Antifouling technologies for coastal pools and platforms and community responses

Todd Walton

Supervisors:

Professor Peter Steinberg
Dr Wendy Shaw
Dr Tim Charlton

Submitted in partial fulfilment of the requirements for the degree of Bachelor of Environmental Science, School of Biological, Earth and Environmental Sciences,
Faculty of Science,
The University of New South Wales

October 2009

THE UNIVERSITY OF
NEW SOUTH WALES

Faculty of Science
School of Biological, Earth and Environmental Sciences

Honours Thesis Declaration

I hereby declare that this submission is my own work and to the best of my knowledge it contains no materials previously published or written by another person, nor material which to a substantial extent has been accepted for the award of any other degree or diploma at UNSW or any other educational institution, except where the acknowledgement is made in the thesis. Any contribution made to the research by others, with whom I have worked at UNSW or elsewhere, is explicitly acknowledged in the thesis.

I also declare that the intellectual content of this thesis is the product of my own work, except to the extent that assistance from others in the project's design and conceptions or in style, presentation and linguistic expression is acknowledged.

I HAVE submitted a digital copy of this thesis.

Word count excluding references, tables and captions: 9150

(Signed)………………………………………Date……………………….

Thesis committee (names, not signatures):

Supervisor: Prof Peter Steinberg Co-supervisors: Dr Wendy Shaw, Dr Tim Charlton

Committee: Dr Rob Brander, Dr Jes Sammut

I am fully aware that the School retains a copy of the thesis and is free to allow them to be consulted or borrowed. The thesis may be restricted for up to 2 years or longer by a written request to the Head of School.

Table of contents page no.

Section A – Antifouling technologies

Table of contents page no.

Section B – Community responses

List of Figures and Tables page no.

Section A – Antifouling technologies

Figures:

Tables:

List of Figures and Tables page no.

Section B – Community responses

Figures:

Tables:

List of Appendices

Section A – Antifouling technologies

Section B – Community responses

Acknowledgments

Firstly thanks to my three supervisors, Prof Peter Steinberg for giving me a shot and taking me on as his honours student, Dr Wendy Shaw for her good advice whenever I needed it and Dr Tim Charlton for all his time and effort throughout the year.

Thanks heaps to Dr Rebecca Swanson for everything she did. Without Rebecca's help this thesis would not have been possible.

Thank you to Alex and Shaun in the post grad room for helping me out with my stats, it was really appreciated. I also extend my gratitude to Ann and Matt at the BEES office for their help and patience.

Thanks to all the boys back home for leaving me alone when I asked during the last few weeks of writing.

Lastly thank you to my family; mum and dad for putting up with me, Jarrod for letting me use the computer and Nana for being awesome.

Without help and support from everyone mentioned, this year would not have been half as good.

Abstract

This study addressed the issues associated with slippery surfaces that result from the growth of algae around public ocean pools, and the potential for an antifouling paint as a solution. It also acknowledges the role of public opinion in such matters with the inclusion of results from a community survey.

Sydney's Coastal Council's faces a continual challenge from the settlement and growth of marine organisms (fouling) on coastal rock pools, platforms, steps and ramps leading into bays and pools. The challenge arises from public health and safety concerns (and associated council liability) for bathers who can slip on the fouled surfaces. In this project, eight non-toxic, near commercially available antifouling coatings were trialled to find an alternative to the costly and largely inadequate method of mechanical cleaning currently used at ocean pools. The coatings were each applied to separate 10cm X 10cm cement tiles and trialled over a ten week period with fouling accumulated over this time analysed and assessed. The results suggested four coatings displayed potential for future application, whilst no coating was as yet ready for use on coastal platforms at the conclusion of this study. Wax coatings on two of the treatments were the most successful with around 50% fouling coverage after ten weeks of fouling, compared with 80-90% coverage of controls.

In conjunction with trialling coatings, a social survey of the public was conducted using a representative sample of stakeholders relevant to the issue of slippery surfaces around ocean pools. Through use of a questionnaire, pool user attitude was established pertaining to antifouling of ocean pools as well as the subsequent slip hazard of fouled surfaces. The research was conducted with approval from Randwick City Council, as the study locations were located within the Randwick Local Government Area (Malabar rock pool and Clovelly beach). Findings from the study suggest public opinion is neither significantly for or against the use of environmentally friendly antifouling alternatives with 79% having no objection, although 76% of respondents acknowledged that the current method (physical cleaning) is sufficient. Thus, a successful antifouling coating with non-toxic properties would likely be accepted by the Randwick community.

1.0 Introduction

In most shallow, hard-bottom marine habitats, sessile life forms dominate the benthic community in terms of number of individuals and species. These species make up the living component of what is known as fouling, a process by which free-living planktonic larva spores or other 'propagules' attach to a substratum (Richmond and Seed, 1991) thereby also creating settlement surfaces for other epibionts (Wahl, 1989; Richmond and Seed, 1991; Evans, 2000; Railkin, 2004).

All inert surfaces including human-made structures deployed either deliberately or accidentally into the sea are subject to levels of biological fouling (Little and Wagner, 1997; Evans, 2000; Hughes *et al*., 2005; Afsar, 2008; Ralston and Swain, 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 *et al*., 2000; Asfar, 2008). The shipping industry alone spends billions of dollars a year on cleaning and antifouling of ship's hulls (Haak, 1996; Asfar, 2008).

The fouling problem is not only confined to the shipping industry but is of major concern for oil and gas structures, seawater piping systems and in the aquaculture industry where huge monetary impacts are incurred cleaning and preventing forms of biofouling (Lewis, 1994; Costa-Pierce and Bridger, 2002). Lewis (1994 p.32) estimates an approximate annual spending of $800,000 on structural fouling issues for the Australian salmon industry alone.

Existing commercial technology intended to minimise or control impacts of fouling primarily involves applying antifouling coatings (Rittschof, 2001) and/or physical cleaning (Gotoh, 2007). The latter applies particularly where toxin-based coatings are hazardous to aquaculture, humans or animals who consume them, but it is labour intensive and costly (Asfar, 2008). The most common and effective antifouling coating is based on organotin compounds (e.g., tributyltin (TBT)(Champ and

Seligman, 1996; Haak, 1996; Abbott *et al*., 2000)), these however have widely known adverse non-target environmental effects (Ralston and Swain, 2009) and the resultant pressure from social and governmental responses to these negative impacts have resulted in a push to finding less damaging alternatives (Rittschof, 2001). A ban on TBT coatings was put in place by the International Maritime Organisation (IMO) effective as of September 2008. Currently, the major active ingredient in antifouling coatings is copper. Alternative coatings have used zinc or copper based pyrithiones, which have become two of the biggest selling organic actives in marine antifouling technologies. Some studies have indicated however, that these too have non-target effects on marine organisms (Asfar, 2008). Neither copper nor organic biocides inhibit all potential fouling organisms (Champ and Seligman, 1996).

As a consequence of the toxic nature of these current antifouling solutions, much research into non-toxic, environmentally friendly alternatives has been (Kjelleberg and Holmstrom, 1994; Steinberg and de Nys, 1995; Rittschof, 2001), and is currently, being undertaken (Ralston and Swain 2009; Asfar 2008). One strategy involving foul-release, non-stick coatings was first introduced in the 1990s (Callow *et al.,* 2003) provides a promising alternative to current heavy metal based antifouling coatings (Munn, 2004; Asfar, 2008). Other possible alternatives include wax coatings, surface and/or coating topography methods and non-toxic deterrents.

High use public areas such as ocean rock pools are an example of an area in need of an effective non-toxic antifouling solution. Pools provide a refuge for coastal fouling organisms against many of the stresses associated with intertidal living (Hayes, 2007); the resulting communities are of particular concern when they eventually grow large enough to create a slip hazard. This is of concern for Local Councils who are required by the *Civil Liabilities Act 2002* and under the Local Government (General) Regulation 2005 to clean public areas of hazards (which include fouling). The current method used by local authorities primarily involves manual cleaning in the form of a (water) Jet

Blaster truck. At the moment there is one truck that services the entire Randwick Council area and is used to clean other public areas (parks) in addition to coastal platforms/pool access which get cleaned about once a month. The frequent mechanical cleaning of fouled surfaces costs Sydney's coastal councils hundreds of thousands of dollars per annum in labour (Charlton, 2008).

This project has trialled a series of coatings designed to prevent fouling of intermittently wet concrete surfaces. An antifouling technology in the form of paint or a wax could deter fouling eliminating or significantly reducing the need for mechanical cleaning of surfaces. There is an obvious potential to reduce the cost of labour for Sydney's coastal councils associated with mechanical cleaning and the maintenance of safe coastal pools and platforms.

As well as being a liability for associated councils in the form of cleaning and compensation, slippery fouled surfaces form a public health and safety concern. Being a major stakeholder in the issue, it is relevant to assess public opinion regarding the situation which may entail significant changes. This was done using qualitative social research methods. Playing a fundamental in better understanding social structures and individual experiences (McGuirk and O'Neill 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 *et al*., 2002; McGuirk and O'Neill 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 *et al*., 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 *et al*., 2002) with a much smaller representative sample.

Thus in this project two main questions were asked:

1) Are there environmentally benign antifouling coatings which are effective in determining fouling on coastal platforms, pools, and;
2) What are public attitudes to fouling and the use of antifouling technologies?

The experimental application of a number of non-toxic antifouling coatings were tested in this study and their potential as a substitute for mechanical cleaning of coastal ocean pools was assessed. Also included in this research are the results of a social survey, which investigated community attitudes towards the possible integration of an antifouling coating onto coastal platforms at Clovelly and Malabar pools.

SECTION A – ANTIFOULING TECHNOLOGY

This section details the trial of antifouling coatings for use on coastal platforms. Firstly the methodology and experimental design of the trial process, followed by a detailed description of findings from the trial period. The results are then discussed and recommendations made for further developing the technology. Community responses are discussed in section B, with overall conclusions outlined at the end of the thesis.

2.0 Materials and basic methodologies

2.1 Coatings

A number of paint companies were contacted for involvement in the project and a total of eight antifouling coatings were obtained and used in the field trials. The outsourced paints had to adhere to a set of guidelines appropriate to the conditions experienced around public-used coastal platforms.

-Coating specifications. These were established by Professor Peter Steinberg, Centre for Marine Bio-Innovation, in consultation with the Sydney Coastal Councils Group.

Mandatory:

- Prevent fouling for at least 6 months
- Non-slip when wet or dry
- (Substantially) Non-toxic and non-hazardous to humans and non-target species
- Biocides used must be biodegradable

Secondary (preferred):

- Takes less than 2 hours to dry
- Cures while exposed to salt spray and water
- Can be applied to a wet surface

The paints used were commercial or near-commercially available. They were water based and any low toxicity biocides used were, for example used in other products such as anti-dandruff shampoos (McDonnell, 2007)), as well as being erodible with particulate material to make them non-slip. The coating specifications excluded many standard antifouling coatings because of the actives used or for other reasons. Generally, standard antifouling paints need to be applied to a dry surface and a curing time of up to three days is often required. Paints that require standard application procedures *in-situ* are not suitable for coastal platform areas that are exposed intermittently at low tide or constantly wet from spray.

2.2 Tiles

Tiles of sand and cement were used as test plates for the coatings in the field. Making the tiles involved pouring cement mix in to 10cm x 10cm x 1cm thick moulded plastic trays where they were left for five to six days to cure.

Due to swell and wave action it was necessary to make the tiles as tough as possible. This was achieved through reinforcing each tile with aluminium chicken wire cut to fit inside the tiles.

The surface of the tiles were roughened to promote fouling, this was done by putting fly screen in the mould and removing it after the mix had dried, creating a mesh-like surface on the tile.

The tiles sent to Company A were prepared differently to the other trials in that they had a smooth surface as opposed to roughened mesh. In order to rectify this, the painted tiles, before being sent to Company A, were scratched with a chisel to make the surface more consistent with the tiles representing the other companies, as can be seen in figure 1.

2.3 Racks

Two types of racks were used as frames to which the coated tiles were attached. These acted as platforms for the tiles.

Rack type one was a Perspex plate, the biggest of which holds up to nine tiles. The tiles were tied on using cable ties. Holes in the four corners of each tile were drilled (before being sent away for coating) and aligning holes were drilled on the plate allowing for the cable ties to hold the block in place on the mat. The racks were bolted in place at the trial site with ‘Dynabolts’ © hammered into holes drilled into the concrete surface of the test site.

Figure 1. Example of rack laid at Clovelly and Malabar field sites. Scratched company 'A' (blue) tiles pictured.

Rack type two was a net of nylon rope reinforced with PVC piping approximately 2m x 1m. The tiles were held in place with cable ties which were tied through the holes on the tiles and around the rope netting of the rack. The rack was held in place on location by tying off the corners to a surrounding pontoon with ropes with buoyancy assisted by empty drink bottles.

Figure 2. Picture of the rack and experimental tiles at Rozelle Bay.

2.4 Field Sites

Three field sites were chosen as a representative sample of Sydney’s coastal ocean pools and platforms.

Clovelly

There are five access points (stairs) that lead into Clovelly bay from the southern promenade. The access points are stainless steel steps that lead down to a concrete platform that is submerged most of the time except around low tide. This platform gets heavily fouled with green algae (*Ulva* spp.) within one to two weeks of cleaning and becomes extremely slippery and dangerous for bathers. The experiment was located on the platform at the bottom of the steps leading into the bay directly opposite Clovelly surf club.

Malabar

Malabar ocean pool has two sets of steps entering the pool in the north east and south east corners as well as an access ramp in the south east corner. The steps get heavily fouled by a brown microfouling alga (most likely *Porphyra* spp.) and can become very slippery after about two weeks of being cleaned. The site for this trial was located on the third step on the south eastern corner which is almost always submerged.

Rozelle

The super yacht marina in Rozelle Bay located in Sydney harbour was the location for the third set of tiles. The rack was placed under the water among the docked yachts and tied off to one of the pontoons. The harbour location experiences a different and set of foulers, including the barnacles’ *B. variegatea* and *B. amphirite* (Jones, 1992) and the occasional polychaete worm. Trials in the harbour also made it possible to compare the trial coatings against a toxic, heavy metal based commercial antifouling paint.

3.0 Experimental design

3.1 Length of trials

In order to rule on a coating's success or failure it had to be subject to conditions under which fouling is possible. For this, the racks of tiles were left on location for ten weeks from the 22/07/09 to 29/09/09, allowing adequate time for fouling to occur under normal circumstances.

3.2 Tile allocation

Three external paint companies provided coatings for the project. Eight tiles per coating were sent to the companies with company 'A' supplying one coating (8 tiles), company 'B' two (16 tiles) and the third company 'C' provided four coatings (32 tiles). The eighth coating was a wax based coating developed *in-situ* at UNSW in the Centre for Marine Bio-Innovation. The wax coating was also applied to one of the two coatings sent by paint company 'B'.

The tiles were randomly allocated within each site using a random number generator on Microsoft Excel with the additional guideline that each mat of tiles had to have at least one control tile. The late arrival of four sets of coatings from paint company 'C' meant these tiles were randomly placed at Malabar and Rozelle with new controls, but were put in the field two weeks after the first set of tiles. In order to make analysis easier, the tiles already in place at Clovelly were removed and cleaned. They were then redistributed with the newly arrived 'C' coatings in a new random layout (figure 3). At the Malabar site the new coatings were simply allocated new boards and given their own controls whilst the tiles already in place were not disturbed.

The coatings used in the experiment were labelled as follows:
Z3 (Company A)
Y3 (Company B)
W4 (Company B) (coating Y3 + wax)
W3 (Wax)
X3 (Company C) X4 (Company C) X5 (Company C) X6 (Company C)
C (Control)
XC (Control added 2 weeks after C)
CC (commercial antifouling paint) (Rozelle only)

The layout of the different treatments was:

Malabar

Board 1

W4	W4	Z3
C	Y3	W3
C	W3	Y3

Board 2

Z3	Z3
W4	Y3
W3	C

Board 3

X5	X3	X3
XC	X4	X4
X5	XC	X6

Board 8

X6	X5
XC	X6
X3	X4

Clovelly

Board 4

X3	Y3	C
W3	Y3	W4
W4	Z3	Z3

Board 5

C	X3	X4
X5	Y3	Z3
X6	W3	X6

Board 6

X4	W3	X5
X4	X6	C
X5	W4	X3

Rozelle

W4	Y3	X3	W3	C	C	CC	X4
X5	W3	CC	X4	X6	W4	Z3	[W2]
XC	X3	XC	X6	Y3	X5	Z3	[W2]

Figure 3. Experimental design of racks deployed with attached tiles. Boards 1, 2, 3 and 7 were assigned to Malabar; 4, 5, 6 assigned to Clovelly and the large rack (bottom) was deployed at Rozelle Bay. W2 tiles on the Rozelle rack were not a part of this report.

3.3 Assessment of fouling

3.3.1 Percentage cover

Analysis of fouling for all field experiments was based upon percentage cover determination over an 8 to 10 week period in the field. Once a week over the time of the trial, photographs of each rack were taken and later on in the trial, photographs of each individual tile. The latter was performed when fouling had become substantially visible; this occurred after 6 to 8 weeks depending on the site. Photographs were taken using a Canon Power Shot A2000 digital camera and then uploaded onto a computer for digital analysis. The image analysis software Image J was used to determine percentage cover of fouling (which was almost entirely algal) there was on each tile.

3.3.2 Slip test

Since ultimately the coatings are intended to reduce slipperiness to bathers, at the completion of the ten week trial period a slip test was performed on site on all 57 test tiles. The method to test this involved attaching a force measurement gauge to a small container, or ‘sled’, which had a weight inside and a foam mat at its base to slide along the tile’s surface. The force gauge was held in hand while a rope attached it to the sled which was pulled horizontally over about 5cm of the tile. The gauge was held at about a 20 degree angle to the sled and a consistent force was applied over the length of the slide. These results were then compared with the slip-test data prior to setting the tiles out in the field.

3.3.3 Adhesion test

A third measure of a coatings success involved performing an adhesion test at the end of the experiment. The idea was to see how strongly attached the algae was to the tiles and their coatings. Using a regular garden hose, a steady stream was applied to each tile for 10s on varying pressures of low, medium and high. To determine pressure, the hose was placed in a bucket and timed as to how long it took to reach the bucket’s 2L mark. Using this method the pressures were determined as follows:

Low = 2L in 20s (~50kPa)
Medium = 2L in 10s (~100kPa)
High = 2L in 5s (~200kPa)

Photographs were taken of the racks after each pressure test, and the images uploaded to a computer for Image J analysis.

3.4 Statistical Analysis

Differences in percentage fouling cover and fouling adhesion among sites, among treatments and over time were analysed by analysis of variance (ANOVA). One-way ANOVA's were used for assessing fouling cover and tile slipperiness, whilst two-way ANOVA were (with different coatings as treatments) used in analysing differences in adhesion tests against treatment and level of water pressure.

To determine whether the data satisfied the assumptions of ANOVA, homogeneity of variance ($p>0.05$ and $p>0.01$) was examined using Levene's test, and normality explained using Kolmogorov-Smirnov's test ($p>0.05$). Most data was transformed by arcsin√p, the common transformation for percentage and proportion data (Sheskin, 2004). Some data failed to meet the assumptions of ANOVA, so to minimise the increased risk of Type 1 error, alpha significance levels in these instances were set to 0.01 instead of 0.05; this applied notably to Rozelle fouling coverage and pre-deployment slip test data sets.

Tukey's multiple-comparison test was used to identify differences between treatments following ANOVA with $\alpha=0.05$ for all samples.

4.0 Results

4.1 Fouling coverage

Week by week photographic analysis of fouling on the tiles enabled a comparison of each coating's efficacy against relevant controls and against other treatments. Because treatments were not laid down at the same time and some trials went longer than others (section 3.2), an overall summary of coating success is shown in two separate charts (figures 4 and 5).

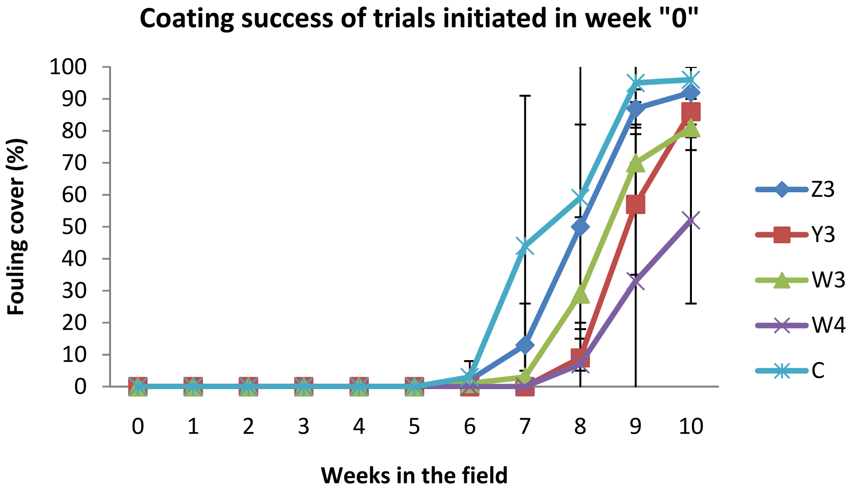

Coating success of trials initiated in week "0"

Figure 4. Percent cover of fouling over 10 weeks in the field averaged across Malabar and Clovelly replicates. Data are $\bar{x}$ ± SE (n=6)

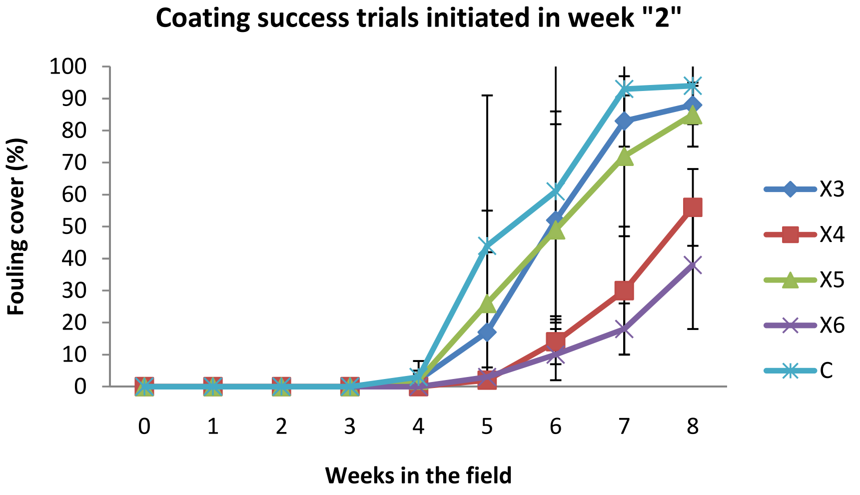

Coating success trials initiated in week "2"

Figure 5. Percent cover fouling on treatments deployed two weeks after the first set of tiles. Data are $\bar{x}$ ± SE (n=6)

Figures 4 and 5 suggest that the most successful coatings were W4 and X6. After X6, the coating that remained foul-free for the longest time was Y3, although once fouling occurred accumulation was fast, as seen in the week 8 data for Y3. Fouling was visible for most treatments after four to five weeks. Analysis of variance (ANOVA) was not performed on this data instead, data for each site was analysed.

4.2 Treatment efficacy at each site

The data displayed in figures 4 and 5 is a summary of results for treatment success over all three field locations. To more accurately examine the results for each coating a site by site analysis was performed.

4.2.1 Malabar

The first sets of tiles and a control set (Z3, Y3, W3, W4, C) were placed on location at Malabar rock pool in week zero. The second sets of tiles were placed in week two (X3, X4, X5, X6, XC) with a separate set of controls.

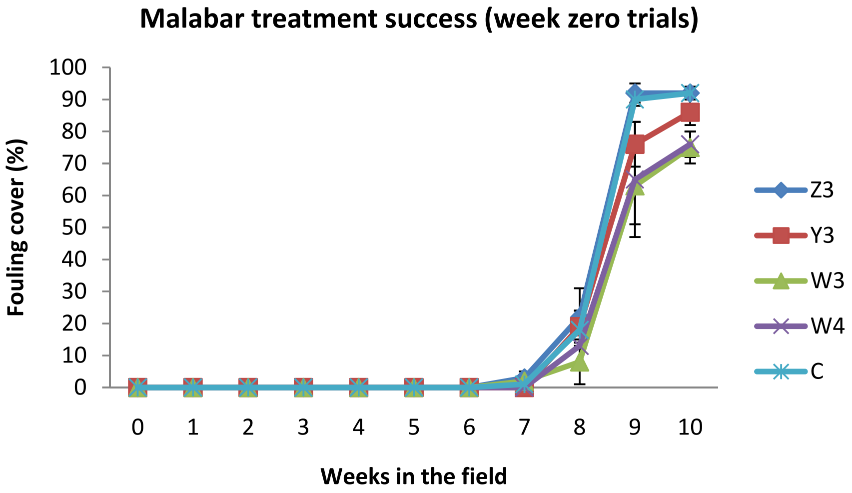


Figure 6. Percent fouling cover for week zero deployed treatments. Data are $\bar{x}$ ± SE (n=3)

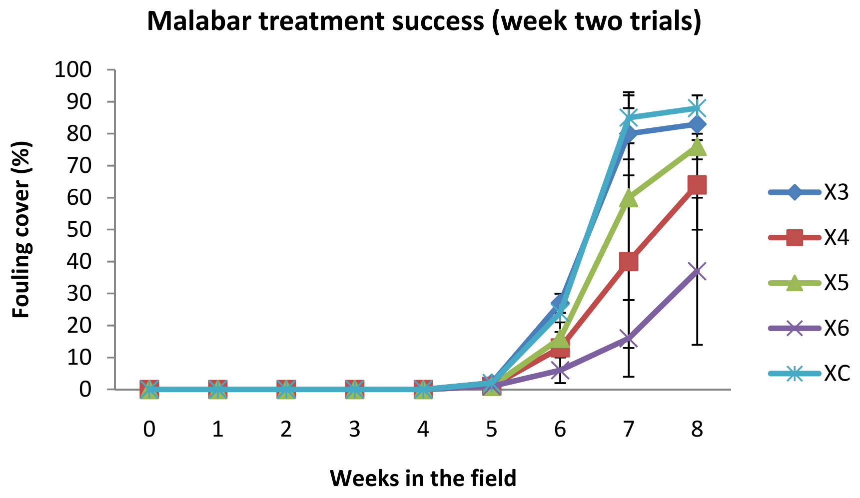


Figure 7. Percent fouling cover for week two deployed treatments. Data are $\bar{x}$ ± SE (n=3)

Fouling appears to begin for all tiles within the sixth week of the trial, even tiles that were submerged two weeks after the start of the experiment. Once visible fouling begun, most tiles were quickly covered to a large extent. X6 performed the strongest, with X4 also appearing to have some success compared with the controls.

One-way ANOVA indicated significant differences in fouling between the week zero treatments ($F_{4,10}$=19.9, *p*<0.01, Fig. 6) at week ten. Tukey's test (α=0.05) indicated a significant difference between W3 and the control, and W4 and the control, both with a *p*-value of 0.001. A one-way ANOVA of the week two deployed coatings also showed a significant difference between treatments ($F_{4,10}$=9.9, *p*<0.01, Fig. 7) at week ten. Tukey's pairwise comparison showed a significant difference for X6 against XC at *p*<0.01.

Although X6 appears to have performed well, it should be noted the fact that one of its replicates had significantly less fouling than the other two replicates. The first two X6 tiles gave an end point fouling cover of 40 and 59% whilst the third had only 13% cover (figure 8).

Figure 8. Replicates of the treatment 'X6', illustrating a possible outlier in the third (far right) replicate.

This phenomenon was most likely due to the feeding of small aquatic snails. A large number of black N*erita* sp. were found huddled in a cluster next to the tile in question. *Nerita atramentosa* eat algae (Wilson 1993).

4.2.2 Clovelly

All tiles at the Clovelly filed site were measured over the same time frame, as opposed to the Malabar site where an extra set of controls were required. Tiles were originally laid down in week zero, however with the arrival of the second set of coatings (X3, X4, X5, X6), the racks were taken out of the water and the tiles were washed and scrubbed so the fouling process could restart and a new set of controls was not needed.

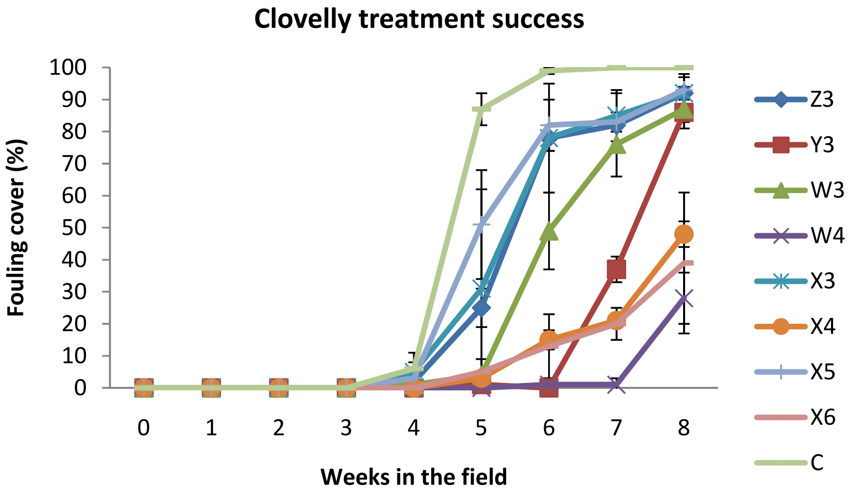


Figure 9. Percent fouling cover of Clovelly treatments over 8 weeks. Data are $\bar{x}$ ± SE (n=3)

One-way ANOVA revealed significant differences ($F_{8,18}$=43.4, $p<0.01$, Fig. 9) between treatments at the Clovelly site after eight weeks of fouling, with Tukey's test revealing W4, X4 and X6 were significantly different to the control ($p<0.01$ for all three).

The Y3 treated tiles up to the eighth week of testing were, along with W4, the most successful tiles in terms of fouling cover. These tiles (Y3) appear to have been fouled by a different organism to the green (*Ulva* spp.) algae which dominated all other tiles at the Malabar and Clovelly sites.

Figure 10. Y3 treated tile (top left) at Malabar versus Y3 treated tile at Clovelly (top right), and the same Clovelly tile compared with other tiles. Both Y3 tiles (centre and top centre) appear to have a different dominant fouling organism.

The brown/reddish (when submerged) coloured fouling on the Y3 replicates was most likely the red algae *Porphyra* sp.

4.2.3 Rozelle

Similarly to the Malabar site, the late arriving 'X' coated tiles from company C, were simply added to the rack already in place at Rozelle. This meant that the first set of tiles was submerged for ten weeks as opposed to the eight week submersion of the company C tiles (with a new control set).

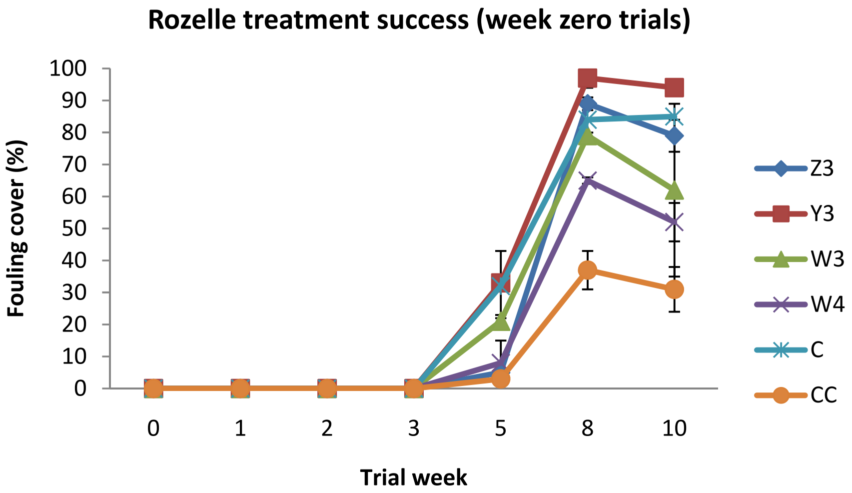


Figure 11. Percent fouling cover of week zero treatments at Rozelle. Data are $\bar{x}$ ± SE (n=2)

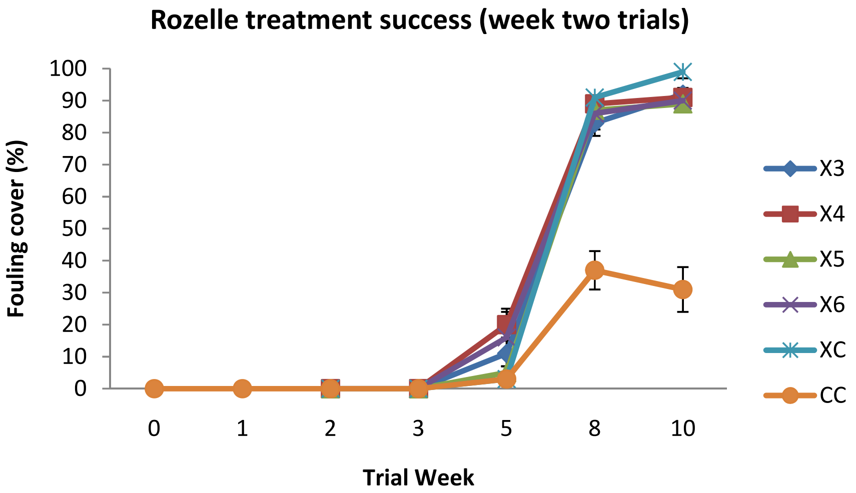


Figure 12. Percent fouling cover of week two treatments at Rozelle. Data are $\bar{x}$ ± SE (n=2)

Photos of the Rozelle experiments were taken during weeks 1, 2, 3, 5, 8 and 10 as it was decided that a week by week analysis was not required. Fouling data from Clovelly and Malabar was thought to be more important so images were taken more frequently at these sites compared with Rozelle.

A one-way ANOVA was performed showing no significant difference between week zero treatments (Z3, Y3, W3, W4, C, CC) at the end of the experiment ($F_{5,6}$=6.7, *p*>0.01, Fig. 11). A second ANOVA was then run without the presence of the commercial control returning values of $F_{4,5}$=3.2, *p*=0.1 as Tukey's test revealed treatment 'CC' was the only significantly different treatment from the control (*p*<0.04). The week two trials (X3, X4, X5, X6, XC) were also compared with the commercial anti-fouling coating ($F_{5,6}$=110.9, *p*<0.01, Fig. 12) and without ($F_{4,5}$=8.6, *p*>0.01), the later showing no significant variation. X5 was reported to be the best performer out of the week two trials (Tukey's *p*-value=0.02).

Fouling of the tiles at Rozelle became visible somewhere between three to five weeks in the water. At each visit to the site, the rack was lifted from the harbour to analyse the tiles which had accumulated a layer of slime or dirt. This slime was not attached to the tiles so was not considered to be fouling and was subsequently washed away with a bucket of water before images of the tiles were taken. The commercially available antifouling coating denoted 'CC' was the least fouled (figures 11 and 12). Of the non-toxic, experimental coatings, X4 and W3 appear to have had the most success. Interestingly, many of the fouling means dropped from week eight to week ten.

The W4 treated tiles significantly inhibited fouling at Clovelly and Rozelle and had some success at Malabar. It was observed that much of the fouling on these tiles had accumulated in between the blotches of wax, which was patchy in application (figure 13).

Figure 13. Replicates of W4 coated tiles from Malabar (top), Clovelly (centre) and Rozelle (bottom) showing accumulation of algae around wax treated areas.

4.3 Adhesion test

4.3.1 Adhesion test results by site

Tests were carried out at the conclusion of the ten week experiment on location at each respective field site immediately after the racks were removed from the steps or from out of the water.

4.3.1.a Malabar

Two-way ANOVA indicated significant differences in adhesion among pressure levels ($F_{3,80}=4.2$, $p<0.01$, Fig. 13, 14 and 15), but there was no differences among treatments or in the interaction of pressure and treatment ($F_{27,80}=0.9$, $p = 0.67$). Tukey's multiple comparisons test showed a significant difference between the pre-test fouling cover of the tiles and the cover after high pressure blasting ($p<0.01$). Significant difference was not detected for low ($p=0.06$) or medium ($p=0.07$) pressure.

4.3.1.b Clovelly

According to two-way analysis of variance there was no significant difference between water pressure tests ($F_{3,72}=0.6$, $p = 0.6$, Fig. 13, 14 and 15) or in the interaction between pressure and treatments ($F_{24,72}=0.4$) at Clovelly.

4.3.1.c Rozelle

The pressure tests at Rozelle were significantly different (two-way ANOVA; $F_{3,44}=9.7$, $p<0.01$, Fig. 13, 14 and 15), however fouling loss from water blasting was consistent over treatments ($p=0.9$). Tukey's test showed significant differences in fouling percentage cover between all three pressure levels and the pre-test cover (all $p<0.05$); although from low to medium ($p = 0.2$) and medium to high ($p = 0.3$) there was no significant difference.

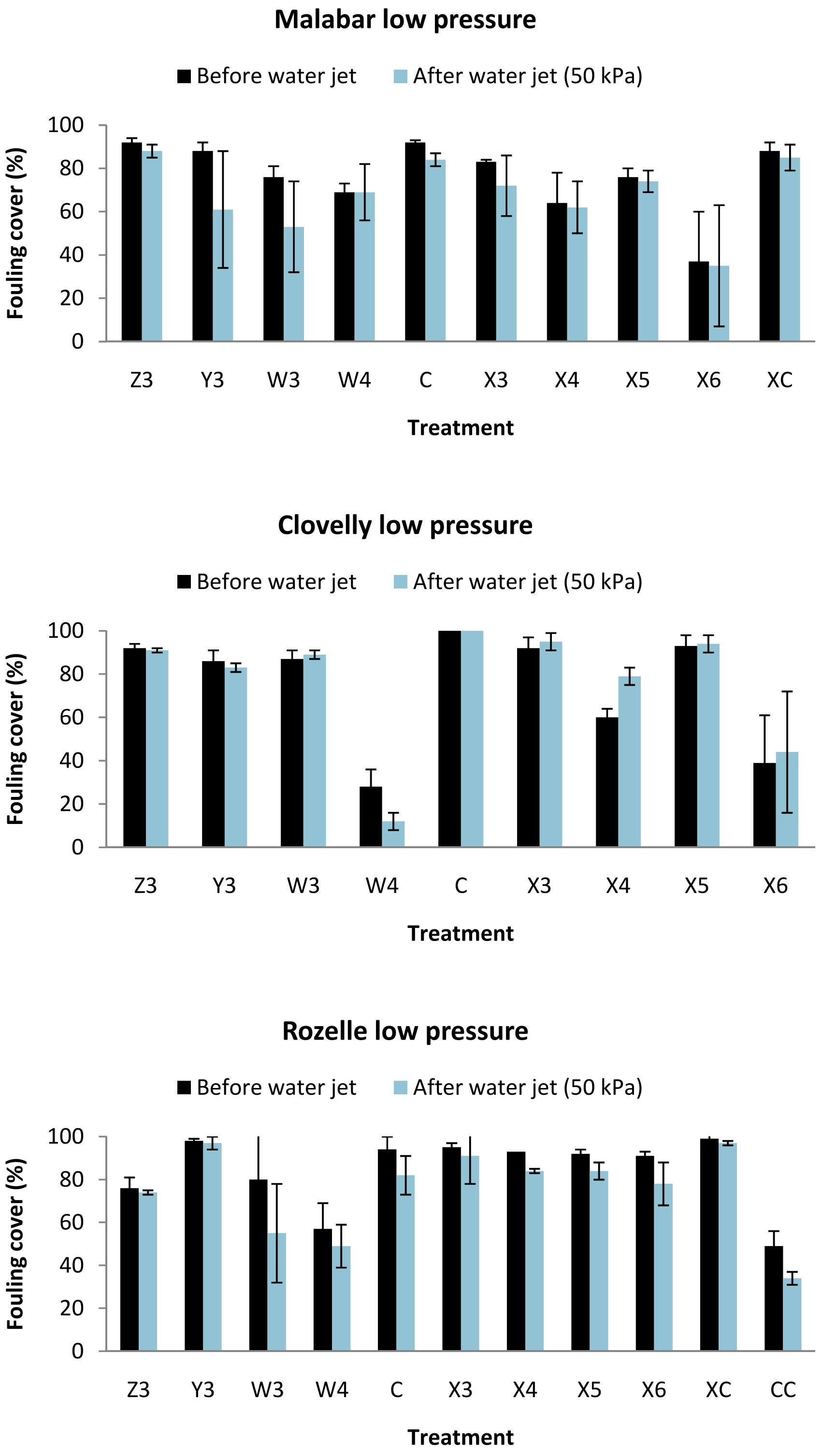


Figure 14. Fouling on tiles before and after the application of a low pressure water blast after 10 weeks exposure in the field. Data for Clovelly and Malabar are $\bar{x}$ ± SE (n=3), Rozelle data are $\bar{x}$ ± SE (n=2)

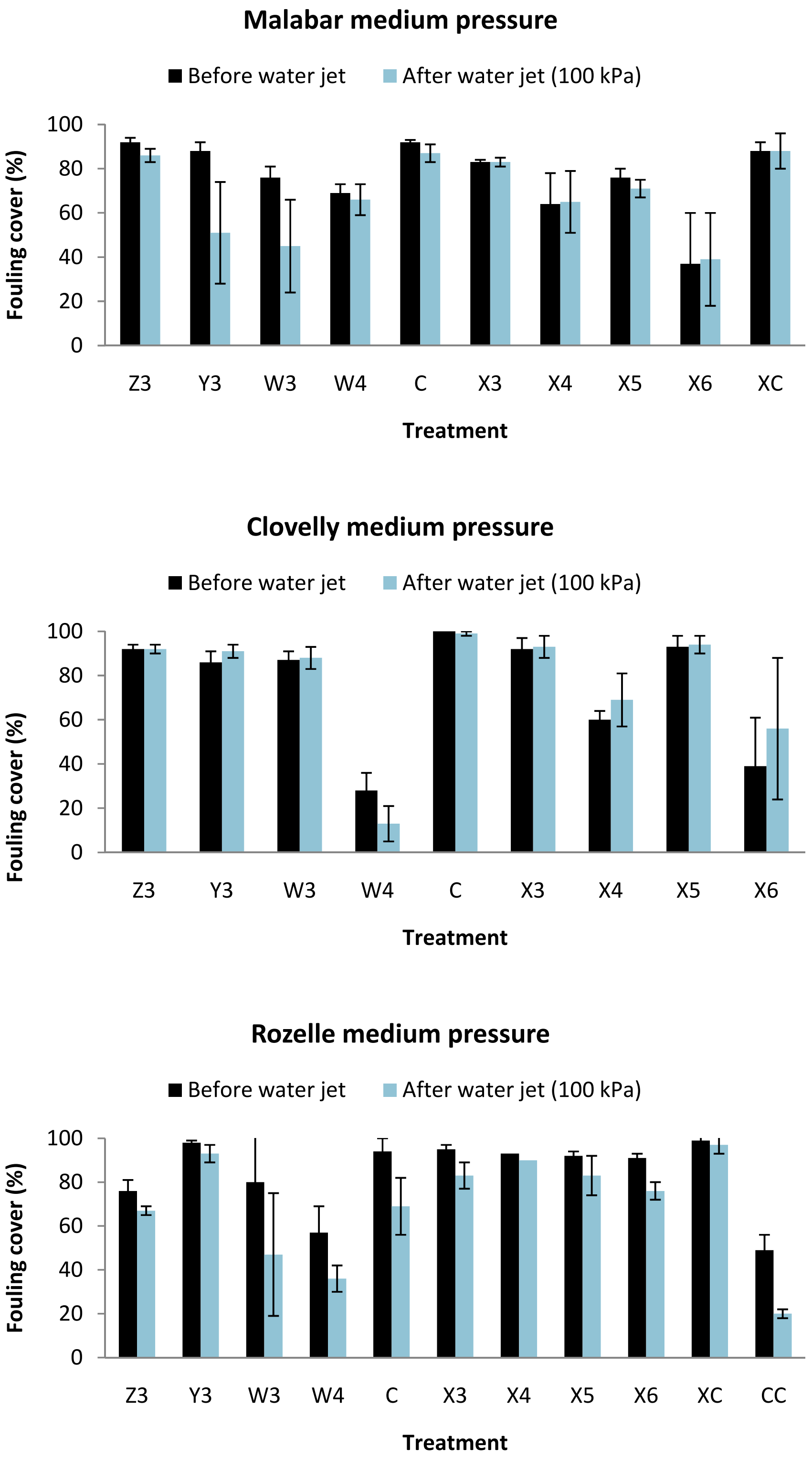
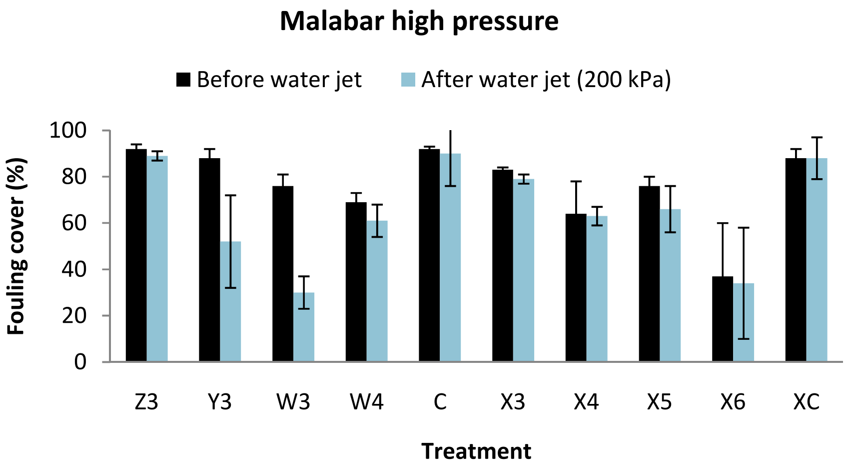
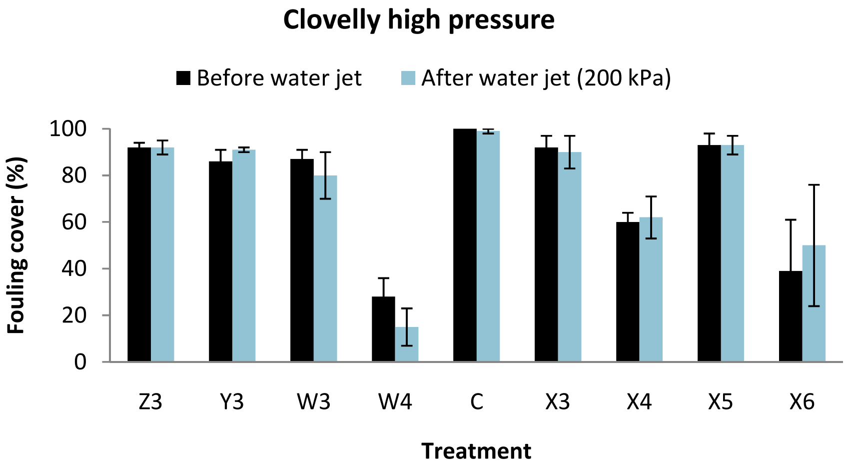


Figure 15. Fouling on tiles before and after the application of a medium pressure water blast after 10 weeks exposure in the field. Data for Clovelly and Malabar are $\bar{x}$ ± SE (n=3), Rozelle data are $\bar{x}$ ± SE (n=2)





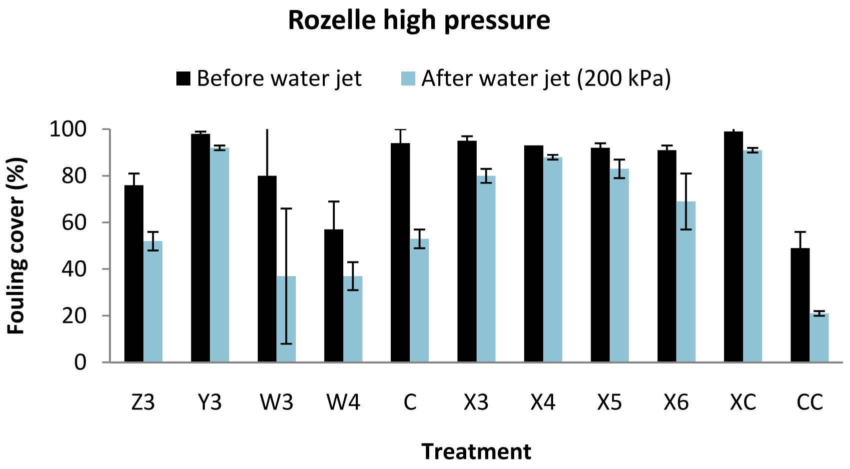


Figure 16. Fouling on tiles before and after the application of a low pressure water blast after 10 weeks exposure in the field. Data for Clovelly and Malabar are $\bar{x}$ ± SE (n=3), Rozelle data are $\bar{x}$ ± SE (n=2)

4.3.2 Summary of adhesion test results

Along with ‘W4’, treatment W3 had a relatively higher percentage loss compared with other treatments (figures 14, 15 and 16). Reason for this may have been due to the fact that whilst blasting the W3 treated tiles (especially with high pressure), small amounts of wax coating with fouling attached would break away (figure 17).

Figure 17. W3 treated tile before water blasting (left) versus the same tile after high pressure water blasting (right).

The treated tiles at the Rozelle site appeared to be the most responsive to the adhesion tests whilst Clovelly tiles were the least, with the exception of W4 and W3.

4.4 Slip test

Slip tests were performed on the first set of trials (Z3, Y3, W3, W4, C) before deployment only for Malabar and Clovelly field sites; and only Clovelly’s ‘X’ treated tiles had slip tests performed on them. This should not have any implication on the results, as all replicates were presumed to be the same when received from the participating companies.

One-way ANOVA performed on tiles before deployment, revealed a significant difference between the slipperiness of treatment surfaces ($F_{8,72}=13.9$, $p<0.01$, Fig. 18). Tukey’s test revealed that W4 ($p<0.01$) and Y3 ($p<0.01$) were significantly less slippery.

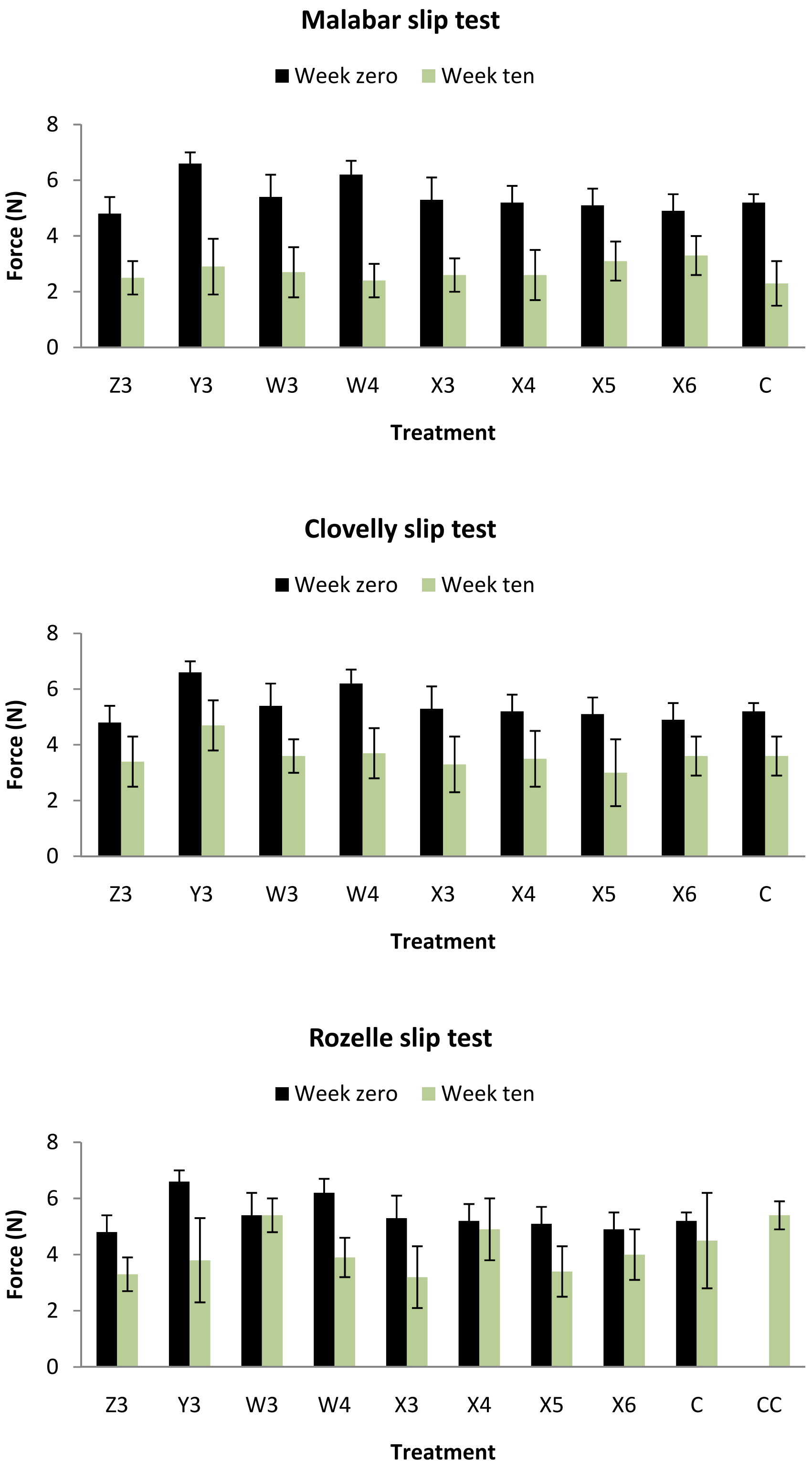


Figure 18. Mean slip test results for treatments across all three sites (Malabar; top, Clovelly; centre and Rozelle; bottom) for week zero and week ten. Note 'CC' did not have a slip test performed on before deployment at week zero. Data for Clovelly and Malabar are $\bar{x}$ ± SE (n=9), Rozelle data are $\bar{x}$ ± SE (n=6)

There was no significant difference between the slipperiness of treatments at the end of the experiment at Malabar (one-way ANOVA, $F_{8,72}$=1.8, *p*=0.097, Fig. 18). There was a significant difference detected at Clovelly (one-way ANOVA, $F_{8,72}$=2.4, *p*<0.05) although Tukey's test indicated that no treatment was significantly different from the control; the closest however was Y3 (*p* = 0.183). One-way ANOVA of the Rozelle results suggested a significant variation between treatments ($F_{9,50}$=3.9, *p*<0.01), however no treatment performed significantly better than the control (Tukey's test, α=0.05).

A slip test was performed at Clovelly on a heavily fouled step 10m from the experiment site. On the set of steps one step up, it was observed that the step was free of fouling. A slip test was performed on the foul-free concrete step also.

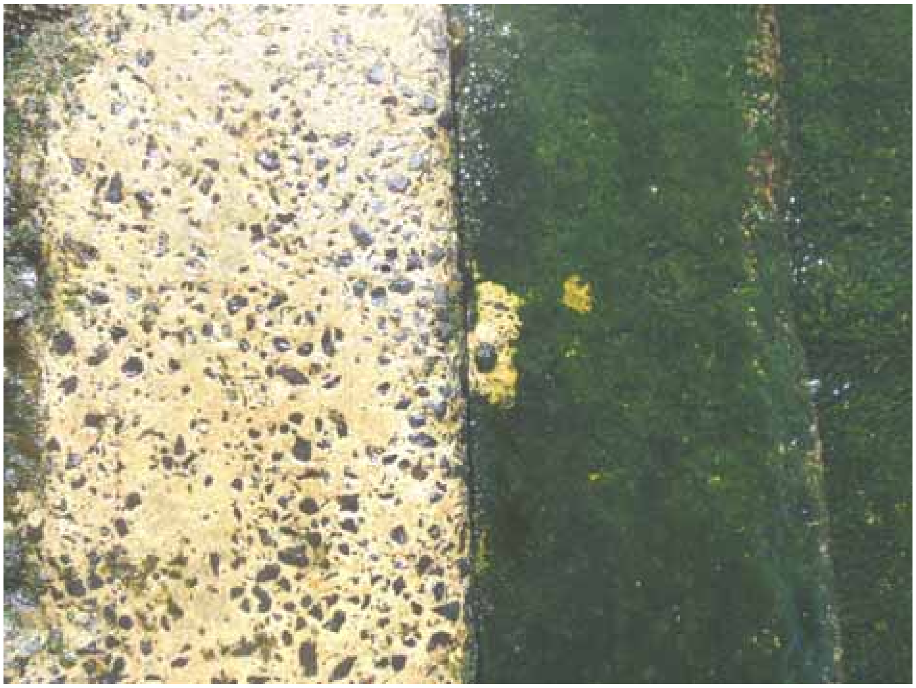


Figure 19. Picture of a step leading into the bay at Clovelly from the southern promenade.

	Test 1	Test 2	Test 3	Test 4
Algae	2.88	3.38	2.68	3.08
Concrete	5.7	4.84	5.44	4.08

Table 1. Results of slip test on Clovelly step (figure 19). Values were obtained using a force gauge and are expressed in Newtons.

5.0 Discussion

Once submerged in a marine environment, an object will within a matter of hours begin to accumulate biological settlers, a process known as biofouling (Wahl, 1989; Richmond and Seed, 1991; Underwood and Anderson 1994; Round, 1996; Wahl, 1997; Evans, 2000; Railkin, 2004; Ralston and Swain, 2009). Biofouling initially begins with the settlement of a biofilm (Wahl, 1989; Little and Wagner, 1997), followed later by the growth of macroalgae such as seaweeds and after a couple of months, barnacles (Wahl, 1989; Evans, 2000; Railkin, 2004). Fouling of coastal platforms is a major concern for public safety and liability. Areas subject to high levels of foot traffic are particularly vulnerable to the possibility of an incident that may result in injury and/or legal action. The inability of current antifouling technology to address this issue means research into possible alternatives provides an opportunity for the development of a unique, highly marketable solution. The increased restrictions on heavy metal based antifouling paints (Rittschof, 2001) also means an environmentally friendly coating developed for coastal platforms could offer wider application possibilities for marine industries (Clare, 1996; Holmstrom *et al.*, 2004).

The first aim of this study was to trial a number of near commercially available, non-toxic antifouling coatings that could be applied to high-use public areas. The second was to assess public opinion on the issue (Section B). In total, eight prospective coatings were reviewed with varying results. Fouling was typically dominated by green algae (*Ulva australis*) without the presence of barnacles, which usually take longer than ten weeks to appear. This is representative of what type of fouling generally occurs on ocean pool platforms. The outcome at the conclusion of the ten week experiment saw, for the most part, all eight coatings substantially fouled. The success of a coating was therefore judged on comparison with untreated controls, and in this context a number of coatings had significant efficacy over ten weeks. Treatments X4, X6 and W4 had the greatest efficacy. Fouling coverage of W4 (figure 4), X4 and X6 (figure 5) after ten weeks all averaged below 50% at the Malabar and Clovelly field sites compared with >80% for the other treatments. Coating Z3 performed the most poorly (section 4.2), >90% covered by the dominant *Ulva* sp. at Malabar and Clovelly. Fouling organisms typically prefer roughened surfaces as opposed to smooth (Underwood and Anderson, 1994; Lin and Shao, 2002), an exposed patch of rough, untreated cement on the Z3 tiles likely lead to edge effect fouling (section 2.2 and appendix A1). This occurs when fouling first happens on a more suitable environment (untreated part of tile) and then spreads to less suitable areas through growth and space/resource requirements (Nandakumar *et al.*, 2004). This phenomenon would have undoubtedly impacted most of the treatments if not every replicate.

Treatment efficacy varied between sites. This was most notable for treatment Y3, which was the only coating that experienced settlement of varying fouling organisms. Where all other tiles were fouled by the green *Ulva* sp. algae, Y3 replicates at Clovelly were covered by *Porphyra* sp., a red alga. One reason for this may be the black colour of the coating as studies have found optimal growth of some red algae sporelings are increased by exposure to different wavelengths (Round, 1996) or the surface roughness (Howell and Behrends, 2006). Little however is actually known about the physiological effects of surfaces on spore attachment and growth (Round, 1996). The red alga, which appeared two weeks after the visible attachment of *Ulva* sp. (figure 10), was less slippery than the green algae covered tiles (figure 18). In fact the mean force measurements (slip test) for Y3 at Clovelly after ten weeks (around 5 N) were very similar to that of an un-fouled concrete step (table 1).

Tiles coated with wax (W3) developed in the Centre for Marine Bio-Innovation, were reasonably successful in inhibiting fouling at Malabar and Rozelle. Both locations are low wave impact sites compared with the rough conditions experienced by the steps leading into Clovelly bay. This, and the fact that the W3 tiles were most affected by adhesion testing (figures 14 to 16), suggests their application may be more suited to calm, low impact areas. Thus not surprisingly, one significant issue for these coatings at Clovelly was the removal of the wax coating itself from the test tile. This may be an application issue that needs to be adjusted. W4 was the most successful coating after ten weeks exposure at Clovelly and Rozelle and was significantly less fouled than the controls at Malabar (section 4.2). Similar to tiles coated with Z3, the success of the wax treated portion of the tiles may have been compromised by edge effects (Round, 1996) from the less successful exposed Y3 part of the tiles. Interestingly also is the absence of *Porphyra* sp. from the W4 tiles which, like all but the Y3 tiles at Clovelly, were covered in green *Ulva* sp.

Whilst they were deployed two weeks after the first set of trials, the tiles from company C (X3, X4, X5 and X6), begun to experience visible fouling around the same time as the week zero tiles at Malabar and Rozelle. It was concluded that this was most likely due to an external occurrence such as a rain or storm event which brought increased nutrients to promote fouling (Richmond and Seed, 1991; Underwood and Anderson 1994; Round, 1996; Wahl, 1997; Evans, 2000; Railkin, 2004; Ralston and Swain, 2009).

Two of the four coatings supplied by company C, X4 and X6, showed promise for future applications. X3 and X5 had results similar, in terms of fouling levels, to that of the control tiles. X6, even without the assistance of snails (*Nerita atramentosa*) (figure 8), demonstrated strong antifouling properties. X4 and X6 both were significantly less fouled than the controls at Clovelly (figure 9) and also performed well at Malabar (figure 7).

An issue with this project was the low power associated with the statistical analysis of results. This was due to the small number of replicates (three at Malabar and Clovelly, and two at Rozelle) of each treatment, which was dictated by the coating and tiles supplied by the commercial partners. Despite this however success (or lack thereof) of the different coatings was still adequately determined without the need for a higher significance level such as used by Xavier *et al*. (2008) where larger significance levels were chosen (α=10%) to reduce the chance of Type II error (Underwood, 1997). Efficacy of treatments within this study was easily quantifiable as a success or failure with the amount of replication used. It is also worth noting that the overall aim of the project was to trial as many different variations of coatings as possible, which necessarily constrained the amount of replication per coating.

SECTION B – COMMUNITY RESPONSES

Section B details the process of data collection and analysis used in assessing public opinion related to issues associated with Section A. This is followed by a detailed account of results representing Sydney pool users. Results have then been discussed with conclusions drawn from the findings.

6.0 Survey methodology

6.1 Role of survey

A qualitative assessment was required to assess the extent to which a new antifouling technology would be accepted by the public, and any possible reason to the contrary. This data was then used to help better decide on the possible integration of a successful coating.

6.2 Survey design

Using a representative sample of the population, a survey was used to gain primary data regarding project impacts. A questionnaire was developed to elicit information specific to the issue of slippery surfaces. As outlined by McGuirk and O'Neill (2005, p.147), this includes questioning designed to garner an understanding of what community stakeholders of this project's, attitudes are to the issue and the proposed solutions.

One of the initial tasks required was to set out a set of questions that could be reasonably answered by members of the target demographic: "To conduct a survey we must translate any concepts into a form in which they are measurable." (De Vaus, 2002 p.43) The issues in question therefore were put into a quantifiable questionnaire. The questions asked required that the respondents have some knowledge of the situation which is why swimming pool (ocean bath) 'users' were chosen as representatives. The term 'pool' refers not so much to the actual pool itself, although it is included, but to the platforms, stairs and ramps that make up the whole pool area. For the Malabar field site this area is decidedly smaller than Clovelly, this fact however should not impact significantly on the results of the questionnaire.

The questionnaire was designed to obtain as many respondents as possible in one outing. This was done by making the questioning process short enough for respondents to agree to participate, whilst still being in depth enough to get the necessary information. Additionally, the survey was conducted in person, and this combination resulted in a high positive response rate which reached almost 90%.

6.3 Questionnaire

The questionnaire contained a combination of questioning methods including likert scales[1] and open and closed questions offering a change of pace assisting in maintaining respondents' interests (Neuman, 2000) and limiting the non-response rate (Lindner 2001; De Vaus, 2002; Stoop, 2005).

A sample of the survey can be viewed in appendix B3.

6.4 Data collection

With permission from Randwick council (appendix B1), respondents were recruited at the Malabar and Clovelly field sites by approach. The questionnaire was conducted on the spot by verbal questioning and answers recorded on clipboard and paper. The questionnaire took on average about four minutes to complete with participants recruited between the 20/08/2009 to 06/09/2009.

It should also be noted that up to 80% of respondents were recruited from the Clovelly site.

---

[1] Also known as summated rating scales, likert scales are used in attitude assessment to place the extent to which a respondent agrees with a particular question. For example a rating from one to five, five being strongly agree, one being strongly disagree. (Corbetta, 2003)

7.0 Results

The survey was conducted over two weeks with a total 128 respondents to the questionnaire. The following details the data obtained over the fortnight and its significance.

7.1 Age and suburb

At the conclusion of each survey, the respondent was asked to supply the interviewer with some anonymous but personal information. The respondents were queried on their age and the suburb they lived in, and were told that this part of the survey was optional meaning if they did not want to divulge their age or location they did not have to.

7.1.1 Age structure

Due to the nature of the question, age brackets were thought to be more appropriate and were received with a high positive response rate. Ages were categorised into five fifteen year segments with over sixty year olds forming the last age bracket.

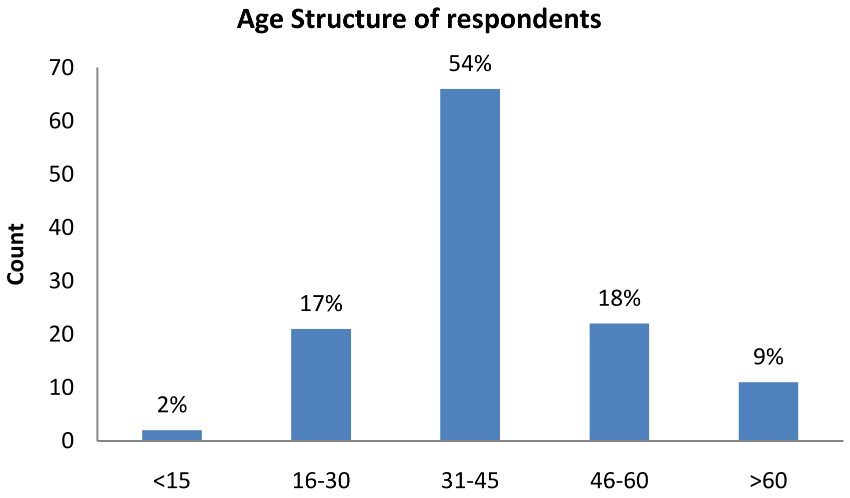


Figure 1. Graph illustrating the number of respondents from the five age brackets as well as a percentage amount for each category.

Over 50% of respondents were from the 31 to 45 age category; this seems an accurate representation of swimming pool users at the field sites. This was corroborated visually during field work and whilst conducting the survey. The 2006 census shows that people aged between 25 and 49 make up 41% of the population of Randwick City which is higher than the Sydney Statistical Division average (Australian Bureau of Statistics, 2006 Census of Population and Housing). The suburb of

Clovelly, where a large number of respondents were from (figure 2), shows an even greater percentage, 48%, of residents aged 25 to 49.

The age structure of a population is an indicator of an area's residential role and function and how it is likely to change in the future. For example an ageing community is likely to see less development of youth infrastructure such as skate parks and playgrounds, and more attention given to care facilities and hospitals. Age is an important determinant, which shapes both demographic and economic dynamics (Singh, 2007). What this means for this research is that in any steps taken to implement change, consideration must be given to the needs and desires (as revealed via the survey), and potential impacts on the dominant age group, being 31 to 45 years old at present (and ageing).

7.1.2 Locality of respondents

The last question in the survey asked what suburb does the respondent live in. Respondents were told prior to answering that this information was optional.

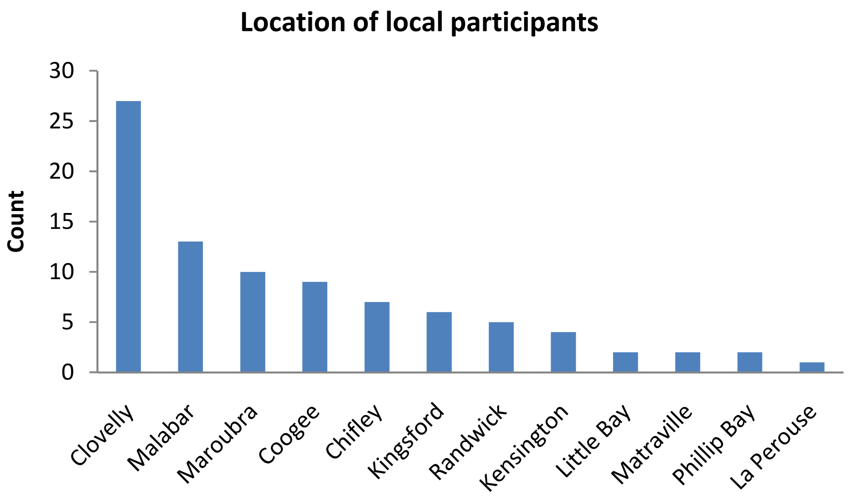


Figure 2. Graph showing location of local residents whom participated in the survey. In total 88 respondents were from Randwick City.

It was found that 69% of respondents were, at the time of the survey, living within the Randwick local government area, 31% of which were from the suburb of Clovelly. This equates to Clovelly representing over 20% of total participants. The full list of suburbs can be viewed in appendix B4.

“People’s lives are circumscribed by the localities in which they live” (Peet, 1998 p.181) and the fate of these places are influenced by the people who live in them and vice versa. Localities can be seen as simply an outcome of structural determination (Cook, 1989), this however fails to acknowledge the potentially effective power of the active practices of local people. ‘People power’ often has a leading role in shaping an area; as seen in the town of Taos, New Mexico where locals grow their own food and recycle everything without electricity or outside assistance. Combined with a strong sense of community, stakeholder locality is a powerful determinant in shaping an area’s future.

7.2 Ocean pool usage

A question involving individual patronage was asked with regard to how often the respondent ‘uses’ the pool. Five options were provided for the respondent on usage per week, month including whether the pool is used/visited at all.

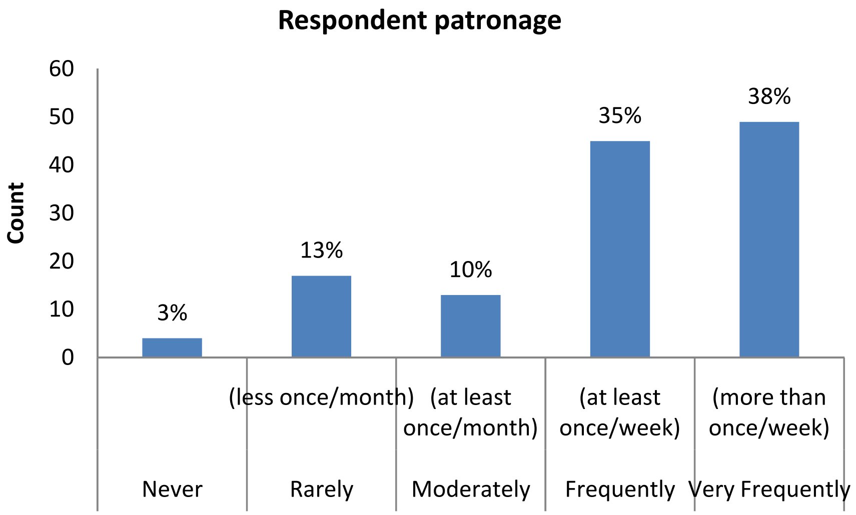


Figure 3. Graph detailing the frequency of pool use by respondents with a count value on the x axis and a percentage value above each usage bracket.

From figure 3 it can be said that the majority of respondents are frequent pool users, from which it can be reasonably surmised of them being local residents. Only a small number of respondents (26%) visited the pools on an average of less than once a week making the pool areas usage a locally dominated activity.

In understanding the concepts and variables of pool use, it is important to attempt to fully understand how one individual can represent a broader purpose of understanding a group of people (De Vaus, 2002; Babbie, 2009). By establishing behavioural information (McGuirk and O’Neill, 2005) such as pool usage, a stakeholder's reaction to change can be more accurately assumed. Within the example above, determining the patronage of individuals, mostly members of the majority group (locals), is vital in gauging the importance of the pool for the local community.

7.3 Hazards associated with ocean pool use

In order to find out what pool users believe to be issues of concern regarding their health, a question about pool dangers was asked using a likert scale[1] system. Each respondent was asked to rate a set of potential dangers that were read out to them. Each participant ranked, from one to five, the least concerning through to five, the most dangerous potential hazard.

	Dangerous surf/weather	**Rock falls**	**Pollution**	**Slippery surfaces**	**Blue Bottles**
1	70%	66%	23%	16%	51%
2	16%	25%	34%	35%	36%
3	6%	6%	16%	26%	4%
4	4%	2%	23%	13%	3%
5	3%	1%	4%	10%	6%

Table 1. Lists individuals' responses from 1 to 5 on the extent of danger each column represents to them as a pool user. Each row (1-5) represents what percent of users rated the issue with the corresponding score out of five.

This data was then quantified. This was achieved by giving each score from one to five a value. In this system a score of one equals one point, a score of two equates to two points and so on up to five equalling five points. The count of each score was then made a value and added up with the other scores for that hazard to create a total, for example; for dangerous surf and weather:

90 people gave a score of 1 = 90 points
21 people gave a score of 2 = 42 points
8 people gave a score of 3 = 24 points
4 people gave a score of 4 = 16 points
5 people gave a score of 5 = 25 points

total equals 196.

	Dangerous surf/weather	**Rock falls**	**Pollution**	**Slippery surfaces**	**Blue Bottles**
Score	196	189	320	342	228

Table 2. Aggregate score of each hazard as determined by ranking system described on p.45. The scores are an overall mark determined from all age categories.

From this it is seen that the general user consensus is that pollution and slippery surfaces provide the most risk to pool user's health (table 2). During the questionnaire the respondent was given the option of describing any other issue they consider to be a health hazard, these can be viewed in appendix B5.

The study of individual concerns is vital in establishing an overall view, as Babbie (2009, p.15) explains "(s)ocial research, involves the study of variables and their relationships. Social theories are written in a language of variables, and people get involved as the "carriers" of those variables." Establishing what is considered dangerous to each individual, a trend emerged about what was thought to be of least and most significance. Slippery surfaces, as determined in table 2, present the highest perceived danger to the represented community. But, as alluded to, this may vary by age-group.

7.4 Slip hazard

To meet the aims of this project requires knowledge of the occurrence of injury resulting from a slip incident. To satisfy this, survey participants were asked bivariatively if at any time in the past they have indeed been injured by slipping over whilst using the pool area. Twenty-nine individuals, or 23% of respondents, had hurt themselves from slipping over. The other 99 had never slipped and been hurt. Injuries that were sustained by those who answered 'yes' included;

- Cuts and bruises
- Lacerated leg
- Lacerated back of head
- Broken wrist

Two respondents explained that they were 'taking action' against Randwick Council for compensation. One slipped on an access ramp at Malabar pool and hurt their forehead and claimed medicated cream for the injury. The second compensation claim occurred when the other individual slipped on the steps leading into Clovelly bay and resulted in them injuring their back and requiring physiotherapy.

Of the twenty-nine slip victims, four resulted in a trip to the hospital equating to 3% of the sample population.

The respondent was asked firstly if they had ever slipped and if they replied 'no', the follow-up questions of "how were you injured" and "did you take action" were not asked. Gathering sensitive information such as asking a respondent to recall an incident resulting in harm or injury is often necessary to a research plan, as it is in this instance. Anonymity in response can play a major role in a respondents' choice whether or not to answer truthfully or answer at all. As Walden (2006 p.262) states; in minimising both response and non-response bias in surveys, a common technique is to combine sensitive questions with innocuous ones in a manner in which responses can be attributed to respondents only on a probability basis. This method could be viewed as unethical, depending on the invasiveness of the question being asked (De Vaus, 2002). This issue is avoided in this study due to the mostly un-intrusive nature of the topic.

7.5 Council treatment of slippery surfaces

Respondents were queried on their knowledge of council treatment of slippery surfaces. They were asked whether or not they are aware of any current council program or activity to remove algae off coastal platforms which in turn minimises the slip hazard.

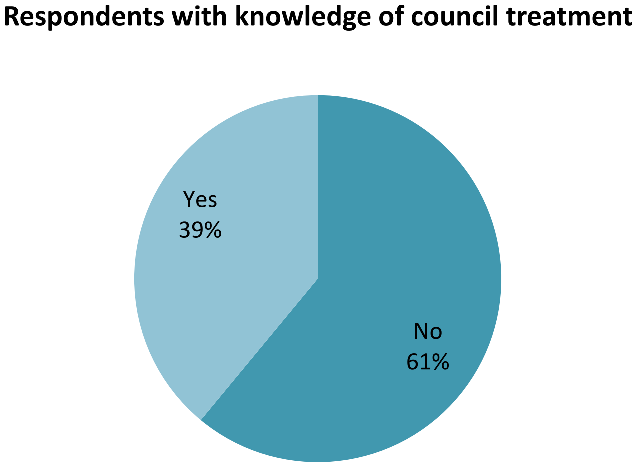


Figure 4. Pie chart displaying the percentage of survey respondents aware of Randwick Council's algae removal treatment.

Fifty respondents displayed some knowledge of council treatment; four still think chlorine is used. Of the individuals aware of treatment, 32 (64%) know of it involving water blasting.

After establishing the respondent's knowledge of council pool cleaning, the questionnaire asked their opinion on the adequateness of the treatment. If a respondent had answered no to knowing of any council treatment, the use of a Jet Blaster truck (section 1 and appendix B3) was explained to them.

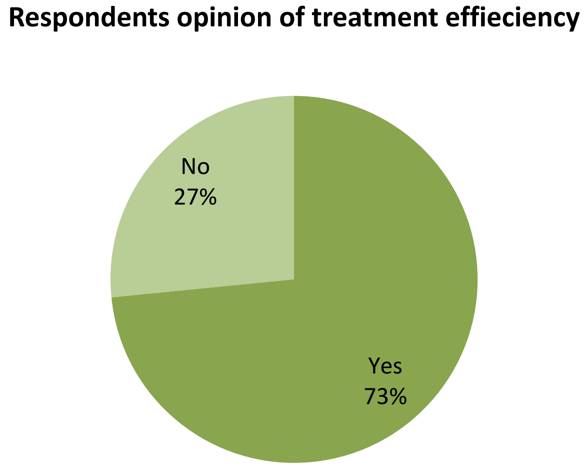


Figure 5. Pie chart displaying respondent's opinion of whether or not the council's use of water blasting to remove slip hazard is sufficient.

Figure 5 shows that almost three quarters of respondents believe that using water blasting to remove algae, and the subsequent slip hazard, is an adequate method.

These results are not surprising considering the high percentage of local respondents and the inherent knowledge of the area, including slippery surfaces, that comes with being a local. Many (local) respondents expressed the opinion that individuals themselves should be aware of slippery surfaces, and that each individual is responsible for their own safety regardless of council effort to remove algae. It should also be noted that the percentage of slip victims, 23%, is very similar to the percentage of respondents who believe the current antifouling method is unsuitable; 27%.

7.6 Antifouling of ocean pools

Participants were informed of the possibility of replacing jet blasting with anti-foul coated surfaces. They were then asked if they had any objections at all to this course of action. The results are as follows:

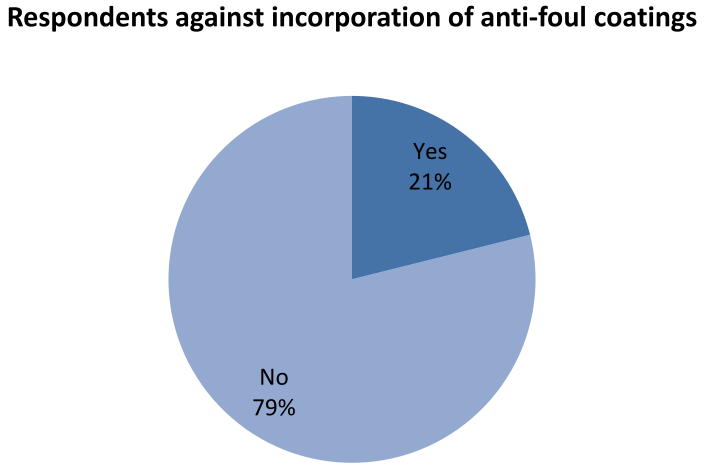


Figure 6. Pie graph showing the percentage of respondents who have reservations about replacing water blasting with anti-foul coatings.

101 respondents had no concern over the incorporation of anti-foul paints at the expense of water blasting. Reasons against included; the “unnatural nature” of antifouling (14 respondents), adverse non-target effects (6 respondents), chemical leeching (5 respondents), one respondent was concerned that the paint would be ugly. Respondents were told of the non-toxic nature of the paint trials for this research prior to asking the question, yet many, as detailed above, still expressed concerns.

The cleaning issue discussed in the question above, hinges on the concept of what is considered safe to people and the environment, and what is considered dangerous. This concept is especially important for a liable council. Concepts however, are terms which people create for the purpose of communication and efficiency which develops into indicators for how they are ‘defined’ (De Vaus, 2002). If concepts have no set meaning, anyone can define a concept whichever way they wish; unless people mean the same thing, communication is impossible (De Vaus, 2002; Babbie, 2009). The concept of a safe pool area is therefore defined in this research by it being clean of algal growth, hence lowering the risk of slipping over.

7.7 Altered pool usage

The theory behind altered pool use is based around whether a respondent's patronage would decrease under certain circumstances. Three scenarios were presented to each respondent who were to answer whether they would reduce using the pool, stop use altogether or continue using the pool unchanged.

	Slipped and hurt	Water blasting replaced with antifouling paint	Algae left to grow
Reduce	8%	3%	29%
Stop	6%	2%	18%

Table 3. Table showing the percent of respondents who would alter their pool use under certain circumstances.

Table 3 suggests respondents are, for the most part, unlikely to stop or limit pool usage if water blasting is replaced with antifouling paints. 47% of respondents would limit or stop using the pool if algae growth was allowed to thrive unabated, however only 14% would alter their usage if they slipped and hurt themselves.

Social research often studies motivations that affect individuals. However the individual as such is seldom the subject of the research, instead, the objects of the study are typically aggregates, or collections of social groups rather than individuals (Babbie, 2009). The motivation of individuals to cease or continue using a pool in this instance is based on the variables of perceived danger and in some instances aesthetics. The system therefore, is reliant on group opinion of what affects pool patronage, which is comprised of varying individual attitudes.

8.0 Discussion

Evaluating the significance of respondent opinion – which is sometimes based on experience – is an important part of social research (Babbie, 2009). The fact that the respondent's represent a social group that will be impacted by the results of this research, does not necessarily lend weight to their opinion or stance on the issue. What makes their opinion vital is the scale of impact the research, and any subsequent change, may have on them. Patton (2002, p.568) explains that "researchers should strive to neither overestimate nor underestimate their (projects) effects but to take seriously their responsibility to describe and study what those effects are." One of the issues in assessing the data is interpreting the meaning of people's responses. Individuals can experience similar events that may mean different things or indicate different things and elicit different behavioural responses for some people (De Vaus, 2002). This issue is partly overcome by using varying questioning techniques (Neuman, 2000; Sutton, 2004 McGuirk and O'Neill, 2005; Walden, 2006). De Vaus (2002, p.54) explains that the patterns of people's responses can help us understand the meaning of a particular response, where other information can be used to help put the response to a particular question in context. With this in mind it can be said that the results suggest respondents in general prefer the pool area to be free of algae but not so much free of a the slip hazard. This is demonstrated by respondent's opinion of the current treatment's efficiency (figure 5) and the local's ideal of self accountability.

Public opinion although integral to social research, can be ambiguous and often misleading (Neuman, 2000). Empirical research requires the linking of data to concepts. Where opinions are involved this means focusing on group attitude as a whole and not individual case studies (Babbie, 2009). Punch (2005, p.45) stresses the idea behind empirical research as a link between research questions and data, or between concepts and indicators all form part of the overall logic chain within a social study. Some constituents in this research are so opposed to replacing water blasting with antifouling paints, they would consider ceasing all use of a treated area. The vast majority however, 95%, maintain that this change would not impact their patronage at all. The empirical criterion of research questions requires that the link is made from concept to data (Punch, 2005); the concept of discontinued pool use due to paints replacing blasting is operationally defined and quantified by asking respondents if they would cease using the pool if antifouling coatings were applied instead of water blasting (table 3).

Establishing group attitudes from a representative sample, a researcher is often faced with the issue of non-response (Linder, 2001; De Vaus, 2002; Stoop, 2005). A high rate of non-response can pose a threat to survey quality by causing unwanted systematic deviations from the true outcome of a survey. Of the three survey protagonists (interviewers, respondents and non-respondents), non-respondents are often over looked when they can in fact be a major player in results and in bias (Stoop, 2005). This issue is very hard to overcome in whatever form of social research being conducted, a lot of the time the only thing that can be done is to take it (non-response) into consideration. This is not the only response issue however; Groves and Couper (1998, p.62) in the meta-analysis of their research were concerned over the high response rate (82% to 97%) and cooperation rate (87% to 98%) they had received. If overall survey cooperation exceeds 90%, it is difficult to detect subgroups that exhibit large differences in cooperation (Stoop, 2005). A similar response rate (88%) was experienced in this research. The reason for this could be attributed to high local patronage and a sense of ownership many local patrons exhibit. The stake the local community hold in the management of pools within Randwick could be viewed has high with local groups often performing their own cleaning and maintenance on pools; such as the Bondi Icebergs swimming club, sacrificing much of their own time and money to maintain the pool at Bondi beach.

Although some local opinion preaches self-liability regarding pool safety, it is hard to say for certain the extent to which locals, and any other pool users, would tolerate a slippery unsafe pool area, or how many would consider holding council liable for any resultant injury. According to Marie-Louise McDermott (2005) of the NSW Heritage Office:

> “attitudes toward management of the associated risks of rock pool usage have changed over time; nineteenth century bathers were expected to be prudent enough to avoid dangerous situations, as the pleasures of a ‘dip’ were thought to outweigh any minor injuries sustained as pools were seen as a safer swim option than rough, shark-infested beaches. Today, people are more likely to seek compensation from council’s for injuries sustained at pools or other council-controlled spaces. Councils found the cost of public liability insurance rising to barely affordable levels and sought to minimise their risk exposure.”

Gauging the sort of information required to understand how likely it is for someone to sue a council is beyond the scope of this research (and is possibly unethical). What can be deduced is how likely people are to use, or continue using the pool in the face of some event (table 3).

There were some issues encountered whilst analysing the results of this social research. First, as a group cannot be surveyed as an individual respondent due to bias (De Vaus, 2002; David and Sutton, 2004; Walden, 2006), it was often difficult to recruit some individuals who were within a group. These individuals were requested, but in no way coerced, to step out of the group to perform the survey. This was the source of most denials. Although most days of the week and times of day were covered in the recruiting process, a factor that may or may not influence the results pertains to the time of year the research was conducted. Respondents were recruited in the months of August and September where cleaning of pools is performed more often leading into summer. Also in the colder months patronage patterns are likely to be much different and would elicit different results.

As all data was pooled, individual survey results were not available. These could have been used to correlate variables such as age and injury, or patronage and locality. Instead most of these have been reported as observations instead of detailed in quantifiable data. However, the data gathered during this study was sufficient to satisfy the original goals of the research and to draw conclusions relevant to public opinion of antifouling and safety.

Conclusion

Fouling on coastal platforms provides an ongoing challenge for stakeholders. This study investigated possible solutions to this issue through trialling a number of antifouling candidates that could resolve the issue of slippery surfaces on these platforms.

The wax application on W4 was the most successful component of all treatments. However, the overall concept of a wax as an antifouling coating for coastal platforms has logistical difficulties. It would be difficult to apply to vast areas, as seen around many ocean pools. Its effectiveness as an antifouling coating however is apparent, as investigated by Asfar (2008), and does have potential for future applications. Coatings X4 and X6, though not ready as a solution, showed potential with further refinement and experimentation. The same applies to the wax coating W3 whose performance was best suited to calm, low impact conditions, as is seen at a harbour location or bay.

The success of Y3 at Clovelly suggests its use at similar sites (as Clovelly) could be further investigated and could quite reasonably be applied as a substitute to physical cleaning. Otherwise, a period of using the coating with a lower frequency of cleaning could be adopted. The roughness of the surface on Y3 could mean it could be used as an anti-slip coating for occasionally wet/fouled surfaces, such as the Clovelly promenade.

The results of the survey display a 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.

With the development of an antifouling coating that is both environmentally friendly and can substantially inhibit fouling, mechanical cleaning of ocean platforms may no longer be necessary. Future direction in the development of such a coating could look at the success of wax based coatings such as those trialled in this study, and note the positive response from the public to a coating that meets the aforementioned criteria of non-toxic and anti-slip.

References

Abbott, A., Abel, P. D., Arnold, D. W. and Milne, A., (2000) Cost-benefit analysis of the use of TBT: the case for a treatment approach. *The science of the total environment*, **258**: 5-19.

Asfar, A., (2008) Settlement of marine fouling organisms in response to novel antifouling coatings. PhD Thesis, UNSW, Sydney.

Babbie, E. R., (2009) The practice of modern research. 12th edition, Cengage Learning, 1-390

Briggs, C. L., (1986) Learning how to ask: a socio-liguistic appraisal of the role of the interview in social science research. Cambridge University Press, Cambridge, 13-43.

Callow, M. E., Anderson, C., Atlar, M., Candries, M., Nilne, A. and Townsin, R. .L, (2003) The development of foul-release coatings for seagoing vessels. *Marine design and operations*, B4

Champ, M. A. and Seligman, P. F., (1996) An introduction to organotin compounds and their use in antifouling coatings. In: Champ, M. A. and Seligman, P. F., (eds.) Organotin: environmental fate and effects. 1st edition, Springer, San Diego, 1-26.

Charlton, T., (2008) Antifouling technologies for coastal pools and platforms. Project proposal, UNSW, (unpublished)

Clare, A. S., (1996) Marine natural product antifoulants: status and potential. *Biofouling* **9**: 211–229

Cook, P., (1989) Localities: the changing face of urban Britain, Unwin Hyman, London, xiv – 321

Corbetta, P., (2003) Social research: theory, methods and techniques. SAGE, 164-193

Costa-Pierce, B. A. and Bridger, C. J., (2002) The role of marine aquaculture facilities as habitats and ecosystems. In: Stickney, R. R. and McVey, J. P., Responsible marine aquaculture. CBAI, U.K., 105-144

David, M. and Sutton, C. D., (2004) Social research: the basics. SAGE, 15-22

De Vaus, D. A., (2002) Surveys in social research. 5th edition, Routledge, 22-96.

Evans, L. V., (1988) Marine biofouling. In: *Algae and human affairs*. Lembi, C. A. and Waaland, J. R., (eds.), Cambridge University Press, 433-455.

Evans, L. V., (2000) Biofilms: recent advances in their study and control. 1st edition, CRC press, 101-117.

Gotoh, K., (2007) Cleaning using a high speed impinging jet. In: Kohli, R. and Mittal, K. L., (eds.) Developments in surface contamination and cleaning. William Andrew Publishing, 889-918.

Groves, R. M. and Couper, M. P., (1998) Nonresponse in household interview surveys. John Wiley, New York, 62

Haak, P. W., (1996) Antifouling systems, current status and developments. In: The present status of TBT-copolymer antifouling paints: proceedings of the international symposium on antifouling paints for ocean-going vessels. The Hague, 9-16.

Hayes, C., (2007) Vertical distribution of algal species in rock pools in south-eastern Australia. *Cross-sections*, Australian National University, **3**

Hoggart, K., Lees, L. and Davies, A., (2002) Researching human geography. Oxford University Press Inc, New York, 169-175.

Holmstrom, C., Steinberg, P. and Kjelleberg, S., (2004) Bioprospecting novel antifoulants and anti-biofilm agents from microbes. In: Bull, A. T., Microbial diversity and bioprospecting. ASM Press, 405-414

Howell, D. and Behrends, B., (2006) A review of surface roughness in antifouling coatings illustrating the importance of cutoff length. School of Marine Science and Technology, University of Newcastle, U.K., *Biofouling* **22**(6): 401-410

Hughes, D. J., Cook, E. J. and Sayer, M. D. J., (2005) Biofiltration and biofouling on artificial structures in Europe: the potential for mitigating organic impacts. *Oceanographic and Marine Biology Annual Review* **43**: 123-172.

Jones, D. S., (1992) A review of Australian fouling barnacles. In: Morton, B., Asian marine biology. Hong Kong University Press, Hong Kong, **9-10**: 89-100

Kjelleberg, S. and Holmstrom, C., (1994) Antifoulants from bacteria. *Proceedings of an International Workshop, Biofouling: Problems and Solutions*, 32-38

Lewis, T., (1994) Impact of biofouling on the aquaculture industry. In: Kjelleberg, S. and Steinberg, P., (eds.) Biofouling: problems and solutions: proceedings of an international workshop. UNSW, Sydney, 32-38.

Lin, H. J. and Shao, K. T., (2002) The development of subtidal fouling assemblages on artificial structures in Keelung Harbor, Northern Taiwan. *Zoological Studies* **41**(2): 170-182

Lindner, J. R., (2001) Handling of nonresponse error. *Journal of International Agricultural and Extension Education*, **9**(3) 55-60

Little, B. J. and Wagner, P. A., (1997) Succession in microfouling. In: Nagabhushanam, R. and Thompson, M., (eds.) Fouling organisms in the Indian Ocean: biology and control technology. Oxford & IBH Publ Co Put Ltd, New Delhi, 105-134.

McDonnell, G. E., (2007) Antisepsis, disinfection, and sterilization: types, action, and resistance. Wiley-Blackwell, United States, 144-156.

McGuirk, M. and O'Neill, P., (2005) Using questionnaires in qualitative human geography. In: Hay, I., (ed.) Qualitative research methods in human geography. 2nd edition, Oxford University Press, Victoria, 147-162.

Munn, C. B., (2004) Marine microbiology: ecology and application. 1st edition, BIOS Scientific Publ, New York, 255-272.

Nandakumar, K., Sekar, R., Venugopalan, V. P., Nair, K. V. K. and Rao, V. N. R., (2004) Hydrobiologia: early stages of biofilm succession in a lentic freshwater environment. Springer, Netherlands, **512**: 97-108

Neuman, W. L., (2000) Social research methods: Qualitative and quantitative methods. Allyne and Bacon, Boston, 327-341

Patton, M. Q., (2002) Qualitative research and evaluation methods. 3rd edition, SAGE, 541-574

Peet, R., (1998) Modern geographical thought. Wiley-Blackwell 147-193

Punch, K., (2005) Introduction to social research: quantitative and qualitative approaches. 2nd edition, SAGE, 44-61

Railkin, A. I., (2004) Marine biofouling: colonization processes and defences. 1st edition, CRC press, 25-227.

Ralston, E. and Swain, G., (2009) Bioinspiration – the solution to biofouling control? *Bioinspiration and Biometrics*, Center for Corrosion and Biofouling Control, Florida Institute of Technology, Florida **4**(1): 15007

Richmond, M. D. and Seed, R. A., (1991) A review of marine macrofouling communities with special reference to animal fouling. *Biofouling* **2**: 151-168.

Rittscof, D., (2001) Natural product antifoulants and coatings development. In: McClintock, J. B. and Baker, B. J., (eds.) Marine chemical ecology. 1st edition, CRC Press, New York, 543-559.

Round, F. E., (1996) The ecology of algae. UMI Books, 653

Sheskin, D., (2004) Handbook of parametric and nonparametric statistical procedures. 3rd edition, CRC Press, 406-410

Singh, K., (2007) Qauntitative social research methods. SAGE, 271-307

Steinberg, P. D. and de Nys, R., (1994) Natural Antifoulants from seaweeds. *Proceedings of an International Workshop, Biofouling: Problems and Solutions*, 70-76

Stoop, I. A. L., (2005) The hunt for the last respondent: nonresponse in sample surveys. Sociaal en Cultureel Planbu, 23-63

Underwood, A. J. and Anderson, M. J., (1994) Seasonal and temporal aspects of recruitment and succession in an intertidal estuarine fouling assemblage. *J. Mar. Biol. Ass.* U.K. **74**: 563-584

Underwood, A. J., (1997) Experiments in ecology: Their logical design and interpretation using analysis of variance. Cambridge University Press, U.K., 504

Wahl, M., (1989), Marine epibiosis. I. Fouling and antifouling: some basic aspects. *Marine Ecology Progress Series* 58: 175-189.

Wahl ,M., (1997) Living attached: aufwuchs, fouling, epibiosis. In: Nagabhushanam, R., Thompson, M. F., (eds.) Fouling organisms of the Indian Ocean: biology and control technology. Oxford & IBH Publ Co Put Ltd, New Delhi, 31-83.

Walden, G. R., (2006) Survey research methodology 1990-1999: An annotated bibliography. IAP 237-265

Wilson, B. R., (1993) Australian marine shells: Prosobranch gastropods. Part one, Odyssey Publishing, Western Australia, 408

Winchester, H. P. M., (2005), Qualitative research and its place in human geography. In: Hay, I., (ed.) Qualitative research methods in human geography. 2nd edition, Oxford University Press, Victoria 3-17.

Xavier, E. A., Gama, B. A. P., Porto, T. F., Antunes, B. P. and Pereira, R. C., (2008) Effects of disturbance area on fouling communities from a tropical environment: Guanabara Bay, Rio de Janeiro, Brazil. *Brazilian Journal of Oceanography*, **56**(2)

Appendices

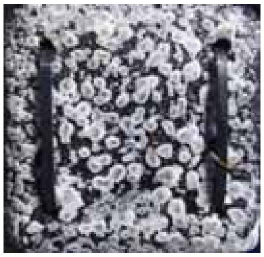
Appendix A1:

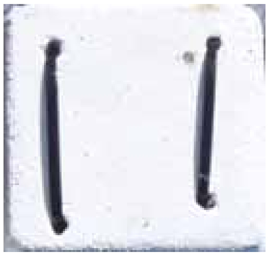
Images of treated tiles used in experiments


Z3

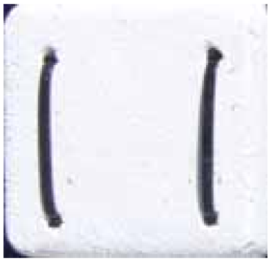

Y3

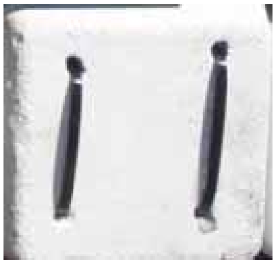

W3


W4


X3


X4


X5


X6


C/XC


CC

Appendix A2:

Percentage fouling cover on tiles after five weeks (note: no visible fouling weeks 1 -4) (4.2)

Site	Treatment	Score	Site	Treatment	Score	Site	Treatment	Score
Malabar	Z3	0	Clovelly	Z3	0	Rozelle	Z3	4
Malabar	Z3	0	Clovelly	Z3	0	Rozelle	Z3	6
Malabar	Z3	0	Clovelly	Z3	0	Rozelle	Y3	26
Malabar	Y3	0	Clovelly	Y3	0	Rozelle	Y3	40
Malabar	Y3	0	Clovelly	Y3	0	Rozelle	W3	21
Malabar	Y3	0	Clovelly	Y3	0	Rozelle	W3	20
Malabar	W3	0	Clovelly	W3	0	Rozelle	W4	6
Malabar	W3	0	Clovelly	W3	0	Rozelle	W4	10
Malabar	W3	0	Clovelly	W3	0	Rozelle	C	37
Malabar	W4	0	Clovelly	W4	0	Rozelle	C	27
Malabar	W4	0	Clovelly	W4	0	Rozelle	X3	8
Malabar	W4	0	Clovelly	W4	0	Rozelle	X3	14
Malabar	C	0	Clovelly	C	0	Rozelle	X4	17
Malabar	C	0	Clovelly	C	0	Rozelle	X4	23
Malabar	C	0	Clovelly	C	0	Rozelle	X5	5
Malabar	X3	0	Clovelly	X3	0	Rozelle	X5	5
Malabar	X3	0	Clovelly	X3	0	Rozelle	X6	9
Malabar	X3	0	Clovelly	X3	0	Rozelle	X6	22
Malabar	X4	0	Clovelly	X4	0	Rozelle	XC	3
Malabar	X4	0	Clovelly	X4	0	Rozelle	XC	2
Malabar	X4	0	Clovelly	X4	0	Rozelle	CC	3
Malabar	X5	0	Clovelly	X5	0	Rozelle	CC	2
Malabar	X5	0	Clovelly	X5	0			
Malabar	X5	0	Clovelly	X5	0			
Malabar	X6	0	Clovelly	X6	0			
Malabar	X6	0	Clovelly	X6	0			
Malabar	X6	0	Clovelly	X6	0			
Malabar	XC	0						
Malabar	XC	0						
Malabar	XC	0						

Appendix A2 cont.:

Percentage fouling cover on tiles after six weeks (4.2)

Site	Treatment	Score	Site	Treatment	Score
Malabar	Z3	0	Clovelly	Z3	1
Malabar	Z3	0	Clovelly	Z3	3
Malabar	Z3	0	Clovelly	Z3	3
Malabar	Y3	0	Clovelly	Y3	0
Malabar	Y3	0	Clovelly	Y3	0
Malabar	Y3	0	Clovelly	Y3	0
Malabar	W3	0	Clovelly	W3	2
Malabar	W3	0	Clovelly	W3	2
Malabar	W3	0	Clovelly	W3	0
Malabar	W4	0	Clovelly	W4	0
Malabar	W4	0	Clovelly	W4	0
Malabar	W4	0	Clovelly	W4	0
Malabar	C	0	Clovelly	C	12
Malabar	C	0	Clovelly	C	5
Malabar	C	0	Clovelly	C	2
Malabar	X3	0	Clovelly	X3	4
Malabar	X3	0	Clovelly	X3	2
Malabar	X3	0	Clovelly	X3	8
Malabar	X4	0	Clovelly	X4	0
Malabar	X4	0	Clovelly	X4	0
Malabar	X4	0	Clovelly	X4	0
Malabar	X5	0	Clovelly	X5	5
Malabar	X5	0	Clovelly	X5	2
Malabar	X5	0	Clovelly	X5	3
Malabar	X6	0	Clovelly	X6	0
Malabar	X6	0	Clovelly	X6	0
Malabar	X6	0	Clovelly	X6	0
Malabar	XC	0			
Malabar	XC	0			
Malabar	XC	0			

Appendix A2 cont.:

Percentage fouling cover on tiles after seven weeks (4.2)

Site	Treatment	Score	Site	Treatment	Score
Malabar	Z3	0	Clovelly	Z3	25
Malabar	Z3	2	Clovelly	Z3	30
Malabar	Z3	4	Clovelly	Z3	19
Malabar	Y3	0	Clovelly	Y3	0
Malabar	Y3	0	Clovelly	Y3	4
Malabar	Y3	0	Clovelly	Y3	0
Malabar	W3	2	Clovelly	W3	5
Malabar	W3	3	Clovelly	W3	5
Malabar	W3	0	Clovelly	W3	3
Malabar	W4	0	Clovelly	W4	0
Malabar	W4	0	Clovelly	W4	0
Malabar	W4	0	Clovelly	W4	0
Malabar	C	2	Clovelly	C	81
Malabar	C	1	Clovelly	C	89
Malabar	C	1	Clovelly	C	90
Malabar	X3	2	Clovelly	X3	12
Malabar	X3	2	Clovelly	X3	15
Malabar	X3	1	Clovelly	X3	67
Malabar	X4	0	Clovelly	X4	2
Malabar	X4	0	Clovelly	X4	3
Malabar	X4	2	Clovelly	X4	4
Malabar	X5	2	Clovelly	X5	70
Malabar	X5	1	Clovelly	X5	44
Malabar	X5	1	Clovelly	X5	39
Malabar	X6	0	Clovelly	X6	8
Malabar	X6	2	Clovelly	X6	7
Malabar	X6	1	Clovelly	X6	1
Malabar	XC	2			
Malabar	XC	2			
Malabar	XC	2			

Appendix A2 cont.:

Percentage fouling cover on tiles after eight weeks (4.2)

Site	Treatment	Score	Site	Treatment	Score	Site	Treatment	Score
Malabar	Z3	17	Clovelly	Z3	79	Rozelle	Z3	90
Malabar	Z3	16	Clovelly	Z3	82	Rozelle	Z3	87
Malabar	Z3	32	Clovelly	Z3	74	Rozelle	Y3	99
Malabar	Y3	14	Clovelly	Y3	0	Rozelle	Y3	95
Malabar	Y3	24	Clovelly	Y3	0	Rozelle	W3	79
Malabar	Y3	18	Clovelly	Y3	0	Rozelle	W3	78
Malabar	W3	16	Clovelly	W3	63	Rozelle	W4	76
Malabar	W3	3	Clovelly	W3	41	Rozelle	W4	54
Malabar	W3	4	Clovelly	W3	44	Rozelle	C	83
Malabar	W4	6	Clovelly	W4	2	Rozelle	C	84
Malabar	W4	15	Clovelly	W4	0	Rozelle	X3	80
Malabar	W4	18	Clovelly	W4	0	Rozelle	X3	85
Malabar	C	12	Clovelly	C	99	Rozelle	X4	88
Malabar	C	20	Clovelly	C	98	Rozelle	X4	89
Malabar	C	23	Clovelly	C	99	Rozelle	X5	88
Malabar	X3	24	Clovelly	X3	85	Rozelle	X5	86
Malabar	X3	26	Clovelly	X3	59	Rozelle	X6	89
Malabar	X3	30	Clovelly	X3	90	Rozelle	X6	82
Malabar	X4	7	Clovelly	X4	12	Rozelle	XC	91
Malabar	X4	7	Clovelly	X4	17	Rozelle	XC	91
Malabar	X4	26	Clovelly	X4	16	Rozelle	CC	32
Malabar	X5	21	Clovelly	X5	91	Rozelle	CC	41
Malabar	X5	16	Clovelly	X5	76			
Malabar	X5	11	Clovelly	X5	79			
Malabar	X6	5	Clovelly	X6	20			
Malabar	X6	11	Clovelly	X6	18			
Malabar	X6	3	Clovelly	X6	2			
Malabar	XC	18						
Malabar	XC	23						
Malabar	XC	30						

Appendix A2 cont.:

Percentage fouling cover on tiles after nine weeks (4.2)

Site	Treatment	Score	Site	Treatment	Score
Malabar	Z3	92	Clovelly	Z3	80
Malabar	Z3	90	Clovelly	Z3	82
Malabar	Z3	95	Clovelly	Z3	84
Malabar	Y3	77	Clovelly	Y3	38
Malabar	Y3	83	Clovelly	Y3	33
Malabar	Y3	69	Clovelly	Y3	40
Malabar	W3	76	Clovelly	W3	81
Malabar	W3	52	Clovelly	W3	64
Malabar	W3	61	Clovelly	W3	83
Malabar	W4	45	Clovelly	W4	1
Malabar	W4	78	Clovelly	W4	0
Malabar	W4	72	Clovelly	W4	3
Malabar	C	88	Clovelly	C	100
Malabar	C	91	Clovelly	C	100
Malabar	C	90	Clovelly	C	100
Malabar	X3	78	Clovelly	X3	89
Malabar	X3	74	Clovelly	X3	76
Malabar	X3	89	Clovelly	X3	91
Malabar	X4	25	Clovelly	X4	20
Malabar	X4	23	Clovelly	X4	21
Malabar	X4	71	Clovelly	X4	21
Malabar	X5	82	Clovelly	X5	93
Malabar	X5	76	Clovelly	X5	82
Malabar	X5	23	Clovelly	X5	75
Malabar	X6	24	Clovelly	X6	24
Malabar	X6	22	Clovelly	X6	22
Malabar	X6	3	Clovelly	X6	14
Malabar	XC	83			
Malabar	XC	79			
Malabar	XC	94			

Appendix A2 cont.:

Percentage fouling cover on tiles after ten weeks (4.2)

Site	Treatment	Score	Site	Treatment	Score	Site	Treatment	Score
Malabar	Z3	94	Clovelly	Z3	93	Rozelle	Z3	82
Malabar	Z3	91	Clovelly	Z3	90	Rozelle	Z3	75
Malabar	Z3	91	Clovelly	Z3	92	Rozelle	Y3	95
Malabar	Y3	86	Clovelly	Y3	91	Rozelle	Y3	93
Malabar	Y3	82	Clovelly	Y3	85	Rozelle	W3	81
Malabar	Y3	90	Clovelly	Y3	81	Rozelle	W3	43
Malabar	W3	80	Clovelly	W3	83	Rozelle	W4	60
Malabar	W3	74	Clovelly	W3	87	Rozelle	W4	43
Malabar	W3	71	Clovelly	W3	90	Rozelle	C	89
Malabar	W4	79	Clovelly	W4	22	Rozelle	C	81
Malabar	W4	72	Clovelly	W4	26	Rozelle	X3	93
Malabar	W4	76	Clovelly	W4	37	Rozelle	X3	90
Malabar	C	91	Clovelly	C	100	Rozelle	X4	91
Malabar	C	93	Clovelly	C	100	Rozelle	X4	91
Malabar	C	92	Clovelly	C	100	Rozelle	X5	90
Malabar	X3	82	Clovelly	X3	88	Rozelle	X5	87
Malabar	X3	82	Clovelly	X3	92	Rozelle	X6	88
Malabar	X3	84	Clovelly	X3	97	Rozelle	X6	91
Malabar	X4	60	Clovelly	X4	44	Rozelle	XC	97
Malabar	X4	53	Clovelly	X4	48	Rozelle	XC	100
Malabar	X4	80	Clovelly	X4	51	Rozelle	CC	26
Malabar	X5	79	Clovelly	X5	98	Rozelle	CC	36
Malabar	X5	72	Clovelly	X5	92			
Malabar	X5	77	Clovelly	X5	89			
Malabar	X6	40	Clovelly	X6	47			
Malabar	X6	59	Clovelly	X6	56			
Malabar	X6	13	Clovelly	X6	14			
Malabar	XC	88						
Malabar	XC	85						
Malabar	XC	92						

Appendix A3

Adhesion test results (low) with percentage cover (4.3)

Site	Treatment	Score	Site	Treatment	Score	Site	Treatment	Score
Malabar	Z3	90	Clovelly	Z3	92	Rozelle	Z3	75
Malabar	Z3	88	Clovelly	Z3	90	Rozelle	Z3	73
Malabar	Z3	85	Clovelly	Z3	92	Rozelle	Y3	95
Malabar	Y3	30	Clovelly	Y3	81	Rozelle	Y3	99
Malabar	Y3	75	Clovelly	Y3	84	Rozelle	W3	71
Malabar	Y3	77	Clovelly	Y3	84	Rozelle	W3	38
Malabar	W3	42	Clovelly	W3	89	Rozelle	W4	56
Malabar	W3	40	Clovelly	W3	87	Rozelle	W4	42
Malabar	W3	77	Clovelly	W3	91	Rozelle	C	88
Malabar	W4	73	Clovelly	W4	11	Rozelle	C	75
Malabar	W4	79	Clovelly	W4	9	Rozelle	X3	89
Malabar	W4	54	Clovelly	W4	17	Rozelle	X3	70
Malabar	C	81	Clovelly	C	100	Rozelle	X4	91
Malabar	C	84	Clovelly	C	100	Rozelle	X4	90
Malabar	C	86	Clovelly	C	100	Rozelle	X5	87
Malabar	X3	61	Clovelly	X3	90	Rozelle	X5	81
Malabar	X3	66	Clovelly	X3	96	Rozelle	X6	70
Malabar	X3	88	Clovelly	X3	98	Rozelle	X6	85
Malabar	X4	66	Clovelly	X4	75	Rozelle	XC	96
Malabar	X4	48	Clovelly	X4	80	Rozelle	XC	97
Malabar	X4	71	Clovelly	X4	82	Rozelle	CC	32
Malabar	X5	79	Clovelly	X5	98	Rozelle	CC	36
Malabar	X5	70	Clovelly	X5	94			
Malabar	X5	73	Clovelly	X5	91			
Malabar	X6	35	Clovelly	X6	59			
Malabar	X6	8	Clovelly	X6	61			
Malabar	X6	63	Clovelly	X6	12			
Malabar	XC	82						
Malabar	XC	80						
Malabar	XC	92						

Appendix A3 cont.:

Adhesion test results (medium) with percentage cover (4.3)

Site	Treatment	Score	Site	Treatment	Score	Site	Treatment	Score
Malabar	Z3	90	Clovelly	Z3	92	Rozelle	Z3	68
Malabar	Z3	84	Clovelly	Z3	90	Rozelle	Z3	65
Malabar	Z3	85	Clovelly	Z3	93	Rozelle	Y3	90
Malabar	Y3	25	Clovelly	Y3	92	Rozelle	Y3	95
Malabar	Y3	67	Clovelly	Y3	94	Rozelle	W3	66
Malabar	Y3	62	Clovelly	Y3	88	Rozelle	W3	27
Malabar	W3	30	Clovelly	W3	83	Rozelle	W4	40
Malabar	W3	36	Clovelly	W3	88	Rozelle	W4	31
Malabar	W3	69	Clovelly	W3	93	Rozelle	C	78
Malabar	W4	69	Clovelly	W4	7	Rozelle	C	59
Malabar	W4	71	Clovelly	W4	10	Rozelle	X3	87
Malabar	W4	58	Clovelly	W4	22	Rozelle	X3	79
Malabar	C	88	Clovelly	C	99	Rozelle	X4	90
Malabar	C	83	Clovelly	C	100	Rozelle	X4	90
Malabar	C	91	Clovelly	C	99	Rozelle	X5	89
Malabar	X3	81	Clovelly	X3	89	Rozelle	X5	76
Malabar	X3	85	Clovelly	X3	91	Rozelle	X6	73
Malabar	X3	82	Clovelly	X3	98	Rozelle	X6	79
Malabar	X4	63	Clovelly	X4	55	Rozelle	XC	99
Malabar	X4	53	Clovelly	X4	74	Rozelle	XC	94
Malabar	X4	80	Clovelly	X4	78	Rozelle	CC	18
Malabar	X5	70	Clovelly	X5	98	Rozelle	CC	21
Malabar	X5	68	Clovelly	X5	94			
Malabar	X5	76	Clovelly	X5	90			
Malabar	X6	37	Clovelly	X6	70			
Malabar	X6	9	Clovelly	X6	78			
Malabar	X6	71	Clovelly	X6	19			
Malabar	XC	84						
Malabar	XC	83						
Malabar	XC	97						

Appendix A3 cont.:

Adhesion test results (high) with percentage cover (4.3)

Site	Treatment	Score	Site	Treatment	Score	Site	Treatment	Score
Malabar	Z3	91	Clovelly	Z3	95	Rozelle	Z3	54
Malabar	Z3	87	Clovelly	Z3	91	Rozelle	Z3	49
Malabar	Z3	90	Clovelly	Z3	90	Rozelle	Y3	91
Malabar	Y3	32	Clovelly	Y3	91	Rozelle	Y3	93
Malabar	Y3	53	Clovelly	Y3	92	Rozelle	W3	54
Malabar	Y3	71	Clovelly	Y3	91	Rozelle	W3	19
Malabar	W3	35	Clovelly	W3	69	Rozelle	W4	41
Malabar	W3	34	Clovelly	W3	85	Rozelle	W4	32
Malabar	W3	22	Clovelly	W3	87	Rozelle	C	56
Malabar	W4	48	Clovelly	W4	8	Rozelle	C	50
Malabar	W4	59	Clovelly	W4	13	Rozelle	X3	82
Malabar	W4	76	Clovelly	W4	23	Rozelle	X3	78
Malabar	C	88	Clovelly	C	99	Rozelle	X4	87
Malabar	C	90	Clovelly	C	100	Rozelle	X4	89
Malabar	C	91	Clovelly	C	100	Rozelle	X5	86
Malabar	X3	76	Clovelly	X3	87	Rozelle	X5	80
Malabar	X3	78	Clovelly	X3	86	Rozelle	X6	60
Malabar	X3	84	Clovelly	X3	98	Rozelle	X6	77
Malabar	X4	54	Clovelly	X4	52	Rozelle	XC	91
Malabar	X4	50	Clovelly	X4	65	Rozelle	XC	90
Malabar	X4	84	Clovelly	X4	69	Rozelle	CC	20
Malabar	X5	62	Clovelly	X5	96	Rozelle	CC	22
Malabar	X5	59	Clovelly	X5	93			
Malabar	X5	77	Clovelly	X5	89			
Malabar	X6	39	Clovelly	X6	70			
Malabar	X6	7	Clovelly	X6	60			
Malabar	X6	55	Clovelly	X6	20			
Malabar	XC	86						
Malabar	XC	84						
Malabar	XC	95						

Appendix A4:

Mean percentage fouling loss due to pressure (4.3.2) (data are $\bar{x}$ ± SE (n=3(n=2, Rozelle))

Site	Treatment	Low pressure	Medium pressure	High pressure
Malabar	Z3	4	7	3
	Y3	31	42	41
	W3	30	41	61
	W4	0	4	10
	C	9	5	2
	X3	13	0	5
	X4	3	0	2
	X5	3	7	13
	X6	5	0	8
	XC	3	0	0
Clovelly	Z3	1	0	0
	Y3	3	0	0
	W3	0	0	8
	W4	57	54	46
	X3	0	0	2
	X4	0	0	0
	X5	0	0	0
	X6	0	0	0
	C	0	1	1
Rozelle	Z3	3	12	32
	Y3	1	5	6
	W3	31	46	54
	W4	14	37	35
	C	13	27	44
	X3	4	13	16
	X4	10	3	5
	X5	9	10	10
	X6	14	16	24
	XC	2	2	8
	CC	31	59	57

Appendix A5:

Slip test results for Malabar (4.4)

Treatment	Replicate	Force(N) Start	Force(N) End		Treatment	Replicate	Force(N) Start	Force(N) End
Z3	1	4.9	3.16		X3	1	6.32	3.08
Z3	2	4.48	2.52		X3	2	6.22	2.62
Z3	3	4.56	2.3		X3	3	6.22	1.68
Z3	4	4.66	3		X3	4	4.38	2.52
Z3	5	4.5	3.12		X3	5	4.76	2.46
Z3	6	4.98	2.62		X3	6	5.64	3.2
Z3	7	5.36	1.04		X3	7	4.28	3.38
Z3	8	4.96	2.54		X3	8	5.1	2.46
Z3	9	4.96	2.66		X3	9	5.26	1.92
Y3	1	6.52	2.9		X4	1	4.48	2.56
Y3	2	6.84	3.8		X4	2	5.04	3.48
Y3	3	7.02	2.38		X4	3	5.98	1.6
Y3	4	6.62	1.42		X4	4	4.16	1.26
Y3	5	6.7	3.06		X4	5	4.88	2.28
Y3	6	6.44	1.46		X4	6	5.16	2.48
Y3	7	6.7	3.5		X4	7	5.54	3.5
Y3	8	6.42	3.42		X4	8	5.64	2.82
Y3	9	6.4	4.32		X4	9	5.74	3.72
W3	1	5.4	3.2		X5	1	6.12	2.64
W3	2	5.92	3.5		X5	2	5.12	3.66
W3	3	4.9	4.19		X5	3	5.84	2.32
W3	4	5.42	1.52		X5	4	4.76	3.86
W3	5	5.16	2		X5	5	5.06	3.64
W3	6	5.08	1.64		X5	6	4.92	3.32
W3	7	5.54	3.1		X5	7	4.4	3.78
W3	8	5.76	2.22		X5	8	4.88	2.28
W3	9	5.88	2.9		X5	9	4.62	2.32
W4	1	6.02	2.9		X6	1	5.52	2.18
W4	2	5.86	2.58		X6	2	4.71	4.08
W4	3	6.06	2.82		X6	3	5.44	3.78
W4	4	5.84	1.8		X6	4	4.5	3.3
W4	5	6.22	2.96		X6	5	4.42	3.9
W4	6	6.02	2.72		X6	6	3.9	3.04
W4	7	6.62	1.56		X6	7	5.32	3.74
W4	8	6.72	1.68		X6	8	5.24	2.28
W4	9	6.58	2.22		X6	9	5.26	3.38
C	1	5.02	2.5					
C	2	4.52	2.54					
C	3	4.58	3.84					
C	4	5.4	1.08					
C	5	5.38	2.32					
C	6	5.4	1.88					
C	7	5.54	2.54					
C	8	5.52	1.88					
C	9	5.2	1.9					

Appendix A5 cont.:

Slip test results for Clovelly

Treatment	Replicate	Force(N) Start	Force(N) End		Treatment	Replicate	Force(N) Start	Force(N) End
Z3	1	4.9	4.06		X3	1	6.32	3.94
Z3	2	4.48	3.44		X3	2	6.22	1.92
Z3	3	4.56	3.88		X3	3	6.22	2.18
Z3	4	4.66	3.84		X3	4	4.38	4.56
Z3	5	4.5	1.24		X3	5	4.76	4.5
Z3	6	4.98	3.72		X3	6	5.64	3.46
Z3	7	5.36	3.04		X3	7	4.28	2.66
Z3	8	4.96	4.02		X3	8	5.1	3.88
Z3	9	4.96	3.18		X3	9	5.26	2.84
Y3	1	6.52	4.26		X4	1	4.48	2.8
Y3	2	6.84	4.08		X4	2	5.04	2.88
Y3	3	7.02	3.96		X4	3	5.98	2.64
Y3	4	6.62	6.78		X4	4	4.16	5.52
Y3	5	6.7	5.42		X4	5	4.88	3.38
Y3	6	6.44	3.92		X4	6	5.16	3.52
Y3	7	6.7	5.14		X4	7	5.54	3.12
Y3	8	6.42	4.26		X4	8	5.64	4.66
Y3	9	6.4	4.48		X4	9	5.74	3.02
W3	1	5.4	3.88		X5	1	6.12	1.62
W3	2	5.92	4.1		X5	2	5.12	1.42
W3	3	4.9	3.14		X5	3	5.84	3.84
W3	4	5.42	3.7		X5	4	4.76	2.54
W3	5	5.16	3.02		X5	5	5.06	4.1
W3	6	5.08	3.62		X5	6	4.92	4.04
W3	7	5.54	3.08		X5	7	4.4	4.34
W3	8	5.76	4.58		X5	8	4.88	3.82
W3	9	5.88	3.04		X5	9	4.62	1.72
W4	1	6.02	4.06		X6	1	5.52	3.52
W4	2	5.86	4.04		X6	2	4.71	2.94
W4	3	6.06	3.72		X6	3	5.44	2.96
W4	4	5.84	2.56		X6	4	4.5	4
W4	5	6.22	4.6		X6	5	4.42	4.5
W4	6	6.02	4.8		X6	6	3.9	4.06
W4	7	6.62	2.46		X6	7	5.32	2.52
W4	8	6.72	4.23		X6	8	5.24	4.04
W4	9	6.58	2.8		X6	9	5.26	4.06
C	1	5.02	4.6					
C	2	4.52	2.22					
C	3	4.58	3.32					
C	4	5.4	4.32					
C	5	5.38	3.7					
C	6	5.4	3.02					
C	7	5.54	3.72					
C	8	5.52	3.32					
C	9	5.2	4.12					

Appendix A5 cont.:

Slip test results for Rozelle

Treatment	Replicate	Force(N) Start	Force(N) End		Treatment	Replicate	Force(N) Start	Force(N) End
Z3	1	4.9	3.28		X3	1	6.32	2.24
Z3	2	4.48	3.88		X3	2	6.22	3.88
Z3	3	4.56	4.23		X3	3	6.22	2.58
Z3	4	4.66	2.96		X3	4	4.38	3.24
Z3	5	4.5	2.88		X3	5	4.76	2.24
Z3	6	4.98	2.54		X3	6	5.64	4.9
Z3	7	5.36			X3	7	4.28	
Z3	8	4.96			X3	8	5.1	
Z3	9	4.96			X3	9	5.26	
Y3	1	6.52	6.3		X4	1	4.48	5.33
Y3	2	6.84	3.58		X4	2	5.04	5.66
Y3	3	7.02	4.96		X4	3	5.98	4.3
Y3	4	6.62	3.14		X4	4	4.16	5.46
Y3	5	6.7	2.9		X4	5	4.88	2.86
Y3	6	6.44	2.16		X4	6	5.16	5.64
Y3	7	6.7			X4	7	5.54	
Y3	8	6.42			X4	8	5.64	
Y3	9	6.4			X4	9	5.74	
W3	1	5.4	5.74		X5	1	6.12	3.54
W3	2	5.92	5.26		X5	2	5.12	4.5
W3	3	4.9	5.16		X5	3	5.84	4.28
W3	4	5.42	5.88		X5	4	4.76	2.54
W3	5	5.16	4.36		X5	5	5.06	2.32
W3	6	5.08	5.96		X5	6	4.92	3.44
W3	7	5.54			X5	7	4.4	
W3	8	5.76			X5	8	4.88	
W3	9	5.88			X5	9	4.62	
W4	1	6.02	3.26		X6	1	5.52	2.56
W4	2	5.86	2.96		X6	2	4.71	3.74
W4	3	6.06	3.62		X6	3	5.44	3.8
W4	4	5.84	4.58		X6	4	4.5	4.48
W4	5	6.22	4.86		X6	5	4.42	4.84
W4	6	6.02	3.88		X6	6	3.9	4.82
W4	7	6.62			X6	7	5.32	
W4	8	6.72			X6	8	5.24	
W4	9	6.58			X6	9	5.26	
C	1	5.02	4.5		CC	1		4.9
C	2	4.52	5.7		CC	2		5.26
C	3	4.58	6.06		CC	3		5.7
C	4	5.4	1.58		CC	4		5.36
C	5	5.38	5.64		CC	5		5.02
C	6	5.4	3.78		CC	6		6.16
C	7	5.54						
C	8	5.52						
C	9	5.2						

Appendix B1:

Letter of approval from Randwick City Council to recruit respondents for survey (6.4)

Doc No: D00836727
File No: F2004/06176

Dear Mr Walton

I refer to an EMail forwarded by Dr Swanson to Randwick City Council requesting approval for you to carry out research by surveying members of the Randwick Local Government area, which will assist you with your Environmental Science Degree.

We confirm that you have approval to complete your survey and we look forward to receiving your results.

If you require any further information, please do not hesitate to contact Mr Mark Bush, Manager Waste and Cleaning Services, on 9399 0738.

Kind regards

Jorde Frangoples
Director City Services

Appendix B2:

Confirmation of ethics approval from UNSW to recruit respondents for survey (6.4)

Dear Todd and Wendy

Your application File No. 1194

Title: “Antifouling technologies for coastal pools and platforms and community responses” has received ethical clearance.

You may proceed to recruit participants for your project.

Please quote your file number in any future correspondence.

Regards
Linda

Linda Camilleri
Personal Assistant to Head of School
School of Psychology
University of New South Wales
Room 1013, Mathews Building
Sydney NSW 2052, AUSTRALIA

Appendix B3

Copy of survey used in study (6.3)

SURVEY OF RANDWICK CITY COUNCIL OCEAN POOL USERS

For the University of New South Wales
In association with Sydney Coastal Councils Group
And Randwick City Council

-How often do you use this pool?

- ☐ Never
- ☐ Rarely (less than once a month)
- ☐ Moderately (at least once a month)
- ☐ Frequently (at least once a week)
- ☐ Very frequently (more than once a week)

-Do you consider any of the following to be a significant health hazard to you and other pool users?

(if yes scale from 1-5 with 5 being the most hazardous and 1 being the least)

	(No Hazard)	(Least Hazard)				(Most Hazard)
	0	1	2	3	4	5
Dangerous surf/weather	☐	☐	☐	☐	☐	☐
Rock falls	☐	☐	☐	☐	☐	☐
Pollution	☐	☐	☐	☐	☐	☐
Slippery surfaces	☐	☐	☐	☐	☐	☐
Blue bottles	☐	☐	☐	☐	☐	☐
Other/_________________	☐	☐	☐	☐	☐	☐

-Have you ever slipped over whilst walking around the pool area?

(if yes how badly were you hurt? Scale 1-5 where 1 is not badly hurt and 5 is badly hurt)

(Never slipped) (Badly hurt)

☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

-If yes, how were you injured?

-Did you take any action due to this event? If yes what sort of action?

I will read a short statement in reference to the next few questions.

*If you are an ocean pool user you may have noticed at one time or another a green or black layer of slime on the concrete surfaces of the pool and surrounding areas and on the steps leading into the pool. This is algae and its accumulation which can occur in a matter of days.

-Are you aware of any council treatment of slippery surfaces on steps covered by algae?

☐ Yes ☐ No

Comments

*(**If asked about council treatment read):** The current method used by Randwick council to clean slime affected steps is by high power water blasting which is performed by a Jet Blaster truck.

-In your experience do you consider the current method of antifouling sufficient?

☐ Yes ☐ No

-The slip hazard may be reduced by limiting algal growth with non-toxic coatings. Would you have any reservations about the use of these antifouling coatings as an alternative to jet blasting? If yes why?

☐ Yes ☐ No

-Do you have any proposed alternatives or suggestions to the current method of antifouling?

-Would you cease or reduce using the pool if:

	Yes	**No**	**Reduce**
You slipped and hurt yourself?	☐	☐	☐
Water blasting was replaced with antifouling coating?	☐	☐	☐
Algae was left to grow without cleaning?	☐	☐	☐

GENERAL INFORMATION

What age bracket do you belong to?

☐ Under 15 ☐ 16-30 ☐ 31-45 ☐ 46-60 ☐ Over 60

What suburb do you live in?

Thank you very much for your time and effort!

If you have any questions about this survey and its purpose please don't hesitate to contact me at the following address.

E-mail: t.walton@student.unsw.edu.au

Regards,

Todd Walton

University of New South Wales

Appendix B4:

List of suburbs respondents reside in (7.1.2)

Location	Count
Arncliffe	1
Artarmon	1
Bondi Junction	6
Botany	1
Bronte	7
Chifley	7
Clovelly	27
Coogee	9
Cromer	1
Darlinghurst	1
Drummoyne	1
Five Dock	1
Hornsby	1
Kensington	4
Kingsford	6
La Perouse	1
Leichhardt	2
Little Bay	2
Malabar	13
Maroubra	10
Mascot	1
Matraville	2
Mosman	1
Newtown	1
Phillip Bay	2
Queens Park	1
Randwick	5
Rose Bay	1
Rozelle	1
Ryde	1
Strawberry Hills	1
Surry Hills	1
Vaucluse	2
Waterloo	1
Waverly	1
Willoughby	1
tourist	2

Appendix B5:

List of occurrences around pools considered hazards by respondents (7.3)

Hazard	Count
Broken bottles	1
Bad behaviour	4
Cars	2
Gaps in the railings	1
Not enough lifeguards	1
Shallow rocks/banks	11
Sharks	25
Tourists	1
Uneven surfaces	1
Unsupervised children	1
Urchins/oysters	15