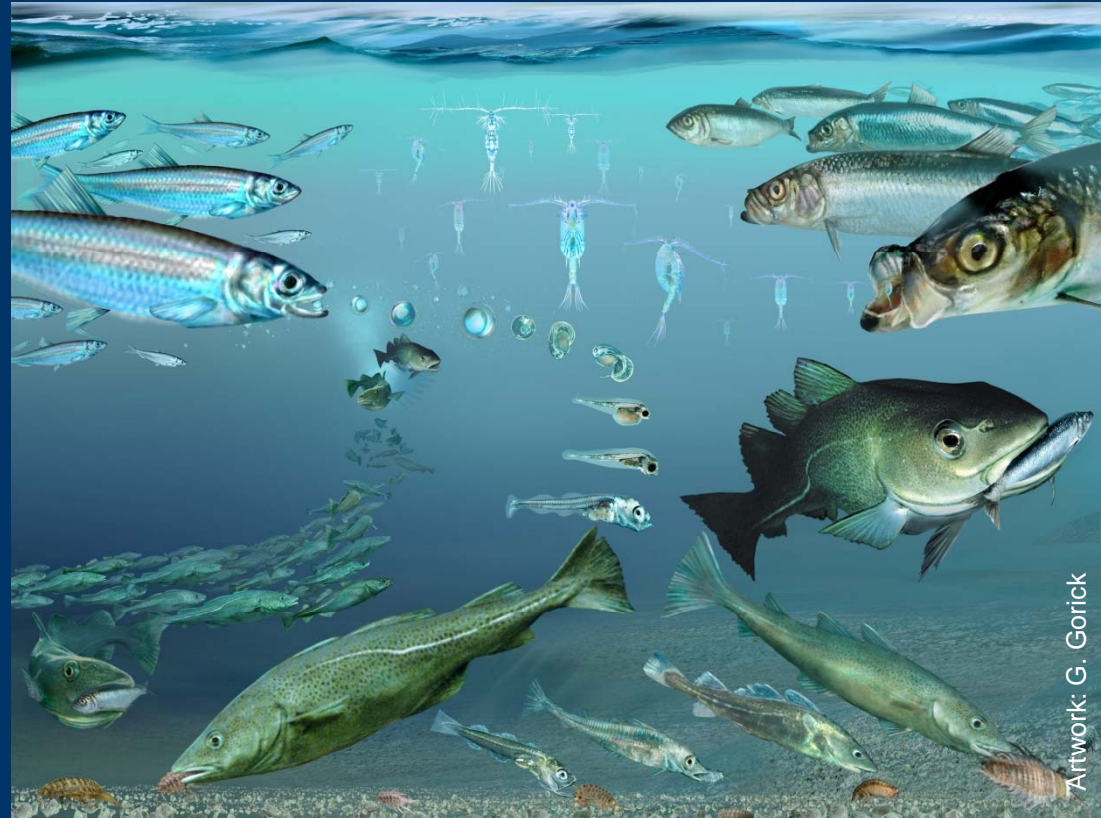


How Many Cod are Needed in a Balanced Baltic Sea?

Swedish Inst. Mar. Env.
Stockholm, Sweden
Aug. 25, 2010



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Acknowledgements



-EU Network of Excellence on Marine Biodiv. & Ecosyst. Funct.



-HMAP (www.hmapcoml.org)



-Danish climate change project

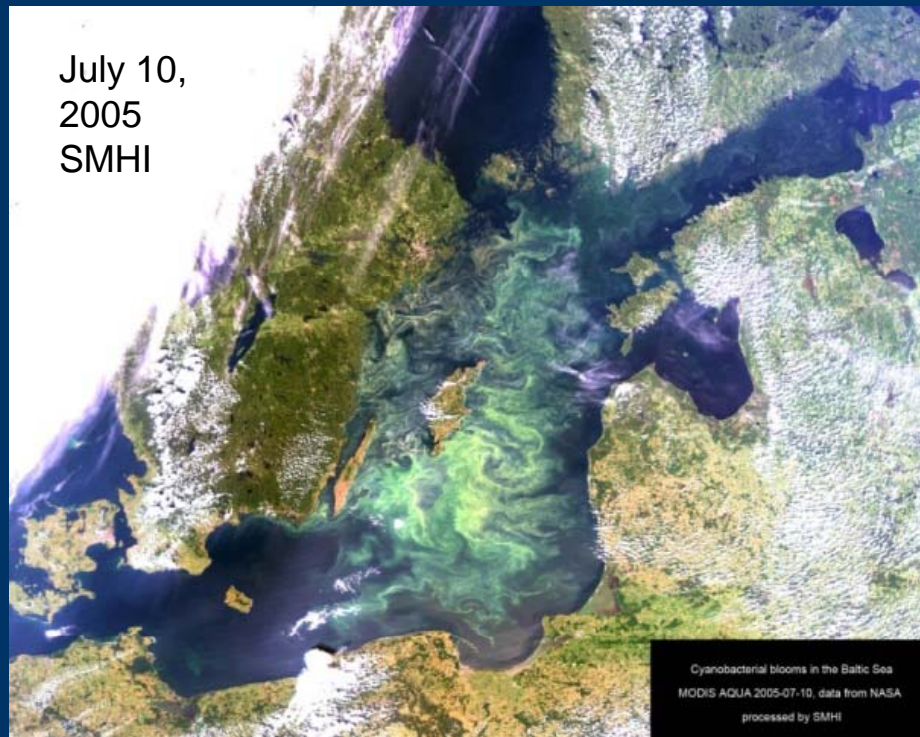
www.conwoy.ku.dk



BONUS+ / EU project

Baltic Sea

- in ecological balance?



-probably not, if one considers:

-algal blooms

-bottom life in anoxic areas

-cod, salmon, eels, sturgeon, seals, harbour porpoise

When, if ever, Has the Baltic Sea Been In Balance?

Are there historical precedents for a balanced Baltic Sea?

If yes, when were they?

If yes, what were the external forcing conditions like?

-fishing levels, climate, mammal hunting, nutrient loading, etc.

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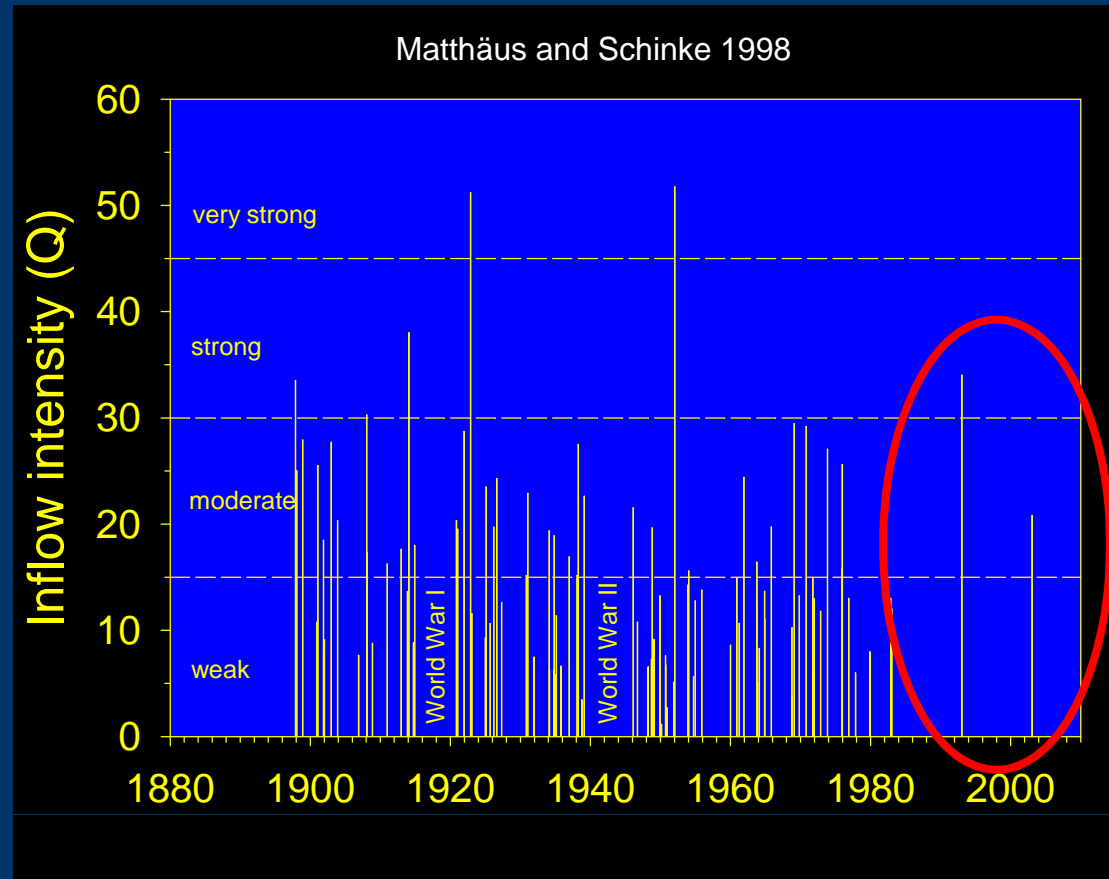
-fishing levels, climate, mammal hunting, nutrient loading, etc.

Perhaps never, depending on perturbation frequency and magnitude

But we do have some knowledge of how the Baltic Sea looked like under lower levels of human impact

-this knowledge gives us guidance for new baselines for ecosystem and fisheries management, and on how variable the system has been before

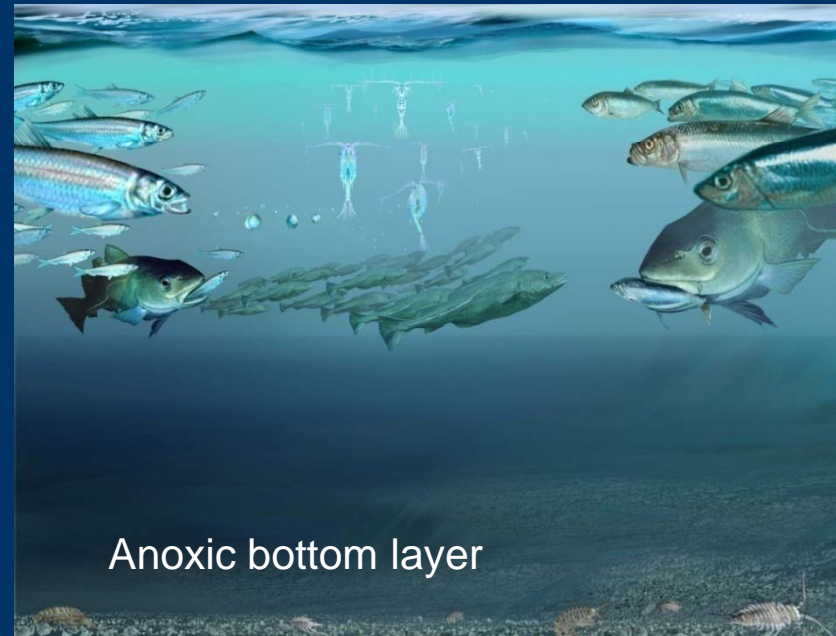
Hydrographic Variability and Ecological Balance



-ecological consequences on next slide...

Balance and Perturbations to the Baltic

- when inflows are rare:
 - benthic life dies in deep areas
 - cod reproduction fails
 - herring and sprat increase
 - plankton communities re-organize
 - biogeochemical cycles change, etc.



Artwork: G. Gorick

Hydrographic Variability and Ecological Balance

-changes in hydrographic conditions can lead to major changes in foodwebs and biodiversity (regime shifts)

-e. g, loss of entire benthic communities

→ System no longer in balance!

E.g., cod no longer will eat benthic food (e. g., *Saduria*) since these prey are dead

-instead they will eat more herring and sprat

-has direct implications for fisheries management

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Developing Biomass Baselines for Baltic Cod

Consider contemporary situation (last 40-45 years)

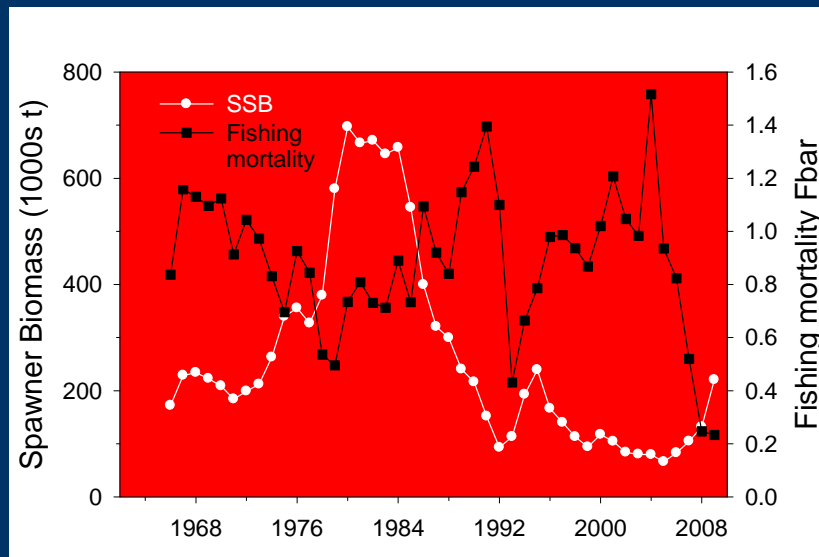
Consider historical situations

- early 1900s;

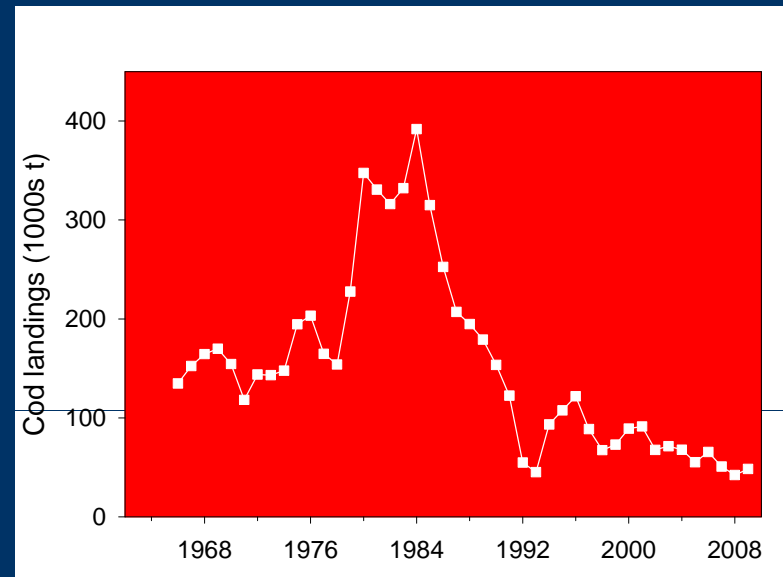
- late 1500s - early 1600s

Dynamics of Cod Population and Landings 1966-2009

Spawner biomass and F

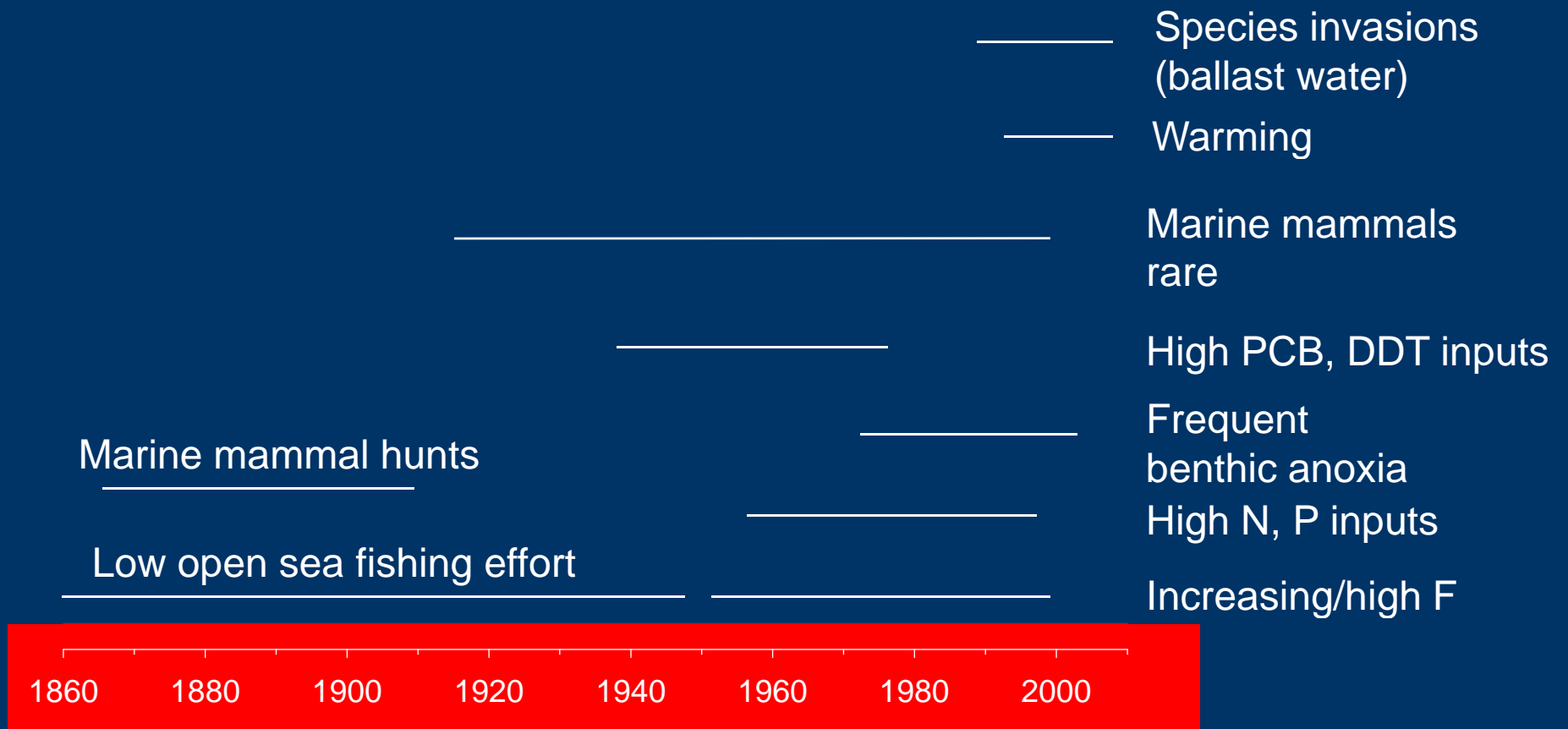


Landings



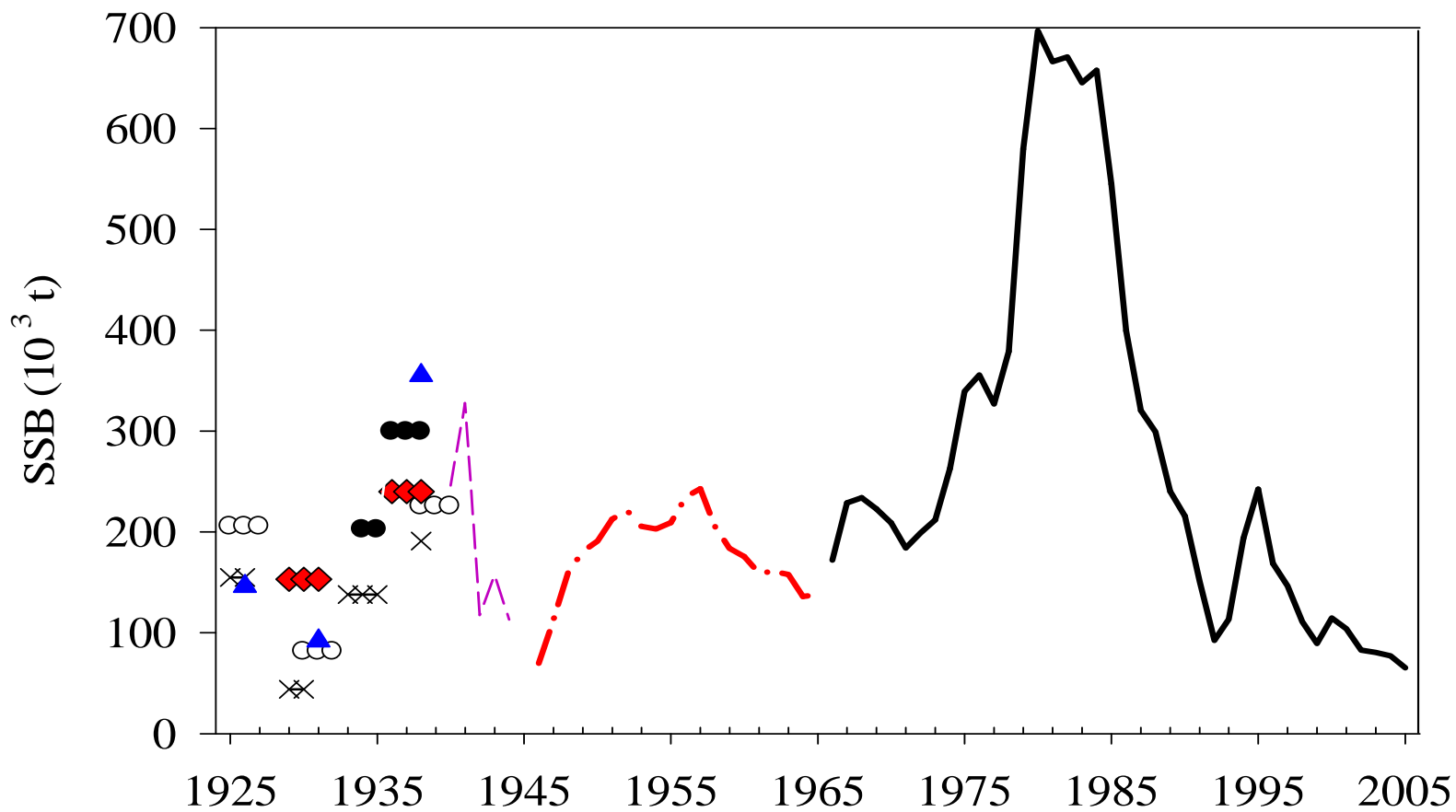
-time series too short relative to timing of human impacts...

Time Line of Anthropogenic Impacts for the Baltic Sea



Elmgren 1989
MacKenzie et al. 2002
Helcom 2009

Reconstruction of cod SSB:



Eero et al. 2008
CJFAS



All Forcings Important, But at Different Time Periods



Climate (salinity) – pos.



Seal predation – neg.



Eutrophication – pos.



Fishing – neg.

Human-induced

-forcings change over time

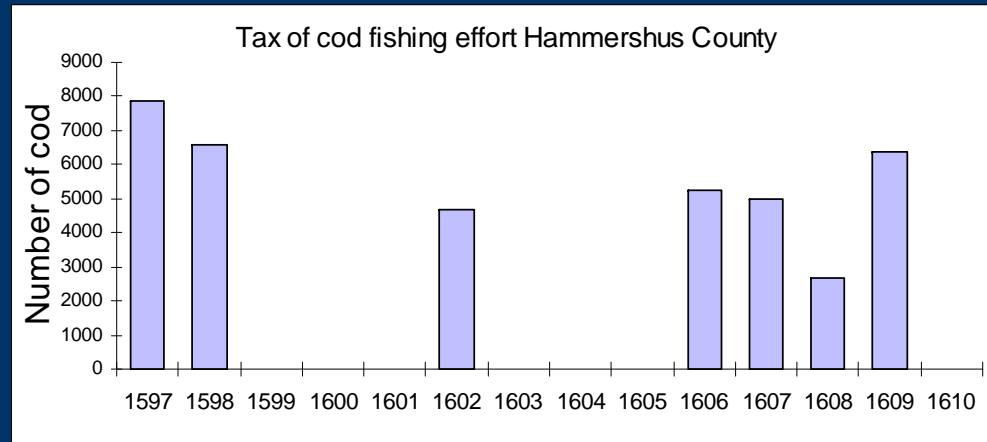
Looking Farther Back in Time...

- when human impacts were fewer and less intense
- examine trade and tax records in historical archives from several centuries ago
- collaboration with maritime and fisheries historians

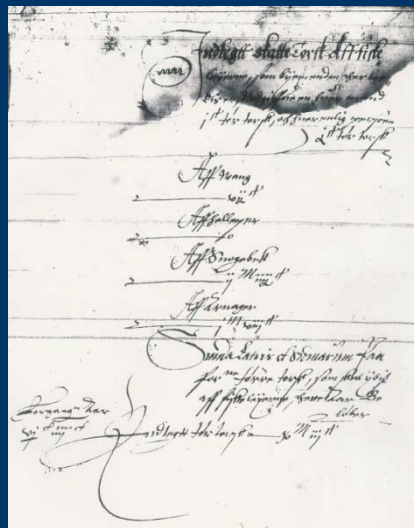
Cod Tax Paid to Hammershus, Bornholm



Photo: A. Maciejewska



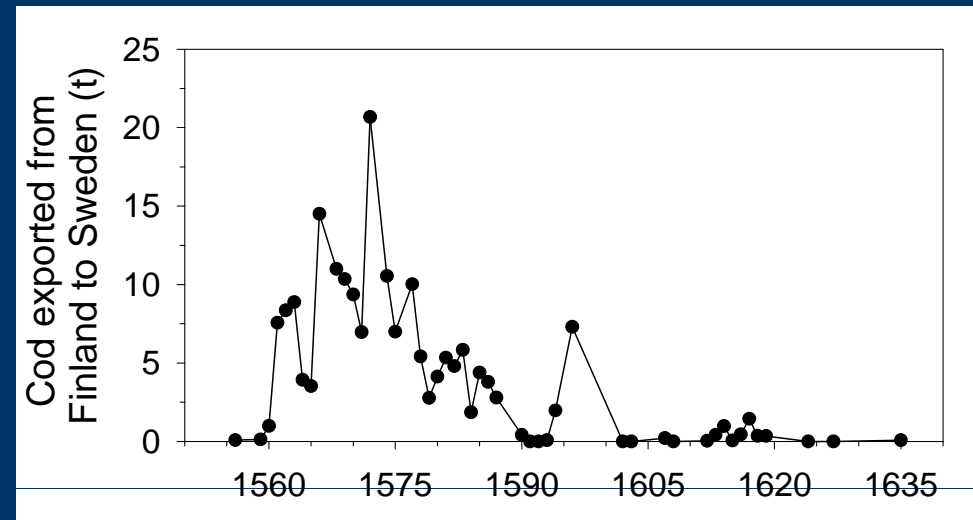
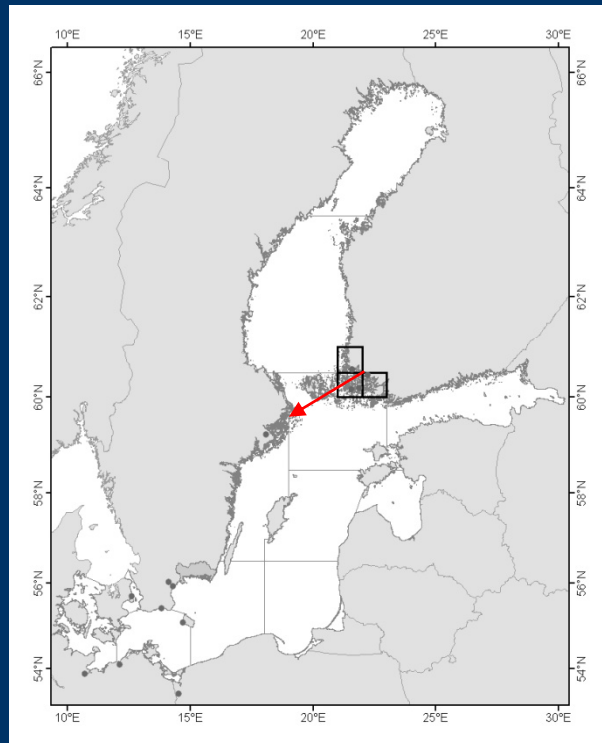
Holm and Bager 2002



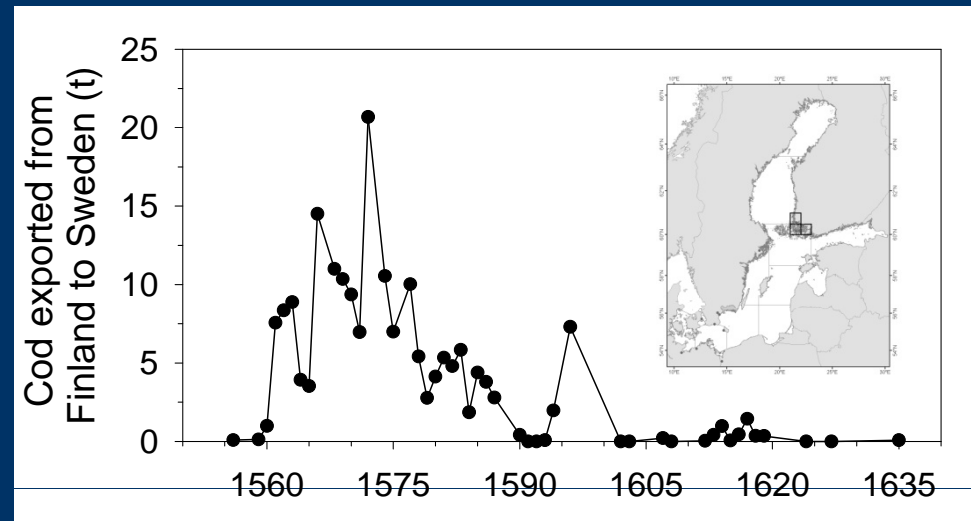
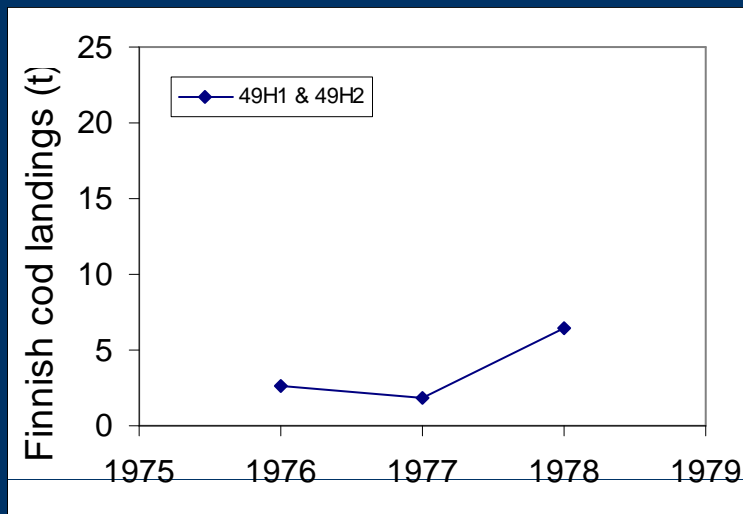
- cod were abundant in commercially relevant quantities
- source of revenue to the King

Original tax account from 1602;
M. Bager, Univ. So. DK

Annual Cod Exports from Southern Finland to Sweden 1556-1635



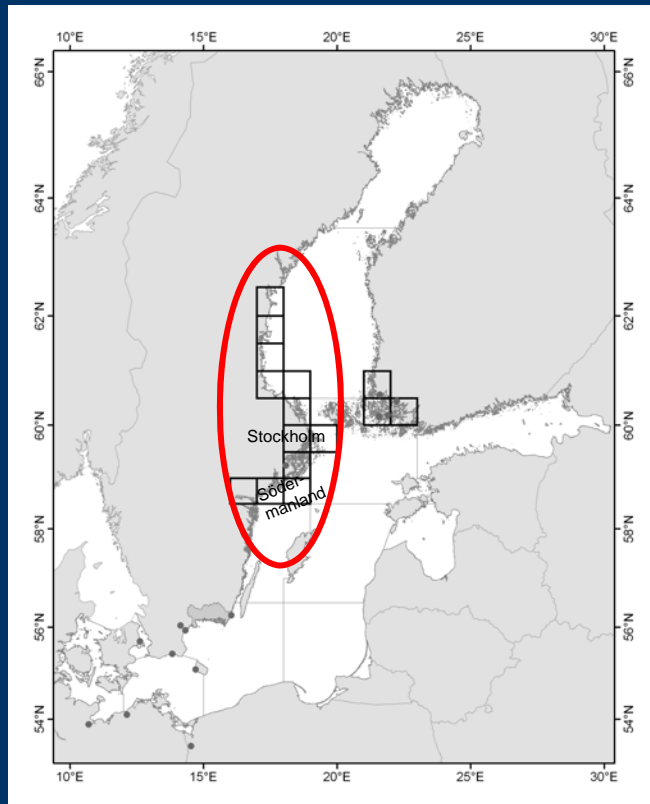
Annual Cod Exports from Southern Finland to Sweden 1556-1635



-landings 400 years ago were higher than during 1976-78

-only get cod landings in SW Finland when biomass is high or salinity is high (such periods usually coincide)

Swedish Cod Fishery 1550s-1750s



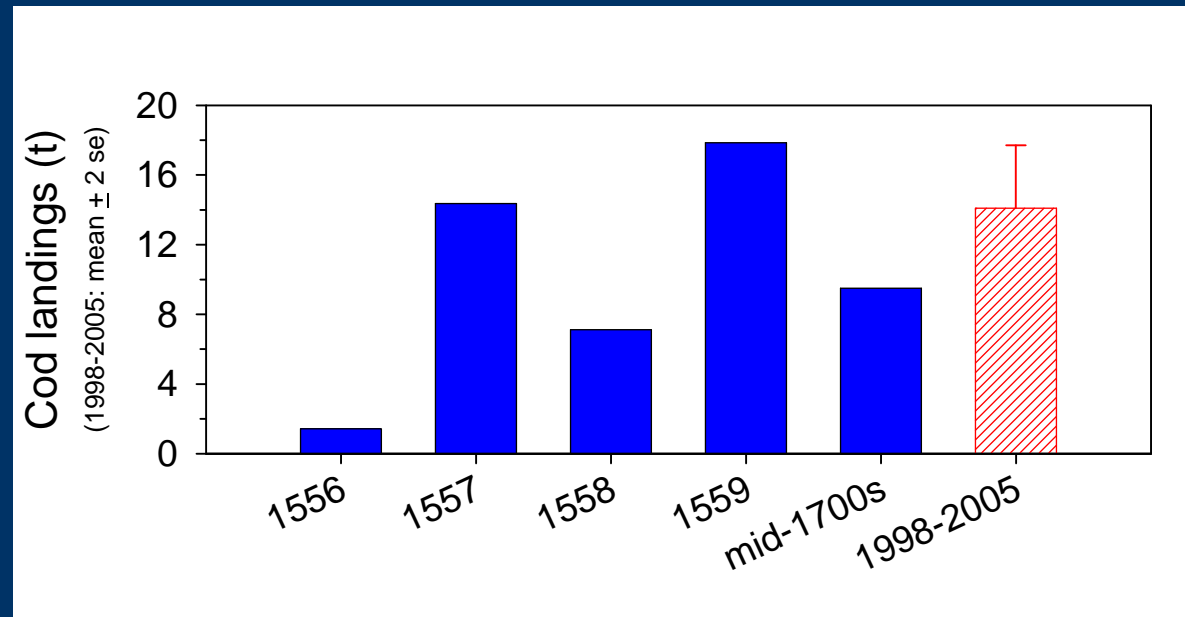
-conducted short prelim. search of Swedish archives for area near Stockholm

-period 1550s-1750s

-some data recovered

-compare with recent Swedish landings in same ICES squares

Central-Northern Swedish Cod Landings, 1550s-1750s

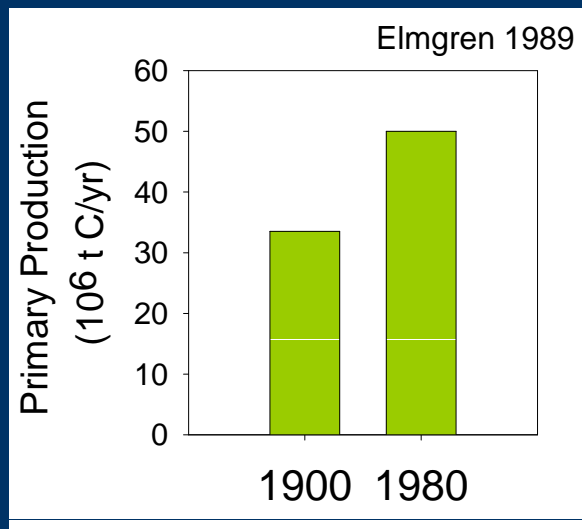


-Swedish local fishery caught ca. 10 t / year during same time period as cod was being imported from Finland (two geographically-separated fisheries of similar magnitude at nearly same time)

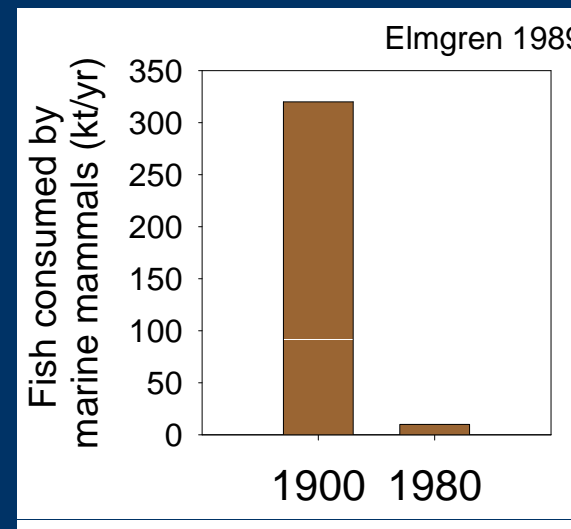
Baltic Ecosystem Status During 1550-1630

Contemporary knowledge suggests it could have been “cod-hostile” (!):

Lower 1° Prodn.



High seal predation & compet.



-but cod biomass was high and widespread in Baltic (supported economically important fisheries in northern and southern Baltic)

Cod in a Hostile Baltic?

How could there be important fisheries in the (northern) Baltic in an apparently cod-hostile ecosystem?

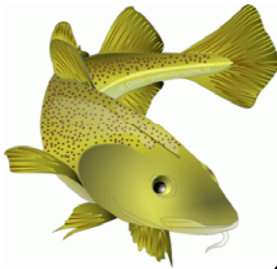
Hypotheses:

1. Fishing effort and mortality rates were much lower than during late 20th C.
 - allowed cod biomass to remain high, despite potentially lower 1^o prodn. and higher predation rates and food competition due to seals
 - is *very likely* (simpler technologies, no fishing offshore, etc.)
2. Better salinity and oxygen conditions? (positive effects on recruitment and spatial distribution)
 - not confirmed and needs paleo- or modelling evidence*

Management Policy Implications...

- time scale and baseline for decisionmaking too short and too recent
- many perturbations to Baltic occurred before we started monitoring ecological status

Routine stock assessments



Data



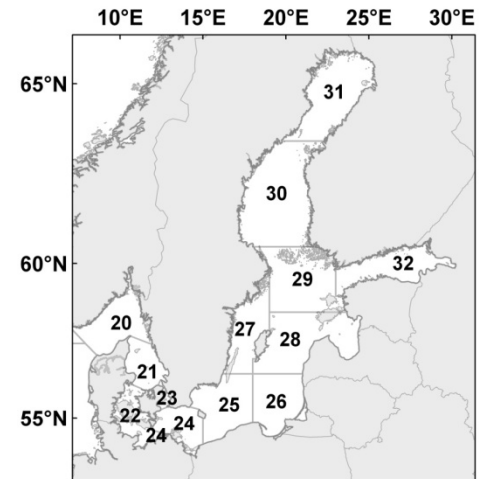
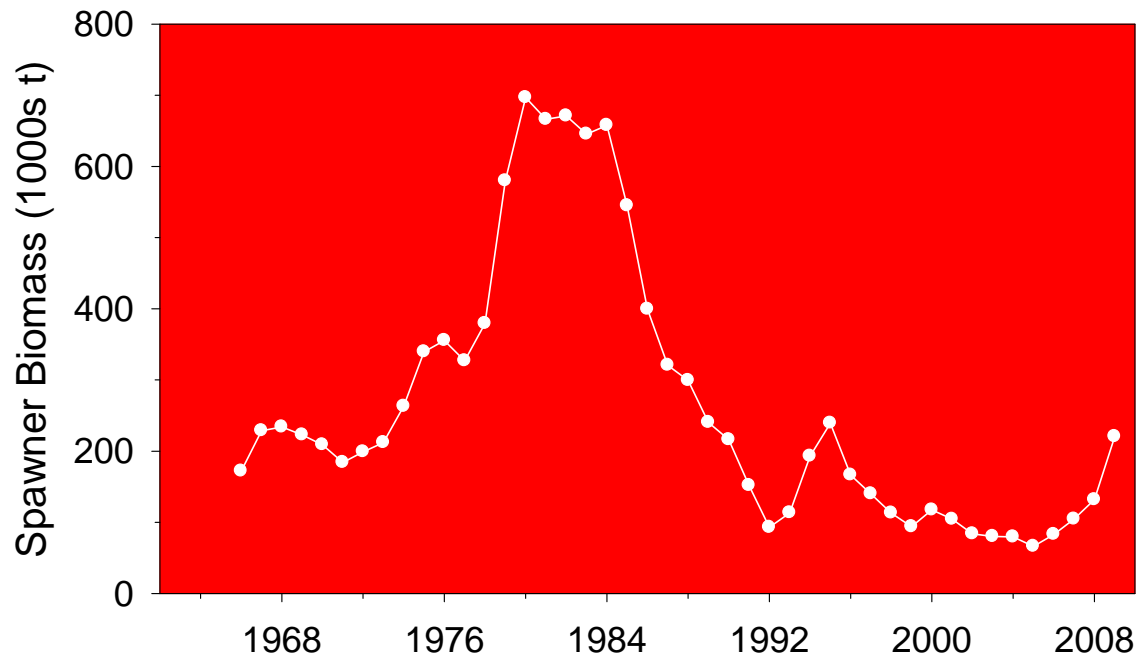
Time-scale (recent decades)

Knowledge-base for management decisions

?



Sustainable management of cod and ecosystem?



Routine stock assessments

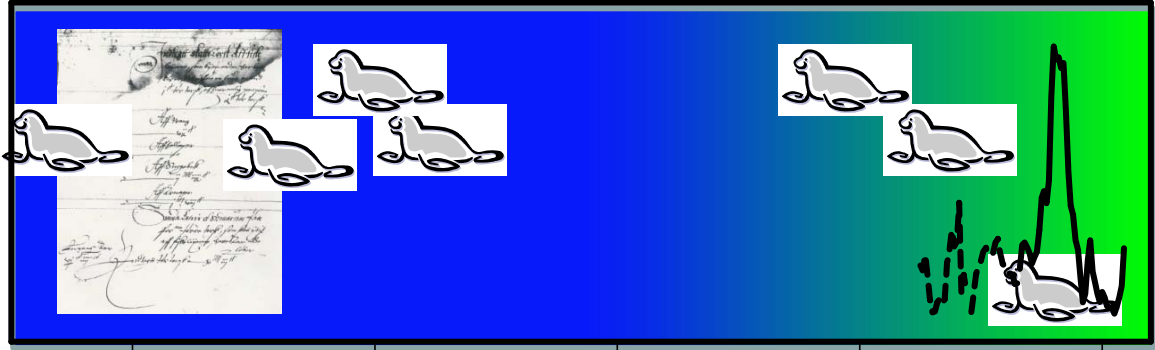


Data

Knowledge-base for management decisions

?

Time-scale (recent decades)



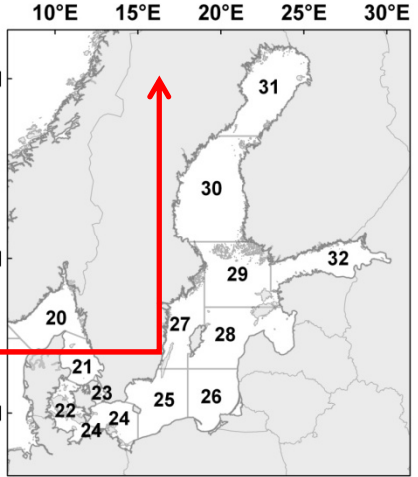
Sustainable management of cod and ecosystem

Historical ecology

Data

Knowledge-base for management decisions

Time-scale (centuries)

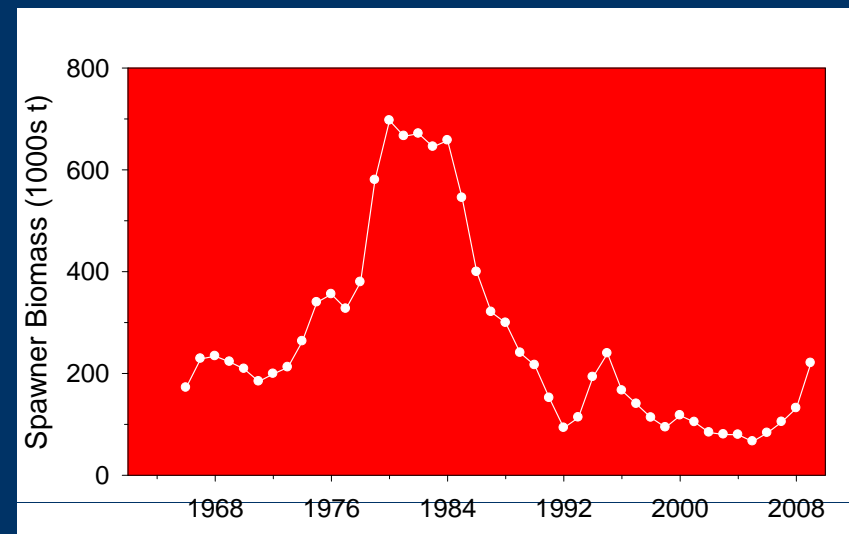


Mackenzie et al. In press
Mar. Policy

Baltic Cod Biomass in the Next Few Decades

- depends on fishing level, *and* hydrographic – climatic conditions
- given regular inflows, it should be possible to reach and maintain at least 300-400 ktons

- would support yields of 90-120 kt/year if $F = 0.3$ (ICES management plan F)
 - i. e., yields would be > 2 fold higher than in 2009



Conclusions: Balance, Baselines and the Baltic

Balance may be difficult to achieve due to perturbations (fishing, climate change, eutrophication, etc.)

Balance will be different under different perturbation situations.

Ecosystem conditions and their variability under less human impact may be more appropriate targets and baselines for ecosystem management.

Management policies and efforts should

- aim to reduce and avoid multiple negative impacts from society (i. e., promote resilience and build “insurance” within the ecosystem to perturbations)

- be flexible and adaptive to changing conditions

-thank you

