



Australian Government
Department of Defence
Defence Science and
Technology Organisation

Biofouling Issues From A Defence Perspective

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MPD Capability Environmental Protection

**National & International
Regulation**

**Defence Environmental
Management Framework**

**Ozone Depleting
Substances**

Operational Impact

**Shipboard Pollution
Control**

Pipework Fouling

Waste Treatment

Antifouling Coatings

**Invasive Marine
Pests**



Royal Australian Naval Platforms



Amphibious Landing Platform

20 knots



Guided Missile Frigate

30 knots



Collins Class Submarine

10-20 knots



Huron Class Coastal Minehunter

14 knots



Anzac Class Frigate

27 knots



Landing Ship Heavy

16 knots



Armada Class Patrol Boat

25 knots



Heavy Landing Craft

9 knots



Replenishment Ship

16 knots



Hydrographic Survey

12 knots

Problems – Copper based systems



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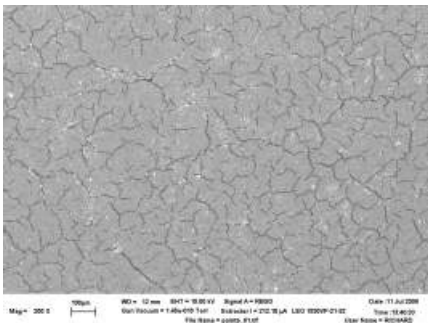
Paint system failure



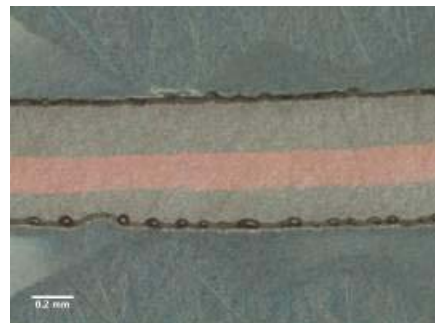
Delamination of a/f system



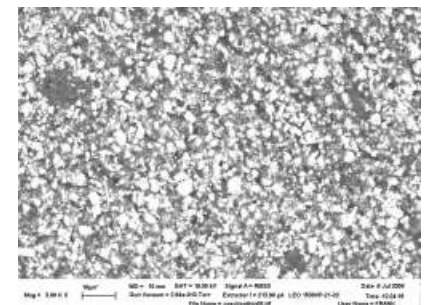
Algae at the waterline



Paint cracking characterisation



Paint film thickness



Cuprous oxide pigment size

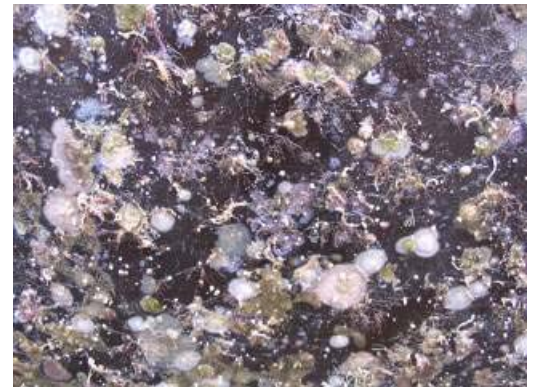
Problems – Foul-release systems



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Patrol Boats spend time docked in tropical water and can foul quickly, encrusting bryozoan and tubeworms not released. Areas of vessel not experiencing shear often prone to heavy fouling



Problems – Niche areas



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Bow tunnel

Paint damage

Sea chest

Grates



Minehunter (MHC)



Anzac Class Frigates



Trellenberg hose -Collins

Marine Growth Protection Systems

- **Copper dosing vs chlorine injection**
- Many species are copper tolerant including some tubeworms and hydroids. A trial on HMAS Penguin demonstrated that > 100ppb was required to be effective
- Copper dosing requires effort from crew to monitor and alter dosing rate based on flow rate
- Many instances of strainer boxes full of mussels
- RAN vessels spend long periods alongside in high risk fouling areas compared to commercial vessels in Australia and sea chests are smaller, with systems more critical in terms of temperature tolerance (eg combat system cooling).
- Automated chlorine system converts saltwater into chlorine.
- Initial evidence from patrol boats indicates this system is system is effective



Strainer box

DSTO antifouling research



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Static immersion trials in southern and northern Australia



Rotor facility to evaluate coating durability



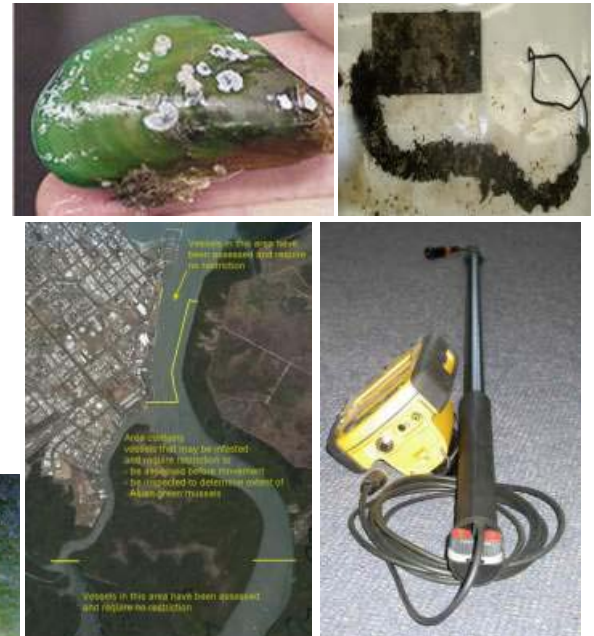
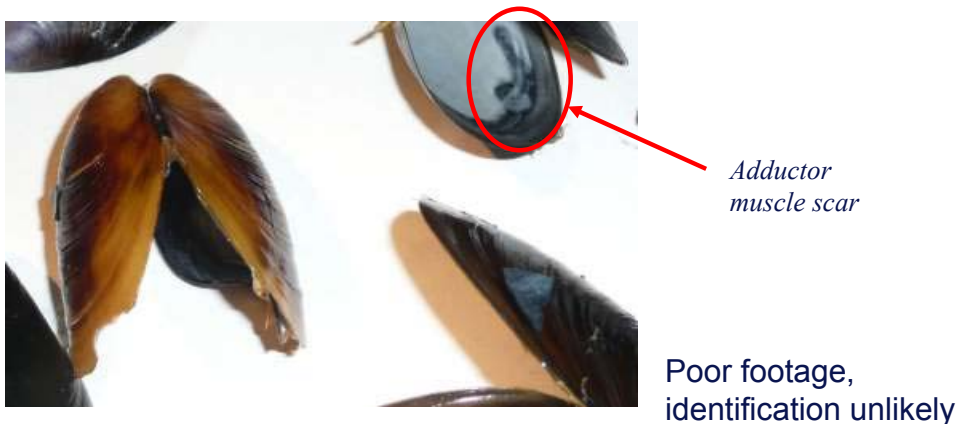
Patch trials of RAN vessels



Flow chamber to evaluate adhesion strength and foul-release capabilities

Marine pest detection

- Regular hull and niche inspections necessary
- Diver aids required to detect high risk species
- Reliable footage needed for timely identification



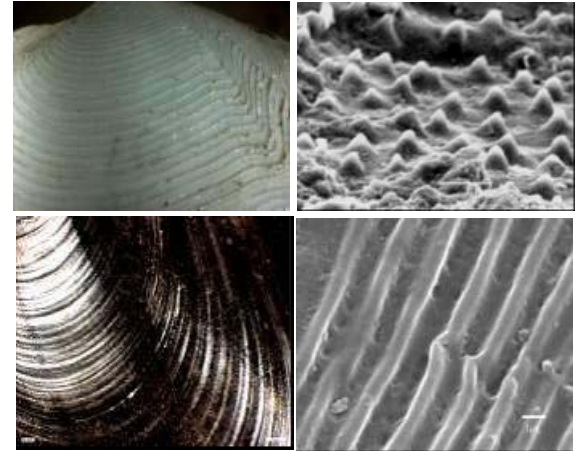
Marine pest detection: Asian green mussels, settlement ropes and diver aids

Collaborative Research

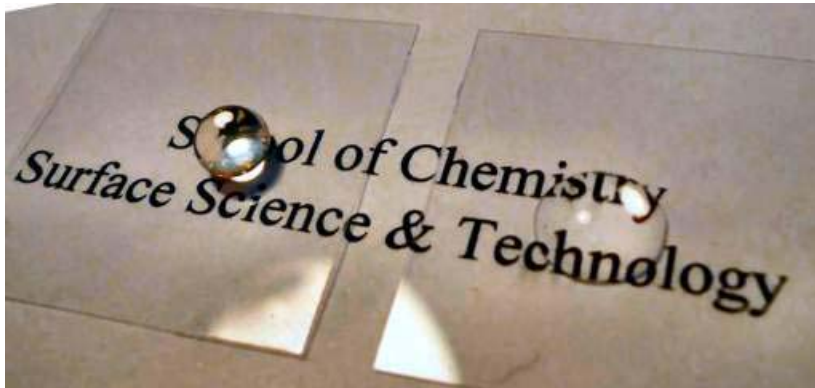


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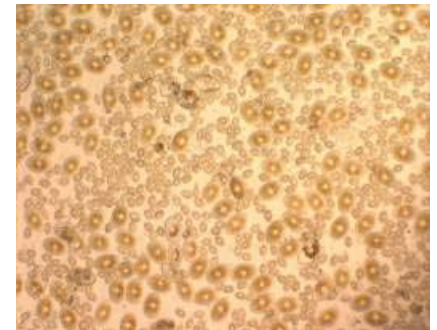
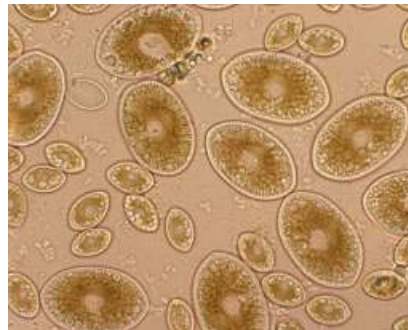
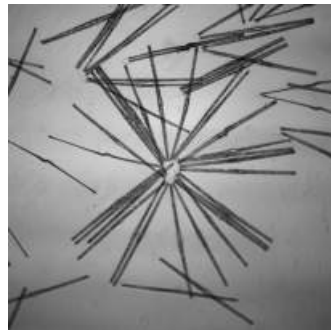
- JCU – Biomimetic antifouling surfaces



- Melbourne University, extreme wettabilities

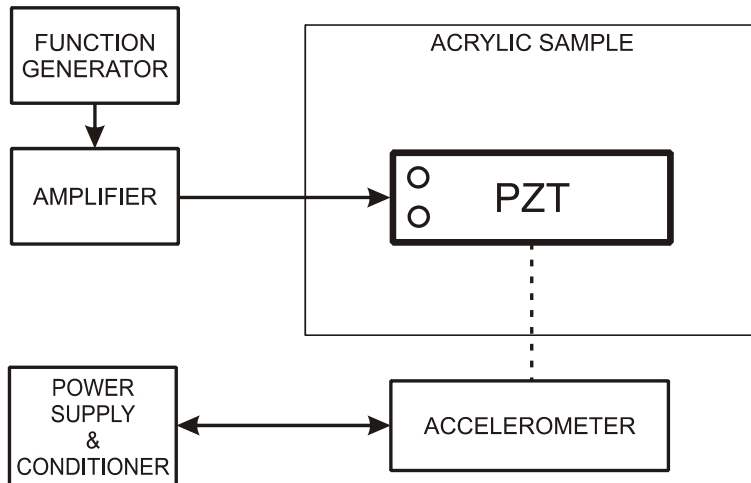


- Melbourne University, School of Botany – Foul-release, diatom adhesion



DSTO A/F Research

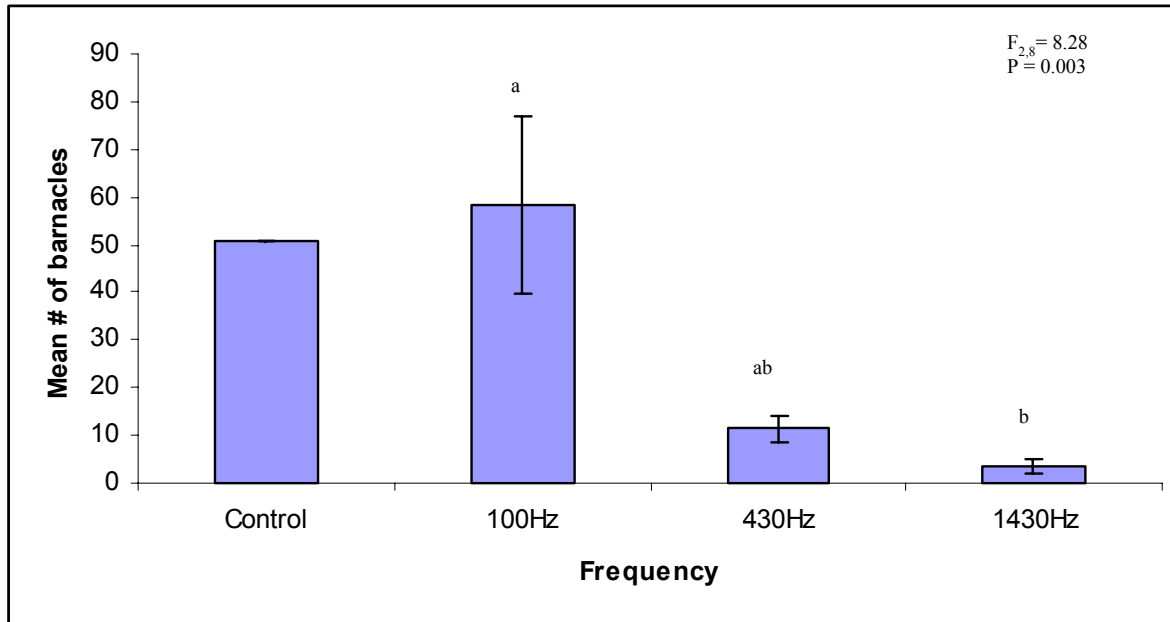
- Fouling control using vibration
- PZT embedded panels tested in static immersion trials over several fouling seasons
- A range of frequencies (100Hz – 2000Hz) and amplitudes (10V - 50V) examined



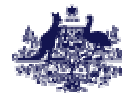
A/F using vibrational effects



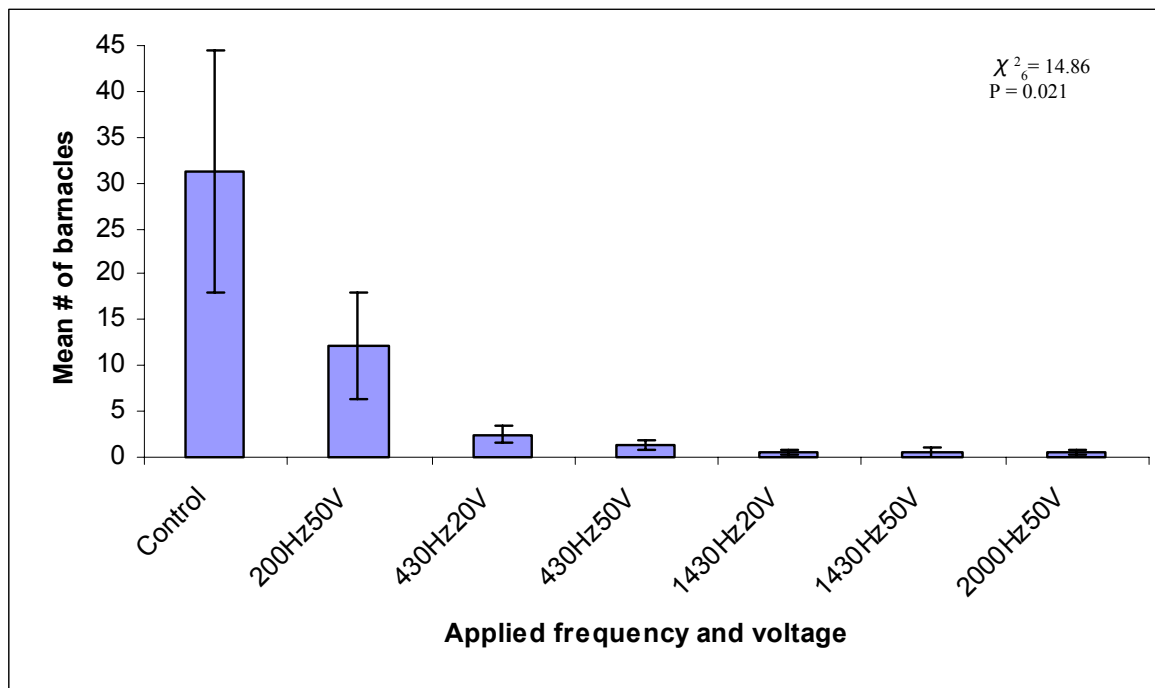
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- A deterrence found at frequencies of 430 Hz and beyond for barnacles only
- No effect on other fouling organisms including algae, tubeworms and encrusting bryozoans



A/F using vibrational effects



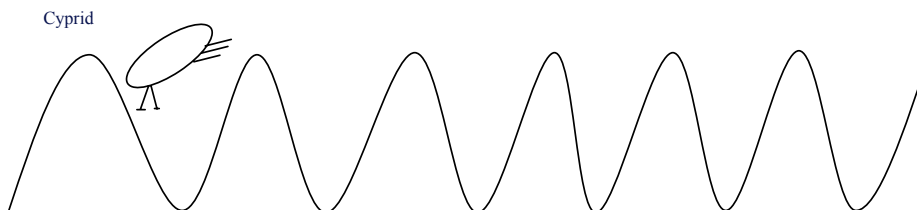
- Barnacle deterrence found again in repeat experiment with frequencies ≥ 430 Hz, no real effect of amplitude
- Again no effects on other fouling organisms



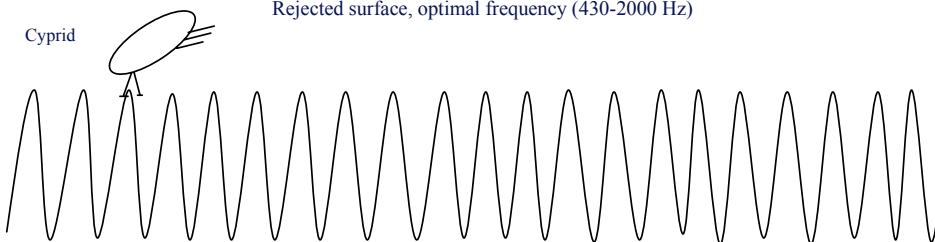
Mechanism of barnacle cyprid deterrence?

- High frequency may interfere with cyprid searching antennules, unclear why effects aren't seen for other invertebrate larvae
- There are various marine acoustics noises that could attract or repel larvae such as waves crashing, snapping shrimp/predators
- Acoustic cues recorded for fish larvae and crustaceans within these frequency ranges (Popper et al. 2001, Leis et al. 2002, Lovella et al. 2005)

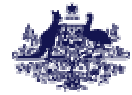
Favourable surface, low frequency (<200 Hz)



Rejected surface, optimal frequency (430-2000 Hz)

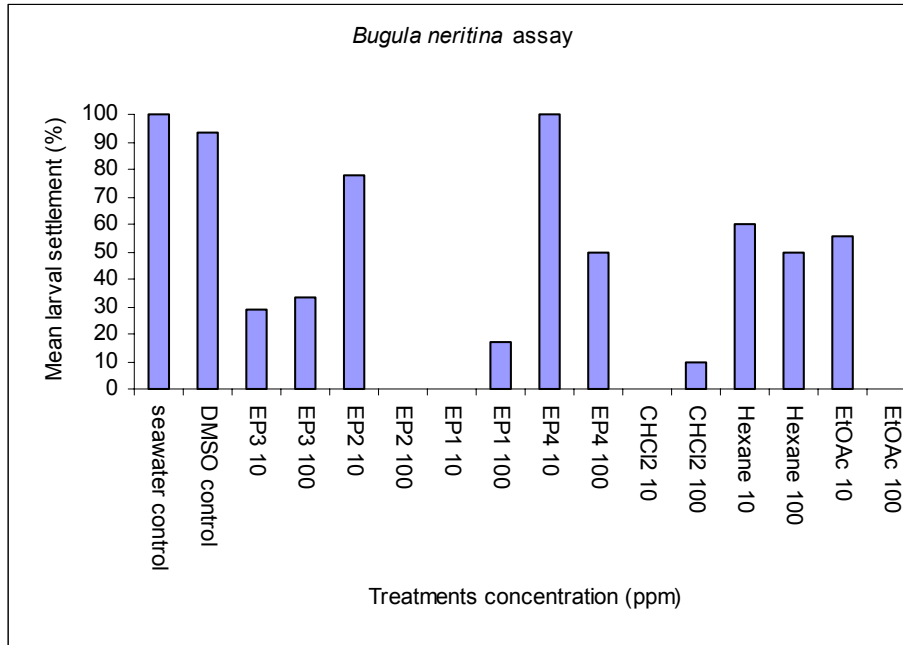


DSTO A/F Research

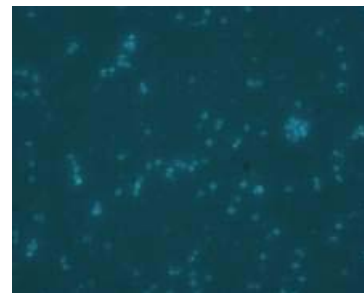
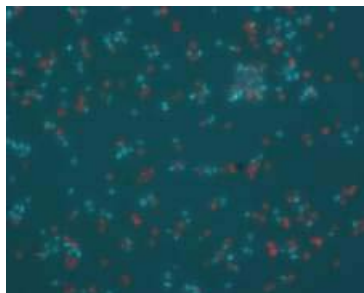
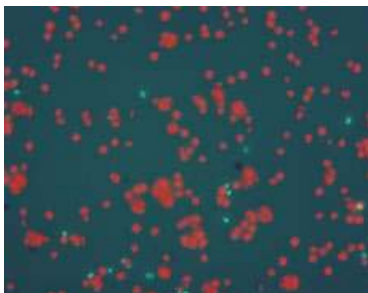


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■ Mytilid Periostracum



Periostracum – thin
proteinaceous layer found
on the surface of the shell



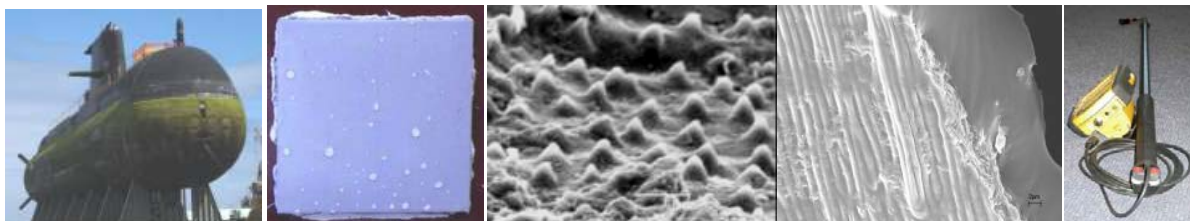
Amphora cells



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Future Studies

- Fouling penalty and increases in fuel consumption and emissions
- Torque meters and changes in shaft power, cleaning regimes and docking cycles e.g trigger system used by RN
- In dock support for foul-release coatings
- Marine pest management, inspections and diver aids
- Alternatives to copper based systems:
 - additives to foul-release coatings
 - biomimetic engineering
 - living paints encapsulating a natural fouling deterrent biofilm
 - Multiple strategies



Acknowledgements



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