Integrating different user groups into fishery management

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Conflicting interests between fisheries user groups

- Different user groups have stakes in fisheries
  - larger scale commercial fishing firms etc...
  - small-scale or part-time artisanal fishermen
  - recreational fishermen

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- Negative externalities undermine the **sustainability** and **value** withdrawn by society from fisheries resources

Facts about Recreational Fisheries

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- Regarding Europe, marine recreational fisheries gain importance:
  - In 2008, Bay of Biscay: recreational catches of sea bass ≈ **same order of magnitude** as those of the professional sector (Ifremer and BVA, 2009)
  - Between 2005–2010, the western Baltic Sea: annual recreational fishery cod harvests ≈ a share varying **between 34 to 70%** of the German commercial landings (Strehlow et al., 2012)

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- Management of recreational fisheries observed worldwide generally relies on a combination of regulatory measures
  - prohibition to cell caught fish
  - purchase of an angling license
  - control of fishing effort (protection of some species, bag limits, legal size, gear restrictions, protected areas or closed seasons, etc.)

- Harry V. Strehlow, Norbert Schultz, Christopher Zimmermann, and Cornelius Hammer. Cod catches taken by the German recreational fishery in the western Baltic Sea, 2005—2010 : implications for stock assessment and management. *ICES J. Mar. Sci.* (2012) 69 (10): 1796—1780

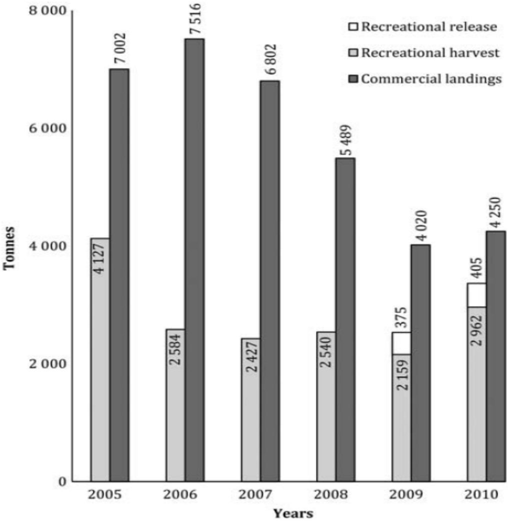

Figure: Cod harvest in t y^{-1} in the German Baltic Sea (SD 22 + 24), and total landings in the German commercial fishery (SD 22 + 24) from 2005 to 2010, including recreational cod releases in 2009/ 2010

Facts about Small Scale Fisheries in Europe

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- Large number of vessels: 84% of the vessels of the EU's fishing fleets (STECF, 2013)
- About 30% of EU landings in value and 9% in volume
- The regulation of the Small Scale Fisheries sector is heterogenous
  - So far the CFP has not managed to provide a regulatory frame that addresses the needs of the SSF
  - There is no commonly agreed definition of SSF at European level
  - Conservation measures are decided in practically equal proportions at EU, national or regional/local levels
    $\rightarrow$ Open access situations are possible in SSF (Guyader et al., 2013)

Objective function

Question: What is the efficient or socially optimal quota allocation of resource use rights over fishermen with different objectives, so as to

- maximize the societal benefits withdrawn from living marine resources
- prevent overexploitation of fish stocks
- improve the economic benefits derived by the various users of the fishery?

$$U(H_t, L_t) = u(H_t; \eta) + \alpha v(L_t; \beta)$$

Utility from catching a quantity H_t with fishing time (labor) L_t
User groups are differentiated via parametrization: α, η, β

Production function

$$H_t = F(x_t, K_t, L_t) = q x_t^{\theta} \underbrace{L_t^{\gamma} K_t^{1-\gamma}}_{= E_t \text{ ('effort')}}$$

Cost minimization

$$\min_{L_t, K_t} \left\{ w L_t + r K_t - u\left(H_t, L_t\right) \text{ s.t. } H_t \geq F\left(x_t, L_t, K_t\right) \right\}$$

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From the F.O.C of the cost-minimization program

$$\frac{w - \alpha v'\left(L_t\right)}{r} = \frac{F_{L_t}\left(x_t, L_t, K_t\right)}{F_{K_t}\left(x_t, L_t, K_t\right)} = \frac{\gamma}{1-\gamma} \frac{K_t}{L_t}$$

$$\Leftrightarrow K_t = \frac{1-\gamma}{\gamma} \frac{w - \alpha v'\left(L_t\right)}{r} L_t$$

$$H_t = F\left(x_t, L_t, K_t\right) = q x_t^{\theta} \left(\frac{1-\gamma}{\gamma} \frac{w - \alpha v'\left(L_t\right)}{r}\right)^{1-\gamma} L_t$$

The demand for time at sea

Differentiating with respect to H gives

$$L^{*\prime}(H_t) = \frac{1}{\frac{H_t}{L_t} - \frac{(1-\gamma)^2}{\gamma r}(qx_t^{\theta}L_t)^{\frac{1}{1-\gamma}} H_t^{\frac{-\gamma}{1-\gamma}} \alpha v''(L_t)} > 0$$

$L^*(H_t)$ is increasing in H_t for $v''(L_t) \leq 0$

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The demand for time spent at sea admits a lower boundary

$$H \to 0 \quad \Leftrightarrow \quad L_{min} = \left(\frac{\alpha}{w}\right)^{\frac{1}{\beta}} \geq 0$$

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The second derivative of $L^*(H_t)$, with respect to H_t

$$L^{*\prime\prime}(H_t) \geq 0 \quad \Leftrightarrow \quad \hat{L} \leq L_{min}\left(1 + \frac{\beta}{1-\beta}\gamma\right)^{\frac{1}{\beta}}$$

- The demand for time at sea is convex in harvest for L_t below the threshold level $\hat{L}$
- Displays constant returns to scale for $\alpha = 0$

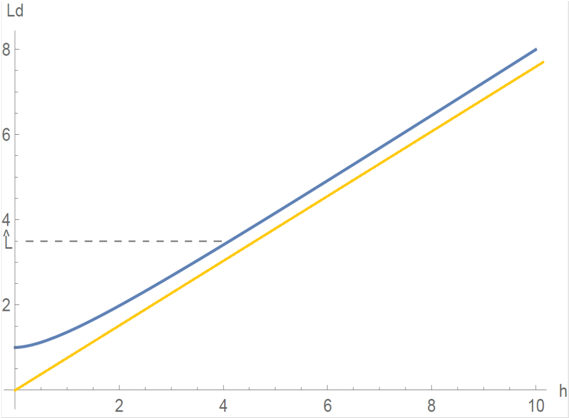

Figure: Demand for time at sea $L^*(H_t)$ for users with $\alpha > 0$ (blue) versus $\alpha = 0$ (yellow)

Profit maximization

$$\max_{H_t} \left\{ U\left(H_t, L^*(H_t)\right) - w\, L^*(H_t) - r\, K_t^* - p\, H_t \right\}, \quad \Leftrightarrow$$

$$\max_{H_t} \Big\{ u\left(H_t\right) + \alpha v\left(L^*(H_t)\right) - \frac{w}{\gamma} L^*(H_t) + \frac{1-\gamma}{\gamma} \alpha v'\left(L^*(H_t)\right) L^*(H_t) - p\, H_t \Big\}$$

Inverse demand function for quota

$$p = u'(H_t) - \left(\frac{w - \alpha v'(L^*(H))}{\gamma} - \frac{1-\gamma}{\gamma} \alpha v''(L^*(H))\, L^*(H_t) \right) L_H^*$$

Inverse demand function for quota

Appling the following specification for $v(L_t)$

$$v(L_t) = \frac{L_t^{1-\beta} - 1}{1 - \beta}$$

where β conveys the scale of the recreational fishing activity as well as the satiety of this fishing group w.r.t. L_t.

The specification of p becomes

$$p = u'(H_t) - \frac{L^*(H_t)}{H_t} \frac{\left(w - \alpha L^*(H_t)^{-\beta}\right)}{\gamma},$$

User groups who derive utility from time at sea have a higher demand for harvesting rights

The slope of the inverse demand function:

$$p_{H_t} = u''(H_t) - \frac{(w - \alpha L^*(H_t)^{-\beta})}{H_t^2} \frac{\beta\alpha L^*(H_t)^{1-\beta}}{w - \alpha L^*(H_t)^{-\beta}(1-\beta(1-\gamma))} \leq 0,$$

For $u''(H_t) \leq 0$

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For $u''(H_t) \leq 0$

The derivative of p w.r.t. x_t:

$$p_{x_t} = \frac{q\theta}{\gamma x_t} L^*_{H_t}\left(w - \alpha(1-\beta)L^*(H_t)^{-\beta}\right) \geq 0$$

The price of fishing quotas is increasing in the stock level of the targeted species.

Assuming the following specification for utility derived from harvest

$$u(H_t) = \frac{H_t^{1-\eta} - 1}{1 - \eta},$$

with $u'(H_t) = H_t^{-\eta} \geq 0$, and $u''(H_t) = -\eta H_t^{-\eta} \leq 0$.
The derivative of p w.r.t. η gives

$$P_\eta = u_{H_t,\eta} = -H_t^{-\eta} ln(H_t).$$

The level of the TAC determines the willing to pay for rights to fish of a given group.

Notice that as $u(H_t)$ and $v(L_t)$ have the same specification, the parameters η and β relate to there elasticity of substitution.

The boundary of the inverse demand function for $H \to 0$

$$\lim_{H_t \to 0} p = u'(H_t) - \left(\frac{1-\gamma}{\gamma} \beta w \right) L_H^* = u'(H_t)$$

On the other hand, when $\alpha = 0$, we have

$$\lim_{H_t \to 0} p = u'(H_t) - \frac{w}{\gamma} L_H^*.$$

This difference comes from the substraction of the marginal operating cost of fishing.

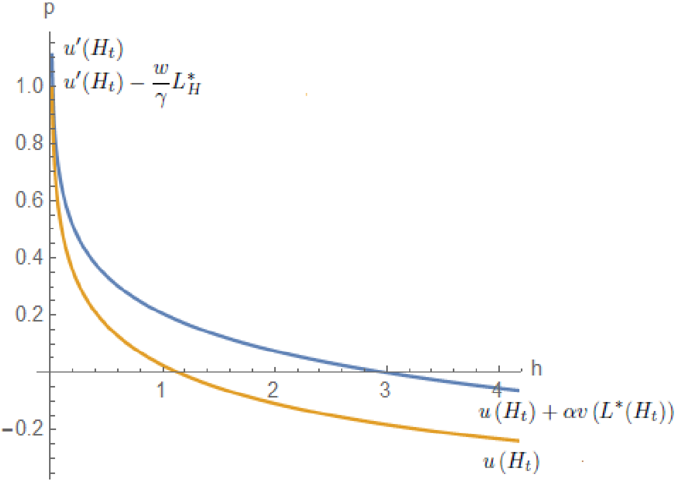
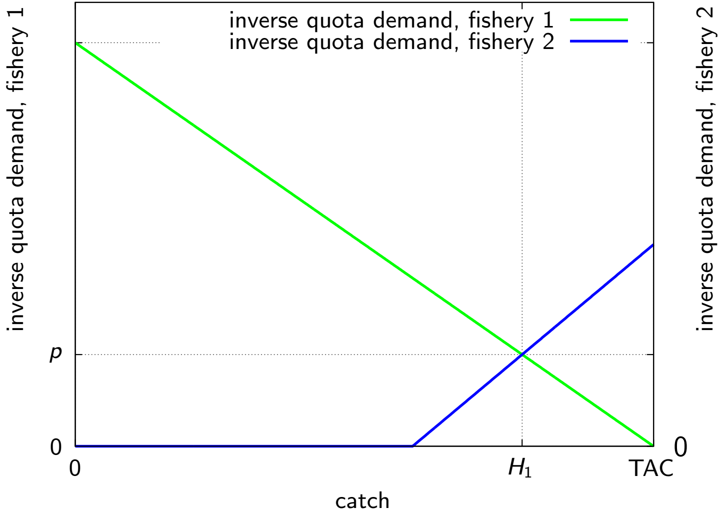
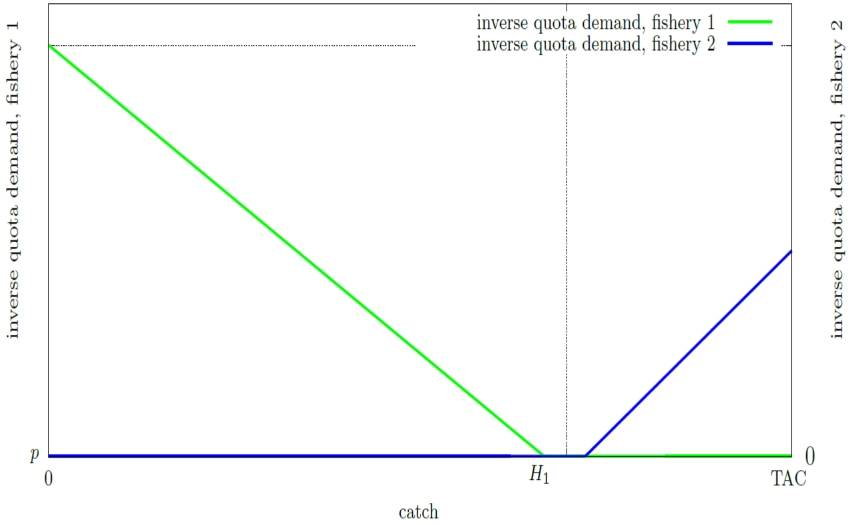


Figure: Difference in p for users with $\alpha > 0$ (blue) versus $\alpha = 0$ (yellow)


inverse quota demand, fishery 1
inverse quota demand, fishery 2
inverse quota demand, fishery 1
inverse quota demand, fishery 2
p
0
0
0
H1
TAC
catch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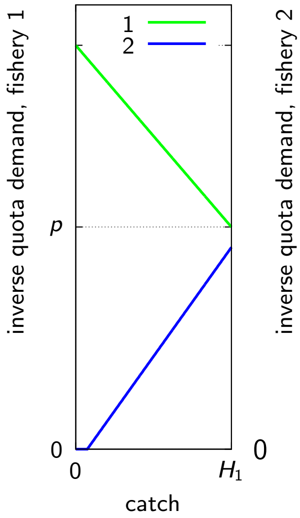
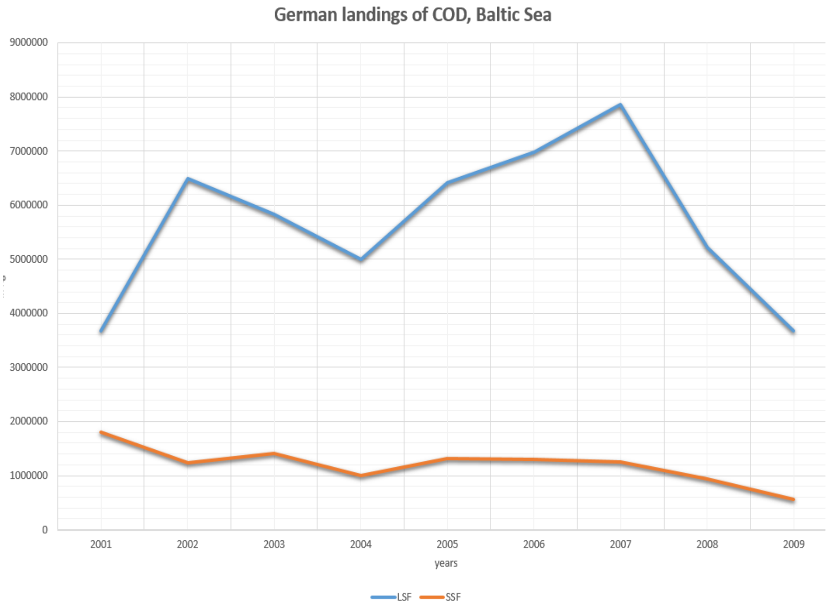
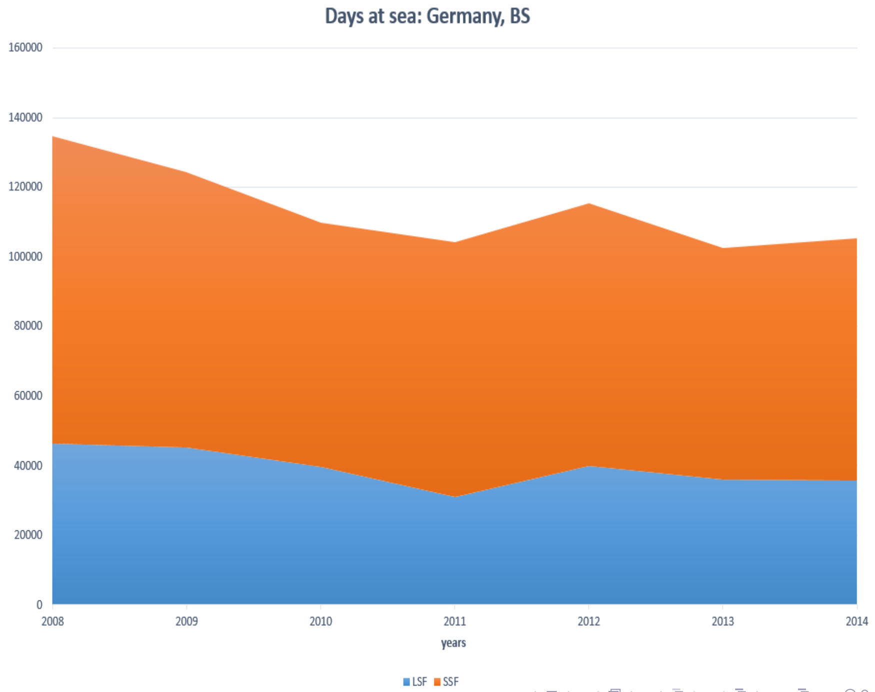
p
0
0
H_1
TAC
catch

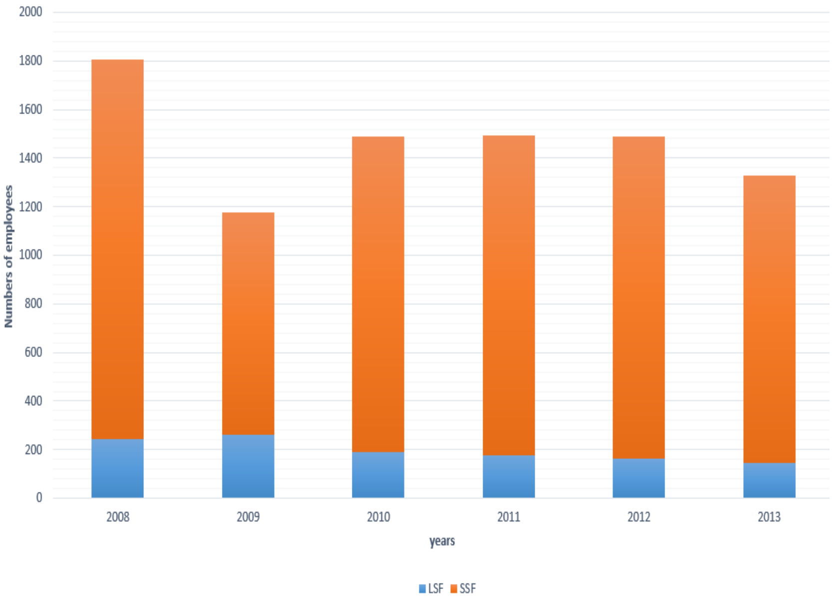

inverse quota demand, fishery 1
inverse quota demand, fishery 2
1
2
p
0
0
0
H1
catch

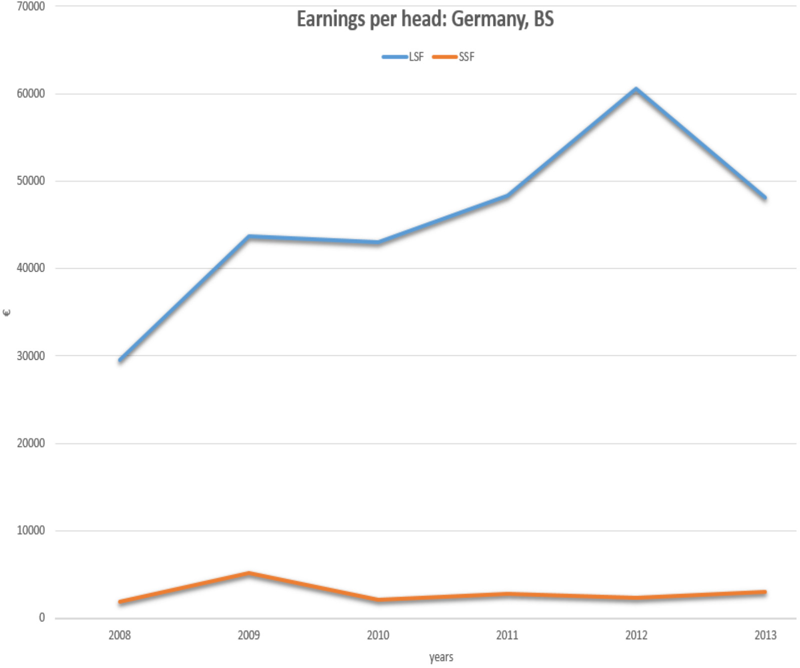


Sources: STECF 14-16


Days at sea: Germany, BS
160000
140000
120000
100000
80000
60000
40000
20000
0
2008
2009
2010
2011
2012
2013
2014
years
LSF
SSF

Employment in FTE: Germany, BS




Earnings per head: Germany, BS
LSF
SSF
70000
60000
50000
40000
30000
20000
10000
0
€
2008
2009
2010
2011
2012
2013
years

Forthcoming research lines

- Apprease the welfare loss subsequent to an inefficient regulation: $\rightarrow$ different quota price across user groups

- Introduce ecosystem dynamics and either
  - Seek for the socially optimal TAC and its allocation
  - Conduct a dynamic programming analysis under a set of constraint (Viability approach) to explore sustainable quota allocations

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Cooke, S. J. and Cowx, I. G. (2004). The role of recreational fishing in global fish crises. *BioScience*, 54:857–859.

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Thank you !