# The value of Earth Observation for marine water quality management

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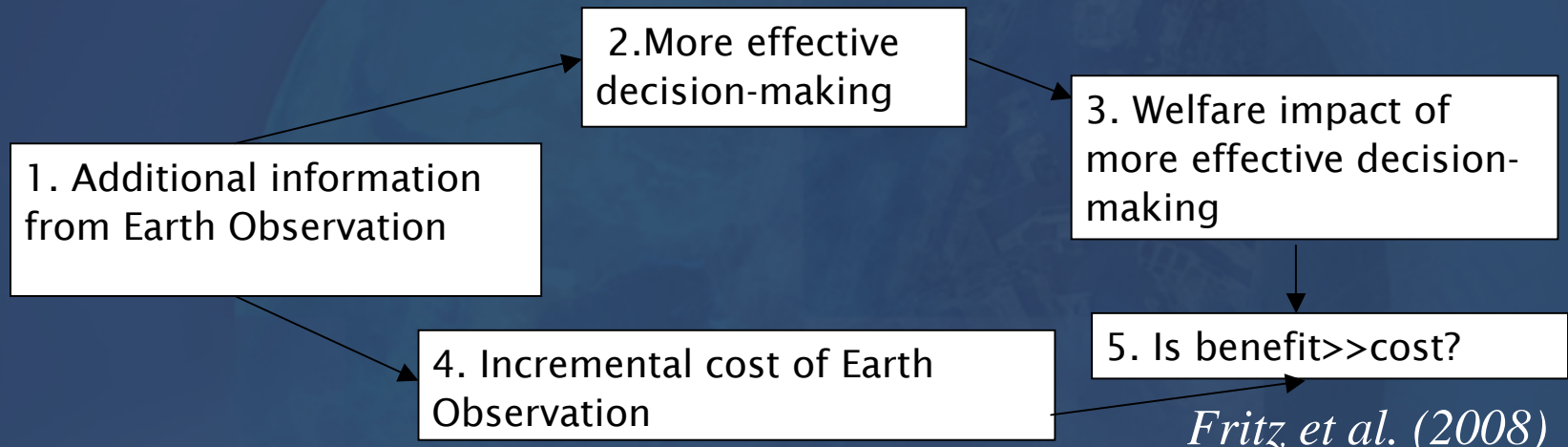
# Introduction

- Tool: Expert elicitation approach (questionnaire) to assess the contribution of EO to decision-making




*Fritz et al. (2008)*

- Two case studies: North Sea and Great Barrier Reef
- North Sea: focus on the prediction of potentially harmful algal blooms.
- Great Barrier Reef: focus on increased spatial and temporal insight in chlorophyll-a and sediment flows

# Background

- The value of information is determined by its impact on the ***expected utility*** of decision making (Hirshleifer and Riley 1979)

| | | States | | |
|---|---|---|---|---|
| | | s=1 | s=2 | Utility of the acts |
| Acts | a=1 | $c_{11}$ | $c_{12}$ | $u_1$ |
| | a=2 | $c_{21}$ | $c_{22}$ | $u_2$ |
| | Beliefs as to the state | $\pi_1$ | $\pi_2$ | |

$$u(a) \equiv \pi_1 v(c_{a1}) + .. + \pi_{aS}(c_{aS}) \equiv \sum_{s=1}^{S} \pi_s v(c_{aS})$$

# Background

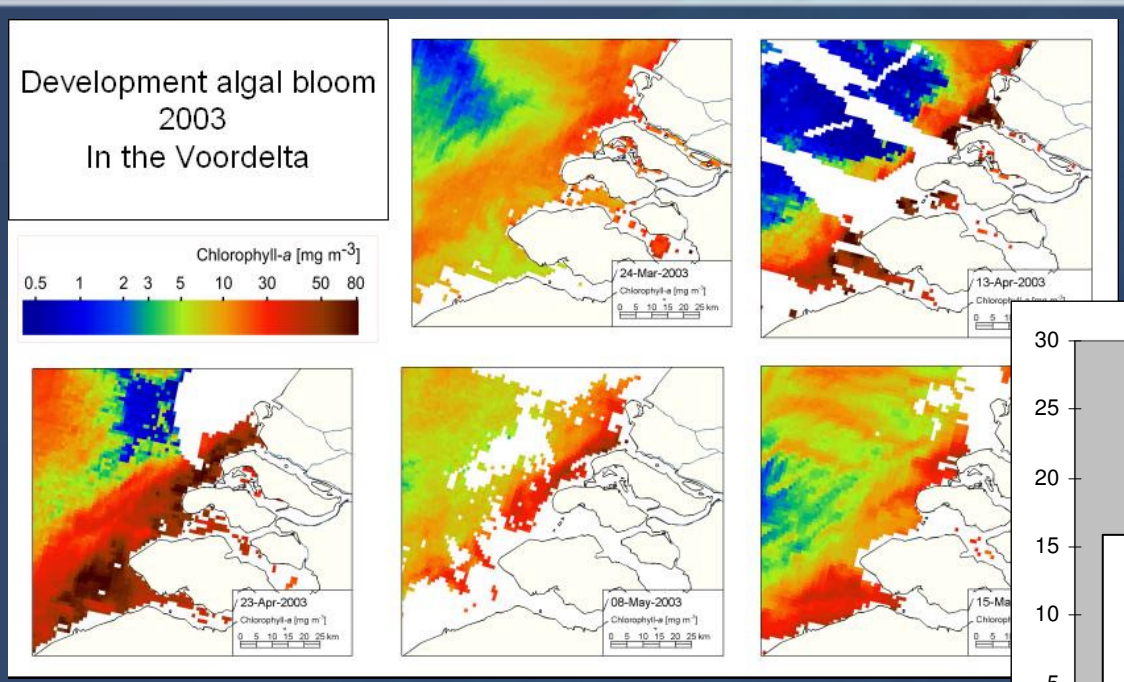
- The value of information is determined by whether the decision-maker updates his beliefs. Bayes' rule:

$$\pi_{s,m} = \Pr(s \mid m) = \frac{\Pr(m \mid s)\Pr(s)}{\Pr(m)} = \frac{q_{m,s}\pi_s}{q_m}$$

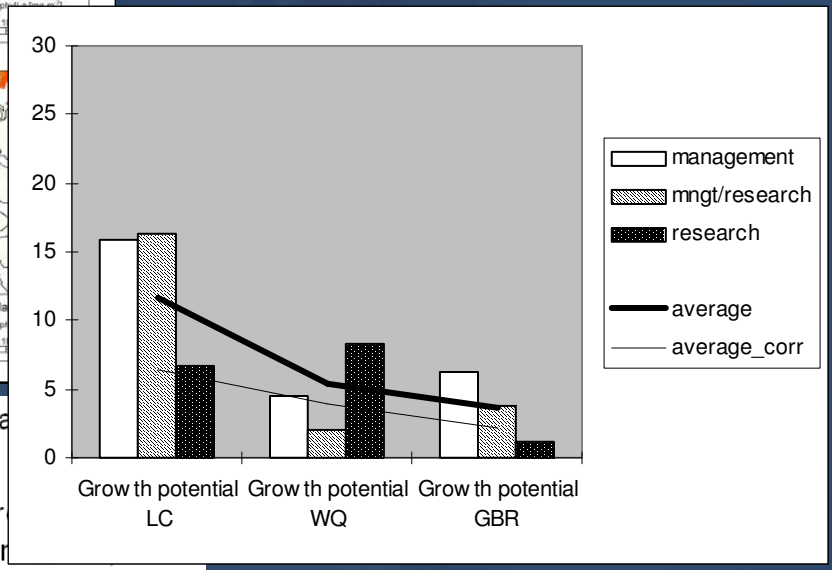
$$q_m = \sum_{s=1}^{S} q_{m,s}\pi_s$$

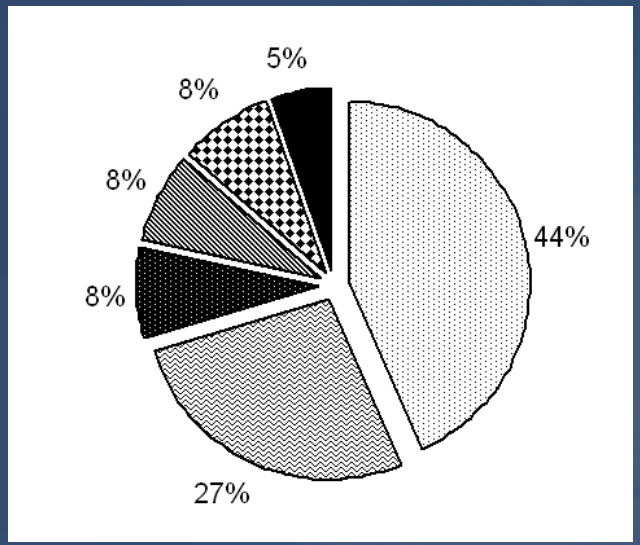
- We require information about Pr (m/s) or the likelihood of the message given state 1 or 2.
- Basically, this is similar to saying we need information about the type 1 and type 2 error of EO information

# Questionnaire




- Respondents: policy makers, water managers, researchers




- Spatial coverage (high spa possibility to monitor large
- Temporal coverage (time r possibility to look at LT trer
- Cost-effectiveness (large area at low costs)
- Visual evidence (confidence in monitoring programs)
- Integrating tool for ecosystem approach
- Rapid assessment/real-time information

- Qualitative and quantitative results: open questions and probabilities

# North Sea

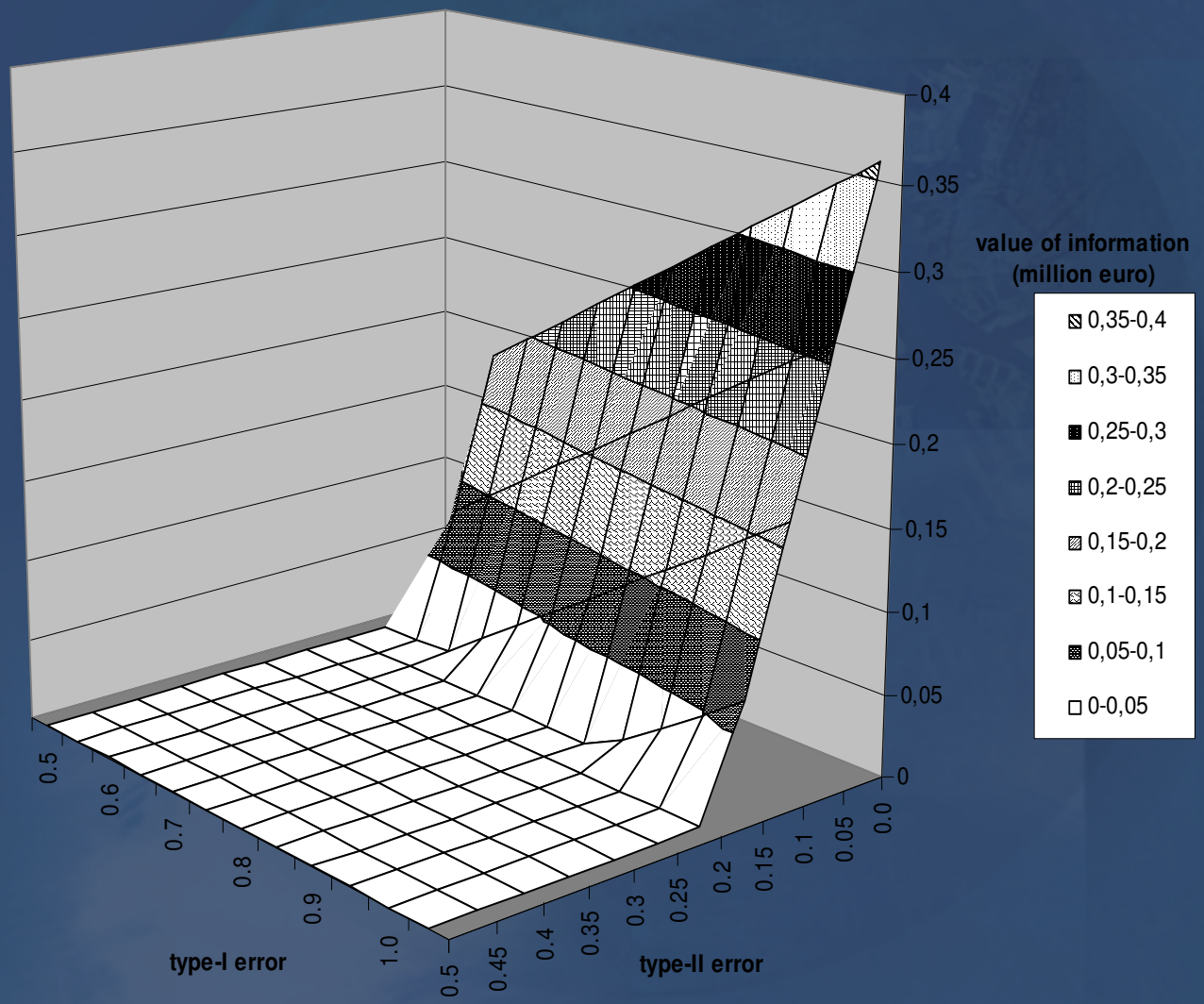
- Welfare impact alternative actions: Move fishing nets (cost: 2 million euro) to avoid economic damages (cost: 20 million euro)

| | Actions (x) (million euro/week) | | | Likelihoods ($q_{m,s}$) | |
|---|---|---|---|---|---|
| States (s) | x1: Move nets | x2: No move | $\pi_s$ | m1: Bloom | m2: No bloom |
| S1: Bloom | -2 | -20 | 2% | 0.75 | 0.25 |
| S2: No bloom | -2 | 0 | 98% | 0.10 | 0.90 |

# North Sea

- Cost of EO information
  - Approx. annual cost of EO information for Dutch marine water quality management (2.5 million euro)
  - Approx.reduction in monitoring costs Dutch marine water quality management (2 million euro)
- Hence..predicting HAB should generate benefit of at least 500.000 euro/year
- Comparison costs and benefits:
  - 95% confidence interval of benefits ranges from 340,000 to 1.030,000 euro/year
  - 75% probability that investment in early warning is welfare enhancing

# North Sea

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# Great Barrier Reef

| | Actions (x) | | Priors |
|---|---|---|---|
| States (s) | $x_1$: Reduce N and sediment in entire catchment | $x_2$: Reduce N and sediment in selected catchments | $\pi_s$ |
| $s_1$: No spatial variability in effectiveness of emission reduction | -1.1 billion USD | -1.3 billion USD | $\pi_1$ |
| $s_2$: Spatial variability in effectiveness of emission reduction | -1.1 billion USD | -0.6 billion USD | $\pi_2$ |

# Great Barrier Reef

The value of EO information (million USD/year)

| $\pi_1$ | Current value | Sensitivity range | Potential value |
|---|---|---|---|
| 0.8 | 21.2 | 4.6- 36.2 | 48 |
| 0.7 | 49.8 | 30.9- 67.3 | 82 |

- Prior beliefs derived from actual decision-making
- Current accuracy estimates on average 66%. Future expected accuracy around 80%
- Cost information not available: but benefit range gives indication of when EO investment is welfare enhancing

# Conclusions

- Use of expert elicitation approach generates valuable insights regarding the perceived value of EO
- Disregarding the (perceived) accuracy of information results in overestimation of benefits..
- … and paying attention to the accuracy of information also helps EO technology developers to do their job
- Assessment of economic benefits depends on a) prior beliefs and b) alternative actions and welfare impacts
- Applications confined to marine water quality, but can be applied to other core areas of EO
- Further research required to fine-tune methodology and pay attention to risk-aversion of decision-makers too

# Thank you!

For further reading please see the conference proceedings and

Bouma, J.A., H.van der Woerd and O.Kuik (2009). 'Assessing the value of information for water quality management in the North Sea', *Journal of Environmental Management* 90 (2): 1280-1288

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