydney Harbour and vicinity – A chemical dataset for evaluating sediment quality guidelines. Environment International, 32, 455–465
- McCready S, Birch G F, Long E R, Spyrikis G & Greely C R, 2006b. 'Predictive abilities of numerical sediment quality guidelines for

- Sydney Harbour, Australia and vicinity', *Environment International*, vol. 32, pp. 638–649.
- McCready S, Birch G F, Long E R, Spyrikis G & Greely C R, 2006c. 'Relationships between toxicity and concentrations of chemical contaminants in sediments from Sydney Harbour, Australia, and vicinity', *Environmental Monitoring and Assessment*, vol. 120, pp. 187–220.
- McDonald W S, Cocks L K, Wood N, Ive J R & Yapp G A, 1993. 'The future population of Australia's coastal lands' *Australian Geographic Studies*, vol. 31, no. 2, pp. 177–188.
- McLoughlin I. C, 1985. *The Middle Lane Cove River: a history and a future*, Centre for Environmental and Urban Studies, Macquarie University, NSW.
- McLoughlin L. C, 2000. 'Shaping Sydney Harbour: sedimentation, dredging and reclamation 1788–1990s', *Australian Geographer*, vol. 31, no. 2, pp. 183–208.
- Murray O A, 2003. *A history of reclamation in Sydney Harbour 1788–2002*. MAppSci thesis, University of Sydney, Sydney.
- NLWRA, 2002. *National land and water resources audit (2002) Australian catchment, river and estuary assessment 2002, vol. 1. National Land and Water Resources Audit*, Canberra.
- Phillips D J H, Richardson B J, Murray A P & Fabris J G, 1992. 'Trace metals, organochlorines and hydrocarbons in Port Phillip Bay, Victoria, A historical review', *Marine Pollution Bulletin*, vol. 25, pp. 5–8 & 200–217.
- Pirbado R M, 1978. Estuarine modelling; the development and validation of a 2-layer, real-time model for the Parramatta River estuary, PhD thesis, University of Sydney, Sydney.
- Powell C, 1987. *A river revived: the Parramatta*. NSW University Press, Sydney.
- Proudfoot P, 1996. *Seaport Sydney: the making of the city landscape*, University of Sydney, Sydney.
- Richardson J, 1985. 'Polychlorinated biphenyls (PCBs) in Australian waters', in Chan M W H, Hoare R W M, Holmes P R, Law R J S & Reed S B (eds.), 'Pollution in the Urban Environment Palmer 85', pp. 652–658, Elsevier Applied Science Publishers, London.
- Roach A C & Rance J, 1998. 'Levels of selected chlorinated hydrocarbons in edible fish tissues from polluted areas in the Georges/Cooks Rivers and Sydney Harbour, New South Wales, Australia', *Marine Pollution Bulletin*, vol. 36, pp. 323–344.
- Roy P S, 1981. 'Quaternary Geology' in Herbert C, (ed.) *Geology of the Sydney*, 1:1000,000 sheet 9130, Geological Survey of New South Wales, Sydney, pp. 41–91.
- Roy P S, Zhuang W, Birch G F, Cowell P J & Li C, 1997. *Quaternary geology of the Port-Jackson east and shelf. Southeast Australia*, Geological Survey of New South Wales, Department of Minerals Resources, Sydney.
- Roy P S, 1998. 'Cenozoic geology of the coast and shelf', in Scheibner, E. & Basden H (eds.), *Geology of New South Wales Synthesis vol. 2 Geological Evolution*, Geological Survey of New South Wales, Memoir Geology, vol. 13, no. 2, pp. 361–385.
- Shore H, 1981. *From the Quays*, NSW University Press, Sydney.
- Snowdon R & Birch G F, 'The nature and distribution of copper, lead, and zinc in soils of a highly urbanised sub-catchment (Iron Cove) of Port Jackson, Sydney', *Australian Journal of Soil Research*, vol. 42, no. 3, pp. 329–338.
- Stephensen P R, 1966. *History and Description of Sydney Harbour*, Rigby Limited, Sydney.
- Solling M & Reynolds P, 1977. *Leichhardt: on the margins of the city: a social history of Leichhardt and the former Municipalities of Ammandale, Balmain and Glebe*, Allen and Unwin, Sydney.
- Stringer M, 1984. *Sydney Harbour: a pictorial history from the first settlers to the present day*, Rankin & Company, Sydney.
- Suh J, Brown P & Birch G F, 2003a. 'Geochemical factors affecting leachate composition derived from soils in reclaimed land using laboratory freshwater and saline water column experiments', *Marine and Freshwater Research*, vol. 54, pp. 885–893.
- Suh J, Brown P & Birch G F, 2003b. 'Hydrogeochemical characteristics and importance of natural and anthropogenic influences on soil and groundwater in a reclaimed land adjacent to Port Jackson, Sydney, Australia', *Marine and Freshwater Research*, vol. 54, pp. 767–779.
- Suh J, Birch G F, Marthai C & Hughes K, 2004a. 'Spatial distribution and sources of heavy metals in reclaimed lands of Homebush Bay, the venue of the 2000 Olympic Games, Sydney, New South Wales', *Australian Journal of Earth Sciences*, vol. 51, pp. 53–66.

- Seh J, Birch G F & Hughes K, 2004b. 'Hydrochemistry in reclaimed lands of the 2000 Olympic Games site, Sydney, Australia', *Journal of Coastal Research*, vol. 20, no. 3, pp. 709–721.
- Taylor S E, 2000. The source and remobilisation of contaminated sediment in Port Jackson, Australia. PhD thesis, the University of Sydney, Sydney.
- Taylor S E, Birch G F & Links E, 2004. 'Historical catchment changes and temporal impact on sediment of the receiving basin, Port Jackson, New South Wales', *Australian Journal of Earth Sciences*, vol. 51, no. 2, pp. 233–246.
- Thom B G & Roy P S, 1985. 'Relative sea levels and coastal sedimentation in southeast Australia in the Holocene', *Journal of Sedimentary Petrology*, vol. 55, pp. 257–264.
- Walsh G P, 1963. 'The Geography of Manufacturing in Sydney 1788–1851', *Business Archives and History*, vol. 3, no. 1, pp. 20–52.
- Webber & Daly, 1971. 'Location of manufacturing growth within cities: a predictive model for Sydney 1954–1966', *Royal Australian Planning Institute Journal*, vol. 9, pp. 130–136.
- Woodward P & Serfle H, 1978. 'PCB residues in mullet, *Mugil cephalus* fed to captive Eastern Australian water rats, *Hydromys chrysogaster*', *Bulletin of Environmental Contamination and Toxicology*, vol. 20, pp. 606–612.
- Zann I. P, 1996. 'The state of the marine environment report for Australia (SOMER). Process, findings and perspective', *Ocean and Coastal Management*, vol. 33, pp. 1–3 & 63–86.

Energy from offshore wind: an overview

Dong-Sheng Jeng and Yun Zheng

Abstract

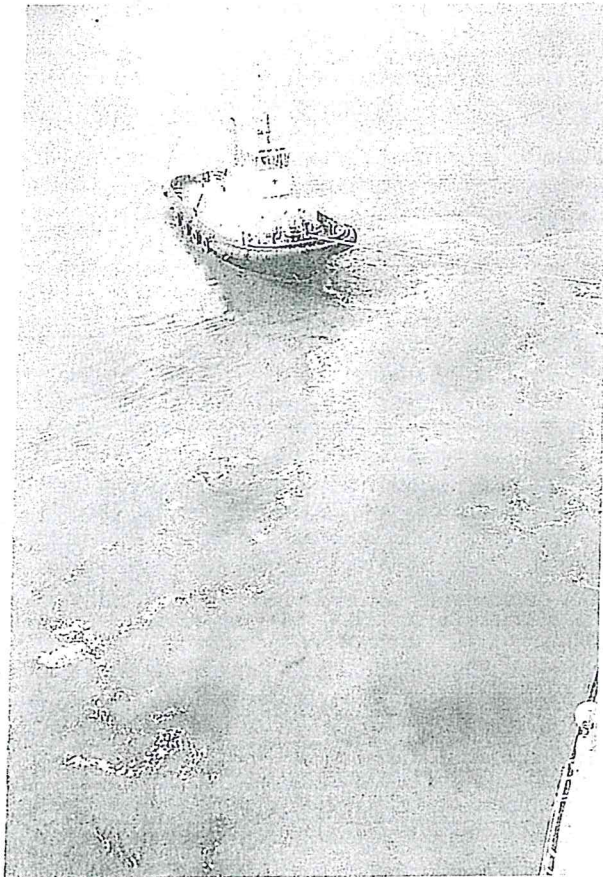
Renewable energy has attracted a great deal of attention among governments, industries, academics and societies throughout the world in recent times. Offshore wind energy is a renewable energy source that has great potential in energy markets worldwide as our current knowledge of offshore engineering technology makes it ready for implementation immediately. In this chapter, offshore wind energy is compared with other renewable energy sources, and existing offshore wind energy projects throughout the world are reviewed. Current design codes of offshore wind energy are outlined and a set of criteria for the selection of appropriate sites for offshore wind energy is established for Australia. Finally, potential sites in Australia are evaluated and based on our analysis, the southern part of Western Australia (WA) is the most appropriate site for wind farms.

Introduction

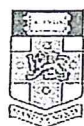
Due to the world's rising energy consumption, limited existence of fossil energy sources and dramatic changes to the world's climate, the extension of renewable energy has drawn a great deal of attention from governments, industries and academics world-wide. Renewable energy has considerable potential and could theoretically provide a nearly unlimited supply of relatively clean and mostly local energy. Recently, global renewable energy supply has been growing strongly; the annual growth for wind energy, for example, has been around 30 per cent recently, from a very low base of 6.29 per cent of total renewable energy resources. In relative terms, however, the share of modern renewable

IS THE ECOLOGY OF SYDNEY HARBOUR THREATENED BY THE DISTURBANCE OF CONTAMINATED SEDIMENTS?

An experimental assessment of the effects of resuspension of
contaminated sediment on sessile animals of Sydney Harbour



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Abstract

Sediments in many sections of Sydney Harbour are heavily contaminated. These contaminants have flowed into the harbour from surrounding industrial and urban areas for more than a century. Often the contaminants enter the waterway and bind to suspended sediments – eventually sinking to the harbour floor. It is well documented that contaminated sediments affect the ecology of organisms living in the sediments. Very little, however, is known about the potential for the resuspension of contaminated sediments to pose a threat to the ecology of organisms in the water-column or on surrounding rocky reefs. This is surprising because there are a range of natural (storms, tidal currents) and human (shipping movements, dredging) disturbances that can resuspend (i.e. lift) sediments into the water-column, potentially releasing a range of contaminants and dispersing them well away from the harbour floor. Only two studies world-wide to date have attempted to assess the effects of the resuspension of contaminated sediments in the field.

The aim of the current study was to assess whether repeated short-term resuspension of contaminated sediments would affect the diverse assemblages of rocky reef sessile invertebrates (e.g. sea-squirts, barnacles and sponges) in Sydney Harbour. We specifically used the sessile invertebrates as our "mine canaries" as they are sensitive filter-feeders and cannot move away from water-borne sediment plumes. The experimental method, which we designed and developed, was specifically an attempt to mimic the resuspension of contaminated sediment created by short-term disturbances, such as frequent shipping movements.

Despite being exposed to resuspensions of some of the most contaminated sediments in the world, a diverse range of Sydney Harbour sessile invertebrates clearly showed no short-term ecological effects. The soft bodied invertebrates (e.g. colonial sea-squirts and sponges) were predicted to shrink or decompose rapidly if the resuspensions lethally stressed these organisms. Similarly, the densities of the live invertebrates with hard bodies (e.g. barnacles and polychaete tube worms which can be clearly identified as live or dead) were predicted to decrease, with dead individuals increasing. The abundances and area that the invertebrates covered did not differ among the assemblages exposed to the resuspension and control treatments indicating that there were no immediate impacts of the resuspension of contaminated sediments. Also, not even the high levels of relatively clean sediments affected the invertebrates, which is surprising as suspended sediments at the level used in this experiment are generally thought to have substantial negative effects.

Hence, this study provides no support for the model that intense and repeated dosing of relatively clean or contaminated sediments over hourly, daily and weekly time scales have strong short-term effects on sessile invertebrates. This indicates that small infrequent disturbance of contaminated or relatively uncontaminated sediments may not be an ecological problem, possibly as the invertebrates have evolved to deal with frequent natural changes in the water condition of estuaries (e.g. salinity and turbidity). Nevertheless, as the current study focused on the immediate impacts of resuspension over a relatively short time period, further research is required to assess the potential impacts long-term exposure of resuspension of contaminated sediments. This research is currently being undertaken by the authors.

Introduction

The accidental or regulated release of pollution from industry and urbanisation has severely affected the diversity and abundance of plants and animals in harbours and estuaries (Luoma and Phillips 1988, Morrissey et al. 2003, Johnston and Roberts 2009). Heavy metals, many of which are highly toxic to marine organisms (McLusky et al. 1986, ANZECC and ARMCANZ 2000), are amongst the most common contaminants in estuarine environments (Birch and Taylor 1999). A large proportion of these metals bind within sediments and through time accumulate to extremely high concentrations (Long 2000, Birch and Taylor 1999, Cundy et al. 2003). The management of harbour and estuarine sediments has, therefore, been recognised as a substantial problem for many governments and regulatory bodies (Australian State of the Environment Report 2001, Long 2000). Contaminated sediments clearly affect the diversity and abundance of organisms living within them (e.g. Clements 2004, Millward et al. 2004), but their threat goes well beyond the seafloor – potentially affecting mammals, fish, invertebrates and algae living in the water-column or on nearby hard surfaces (e.g. rocky reefs).

Anthropogenic activities such as shipping and dredging can cause the resuspension of contaminated sediments and may release significant quantities of heavy metals into the water-column (Simpson et al. 1998, Saulnier and Mucci 2000). Resuspension of sediments releases sulfides and exposes anoxic sediments to the water-column which may cause the dissociation of heavy metal ions from bonds with organic material (Apte and Batley 1995). The free ionic forms of heavy metals are considered most toxic or biologically available (Campbell 1995). Resuspension of contaminants may also make sediment-bound metals available to suspension-feeding organisms. Furthermore, the suspension of sediments, on its own, can cause serious effects through mechanical damage or clogging of the breathing or respiring organs of invertebrates and fish (Airoldi 2003) or smothering of photosynthetic surfaces of algae. These effects may also leave marine organisms more susceptible to contaminants, such as heavy metals.

Very few studies have, however, examined the impacts of resuspended contaminated sediment. Of these, most have been ecotoxicological laboratory studies and have usually used sediments spiked with contaminants and mechanical agitation, vigorous airlift, recirculating pumps or serial diluters to maintain suspension of sediments (Sved and Roberts 1995, Cope et al. 1996, Herbranson et al. 2003). Each of these studies has found severe effects of resuspended contaminated sediments upon marine organisms. Laboratory experiments have, however, been criticised for being too simplistic and inadequate in predicting the effects of toxicants in the real world (Kimball and Levin 1985, Underwood 1995, Johnston and Keough 2003, ANZECC and ARMCANZ 2000). Field experiments are thought to be a more realistic way to assess ecological threats as they incorporate the physical, chemical and biological complexity of the real world (Underwood 1995).

Surprisingly, however, there appear to be few field studies on the ecological effects of the resuspension of contaminated sediments on organisms living above the sediment. Only two related field studies have been published. Most recently Knott et al. (2009) demonstrated that the large-scale resuspension of contaminated sediments dramatically reduced the recruitment of sessile invertebrate such as barnacles and polychaete tube worms, which were the major space-occupiers in these assemblages. Furthermore, Nayar et al. (2004) experimentally determined that phytoplankton and bacteria can be affected by the small-scale resuspension of contaminated sediments. Hence, these studies indicate that the resuspension of contaminated sediments may pose a real ecological threat to organisms exposed to the water-column.

Many sections of Sydney Harbour have sediments that are heavily contaminated with heavy metals (Birch and Taylor 1999). This contamination causes concern for the general public, environmental managers and scientists, and governments. Shipping and dredging activity occur frequently in the harbour and can disturb contaminated sediments causing them to be resuspended. Such a disturbance could cause the release of heavy metals into the water-column which may disperse through the harbour into less polluted areas - affecting fish, invertebrates and algae (Honkoop et al. 2003). Given the current shipping activity and consistent scheduled dredging projects of sections of Sydney Harbour, the extent and ecological impact of sediment resuspension events this is a pressing concern.

An amazingly diverse group of animals live attached to rocks and other hard surfaces in Sydney Harbour. These include well known animals such as barnacles, mussels and oysters; as well as virtually unknown animals such as ascidians (sea-squirts), sponges and bryozoans. These animals form fascinating communities which the public generally know little about, yet are a very important part of the Harbours' ecosystem and biological diversity. They are filter feeders and so are relatively sensitive to waterborne pollution and are sessile (i.e. stuck in one place) so they can not move away from pollution (cf. fish). Also, numerous individuals from many different species can be found occupying small areas on a variety of hard surfaces. These properties make sessile animals excellent organisms to study the effects of pollution.

To evaluate whether the resuspension of contaminated sediments poses an ecological threat to the animals of Sydney Harbour, we tested whether the rocky reef invertebrates from Chowder Bay (Sydney Harbour) would be affected by exposure to pulses of resuspended contaminated sediments from polluted parts of the Harbour. In this test we experimentally resuspended contaminated sediment so that the invertebrates were realistically exposed to suspended sediment levels similar to that created by shipping movements and dredging activities. If exposure to resuspended contaminated sediments poses a risk to the animals of Sydney Harbour, we predicted that we would find fewer live animals (or less coverage of them) on plates which were exposed to heavily contaminated sediments than on those exposed to less contaminated sediments or in the procedural control treatment ($H_1: X_{\text{Contaminated}} < X_{\text{Uncontaminated}} = X_{\text{Procedural Control}}$). Alternatively, if the sediments themselves were having an effect, then we predicted similar numbers of live animals on the plates exposed to the heavily and less contaminated sediments, and more on the procedural control treatment ($H_2: X_C = X_U < X_{PC}$). Furthermore, communities may respond to resuspended sediments, but with the strongest responses to sediments contaminated with metals. In this situation we predicted that we would find fewer live animals on plates which were exposed to the heavily contaminated sediments, more on those exposed to less polluted sediments and the greatest abundance on the procedural control treatments ($H_3: X_C < X_U < X_{PC}$).

Methods

At the Sydney Institute of Marine Science (Chowder Bay) we deployed 40 recruitment panels into the water in January 2008. The panels were made of 6 mm grey PVC (40 x 40 cm) with four roughened perspex plates attached to each of panel.

In May 2008, the plates were covered by a diverse array of sessile invertebrates after being submerged in the Harbour for 4 months and were ready to be used to test the stated hypotheses (Plate 1). In order to experimentally expose sessile invertebrates to resuspended sediments, we designed and constructed an apparatus that could isolate a body of water and contain these resuspensions. The large *in situ* cylinder (i.e. plastic cylinders ribbed with tough plastic tubing; diameter: 60cm; depth: 3.5m; Plate 2) held over 600 litres of water. Within each of these *in situ* cylinders we were able to deploy the sessile invertebrate assemblages attached to the recruitment panels during the experimental resuspension events. Nine experimental *in situ* cylinders were constructed and used in this experiment so we were able to run simultaneous treatments. A benefit of the use of the *in situ* cylinders, we have designed and built, is that we can create a relatively small resuspension event and make it last for a long period of time in a small area, thereby mimicking exposure to a much larger event. Also, the *in situ* cylinders restrict the area that is affected by the resuspension event. Nevertheless, it was decided to deploy the cylinders from the Chowder Bay harbour pool which was approximately 500 m from the Chowder Bay wharf to ensure no other experimental research on-going at the Chowder Bay wharf would be affected.

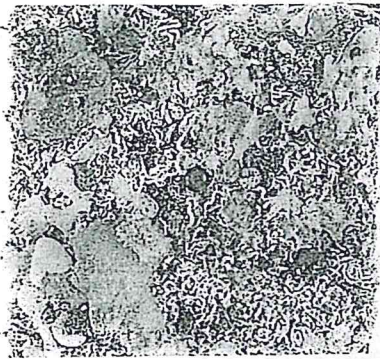


Plate 1. A recruitment plate covered by an abundant and diverse array of sessile animals. This plate is mainly covered by solitary and colonial ascidians, polychaete tube worms, bryozoans and barnacles.

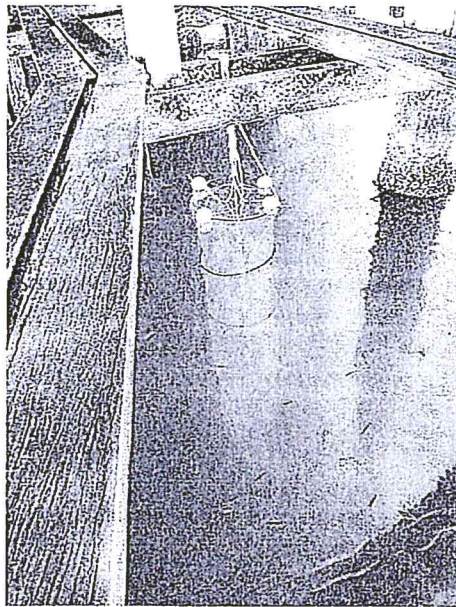


Plate 2. An in situ cylinder isolating a column of water to contain experimental resuspension events. These cylinders allowed resuspension events to be manipulated over small spatial scales (i.e. metres) enabling the potential effects of resuspended sediments on sessile animals within Sydney Harbour to be tested.

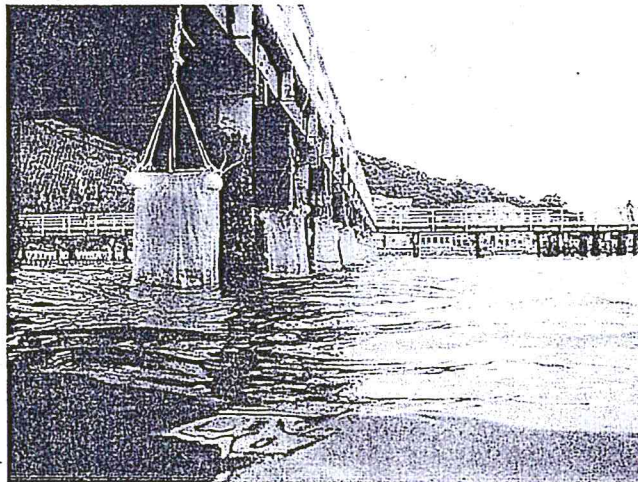


Plate 3. The in situ cylinders deployed on the outside of Chowder Bay harbour pool.

Into the body of water isolated by the cylinder, we introduce a rigorously stirred mixture of 1 litre of sediment with 5 litres of water. This mixture was poured into one of the water columns (cylinders) causing the water to become very turbid (reaching approximately 200 ntu). This is much greater than occurs with shipping movements (c.a. 50 ntu) or during dredging (approximately 100 ntu). This experimental resuspension can maintain levels of suspended sediments well above background (i.e. 2-5 ntu) for periods in excess of two hours. To mimic exposure to resuspensions caused by frequent shipping activity or dredging, we exposed the animals to the experimentally produced resuspension events approximately three times a day

(every 2 hours) every second day over a ten day period (i.e. fifteen doses per sediment treatment).

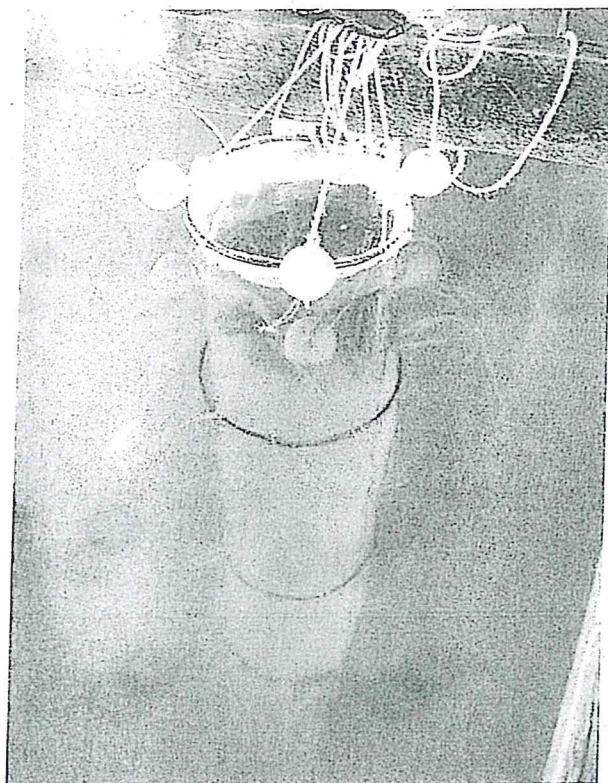


Plate 4. An experimental resuspension gradually falling to the bottom of the cylinder and on its way exposing the sessile invertebrates attached to the panel to the contaminated sediments and any metals released from the resuspended sediments. Resuspensions like this were repeated 3 times every 2 hours and maintained suspended sediments well above background throughout this dosing period.

Four resuspension treatments were used run to test the stated hypotheses. Two treatments used sediments from heavily polluted areas of Sydney Harbour (i.e. Rozelle Bay, Birch and Taylor 1999) and Port Kembla Harbour (Fig. 1, Knott et al. 2009); and sediments from one area that was far less polluted (e.g. Tambourine Bay, Lane Cove River; Fig. 1, Birch and Taylor 1999). We also ran a procedural control treatment which involved putting the animals into the *in situ* cylinders but not exposing them to resuspended sediments. Sediments were collected using a Van Veen grab from each location and sediments usually collecting the top 10 cm of sediment. These sediments are most likely to be resuspended by shipping type activity. The collected sediments were kept cool and moist until used in the experiments and fresh sediments were collected every three days.

We recovered two assemblages (i.e. on plates) from each panel five days after the final dosing. Each plate was taken to the laboratory, photographed and sampled under a microscope. This involved identifying and counting each of the animals on each plate or estimating their covers using a point-intercept method with 100 points uniformly distributed across the plate. For hard bodied organisms, such as, barnacles and bryozoans whether they were alive or dead could be identified and was also recorded.

We also analysed the heavy metals in the sediments from each location to confirm and quantify that the pollution loads of the sediments (i.e. relatively high and low heavy metal

contamination). Sediments from Rozelle Bay and Port Kembla were far more contaminated than those from Tambourine Bay (see Table 1 for details).

Table 1. Concentrations of metals in sediments from each collection site. Average metal concentrations are shown ($\mu\text{g/g}$; $n = 4-5$) with values greater than the ANZECC lower and upper levels are shown in grey or bold respectively.

Metal	Port Kembla	Rozelle Bay	Tambourine Bay
Arsenic	15	0	1
Cadmium	1	2	0
Cobalt	3	2	2
Copper	483	24	27
Iron	12457	11122	8696
Manganese	138	33	31
Nickel	7	8	3
Lead	689	415	123
Tin	87	7	3
Zinc	921	1196	314

Experimental design and statistical analyses

There were three experimental treatments (as outlined above): heavily contaminated sediment; less contaminated sediment; and a procedural control. These treatments were the fixed orthogonal factor of "Treatment". Six panels were used in each treatment this formed the random nested factor of "Panel". Two plates from each panel were sampled and formed the lowest level of the analysis. Analysis of variance and permanova were used to test the stated hypotheses. All analyses were done on raw data.

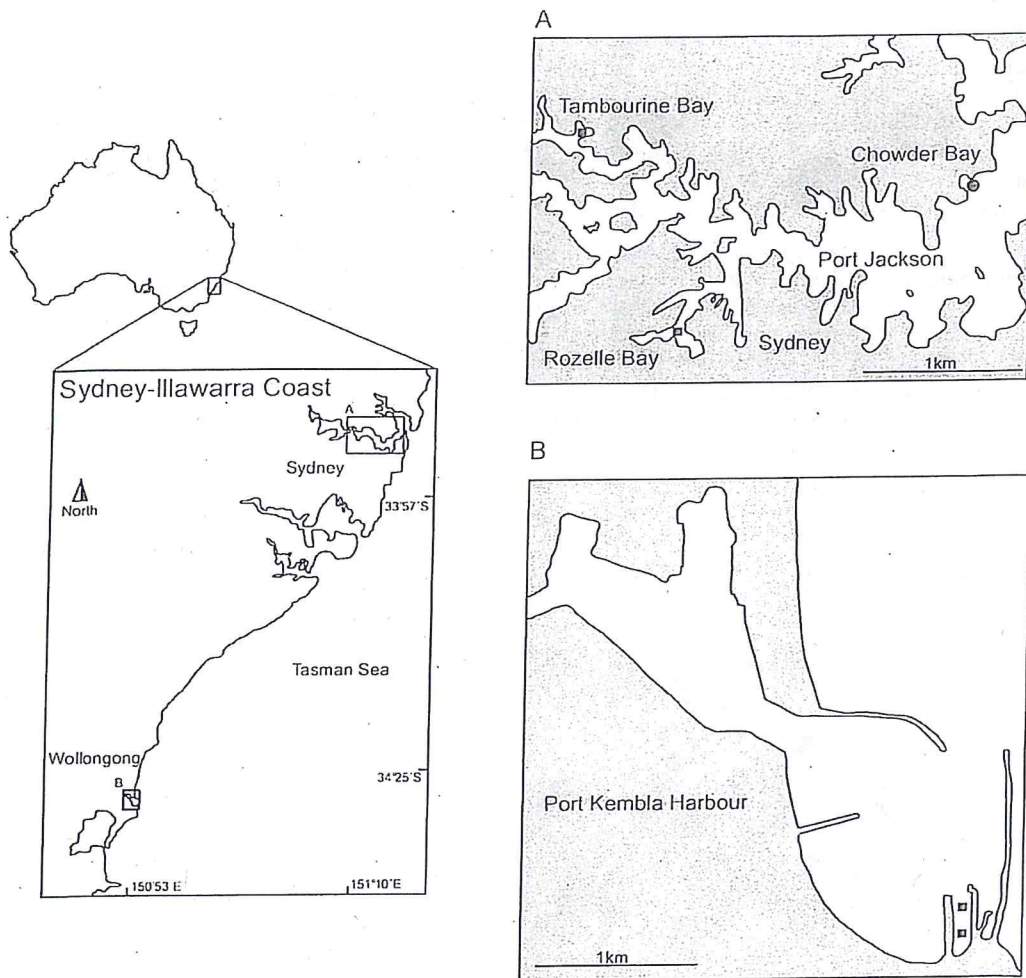


Figure 1. A map of the experiment site and sediment collection areas. The assemblages of sessile invertebrates were developed at the Chowder Bay Wharf and the experiments were conducted alongside the Chowder Bay harbour swimming pool. Contaminated sediments originated from Rozelle Bay in Sydney Harbour and Port Kembla Harbour (approx. 70 km south of Sydney). Relatively uncontaminated sediments originated from Tambourine Bay, Lane Cove River.

Results

A diverse and abundant assemblage of sessile invertebrates recruited to the plates between January and May 2009 (Plate 1). Colonial ascidians, sponges and encrusting bryozoans covered much of the surface of the recruitment plates and the introduced serpulid polychaete worm, *Hydroides elegans*, also recruited in enormous numbers. Solitary ascidians and arborescent bryozoans were also relatively abundant, however, barnacles were comparatively rare. This was unfortunate as barnacles were one of the main groups to show strong effects in related resuspension study (i.e. Knott et al. 2009).

The exposure of Sydney Harbour sessile invertebrates to repeated pulses of resuspended contaminated or relatively uncontaminated sediments had no detectable ecological effects (Permanova: $P = 0.76$; Fig. 2 & 3; Table 2). The assemblages represented by symbols in the Figure 2 (an nMDS plot) show how they are all overlapping with no separation among the treatments. This in conjunction with the multivariate analysis of these assemblages indicates that the assemblages of sessile invertebrates (i.e. their abundances and covers) were all very similar on plates in each of the experimental treatments.

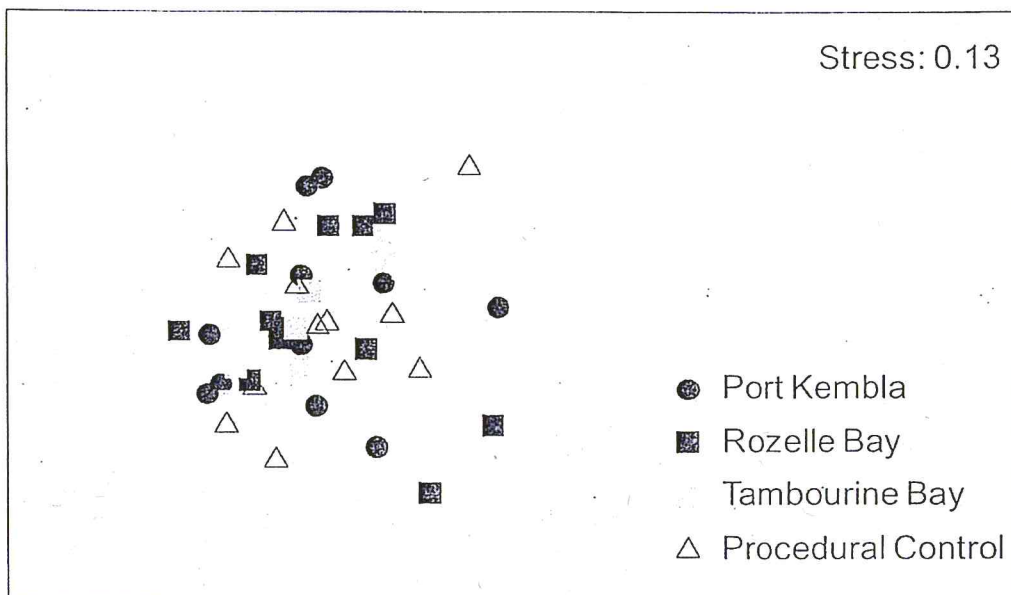


Figure 2. Non-metric multi-dimensional scaling plot representing the assemblages in each of the experimental treatments and the procedural control. This plot demonstrates the general similarity (or overlap) of the assemblages indicating that they were not affected by exposure to the resuspension of contaminated sediments ($n = 12$).

Diplosoma listerianum was the colonial ascidian that covered the largest areas in the recruitment assemblages. This species and *Botrylloides leachi* were responsible for most of the colonial ascidian coverage in these assemblages and neither was affected by the resuspension of contaminated or relatively uncontaminated sediments (Fig. 3a-c). Sponges also showed no effects (Fig. 3d). Sponges and colonial ascidians could have easily regressed in coverage if the resuspensions were causing significant stress.

None of the encrusting or arborescent bryozoans showed any difference in their coverage or densities among the resuspension treatments and procedural control (Fig. 2e-h, 3f). In fact, were actually very few dead (or partially dead) colonies observed in any of the recruitment assemblages. This clearly indicates that they were unaffected by the resuspension of contaminated or relatively uncontaminated sediments.

The solitary ascidians, which would be expected to decompose rapidly if the resuspensions were toxic to the ascidians, generally showed much more variation in the abundance among panels than among treatments and procedural controls (Fig 3c-e). Solitary ascidian sp. 1 (Fig. 3d) was the only ascidian to show a pattern of abundance consistent with an effect of the resuspension of contaminated sediments, although this was clearly not significant (Table 1).

The super abundant *Hydroides elegans* showed no difference in its numbers of live or dead individuals among the treatments and the procedural control (Fig. 3a-b). This pattern clearly indicated that they were unaffected by the resuspension of contaminated and relatively uncontaminated sediments.

Barnacles were relatively scarce in the assemblages at Chowder Bay (Fig. 3g-h). The few live barnacles on the plates showed no effect of resuspension, and there was obviously no increase in dead barnacles in the assemblages exposed to resuspensions of the contaminated or relatively uncontaminated sediments.

Table 2. Summary of the analysis of variance to test for the effect of resuspending contaminated sediments. The mean square values are shown for each level in the analysis. The stated hypotheses were tested by the factor "Treatment". Bold values indicate that the statistical term was significant ($P < 0.05$).

Source	Treatment	Panel(Treatment)	Residual
DF	5	30	36
Percentage cover			
<i>Diplosoma listerianum</i>	37	417	96
<i>Botrylloides leachi</i>	28	55	17
Colonial ascidians	16	380	116
Sponges	38	345	25
<i>Cellerporaria</i> sp.	12	277	53
<i>Schizoporella errata</i>	26	66	27
<i>Fenestrulina mutabilis</i>	3	9	9
Encrusting bryozoans	105	343	64
Density			
<i>Hydroides elegans</i> alive	34405	41651	28151
<i>Hydroides elegans</i> dead	6847	16319	6406
<i>Pyura ganglia</i>	126	121	80
Solitary ascidian sp. 1	30	66	68
Solitary ascidians	225	678	356
Arborescent bryozoans	678	705	372
Barnacles alive	96	92	116
Barnacles dead	18	19	21

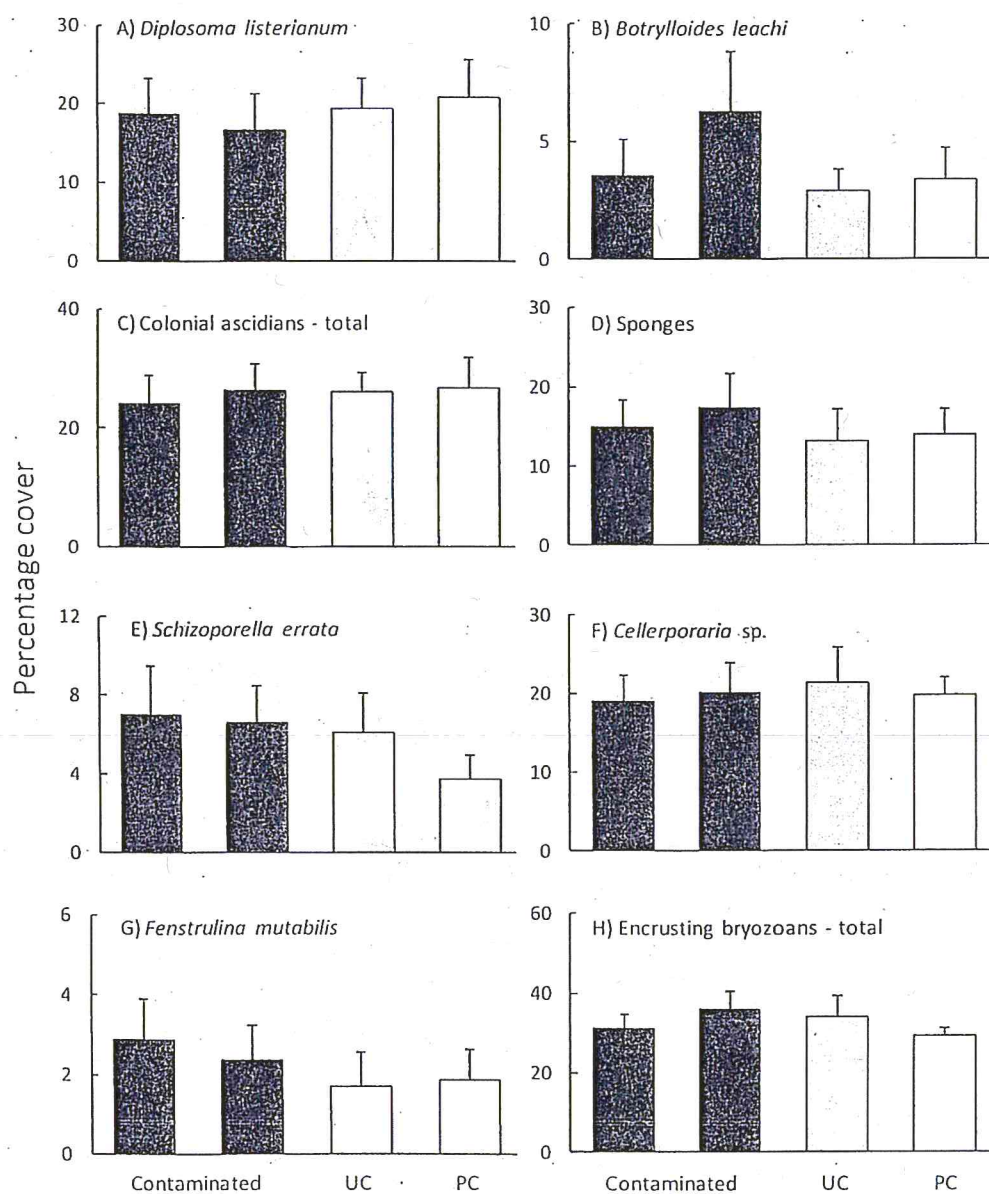


Figure 3. Percentage cover of the major encrusting sessile invertebrates exposed to resuspensions of contaminated and relatively uncontaminated sediments. Black = Heavily contaminated sediments; Grey = Relatively uncontaminated sediments; White = Procedural control. Mean + s.e., $n = 6$.

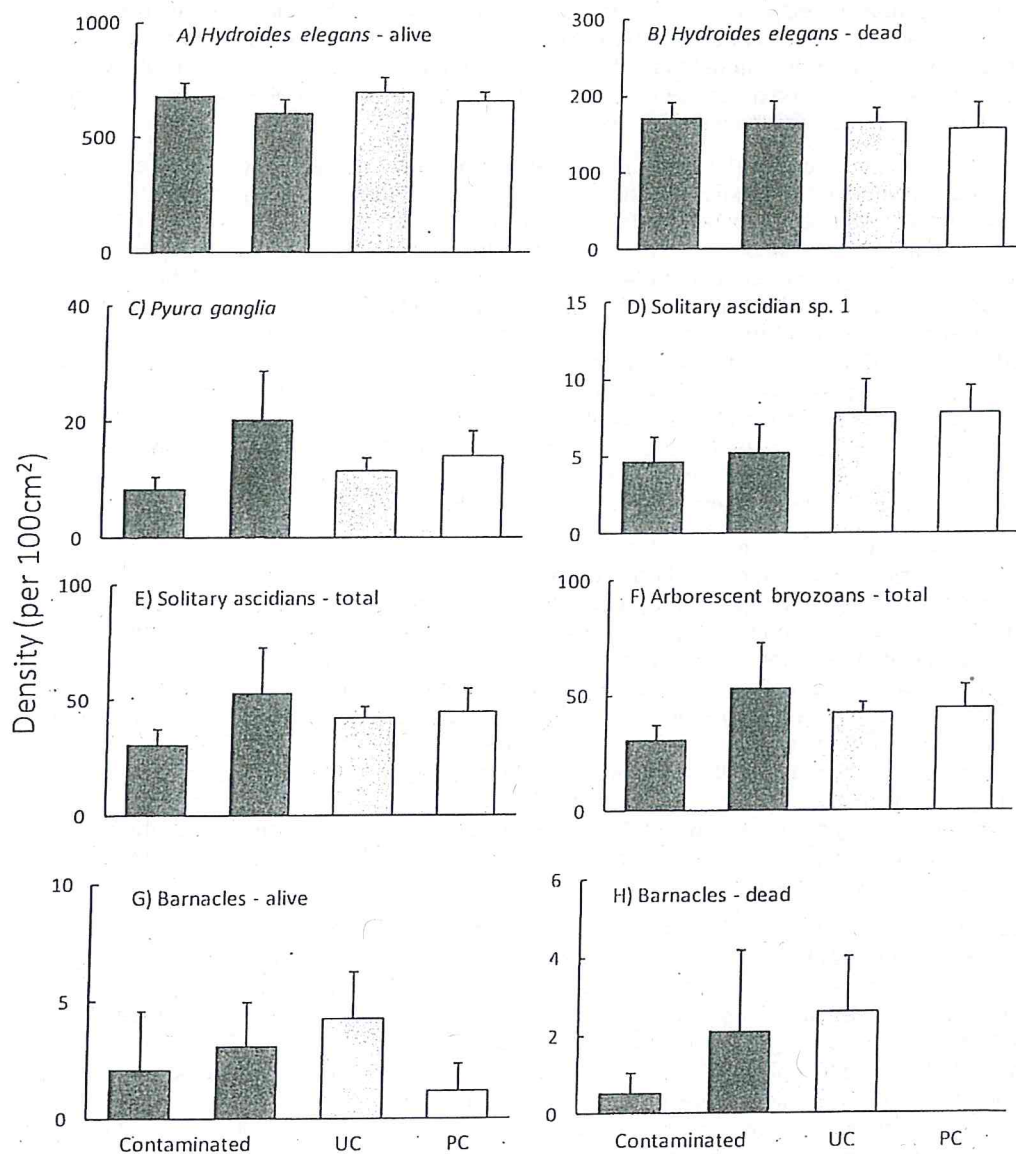


Figure 4. Density of the major encrusting sessile invertebrates exposed to resuspensions of contaminated and relatively uncontaminated sediments. Black = Heavily contaminated sediments; Grey = Relatively uncontaminated sediments; White = Procedural control. Mean + s.e., $n = 6$.

Discussion

The current study used a novel experimental technique to expose sessile invertebrates to repeated long-term doses of resuspended contaminated sediments. This experiment was an attempt to mimic the resuspension of contaminated sediment created by short-term disturbances, such as frequent shipping movements. No effects on a range of Sydney Harbour sessile invertebrates were, however, detected despite them being exposed to some of the most contaminated sediments in the world (both from within heavily contaminated sections of Sydney Harbour and elsewhere; Birch and Taylor 1999). Hence, this study provides no support for the model that intense, prolonged and repeated dosing of relatively clean or contaminated sediments over hourly, daily and weekly time scales have strong short-term effects on these sessile invertebrates.

The lack of an effect from relatively short-term resuspension of contaminated sediments is surprising considering the dramatic effects caused by the large-scale resuspension of contaminated sediments associated with dredging (Knott et al. 2009). Knott et al. (2009) observed that the recruitment of the most abundant taxa such as the barnacle *Amphibalanus variegatus* and the polychaete worm *Hydroides elegans* was greatly reduced. Arborescent bryozoans showed a similar pattern, although this pattern was not statistically significant. *H. elegans* and arborescent bryozoans recruited in great numbers in the current study, but were clearly unaffected by repeated dosing over the ten day period of the experiment. Barnacles (including *A. variegatus*) recruited in very low numbers and, thus, this experiment does not represent a good test for this taxon. Nonetheless, the abundance of barnacles was relatively low on all of the plates and the numbers of live or dead barnacles did not differ significantly among treatments. Hence, the duration of the exposure to resuspensions would appear to be an important factor in determining the likelihood of ecological impacts.

Many sessile invertebrates may be able to regulate their exposure to short-term resuspension events by closing the apertures and not filter-feeding. Such responses have been observed for barnacles (Lopez and Lopez 2005) and polychaete worms (Hill et al. 2009). Hence, despite their inability to move away from such resuspension events, estuarine invertebrates may still regulate their exposure to water conditions through behavioural responses. Such behaviour may have developed in response to the dramatic changes in salinity or turbidity that occur in these areas. Nevertheless, observed effects caused by longer-term exposure to resuspended contaminated sediments caused by dredging (Knott et al. 2009) suggest that they may be unable to deal with such events over longer periods of time. Logically, their isolations to the surrounding water-column would reduce the ability of these organisms to feed and in the long run they would either starve or need to expose themselves to the resuspended contaminants to feed. Either response would be likely to lead to the death or severe stress for the organism.

Surprisingly, there was no indication that exposure to high levels of suspended sediments themselves had any short-term effects. High levels of suspended sediments are often argued to impact upon sessile invertebrates (Airoldi 2003) and on this basis the relatively uncontaminated sediments were also predicted to affect the assemblages. Nevertheless, our results support the findings of a review by Wilber and Clarke (2001) that indicated that suspended sediments only tend to affect estuarine invertebrates and fishes at extremely high levels are used in laboratory experiments. These extremely high values are much greater than that experienced in observed in most estuaries (Wilber and Clarke 2001). Our study indicates that even exposure to very high levels of suspended sediments for 6 hours periods may not affect estuarine sessile invertebrates on vertical surfaces.

The results of this study indicate that small infrequent disturbance of contaminated sediments may not be an ecological problem, possibly because invertebrates have evolved to deal with frequent natural changes in the water condition of estuaries. If this lack of effect is general across other organisms within Sydney Harbour, then a reasonable management strategy for such contaminated sediments that are only infrequently disturbed may be to continue to leave them as they are (see Birch 2000 for discussion). Especially considering the great expense associated with moving and cleaning sediments (Kelaher et al. 2003). Active management methods may need to be developed if, however, contaminated sediments were frequently disturbed either by natural (e.g. storms, tidal currents) or human-induced (e.g. boating, shipping) as they may be causing impacts to the ecology of these estuaries (see Knott et al.

2009). Further research is currently being carried out by the authors to assess the long-term exposure of resuspension of contaminated.

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References

- Airolidi, L. 2003. The effects of sedimentation on rocky coast assemblages. *Oceanography and Marine Biology* 41:161-236.
- ANZECC, and ARMCANZ. 2000. Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian Government Publishing Service, Canberra.
- Aple, S., and G. E. Balley. 1995. Trace Metal Speciation of Labile Chemical Species in Natural Waters and Sediments: Non-Electrochemical Approaches. Pages 259-306 in A. Tessier and D. R. Turner, editors. Metal speciation and bioavailability in aquatic systems. J. Wiley, Chichester.
- Australian State of the Environment Committee. 2001. Australia State of the Environment 2001: Independent Report to the Commonwealth Minister for the Environment and Heritage. CSIRO Canberra.
- Birch, G. F. 2000. Marine pollution in Australia, with special emphasis on central New South Wales estuaries and adjacent continental margin. *International Journal of Environment and Pollution* 13:573-607.
- Birch, G., and S. Taylor. 1999. Source of heavy metals in sediments of the Port Jackson estuary, Australia. *Science of the Total Environment* 227:123-138.
- Campbell, P. G. C. 1995. Interactions between Trace Metals and Aquatic Organisms: A Critique of the Free-ion Activity Model. Pages 45-102 in A. Tessier and D. R. Turner, editors. Metal speciation and bioavailability in aquatic systems. J. Wiley, Chichester.
- Clements, W. H. 2004. Small-scale experiment support causal relationships between metal contamination and macroinvertebrate community responses. *Ecological applications* 14:954-967.
- Cope, W. G., J. G. Wiener, and M. T. Steingraeber. 1996. Test system for exposing fish to resuspended, contaminated sediment. *Environmental Pollution* 91:177-182.
- Cundy, A. B., I. W. Croudace, A. Cearreta, and M. J. Irabien. 2003. Reconstructing historical trends in metal input in heavily-disturbed, contaminated estuaries: studies from Bilbao, Southampton Water and Sicily. *Applied Geochemistry* 18:311-325.
- Herbrandson, C., S. P. Bradbury, and D. L. Swackhamer. 2003. Influence of suspended solids on acute toxicity of carbofuran to *Daphnia magna*: I. Interactive effects. *Aquatic Toxicology* 63:333-342.
- Hill, N., C. King, L. Perrett, and E. Johnston. 2009. Contaminated sediments toxic to an Antarctic filter feeder: aqueous and particulate phase effects. *Environmental Toxicology and Chemistry* 28:409-417.
- Honkoop, P. J. C., B. L. Bayne, A. J. Underwood, and S. Svensson. 2003. Appropriate experimental design for transplanting mussels (*Mytilus* sp.) in analyses of environmental stress: an example in Sydney Harbour (Australia). *Journal of Experimental Marine Biology and Ecology* 297:253-268.
- Johnston, E. L., and M. J. Keough. 2003. Competition modifies the response of organisms to toxic disturbance. *Marine Ecology Progress Series* 251:15-26.
- Johnston, E. L., and D. A. Roberts. 2009. Contaminants reduce the richness and evenness of marine communities: A review and meta-analysis. *Environmental Pollution* 157:1745-1752.
- Kimball, K. D., and S. A. Levin. 1985. Limitations of Laboratory Bioassays: The Need for Ecosystem-Level Testing. *Bioscience* 165-171.
- Knott, N. A., J. P. Aulbury, T. H. Brown, and E. L. Johnston. 2009. Contemporary ecological threats from historical pollution sources: impacts of large-scale resuspension of contaminated sediments on sessile invertebrate recruitment. *Journal of Applied Ecology* 46:770-781.
- Long, E. R. 2000. Degraded sediment quality in U.S. estuaries: a review of magnitude and ecological implications. *Ecological applications* 10:338-349.
- López, B. A., and D. A. López. 2005. Moulling frequency and behavioural responses to salinity and diesel oil in *Austromegabalanus psittacus* (Molina) (Cirripedia: Balanidae). *Marine and Freshwater Behaviour and Physiology* 38:249 - 258.
- Luoma, S. N., and D. J. H. Phillips. 1988. Distribution, variability, and impacts of trace elements in San Francisco Bay. *Marine Pollution Bulletin* 19:413-425.
- McLusky, D. S., V. Bryant, and R. Campbell. 1986. The Effects of Temperature and Salinity on the Toxicity of Heavy-Metals to Marine and Estuarine Invertebrates. *Oceanography and Marine Biology* 24:481-520.
- Millward, R. N., K. R. Carman, J. W. Fleeger, R. P. Gambrell, and R. Portier. 2004. Mixtures of metals and hydrocarbons elicit complex responses by a benthic invertebrate community. *Journal of Experimental Marine Biology and Ecology* 310:115-130.
- Morrisey, D. J., S. J. Turner, G. N. Mills, R. B. Williamson, and B. E. Wise. 2003. Factors affecting the distribution of benthic macrofauna in estuaries contaminated by urban runoff. *Marine Environmental Research* 55:113-136.
- Morrisey, D. J., R. B. Williamson, L. Van Dam, and D. J. Lee. 2000. Stormwater contamination of urban estuaries. 2. Testing a predictive model of the build-up of heavy metals in sediments. *Estuaries* 23:67-79.
- Nayar, S., B. P. L. Goh, and L. M. Chou. 2004. Environmental impact of heavy metals from dredged and resuspended sediments on phytoplankton and bacteria assessed in situ mesocosms. *Ecotoxicology and Environmental Safety* 59:349-369.
- Saulnier, I., and A. Mucci. 2000. Trace metal remobilization following the resuspension of estuarine sediments: Saguenay Fjord, Canada. *Applied Geochemistry* 15:191-210.
- Simpson, S. L., S. C. Aple, and G. E. Balley. 1998. Effect of Short-Term Resuspension Events on Trace Metal Speciation in Polluted Anoxic Sediments. *environmental science and technology* 32:620-625.
- Sved, D. W., and M. H. Roberts. 1995. A novel use for the continuous-flow serial diluter: Aquatic toxicity testing of contaminated sediments in suspension. *Water Research* 29:1169-1177.
- Underwood, A. J. 1995. Toxicological testing in laboratories is not ecological testing of toxicology. *Human and Ecological Risk Assessment* 1:178-182.
- Wilber, D. H., and D. G. Clarke. 2001. Biological Effects of Suspended Sediments: A Review of Suspended Sediment Impacts on Fish and Shellfish with Relation to Dredging Activities in Estuaries. *North American Journal of Fisheries Management* 21:855-875.

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1 June 2015

Save Rozelle Bay Association
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Dear sir

Re: Section 75W modification application, Sydney Superyacht Marina, Rozelle Bay (MP09_0165 MOD 1)

We would like to comment on the proposed modification of Sydney Superyacht Marina and consolidation and expansion of the operations of its existing facility.

The land owned by NSW Maritime, an area of approximately 11,640m², is currently being used as a superyacht marina with a capacity of 24 berths and associated use.

The existing facility was approved in May 1999 and in December 1999 approval was granted to cater for large recreational vessels visiting Sydney for the 2000 Olympic Games and America's Cup 2001 and were to be removed following these events. Temporary approvals had been granted over the following years, usually granting 12 month extensions for the continued operation of the facility.

Significant expansion of the facility including reconfiguration of the existing berths, additional berths, changing the parking layout and improvement to public access and landscaping was given consent in August 2008.

This modification proposal seeks to further increase all aspects of the marina's land and water based components. The application seeks: the GFA for the development to be increased from 6200 m² to 6880m²; reconfiguration of the marina with an increase in the number of berths from 24 to 43 (plus tender berths) and changes to berthing arrangements; changes to the eastern building with an additional roof level terrace; design changes to the car park building with additional 4 & 5 levels and expansion to the north; increase to the car parking spaces from 219 to 307 and arrangements; use of outdoor seating areas and changes to staging.

Multi-storey car park and parking:

The proposed multi-storey car park is in a visually prominent location clearly viewed from the Anzac Bridge, Victoria Road and the Bicentennial Park. As the gateway experience for tourists arriving/departing the Cruise Passenger Terminal, along James Craig Road, en route to the City the structure is totally inappropriate.

The permanent car parking spaces proposed increase is from 219 to 307 which is almost 100%. Proposed changes to the eastern building with an additional roof level terrace and design changes to the car park building with additional 4 & 5 levels and expansion to the north is excessive and ugly. The over-sized rectangular structures are totally out of context with the surroundings, where a positive contributory building to place with unrestricted vistas and views would add to the public enjoyment/ experience of the location. "Rectangular boxy

shapes with flat or skillion roofs usually do not harmonise with their surroundings." (4.5 Built Form; Development Control Plan for Sydney Regional Environmental Plan (Sydney Harbour Catchment) 2005)

"The Harbour and Parramatta River and their tributaries are for everyone's enjoyment and public access to the foreshore and waterway is fundamentally important. Design and siting of water-based and land/water interface development should recognise the importance of these principles. Individual private facilities should not be visually dominant. Development should complement rather than compete with the other established elements." (4.1 Introduction; Development Control Plan for Sydney Regional Environmental Plan (Sydney Harbour Catchment) 2005).

Traffic impact:

The proximity of the site to several major redevelopments will have a huge impact on the road network. The Cruise Passenger Terminal uses James Craig Road as their sole public access. The Crescent/ Victoria Road and The Crescent/ City West Link and adjacent intersections will be at capacity in an already congested area. Local roads will not have the ability to absorb the increased traffic resulting from proposed changes without having an adverse effect on the surrounding road network.

Outdoor seating areas and staging:

The proposed outdoor seating areas and changes to staging will permit restaurants, bars and taverns and provide the opportunity for the outdoor area to become a single large entertainment or function venue. The proposal will also restrict waterfront pedestrian hours between closing time of the licensed facilities and 6am because of 'asset security'.

Restricted waterfront access is inconsistent with the Rozelle and Blackwattle Bays Maritime Precinct Master Plan 2002 which requires 24 hour access to the waterfront. Restriction of access to the waterfront promenade will result in the privatisation of the waterfront.

The site:

The site represents an important opportunity to make a significant contribution to the visual character, identity and functionality of Rozelle Bay. The proposed development lacks adequate physical and perceptual linkages to the surrounding urban fabric and facilities and is contrary to generally accepted urban design principles associated with mixed use development. The wide range of commercial and entertainment facilities proposed for the site, being an 'out of centre' location will have significant detrimental impact upon other local commercial centres. *"the cumulative impact of development along the shoreline is considered having regard to preserving views of special natural features, landmarks or heritage items."* (4.5 Built Form, Development Control Plan for Sydney Regional Environmental Plan (Sydney Harbour Catchment) 2005).

Architectural character and design:

The proposed architectural form is inconsistent with the Development Control Plan for Sydney Regional Environmental Plan (Sydney Harbour Catchment) 2005, which is a comprehensive, well considered document:

4 Design Guidelines for Water-Based and Land/Water Interface Developments

4.2 General Requirements:

The following objectives and requirements must be considered for all water-based and land/water interface developments:

- public access to waterways and public land is maintained and enhanced;*
- congestion of the waterway and foreshore is minimised;*
- conflicts on the waterway and foreshore are avoided;*
- the development warrants a foreshore location;*
- the development does not interfere with navigation, swimming or other recreational activities;*

- the demand for the development has been established;
- the structure does not obstruct or affect the natural flow of tides and currents;
- development does not dominate its landscape setting;
- the extent of development is kept to the absolute minimum necessary to provide access to the waterway;
- shared usage of facilities is encouraged to minimise the number of structures and their cumulative impact on the environment of the Harbour and its tributaries; and
- development is setback at least 2.5 metres from the division of the waterway as established by the NSW Maritime Authority and illustrated in Figure 4.

4.3 Foreshore Access

Foreshore access is to be encouraged and promoted. Wherever possible, public access to and along the foreshore including the inter-tidal zone should be secured or improved.

Foreshore links joining public open spaces or access points are most desirable. These can be obtained by right of way or dedicated or acquired strips of land and may link with tracks across beaches and rock platforms. Where foreshore links are not available, a link through adjacent streets is usually possible. The maps accompanying this DCP indicate existing and potential pedestrian and bicycle access around the foreshore. When designing and assessing a development, consideration should be given to providing these access routes.

4.4 Siting of buildings and Structures

Most councils around the foreshores have set foreshore building lines governing the setback of structures from the waterway. In addition to these foreshore building lines, the following criteria should be observed when siting buildings and structures:

- where there is existing native vegetation, buildings should be set back from this vegetation to avoid disturbance to the vegetation;
- buildings should address the waterway;
- buildings should not obstruct views and vistas from public places to the waterway;
- buildings should not obstruct views of landmarks and features identified on the maps accompanying this DCP.

4.5 Built Form

Buildings and other structures should generally be of the same scale and of a design sympathetic to their surroundings; well designed contrasts will be considered where they enhance the scene. Many councils have development controls governing built form and the heights of buildings. The following guidelines are designed to reinforce the local requirements:

- where buildings would be of a contrasting scale or design to existing buildings, care will be needed to ensure that this contrast would enhance the setting;
- while no shapes are intrinsically unacceptable, rectangular boxy shapes with flat or skillion roofs usually do not harmonise with their surroundings. It is preferable to break up facades and roof lines into smaller elements and to use pitched roofs;
- bright lighting and especially floodlighting which reflects on the water, can cause problems with night navigation and should be avoided. External lights should be directed downward, away from the water. Australian Standards (AS4282-1997)

Guidelines for Outdoor Lighting and Pedestrian Area (Category P) Lighting (AS/NZ 1158.3 - 1999) should be observed;

- except where otherwise required for navigation purposes, all lights on structures shall be shielded seawards and positioned to avoid disturbance to neighbouring properties;
- use of reflective materials is minimised and the relevant provisions of the Building Code of Australia are satisfied;
- colours should be sympathetic with their surrounds and consistent with the colour criteria, where specified, for particular landscape character types in Part 3;
- the cumulative visual impact of a number of built elements on a single lot should be mitigated through bands of vegetation and by articulating walls and using smaller elements; and

- *the cumulative impact of development along the shoreline is considered having regard to preserving views of special natural features, landmarks or heritage items.*

Pedestrian promenade:

The proposed pedestrian promenade along the waterfront is up to 25m wide with no vertical features or definition of space. No consideration has been given to the ways in which these spaces will be used. Microclimatic effects such as exposure to sun, wind and rain have not been translated into the urban design and landscape elements. Such elements could make a significant contribution to the place becoming a welcoming and attractive destination for the public as well as users of the facilities.

Noise:

There will be an impact from noise generated across the bay to parklands and residential properties in Glebe, Annandale and Rozelle which are adjacent to the parklands/open space. The noise generated by services, such as garbage collection, both during and outside the hours of operation will also have a significant impact.

Social Impact :

Apart from impacts mentioned above there will be others. Alcohol related incidences, including crime, are most concentrated within 500 metres of licensed premises which are likely progressions of this application. The scale of the proposed development will have a negative impact on the visual amenity and pedestrian access to water views and access to the water frontage. The proposal should desire to enhance the existing public domain by increasing pedestrian thoroughfares and the walkability of local neighbourhoods, including disabled access, in an unbroken promenade along the foreshore of Rozelle Bay.

There is a concern that the cumulative impacts of the night time entertainment activities of licensed premises will change the perceived character of the neighbourhood from being a low impact, working waterfront to an entertainment and privileged leisure precinct, of a markedly different character to the working harbour origins of the site.

Passive use of Rozelle Bay/Social Significance:

The Glebe Rowing Club (1879) and University of Sydney Women's Rowing Club (formed 1860: has had presence in various locations on Sydney Harbour since 1886), and various Dragon Boat teams are located in Blackwattle Bay and use Rozelle Bay for training purposes. These teams are part of the social significance of Rozelle Bay and the passive nature of the bay should be retained because of this continuing use and Social Significance of the bay since 1879.

Conclusion:

The proposed modifications are inappropriate for the site. The proposed architectural character is inconsistent with that of nearby harbourside areas and the buildings do not reflect the character and diversity of waterside buildings in the area. It does not make a positive contribution to the sense of place nor respect the Social Significance of the bay. We object strongly to these proposed changes.

Yours sincerely

Janice Cave
President
Save Rozelle Bay Association