Antifouling Technologies for Coastal Pools and Platforms
Project outline and specifications, February 2009

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i) Background

The Sydney Coastal Councils Group faces a continual challenge from the settlement and growth of marine algae ("fouling") on coastal rock pools, platforms and steps leading into bays/pools. The challenge arises from public health and safety concerns (and associated council liability) for bathers who can slip on fouled surfaces.

The current method that is used to remove fouling is frequent mechanical cleaning with a jet stream of high pressure water (jet blast) or by scrubbing with a hard brush and granules. Previously, biocides such as chlorine-based bleaches were used in conjunction with mechanical cleaning to remove fouling. This practise has been discontinued, however, due to concerns over possible non-target effects in the marine environment.

Frequent mechanical cleaning alone is not a satisfactory option for maintaining safe coastal platforms and non-slip access to bays/pools due to the rapid regrowth of fouling organisms. Micro-fouling (bacteria, diatoms, protozoa, unicellular algae) can form a slippery layer of slime within a day or two while macro-fouling, commonly the green alga *Ulva lactuca* and *Enteromorpha sp.*, will cover submerged surfaces within two weeks. The frequency of mechanical cleaning of fouled surfaces is also constrained by several factors:

1) Availability of Jet Blaster truck for e.g., one truck services the whole Randwick Council area and is used to clean other public areas (parks) in addition to coastal platforms/pool access
2) Access of Jet Blaster to problem areas is limited by physical barriers
2) Access to coastal pools/platforms is limited during periods of high patronage
3) Access to submerged fouled surfaces (i.e., concrete steps) is possible only at very low tides.

There are a range of problem areas affected by fouling which are common along Sydney's coastline: access steps leading into bays or rock pools, concrete and sandstone areas adjacent to bays and pools, and coastal concrete pools. The frequent mechanical cleaning of fouled surfaces costs Sydney's coastal councils hundreds of thousands of dollars per annum in labour. An alternative approach to maintaining safe coastal pools and platforms is to apply antifouling coatings to affected concrete/sandstone surfaces. Antifouling technologies could deter fouling eliminating the need for mechanical cleaning of these surfaces. Or levels of fouling could be reduced significantly such that mechanical cleaning was not required as often, or to the same extent (i.e., surface can be cleaned with a broom instead of by jet blasting). Clearly, there is great potential to reduce the labour costs of Sydney coastal councils associated with the maintenance of safe coastal pools and platforms.

Test sites have been selected based on the range of slip hazards found along the coastline represented by the Sydney Coastal Councils Group. The following sections provide a detailed description of each site, grouping of sites by characteristic features, factors to consider for anti-foul coatings and an outline of the trial design and schedule.

ii) Fouling Issues at Coastal Sites

Coastal pools and platforms that are of concern to the Randwick and Sutherland Shire Councils have been surveyed and are described below.

Randwick City Council Sites

Clovelly Bay Promenade

The concrete promenade on the southern and northern sides of Clovelly Bay is extensively fouled by black micro-algae (probably a blue-green alga). The fouled concrete is not slippery when it is dry but becomes extremely slippery when wet (photo 1). The growth of the micro-fouler occurs across the whole southern promenade but is more pronounced and of particular concern near the edges of the promenade adjacent to the bay. Problem areas of the promenade are cleaned (jet-blast with water) at approximately 3 weekly intervals (photo 2).

Clovelly Bay Steps

There are 5 access points (stair wells) into Clovelly Bay from the southern promenade and 4 access points from northern promenade. The access points are a set of stainless steel steps leading down to the waters edge. There are concrete steps at the bottom of the stainless steel steps which are submerged most of the time and get fouled with green algae (*Ulva lactuca / Enteromorpha sp.*) within a week or two of cleaning. These fouled concrete steps are extremely slippery and present a very real hazard for bathers entering or leaving the water (photo 3). The concrete steps are only accessible for jet-blast cleaning when the tide, sea conditions and public activity allow. The usual period between cleaning is approximately every 4-6 weeks (photo 4).

Clovelly Pool

The concrete pool is painted with standard blue pool paint. Pool surfaces get fouled with green algae (photo 5) and become slippery within a week or two of cleaning. Kelp and sand also collect in the pool. The pool gets cleaned approximately 3 times per month by scrubbing with a broom. When the pool is filled with sand and kelp seaweed after a storm the pool is drained to help cleaning. When this occurs the pool sides and floor is jet-blasted to remove the algal fouling. This occurs approximately once a month. Pool maintenance would be greatly reduced if pool surfaces were not fouled.

Clovelly Beach Wheelchair Access

There is a timber wheelchair access ramp at the northern side of the beach which leads into the sea. The timber gets heavily fouled by green algae and is jet-blasted every 4-6 weeks.

Mahon Rock Pool

Mahon rock pool in Maroubra is a predominantly natural sandstone structure located on the oceans edge. There is a concrete walkway around the pool but the majority of surfaces (surrounds, walls, floor, steps) are sandstone. Black micro-algae grow on the concrete and sandstone areas surrounding the pool (photo 6). These areas are jet blasted as necessary, usually once a month. There are 3 sets of concrete/sandstone steps at the western end of the pool which get heavily fouled by green algae (photo 7). This rock pool seems to experience heavier fouling on submerged surfaces. The pool and steps are scheduled for cleaning once a month.

Malabar Rock Pool

Malabar rock pool is situated in Long Bay and is predominantly a concrete structure surrounded by natural sandstone rock platforms. Black micro-algae grow on the concrete and sandstone areas surrounding Malabar rock pool. These areas are jet blasted as necessary, usually once a month. There are 2 sets of steps in the rock pool in the SE and NW corners, as well as a wheelchair ramp in the SE corner. The concrete steps and ramp get fouled by brown algae and become very slippery (photo 8). The concrete vertical surfaces of the pool experience low- moderate levels of fouling. The pool and steps are scheduled for cleaning once a month. The rock pool is just below Randwick Golf Course which is fertilised regularly. Consequently, the pool can experience a high nutrient loading after rain due to run-off from the golf course.

Malabar Boat ramp

Malabar boat ramp is the primary launch site in the Randwick area (photo 7). The ramp becomes very slippery for pedestrian traffic and is jet-blasted approximately once every 3 months.

There are two other boat ramps in the Randwick Council area, one at Frenchmans Bay and one at Yarra Bay, both of which are not cleaned by council staff.

Sutherland Shire Sites

Cronulla Rock Pool

Cronulla rock pool is the most popular rock pool in the area. It experiences similar fouling conditions to the rock pools described for the Randwick area with a few notable differences. The main slip hazard here is the NW corner of the pool where the pool surrounds are constantly wet as it is the lowest point in the pool design. Access stairs are also in this corner and consequently it is a high use area. The concrete surface in this NW corner gets heavily fouled by brown and green algae (photo 9) which is extremely slippery. This area is usually cleaned every fortnight by scrubbing with a hard brush and a granular solution. Sometimes the area is cleaned by jet blasting but it is difficult to get the equipment to this area. Council staff consider jet-blasting to be an ineffective cleaning method due to rapid regrowth of fouling organisms (within 2 weeks of cleaning).

There is a large concrete access ramp on the western side (photo 10) which becomes very slippery when fouled by brown-orange micro-algae. Fouling is removed using a concrete grinding machine which removes the top layer of concrete. This procedure has proved to be effective for up to 6 months, depending on fouling pressure (i.e., sea and weather conditions). The steps in the pool are covered with thick black rubber which gets heavily fouled by green algae but the fouled rubber steps are not as slippery as fouled concrete steps found in other rock pools. These steps are cleaned by scrubbing with a hard brush and a granular solution when the pool is emptied for cleaning (every 2-6 months, depending on fouling pressure) and perhaps once in between pool cleans if necessary. Hard-fouling organisms such as oysters grow more abundantly in the rock pools in the Shire but are not a common fouling organism in the Randwick area. These are scraped off the vertical pool surfaces with a shovel when the pool is emptied for cleaning.

Shelley Rock Pool

Shelley rock pool is never emptied for cleaning. It is predominantly a concrete structure with concrete walls, steps and wheelchair access ramp. The concrete steps and ramp get fouled by brown algae. They are cleaned by jet-blasting or by scrubbing with a hard brush and a granular solution approximately every 2 months. Extensive fouling occurs on the vertical walls. Hard-soft fouling is scraped off of the walls using the back of a shovel approximately every six months. The pool is used by a local swimming club for lap swimming. The vertical walls at the lap-end are cleaned more frequently (usually by divers) at the request of the swimming club.

Oak Rock Pool is rarely maintained.

Boat launch ramps

There are many boat launch ramps (approximately 15) in the Sutherland Shire due to the many waterways in the area (Port Hacking, Georges River, Woronora River, Bate Bay, Offshore). Some of these boat ramps experience a high level of fouling and pose a significant slip hazard while others do not have fouling issues. For example, a fairly serious slip incident occurred last year at the boat ramp at Water St, Woolooware while another slip incident occurred recently at the boat ramp at Hawkesbury Reserve, Sylvania Waters. Boat ramps are cleaned by scrubbing with a hard broom and a granular solution (sand) in response to local's requests.

Timber Wharves

There a number of timber wharves in the Sutherland Shire, some with concrete pontoons which do not get fouled by algae (e.g., Cronulla Wharf, Prince Edward Park Woronora). Other wharves have lower steps in the intertidal zone which get fouled with algae and become very slippery (Bundeena, Bull's Rd Woolooware).

iii) Site categories

The sites described above have a number of common characteristics.

- Concrete steps leading to the pools or bays. These are regularly used by most bathers to enter or leave the water and are submerged most of the time. The rapid fouling makes the surface very slippery for the majority of time despite regular cleaning.
- Concrete or sandstone platforms surrounding the pools and bays. These areas are heavily used. The public cross these areas to access the bathing areas and they are used as a communal place for sunbathing, walking and other activities. The thin layer of fouling is deceptively slippery when wet and difficult to completely remove by jet-blasting.
- The side and bottom surfaces of the man-made pools (excluding natural bays and inlet). Although in areas of high public use these surfaces are likely to be a lower slip hazard because people are only exposed to these surfaces when they are in the water. The main issues appear to be: a) if left unchecked the pool would be an unpleasant place for swimming, b) other fouling would likely start to cause problems, and b) regular cleaning is required to maintain the pool's amenity.
- Wooden walkways/steps in the intertidal zone. These surfaces become rapidly fouled with a green alga and present a high slip hazard. The number of wooden structures in Sydney Coastal Councils area that present this type of slip hazard to the public are unknown. Based upon the current survey it is considered that this type of problem is limited.

iv) Selected Sites for Field Trial of Antifouling Technologies

The concrete surfaces that form the steps, platforms and pools will be the priority of this trial given the surface area, level of public usage and the slip hazard they present from rapid fouling. Timber surfaces may be addressed in the next field trial to be conducted over the summer of 2009-2010. The sites chosen for Randwick and Sutherland Shire are listed below. As Clovelly Bay and Malabar Rock Pool are representative of the coastal pools in Cronulla, test coatings for immersed surfaces (i.e., steps) will not be tested in the Sutherland Shire. However, test coatings which can be directly applied to coastal platforms will be tested at Cronulla Rock Pool and at the boat ramp at Hawkesbury Reserve, Sylvania Waters. The environmental factors experienced by selected sites are summarised in Table 1. The experimental design and application and performance specifications applicable to each site are summarised in Table 2.

1) Clovelly Bay Promenade (photo1,2)
2) Clovelly Bay Steps (photo 4)
3) Clovelly Pool (photo 5)
4) Malabar Rock Pool Steps (photo 8)
5) Malabar Boat Ramp
6) Cronulla Rock Pool Western Edge (photo 9, northern edge)
7) Cronulla Rock Pool Access Ramp (photo 10)
8) Hawkesbury Reserve Boat Ramp, Sylvania Waters
9) Kirribilli Wharf (protected site)

v) Antifouling solutions and specifications

Most ship antifouling paints are not appropriate for use on coastal pools and platforms as they use toxic chemicals (typically heavy metals or organic biocides) or non-stick (foul-release) technology which would only exacerbate the problem of slippery surfaces. Foul-release coatings are also expensive and require specialist application knowledge. They also require a reasonably high level of shear (equivalent to 10-15 knots boat speed) to remove fouling.

A major challenge in formulating novel antifouling non-slip coatings for coastal areas relates to their application as outlined in the specifications below. Generally, standard antifouling paints need to be applied to a dry surface and a curing time of 72 hours is often recommended. Paints requiring standard application procedures *in-situ* are unlikely to be suitable for coastal platforms areas that are only exposed at low tide or constantly wet or from spray or bathers.

The concrete platform and pool areas are likely to present fewer problems for *in-situ* application compared to the steps leading in the pools and bays. Although the platform areas are exposed to seawater during heavy weather and high tides there are frequent periods when they can be treated as a standard outdoors concrete surface. The large surface areas of these sites also make direct application of a paint or coating the only likely method of application.

The concrete steps that provide access to the sea are more of a challenge for direct application. Some commercially available coatings are able to be applied directly to damp or underwater marine surfaces. There are however no known anti-foul paints that meet these criteria. Given the small surface area a possible approach is to apply the coating off-site to a suitable material. The coated material could then be fixed to the concrete steps by anchored bolts and physically replaced as required.

There is likely to be considerable flexibility in terms of acceptable maintenance options for an anti-foul coating. An example might be a coating that is fouled but the fouling is easily removed and the period between cleaning is extended. If a coating requires some physical cleaning then this should be considered as part of the trial protocol.

The other major challenge is the assessment of safety to humans who stand or lie on the coatings, and to non-target species. Biocides that for anti-foulant coatings are not out of the question however primary concerns are direct human contact with the coating and the effect of leached active constituents on non-target organisms. If active anti-fouling constituents are to be used in the coatings for trial and these compounds are not registered for direct human contact then these coatings will be placed in trial areas where no human contact is possible. Any formal human or environmental safety trials are however beyond the scope of this project.

<u>Coating Specifications</u>

1. Primary
    a. Prevent fouling for 1 month
    b. Can resist pedestrian traffic.
    c. Non-slip when either wet or dry

d. Substantially non-toxic and non-hazardous to humans, dogs and non-target species
e. Biocides must be biodegradable

2. Secondary
    a. Dries in less than 1 hour
    b. Cures while exposed to salt spray or submerged
    c. Can be applied to a damp or submerged surface
    d. Prevents fouling for 3 - 6 months

vi) Trial design

All experimental coatings will be tested on concrete tiles prepared off-site and attached to Perspex backing plates using cable ties. These test plates (9 tiles per plate) will be dyna-bolted to concrete steps in Clovelly Bay and Malabar Rock Pool. These test plates will run the length of the steps and will be prepared so as to minimise the trip hazard and stubbing of toes. Some test coatings will be applied directly to concrete surfaces on Clovelly promenade, Clovelly Pool, Malabar boat ramp, Cronulla rock pool and Hawkesbury Reserve boat ramp. In the future, successful coatings could be applied directly to the problem areas by council staff.

The concrete tiles (10 x 10 x 2 cm) have been prepared by the Centre for Marine Biofouling (UNSW). The tiles have rounded edges on the test surface to minimise the risk of stubbing toes. The material is a standard commercial sand/cement mix (no aggregate). Tiles will be available for coating by participating paint manufacturers by mid February. We are testing paints/coatings from 3 manufacturers in the field trial.

The test coatings which are appropriate for direct application to concrete surfaces in the field will be applied by the manufacturers/applicators.

The main test site will be Clovelly and Malabar as these sites are located close to UNSW and will allow close monitoring. Coatings to be tested at Clovelly will be safe for direct human contact and will not present a significant hazard to non-target organisms. Clovelly represents an “actual-use” field site which provides a range of representative environments and, in particular, will allow the effect of pedestrian activity on fouling to be assessed for selected coatings. Experimental coatings for direct application only will be tested at Sutherland Shire sites. The coatings selected for these sites will require minimal maintenance and will not be monitored as frequently as those at Clovelly or Malabar. A Sydney Harbour location (Kirribilli Wharf) will provide the opportunity to compare the efficacy of test coatings against a commercial anti-foul paint (toxic therefore can not be tested at other sites). This site has limited public access and therefore provides a tamper free test of coatings. Tiles will be tested on submerged racks hung off of Kirribilli Wharf.

All treatments will be subjected to statistical analysis.

Measures of success

1. All anti-foul treatments will be compared to controls i.e., uncoated concrete tiles (a limited number maybe subjected to cleaning protocols).
2. Slip tests: (to be defined)
3. % cover of fouling: quantitative analysis of digital photographs

4. Fouling adhesion: Measure % cover before and after application of a standardised stream of water on selected coatings.
5. Type of fouling organisms (micro-foulers, macro-foulers –soft or hard).

vii) Project Milestones

1. Feb 2009: Report - Project specifications.
   Test sites
   Needs of the participating councils
   Application to other Coastal Councils
   Application and performance specifications for test materials.

   Mar 2009 – First Trial starts

2. Mar 2009: Site visit - Participating Councils, Sydney Coastal Councils Group, Public reps.

3. Jul 2009: Report - Results of Trial (Mar 09 – Jun 09).
   Identify products suitable for trial in Summer 2009-10.

4. Jul 2009. Presentation to participating Councils and Sydney Coastal Councils Group

5. Aug 2009: Report - Project specification.
   Refine application and performance specifications

   Oct 2009 – Second Trial starts

6. Mar 2010: Report - Results of Trial (Oct 2009 – Feb 2010).
   Identify products suitable for commercial application to Coastal Platforms.
   Identify materials with potential.

7. Mar 2010. Presentation to participating Councils and Sydney Coastal Councils Group

Photo 1

Photo 2

Black micro-fouler on concrete promenade at Clovelly Bay. Note wet versus dry patches in photo 1 (slippery when wet). Compare area cleaned by jet blaster versus fouled area of promenade in Photo 2.

Photo 3

Photo 4

Concrete steps in Clovelly bay heavily fouled with green algae (photo 3). Large concrete step after cleaning with jet blaster (photo 4)

Photo 5

Fouling of pool surfaces by green algae

Photo 6 – Sandstone platform at western end of Mahon Pool showing black micro-fouler

Photo 7 – Steps in Mahon pool heavily fouled by green alage

Photo 8 – Steps in Malabar rock pool fouled by brown algae

Photo 9 – Northern edge of Cronulla rock pool fouled by brown and green algae

Photo 10 – Access ramp at Cronulla rock pool gets fouled by microalgae

Table 1 – Environmental factors at field sites chosen for testing of non-slip, anti-foul technologies for coastal pools and platforms

Site location	Substrate	Surface	Fouling	Wave action	Pedestrian Traffic	Max Temp
Clovelly Bay						
Steps	Concrete	Intertidal	Green algae (macro-fouling)	Strong (eastern steps) Weak (in shore steps)	Infrequent (eastern steps) Heavy (in shore steps)	<25°C
Promenade	Concrete	Exposed	Black algae (micro-fouling, blue-green alga?)	Weak (generally) Strong (big swell, Spring tides)	Heavy pedestrian traffic Frequent vehicular traffic	High (~50°C in full sun)
Pool	Painted concrete	Submerged	Green algae on all surfaces	Weak (generally) Strong (occasionally)	Frequent	<25°C
Malabar						
Rock pool steps	Concrete	Submerged	Brown algae (micro-fouling)	Weak	Frequent	<25°C
Boat ramp	Concrete	Intertidal	Brown & green algae	Weak-Strong	Frequent	High
Cronulla rock pool						
Western wall	Concrete	Wet	Brown & green algae	Weak-Strong	Infrequent	<25°C
Access ramp	Concrete	Exposed	Brown/orange algae	Weak-Strong	Heavy	High
Sylvania Waters						
Boat ramp	Concrete	Intertidal	Brown algae	Weak	Frequent	High
Kirribilli wharf	Concrete tiles	Submerged	Brown algae	Weak-Moderate	Infrequent	<25°C

Table 2 – Experimental design and the application and performance specifications for each test site

Site	Experimental Design	Application Specifications	Performance Specifications
Clovelly Bay			
Steps	Concrete Tiles fixed to perspex plate, bolted to step *Test coatings 13 (n=5)*	Dry concrete (prep tiles off site) Direct application specs: Dry in 2-3 hr (time til immersion) < 25°C, Surface Area (~5 m^2)	Tidal immersion Non-toxic Non-slip Foot traffic Bathers sit on steps
Promenade	Concrete Tiles fixed to perspex plate, bolted to promenade *Test coatings 10 (n=3)* Direct application *Test coatings 6 (n=3)*	Dry concrete (prep tiles off site) Dry / Damp concrete Cure with salt spray Apply in morning for < 25°C Large surface area (>100 m^2)	Occasional immersion Damp frequently Non-toxic Non-slip Foot traffic Sunbathing
Pool	Direct application *Test coatings 6 (n=3)*	Damp concrete Pool emptied for application < 25°C	Immersed Non-toxic
Malabar			
Rock Pool Steps	Concrete Tiles fixed to perspex plate, bolted to step *Test coatings 12 (n=3)*	Dry concrete (prep tiles off site) Direct application specs: Damp concrete Pool emptied for application, < 25°C	Immersed Non-toxic Non-slip Foot traffic Bathers sit on steps

Table 2 cont. – Experimental design and the application and performance specifications for each test site

Site	Experimental design	Application specifications	Performance specifications
Malabar Boat Ramp	Direct application *Test coatings 6 (n=3)*	Damp / Wet concrete Dry in 2-3 hr (time til immersion) < 25°C Surface Area (~25 m^2)	Tidal immersion Non-toxic Non-slip Foot / vehicular traffic
Cronulla Rock Pool Access Ramp	Direct application *Test coatings 5-6 (n=3)*	Damp / Dry concrete Cure with salt spray Apply in morning for < 25°C Surface Area (~15 m^2)	Occasional immersion Damp frequently Non-toxic Non-slip Foot traffic
Rock Pool Wall western edge	Direct application *Test coatings 5-6 (n=3)*	Damp concrete Pool emptied for application < 25°C Dry in 2-3 hr (time til wet)	Always wet Non-toxic Non-slip Foot traffic Bathers sit on walls
Sylvania Waters Boat ramp ('Hole in the wall')	Direct application *Test coatings 5-6 (n=3)*	Damp / Wet concrete Dry in 2-3 hr (time til immersion) < 25°C Surface Area (~25 m^2)	Tidal immersion Non-toxic Non-slip Foot / vehicular traffic
Kirribilli Wharf	Tiles on submerged rack *Test coatings 14 including commercial anti-foul paint (n=3)*		n/a