

DISCOBIOL Program: The Use of Dispersants in Coastal and Estuarine Waters

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François Xavier Merlin (1), Stéphane Le Floch (1), Matthieu Dussauze (1),
Michael Theron (2), Claire Quentel (3), Hélène Thomas (4)

(1) Cedre

(2) ORPHY-UBO Brest University, European University of Brittany

(3) AFSSA, French Food Safety Agency,

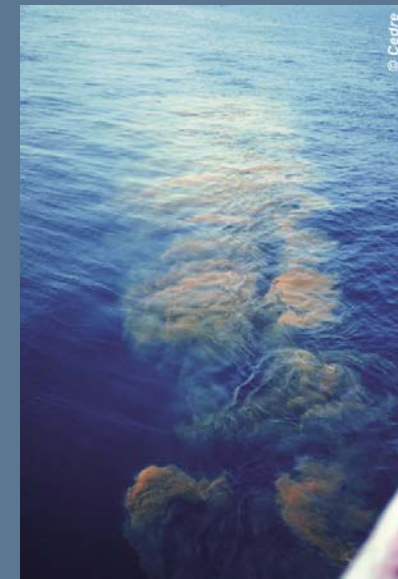
(4) LIENS, CNRS-University of La Rochelle

Email: Francois.Merlin@cedre.fr



Chemical Dispersion

- Suspension of finer oil droplets in the water column.
- Reducing / avoiding arrivals of pollutant on shoreline
- Enhancing oil biodegradation
- Limitations on viscous and/or weathered oils
- **Temporarily and locally increasing the oil toxicity**

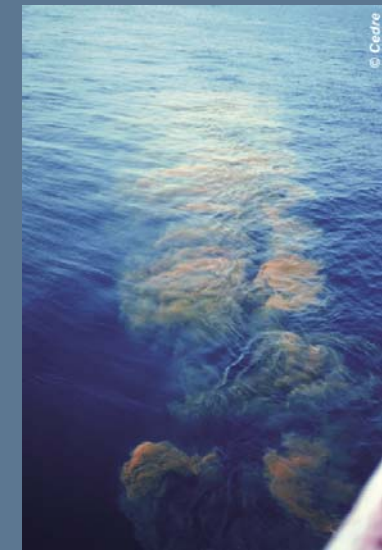


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Chemical Dispersion

- Temporarily and locally increasing the oil toxicity
- The toxicity of the dispersed oil is related to the dispersed oil concentration in the water column, and therefore to the natural dilution of the dispersed plume
- NEBA: Net Environmental Benefit Analysis



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N.E.B.A.

- **Definition**
 - *Net Environment Benefit Analysis (on the use of dispersants)*
 - *Comparison between the consequences of the use and non use of dispersants in a given situation (spill, location, season....)*
 - *Comparison between the impact of the chemically dispersed oil and non chemically dispersed oil on local resources*
- **Objective**
 - *Facilitating the decision making process on the use or non use of dispersants*
- **Example**
 - *Offshore situation*
 - *Few resources in competition*
 - *High potential for dilution*
 - *Coastal location*
 - *Many resources at stake*
 - *Possibly low potential for dilution*

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N.E.B.A.

- *Practically:*

- *NEBA analysis is difficult and long (unrealistic in an operational time frame)*
- *NEBA can only be conducted in preparation of operations: contingency planning implementation*
- *In fact, this analysis is often replaced by limitations on dispersant use in coastal areas where depth and distance to the shore are limited, and/or in the vicinity of the sensitive resources*

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Limitations close to the shore

Close to the shore, the possibility of dilution and the vicinity of sensitive resources leads to limitations on dispersion

Limitations in European countries

- Germany: prohibited in coastal shallow waters (<10m), sheltered areas and restriction for depth between 10 and 20 m
- Italy: need for authorisation when depth <30 m and distance to the shore <1 NM
- Malta: generally prohibited when distance is <3 NM and depth <60m
- Norway: prohibited when depth <20 m and distance <200 m
- UK: need for authorisation when depth <20 m and distance <1 NM

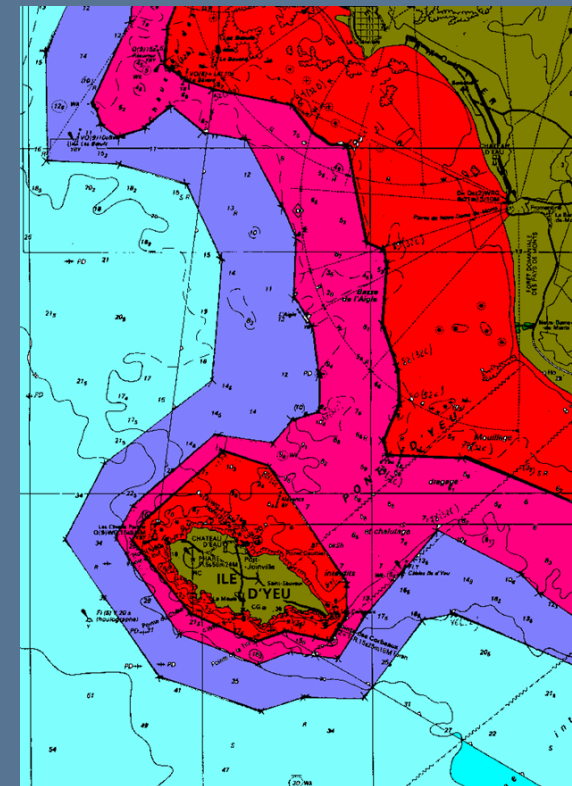


France: Dilution Concept

Dilution is related to the volume of water available.
The volume of water is related to depth and distance to the shore.

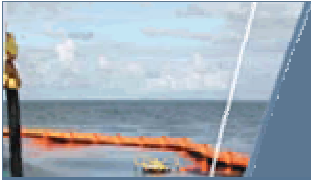
- France requirements:
 - 1) dispersed oil with concentration $< 10 \text{ ppm}$
 - 2) the potential of dilution = f (amount of oil)

Oil (T)	Distance (NM)	Depth (m)
10	0.5	5
100	1	10
1000	2.5	15



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Dispersed oil concentrations

At sea (e.g. Sea Empress incident 1995- 72,000 t released)

Up to 10 ppm	straight after dispersant spraying
1 ppm	2 days after
0.5 ppm	1 week after
0.2 ppm	1 month after
Background level	3 months after

Considered in NEBA process (NOAA)

Consensus on exposure thresholds of concern in ppm for dispersed oil in ppm

Exposure	Level of concern	Sensitive life stages		Adult fish		Adult crustacea	
		Regular	More protective	Regular	More protective	Regular	More protective
0-8 h	Low	< 5	< 1 – 5	< 10	< 10	< 5	< 5
	Medium	5-10	5 – 10	10 – 100	10 – 100	5 – 50	5 – 50
	High	> 10	> 10	> 100	> 100	> 50	> 50
8-24 h	Low	< 1	< 0.5	< 2	< 0.5	< 2	< 0.5
	Medium	1 – 5	0.5 – 5	2 – 10	5 – 10	2 – 5	0.5 – 5
	High	> 5	> 5	> 10	> 10	> 5	> 5
24-96 h	Low	< 1	< 0.5	< 1	< 0.5	< 1	< 0.5
	Medium			1 – 5	0 – 5	1 – 5	0.5 – 1
	High	> 1	> 0.5	> 5	> 5	> 5	> 1

Discobiol objective

- Recommendations on the use of dispersant in coastal and estuarine waters in temperate climates
 - Improvement of operational guides
- Getting robust technical information on dispersed oil toxicity

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Program description

- Comparison of toxicity and impact of dispersed and non dispersed oil in main estuarine habitats
 - Phase 1 A & B => Water column
 - Phase 2 A & B => Mudflat habitat & Salt marsh
 - Complementary works
 - Phase 3 implementation of recommendations on the use of dispersants
- Several representative species of studied habitats were used: fish (pelagic and benthic), bivalves and shellfish
- Tests carried out on dispersed oil (not soluble fraction)
- Tests carried out on lightly weathered oil (to simulate oil having weathered for a few hours at sea)
- Short exposure 24h (initially)... Then 48h

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Phase 1A Objective & Content

Data on dispersed oil acute toxicity [LC_{50} (24h)]

- on fish (Sea Bass, Turbot and Grey Mullet),
- on bivalves (Oyster and Mussel)
- on Crustaceans (Shrimp)



- *Method:*
 - *One oil; 2 dispersants*
 - *Exposure to increasing concentrations*
 - *24h exposure followed by 24h recovery in water*
- *Equipment:*



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Experimental conditions

DM = Mechanical Dispersion

DC1 = Chemical Dispersion dispersant A

DC2 = Chemical Dispersion dispersant B

T = Control (without oil)

PS = mineral (Sedimentary) Particle

PSDC1 = mineral (Sedimentary) Particle + Chemical Dispersion dispersant A

ds1 = dispersant A alone

ds2 = dispersant B alone

WSF = Water Soluble Fraction

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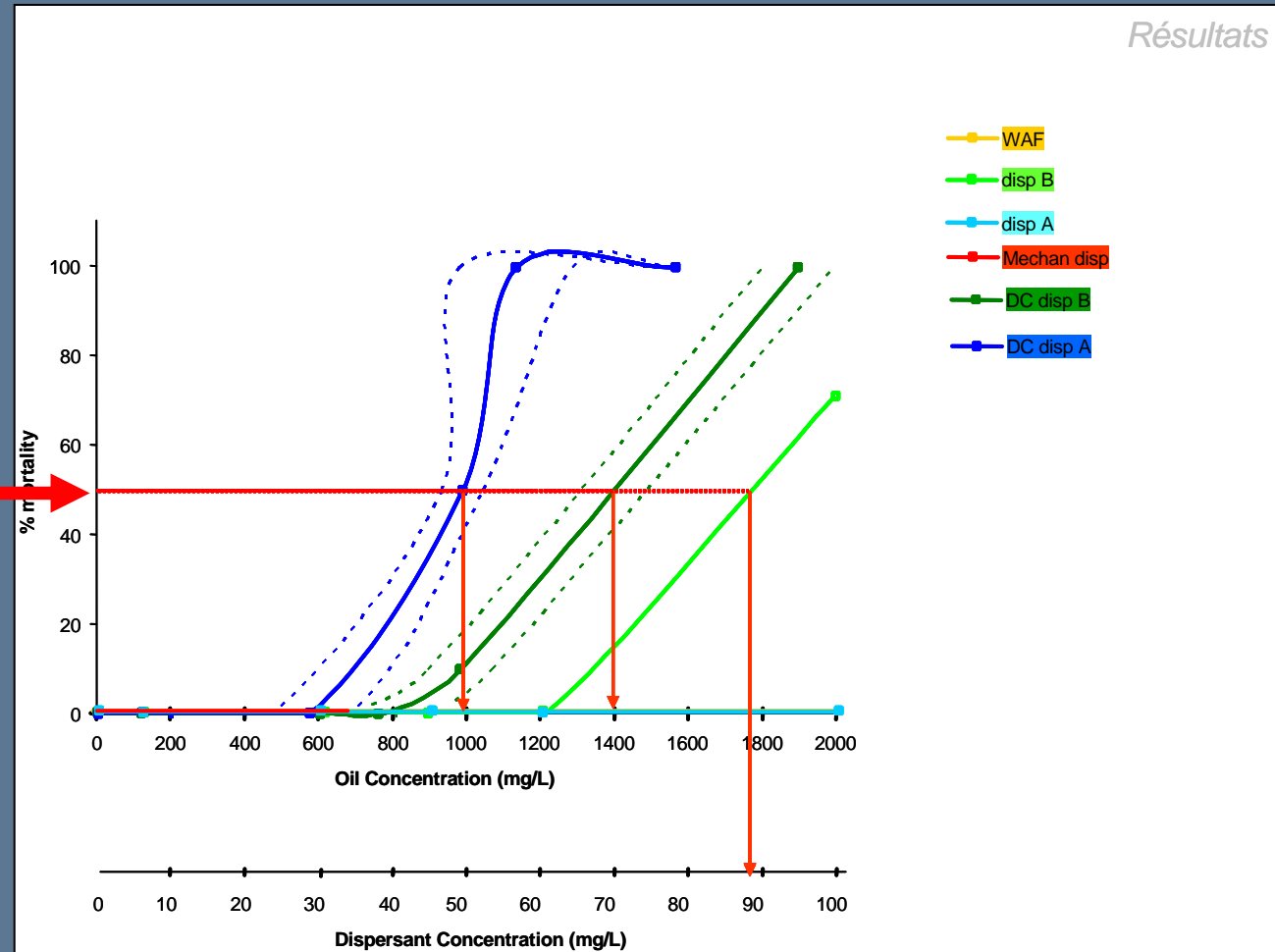
Phase 1 A Results on fish

- LC_{50} Sea Bass

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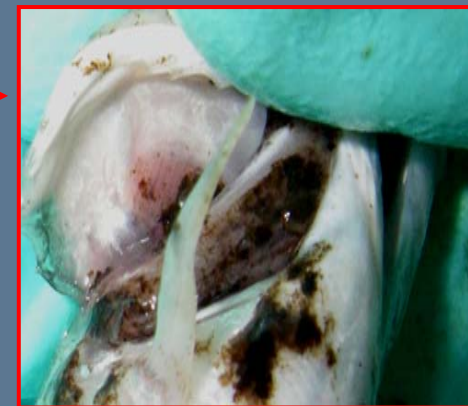
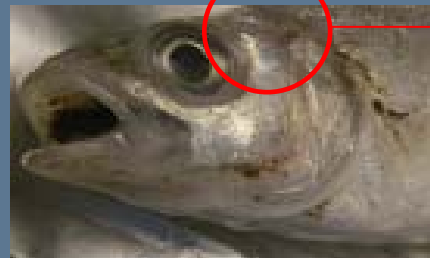
50%



Phase 1 A Results on fish

- LC_{50}

	DM	DC1	DC2
Shrimp	not reached	---	700 ppm
Sea Bass	not reached	870 ppm	1175 ppm
Turbot	not reached	315 ppm	480 ppm
Mullet	not reached	680 ppm	1270 ppm

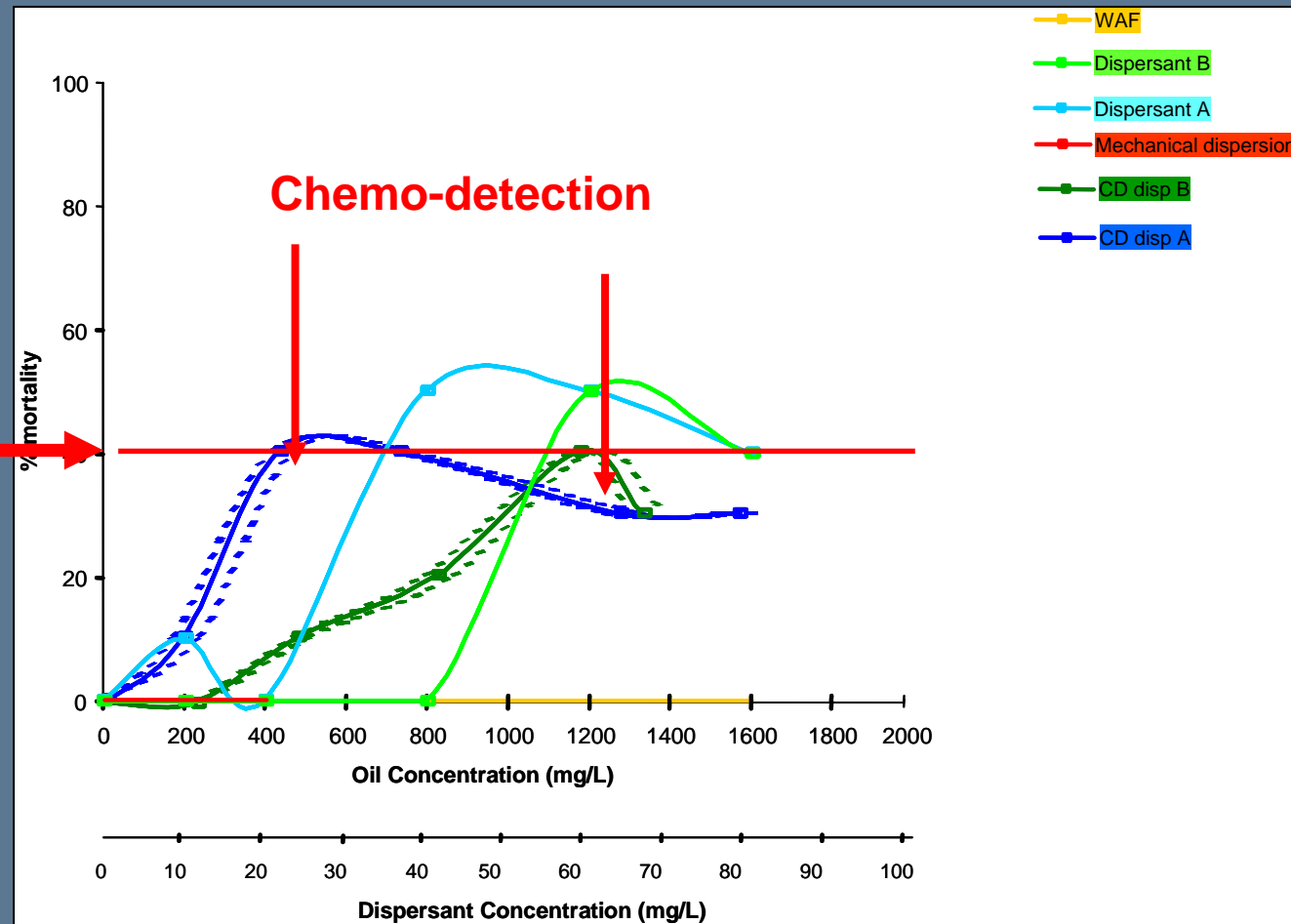


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Phase 1A Results on bivalve

- Exposure response curve: no LC_{50} 24h



50%

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Phase 1 A Conclusions

- *DM LC₅₀ not reached*
- *Toxicity: DC > DM*
- *Dispersed oil seems to alter respiration process*
- *LC₅₀ 24h >>> dispersed oil concentrations found during real incident (ppm to x10 ppm)*
- *According to these results: no mortality (on adults) should be promoted by the use of dispersant*
- *But what about possible sub lethal effects??*



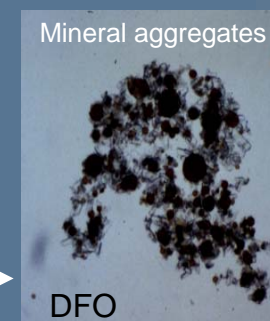
Phase 1B: Objectives

Objectives

looking for sub-lethal adverse effects promoted by more realistic dispersed oil exposures

Content

- Species:
 - on fish (Sea Bass, Turbot and Grey Mullet),
 - on bivalves (Oyster and Mussel)
- Exposure Conditions: **X10 ppm (30 to 70 ppm), 48 h**
- SPM: Estuarine condition; experimental model: silt → (montmorillonite)
- Parameters:
 - Chemical (oil concentration -disp^d, dissol^d- & bioaccumulation)
 - Biological (biochemical, physiological)



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Phase 1B Analysis & measurements

FISH

- PAH bioaccumulation
- Physiology / Cellular homeostasis
 - (Hydromineral equilibrium, (Osmolality, [Na⁺], [Cl⁻], [K⁺])
 - Gas exchanges (pO₂, pCO₂),
 - Acid-Base equilibrium (pH, [HCO₃⁻], pCO₂, Bu, fer line slope Contamination level)
- Biliary metabolites (343 : 383 nm, 380 : 430 nm)
- Immune system (Glucose, cortisol, lactate)

BIVALVE:

- PAH bioaccumulation
- Immune system
 - phenoloxidase activities (catecholase and laccase)
 - lysosomal membrane stability (LMS)
 - antioxidant enzyme activities (SOD, CAT, GPx)

Phase 1B: Method & equipent

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Exposure tanks: x14 (300 litres)

Pumps, filters UV....

Stabulation tanks: x4 (4000 litres)

Exposure tanks equipped with a pumping system to skim and continuously recirculate the oil in the water column

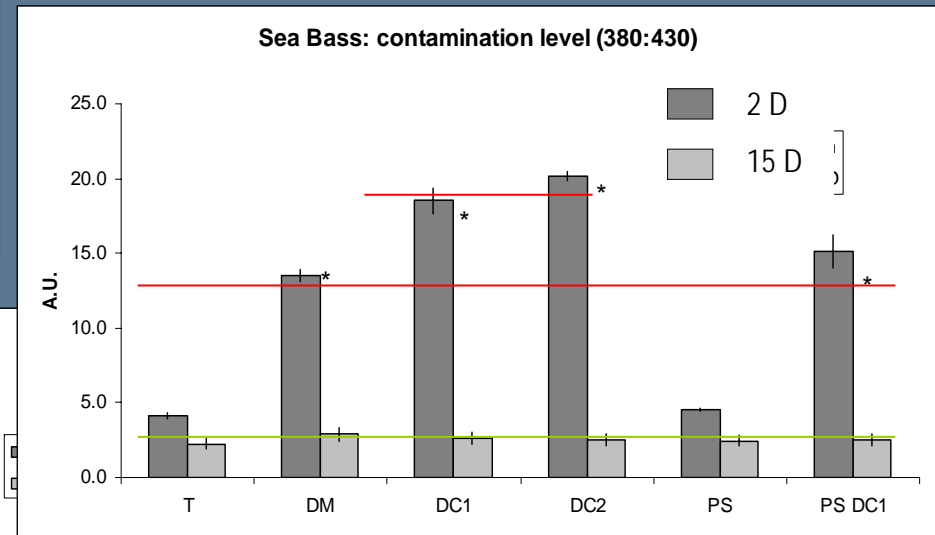
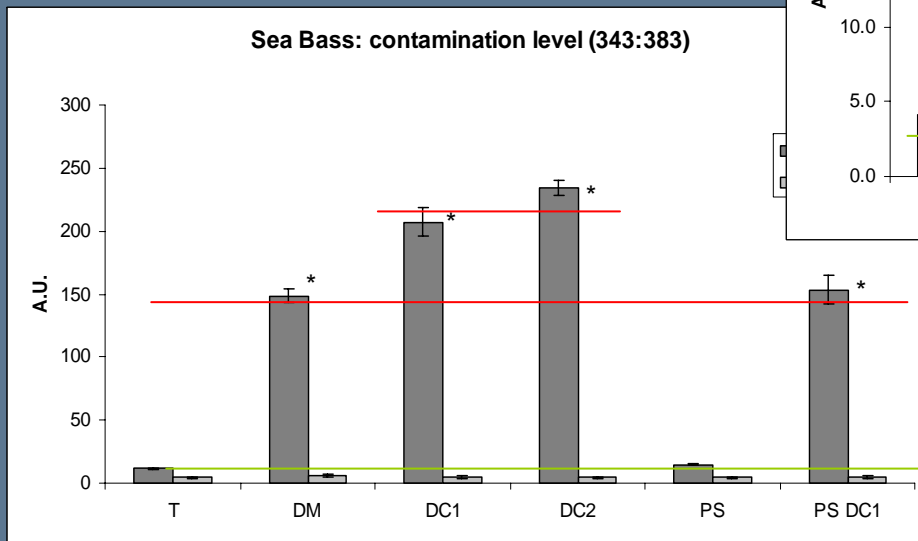


Results on fish

- Sea Bass: metabolites in liver



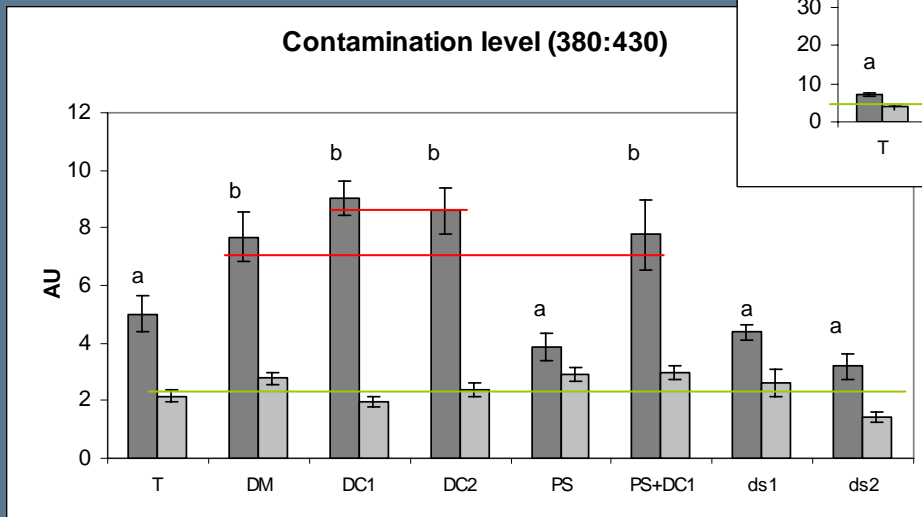
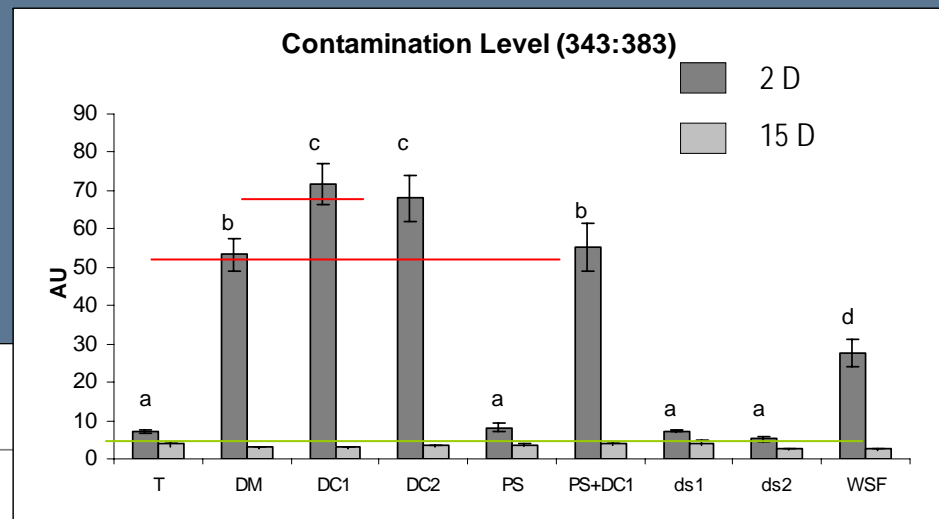
- After exposure
- DC1 = DC2 > DM = PSDC1 >> PS = T
- After 2 weeks
- DC1=DC2=DM=PSDC1=PS=T



Results on fish

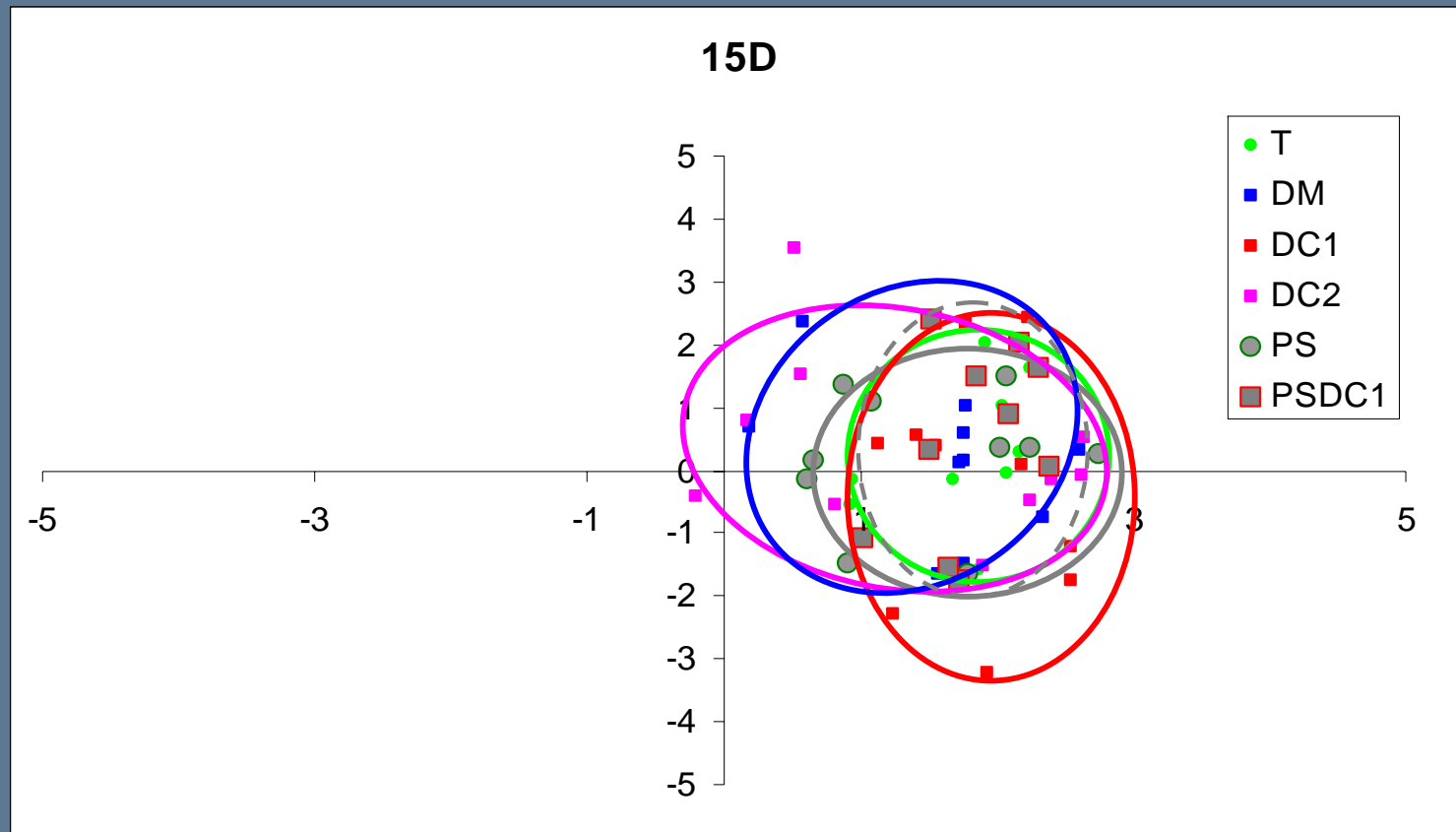
- Turbot: metabolites in liver

- After exposure
- DC1 = DC2 # DM = PSDC1 >> PS = T
- After 2 weeks
- DC1=DC2=DM=PSDC1=PS=T



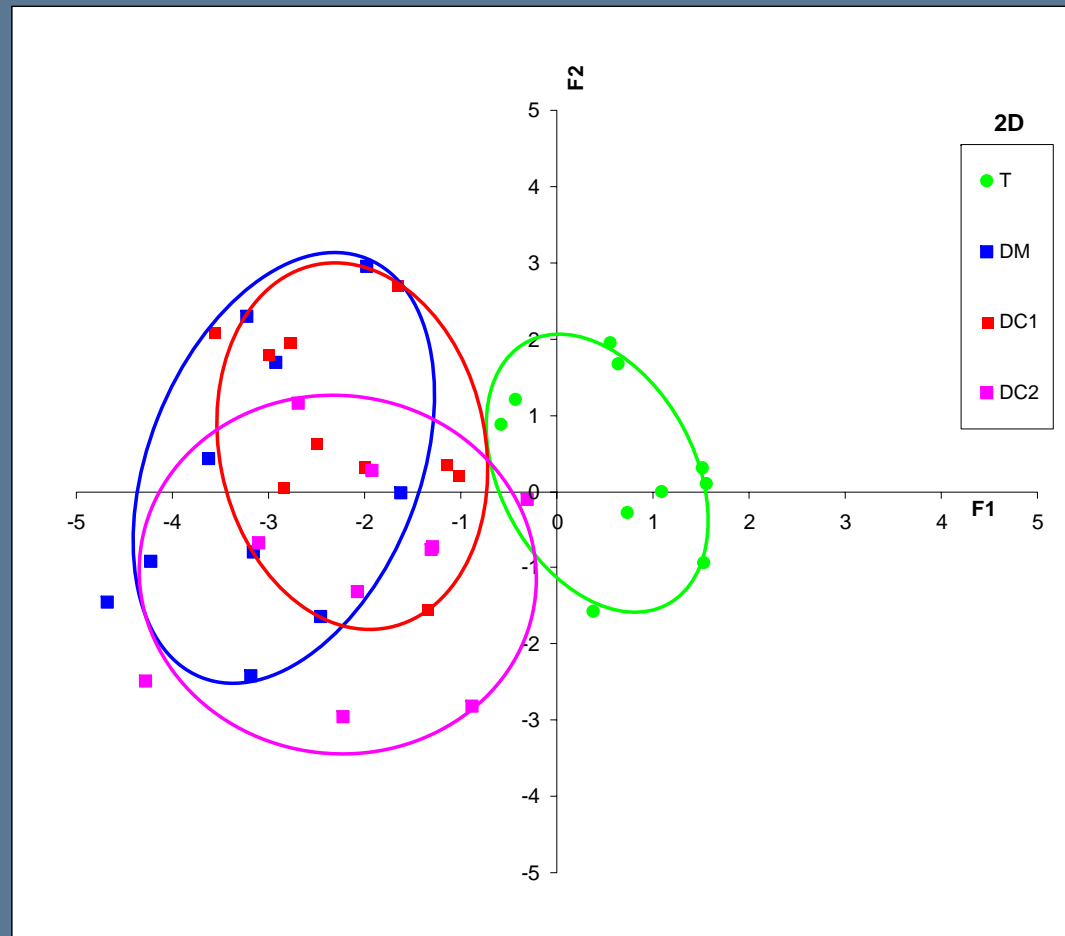
Results on fish integration: CPA analyses Sea Bass

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Results on fish integration: CPA analyses

Turbot



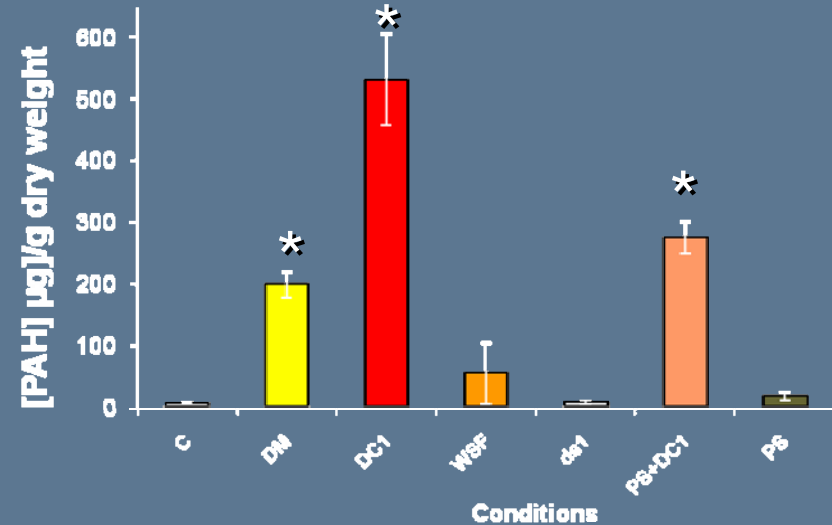
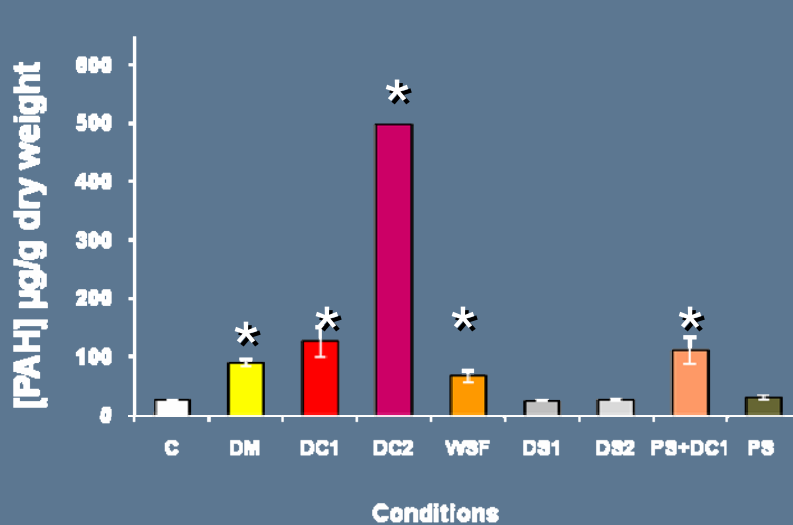
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Results on bivalves

PAH content in bivalves: Exposure period

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n=3, * p < 0.05



After the exposure period: a higher bioconcentration of hydrocarbons is observed for DC



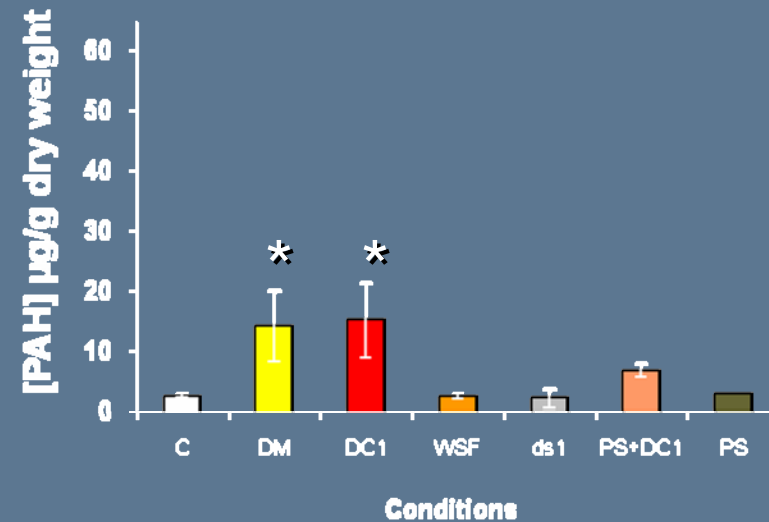
Results on bivalves

PAH content in bivalves: Depuration period

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Data not available



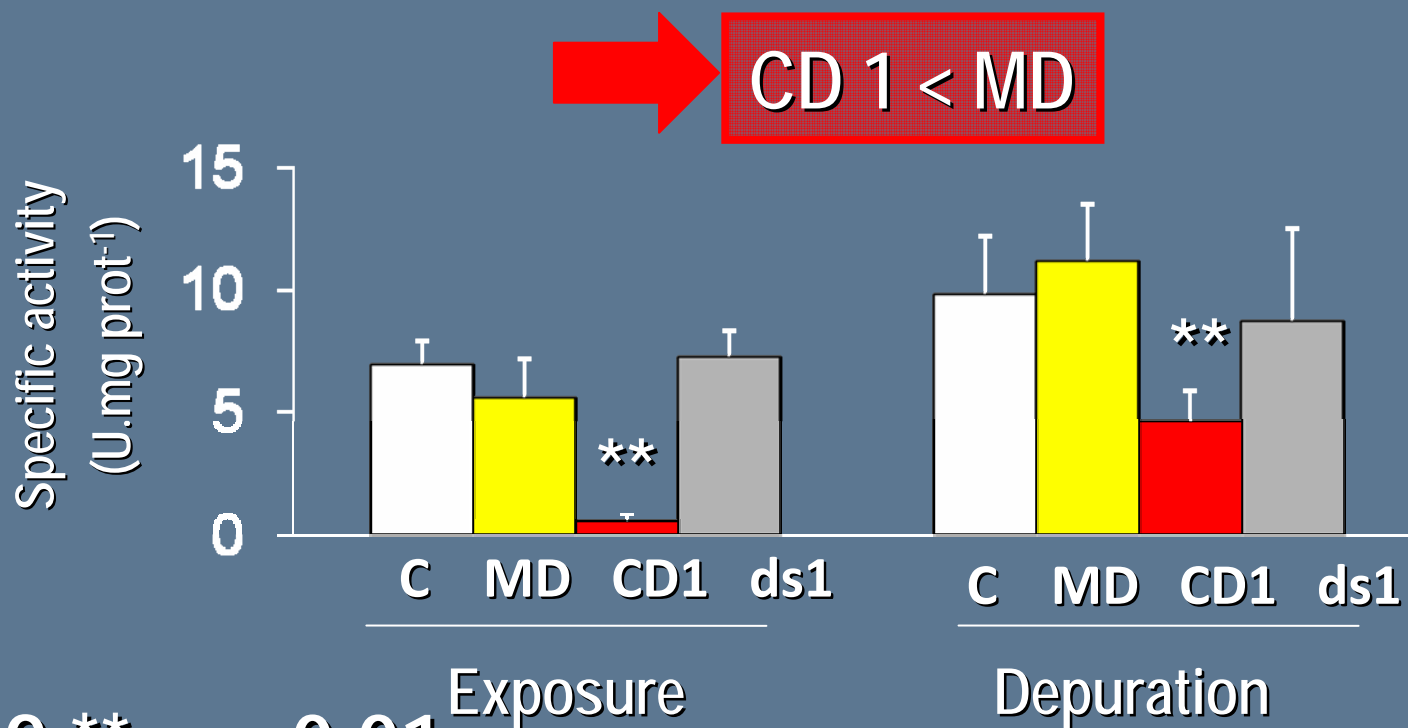
$n=3, * p < 0.05$

After the depuration period: hydrocarbons are almost **completely depurated** by oysters, even for DC



Results on bivalves

Laccase activity in plasma

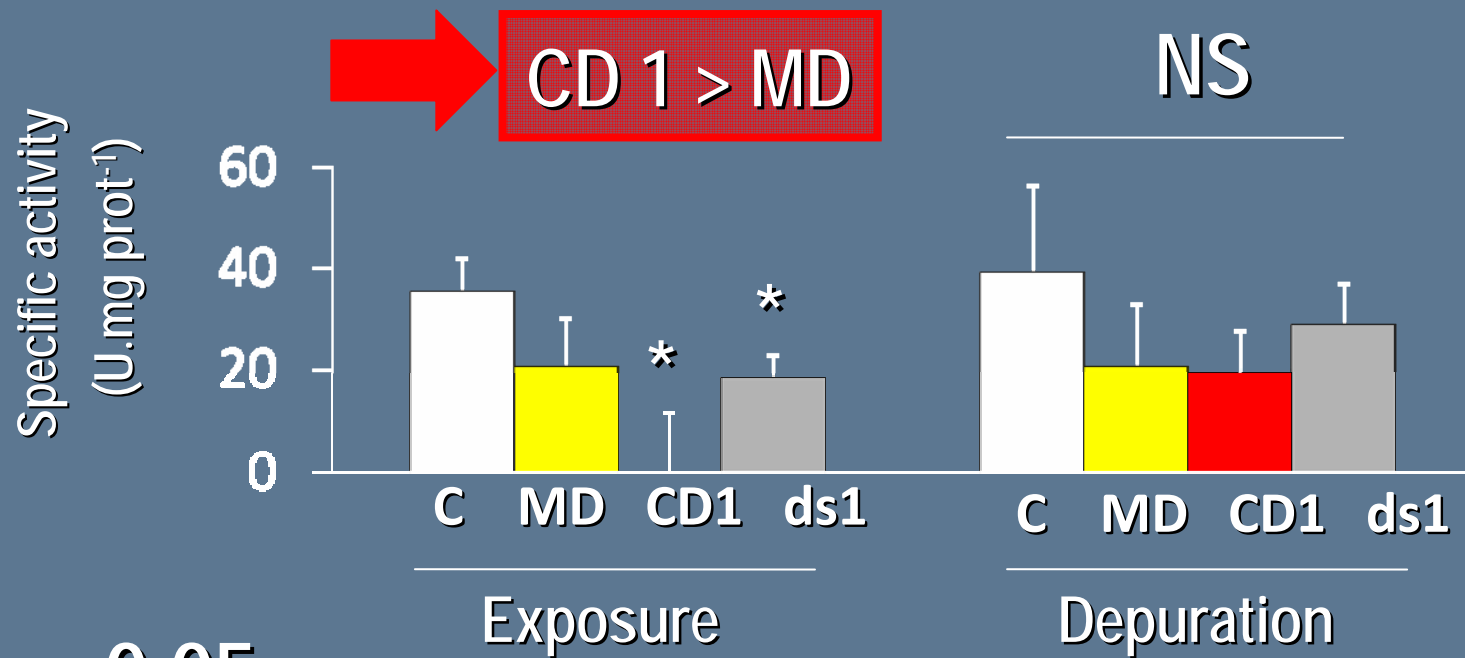


n=9, ** p < 0.01



Results on bivalves

Glutathione peroxidase activity in gills



* $p < 0.05$



Conclusions

On fish

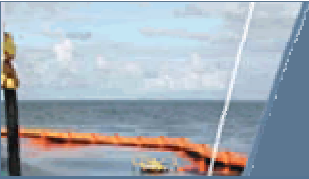
- After contamination (often but not always) **differences between DM and DC**
- After 15 days in clean sea water (deuration), **almost complete recovery**

On bivalves

- After contamination, the effect of DC is **greater than or equal to the effect of MD**
- After 15 days in clean sea water (deuration), hydrocarbons have almost been completely **depurated**, but some effects are still observed, especially for DC

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Conclusions and consequences

- Lethal effects

- LC50 found are higher than concentrations during an oil spill

- Sublethal effects

- Discobiol Exposure \geq to what is observed in real case

- 30 to 70 ppm for 48 h $<$ 10 to 1 ppm

- Reversible impact of oil intoxication for the majority of our biomarkers

- No persistence of differences (after 2 weeks or slightly more) between DC and DM

- \Rightarrow These preliminary results tend to facilitate the regulations / recommendations on the use of the chemical dispersion of oil slick in coastal and estuarine areas

- But considering occasional use (non repetitive use)

- But considering adult and juvenile stages... not more sensitive larval stages

- But considering surface pollution (not subsea)

- However, need to wait for the study to be fully completed before giving final conclusions

- *Note: Results of North American studies often lead to more restrictive results (fresh – weathered oil) and often more sensitive stages.*

Conclusions and consequences

- => These preliminary results tend to facilitate the regulations / recommendations on the use of the chemical dispersion of oil slicks in coastal and estuarine areas

This conclusion is supported by other studies

- *Cedre study on Coral (10 ppm/6h, 1000 ppm/6h)*
- *TROPIC experiment (DC better than MD for mangroves, preservation of flora, recolonization of fauna, acceptable effect on coral)*

This conclusion is supported by observations during real incidents

- *Sea Empress....1995 – 440 t dispt*
- *Braer*
- *...*

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Conclusions and consequences

French Geographical Limits for chemical dispersion:

- Probable proposition easing these limits by
 - Moving the limits towards the shore or,
 - Keeping the limits but increasing the quantity of oil to be dispersed
 - 10 ppm/6 hours to 30-70 ppm/48h => x5 to x10
 - => 3 limits: 50, 500 and 5,000 t or 100, 1,000 and 10,000 t

Input into documents under revision:

- National policy on dispersant use
 - Revision country by country.....template policy document
 - Algeria, Turkey, South West Indian Ocean, West African countries
- Revision of international documents
 - REMPEC document (Model for the Mediterranean countries)
 - IPIECA and IMO guidelines on dispersants

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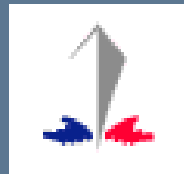
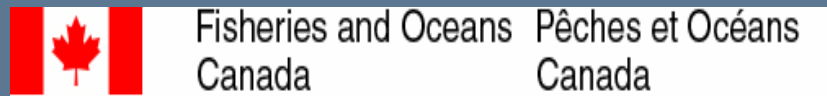
Phase 1b: Sub-Lethal Toxicity Assessment

Acknowledgements:

– Initial French Partners:



– Additional Partners & Support:



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Basic principles for conducting a NEBA for the use of dispersant in a coastal area (1)

- 1) To consider the use of dispersant first for an offshore area, far enough to prevent / reduce oil drifting to the shore and sensitive items
(sensitive items = areas for which the quality of the (sea) water must be preserved)
- 2) Generally speaking no chemical dispersion close to sensitive areas.
- 3) In coastal areas for which several sensitive items may be at stake a comparative analysis of the situation (NEBA) should be completed; such an analysis should be based on realistic scenario studies.

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Basic principles for conducting a NEBA for the use of dispersant in a coastal area (2)

When conducting a NEBA:

4. The different items (or resources) must be listed and the sensitivity / vulnerability assessed.
5. When there is conflict between several items,

5-1=>preserve the biotope (habitats) before the species

5-2=> Preserve the reproduction capability before the larval and juvenile stages

6. Bird areas: special care should be taken to avoid spraying dispersant into winds blowing towards these areas (no dispersant on birds feadows).

Note 1: Caution: the use of dispersant is a response technique for accidental pollution. In coastal areas, the repeated use of dispersant can lead to chronic pollution.

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