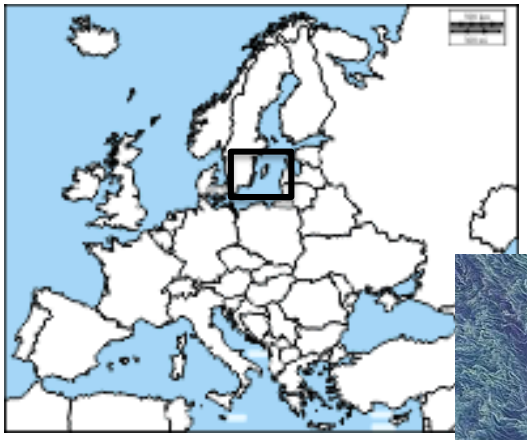
Fishing for Nitrogen

– Environmental Impact of Fisheries Management on Nutrient Dynamics in the Baltic Sea

Rasmus Nielsen, Ayoe Hoff, Staffan Waldo, Cecilia Hammarlund, and Jarno Virtanen

Eutrophication in the Baltic Sea



- The problem
  - Hypoxia
  - Algae blooms

Causes of eutrophication

- Nitrogen (N)
- Phosphorous (P)

- Natural losses
- Point sources
  - Waste water
  - Aquaculture
- Diffuse sources
  - Agriculture

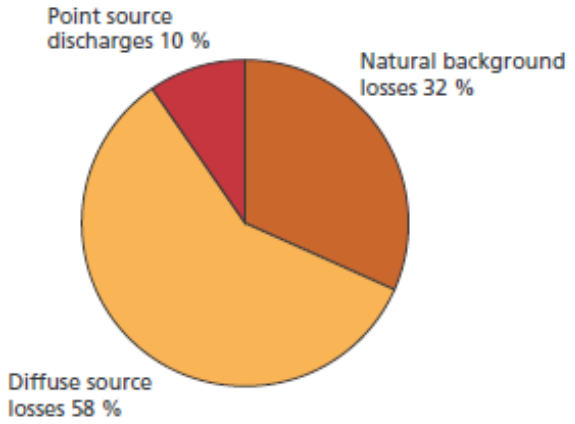


Figure 4.
The input of nitrogen by source into surface waters within the catchment area in 2000[3,4]

Source: Helcom

Reduce loadings of nutrients to the sea

- Baltic Sea Action Plan
- Maximum annual loads (2013 revision)
  - Nitrogen 792 000 tons
    - reduction with 118 000 tons needed
  - Phosphorous 21 000 tons
    - reduction with 15 000 tons needed
- Land based measures are getting costly
  - Waste water management
  - Subsidies for reducing N and P in agriculture

Removal of nutrients from the Baltic Sea

- Natural: sedimental burial, denitrification and export to Skagerrak (HELCOM 2009).
- Mussel/seaweed farming
  - Seaweed costly
  - Mussels grow slowly (low salinity)
- What about fisheries?

Fishing for nutrients

- Herring contains
  - 2.4 % N
  - 0.43 % P

- Bernes et al. 2015: Improved fresh water quality through fishing (water transparency)

- TAC pelagic (thousand tons)
  - Herring (25-29) 186
  - Sprat 240

Photo: Staffan Waldo

- Alternative: Cod 60 thousand tons

Case study

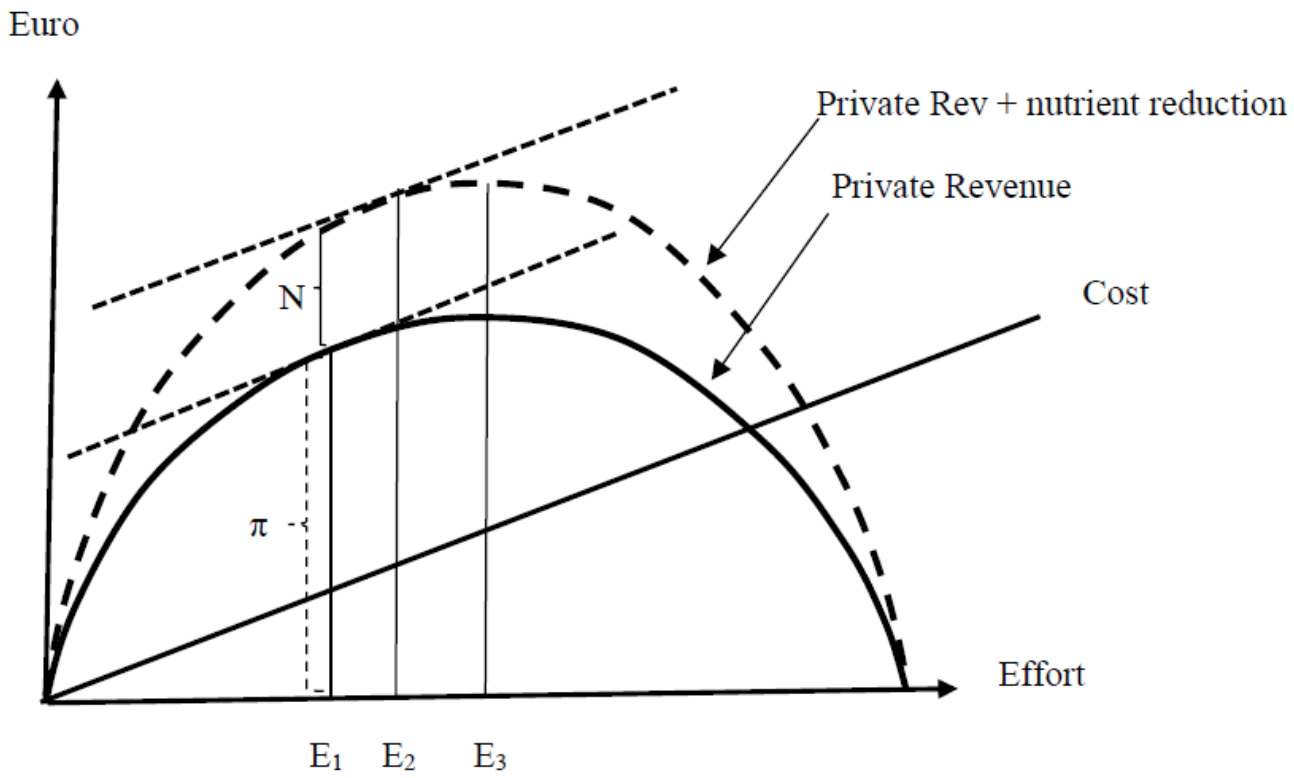
- Pelagic fleets in Denmark, Sweden, and Finland
- Data from 2012-2014
  - EU Economic Data
  - Logbook
- Species (ICES area)
  - Herring (25-29)
  - Herring (30-31)
  - Sprat (22-32)
- FishRent Model (Frost et al, 2013)
  - 25 year time horizon

Fleet segment	Vessels
Denmark	
Purse VL40	4
Sein VL 1518	7
Trawl VL 1215 BA	27
Trawl VL 1518 BA	28
Trawl VL 1215 NS	5
Trawl VL 1518 NS	12
Trawl VL 2440 Ind	3
Trawl VL 2440 Mix	6
Trawl VL 40 Ind	16
Sweden	
PEL VL 1824	9
PEL VL 24XX	21
Finland	
PEL VL 1224	41
PEL VL 2440	22

Management scenarios

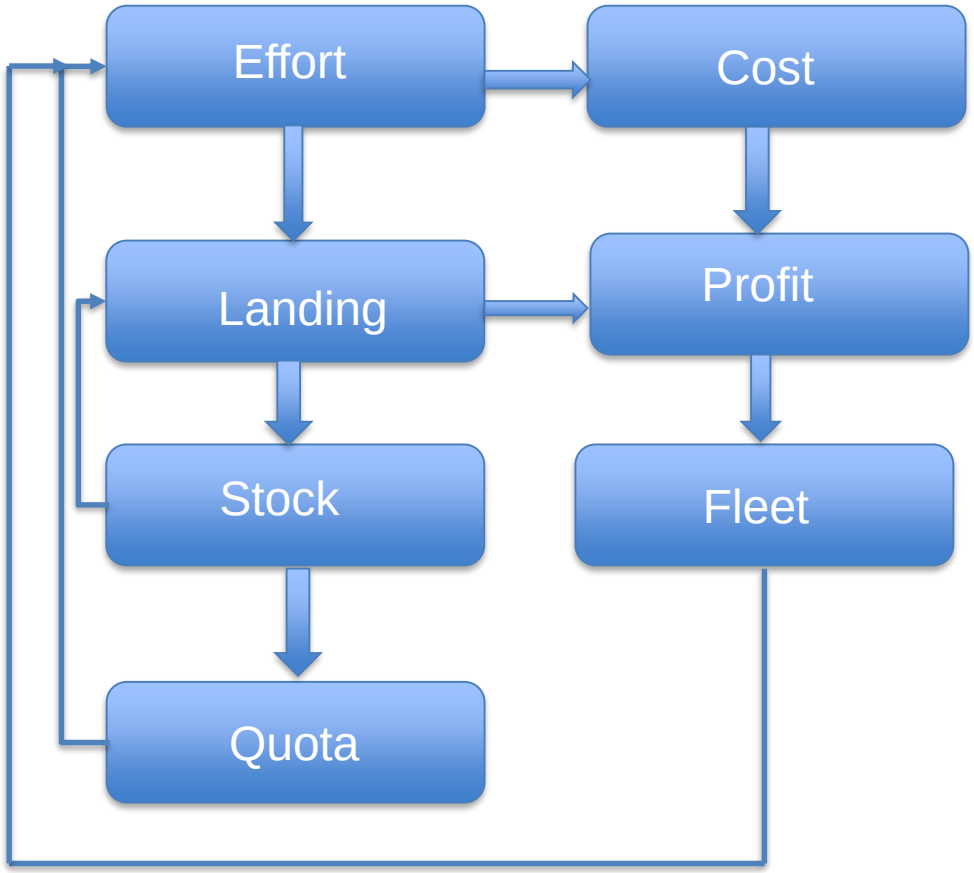
- Take the value of N and P reductions into account
- Scenarios:
  - Fisheries management
    - Business as usual (BAU)
    - National ITQ
    - Baltic ITQ
  - Economic compensation
    - Subsidize fishery with the value of N and P reduction
      - €0.37 per kilo (Gren et al, 2008)
    - BAU, National ITQ, Baltic ITQ
  - MSY
    - Require fisheries to catch at MSY rather than MEY
    - BAU, National ITQ, Baltic ITQ

Management scenarios

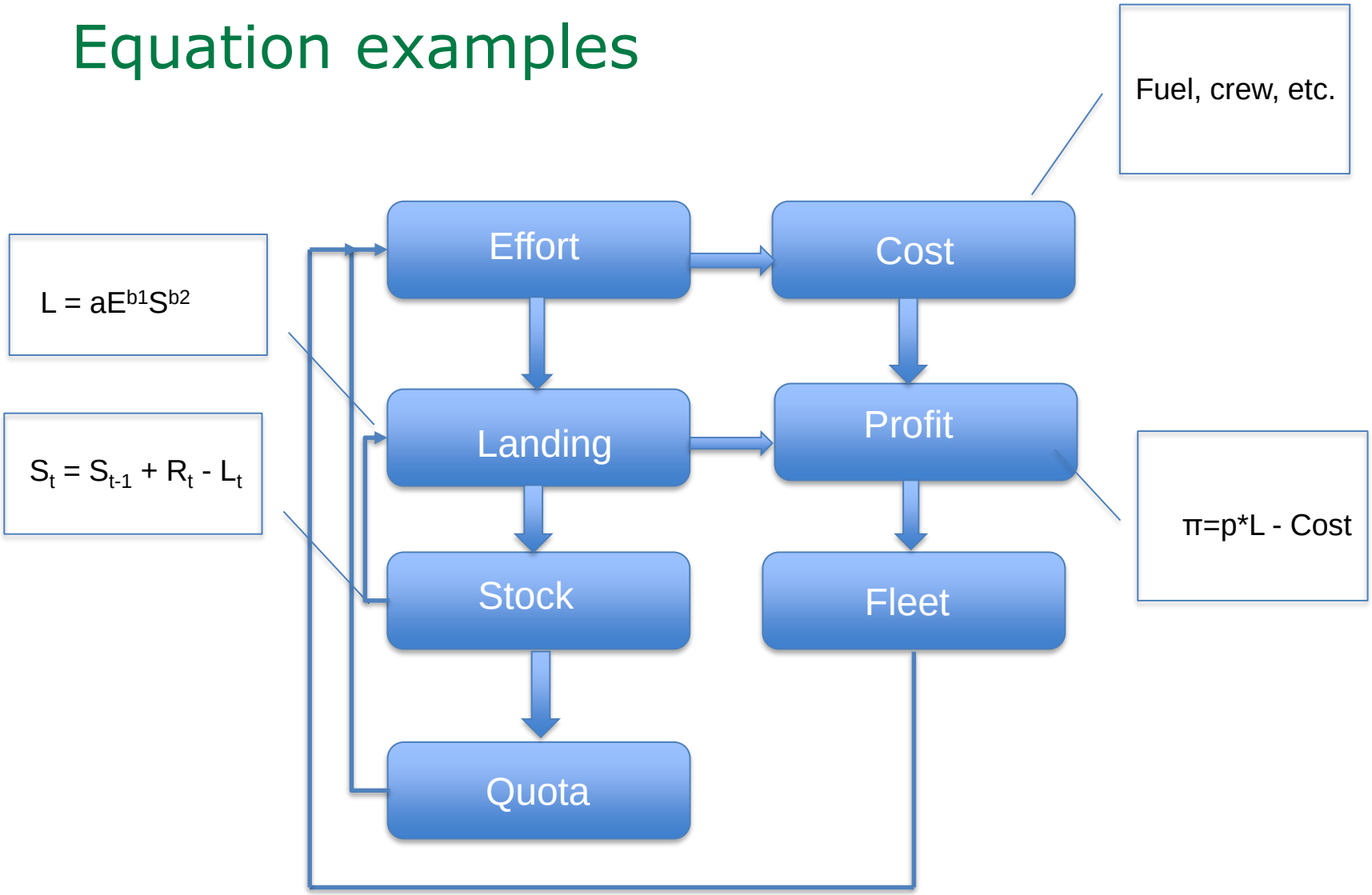


E1 = ITQ
E2 = Economic compensation
E3 = MSY

The FishRent-model



Equation examples



The FishRent Model

- Simulation / Maximization

- Max:

$$NPV\ \pi = \sum_{y,f,s} [p_{f,s} \cdot L_{y,f,s}(X_{y,s}, E_{y,f}) - C(E_{y,f}, R_{y,f})] \cdot (1+\rho)^{-y}$$

s.t.

$$\sum_{f} L_{y,f,s} \leq \text{Quota}_{y,s}$$

$$E_{y,f} \leq \text{DASmax}_{f} * V_{y,f}$$

Result, catch

Scenario	Total catch (1000 ton)	Catch increment compared with FR1_BAU (1000 ton)
Fisheries Regulation		
FR1_BAU	5426	0
FR2_National ITQ	5248	-178
FR3_Baltic ITQ	4759	-668
Economic Compensation		
EC1_BAU	5482	56
EC2_National ITQ	5605	179
EC3_Baltic ITQ	5817	391
MSY		
MSY1_National ITQ	5882	456
MSY2_Baltic ITQ	6333	907

Result

Scenario	Total catch (1000 ton)	Catch increment compared with FR1_BAU (1000 ton)	Subsidy (€) per extra kg of fish removed, average over period
Fisheries Regulation			
FR1_BAU	5426	0	-
FR2_National ITQ	5248	-178	-
FR3_Baltic ITQ	4759	-668	-
Economic Compensation			
EC1_BAU	5482	56	36.51
EC2_National ITQ	5605	179	11.62
EC3_Baltic ITQ	5817	391	5.51
MSY			
MSY1_National ITQ	5882	456	0.29
MSY2_Baltic ITQ	6333	907	0.17

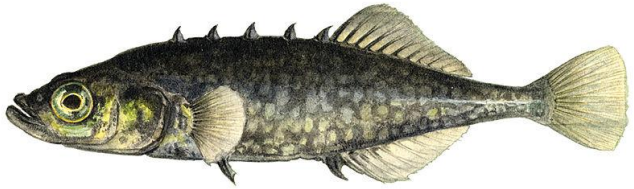
Discussion

- Abatement costs for Nitrogen
  1. Mussels €9.4-13 per kilo
  2. Seaweed €77-108 per kilo
  3. Fisheries €4.6-7.5 per kilo

- Fisheries can contribute to a reduction of N and P in the Baltic Sea

- Current fisheries close to MSY

- New species?



- Ecosystem based fisheries management

Thanks