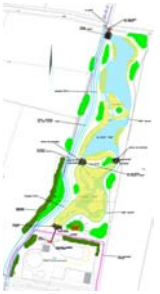
Wetland workshop: Discussion about the Waterharmonica



Ruud Kampf and Lluis Sala
EU-Neptune meeting Koblenz
22 April 2009, 17.15 - 18.00

Contents

- Nature in the Empuriabrava wetland
- Waterharmonica: a mixing zone….
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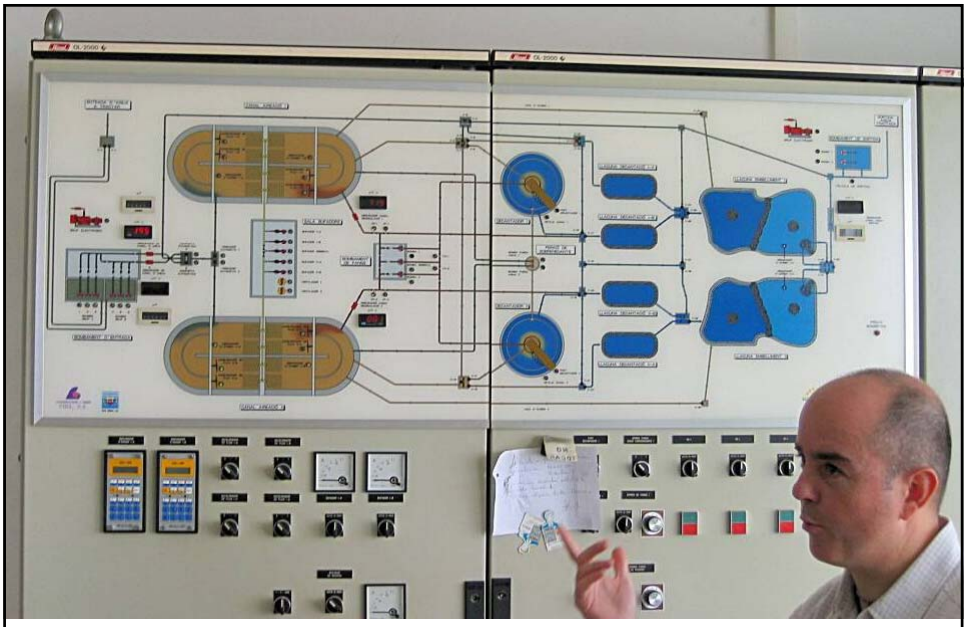
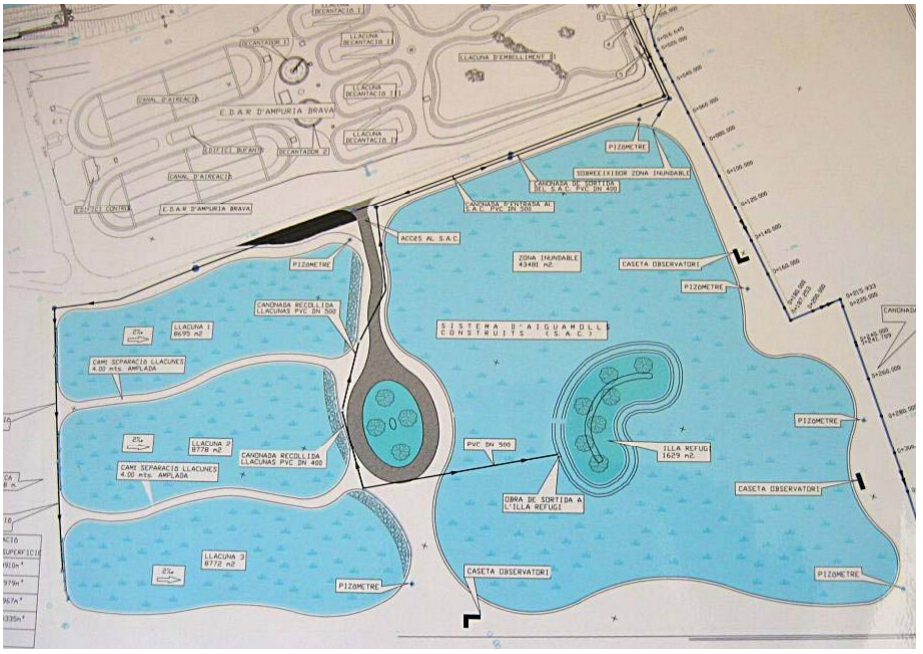
Empuriabrava, Costa Brava

From Lluis Sala, Concorsi de la Costa Brava





LLACUNA DECANTACIÓ 1
DECANTADOR 1
LLACUNA DECANTACIÓ 1
LLACUNA D'EMBELLIMENT 1
CANAL D'AIREACIÓ
E.D.A.R D'AMPURIA BRAVA
LLACUNA DECANTACIÓ 1
LLACUNA DECANTACIÓ 1
EDIFICI BUFANDA
DECANTADOR 2
CANAL D'AIREACIÓ
EDIFICI CONTROL
E.D.A.R D'AMPURIA BRAVA
PIZÓMETRE
SOBREEIXIDOR ZONA INUNDABLE
CANONADA DE SORTIDA DEL S.A.C. PVC DN 400
CANONADA D'ENTRADA AL S.A.C. PVC DN 500
ACCÉS AL S.A.C.
ZONA INUNDABLE 43481 m2.
CASETA OBSERVATORI
PIZÓMETRE
PIZÓMETRE
CANONADA RECOLLIDA LLACUNAS PVC DN 500
SISTEMA D'AIGUAMOLLS CONSTRUITS (S.A.C.)
LLACUNA 1 8695 m2
CAMI SEPARACIÓ LLACUNES 4.00 mts. AMPLADA
PIZÓMETRE
LLACUNA 2 8778 m2
CANONADA RECOLLIDA LLACUNAS PVC DN 400
CAMI SEPARACIÓ LLACUNES 4.00 mts. AMPLADA
PVC DN 500
ILLA REFUGI 1629 m2.
OBRA DE SORTIDA A L'ILLA REFUGI
CASETA OBSERVATORI
LLACUNA 3 8772 m2
PIZÓMETRE
CASETA OBSERVATORI
PIZÓMETRE

The wetland system

The final wetland

It is not only about water quality but also many other values

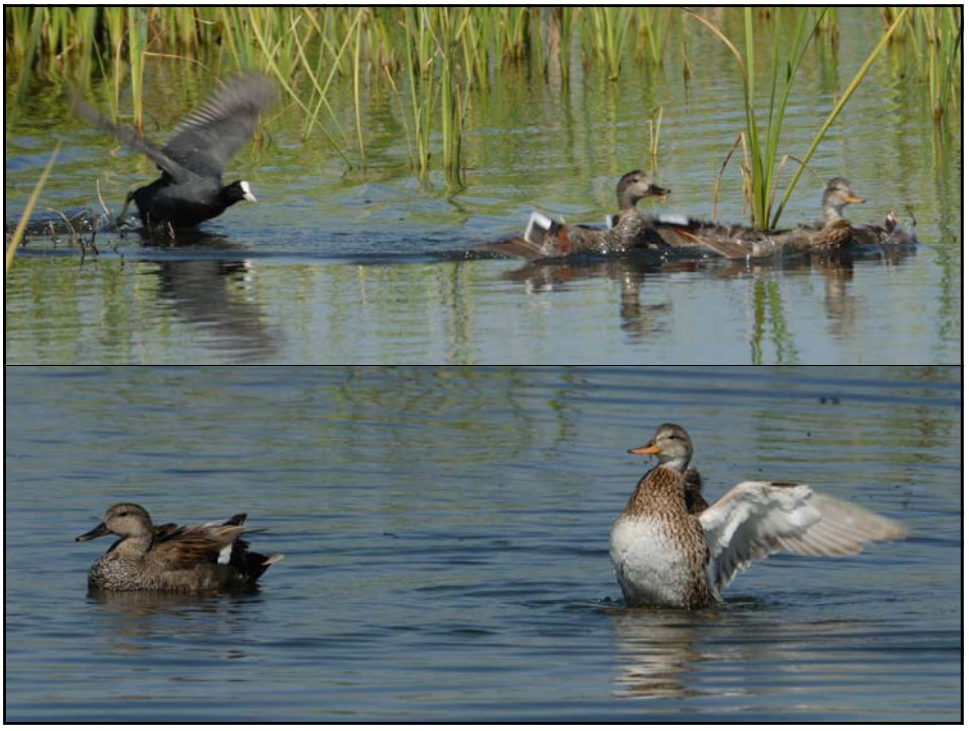
Turism, nature

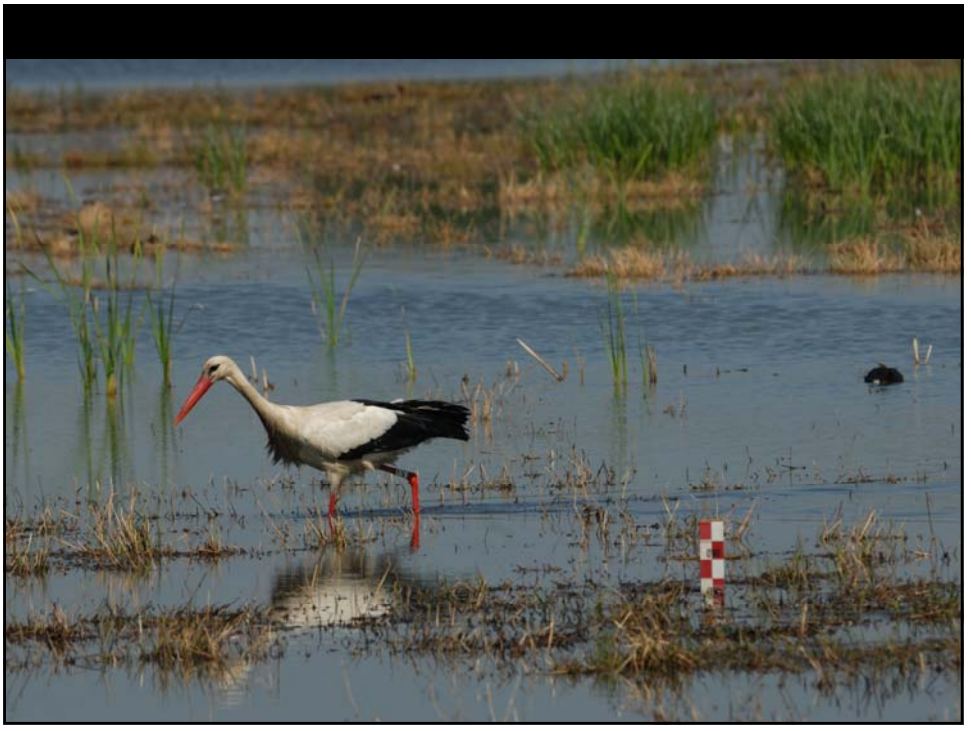
Natural park

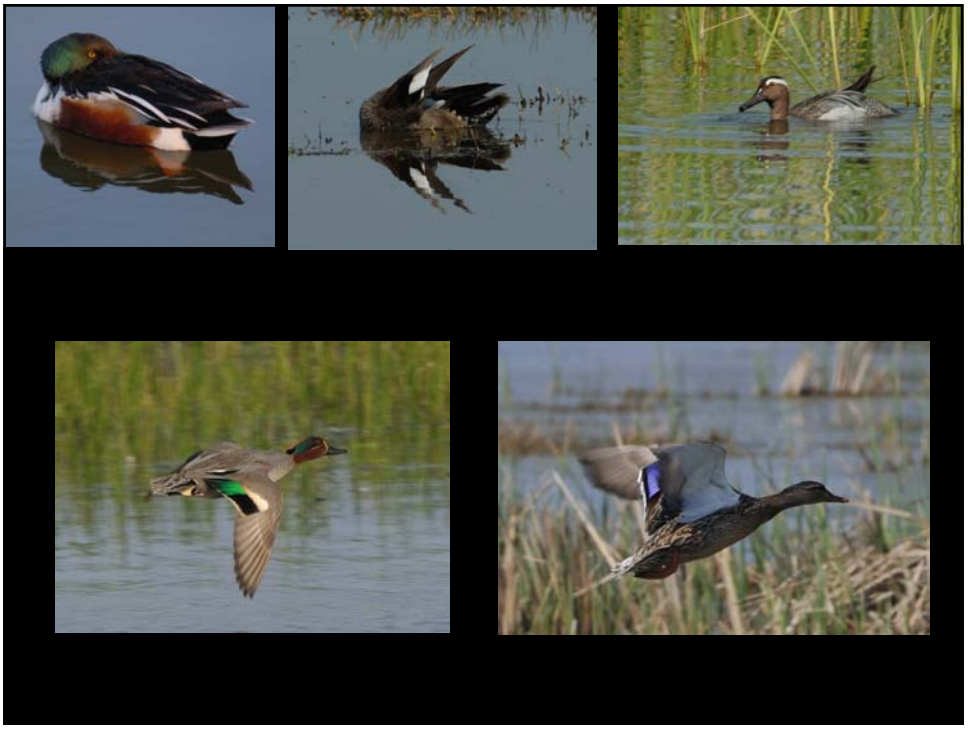
Aiguamolls d l'Emporda

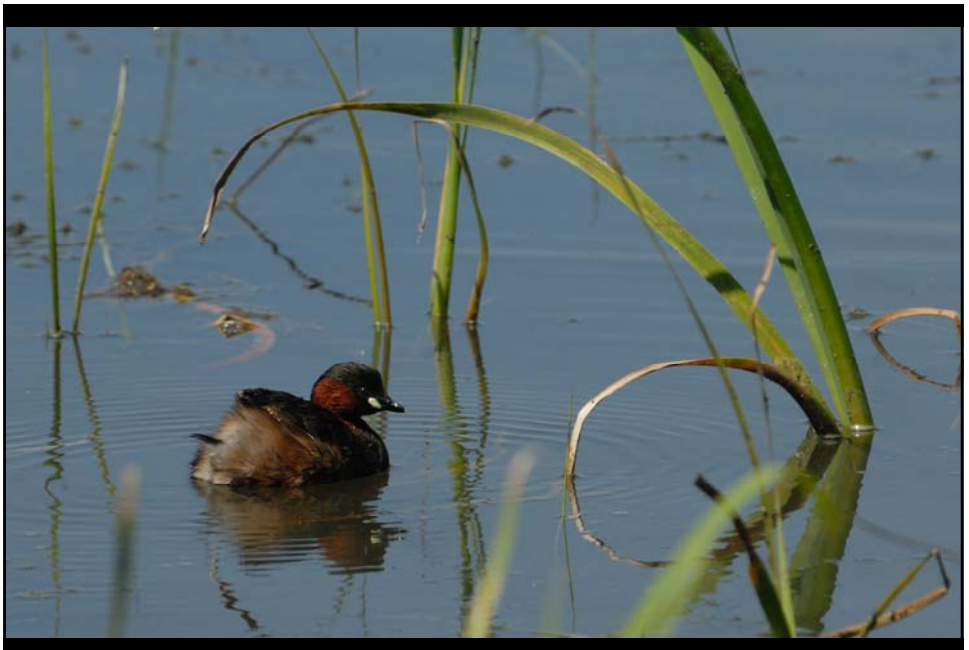
Parc Natural dels Aiguamolls de l'Empordà

Well treated waste water as source for the natural park

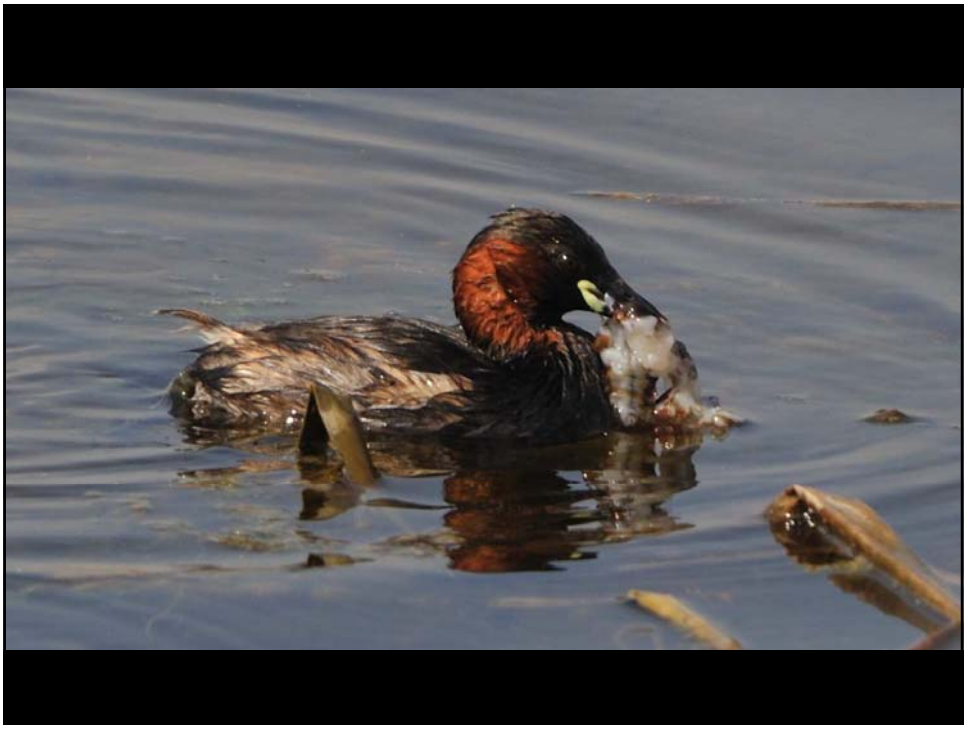


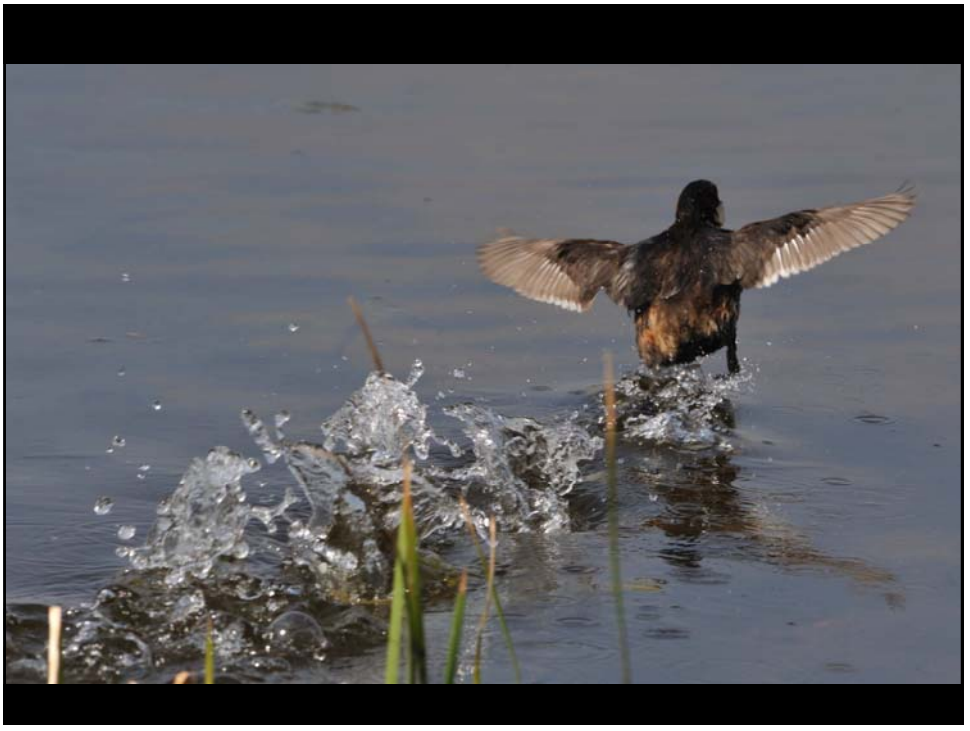






Little Grebe

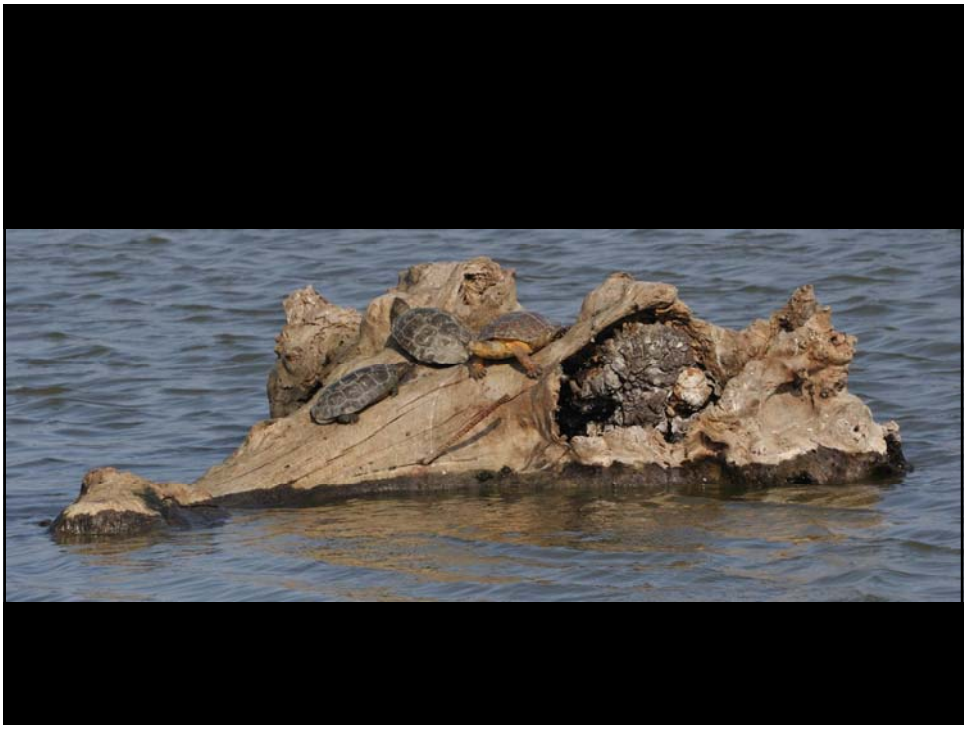


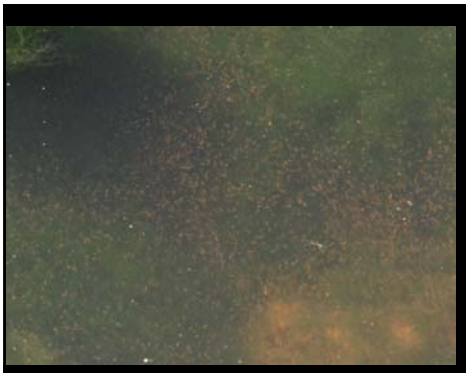


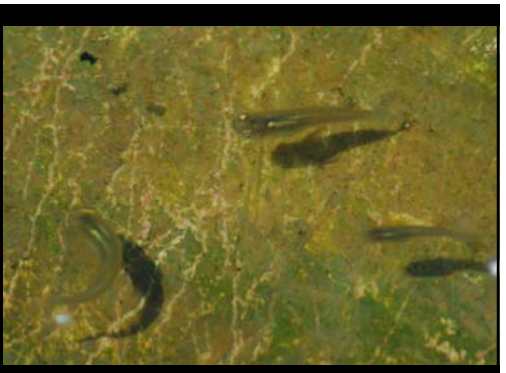
Porzana parva in flight

White-winged and White-cheeked Terns

Bee-eaters nesting in the final wetland







Food chains

Value of nature

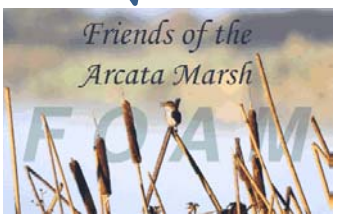
- Small Koi €1.50

Promise:

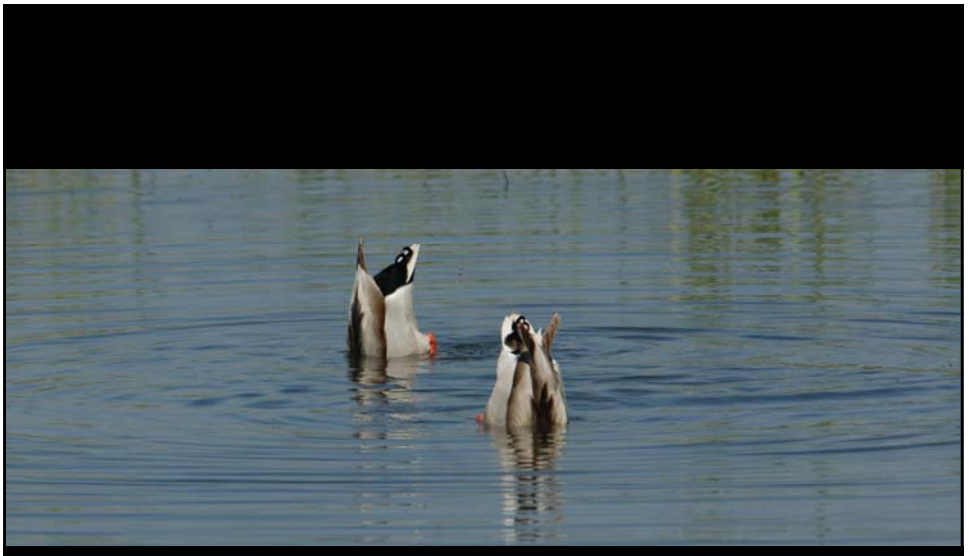
- Large ones € 15 / 75

It is about making friends

ARCATA MARSH
INTERPRETIVE CENTER



to stimulate understanding of the Arcata Marsh Wildlife Sanctuary, it's relationship with Arcata's integrated wastewater treatment system…….



Time for waterquality
Biodiversity

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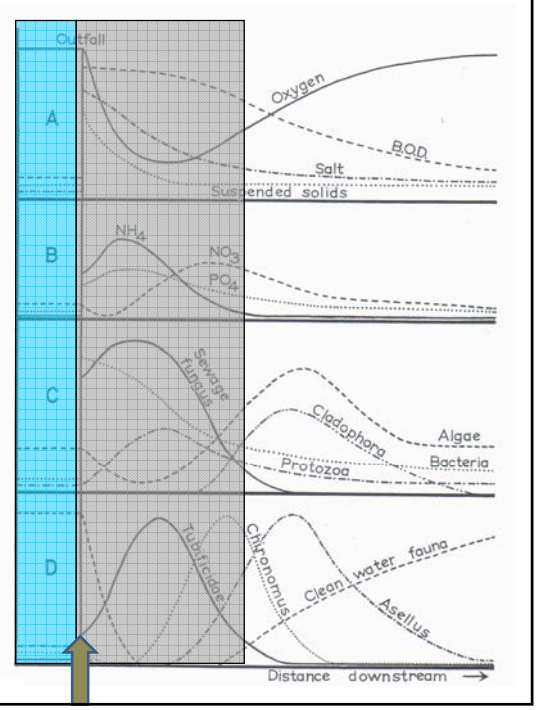
Influence of a wastewater discharge

A physical – chemical

B nutrients

C micro-organisms

D macro-organisms



Based on Hynes, 1960 The biology of polluted waters

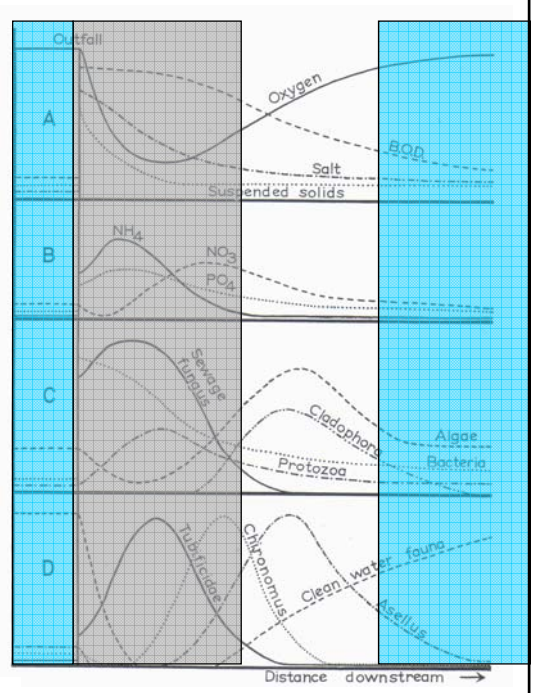
Schematic effect of discharges of wastewater

A physical – chemical

B nutrients

C micro-organisms

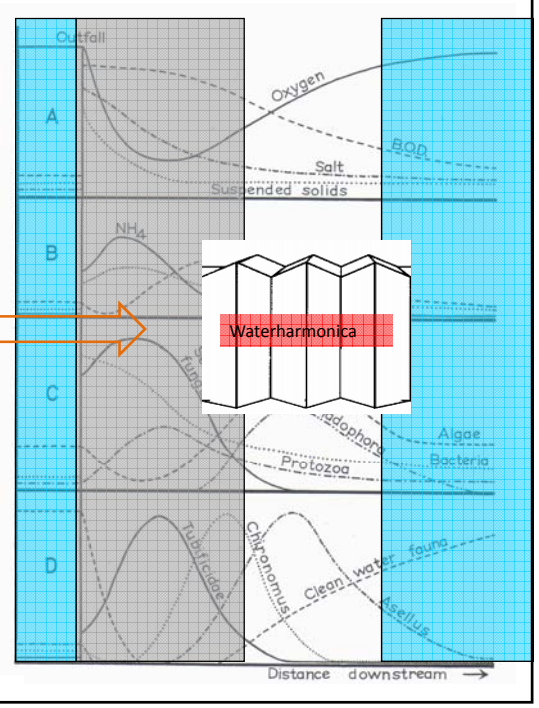
D macro-organisms



Based on Hynes, 1960 The biology of polluted waters

The Waterharmonica:

Bridge between sewage treatment and surface water



Based on Hynes, 1960 The biology of polluted waters

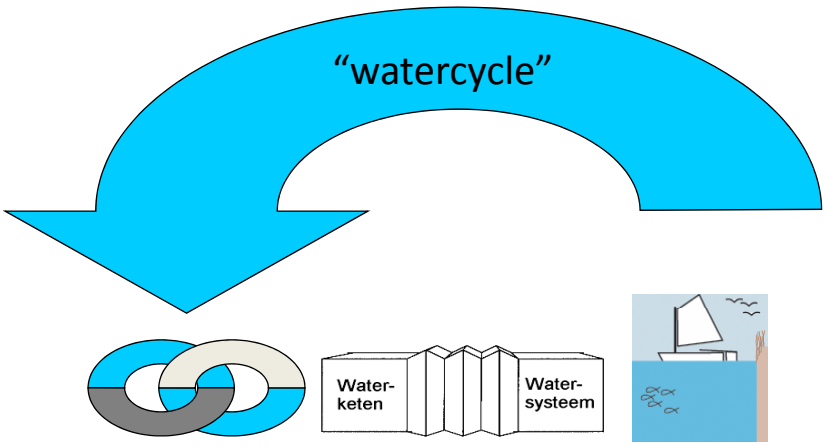
Mixing zone < -> Waterharmonica ?

Tomas Bleninger, Gerhard H. Jirka
How to deal with mixing zones fro priority pollutant discharges?
Workshop Water Framework Directive, Koblenz, 21-22 April 2009

- Mixing of discharges in river is very problematic
  - It can take 100's of km before a discharge is mixed
  - Much stricter regulations for rivers than for discharges
  - → Mixing zones important in WFD
  - → Why not take the mixing zones out of the river??
  - → Optimize the mixing zones into "constructed natural reactors"

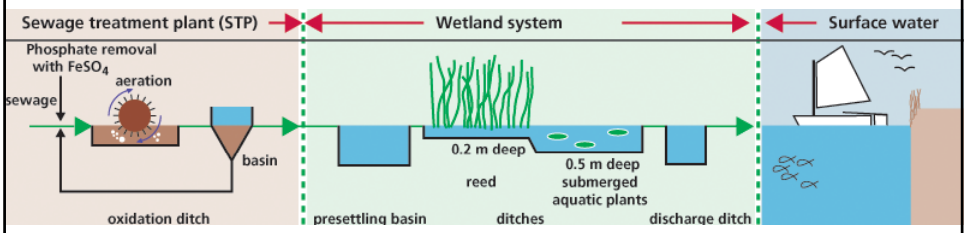
Similar to the Waterharmonica: *www.waterharmonica.nl*

Missing link in Water Management



The natural link between drinking water and surface water: The Waterharmonica:

From STP via wetland to surface water



STP Oxidation Ditch

Constructed wetland

Surface water

A constructed wetland to make a "living water" from treated waste water

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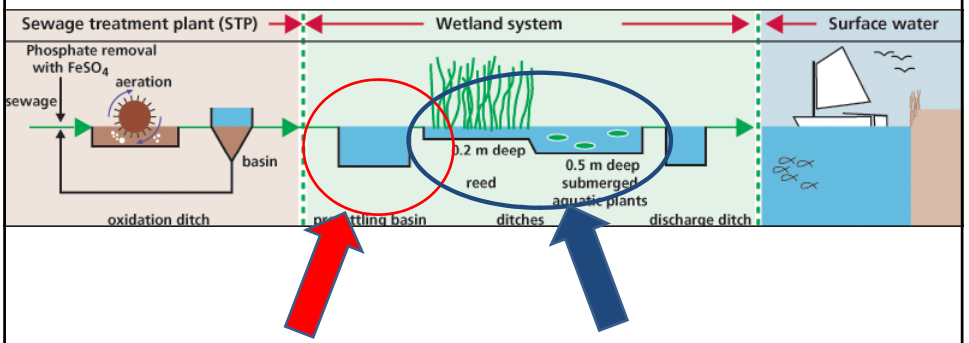
From STP via wetland to surface water



Daphnia ponds:
- Biological filtration

Processes in wetlands
- Fate of particles
- Ecotox
- other processes

Development of "unit processes" in constructed nature

A constructed wetland to make a "living water" from treated waste water

Daphnia
food chains

Empuriabrava

Grou

Everstekoog

www.waterharmonica.nl

Equal experiments on three STP's

research in a network construction since 2006 founded by Ruud Kampf

Horstermeer

Netherlands

Effluent

Filtrated effluent

Grou

Netherlands

Parallel to ponds

Empuriabrava

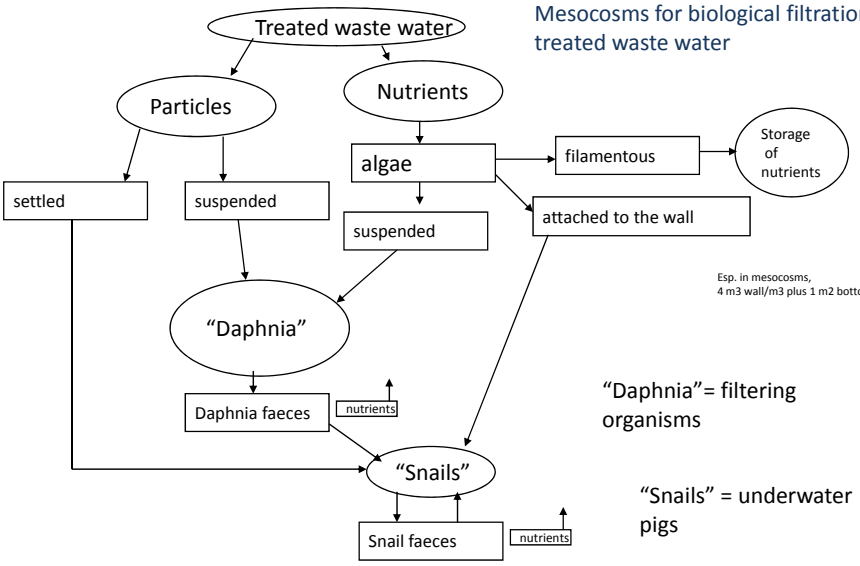
Spain

Parallel to ponds

www.waterharmonica.nl

Simplified scheme

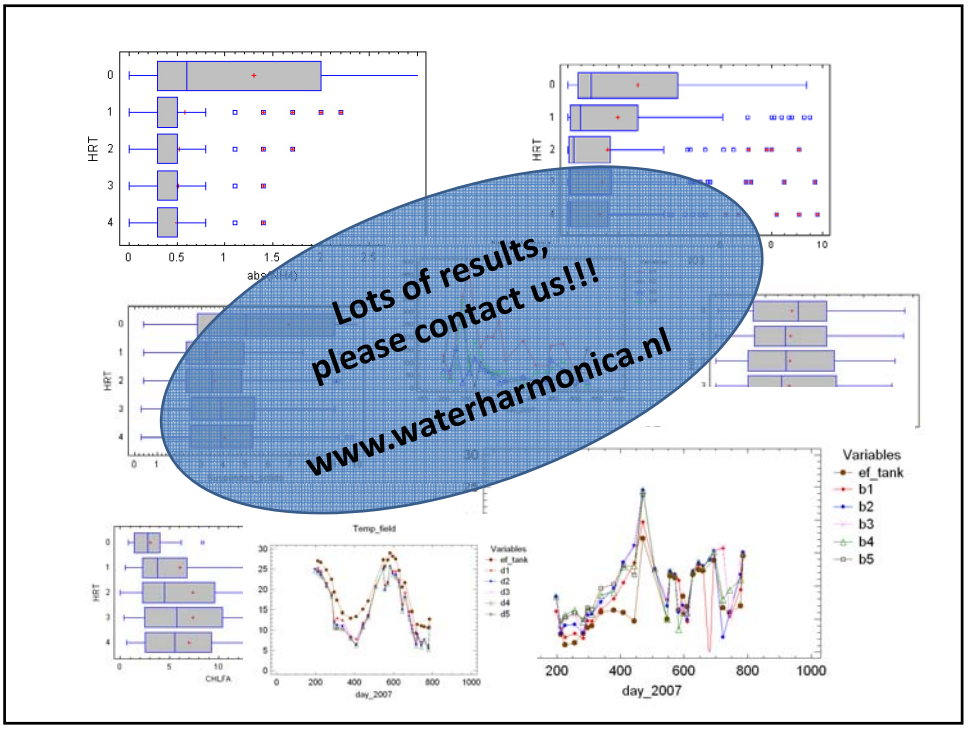
Mesocosms for biological filtration of treated waste water



"Daphnia"= filtering organisms

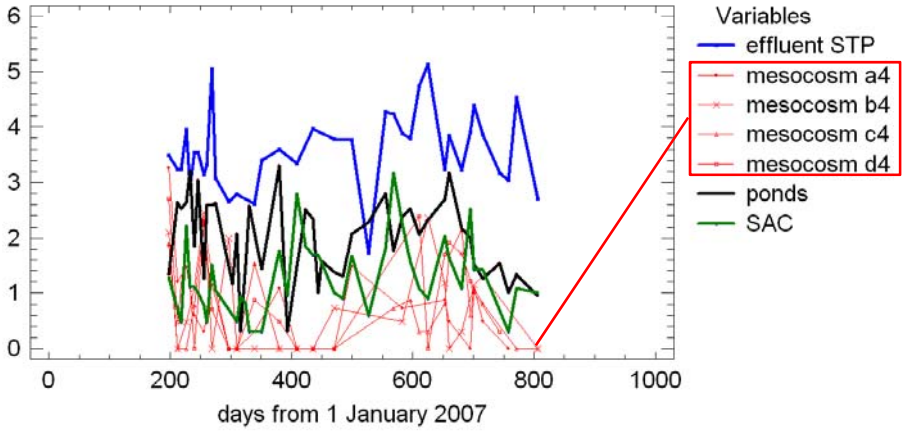
"Snails" = underwater pigs

Ruud Kampf
April 2009


HRT
day_2007
Variables
ef_tank
b1
b2
b3
b4
b5
Temp_field
CHLFA
Lots of results,
please contact us!!!
www.waterharmonica.nl

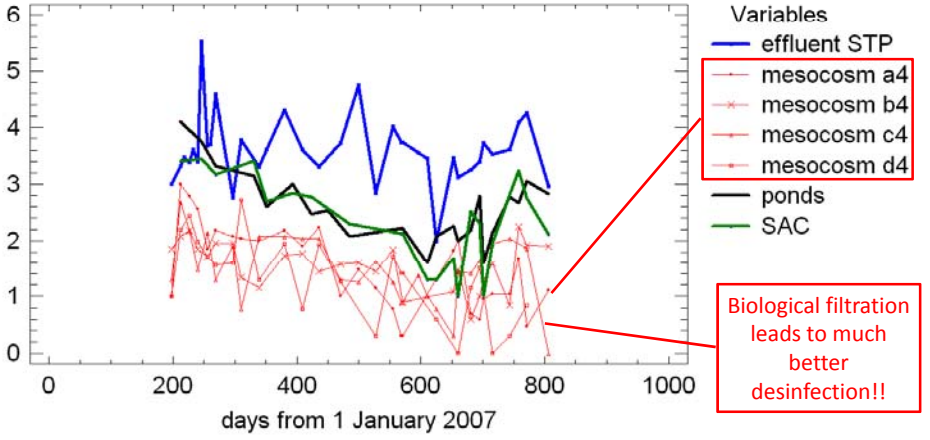
Mesocosms:
process optimizing for full scale - 1

Log E.Coli levels (nr/100 ml)



Mesocosms:
process optimizing or full scale - 2

Log of Clostridium spores (nr/100 ml)



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Aqualân Grou and STP

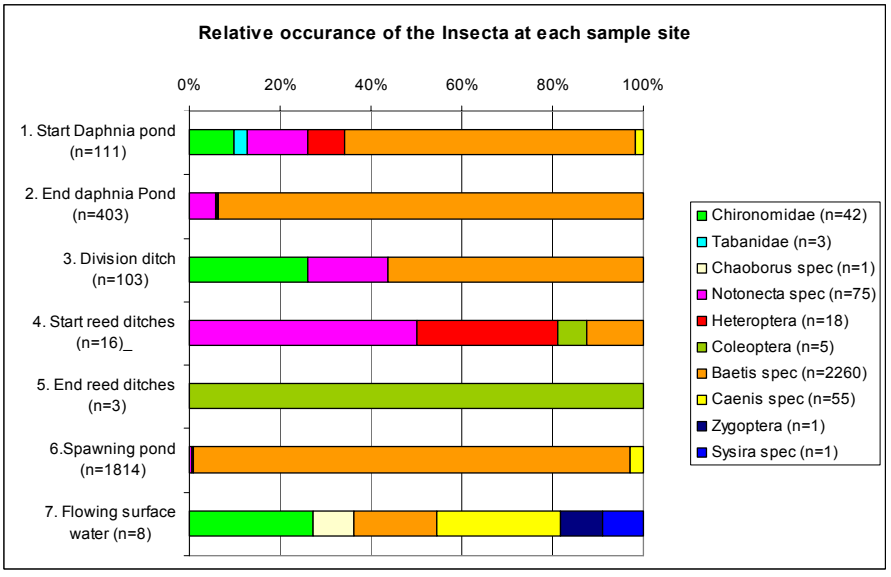
Aqualân Grou

Aqualân Grou: fish species 9 Juli 2008

Fish species	Daphnia pond	End of reed	Fish pond
Baars			9
Blankvoorn			54
Kleine modderkruiper			4
Paling			2
Ruisvoorn			6
Tiendoornige stekelbaars	0	23	1
Zeelt			5
Brasem			2
Driedoornige stekelbaars			1
Snoek			3
Giebel			2
Kolblei			2
Riviergrondel			6

European Water Frame Work Directive: Biodiversity!!!!!!

Macrofauna



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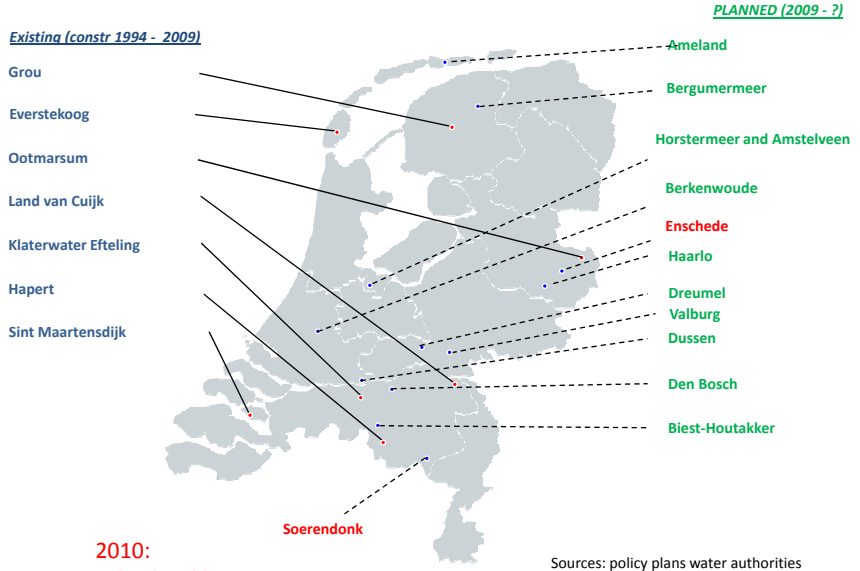
WATERHARMONICA SYSTEMS



2010:
subsidised by Innovation program

Sources: policy plans water authorities
Senter-Novem innovation programme

www.waterharmonica.nl

Waterharmonica Soerendonk

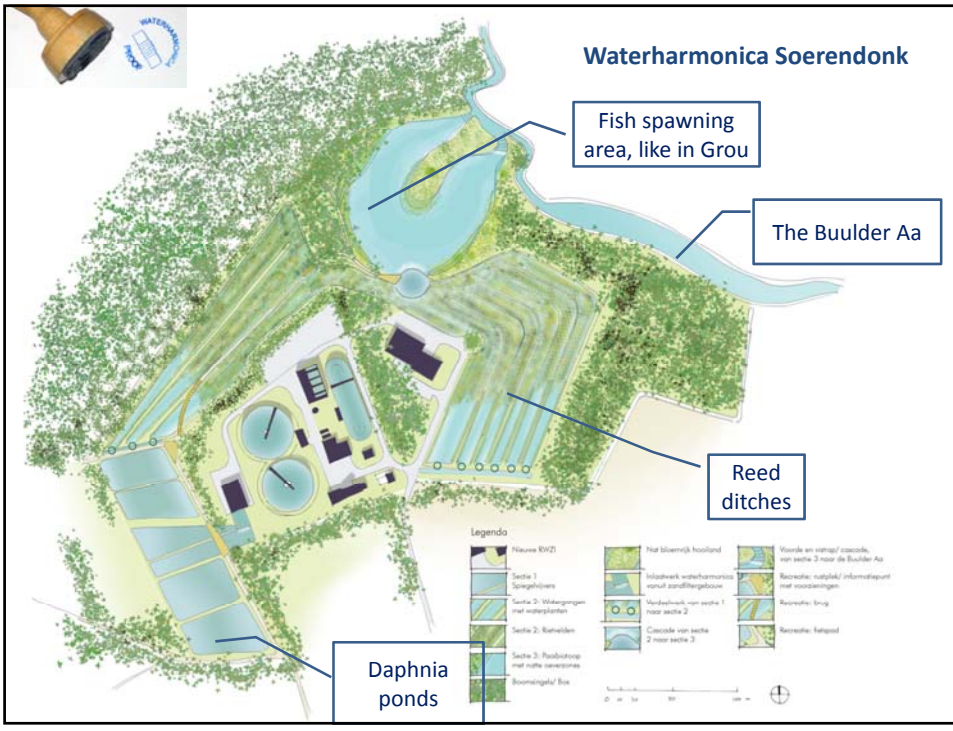
New Waterharmonica system

- part of landscape reconstruction plan
- converting treated waste water into a quality suited for nature
- creating wet nature
- water storage, flood prevention

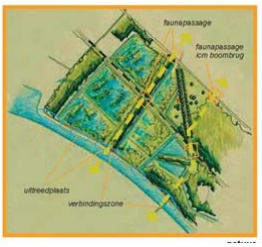
Project cost € 1.859.829

Innovation subsidy € 929.915

Ready in 2010



water



landschap en recreatie

Waterharmonica Kristalbad Enschede

New Waterharmonica system

- reconstruction plan 50 ha
- nature-water-landscape-recreation
- Project cost € 5.055.772

Innovation subsidy € 2.527.886

Ready in 2010 ?

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Waterharmonica research in Holland!!

- The network construction founded by Ruud Kampf
  - PhD study VU, TU-Delft (Waternet, Wetterskip Fryslan, Consorci de la Costa Brava, Witteveen+Bos, plus UvA en University of Girona)

PLUS

- A boost in Waterharmonica research, 2009-2010 alone
  - Stowa: fate of particles: € 230.000
    - Incl. PhD study Bram Mulling on particles at UvA: plus € 200.000
  - SenterNovem project “Moeraszuiver afvalwater”: € 1.200.000
  - Plus Waternet, Wetterskip Fryslan, Aa en Maas, etc several 100.000 Euro

Research topics in Waterharmonica systems

- Soluble:
  - Nutrients: new microbiological methods
- Particles:
  - What happens with particles from STP?
    - Originating from waste water
    - Activated sludge flocs, bacteria, pathogens, etc.
  - What kind of particles are formed?
    - Algae, bacteria, pathogens from birds, etc.

Research topics in Waterharmonica systems

- Processes
  - Food chain approach
    - Daphnia filtration
    - Role of snails
- Biodiversity
    - Results from all in same direction: interesting!
- Ecotoxicity
- Algae: use of algae for storage of nutrients !

“Moeraszuiver afvalwater”

Upgrading Treated Wastewater in Constructed Wetlands

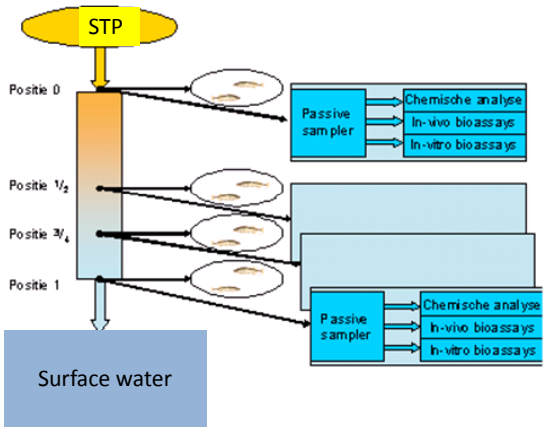
Senter Novem Project

Project cost: 1.267.480 Euro, subsidised 1.073.980 Euro.

Partners: Waternet, Imares, Deltares, WUR,
Water Authorities Fryslân, De Dommel and Aa en Maas

Experimental design

- Integral monitoring of SWTP effluent purification at 3 wetlands:
  - Passive samplers: chemical analyses & bioassays
  - Fish biomarkers: DNA microarrays
  - Ecology: survival, growth & reproduction



Some of the wetland topics in Costa Brava

- Inactivation of different fecal indicators
- Interaction between plants and micro-organisms in removal of nutrients
- Characterization of nitrifying bacteria
- Persistence of pathogens (bacteria and viruses)
- Quantative determination of *Clostridium* producing toxins with molecular techniques

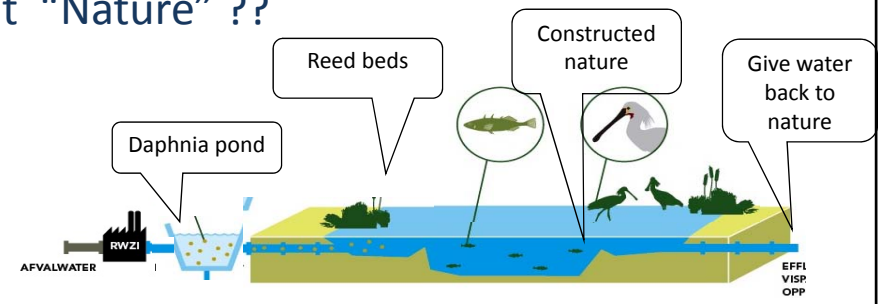
What can we learn from each other

What can we do together: program

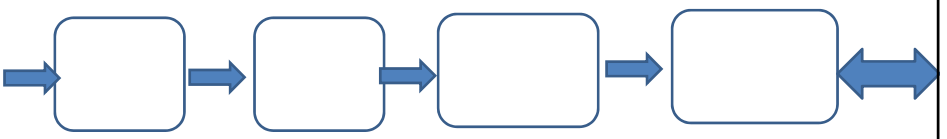
How can we bring the initiatives together in a research program: EU-projects

?

Is it "Nature" ??



Or a process??



Daphnia reactor
Biological filtration

Algae reactor for nutrient storage

Free flow wetland as phototrophic biofilm reactor

Fish spawning area to meet EU biodiversity criteria

Discussion

- Everstekoog: old results
- Snails Horstermeer
- "Moeraszuiver afvalwater": Upgrading Treated Wastewater in Constructed Wetlands

Everstekoog: old results

return

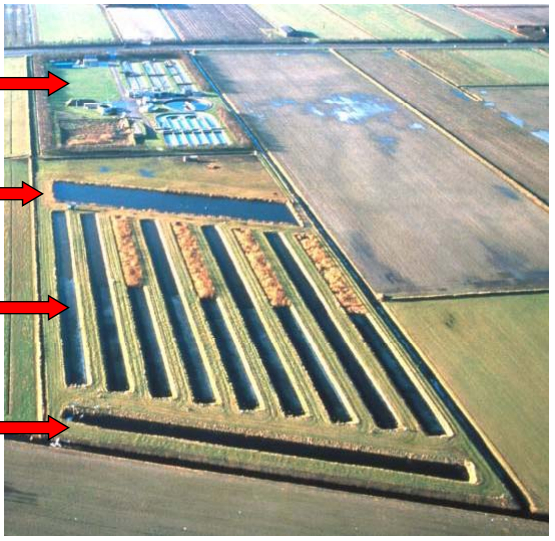
Everstekoog, Texel

sewage treatment plant

presettling basin

9 parallel ditches with reed/cattail and aquatic plants

discharge ditch

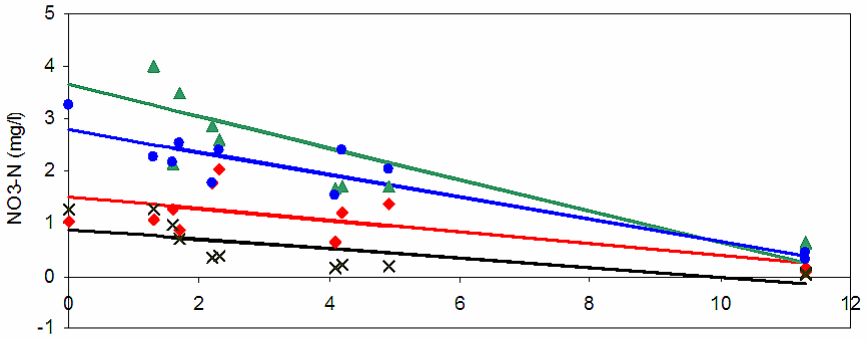


Research project
1995 - 1999

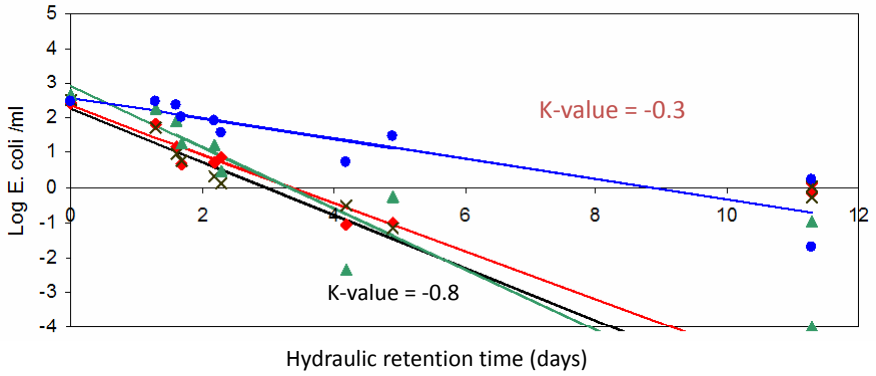
Stowa rapporten

www.waterharmonica.nl

Nitrate (mg/l) vs retention time



Log E.Coli (per ml) vs retention time



Spring Summer Autumn Winter

After constructed wetland different water

- Natural oxygen regime

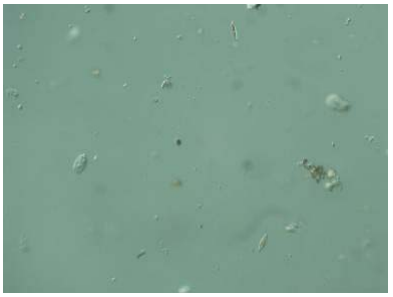
No odour

Less sludge particles lead to desinfection

More, but different suspended solids

Living water:

algae, daphnia
all kind of “waterlife”
fish
birds

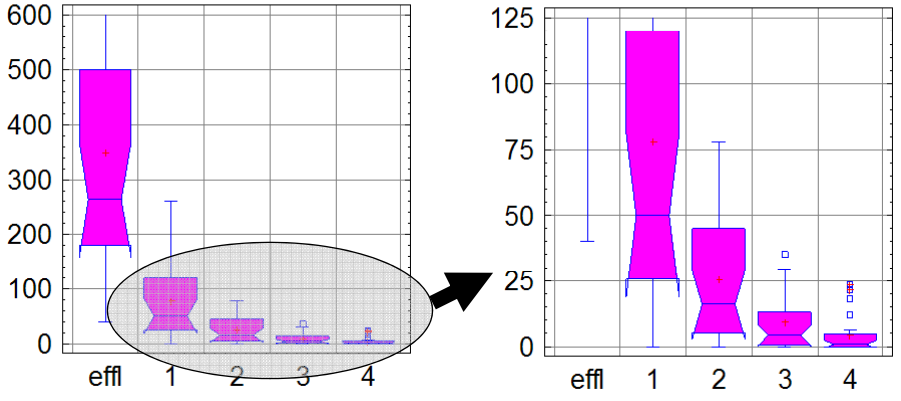


Experiments Everstekoog, Texel

1998 - 2006

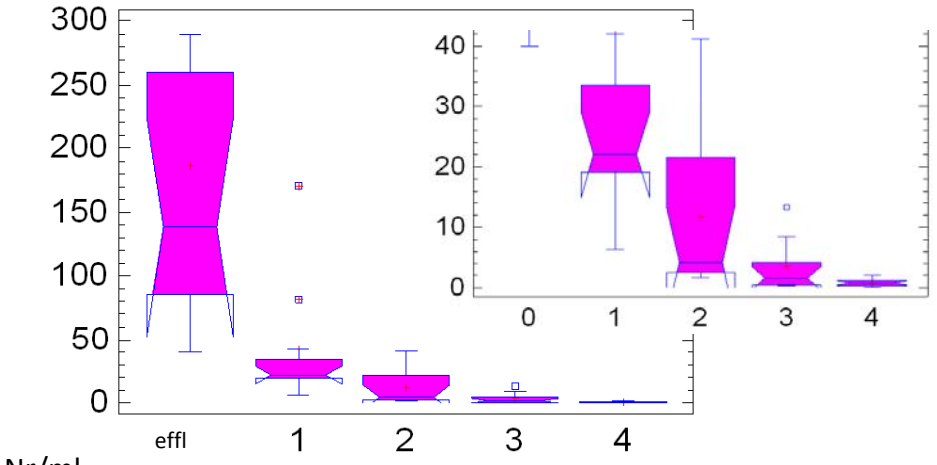
Fecal Coli removal

mesocosms 2003-2004



Nr of fecal coli/ml vs hydraulic retention time

Fecal Coli Winter 2004 - 2005



Nr/ml

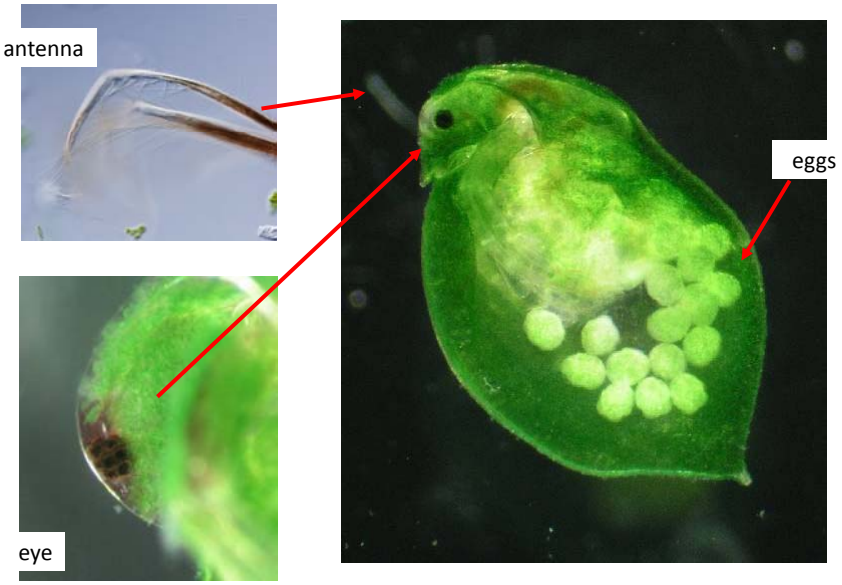
pond nr.

October 2004 – March 2005

Average water temperature 9 ‘C

28 – 2 – 2006

winter Daphnia magna, overgrown with algae, temp +2ºC



Ecotox effluents

- Growth of algae inhibited
- Daphnia
- New test method!

Toxicity effluents normally no problem for growing biomass on wastewater

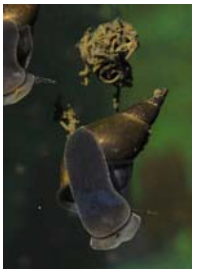
But:

do not overload your STP

stay alert and use the test method

Snails Horstermeer

return



Not only Daphnia:

Suspended solids and algae:

- *biological filtration by Daphnia*
  - *mainly Daphnia magna, but also other Cladocera*

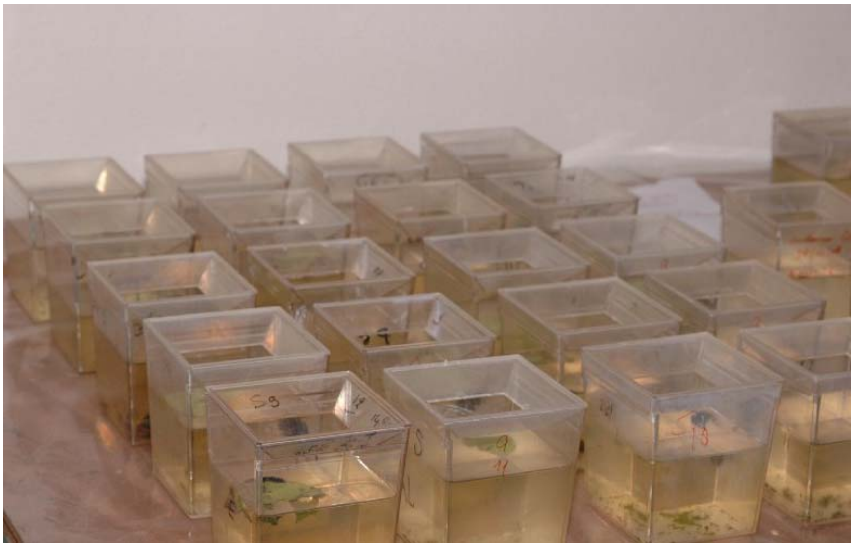
Attached algae and settled sludge:

- *grazing by snails*
  - *Holland: mainly Great pond snail Lymnaea stagnalis*

www.waterharmonica.nl

Mesocosms Horstermeer, autumn 2007

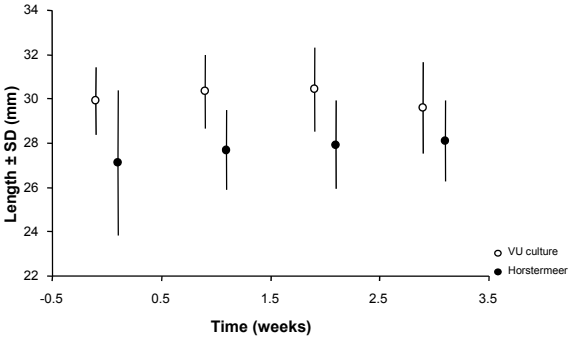
Snail experiments VU



Internship Mukete Beckline
Standard method Vrije Iuniversiteit, Amsterdam
Koene, J.M. and Ter Maat, A., (2004). Energy budgets in the simultaneous hermaphroditic pond snail, Lymnaea stagnalis, a trade-off between growth and reproduction during development. Belgian Journal of Zoology134:41-45

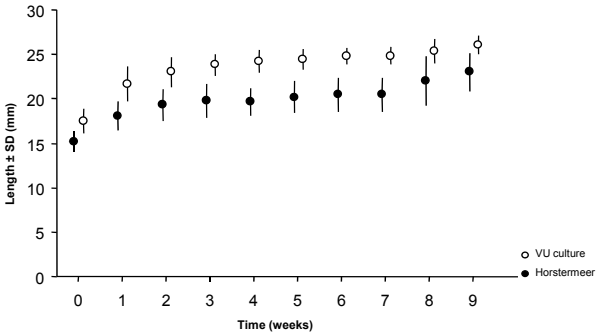
Feeding lettuce

What is the growth response of adult Horstermeer Snails under VU lab conditions ?



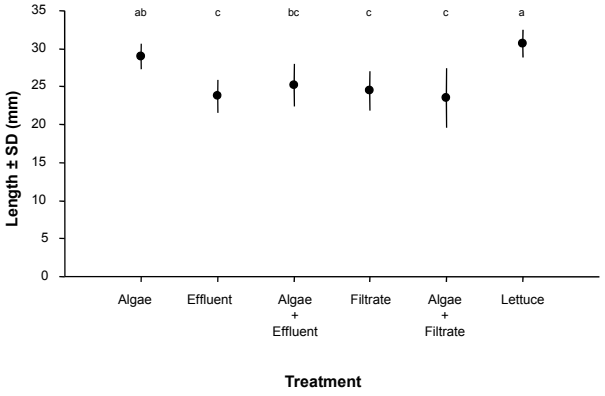
- *No difference in growth pattern and behavior.*
- *Steady growth week 1 to 3 then levels off*

What is the growth response of juvenile Horstermeer snails under VU lab conditions?

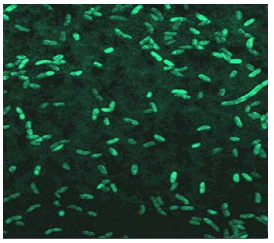


- *No difference in growth patterns,*
- *But VU juveniles start a bit higher because bit larger*
- *VU juveniles have a steeper growth curve and level off later*

How do young snails respond to and grow on different food sources

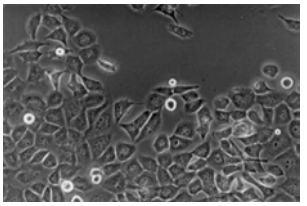


Toxicity Identification Evaluation of Horstermeer Effluent



Samuel Ayesu

Supervisors:
Kees Van Gestel
Joris Koene
Ruud Kampf



Method

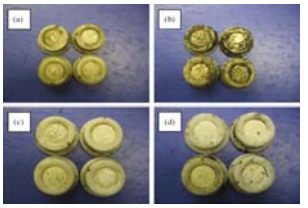
Experiment 1

In situ extraction of chemicals in effluents for 4 weeks with:

- SPMD (non polar organic compounds)
- POCIS (polar organic compounds)
  - Pesticides
  - Pharmaceuticals
- DGT (metals)

Deployment of sampling devices in:

* STP at beginning
* STP at end
* snail culture (control)

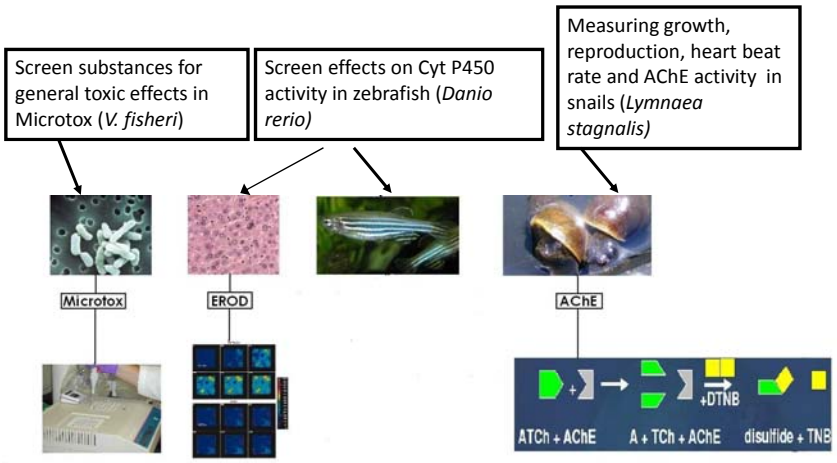


Toxicity test

Endpoints: acute and chronic bioassays

- **Snail (*L. stagnalis)* AChE assay**
  - heartbeat rate, growth, reproduction and AChE
- **Microtox assay**
  - *V. fisheri* (luminescent bacteria)
- **H4IIE assay (EROD)**
  - H4IIE rat liver hepatoma or fish liver cells

Method



“Moeraszuiver afvalwater”

Upgrading Treated Wastewater in Constructed Wetlands

Senter Novem Project

Project cost: 1.267.480 Euro, subsidised 1.073.980 Euro.

Partners: Waternet, Imares, Deltares, WUR,
Water Authorities Fryslân, De Dommel and Aa en Maas

Research questions

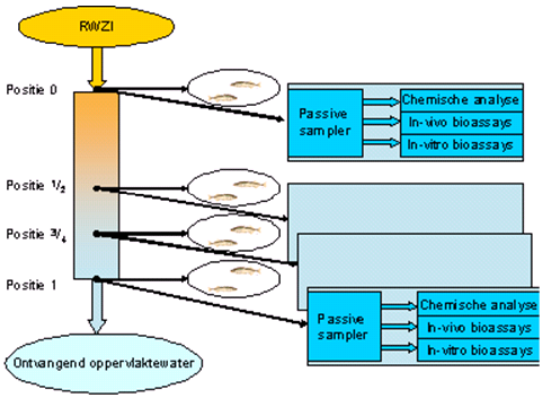
- What are the risks and effects of (unknown) organic substances in treated wastewater?
- Which wetlands compartments are most efficient in removing emerging substances and pathogens?
- Which integral monitoring strategy is most feasible to measure the impact of wetlands purification on aquatic toxicology?

Objectives & delivarables

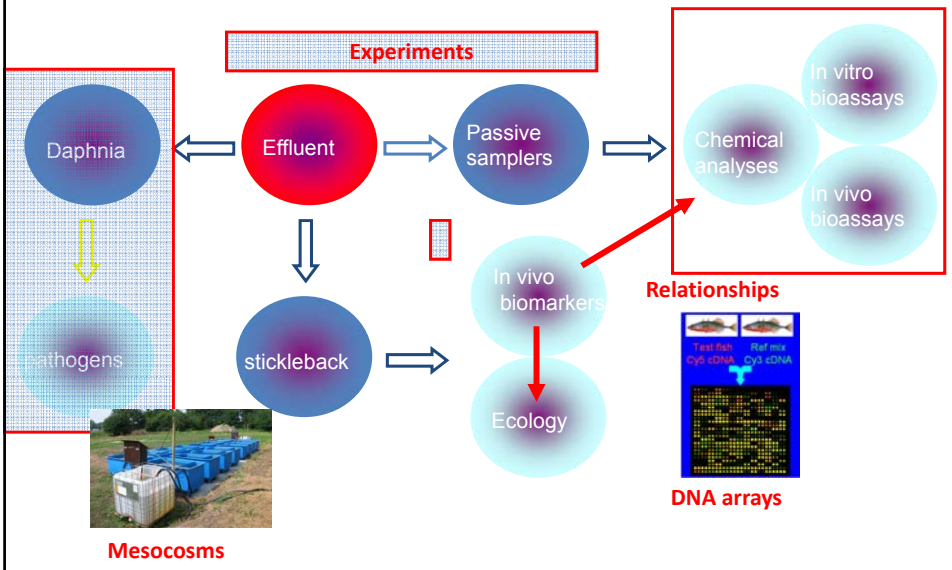
- Guidelines for an optimal design of wetlands for purification regarding emerging substances and pathogens
- Design of an integral monitoring strategy for environmental risk assessment of treated wastewater effluents
- Improvement of both chemical and ecological status of the receiving surface waters

Experimental design

- Integral monitoring of SWTP effluent purification at 3 wetlands:
  - Passive samplers: chemical analyses & bioassays
  - Fish biomarkers: DNA microarrays
  - Ecology: survival, growth & reproduction



Integral TRIADE monitoring



return

Me,

running away

from ecotox?

??