Potential Ecological Effects of Chemically-dispersed and Biodegraded Oils

- MMS
- Defra
- MCA
- DTI

Research organisms

- Mussels

  Mytilus edulis

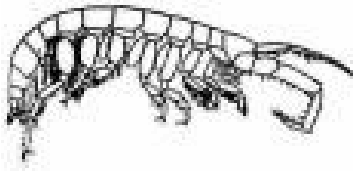
  - Feeding rate
  - Biomarkers

- Mud-shrimp

  Corophium volutator

  - 10 day sediment and aqueous tests
  - Life cycle tests

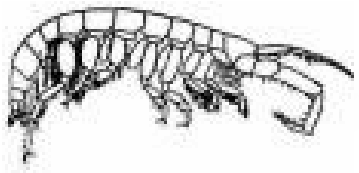
Why *Corophium*?



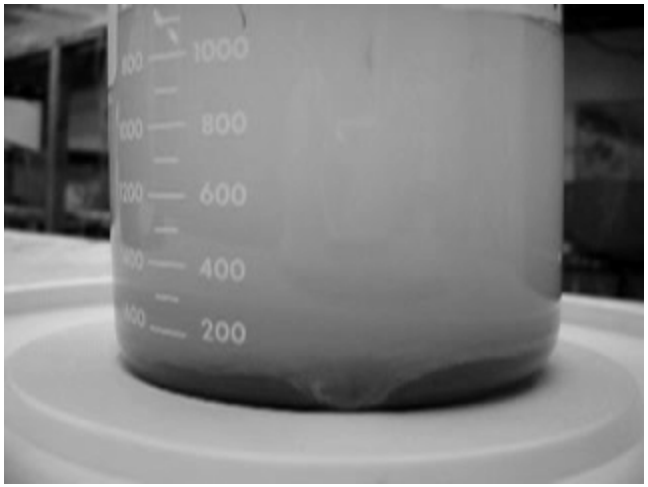
- Standard European sediment test organism
- Widespread geographic range
- Inter-tidal estuarine and coastal habitat
- Important ‘Keystone’ estuarine species
- Filter water and graze sediment surface
- Easy to maintain under lab conditions

Observed problems

- Mortality of benthic organisms, especially amphipods, following oil spills
- Slow recovery at some sites, therefore:
- Possible chronic effects



Behavioural responses of stressed *Corophium*



Normal behaviour:

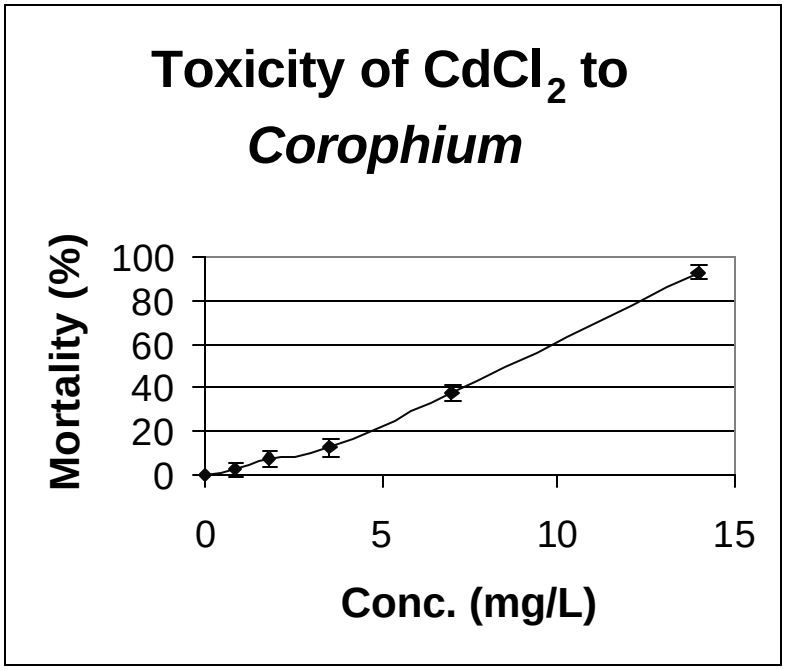
- Stay in burrows
- Males crawl on mud
- Very rarely swim

Stressed behaviour:

- Inability to burrow
- Erratic swimming
- Greater turbidity

Sensitivity of *Corophium*

Quality Assurance and Quality Control (**QA/QC)**



72 h $CdCl_2$ aqueous exposure (no sediment)

- LC_{50} 7.5 mg/L
- Published range 2.7 - 9.9 mg/L
- Local population similar sensitivity as general population

The oils

Forties crude oil

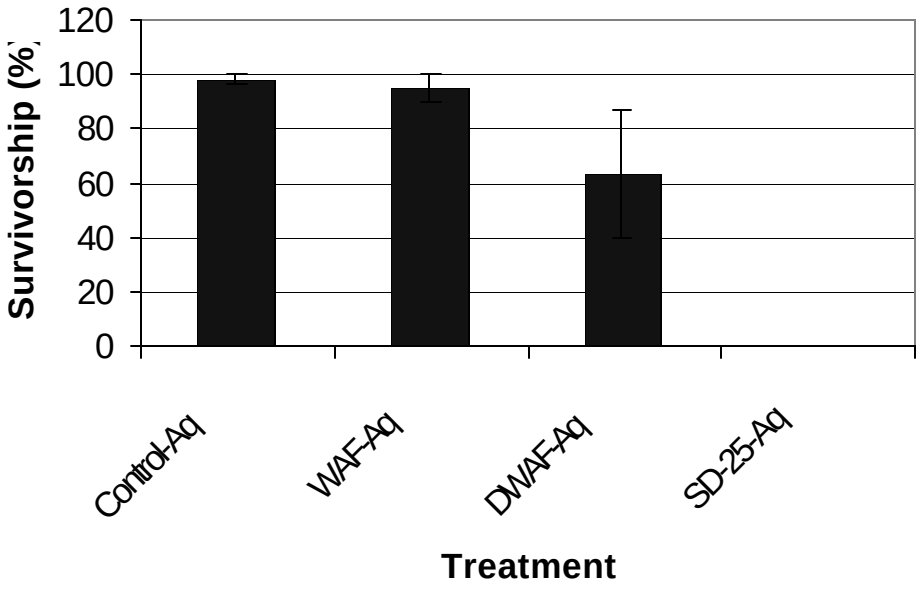
- Sea Empress spill

Alaskan North Slope (ANS) crude oil

- Exxon Valdez spill

- Crude oil weathered to simulate 2-3 h at sea
- Slowly vortex-mixed with seawater
- Water:Oil ratio 99:1
- Water-Accommodated-Fraction (WAF) created
- Oil:Dispersant ratio 25:1

Acute exposures to Forties oil



Aqueous exposure

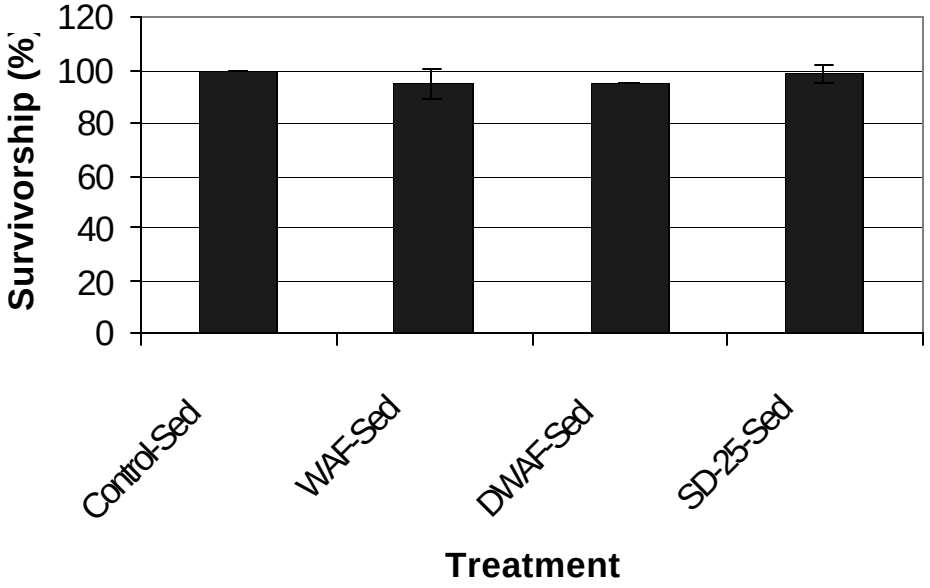
WAF:

- No effect at 100%

DWAF:

- Variable effect at 100%

Acute exposures to Forties oil



Sediment exposure

WAF:

- No effect at 100%

DWAF:

- No effect at 100%

The dispersants

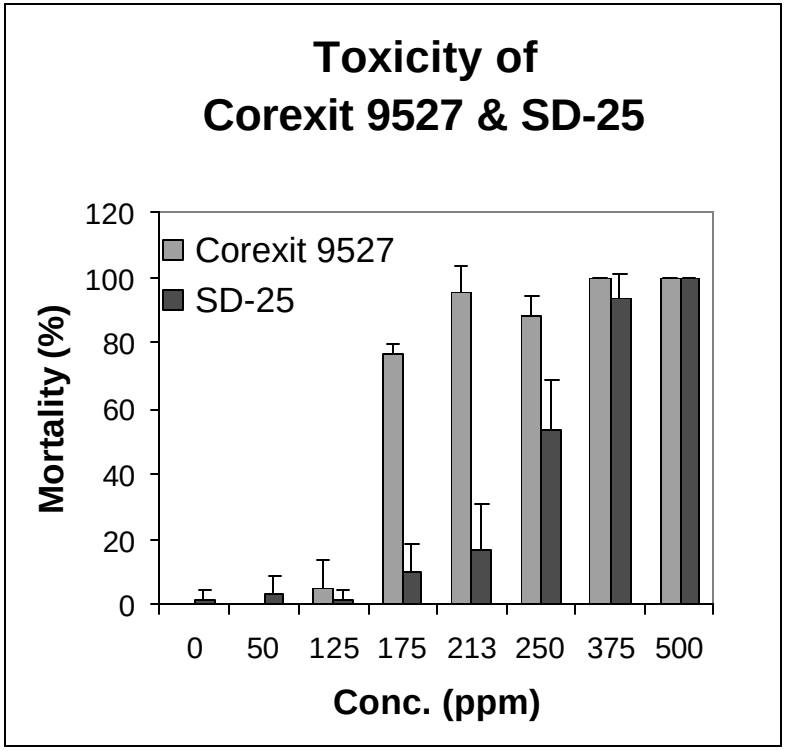
Corexit 9527

- Widely used in US
- Many literature reports
- Wide range of toxicity
- Amphipod LC_{50} values: 3 - >175 ppm reported
- Variation due to exposure time and conditions

Superdispersant-25

- Used in UK and world-wide
- No literature reports.
- Manufacturers state ‘low toxicity’
- Assume LC_{50} >100ppm

Toxicity of Dispersants



- Static exposure
- Both show low toxicity
- SD-25 less toxic than Corexit 9527
- Small range from no-effect to lethal
- Maximum dispersant concentration in sea reported: 13 ppm

Chronic exposures - current

Sediment spiked with:

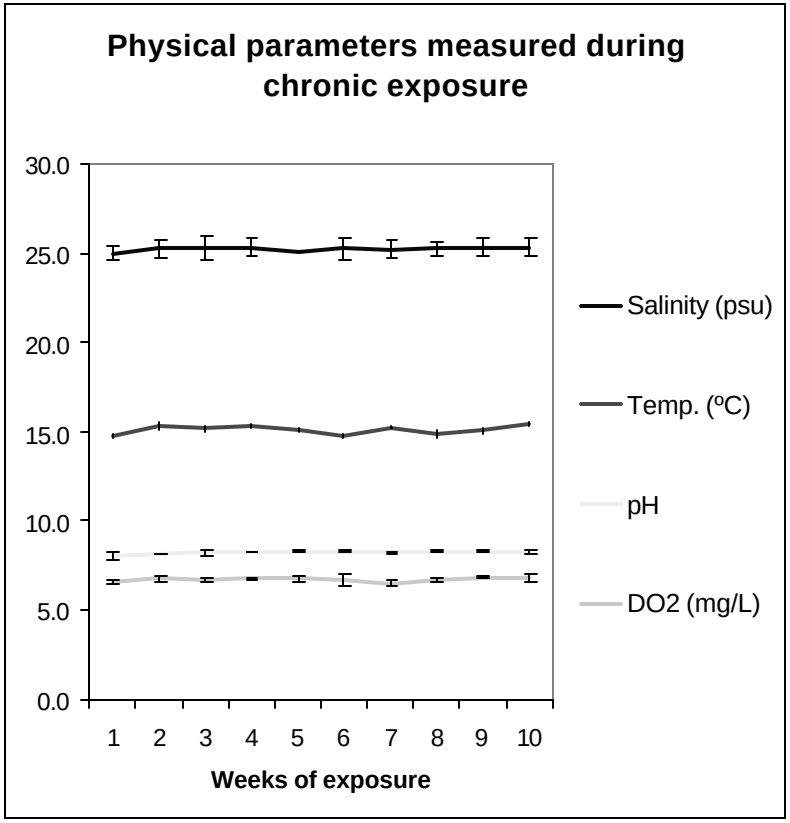
- WAF 100%
- DWAF 100%
- Dispersant
- Crude oil (realistic sub-tidal concentration after dispersed spill)
- Seawater control
- 9 replicates

Bioassay:

- Juvenile *Corophium* exposed to sediment
- Growth, reproduction & mortality recorded
- Sediment and tissue chemically analysed
- Monitored after 28, 70 & 110 days

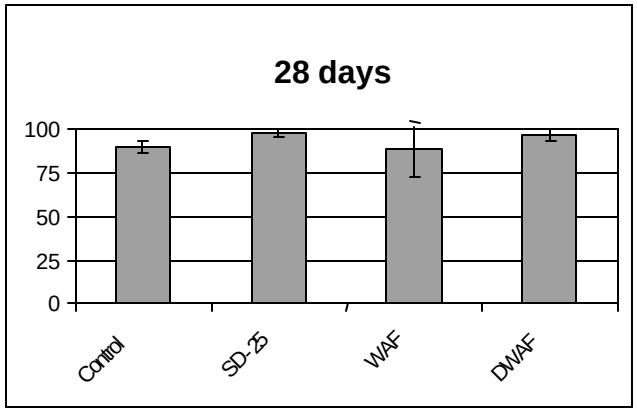
QA/QC *Corophium*

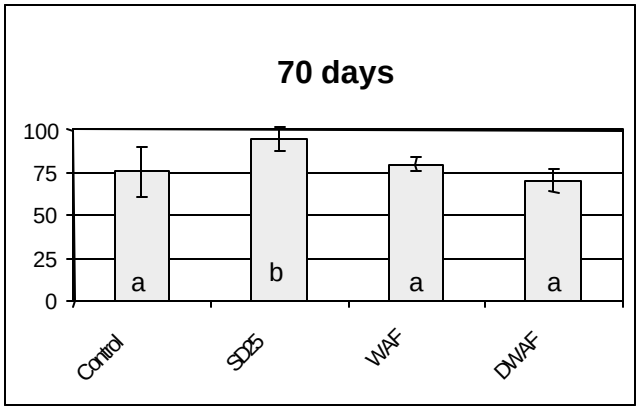
Example

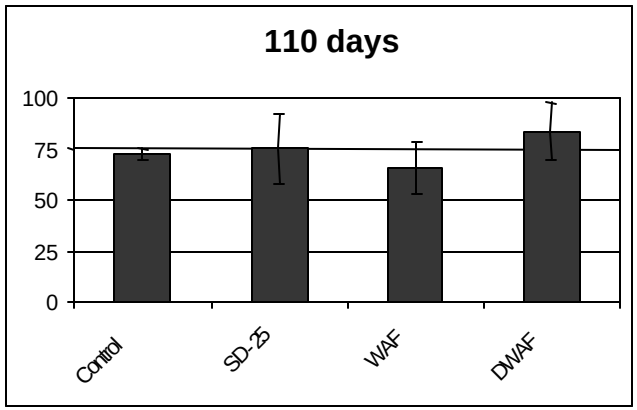


- Very little variation between exposures (Coef. Of Variation <3%)
- Low temporal variation
- Low mortality in control organisms (<2%)
- Sub-sets of counts and measurements checked by third party

Chronic exposure: Survivorship (%)

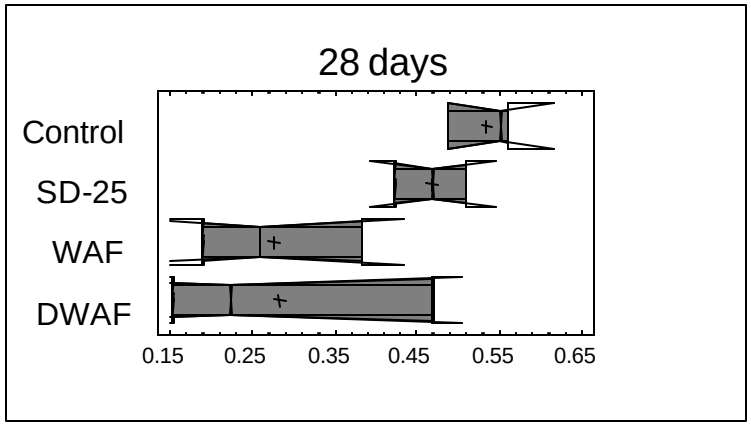


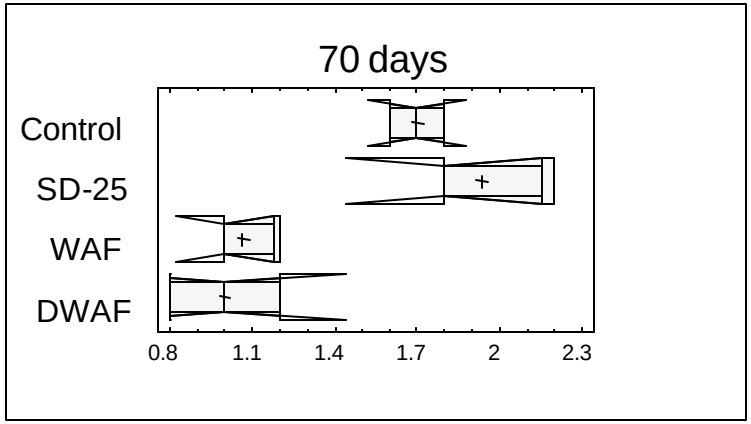


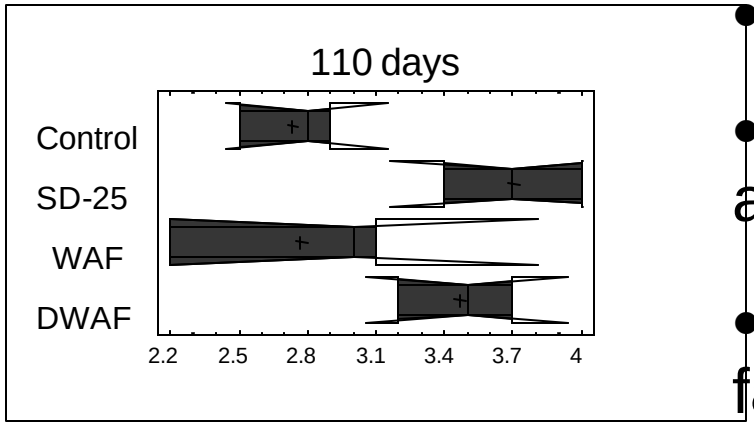


- Survival high
- Survival unaffected by WAF or DWAF

Chronic exposure: Weight (mg)

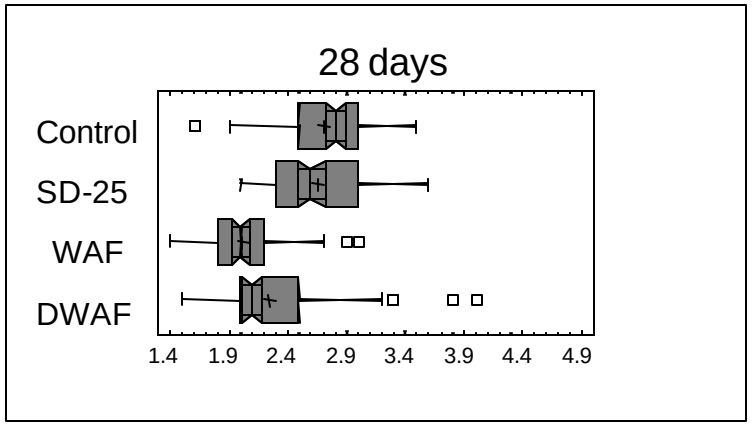


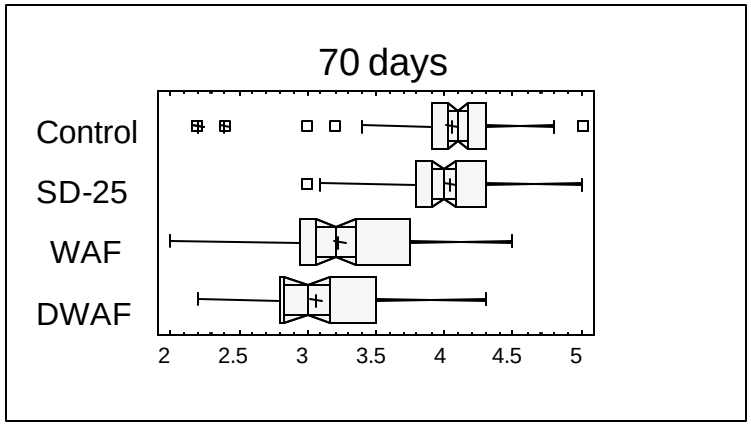


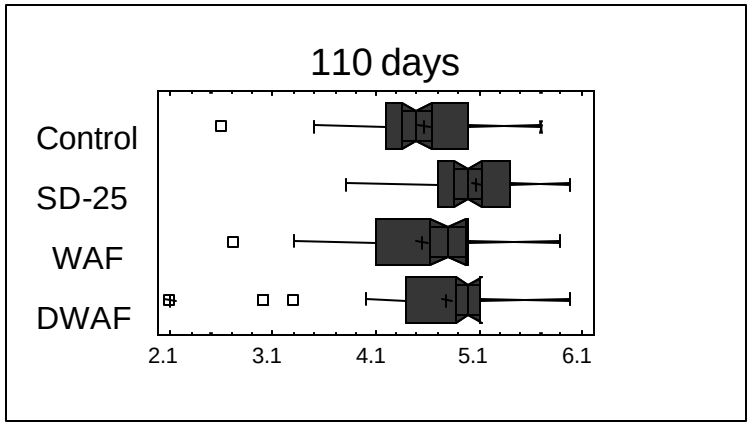


- Low variability controls
- WAF and DWAF reduced at 28 and 70 days
- At day 110 not reduced in fact DWAF & SD25 increased

Chronic exposure:
Length (mm)

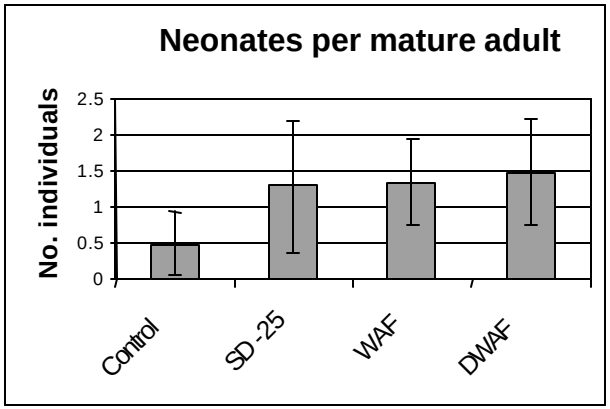


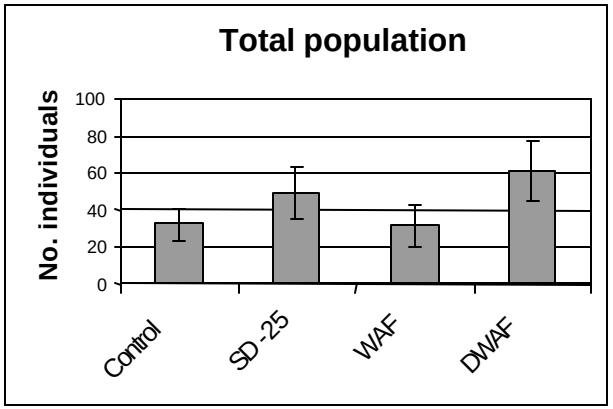


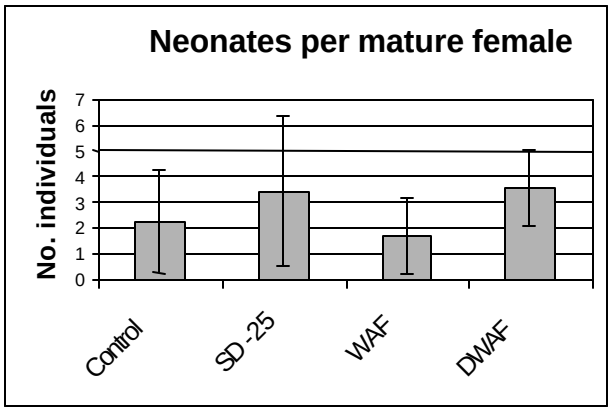


- Same pattern as weight

Chronic exposure:
Reproduction at 110 days





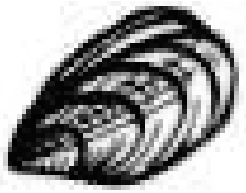


- Reproduction occurred in over 80% of exposure vessels
- Large variation between replicates
- No significant differences in reproductive success

Forties chronic exposure Interim conclusions:

- Survivorship unaffected by WAF or DWAF
- Growth significantly reduced by both up to 70 days exposure but by 110 days has recovered
- Higher variation within oil-exposed *Corophium*
- Reproduction unaffected by WAF or DWAF
- No major differences between dispersed and non-dispersed oils

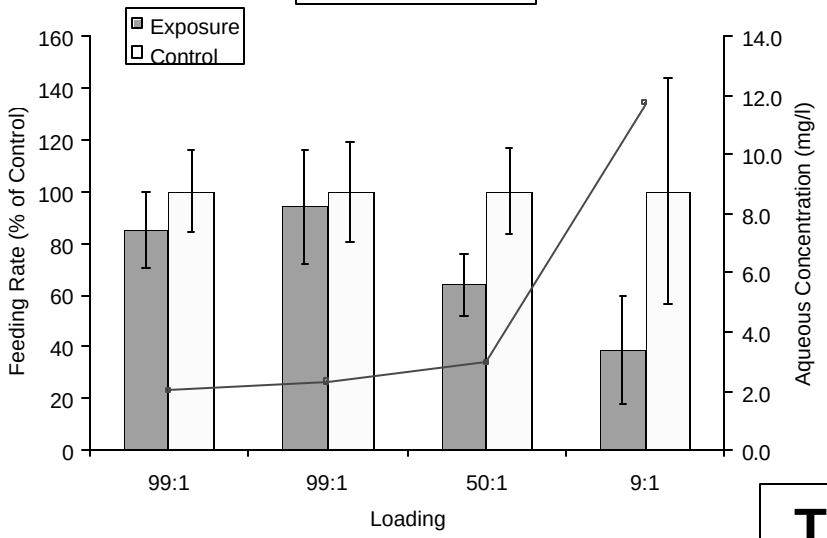
Why *Mytilus edulis*?



- Widespread geographic range
- Dominant member of coastal and estuarine communities
- Sessile filter feeders
- ‘Bioindicators’
- Scope for Growth
- Significant correlation with hydrocarbons

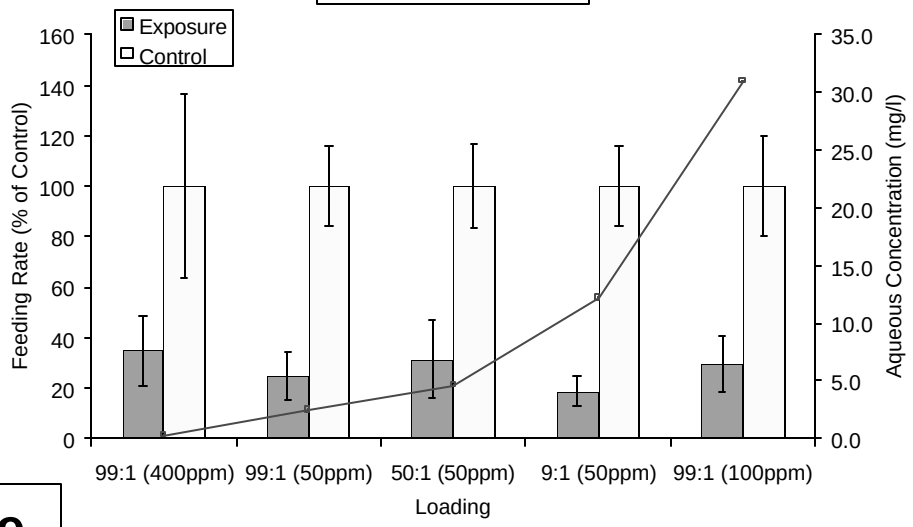
Mussel feeding rate

WAFs

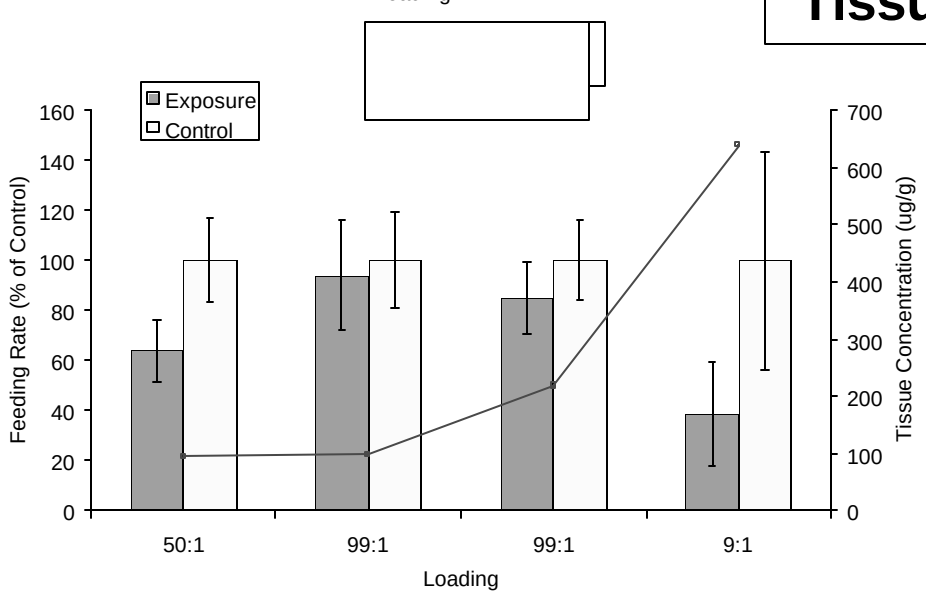


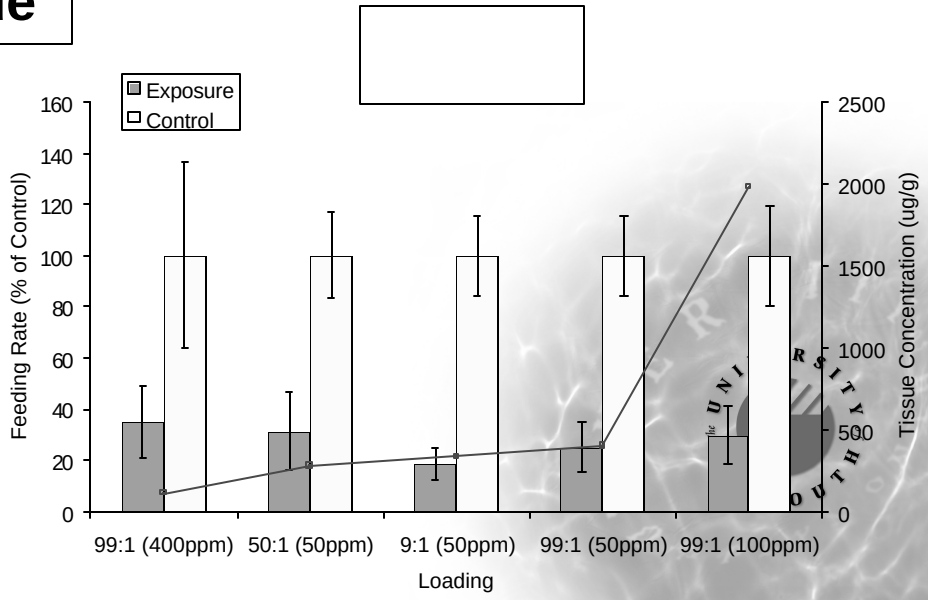
Aqueous

DWAFs



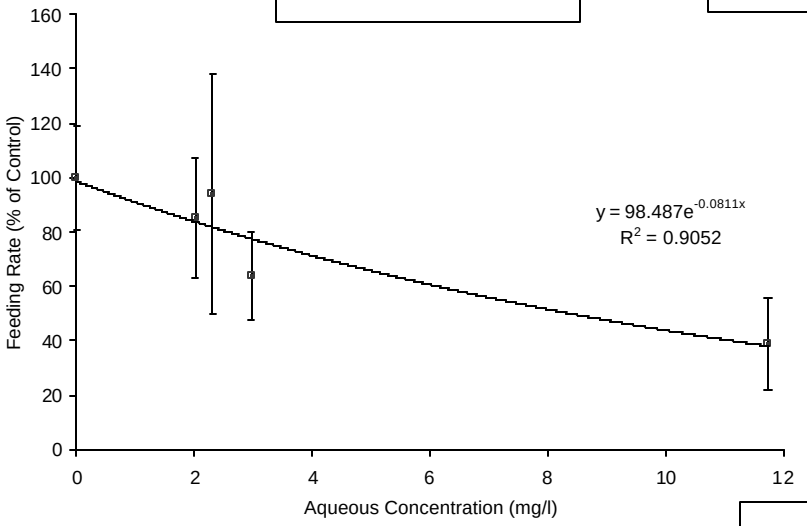
Tissue





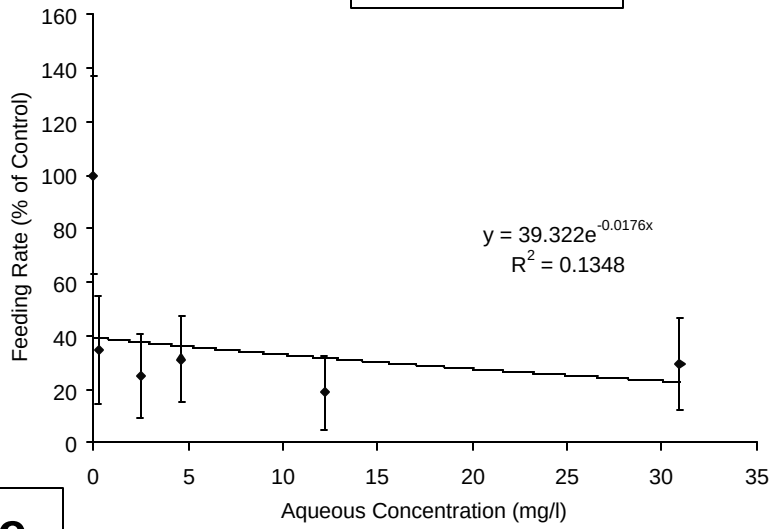
Mussel feeding rate

WAFs

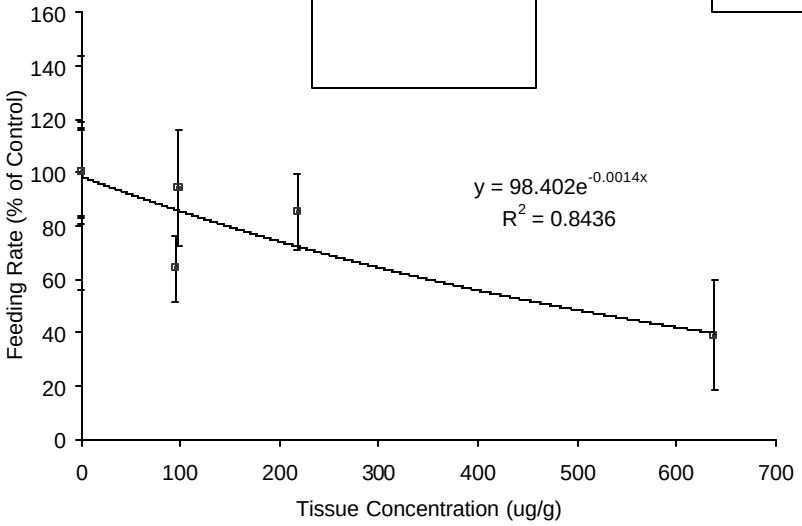


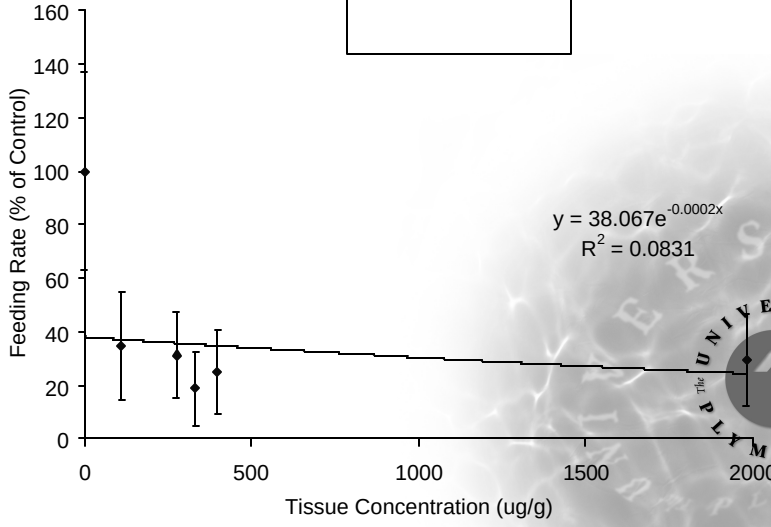
Aqueous

DWAFs



Tissue

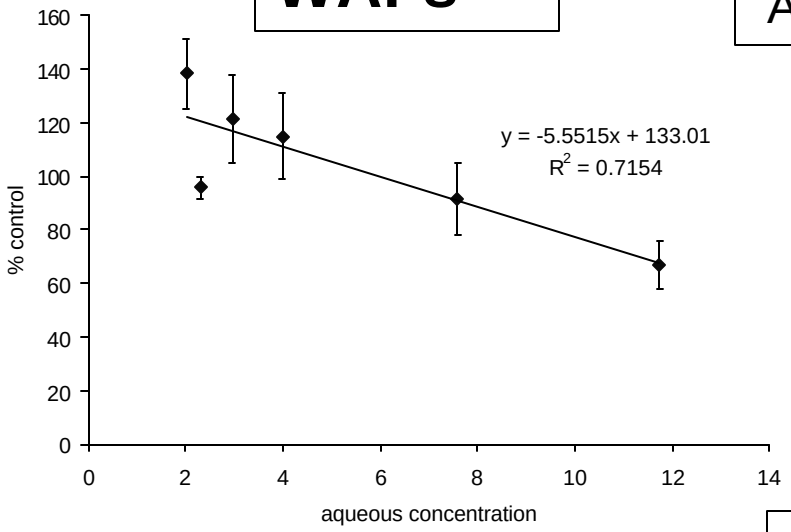




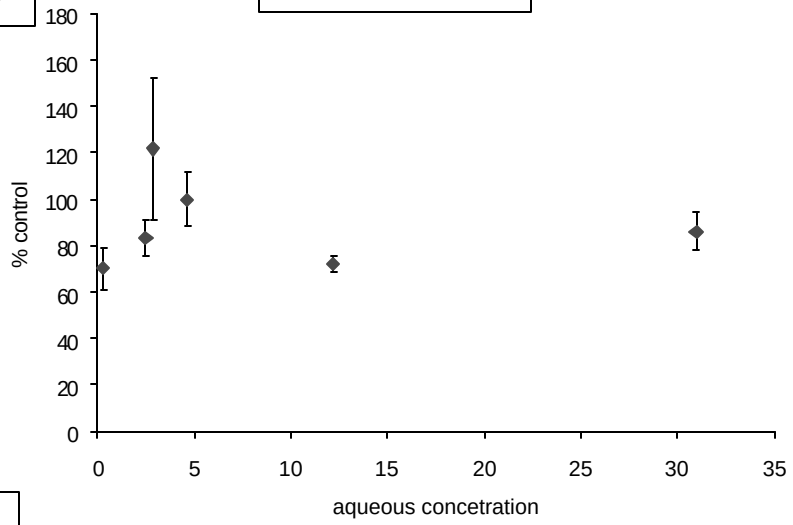
Neutral Red Retention

WAFs

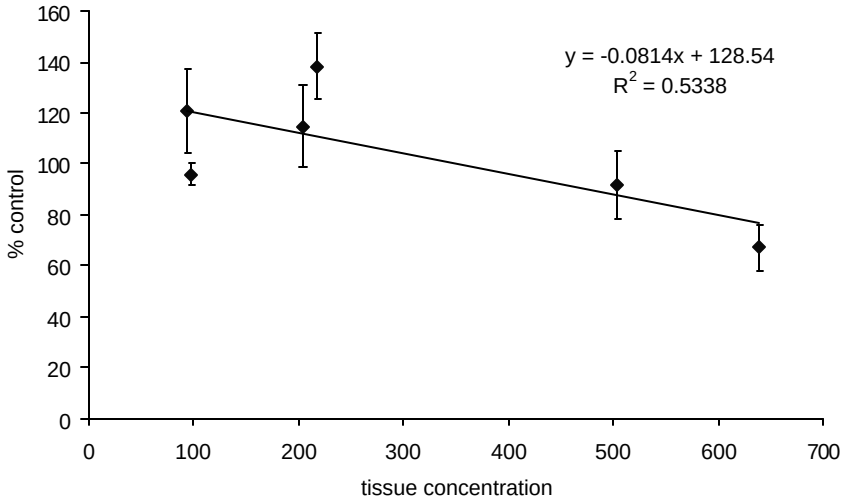
Aqueous

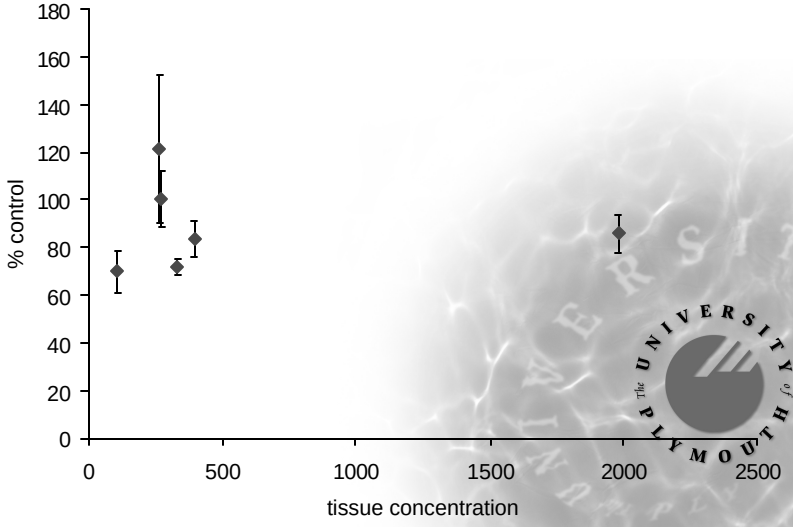


DWAFs

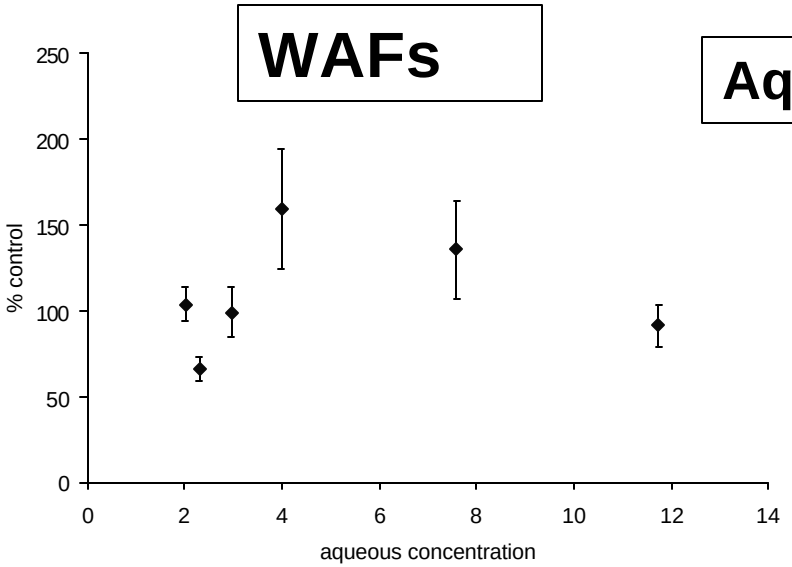


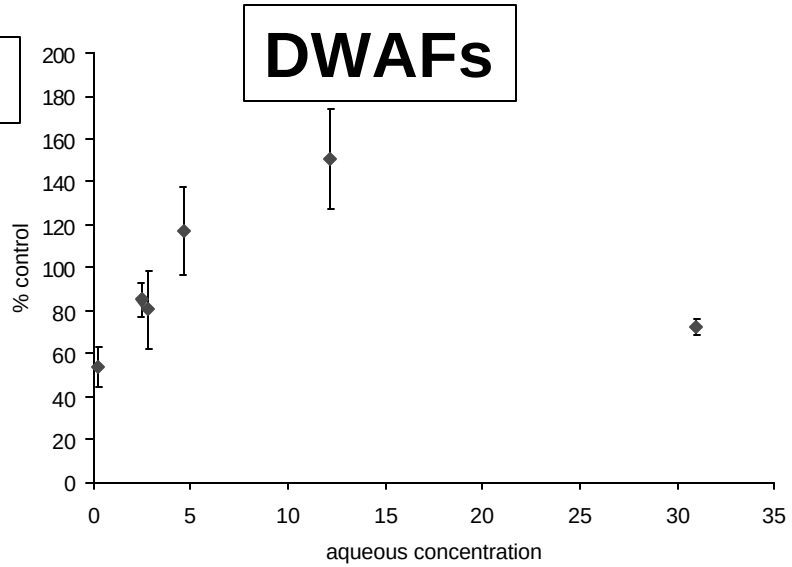
Tissue

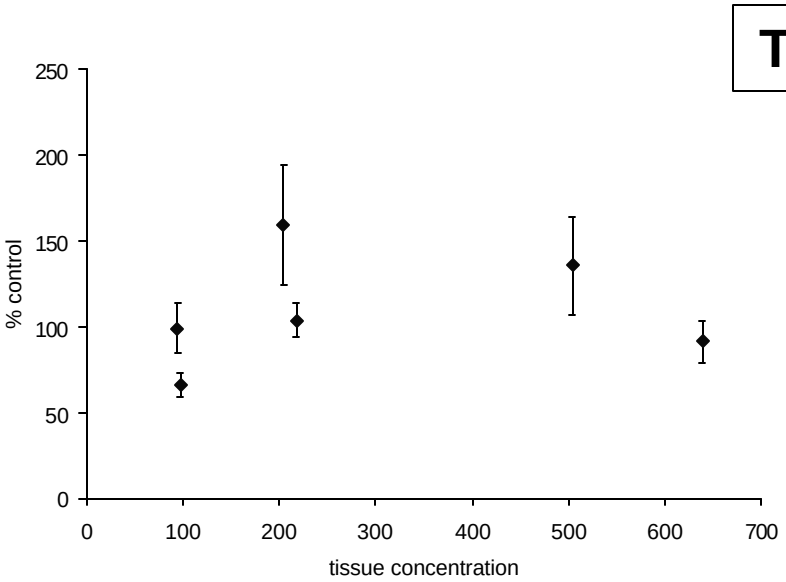


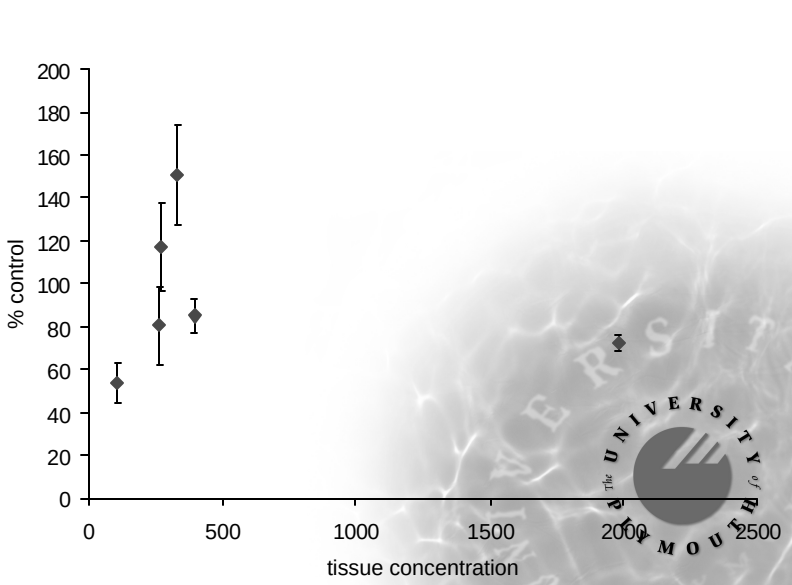


Phagocytosis







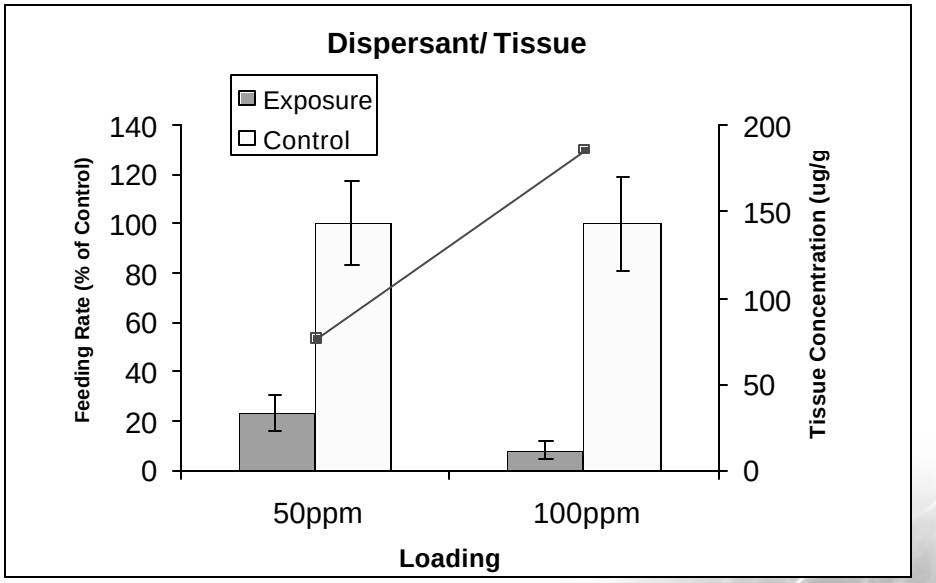


Forties exposure: Interim conclusions

- Feeding rate
  - reduced in all DWAF exposures
  - only at very high WAFs
  - WAFs correlate with increasing aq/tissue conc
  - DWAFs no pattrern observed
- Neutral Red Retention
  - aq/tissue correlation with WAFs not DWAFs
- Phagocytosis
  - typical pattern observed in both
- Micronuclei

Superdispersant 25

- Dispersant affecting membrane?
- All measures affected
- 96 hour LC 50 188ppm

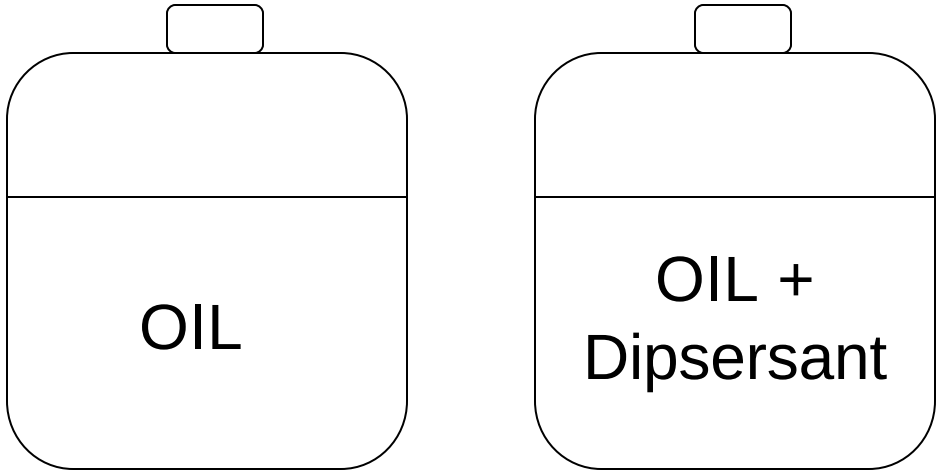


Future Work

- Change loadings of DWAFS to simulate environmental levels for mussel exposures
- Mussel assays - Forties and ANS
- Chemical analysis of sediments
- ANS acute tests
- Chronic life cycle ANS tests
- Prepare biodegraded oil for toxicity tests

Biodegradation

- Large aspirators
- Use water phase
- Extract out dispersed oil for spiking sediments
- Monitor droplets/MPN/chemistry
- Calculate % biodegradation of total oil



Research Plan 2004