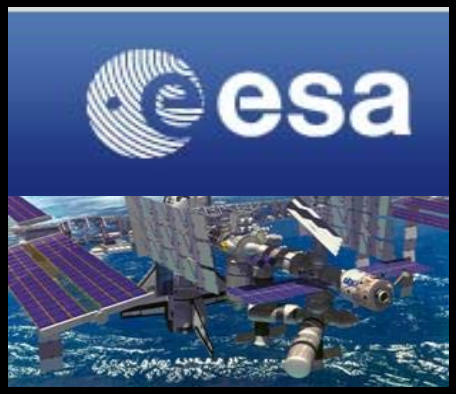
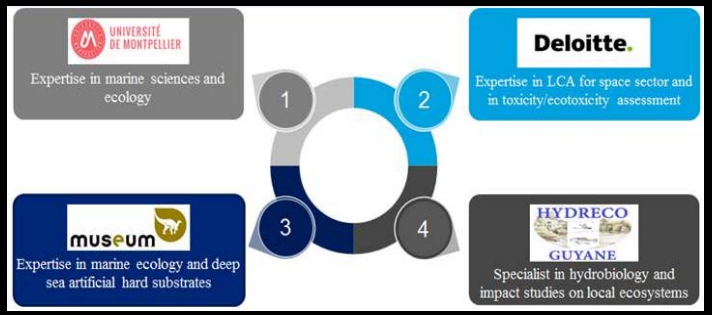


Functional Ecology to Reduce Launchers Impact on Deep Sea (ESA AO 1-8623/16/NL/KML)

Prof. Tatiana Valleys & Prof. Jehan-Hervé Lignot
University of Montpellier




TF1
UN MORCEAU DE FUSÉE ÉCHOUÉ SUR UNE ÎLE BRETONNE
-00:46
01:38

AS SEEN ON TV

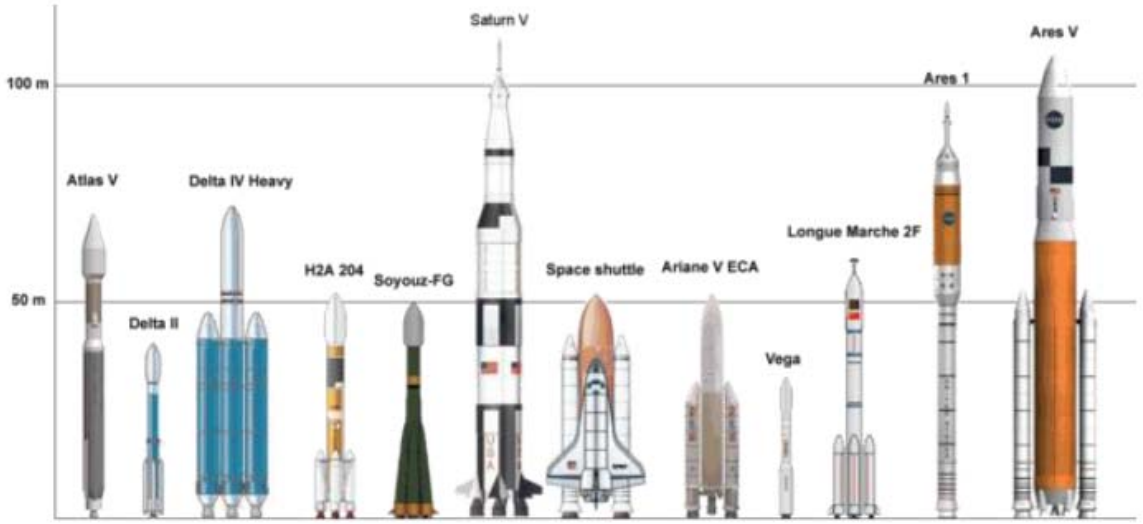

DIR

Barnacles

Anatife : *Lepas anatifera*

Available:

Launcher composition (ARIANE and VEGA) : list of components



Estimation of the behaviour and toxicity of the components of the launchers in marine conditions

- Litterature was checked for fate and behaviour of Ariane and Vega components
- Toxicity experiments were performed for a set of representative **non-metallic components** of VEGA and & ARIANE LAUNCHERS
- **Metallic corrosion and toxicity in seawater** for a set of representative alloys used for aerospace vessels

Substances with known toxicological or ecotoxicological hazards

List of LD50, LC50 and EC50 of substances

Color code for mass classification of launcher materials (in kg)

<1
1-10
10-70
70-150
150-500
500-1000
1000-2000
2000-8000
>19 000

Component	Mass A5	Mass VEGA	Mammals LD50 (mg/kg)	Mammals LC50 (mg/L)	Aquatic species LC50 (mg/L)	Aquatic species EC50 (mg/L)
Alumina			> 5000 (oral, rat)	> 2.3 (4h, inhalation, rat)	> 218.64 (96h, fish)	
Aluminium			2000 mg/kg (oral, rat)			1,5 (algae)
Ammonium perchlorate			1900 (oral, rat)			2 (bacteria)
Antimony trioxide Sb2O3			34600 (oral, rat)		> 1,000 (96h, fish)	>1,000 (daphnia magna) 67 (algae)
Antimony			7 (oral, rat)		261 (24h, larvae) 4.92 (24h, flea) 206 (72h, algae)	
Aramid fibre			7500 (oral, rat)			
Bentonite			35 (intravenous, rat)		19000 (96h, fish)	
BeO (beryllium oxide)			2062 (oral, mouse)			
Boron			650 (oral, rat)			
Bromine			2.600 (oral, rat)	2,700 (inhalation, rat)		Fish > 10 (fish) 10 (daphnia magna)
CaCO3 (calcium carbonate)			6450 (oral, rat)		56 000 (48h, fish)	
Cadmium			2330 (oral, rat)		0,001 (96h, fish)	0.024 (daphnia magna) 0.023 (algae)
Ceramic			>22,500 (oral, rat)		> 10 000 (72h, fish)	
Chlorine				293 ppm (1h, inhalation,	0.014 (96h, fish)	0.019 (daphnia magna)

Risk ranking for substances present in the launchers

Component, for A5		Component, for VEGA
Paint		**Paint**
Chlorine		**Cadmium**
Copper		**Copper**
Cadmium		**Zinc**
Zinc	Top 5	**Chlorine**
Xylene		Phenol
Sulfur		**Alumina**
Dicyclopentadiene		**Xylene**
Alumina		**Mercury**
Ethylbenzene	Top 10	**Sulfur**
Nickel		**Ethylbenzene**
Explosive		EPDM rubber
Mercury		**Explosive**
Phosphorus		**Nickel**
Toluene	Top 15	Lead
Molybdenum		Phosphorus
Vinyl acetate		Toluene
Lead		Vinyl acetate
Graphite		Lithium salts
Zirconium oxide		Dicyclopentadiene
Potassium hydroxide		Molybdenum
Antimony trioxide Sb2O3		Potassium hydroxide
EPDM rubber		Graphite
Phenol		Zirconium oxide
Bentonite		Lime
Lithium salts		Titanium tetrabutanolate
Petroleum naphtha		Antimony trioxide Sb2O3
Lime		Petroleum naphtha
Titanium tetrabutanolate		Bentonite
Ceramic		Ceramic
Chromium(III) oxide		Chromium(III) oxide
Caco3 (calcium carbonate)		Caco3 (calcium carbonate)

Substances with limited or no known toxicological or ecotoxicological hazards

Color code for mass classification of launcher materials (in kg)

<1
1-10
10-70
70-150
150-500
500-1000
1000-2000
2000-8000
>19 000

No toxicological data

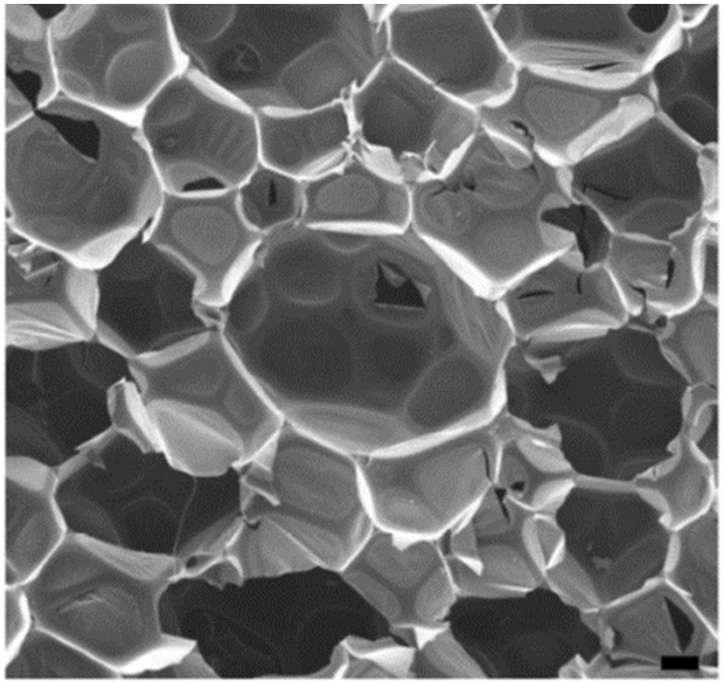
- Bismaldeide triazine
- Carbon
- Chemosil
- Chromium
- Epoxy resin - curative - 4,4'-DDS diaminodiphenylsulfone
- Glass
- Glass fibre
- Gold
- Helium
- Hydrogen
- Hydroxyl-terminated polybutadiene HTPB
- Lanthanum
- Lithium Cobalt Oxide
- Magnesium
- Magnesium alloy
- Mastic Silicone
- Melamine resin foam
- Niobium
- Phenolic resin
- Polyethylene terephthalate PET
- Polyimide PI
- Polyisoprene IR
- Polyphenylene sulfide PPS
- Polypyrrole PPy
- Polyurethane PU
- Polyvinyl chloride PVC
- Silica fibre
- Tetrakis(2-butoxyethyle)orthosilicate
- Viscose
- Zinc
- Zirconium oxide

No ecocological data

Antimony	Nylon
BeO (beryllium oxide)	Paper
Bismaldeide triazine	Phenol formaldehyde resin
Carbon	phenolic resin
Chemosil	Polycarbonate PC
Cobalt	Polyethylene terephthalate PET
Epoxy resin - curative - 4,4'-DDS diaminodiphenylsulfone	Polyimide PI
Epoxy resin (MY720)	Polyisoprene IR
Glass	Polyphenylene sulfide PPS
Glass fibre	Polypyrrole PPy
Glue Wacker T77	Polytetrafluoroethylene PTFE (Teflon)
Gold	Polyurethane PU
Helium	Silica
Hydrogen	Silica fibre
Hydroxyl-terminatedpolybutadiene HTPB	Silicon
Lanthanum	Silicon rubber
Lithium Cobalt Oxide	Silver
Magnesium alloy	Tetrakis(2-butoxyethyle) orthosilicate
Manganese Dioxide	Titanium
Mastic Silicone	Titanium dioxide
Melamine	Tungsten
NEXTEL	Vanadium
Melamine resin foam	Viscose
Niobium	Zirconium
Nitrogen tetroxide N2O4	

Aluminium
Titanium
Epoxy resin
Phenolic resin
Polyurethane (PU)

Substances with limited or no known toxicological or ecotoxicological hazards



100 µm

Aluminium
Titanium
Epoxy resin
Phenolic resin
Polyurethane (PU)

Risk ranking for substances present in the launchers

Component, for A5		Component, for VEGA
Paint		**Paint**
Chlorine		**Cadmium**
Copper		**Copper**
Cadmium		**Zinc**
Zinc	Top 5	**Chlorine**
Xylene		Phenol
Sulfur		**Alumina**
Dicyclopentadiene		**Xylene**
Alumina		**Mercury**
Ethylbenzene	Top 10	**Sulfur**
Nickel		**Ethylbenzene**
Explosive		EPDM rubber
Mercury		**Explosive**
Phosphorus		**Nickel**
Toluene	Top 15	Lead
Molybdenum		Phosphorus
Vinyl acetate		Toluene
Lead		Vinyl acetate
Graphite		Lithium salts
Zirconium oxide		Dicyclopentadiene
Potassium hydroxide		Molybdenum
Antimony trioxide Sb2O3		Potassium hydroxide
EPDM rubber		Graphite
Phenol		Zirconium oxide
Bentonite		Lime
Lithium salts		Titanium tetrabutanolate
Petroleum naphtha		Antimony trioxide Sb2O3
Lime		Petroleum naphtha
Titanium tetrabutanolate		Bentonite
Ceramic		Ceramic
Chromium(III) oxide		Chromium(III) oxide
Caco3 (calcium carbonate)		Caco3 (calcium carbonate)

Aluminium
Titanium
Epoxy resin
Phenolic resin
Polyurethane (PU)

Aluminium may be toxic for ocean life according to pressure, redox conditions, and essentially pH. Oceanic acidification due to solubilization of atmospheric CO_2 may increase aluminium solubility and toxicity.
For humans, 20% of consumed aluminium ends up in bones. Aluminum is supposed to play a part in Alzheimer disease or breast cancer.

Titan alloys are reported less toxic than aluminum

Metallic compounds	**Aluminium 2024** **Titanium 6Al 4V**
Non metallic compounds	**Epoxy resin** **Phenolic resin** **Polyurethane (PU)**

phenolic compounds are toxic and eco toxic. Phenol consumption is lethal (acting essentially on kidneys) and presents high toxicity risk due to heat resistance. Diffusion of phenolic compound derivatives is a risk.

Organic compounds

Litterature check

Behaviour in seawater

Ecotoxicological & Biofouling assessments in laboratory conditions

Organic compounds

10 organic substances out of 29 non-metallic degradation products with **no quantitative toxicological information available**

15 substances (out of 29) with **no quantitative ecological data available**

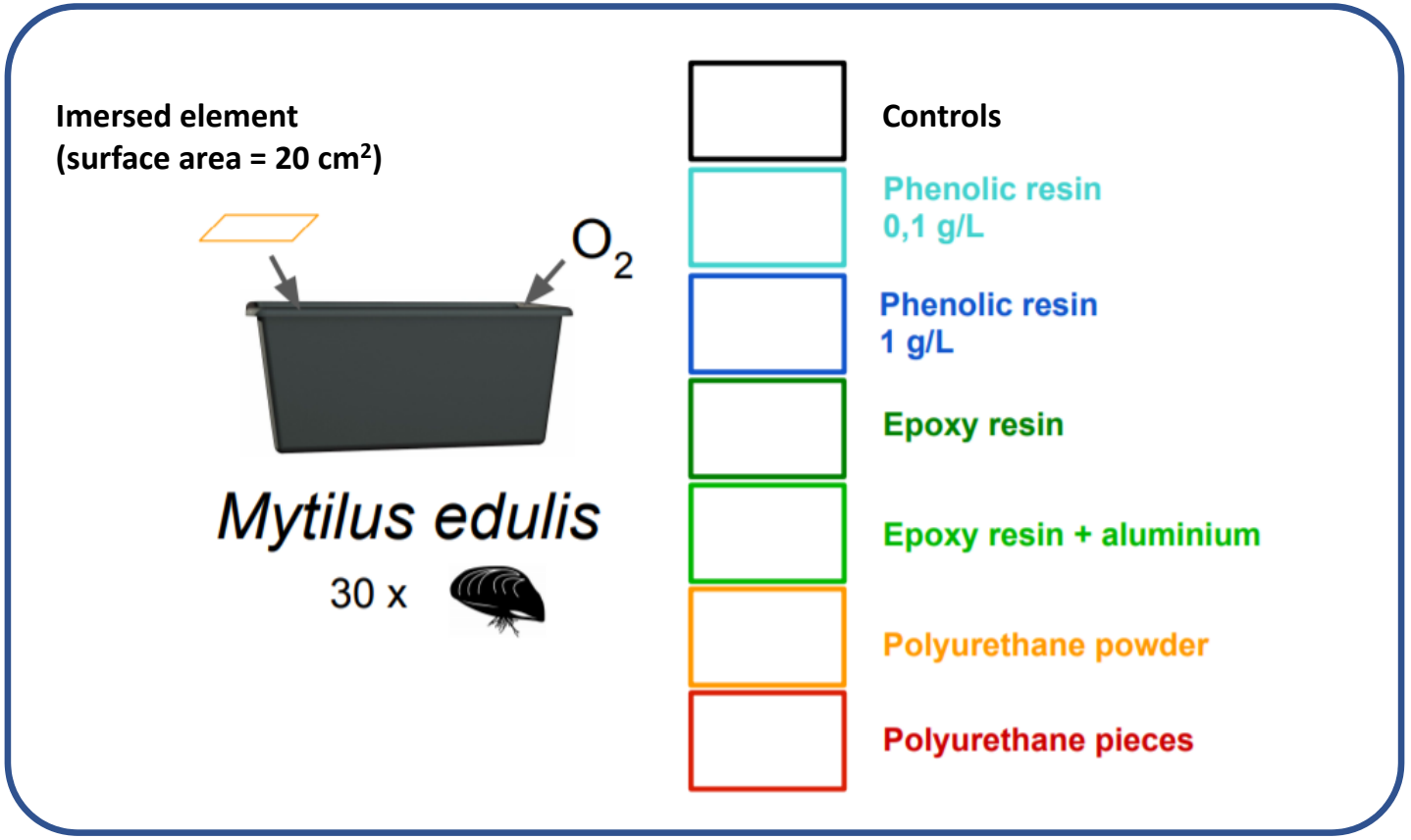
We selected :

- Phenolic resin @ 2 ≠ concentrations
- Epoxy resin @ 2 ≠ concentrations
- Polyurethan : powder / blocks

Organic compounds

Ecotoxicity evaluation

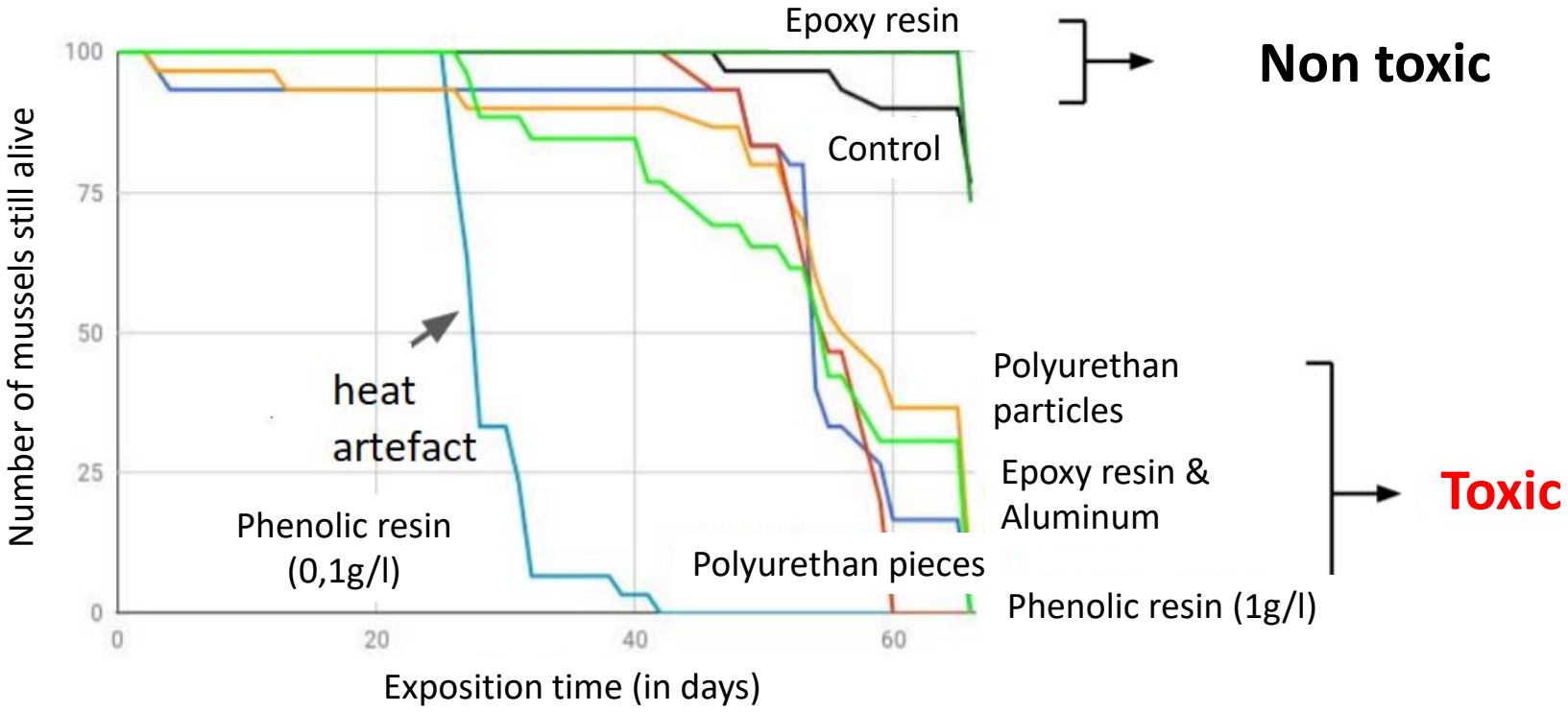
Macrofauna *in vitro*



Organic compounds

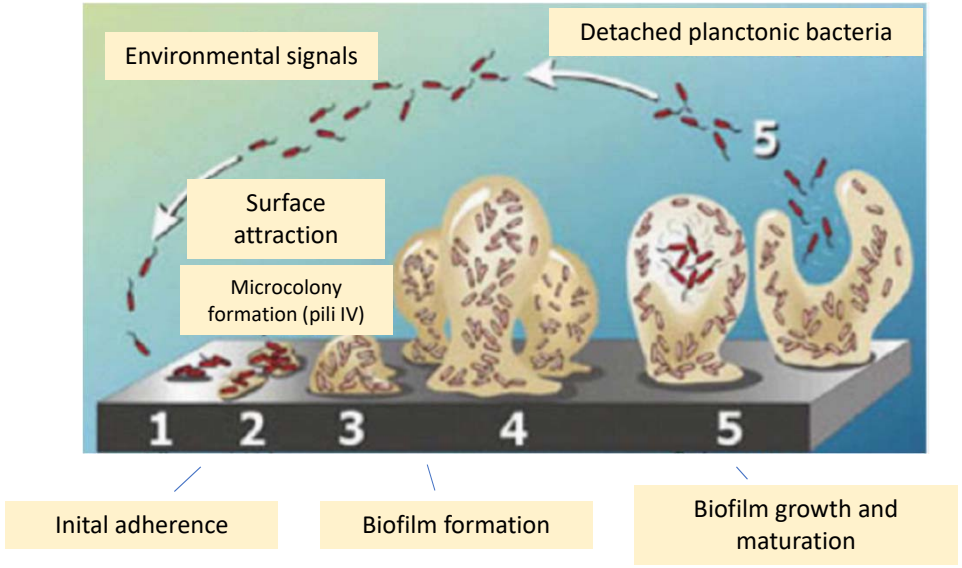
Macrofauna *in vitro*

Survival curves for mussels exposed to components



Organic compounds

Surface evaluation ——— **Background**



Use of Vibrio alginolyticus medium

Organic compounds

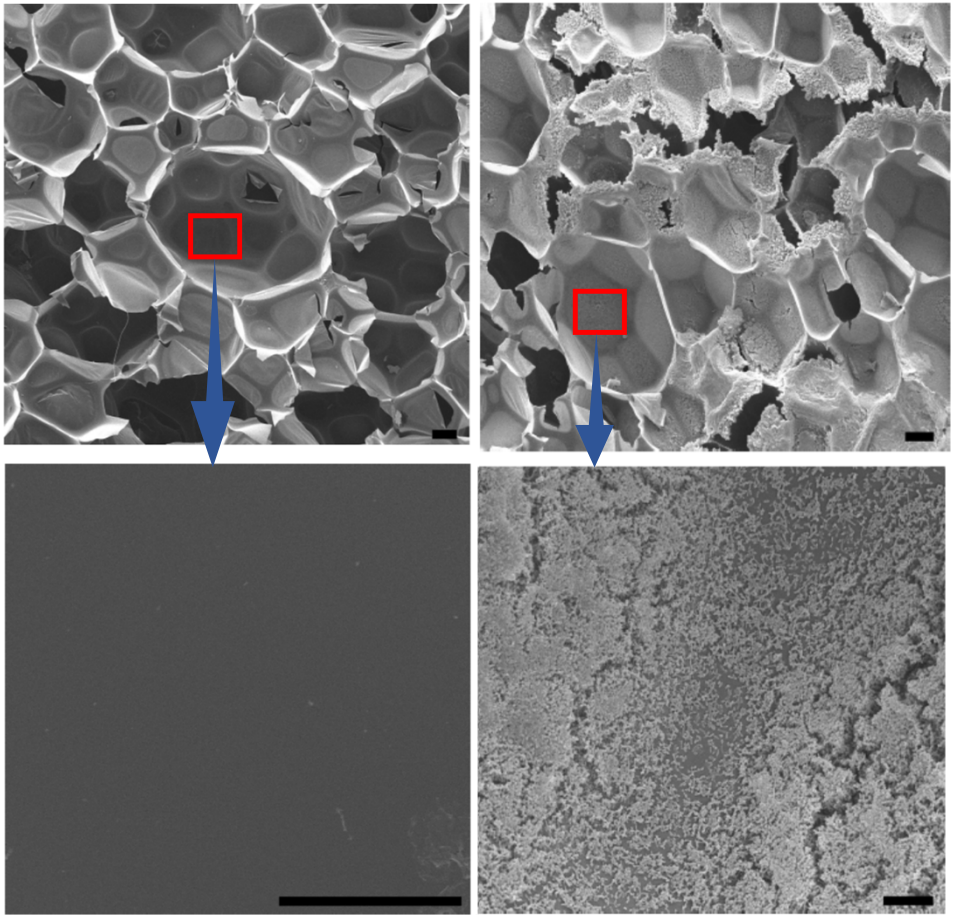
Surface evaluation

Polyurethane in *seawater*

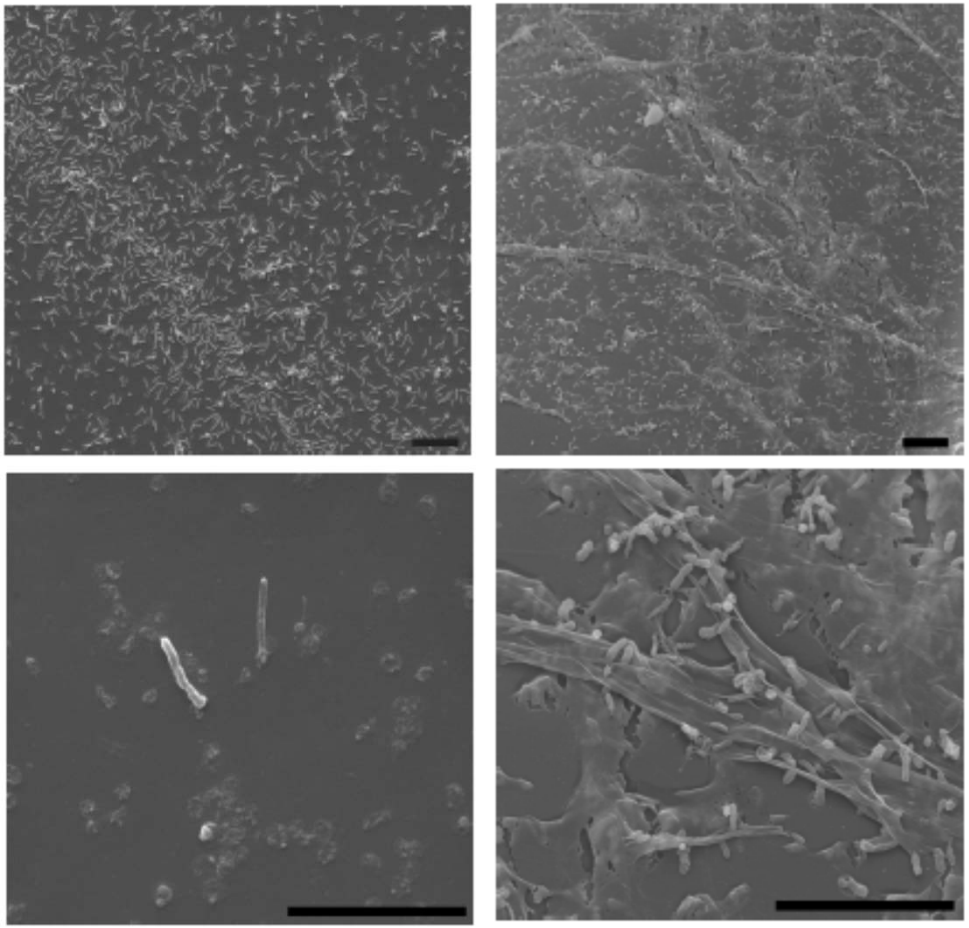
Polyurethane in *Vibrio alginolyticus* medium

Epoxy resin in *seawater*

Epoxy resin in *Vibrio alginolyticus* medium



for 44 days



Bars : 10 µm

Metallic compounds

Litterature review

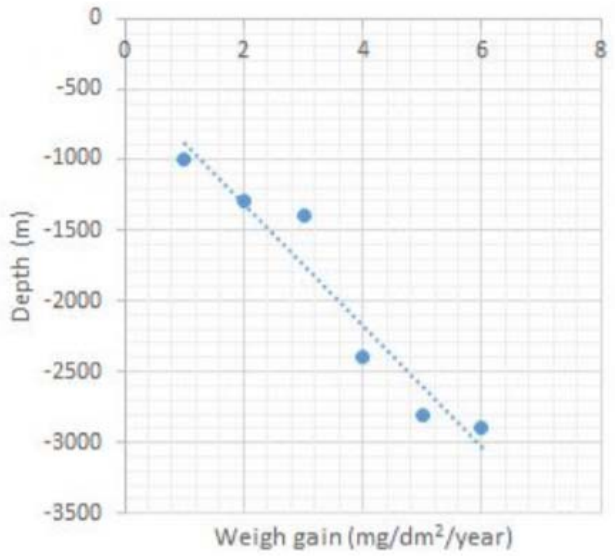
On-site studies in French Guyana

Model experiments in laboratory conditions

Metallic corrosion as a function of depth

Very limited relevant bibliography is available for "**Biodegradation**" or "**biofilm allowing corrosion**" for the alloys used in the launchers

Weight gain as a function of depth for **stainless steel**

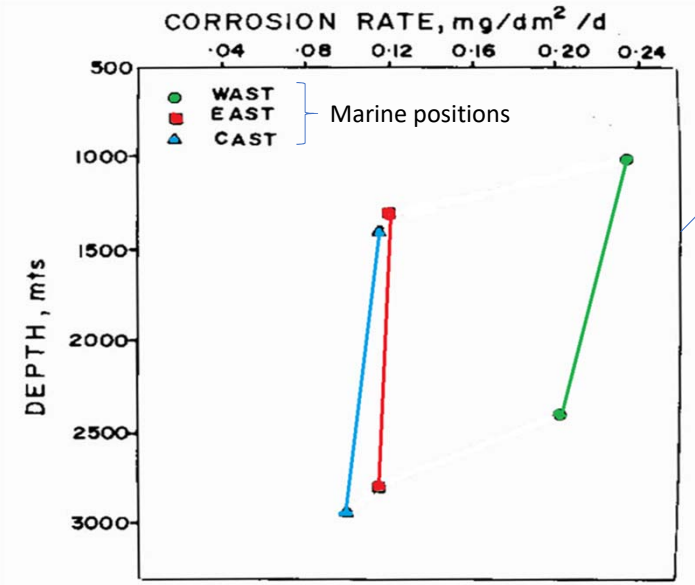


The gain weight indicates the formation of oxide (protection for the alloy)

(adapted from Sawant and Wagh, 1990)

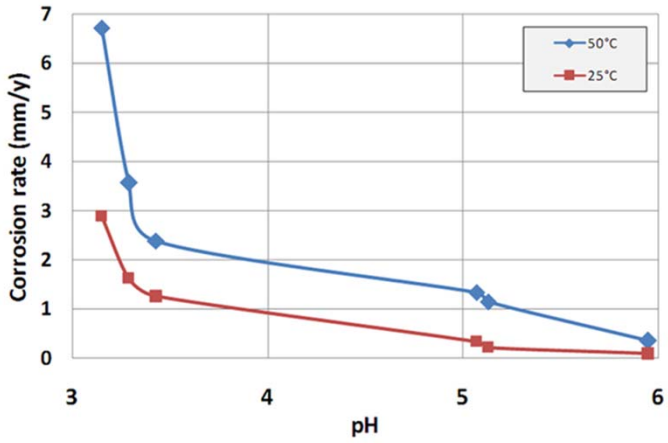
Metallic corrosion as a function of depth

! **Very limited relevant bibliography** is available for "**Biodegradation**" or "**biofilm allowing corrosion**" for the alloys used in the launchers



Corrosion rate as a function of depth for stainless steel (adapted from Sawant and Wagh, 1990)

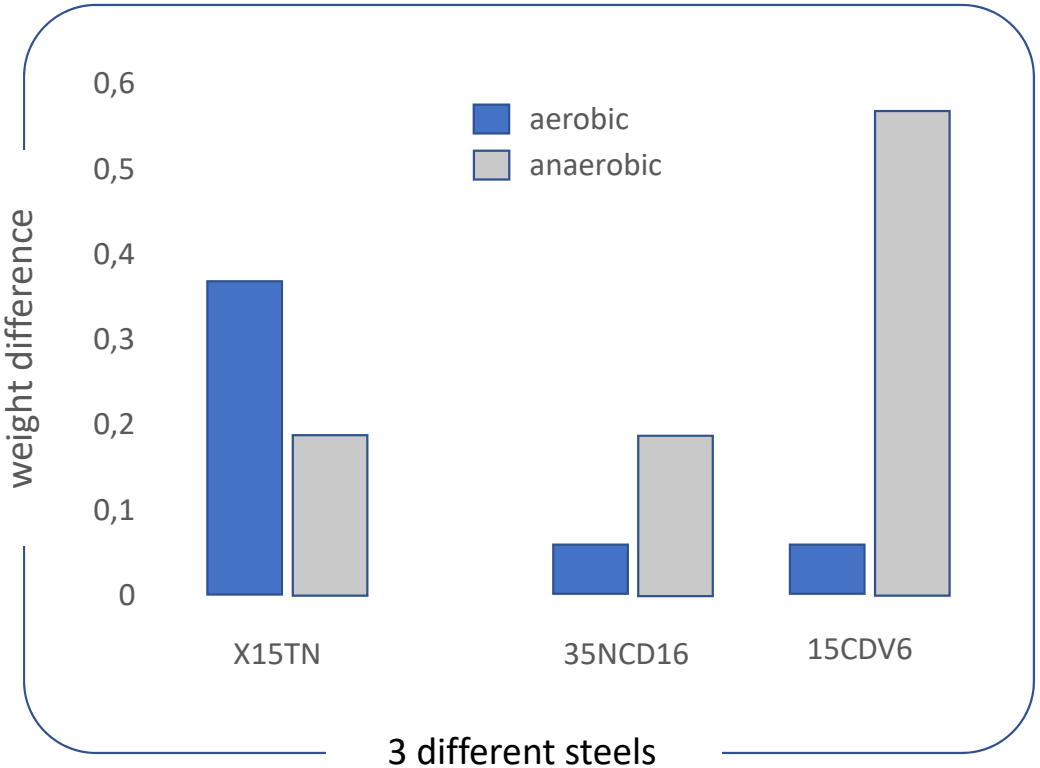
! Inverse relationship for the corrosion rate of aluminium with depth



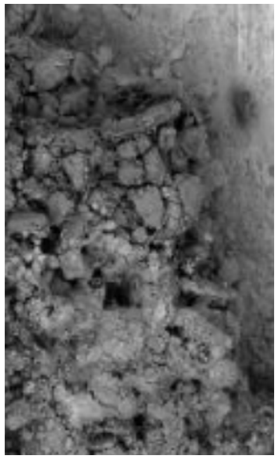
Corrosion rate of stainless steel as a function of pH
Prawoto et Al. (2009)

Metallic corrosion as a function of metallic composition and seawater oxygen level

Corrosion in seawater estimated from weight in **aerobic** & **anaerobic** conditions

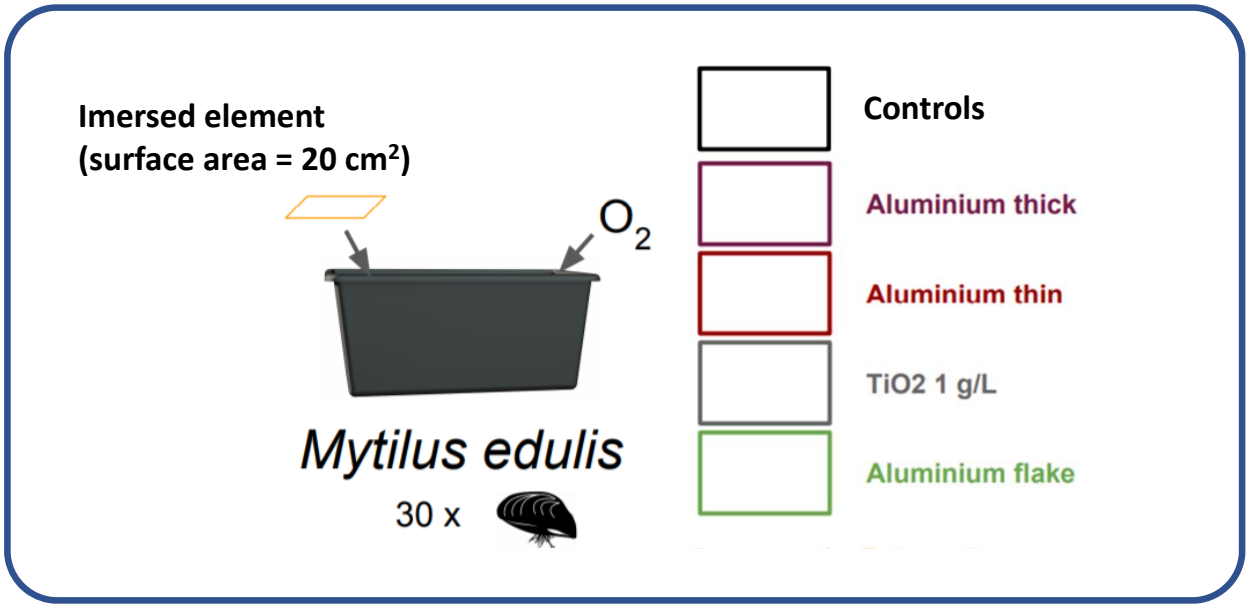


Surface pitting and cracks



Ecotoxicity evaluation

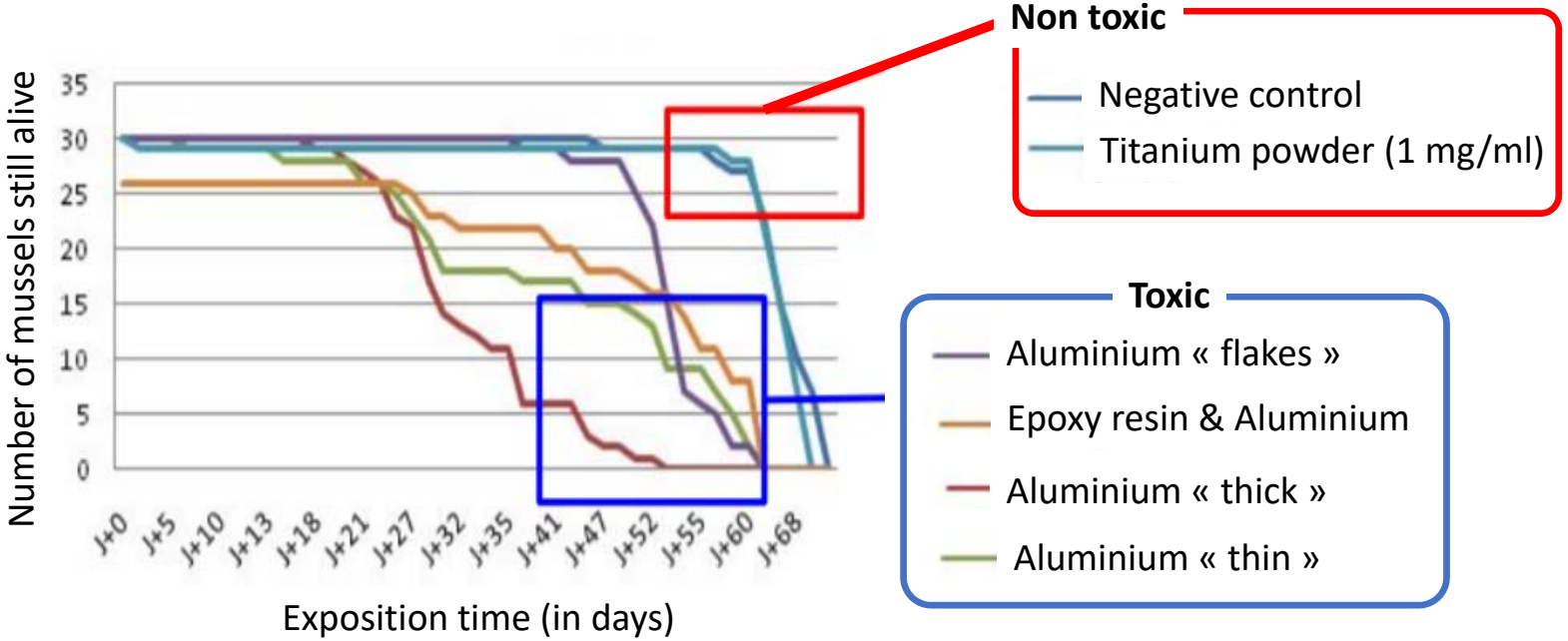
Macrofauna *in vitro*



Ecotoxicity evaluation

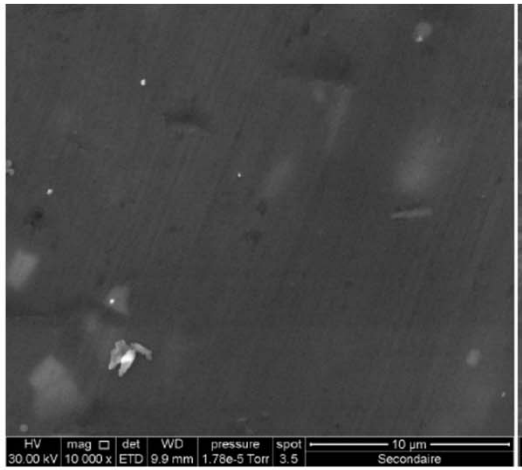
Macrofauna *in vitro*

Survival curve for mussels exposed to different metals

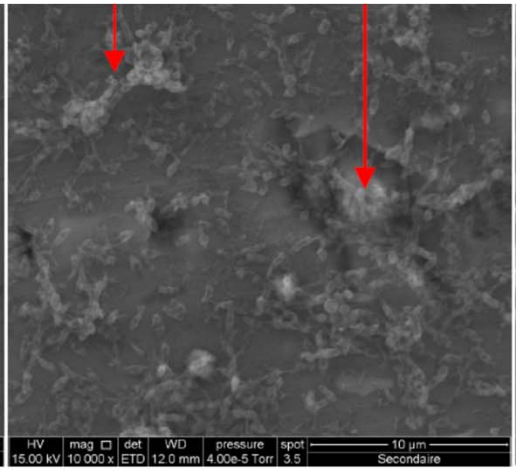


Surface evaluation

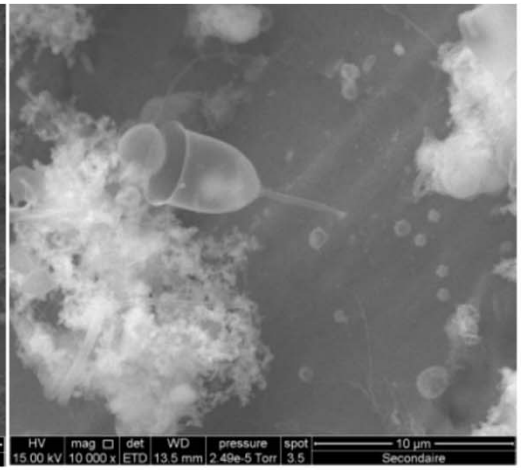
Aluminium surface



Vibrio alginolyticus medium

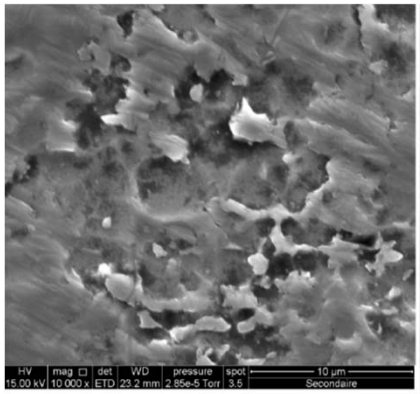


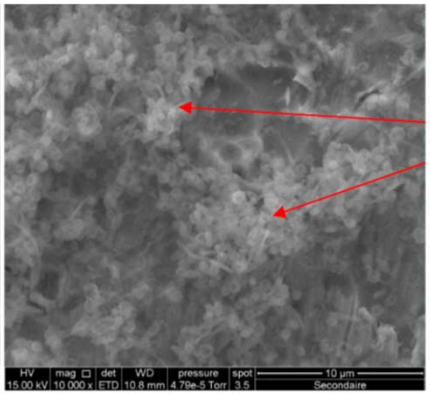
7 days in seawater



Unicellular organism
fixed at the surface

Titanium 6AL-4C





Vibrio alginolyticus aggregates

Conclusions & Perspectives

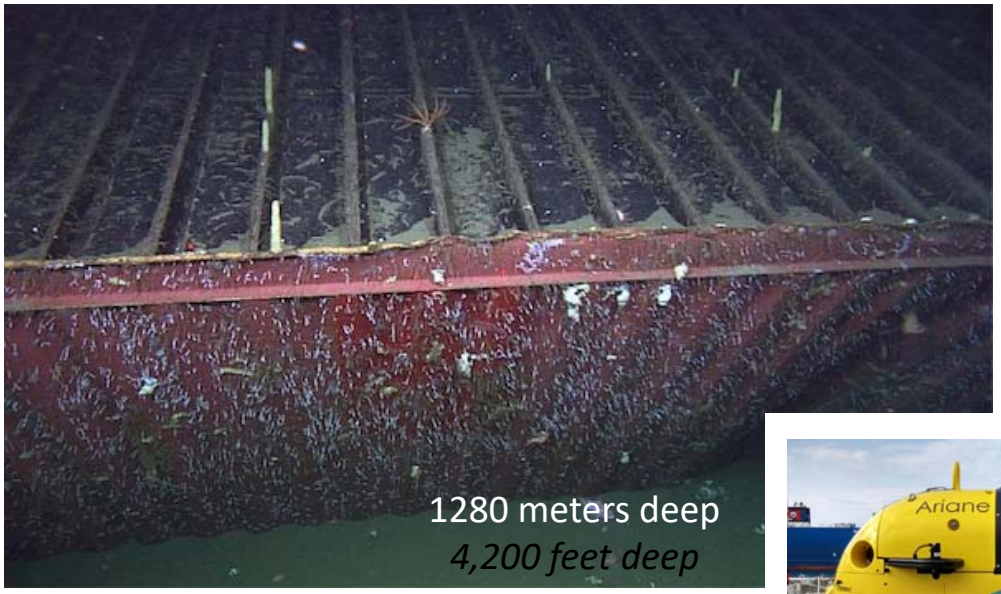
- Behaviour and toxicity of the different compounds carried out varry according to the substrate but also to environmental conditions (depth oxygen availaibilities)

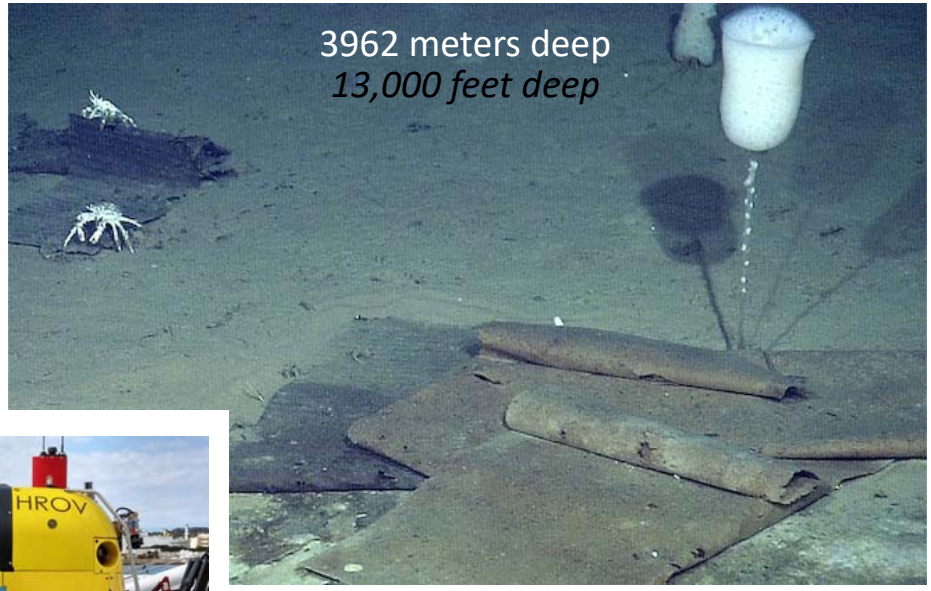
- Exposure time must be taken into consideration and no ‘rapid’ conclusion can be driven from the available litterature

  => experimental approach used during the project

- Longer impacts need to be investigated

Conclusions & Perspectives


1280 meters deep
4,200 feet deep


3962 meters deep
13,000 feet deep


Ariane
HROV
Ifremer

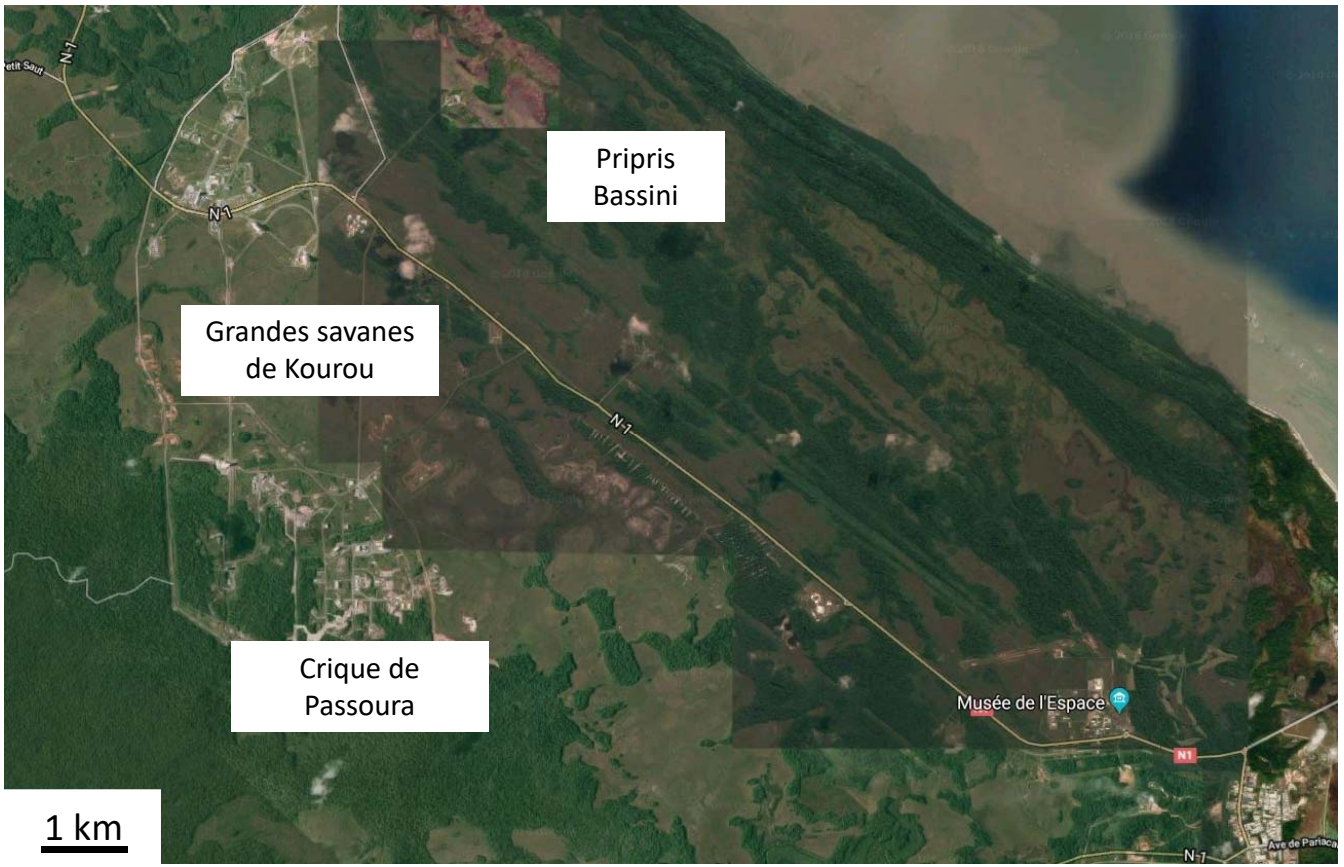

470 meters deep
1,548 feet deep


870 meters deep
2,850 feet

Conclusions & Perspectives

IN SITU IMPACT STUDIES in French Guyana

Savanes de Karouabo



IN SITU IMPACT STUDIES in French Guyana

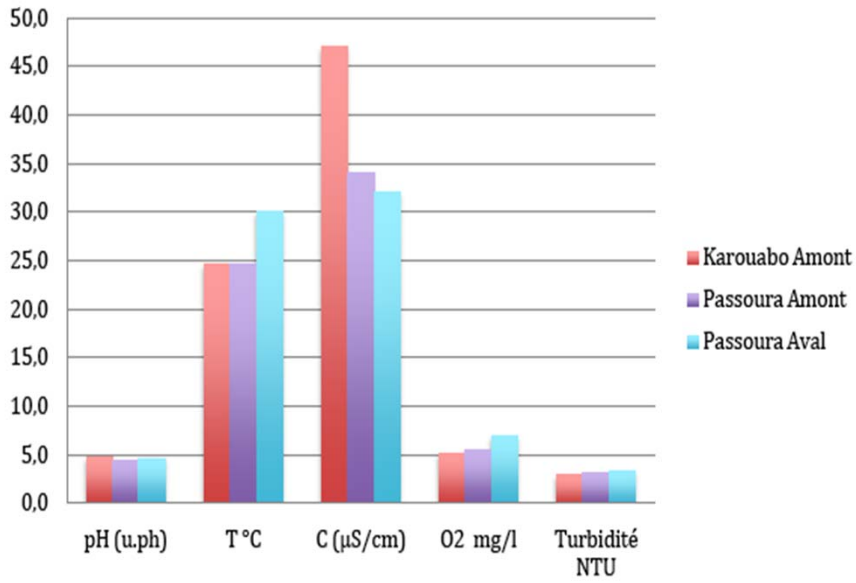
Water Quality

- Clear waters (low turbidity)
- **pH & conductivity values are low**
- Physico-chemical characteristics of the **environment change according to the season**

Fish populations

- **Sites in good environmental health**
- **Strong imbalance in local fish population distribution** (Vigouroux & Guillemet, 2006)

In situ measurements (September 2014)



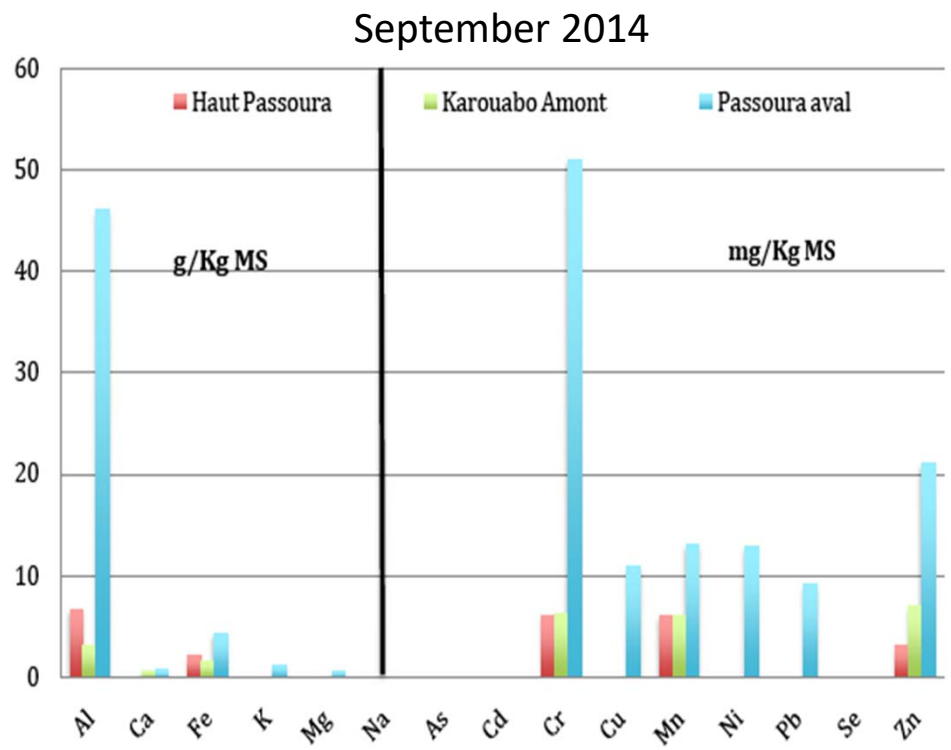
The successive launches of Ariane can induce the release of various products into the environment (including aluminium), with potentially a non-negligible impact on fish & other organisms

HYDRECO GUYANE

IN SITU IMPACT STUDIES in French Guyana

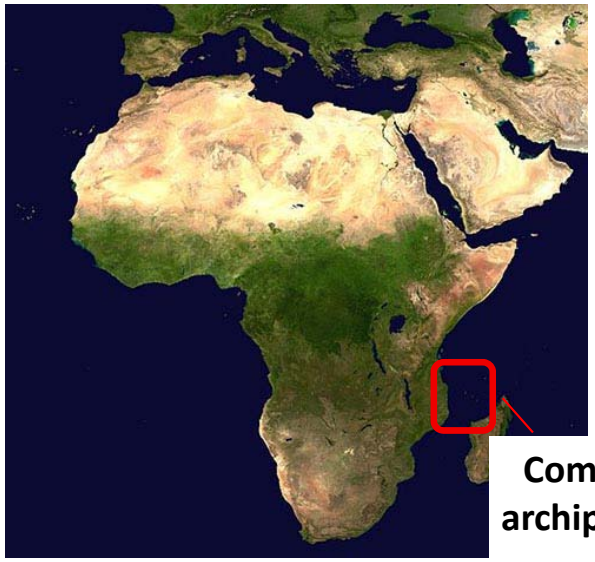
Sediments

In some locations, **aluminium concentrations** are high



Anthropogenic contaminations ?

HYDRECO
GUYANE



Comoros archipelago

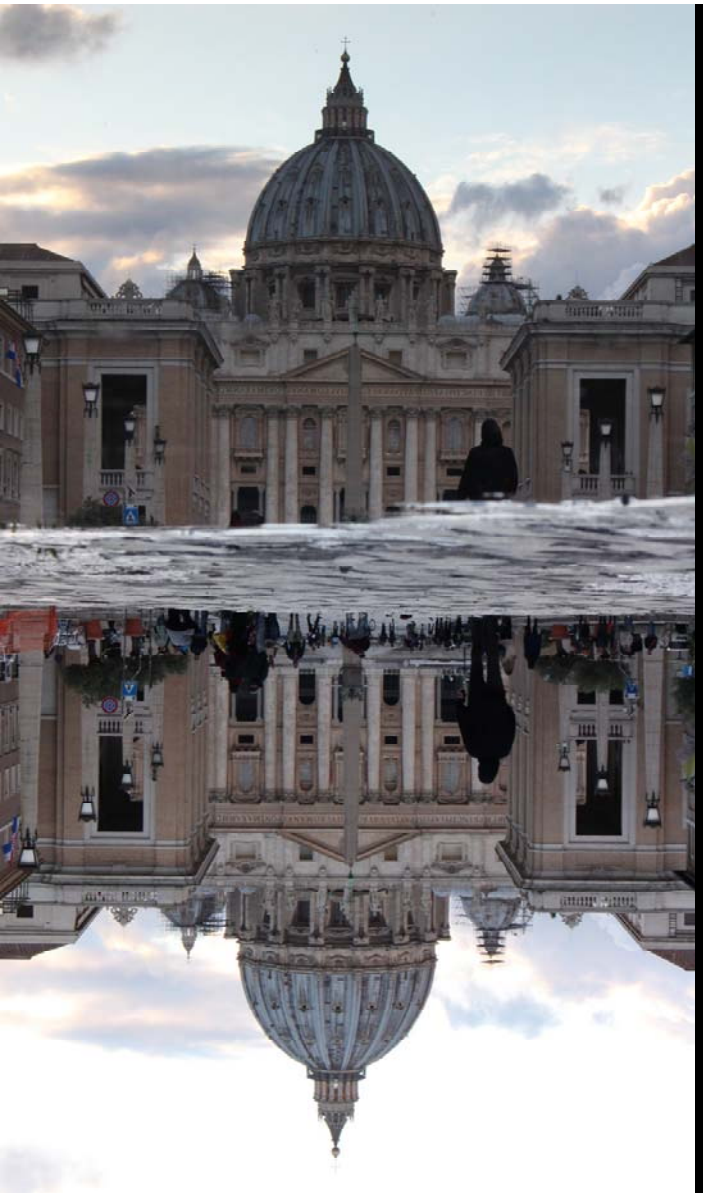
Mayotte island

The mangrove as a biofiltering system for domestic wastewaters

Use of **sentinel species** (bioindicators) → **Physiological biomarkers**

Energy balance
Hydromineral balance
Redox metabolism ….

‘Conservation Physiology’



Thank you for
your attention !