

Are Fisheries Sustainable Resources?

... biological, environmental & socio-economic issues

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Outline

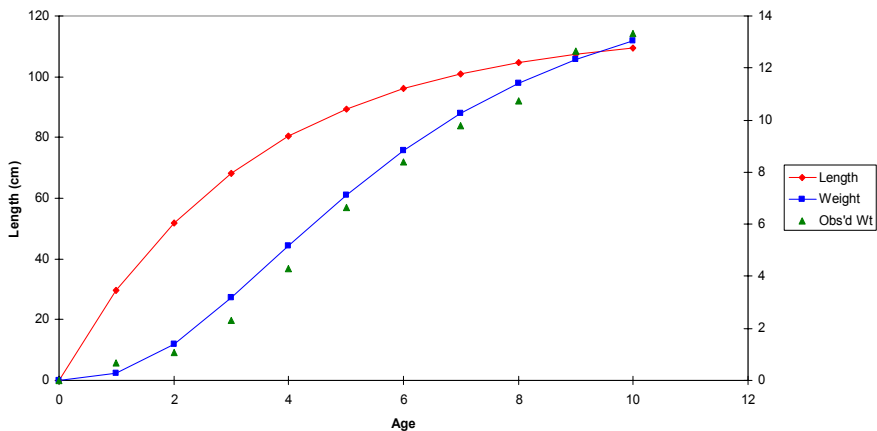
- Basics of fish stock dynamics
- Biological/Economic interactions
- Causes of over-exploitation
- The state of the stocks
- Environmental forcing
- Population dynamics & reproduction
 - the stock/recruitment problem
 - the risk of stock collapse
- Management tools & options

The three big factors

- ◆ Economics
 - short-term losses versus long-term gains
- ◆ The environment
 - year-to-year fluctuations, & longer-term trends
- ◆ Reproduction
 - the stock-recruitment relationship
 - the possibility of collapse

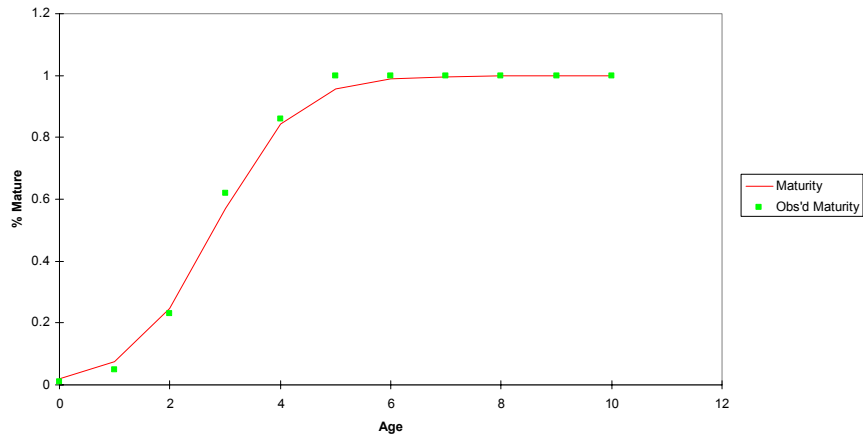
Fish Growth

North Sea Cod : Growth



Fish Maturation

North Sea Cod : Maturity Ogive

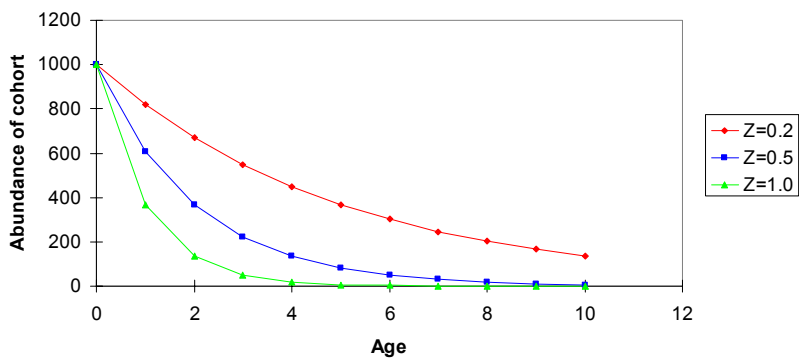


Death in the Sea

- ◆ IF a constant fraction Z of fish die per unit time (usually per year), then
- ◆ $dP/dt = -Z P(t)$
- ◆ which is a classic differential equation with the solution :
- ◆ $P(t) = P(0) \exp\{ -Zt \}$
- ◆ i.e. an exponential decline in number with time (and thus also with age)
- ◆ Z is the **total mortality rate** (coefficient)

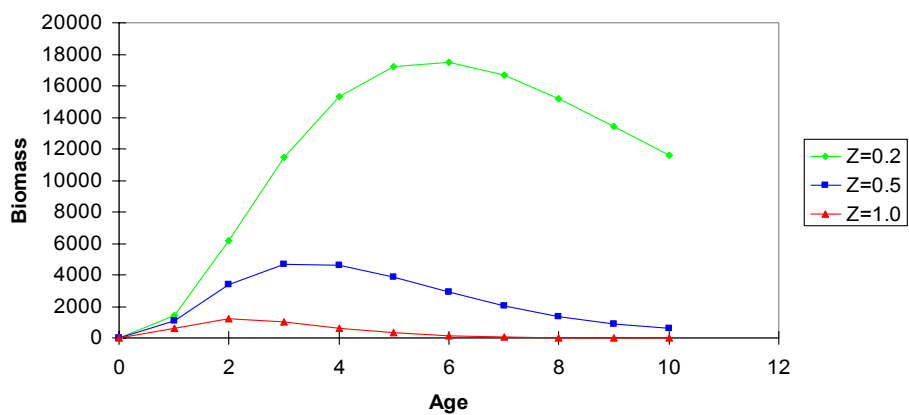
Effect of mortality on a cohort

Decline in abundance with age



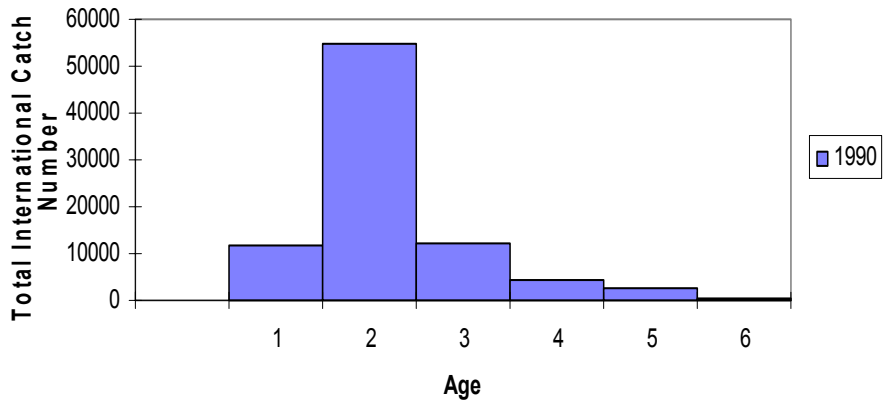
Biomass as a function of age

Biomass of a cohort at various ages



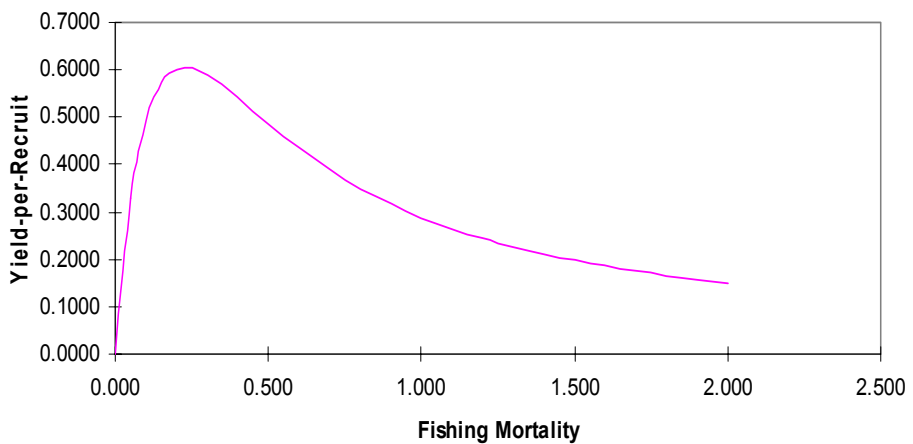
Age compositions

North Sea cod : Age composition of Catch (numbers)



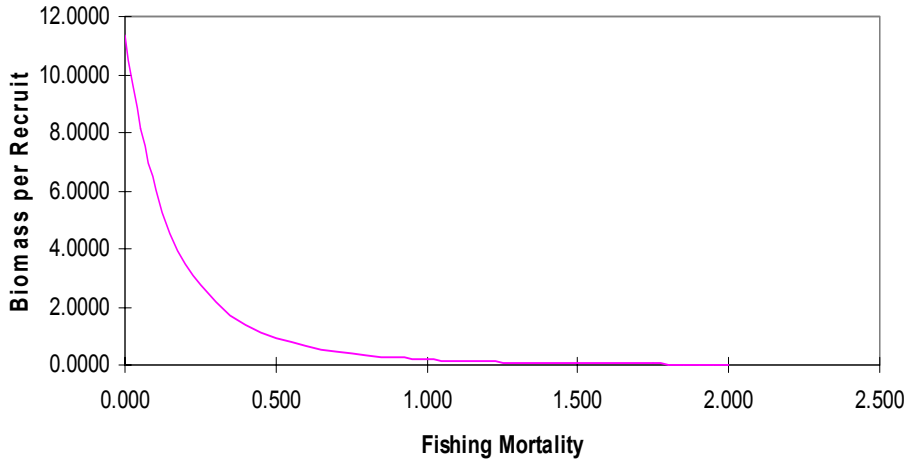
Yield-per-recruit curve (The "Yield Curve")

North Sea Cod : Yield per Recruit



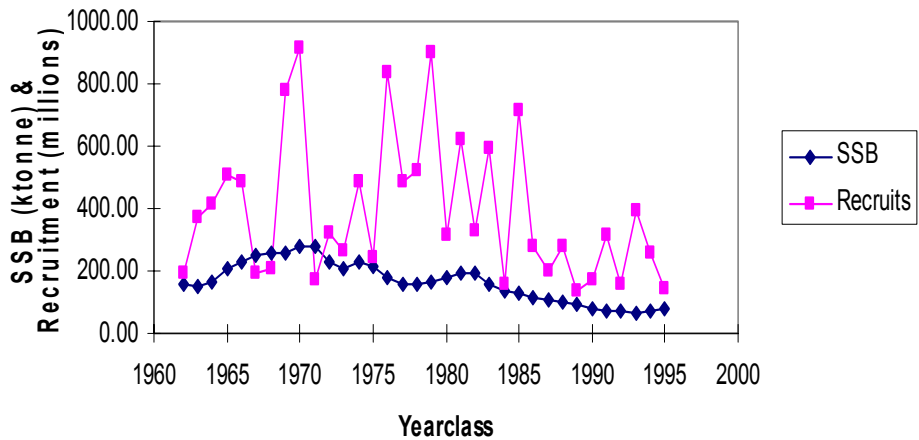
Biomass-per-recruit

North Sea Cod : Biomass per Recruit



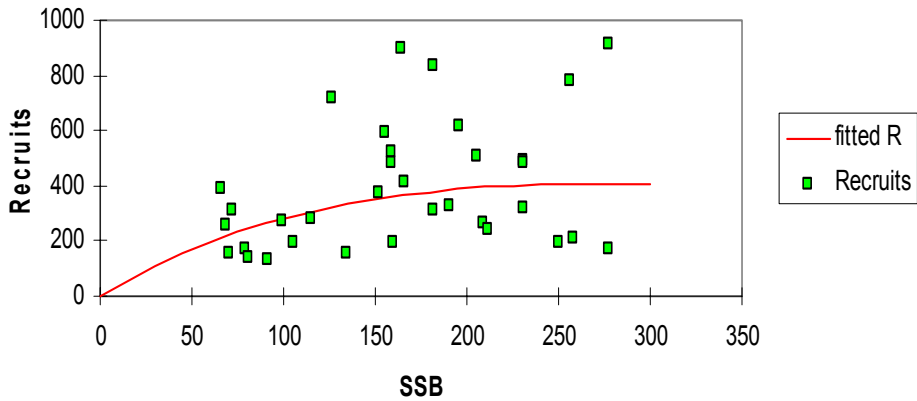
The Stock & Recruitment Problem

North Sea Cod : Stock and Recruitment



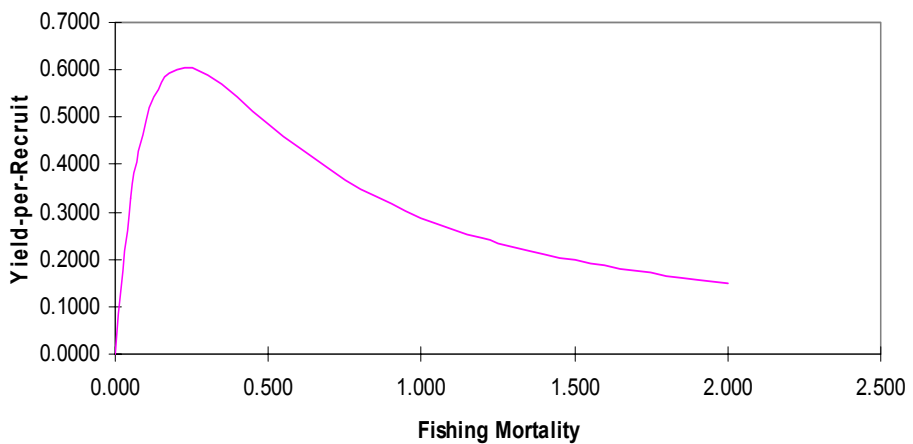
Stock & Recruitment

North Sea Cod : Stock & Recruitment



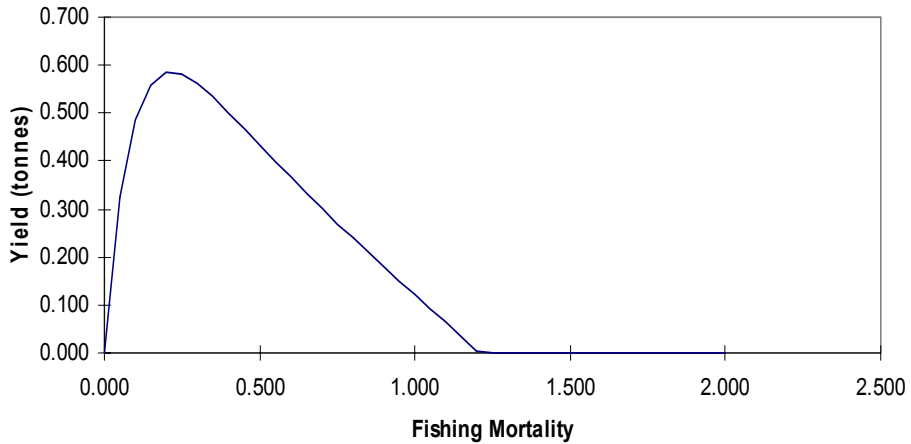
Yield-per-recruit curve (The "Yield Curve")

North Sea Cod : Yield per Recruit



Example of Combined Yield Analysis (3) Yield

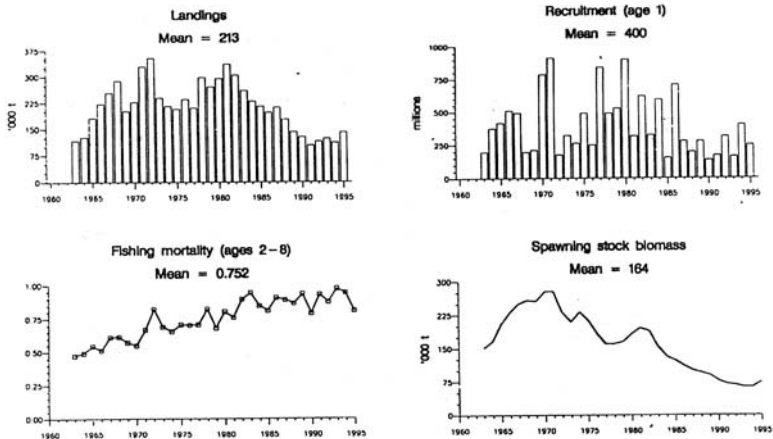
North Sea Cod : Estimated Total Yield



Example : The State of North Sea Cod

Figure 3.1.1

Cod in Fishing Areas IV, Skagerrak and VII d 9-10-1996



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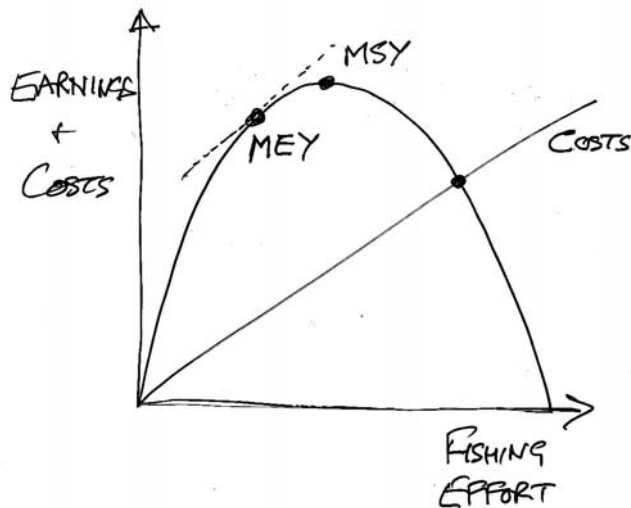
ICES WG Assessment in 1998

Catch forecast :

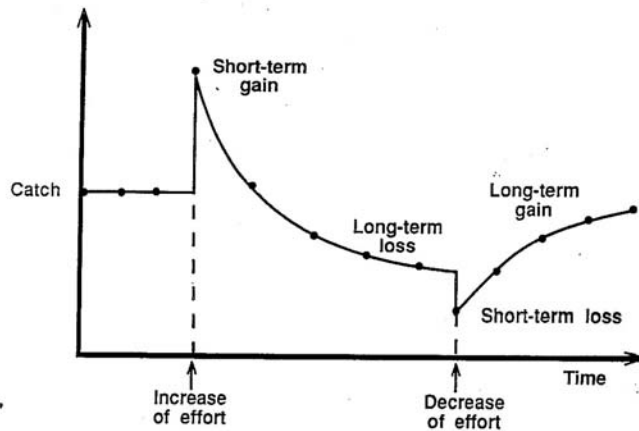
1997 assumptions : *status quo* $F=0.64$,

F (98)	basis	Landings in combined area (98)	Lndgs in IIIa (98)	Lndgs in IV (98)	Lndgs in VIId (98)	SSB (99)	Medium term effect of fishing at given level
.26	0.4F(96)	84	10.2	71.4	2.3	252	SSB rebuilds with low probability of SSB falling below MBAL ¹
.38	0.6F(96)	119	14.6	101.6	3.2	223	"
.51	0.8F(96)	151	18.4	128.7	4.1	198	"
.64	1.0F(96)	180	21.9	152.9	4.9	176	"
.76	1.2F(96)	205	25.0	174.7	5.5	156	High probability of SSB falling below MBAL is

Costs, Earnings, and Effort



Short-term losses vs. Long-term gains (3)



~~Figure 8. The same thing drawn in a different way~~

RESPONSE OF YIELD TO
CHANGES OF FISHING EFFORT

Real Management Problems

- ◆ **Not** poor scientific advice
- ◆ **Not** the Common Fisheries Policy
- ◆ Interaction of Biology & **Economics**
- ◆ Need for economic **intervention**

Real Scientific Problems (research opportunities)

- ◆ What Determines Recruitment ?
 - Fluctuations (weather, etc ?)
 - Stock size : the SRR (possible collapse)
- ◆ Multi-species interactions
 - Predators and prey (who eats who ?)
 - competition (limited resources) ???
- ◆ Basic biology, including ... stock identity, distribution, migration, growth, maturation, natural mortality, etc, etc ...

The International Dimension

- ◆ Effective conservation is **only** possible by international co-operative action
 - fish migrate between national zones
 - stocks are fished by several nations
- ◆ National management of the UK EEZ is not practicable
- ◆ **If the CFP did not exist, we would have to invent it !**

Is Sustainable Exploitation Possible ?

- ◆ Maybe, if...
 - Enforcement is effective
 - International co-operation is good
 - Fishing effort & mortality can be kept low
 - i.e. $F = \text{about half } F_{\text{collapse}}$ [ie $F \sim M$???]
 - Spawning stocks are not severely depleted
 - Recruitment failure can be avoided
 - Economic forces can be moderated
 - The environment does not change
 - Ecosystem structure & function is preserved

Fishing : the facts of life

- ◆ Fishing kills fish
- ◆ Effective conservation means :-
 - **killling fewer fish**
 - especially small & immature fish
 - **reduced catch & effort**, larger mesh sizes, closed areas, etc.
 - **short-term loss of earnings**
 - **long-term gains** *when stocks recover*
- ◆ Need for transitional aid
 - To help the fishermen get from here to there...

Conclusions

- ◆ Most fish stocks are over-exploited
- ◆ We know why (bio-economics)
- ◆ We know what to do about it (well enough)
- ◆ The problems are
 - **political** : social & international factors
 - **economic** : transitional (short-term) losses
 - **practical** : effective enforcement
 - **scientific** : uncertainties in assessments
- ◆ Sustainable Development & Management ...
 - **is easy to say : but not easy to do.**