Understanding the Antifouling Coating Options Available to Ship Owners

Agenda

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

International

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

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

The Fouling Problem

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

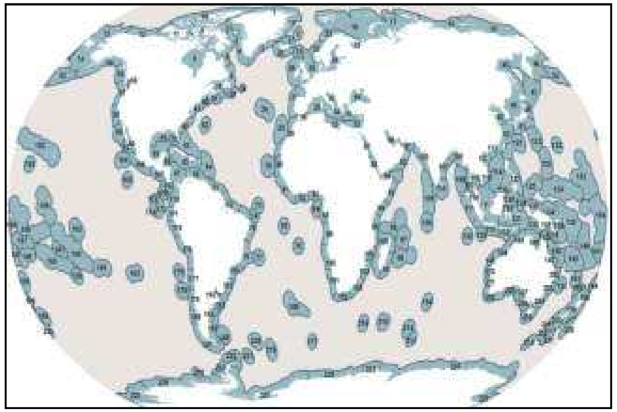
Weed

Hydroids

Barnacles

The Fouling Problem – Factors Affecting Fouling

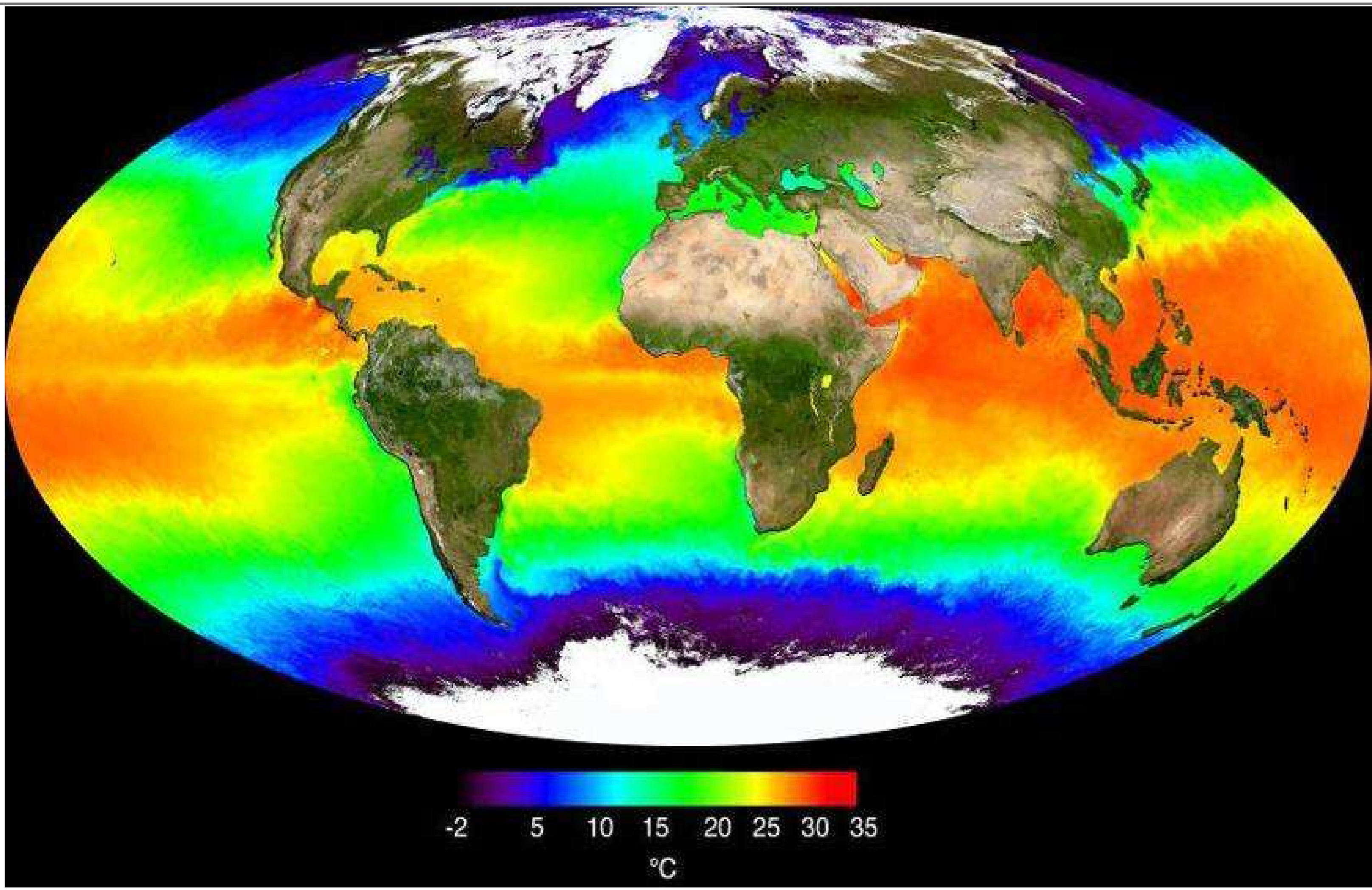
- Temperature
- Speed/Motion
- Light & Nutrients



- 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

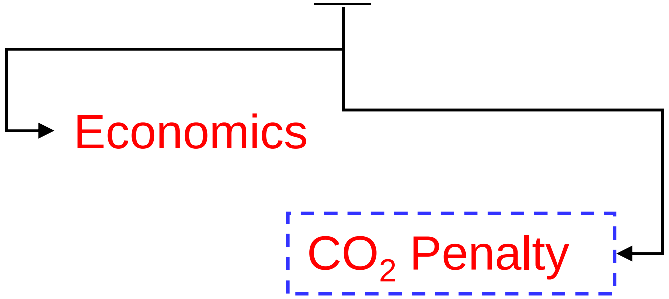
Fouling



International

Why Use Antifouling Coatings?

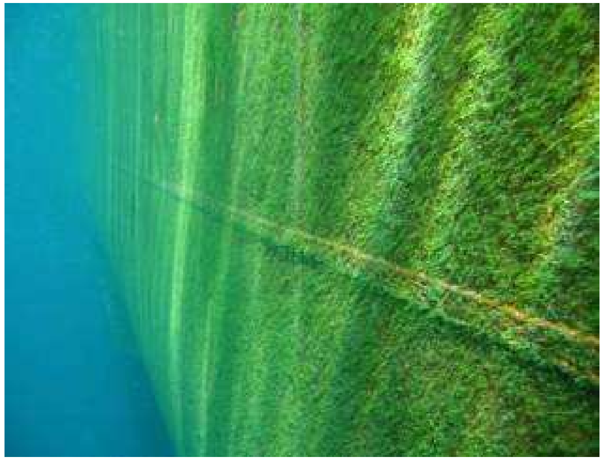
Fouling increases the hydrodynamic drag of a vessel therefore more energy is required to drive through water



- 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

The Effects of Fouling

Slime ~ 8% drag increase



Weed ~ 10% drag increase

Hard ~ 40% drag increase

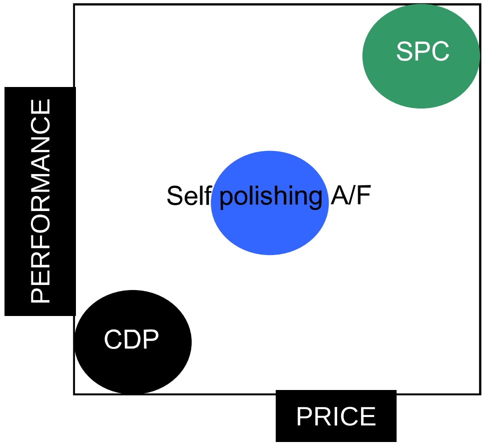
What drives the AF market?

- **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:

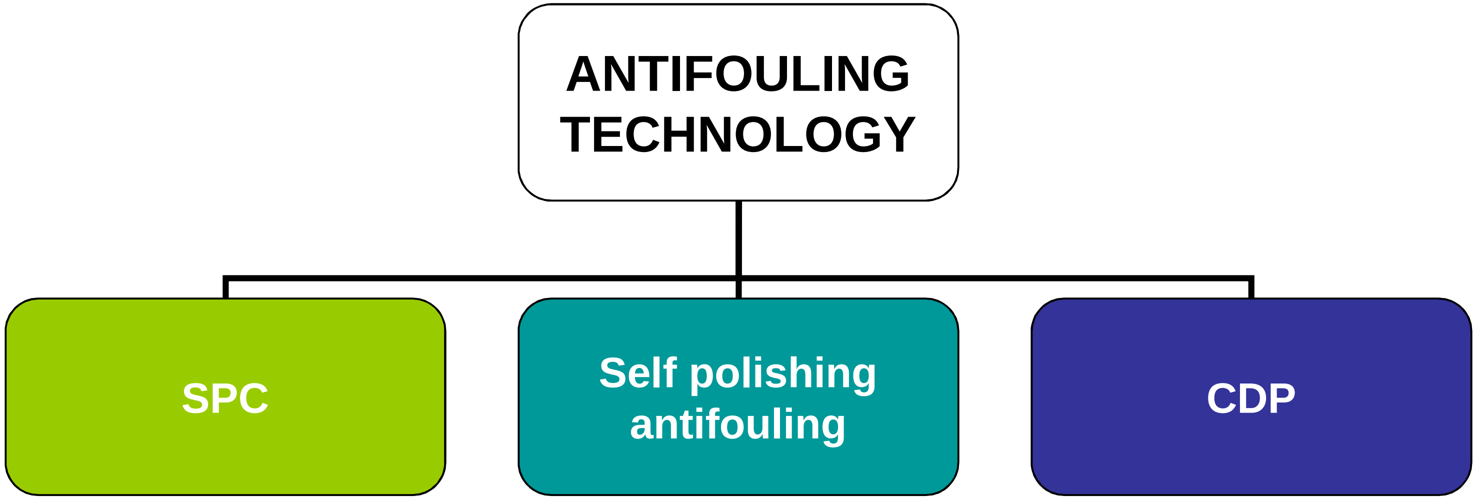
    - **Self-polishing copolymer (SPC)**
    - **Self polishing antifouling**
    - **Controlled depletion polymer (CDP)**



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

Antifouling Technology

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



Antifouling Technology

- When using biocides to control fouling there are two key issues:

- Biocides – types, quantities

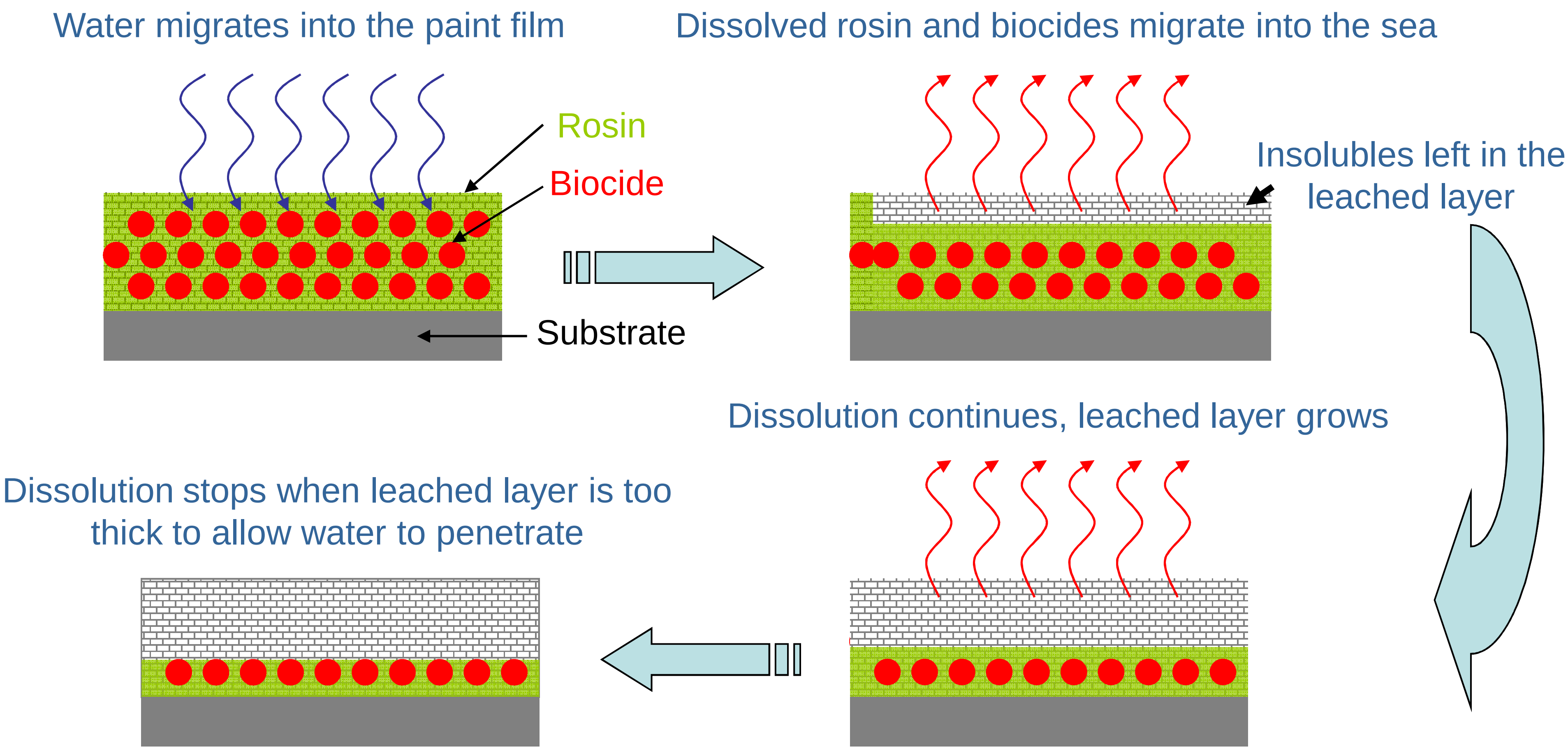
- Release mechanism – binder technology

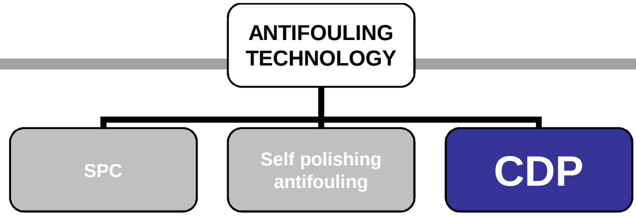
Antifouling Technology

- 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.

ANTIFOULING TECHNOLOGY

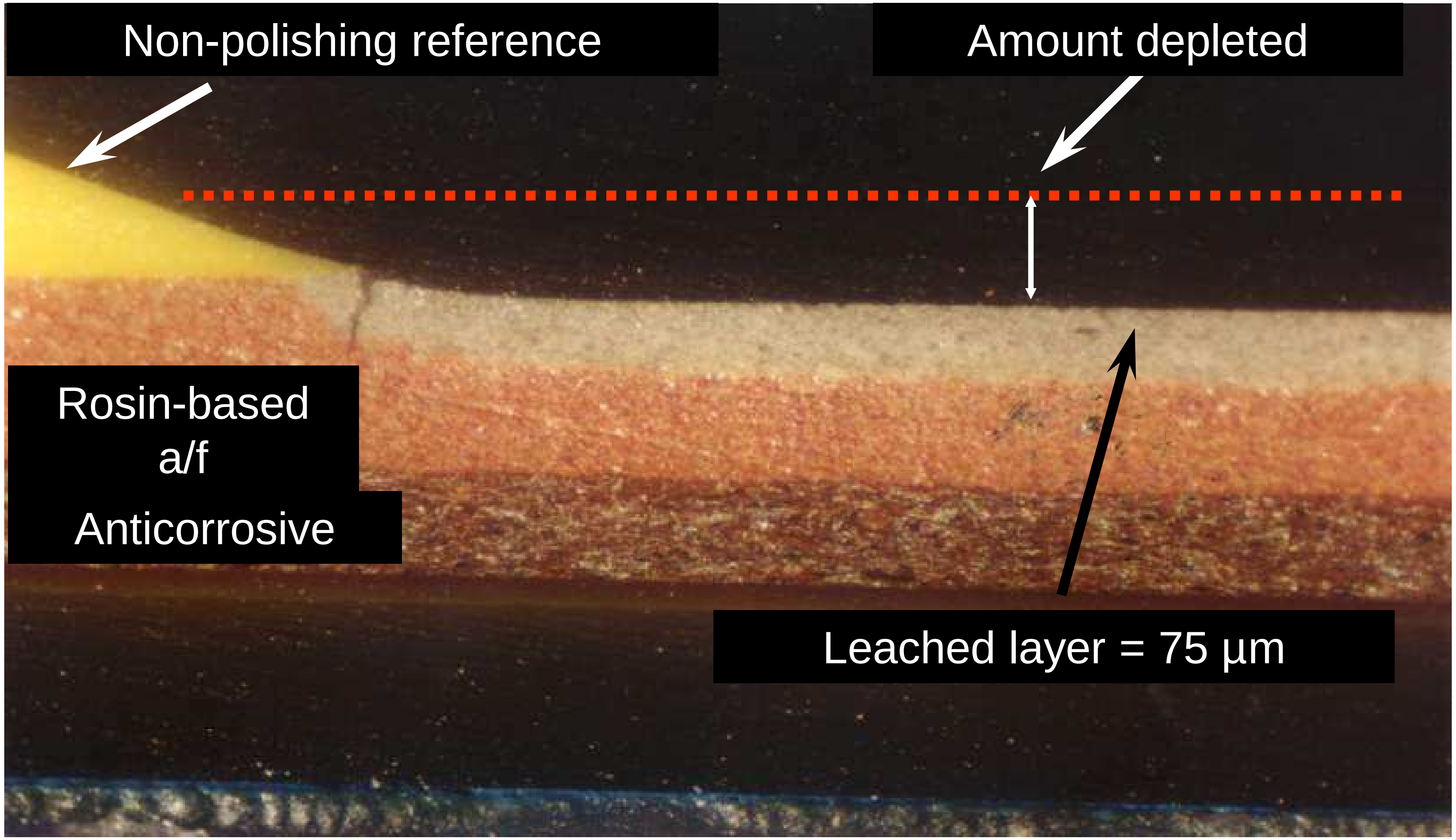
SPC | Self polishing antifouling | **CDP**





- 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

- 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



Typical CDP cross-section

International

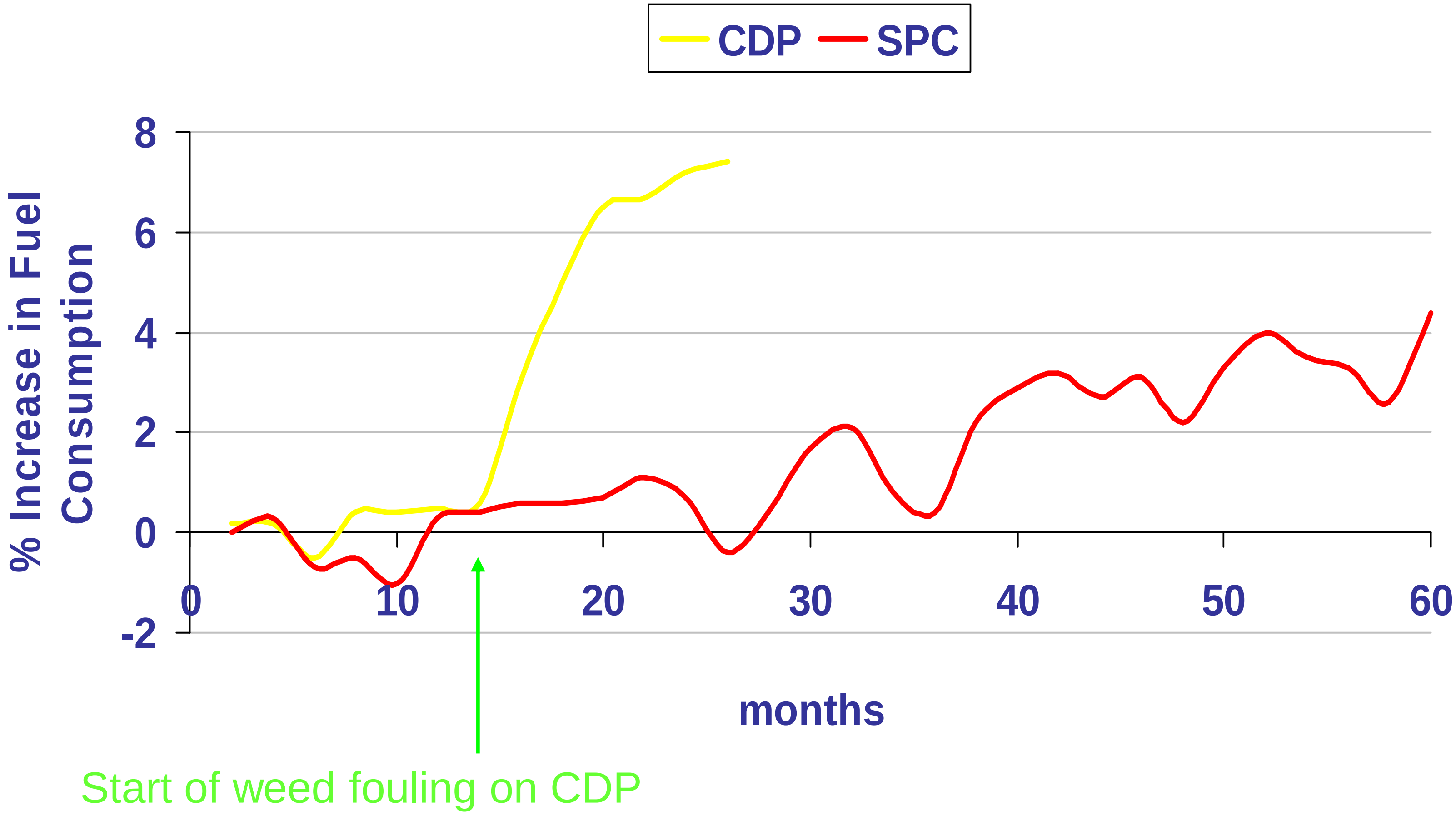
ANTIFOULING TECHNOLOGY

SPC

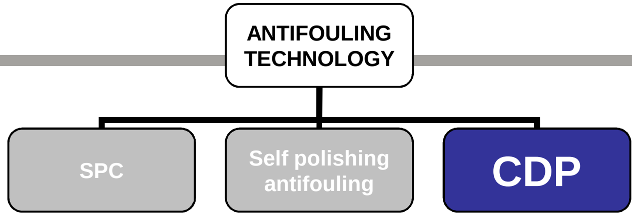
Self polishing antifouling

CDP

Rough CDP surface after washing



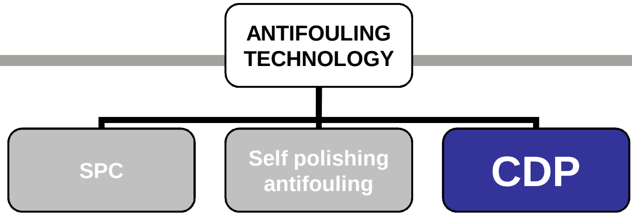
The effect of fouling on a CDP ship



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

  “Hydration”, “Ablative”, “Eroding”, “Polishing”, “Self-polishing”, “Ion Exchange”

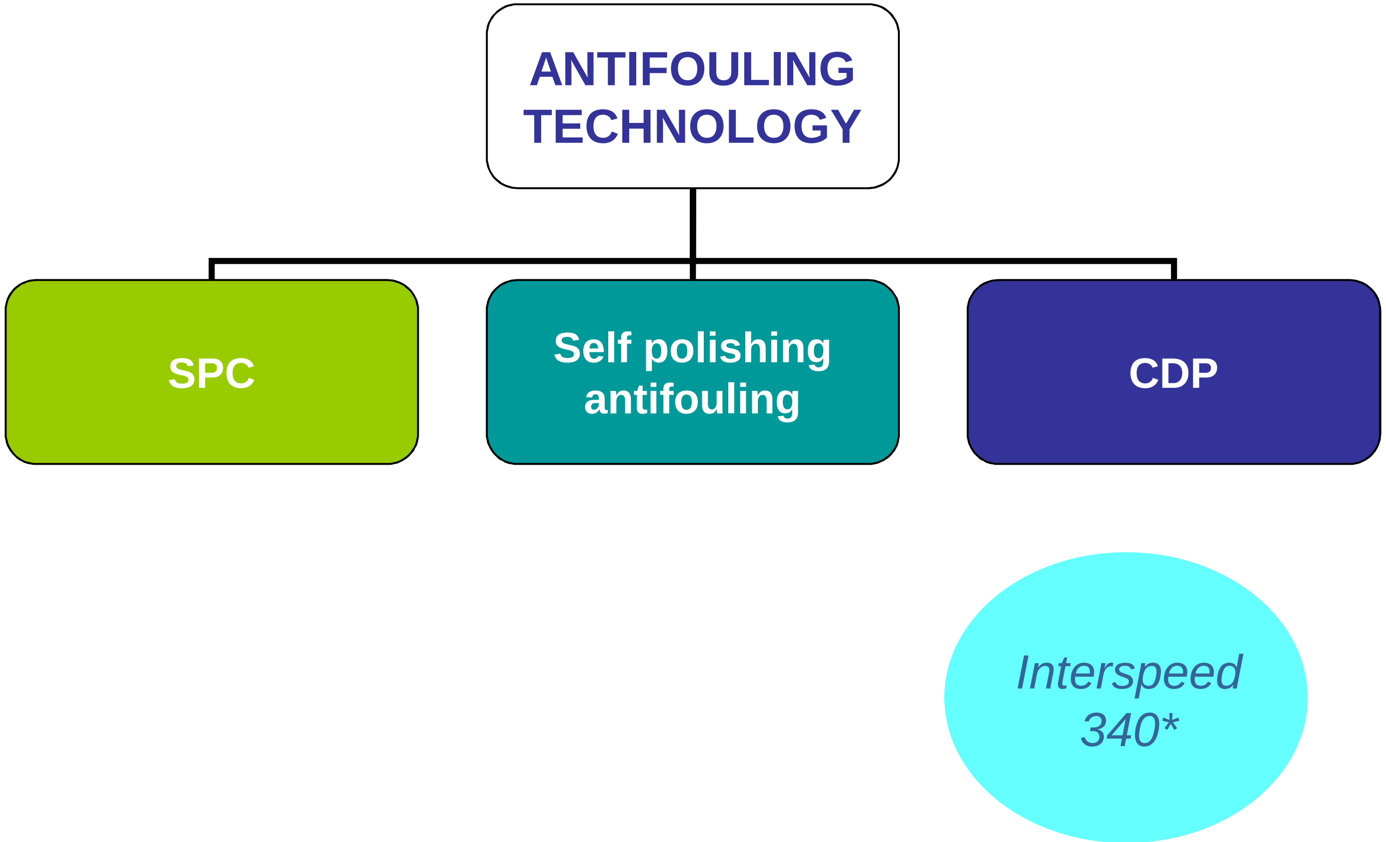
- Key tests for CDP a/f paints are:
  - Use of rosin, or rosin derivatives (ASTM D-1542)
  - Higher solids (55~60% vol. solids)
  - Thick leached layers
  - Film integrity is generally poor, and re-blasting is needed after 10 years



Summary:

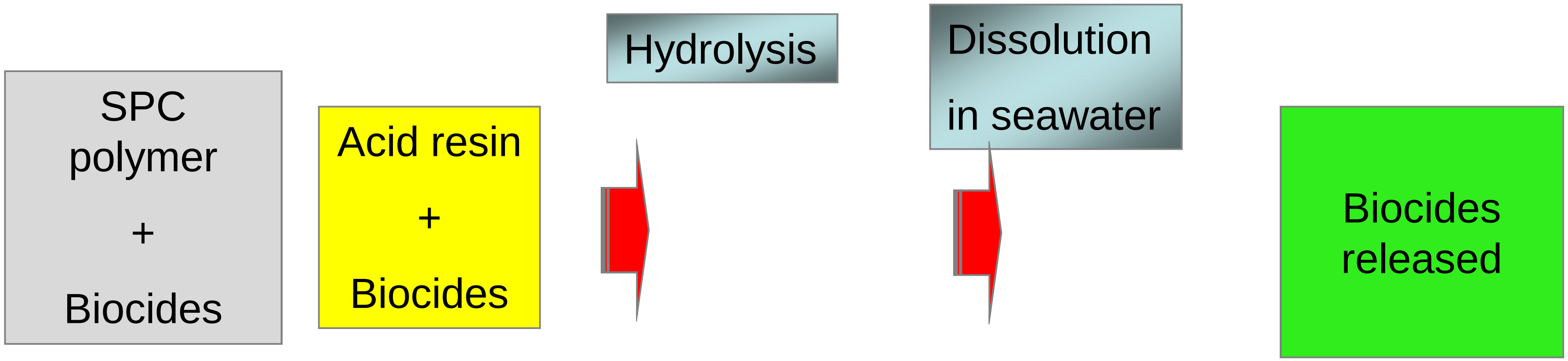
- CDP (rosin-based) antifoulings are not as effective as Self Polishing Copolymer (SPC) systems
- CDP products generally have thick leached layers, which limit performance and negatively affect re-coatability
- However, CDP products have a place as the lowest cost per m^2, "value for money" antifoulings,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

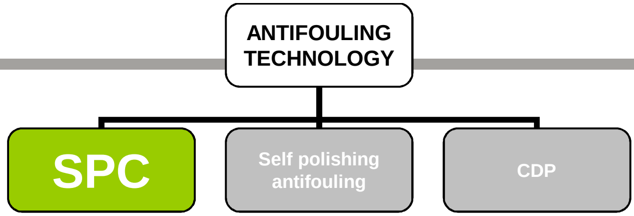
Antifouling Technology



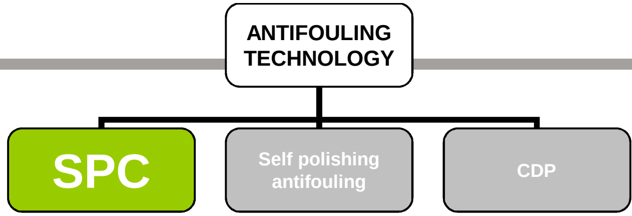
*Interspeed 640 (US)

- 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:



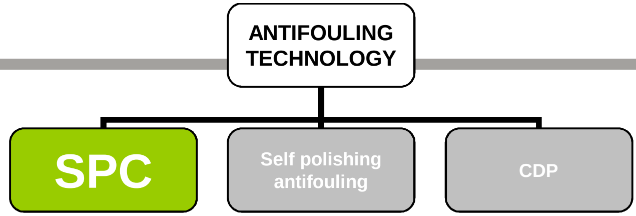


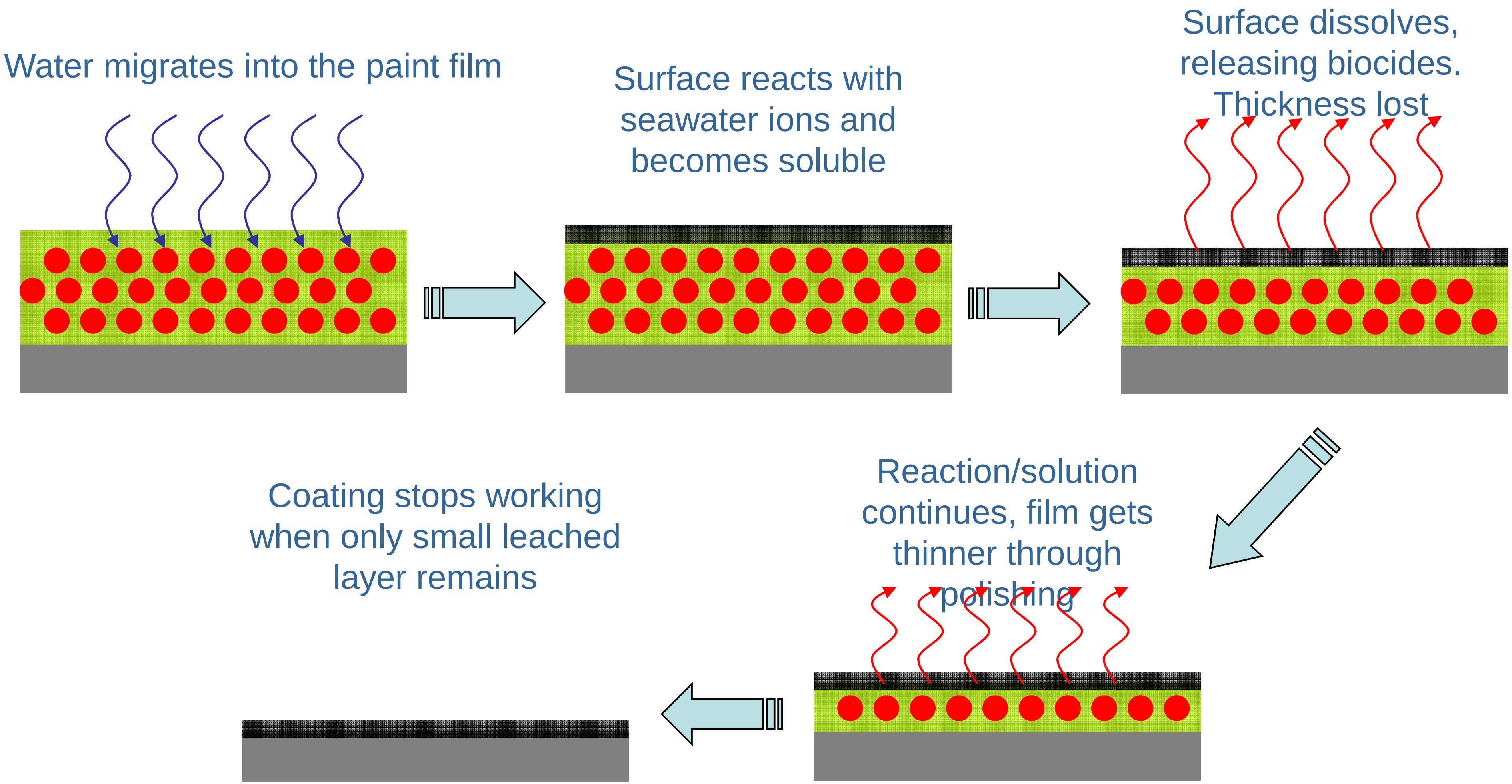
- To date, only three SPC technologies have been commercialised:
  - Copper acrylate (Polymer --- COO --- Cu --- R)
  - Zinc acrylate (Polymer --- COO --- Zn --- R)
  - Silyl acrylate (Polymer --- COO --- Si --- R_3)

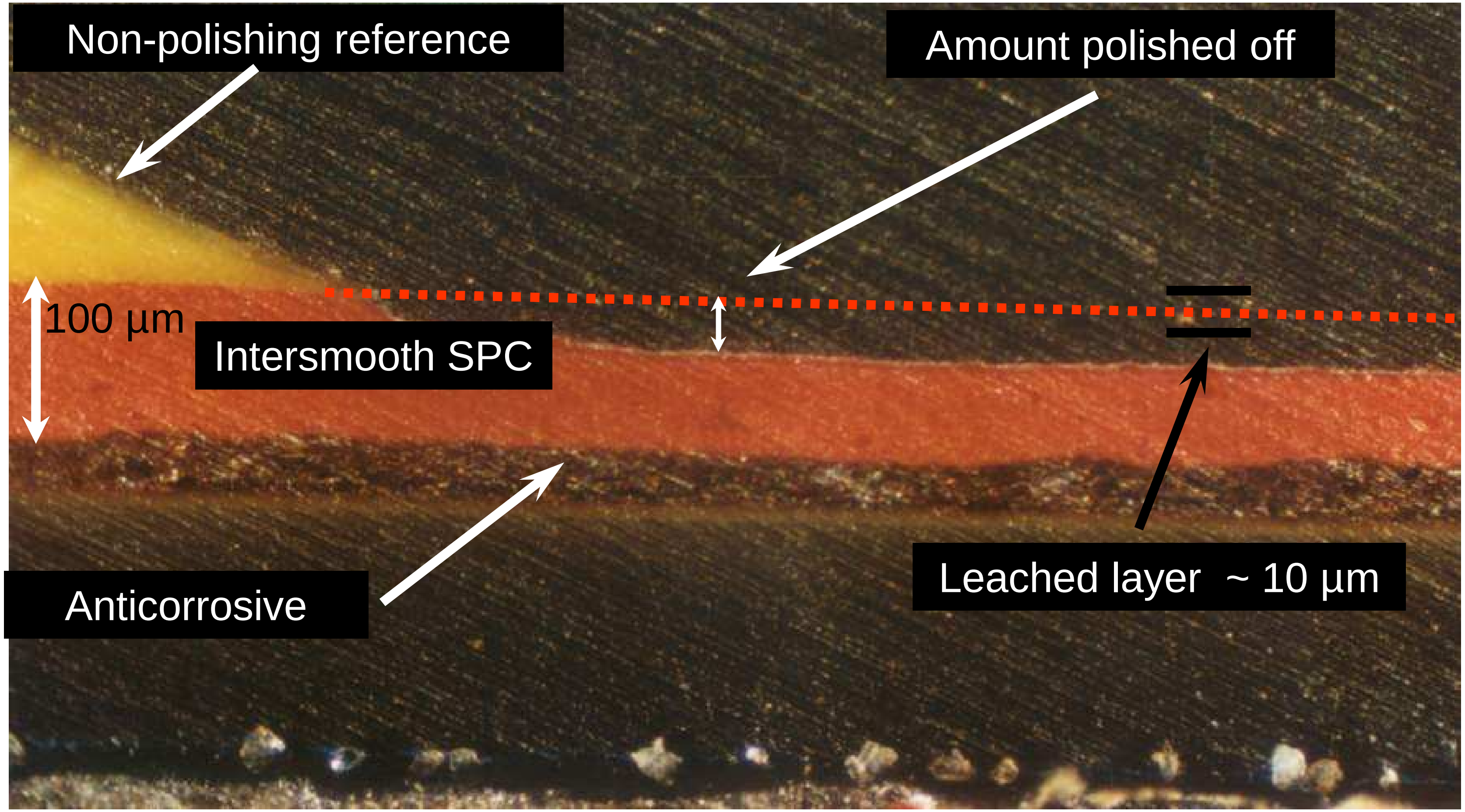


SPC features

- 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)

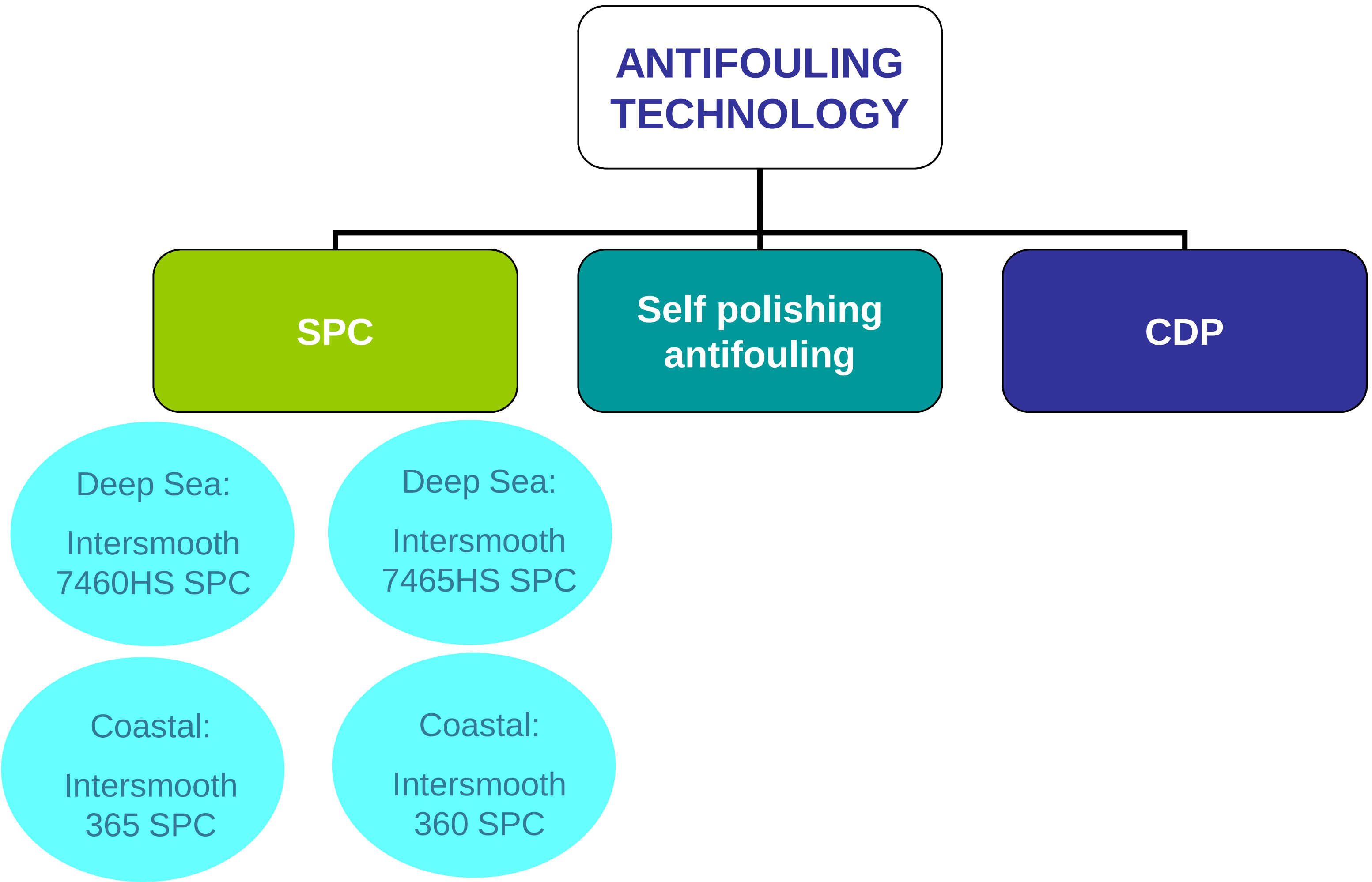

ANTIFOULING TECHNOLOGY
SPC
Self polishing antifouling
CDP


Water migrates into the paint film
Surface reacts with seawater ions and becomes soluble
Surface dissolves, releasing biocides. Thickness lost
Reaction/solution continues, film gets thinner through polishing
Coating stops working when only small leached layer remains



Copper acrylate SPC cross-section

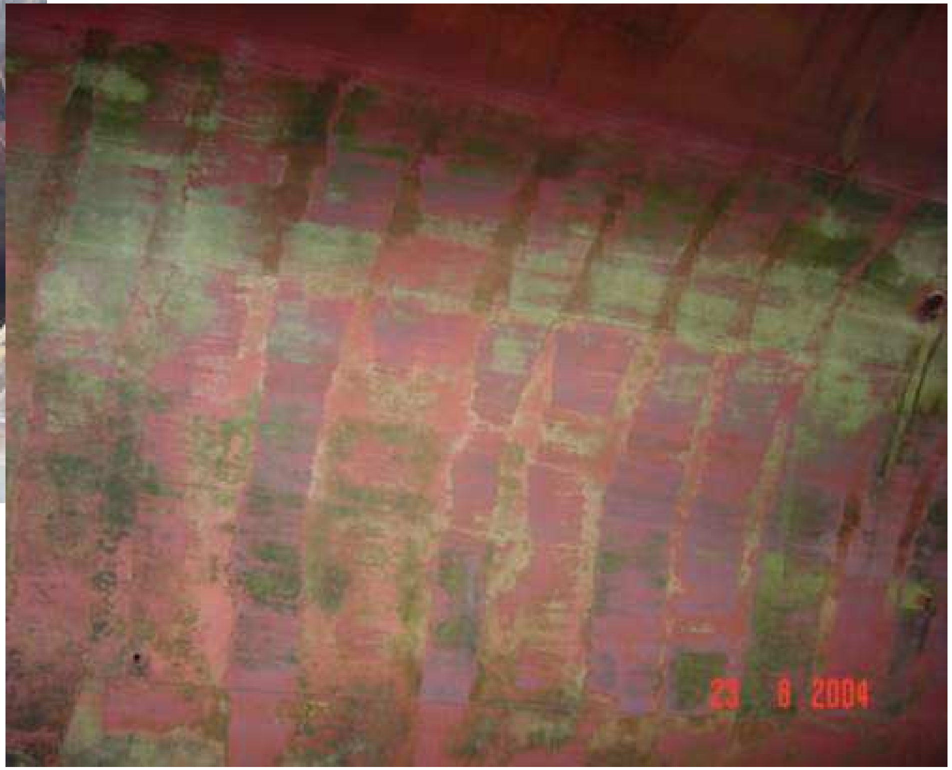
Antifouling Technology

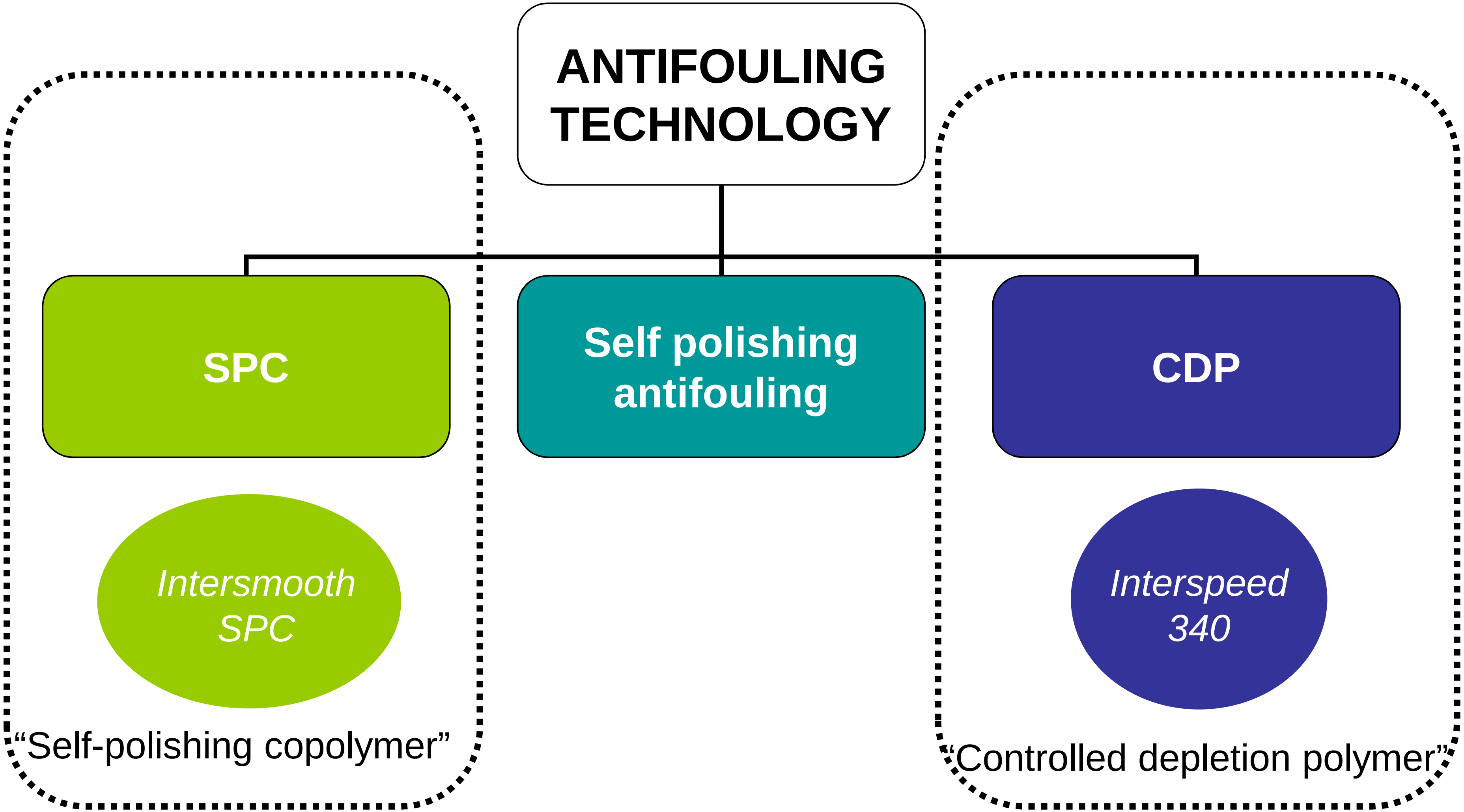


ANTIFOULING TECHNOLOGY

SPC | Self polishing antifouling | CDP

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




ANTIFOULING TECHNOLOGY
SPC
Self polishing antifouling
CDP
Intersmooth SPC
Interspeed 340
"Self-polishing copolymer"
"Controlled depletion polymer"

SPC

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

Self polishing antifouling

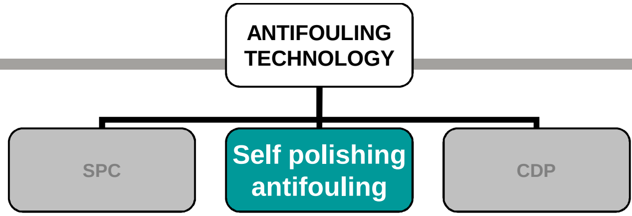
- High volume solids content
- Polishing control
- Surface tolerant
- Good film properties
- Control of biocide release
- Good AF performance

International Paint Patent: WO 00/43460

(27th July 2000)

CDP (rosin)

- High volume solids content
- Surface tolerant

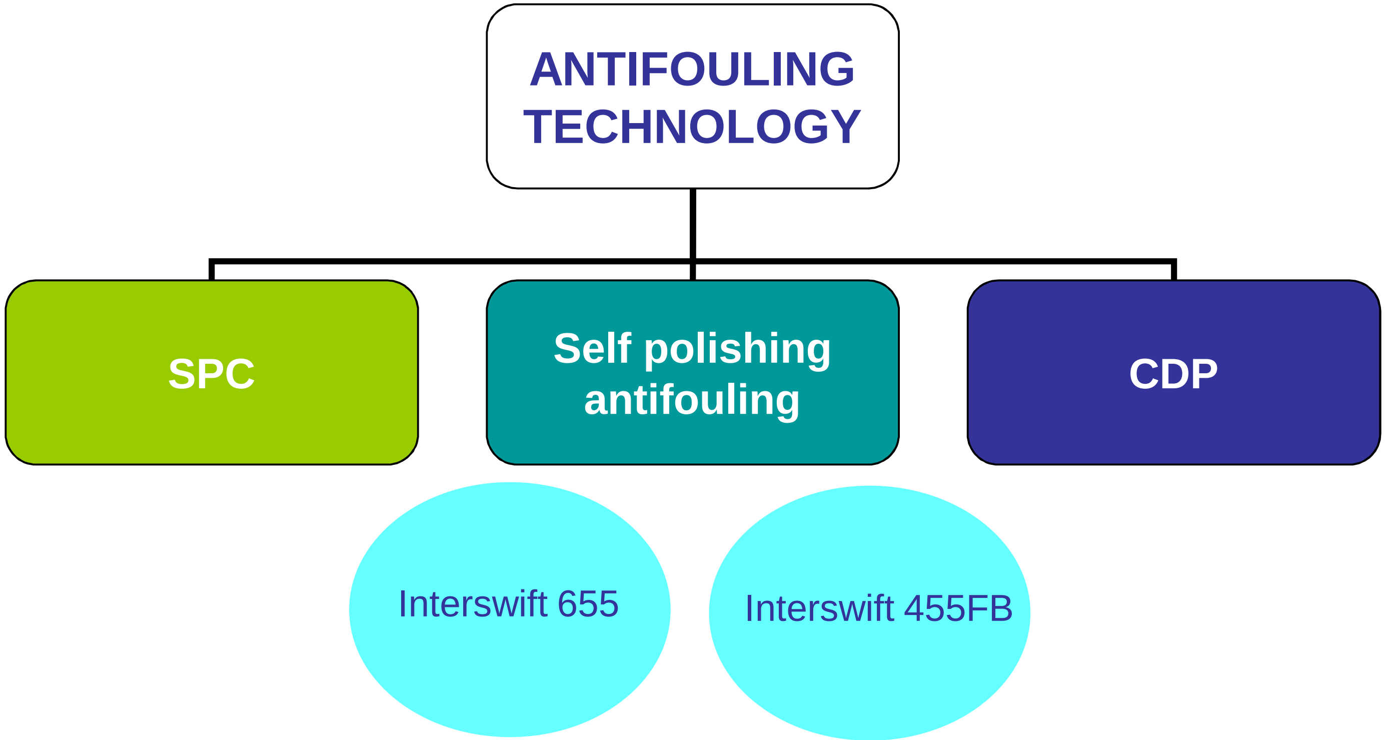


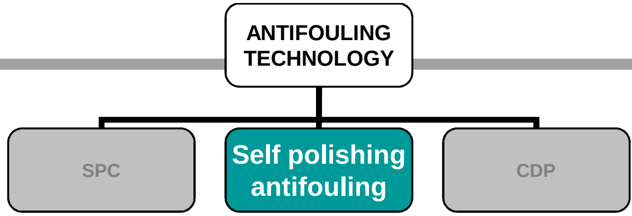
- Self polishing antifouling technology works by a mixture of hydrolysis and hydration mechanisms combining SPC acrylic polymers with a certain amount of rosin

- 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

Antifouling Technology





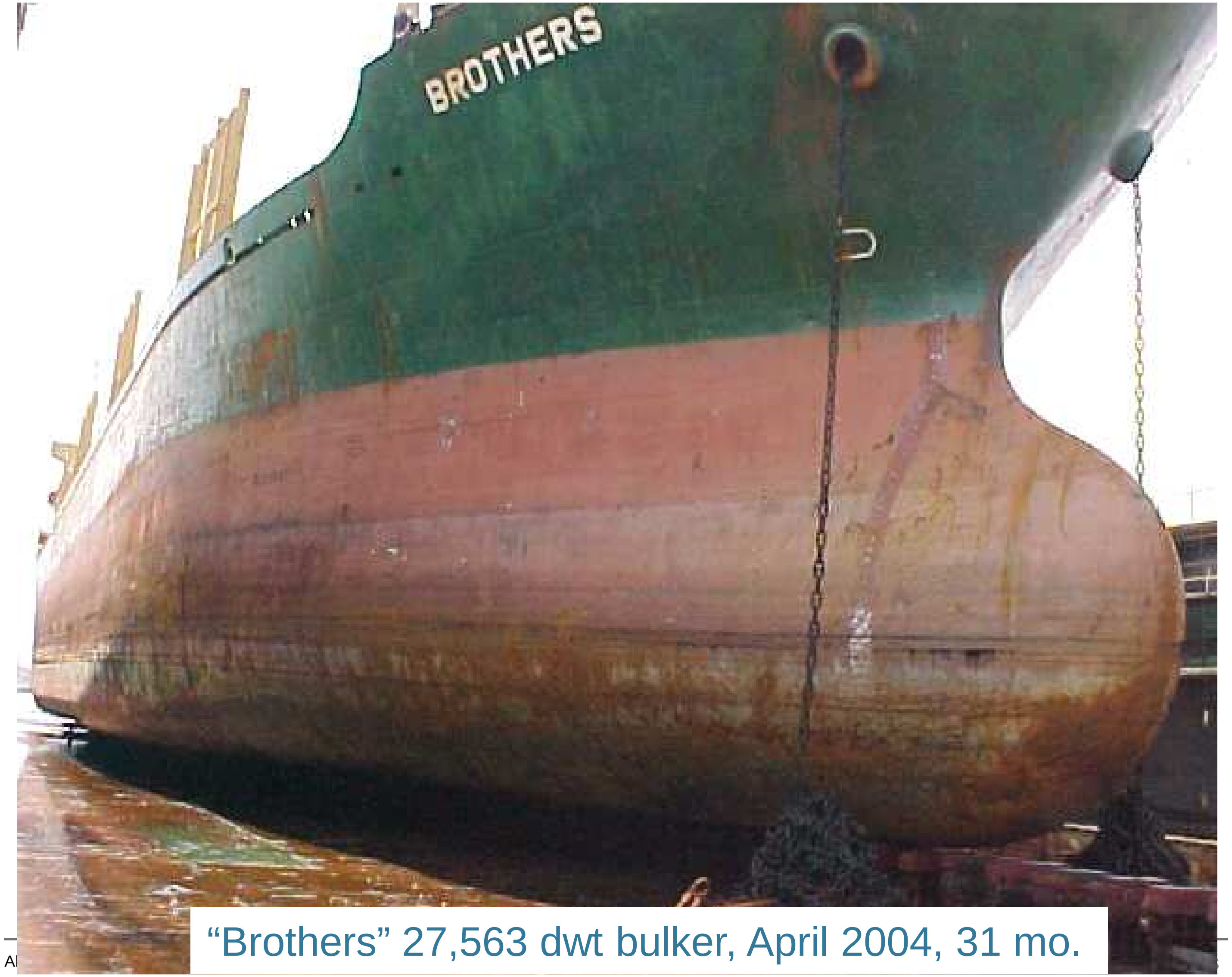
- Self Polishing antifoulings will give significant performance improvement over CDP Antifoulings for virtually all the major trading routes worldwide

- Self Polishing antifoulings are particularly suitable for vessels trading permanently in tropical and semi-tropical waters

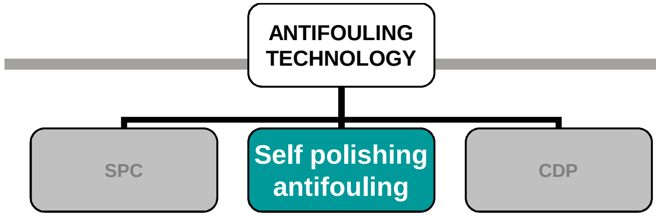
- Self Polishing antifoulings have a thinner leached layer than CDP antifoulings, and have better film properties, so making M&R easier

ANTIFOULING TECHNOLOGY

SPC | **Self polishing antifouling** | CDP



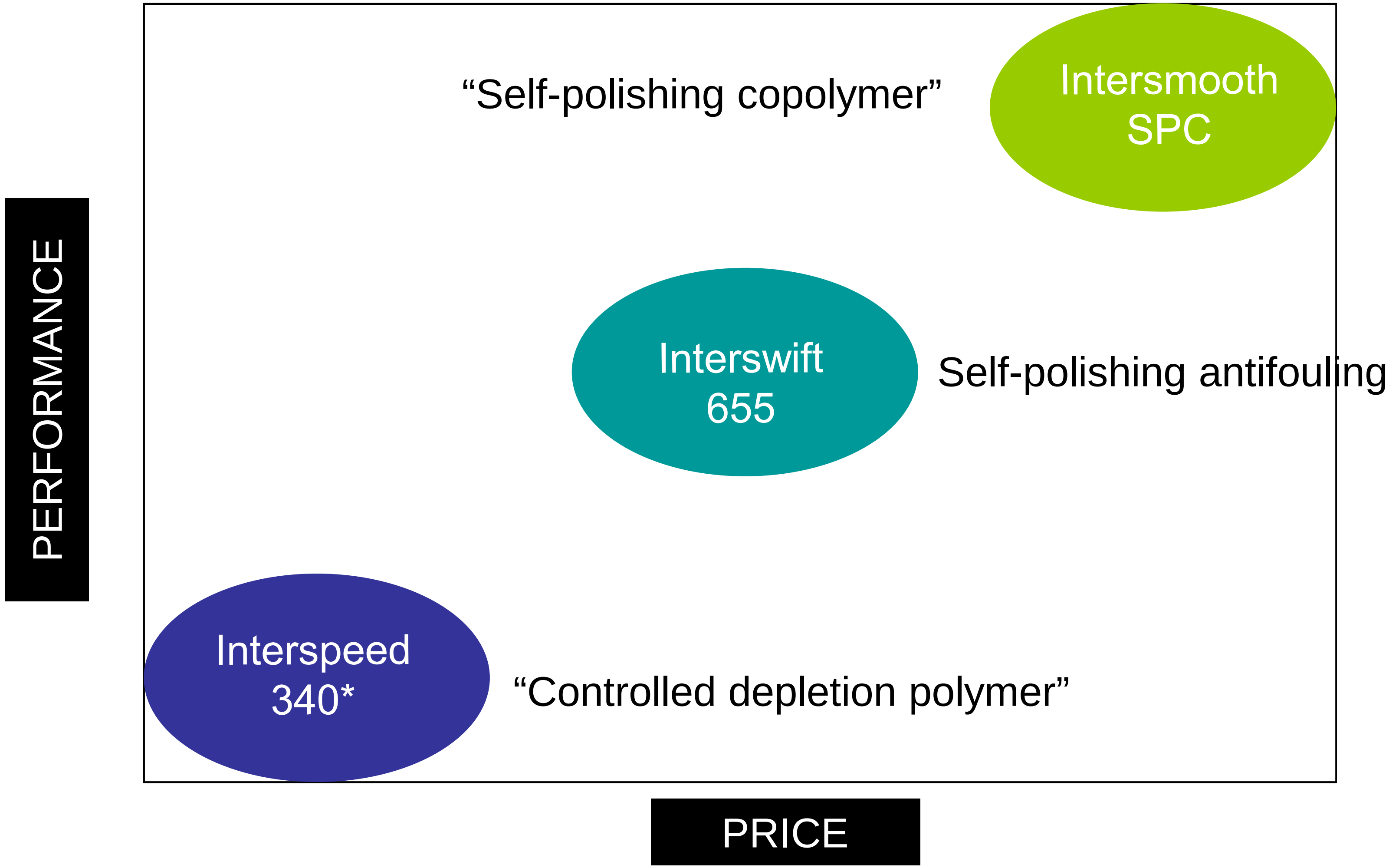
"Brothers" 27,563 dwt bulker, April 2004, 31 mo.



Summary

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

Product range



* Interspeed 640 (US)

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

Biocide Free Antifoulings
Technology – Present

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

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

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

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

Foul Release Coatings - Silicone

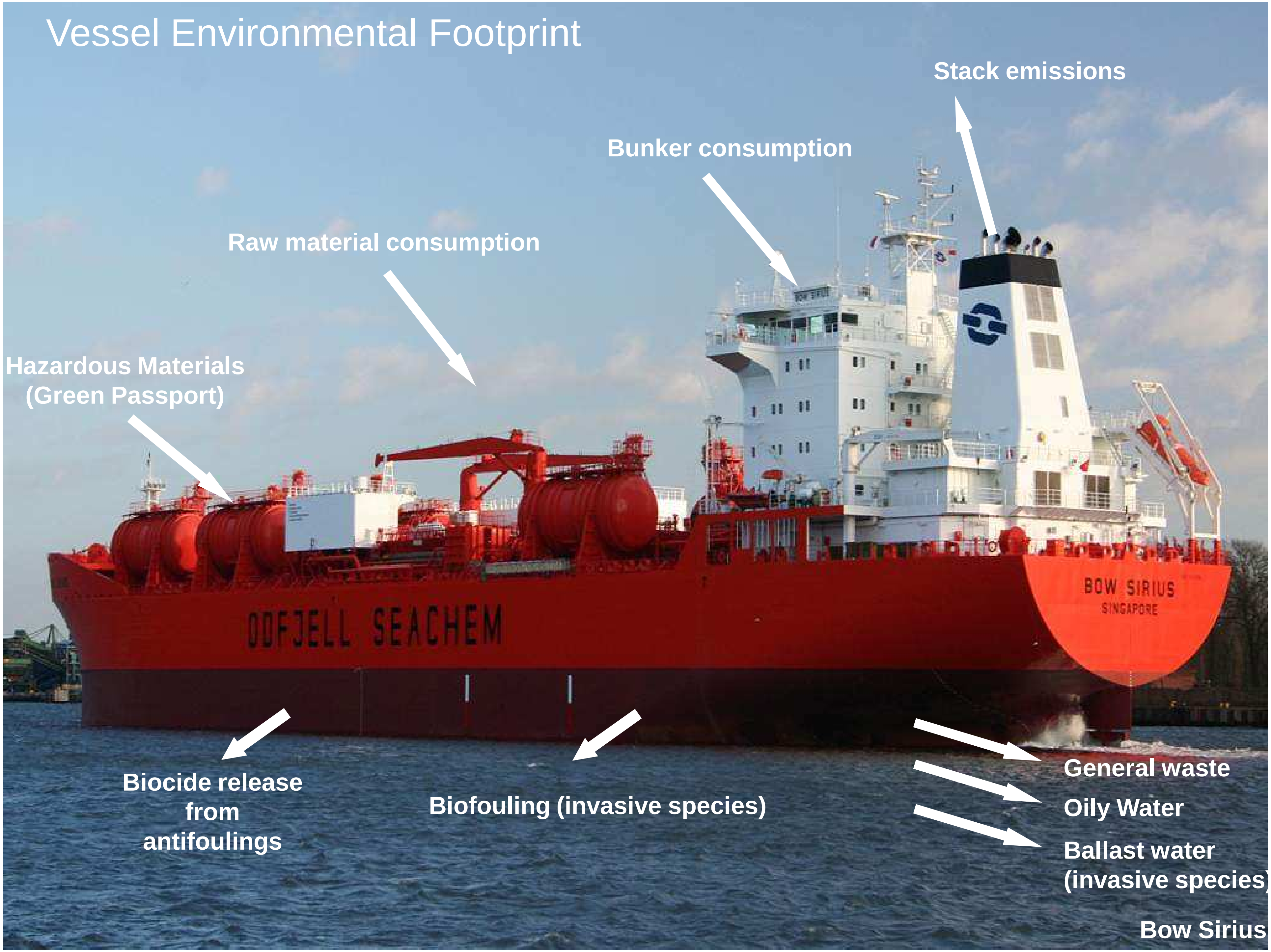
International

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 ?

Vessel - Environmental Footprint

- VOC generation
- Greenhouse gases – SOx, NOx, CO_2
- Noise
- Oily water discharge
- Waste water
- General waste
- Ballast water
- Antifoulings - Biocides


Vessel Environmental Footprint
Stack emissions
Bunker consumption
Raw material consumption
Hazardous Materials
(Green Passport)
ODFJELL SEACHEM
BOW SIRIUS
SINGAPORE
Biocide release
from
antifoulings
Biofouling (invasive species)
General waste
Oily Water
Ballast water
(invasive species)
Bow Sirius

- Questions?