Algal fouling - a cleaning problem and slip hazard: community perceptions and coating solutions

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Introduction

The ocean pools and adjacent platforms along the NSW coast can become rapidly fouled with algae. This makes the surfaces a slip hazard for pedestrians and degrades the water quality of ocean pools. Local Councils find it difficult to control algal growth with current cleaning methods. The Sydney Coastal Councils Group contracted the University of New South Wales to identify coatings and cleaning methods to improve control of the algae without the use of biocides. In addition to testing a range of coatings a community survey on the perception of risks associated with public use of coastal pools and platforms and different methods used for cleaning.

All inert surfaces including human-made structures deployed either deliberately or accidentally into the sea are subject to levels of biological fouling (Little, 1997; Evans, 2000; Hughes, 2005; Afsar, 2008; Ralston, 2009). Known as biofouling, this process presents problems for many marine industries and poses a major economic and technical problem worldwide (Evans, 1988; Lewis, 1994; Abbott, 2000; Afsar, 2008).

Local Councils have been forced to rely upon physical cleaning for coastal pools and platforms. Biocide-based controls for fouling of coastal pools and platforms are not generally permitted in NSW as legislated by Section 120 of the Protection of the Environment Operations Act 1997. At the same time Local Councils are required by the Civil Liberties Act 2002 and the Local Government (General) Regulation 2005 to clean public areas of hazards. Existing commercial coatings intended to control fouling primarily involves applying biocide-based antifouling paints (Rittschof, 2001) with physical cleaning being applied where toxin-based coatings are hazardous to aquaculture, humans or animals (Gotoh, 2007).

Fouling of the trial surfaces and the surrounding areas is dominated by algae; the green algae *Ulva* and (uncharacterised) brown algae. The green algae grows as long filaments in protected areas such as Malabar Pool and Cronulla Pool and as short strands in areas subjected to wave action such as the steps at Clovelly Bay. The brown algae grows primarily on areas that are only intermittently exposed to seawater (such as Clovelly promenade and Cronulla pool ramp) or on surfaces that are constantly damp (such as top sections of the wall at Cronulla Pool).

Both types of algae make the steps, ramps and other surfaces extremely slippery. The green algae grows rapidly, especially in summer, with growth being observed on concrete within 2-3 days after cleaning. More commonly, algal growth was observed 1-2 weeks after cleaning.

The algae is currently removed with high-pressure water from a truck-mounted 'jet-blaster' every 2 to 4 weeks, depending upon the time of the year. For enclosed areas such as pools a valve is opened to allow the water to be released during an ebb tide and then closed to prevent the pool refilling. For non-enclosed surfaces, such as the steps at Clovelly Bay, cleaning needs to coincide with low tides of 0.5m (or less) during daylight hours.

The drawbacks of the jet-blast method are:

- Surfaces that are underwater cannot be cleaned with a water 'jet-blaster' and therefore pools need to be emptied before cleaning.
- Cleaning can be delayed because:
    - water jet-blasting is required for other general cleaning demands
    - mechanical breakdown during scheduled cleans
    - access is prevented or limited during periods of high public use
    - high swell conditions prevent safe access
- Rapid growth of the algae can occur within days and make the surface slippery and hazardous before scheduled cleaning (fortnightly or monthly).
- The public is inconvenienced with pool closures and cleaning and fouling is more of a problem in Summer when the pools are most in demand.

The level of community satisfaction with public use of the pools and the Local Council's efforts to maintain the pool and surrounding platforms is of significant interest to the participating Councils. As the public are a major stakeholder it is relevant to assess public opinion regarding current levels of satisfaction and possible changes to cleaning practices. This was done using qualitative social research methods. Playing a fundamental role in better understanding social structures and individual experiences (McGuirk, 2005), qualitative social research is done through the use of social surveys, and specifically in this research, questionnaire.

The most common method of collecting survey data, questionnaire design involves thinking ahead about the research problem, what the concepts mean and how to analyses the data (De Vaus, 2002; Hoggart, 2002; McGuirk 2005). Surveys incorporate not just questionnaires, but other techniques such as in-depth interviews, observations and content analysis are also used (De Vaus, 2002; Hoggart, 2002; Winchester, 2005). There are criticisms on the use and validity of survey data (Briggs, 1986). However, the key advantage of social surveys, and reason for inclusion in this study, arises from their ability to obtain broad coverage of populations (Hoggart, 2002) with a much smaller representative sample.

Aims

The aims of the study were to:

- Determine public attitudes to fouling and the use of antifouling technologies.
- Identify coatings/materials with the following specifications:
    - No biocides used in the coatings.
    - Effective control of marine fouling for at least 1 month.
    - Suitable for on-site application to concrete surfaces.

Results

Community Survey

The Community Survey was conducted as part of Todd Walton's Honours Thesis (Walton 2009). With permission from Randwick City Council, respondents were recruited at the Malabar and Clovelly field sites by approach. The questionnaire was conducted verbally on-the-spot with answers recorded by clipboard and paper. The questionnaire took on average about four minutes to complete with a total of 128 participants recruited between 20 Aug and 6 Sept 2009. Most of the respondents (80%) were recruited from the Clovelly Bay site. Over half of the respondents were in the 31-45 age group and lived within the Randwick City Council. The majority of respondents (> 70%) used the pool at least at least once a week.

O the issue of anti-fouling and the slip hazard presented by fouling. Key findings of the survey were:

- slippery surfaces present the highest perceived danger (Table 1)
- 23% of participants in the survey had hurt themselves slipping over, and
- a minority of respondents (39%) were aware of the Council programme to control fouling and when informed of the jet-blast treatment most (73%) thought it was sufficient.
- Interestingly the percentage of those who were injured by slipping was similar to those who thought the current control method was inadequate (27%).
- The following percentage of respondents would reduce or stop their use of the pool under the following circumstances:
    - 47% if the algae was left to grow
    - 14% if they slipped and hurt themselves
    - 5% if water blasting was replace with anti-fouling coatings
- The possible use of non-toxic coatings to control algal fouling was explained to the respondents and 79% were not concerned if 'jet-blasting' was replaced by

such coatings. Of those who were concerned there reasons were that anti-fouling was 'unnatural', possible adverse effects on non-target organisms and chemicals leaching from the coatings.

Slippery Surfaces	Pollution	Blue Bottles	Dangerous surf/weather	Rock falls
27	25	18	15	15

Table 1. Percentage Aggregate Score for each hazard as determined by the ranking system described by Walton (2009).

Coatings and Cleaning Methods to Control Algal Fouling

Preliminary Trials

The first field trial tested a range of coatings from commercial suppliers and UNSW over March - June 2009. The coatings were applied primarily to test blocks made of concrete (10 cm x 10 cm) and placed at steps leading to the water at Clovelly Bay, Malabar Pool and Rozelle Bay. A limited number of coatings were also applied directly to a variety of concrete surfaces at two boat ramps, pool walls and a promenade. One coating from company C and two coatings from UNSW were observed to reduce fouling compared to uncoated concrete blocks. One coating from Company C also reduced algal fouling when applied directly to the wall of Malabar Rock Pool. These results were used by Company C and UNSW to guide re-formulation and make coatings for testing in the second and third trials.

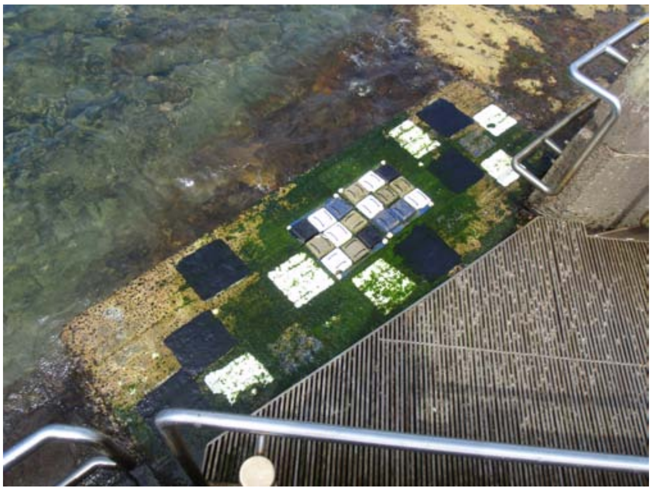
The second trial was conducted from June-September 2009 using the most promising coatings from the first trial and reformulated coatings. All coatings were tested on concrete blocks located at Rozelle Bay, Clovelly Bay and Malabar Rock Pool. Results were consistent with the findings of the first trial.

Final Coatings Trial

The final field trial ran from Dec 2009 - March 2010 and focussed on the direct application of selected coatings at access points to coastal pools (i.e. steps, ramps, pool edges and promenade areas). A selected number of coatings were also tested as pool wall coatings at Malabar Pool. The coatings were also tested on concrete blocks at Clovelly steps. The blocks could be coated under optimum conditions off-site and provided a more uniform substrate than the surfaces at the field sites.

Three test locations were used; Clovelly Bay; Malabar Ocean Pool and Cronulla Ocean Pool. The coatings were assessed visually for anti-fouling efficacy and foul-release efficacy. Anti-fouling was defined in this study as the control of algal fouling without cleaning. Foul-release efficacy was defined as the ability to remove fouling with manual cleaning.

At Clovelly Bay the test panels on the steps were in the inter-tidal zone and exposed to ocean swell (Fig 1A). The steps are cleaned with a high-pressure 'jet-blast' every 2-4 weeks. They are notoriously slippery. The other test site at Clovelly Bay was on the southern promenade close to the ocean (Fig 1B). This site is usually above the high water mark and exposed intermittently to ocean spray and freshwater run-off. The promenade is cleaned with a rotating mechanical brush and high-pressure water 'jet-blast' every 4-8 weeks to remove 'brown-black' algae.

A. 

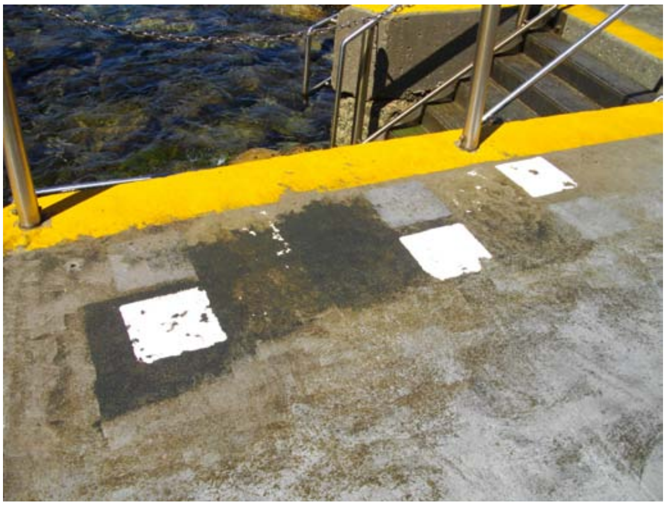
B. 

Fig 1. Clovelly Bay test sites: A. steps with test panels and blocks, and B. promenade.

Test panels at Malabar Ocean Pool were placed on the, steps and ramp (Fig 2A) and the inner wall facing north (Fig 2B). The pool is not subject to the tide so the test surfaces were classed as sub-tidal. The pool is usually protected from swell so the fouling can grow to considerable length due to the lack of water movement. The pool is regularly emptied for cleaning with a high pressure 'jet-blast' during Spring and Summer, every 2 - 4 weeks and less frequently during Autumn and Winter.

A.


B.


Fig 2. Malabar Ocean Pool test sites: A. steps and ramp and B. inner wall.

Cronulla Ocean Pool steps (Fig , 3A) have similar fouling to the steps and ramp at Malabar. The steps became slippery within 2 weeks from cleaning during the trial period. There was little fouling on the ramp (Fig 3B) during the test period although previously it was similar to the fouling at Clovelly promenade. The top of the pool wall (Fig 3C) had a mix of green and brown fouling which appeared within 2-4 weeks after cleaning.

A. 

B. 

C. 

Fig 3. Cronulla Ocean Pool. Test sites were: A. steps B. ramp, and C. top of the pool wall.

The results for the recommended coatings and cleaning methods for each field site are summarised at **Table 2**. The coatings found to be most effective were a paint (coded 'White-X8') and a sand-wax mixture over a rubber mat (coded 'SW-Mat').

For the sub-tidal protected sites (Malabar Pool steps and ramp and Cronulla Pool steps) the SW-Mat was found to be most effective with the paint also demonstrating good efficacy except when the rate of algal growth was high. Both coatings were cleaned after 4 weeks with the best foul release from the SW-Mat. The algae that had started to grow on the SW-Mat was removed by manual cleaning with plastic scouring pad and the surface was refreshed with additional wax by rubbing with a block of wax. The paint, White-X8 was only cleaned by hand-rubbing because more abrasive methods would remove the paint.

For the inter-tidal area (Clovelly steps) the paint 'White-X8' was the most effective anti-fouling coating (minimal fouling upto 4 weeks) and was also effective for fouling release as the algae was removed with a medium pressure 'jet blast' as compared to the high pressure 'jet-blast' for the control concrete surface after 8 weeks. The SW-mat was not suitable for testing on inter-tidal or exposed surfaces due to the low melting point of the waxes.

The paint 'White-X8'was very effective at controlling the algae on the exposed test areas (Clovelly Promenade and the top of the Cronulla Ocean pool wall). No algal growth was observed during the trial period and no sign of fouling was apparent at the last timepoint (3 months).

For pool walls the limited trial at the Malabar Pool gave an encouraging preliminary result with a number of coatings demonstrating reduction in the level of algal fouling. Both a wax-based formulation and the 'White-X8' coating had the best efficacy with only limited fouling observed after 11 weeks.

A number of improvements could be made to the coatings. For 'White-X8' improved adhesion to older concrete and aggregate maybe required and an alternative colour to white maybe required to reduce the visual impact of painted surfaces. For 'SW-Mats' the main area of improvement is in adhesion of the sand-wax mixture to the underlying rubber mat.

Site	Coating	Cleaning	Min. Cleaning Frequency (wks) [1]
Clovelly Bay			
- Steps	White-X8	Empty pool, then Water jet	4 – 6
- Promenade	White-X8	Water jet	> 12
Malabar Pool			
- Steps and Ramp	SW-Mat	Plastic scouring pad, then Rub with wax block	2–4
	White-X8	Empty pool, then Water jet	4– 6
- Pool Wall	White-X8 Wax-formulation	To be determined	-
Cronulla Pool			
- Top of pool wall	White-X8	Med pressure water jet	> 12
- Steps	SW-Mat	Plastic scouring pad Refresh surface with wax block	2-4
	White-X8	Empty pool to expose surfaces Med. pressure water jet	4-6
- Ramp	White-X8	Med. pressure water jet	> 12

Table 2. Recommended coatings and cleaning protocols by test site.

Conclusions

The results of the community survey display the vested concern of pool users in pool maintenance and safety. The introduction of antifouling paints at the expense of water blasting is likely to draw more interest than objection from patrons. The major issue expressed by the public relates to how much algal growth there is around the pool, whether this relates to a perceived danger or an aesthetic concern, depends entirely on the success of the treatment. Public response to use of an antifouling coating will largely be determined by the non-toxic nature of the coating (section 7.6) as well as its ability to inhibit fouling (section 7.7). If antifouling paints were to be integrated, pool use is likely to remain stable neither attracting nor discouraging pool users either way.

Trials of coatings and cleaning methods to control fouling were conducted in 2009-10 at coastal pools and platforms managed by the Randwick City Council and Sutherland Shire Council. Two coatings, 'White-X8' and 'SW-Mat', were found to reduce algal fouling and be easier to clean compared to concrete surfaces. It is expected that the application of these coatings to the steps, ramps and surrounding platforms of coastal pools will reduce the risk of pool users and other pedestrians slipping and reduce the resources required to clean these surfaces of algae.

It is recommended that promenades and other similarly exposed areas such as pool edges are coated in White-X8. The results from this study indicate that these surfaces would remain free of algae for at least 12 weeks. Cleaning with a medium pressure water jet-blast is recommended as soon as algal fouling is observed on the coating. This approach is an improvement on the current situation where algal fouling of concrete cleaned with a high pressure water jet-blast can occur within 2-4 weeks.

It is recommended that submerged and inter-tidal surfaces such as steps and ramps of coastal pools and bays are coated with either 'White-X8' or 'SW-Mats'. In both cases cleaning is likely to be required every 4-6 weeks. White-X8 is more easily applied over broader areas than 'SW-Mats' but it is recommended that only a medium-pressure water jet be applied for cleaning. This requires that pools are emptied to expose the surfaces for cleaning. As 'SW-Mats' can be cleaned underwater pools would not have to be emptied for cleaning access points.

The results and conclusions of this study were obtained from trials that were conducted over relatively short periods of time (up to 3 months). The level of fouling and the performance of the coatings can be affected by many variables so the times recommended for cleaning need to be treated as only indicative. It is therefore recommended that the next step for the recommended coatings is a commercial-based trial.

Disclosure

Drs Tim Charlton and Peter Steinberg are shareholders and Directors of Ecozean Pty Ltd and co-Inventors of a patent (WO 2008/009067) that covers materials used in the SW-Mat. Ecozean Pty Ltd was recently established to commercialise research into anti-fouling materials conducted at the University of New South Wales.

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