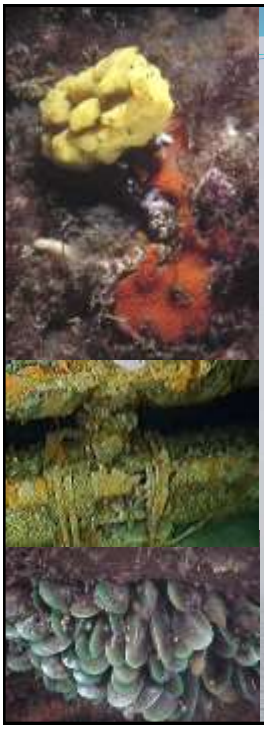


Battling Biofouling in the Offshore Industry: its characteristics, consequences and control

John A. Lewis
ES Link Services Pty Ltd

MI@NUS Sustainable Management of Marine Fouling Workshop
Singapore, 17 June 2014

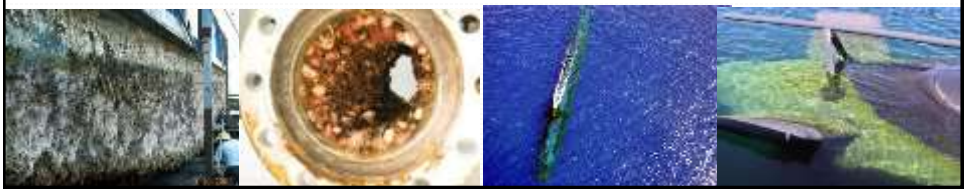
Marine Biofouling

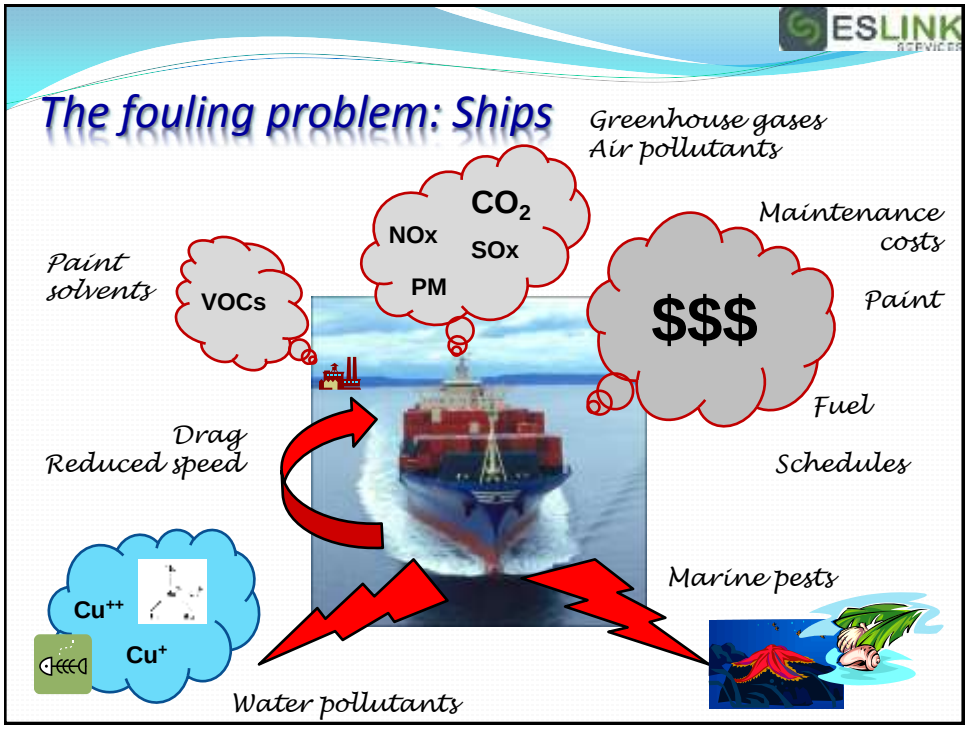
"a process of adsorption, colonisation, and development of living and non-living material on an immersed substratum"

Marine Biofouling

Global Biofouling

Source: Chogoku




ESLINK
The fouling problem: Ships
Greenhouse gases
Air pollutants
CO2
NOx
SOx
PM
Maintenance costs
Paint solvents
VOCs
$$$
Paint
Fuel
Drag
Reduced speed
Schedules
Cu++
Cu+
Marine pests
Water pollutants


ESLINK
GHG Emissions & Fuel Efficiency
BANI BHUM
BANGKOK
30/10/2012
6

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Air emissions

The latest information has international shipping contributing approximately 2.7% of global carbon emissions. Even considering the effects of the global financial crisis, predicted growth in global trade and likely future emissions reduction from land based industries, means that in real terms and in terms of percentage, the industry's contribution is likely to significantly increase.

MEPC measures address GHG emissions

IMO's Marine Environment Protection Committee (MEPC) has agreed to disseminate a package of interim and voluntary technical and operational measures to reduce greenhouse gas (GHG) emissions from ships, as well as a work plan for further consideration of market-based instruments to provide GHG-reduction incentives for the shipping industry

Energy efficiency regulations enter into force

New regulations aimed at improving the energy efficiency of international shipping entered into force on 1 January 2013 ... performance-based mechanism that leaves the choice of technologies to use in a specific ship design to the industry. As ... for the control of emissions of nitrogen oxides (NO_x), sulphur oxides (SO_x) and particulate matter under regulations ...

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Lloyd's Register
LIFE MATTERS

Ship Energy Efficiency Management Plan (SEEMP)

SEEMP template for owners and operators

3.	Measures for hull and propeller optimisation	Implementation actions	Monitoring and recording actions
3.1	Hull resistance optimisation	a. Hull condition is assessed on a quarterly basis during port stays where this is practical through in-water inspection. Responsible Person(s): Head Office Company procedures: [insert #]	a. Keep records of in-water inspections and identify areas for underwater cleaning. Responsible Person(s): Head Office
		b. In water hull cleaning is performed on a 1-year basis, in port stays where this is practical, in areas identified during inspections. Responsible Person(s): Head Office Company procedures: [insert #]	

8

Invasive Marine Species

9

Invasive marine species





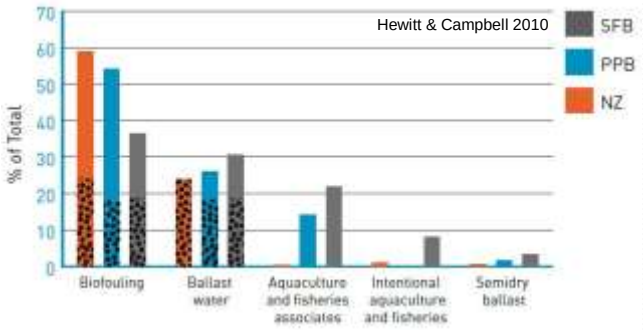


THE AGE SATURDAY 9 OCTOBER 1999

Sea creatures invade bay

Up to 400 exotic marine species may have been introduced into Port Phillip Bay

Shipping vectors



NZ Survey:

~70% of 500 commercial vessels had macrofouling
187 species identified; 128 non-indigenous, 10 cryptogenic
94 NIS not recorded from NZ
Non-NZ NIS on 30% of vessels

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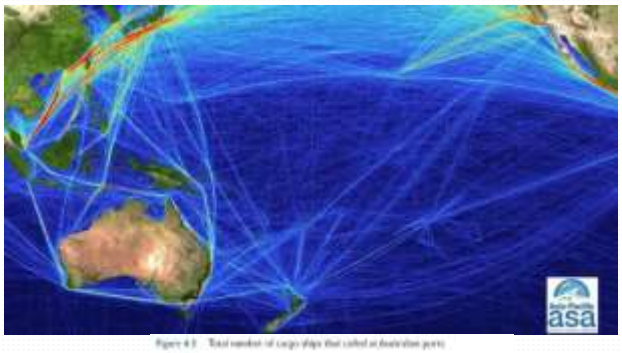
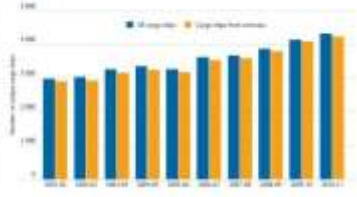
The Challenge





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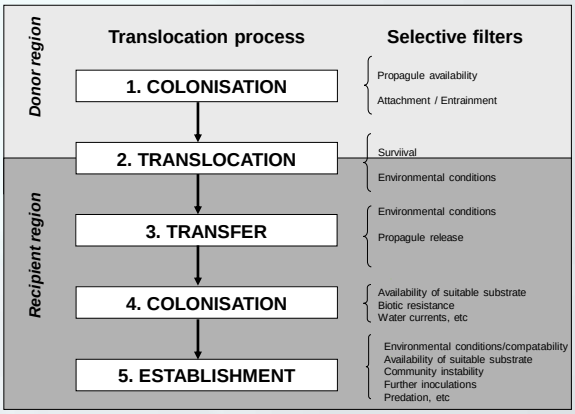
Translocation Process



Prevention is Better than Cure

…and less costly

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The fouling problems: offshore

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Buoyancy

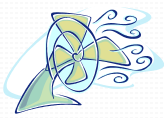
Structural drag

Fuel Schedules

Seawater intake / pipeline blockage

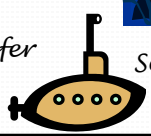
Marine pests

Corrosion



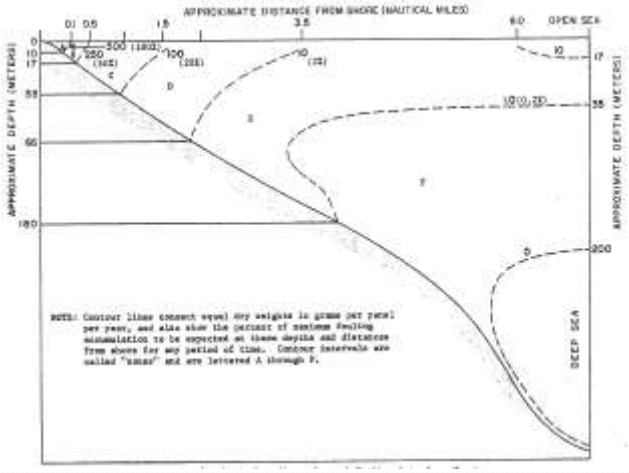
Undersea instruments

Heat transfer



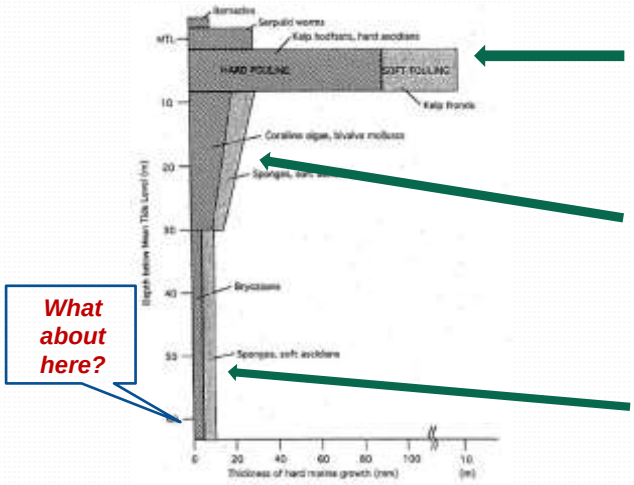
Sensor/Optical Windows

The Offshore Fouling Environment



DePalma 1972: *"Fearless Fouling Forecasting"*

Platform Fouling Growth Profile



What about here?

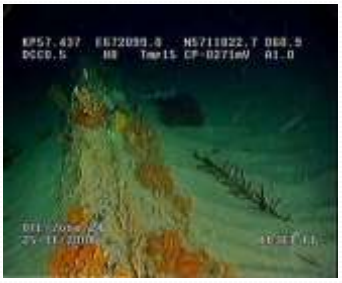
Currie & Jenkins 1994

Deep water communities - Bass Strait

20 m

57 m

60 m



90 m

Invasive Marine Species

Ocean Patriot

Biofouling management

Antifouling coatings
- Biocidal (Toxic)
- Foul release

Cleaning
- Careening
- Slipping/dry-docking
- In-water

Isolation
- Dry-berthing

Historically, biofouling management is a response to economic & operational impact:
- Cost/benefit basis: docking intervals, fit for purpose (not necessarily best for purpose)
- Focus: (tolerable) hull fouling

Antifouling paint development

		Effective life
• Pre-18th C	Beaching, careening, pitch & tar	
• 1758	Copper sheathing	
• 1860s	Copper "paints"	
• 1950s	Copper, mercury, arsenic paints Soluble matrix, Contact leaching	18 – 24 mth
• 1960s	Organotin biocides	
• 1970s	Self-polishing copolymer paints	
• 1990-2000s	TBT banned	36 – 60 mth*
• 1990s	Foul release coatings	
• 21st C	Copper SPCs, safer co-biocides	

* Except for aluminium hulls

*Copper has been a mainstay of antifouling for 250 years

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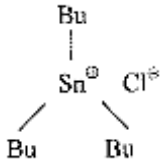
Antifouling biocides

Copper leaching threat to Milford Sound marine life

Home > News > Regions
Fri, 25 Jan 2013
The Regions: Southland




Paint and Coatings Industry News

CA Antifouling Bill Nears Finish Line

Tuesday, September 24, 2013

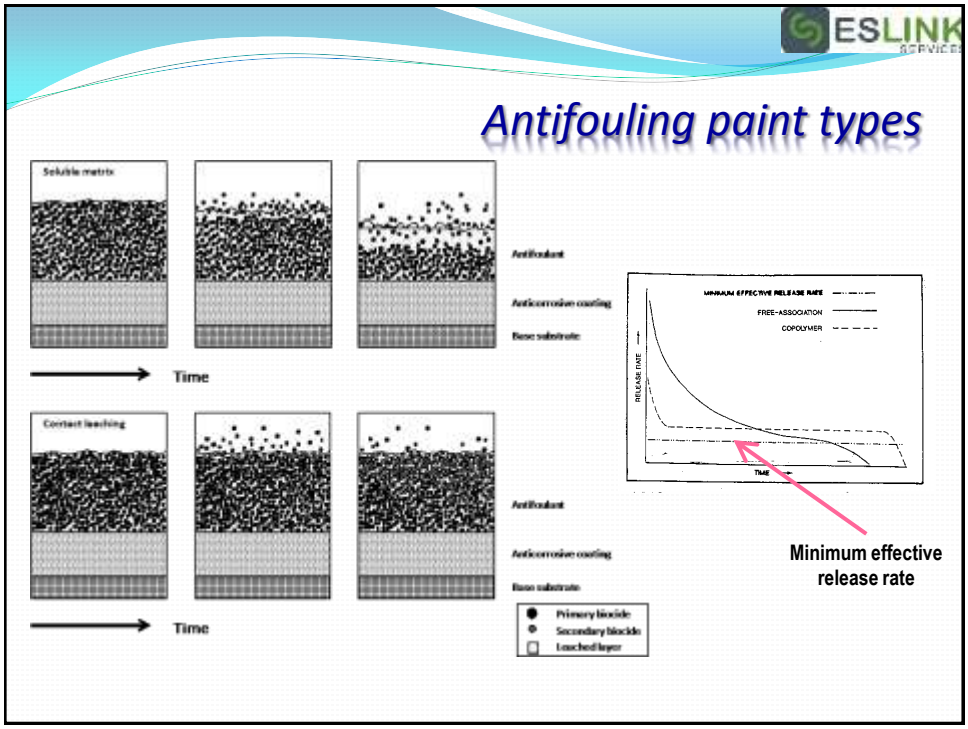
More items for Coating Materials

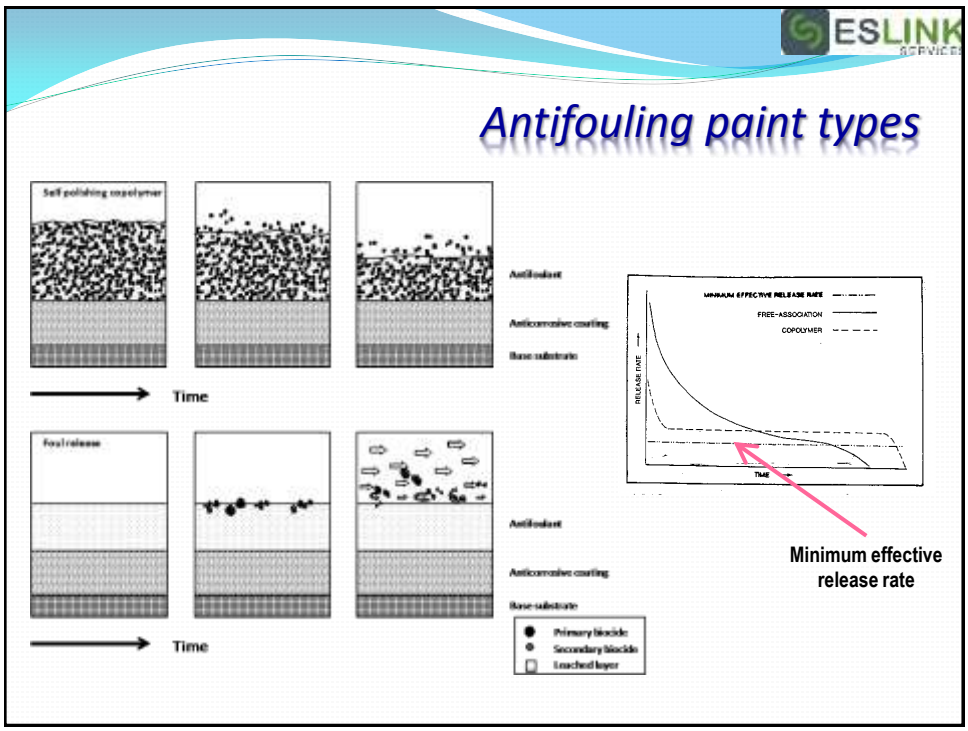
Antifouling biocides need to be:

Toxic,	yet non-toxic
Stable ,	yet unstable
Broad spectrum,	yet not too broad
Leachable,	but not too fast,
	nor too slow

Co-biocides:

Diuron, Irgarol, DCOI, ZPT, CPT, Dichlofluanid, Tralopyril


ESLINK
Antifouling paint types
Soluble matrix
Antifoulant
Anticorrosive coating
Base substrate
Time
Contact leaching
Antifoulant
Anticorrosive coating
Base substrate
Time
Primary biocide
Secondary biocide
Leached layer
MINIMUM EFFECTIVE RELEASE RATE
FREE-ASSOCIATION
COPOLYMER
RELEASE RATE
TIME
Minimum effective release rate


ESLINK
Antifouling paint types
Self polishing copolymer
Antifoulant
Anticorrosive coating
Base substrate
Time
Final release
Antifoulant
Anticorrosive coating
Base substrate
Time
Primary biocide
Secondary biocide
Leached layer
MINIMUM EFFECTIVE RELEASE RATE
FREE-ASSOCIATION
COPOLYMER
RELEASE RATE
TIME
Minimum effective release rate

Non-toxic, foul[ing] release coatings

- Also known as minimally adhesive coatings
- Surface character prevents adhesion or minimizes adhesion strength of fouling organisms
- Based on silicone or fluorinated polymers
- Only suitable for continuously active, higher speed (> 15 knot) vessels
- Prone to abrasion damage, problematic to clean in-water

What is an effective antifouling?

Biocidal:
- Continuous copper release rate from stationary hull:
  - ≥ 10 µg Cu/cm^2/day
- Short half life co-biocide (algaecide/slimicide)

Non-biocidal:
- Self-cleans @ ≥ 15 knots on high activity vessels

*Hull niches cannot always be effectively antifouled

Niche fouling

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Natural Antifouling ??

- Minimal adhesiveness
- Microtopography
- Mucous secretion
- Sloughing
- Hydrophobic or hydrophilic?
- Filtration
- Chemical deterrence
- Toxic metabolites

Natural product antifoulants:

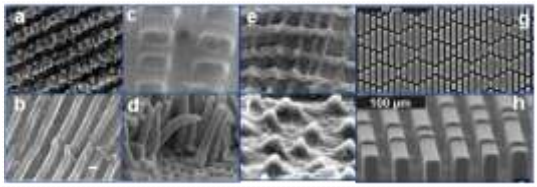
- classed as biocides
- registration cost Ɛ 7-9 million
- registration process ~10 yrs

Novel methods for biofouling control

Natural products from mussel shells: Potential for novel antifouling coatings

Nano-scale superhydrophobic coatings

Extreme water repellency copied from nature – For rapid drain down



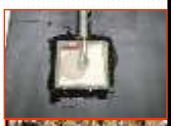
Biomimetic surfaces

a-f - Surface microtopgraphies on marine molluscs; source: Scardino, 2006.
g, h - Bioinspired shark skin topography; source: Schumacher et al. 2007.

Air bubble curtains to protect vessels in dock

Bubble zone control

Fouling control using vibration effects – PZT embedded panels deter barnacle cyprids at specific frequencies



Antifouling Options – Paint type

Paint Type	Effective life (months)
Copper-based conventional	12 – 24
Copper-based erodible	36
Copper-based SPC	60
Biocide-free fouling release	> 60 but….
Novel technologies “natural products”, fibre coatings etc.	unproven

$

*except for aluminium

How do we manage biofouling? In-water cleaning

33

In-water cleaning of ships' hulls

Australia & New Zealand Environment Consultative Council (ANZECC Code, 1997):

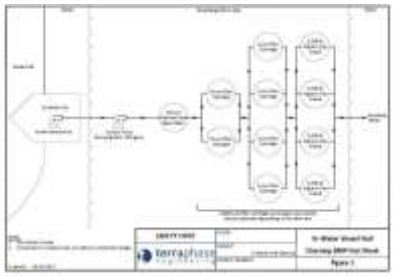
No part of a vessel's hull treated with antifoulant is to be cleaned in Australian waters……

"On 26 June 2013, the Standing Council on Primary Industries endorsed the "Anti-fouling and in-water cleaning guidelines":

Controlled in-water cleaning:

To clean or not to clean?

"*When do the environmental costs of releasing non-indigenous species and chemical contaminants during in-water cleaning outweigh the risks of no action?*"



Fisheries Occasional Publication No. 114, 2013

Report 1

In-water hull cleaning and filtration system: In-water cleaning trials

26-28 November 2012

Government of Western Australia
Department of Fisheries

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How do we manage biofouling?
Marine Growth Prevention Systems

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Marine Growth Prevention Systems..

- Direct chemical dosing
  - Sodium hypochlorite
  - "Antifoulant" solution
- Electrochemical dosing
  - Copper (+aluminium) anodes
  - Hypochlorite generation
- Other
  - Ultrasound

Questions:

Do they work?
Should they work?
How should they be worked?
How do they compare?

How do we manage biofouling?
Rules & Regulationx

38

Regulations & requirements

IMO

- Biofouling Management Guidelines (2011)

Western Australia

- Ministerial conditions on project s (Current)

California

- Biofouling management regulations (2015)

New Zealand

- Craft Risk Management Standard (2018)

Australia

- Sectoral guidelines
- Quarantine Act [“Quarantinable pests” / Species of concern] (??)
- Marine Growth Risk Assessment

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What is antifouling & biofouling management best practice?

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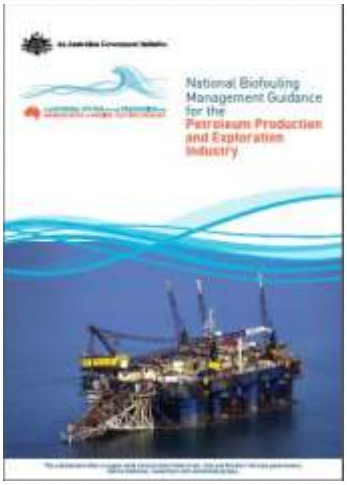
Vessel Biofouling Management



www.marinepests.gov.au

IMO biofouling management guidelines

Objective: "a clean ship" = slime layer only [?]

How are risks best reduced?

Proactive antifouling prevention:

- External- Effective antifouling coatings
- Internal- Marine Growth Prevention Systems / antifouling material (e.g. CuNi)
- Prescribed dry-docking intervals

Additional hull husbandry

- Controlled in-water cleaning
- Internal- Chemical (acid, disinfectant), physico-chemical (temperature, salinity, deoxygenation)

Good biofouling management is not a single strategy, but a combination of strategies

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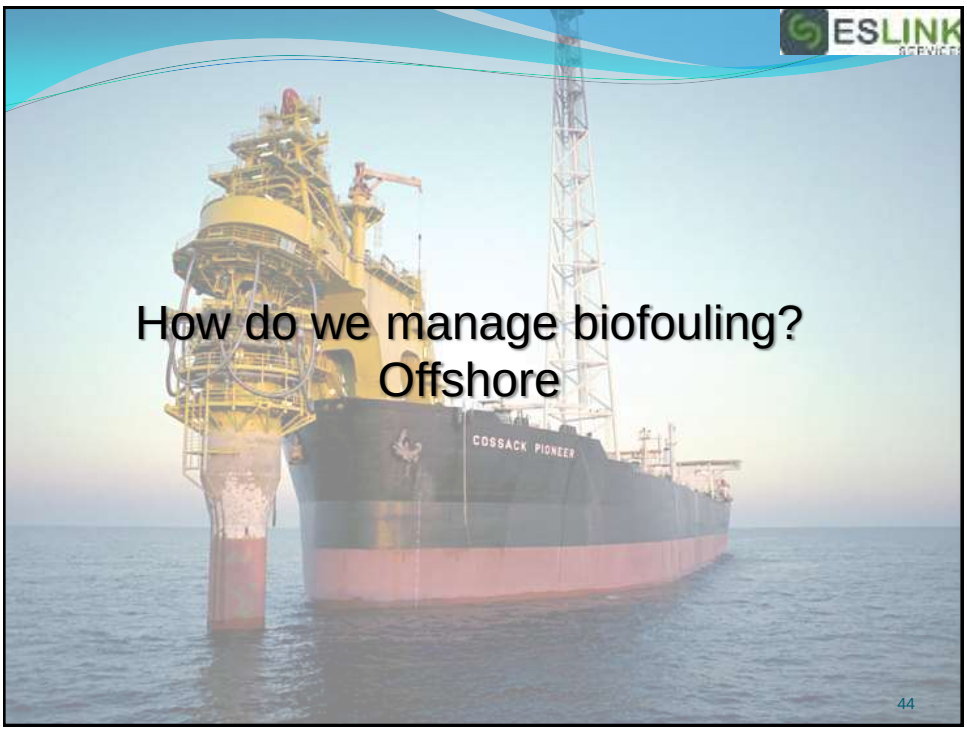
How do we manage biofouling? Offshore



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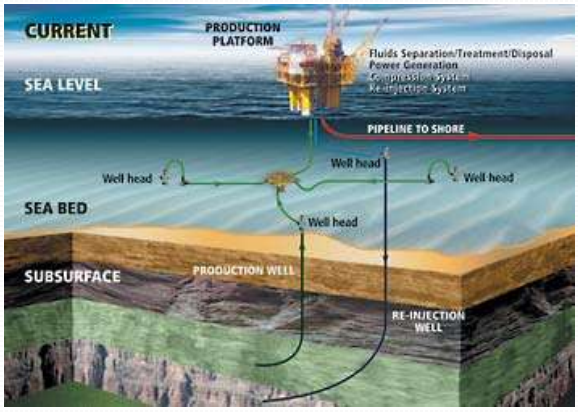
Subsea coolers



Offshore Gas Fields

- Well heads remote from production platforms
- Gas flow recovered @ ~80ºC ; corrosive within standard pipelines
- Coolers on well heads to reduce temperature
- Heat exchange through cooler walls critical
- ~ 100 m depth
- Projected cooler life- 25 years

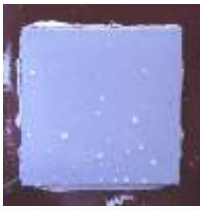
To coat, or not to coat…

Why coat?
- Corrosion protection
- Biofouling reduces heat transfer/cooler efficiency

But…
- Thick coatings also reduce heat transfer/cooler efficiency
- Heat will kill/prevent biofouling?

However…
- No heat during wet storage /down time
- Growth on “cool” end

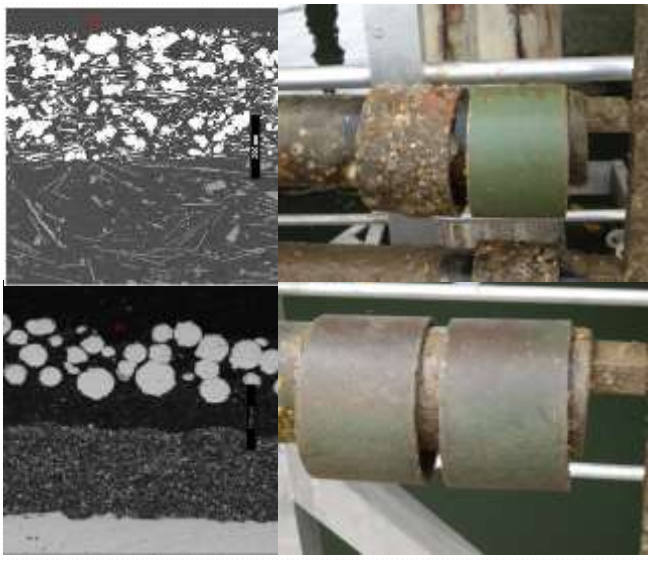
Coating Options



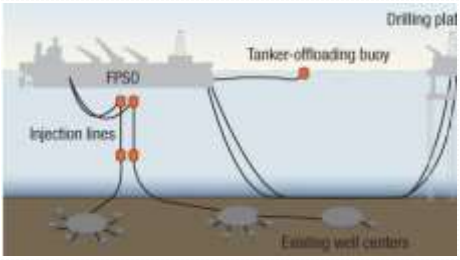
Paint Type	Effective Life (months)	Cost	Suitability
Soluble matrix/ablative	24-36	$	✘
Contact leaching	24	$	✘
CDP	36	$$	✘
SPC	60	$$$	✘
Metallic copper epoxy	120+*	$$$$	?
Foul release	60 +	$$$$$	✘
Mechanically resistant	3**	$$	✘

* scattered biofouling may occur
** coatings are durable and long life is achieved through regular cleaning

Metallic Copper / Epoxy Coatings



The Burden of Biofouling




MARINE FOULING AND ITS PREVENTION

Specific density

- Conventional wisdom:
  - Soft fouling 1.0
  - Hard fouling 1.4
- Calcite = 2.7
- Measured:
  - Soft fouling 1.06
  - Hard fouling 1.74

Needs, wants, uncertainties

Coatings:
- Better, safer, cheaper
- Niche areas
- Structures

Maintenance practices:
- Hull/structure husbandry

Engineering design:
- Prevention (not accommodation)

Offshore:
- Growth rates & characteristics

In-water cleaning:
- Waste capture
- Efficiency
- Safety

Regulations:
- Certainty, uniformity
- Uptake