Understanding the Antifouling Coating Options Available to Ship Owners

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Agenda

- Background
  - Why do we need antifoulings?
  - Measuring the effectiveness of coatings
  - Fouling organisms and controlling factors
  - Antifouling technology options

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Why do we need antifoulings?

"Minimise fuel costs"
"Maximum speed"
"Less engine wear"

"Maximum cargo days"
"Lower stack emissions"
"Minimum M&R costs"

"High speed"
"Readiness for war"
"Noise minimisation"

"Getting there on time"
"Minimise fuel costs"
"Safe for the environment"

Why do we need antifoulings?

NEEDS	=	NEED TO AVOID
Meet schedules Minimise bunker costs Minimise SOx & NOx Minimise repair cost (engines) Vessel appearance		Drag

Maximum operating Efficiency

Minimum fuel consumption

Why do we need Antifoulings?

- The control of surface roughness and of fouling is essential to keep hulls as smooth as possible, and thus minimise drag
- Our primary aim is to provide “smooth hulls”
- Prevent the translocation of invasive species

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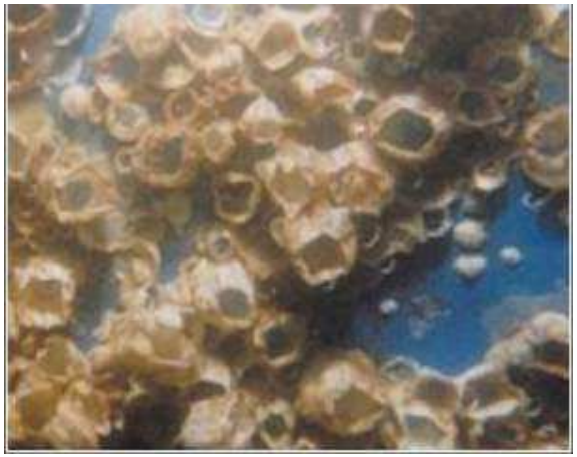
What is Fouling?

- Fouling is the settlement of aquatic organisms onto an immersed substrate



Barnacles

Hydroids

Tube Worms

- Antifouling technology aims to protect the immersed substrate from fouling: i.e. deter fouling settlement, maintain a foul-free ‘clean’ surface

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The Fouling Problem

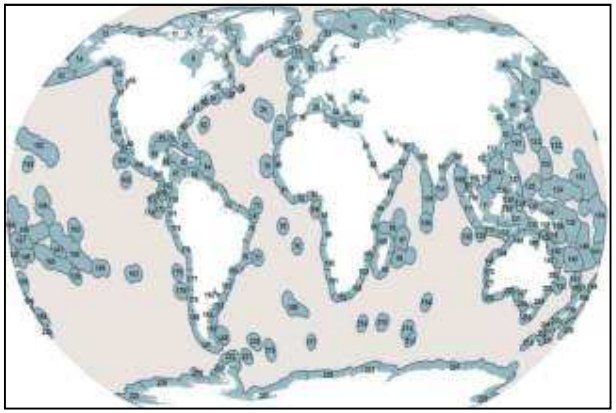
- Fouling Organism
  - Slime
  - Weed
    - Red
    - Brown
    - Green
  - Animal
    - Soft-bodied
      - Hydroids
      - Sponges
    - Hard Bodied
      - Barnacles
      - Tube worms
      - Mussels

Weed

Hydroids

Barnacles

The Fouling Problem – Factors Affecting Fouling



- Temperature
- Speed/Motion
- Light & Nutrients
- Other Factors: Water salinity and pollution

- Generally speaking: greatest risk of fouling is with low activity trading extensively in tropical or sub tropical coastal environments:
- Faster deep-sea vessels at highest risk of fouling when in port (often tropical/sub tropical) for loading/unloading

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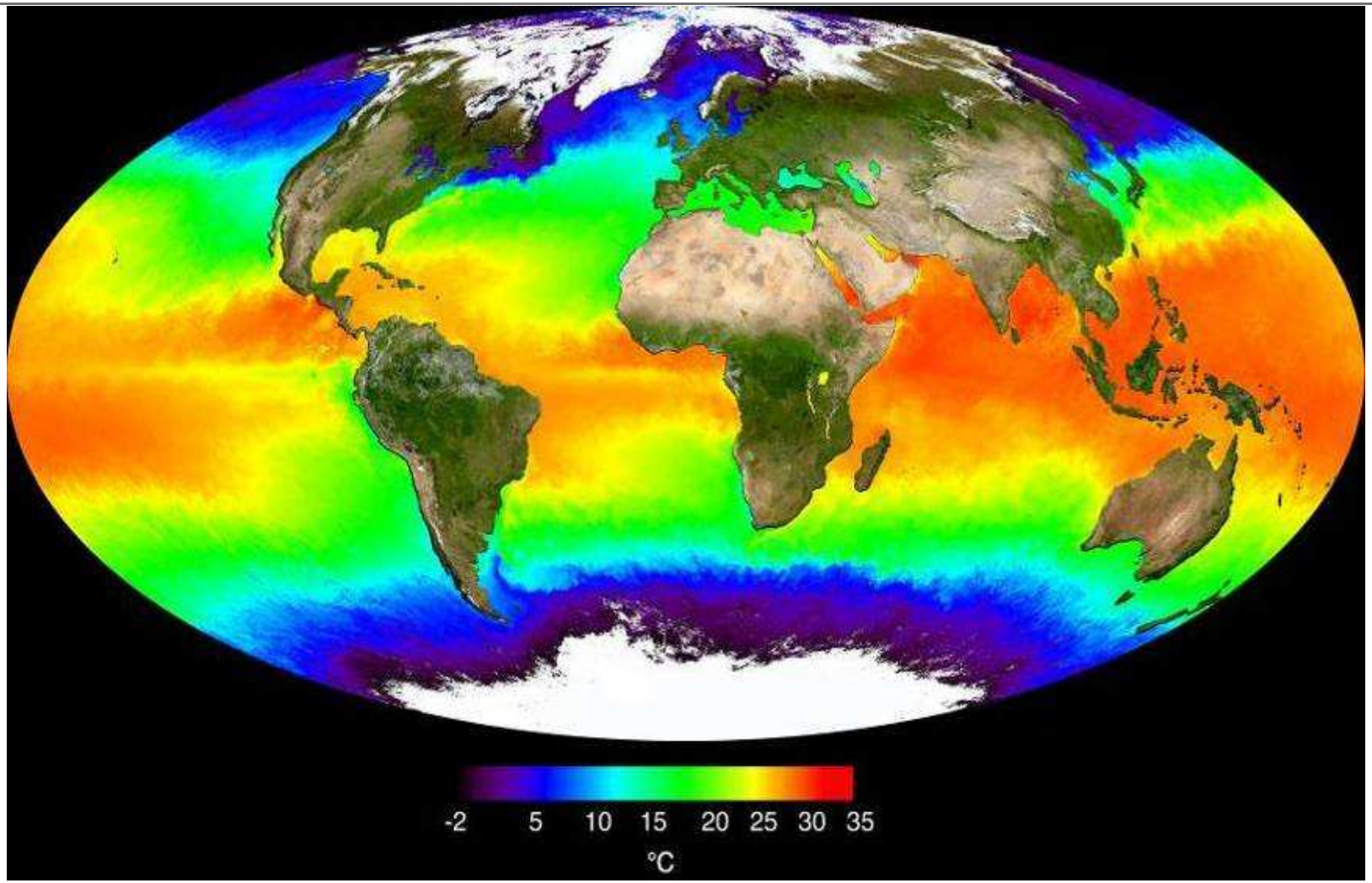
Fouling



Why Use Antifouling Coatings?

Fouling increases the hydrodynamic drag of a vessel therefore more energy is required to drive through water

Economics

CO_2 Penalty

- USN field studies: fuel consumption increases by ~40% due to severe fouling
- 250,000 dwt super tanker: Annual fuel bill ~ $1.8 million. If totally fouled, fuel bill will increase by $720,000
- Consider entire world fleet ~90,000 vessels

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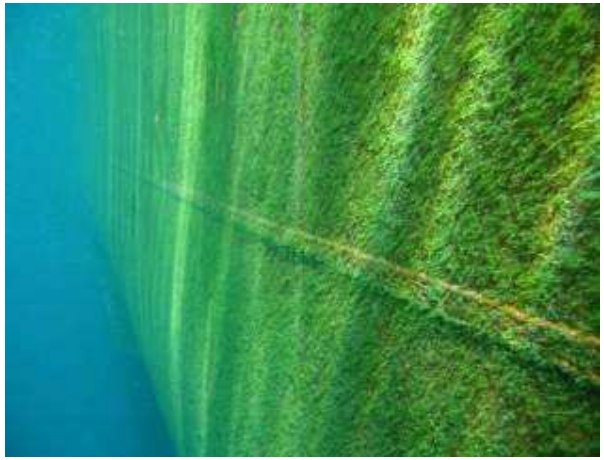
The Effects of Fouling

Slime ~ 8% drag increase



Weed ~ 10% drag increase

Hard ~ 40% drag increase

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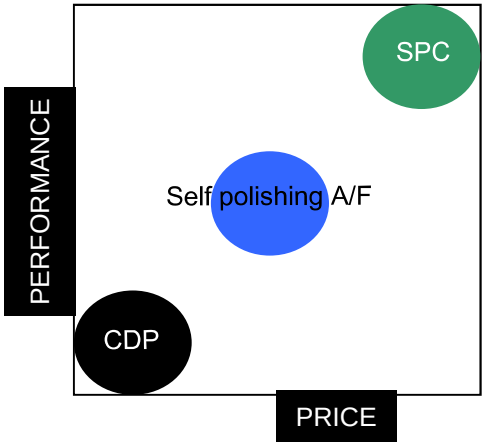
What drives the AF market?

- **Drivers**
  - Main driver for antifoulings is legislation
    - Biocide registration
    - Solvent emissions
    - Substance registration
- **Other drivers**
  - Product Stewardship
  - Raw material costs
  - Petroleum derivatives costs

Antifouling Technology

- There are three main biocidal antifouling technologies currently available:
  - **Self-polishing copolymer (SPC)**
  - **Self polishing antifouling**
  - **Controlled depletion polymer (CDP)**



  - These technologies have :
    - Differing effects on roughness
    - Differing abilities to resist fouling

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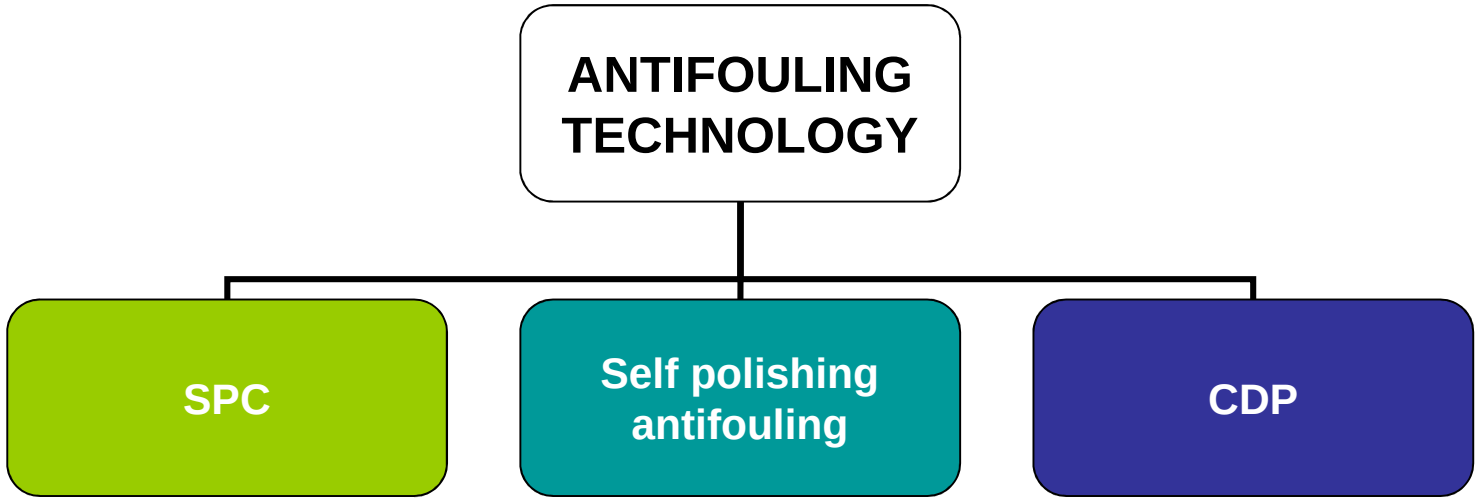
Antifouling Technology

- There are three main soluble acid binder options to enable biocide release in sea water:



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Antifouling Technology

- When using biocides to control fouling there are two key issues:
- Biocides – types, quantities
- Release mechanism – binder technology

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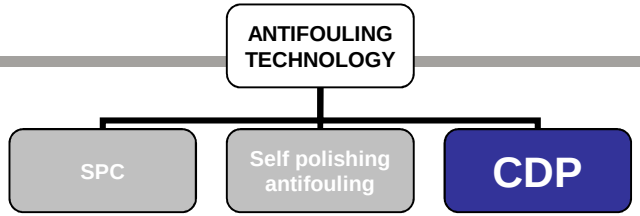
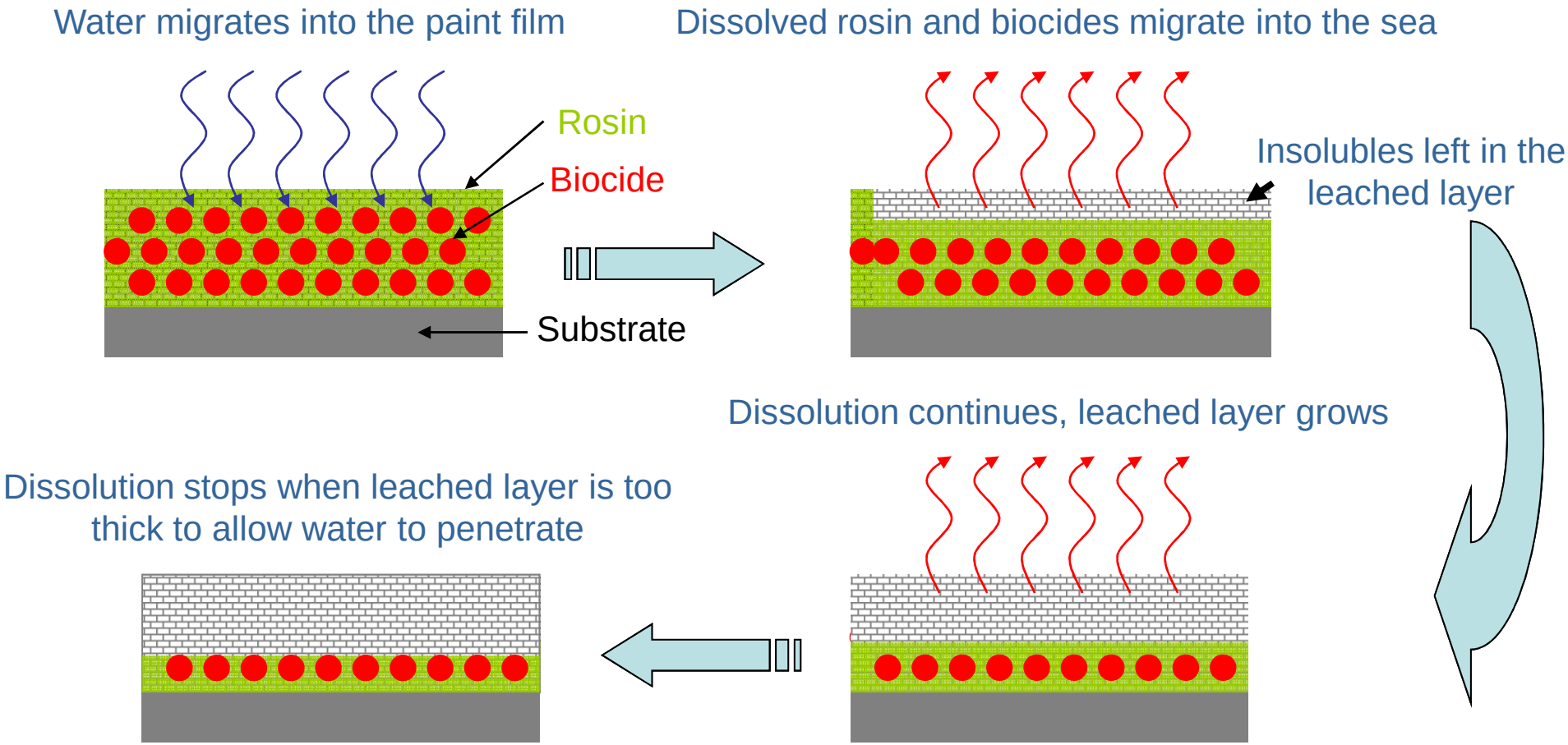
Antifouling Technology

- **For biocides to be effective, they have to be released into the sea from the antifouling.**

- **Sea water is alkaline (pH ~ 8) and biocidal antifoulings work by having an acidic binder component that can dissolve in sea water, thus releasing biocides.**





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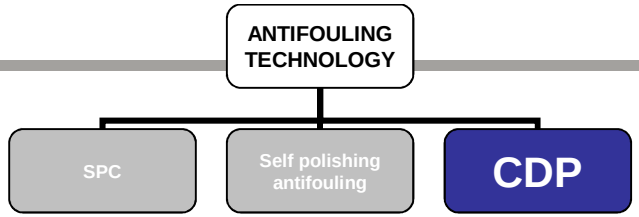

- There is a slow dissolution of the paint film in sea water, similar to the way a bar of soap disintegrates when left in water
- This dissolution gradually slows down over time, due to the formation of insoluble materials at the surface
- The maximum effective life is typically 36 months on the underwater sides, but it can be up to 60 months on the flat bottom of the ship
- Leached layers can become thick, increasing roughness, and care is needed to remove as much as possible before overcoating at M&R drydocking

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- Rosin has some disadvantages:
  - it is a brittle material, and can cause cracking and detachment
  - it reacts with oxygen and has to be immersed relatively quickly
  - It does not prevent water going into the antifouling paint film

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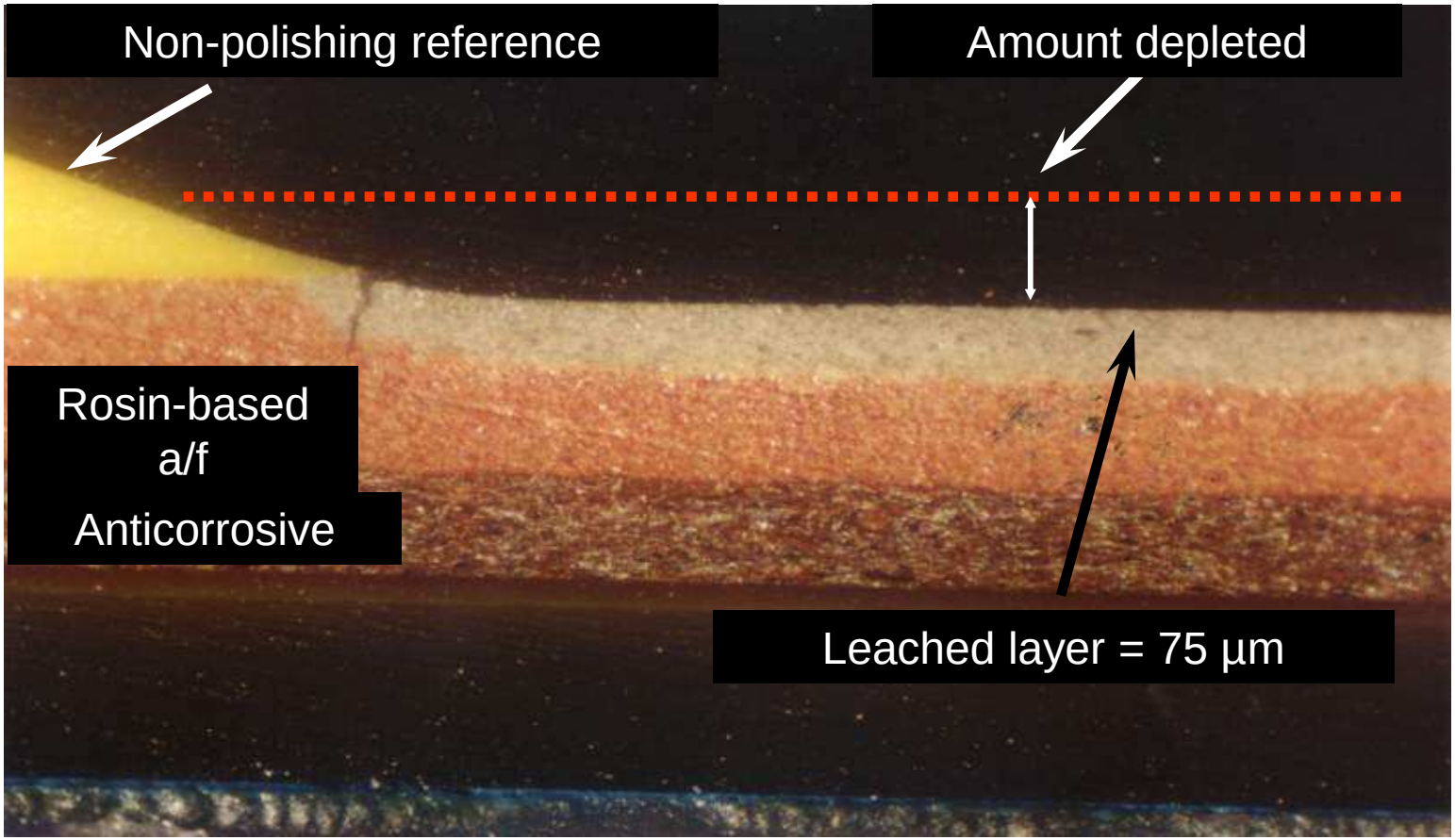

Typical CDP cross-section

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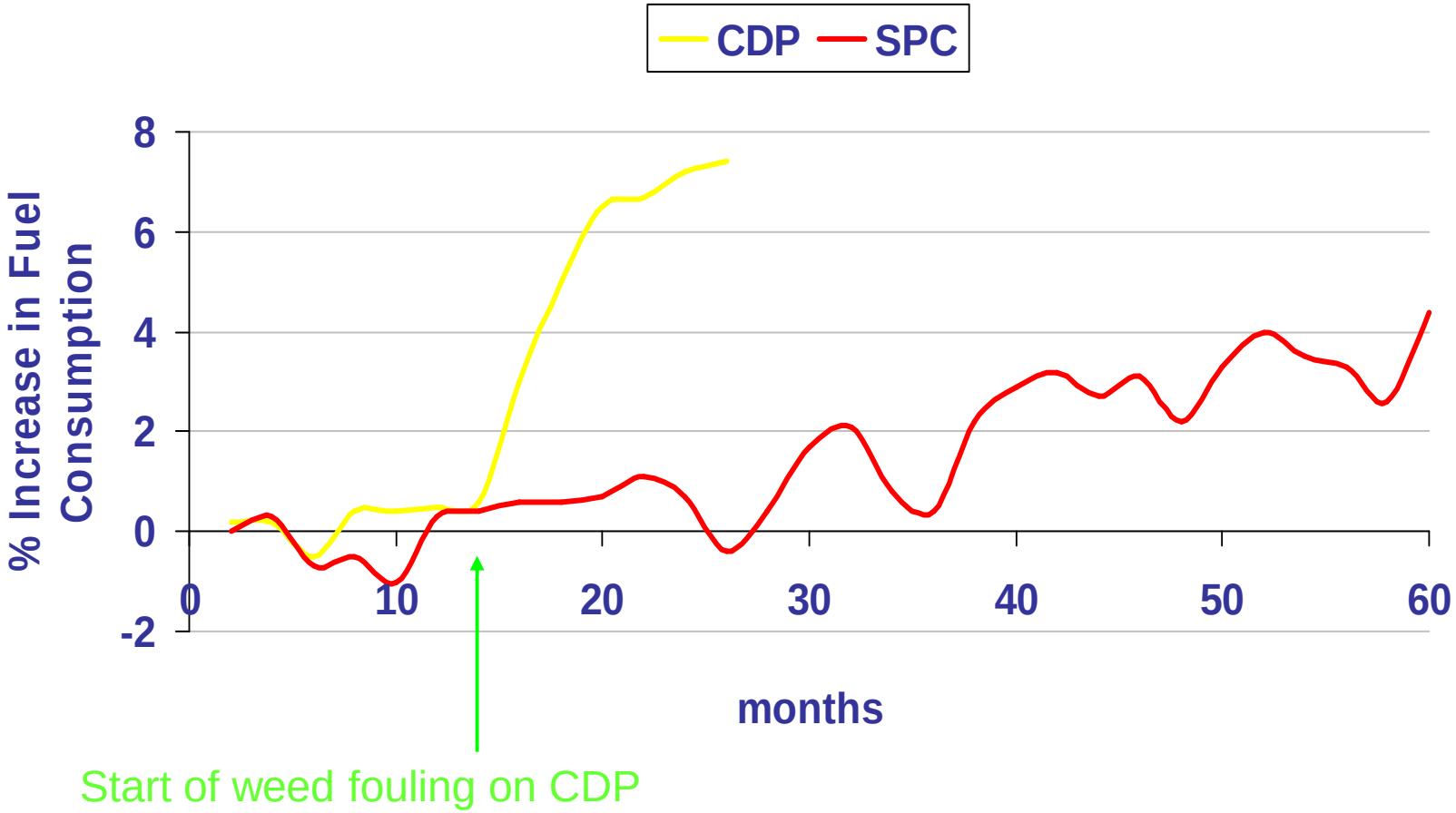
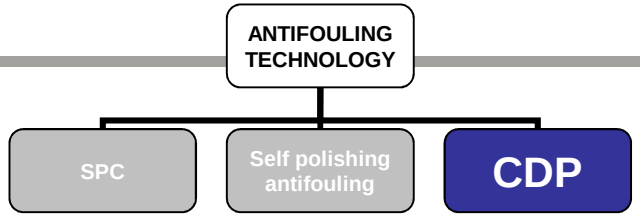
Rough CDP surface after washing



The effect of fouling on a CDP ship



- The words used to describe CDPs can be very confusing:

  "Hydration", "Ablative", "Eroding", "Polishing", "Self-polishing", "Ion Exchange"

- Key tests for CDP a/f paints are:
  - Use of rosin, or rosin derivatives (ASTM D-1542)
  - Higher solids (55~60% vol. solids)
  - Thick leached layers
  - Film integrity is generally poor, and re-blasting is needed after 10 years

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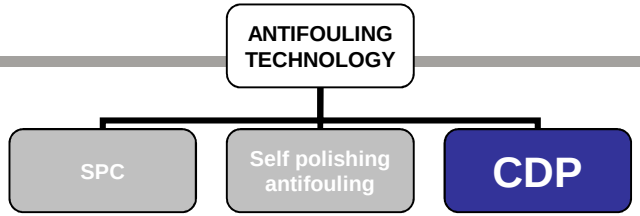

Summary:

- CDP (rosin-based) antifoulings are not as effective as Self Polishing Copolymer (SPC) systems
- CDP products generally have thick leached layers, which limit performance and negatively affect re-coatability
- However, CDP products have a place as the lowest cost per m^2, "value for money" antifoulings, and are suitable for use in low fouling areas or for vessels with short drydock intervals

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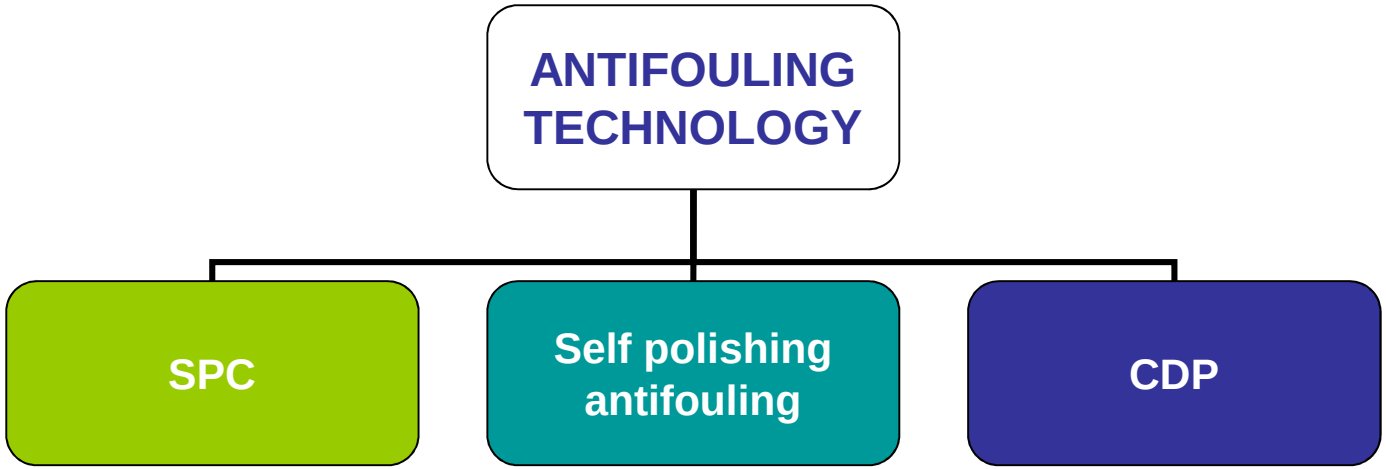
Antifouling Technology



*Interspeed 340**

*Interspeed 640 (US)

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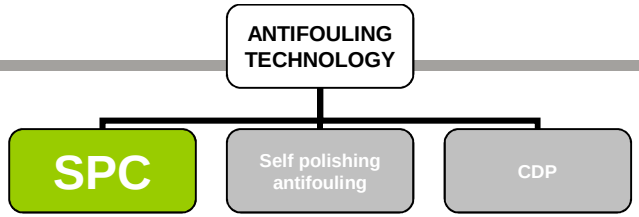
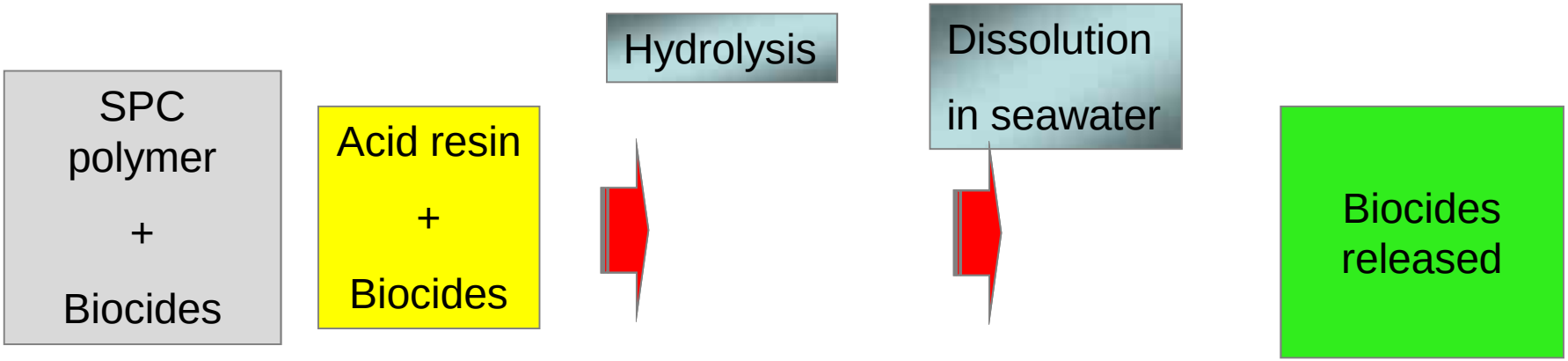


- Self-polishing copolymers (SPC) undergo a reaction ("hydrolysis") with sea water, to form an acid polymer which is then soluble in sea water
- This results in thinner leached layers and thus much better control of biocide release
- Reconsider the simple mechanism as before:
- Add in the SPC step:



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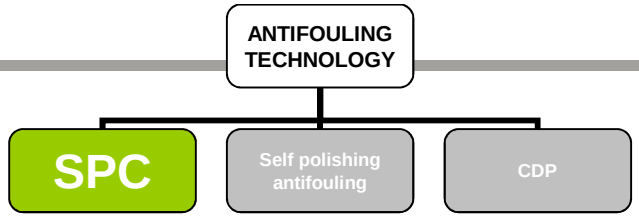

- To date, only three SPC technologies have been commercialised:
  - Copper acrylate (Polymer --- COO --- Cu --- R)
  - Zinc acrylate (Polymer --- COO --- Zn --- R)
  - Silyl acrylate (Polymer --- COO --- Si --- R_3)

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SPC features

- Controlled, chemical dissolution of the paint film, capable of giving long drydock intervals (up to 60 months) and smoothing
- Predictable polishing, enabling "tailor-made" specifications by vessel type/operation
- Thin leached layers, so simple cleaning and re-coating at M&R
- Ideal for newbuildings:
  - Excellent weatherability
  - Fouling control during fitting out
  - Good mechanical properties (eg resistance to block squeeze etc)

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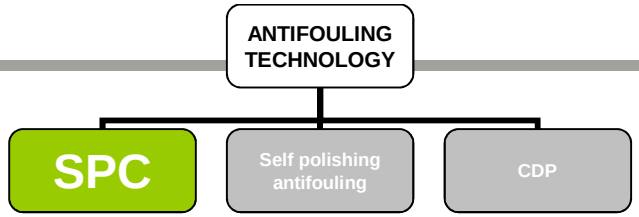

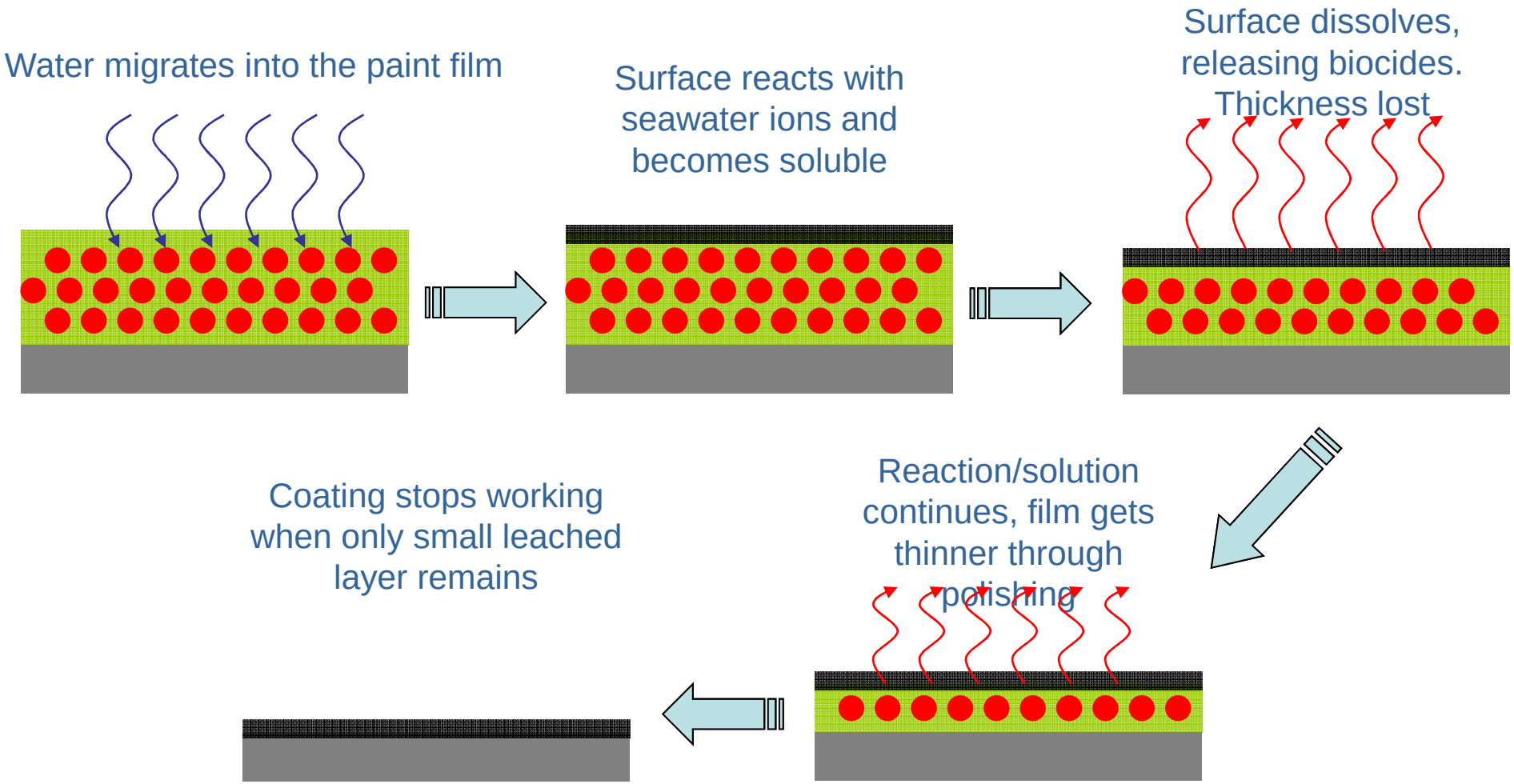

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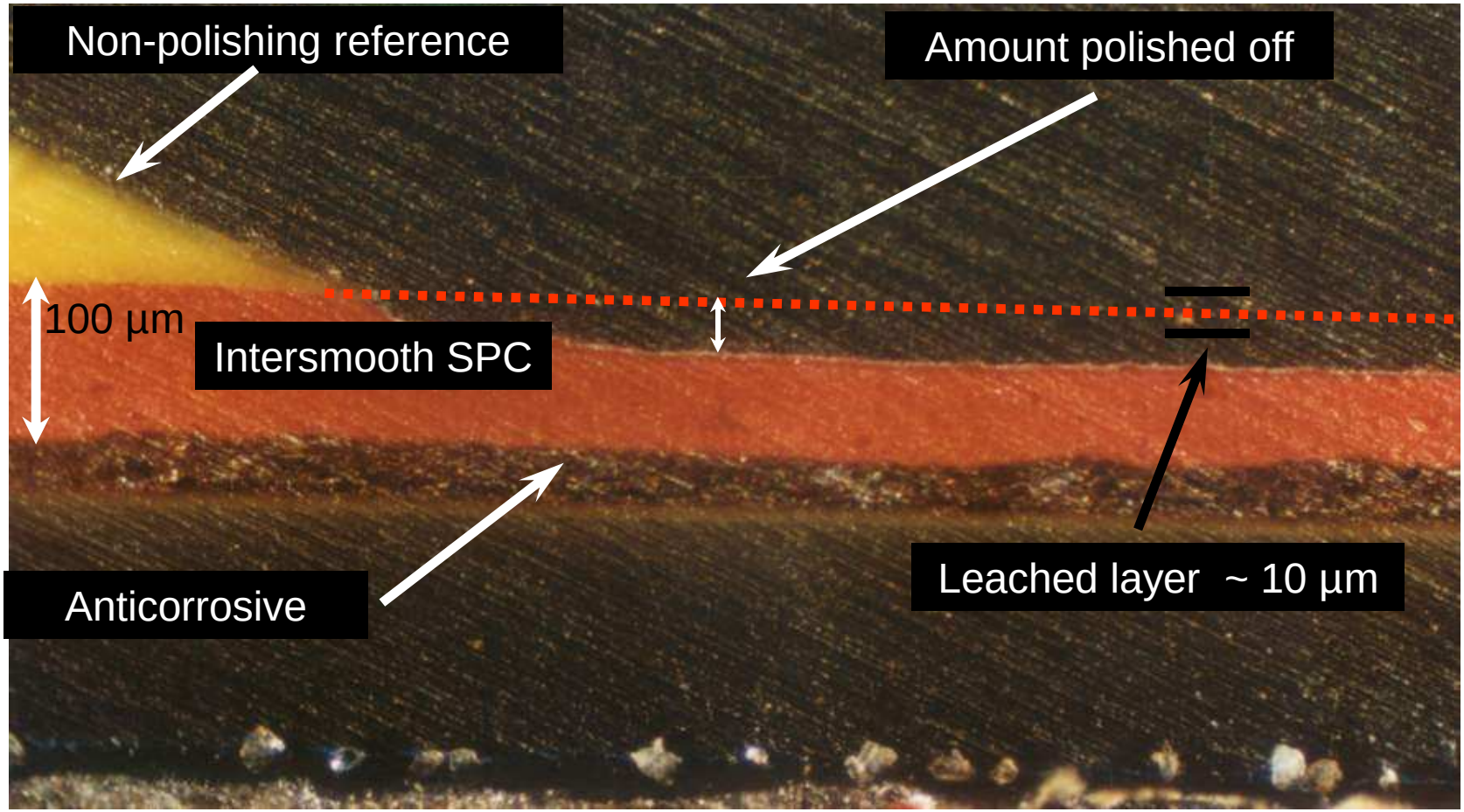
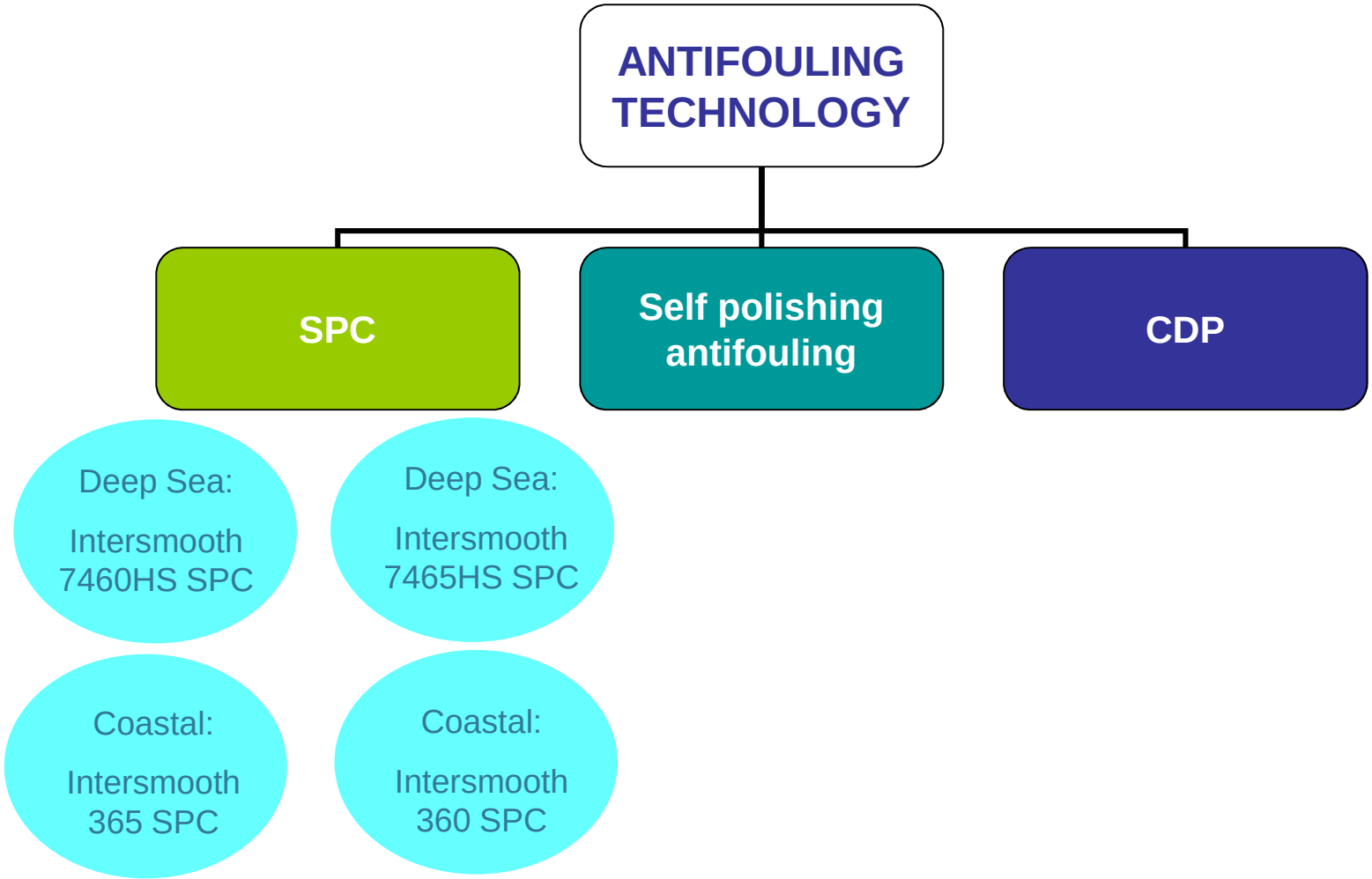


Copper acrylate SPC cross-section

Antifouling Technology



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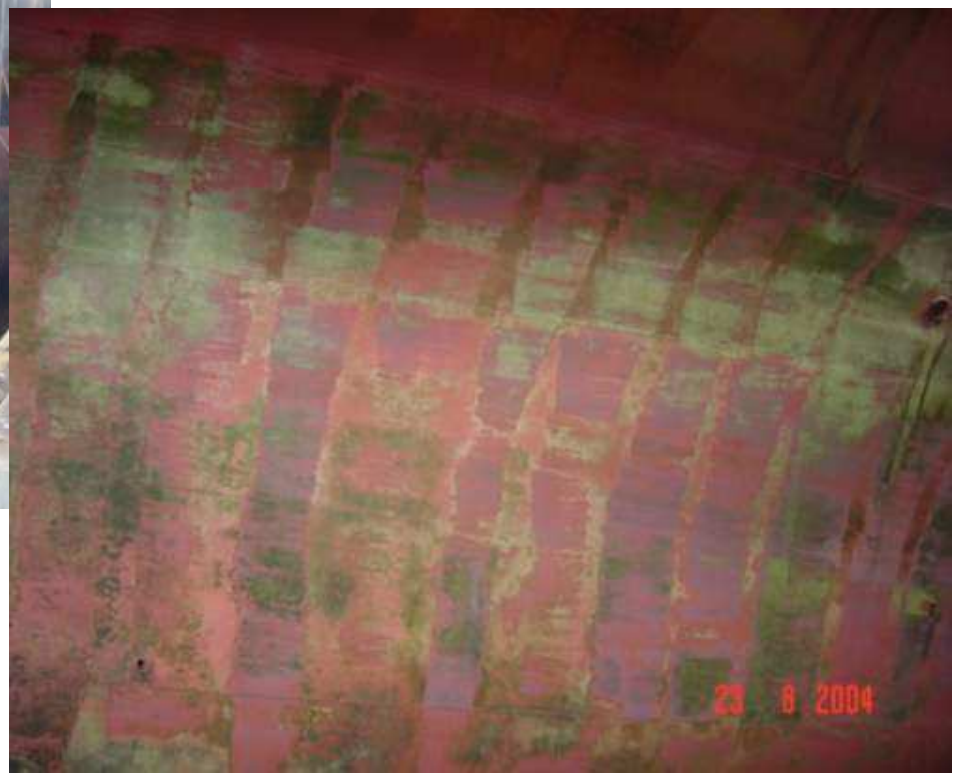
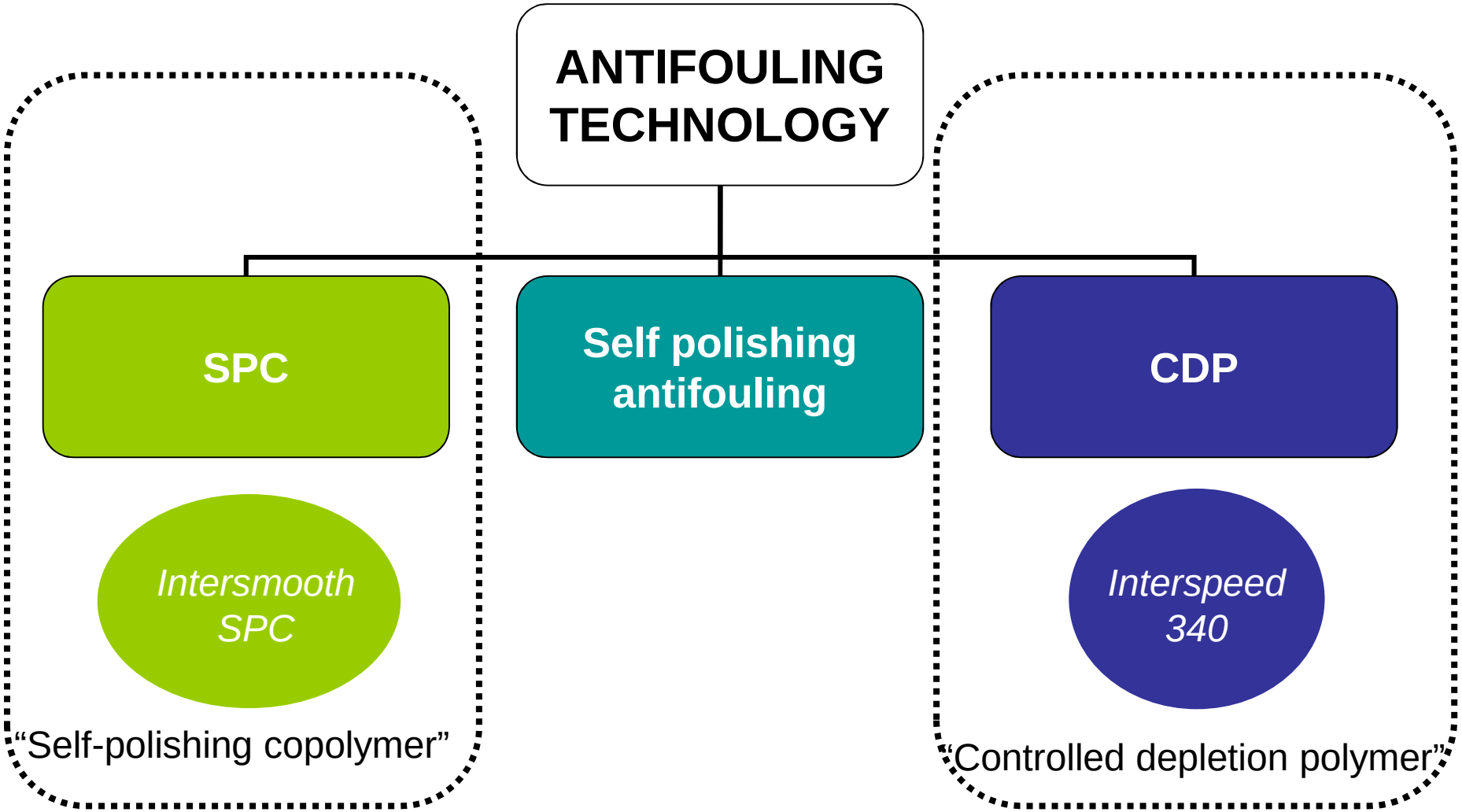
“Constitution”, Aug 2004 (ULCC, 60 mo)



Antifouling Technology



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ANTIFOULING TECHNOLOGY

- SPC
- **Self polishing antifouling**
- CDP

SPC

- **Good film properties**
- **Polishing control**
- **Thin leached layer**
- **Control of biocide release**
- **Best AF performance**

Self polishing antifouling

- High volume solids content
- Polishing control
- Surface tolerant
- Good film properties
- Control of biocide release
- Good AF performance

International Paint
Patent: WO 00/43460

(27th July 2000)

CDP (rosin)

- **High volume solids content**
- **Surface tolerant**

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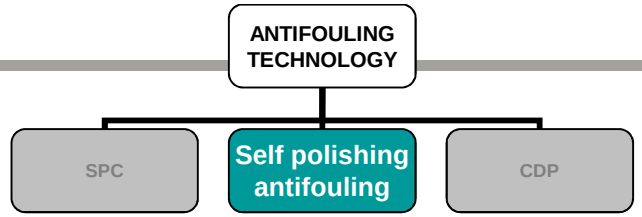

- **<u>Self polishing antifouling</u> technology works by a mixture of hydrolysis and hydration mechanisms combining SPC acrylic polymers with a certain amount of rosin**

- **Performance and price are mid-way between the CDP (rosin-based) and SPC (acrylic) products**

- **3 years maximum on the vertical sides, but 5 years on the flats, where fouling is less severe**

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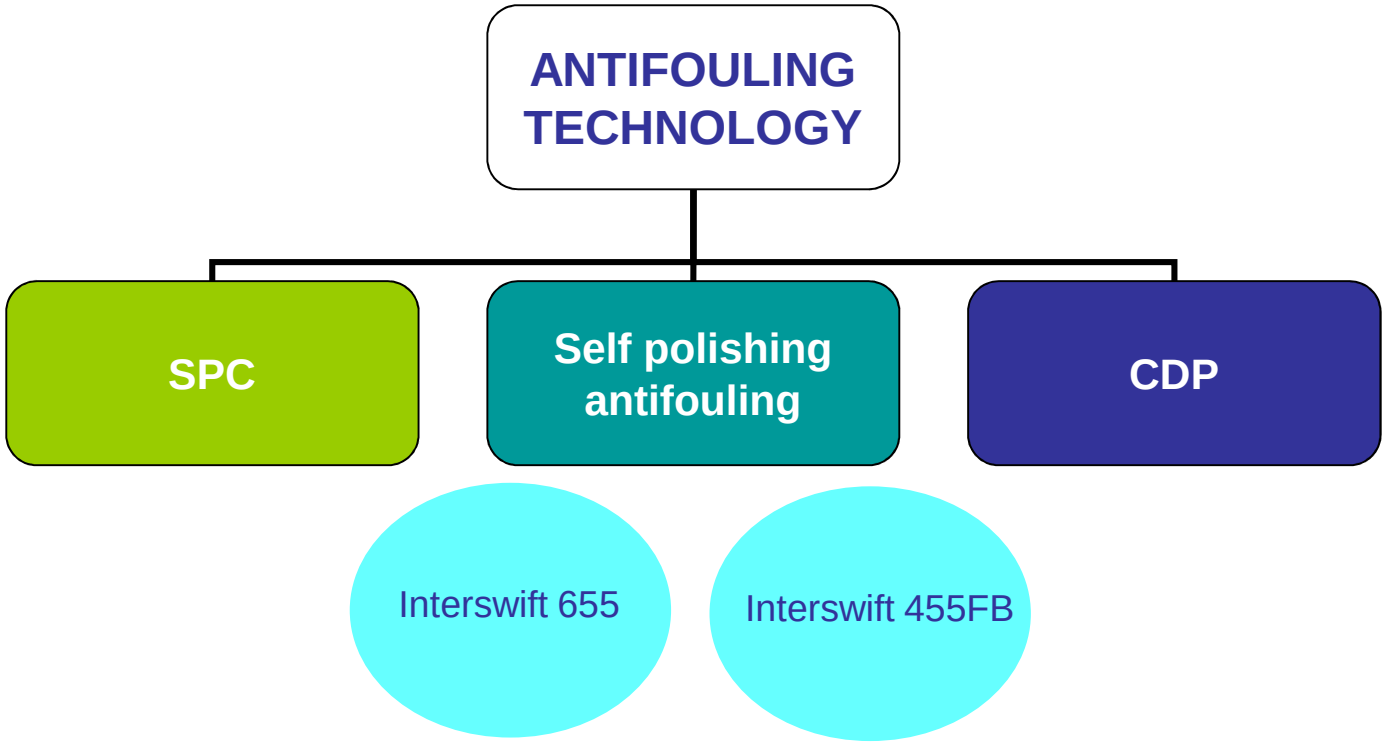
Antifouling Technology



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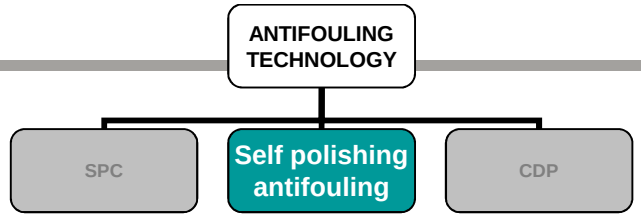

- Self Polishing antifoulings will give significant performance improvement over CDP Antifoulings for virtually all the major trading routes worldwide
- Self Polishing antifoulings are particularly suitable for vessels trading permanently in tropical and semi-tropical waters
- Self Polishing antifoulings have a thinner leached layer than CDP antifoulings, and have better film properties, so making M&R easier

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“Brothers” 27,563 dwt bulker, April 2004, 31 mo.

Summary

- Self Polishing Antifoulings will deliver antifouling performance intermediate between CDP and Self Polishing Copolymer (SPC) products

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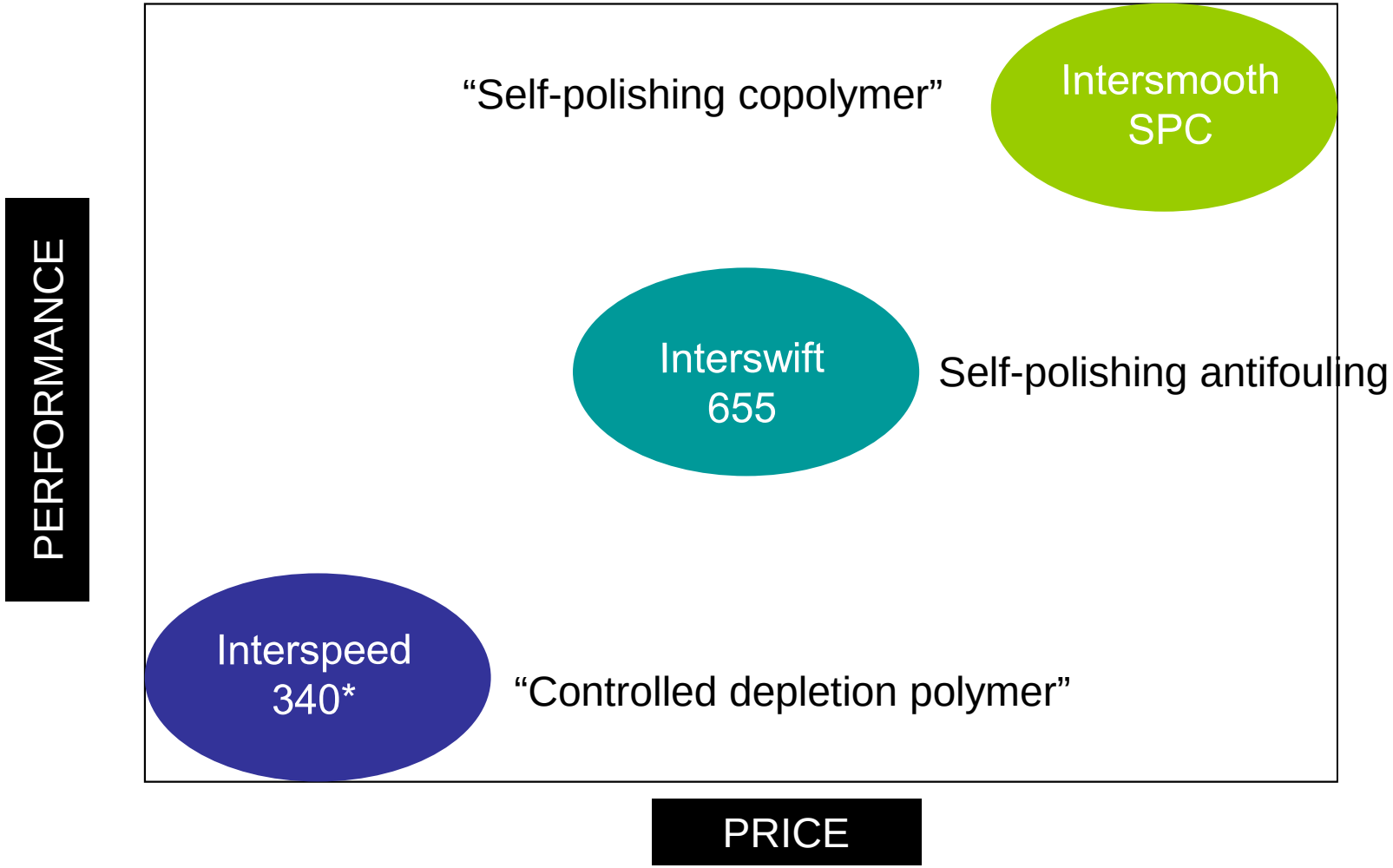
Product range



* Interspeed 640 (US)

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Biocide Free Antifoulings

- From an environmental perspective, most desirable approach to fouling control is one which does not rely on biocide release to achieve its effect
- Plethora of ideas proposed over the years
- Numerous patents issued
- Only foul release or low adherence systems have been commercialized successfully to date

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Biocide Free Antifoulings Technology – Present

- Silicone
- Silicone epoxy
- Siloxane
- Polysiloxane epoxy
- Fluorinated polysiloxane
- Epoxy
- Polyurethane
- Fluorinated polyurethane
- Wax

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Low Adherence

- Concept of Low Adherence first considered in 19th century
- Discovery of fouling control properties of silicones was advent of commercial systems
- Another chemistry to be considered to great extent has been fluorinated polymers

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Foul Release Coatings

- Foul Release is name given to technology which does not use biocides to control fouling
- Relies on ‘non-stick’ principle to minimize fouling adhesion to surface
- Most currently available are based on silicone technology

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Foul Release Coatings - Silicone

- Low surface energy is one key characteristic
- Extremely flexible backbone allowing polymer chain to readily adopt lowest surface energy configuration
- Other important characteristics are coating thickness, elastic modulus and smoothness
- Fouling species prefer to settle on rough surfaces

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Foul Release Coatings - Silicone

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Biocide Free Antifoulings Technology - Future

- Silicone derivatives
- Polysiloxane derivatives
- Polyurethane derivatives
- Epoxy derivatives
- Waxes
- Contoured surfaces
- Nanoparticle coatings
- Dolphin skin effect
- Lotus leaf effect
- Other technologies ?

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Vessel - Environmental Footprint

- VOC generation
- Greenhouse gases – SOx, NOx, CO2
- Noise
- Oily water discharge
- Waste water
- General waste
- Ballast water
- Antifoulings - Biocides

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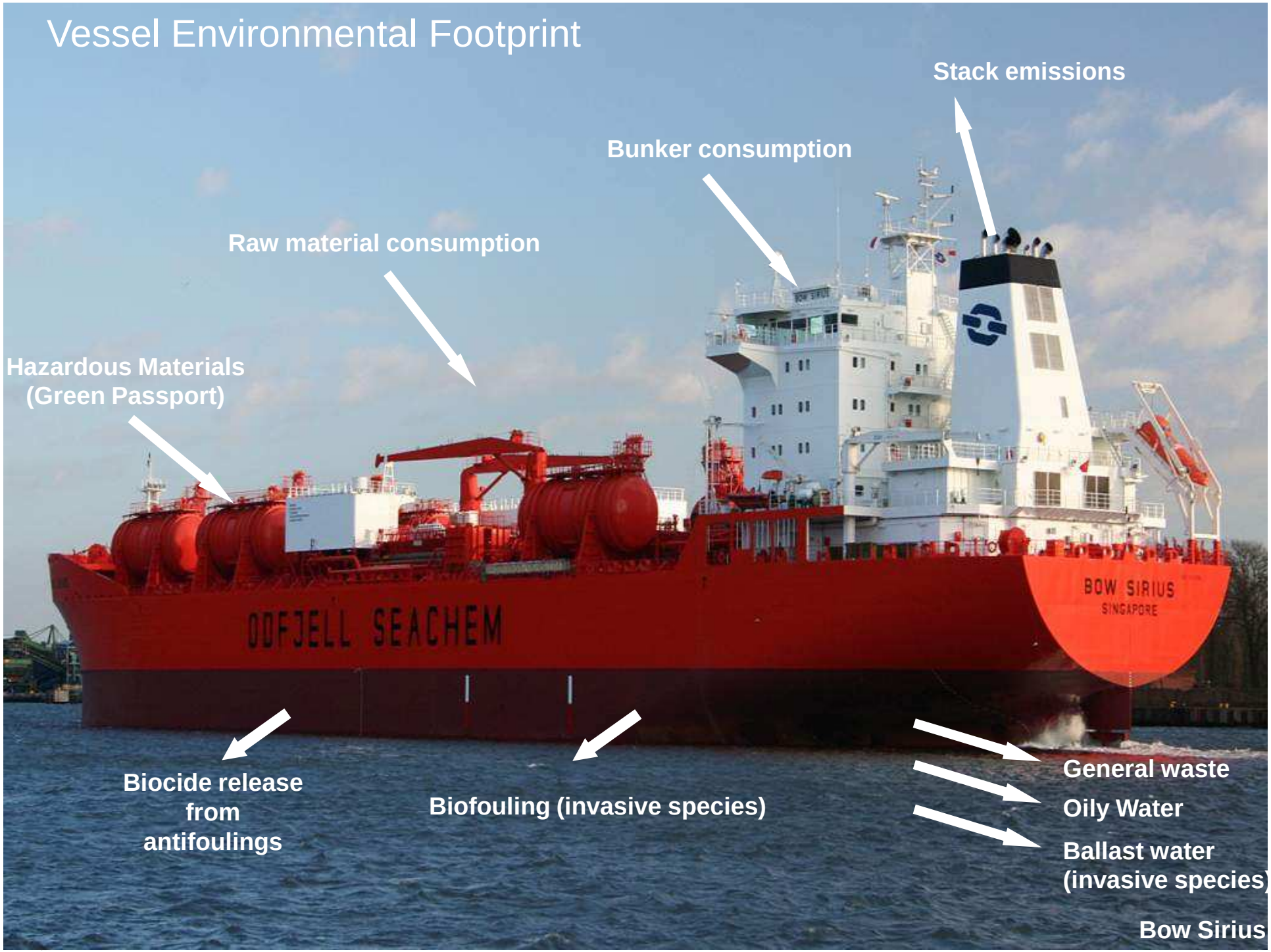
Vessel Environmental Footprint



- Questions?