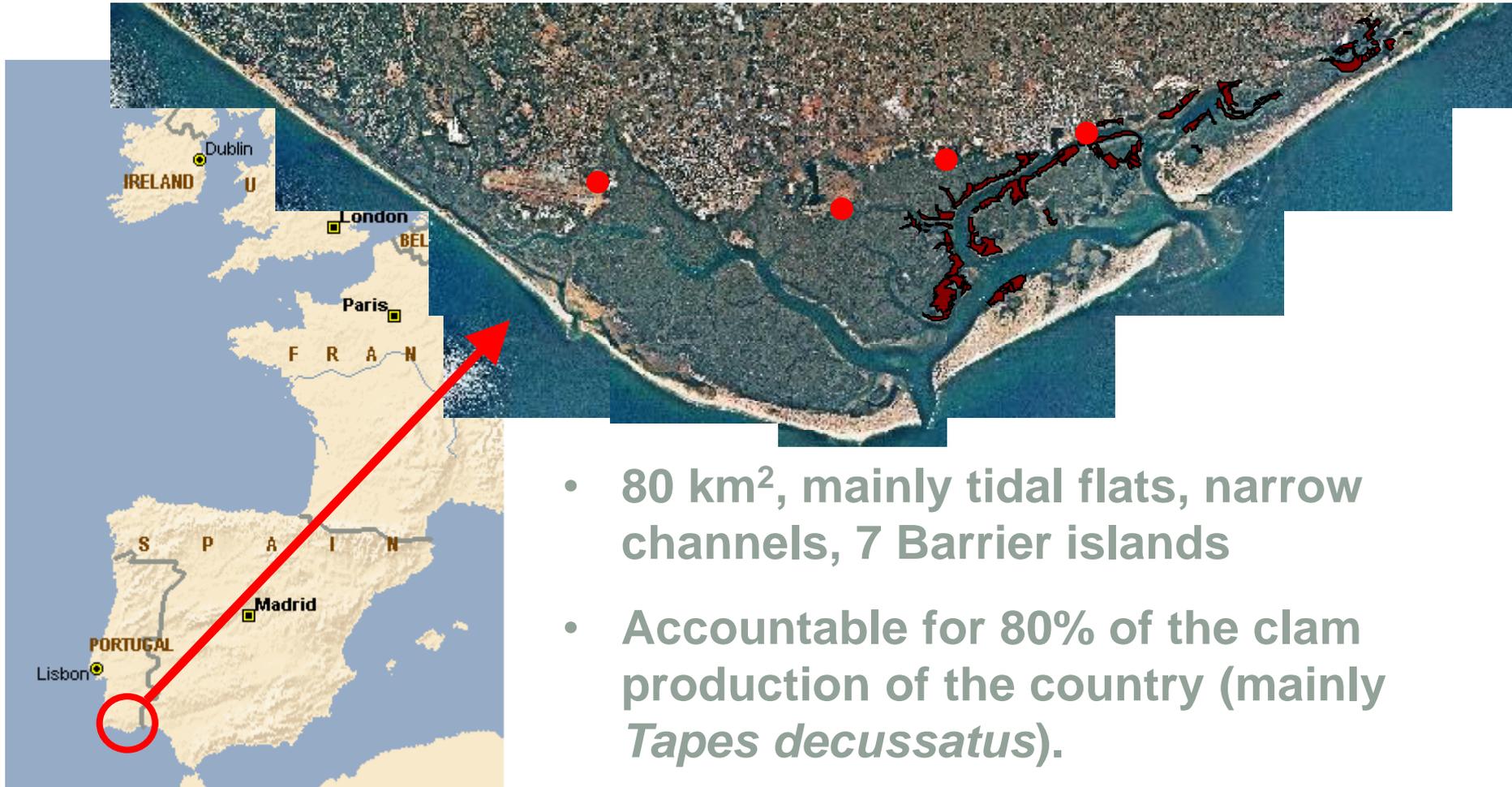


Modelos Matemáticos como Ferramenta de Avaliação da Qualidade da Água da Ria Formosa para a Moluscicultura de Bivalves

Flávio Martins
fmartins@ualg.pt

Ria Fomosa Coastal Lagoon

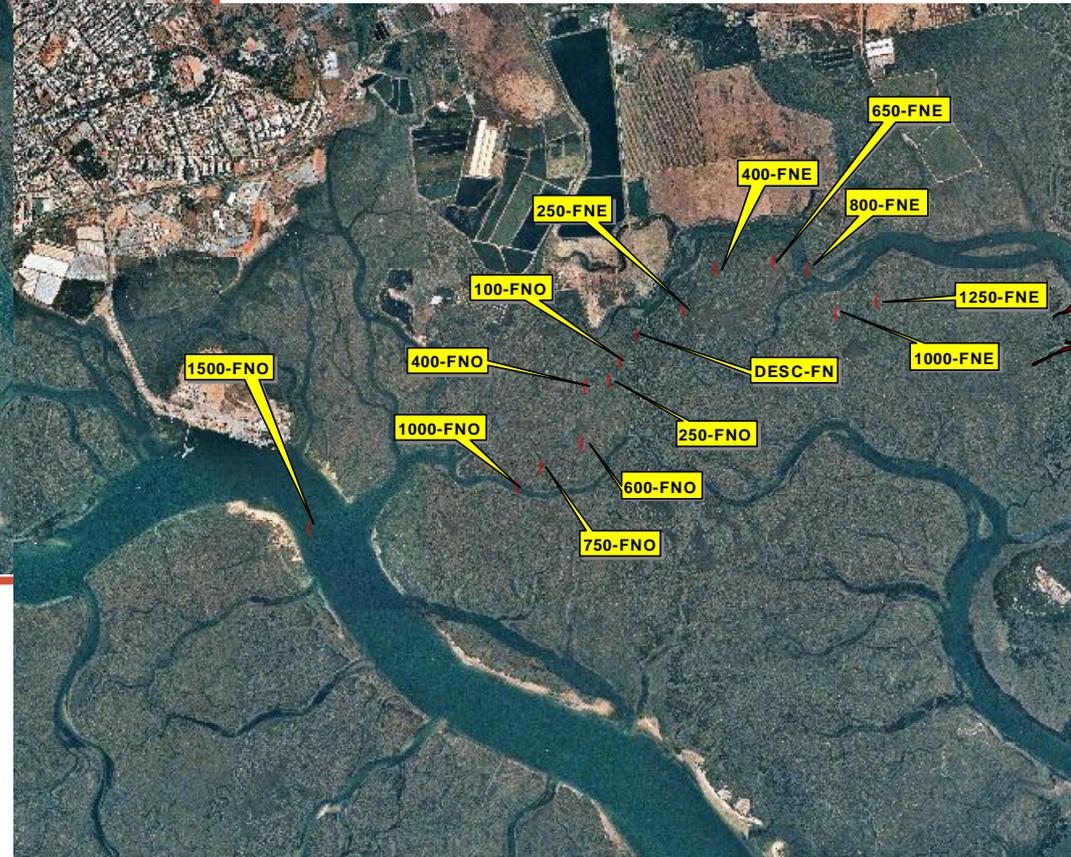


- 80 km², mainly tidal flats, narrow channels, 7 Barrier islands
- Accountable for 80% of the clam production of the country (mainly *Tapes decussatus*).

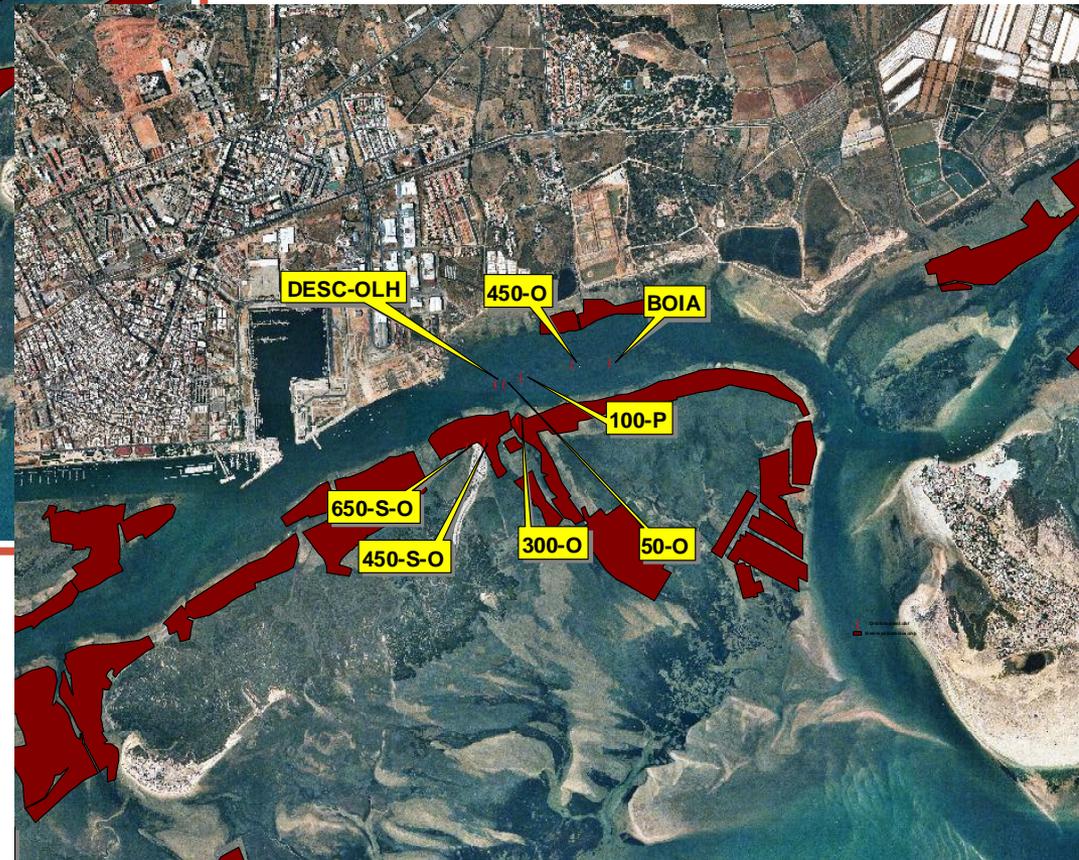
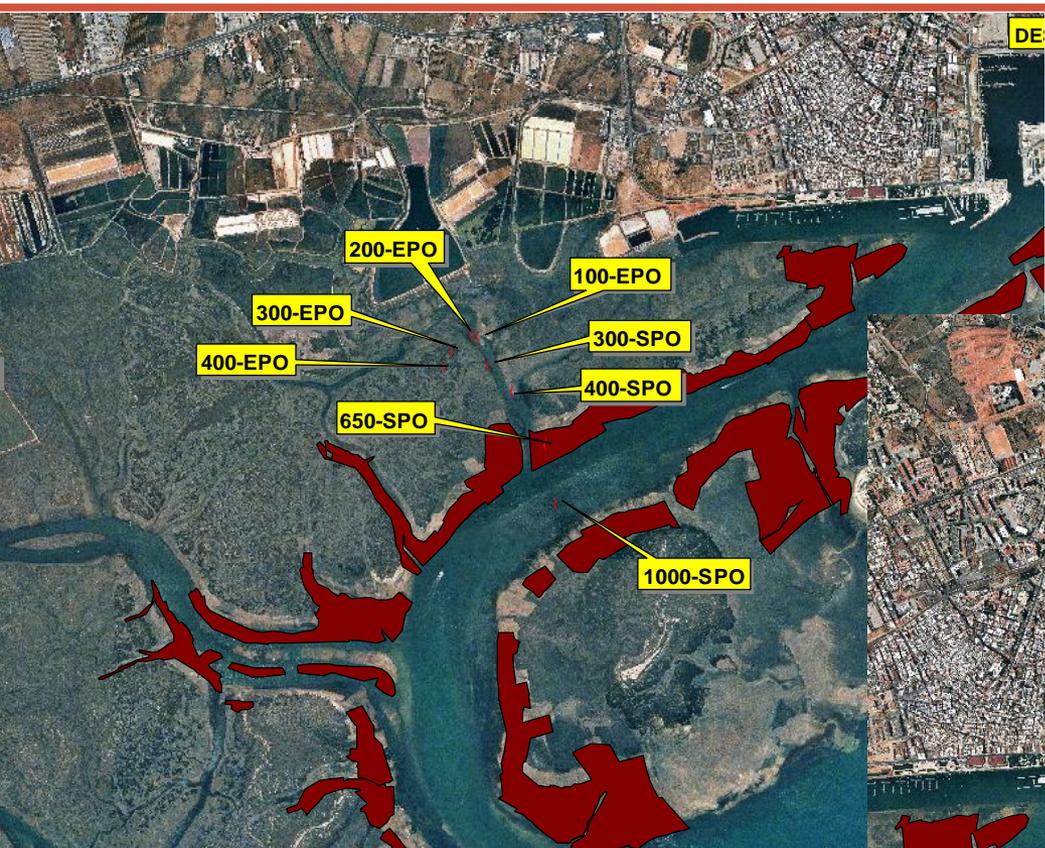
Base projects:

- 2004 Evaluation of the effect of WWTP discharges on the bivalve quality of Ria Formosa (CCDR/ARH)
- 2005-2006 Monitoring the receiving waters or urban WWTPs of Algarve (AdA)
- 2008-2011 Whole-system metabolism and CO₂ fluxes in a coastal lagoon dominated by saltmarsh and seagrass meadows (FCT)
- 2010 Technical Study of the Receiving Waters of Faro and Olhão WWTP (AdA)
- 2014 Technical Study on support of Environmental Impact Assessment of Faro WWTP (AdA)

Sampling Points: (Faro)



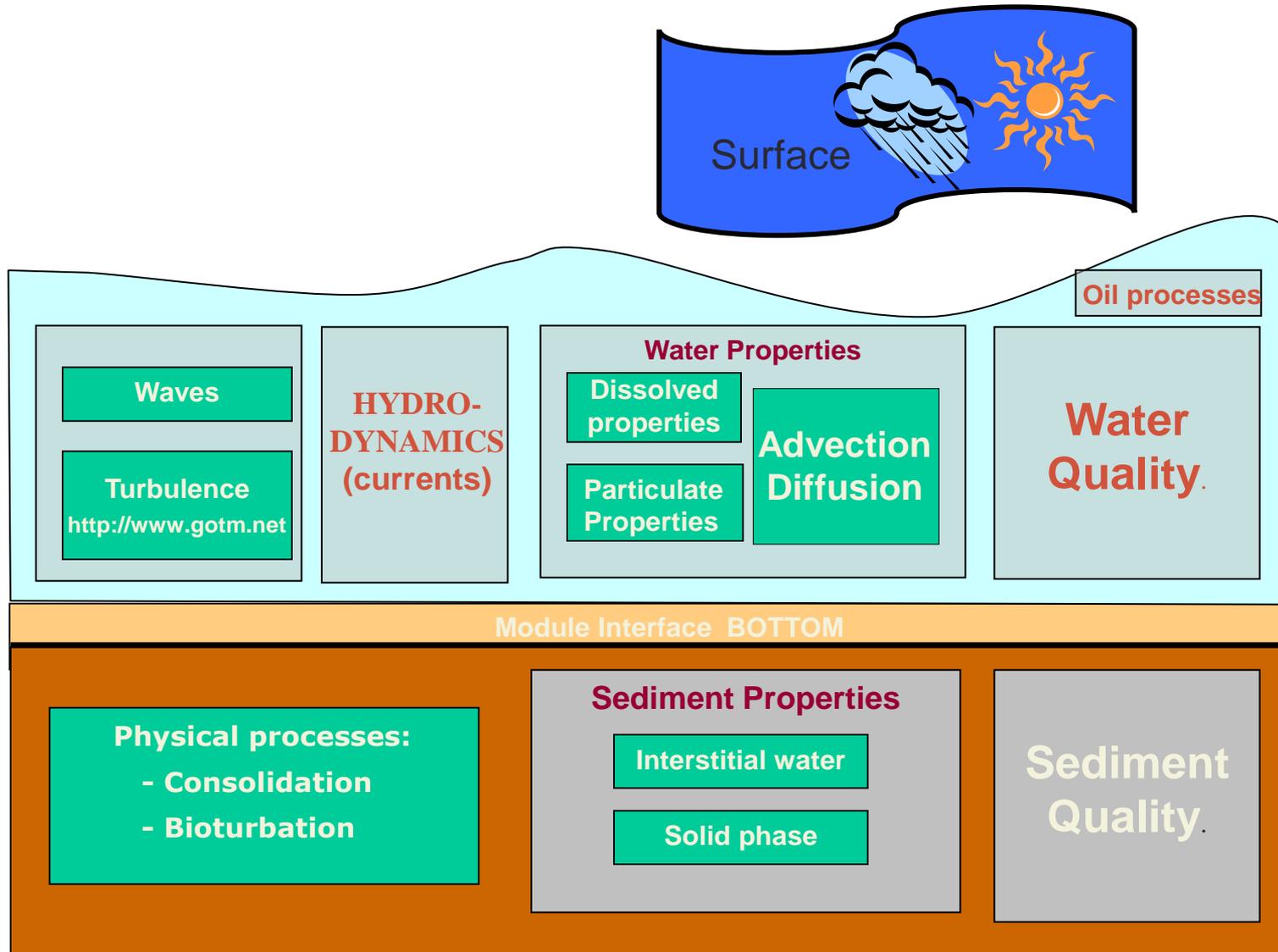
Sampling Points: (Olhão)



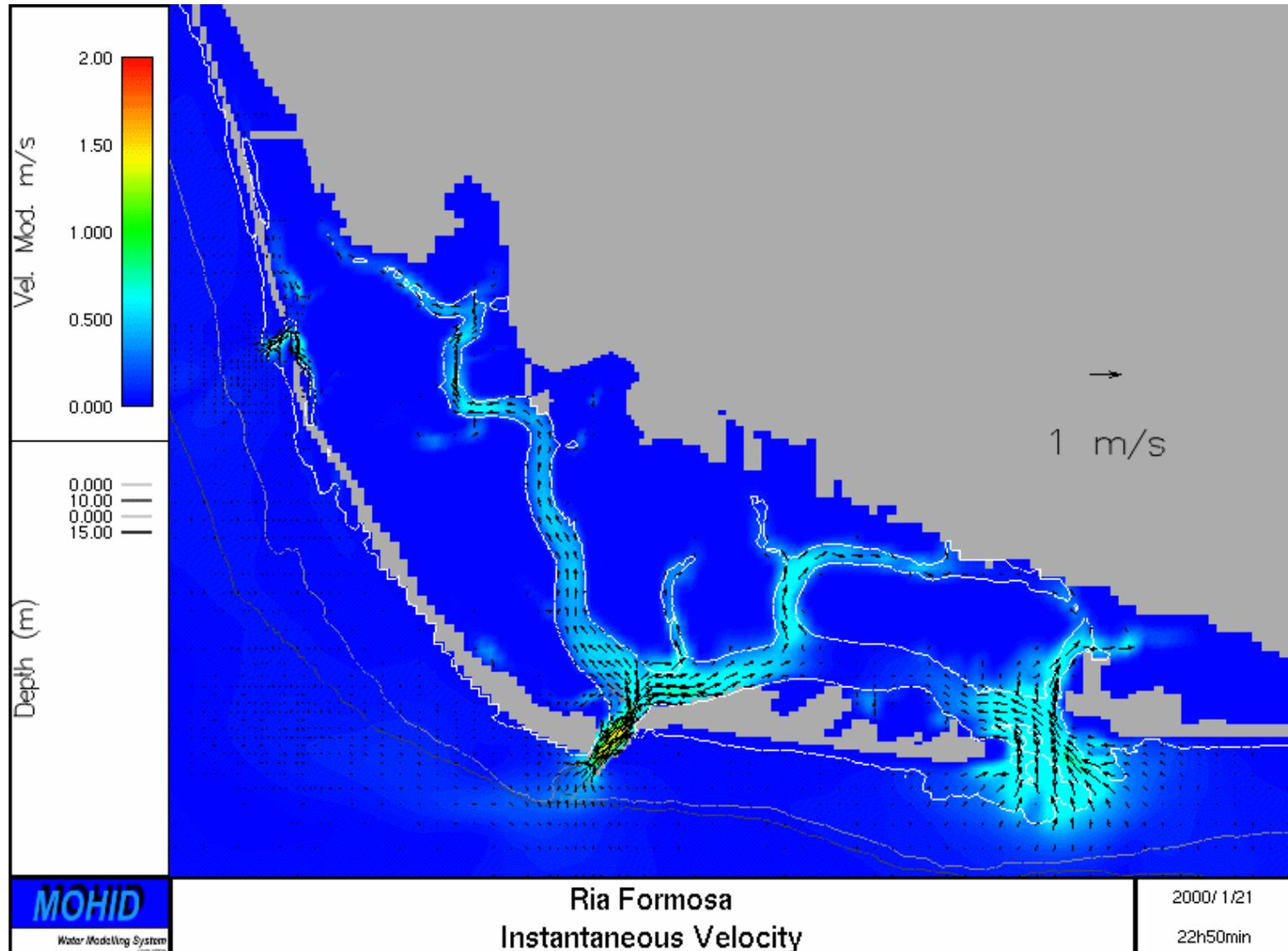
Sampling Points: (Tavira)



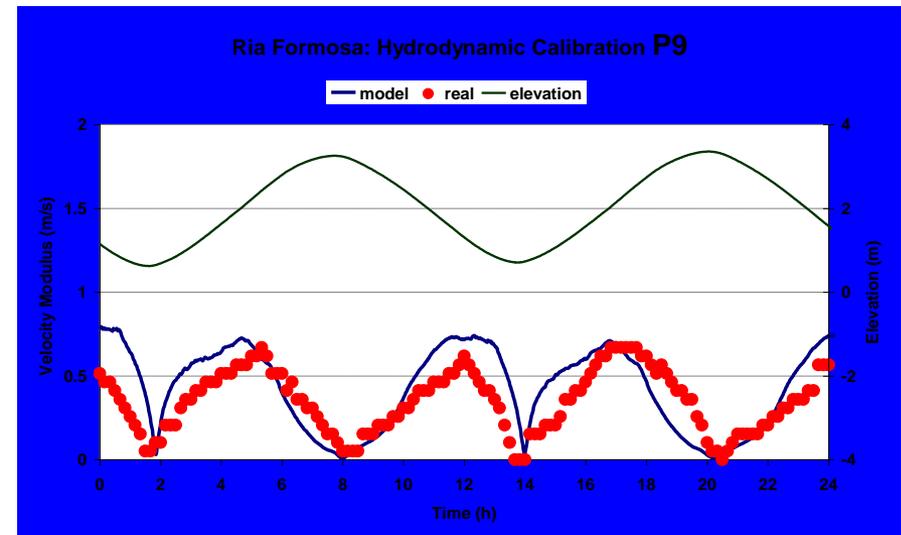
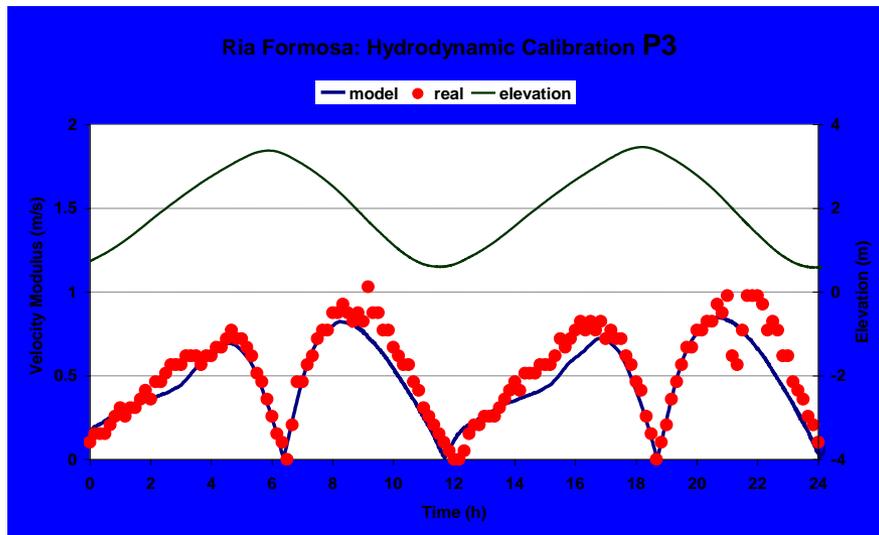
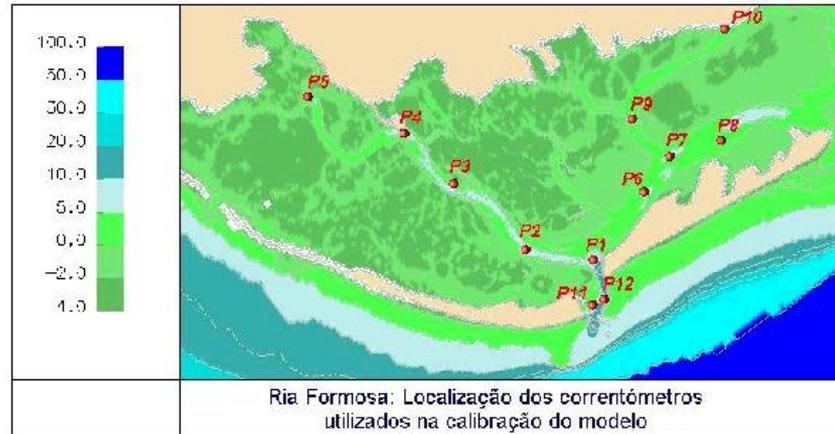
MOHID modelling system www.mohid.com



Transport in the water column

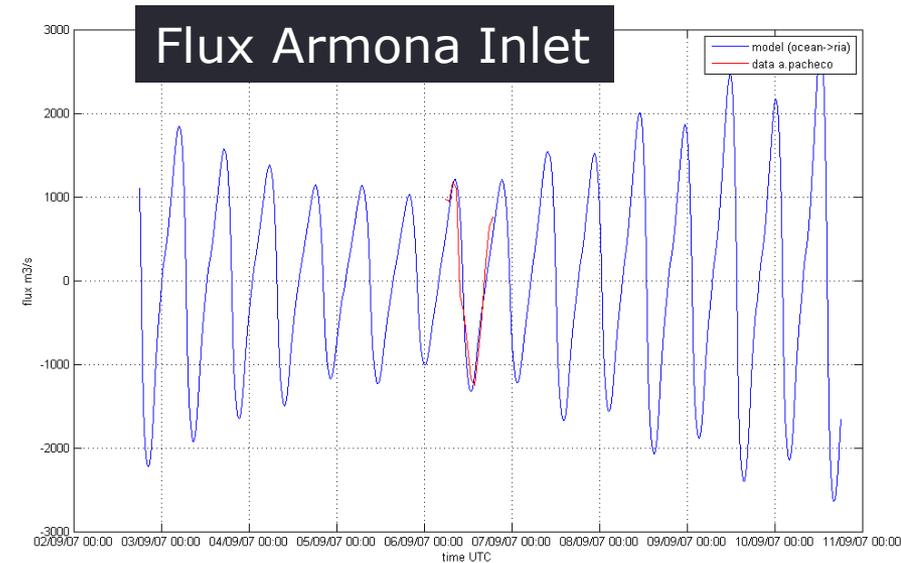
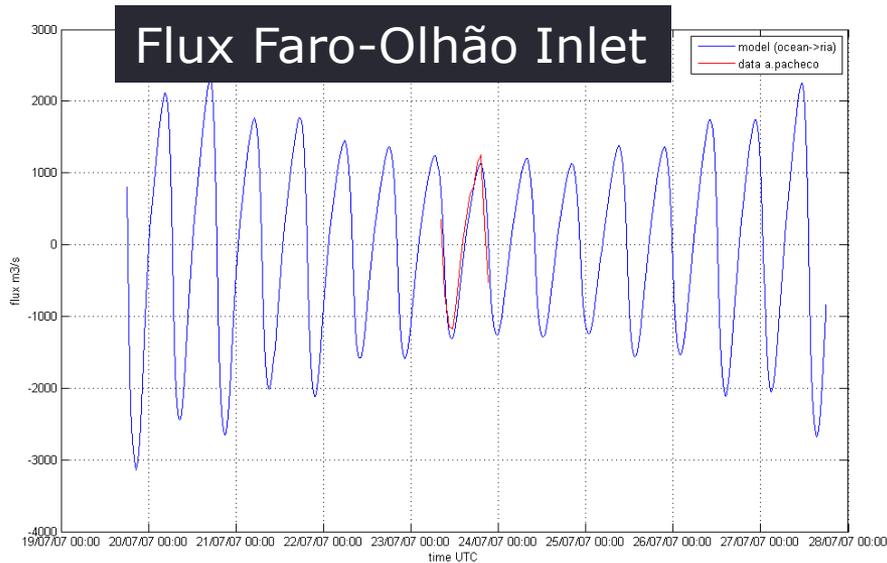
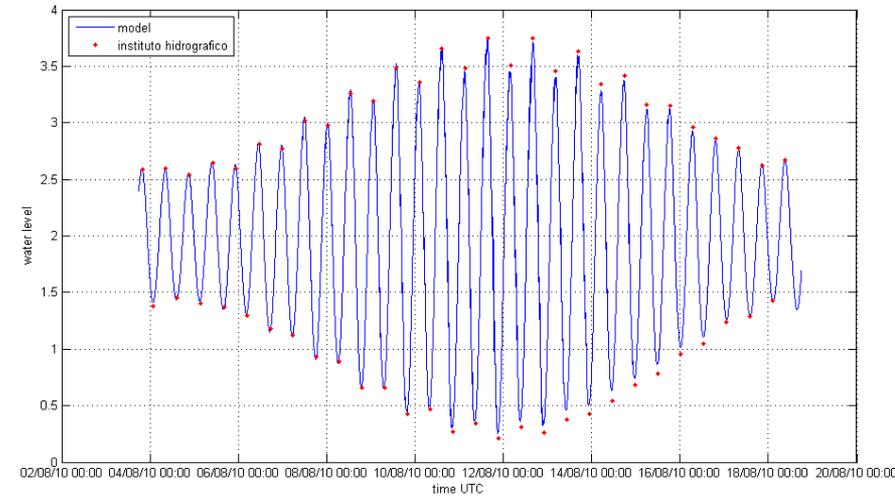


Hydrodynamic Calibration

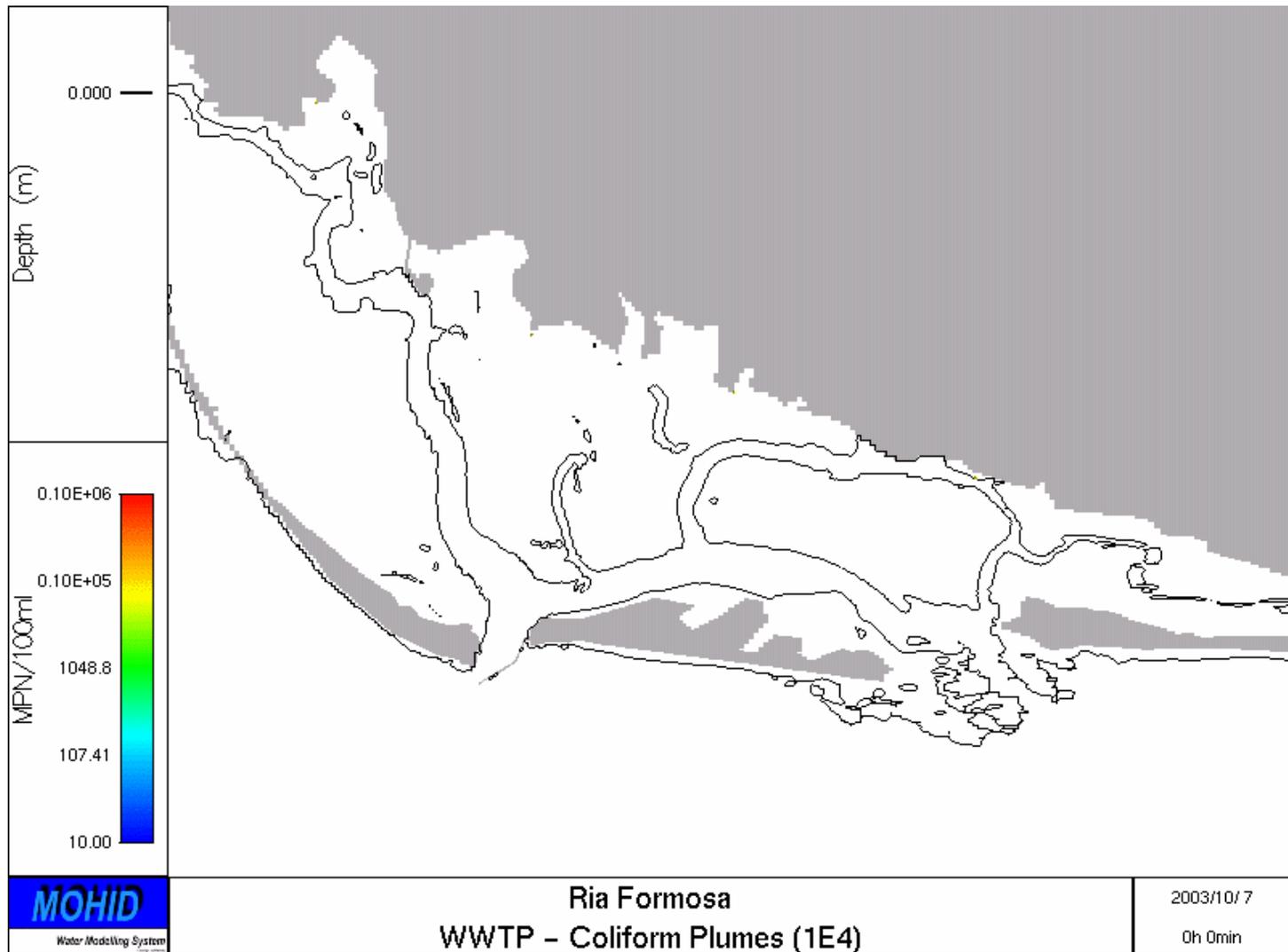


Hydrodynamic Calibration

RMSE: 4,7 cm (1,3%)

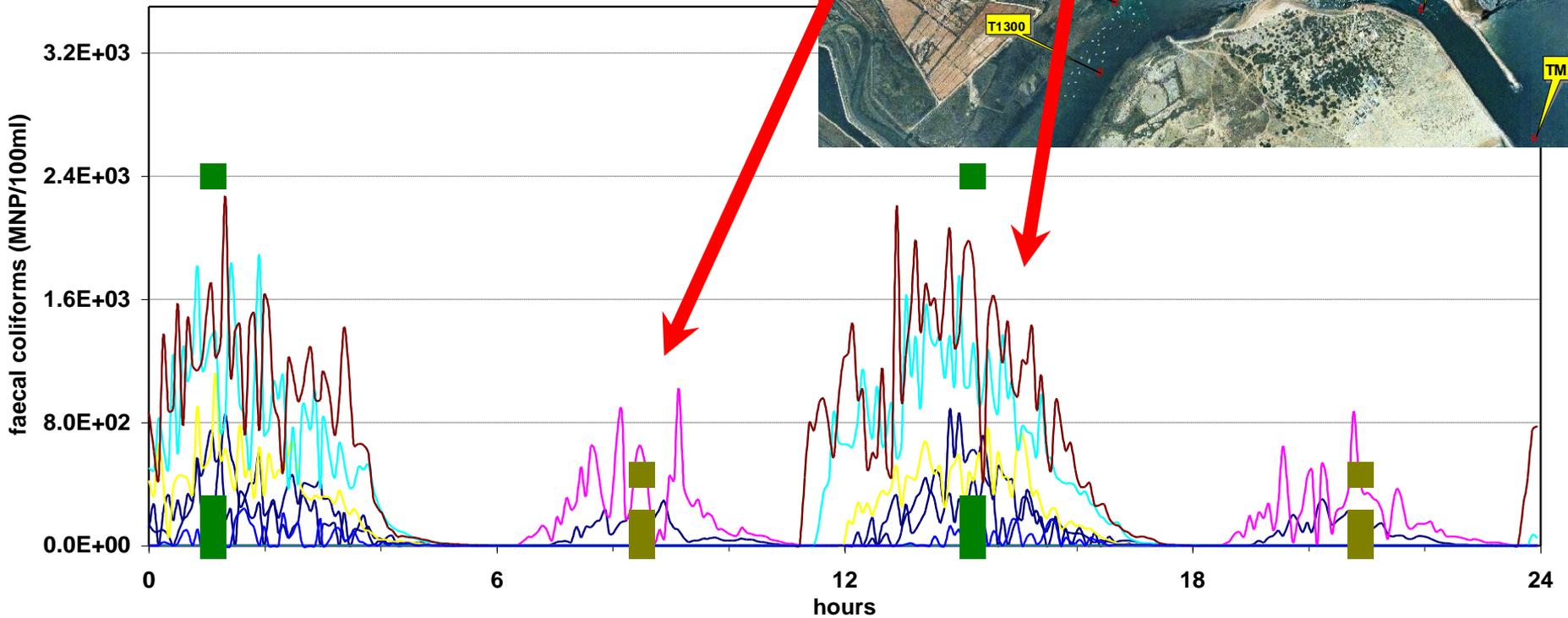
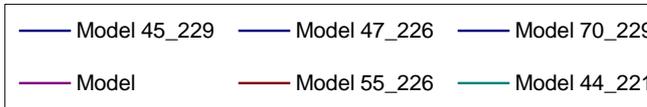


WWTP Plumes



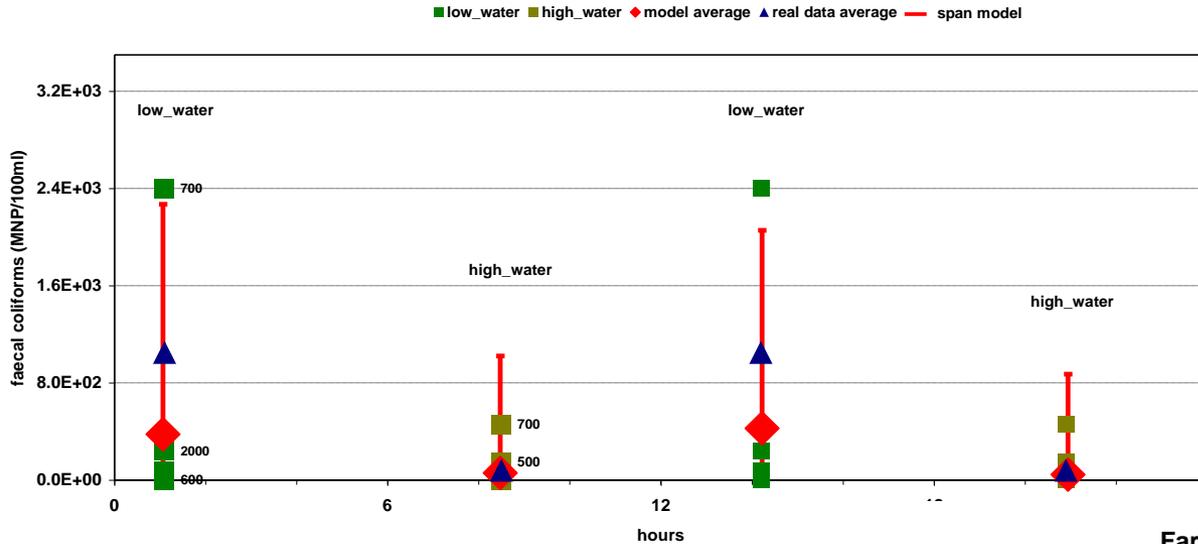
Plume Model Calibration

June 20th, 2002

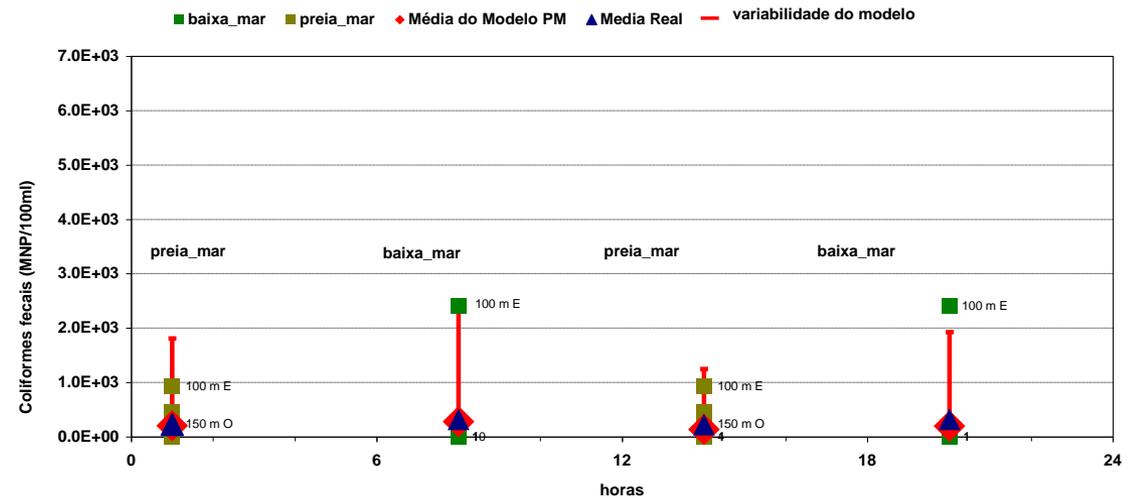


Plume Model Calibration

Tavira June 20th, 2002- (neap_tide)



Faro Nascente (Abril 2002)



Accumulation Model

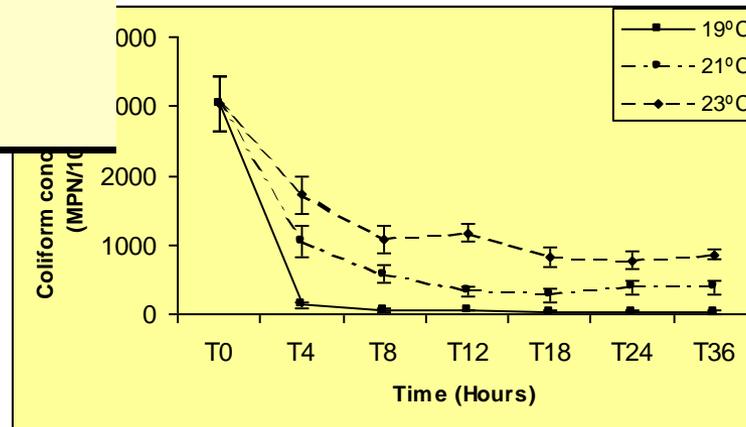
$$\frac{dC_{biv}}{dt} = k_a C_{H_2O} - k_e C_{biv}$$

- C_{biv} : Concentration in Shellfish
- C_{H_2O} : Concentration in Water
- K_a : Accumulation Coefficient
- K_e : Elimination Coefficient

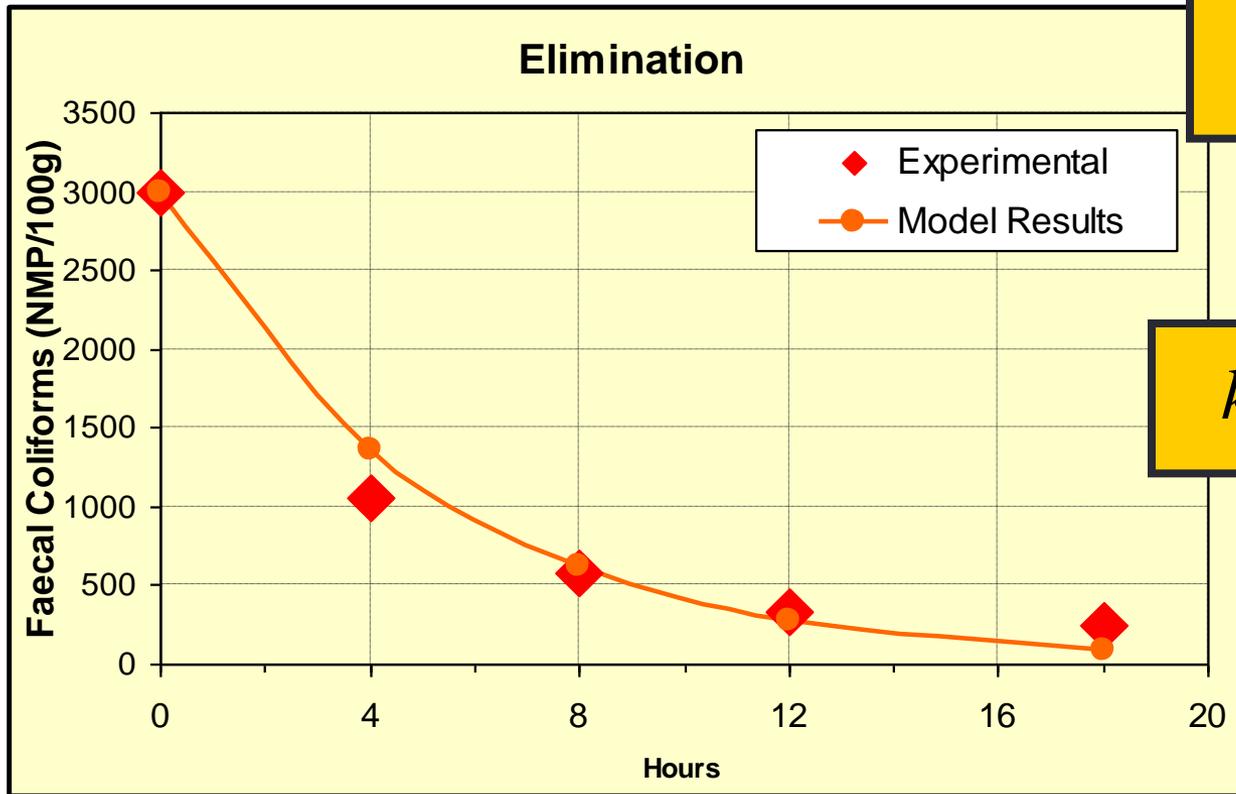
Lab. experiment: elimination

Time (hours)	Cbiv NMP/100g (21°C)
0	3000
4	1056
8	573
12	331
18	247

Bento J.A., 2001



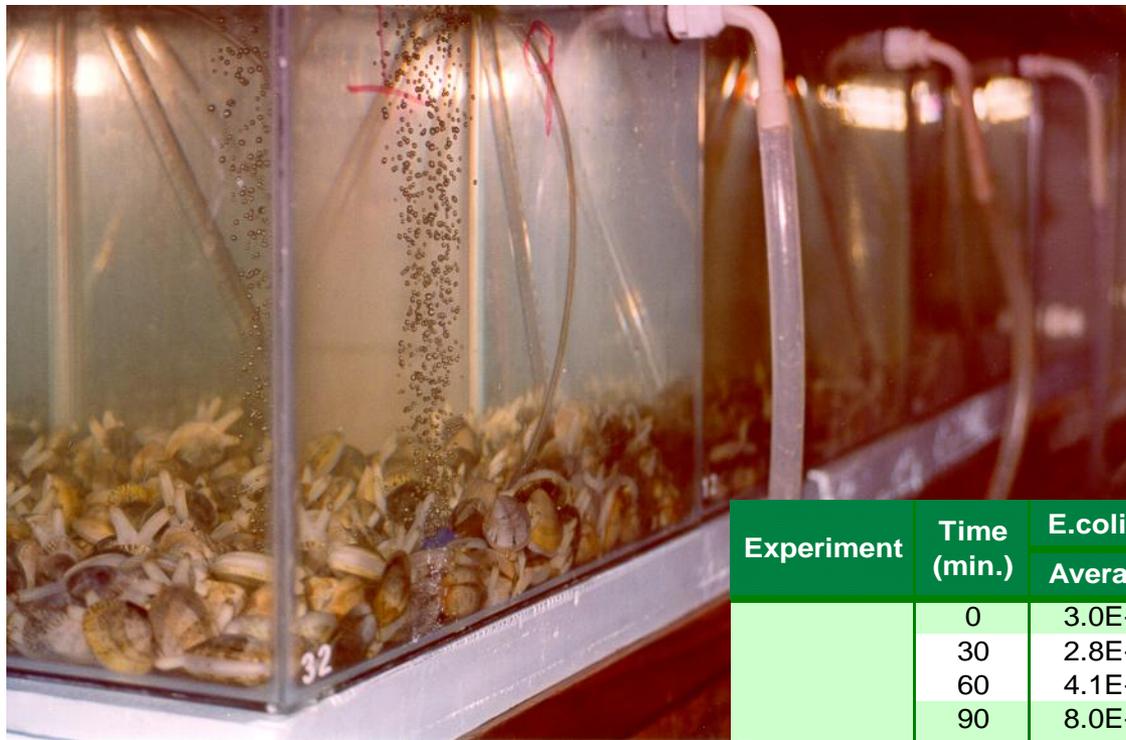
Lab. experiment: elimination



$$k_e = -\frac{\ln \frac{c(t)}{c(0)}}{t}$$

$$k_e = 5.5 \times 10^{-5} \text{ s}^{-1}$$

Lab. experiment: accumulation



- Three 20L aquaria contaminated with *E. coli* ATCC 25922.

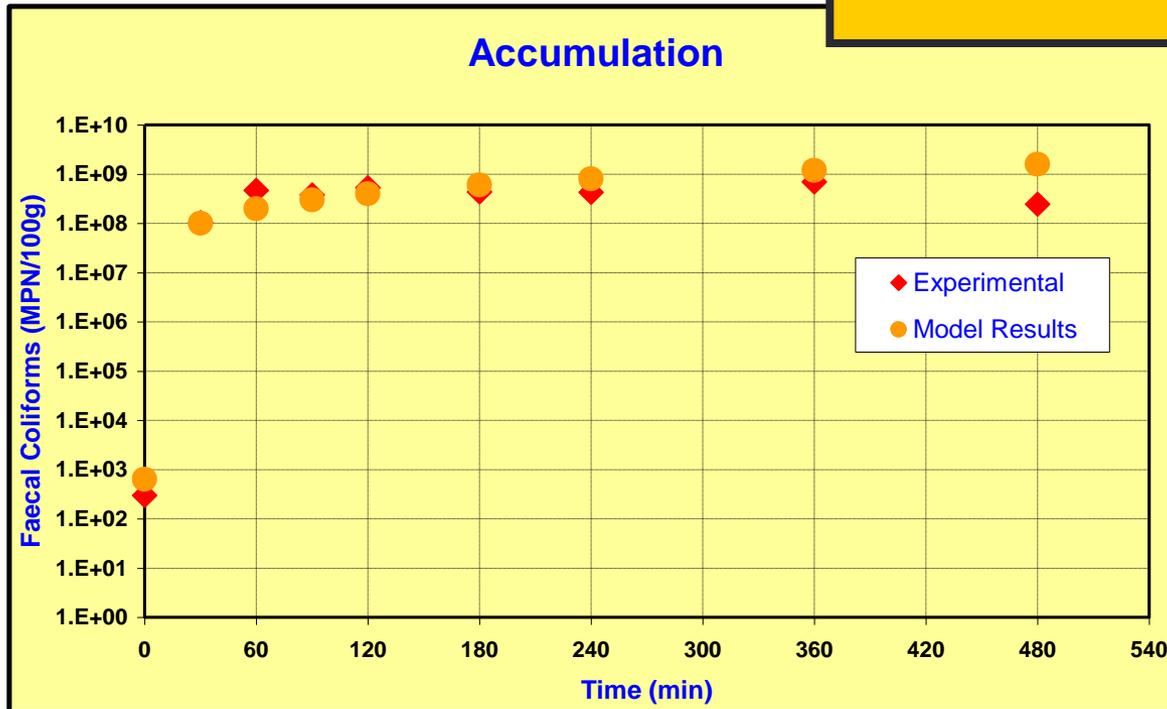
- Initial MPN of *E. coli* was:
 - $3.0 \times 10^8/100\text{mL}$ (Exp. 1)
 - $9.0 \times 10^4/100\text{mL}$ (Exp. 2)

- Samples of 30 ind. and water collected at periods from 30 minutes to two hours.

Experiment	Time (min.)	E.coli MPN/100mL in water			E.coli MPN/100g in clams		
		Average	Min	Max.	Average	Min	Max.
Exp. 1	0	3.0E+08	3.0E+08	3.0E+08	3.0E+02	2.3E+02	3.3E+02
	30	2.8E+08	2.4E+08	3.0E+08	1.0E+08	7.0E+07	1.3E+08
	60	4.1E+08	2.4E+08	5.0E+08	4.7E+08	1.3E+08	7.9E+08
	90	8.0E+08	3.0E+08	1.6E+09	3.7E+08	1.7E+08	4.9E+08
	120	6.8E+08	1.3E+08	1.6E+09	5.3E+08	3.3E+08	9.4E+08
	180	6.6E+08	8.0E+07	1.6E+09	4.3E+08	1.8E+08	7.9E+08
	240	6.1E+08	7.0E+07	1.6E+09	4.3E+08	9.0E+07	1.1E+09
	480	5.8E+08	3.0E+07	1.6E+09	7.0E+08	3.3E+08	1.3E+09
Exp. 2	0	9.0E+04	8.0E+04	1.1E+05	1.9E+03	7.9E+02	2.4E+03
	30	1.0E+05	2.3E+04	2.4E+05	2.0E+05	1.1E+05	3.3E+05
	60	8.0E+04	5.0E+04	1.1E+05	4.6E+05	2.3E+05	7.0E+05
	120	6.5E+04	5.0E+04	8.0E+04	5.5E+06	1.7E+06	9.2E+06

Lab. experiment: accumulation

$$k_a = \frac{c(t) + c(0) \exp(-k_e t)}{c_{H_2O} t}$$



$$k_a = 1.1 \times 10^{-4} \text{ s}^{-1}$$

Field Experiment

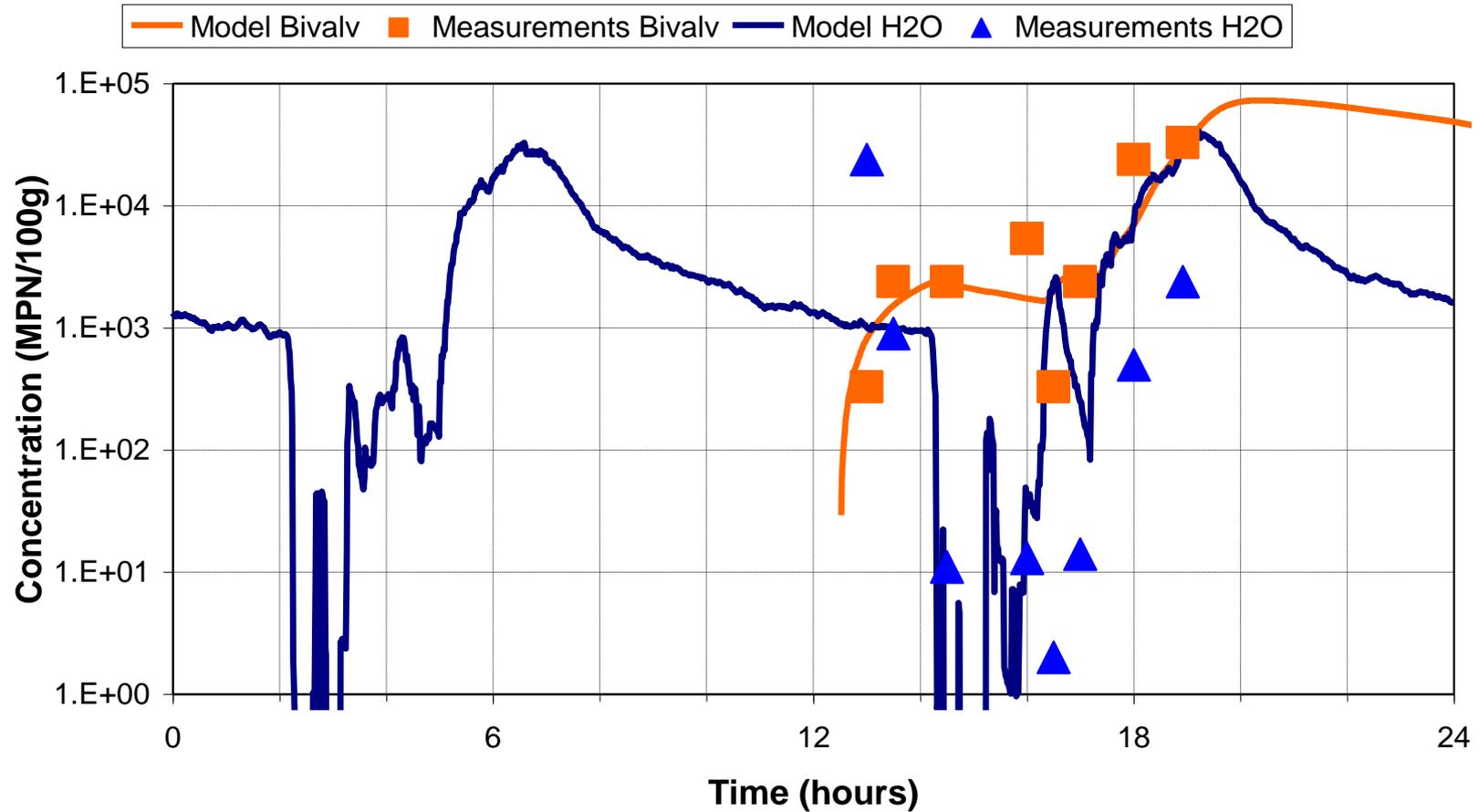


- Net bags with clams sunk at 100m and at 400m of the Faro West WWTP outlet
- Samples (30ind) taken regularly over a period of 7 days

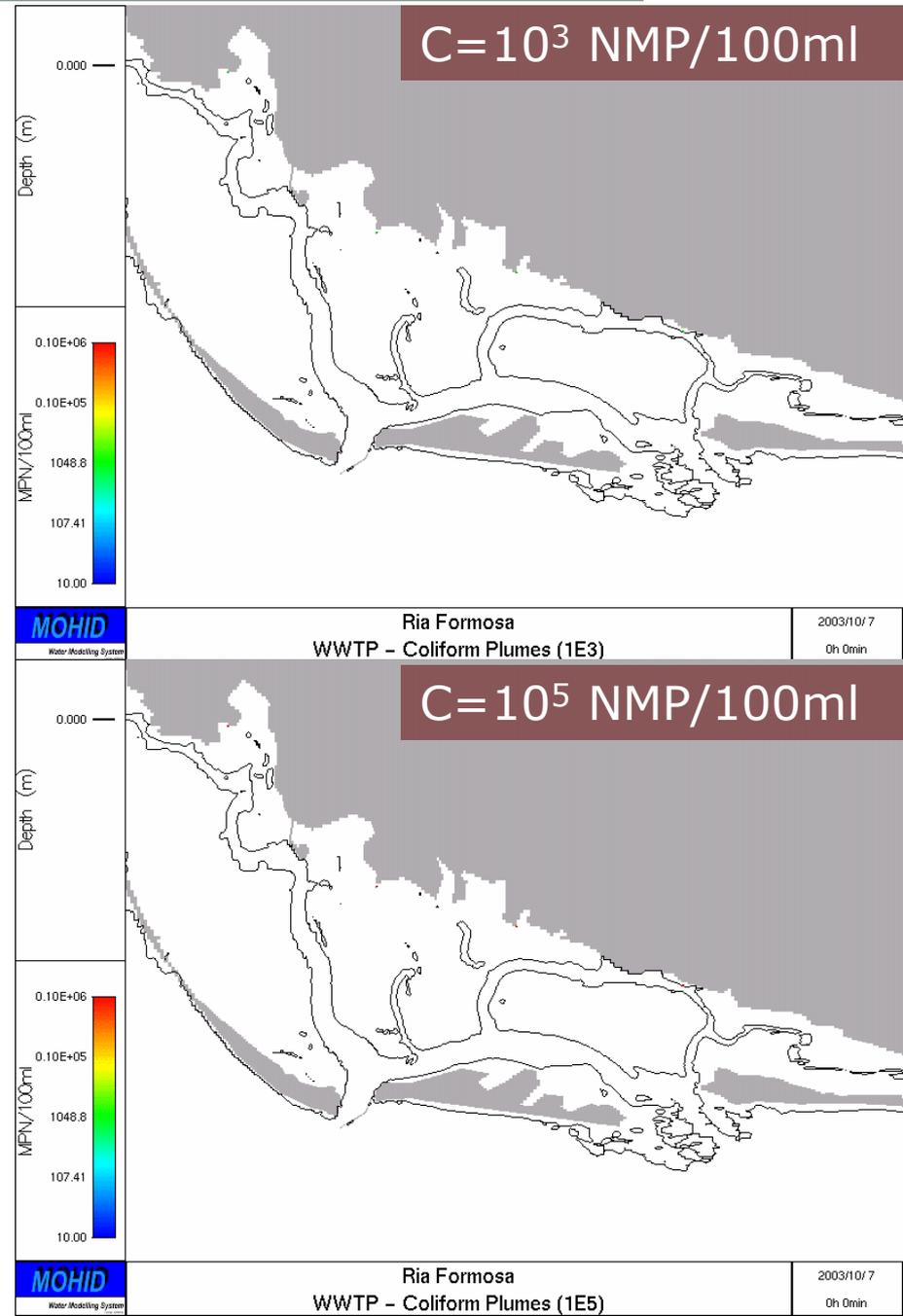
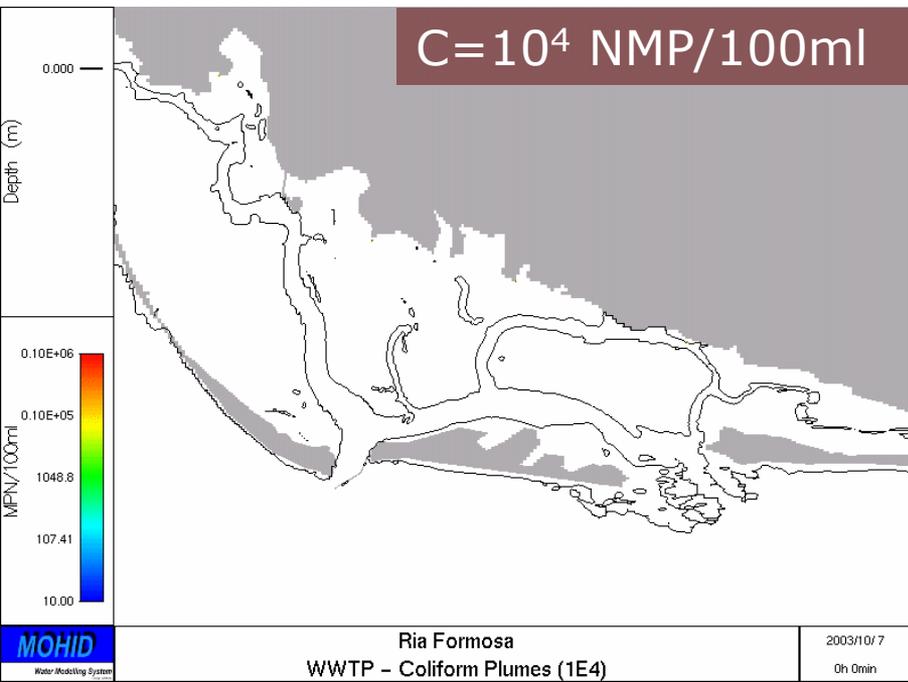
Experiment	Time	Station 1 - 100m		Station 2 - 400m	
		FC MPN/100mL in water	FC MPN/100g in clams	FC MPN/100mL in water	FC MPN/100g in clams
Exp. 3 half flood to flood	0	2.4E+04	3.3E+02	1.7E+03	3.3E+02
	30	9.0E+02	2.4E+03	5.0E+02	2.4E+03
	90	1.1E+01	2.4E+03	2.3E+01	3.5E+03
	180	1.3E+01	5.4E+03	<1	2.4E+03
Exp. 4 flood to half ebb	0	<1	3.3E+02	<1	3.3E+02
	30	1.4E+01	2.4E+04	8.0E+00	2.3E+03
	90	5.0E+02	2.4E+05	3.0E+02	2.4E+04
	145	2.4E+03	3.3E+05	5.0E+02	3.5E+04
Exp. 5	0	<1	3.3E+02	<1	3.3E+02
	7 days	1.6E+03	1.6E+05	2.2E+02	3.5E+04

Field Experiment

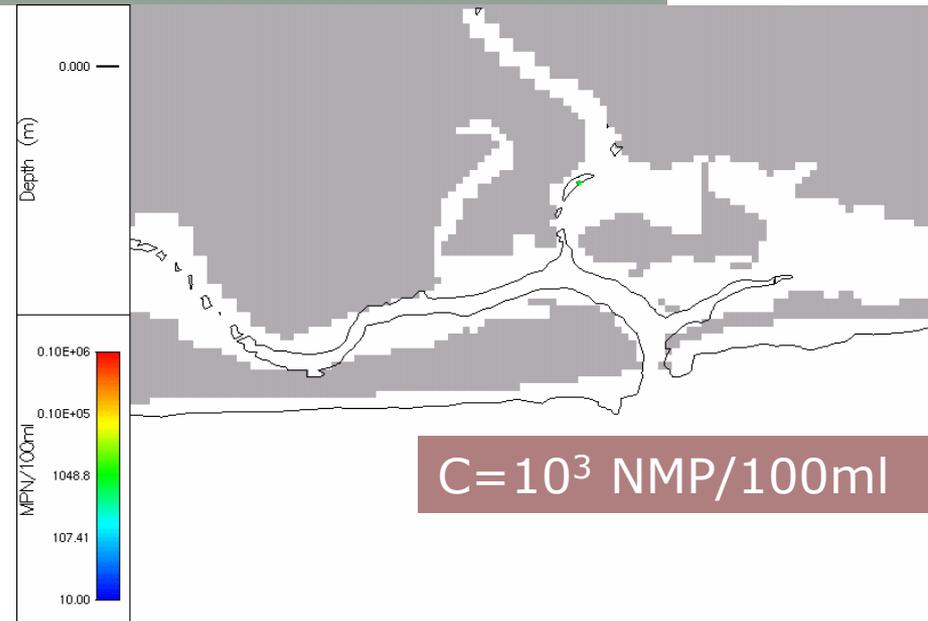
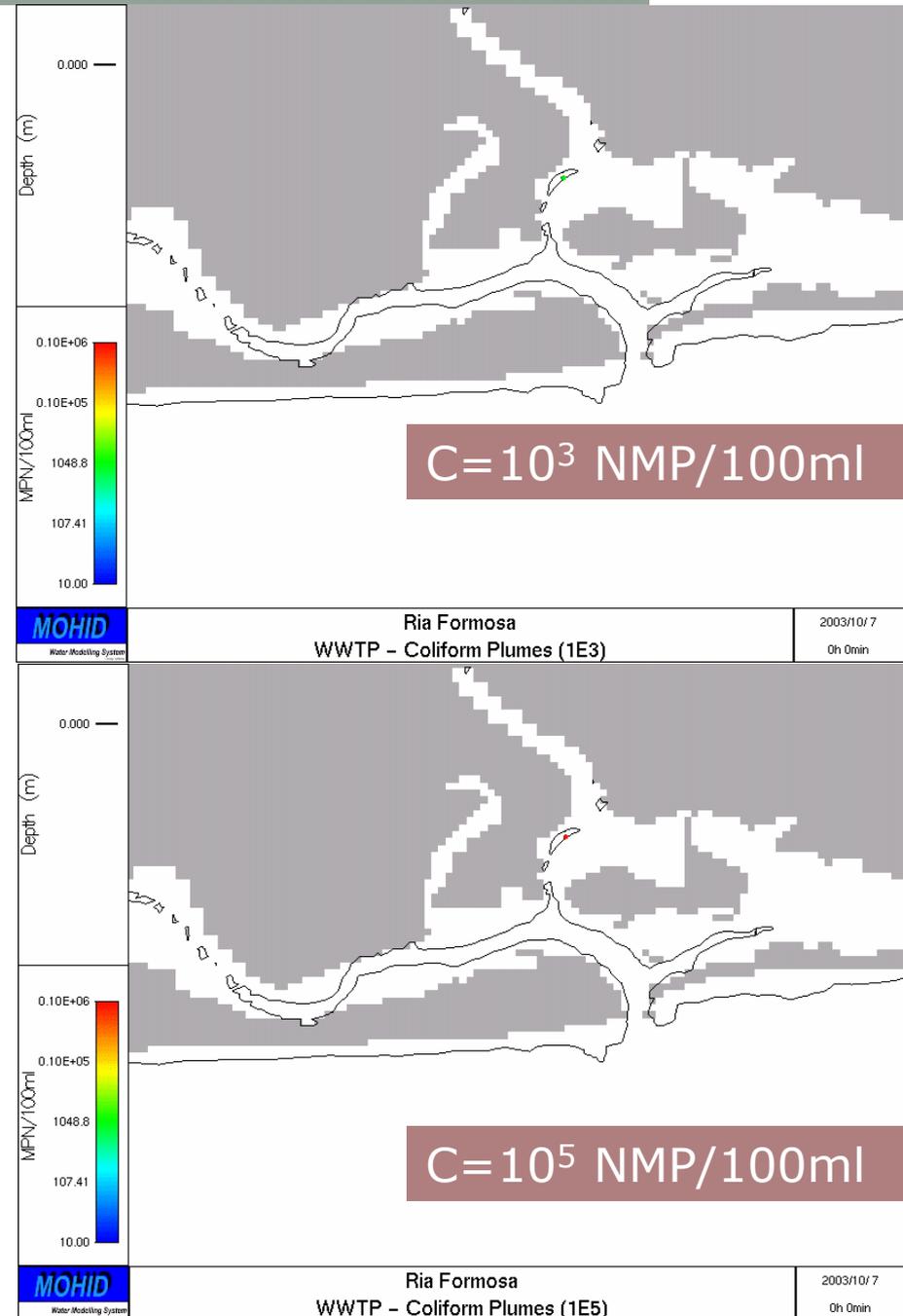
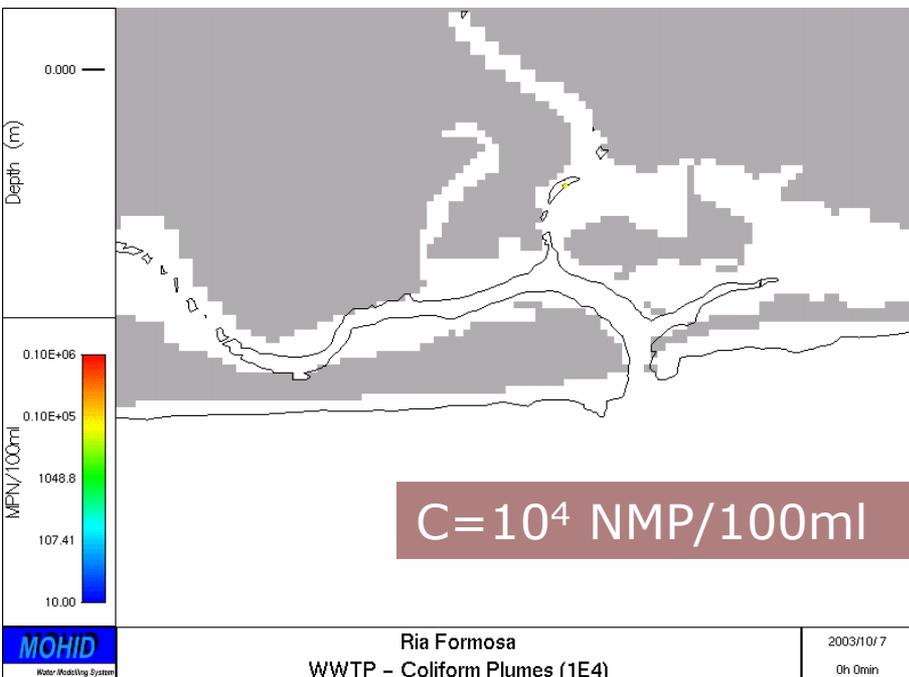
Field and Model Results 100 m station



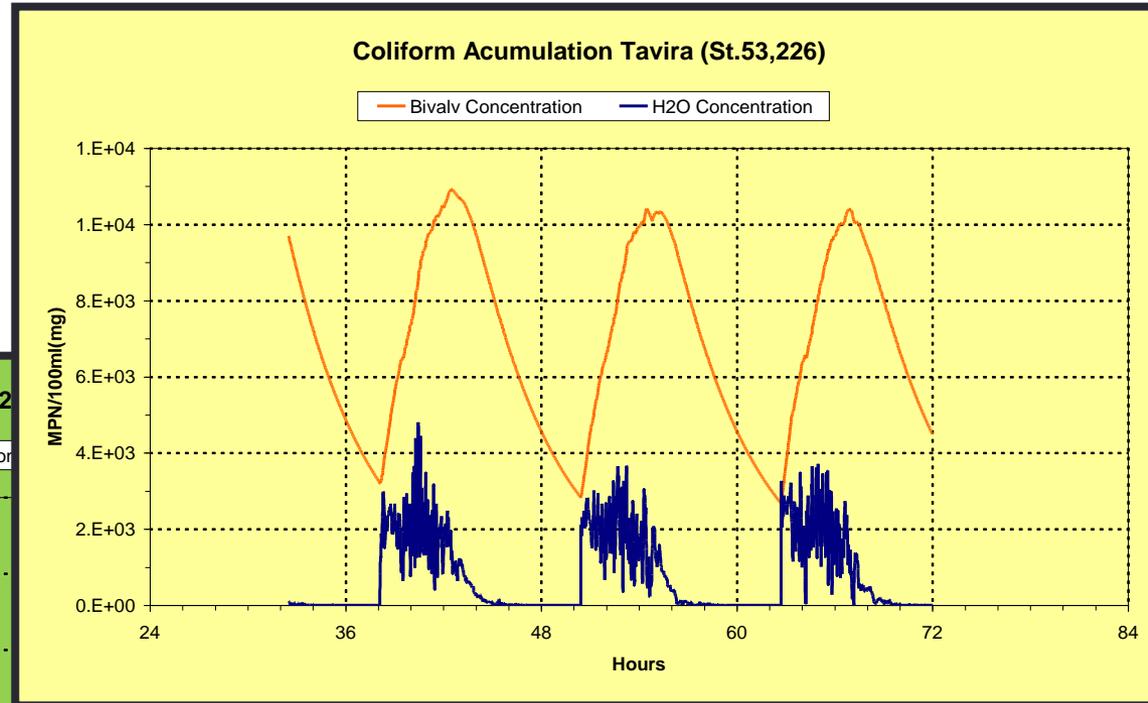
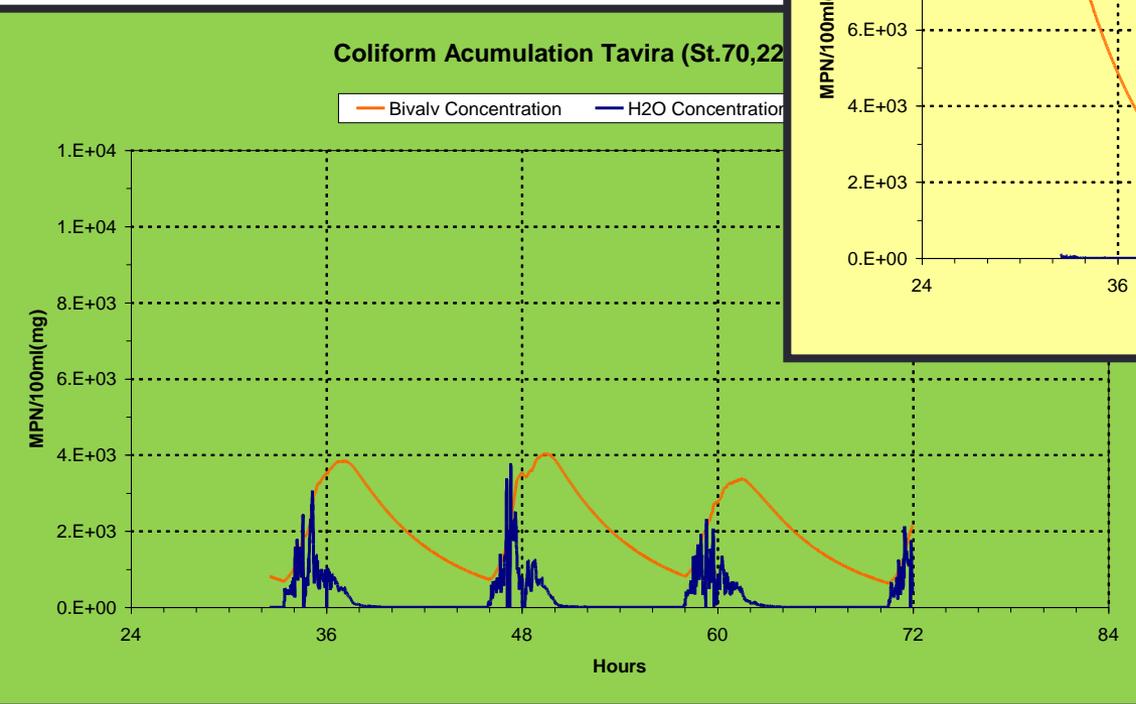
Concentração C.F. na Coluna de Água (3 cenários)



Concentração C.F. na Coluna de Água (3 cenários)

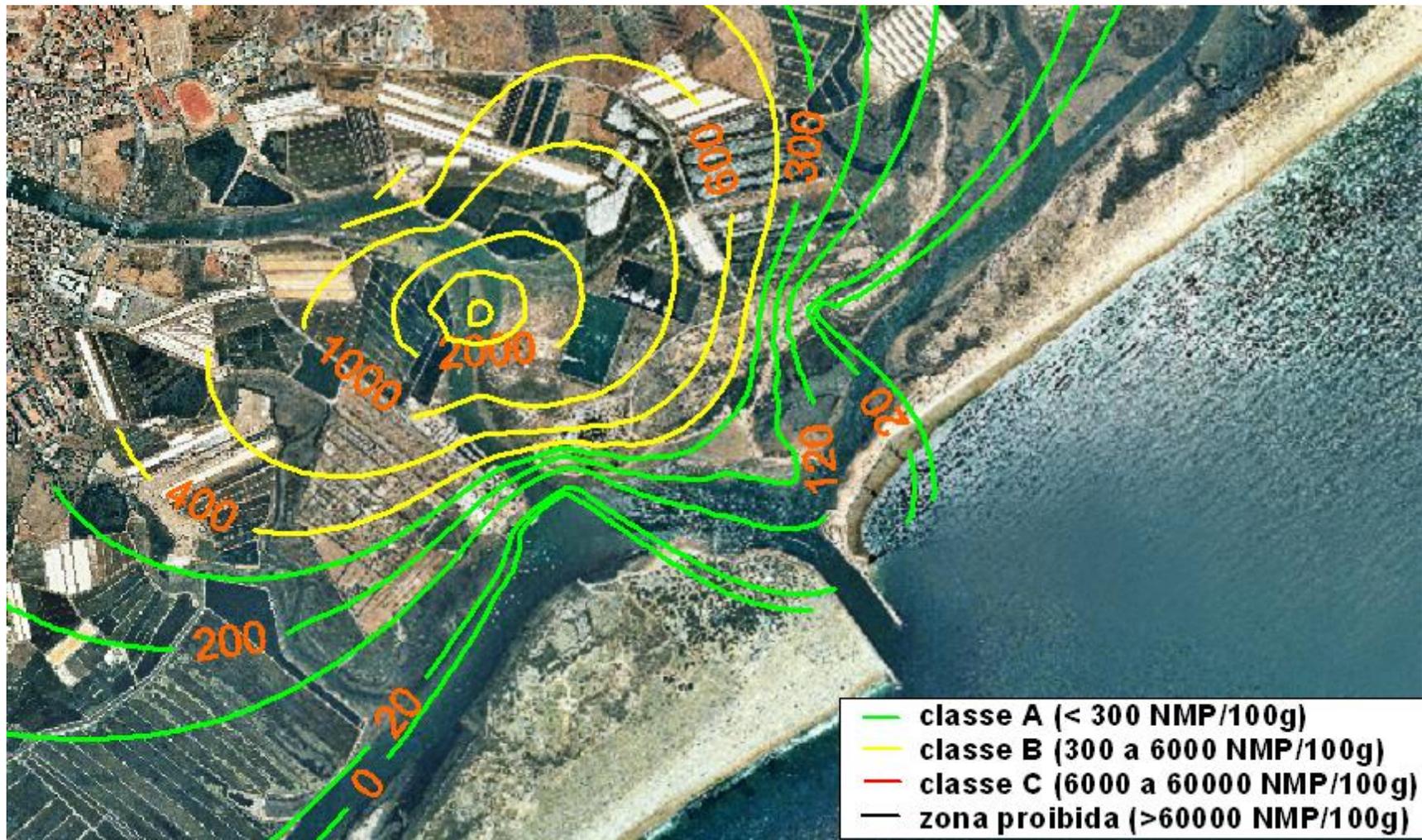


Example: high v.s. low exposition



Shellfish Concentration

Tavira ($C_{out}=10^3$)



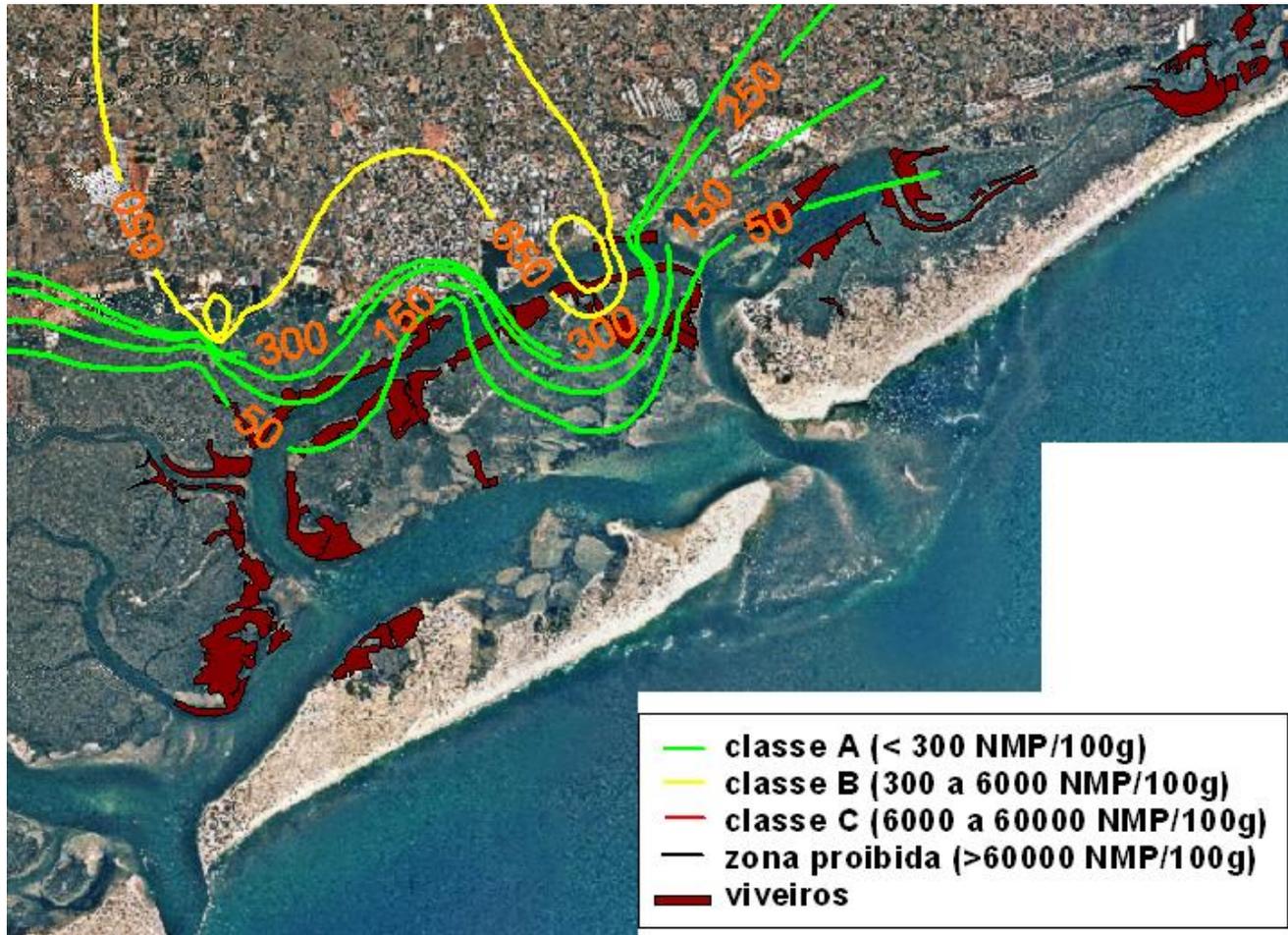
Shellfish Concentration

Tavira ($C_{out}=10^5$)



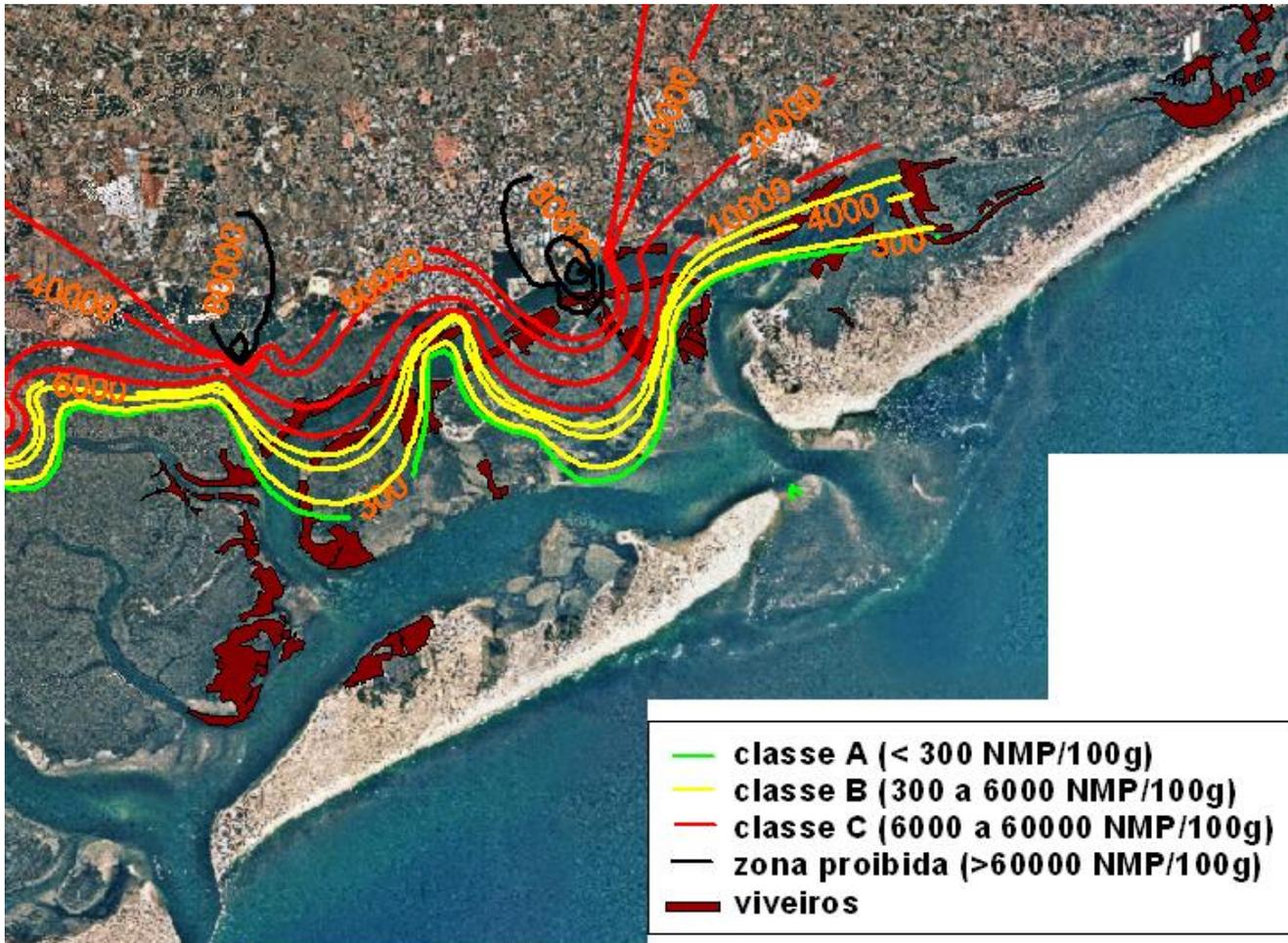
Shellfish Concentration

Olhão ($C_{out}=10^3$)



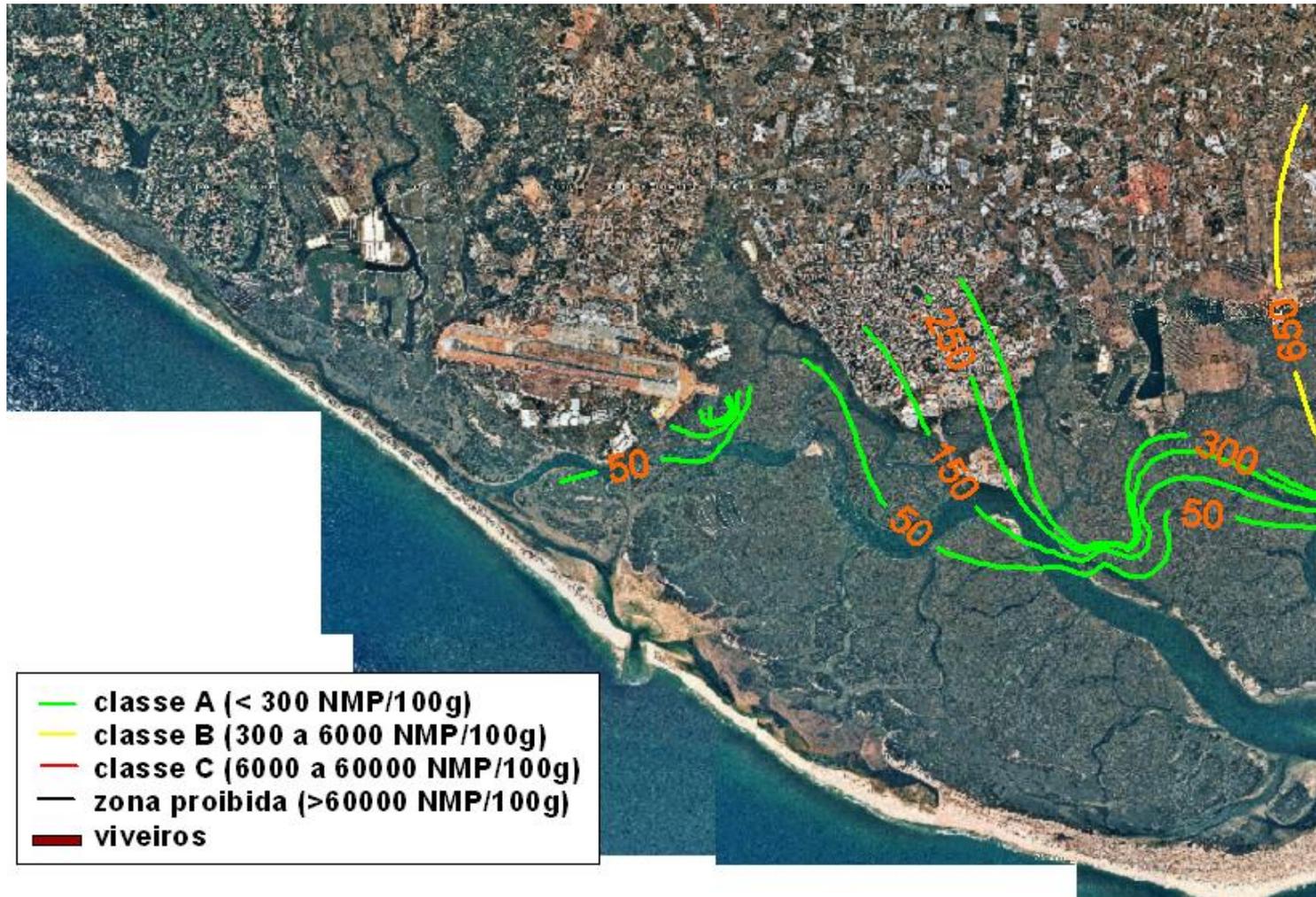
Shellfish Concentration

Olhão ($C_{out}=10^5$)



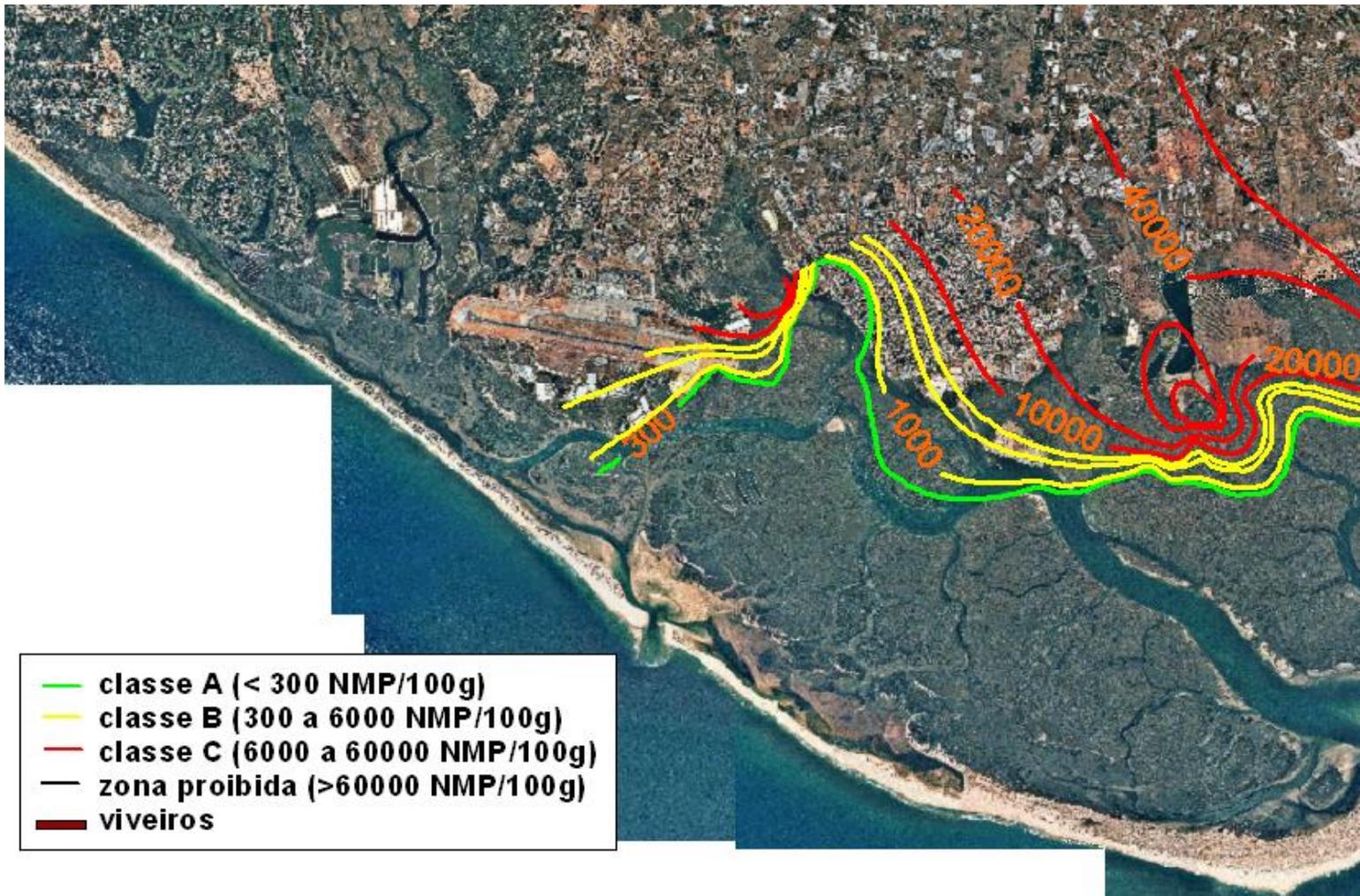
Shellfish Concentration

Faro ($C_{out}=10^3$)

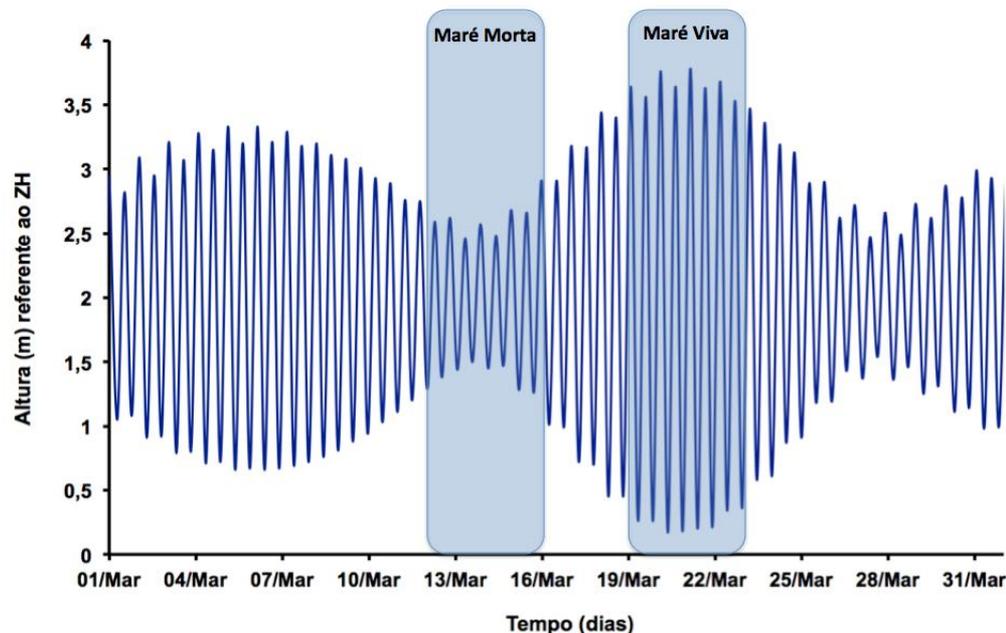
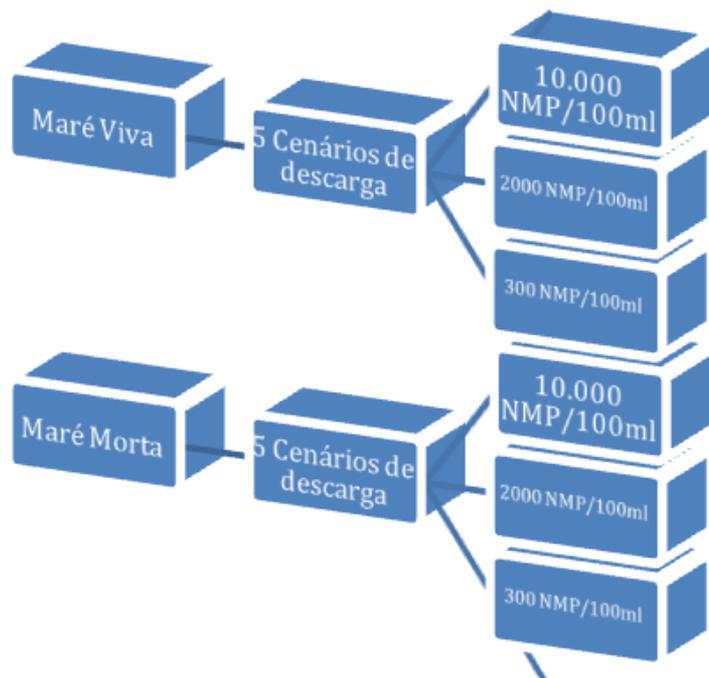


Shellfish Concentration

Faro ($C_{out} = 10^5$)

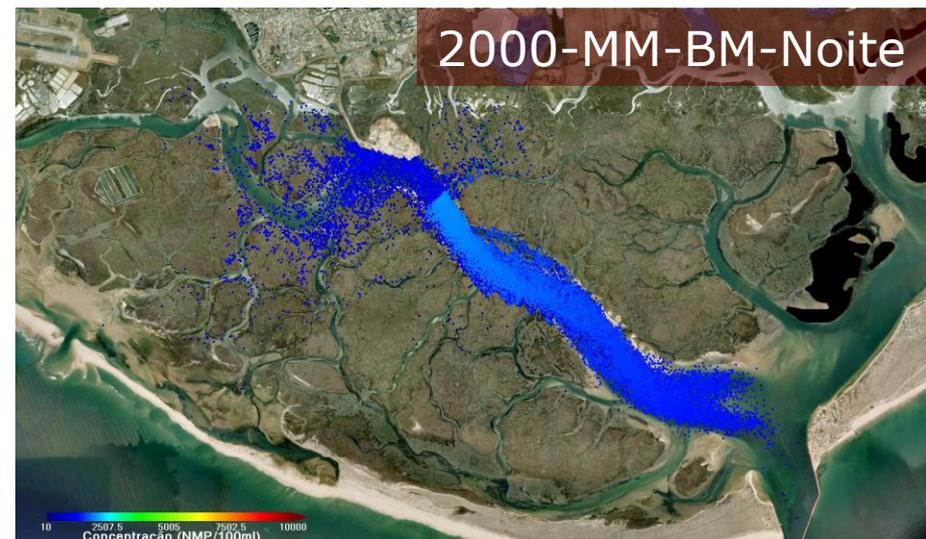
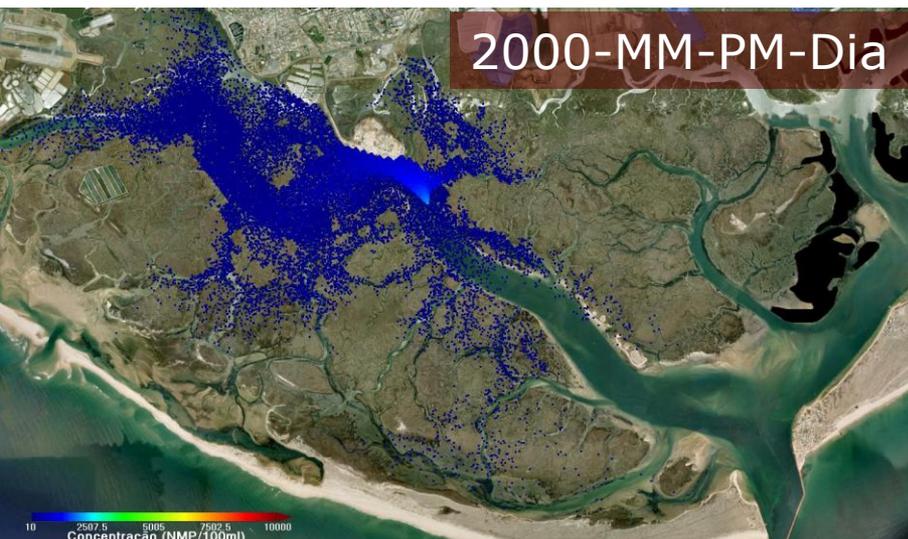
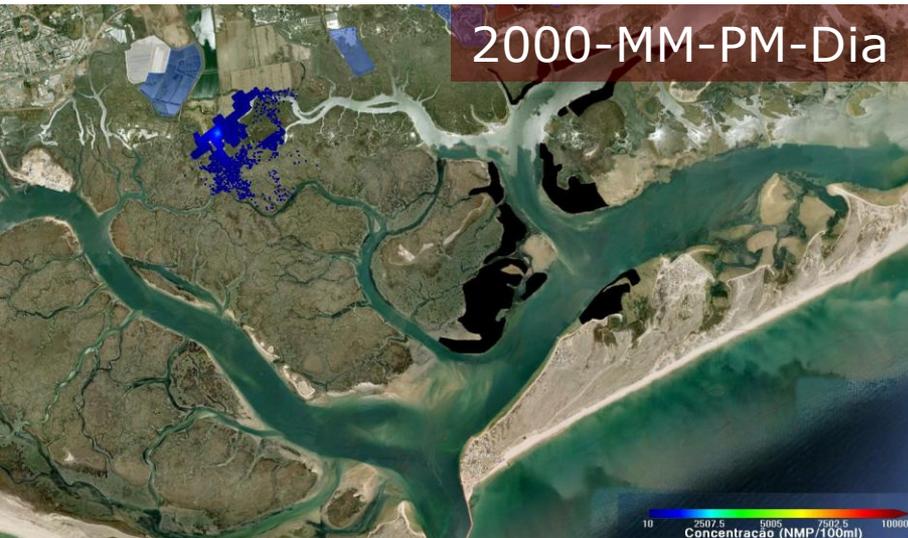


Descarga Microbiológica Nova ETAR Faro Nascente



		Caudal afluyente (m ³ /dia)	Caudal infiltração (m ³ /dia)	Fossas sépticas (m ³ /dia)	Caudal simulado (m ³ /dia)
Cenário 1 e 2	Faro	25327,0	12896	10	38233,0
	Olhão	10233,5	4563	10	14806,5
Cenário 3, 4 e 5		35560,5	17459	20	53039,5

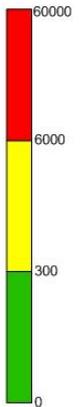
Descarga Microbiológica Nova ETAR Faro Nascente



Descarga Microbiológica Nova ETAR Faro Nascente



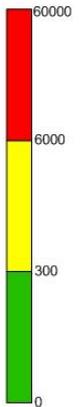
Escala de Depuração
(NMP/100ml)



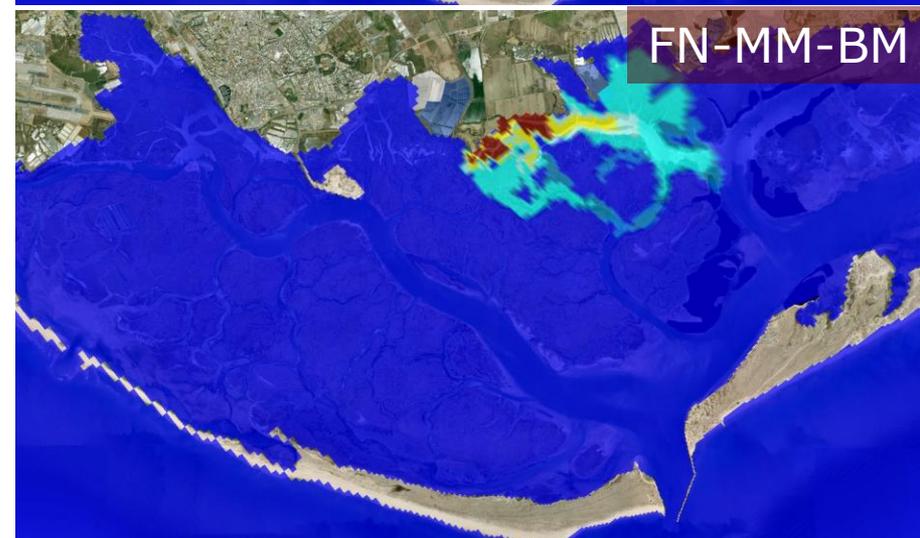
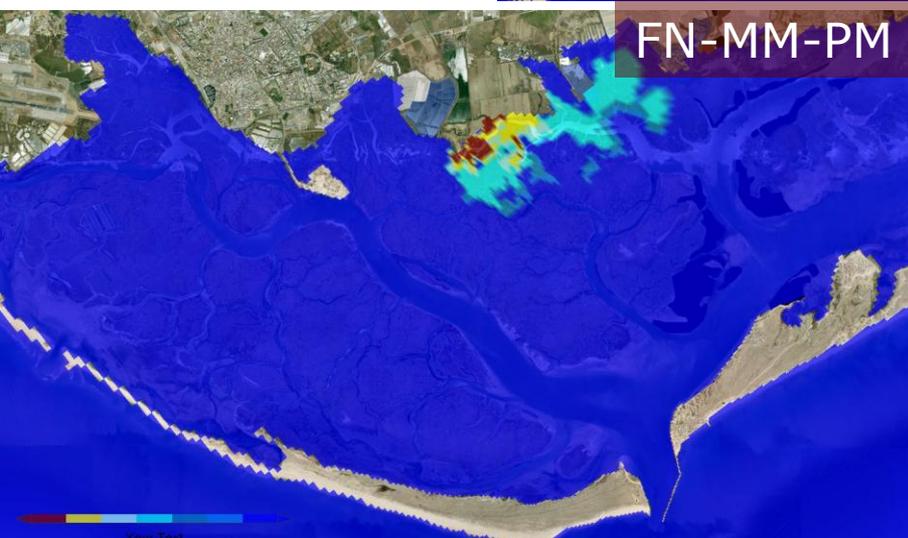
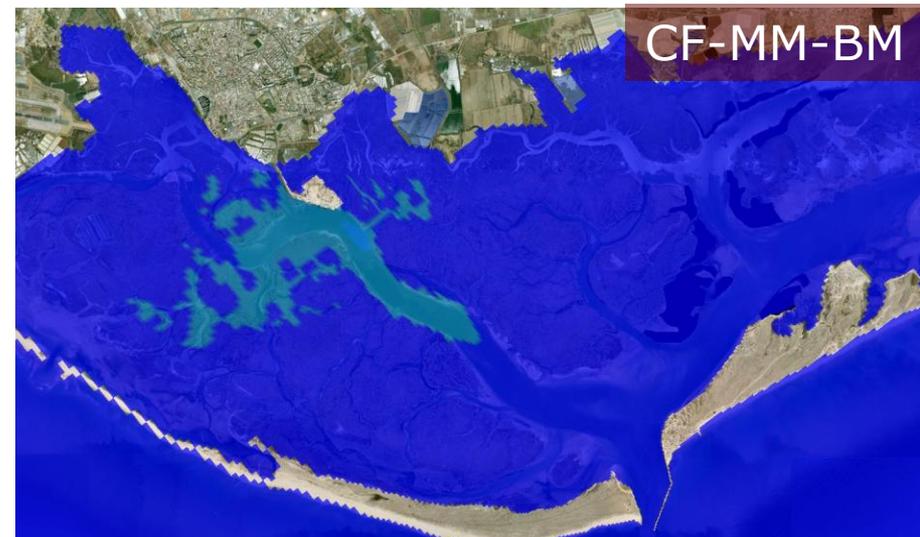
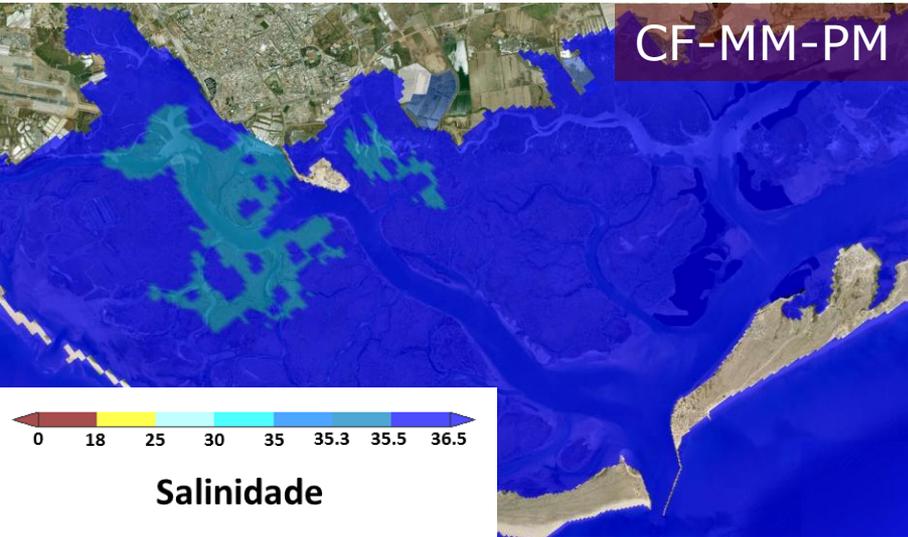
Descarga Microbiológica Nova ETAR F.N. - Canal



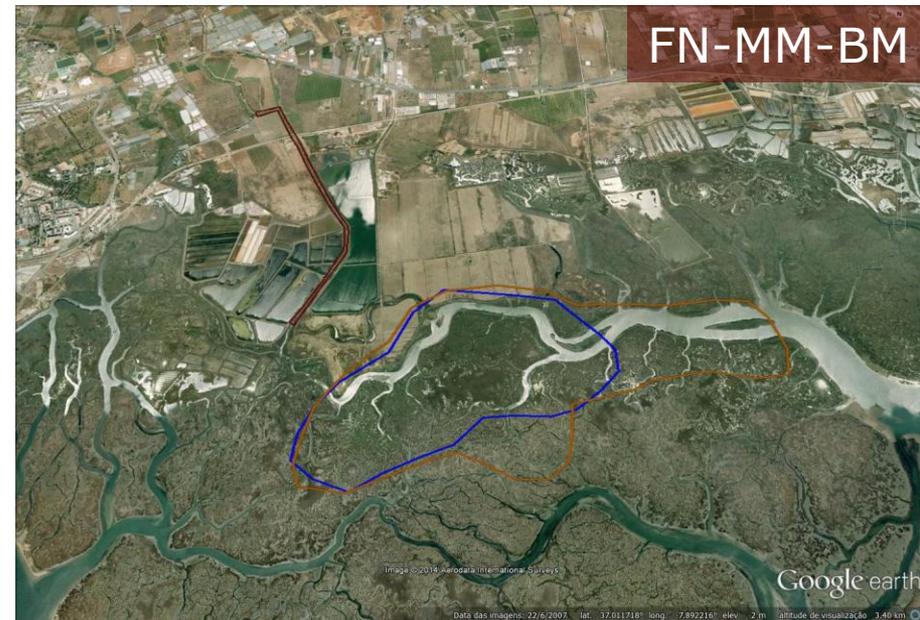
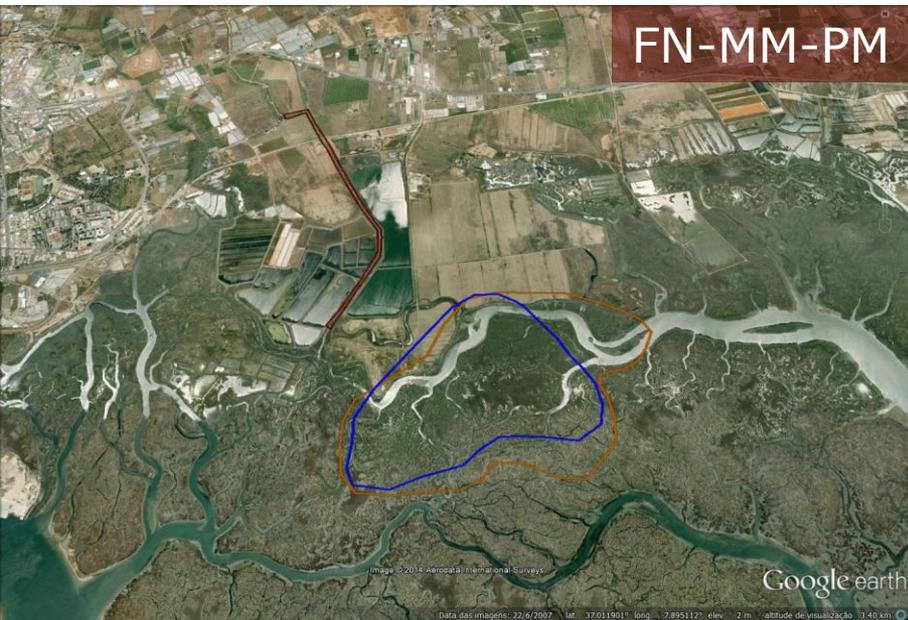
Escala de Depuração
(NMP/100ml)



Influência da Água Doce



Influência da Água Doce



Azul: $S=18$ psu (MONAE/NOAA)
Castanho $S=25$ psu (Veneza)

Conclusions

- Methodology proved adequate
- Localized impact of plumes (500 to 2000 m)
- High sensibility to WWTP concentration
- Large dispersion not always the best for bioaccumulation
- Shellfish accumulate and depurate very fast (2 to 3 hours)
- Fresh water impact is negligible

- Is it possible to manage discharges dynamically?
Function of tidal cycle and light for example (operational modelling)?
- ? What happens to higher trophic levels? Fish? Nursery function?



- Anabela Venâncio
- João Janeiro
- Alberto Brito
- Nadya Basos
- João Lopes
- Equipa IST
- Prof. Margarida Reis
- Prof. Rui Santos