Effective management of deep-water species: The Icelandic redfish fishery in the Irminger Sea

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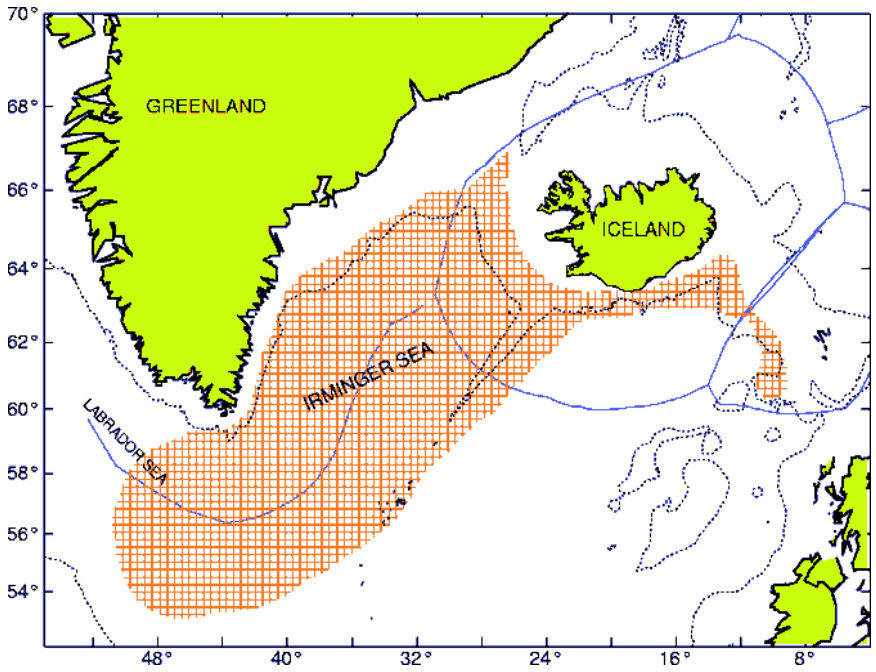
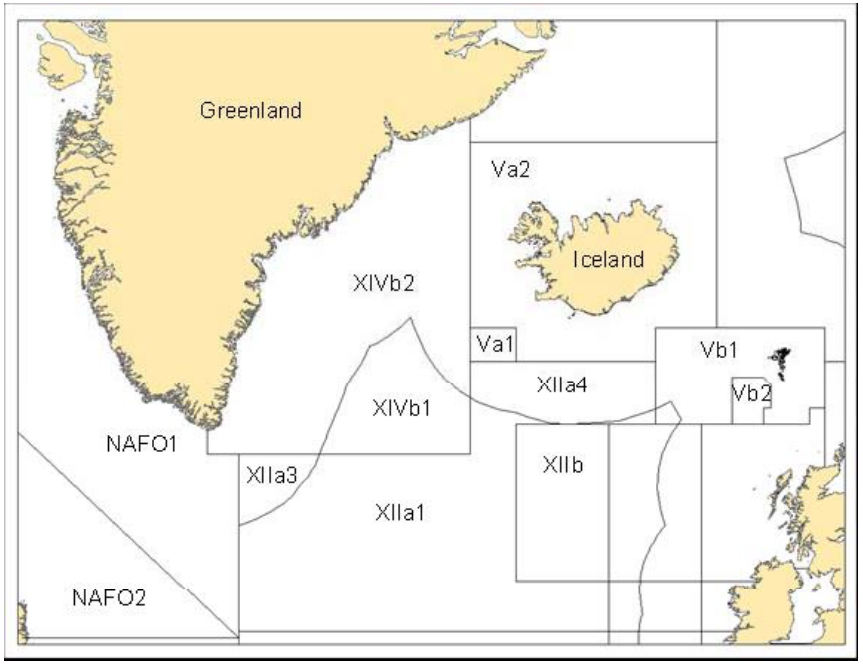
Redfish fishery in the Irminger Sea

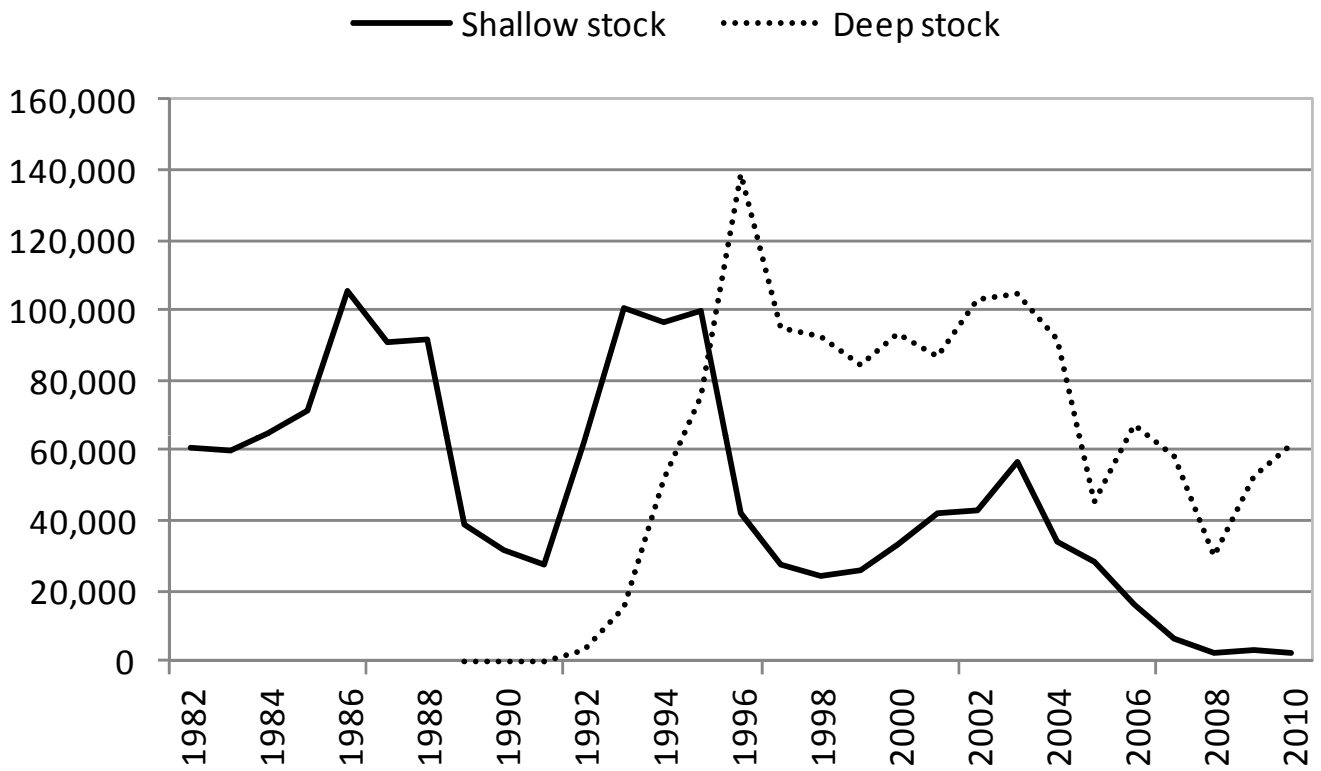




Beaked redfish (*Sebastes mentella*) , defined by ICES as two different biological stocks

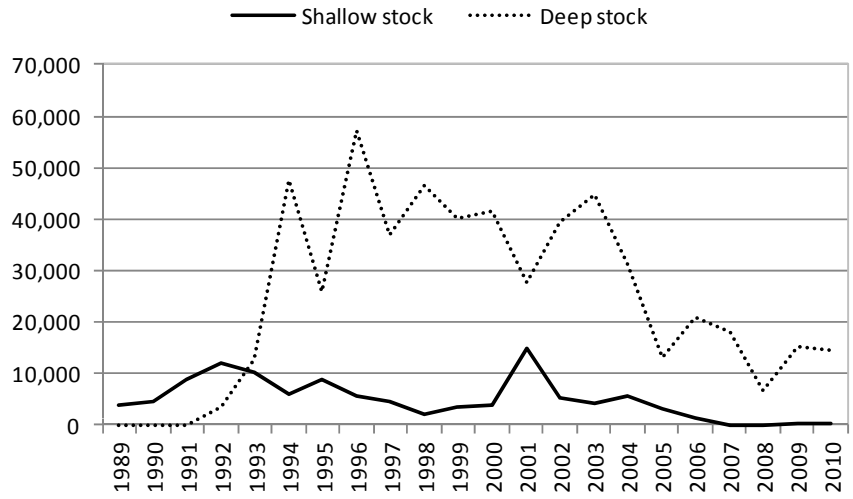
- Shallow stock , above 500 m.
- Deep stock, 600-900 m

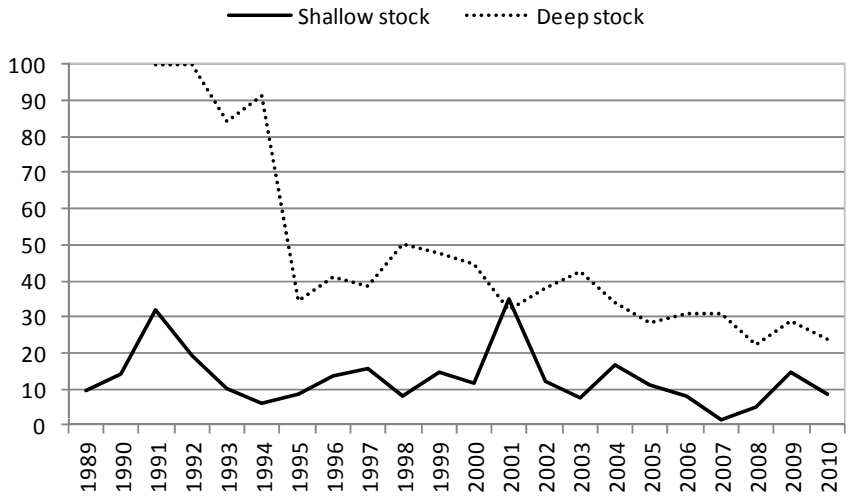
Redfish fishery in the Irminger Sea

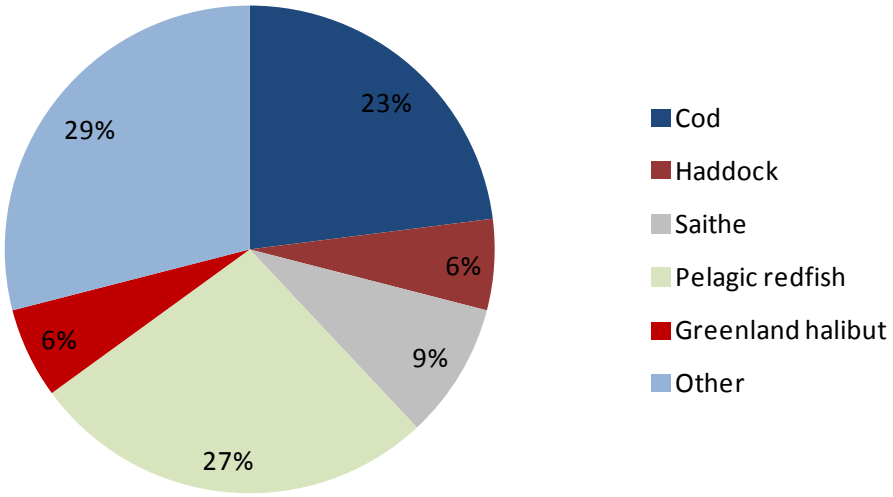


- **Shallow stock** ; fishing began in 1982. Fishing banned since 2009 – Russia not party to that agreement. Stock declined from 2.2 m tonnes in 1994 to 110 thousand tonnes in 2009.
- **Deep stock**; fishing began in early 1990s. Total TAC of 32-38 thousand tonnes in 2011-2012. Stock estimated at 460 thousand tonnes in 2009, 32% smaller than in 2003.

Icelandic fishery in the Irminger Sea







Catch composition of half of the trawlers taking part in the pelagic redfish fishery 1992-2010.

Icelandic fishery in the Irminger Sea

ITQ management system

- Quotas can be transferred between vessels and fishing years.
- The Irminger Sea redfish fishery provides a good illustration.

	2008	2009	2010	2011
Total quota allocated	8,290	14,758	14,758	11,788
Number of vessels with quota allocation	23	24	24	25
Transfers between years	972	1,819	822	0
Transfers between vessels	4,251	6,618	6,239	3,185
- as a percentage of total quota allocated	51.3%	44.8%	42.3%	27.0%
Number of active vessels	11	12	14	14
Total catches	6,785	15,529	14,774	12,066

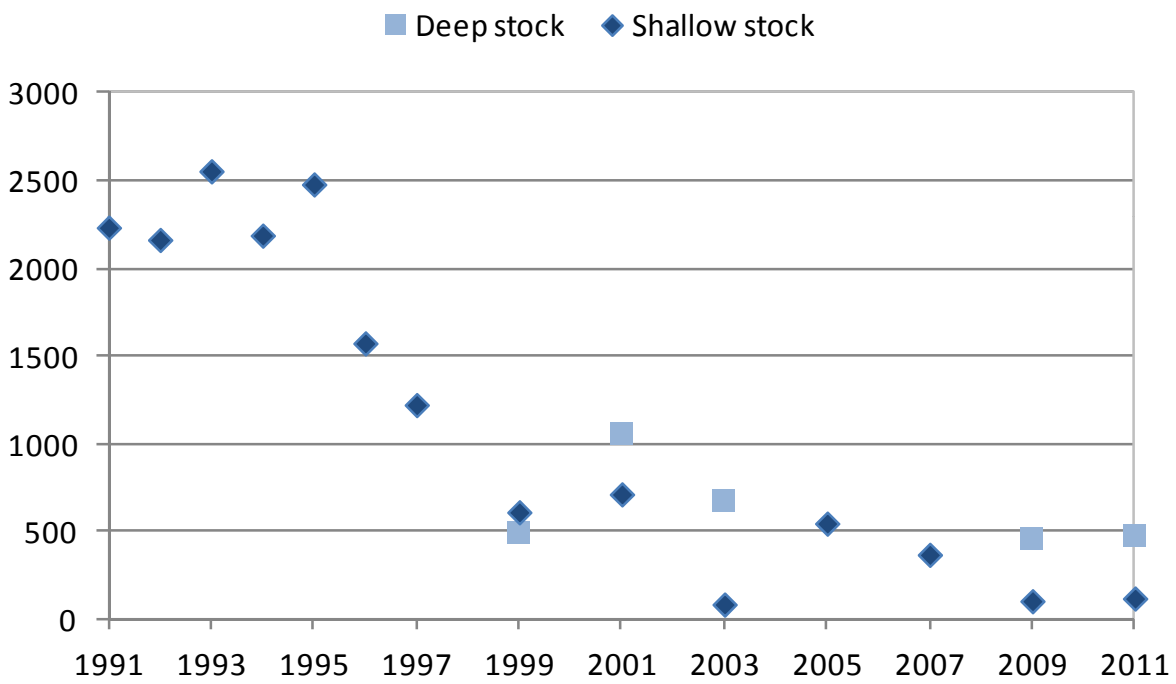
Net profits in the Icelandic fisheries. Percentage of revenue

	All vessels	Small boats (< 10 GRT)	Boats 10-200 GRT	Large boats (> 200 GRT)	Pelagic fleet	Icefish trawlers	Freezing trawlers
1997	-1.7	6.2	-10.5	-6.6	8.1	-5.0	-1.2
1998	1.1	2.0	-8.7	1.0	5.2	-5.6	1.3
1999	0.2	8.2	6.4	11.7	-23.3	-0.1	6.4
2000	-7.7	3.4	-11.9	-4.2	-26.7	-14.2	-0.3
2001	-2.1	4.7	-1.5	-10.5	-11.6	-12.7	4.6
2002	15.8	1.0	16.1	15.2	13.2	18.2	21.0
2003	3.5	-13.5	7.0	5.9	-2.2	5.0	9.3
2004	3.8	-8.4	8.0	5.1	-1.4	0.5	7.3
2005	11.6	3.1	4.1	12.0	3.8	11.5	17.1
2006	-12.5	-4.3	-16.5	-20.1	-26.3	-4.9	-6.5
2007	14.7	-1.8	7.4	22.3	13.3	18.3	14.5
2008	-105.2	-82.0	-219.1	-129.8	-79.6	-59.6	-66.5
2009	9.1	5.1	-1.3	0.7	5.3	15.6	16.6
2010	13.6	10.4	17.9	21.0	12.7	19.0	7.3

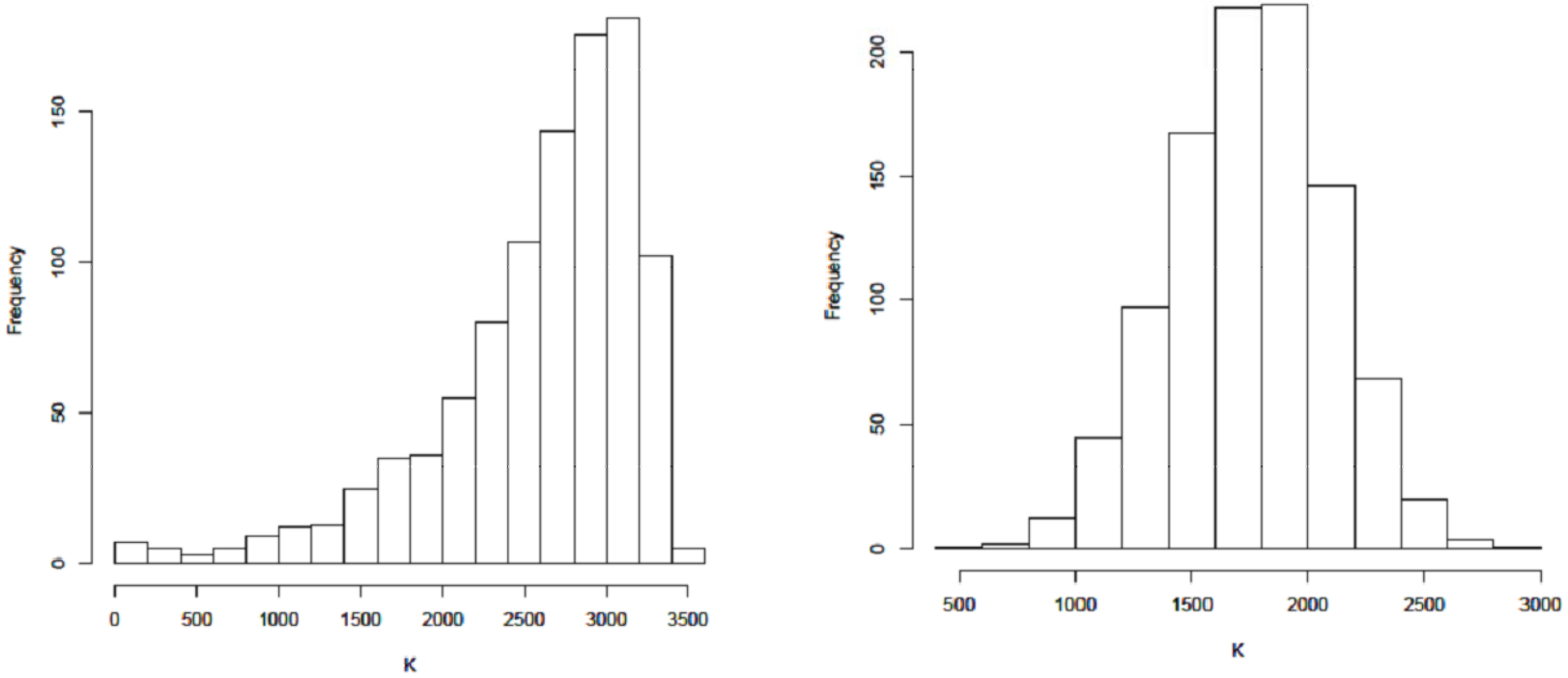
Bioeconomic model of Icelandic redfish fishery in the Irminger Sea

- Aggregate bioeconomic model – no cohorts
- Look at Icelandic fishery in complete isolation
- Model the fishery of each stock independently – harvesting of one stock not assumed to affect the other.
- Deterministic model
- Stochastic model – to take data poorness into account
  - Uncertainty in costs and carrying capacity
  - Stochasticity in prices and growth
- Different management strategies
  - Open access
  - MSY; maximum sustainable yields
  - MEY; maximum sustainable instantaneous profits
  - OSY; equilibrium solution of an optimal control problem that maximises social utility

Poor data – stock estimates

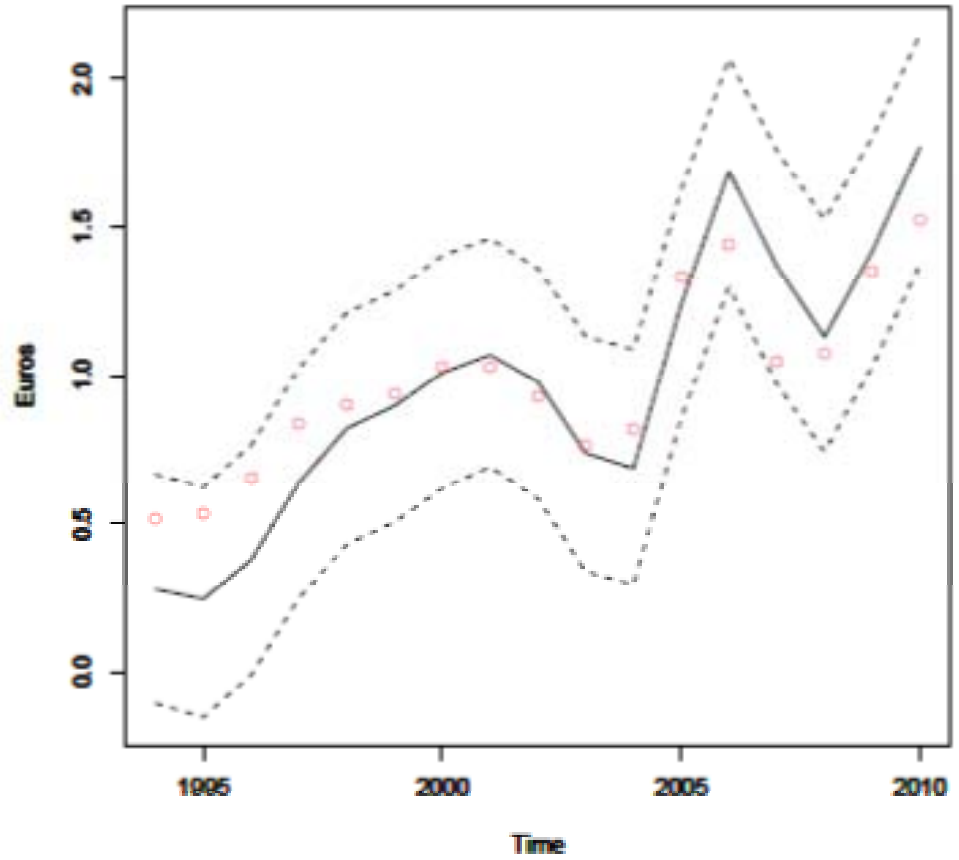


Uncertain carrying capacity



- Shallow stock (left) – generalised Gaussian distribution, fat left tail.
- Deep stock (right) – normal distribution.

Output prices.

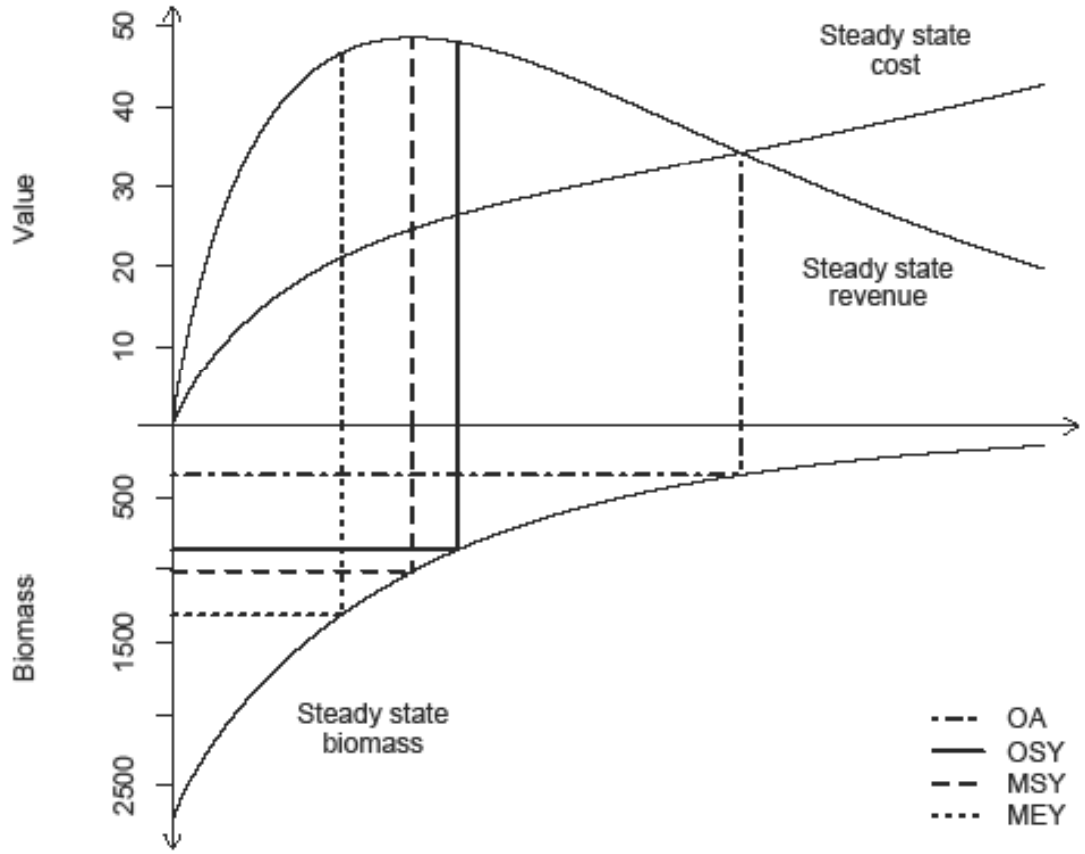


- Deterministic prices – pricetaker in a world market.
- Stochastic – normally distributed.

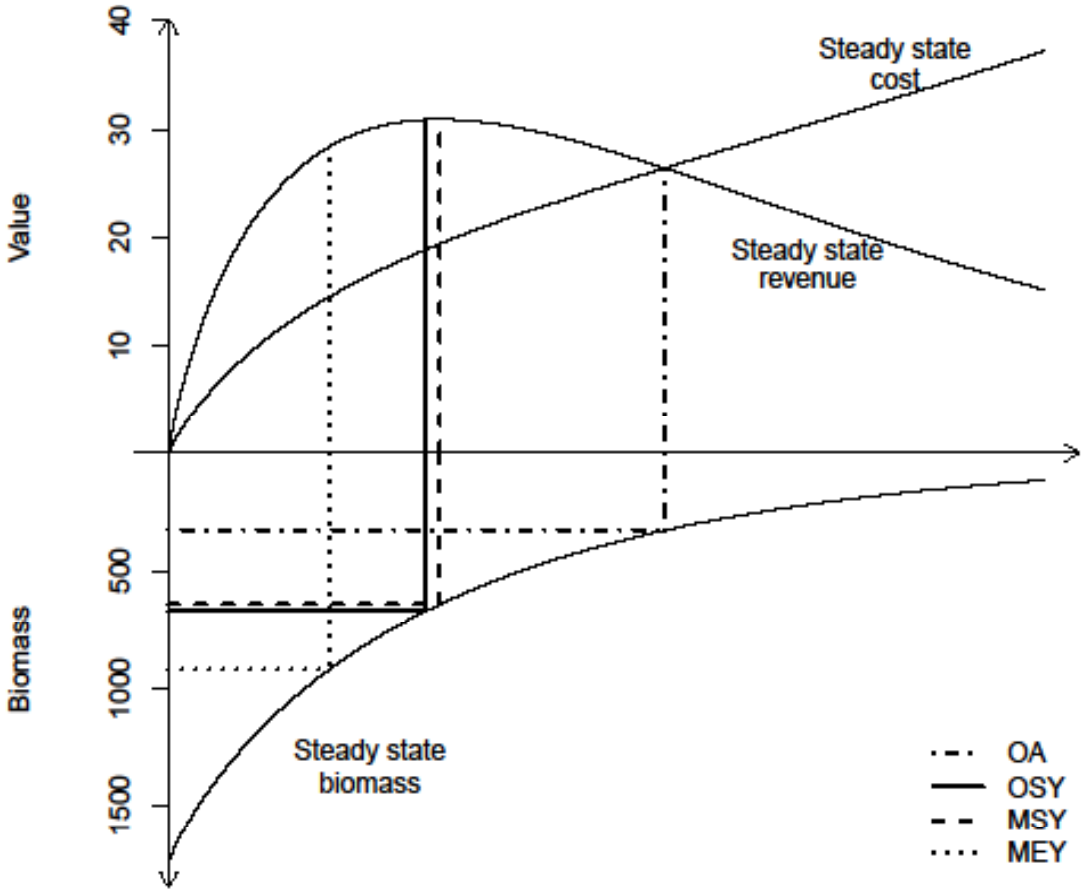
Paramter values used in deterministic model.

Parameter	Symbol	Value	Unit of measurement
Mortality rate	M	0.05	%
Carrying capacity			
Shallow stock	K	2750	Thousand tonnes
Deep stock	K	1750	Thousand tonnes
Output elasticity of effort	ξ	0.85	
Output elasticity of stock	ζ	1.0	
Crew share of revenue	ρ	30	%
Price	P	0.96	€ per kg
Operating costs	ω	343	€ million per unit of effort

Steady state harvest and revenue under different deterministic scenarios. Shallow stock



Steady state harvest and revenue under different deterministic scenarios. Deep stock



Steady state harvest. Thousand tonnes.

	OSY	MEY	MSY
Shallow stock			
Uncertain carrying capacity and cost	50.2	48.8	51.0
Uncertain cost	49.9	48.7	50.6
Uncertain carrying capacity	50.4	49.0	51.0
Deterministic	50.0	48.6	50.6
Deep stock			
Uncertain carrying capacity and cost	33.0	30.5	33.2
Uncertain cost	32.1	29.7	32.2
Uncertain carrying capacity	33.2	30.7	33.2
Deterministic	32.2	29.6	32.2

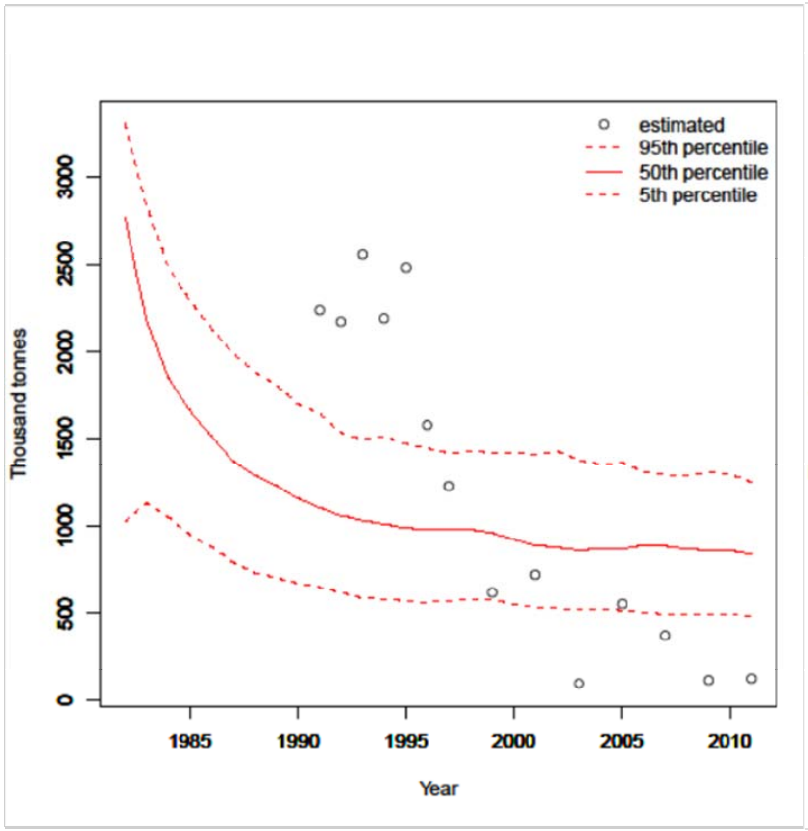
Steady state stock size. Thousand tonnes.

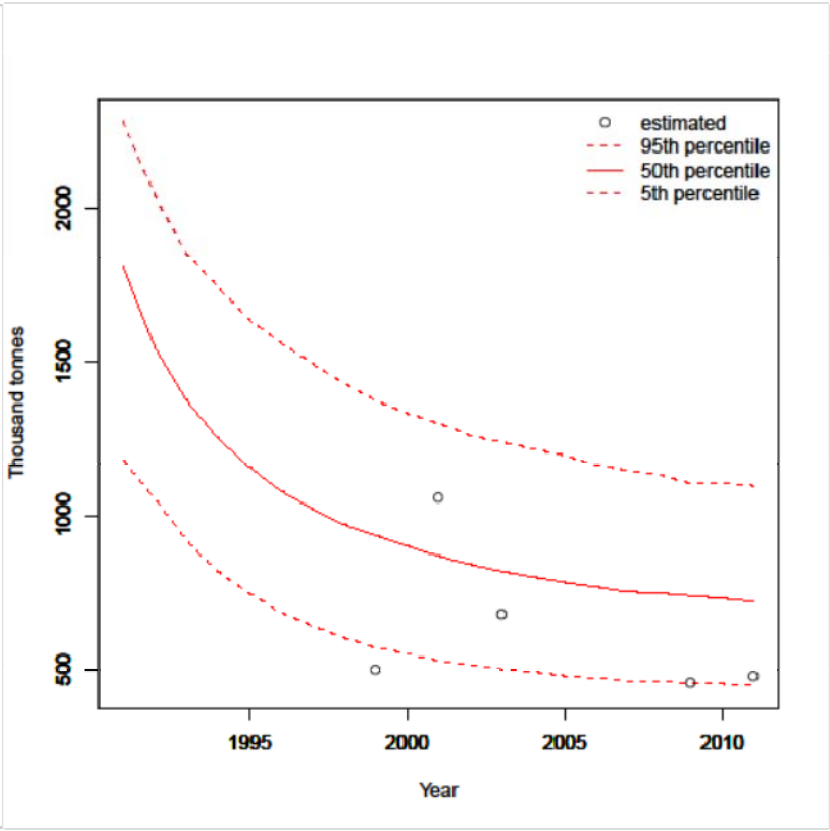
	OSY	MEY	MSY
Shallow stock			
Uncertain carrying capacity and cost	851.1	1319.0	1019.3
Uncertain cost	850.5	1299.0	1011.7
Uncertain carrying capacity	867.1	1316.0	1019.3
Deterministic	863.3	1308.0	1011.7
Deep stock			
Uncertain carrying capacity and cost	673.0	924.0	664.2
Uncertain cost	661.7	911.0	643.8
Uncertain carrying capacity	684.0	941.0	664.2
Deterministic	672.7	919.0	643.8

Present value of steady state profits. € million

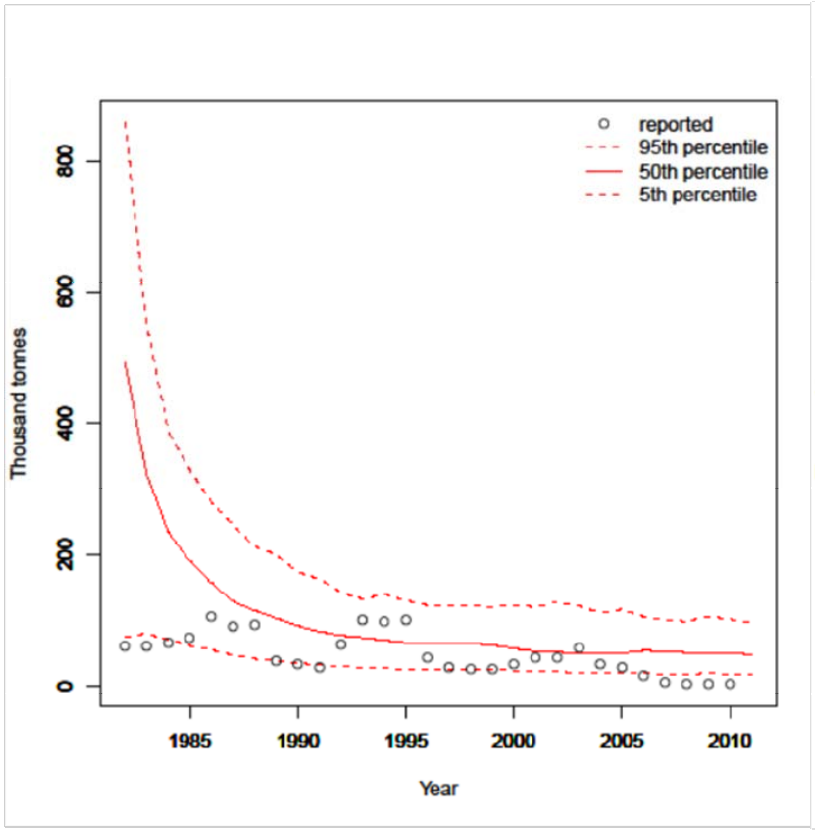
	OSY	MEY	MSY
Shallow stock			
Deterministic	162.8	142.1	160.0
Stochastic biomass and price	193.0	165.7	188.4
Stochastic price	173.2	149.7	169.0
Stochastic biomass	183.5	159.0	179.2
Uncertain carrying capacity and price	157.9	139.5	157.4
Uncertain cost	162.9	143.7	161.7
Uncertain carrying capacity	162.5	143.5	161.4
Uncertain carrying capacity and cost and stochastic biomass and price	174.6	157.9	175.2
Deep stock			
Deterministic	180.2	178.7	161.7
Stochastic biomass and price	210.7	210.0	188.8
Stochastic price	191.8	191.1	170.6
Stochastic biomass	200.5	198.5	179.1
Uncertain carrying capacity and price	188.5	187.1	166.8
Uncertain cost	184.1	182.3	164.1
Uncertain carrying capacity	186.3	185.5	167.3
Uncertain carrying capacity and price and stochastic biomass and price	219.9	215.8	193.4

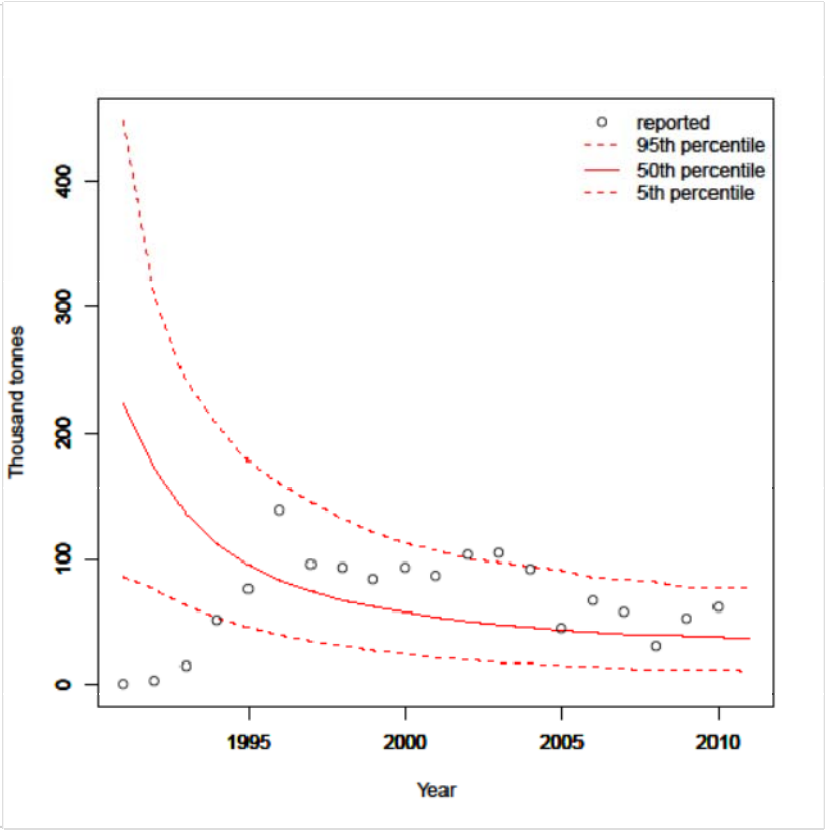
Estimated and simulated stocks. Shallow (left) and deep (right) pelagic stock.



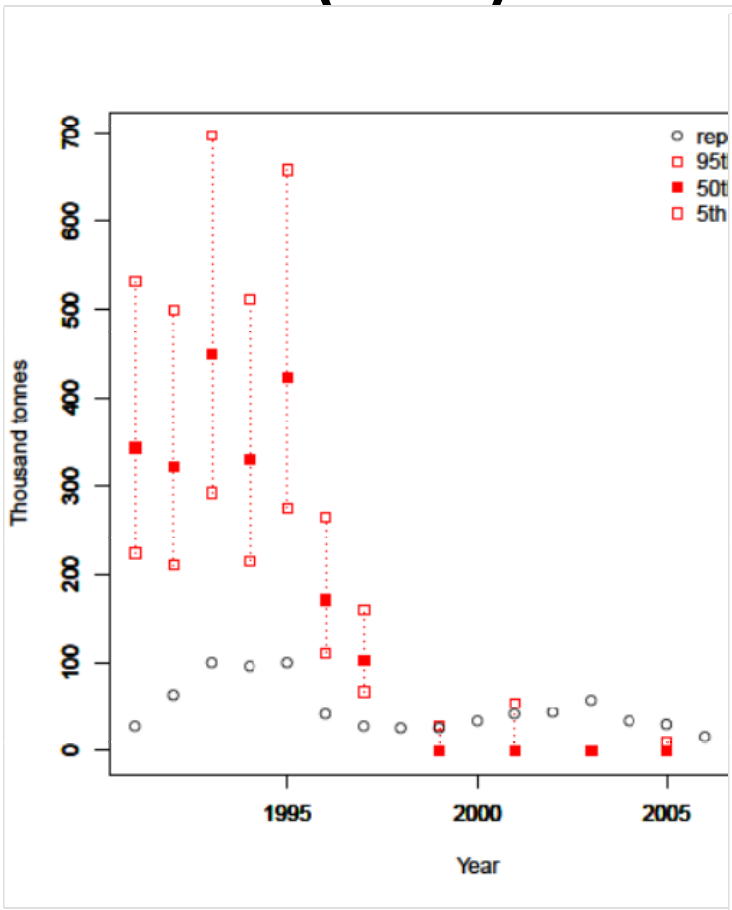


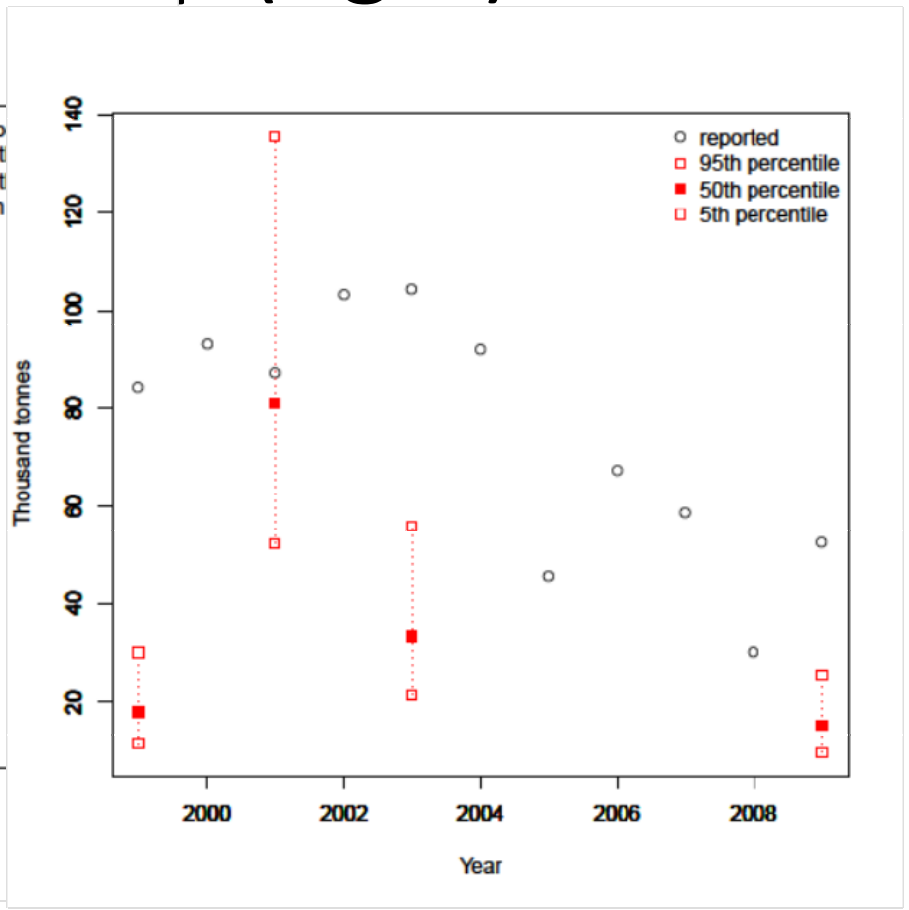
Estimated and simulated harvests. Shallow (left) and deep (right) pelagic stock.





Real and simulated harvests. Shallow (left) and deep (right) stocks.





Summary and conclusions

- Shown how data poverty can be taken into account.
- Allows for comparison between different type of management aims.
- Shallow stock; harvests should have been far greater in the beginning – catch as much of the fish that disappeared as possible.
- Deep stock; actual harvests always exceeded optimal harvests.
- Don’t allow for environmental factors.
- Try model out on other Deepfishman cases.

Thank you