Contaminated Dredged Material

Mike Waldock

on behalf of
Kevin Thomas, Jacquie Reed, Rebekah Owens, Jan Balaam and Steve Brooks CEFAS Burnham
Jim Readman, PML
and John Zhou, University of Sussex

FEPA Topic Review 23rd June 2005

Three completed projects

- AE0233 - The Risk Assessment of Contaminated Mixtures in the Context of Beneficial use
- AE0232 – The fate of TBT in spoil and feasibility of remediation to eliminate environmental impact
- AE0255 - Fate and bioavailability of antifouling booster biocides in harbour, dock and marine dredge material

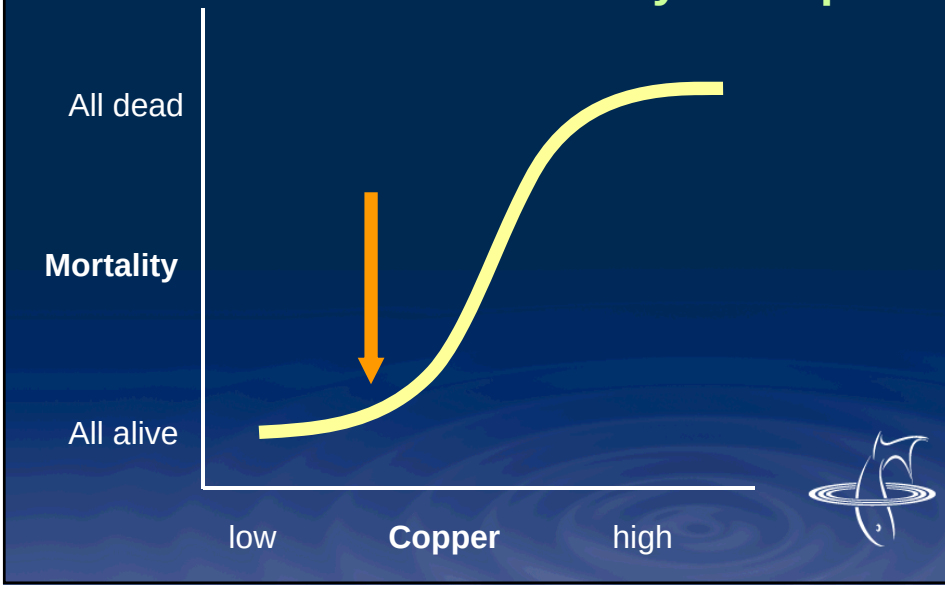
AE0233- The Risk Assessment of Contaminated Mixtures in the Context of Beneficial use

AE0233 -Aims and Objectives

- Definition of tentative NOEC and LOEC for contaminant mixtures in dredged materials.
- Development of an appropriate testing regime to evaluate the effects of contaminant mixtures
- Identify synergy, additivity or antagonistic behaviour in model systems.
- Identify the reasons for deviation from the model.
- Improved risk assessment procedure for evaluating beneficial use scenarios.

AE0233 - background

Action levels – do they add up?



AE0233 - background

Traditional approach

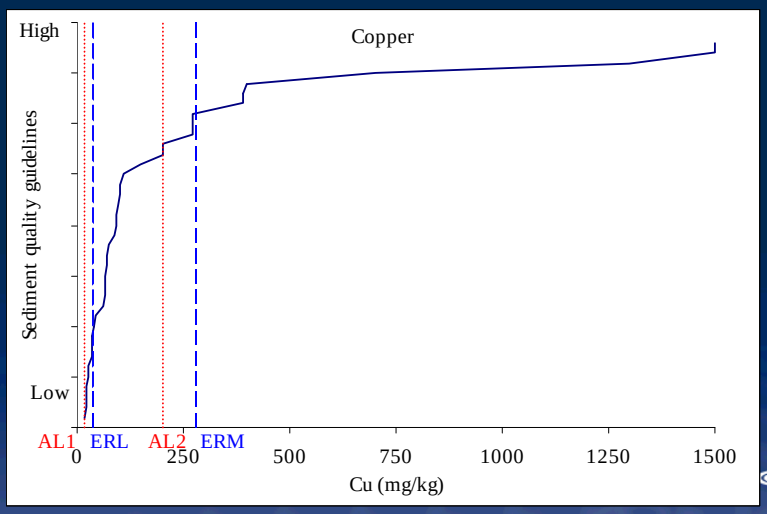
Test

- Compound 1
- Compound 2
- Add compound 1+ 2
- Compound 3
- Add compound 1+ 2 + 3…….v. expensive

This approach – take 6 metals add at 1/6 of the effect level and determine if the effects are additive, antagonistic or synergystic

AE0233 - Results

Model System



AE0233 - Results

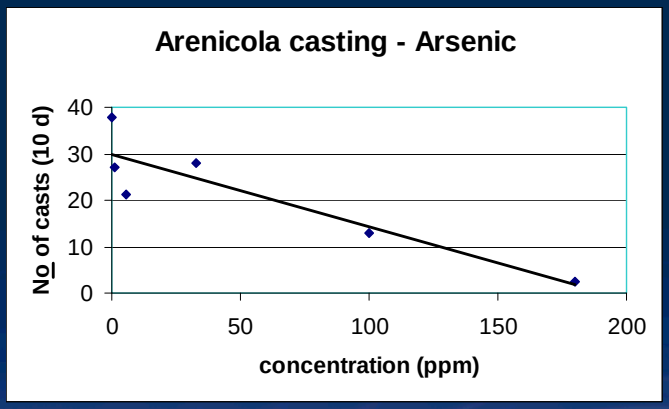
Model

Arenicola

nb – also work on Zostera and skeletonema

AE0233 - Results

Mixtures of metals and Arenicola



- Offer up the casting model to the standards data
- express in toxic equivalences
- add as a mixture to produce same putative response

Antagonism -reduced effect

Synergy leading to death

AE0233 - Results

Toxicity to Arenicola

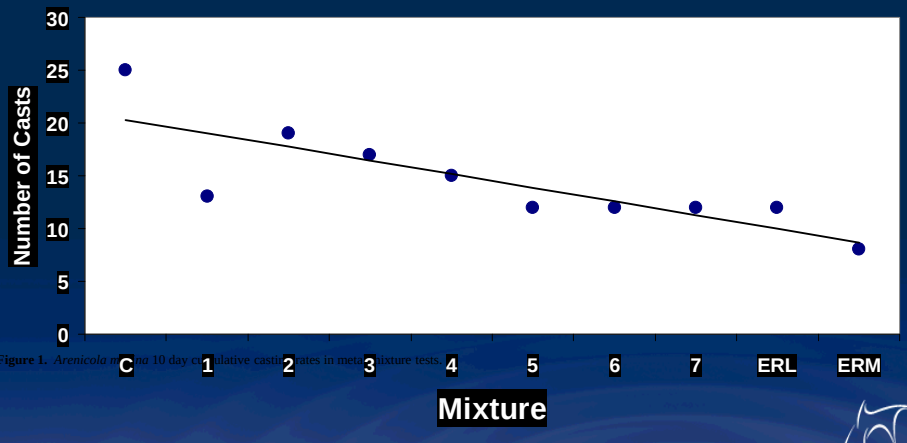
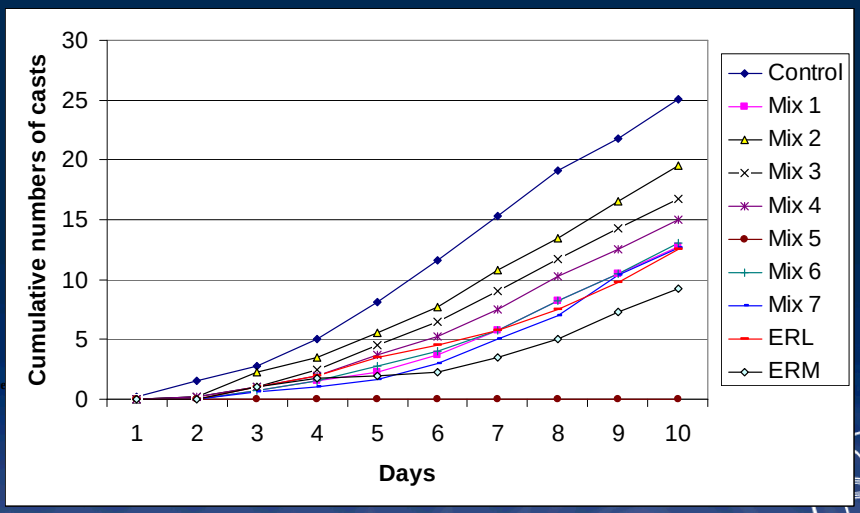


Figure 1. *Arenicola marina* 10 day cumulative casting rates in metal mixture tests.

AE0233 - Results

Toxicity to Arenicola



AE0233 - Results

Partitioning

Tests conducted at PML:

- Focus on Polycylic aromatic hydrocarbons and sterols
- Data generated on Kinetics of benzo(a)pyrene, oestrone and 17βoestradiol sorption investigated in estuarine sediments.
- Contaminant concentration, particle concentration, particle size and salinity has a significant affect on the partitioning values
- Stormy weather resulted in more PAH in the water column than during dredging

AE0233 - Implications

Implications for Defra

- No major impacts on policy
- Results are reassuring in that the concentrations at action level 1 did not show biological effects,
- Factors other than contaminant concentration are important in governing toxicity e.g. enzyme induction and partitioning behaviour
- Few firm conclusions can be drawn.

AE0233 - Summary

Summary and Further Work

- Useful information on partitioning of compounds
- Underpinning work in developing model systems for evaluating the effects of mixtures
- Work in hand is developing the mixtures model further, but using dosing systems in water to avoid complications with using sediment

AE0232 – The fate of TBT in spoil and feasibility of remediation to eliminate environmental impact

AE0232 - aims and objectives

- provide a list of priority sites of concern with regard to TBT contamination;
- measure TBT contamination at disposal sites and to relate the contaminants to the bulk properties of the sediment;
- evaluate methods presently available for remediation;
- examine the nature of the sediment material to establish the viability of physical methods of remediation;
- investigate the fate of paint-derived TBT within dredged material;
- assess bioavailability of paint-derived TBT from contaminated sediment;
- assess biological impact on sensitive species; and
- investigate benthic community change related to TBT

AE0232 - aims and objectives

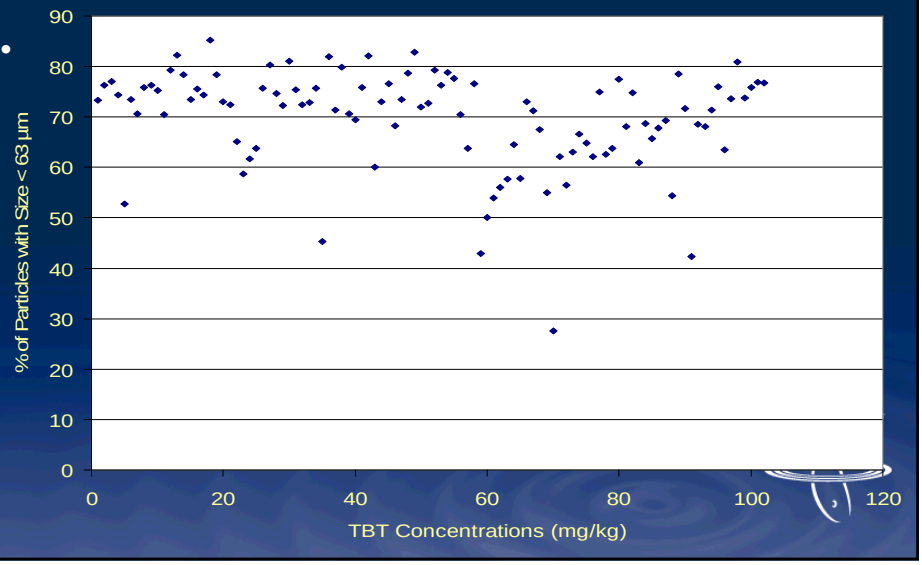
Priority Sites

TBT Levels (mg/kg)	1998	1999	2000	2001	Total levels 1992-2001
0-0.1	52%	46%	60%	65%	52% (1511)
0.1-1	38%	31%	32%	32%	30% (1049)
1-10	9%	17%	7%	3%	10% (293)
>10	1%	6%	0%	0%	2% (68)
					2921

R. Tyne,Southampton Water, R. Tees, R. Mersey, R. Humber and Newport, Barry and Cardiff.

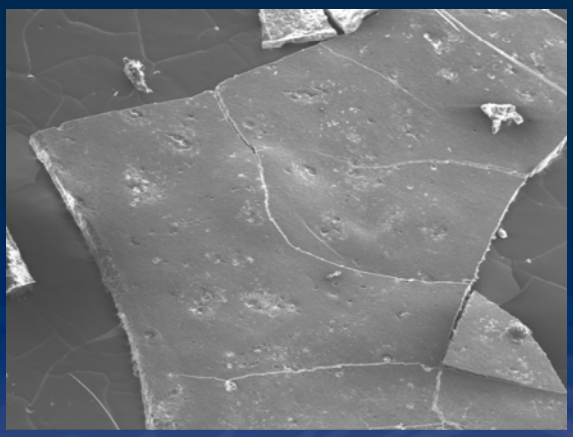
AE0232 - results

What sort of sediment particles is the TBT associated with?



AE0232 - results

What sort of sediment particles is the TBT associated with?

- 

AE0232 - results

TBT particles in sediments

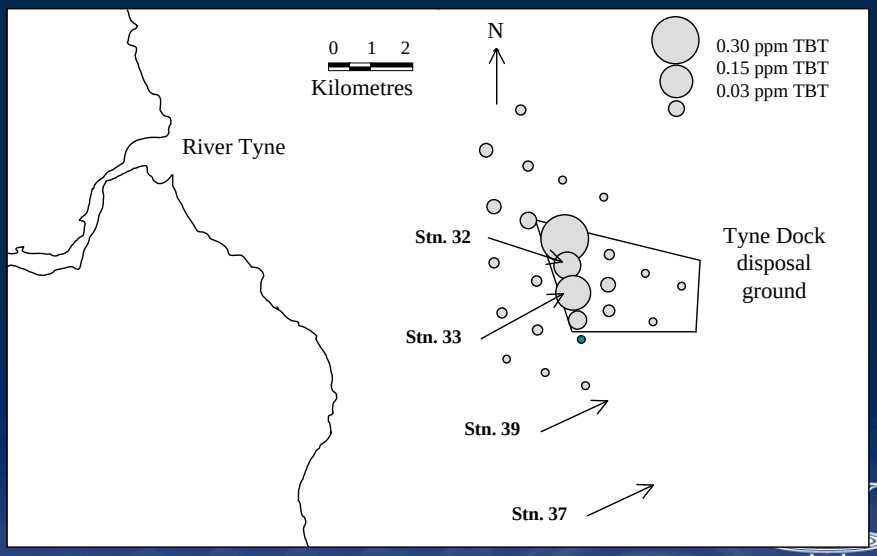
Sediment contaminated at 4ppm

	38µm	63µm	125µm	250µm	500µm
light	0.73	0.97	3.25	11.48	8.1
medium	0.44	0.22	2.05	1.85	4.01
heavy	0.21	0.32	0.2	1.84	3.46

Volume reduced by up to 80%

AE0232 - results

Disposal Sites



Stage 3 imposex in female whelk

AE0232 - results

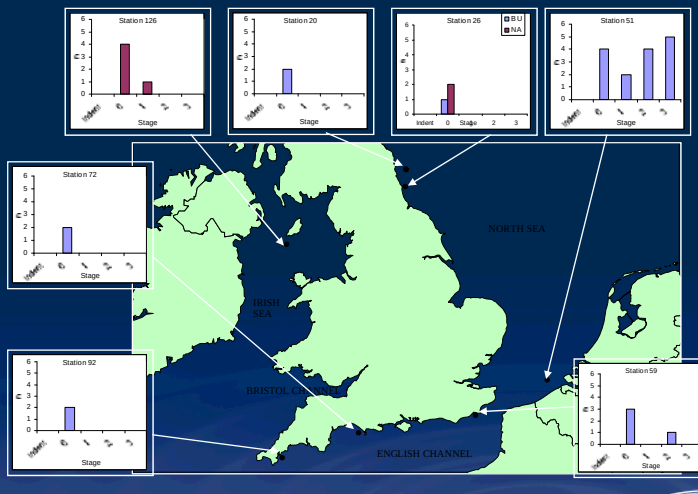
Disposal Site Whelks

Table 7: Morphometric changes in *Neptunia antiqua*

NEPTUNIA ANTIQUA	RESULTS FOR TYNE SAMPLING 28/9/00
Number of *Neptunia* analysed	7
Average Shell Height	88.0
Largest Shell	105.5
Smallest Shell	72.8
Sex Ratio (Male:Female)	3:4
Imposex Sequence Index	2.5
Average female penis length	4.4
Average male penis length	11.3
Relative Penis Size Index	5.9
Incidence of Imposex	100%

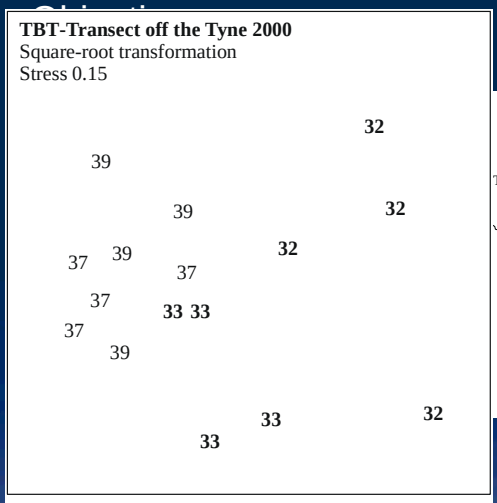
AE0232 - results

Coastal Site Whelks

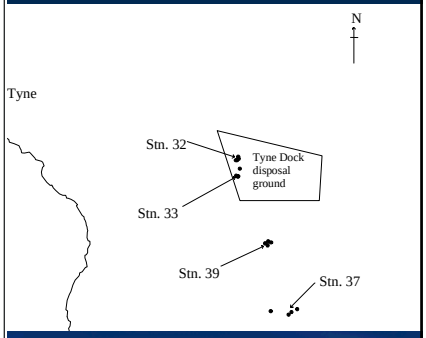


AE0232 - results

Changes in meofaunal ecology.



Station 32 inside the disposal ground
Station 33 inside the disposal ground (south of stn. 32)
Station 39 outside the disposal ground (south of stn. 33)
Station 37 outside the disposal ground (south of stn. 39)



AE0232 - Implications

Implications for Defra

- TBT is still the biggest problem for dredged material disposal
- Tyne disposal site is “full” – not possible to conventionally dispose more highly contaminated waste at the site
- Biological effects are occurring at the disposal site, but confined to the vicinity
- Operational remediation is possible, but costly – responsibility of licensees to pursue further.

Summary and Further work

- Valuable study on fate of TBT and biological effects at disposal sites. First exploration on how to mitigate effects.
- For the Tyne – policy decision to trial a capping exercise at the disposal site – not the best scientific option but compromise on cost. Await results
- Now in a position where we have an excellent understanding of fate and effects of TBT way forward is mainly surveillance of efficacy of the IMO regulations

AE0255: Fate and bioavailability of antifouling booster biocides in harbour, dock and marine dredge material

AE0255 - aims and objectives

- assess the sedimentary partition and fate of booster biocides (including degradation products).
- determination of primary transport pathways.
- to determine the bioavailability and toxicity of booster biocides to relevant commercial species.
- the assessment and use of an environmental fate model to provide information on eventual sinks.

AE0255 - results

Common Antifouling Compounds

Copper
Tributyltin
Diuron
Irgarol 1051
Zinc pyrithione
Dichlofluanid
SeaNine 211
chlorothalonil
TCMTB
Zineb

AE0255 - results

Environmental fate

Requires sophisticated LC/MS analysis

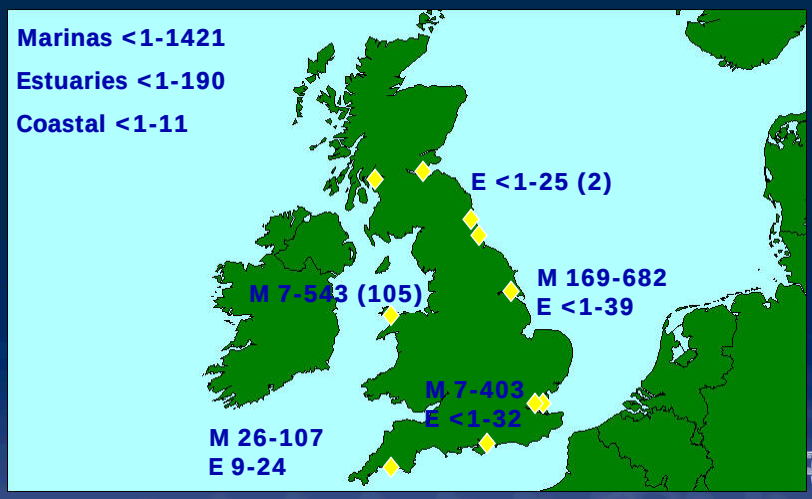
AE0255 - results

Release Rates

Biocide	Alternative trade name	Release Rate (µg cm^{-2} day^{-1})	
		ISO test system	Flume system
Cuprous oxide		25-40[a]	18.6±6.5
TBT		1.5-4.0[a]	1.6
Irgarol 1051		5.0	2.6[b]
Diuron		3.3	0.8
Dichlofluanid	Euparen	0.6	1.7
Zinc pyrithione	Zinc omadine	3.3	-[c]
Kathon 5287	Sea-Nine 211	2.9	3.0
TCMTB	Busan	-[c]	0.9
TCMS pyridine	Densil S	0.6	3.8

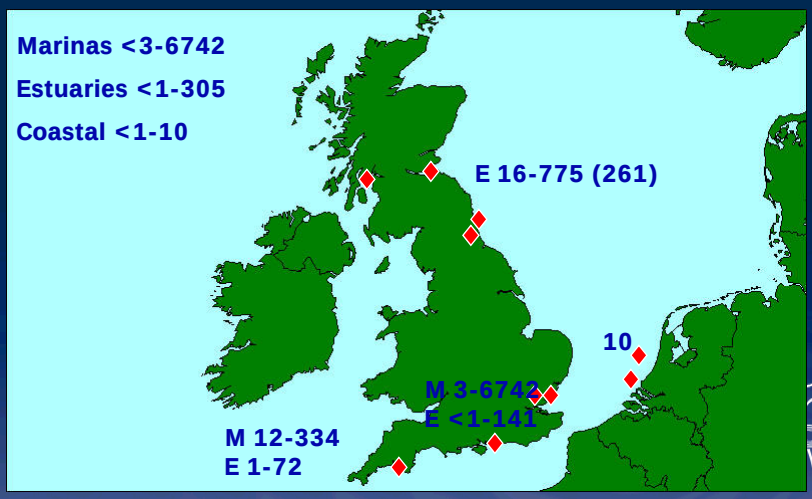
AE0255 - results

Occurrence: Irgarol 1051 (ng l^{-1})



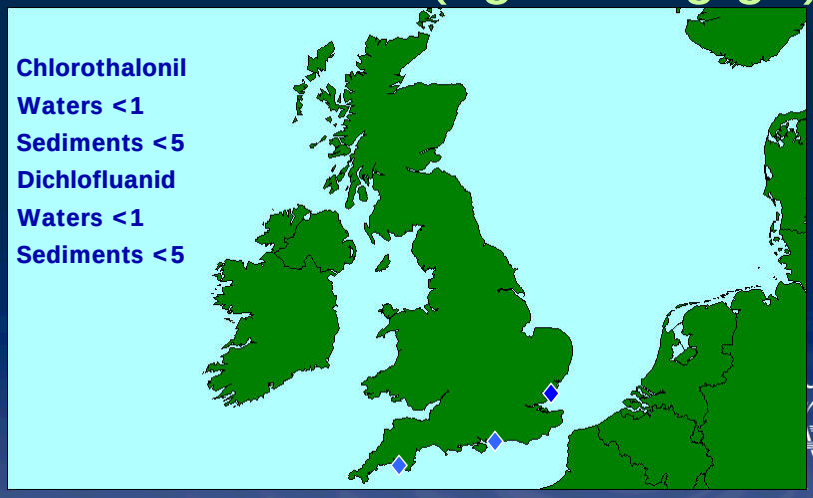
AE0255 - results

Occurrence: Diuron (ng l^{-1})



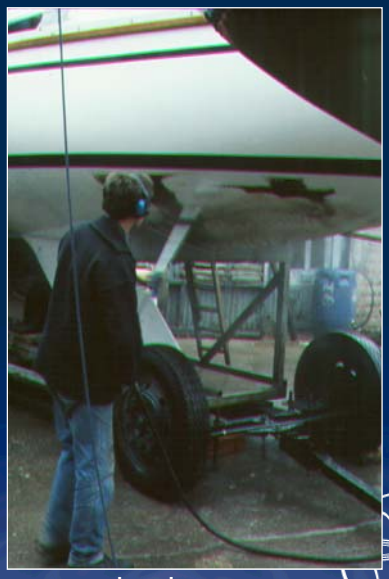
AE0255 - results

Occurrence of dichlofluanid and chlorothalonil (ng l^{-1} & ng g^{-1})



AE0255 - results

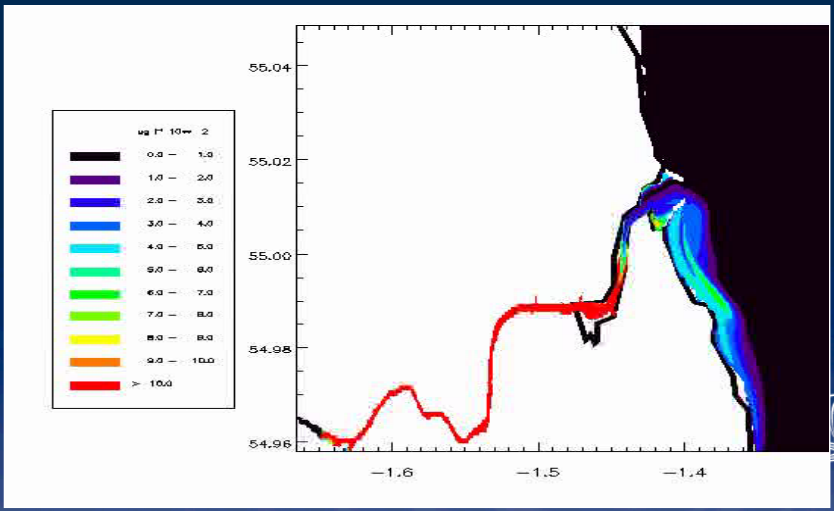
Established
- Degradation in seawater
- Presence in sediments
- Partition data for water/ Sediments
- Degradation rates in sed
- Novel deg products
- Pressure Hosing inputs



Found that up to 17% of inputs each day can come from high pressure hosing

AE0255 - results

Diuron dissolved concentration (x 10^{-2} µg l^{-1}) Tidal and river plume simulation



AE0255 - Implications

Implications for Defra

- Irgarol and diuron posed environmental problems – this data was used by HSE to revoke use of Irgarol and Diuron on small craft (additionally Diuron on ships – worker exposure)
- Replacements potentially better , but the use pattern has changed since this work was done so we don't know
- Short window of widespread use of Irgarol and Diuron means they are unlikely to pose dredged material disposal problems

Summary and Further work

- Extensive range of information on fate of booster biocides – a unique data set
- Moving target as far as use patterns are concerned – TBT then Irgarol/Diuron and copper, few compounds left, but we have no recent data
- Copper work being taken forward by industry consortia at CEFAS. No apparent way forward on others