MARINE RESEARCH CENTRE

Fisheries and Optimal Eutrophication Management: A Bayesian Approach

"Pragmatic Approach for Cost-Effectiveness and Cost-Benefit Analyses for the Marine Strategy Framework Directive"

Soile Oinonen, Heikki Peltonen, Outi Heikinheimo, Laura Uusitalo & Marko Lindroos

The Seventeenth International Conference of the International Institute of Fisheries Economics & Trade (IIFET)

Towards Ecosystem Based Management of Fisheries:

What Role can Economics Play

Queensland University of Technology (QUT), Brisbane, Australia

7-11 July 2014

SYKE

Outline

- Introduction to the Marine Strategy Framework Directive (MSFD)
  - Good Environmental Status (GES) & 11 descriptors
  - Economic analyses of the management measures
- Introduction to Bayesian Nets
- Step-by-step approach for CEA & CBA using Bayesian Nets
- Eutrophication & biomanipulation

Marine Strategy Framework Directive (MSFD)

- Objective: Good Environmental Status (GES) by 2020
  - Initial Assessment
  - Monitoring Programme
  - Programmes of measures

http://ec.europa.eu/environment/marine/eu-coast-and-marine-policy/marine-strategy-framework-directive/index_en.htm

- 11 GES descriptors
  - Biodiversity, non-indigenous species, food webs, commercial fish, eutrophication, sea floor integrity, hydrographical conditions, contaminants, contaminants in seafood, marine litter, energy including underwater noise

MARINE RESEARCH CENTRE

Economic analyses of the programmes of measures

- ”…Member States shall give due consideration to sustainable development and in particular, to the social and economic impacts of the measures envisaged…ensure that measures are cost-effective and technically feasible, and shall carry out impact assessments including cost-benefit analysis, prior to the introduction of any new measure.”
  - Member states do not have such tools (marine ecosystem model coupled with an economic model) that would allow cost-effectiveness analysis with respect to 11 GES descriptors
  - ➢ Pragmatic approach that is able to handle quantitative and qualitative data and expert knowledge needed
    - ➢ **Bayesian Net**

SYKE

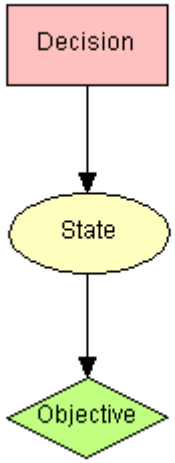
Development of programmes of measures in Finland

- Gap analysis: how far towards GES we can get with the present set of management measures?
- Propose new management measures and analyse their cost-effectiveness
- Separate working groups develop a list of new management measure for each descriptor
- Working group of economists run the CEA&CBA
  - Quantitative information on the impact of the measures needed
    - Existing models only for one descriptor (eutrophication)
  - Estimate on costs (financial + econonomic costs) needed

MARINE RESEARCH CENTRE

Bayesian Net

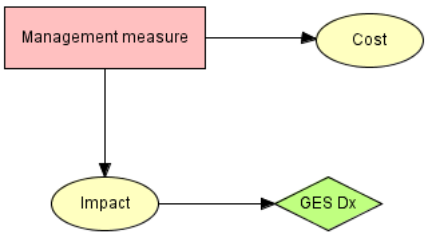
- Graphically presented mathematical models
- Directed acyclic graph denoting (in)depependencies between the model variable's
- Conditional probability tables denoting the strenght of the links between the variables
- Optimisation possible using decison variables and objective functions

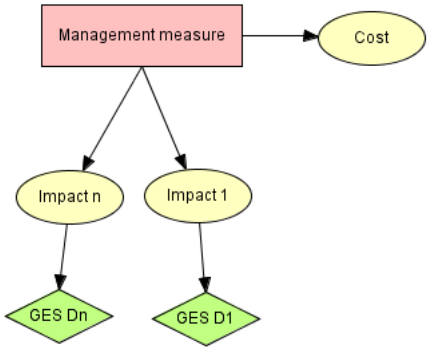


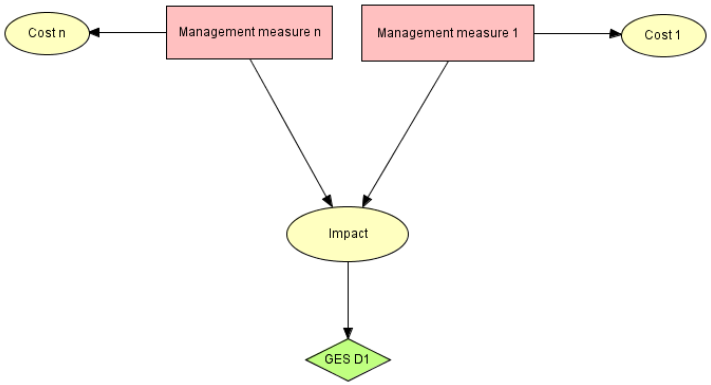
SYKE

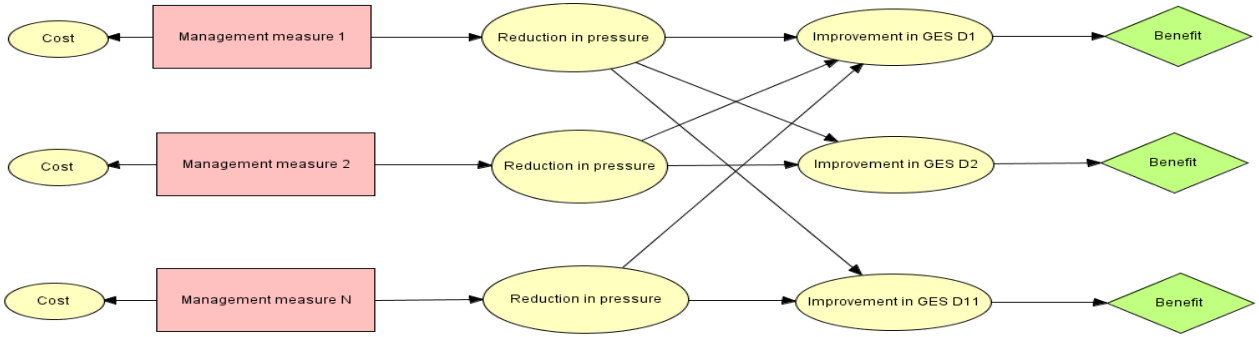
Step by step approach for CEA & CBA using BN

1. 1 measure & 1 descriptor
2. 1 measure & all descriptors
3. All measures & 1 descriptor
4. Full CEA&CBA









Data collection: Effectiveness of a management measure

Impact	Probability										
	D1 Biodiversity	D2 Non-indigenous species	D3 Commercial fish & shellfish	D4 Food webs	D5 Eutrophication	D6 Sea-floor integrity	D7 Hydrographic conditions	D8 Contaminants	D9 Contaminants in seafood	D10 Marine Litter	D11 Energy including underwater noise
No impact	0.1428571		0.2	0	0						
Closes <10 % of the gap	0.1428571		0.8	1	0.05						
Closes 10-25 % of the gap	0.1428571		0	0	0.2						
Closes 25-50 % of the gap	0.1428571		0	0	0.5						
Closes 50-75 % of the gap	0.1428571		0	0	0.15						
Closes 75-100 % of the gap	0.1428571		0	0	0.1						
Good Environmental Status	0.1428571		0	0	0						
Sum of probabilites (=1)	1	0	1	1	1	0	0	0	0	0	0

Impact: probability of closing the gap between the present state and the GES

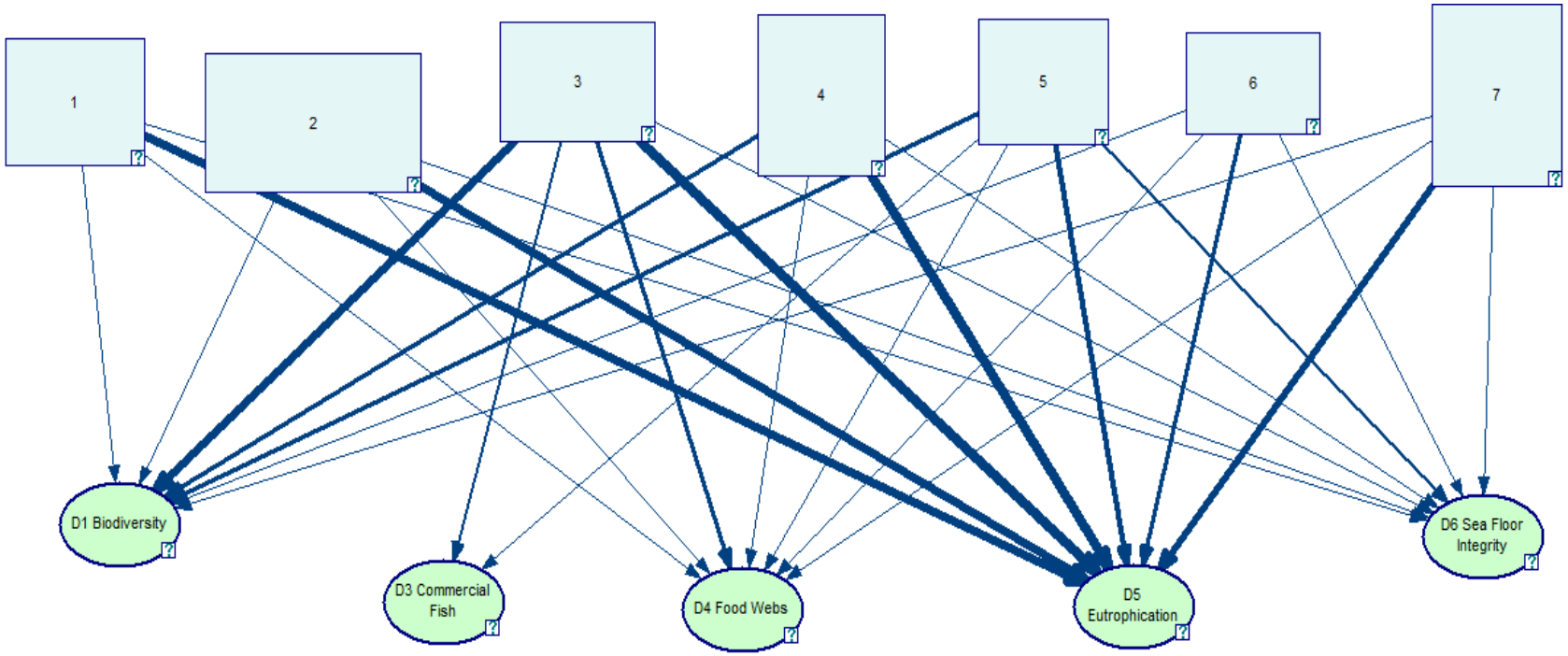
- Models, literature, expert opinion: probability is the common language

Combining expert judgements

- Expected value of the expert's view
- Commonly agreed distribution between a group of experts
- Experts provide their opinion for each measure separately
  - Measures impact is independent
    - Interaction using a modelling technique available in the BN sofwares (Noisy-Max-gate)

MARINE RESEARCH CENTRE

Effectiveness analysis



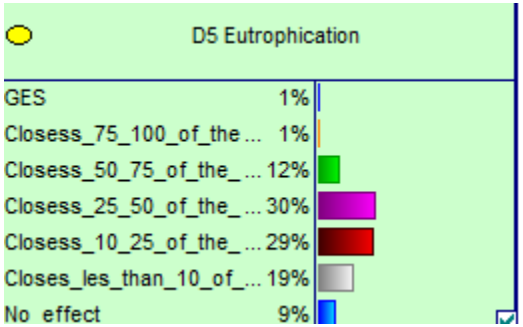
Strength of influence of 7 measures on 5 GES descriptors using GeNIe software

SYKE

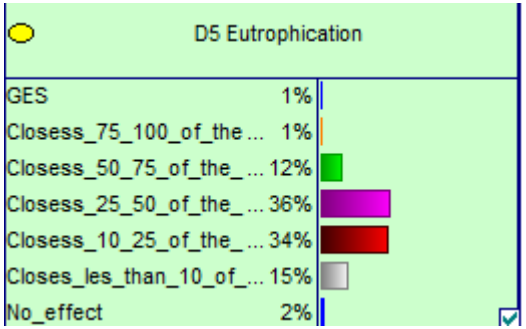
MARINE RESEARCH CENTRE

Effectiveness analysis

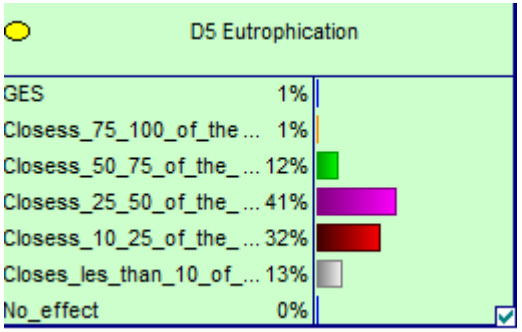
Measure 1



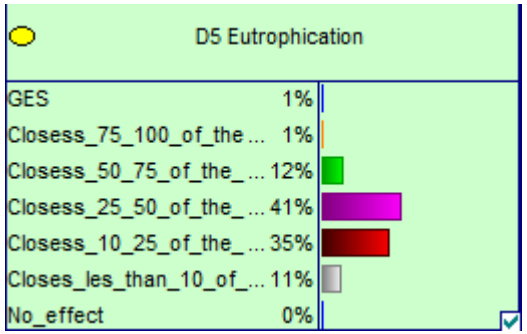
Measures 1+2



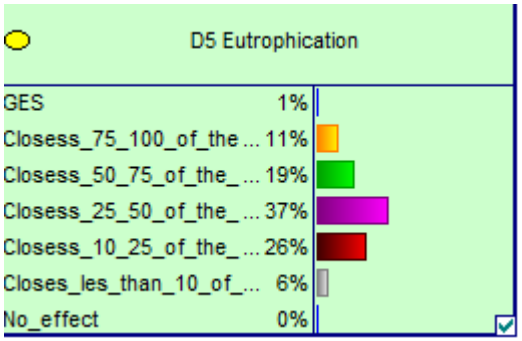
Measures 1+2+3



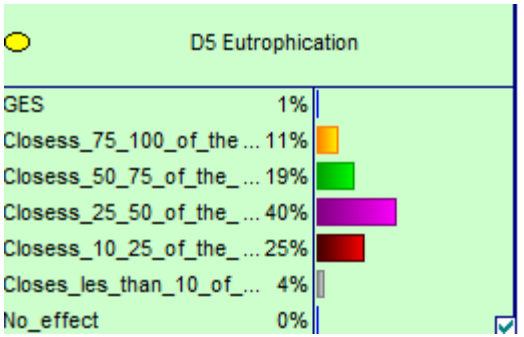
Measures 1+2+3+4



Measures 1+2+3+4+5



Measures 1+2+3+4+5+7



SYKE

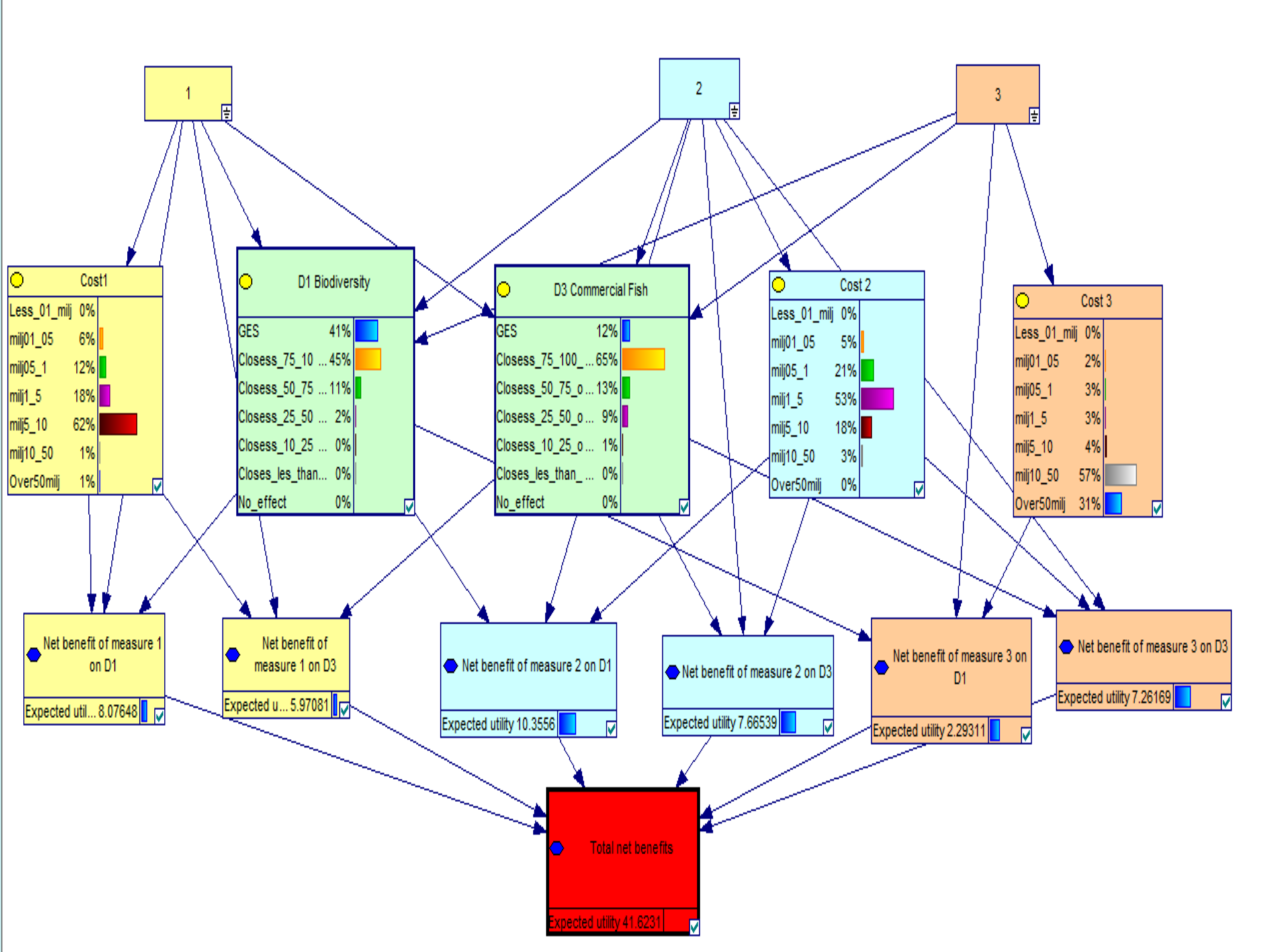
Data collection: costs of management measures?

Total costs of the management measure in years 2016-2021	Probabillity
< 0,1 milj. €	0
0,1 - 0,5 milj. €	0.2
0,5 - 1 milj. €	0.2
1 -5 milj. €	0.3
5 -10 milj. €	0.3
10 - 50 milj. €	0
> 50 milj. €	0
Sum of probabilities =1	1

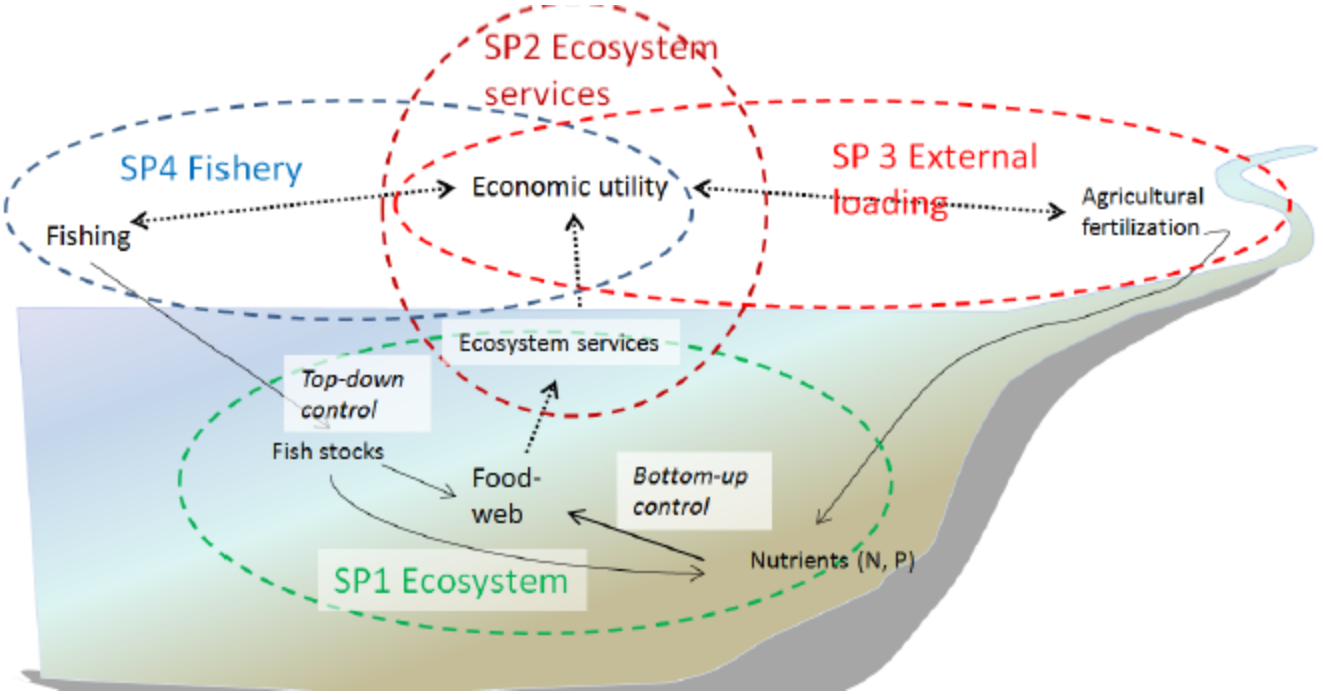
Good Environmental Status: scoring system (Society's utility function)

- Defining objective function/scoring system faciliates analysis
  - Expected utility of a set of management measures
- How to specify?
  - Use of non-market valuation studies?

Impact	Score
no impact	0
closes less than 10% of the gap	3,125
closes 10-20% of the gap	6,25
closes 20-50% of the gap	12,5
closes 50-80% of the gap	25
closes 80-100% of the gap	50
Good Environmental Status	100


1
2
3
Cost1
Less_01_milj 0%
milj01_05 6%
milj05_1 12%
milj1_5 18%
milj5_10 62%
milj10_50 1%
Over50milj 1%
D1 Biodiversity
GES 41%
Closess_75_10 ... 45%
Closess_50_75 ... 11%
Closess_25_50 ... 2%
Closess_10_25 ... 0%
Closes_les_than... 0%
No_effect 0%
D3 Commercial Fish
GES 12%
Closess_75_100_... 65%
Closess_50_75_o... 13%
Closess_25_50_o... 9%
Closess_10_25_o... 1%
Closes_les_than_... 0%
No_effect 0%
Cost 2
Less_01_milj 0%
milj01_05 5%
milj05_1 21%
milj1_5 53%
milj5_10 18%
milj10_50 3%
Over50milj 0%
Cost 3
Less_01_milj 0%
milj01_05 2%
milj05_1 3%
milj1_5 3%
milj5_10 4%
milj10_50 57%
Over50milj 31%
Net benefit of measure 1 on D1
Expected util... 8.07648
Net benefit of measure 1 on D3
Expected u... 5.97081
Net benefit of measure 2 on D1
Expected utility 10.3556
Net benefit of measure 2 on D3
Expected utility 7.66539
Net benefit of measure 3 on D1
Expected utility 2.29311
Net benefit of measure 3 on D3
Expected utility 7.26169
Total net benefits
Expected utility 41.6231

Eutrophication & biomanipulation



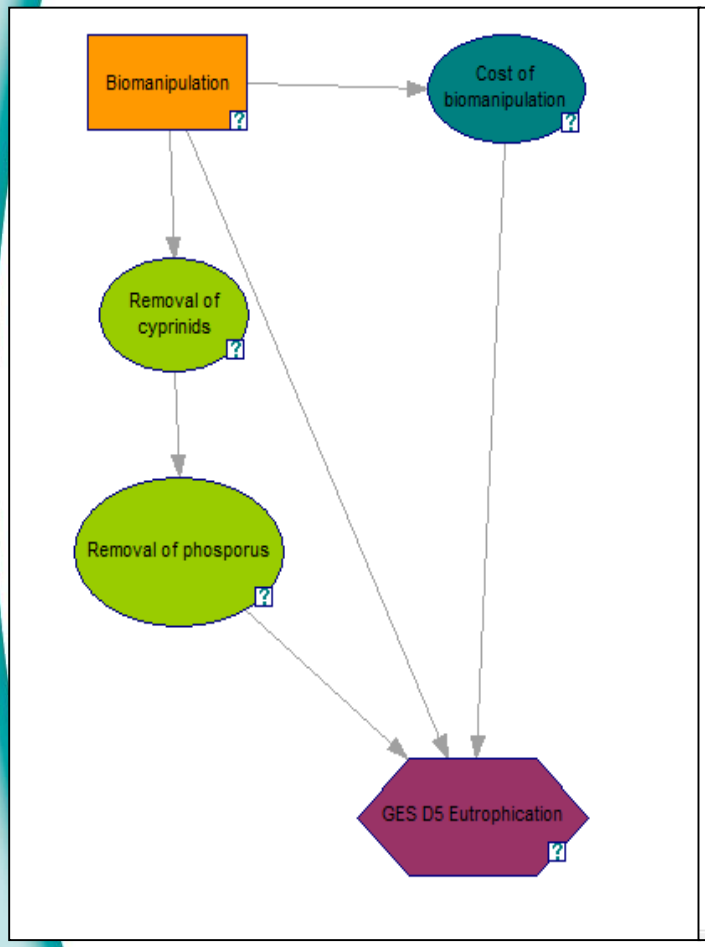
Economics of Aquatic Foodwebs: Finnish Academy Project

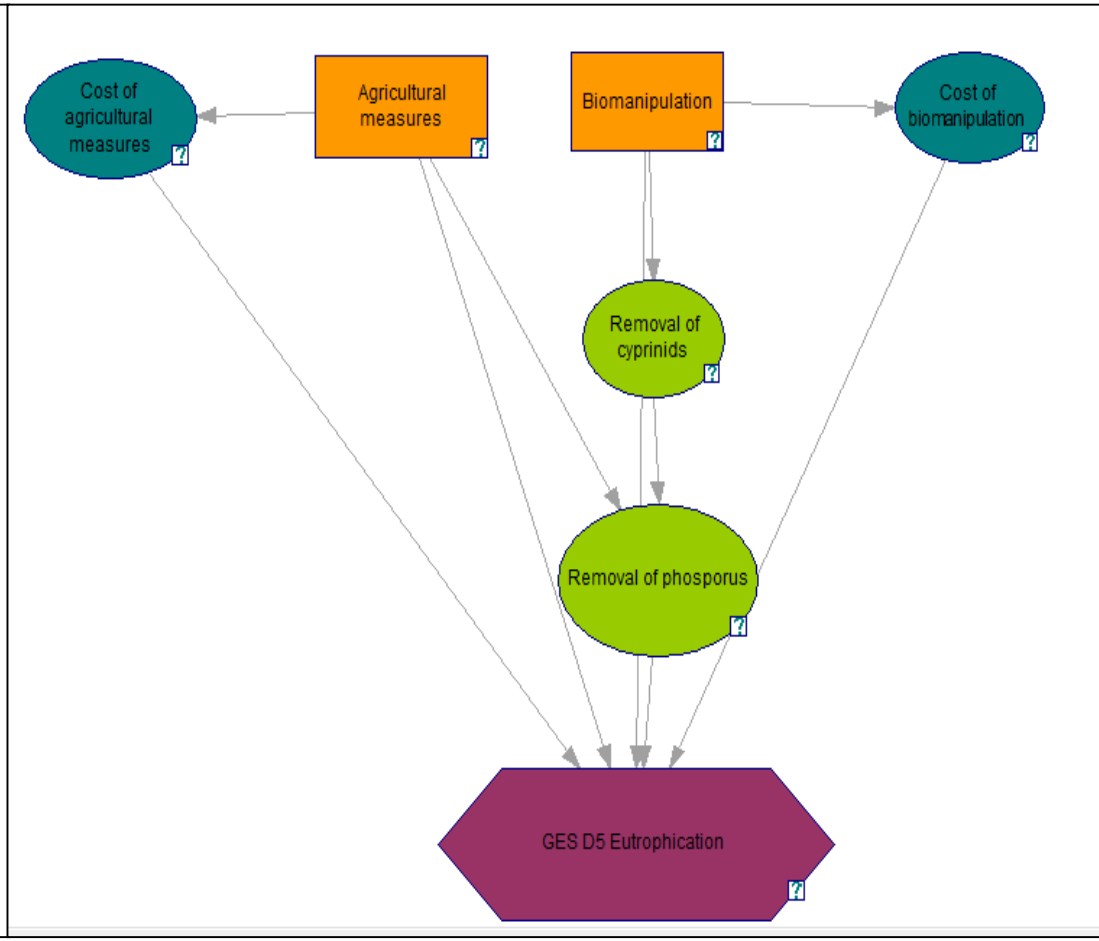
http://www.aka.fi/en-GB/A/Programmes-and-cooperation/Research-programmes/Ongoing/Sustainable-Governance-of-Aquatic-Resources-/AKVA-projects/Economics-of-Aquatic-Foodwebs-ECA/

Eutrophication & biomanipulation

- High concentration of nutrients promotes excessive growth of algae
  - Murky water, toxic blooms, hypoxia, increase in low value fish populations
- Nutrien load reductions: agriculture, waste water treatment
- Biomanipulation through targeted fishing
  - Foodweb effects
  - Nutrients of catch
- Target species of biomanipulation have low value
  - Reversed fisheries problem: subsidies

Optimal eutrophication management





Conclusions

- EU's marine strategy framework directive calls for
  - Ecosystem approach
  - Cost-effectiveness and cost-benefit analyses
- Lack of data, models & resources
  - Pragmatic approach needed
- Bayesian Nets a possible solution
  - Graphics
  - Optimisation
  - Uncertainties

MARINE RESEARCH CENTRE

Thank you!

soile.m.oinonen@ymparisto.fi

SYKE