

MI@NUS Sustainable Management of Marine Fouling Workshop

Biology of Marine Pests



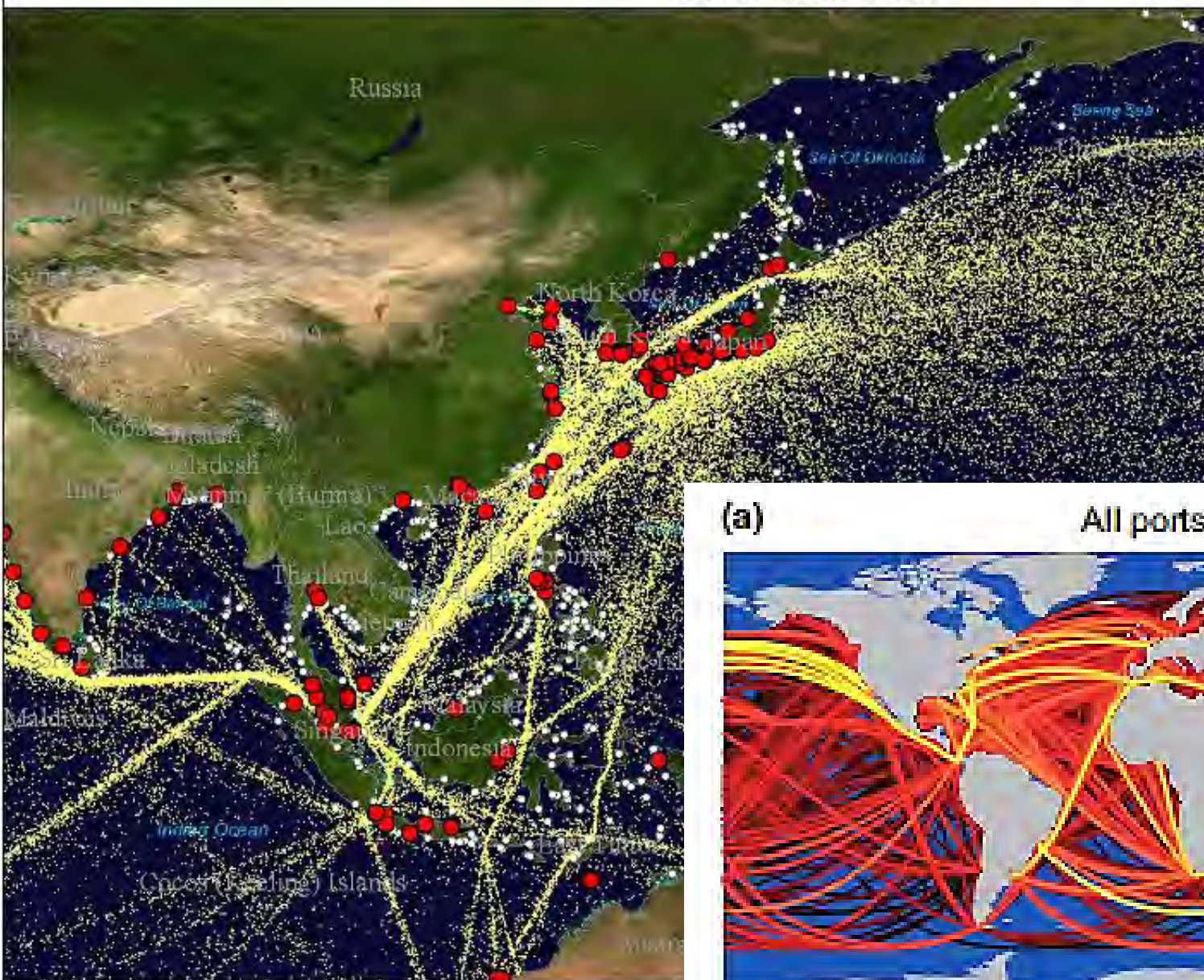
Marine Biosecurity

Invasive species (nuisance or pest species) are a subset of introduced species that have undesirable, or potentially harmful, impacts on the environment, economy and/or human health.

Hub-and-spoke model refers to the concept where an introduced species enters a port with heavy traffic (which acts a hub) and is transported along various routes (spokes) to another port, which become the new hub where the introduced species can radiate along shipping routes and expand its local, regional and global distribution (Carlton, 1996)



Ship Routes from Observed Ship Reporting Positions East Asian Seas



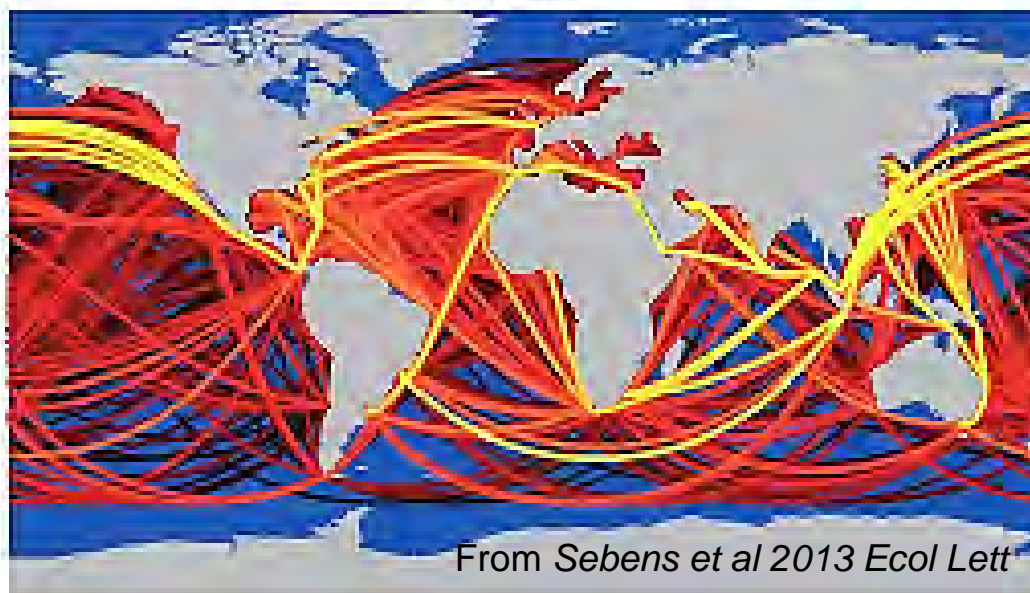
Legend

- Ship Reported Position
- Ports
- Marine Protected Areas



(a)

All ports



From Sebens et al 2013 Ecol Lett

Hitch-hiking across the world's oceans

Types of organisms:

- Planktonic (primarily ballast water)
- Benthic mobile fauna and cryptic species (BW & Fouling)
- Sessile marine organisms (primarily hull fouling; some larval stages via BW)

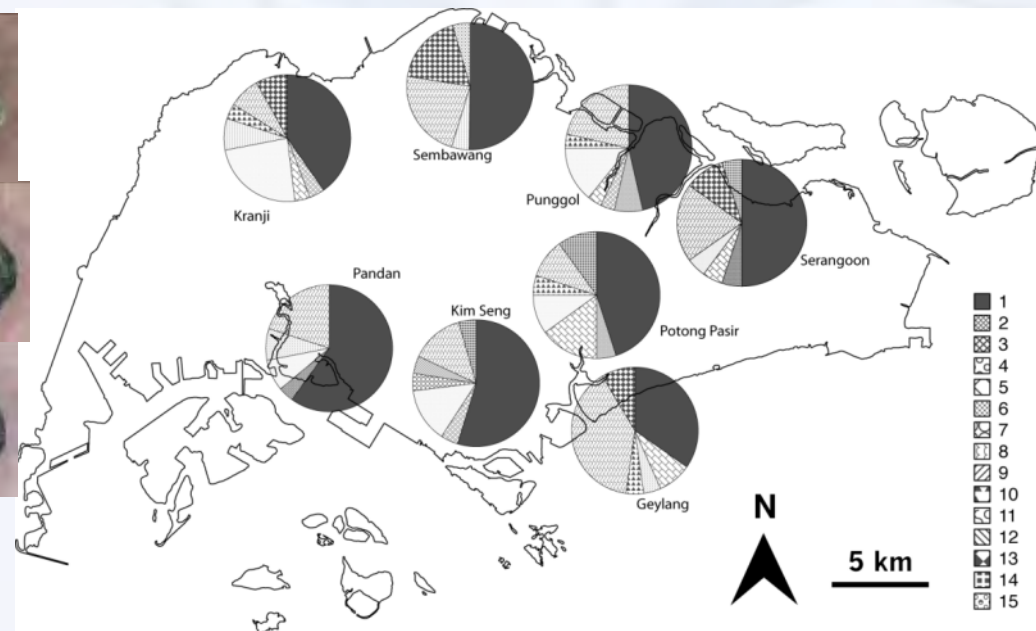
Marine organisms on ships, floating structures occur in ballast water, as hull fouling, crevice fouling, sea chests, etc - in addition to other pests residing in cargo holds etc.

More than 50% of marine pests likely to be have been transported as fouling, mainly through shipping and aquaculture



False Zebra Mussel *Mytilopsis sallei* introduced from the Caribbean

Molecular evidence indicates repeated and sustained invasions



(Tan & Morton, 2006; Wong et al, 2011)

Biofouling Research @ NUS

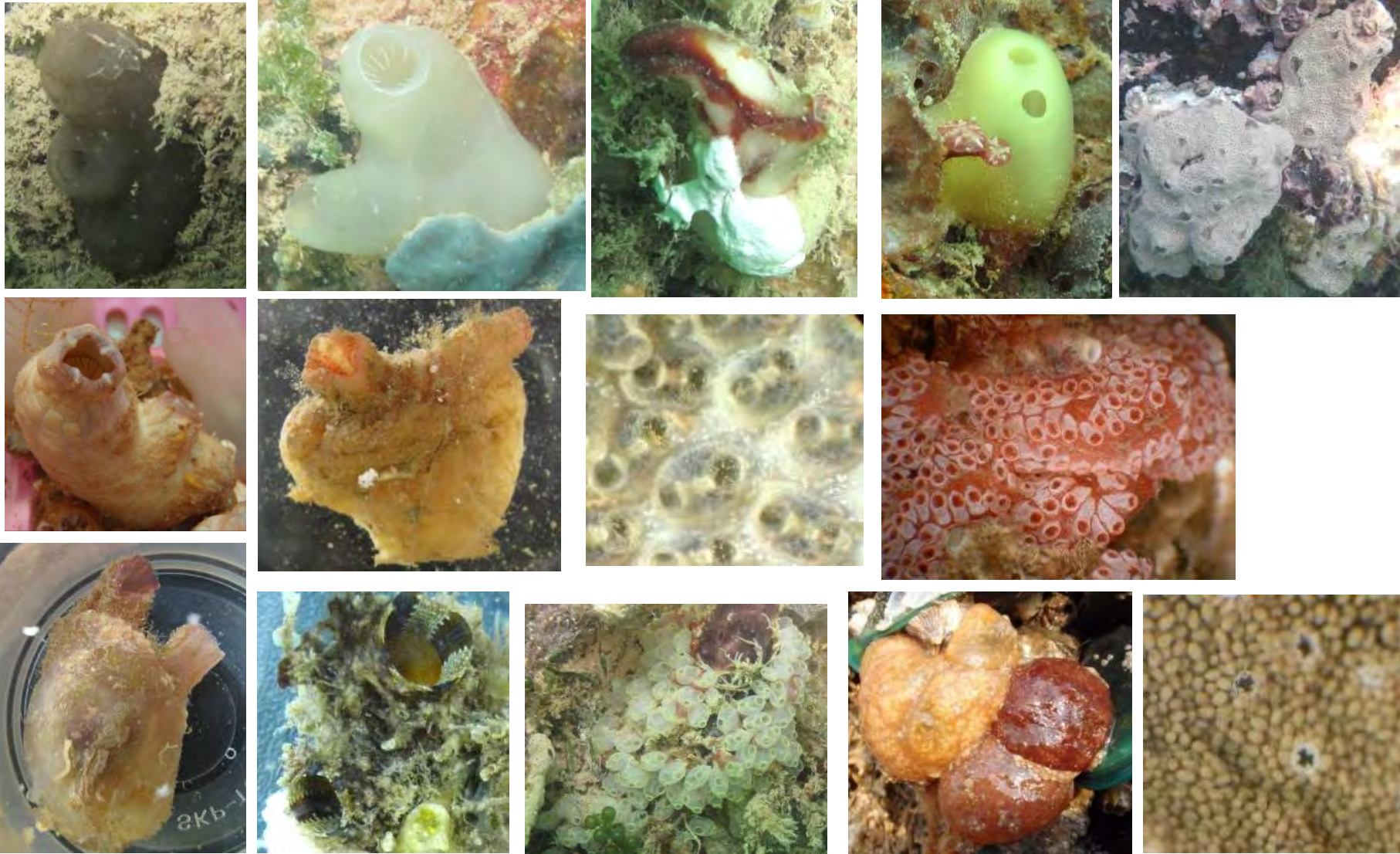
TMSI Port Baseline Studies:

- Biodiversity and Patterns of Fouling in Singapore Port waters (NUS-MPA)
- Marine Anti-Fouling Performance & Biocorrosion in Tropical Southeast Asian Coastal Seas (NUS-ONR-DSTA, 2005-2011)
- Survey of Marine Fouling Organisms in Singapore Waters (NUS-NParks)
- Status of Knowledge of Marine Invasive Species (NUS-NParks)
- Comprehensive Marine Biodiversity Survey (NUS-NParks, On-going)



- Aggressive fouling and corrosion rates result in reduced AF performance cf to other test sites
- Monsoon-driven fouling patterns
- Evidence of frequent introductions but to date, few records of severe invasions.
- Introduced pests mainly occur in urban waterways, man made structures and disturbed habitats

Some common ascidians found on hard structures in Singapore

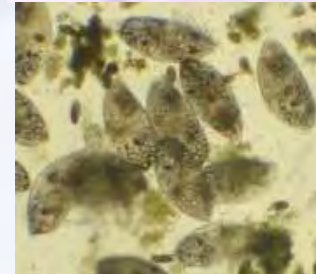


- Lee Serina Siew-Chen, Serena Lay-Ming Teo & Gretchen Lambert (2013). New Records of Solitary Ascidians on Artificial Structures in Singapore Waters. *Marine Biodiversity Records* Vol. 6, e93, 1-18
- Serina S-C Lee, Janlin Y-H Chan, Serena L-M Teo, Gretchen Lambert (submitted). State of knowledge of ascidian diversity in South China Sea. *Raffles Bulletin Zool Special Suppl.*

Antifouling Research @ TMSI

Some Laboratory Antifouling Tests:

- Barnacle assays – toxicity, settlement
- Prevention of slime: microbial assays, *Amphora* attachment assays
- Tubeworm – toxicity, settlement
- Other marine organism larval settlement tests include bryozoan, ascidian and mussels
- Ecotoxicity assays



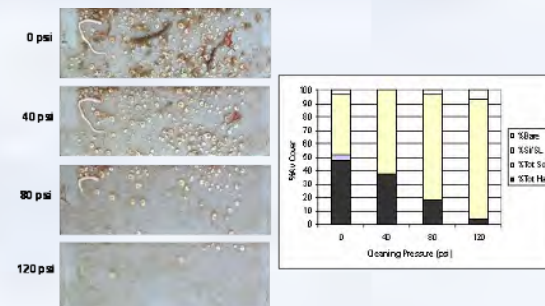
Field Static Immersion Tests:

- Test protocols are modified from ASTM
- Fouling coverage using Photogrid
- Barnacle adhesion test using force gauge measurements
- Water jet test for biofilms
- Tests using small panels (slides) for rapid screening of novel coatings coupled to water jet test for foul release coatings



Dynamic tests for evaluation of antifouling properties in natural seawater (in progress @ TMSI St John's Island):

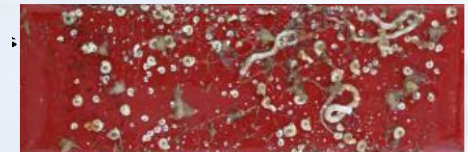
- Flumes to evaluate biofilm development
- Flow channels for study of marine growth in flow



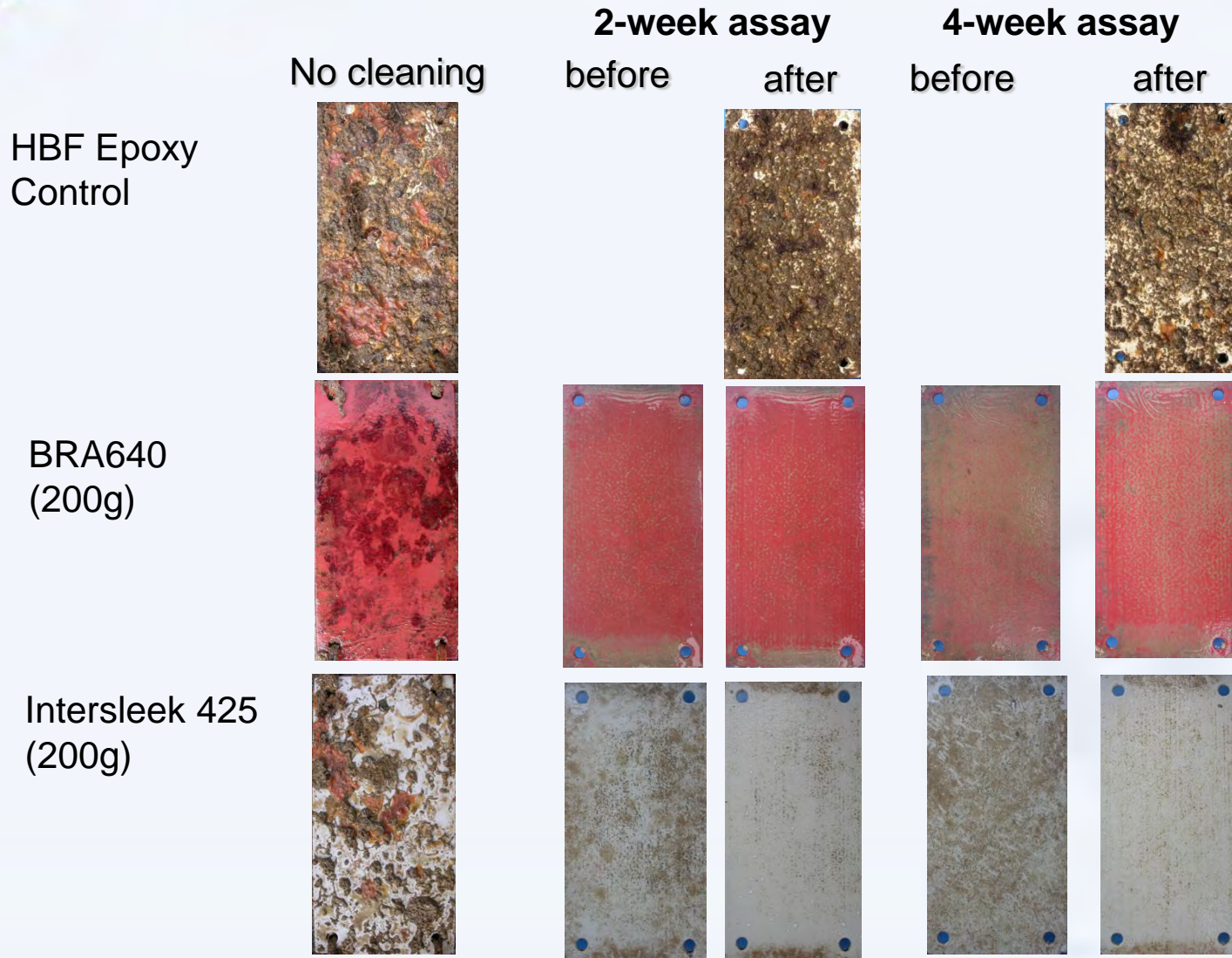
Supporting Project: "ASSESSMENT OF SURFACE ACTIVE ANTIFOULING COATINGS IN BIODIVERSE TROPICAL SEAS" (US Office for Naval Research Global, 2013-ongoing)

Antifouling Technology Development

- New Environmentally Benign Antifouling Agents for Marine Yacht Coatings (NUS-ICES-MPA: Track 1/Chai; SGD Patents 166436, 183158)
- Innovative Marine Antifouling Solutions (A*ICES-IMRE-SIMTECH-NUS, On-going: Track 1/IMAS)
- Molecularly-Engineered Multifunctional 'Green' Surfaces for Combating Biofouling, Corrosion and Biocorrosion in Marine and Submerged Structures (NUS-A*SERC) (Track 1/Kang)
- Effect of Singapore marine atmosphere and bio-film formation by seawater on corrosion of metal and alloys (A*SIMTECH-FCI-NUS)
- Inhibition of barnacle settlement using low frequency and intensity ultrasound (S Guo, HP Lee & Khoo BC, Dept Mech Engrg, NUS)



Cleaning Experiment 26 April 2007
After 9 months static immersion –SINGAPORE



Diver dies after getting sucked in by ship's propeller at Marina South Pier - Posted on 06 June 2014



<http://singaporeseen.stomp.com.sg/singaporeseen/this-urban-jungle/diver-dies-after-horrific-accident-at-marina-south-pier>



