# Metals in the Solent

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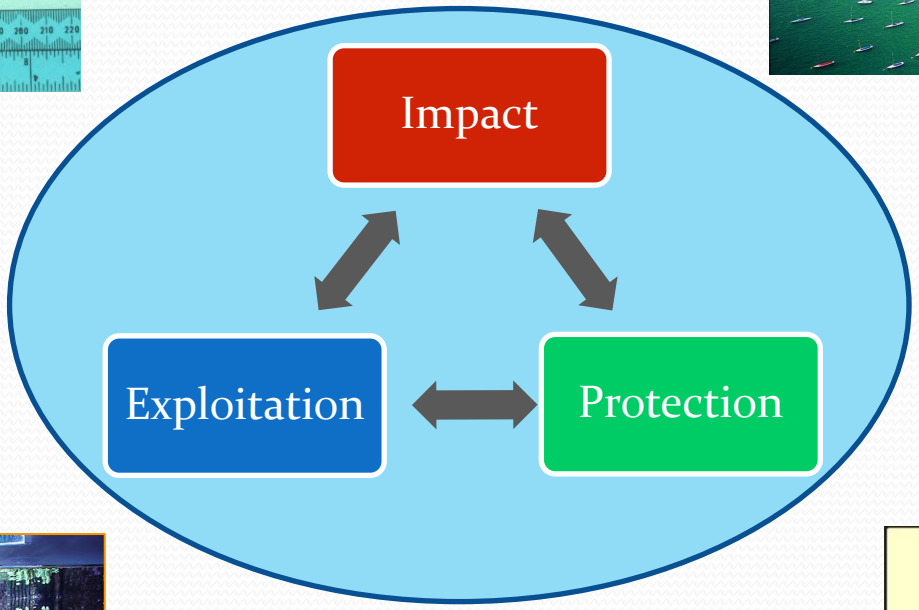
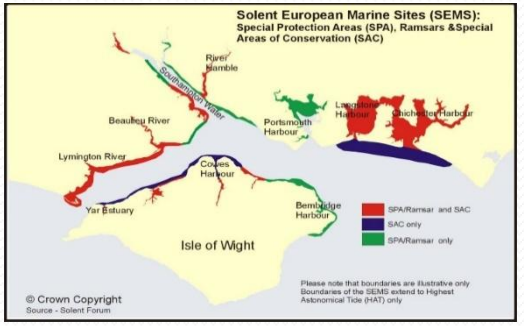
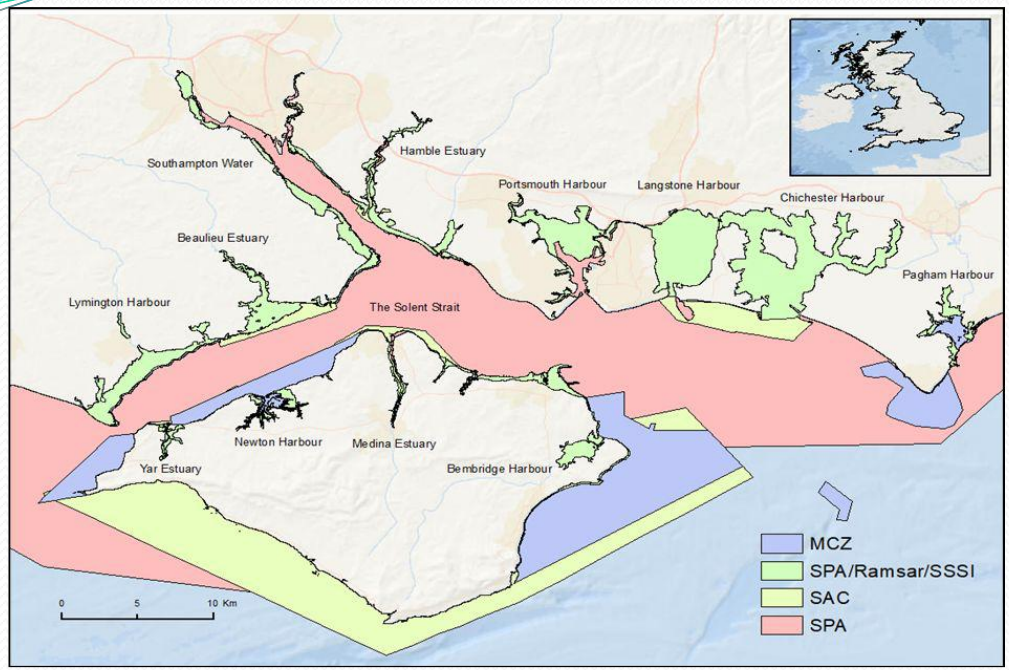
# Research theme: human interactions with the marine environment

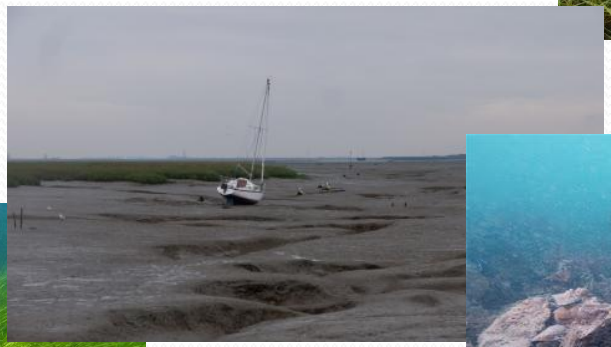



# Which habitats are important?

# Key Solent habitats



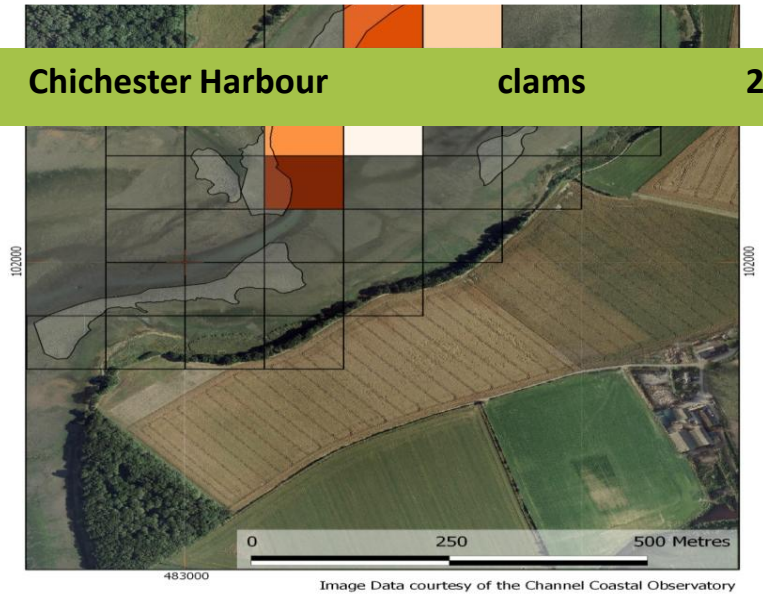



# Why are they important?

# Benthic fisheries


# Value and landings

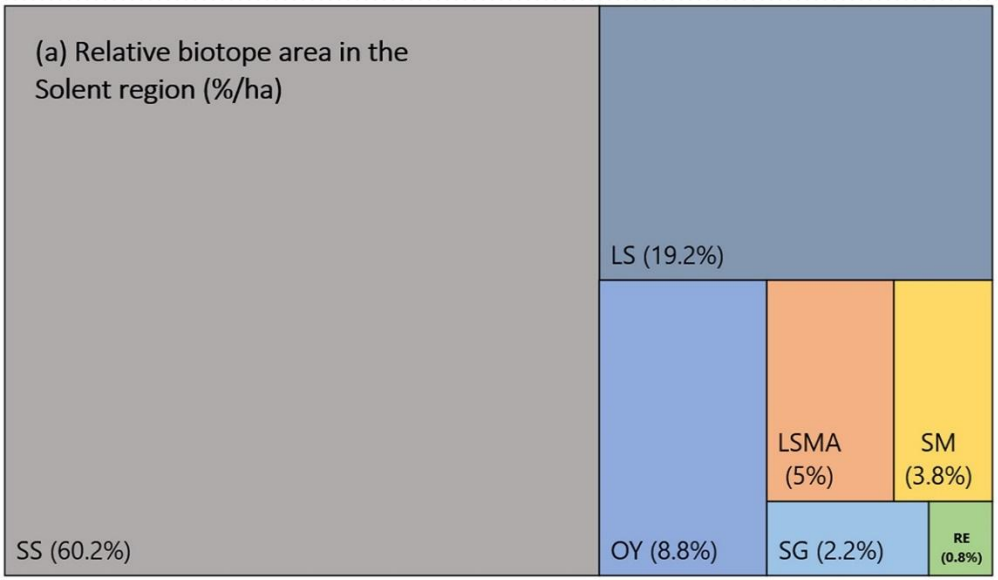
| Location/Site | Species | Date | Total biomass (t) removed $y^{-1}$ | Retail price (£) $kg^{-1}$ | Biomass value (£) removed $y^{-1}$ |
|---|---|---|---|---|---|
| Dell Quay, UK | *A. virens* | 2012 | 4.9 | 33 | 164,000 |
| UK | All polychaetes | 2013 | 2,977 | 33 | 152,000,000 |
| UK (UK vessels) | *H. gammarus* | 2013 | 3,000 | - | 105,000,000 |
| Global | All polychaetes | 2015 | 121,000 | 49 | 5,500,000,000 |
| Global, FAO database | Marine worms | 2012 | 353 | - | - |
| Chichester Harbour | clams | 2023 | 27 | - | 550,000 |

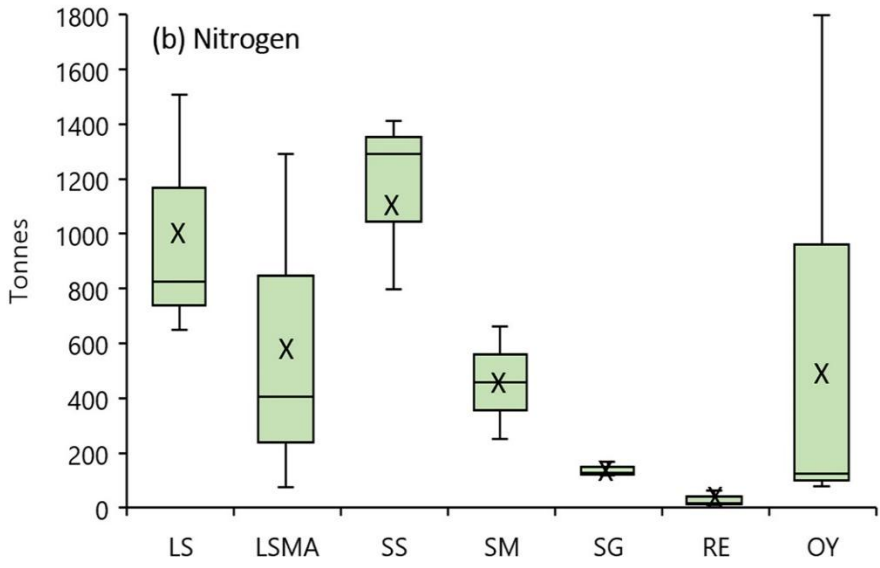


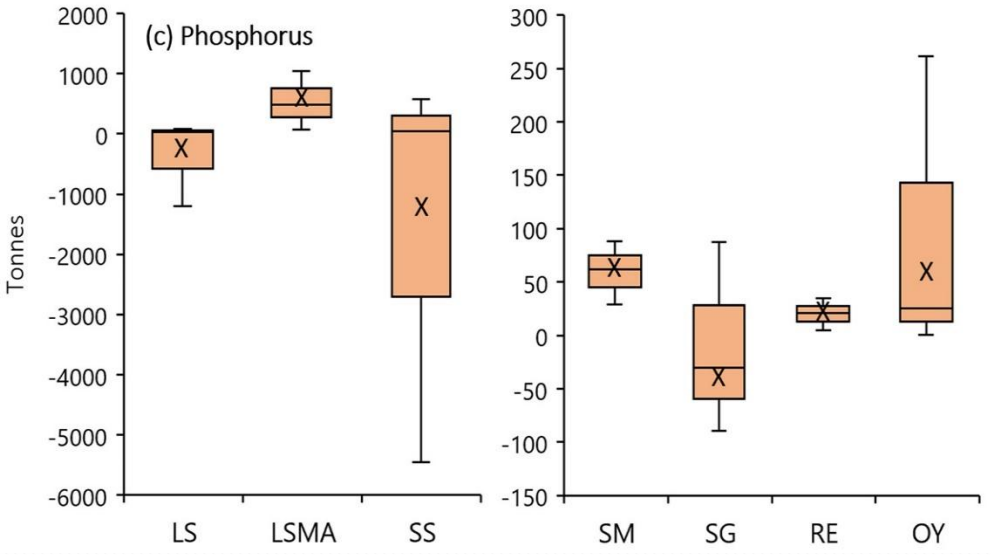

Russel and Watson, 2025

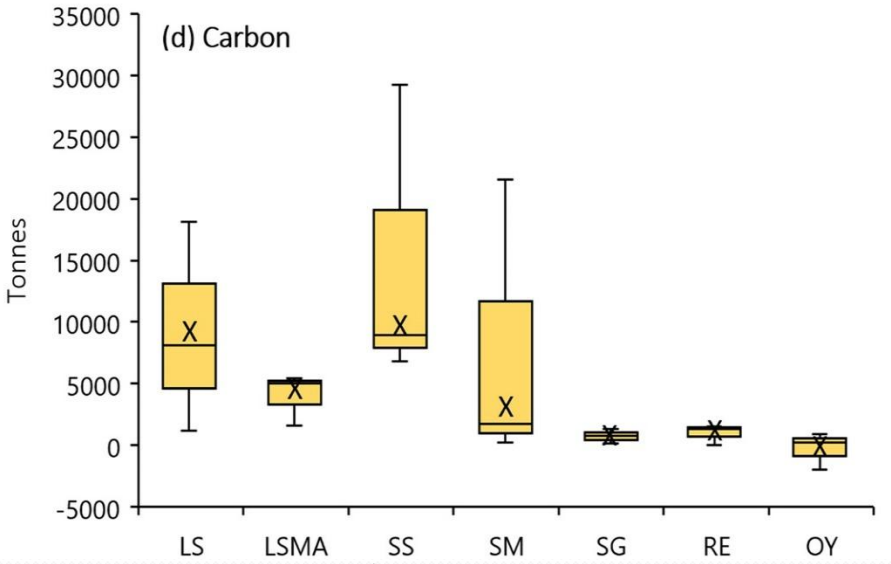
Watson et al. 2016, Fish & Fisheries

# Ecosystem goods & services



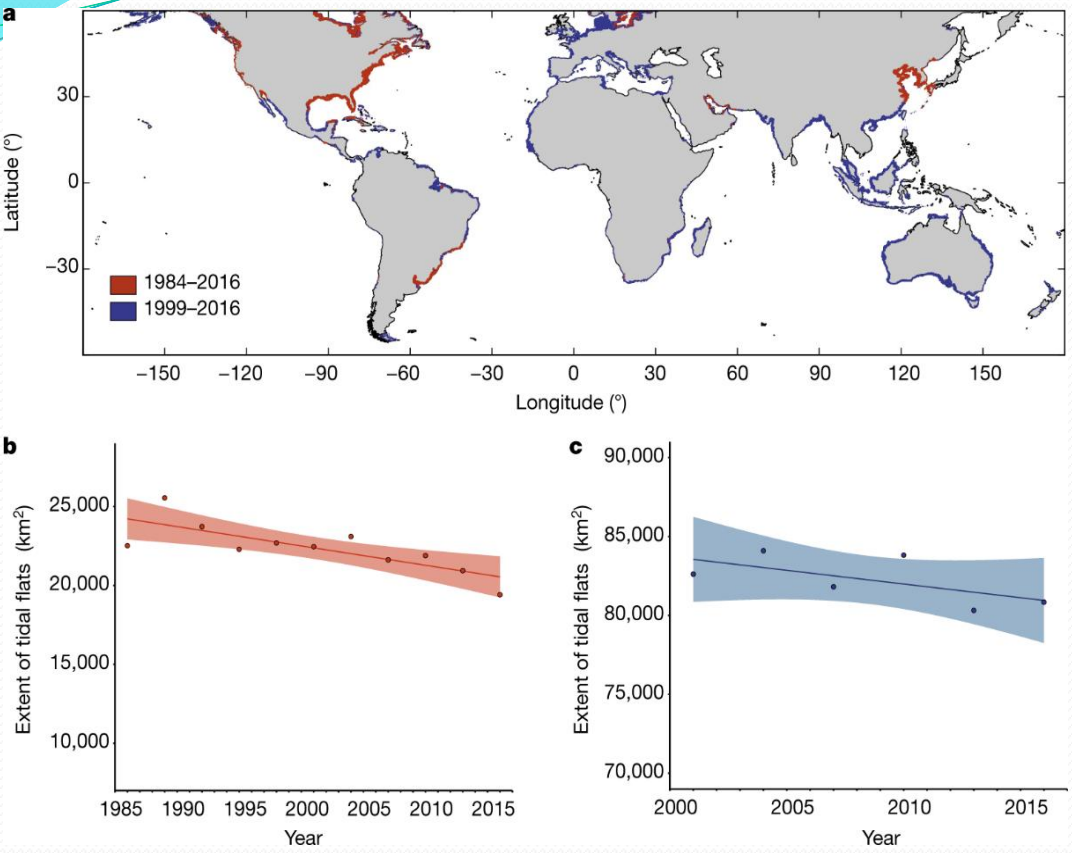



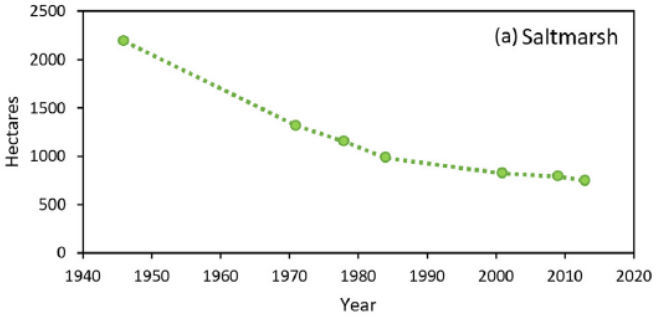




Watson et al. 2020, Sci. Tot. Environ.

# Other goods & services


# Current state



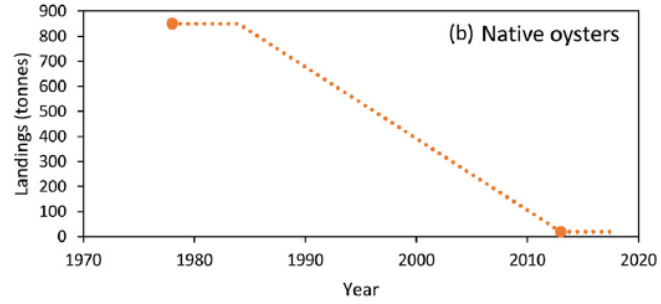
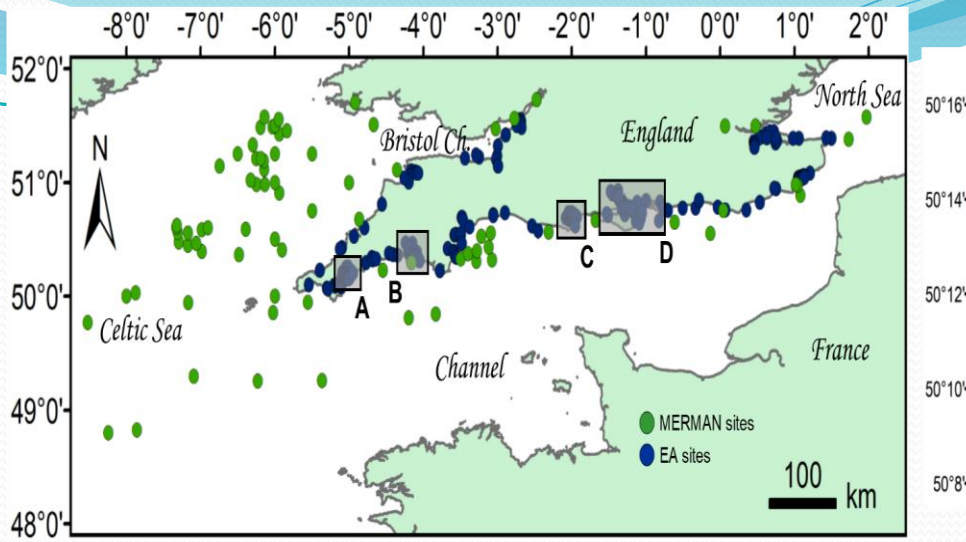




**Fig. 2.** Historic changes in SEMS biotopes (3a) saltmarsh (3b) native oyster landings (3c) littoral sediments with macroalgal mats. Historic saltmarsh data (ha $yr^{-1}$) were sourced from: Haskoning (2004), Cope et al. (2008) and combined for Lymington, Southampton, Portsmouth, Langstone and Chichester. Littoral mudflat with macroalgal mat comparison data (ha $yr^{-1}$) were sourced from the Environment Agency. Native oyster landings were predicted using a moving average based on data from (Key and Davidson, 1981; Pogoda et al., 2019).

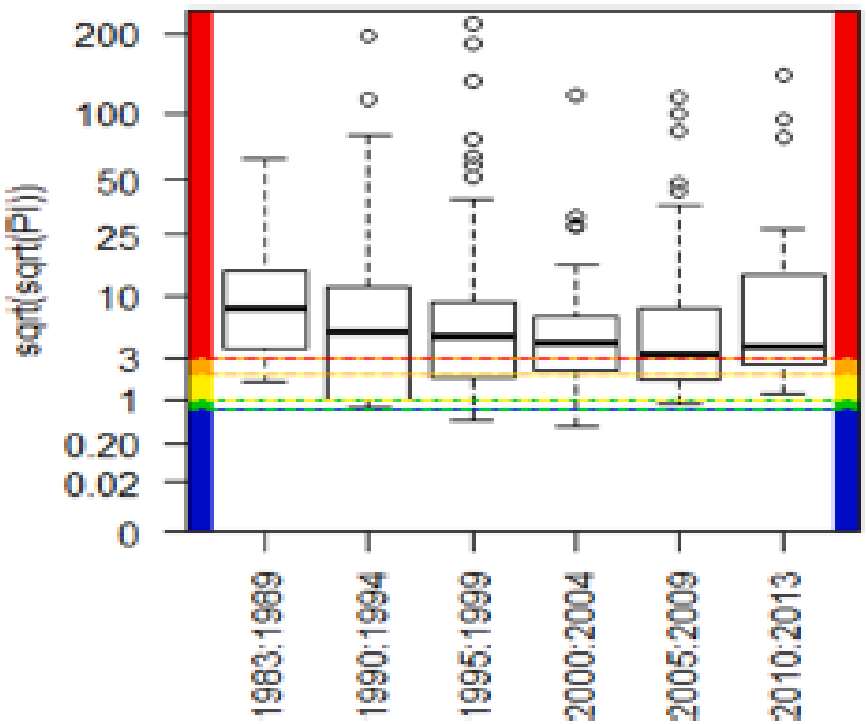
Murray et al. 2018

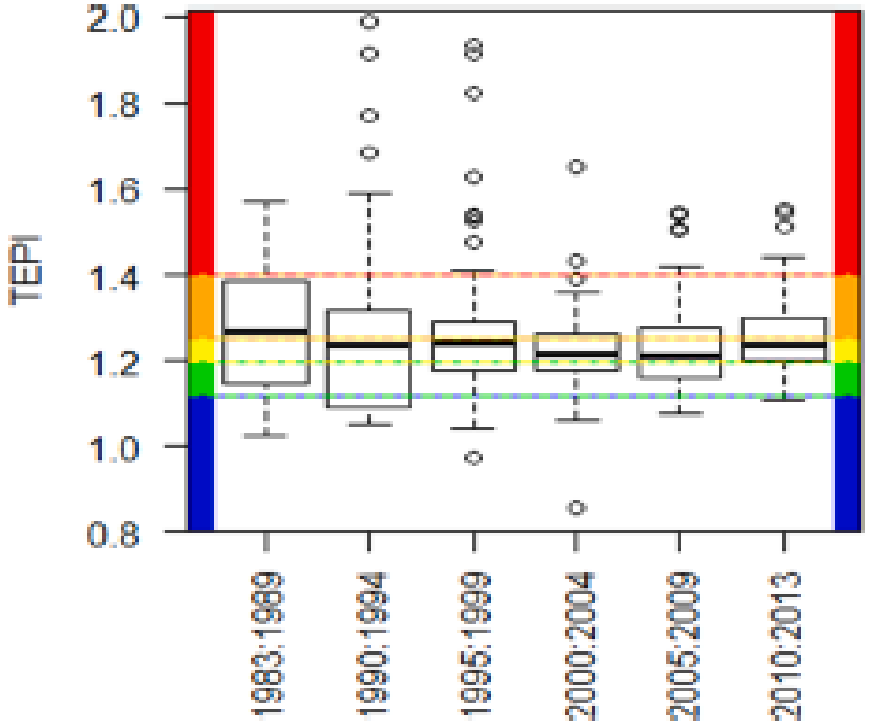
Watson et al. 2020, Sci. Tot. Environ.

# Decadal changes in metals




J. Richir et al.




Richir et al. (2021) Env. Int.

# Metal changes

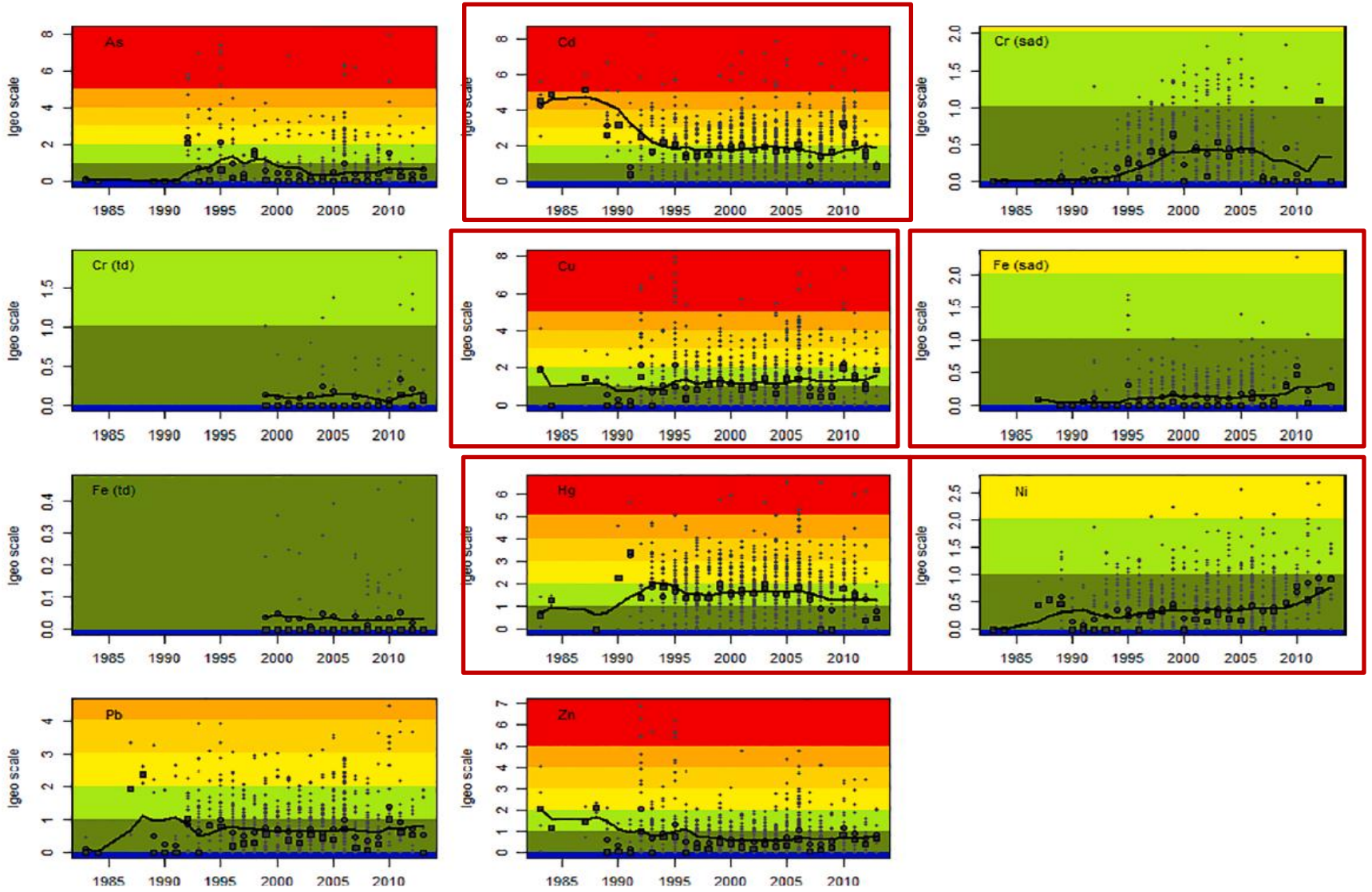



**Fig. 2.** TE sediment contamination evolution using the 7-level Geoaccumulation Index (Igeo) pollution scale classifying sediment from unpolluted (blue) to very strongly polluted (red) (see Table 1 and Müller, 1986 for details). Dark squares: annual medians; dark circles: annual means; light grey crosses: site-specific annual means; full black lines: 5-year moving averages. Digestion techniques: strong acid digestion (sad) or total digestion (td) are specified and considered separately for Cr and Fe. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

# Solent: metal concentrations

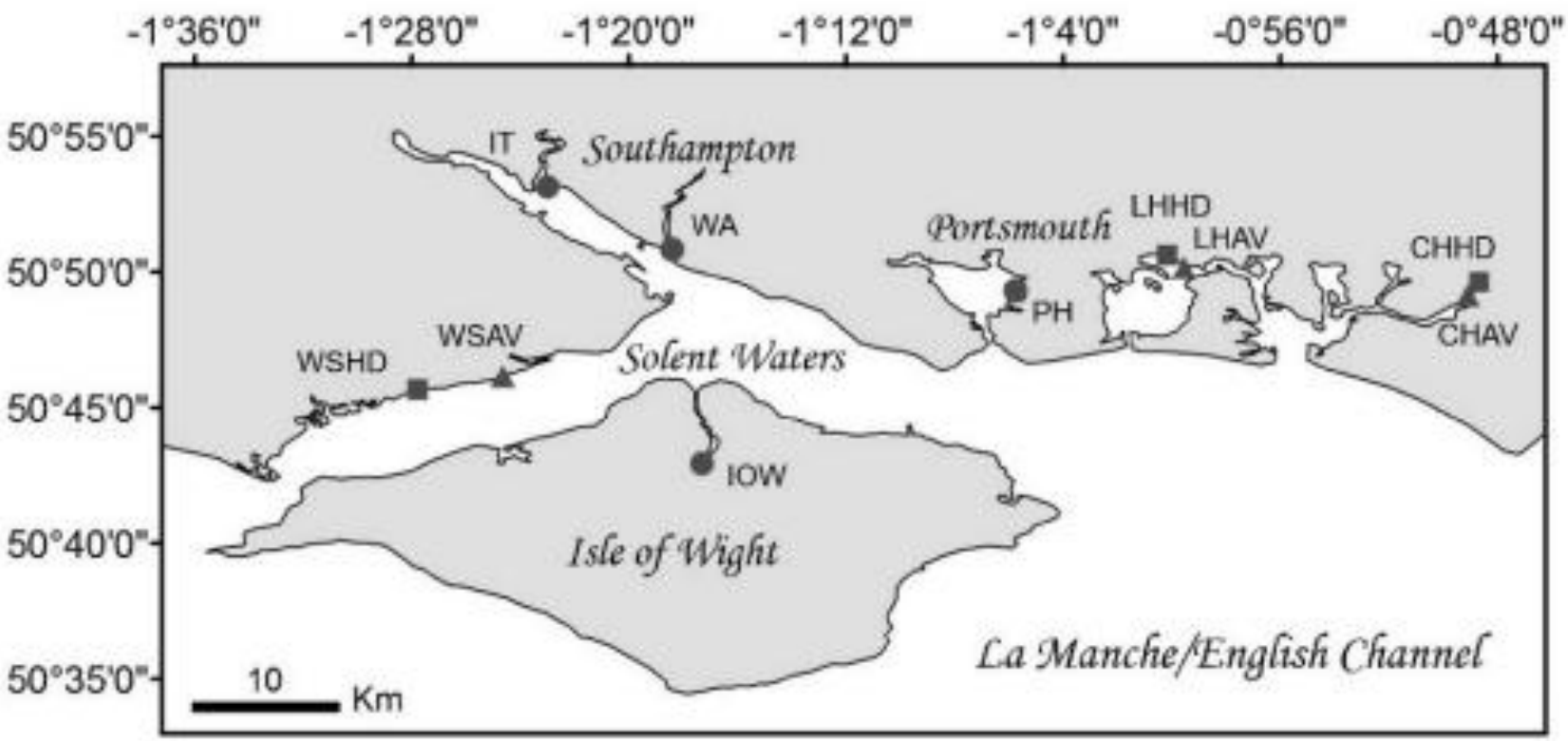
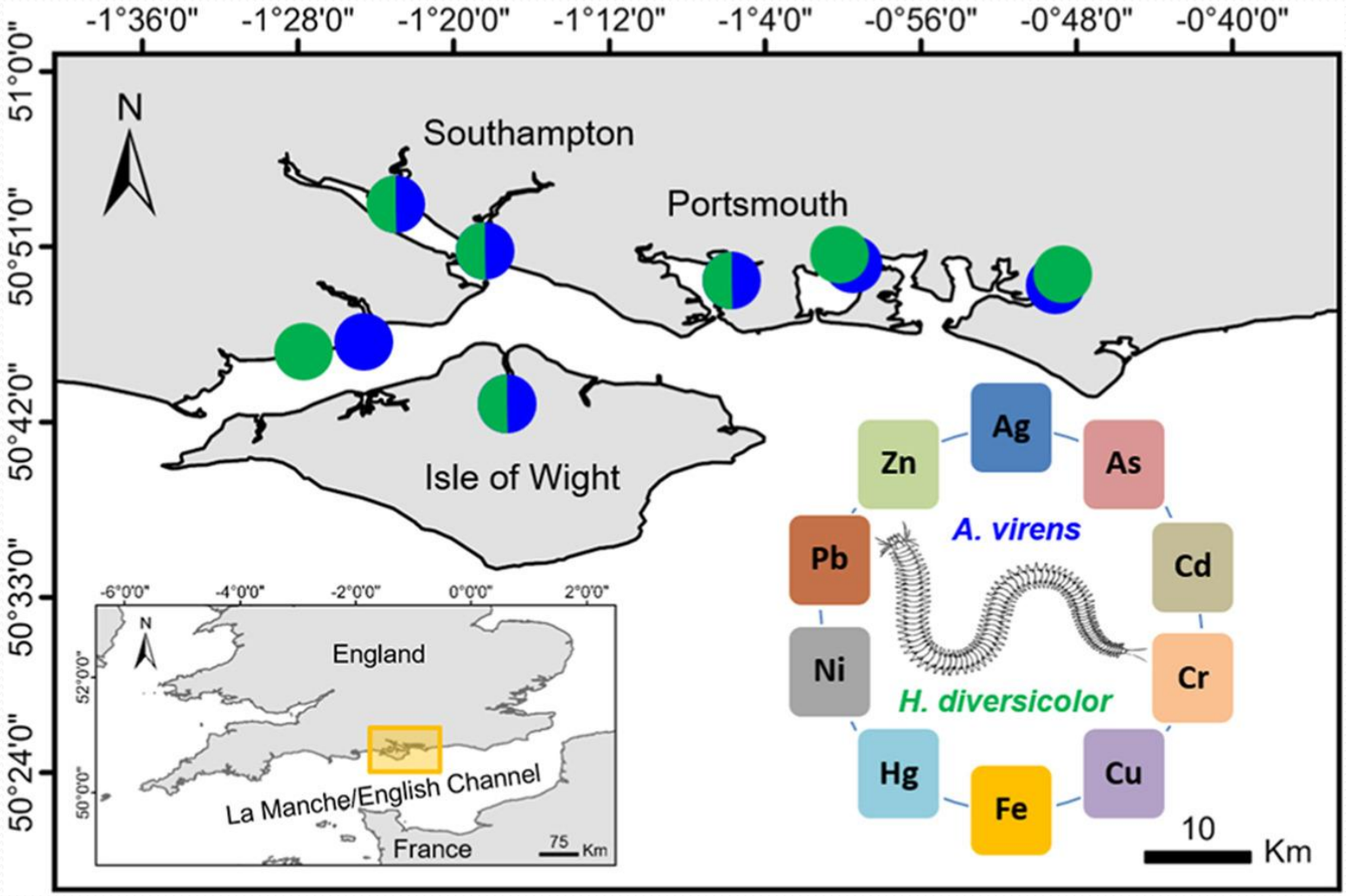



**Fig. 1.** Map of the site locations sampled for sediment and worm collection. Labels correspond with site descriptions (Table 1). Circles represent sites where both species were collected, squares and triangles represent *H. diversicolor* and *A. virens*, respectively.

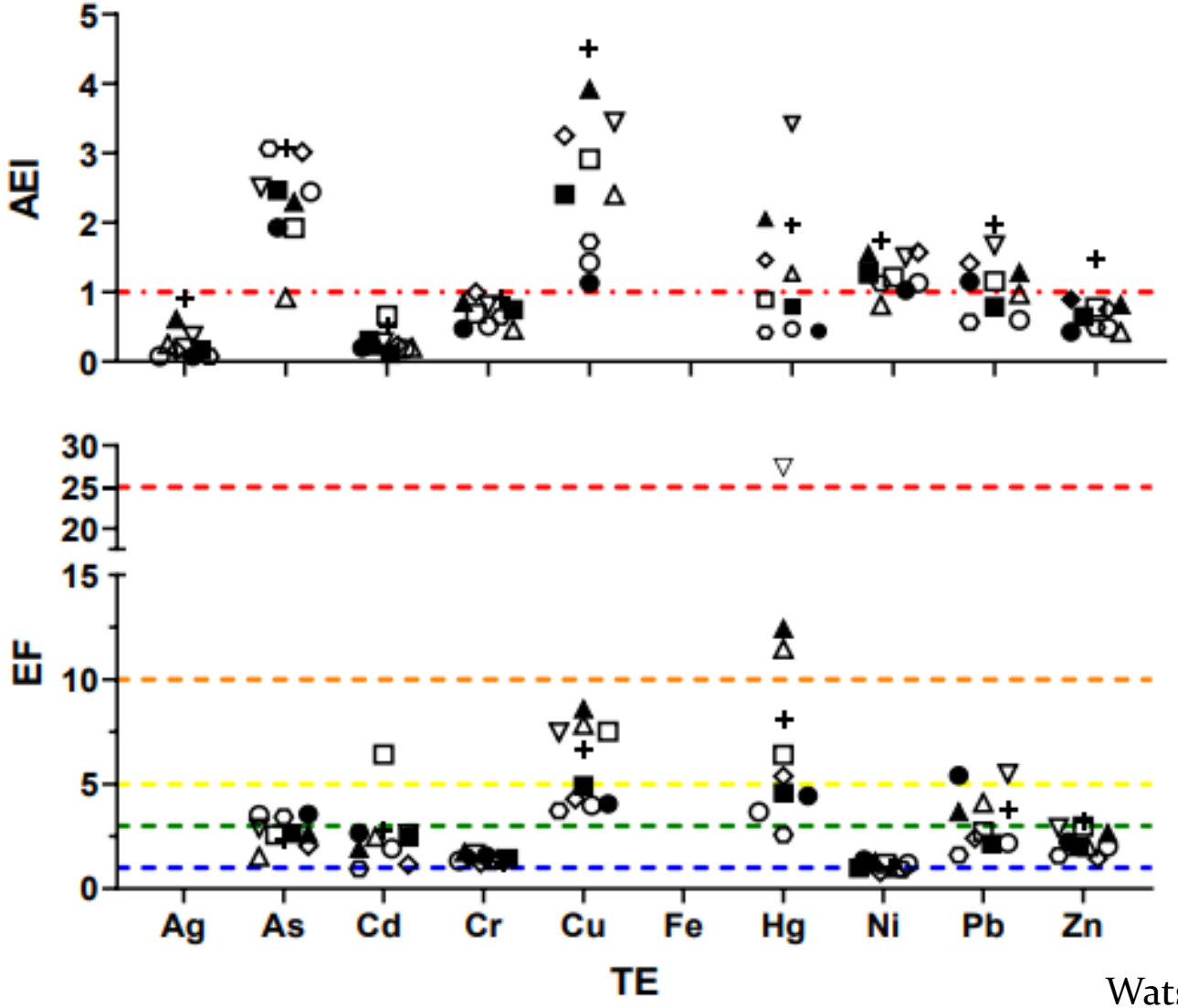
Watson et al. 2025

# Solent: metal concentrations




Watson et al. 2025

# Metal enrichment and toxicity

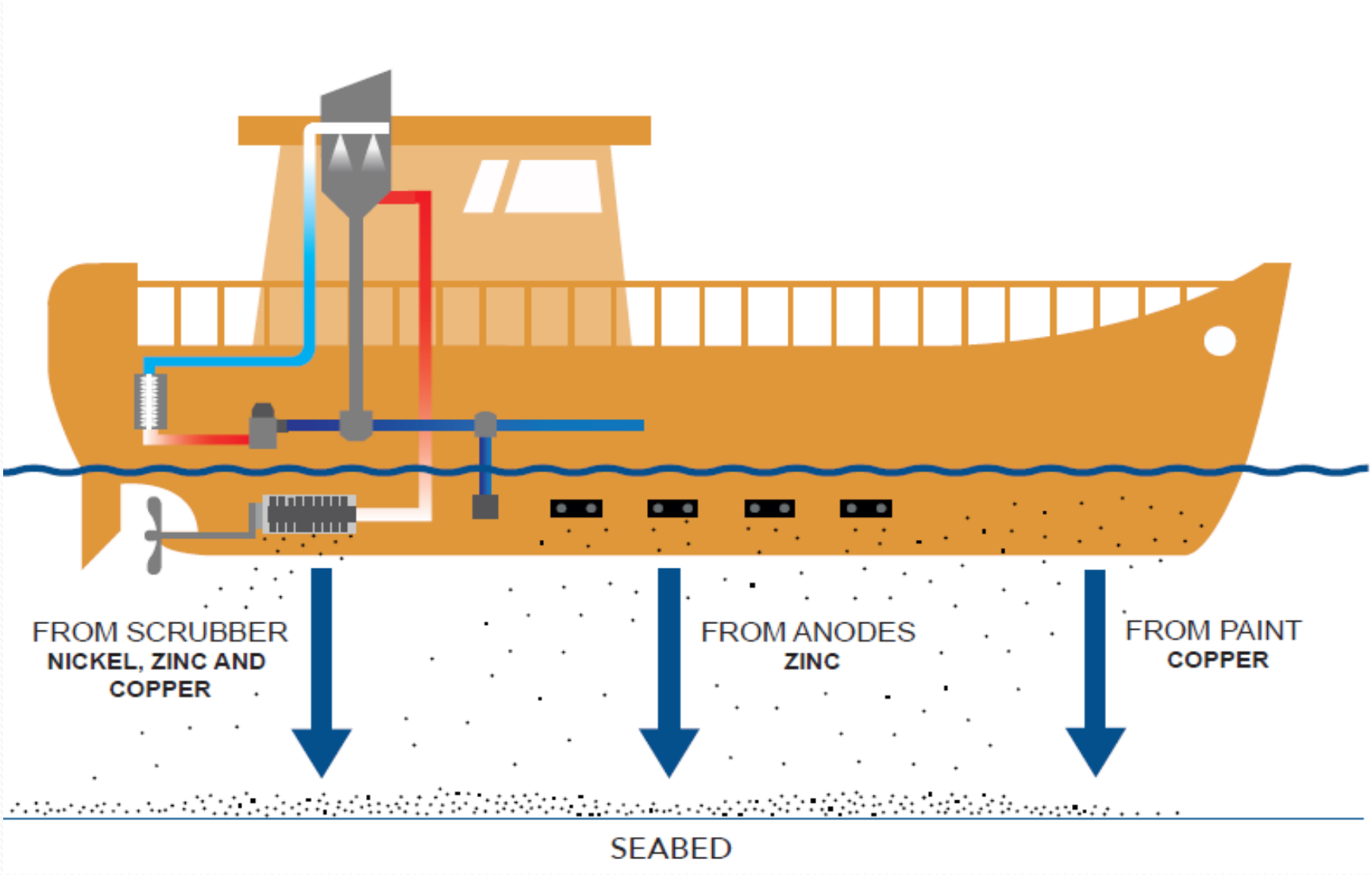



Watson et al. 2025

# Metal uses

INTERNATIONAL MARITIME ORGANIZATION

# Metal sources



# Estimates of numbers

| Vessel numbers | Time frame | Area | Mean (m) / count |
|---|---|---|---|
| All on water | Day | Solent | 13,351 |
| AIS screen grab | Day | Solent | 284 (m) |
| | | | |
| Rec. vessels (2018) | - | UK | 546,818 |
| Rec. vessels (2018) | - | Europe | $5.8 \times 10^6$ |
| Rec. vessels (2018) | - | World | $31.6 \times 10^6$ |
| | | | |
| Merchant fleet (2020) | - | World | 98,060 |

Richir et al. (2021) Env. Int.

# Input sources

| Method | Source | Input region | 2020 Copper | 2040 Copper | 2020 Zinc | 2040 Zinc | 2020 Nickel | 2040 Nickel |
|---|---|---|---|---|---|---|---|---|
| AF | All vess. | Solent | 94 | 153 | 27 | 39 | - | - |
| Anode | All vess. | Solent | - | - | 349 | 503 | - | - |
| Scrubbers | Merchant (AIS only) | Solent | 0.4 | 5 | 0.8 | 9 | 0.2 | 2 |
| | | | | | | | | |
| OSPAR Riv. + dir. | UK | UK | 296-338 | - | 1,028 | - | - | - |
| Atmospheric | UK | UK | 269 | - | 460 | - | 98 | - |

Richir et al. (2021) Env. Int.

# Other metal sources

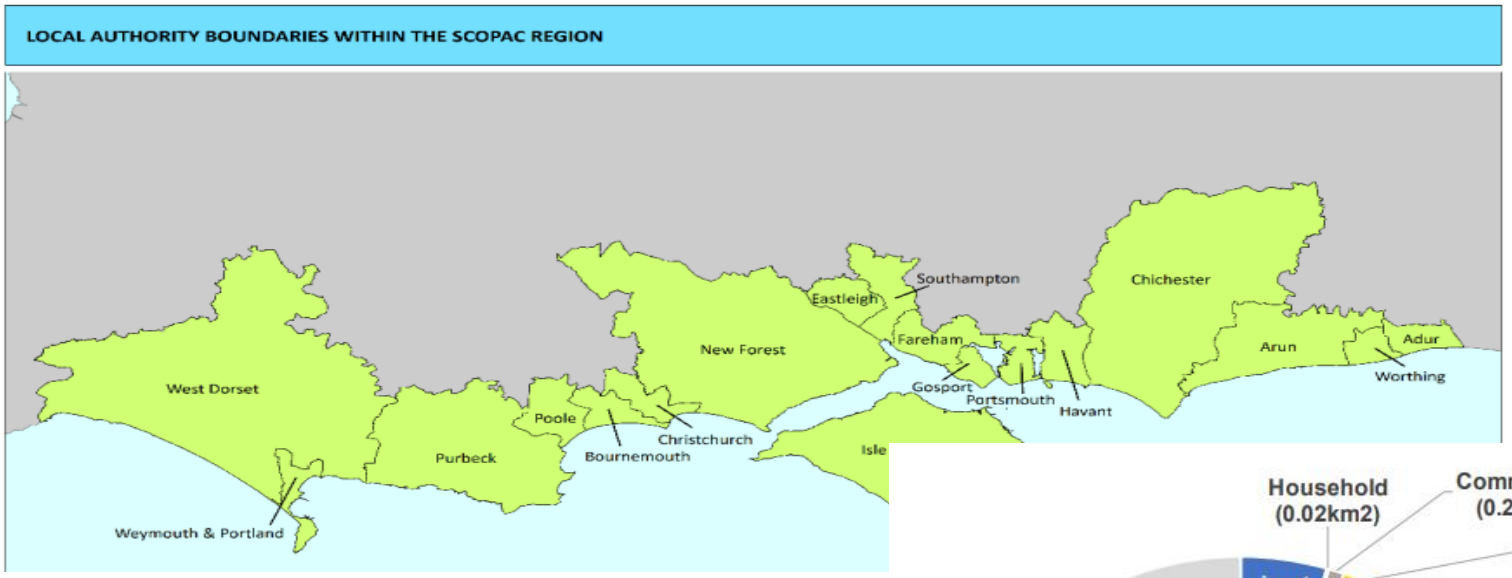
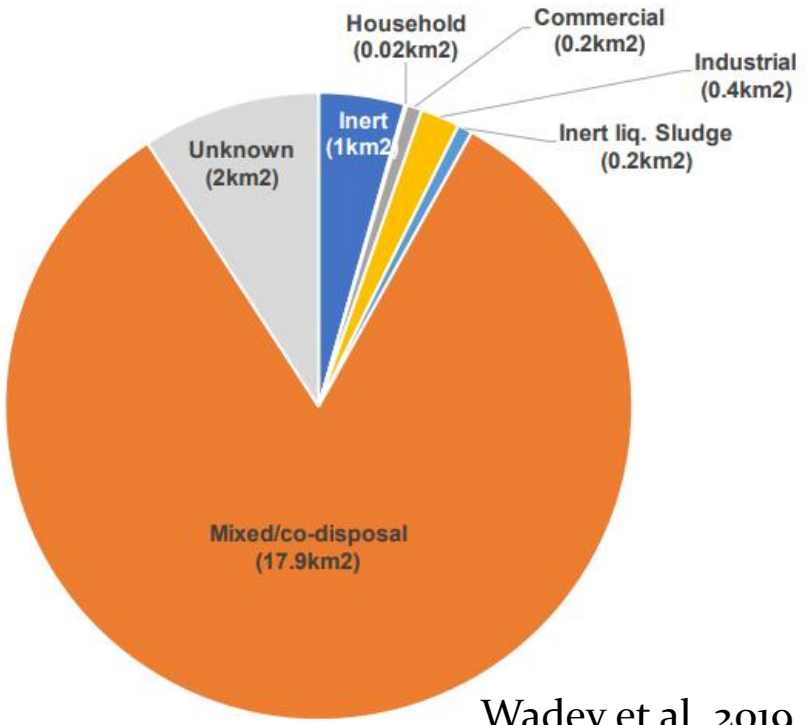



**Table 4.4 Landfill at risk of flooding and/or erosion**

| Risk | No. of landfills | Area of landfill ($km^2$) | Length of shoreline in front of these landfills (km) |
|---|---|---|---|
| Flooding or erosion | 144 | 22 | 86 |
| Erosion only (over the next century) | 108 | 19 | 68 |
| Erosion only – high risk (at the coast now) | 89 | 14 | 64 |
| Tidal flooding only | 136 | 22 | 85 |
| Both erosion & flooding | 106 | 19 | 77 |
| Both erosion (high risk) & flooding | 86 | 14 | 64 |




Wadey et al. 2019

## CASE STUDY SITE - FAREHAM


**FAREHAM**

Aerial Photography: ESRI (2017)

**SMP Erosion Limits & Policy**

- NAI 0 - 20 years
- NAI 20 - 50 years
- NAI 50 - 100 years
- EA Flood Zone 3 (0.5% AEP)
- Landfill Sites

**ST** Short term (0 - 20 yrs) **MT** Medium term (20 - 50 yrs) **LT** Long term (50 - 100 yrs)
**HTL/ATL** Hold/Advance the line **MR** Managed realignment **NAI** No active intervention

N

0 0.25 0.5 km

EASTERN SOLENT | COASTAL PARTNERSHIP

Wadey et al. 2019

## CASE STUDY SITE - HAVANT


**HAVANT**

**SMP Erosion Limits & Policy**

- NAI 0 - 20 years
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- EA Flood Zone 3 (0.5% AEP)
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EASTERN SOLENT | **COASTAL PARTNERSHIP**

Wadey et al. 2019

# Impacts

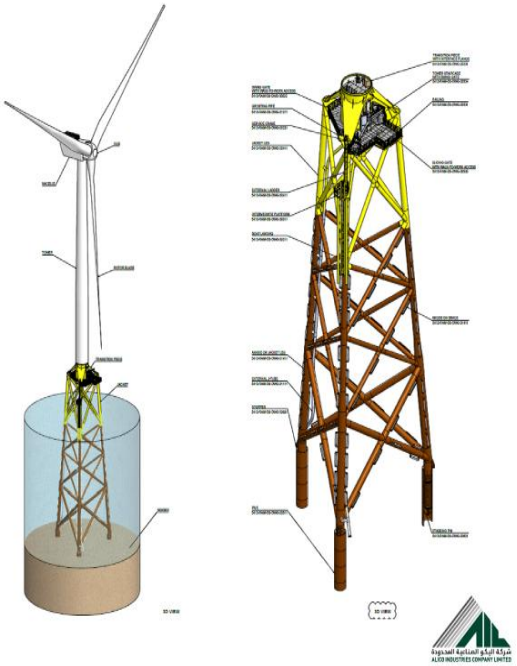




Figure 1. Mean percentage tail DNA damage (± SEM) per box for each treatment and time point and for worms collected from field sites. Mesocosm: n=3 boxes per sampling point, except for HCZ 6 month and HC 9 month which were 2 boxes and 1 box for HCZ 9 months. Number of worms sampled per box varies from 1 to 5 (mean of 2.4) Field sites were sampled between July-September 2013 with 6 worms sampled from each site, except Langstone Harbour with 5

Pini et al. (2018) Env. Poll.

# Impacts

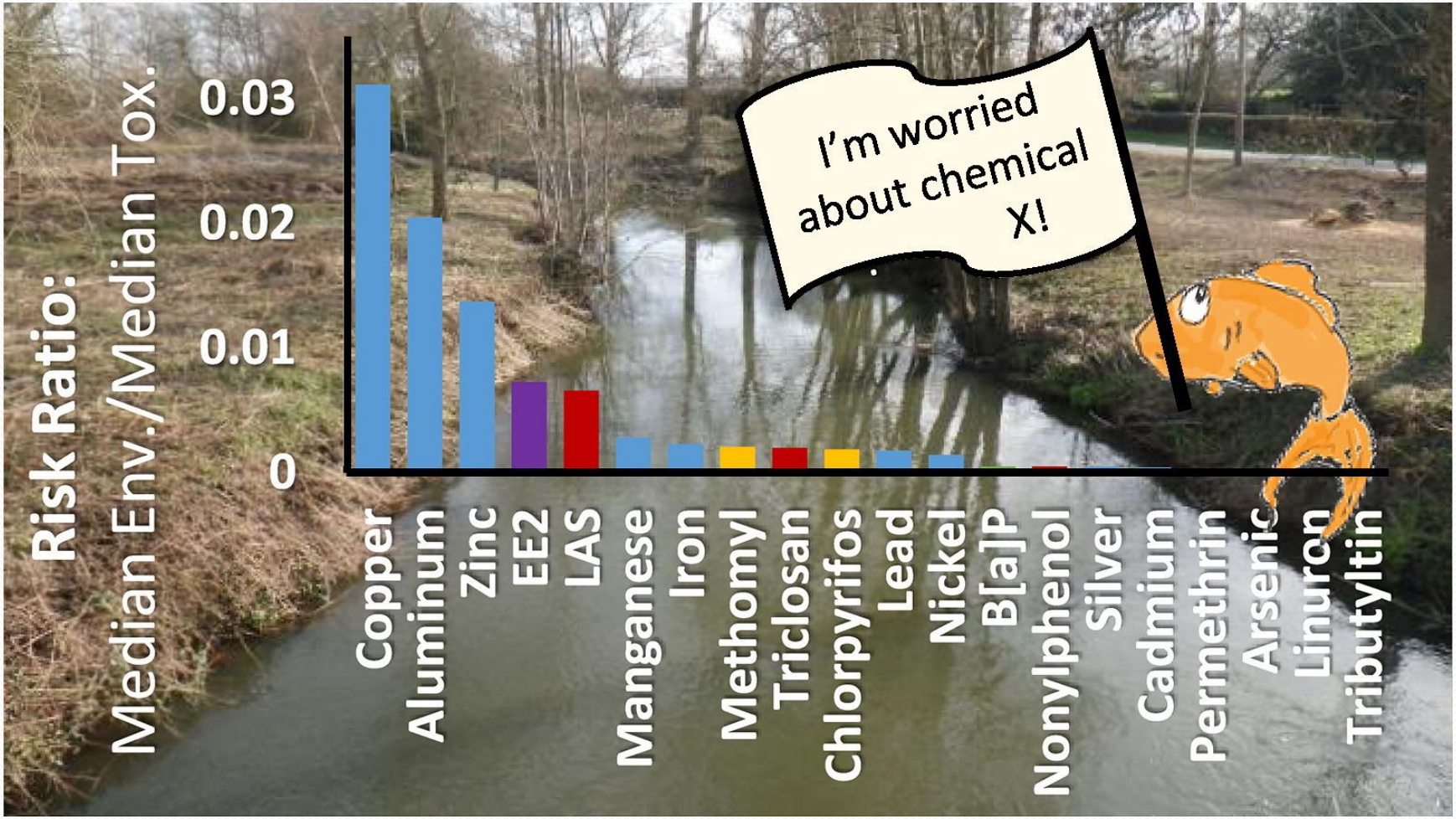


| | | L | M | H | VH |
|---|---|---|---|---|---|
| consume 6 | Zn | | 1.9x | 2.5x | 5.9x |
| | Al | | | | |
| consume 30 | Zn | | | | |
| | Al | | | | |
| consume 5 g | Zn | | | | |
| | Al | | | | |

Key: = % of TWI, 2.5x = 2.5 x TWI

Watson et al. 2024

# How does toxicity compare?



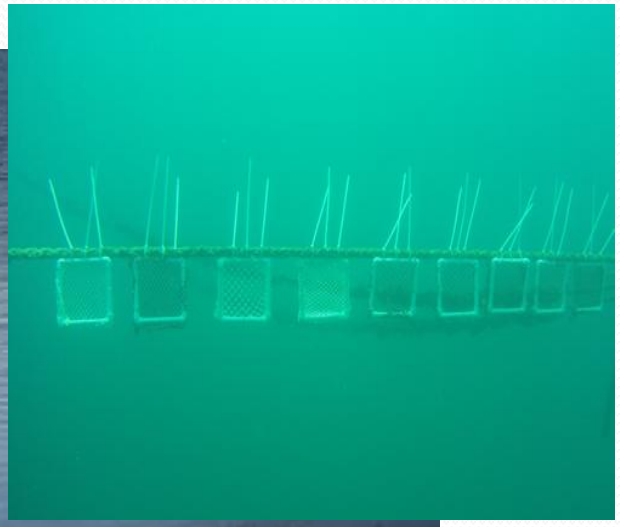

Johnson et al. (2017)

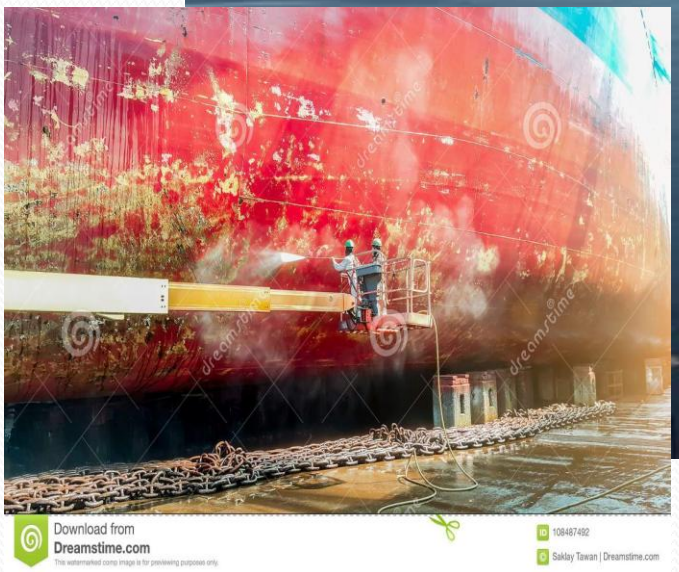
# Next research steps

- Assess concentrations in other species
- Re-analyse metal data to look at proximity to landfill/other sources
- Analyze POP data

# Vessel solutions








# Thank you!

- Acknowledgements
  - Post-docs
  - Postgraduates
  - Undergraduates
  - Collaborators and staff
  - Funders