HELSINGIN YLIOPISTO
HELSINGFORS UNIVERSITET
UNIVERSITY OF HELSINKI

Synthesising biological, economic and sociological knowledge using Bayesian Nets to support broadly based fisheries policy: the case of devising a new Baltic salmon management plan

Polina Levontin, Imperial College London

Soile Kulmala & Katja Parkkila, Department of Economics and Management

Päivi Haapasaari, Fisheries and Environmental Management Group (FEM)

The XIXth EAFE Conference, 6th – 8th July 2009, MALTA

Contents

- Backround: Baltic salmon stocks, fisheries & management
- Project: Data Analysis to Support the Development of a Baltic Sea Salmon Action Plan
- Bayesian Network
- Results
- Conclusions

Background

- Biological, economic and decision overfishing
  - stock decline
  - profitability decline
  - TAC>recommeded catch>reported catch
- Conflicts between different user groups
  - commercial & recreational fishery
  - tourism
  - conservation
- Salmon Action Plan (SAP) 1997-2010
- New management plan as of 2010
- Impact assessment
  - ICES: biological assessment
  - socio-economic assesment

Data Analysis to Support the Development of a Baltic Sea Salmon Action Plan (SAP-IA)

- Economic analyses
  - A: Commercial fishery (bio-economic modelling)
    - restrictions for commercial fishing
    - economic & biological performance
  - B: Recreational fishery (mail survey, valuation techniques)
    - restrictions for commercial and recreational fishing
    - anglers willingness to contribute to the costs of salmon management plan

- Sociological analysis (web questionnaire)
  - Commercial & recreational fishers, fishing tourism, NGOs
  - Prerequisites for successful implementation

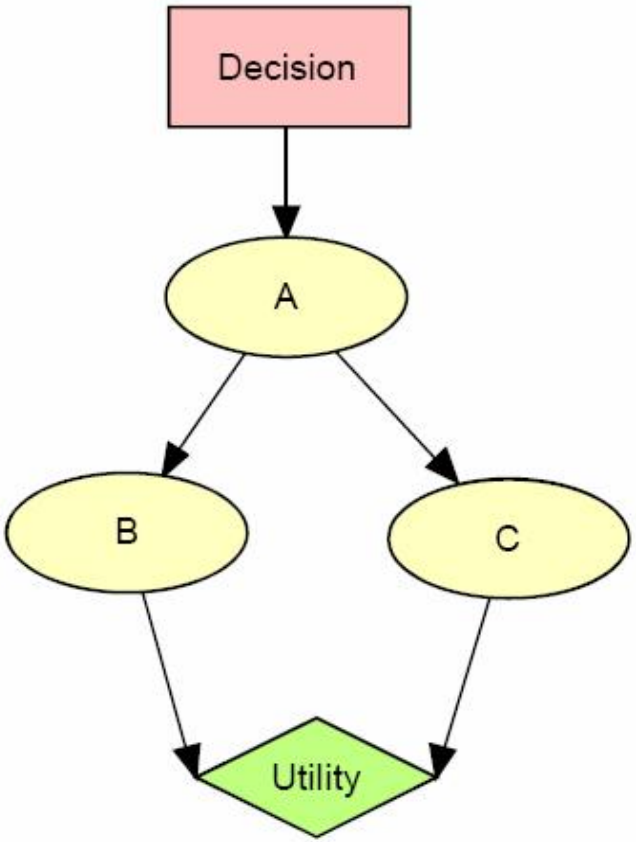
Aims of the present study

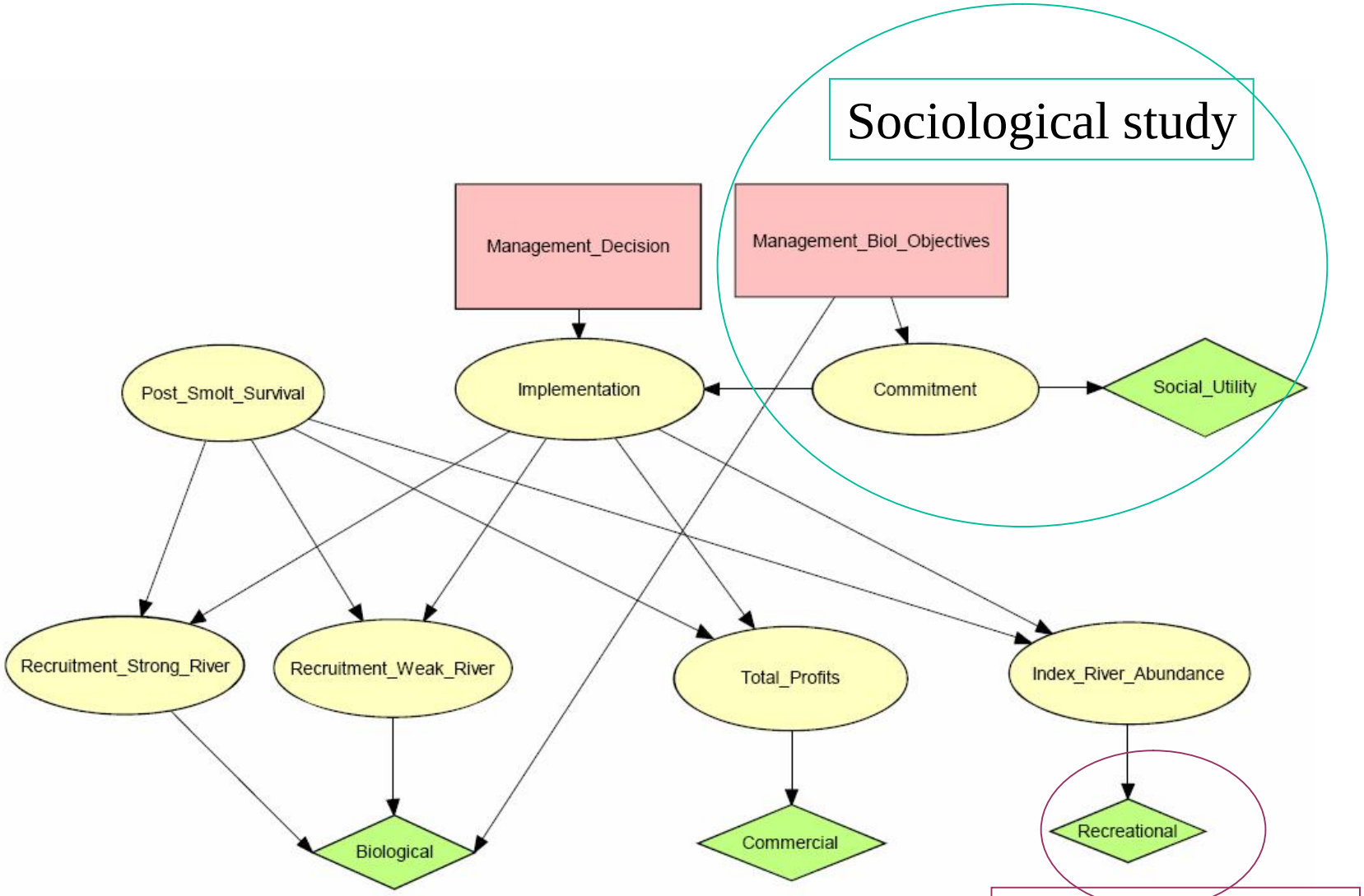
- Synthesize and communicate the results from
  - bio-economic analysis
  - valuation study
  - sociological analysis

- By using Bayesian network methodology

Bayesian networks & influence diagrams

- Conditional dependence between variables
- Updating of knowledge based on Baye's theorem
- Expected utility related to each decision option given the rest of the network





Bio-economic simulations

Variable	Description	Discretized levels	Conditional on
Management Decision	Change in the commercial fleet's fishing effort in relation to 2008 effort levels	no change, -25%, -50%, -75%	None
Management Biol. Objective	Management objective based on the stock specific carrying capacities (CC)	no objective, 50% of CC, 75% of CC, 50% and or 75% of CC	None
Post-Smolt Survival	Survival of juvenile salmon during its first year at sea	high, low	None
Implementation	Implementation of management decision	no change, -25%, -50%, -75%	Management Decision, Commitment
Commitment	Fishermen willingness' to comply with the management decisions	commited, somewhat committed, slightly not committed, not committed	Management Biol. Objective
Recruitment Strong River	Number of smolts with respect to the carrying capacity in river Tornionjoki	0-10% of CC, 10-25%, 25-50%, 50-75%, 75-up%	Post-Smolt Survival, Implementation
Recruitment Weak River	Number of smolts with respect to the carrying capacity in river Simojoki	0-10% of CC, 10-25%, 25-50%, 50-75%, 75-up%	Post-Smolt Survival, Implementation
Total Profits	Net present value of the commercial salmon fleet profits in years 2009-2015. The fleet accounts for Finland, Sweden, Denmark and Poland	losses - 0 profit, 0-5 millions, 5-10 millions, 10-15 millions, above 15	Post-Smolt Survival, Implementation
Index River Abundance	Number of salmon ascending river Tornionjoki	low, medium, reasonable, high	Post-Smolt Survival, Implementation
Biological	Utility in terms of the stock specific carrying capacity	None	Recruitment Strong River, Recruitment Weak River, Management Biol. Objective
Commercial	Utility in terms of the commercial fleet's profits	None	Total Profits
Recreational	Utility from recreational fishery in terms of salmon ascending to river Tornionjoki	None	Index River Abundance
Social	Utility from good implementation	None	Commitment

Variable: "Management Decision"

- Bioeconomic modelling
- Proposed by DG Mare
- Change in the commercial fleet's fishing effort in relation to 2008 effort levels
- 4 states
  - no change
  - -25%
  - -50%
  - -75%
- Decision node → no parent variables

Variable: "Management Biological Objective"

- Sociological study
- Management objectives based on the stock specific carrying capacities (cc)
- 4 states
  - no management plan
  - 50% of cc (old target)
  - 75% of cc (MSY, ICES proposal)
  - 50% and 75% (BS RAC proposal)
- Decision node → no parent variables

Variable: "Post-Smolt Survival"

- Bioeconomic modelling
- Survival of juvenile salmon during its first year at sea
- 2 states
  - high
  - low
- No parents, but this could be a link to another model

Variable: "Implementation"

- Sociological study
- Implementation of the management decision
- 4 states
  - no change
  - -25%
  - -50%
  - -75%
- Conditional on
  - Management Decision
  - Commitment

Variable: "Commitment"

- Sociological study
- Fishermen willingness' to comply with the management decisions
- 4 states
  - committed
  - somewhat committed
  - slightly not committed
  - not committed
- Conditional on
  - Management Biological Objective

Variable: "Recruitment strong river"

- Bioeconomic model
- Number of smolts with respect to the carrying capacity in river **Tornionjoki**
- 5 states
  - 0-10% of cc
  - 10-25% of cc
  - 25-50% of cc
  - 50-75% of cc
  - 75-up% of cc
- Conditional on
  - Post-Smolt Survival
  - Implementation

Variable: "Recruitment weak river"

- Bioeconomic model
- Number of smolts with respect to the carrying capacity in river **Simojoki**
- 5 states
  - 0-10% of cc
  - 10-25% of cc
  - 25-50% of cc
  - 50-75% of cc
  - 75-up% of cc
- Conditional on
  - Post-Smolt Survival
  - Implementation

Variable: "Total Profits"

- Bioeconomic model
- Net present value of the commercial salmon fleet profits in years 2009-2015.
- Fleet: FI, SW, DK, PO
- 5 states
  - losses – 0 profits
  - 0-5 mil. €
  - 5-10 mil. €
  - 10-15 mil. €
  - above 15 mil. €
- Conditional on
  - Post-Smolt Survival
  - Implementation

Variable: "Index River Abundance"

- Bioeconomic modelling
- Number of salmon ascending to river Tornionjoki
- 3 states
  - low
  - medium
  - high
- Conditional on
  - Post-Smolt survival
  - Implementation

Conditional probabilities

	Implementation	No Change		-25%		-50%		-75%	
	Post-Smolt Survival	High	Low	High	Low	High	Low	High	Low
Total Profits	Losses - 0 profit	0	0.006	0	0.003	0	0.002	0	0.002
	0-5 mil.	0.013	0.046	0.018	0.065	0.035	0.107	0.176	0.365
	5-10 mil.	0.054	0.124	0.09	0.176	0.202	0.34	0.547	0.528
	10-15 mil.	0.122	0.218	0.2	0.3	0.319	0.333	0.228	0.097
	above 15 mil.	0.811	0.606	0.692	0.456	0.444	0.218	0.049	0.008

	Implementation	No Change		-25%		-50%		-75%	
	Post-Smolt Survival	High	Low	High	Low	High	Low	High	Low
Recruitment Weak River	0-10%	0.013	0.016	0.009	0.012	0.005	0.008	0.004	0.006
	10-25%	0.157	0.209	0.112	0.166	0.096	0.13	0.069	0.096
	25-50%	0.568	0.575	0.531	0.576	0.495	0.53	0.439	0.493
	50-75%	0.232	0.177	0.288	0.221	0.322	0.289	0.384	0.335
	above 75%	0.03	0.023	0.06	0.025	0.082	0.043	0.104	0.07

	Commitment	**Committed**				**Somewhat Committed**				**Slightly Not Committed**				**Not Committed**			
	Management Decision	**No Change**	**-25%**	**-50%**	**-75%**	**No Change**	**-25%**	**-50%**	**-75%**	**No Change**	**-25%**	**-50%**	**-75%**	**No Change**	**-25%**	**-50%**	**-75%**
Implemen-tation	**No Change**	**1**	**0**	**0**	**0**	**0.9**	**0.2**	**0.1**	**0**	**1**	**0.8**	**0.3**	**0.1**	**1**	**1**	**1**	**1**
	-25%	**0**	**1**	**0**	**0**	**0.1**	**0.8**	**0.3**	**0.2**	**0**	**0.2**	**0.6**	**0.5**	**0**	**0**	**0**	**0**
	-50%	**0**	**0**	**1**	**0**	**0**	**0**	**0.6**	**0.3**	**0**	**0**	**0.1**	**0.3**	**0**	**0**	**0**	**0**
	-75%	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0.5**	**0**	**0**	**0**	**0.1**	**0**	**0**	**0**	**0**

Utility functions

- Commercial utility: in terms of commercial fleet's profits
- Recreational utility: in terms of number ascending to river Tornionjoki
- Social utility: utility emerging from good implementation

Commercial	Total Profits	*Losses-0 mil.*	*0-5 mil.*	*5-10 mil.*	*10-15 mil*	*15 < mil.*
	Utility	**0**	**0.4**	**0.6**	**0.9**	**1**
Recreational	Index River Abundance	*Low*	*Medium*	*Reasonable*	*High*	
	Utility	**0.2**	**0.6**	**0.8**	**1**	
Social	Commitment	Not Committed	Somewhat Committed	Slightly Not Committed	Not Committed	
	Utility	**0**	**0.5**	**0.75**	**1**	

Management Biol. Objectives	No Management Plan																								
Recruitment Strong River	0-10%					10-25%					25-50%					50-75%					75%<				
Recruitment Weak River	0-10%	10-25%	25-50%	50-75%	75%<	0-10%	10-25%	25-50%	50-75%	75%<	0-10%	10-25%	25-50%	50-75%	75%<	0-10%	10-25%	25-50%	50-75%	75%<	0-10%	10-25%	25-50%	50-75%	75%<
Utility	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Management Biol. Objectives	50% of CC																								
Recruitment Strong River	0-10%					10-25%					25-50%					50-75%					75%<				
Recruitment Weak River	0-10%	10-25%	25-50%	50-75%	75%<	0-10%	10-25%	25-50%	50-75%	75%<	0-10%	10-25%	25-50%	50-75%	75%<	0-10%	10-25%	25-50%	50-75%	75%<	0-10%	10-25%	25-50%	50-75%	75%<
Utility	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0.2	0	0	0.3	1	1	0	0	0.5	1	1
Management Biol. Objectives	75% of CC																								
Recruitment Strong River	0-10%					10-25%					25-50%					50-75%					75%<				
Recruitment Weak River	0-10%	10-25%	25-50%	50-75%	75%<	0-10%	10-25%	25-50%	50-75%	75%<	0-10%	10-25%	25-50%	50-75%	75%<	0-10%	10-25%	25-50%	50-75%	75%<	0-10%	10-25%	25-50%	50-75%	75%<
Utility	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0	0	0	0.4	0.6	0	0	0.2	0.6	1
Management Biol. Objectives	75% and 50% of CC																								
Recruitment Strong River	0-10%					10-25%					25-50%					50-75%					75%<				
Recruitment Weak River	0-10%	10-25%	25-50%	50-75%	75%<	0-10%	10-25%	25-50%	50-75%	75%<	0-10%	10-25%	25-50%	50-75%	75%<	0-10%	10-25%	25-50%	50-75%	75%<	0-10%	10-25%	25-50%	50-75%	75%<
Utility	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0.5	0.6	0	0	0.4	1	1

Results

Management objective in terms of carrying capacity target to be achieved by 2015	Management decision in terms of effort reduction in commercial fisheries	All utility functions combined	Recreational utility only	Commercial utility only	Social utility only	Biological utility only
50%	no	231 (4)	145 (4)	**213 (1)**	72 (3)	164 (4)
50%	-25%	238 (3)	147 (3)	211 (2)	72 (3)	167 (3)
50%	-50%	241 (1)	151 (2)	208 (3)	72 (3)	171 (2)
50%	-75%	240 (2)	155 (1)	199 (4)	72 (3)	**174 (1)**
75%	no	211 (4)	145 (4)	**213 (1)**	75 (2)	139 (4)
75%	-25%	215 (2)	148 (3)	211 (2)	75 (2)	141 (3)
75%	-50%	217 (1)	151 (2)	207 (3)	75 (2)	144 (2)
75%	-75%	214 (3)	155 (1)	198 (4)	75 (2)	146 (1)
50 and 75 %	no	238 (3)	145 (4)	**213 (1)**	**82 (1)**	159 (4)
50 and 75 %	-25%	243 (2)	148 (3)	211 (2)	**82 (1)**	162 (3)
50 and 75 %	-50%	**246 (1)**	152 (2)	207 (3)	**82 (1)**	165 (2)
50 and 75 %	-75%	243 (2)	**156 (1)**	196 (4)	**82 (1)**	169 (1)

Conclusions

- Bayesian influence diagrams were applicable in synthesising sub-studies from different fields applying different methods

- If different interests are weighted equally, the sought after compromise is to
  - reduce the commercial fishing effort by 50% and set
  - river specific management objectives

Thank you for your attention

soile.kulmala [a] helsinki.fi