Acute and sub lethal effects of oil, dispersant and dispersed oil to sensitive symbiotic cnidarian species, including coral.

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Our Questions

- How sensitive are symbiotic cnidarians - corals, to oil and/or dispersant?
- Effects of chemical dispersants?, WAF and CEWAF comparisons.

- Route of exposure for toxic effects? physical / chemical (dissolved/colloidal/droplet).
- Recovery or sub lethal / delayed responses ?

Model Species Used

(1) Temperate anemone (*Anthopleura elegantissima*)

- Important primary producer in intertidal zone
- Symbiotic with algae
- 'Model' cnidarian for corals?

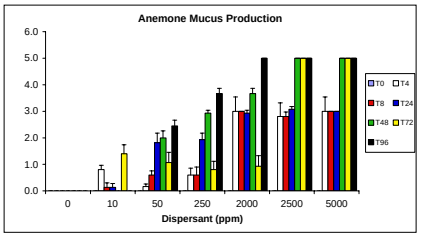
(2) Tropical soft coral (*Xenia elongata*)

- Common tropical soft coral
- Obligate symbiosis with algae
- Demonstrated sensitivity to changes in water quality
- Behavioral stress markers such as changes in rigidity and rhythmic pulsing

Results: Anemone dispersant

Acute :
LC50 96 hours >250ppm

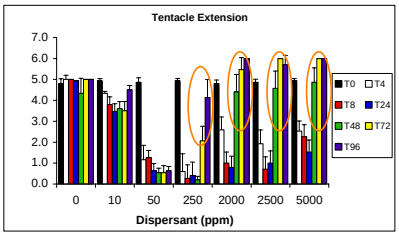
Sub lethal : **Mucus production**



- Mucus production EXCESSIVE…time / dose dependent
- Solubilization of anemone tissues, as low as 10ppm.

Results: Anemone dispersant

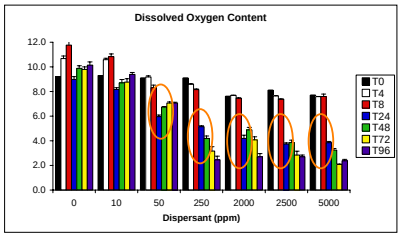
Sub lethal : **Tentacle extension**



- Reduction in extension…time / dose dependent.
- Significant reduction at 10ppm ; recovery by 96hr.
- Doses 250ppm and higher complete loss of contractile ability.

Results: Anemone dispersant

Sub lethal : **Dissolved Oxygen Content (photosynthesis)**



- Dose- / time-dependent reduction in DO. Direct or indirect algal effects?
- Significant reduction 50ppm and greater.
- Potential issue : DO could become a co-stressor!

Results: Coral dispersant

Acute :

- 100% Mortality in doses 50 ppm and higher after <24 hours

  LC50 96 hours based on 3 repeated experiments is < 30 ppm

- Visual; solubilization of corals, ulcerations….

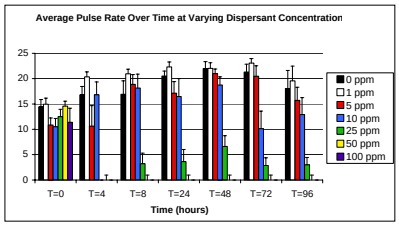
Control

Dispersant
(50 ppm, 1 hr)

- Compared to a similar species ; Hydra LC50 96 hours 160 ppm
- Compared to temperate anemone (*Anthopleura)* of >250 ppm

Results: Coral dispersant

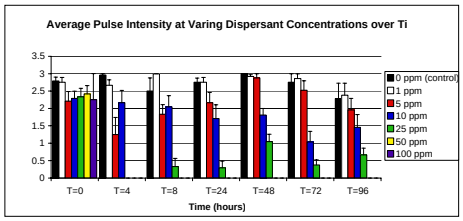
Sub lethal : Behavioral responses (1) Pulse rate



- Pulsing stops at 4 hours at levels of 25ppm and higher.
- Pulsing resumes after 8 hours at 25ppm dose, but reduced.
- Pulsing reduced at later time points in 10ppm dose.
- Narcotic type response with later recovery.

Results: Coral dispersant

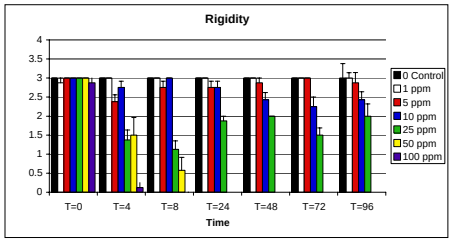
Sub lethal : Behavioral responses (2) Pulse Intensity



- Similar to pulse rate responses.
- Intensity reduced even at 5ppm level.
- Pulsing intensity reduced at later time points in 10ppm dose.

Results: Coral dispersant

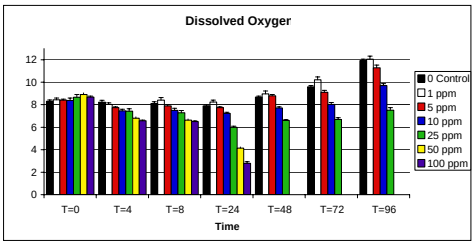
Sub lethal : Behavioral responses (3) Rigidity



- At 24 hours 50 and 100ppm dead (0 rigidity score).
- Significant effects at 10ppm and above.

Results: Coral dispersant

Sub lethal : Dissolved oxygen content (photosynthesis)

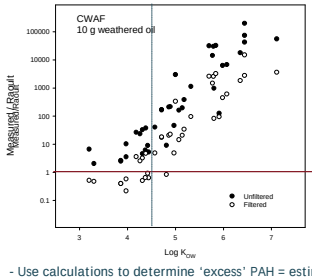


- Experiment modified to reduce DO increases (cloud cover episodes).
- Is reduction in DO from control at 10ppm and above.
- Significant impact to algae?

Results: Anemone Oil

(1) Chemistry cont….

- WAF is a well-behaved emulsion with respect to Raoult's Law partitioning of PAHs - Able to predict concentrations to within a factor of 3 (no tweaking).



CEWAF:

tPAH unfiltered : 1090 ug/l
tPAH filtered : 115 ug/l

Note : log scale!

Most of the PAH with Kow >4.5 are in the colloids

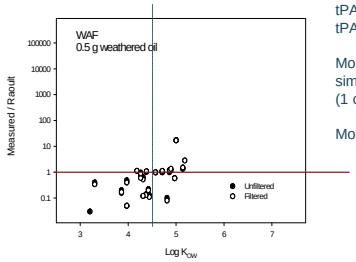
So not all oil is removed by filtering

- Use calculations to determine 'excess' PAH = estimate amount colloids in suspension.

Results: Anemone Oil

(1) Chemistry cont....

- Compare with the WAF calculations below:



WAF:

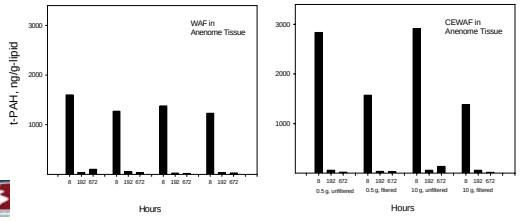
tPAH unfiltered : 37 ug/l
tPAH filtered : 23 ug/l

Most of the PAH are similar to predicted values (1 or less).

Most Kow <5.2

Results: Anemone Oil

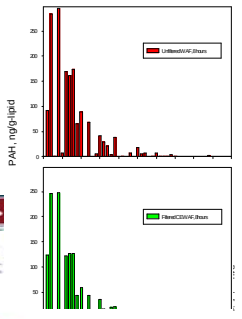
(2) Further chemistry ; Anemone PAH bioaccumulation

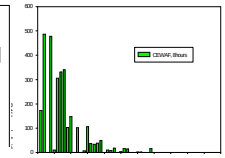


- WAF 8 hour exposure; similar across all treatments.
- CEWAF 8 hour exposure; similar in doses, **less in UF** and similar to WAFs.
- Significant depuration by 7 days.

Results: Anemone Oil

(2) Further chemistry ; Anemone PAH bioaccumulation cont....





- PAHs in anemones after 8 hours
- Despite much higher total aqueous exposure in CEWAF, filtering reduces accumulation (at least x2 fold).

(1) Acute:

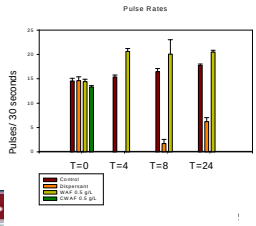
Results: Coral Oil

- Oil loading driven by dispersant toxicity (max used 20ppm)
- Stock 1g/l oil; with 1:25 dispersant:oil ratio = 40ppm dispersant
  - Oil; 0, 0.01, 0.05, 0.1 and 0.5g/l (max. as 20ppm disp.)
- Acute and sub lethal metrics (as in dispersant exposures)

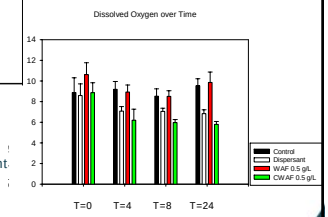
Results: Coral Oil

(1) Acute:

(a) Pulse rate



(b) Dissolved Oxygen

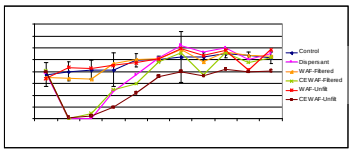


- WAF no effect; CEWAF more potent than dispersant alone, hard to see additive effect.
- DO not as apparent as anemone as tried to minimize this reduction (with volume and lighting etc).

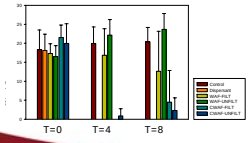
Results: Coral Oil

(2) Detailed:

- Oil loading driven by dispersant (max used 20ppm; so 0.5g/l oil)
- Filtered versus unfiltered preparations



CWU – after 1 week recovery

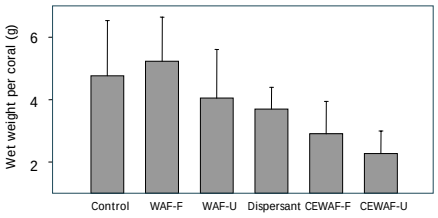


- Dispersant and CEWAF similar 8hrs
- WAF no effects
- Recovery longest in CEWAF filtered

Results: Coral Oil

(2) Detailed:

Final weights of corals at Day 38



- Recovery dependent on exposure..significant reductions.
- Effects of filtered / unfiltered?
- Also mortality of 2 (of 8) in CEWAF-U
  (so total av. weight would be lower)

Results: Coral Oil

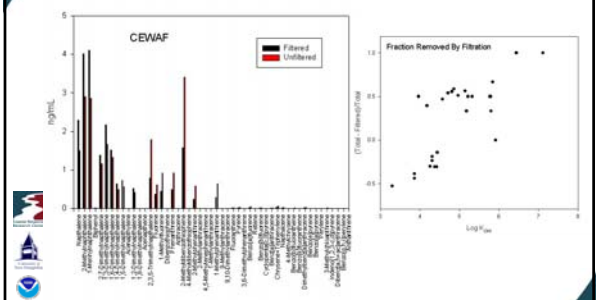
(3) Chemistry: **Detailed study (t-PAH, ng/ml)**
Stocks and after 8 hour exposure ( )

	Unfiltered		Filtered	
Control	0.0	(0.01)	-	
Dispersant	0.14	(0.08)	-	
WAF (0.5g/l)	3.17	(10.64)	2.38	(3.33)
CEWAF (0.5g/l)	22.04	(19.35)	21.76	(15.10)

- CEWAF x7 higher cf. equal load WAF
- Filtering does NOT reduce t-PAH CEWAF much

Results: Coral Oil

(3) Chemistry: **Detailed study (PAH, ng/ml)**



- Filtering reduces larger Kow fraction (colloids)

Conclusions : Implications

- Acute toxicity of dispersant to anemones similar or less than related species, corals more sensitive.
- Behavioral biomarkers are sensitive endpoints.
- Filtering CEWAF reduces t-PAH, remaining colloidal fraction.
- Route of exposure important: role of colloidal material in enhanced uptake in anemones.
- Behavioral response of anemones may moderate PAH accumulation.
- Anemones quick to depurate PAHs and recover sub lethal endpoints
- CEWAF effect on sub lethal endpoints; hard to show additive effect over dispersant only.
- Long-term effect of dispersant and CEWAF on coral growth.

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