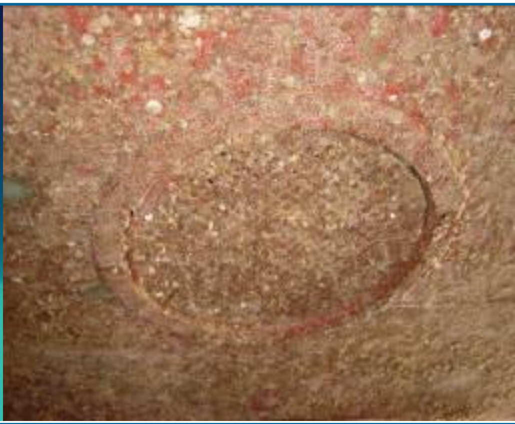
Alien Species and Biofouling of Maritime Vessels



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- Biology of fouling organisms

Hull Fouling Activities: Hawaii

- Edmondson 1944: Pearl Harbor
- Eldredge and Carlton 2000-2009: Historical
- Godwin 1999-2004: Field Sampling and Management Options
- State of Hawaii: 2007-2010, 2012-2015
- Papahānaumokuākea Marine National Monument 2007-Present: Management

Brief Overview: Hull Fouling Introductions

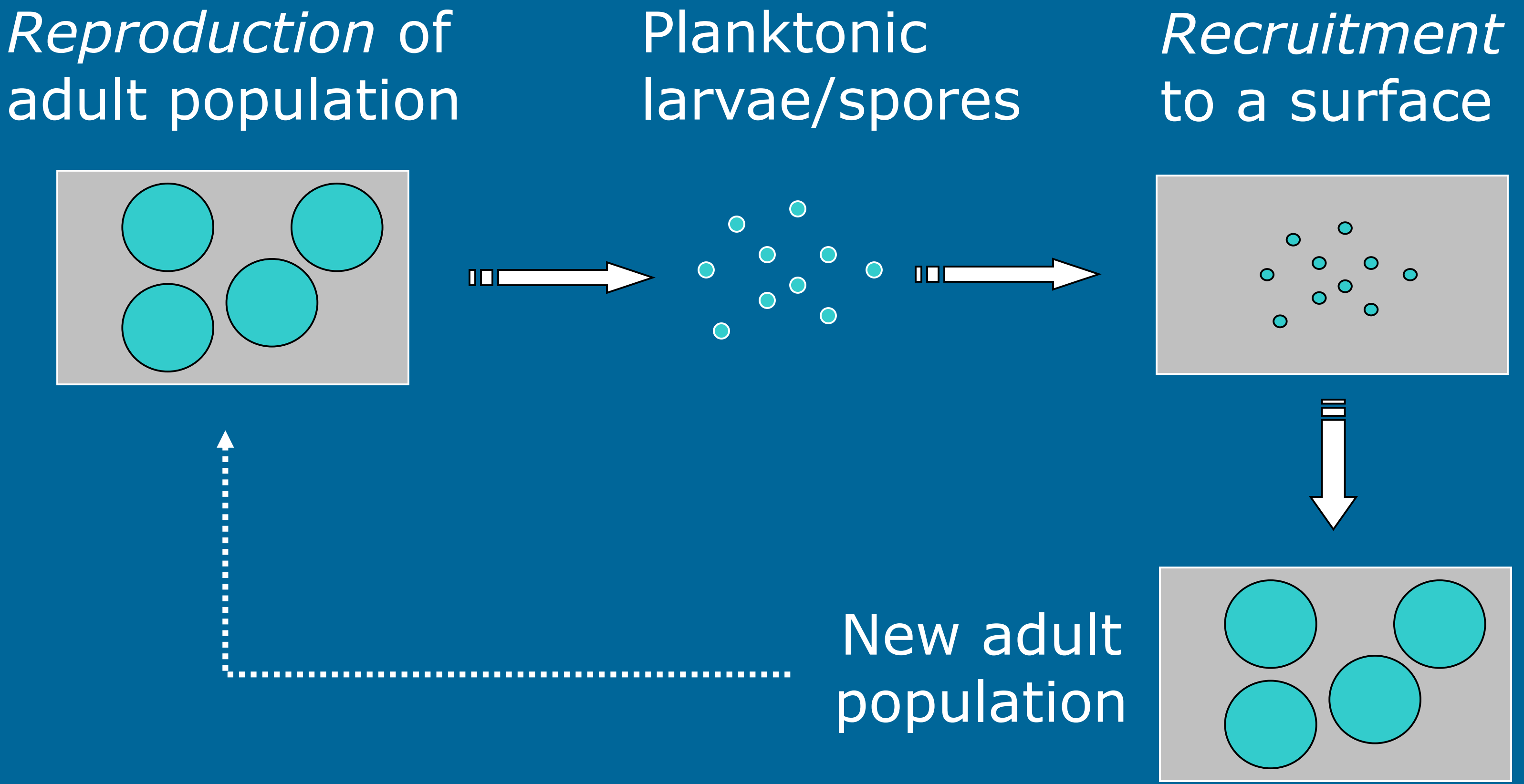
A paper recently submitted to the IMO (BLG 12/11) 2007 reported that "biofouling has been estimated to be responsible for:

- **74%** of non-indigenous marine invertebrates transported to the Hawaiian Islands (Eldredge and Carlton, 2002)
- **42%** of marine species unintentionally introduced into Japan (Otani, 2006)
- **69%** of adventive marine species arrivals in New Zealand, with a further 21% possibly as biofouling or in ballast water (Cranfield et al., 1998)
- **78%** of introduced marine species in Port Philip Bay, Australia (Hewitt et al., 2004)
- More than half of the ship-mediated species introductions into the North Sea (Gollasch, 2002)
- **70%** of the species that have invaded coastal North America via ships have either been moved by biofouling alone, or could have been moved by biofouling and ballast water (Fofonoff et al., 2003)"

Life-history of marine sessile invertebrates

Barnacles

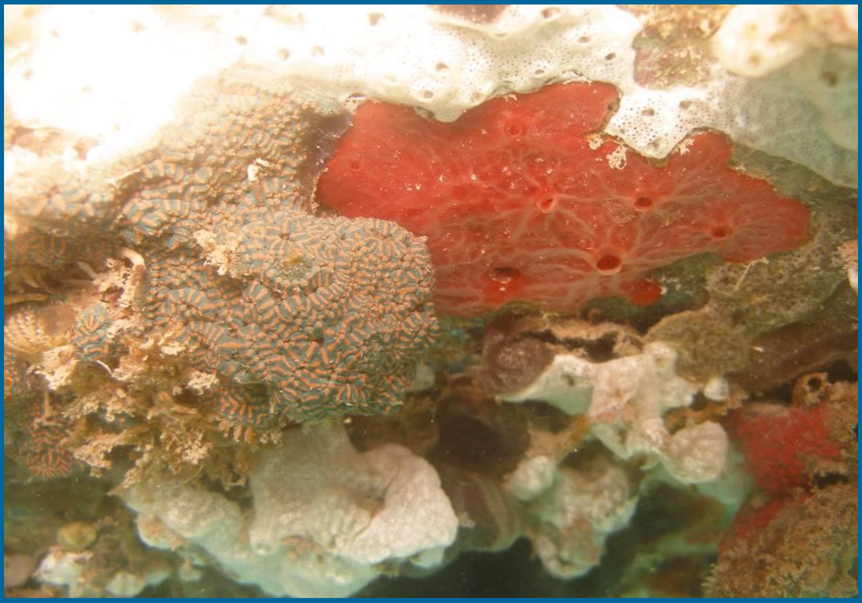
Ascidians



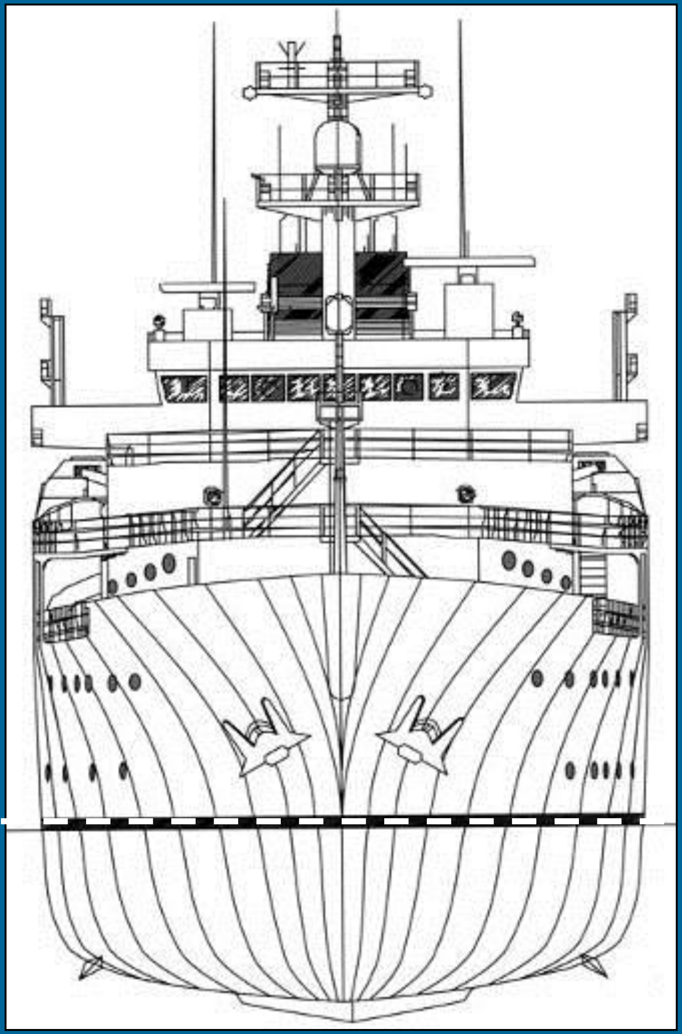
Port structure → Ship hull
Ship hull → Port Structure
Ship hull → Ship hull

Port environments: large amount of artificial hard surfaces – breakwalls, pontoons, pilings, buoys, markers

In the tropics reproduction of marine sessile invertebrates occurs throughout the year – vessels in ports virtually swim in a Larval soup



Ship hulls are diverse and complex habitats

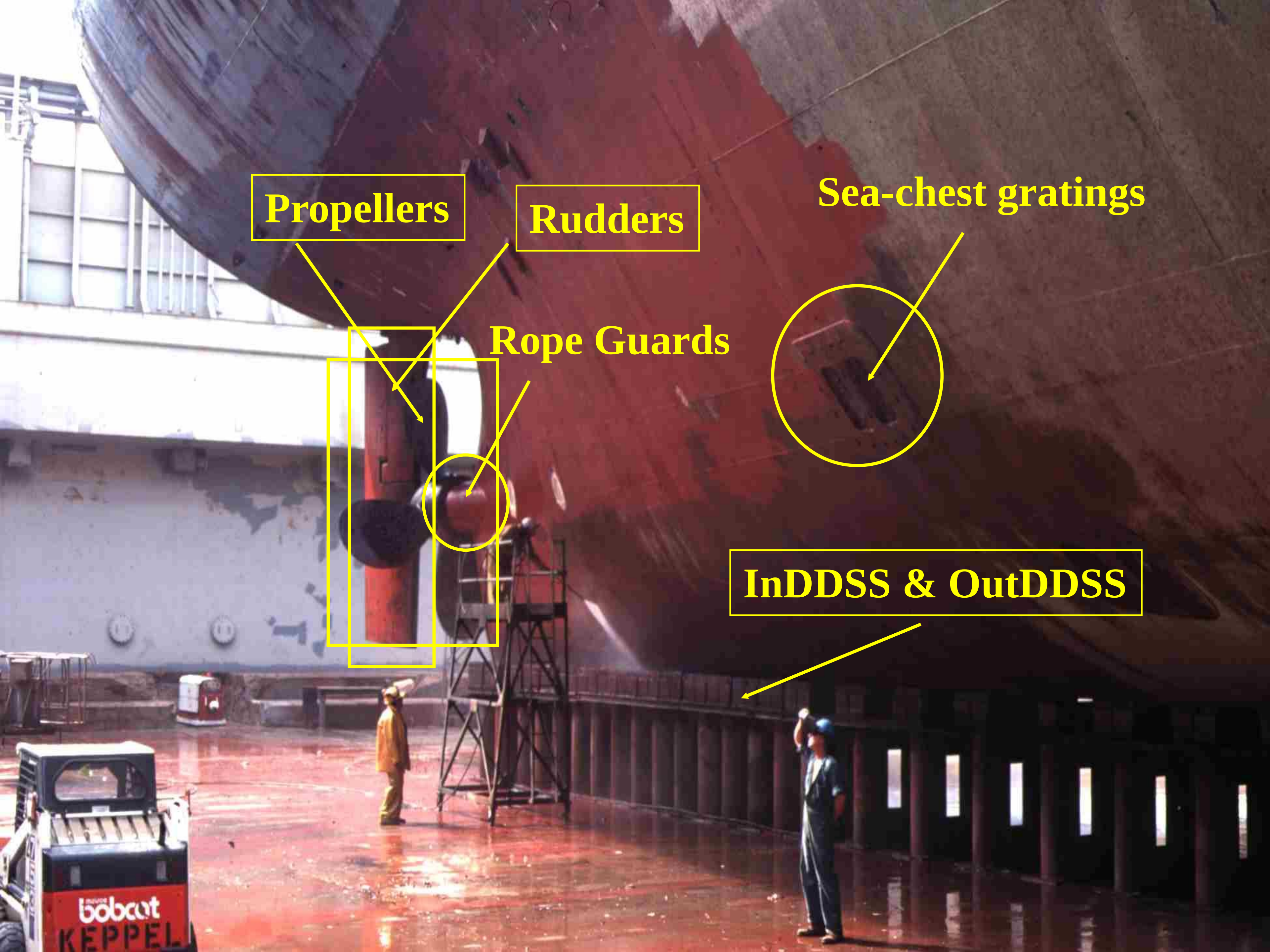


vertical

horizontal

sunlight

shaded



Propellers
Rudders
Sea-chest gratings
Rope Guards
InDDSS & OutDDSS
bobcat
KEPPEL

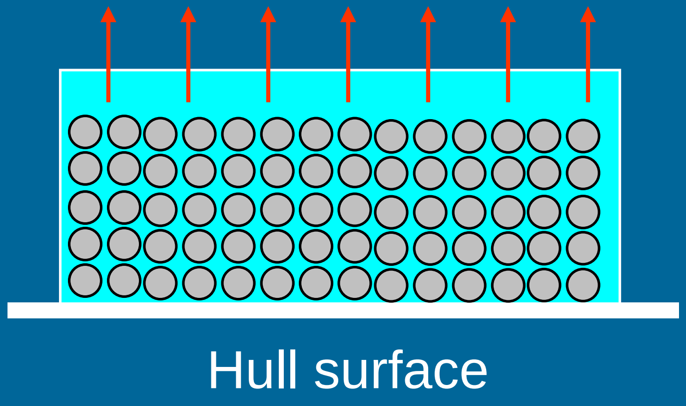
Factors that influence marine growth on ship hulls

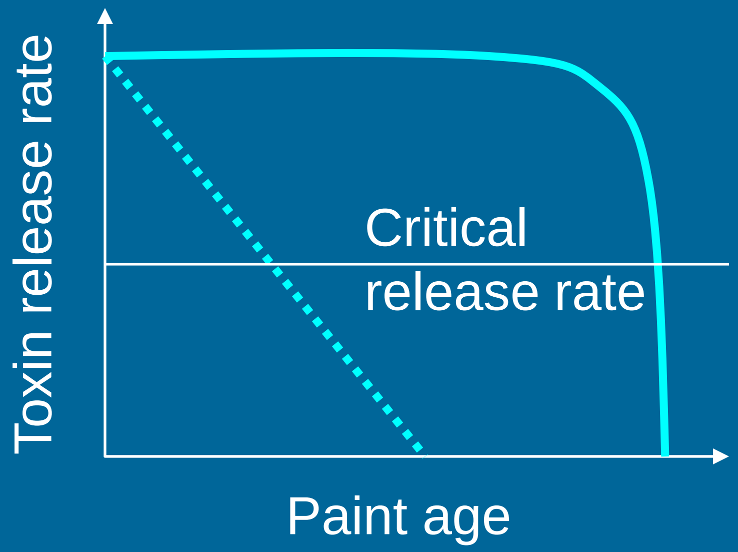
- Characteristics of ships
- Characteristics of source ports
- Biology of fouling organisms

(i) Characteristics of ships

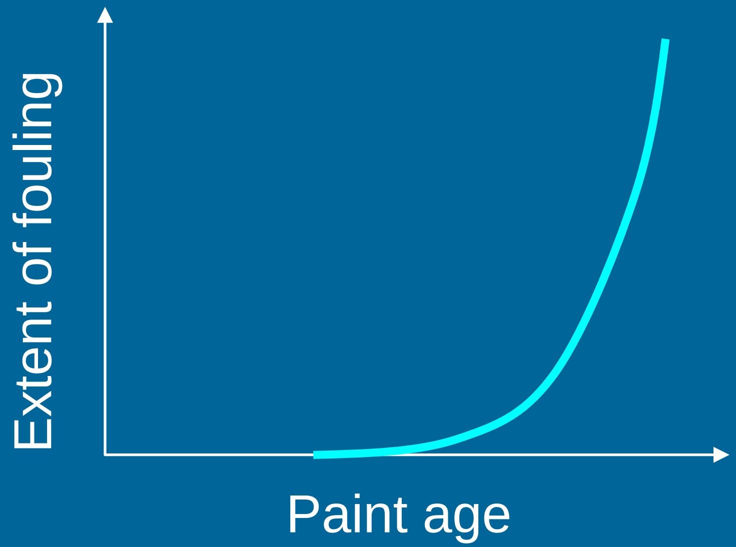
Antifouling paints release biocidal agents that deter or kill marine invertebrate/plant larvae/spores

Tributyltin (TBT) and copper are the most common antifouling toxins. Although TBT is now banned and copper is also toxic to marine life.





Old, ineffectual antifouling paint will NOT protect vessel hulls from colonization

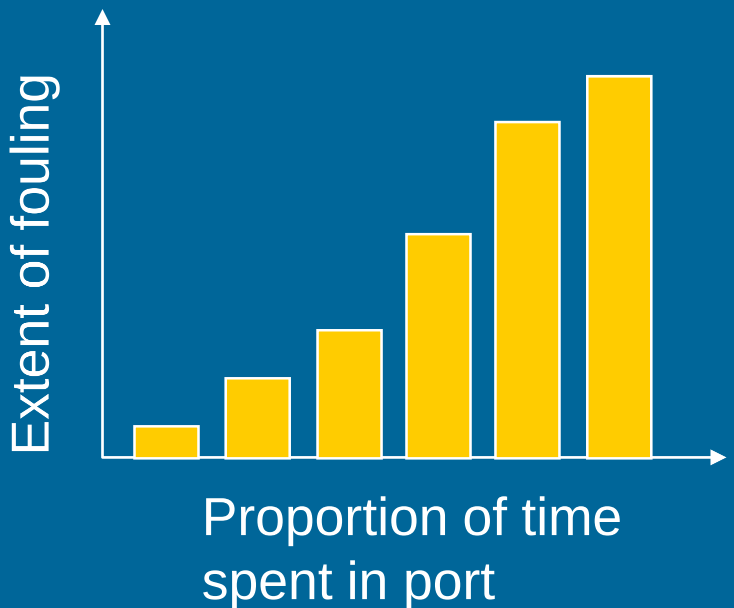


Antifouling paints work, but many vessel operators do not renew them at appropriate intervals

Areas devoid of antifouling paint (e.g. dry-docking support strips) are NOT protected from fouling

Wear of antifouling paint is NOT the same across the hull

Full steam ahead: most antifouling paints work best on vessels that are very ACTIVE



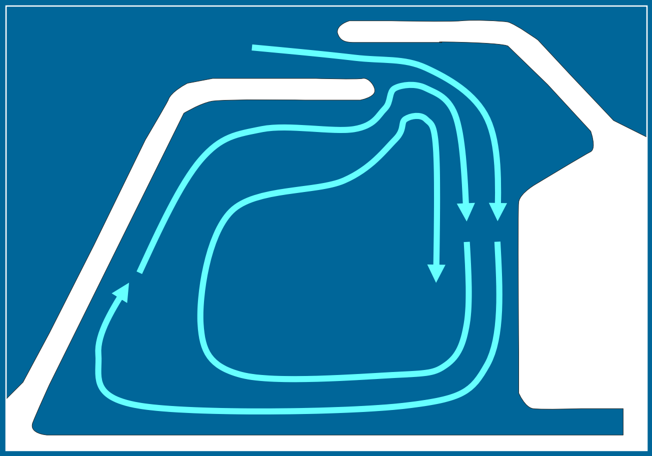
Movement of water (drag) required for proper working of many antifouling paints (ablative)

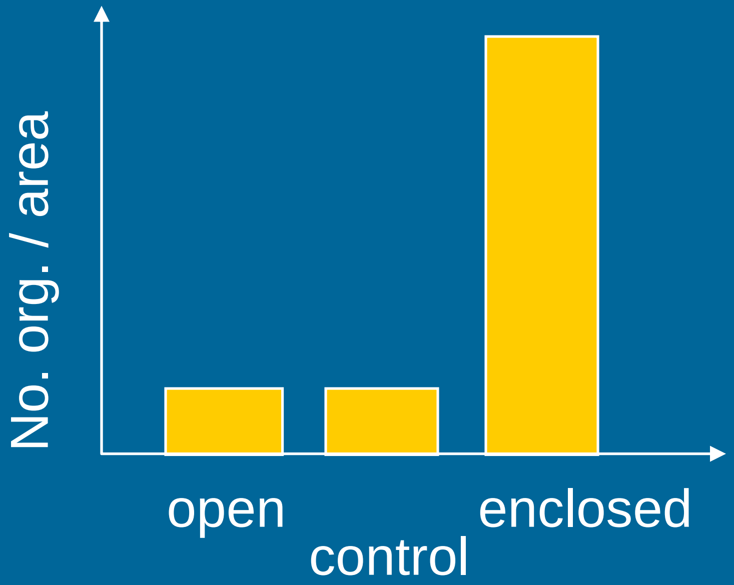
Far more larvae/spores in coastal waters than open ocean

More difficult to attach to moving ships

(ii) Characteristics of port environments

Port design / architecture





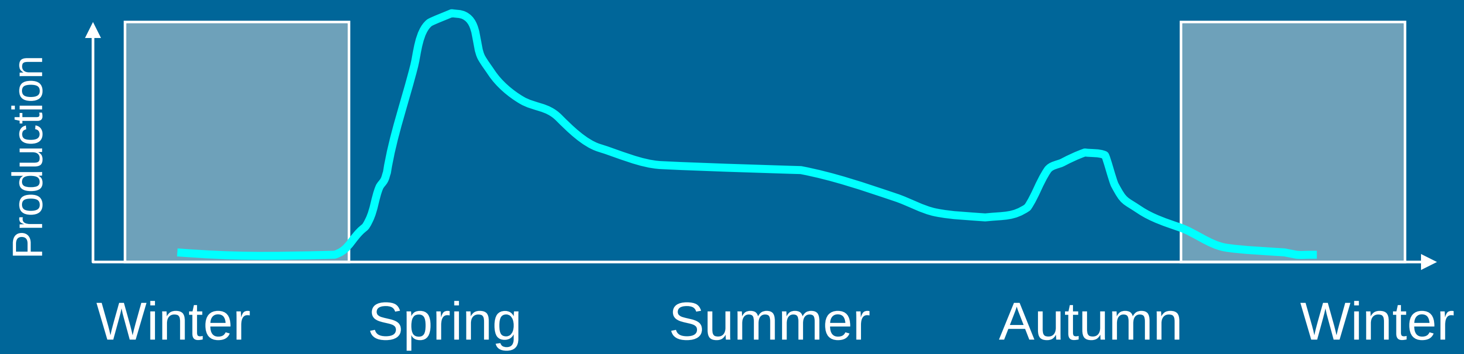
Semi-enclosure of ports by breakwalls “traps” water within the port basin. It also traps reproductive propagules and can elevate levels of recruitment up to **19-fold** compared to open ports and control locations (open areas, no ports) (Floerl, 2005)

Open ports

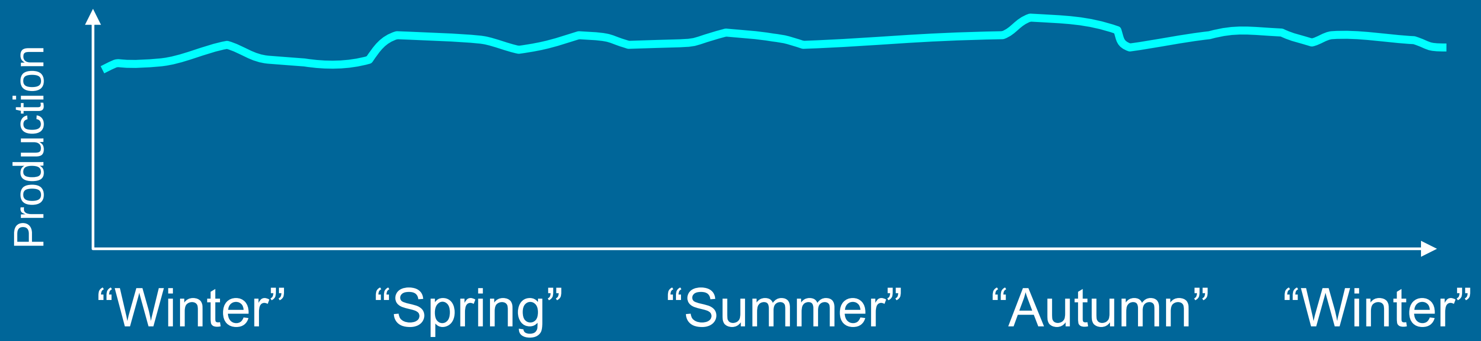
Enclosed ports

Availability of reproductive propagules

- Temperate ports



- Tropical ports



(iii) Biology of sessile organisms

Bryozoan: Watersipora sp.

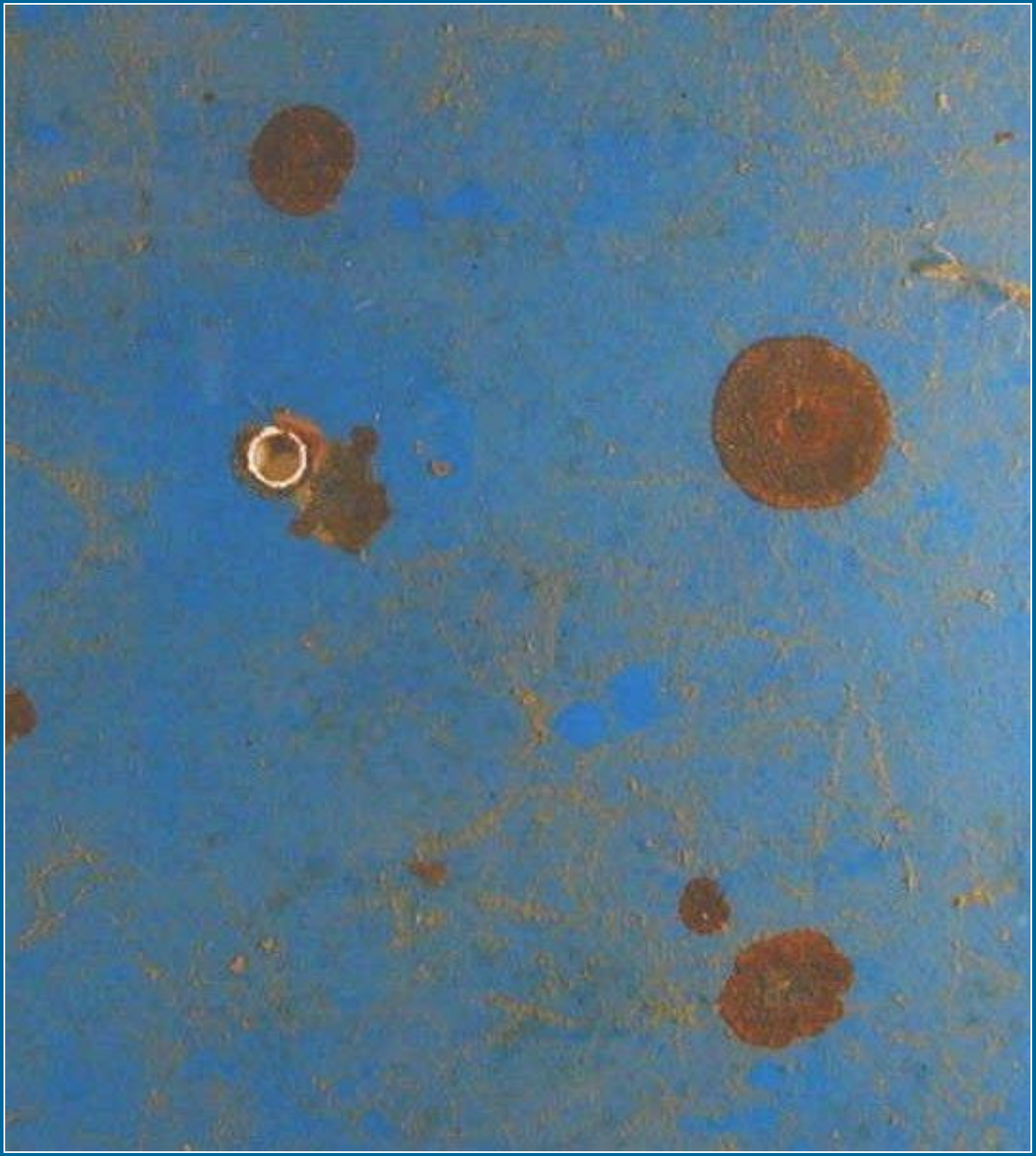
Frequently occurs on ship hulls and in port environments

Has far higher tolerance to copper than other hull fouling species

Can settle on brand-new antifouling paint

Facilitates transport of other taxa by epibiosis !!!

Photo: Cawthron Institute



Summary

Marine fouling will (eventually) occur on ANY surface submersed in the sea

Ship hulls provide a vast and diverse habitat for marine sessile organisms

The nature and extent of fouling depends on factors associated with

- the ships (antifouling paint, activity pattern),
- the port environment (design, location), and
- the biology and physiology of available organisms