Antifouling Technologies for Coastal Pools and Platforms

Final Report on Field Trial (March-June 2009)

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i) Executive Summary

Novel, non-toxic, anti-foul coatings were applied directly to concrete surfaces at coastal sites (Photo 1) and onto small concrete blocks which were deployed to various coastal sites (Photo 2) within the Randwick and Sutherland Shire Municipalities. Coatings from 3 companies and UNSW were tested in a field trial from March-June 2009.

Some coatings exhibited anti-fouling effects during the trial

- Three coatings at Clovelly (step) over 6-12 weeks
  (W1, W2 and Z2B on blocks)
- Two coatings at Malabar Rock Pool (step) over 9-12 weeks
  (W1 and X1 on blocks)
- One coating at Rozelle Bay over 18 weeks
  (W2 on blocks)
- Two coatings on Malabar Rock Pool Wall over 12 weeks
  (W1 and X1 by direct application)

Future directions

- Additional trial to start July 2009 (Honours Student Project).
- Additional coatings for testing from 2 of the 3 companies for Honours Student Project.
- Preliminary design for a non-slip tile and optimised formulation for UNSW coating(s).
- Second trial from October 2009-January 2010 (as planned).

Conclusions

- The wax coatings from UNSW were the most effective across the widest range of test sites and look promising to reduce slipping on steps in particular. Further development of this material is being considered for this application before the next trial in Oct 2009-Jan 2010.
- Some of the commercial coatings have also been successful in reducing fouling. New formulations are being provided by participating companies for further testing before trial in Oct 2009-Jan 2010.

ii) Summary of participants, coastal sites and proposed analysis

Table 1 - A summary of companies involved and length of trial at each field site

Field sites	Company involved	Trial period (weeks)
Clovelly Bay		
Step	A, B, UNSW	12
	C	10
Promenade	A, B, UNSW	16
	C	13
Pool	UNSW	9
Malabar		
Rock Pool Step	A, B,	8
	UNSW	12
	C	9
Rock Pool Wall	A, B, UNSW	15
	C	12
Boat Ramp	A	12
	C	2-4
Rozelle Bay	A, B, UNSW	18
	C	17
Cronulla		
Rock Pool Edge	A	12
Rock Pool Ramp	A	12
Sylvania Waters		
Boat Ramp	A	12

Field sites

Clovelly Bay

The concrete step in the bay site is submerged at mid to high tide and exposed at low tide. The promenade is exposed most of the time and is submerged only during very high tides or high seas. The bay/promenade experiences heavy surges of seawater during high seas which led to the loss of a significant number of blocks from the step and promenade during the trial. A stronger cable-tie method was later employed which rectified the problem (no more blocks were lost).

Malabar Rock Pool

This rock pool experiences heavy fouling pressure probably due to high levels of nutrients. Nutrient run-off occurs from a golf-course situated above it after rain and because it is raised above sea level, only a limited amount of seawater is exchanged

under normal conditions. The test area is always submerged, approximately 20 cm under water although the level changes with tides and swell. The rock pool generally experiences calm conditions except during big seas.

Malabar Boat Ramp
The boat ramp is situated on the northern side of Long Bay and is not used frequently to launch boats. It is exposed to high seas, particularly swell coming from S, SE direction.

Rozelle Bay
This harbour site is a boat marina and is quite polluted relative to other sites. The marina is in a sheltered area of the bay and only experiences calm conditions. Test blocks were attached to racks which were submerged approximately 10 cm under water beneath a jetty.

Hawkesbury Reserve Boat Ramp
The boat ramp is situated on the southern side of Georges River, near Captain Cook Bridge. This boat ramp is a high use area with multiple boat/jet-ski launches each day. Consequently, it is the most polluted of all sites used in field trial.

Cronulla Rock Pool
This rock pool is situated at Cronulla Beach and is completely exposed to sea swell, particularly from S/SE direction. During big swells the pool and surrounds are completely awash which results in a degree of 'self-cleaning'.

Photo 1 – Direct Application
A section of the direct application experiment at Malabar Rock Pool

Photo 2 – Block experiment
The block experiment deployed on concrete step in Clovelly Bay

Measures of success

- **Photographic analysis (block and direct application experiments)**

  The amount of algal growth (i.e., fouling) on the test area was graded as

Low/Light	(algae growing on ~5-30% of surface)
Medium/Moderate	(algae growing on ~35-65% of surface)
High/Heavy	(algae growing on ~70-100% of surface)

- **Slip tests (block experiments only)**

  Slip tests were carried out on blocks using a force gauge (Manotronics) which measures the peak force required to pull a weighted sled across the block.

- **Adhesion tests (block experiments only)**

  Adhesion tests were carried out on blocks when the experiment was completed which involved hosing the blocks at low (~40 kPa), medium (~100 kPa) and high (~160 kPa) pressure (house-mains only). An adhesion test was also carried out on a direct application of wax at Clovelly Pool.

iii) UNSW wax-based coatings

A wax-based coating was tested in block experiments in two ways (Photo 3); either as a smaller block mixed with sand, inlayed within concrete blocks (our code W1), or rubbed onto the surface of blocks already coated with non-slip paint by Company B (our code W2). Likewise, wax-based coating was tested in direct application experiments in two ways, either rubbed directly onto concrete surface (W1) or rubbed onto non-slip paint applied by Company B (W2)

Table 2 – Summary of test sites and experimental design for W1 and W2

Site	W1	W2
Clovelly Bay		
Step	Blocks	Blocks
Promenade	Blocks	
Pool	Direct application	
Malabar Rock Pool		
Step	Blocks	
Wall	Direct application	Direct application
Rozelle Bay		
Marina	Blocks	Blocks

Results for Wax 1 (W1)

Block experiments

Photographic analysis

Summary of best outcome

W1 blocks had reduced fouling by *Ulva* sp. compared to controls after 12 weeks in Malabar rock pool. W1 was effective at reducing fouling on Clovelly Step for 8 weeks (result is based on one block only).

1) Clovelly Bay Step

- Three out of five W1 blocks were lost in the first 2 weeks. Changes to W1 block design and attachment method should reduce loss of blocks in next trial
- One W1 block showed a low level of fouling by *Ulva* sp. at 4 weeks with no fouling observed on the 'sheared' W1 block. Control blocks showed a low-medium level of fouling at 4 weeks (Photo 4)
- The only remaining W1 block ('sheared') had low level fouling at 6 weeks with very little fouling actually growing on wax/sand inlay (Photo 5A). By 8 weeks, the outer concrete border of W1 block was completely fouled while the inner wax/sand inlay showed a low level of fouling (Photo 5C)
- Control blocks were heavily fouled at 6 weeks and completely fouled at 8 weeks (Photo 5B, D)

2) Clovelly Promenade

- Blocks deployed onto the promenade took at least 8 weeks to begin fouling. By this time 2 out of 3 W1 blocks were lost to high seas
- The remaining W1 block showed a low level of fouling by brown-orange algae at 9 weeks and was heavily fouled by 11 weeks (Photo 6A)
- Control blocks showed a low-medium level of fouling by brown-orange algae at 9 weeks and low-high level fouling at 11 weeks (Photo 6B)
- W1 block was heavily fouled by red-brown algae (predominately) at 12 weeks as were control blocks (Photo 6C, D)

3) Malabar rock pool

- Control blocks showed a low-high level of fouling by *Ulva* sp. at 2 weeks
- W1 blocks showed low level fouling at 3 weeks while control blocks were heavily fouled at 3 weeks (Photo 7A, B)
- Algal cover decreased dramatically to almost zero at 5 weeks, probably removed by the large swell/seas of the previous fortnight
- Two out of 3 W1 blocks were heavily fouled by 8 weeks as were control blocks. One W1 block showed low level fouling at 8 weeks
- At 12 weeks, the least fouled W1 block was moderately fouled whereas control blocks were completely fouled and the other two W1 blocks were heavily fouled (Photo 7C, D)

4) Rozelle Bay

- The wax-sand inlay of W1 blocks showed no fouling or low level fouling at 3 weeks, however, the outer concrete border of W1 blocks were moderately fouled.

- Control blocks showed low-moderate level of fouling at 3 weeks
- Serpulid polychaete hard worms were the dominant fouling organism at 3 weeks
- By 5 weeks, W1 blocks (inlay) showed light-heavy fouling while control blocks were heavily fouled (Photo 8A, B). Algae now outgrowing hard worms.
- By 9 weeks, W1 blocks were heavily-completely fouled while controls were completely fouled

Slip tests

W1 blocks from Clovelly Bay showed no change in measurements between un-fouled blocks at week 0 and slightly fouled blocks (2) at week 4 (Figure 1A). No measurement was taken at the end of the experiment due to the loss of all W1 blocks. W1 blocks from Malabar became more slippery as they got fouled, as indicated by less force required on average to drag sled across fouled blocks (Figure 1B). W1 blocks from Rozelle Bay showed no change in measurements between un-fouled and fouled blocks (Figure 1C). Any slippery effect of fouling algae on these blocks was negated by the presence of hard worms in the fouling community (i.e., hard worms increased friction which in turn increased the force required on average to drag sled across heavily fouled blocks).

Adhesion tests

Adhesion tests found algae to be firmly attached to W1 blocks at the conclusion of the experiment at Clovelly and Malabar i.e., negligible amounts of algae were removed by hosing at pressures up to ~160 kPa. The exception was W1 blocks from Rozelle bay: algae were not firmly attached to these blocks. Fouling was loosely attached to W1 blocks at the end of the experiment at 18 weeks and could be removed by hand and by hosing at house-mains pressure (Photo 8C). Considerably less fouling was removed from control blocks by hosing (Photo 8D).

Direct application experiments (W1)

Photographic analysis

Summary of best outcome

There were application issues for the wax-based coating, however, it exhibited antifouling effects for up to 12 weeks where present on pool wall surfaces (Clovelly Bay pool and Malabar rock pool)

1) Clovelly Bay Pool

A number of wax formulations were tested on the pool wall by rubbing wax onto pool paint. A uniform homogenous application was not achieved due to the bumpy pool surface however wax did attach to the raised areas of the surface.

- The test area was heavily fouled after 4 weeks (Photo 9A) however no algae was attached to raised areas of pool surface where wax was attached (Photo 9B)
- By 9 weeks the whole test area was heavily fouled (Photo 10)
- Fouling algae was easily removed from wax coated areas (raised surface) with low pressure hosing (house-mains pressure), however, fouling remained firmly

attached to other areas of pool surface where wax was not present (Photo 11). This demonstrates poor attachment of fouling to wax-based coatings (i.e., low adhesion strength)

2) Malabar Rock Pool

- W1 panels showed low-level fouling at 3 weeks (Photo 12) while control panels were lightly-moderately fouled
- Algal growth on all test and control panels was reduced to almost zero at 5 weeks, probably removed by the large swell/seas of the previous fortnight
- At 8 weeks, W1 panels were moderately-heavily fouled however there was little fouling in sections of panels where wax was still attached (Photo 13, 14)
- Control panels were only lightly fouled however they were almost 2 metres away where adjacent test panels were also only lightly fouled. Fouling showed localised variation in the test area which spanned 4 metres.
- At 12 weeks, W1 panels were moderately fouled however there was little fouling in sections of panels where wax was still attached (Photo 15)
- No antifouling effects of W1 were observed at 15 weeks

Results for Wax 2 (W2)

Block experiments

Photographic analysis

Summary of best outcome

W2 blocks had low level fouling compared to controls after 18 weeks in Rozelle Bay.

1) Clovelly Bay Step

- Most of the wax rubbed onto W2 blocks peeled off surface in first two weeks. No wax was visible on two W2 blocks while the remaining 3 blocks had wax on 5-10% of surface
- W2 blocks had low level fouling by a red alga at 4 weeks with no fouling actually growing on wax itself. Control blocks had low-medium level of fouling at 4 weeks
- W2 blocks were moderately-heavily fouled at 6 weeks with little or no fouling growing on wax itself. By 8 weeks all W2 blocks were heavily fouled however there was no fouling on patches where wax was still attached to surface of the blocks (Photo 16A). At 12 weeks, one patch of wax remained free of fouling (Photo 16C).
- Control blocks were heavily fouled at 6 weeks and completely fouled at 8 (and 12) weeks (Photo 16B, D)

2) Rozelle bay

- W2 blocks were lightly fouled by hard worms at 3 weeks
- Control blocks showed low-moderate level of fouling by hard worms and some algae at 3 weeks
- By 5 weeks, W2 blocks showed light-moderate fouling by hard worms predominately
- Control blocks were heavily fouled at 5 weeks with algae now outgrowing hard worms

- At 9 weeks, W2 blocks were only lightly fouled by hard worms while controls were completely fouled by algae (Photo 17)
- At 18 weeks, W2 blocks were only lightly fouled by hard worms while controls were completely fouled by algae (Photo 18)

Slip tests

W2 blocks from Clovelly Bay and Rozelle Bay showed no change in measurements between un-fouled and fouled blocks (Figure 1A, C). At Clovelly, algal grew very close and flat to the surface and was not particularly slippery. At Rozelle, any slippery effect of fouling algae on these blocks was negated by the presence of hard worms in the fouling community (i.e., hard worms increased friction which in turn increased the force required on average to drag sled across heavily fouled blocks).

Adhesion tests

Adhesion tests found algae to be firmly attached to W2 blocks at the conclusion of the experiment at Clovelly i.e., negligible amounts of algae were removed by hosing at pressures up to ~160 kPa. At no stage did significant algal growth occur on W2 blocks from Rozelle Bay. The algae that was growing on one W2 block was loosely attached and could be removed by hand.

Direct application experiments (W2, wax rubbed onto non-slip paint)

Photographic analysis

Summary of best outcome

There were application issues for the wax-based coating, however, it exhibited antifouling effects for up to 12 weeks where present on pool wall surface (Malabar rock pool)

1) Malabar Rock Pool

- W2 panels were not fouled at all at 3 weeks while control panels were lightly-moderately fouled (Photo 12)
- Algal growth on all test and control panels was reduced to almost zero at 5 weeks, probably removed by the large swell/seas of the previous fortnight
- At 8 weeks, W2 panels were lightly-heavily fouled (Photo 13) depending on their position in the test area. On moderately-heavily fouled panels, there was little fouling in sections of panels where wax was still attached (Photo 13, 14)
- Control panels were only lightly fouled however they were almost 2 metres away where adjacent test panels were also only lightly fouled. Fouling showed localised variation in this test area which spanned 4 metres
- Similar fouling patterns were observed at 12 weeks (as at 8 weeks) for W2 and control panels.
- No antifouling effects of W2 were observed at 15 weeks

A  B 

Photo 3 – Top view of wax-based blocks
W1 (A) with wax-sand inlayed into concrete block and W2 (B) with wax-based formulation rubbed onto blocks already painted with non-slip paint.

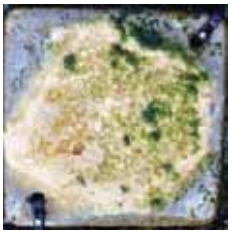
A  B  C 

Photo 4 – Clovelly Bay Step
W1 blocks (A, B) and a control block (C) after 4 weeks.

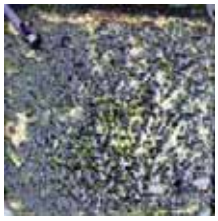
A  B  C  D 

Photo 5 – Clovelly Bay Step
Last remaining W1 block (A) and a control block (B) after 6 weeks, note very little fouling on wax-sand inlay. W1 block (C) and a control block (D) after 8 weeks, note low level fouling on wax-sand inlay relative to concrete surround.

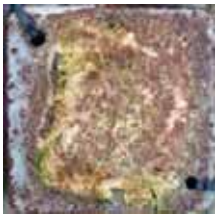
A  B  C  D 

Photo 6 – Clovelly Bay Promenade
Last remaining W1 block (A) and a control block (B) after 11 weeks, note different species of fouling algae than that growing on step, and wet appearance of algae. Same W1 block (C) and control block (D) at 12 weeks, note dry appearance of algae.

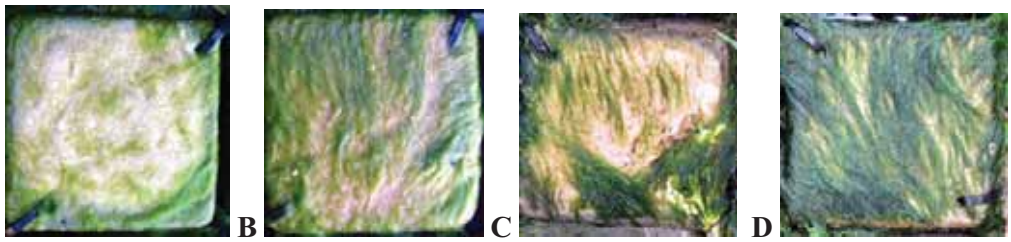


Photo 7 – Malabar Rock Pool
W1 block (A) and a control block (B) after 3 weeks. The least fouled W1 block (C) and a control block (D) after 12 weeks. Note that the heavy growth in bottom right hand corner of W1 block (C) originates from a crack in wax inlay and from the concrete border.

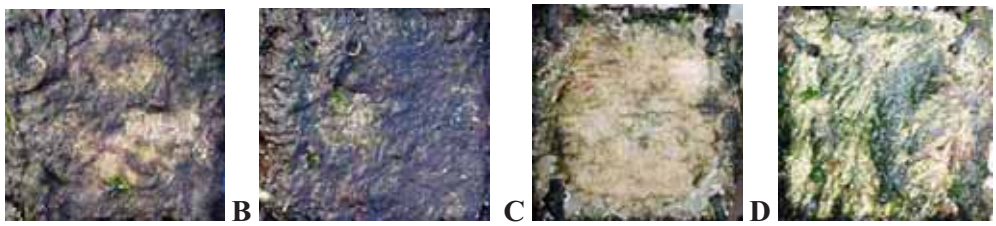


Photo 8 – Rozelle Bay Marina
W1 block (A) and a control block (B) after 5 weeks. Fouling algae was only loosely attached to W1 blocks at 18 weeks as some fouling could be rubbed off by hand and and most fouling was removed by hosing (C). Algae attached more strongly to controls although some fouling was removed by hosing (D).

Photo 9 – Clovelly Bay Pool
The direct application of wax-based formulations on standard pool surface (pool paint, A) after 4 weeks. Squares represent test areas and areas bordering squares are untreated. One test square of W1 is shown up close (B). White areas are the raised surface where wax is attached which remain free of fouling

Photo 10 - Clovelly Bay Pool
The direct application experiment after 9 weeks. Whole test area is heavily fouled with very few white patches (wax) remaining free of fouling

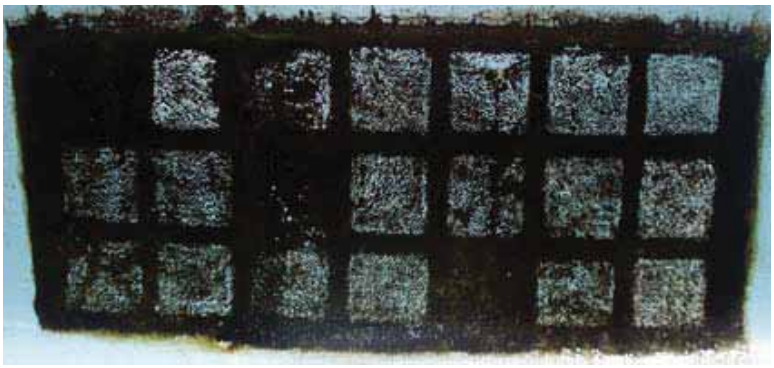


Photo 11 - Clovelly Bay Pool
The direct application experiment after 9 weeks after hosing at house-mains pressure. Even though test areas became fouled, fouling attaches loosely to wax-based coating and can be removed by hosing. Edge effects may have contributed to heavy fouling on test areas.

Photo 12 – Malabar Pool Wall
A section of the direct application experiment at 3 weeks. Panel 1B is W1 (note white flaky appearance of W1. Panel 1D is W2 (wax on top of non-slip paint). Note very little fouling on panels 1B, 1D whereas other test panels (1F, 1G) have heavy growth in upper portion of panel. Control panels not shown but similar to panels 1F, 1G.

Panel
1D 1C 1B 1A

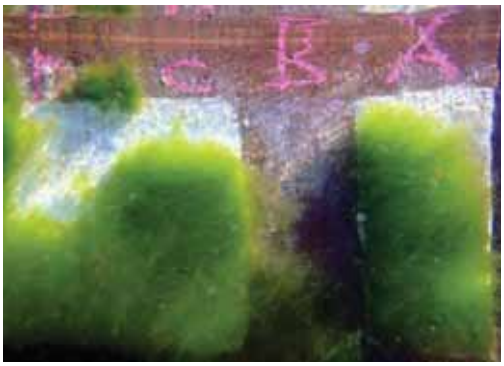


Photo 13 – Malabar Rock Pool
A section of the direct application experiment at 8 weeks. Panel 1B is W1, note no fouling in upper part of panel where wax attached. Panel 1D is W2, note no fouling in upper part of panel where wax attached. Note heavy fouling on other panels 1A, 1C which are non-slip paint

A

B


Photo 14 – Malabar Rock Pool
The upper portion of W1 panel 1B (A) and of W2 panel 1D (B). Note very little algal growth here where wax still attached.

Panel
1E 1D 1C 1B 1A

Photo 15 – Malabar Rock Pool
A section of the direct application experiment at 12 weeks. Panel 1B is W1, note very little fouling in upper part of panel where wax attached. Panel 1D is W2, note very little fouling in upper part of panel where wax attached. Note heavy fouling on other panels 1A, 1C which are non-slip paint

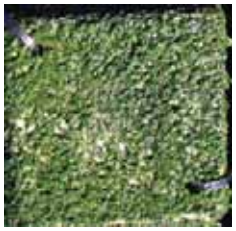
A  B  C  D 

Photo 16 – Clovelly Bay Step

W2 blocks at 8 weeks (A) and at 12 weeks (C). Note that white areas on blocks are where wax is still attached to block. No fouling is attached to patches of wax in (A) whilst larger wax patch is free of fouling in (C). Control block completely fouled at 8 weeks (B) and at 12 weeks (D).

A  B  C 

Photo 17 – Rozelle Bay Marina

The most fouled W2 block (A) and least fouled W2 block (B), and a heavily fouled control block (C), at 9 weeks. Note fouling on A was loosely attached and could be removed by hand

A  B 

Photo 18 – Rozelle Bay Marina

A W2 block (A) and a control block (B) at 18 weeks. Blocks were cleaned by pouring water over them and gently swishing hand over block surface to remove layer of scum on surface of blocks. Note that some algae growing on control blocks has dyed since 9 week photographs.

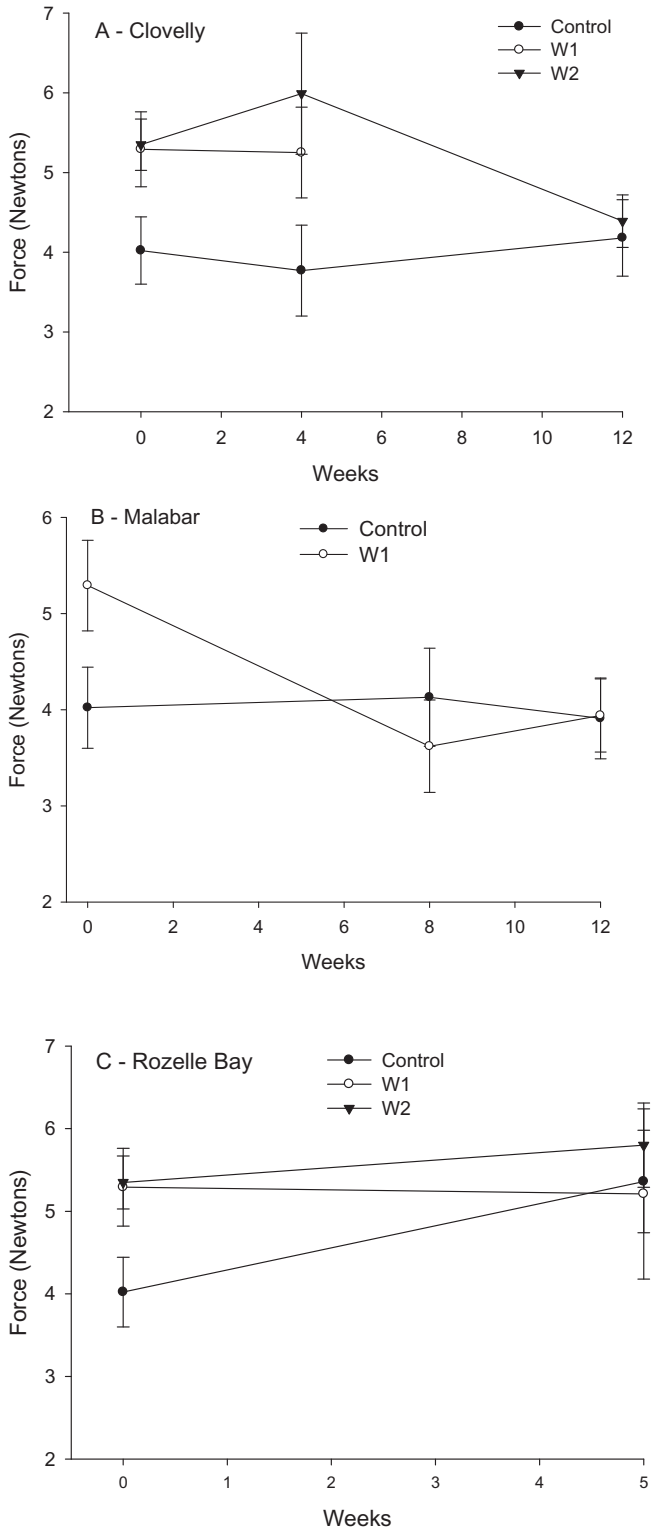


Figure 1 – 'Slip test' data for W1 and W2 blocks from Clovelly (A), Malabar (B) and Rozelle Bay (C) experiments based on force gauge readings (lower force readings indicate increased 'slippery-ness').

iv) Company C coatings

2 formulations from Company C were tested in the field trial

- our code X1
- our code X2

Table3 - Summary of test sites and experimental design for X1 and X2

Site	X1	X2
Clovelly Bay		
Step	Blocks	Blocks
Promenade	Blocks	Blocks
		Direct application
Malabar Rock Pool		
Step	Blocks	Blocks
Wall	Direct application	
Malabar Boat Ramp	Direct application	
Rozelle Bay		
Marina	Blocks	Blocks

Results for X1

Block experiments

Summary of best outcome
X1 blocks showed a reduced level of fouling compared to controls after 9 weeks on Malabar Rock Pool step, however X1 blocks were heavily fouled.

Photographic analysis

1) Clovelly Bay Step

- Grey/green dots started to appear on X1 blocks at 2 weeks covering <5% of surface. No fouling was observed on control blocks.
- X1 blocks showed low-moderate fouling at 4 weeks with tufts/filaments of the green alga *Ulva* sp. (Photo 19B), which appear to have grown from grey/green dots observed at 2 weeks
- Most control blocks had very little fouling at 4 weeks but one control was moderately fouled (Photo 19A)
- X1 blocks and controls showed low-moderate fouling at 6 weeks
- X1 blocks were heavily fouled by 8 weeks while controls showed low-heavy fouling (Photo 20A, B)

2) Clovelly Bay Promenade

- The edges of X1 and control blocks began to foul with red and green algae at 10 weeks, probably because the edges of blocks remain moist for longer than the surface (seen in Photo 21B at 13 weeks)

- The surface of X1 and control blocks were not fouled at 13 weeks (Photo 21A, B)

3) Malabar Rock Pool Step
- X1 and control blocks showed a low level of fouling by green dots and short filaments of the green alga *Ulva sp.* after 2 weeks
- X1 blocks were moderately-heavily fouled at 5 weeks while control blocks were heavily fouled
- X1 blocks were heavily fouled at 8-9 weeks but to a lesser degree than control blocks (Photo 22)

4) Rozelle Bay
- X1 and control blocks showed very little (<5% algal cover) fouling at 2 weeks
- X1 blocks showed medium-high level of fouling at 4 weeks by brown (predominantly) and green filamentous algae (*Ulva* sp.)
- Control blocks showed low-medium level of fouling at 4 weeks
- X1 blocks were heavily fouled by brown filamentous algae and *Ulva* sp. (filamentous and lettuce-like growth form) at 8 weeks (Photo 23B)
- Control blocks were moderately-heavily fouled by algae at 8 weeks (Photo 23A)

Slip tests

X1 blocks from Clovelly showed no difference in slip tests between clean and fouled X1 blocks (Figure 2A). X1 blocks from Malabar (Figure 2B) and Rozelle Bay (Figure 2C) became more slippery as they got fouled, as indicated by less force required on average to drag sled across fouled blocks.

Adhesion tests

Adhesion tests found algae to be firmly attached to X1 blocks i.e., negligible amounts of algae were removed by hosing at house-main pressure of ~160 kPa.

Direct application experiments (X1)

Summary of best outcome
X1 panels show a low-level of fouling after 12 weeks on Malabar Rock Pool wall compared to heavily fouled control panels adjacent to X1 panels.

Photographic analysis

1) Malabar Rock Pool Wall
- X1 panels (2/3) remain largely without fouling at 5 weeks while adjacent control panels were heavily fouled. One X1 panel was heavily fouled but this panel was completely surrounded by heavy fouling therefore edge effects may have increased degree of fouling in this panel (Photo 24)
- Similar results for X1 and control panels were observed at 9 and 12 weeks (Photos 25, 26)

2) Malabar Boat ramp

- Most of the X1 coating had peeled away at 4 weeks (Photo 27). This was the first time that I had returned to photograph experiment so paint may have peeled soon after application or sometime later.

Results for X2

Block experiments

Summary of best outcome
X2 blocks showed a reduced level of fouling compared to controls after 9 weeks on Malabar Rock Pool step however X2 blocks were heavily fouled.

Photographic analysis

1) Clovelly Bay Step

- X2 blocks were covered with small grey dots at 2 weeks, more so than X1 blocks. No fouling was observed on control blocks.
- X2 blocks showed heavy-complete fouling at 4 weeks with tufts/filaments of the green alga *Ulva* sp. (Photo 19C)
- Most control blocks had very little fouling at 4 weeks but one control was moderately fouled (Photo 19A)
- X2 blocks were completely fouled by 6 weeks while controls showed low-moderate fouling (Photo 20C, at 8 weeks)

2) Clovelly Bay Promenade

- The edges (but not the surface) of X2 and control blocks began to foul with red and green algae at 10 weeks, probably because the edges of blocks remain moist for longer than the surface (seen in Photo 21C at 13 weeks)
- The surface of X2 blocks began to foul with red algae by 13 weeks. Control blocks were not fouled at 13 weeks (Photo 21A, C).

3) Malabar Rock Pool Step

- X2 showed very little fouling (< 5% algal cover) after 2 weeks while control blocks showed a low level of fouling with *Ulva* sp.
- X2 blocks were moderately-heavily fouled at 5 weeks while control blocks were heavily fouled
- X2 blocks were heavily fouled at 8-9 weeks, slightly less than control blocks (Photo 22)

4) Rozelle Bay

- X2 blocks showed a low level of fouling at 2 weeks
- Control blocks showed very little (<5% algal cover) fouling at 2 weeks
- X2 blocks were moderately fouled at 4 weeks by brown (predominantly) and green filamentous algae (*Ulva* sp.)
- Control blocks showed low-medium level of fouling at 4 weeks
- X2 blocks were heavily fouled by brown filamentous algae and *Ulva* sp.(filamentous and lettuce-like growth form) at 8 weeks (Photo 23C)

- Control blocks were moderately-heavily fouled by algae at 8 weeks

Slip tests

X2 blocks from Clovelly became more slippery as they got fouled, as indicated by less force required on average to drag sled across fouled blocks (Figure 2A). X2 blocks from Malabar and Rozelle Bay showed no difference in slip tests between clean and fouled X2 blocks (Figure 2B, C).

Adhesion tests

Adhesion tests found algae to be firmly attached to X2 blocks i.e., negligible amounts of algae were removed by hosing at house-mains pressure of ~160 kPa.

Direct application experiments (X2)

1) Clovelly Promenade

- X2 squares showed a low level of fouling with red-brown microalgae at 6 weeks
- X2 squares showed a low level of fouling with red-brown and green microalgae at 8 weeks
- X2 squares showed a moderate level of fouling with red-brown microalgae at 13 weeks (Photo 28)
- It is difficult to compare painted test squares to control squares as control squares are 'bare' concrete. It is hard to see low-level fouling on bare concrete which would otherwise be seen on lightly coloured paint (Photo 29).
- It appears the experiment was applied in a low-foul area as fouling barely visible on concrete control squares and on surrounding test area.
- A small amount of X2 paint started to peel off one square at 2 weeks, with small amounts peeling off other squares during the trial (Photo 28, 29).

A  B  C 

Photo 19 – Clovelly Bay Step
A control block (**A**), X1 block (**B**) and X2 block (**C**) after 4 weeks

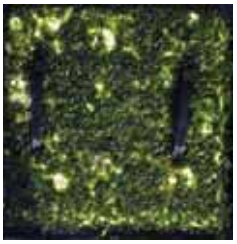
A  B  C 

Photo 20 – Clovelly Bay Step
A control block (**A**), X1 block (**B**) and X2 block (**C**) after 8 weeks

A  B  C 

Photo 21 – Clovelly Bay Promenade
A control block (**A**), X1 block (**B**) and X2 block (**C**) after 13 weeks. Note algal growth only on edges of X1 block (**B**) and red algae growing on surface and edges of X2 block (**C**).

Photo 22 – Malabar Rock Pool Step
Test board after 9 weeks showing 3 blocks with X1 or X2 coatings and 3 control blocks (see diagram below for block I.D.)

X2	X1	control
control	X2	X1
X2	X1	control

Photo 23 – Rozelle Bay Marina
A control block (**A**), X1 block (**B**) and X2 block (**C**) after 8 weeks

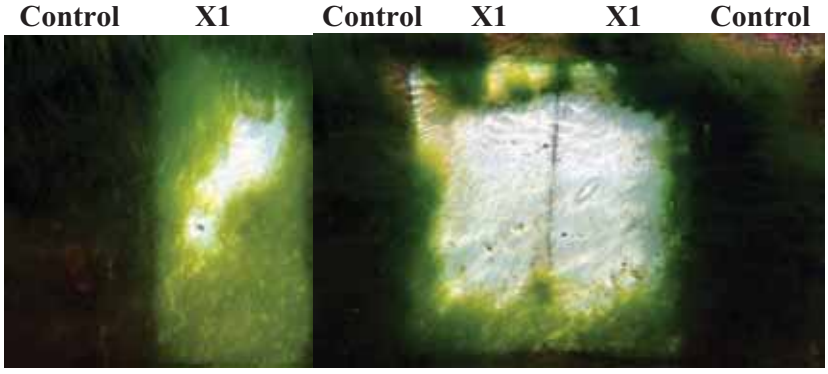


Photo 24 – Malabar Rock Pool Wall
Two X1 panels show low level fouling at 5 weeks despite heavy algal growth on adjacent control panels. Note that the heavily fouled X1 panel was completely surrounded by dense algal growth so 'edge effects' may explain heavier fouling in this panel.

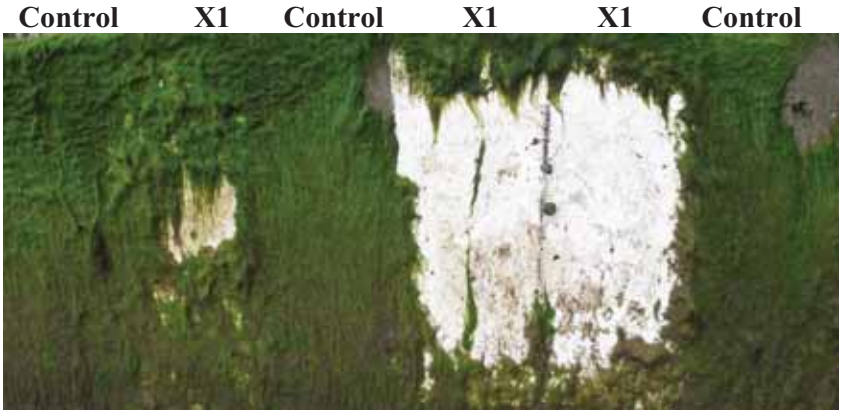


Photo 25 – Malabar Rock Pool Wall
X1 and control panels at 9 weeks (pool empty)

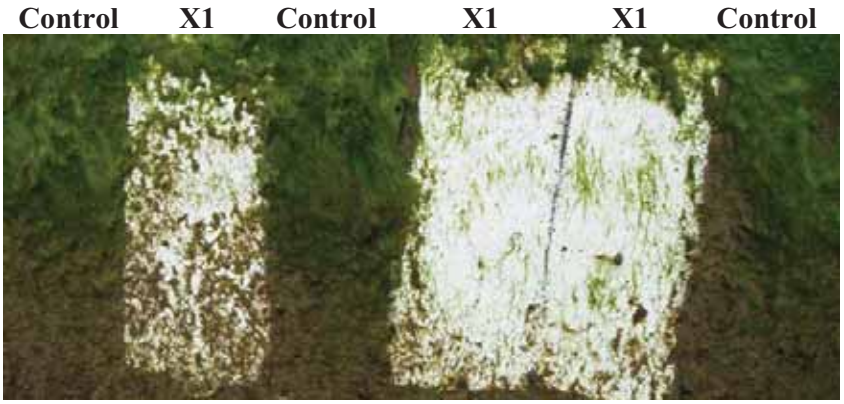


Photo 26 – Malabar Rock Pool Wall
X1 and control panels at 12 weeks (pool empty)

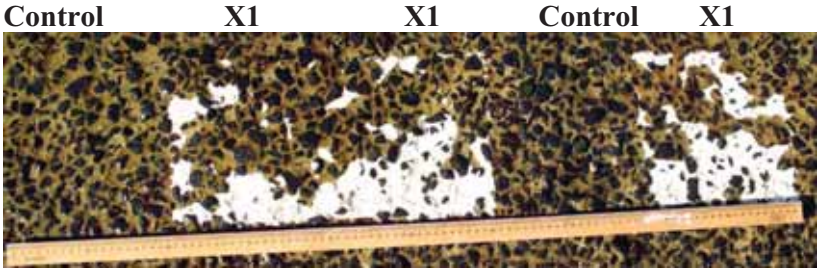


Photo 27 – Malabar Boat Ramp
Peeling X1 squares in direct application experiment at Malabar boat ramp at 4 weeks

Photo 28 – Clovelly Bay Promenade
X2 squares showing micro-fouling at 13 weeks and peeling of X2 paint

Photo 29 – Clovelly Bay Promenade
Other X2 squares and adjacent control square. Note that it is difficult to assess presence of micro-fouling in control squares due to background colour of concrete

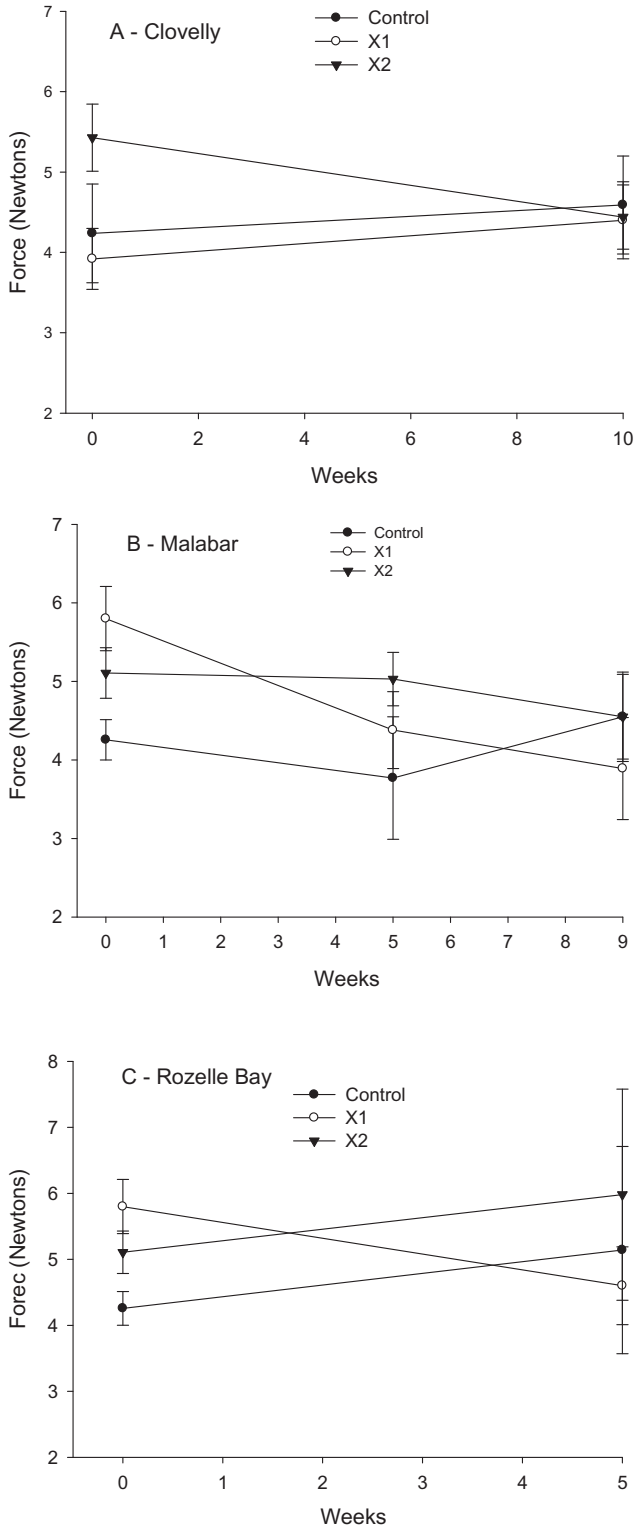


Figure 2 – 'Slip test' data for X1 and X2 blocks from Clovelly (A), Malabar (B) and Rozelle Bay (C) experiments based on force gauge readings (lower force readings indicate increased 'slippery-ness').

v) Company B coatings

2 products from Company B were tested

- non-slip paint (our code Y1)
- barefoot grate (our code Y2)

Table 2 – Summary of test sites and experimental design for Y1 and Y2

Site	Non-slip paint (Y1)	Barefoot grate (Y2)
Clovelly Bay		
Step	Blocks	Blocks
Promenade	Direct application	
Malabar Rock Pool		
Step	Blocks	Blocks
Wall	Direct application	
Rozelle Bay		
Marina	Blocks	Blocks

Results for Y1

Block experiments

Photographic analysis

Summary of best outcome

Y1 was effective at reducing the level of fouling by *Ulva* sp. on blocks for up to 4 weeks in Clovelly Bay. However, by 6 weeks there was no antifouling effect of Y1.

1) Clovelly Bay Step

- Blocks coated with non-slip paint started to foul after 4 weeks
- Y1 blocks showed a low level of fouling by the green alga (*Ulva* sp. prostrate growth form) and a red-brown alga at 4 weeks (Photo 30B)
- Control blocks showed a low-medium level of fouling by *Ulva* sp. at 4 weeks (Photo 30A)
- Y1 and control blocks showed a high level of fouling at 6 weeks
- Y1 and control blocks were completely fouled at 8 weeks (Photo 30C,D)

2) Clovelly Promenade

- Blocks deployed onto the promenade took at least 8 weeks to begin fouling
- Y1 blocks showed a low level of fouling by brown-orange algae at 9 weeks
- Control blocks showed a low-medium level of fouling by brown-orange algae at 9 weeks
- Y1 blocks showed a medium level of fouling at 11 weeks
- Control blocks showed a low-high level of fouling at 11 weeks

- Y1 and control blocks were heavily fouled with brown-red algae at 12 weeks (Photo 31)

3) Malabar Rock Pool
- Y1 blocks showed a low level of fouling by *Ulva* sp. (filamentous growth form) at 2 weeks (Photo 32B)
- Control blocks showed a low-high level of fouling by *Ulva* sp. by 2 weeks (Photo 32A)
- Y1 and control blocks were heavily fouled at 3 weeks
- Algal cover decreased dramatically to almost zero at 5 weeks, probably removed by the large swell/seas of the previous fortnight
- Y1 and control blocks were heavily fouled at 8 weeks (Photo 32C, D)

4) Rozelle Bay
- Y1 and control blocks showed a low-medium level of fouling by *Ulva sp.* (filamentous growth form), brown filamentous algae and hard worms at 3 weeks
- Y1 and control blocks were completely fouled with green and brown algae, and hard worms, at 5 weeks (Photo 33A, B)

Slip tests

Y1 blocks from Clovelly and Malabar became more slippery as they got fouled, as indicated by less force required on average to drag sled across fouled blocks (Figure 3A, B). The exception was Rozelle Bay, where there was no change in measurements between un-fouled and fouled blocks (Figure 3C). Any slippery effect of fouling algae on these blocks was negated by the presence of hard worms in the fouling community (i.e., hard worms increased friction which in turn increased the force required on average to drag sled across heavily fouled blocks).

Adhesion tests

Adhesion tests found algae to be firmly attached to Y1 blocks i.e., negligible amounts of algae were removed by hosing at pressures up to ~160 kPa.

Direct application experiments (Y1)

Photographic analysis

Summary of best outcome

Y1 deterred fouling for at least 3 weeks on the wall of Malabar rock pool while control panels and surrounding test panels showed a low-medium level of fouling. However, there was no antifouling effect of Y1 at 8 weeks.

1) Clovelly Promenade
- Most test squares showed no fouling, or a very low level of fouling, after 4 months

- This section of the promenade appears to be a low foul area. Results inconclusive

2) Malabar Rock Pool

- Y1 panels were not fouled at 3 weeks despite heavy growth of *Ulva* sp. (filamentous growth form) directly above Y1 panels, on nearby steps and on other test panels (Photo 34A)
- Control panels showed low-medium level of fouling by *Ulva sp.* at 3 weeks
- Algal growth on all test and control panels was reduced to almost zero at 5 weeks, probably removed by the large swell/seas of the previous fortnight
- Y1 panels were almost completely fouled by 8 weeks as were adjacent test panels (Photo 34B)
- Control panels showed very little fouling however they were almost 2 metres away where adjacent test panels also showed very little fouling. Fouling can be very localised: if control panels were located adjacent to Y1 panels they may also have become as fouled.

Results for Y2

Block experiments

Photographic analysis

Summary of best outcome

Y2 blocks in the Malabar rock pool experiment had no fouling at 2 weeks (Photo36B) when control blocks showed low-high level of fouling (Photo 36A). There was no antifouling effect of Y2 at 8 weeks.

1) Clovelly Bay Step

- *Ulva* sp. (prostrate growth form) started to grow in the crevices of someY2 plates at 2 weeks. Control blocks were not fouled at 2 weeks
- Y2 blocks showed highly variable fouling at 4 weeks, ranging from low level cover to completely fouled
- Control blocks showed low-medium fouling at 4 weeks (Photo 35A, B)
- Y2 and control blocks were heavily fouled at 6 weeks
- Y2 and control blocks were completely fouled at 8 weeks (Photo 35C, D)

2) Malabar Rock Pool

- Y2 blocks started to foul with *Ulva sp.* (filamentous growth form) at 3 weeks
- Y2 blocks showed medium level fouling while control blocks were heavily fouled at 3 weeks.
- Algal cover decreased dramatically to zero coverage at 5 weeks, probably removed by the large swell/seas of the previous fortnight
- Y2 and control blocks were completely fouled at 8 weeks (Photo 36C, D)

3) Rozelle Bay

- Y2 blocks showed low fouling by *Ulva* sp. (filamentous growth form), brown filamentous algae and hard worms at 3 weeks
- Control blocks showed low-medium fouling by *Ulva* sp., brown filamentous algae and hard worms at 3 weeks
- Y2 and control blocks were almost completely fouled with green and brown algae, and with hard worms at 5 weeks (Photo 33A, C)
- Control blocks were completely fouled at 9 weeks

Slip tests

Y2 blocks from Clovelly and Malabar became more slippery as they got fouled, as indicated by less force required on average to drag sled across fouled blocks (Figure 3A, B). The exception was Rozelle Bay, where there was no change in measurements between un-fouled and fouled blocks (Figure 3C). Any slippery effect of fouling algae on these blocks was negated by the presence of hard worms in the fouling community (i.e., hard worms increased friction which in turn increased the force required on average to drag sled across heavily fouled blocks).

Adhesion tests

Adhesion tests found algae to be firmly attached to Y2 blocks i.e., negligible amounts of algae were removed by hosing at house-main pressure of ~160 kPa.

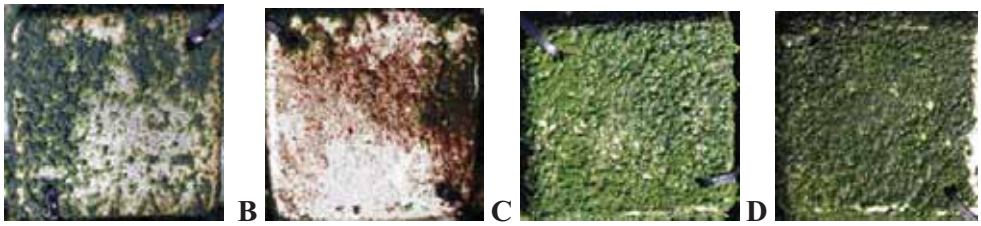


Photo 30 – Clovelly Bay Step
A control block (**A**) and Y1 block (**B**) at 4 weeks, and a control block (**C**) and Y1 block (**D**) completely fouled at 8 weeks. Note the reduced growth of the green alga *Ulva* sp. on Y1 compared to control at 4 weeks. A red-brown alga was the prominent alga on Y1 blocks up until 6 weeks when it was outgrown by *Ulva* sp.

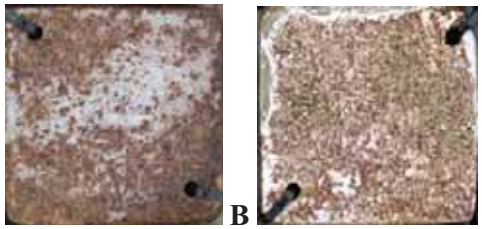


Photo 31 – Clovelly bay promenade
A control block (**A**) and Y1 block (B) heavily fouled by brown-red algae at 12 weeks

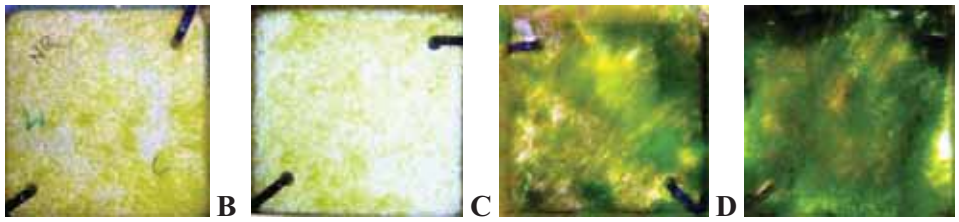


Photo 32 – Malabar Rock Pool Step
A control block (**A**) and Y1 block (**B**) at 2 weeks, and a control block (**C**) and Y1 block (**D**) heavily fouled at 8 weeks. Note filamentous growth form of *Ulva* sp. in C, D in contrast to prostrate growth form seen on Clovelly Bay step (Photo 3C,D).

Photo 33 – Rozelle Bay Marina
A control block (**A**), Y1 block (**B**) and Y2 block (C) completely fouled with green and brown algae and hard worms at 5 weeks.

A 

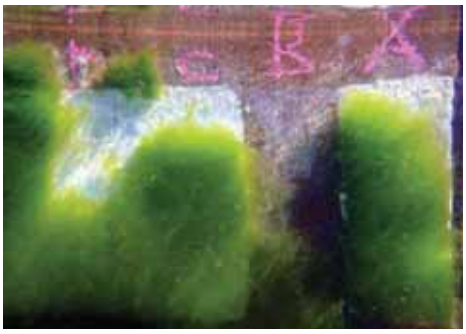
B 

Photo 34 – Malabar Rock Pool Wall

Y1 test panels (panels 1C, 1E) after 3 weeks (**A**) showing minimal algal growth on Y1 non-slip paint. Note heavy algal growth in top section of other test panels 1G and 1F. Algae was growing directly above Y1 panels which was scraped off before photo was taken. (**B)**Y1 test panels (panels A, C) heavily fouled with *Ulva* sp. at 8 weeks

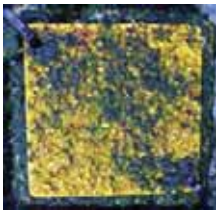
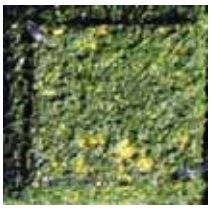
A  B  C  D 

Photo 35 – Clovelly Bay Step

A control block (**A**) and Y2 block (**B**) at 4 weeks, and a control block (**C**) and Y2 block (**D**) completely fouled at 8 weeks.

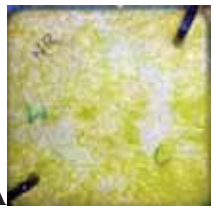
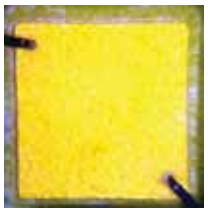
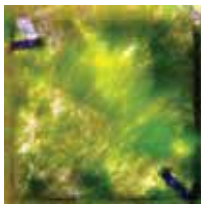
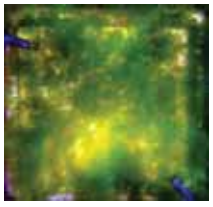
A  B  C  D 

Photo 36 – Malabar Rock Pool Step

A control block (**A**) and Y2 block (**B**) at 2 weeks, and a control block (**C**) and Y2 block (**D**) heavily fouled at 8 weeks.

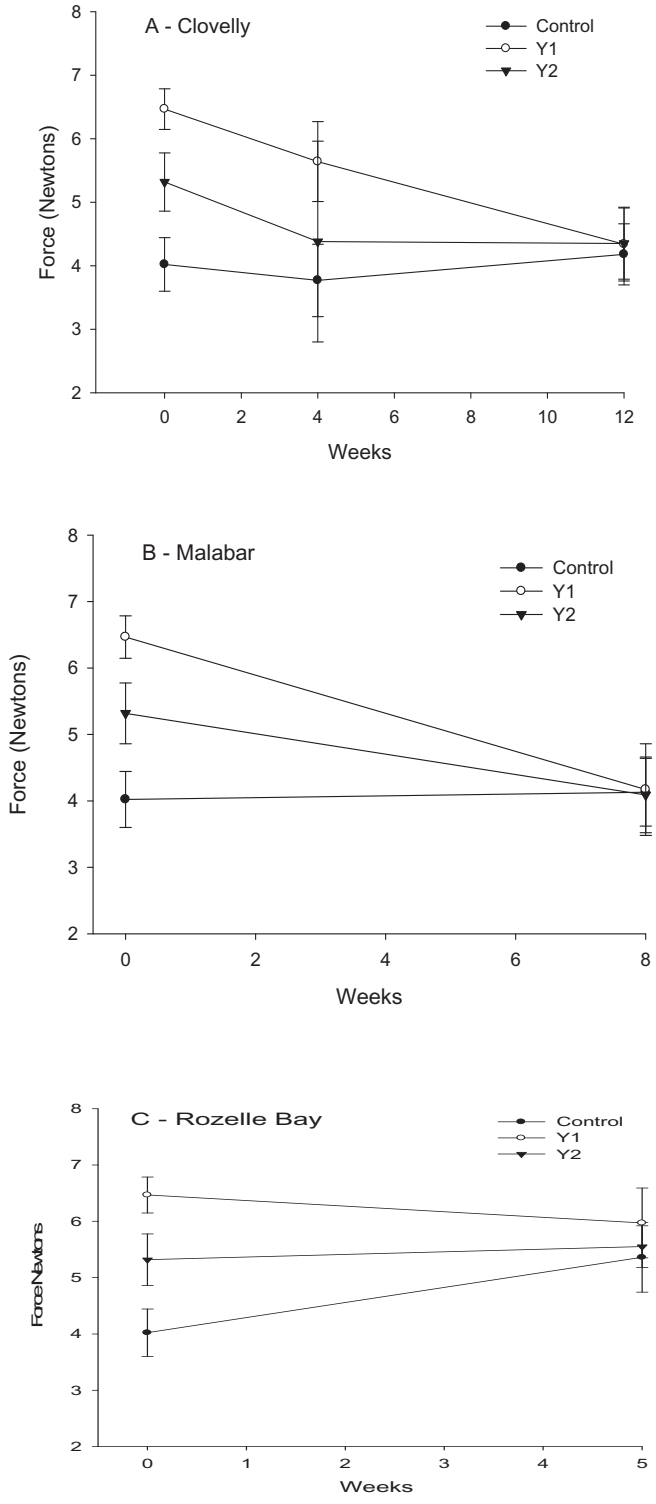


Figure 3 – 'Slip test' data for X1 and X2 blocks from Clovelly (A), Malabar (B) and Rozelle Bay (C) experiments based on force gauge readings (lower force readings indicate increased 'slippery-ness').

vi) Company A coatings

Two coatings from Company A were tested, A (our code Z1) and B (our code Z2). Two application techniques (A and B) were compared for each coating in the block experiments (our codes - Z1A, Z1B and Z2A, Z2B). Only one application method (spray) was used for each coating (Z1, Z2) in the direct application experiments. The effect of adding a primer to the surface before spraying on coating was tested in direct application experiments in the Sutherland Shire (our codes - primer applied PZ1 and PZ2, no primer applied Z1 and Z2).

Table 5 - Summary of test sites and experimental design for Z1 and Z2 coatings. Two application methods were tested in block (A versus B) and direct application experiments (primer-P or no primer).

Site	Block Experiments	Direct Application
Clovelly Bay		
Step	Z1A, Z1B, Z2A, Z2B	
Promenade	Z1A, Z1B, Z2A, Z2B	Z1, Z2
Malabar Rock Pool		
Step	Z1A, Z1B, Z2A, Z2B	
Wall		Z1, Z2
Malabar Boat Ramp		Z1, Z2
Rozelle Bay Marina	Z1A, Z1B, Z2A, Z2B	
Hawkesbury Reserve		
Boat Ramp		Z1, PZ1, Z2, PZ2
Cronulla Rock Pool		
Pool Edge		Z1, PZ1, Z2, PZ2
Access Ramp		Z1, PZ1, Z2, PZ2

Results for Z1A/B and Z2A/B

Block experiments

Photographic analysis

Summary of best outcome
Z2B blocks had considerably less fouling than control blocks after 4 weeks on Clovelly Step. There may have been a slight antifouling effect of Z2B at 6 weeks but no effect at 8 weeks.

1) Clovelly Bay Step

- Z1B blocks showed light-moderate fouling after 2 weeks (Photo 37A). Z1A, Z2A/B blocks and control blocks were not fouled at 2 weeks (Photo 37B).

- By 4 weeks, fouling was highly variable on all coatings. The position of the block on the step (Board 1, 2, 3, 4 or 5) had some influence on the level of fouling, i.e., there was variation in fouling across the step.
- The least fouled blocks were Z2B blocks which either had no fouling or light fouling at 4 weeks. Control blocks were lightly-moderately fouled. Z1A blocks ranged from no fouling to completely fouled. Z2A blocks were lightly-moderately fouled and Z1B were moderately-heavily fouled (Photo 38A-E)
- Z1A, Z1B, Z2A and control blocks were heavily or completely fouled by 6 weeks. Z2B blocks were moderately-heavily fouled (Photo 39A-E).
- All Z blocks and control blocks were completely fouled at 8 weeks
- Some blocks were lost from step during trial. Results are based on 3-4 replicate blocks (5 blocks per coating were deployed) except for Z2A result at 6 weeks (only 2 blocks left). A stronger method for attaching blocks to boards has rectified this problem.

2) Clovelly Promenade

- Blocks deployed onto the promenade took at least 8 weeks to foul.
- Some Z blocks were lost (1 of each coating) from promenade to high seas including all three Z2B blocks.
- Z1A blocks and control blocks were lightly-moderately fouled at 9 weeks. Z1B blocks had no fouling while Z2A blocks were lightly fouled at 9 weeks.
- Z1A, Z2A blocks were heavily fouled at 11 and 12 weeks while fouling on control blocks ranged from light to heavy. Z1B blocks were lightly fouled (Photo 40)
- Blocks with a smooth/shiny finish were less fouled than concrete blocks with a grainy finish (i.e., concrete finish may have influenced result).

3) Malabar Rock Pool

- Control blocks showed a low-high level of fouling by *Ulva* sp. by 2 weeks
- All Z blocks were moderately-heavily fouled at 3 weeks while control blocks were heavily fouled (Photo 41A-E)
- Algal cover decreased dramatically to almost zero at 5 weeks, probably removed by the large swell/seas of the previous fortnight
- All Z blocks and control blocks were heavily fouled at 8 weeks (Photo 42A-E).

4) Rozelle Bay

- All Z blocks were moderately fouled at 3 weeks while control blocks showed low-moderate level of fouling.
- Serpulid polychaete hard worms were the dominant fouling organism at 3 weeks with some green and brown filamentous algae present
- By 5 weeks, all Z blocks were heavily-completely fouled while controls were heavily fouled. Algae now outgrowing hard worms (Photo 43A-E)
- By 9 weeks all Z and control blocks were completely fouled.

Slip tests

All Z blocks from Clovelly (Figure 4 A, B) and Malabar (Figure 4C, D) showed no change in measurements (peak force) between un-fouled and fouled blocks. On

average, fouled Z blocks were more slippery, however, there was large variation in the replicate measurements. Z blocks (and control blocks) from Rozelle Bay became less slippery as they became fouled (Figure 4E-F). Any slippery effect of fouling algae on these blocks was negated by the presence of hard worms in the fouling community (i.e., hard worms increased friction which in turn increased the force required on average to drag sled across heavily fouled blocks).

Adhesion tests

Adhesion tests found algae to be firmly attached to Z blocks at the conclusion of the experiment at Clovelly and Malabar i.e., negligible amounts of algae were removed by hosing at pressures up to ~160 kPa. The exception was Z blocks from Rozelle bay. At 18 weeks, some fouling could be removed by hosing blocks at house-main pressure (up to ~160 kPa) but most fouling remained. A similar amount of fouling was removed from control blocks by hosing. Fouling appeared to be attached less firmly to all blocks at this site, possibly due to calm and polluted conditions, but also due to some degradation of the fouling community towards the end of the experiment.

Direct application experiments (Z1, PZ1, Z2, PZ2)

Photographic analysis

Clovelly promenade
The test squares have very little fouling on them after 5 months. The area chosen for the experiment appears to be a low-foul area (Photo 44).

Malabar Boat Ramp
The test area has a small amount of green and brown algal growth but there appears to be no difference between Z1/ Z2 squares and control squares (Photo 45, 46).

Cronulla Rock Pool Edge

- This rock pool is exposed directly to ocean conditions, particularly to southerly swells
- There was some growth of green and brown algae in the first half of the test area (1A-1G) at 9 weeks. Green algae (*Ulva* sp.) grew on test panel 1A-1E, and brown micro-algae grew on test panel 1A-1G. Similar levels of fouling were observed on control and test panels (Photo 47A-C).
- Very little algal growth was observed on the test area before 9 weeks probably due to big seas which occurred during this part of the field trial. Sand-wash from swell results in pool edge 'self-cleaning'.
- No algal growth was observed on test panels 1H, 2A-2G at any time during the trial. This is in contrast to typical fouling observed on pool edge in February 2009. Brown micro-algae grew in section of test panels 2A-G (Photo 47D), however, calm sea conditions prevailed at this time (no self cleaning).

Cronulla Rock Pool Ramp

- The test area on the ramp showed a very slow fouling rate with brown/orange micro-fouling algae only appearing at 8-9 weeks.

- While most of the ramp became heavily fouled after 12 weeks, the area of the experiment had less algal growth (Photo 48A).
- No difference was observed between test squares (Z1, PZ1, Z2, PZ2) and control squares (Photo 48B, C).
- This section of the ramp undergoes 'self-cleaning' during big swells.

Hawkesbury Reserve Boat Ramp

- The test area on the ramp itself was lightly covered in a brown film/scum, possibly brown algae and organic pollutants from boat use, after 3 weeks.
- Small patches of micro algae started growing on the adjoining wall also used as a test area at 3 weeks.
- Brown scum layer on the boat ramp steadily increased during the trial. No differences were observed between the test panels (Z1, PZ1, Z2, PZ2) and the controls (Photo 49).
- It is possible that brown scum layer on ramp (Photo 49A) masked any antifouling affect of test coatings. However, no antifouling effect was observed on the test panels (Z1, PZ1, Z2, PZ2) on the adjoining wall (Photo 49B).

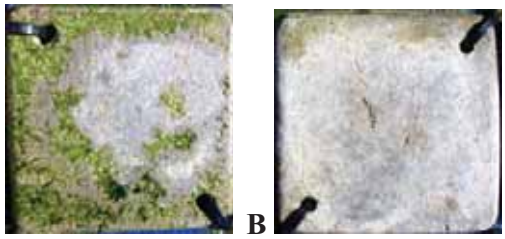


Photo 37 – **Clovelly Bay Step**
The most fouled Z1B block (A) and an un-fouled control block (B) at 2 weeks

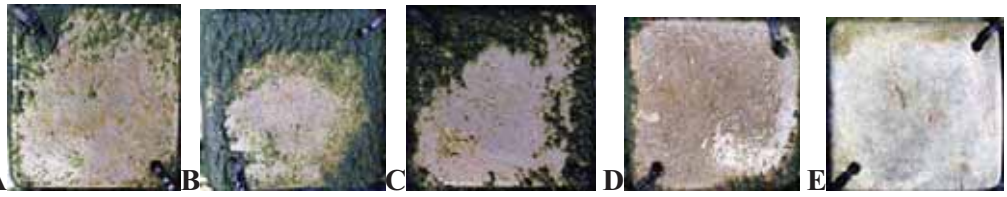


Photo 38 – **Clovelly Bay Step**
The least fouled block for each coating; Z1A (A), Z1B (B), Z2A (C), Z2B (D) and a control block (E) after 4 weeks

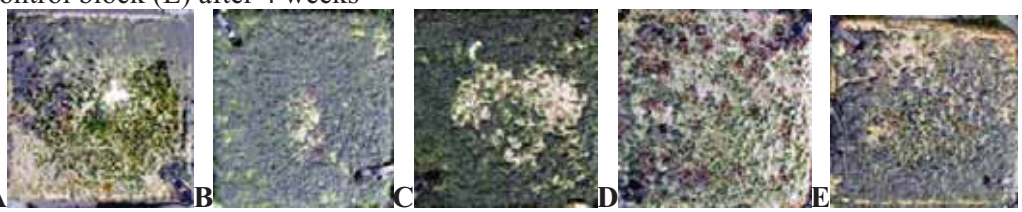


Photo 39 – **Clovelly Bay Step**
The least fouled block for each coating; Z1A (A), Z1B (B), Z2A (C), Z2B (D) and a control block (E) after 6 weeks

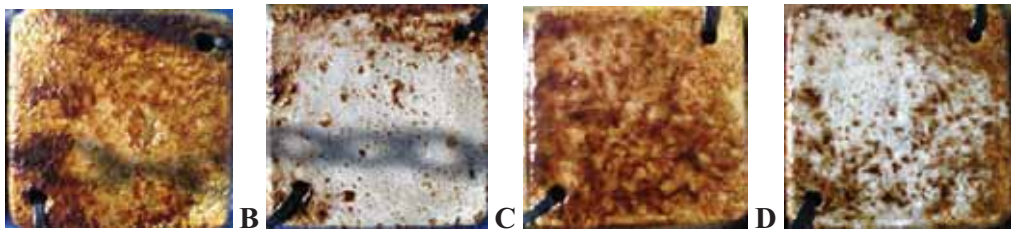


Photo 40 – Clovelly Bay Promenade
Z blocks at 11 weeks; Z1A (A), Z1B (B), Z2A (C) and a control block (D). Similar levels of fouling were observed at 12 weeks.

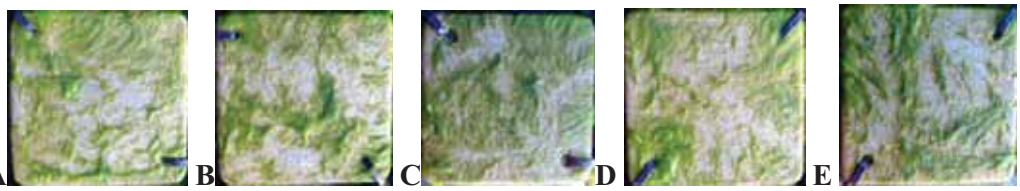


Photo 41 – Malabar Rock Pool
The least fouled block for each coating; Z1A (A), Z1B (B), Z2A (C), Z2B (D) and a control block (E) after 3 weeks

Photo 42 – Malabar Rock Pool
Heavily fouled blocks for each coating; Z1A (A), Z1B (B), Z2A (C), Z2B (D) and a control block (E) after 8 weeks

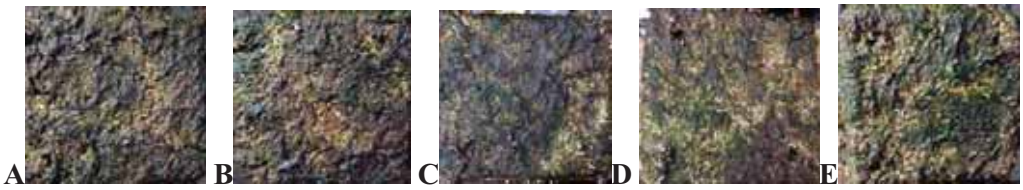


Photo 43 – Rozelle Bay Marina
Heavily fouled blocks for each coating; Z1A (A), Z1B (B), Z2A (C), Z2B (D) and a control block (E) after 5 weeks.

Photo 44 – Clovelly Promenade
The direct application experiment after 12 weeks. Area is low foul area compared to surrounds (foreground).

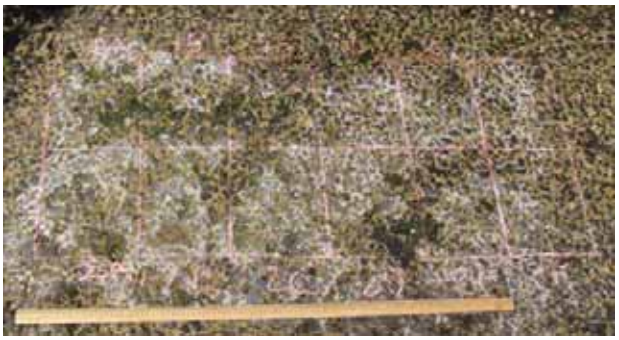


Photo 45 – Malabar Boat Ramp
Direct application experiment testing coatings from BASF

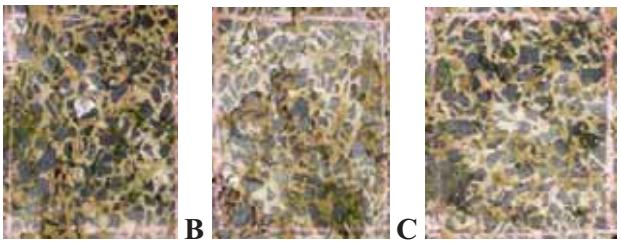


Photo 46 – Malabar Boat Ramp
Representative test squares at 3 weeks, Z1 (A), Z2 (B) and control (C), showing no difference between test squares (A, B) and control squares (C)

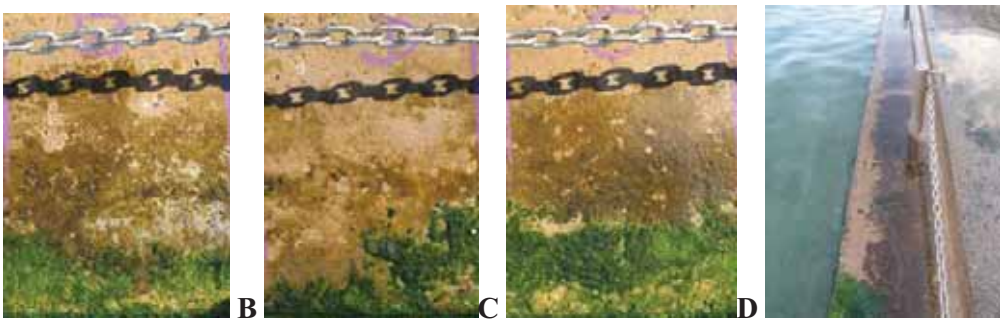


Photo 47 – Cronulla Rock Pool Edge
Representative panels at 9 weeks; PZ1 (A), Z1 (B), control (C), typical fouling observed on test area before the experiment (D)

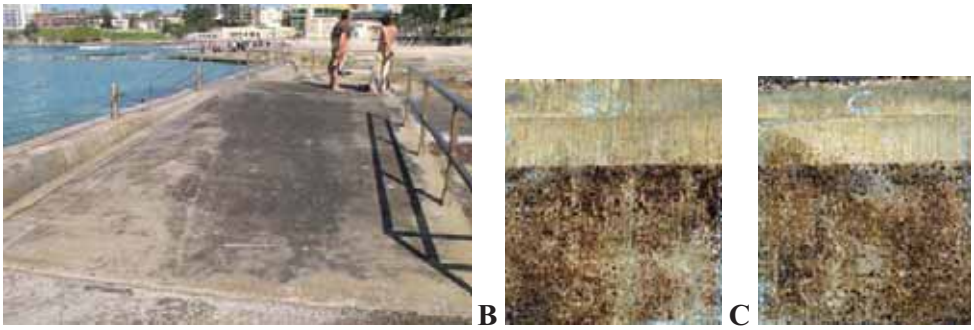


Photo 48 - Cronulla Rock Pool Ramp
Access ramp after 3 months (A). The experiment was on the left side of the ramp alongside the pool wall (in area that is least fouled). A representative test square of PZ1 coating (B) and a control square (C)

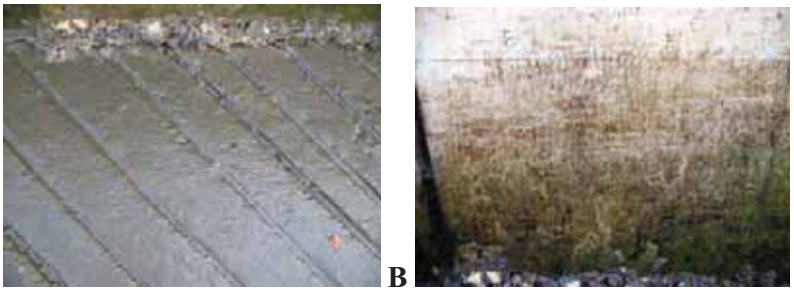


Photo 49 – Hawkesbury Reserve Boat Ramp
Boat ramp showing brown film/scum seen on boat ramp below mid tide level (A) and the adjoining wall showing algal/microbial growth observed in all test panels (B)

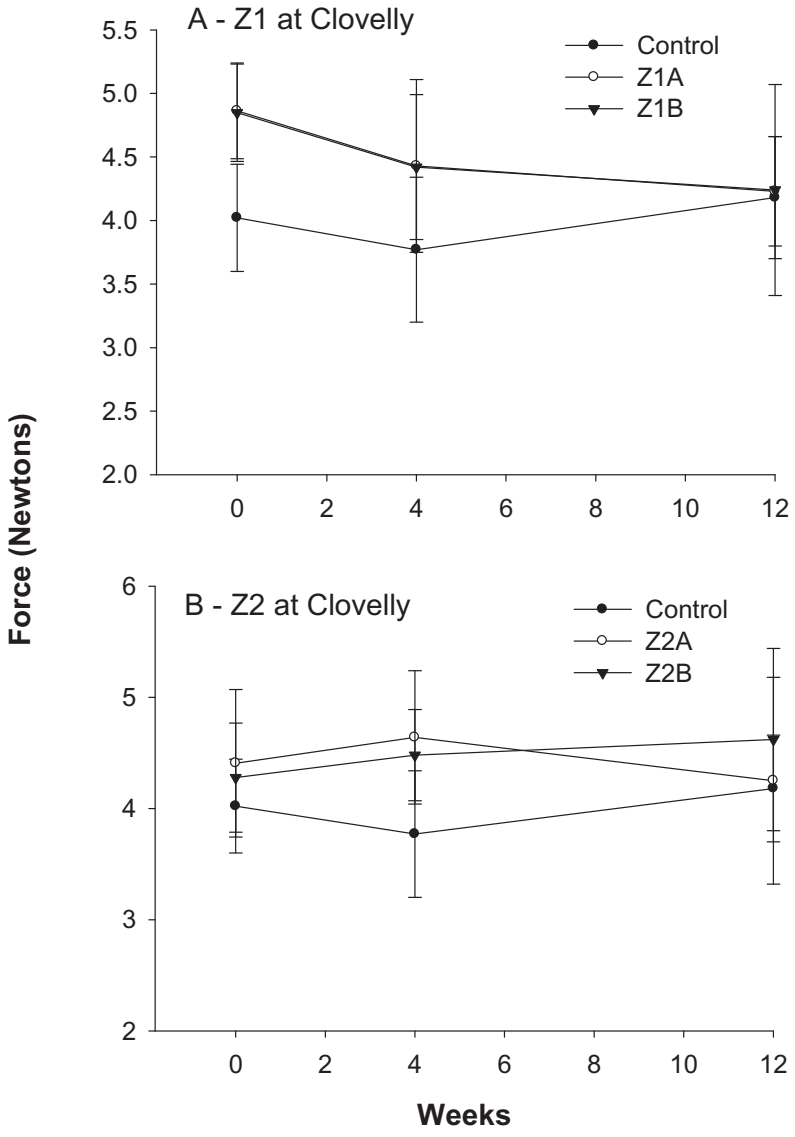


Figure 5A-B – 'Slip test' data for Z1 (A) and Z2 blocks (B) from Clovelly experiments based on force gauge readings (lower force readings indicate increased 'slippery-ness').

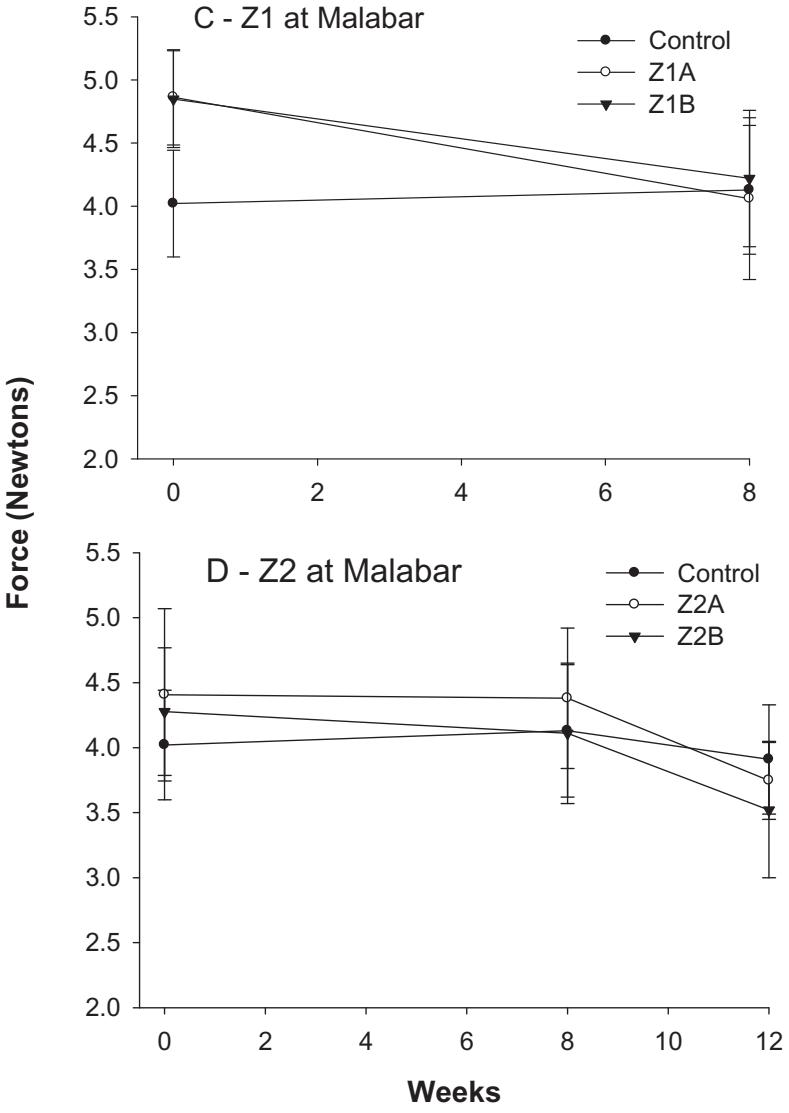


Figure 5C-D – 'Slip test' data for Z1 (C) and Z2 blocks (D) from Malabar experiments based on force gauge readings (lower force readings indicate increased 'slippery-ness').

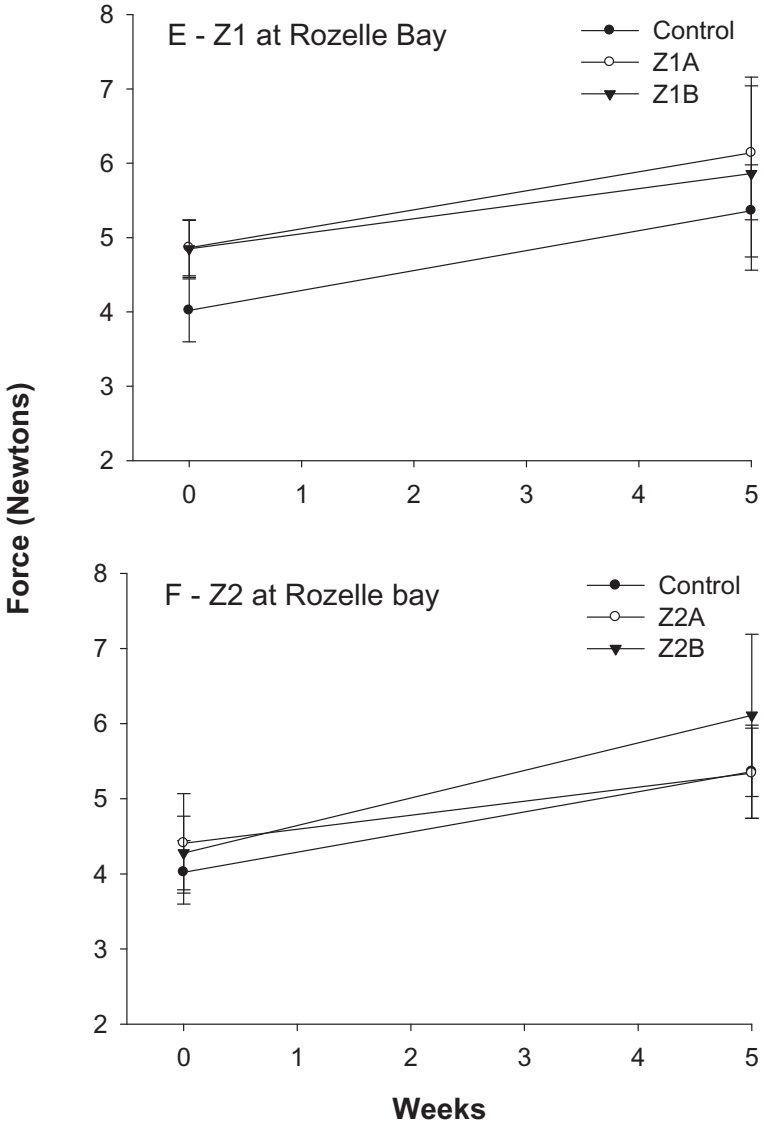


Figure 5E-F – 'Slip test' data for Z1 (A) and Z2 blocks (B) from Rozelle Bay experiments based on force gauge readings (lower force readings indicate increased 'slippery-ness').

vii) Comments on success of experimental design

Durability and longevity of Block Experiments

Blocks (12 x 12 cm) were made from cement/sand mix at UNSW which were reinforced with aluminium wire. Up to 9 blocks were attached to polycarbonate boards by 2 cable ties at opposite corners of each block (Photo 2, 3). The polycarbonate test boards were then bolted to steps (Clovelly Bay, Malabar Rock Pool) or platforms (Clovelly promenade) using stainless steel dynabolts. The initial method of using cable ties at the corners (Photo 3) was replaced with a stronger fastening method of strapping two cable ties through the centre of blocks (Photo 19-21).

Clovelly Bay - The polycarbonate test boards remained firmly fixed to concrete step throughout trial period, despite the huge swell at times. There were gradual, significant, losses of blocks which were cable-tied at the corners over the 11 week trial period (Step, lost 25 of 45 blocks at a rate of 1-4 each week; Promenade, lost 10 of 21 blocks, approx. 1 per week). However, there was no loss of blocks using the revised cable-tie method during the 9 week trial period of Company C coatings.

Malabar Rock Pool and Rozelle Bay – There were no losses of test blocks or boards from Malabar Rock Pool step, nor from racks suspended in Rozelle Bay. The initial cable-tie method was sufficient for these sites due to calmer conditions.

W1 and W2 blocks
Wax-based formulations appeared to be the most effective at reducing algal growth however improvements need to be made to W1 blocks to improve their strength, particularly for sites such as Clovelly Bay. Alternatives to aluminium wire will be used in case corrosion of aluminium wire somehow weakened the integrity of the wax blocks.

Test Surface
The test surface of blocks needs to be rough rather than smooth. Smooth surfaces foul more slowly than slightly granular surfaces, even if no test coating is applied (i.e., control block). Block manufacture has been altered slightly to produce test areas with a rough finish.

Direct Application Experiments

Coatings from Company A, B, and C and UNSW were tested in direct application experiments at one or more field sites. Different sized test areas were used at each site depending on the site area and/or applicator issues. Most direct application experiments were inconclusive for a variety of reasons (refer to direct application results for each company – sections iii-vi). The exception was the direct application experiment in Malabar Rock Pool which was a success as two coatings exhibited antifouling effects for 9-12 weeks (X1 from company C, W1 from UNSW). The position of the experiment at each field site and the size of test squares/panels used will be altered at most sites. For example, the area chosen for the direct application onto Clovelly promenade will be changed as current test area proved to be a low-foul area. Hawkesbury reserve boat ramp will not be included in the next trial du to high

levels of pollution from high use. Instead, the boat ramp at Waters St Woolooware will be included in the study.

Issues to consider for Field Trial 2009/10

There was no evidence of vandalism at any site.

There needs to be more consideration of small scale variability in local conditions occurring within each test area at each field site when designing the next field trial. For example, eastern half of Clovelly step endures more swell/surge than western half (step is approximately 2 metres long) with overall fouling appearing to increase from east to west. Further, middle section (~ 1m wide) of test area on vertical wall of Malabar pool may be exposed to more surge from huge seas than flanking test areas (middle section is considerably less fouled than flanking sections). It appears that swell/surge can remove fouling from some surfaces under certain conditions. A partially randomised block design with more replicates, as opposed to a completely randomised block design, should help to overcome this problem.

Report written by Dr. Rebecca Swanson