



INSTITUTE OF MARINE RESEARCH
HAVFORSKNINGSINSTITUTTET





Methods and models for assessing small pelagic fish stocks

Reidar Toresen



INSTITUTE OF MARINE RESEARCH
HAVFORSKNINGSINSTITUTTET

Outline of the presentation

- Why assessments
- Data and indications of abundance
- Various kinds of assessments
 - Production models
 - Analytical assessments
 - Direct observations



Why do we do these assessments?

- Managers need for advise - primary
- Basis for all kinds of science that tries to relate whatever to stock abundance - by-product

What do we try to find out?

- Quantitative history of stock abundance and exploitation.
- Optimal standards for exploitation

in order to

- Advise on fishery next year
-  Advise on management strategies.

Some basic assumptions:

1. The stock that we look at is a closed unit.

- The only way to get into the stock is to be born by parents in the stock, and the only way out is to die.
- It creates big problems if 'our' stock is part of a bigger one. It is less problematic if it is a mix of several stock units, as long as they are well mixed in the data.

2. The data that we have are representative of the whole stock.

- Catches are removed homogenously from the stock, not only from certain components
- Surveys are relative measures of the whole stock, not only of what happens to be in a restricted area.

Biological and administrative stock units sometimes diverge, we have to consider the biological units.



How much fish is there?

- Will we ever know exactly? p not
- Do we have to know exactly? p not

By applying various harvesting pressures, -
do we, as time goes by, measure more or
less fish?

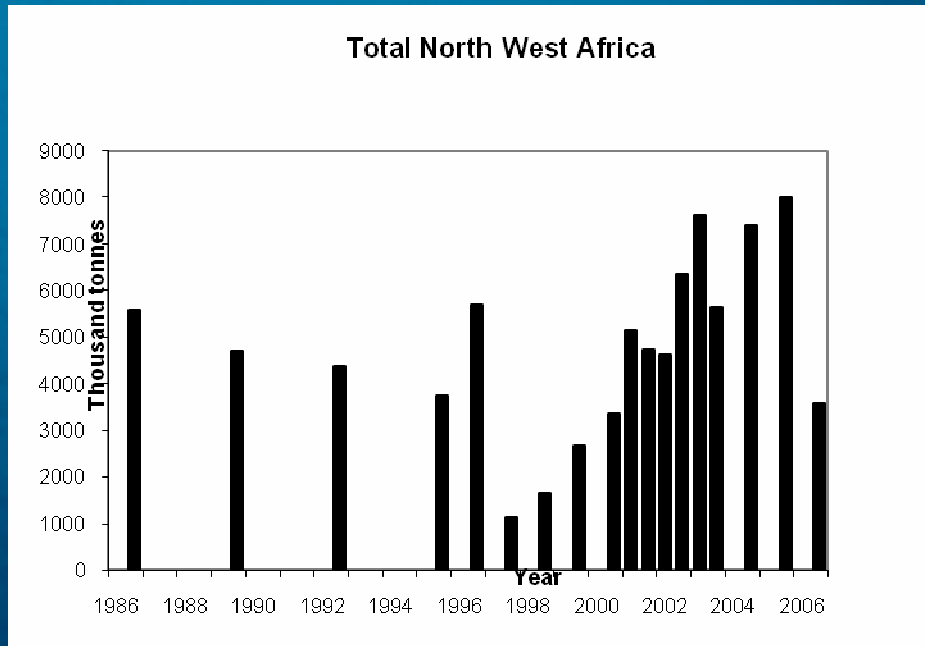


Reliable indicators of the development of a fish stock

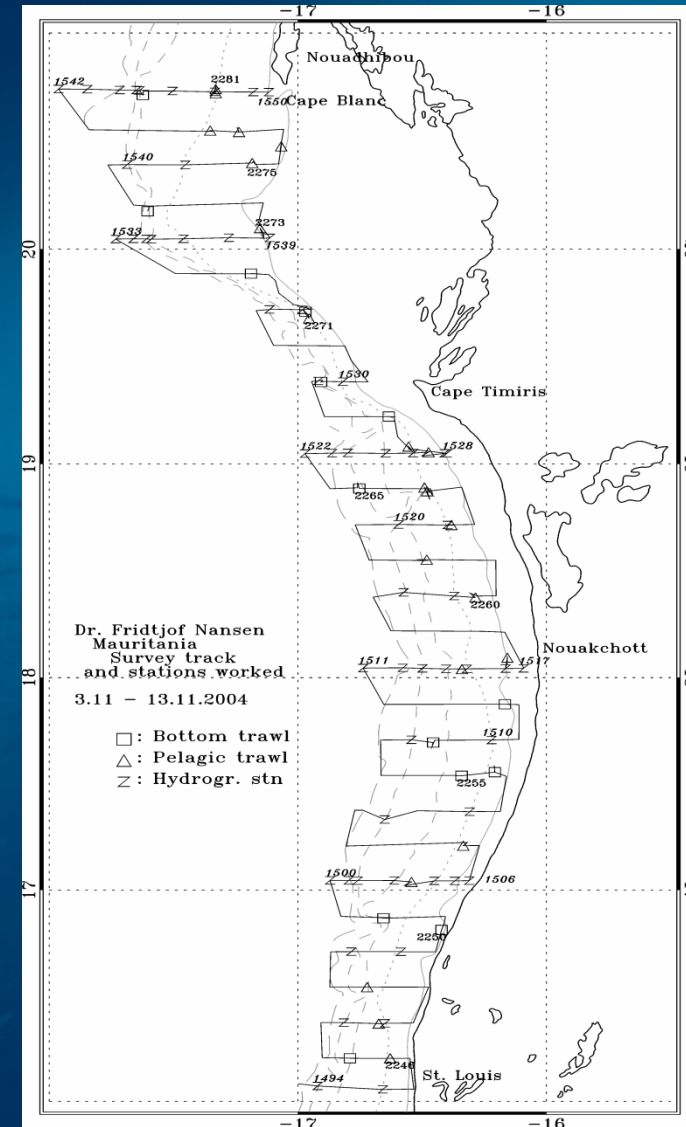
- Time series of (> 5 years)
 - the spawning stock biomass
 - numbers at age
 - recruitment (numbers or biomass)
 - CPUE (if nothing else)



Regional acoustic estimates of sardine off NW Africa 1986 – 2006 (“DR. Fridtjof Nansen”)



An example




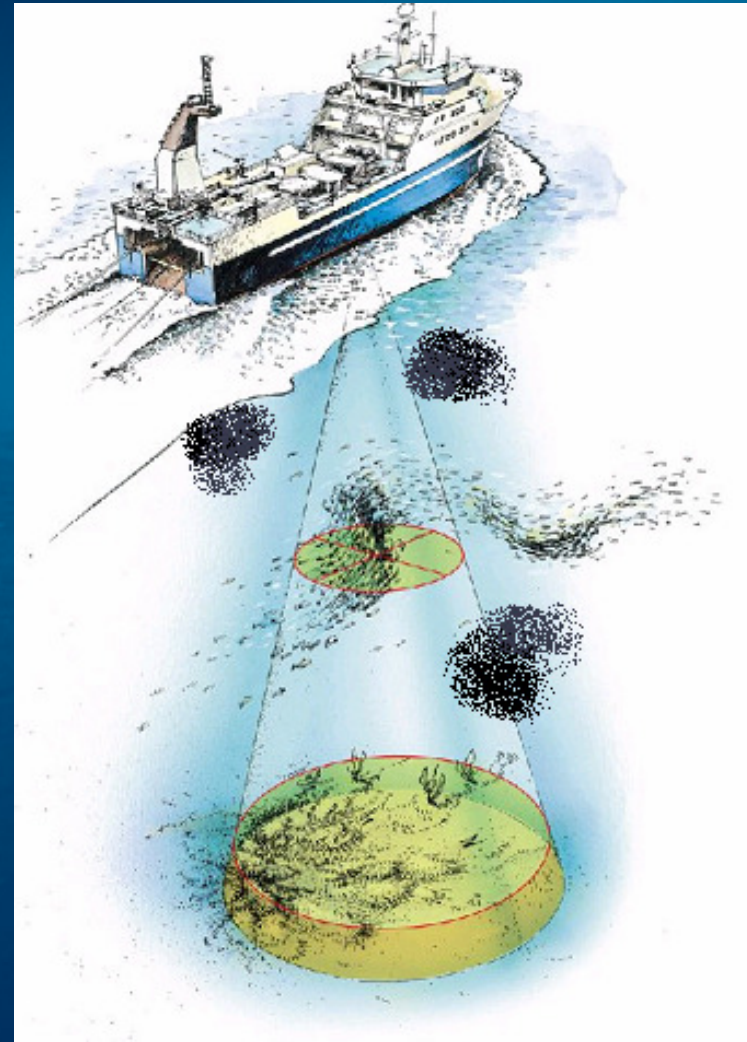
Data quality determines what assessment tool to use

- What kind of data do we have
 - biomass estimates or numbers at age
- How is the consistency (year to year variability)?
 - of abundance estimates
 - of catch
 - is the exploitation a mixed fishery?
 - are the catch figures reliable?



The indications

- **Acoustic surveys**
 - ideal for pelagic fish
- **Trawl surveys**
 - ideal for demersal fish
- **Egg/larvae surveys**
 - can be used for both
-  **Catch per unit effort**
 - not ideal



Various kinds of assessment

- Direct observations (Acoustic (or other) estimates)
- **Production models**, - simple, use when little data are available
- **Analytical single stock assessments**
age structured, not too complex, few param.
- **Multispecies assessment** - very complex
- Ecosystem assessments – even more complex



Production models

Basic Assumptions:

- Stock can be described solely by its biomass
- “Natural” rate of change in biomass depends on current biomass only
- There is a maximum biomass that the system can support (K)
- The relative rate of increase of biomass is maximum when the biomass is close to zero, and zero when the biomass is at the maximum level

Simplest model: Logistic (Schaefer) model



Production models

Widely used, and the origin of important concepts.

Basic idea:

Next years biomass =

last years biomass

+ recruitment

+ growth

- catch

- natural mortality

} **Production**

} - **Loss**

Surplus production is

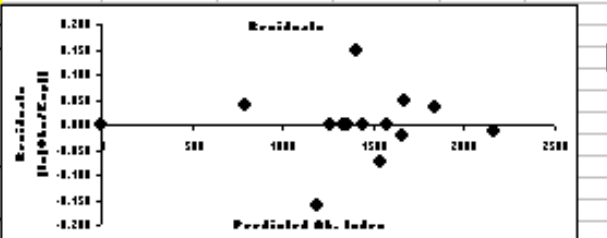
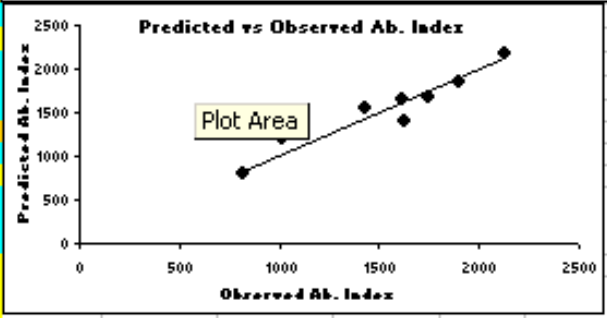
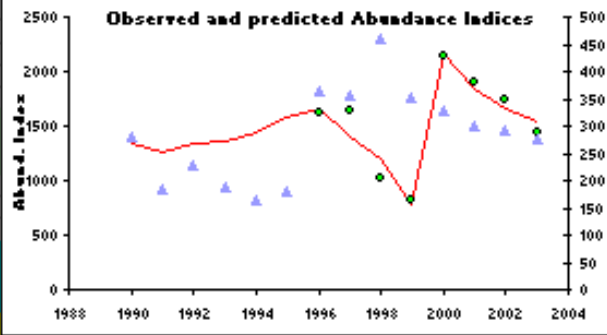
Production - natural mortality loss,

i.e. the amount that can be harvested



Surplus Production Models Using Spreadsheet

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	Species	Sardinella aurita														
2	Stock	All Zones														
3	Catch Data	Capture totale														
4	Abundance Index	indices d'abondance														
5	General production models	Limits to minimisation														
6	Schaefer model	Parameter														
7	Objective function: $\sum(\ln(\text{ObsCPUE}/E))$	K														
8		Initial Val Tolerance														
9	Scaling	1.00E+06														
10																
11	Parameters	Quality of fit														
12	r	0.63														
13	K	1500														
14	B/K	50%														
15	EnvironmentEffect	3.33														
16		ParameterSets														
17	q	1.784														
18	BI	750														
19		r_Average														
20	EnvEffectType	1														
21	ParameterSet	2														
22		K_Average														
23	Assessment of current situation															
24	Quality of catch information for last few years	0														
25	1-Good															
26	0-Bad															
27																
28																
29		Trends in diagnostic ratios														
30		B/BMS1														
31																
32																
33																
34																
35																
36																
37																
38	Time	ObsCatch	ObsCPUE	Environment Level	Weights	Predicted Biomass	EnvMultiplier	r_Year	K_Year	NaturalProduction	BiomassChange	PredCPUE	Relative Values	LnRelVal	Res2	Ln_qi
39	1990	279	0	0	1	750	1.00	0.63	1500.00	236	-43	1338	0.00	#NUM!	#NUM!	#NUM!
40	1991	186	0	0	1	707	1.00	0.63	1500.00	235	49	1261	0.00	#NUM!	#NUM!	#NUM!
41	1992	230	0	0	1	756	1.00	0.63	1500.00	236	6	1349	0.00	#NUM!	#NUM!	#NUM!
42	1993	188	0	0	1	762	1.00	0.63	1500.00	236	47	1360	0.00	#NUM!	#NUM!	#NUM!
43	1994	162	0	0	1	809	1.00	0.63	1500.00	234	72	1444	0.00	#NUM!	#NUM!	#NUM!
44	1995	181	0	0	1	881	1.00	0.63	1500.00	228	48	1573	0.00	#NUM!	#NUM!	#NUM!
45	1996	363	1619	0	1	929	1.00	0.63	1500.00	222	-141	1658	0.98	-0.024	0.000571	0.555229
46	1997	355	1631	0	1	788	1.00	0.63	1500.00	235	-120	1406	1.16	0.148	0.022006	0.727469



$\ln(\text{obs}/\text{exp})^2$ SumLnQ
0.059466 4.633001

Are production models usefull for managers?

- ✓ **MSY – Maximum Sustainable Yield**
- ✓ **B_{MSY} – Biomass producing MSY**
- ✓ **F_{MSY} – Fishing mortality which, if applied for a long period, will lead the stock to B_{MSY}**

**Dependent on data quality, stock and
exploitation history**



Age structured models

- Moderately simple
- Fast to run, fast to optimize
- Require age data
- Require biological knowledge to convert length measurements to age groups



Analytical assessments, VPAs

- Treat cohort by cohort.
- Based on observed data (numbers at age).
- Combine stock estimates and catch
- Can model by statistical methods catch, stock size, recruitment.



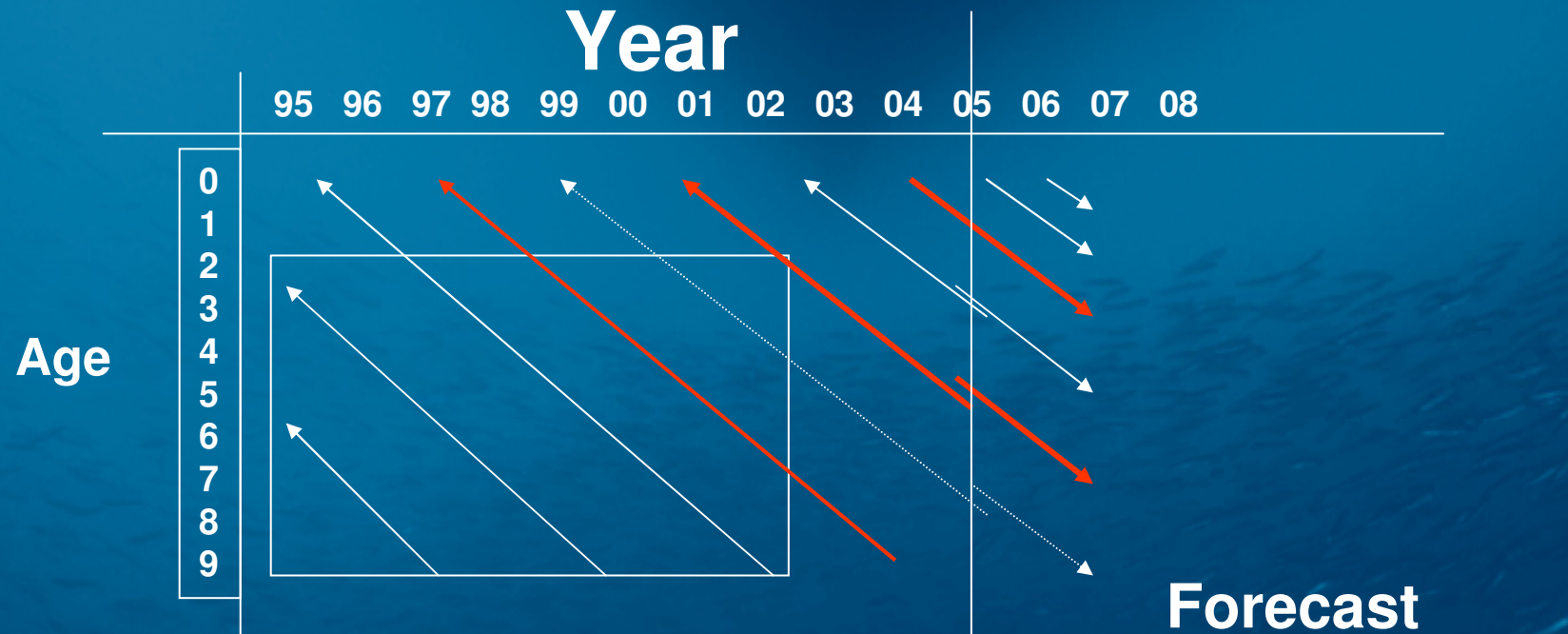
ICA, XSA, ISVPA.....

The principle of the VPA

Cohort

by cohort

Status



Backcalculation

Based on catch by number per age group, natural mortality and time-series of abundance estimates

Forecast

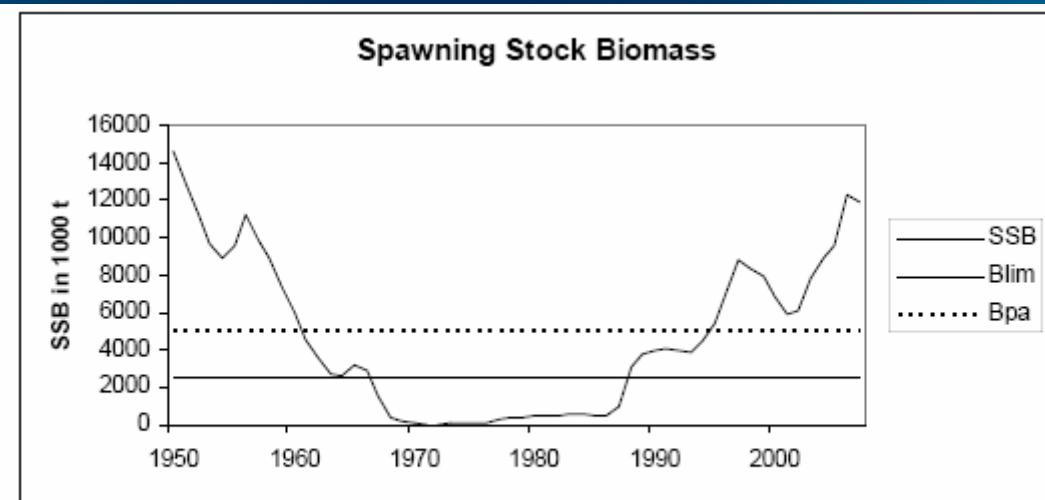
Based on assumed catches or exploitation, natural mortality and recruitment



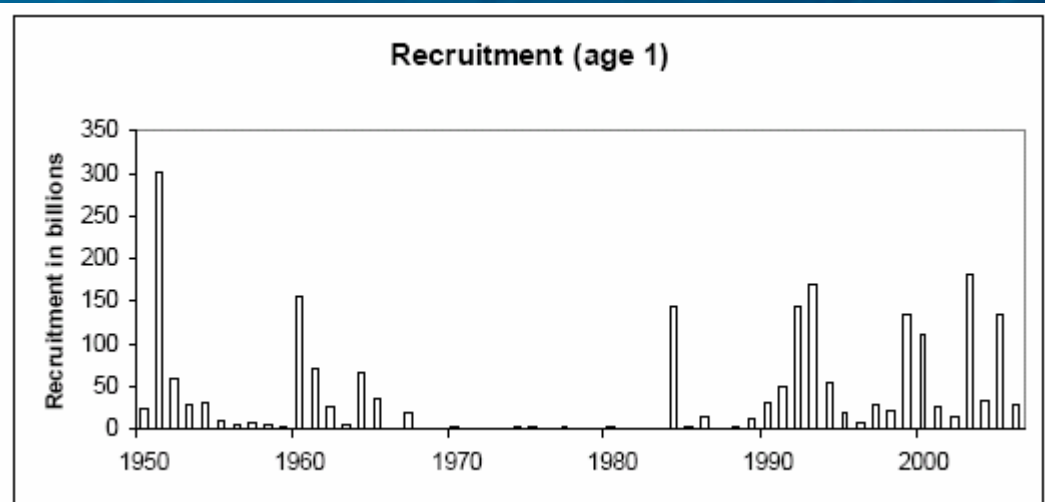
Assessment results of Norwegian spring-spawning herring, 2007



Recruitment pattern indicate future potentials



Norwegian spring-spawning herring. Landings, fishing mortality, recruitment, and SSB.



Catch statistics - a global challenge

- Essential for all kinds of assessments and management
- Are landing figures sufficient?

A challenge for industrial fleets.
An even larger challenge for the artisanal fishery



Management by direct observations, without analytic assessment

May be relevant if:

- Too unreliable data to get a precise assessment (misreporting, variable discarding, abandoned surveys, problems with age-reading, large retrospective errors)
- Short lived species where predictions are not meaningful



Management by direct observations

- Set a precautionary TAC, as a fraction of a directly measured biomass. Adjust, but only gradually, according to indicators of trends in stock abundance.
- Requires relatively stable recruitment, and there must be a mechanism to take drastic measures if things seem to go wrong.
- In-year monitoring for short lived species: Set a preliminary low TAC and adjust it according to measurements early in the fishing season.



Main message

Find out what the data are able to tell about stock and exploitation

Stock unit? Age readings? Consistency?

From there, decide what assessment model to use.

Currently, production models are used but there is a potential in developing competence and capacity in aging techniques pointing towards analytical assessments in the future.



Another piece of wisdom

If the data are good, and the underlying assumptions are not severely violated, the assessment method does not matter.

**If the data are poor, the method does not matter.
You cannot model yourself away from poor data.**

If the data are of variable quality, it may pay to look for a method that relies mostly on the best data.



Conclusion

**Whatever you do, - improve
data quality**

