Evolution of Shannon entropy in a fish system (European seabass, *Dicentrarchus labrax*) during exposure to sodium selenite (Na_2SeO_3)

Harkaitz Eguiraun[1*] and Iciar Martinez[1,2,3]

[1]Research Center for Experimental Marine Biology and Biotech. (PIE), University of the Basque Country UPV/EHU, Spain
[2] IKERBASQUE Basque Foundation for Science, Bilbao, Spain
[3] NFH, University of Tromsø, Tromsø, Norway
*
harkaitz.eguiraun@ehu.eus
*

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The Aim

Non invasive

Biological Warning System

Monitor fish welfare

Pollutants & other stressors

Biochemical & Physiological Processes

Behaviour

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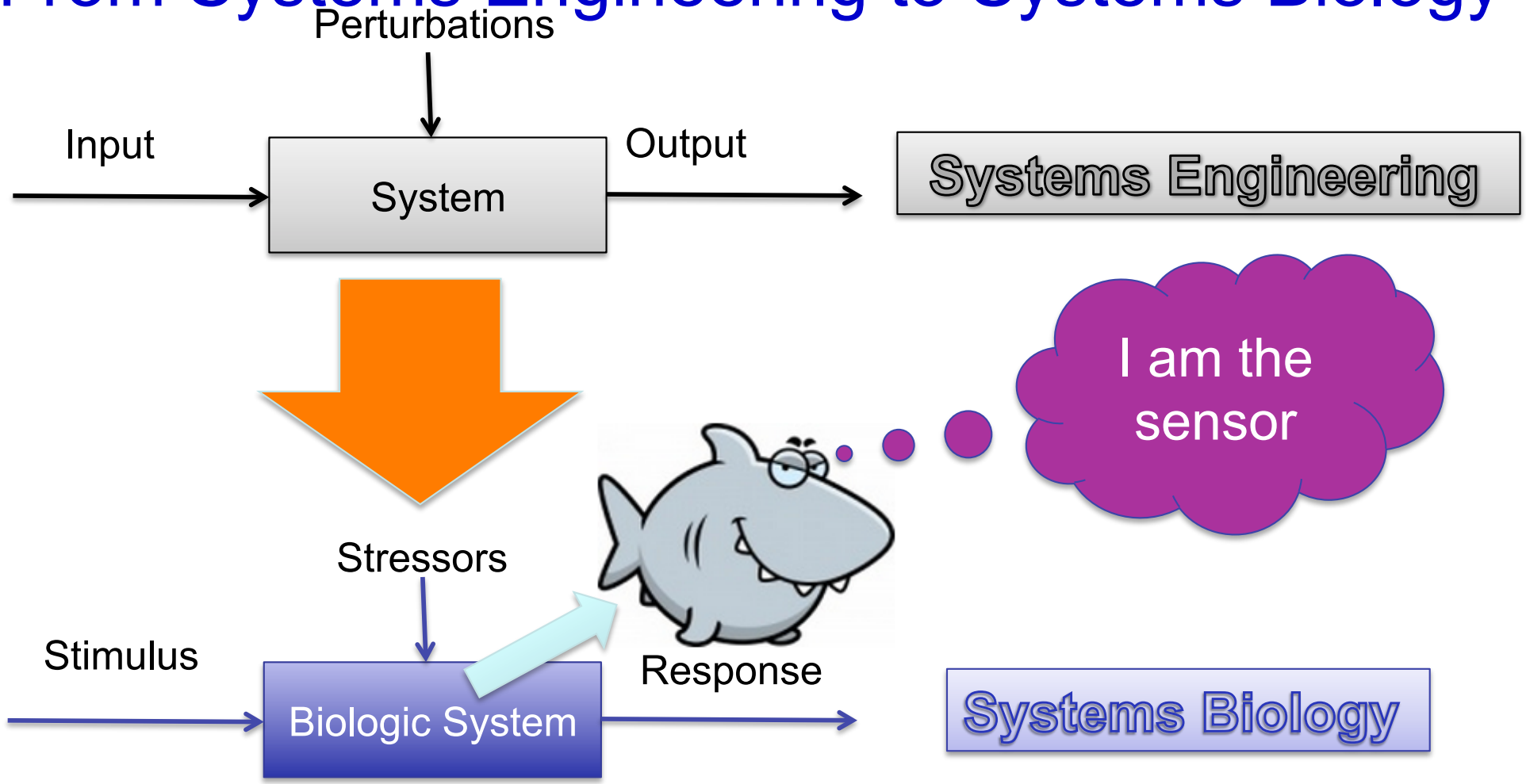
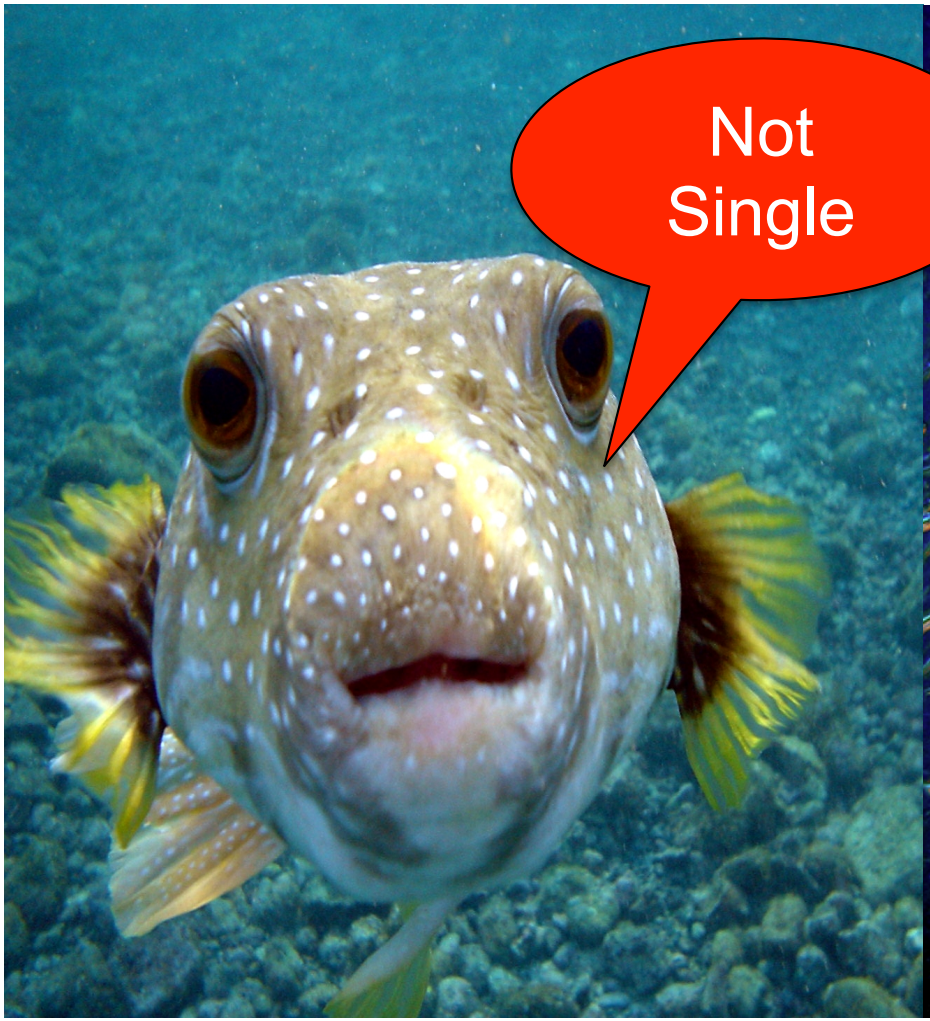
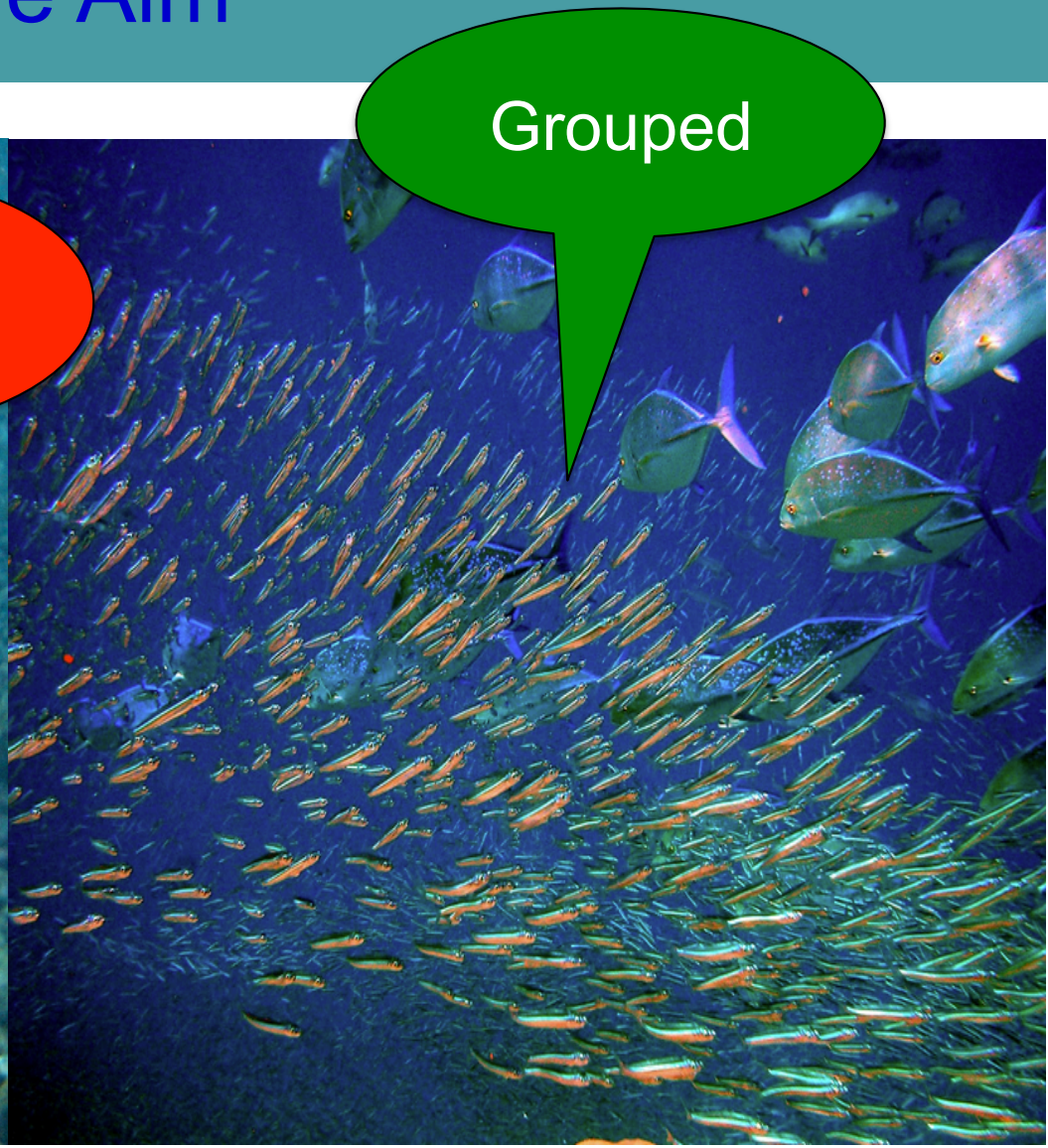
The Aim

- From Systems Engineering to Systems Biology



The Aim





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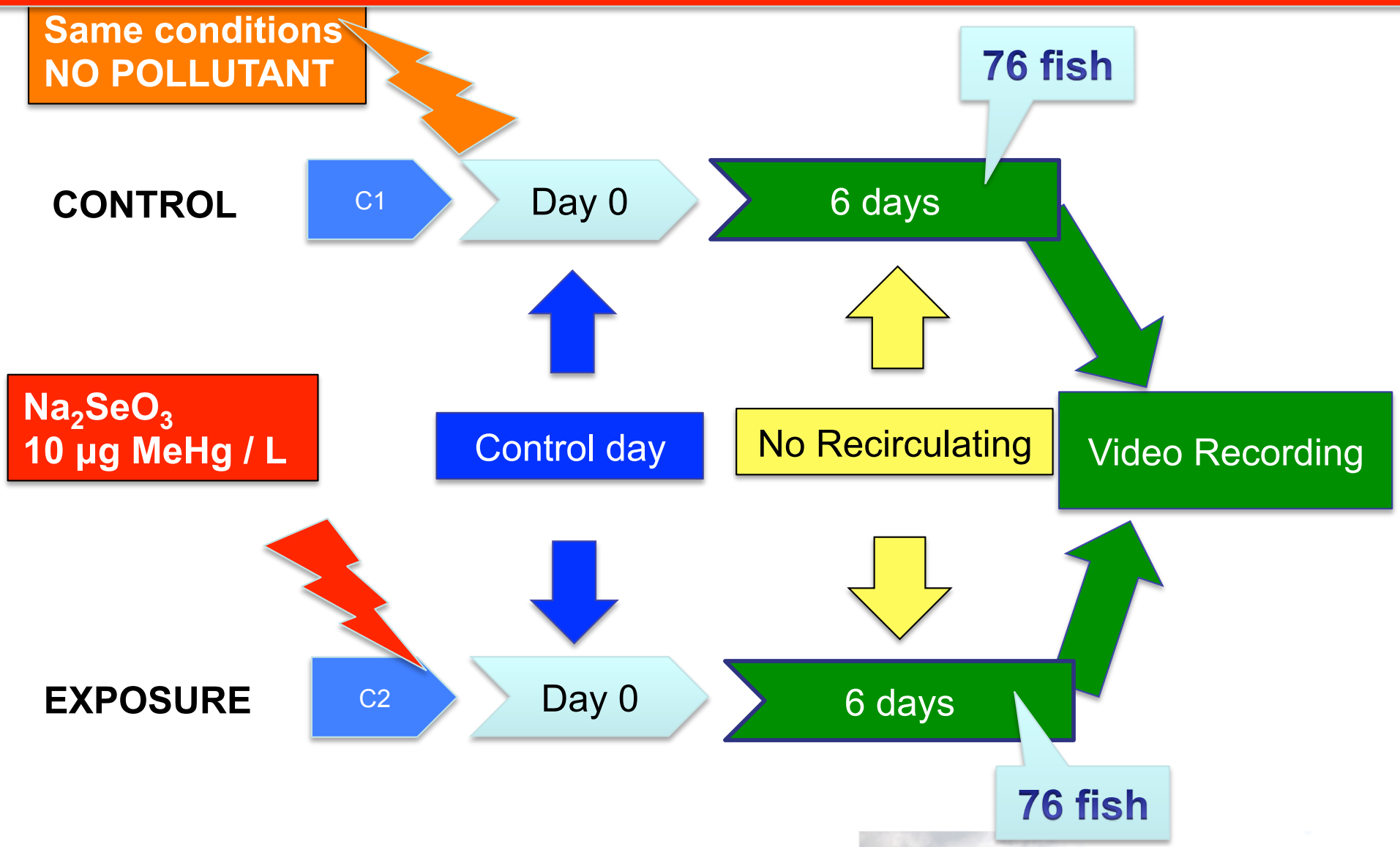
The Experimental Setup



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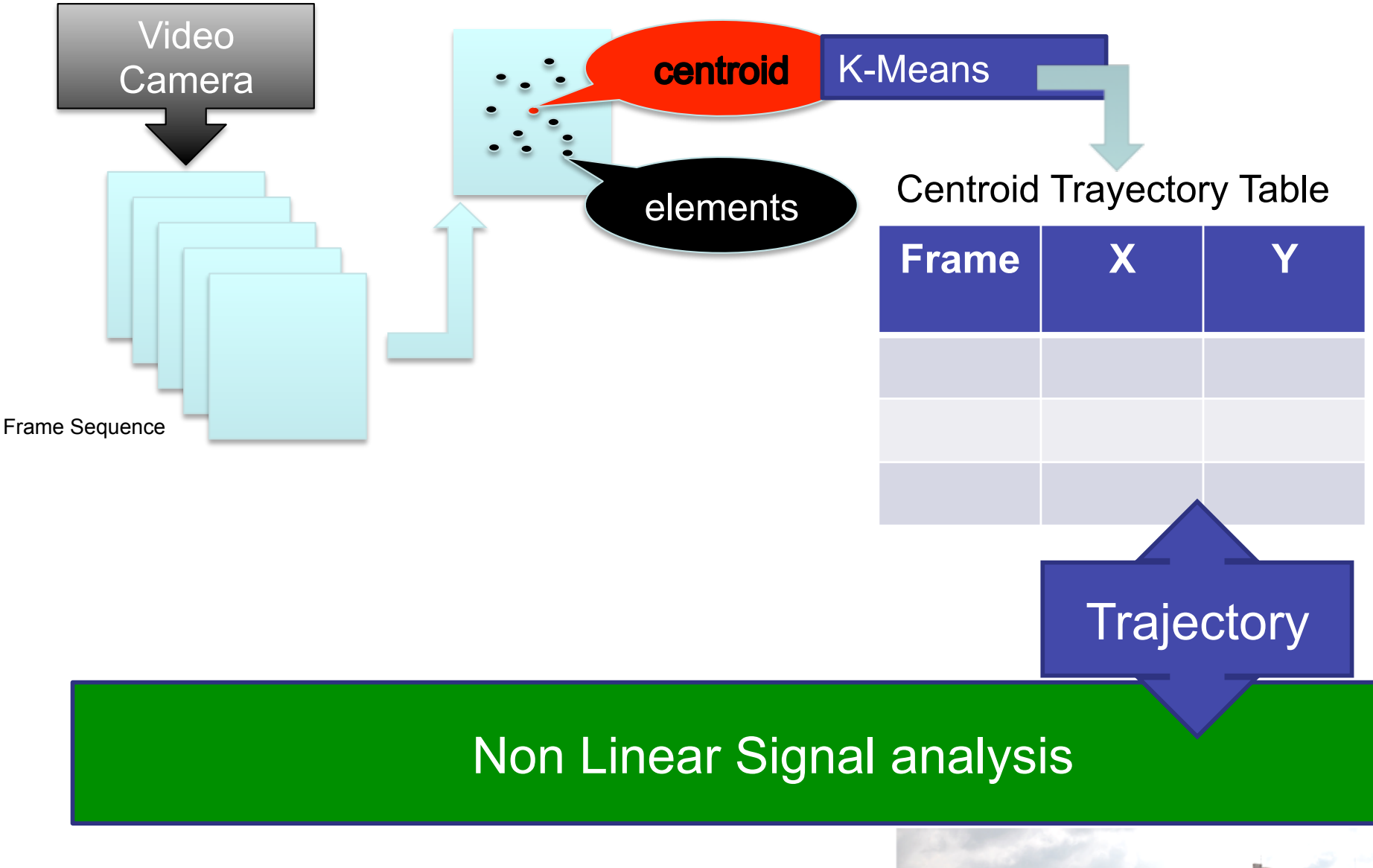

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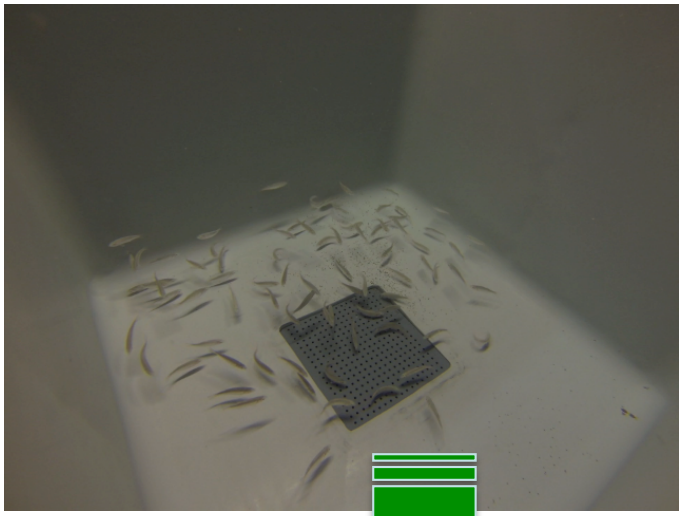
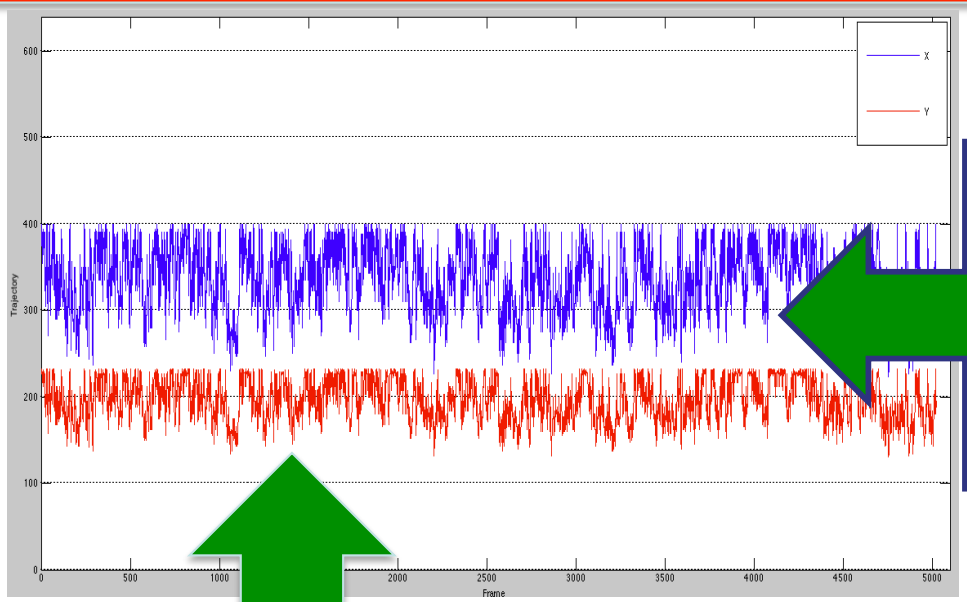
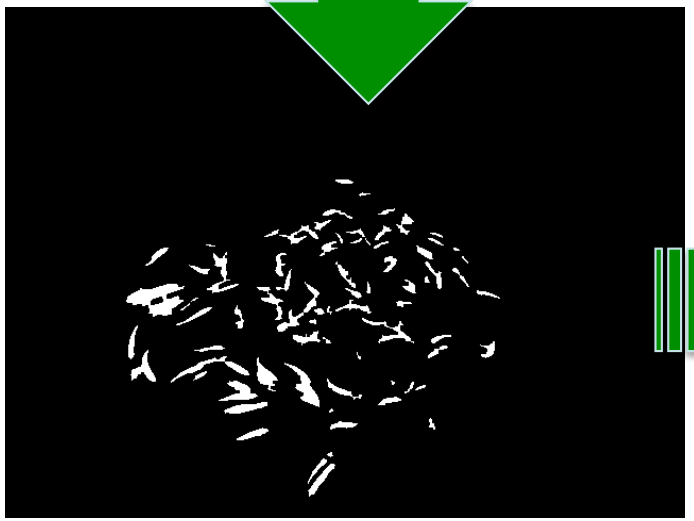
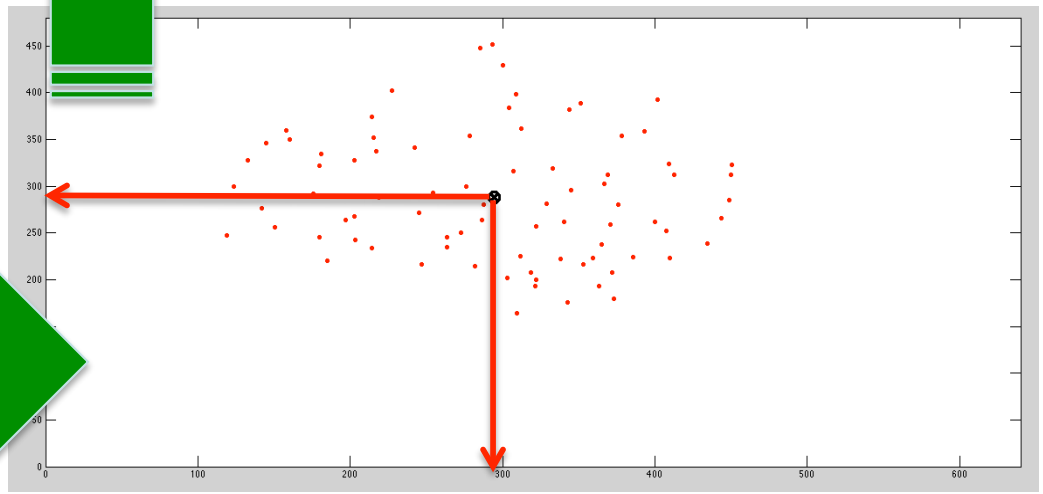




Non Linear Signal analysis





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The Experimental Setup

Trajectory analysis

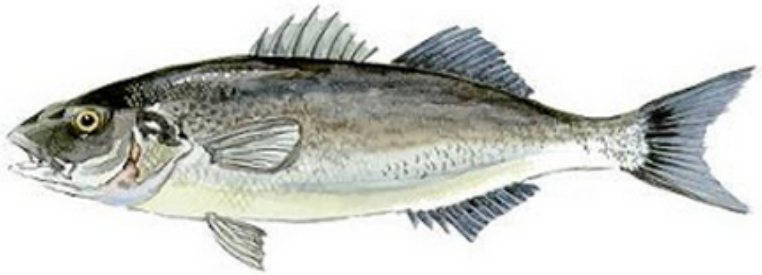
- Fractal dimension (3 window lenghts: 320, 640, 1280)
  - ✓ Higuchi
  - ✓ Katz
  - ✓ Katz Variation proposed by Castiglioni
- Entropy
  - ✓ Shannon
  - ✓ Sample
  - ✓ Multiscale
  - ✓ Permutation
  - ✓ Multiscale Permutation
  - ✓ Modified Multiscale
  - ✓ Normalized Modified Multiscale

Results shown for Shannon entropy

The Experimental Setup

Experimental Conditions

- ✓ European Sea bass (*dicentrarchus labrax*) -> avg 8 cm & 4 g → Widely used in South Europe aquaculture
- ✓ Tanks -> 100 x 100 x 90 cm fibreglass -> 810 l
- ✓ No recirculating water flow
- ✓ Food provided depending on the biomass (NO *Ad líbitum*)
- ✓ 12h/12h photoperiod
- ✓ Environmental variables monitored:
  - O_2 saturation > 80%
  - pH
  - Temperature
  - Ammonium
  - Salinity



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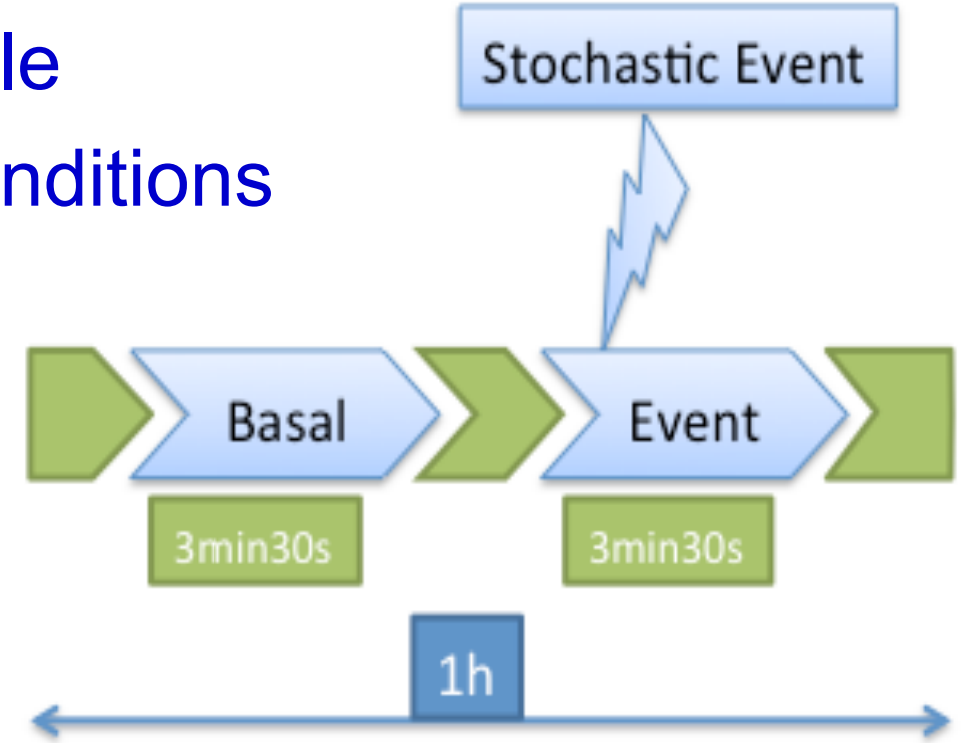
The Experimental Setup

- Video Recording
  - ✓Underwater
  - ✓Same visual angle
  - ✓Same lighting conditions



Results

- Per day

High turbidity

High turbidity

Day	C_1					C_2
	Basal	Basal	Basal	Average Basal	Event	Event
0	5.3707	5.3300	5.4184	5.3697±0.0492	5.6393	5.0132
1	4.6969	4.4265	4.6291	4.5842±0.1407	4.7242	5.1670
2	4.3904	4.0520	4.5787	4.3403±0.2669	5.0367	4.7467
3*	4.9046	4.7100	4.5365	4.7170±0.1842	6.2145	4.7868
4*	4.8874	4.8016	4.7104	4.7998±0.0885	6.0924	5.8601
5	4.6227	4.6259	4.5987	4.6158±0.0149	5.1643	5.2968
6	4.1976	4.0003	4.0387	4.0789±0.1046	4.3488	4.7703

* → water change days

- Summary

		Shannon Entropy
C_1	Basal	4.5227±0.0905
	Event	5.2635±0.7457
C_2	Event	5.1046±0.4365

Conclusions

- Event response higher Shannon entropy values than Basal state
- Selenium Selenite presents NO measurable effect of the fish using this methodology
- “Behaviour” is MEASURABLE
- Limitations of the study regarding image vision mainly during turbidity → this work is a 0.0 version

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Future work

- Improve the Version 0.0
  - ✓Better underwater image acquisition
    - Sonar, Acoustic telemetry, Hiperspectral image, Light beams
  - ✓Develop an online monitoring app
  - ✓Stereo image
- Analyse other stressors´ effect, i.e. contaminants
- Longer experiments

Acknowledgements

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Ethical aspects

- The experiment was approved by the Ethical Committee for Animal Welfare No. CEBA/285/2013/MG

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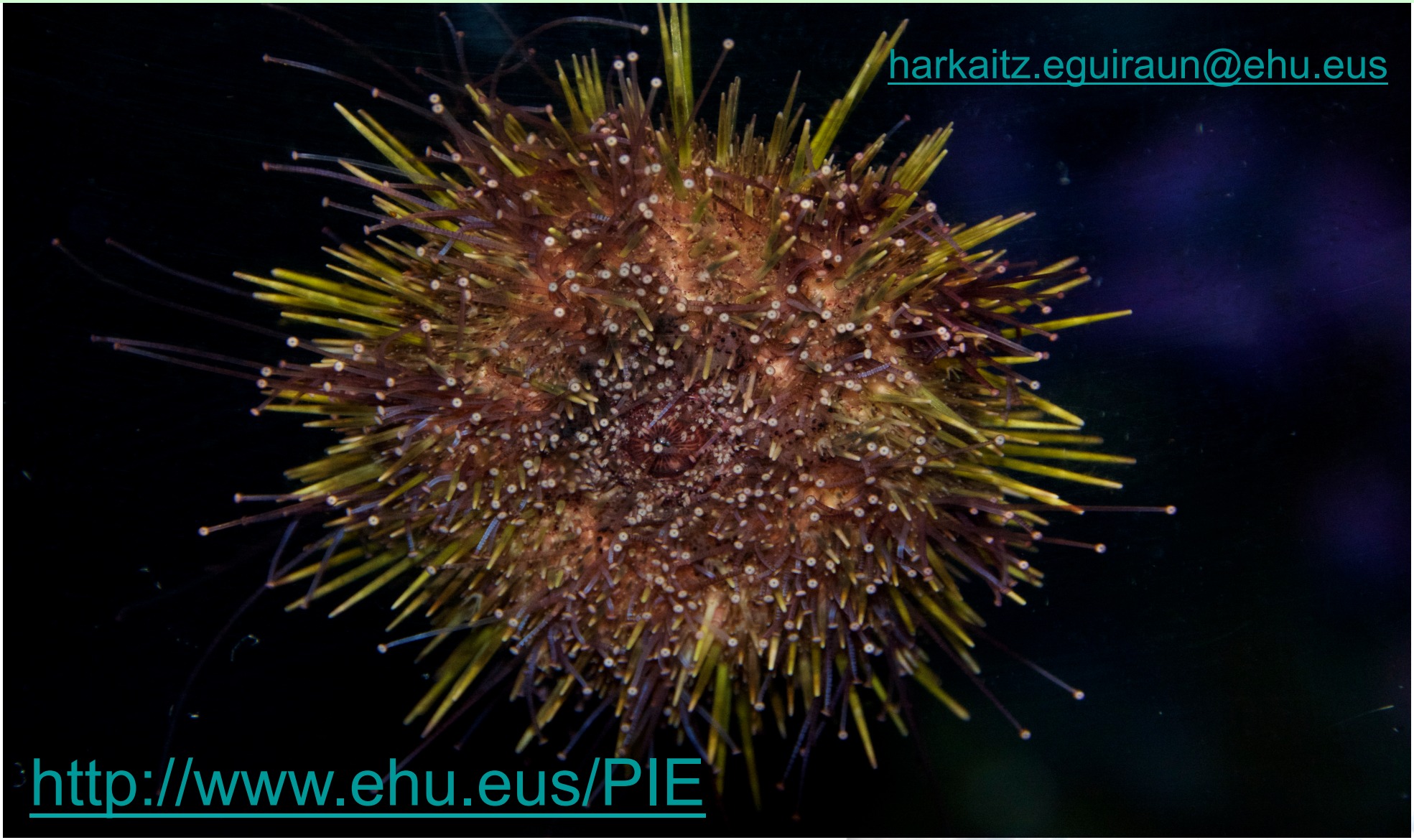
Thanks



harkaitz.eguiraun@ehu.eus

http://www.ehu.eus/PIE

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