

Marine Resource Economics

Rolf Groeneveld
Environmental Economics and Natural Resources Group



SOCIAL SCIENCES GROUP
WAGENINGEN UR

Natural resource problems in economics

- What is the problem?
- What are the policy objectives?
- What instruments are possible?

SOCIAL SCIENCES GROUP
WAGENINGEN UR

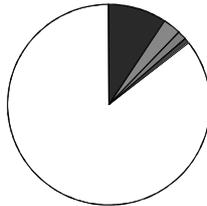
Economic importance of marine resources

- Fish: \$93.9 bln in 2008 (FAO, 2010)
 - A 16% increase since 2000
- Aquaculture: \$98.4 bln in 2008 (FAO, 2010)
 - A 73% (!) increase since 2000
 - But not all is marine
- Tourism: Estimated at \$161 bln in 1995
 - But this is a very shaky figure
- Unregistered uses, especially in poor countries
 - Timber, fuelwood, fish

SOCIAL SCIENCES GROUP
WAGENINGEN UR

Employment in fisheries

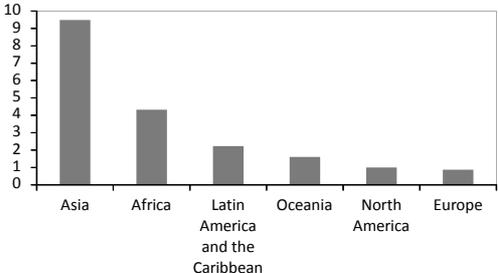
- 44.9 mln people were involved in fisheries or aquaculture in 2008 – that is 0.6% of the total world population



SOCIAL SCIENCES GROUP
WAGENINGEN UR

Employment in fisheries

- Employment in fisheries or aquaculture per 1000 people:



SOCIAL SCIENCES GROUP
WAGENINGEN UR

Economic drivers of resource degradation

- Environmental problems are forms of market failure
- When do markets work best?
- When do they fail?
- Where do they fail with regard to the environment?

SOCIAL SCIENCES GROUP
WAGENINGEN UR

When do markets work best?

- Well-defined property rights
 - Exclusive
 - Transferable
 - Enforced
- No externalities
- Full information
- No transaction costs
- Goods are infinitely divisible

SOCIAL SCIENCES GROUP
WAGENINGEN

When do markets fail?

- Open-access resources
- Public goods
- Externalities
- Limited information
- Transaction costs
- Goods can only be traded or produced in large quantities

SOCIAL SCIENCES GROUP
WAGENINGEN

Types of goods in an economy

	Rivalrous	Non-rivalrous
Excludable	Individual goods 	Club goods 
Non-excludable	Open access resources 	Public goods 

SOCIAL SCIENCES GROUP
WAGENINGEN

Open-access resources



SOCIAL SCIENCES GROUP
WAGENINGEN

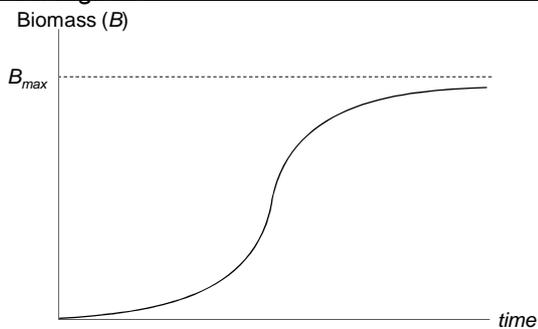
Overfishing as a Prisoner's Dilemma

		Fiji	
		10 boats	20 boats
FSM	10 boats	Fiji: 20 ton FSM: 20 ton	Fiji: 30 ton FSM: 1 ton
	20 boats	Fiji: 1 ton FSM: 30 ton	Fiji: 10 ton FSM: 10 ton

SOCIAL SCIENCES GROUP
WAGENINGEN

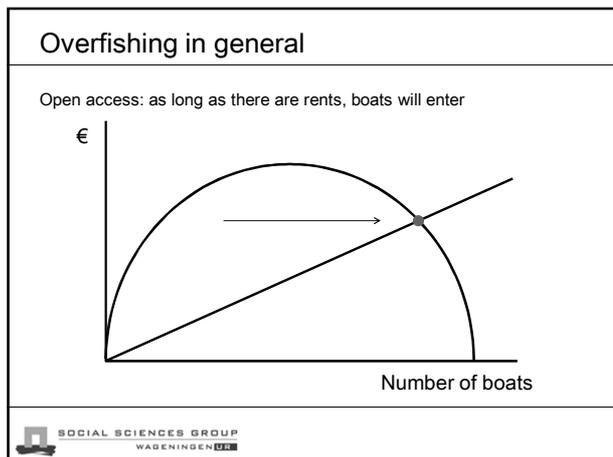
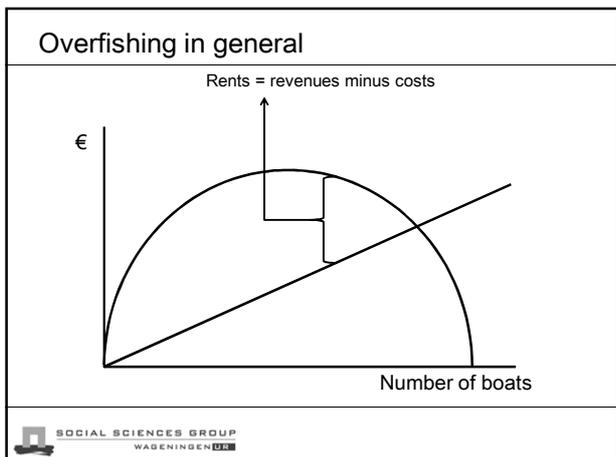
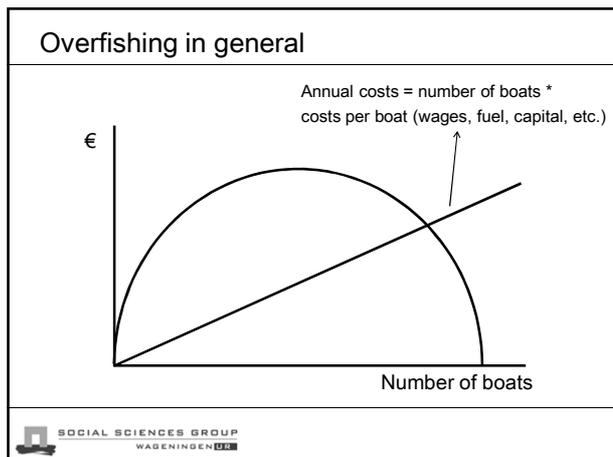
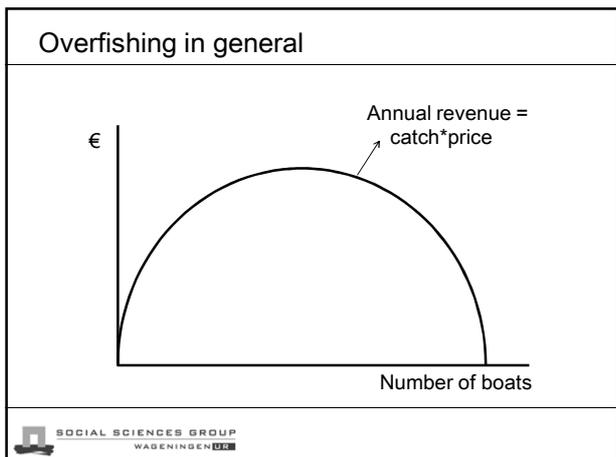
Fish growth

Biomass (B)



time

SOCIAL SCIENCES GROUP
WAGENINGEN



Natural resource problems in economics

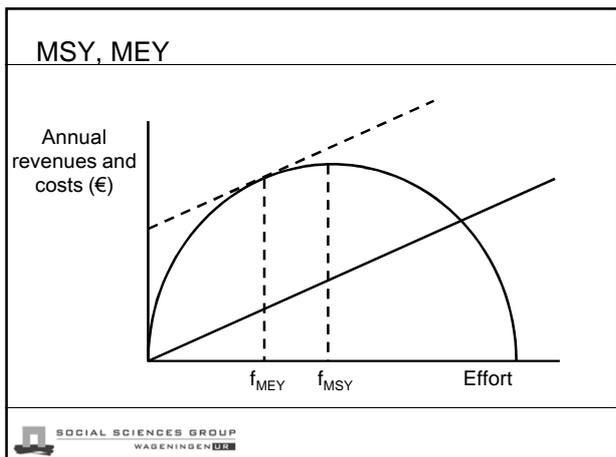
- What is the problem?
- What are the policy objectives?
- What instruments are possible?

SOCIAL SCIENCES GROUP
WAGENINGEN

Policy objectives

- Stock growth: Maximum Sustainable Yield
- Fishing costs: Maximum Economic Yield
- Role of the interest rate
- Risk and uncertainty
- Social objectives

SOCIAL SCIENCES GROUP
WAGENINGEN

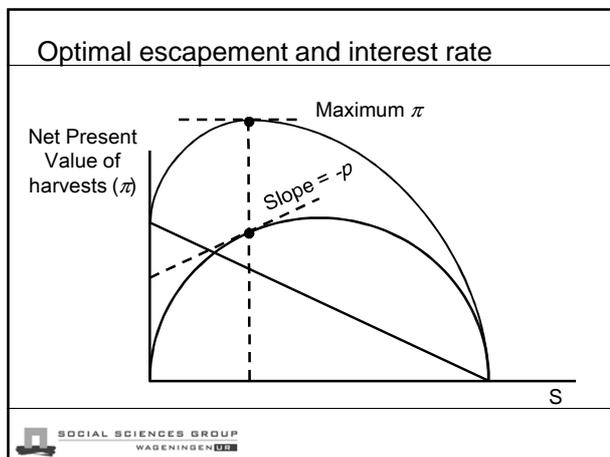
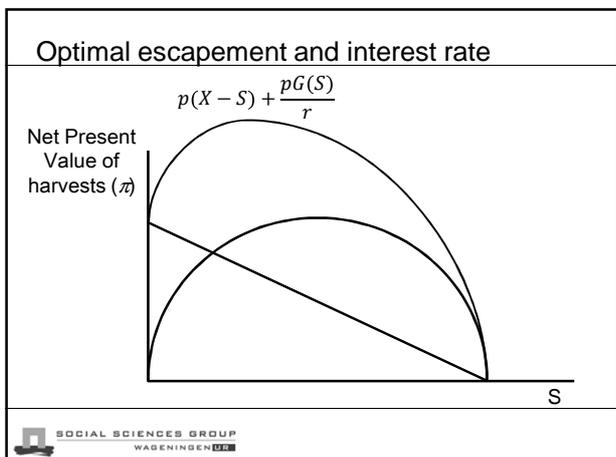
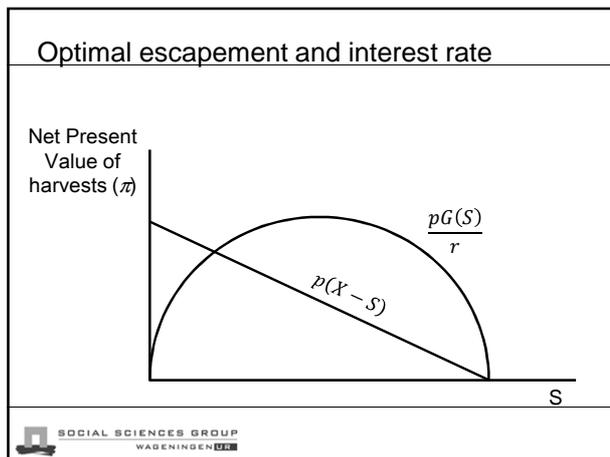


- ### Economic objectives
- Stock growth: Maximum Sustainable Yield
 - Fishing costs: Maximum Economic Yield
 - Role of the interest rate
 - Risk and uncertainty
 - Social objectives
- SOCIAL SCIENCES GROUP
WAGENINGEN

- ### How does the interest rate affect harvest?
- We face the following maximization problem:

$$\max_H \pi = pH + \frac{pG(X-H)}{r}$$
 - In fact it is easier to solve like this:

$$\max_S \pi = p(X-S) + \frac{pG(S)}{r}$$
 - Where S is called 'escapement'
- SOCIAL SCIENCES GROUP
WAGENINGEN



Finding the optimal escapement

Take the first derivative with respect to escapement:

$$\pi = p(X - S) + \frac{pG(S)}{r} \Rightarrow \frac{d\pi}{dS} = -p + \frac{dG/dS}{r} p$$

- Increasing S by one fish has two effects:
 - In the present you earn 1 fish less times its price
 - In the future you earn the offspring of that fish times their price, annually

SOCIAL SCIENCES GROUP
WAGENINGEN UR

Finding the optimal escapement

- In the optimum these two effects are equal:

$$p = \frac{dG/dS}{r} p \Rightarrow \frac{dG}{dS} = r$$
- So the optimal stock size has a marginal growth rate equal to the interest rate
 - Marginal growth: additional growth due to an extra, infinitely small, unit of fish

SOCIAL SCIENCES GROUP
WAGENINGEN UR

Natural capital vs man-made capital

	Man-made	Natural
Forms	Machinery, knowledge, technology, bank accounts	Fish stocks, forests, water
Consumption	Use it, spend it	Catch it, cut it, drink it
Investment	Savings, investments	Don't use it and it grows
Growth rate	Interest rate (r)	$\frac{dG}{dX}$

SOCIAL SCIENCES GROUP
WAGENINGEN UR

Effect of interest rate

- At a zero interest rate you should fish at MSY or MEY
 - The future becomes just as important as the present
- High interest rates stimulate exploitation
 - The future is 'less important'
 - It is more profitable to deplete the resource and put the money on the bank

SOCIAL SCIENCES GROUP
WAGENINGEN UR

Comparing fish stocks and bank accounts

- Market interest rate:
 - Mostly between 0 and 20%
 - Currently about 1%

Species	r (Source:fishbase.org)
Atlantic herring	0.15 - 0.5
Atlantic cod	0.15 - 0.5
Plaice	0.05 - 0.15
Monkfish	0.05 - 0.15
Orange roughy	< 0.05

SOCIAL SCIENCES GROUP
WAGENINGEN UR

Economic objectives

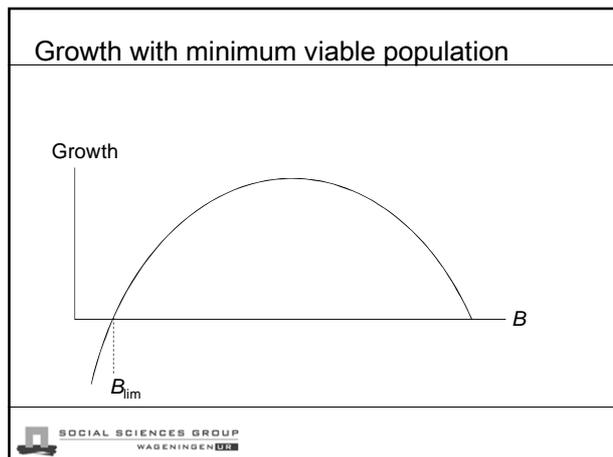
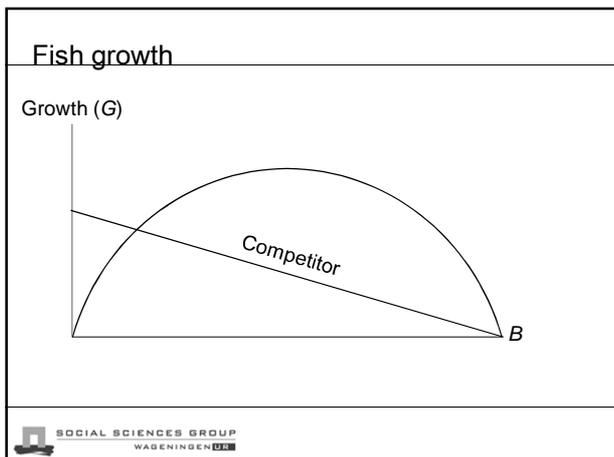
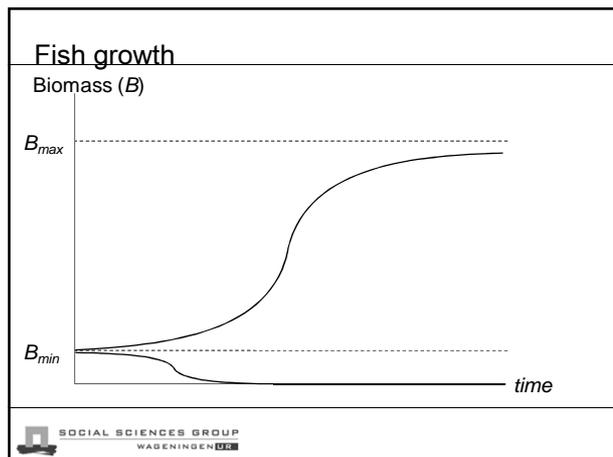
- Stock growth: Maximum Sustainable Yield
- Fishing costs: Maximum Economic Yield
- Role of the interest rate
- Risk and uncertainty
- Social objectives

SOCIAL SCIENCES GROUP
WAGENINGEN UR

Risk and uncertainty

- Climate variability
- Uncertainty in stock assessments
- Unobserved catch, discards, etc.
- ??

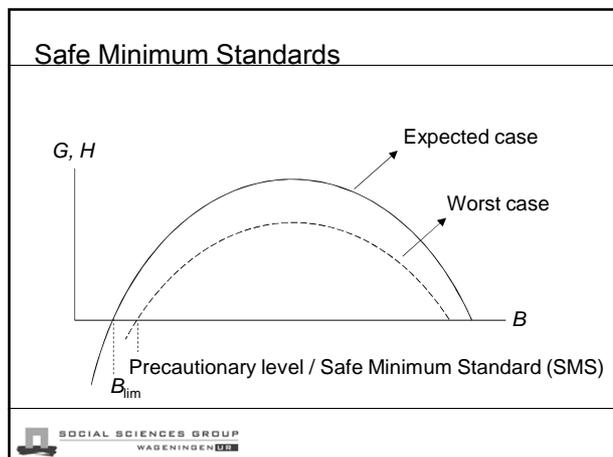
SOCIAL SCIENCES GROUP
WAGENINGEN

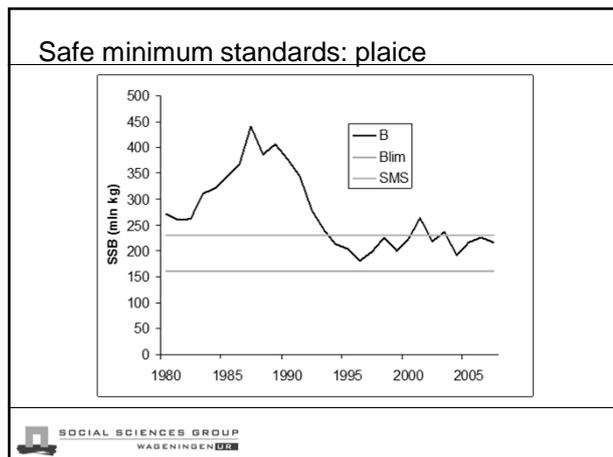
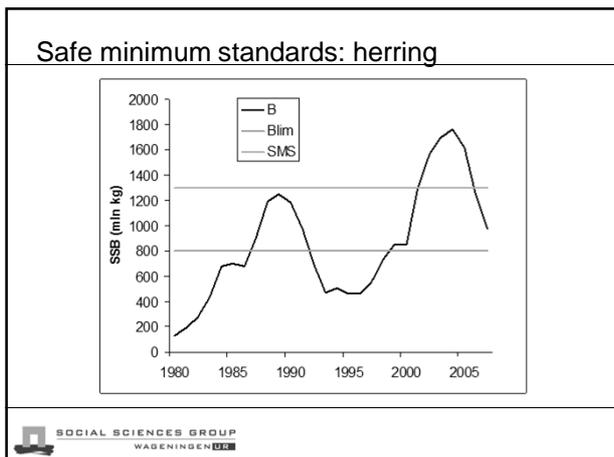


Risk and uncertainty

- Natural variability may push a species 'over the brink'
- May need a safe distance
 - Safe Minimum Standards
 - Precautionary levels

SOCIAL SCIENCES GROUP
WAGENINGEN





- ### Economic objectives
- Stock growth: Maximum Sustainable Yield
 - Fishing costs: Maximum Economic Yield
 - Role of the interest rate
 - Risk and uncertainty
 - Social objectives
- Social Sciences Group
WAGENINGEN

- ### Social objectives
- Employment, family income
 - Biodiversity, endangered species
 - Ecosystem functions ('services')
 - Recreational values
 - Cultures, regional economies
- Social Sciences Group
WAGENINGEN

- ### Natural resource problems in economics
- What is the problem?
 - Open access resources
 - What are the policy objectives?
 - MSY, MEY, discount rate
 - Risk and uncertainty
 - Social objectives
 - What instruments are possible?
- Social Sciences Group
WAGENINGEN

- ### Instruments
- Tradable quota
 - Effort restrictions
 - Taxes and subsidies
 - Restrictions in time and space
- Social Sciences Group
WAGENINGEN

Tradable quota

- Also called ITQs (Individual Transferable Quota)
- Similar to tradable emission permits
- Right to *land* fish
- Main problem: discarding

SOCIAL SCIENCES GROUP
WAGENINGEN UR

TABLE 3
Summary of discards by major types of fishery (tonnes)

Fishery	Landings	Discards ¹	Weighted average discard rate (%)	Range of discard rates (%)
Shrimp trawl	1 126 267	1 895 064	62.3	0-96
Demersal finfish trawl	16 050 978	1 704 107	9.6	0.5-83
Tuna and HMS longline	1 403 591	560 481	28.5	0-40
Midwater (pelagic) trawl	4 133 203	147 126	3.4	0-56
Tuna purse seine	2 673 378	184 152	5.1	0.4-10
Multispear and multispecies	6 023 146	95 436	1.4	n.a.
Mobile trappot	240 551	72 472	23.2	0-61
Dredge	165 660	65 373	28.3	9-60
Small pelagics purse seine	3 882 885	48 852	1.2	0-27
Demersal longline	581 560	47 257	7.5	0.5-57
Gillnet (surface/bottom/trammel) ²	3 350 299	29 004	0.5	0-66
Handline	155 211	3 149	2.0	0-7
Tuna pole and line	818 505	3 121	0.4	0-1
Hand collection	1 134 432	1 671	0.1	0-1
Squid jig	960 432	1 601	0.1	0-1

¹ The sum of the discards presented in this table is less than the global estimate, as a number of discard database records could not be assigned to particular fisheries.
² Low estimates in some fisheries (e.g. gillnet) are partly a result of the inclusion of high Chinese catches with low or negligible discard rates.
 Source: discard database.

SOCIAL SCIENCES GROUP
WAGENINGEN UR

Discards

- Non-edible fish
 - Dolphins, turtles, starfish, etc.
- Edible fish
 - Quota full (especially in multi-species fisheries)
 - Highgrading (discarding low-value fish)
- Effect minimum landing size
 - Immediate catch discarded
 - Incentive to avoid catching small fish

SOCIAL SCIENCES GROUP
WAGENINGEN UR

Instruments

- Tradable quota
- Effort restrictions
- Taxes and subsidies
- Restrictions in time and space

SOCIAL SCIENCES GROUP
WAGENINGEN UR

Restricting effort

- E.g. days-at-sea (EU Cod)
- Closed seasons (Alaskan Halibut)
- Less problems with discarding
- But 'effort' can be many things
 - Days-at-sea
 - Engine power
 - Search technology
 - ...
- Restrict one input, and fishers will increase another

SOCIAL SCIENCES GROUP
WAGENINGEN UR

Alaska Halibut Fishery

Fishing periods introduced in 1977

In the late 1980s the fishing period was shorter than 24 hours!

SOCIAL SCIENCES GROUP
WAGENINGEN UR

Instruments

- Tradable quota
- Effort restrictions
- Taxes and subsidies
- Restrictions in time and space

SOCIAL SCIENCES GROUP
WAGENINGEN UR

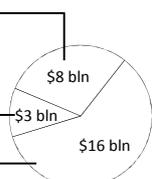
Landing taxes

- Similarities taxes and ITQs
 - Assign price to right to land fish
 - Generate government revenue (ITQs if auctioned)
- Difference taxes and ITQs
 - TAC is not given under taxes

SOCIAL SCIENCES GROUP
WAGENINGEN UR

Subsidies (Sumaila, 2010, J Bioeconomics)

- Total amount in 2003: \$27 bln
- Beneficial subsidies
 - Management, R&D, MPAs
- Ambiguous
 - Buyback subsidies, fisher assistance
- Capacity-enhancing
 - Fuel subsidies, port development, boat construction



SOCIAL SCIENCES GROUP
WAGENINGEN UR

Buy-back subsidies

- Reduce capacity immediately by buying vessels
- Recent Dutch buy-backs
 - 24 of approx. 140 cutters
 - Total budget approx. € 27 mln
- But: construction of new vessels?
 - Trading old boats for new ones
 - Taking away risk of investment

SOCIAL SCIENCES GROUP
WAGENINGEN UR

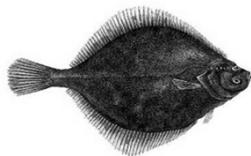
Instruments

- Tradable quota
- Effort restrictions
- Buyback subsidies
- Restrictions in time and space

SOCIAL SCIENCES GROUP
WAGENINGEN UR

Closed seasons and areas

- Spawning period of species
 - Plaice: January – March
 - Monsoon ban in India
- Nursery or spawning areas
 - Plaice: 'Plaice Box' in the North Sea
 - MPAs in EU waters and elsewhere



SOCIAL SCIENCES GROUP
WAGENINGEN UR

North Sea Plaice Box



Off limits for beam trawlers with more than 300 HP (approx. 224 kW)

Marine Reserves



Areas designated as marine reserves in the Dutch Continental Platform under the OSPAR treaty (<http://www.ospar.org>)

Natural resource problems in economics

- What is the problem?
 - Open access resources
- What are the policy objectives?
 - MSY, MEY, discount rate
 - Risk and uncertainty
 - Social objectives
- What instruments are possible?
 - ITQs, days-at-sea, subsidies, MPAs
- What instruments are best?
 - None, probably a mix of instruments needed