

A Historical Example of Fisheries Mismanagement: The Case of Atlanto-Scandian Herring



*“ Le hareng est une de ces productions naturelles dont l’emploi
décide de la destinée des Empires ” (Lacépède 1801)*

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Abstract

Herring in the ocean between Iceland and Norway was one of the largest fish stocks in the world until the fishery crashed in the late 1960s after relatively regular migration for at least a century. The catch in 1971 was only 20 thousand metric tons in contrast with the record of 2 million tons in 1966 and the spawning stock declined from 10 million tons to 10 thousand tons in 20 years. After 25 years of almost no fishing the stock finally recovered. With hindsight the cause of this dramatic change was a combination of biological, technological and ecological factors and the socioeconomic effect was austere. At that time there was no fisheries management authority to limit either catch or effort and signs of overfishing, poor recruitment, lowering sea temperature and reduced plankton abundance came so late that the collapse surprised fishermen, scientists and managers. After describing this development with statistical data and models several questions arise:

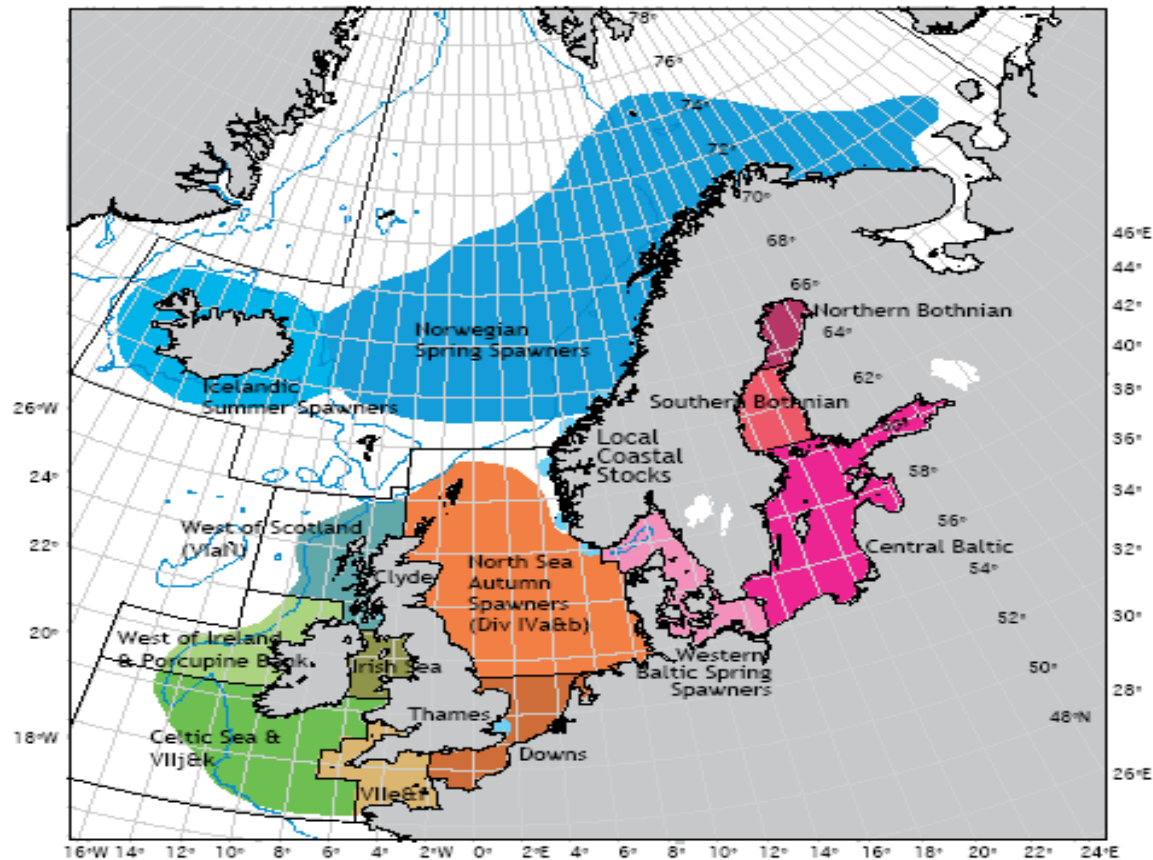
Could it have been predicted and prevented?

Are we able to prepare us for another similar ecosystem change?

Is international cooperation in research, surveillance and regulation sufficient?

Can we learn from history or are we doomed to repeat its mistakes?

Northeast Atlantic herring stocks



(Zimmermann 2000)

The herring puzzle

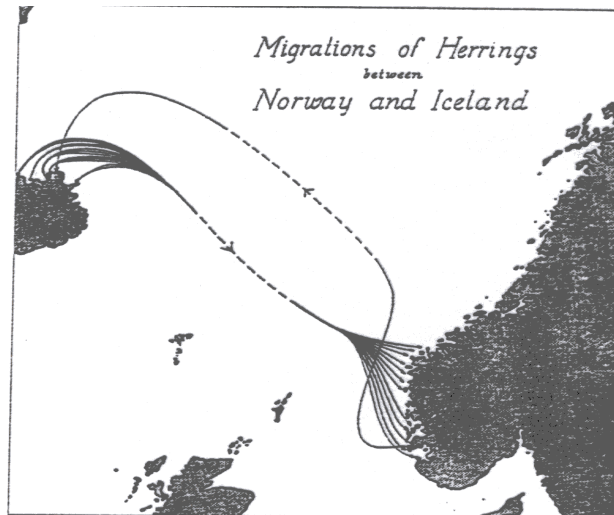
Where do the spring herring spawn and feed?

(Johansen 1927, Lea 1929, Fridriksson & Aasen 1935, 1944, 1950)

Iceland ?



Norway ?

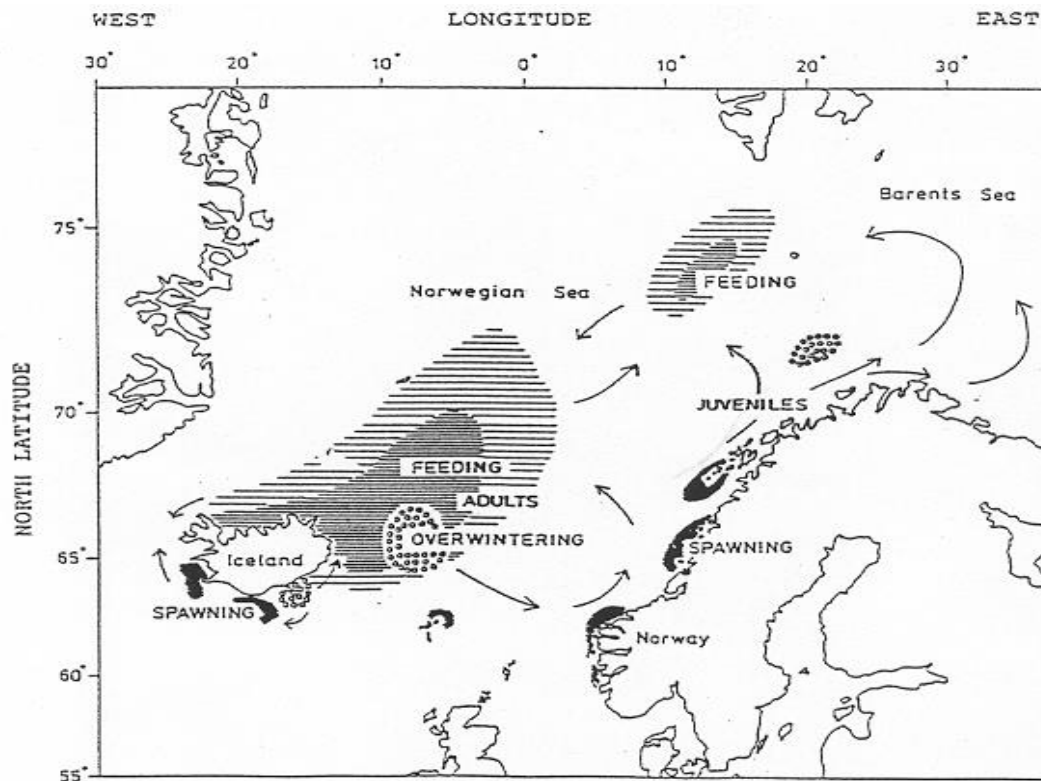


Norway and Iceland
Same stock !

Atlanto-Scandian herring

=

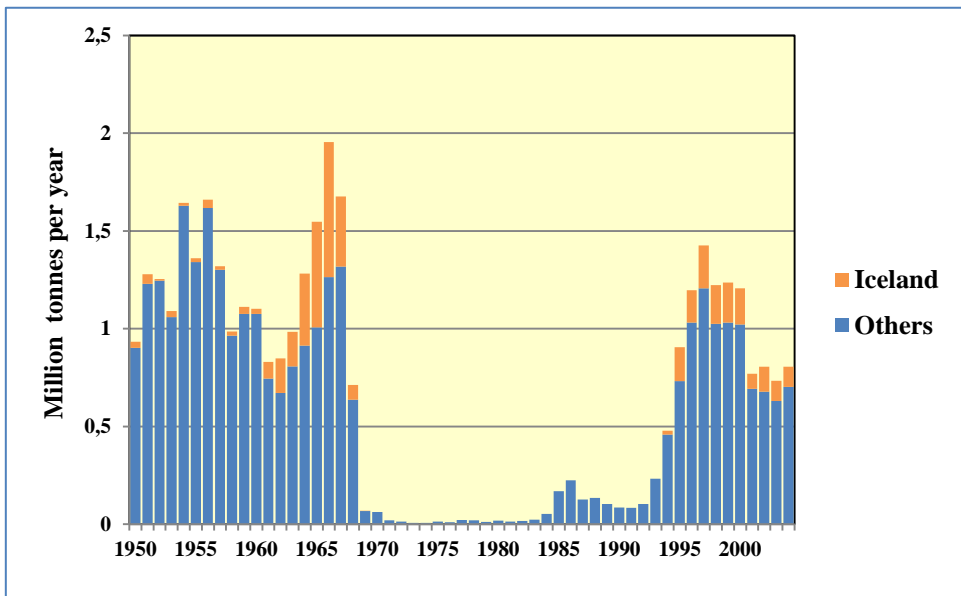
**Norwegian spring spawners + Icelandic spring spawners
+ Icelandic summer spawners**



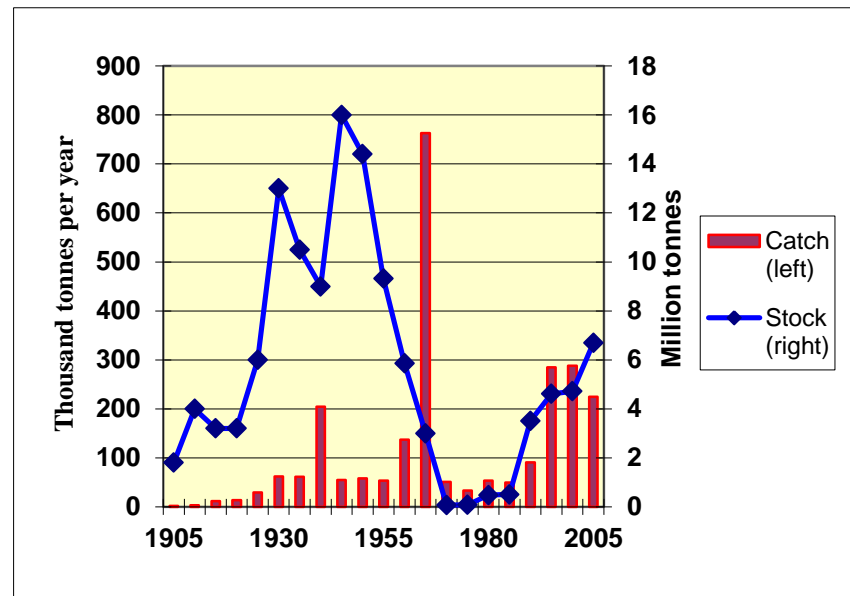
(Bakken, 1983)

100 years of herring history

Source: ICES, Hafro

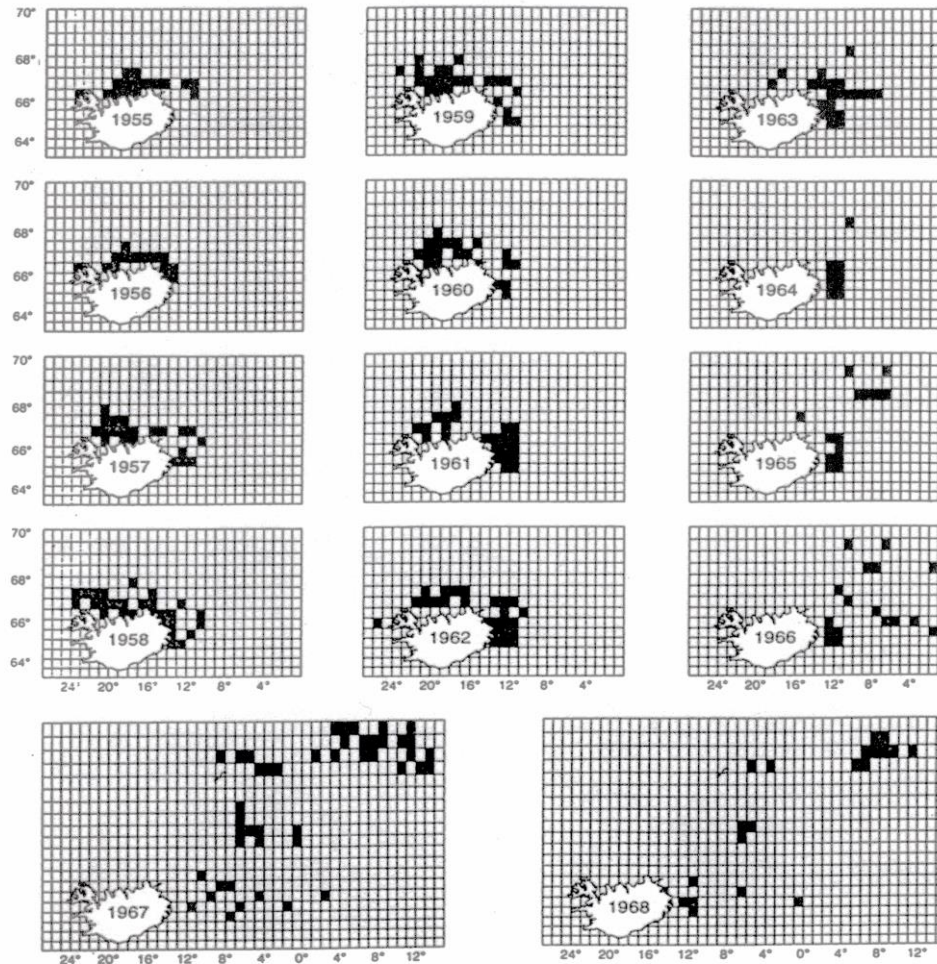


Total landings of spring-spawning herring



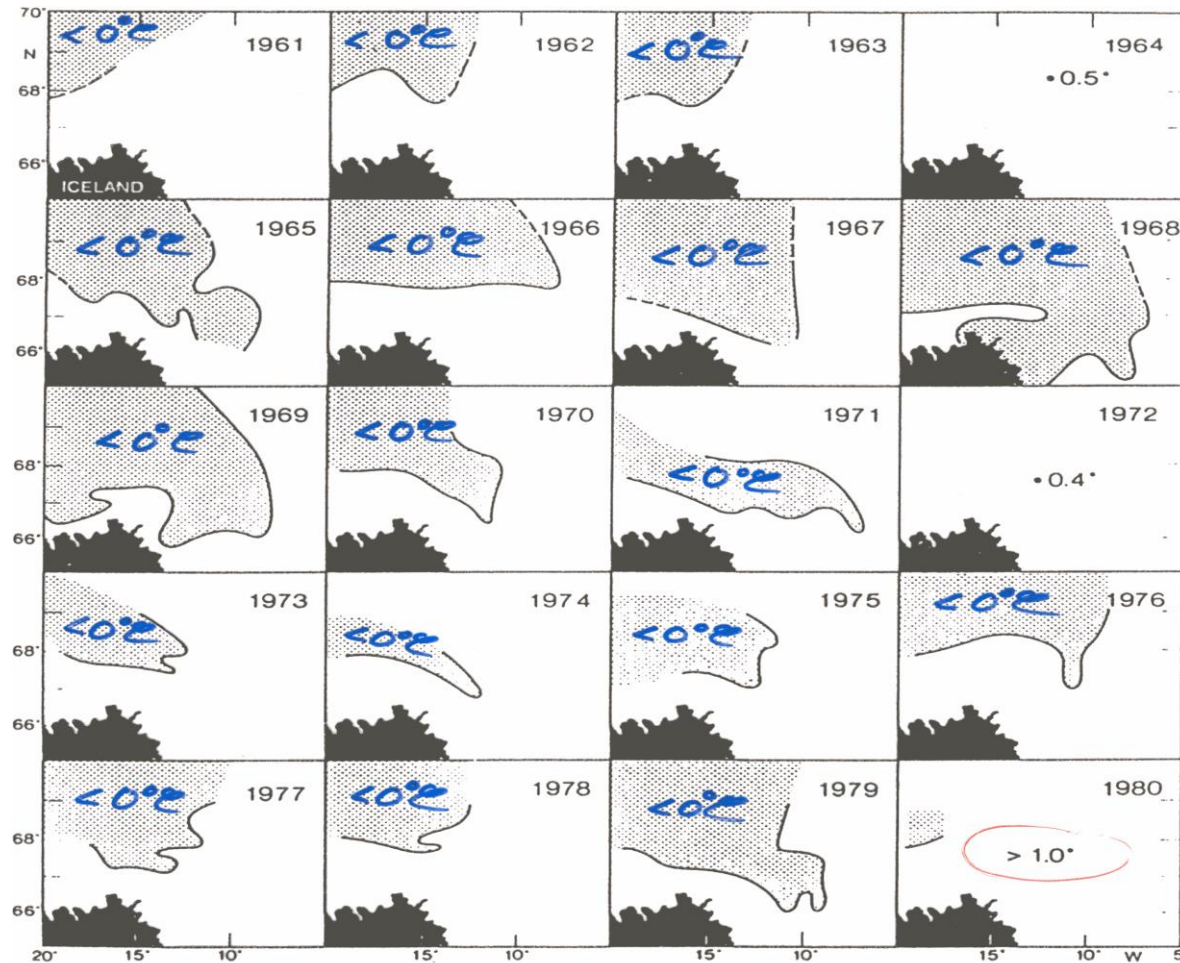
Stock size and Icelandic landings

How did the herring leave Iceland?



Distribution of samples from catches
(*Jakobsson et al., 1996*)

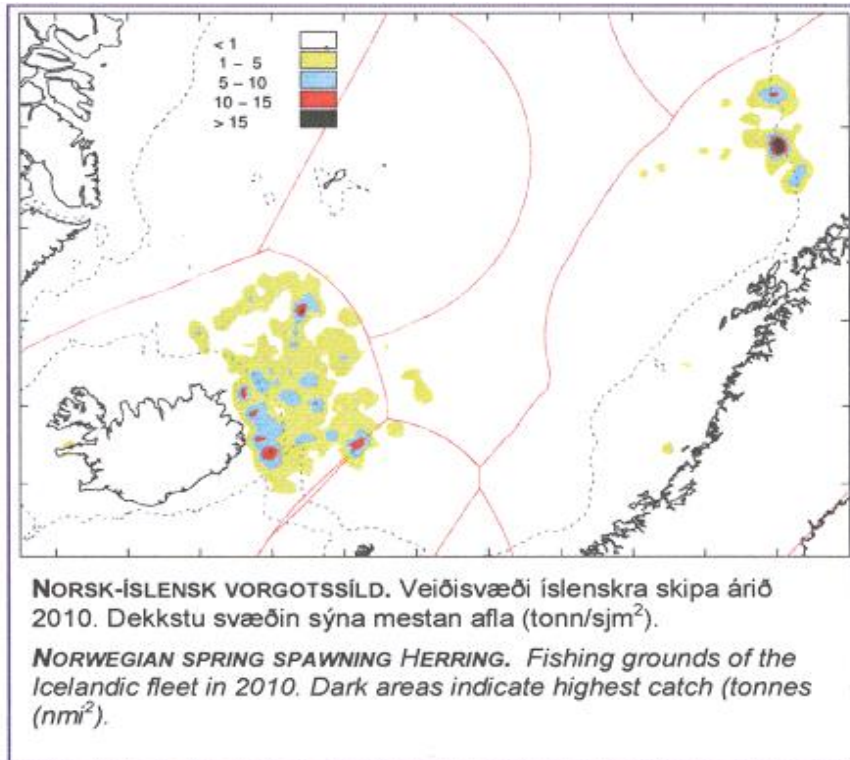
Why did the herring leave Iceland?



The “cold tongue” of the East-Icelandic current
(Malmberg, 1985)

When did the herring return to Iceland?

(Sources: *Hafro; Morgunblaðið, October 5 2010*)



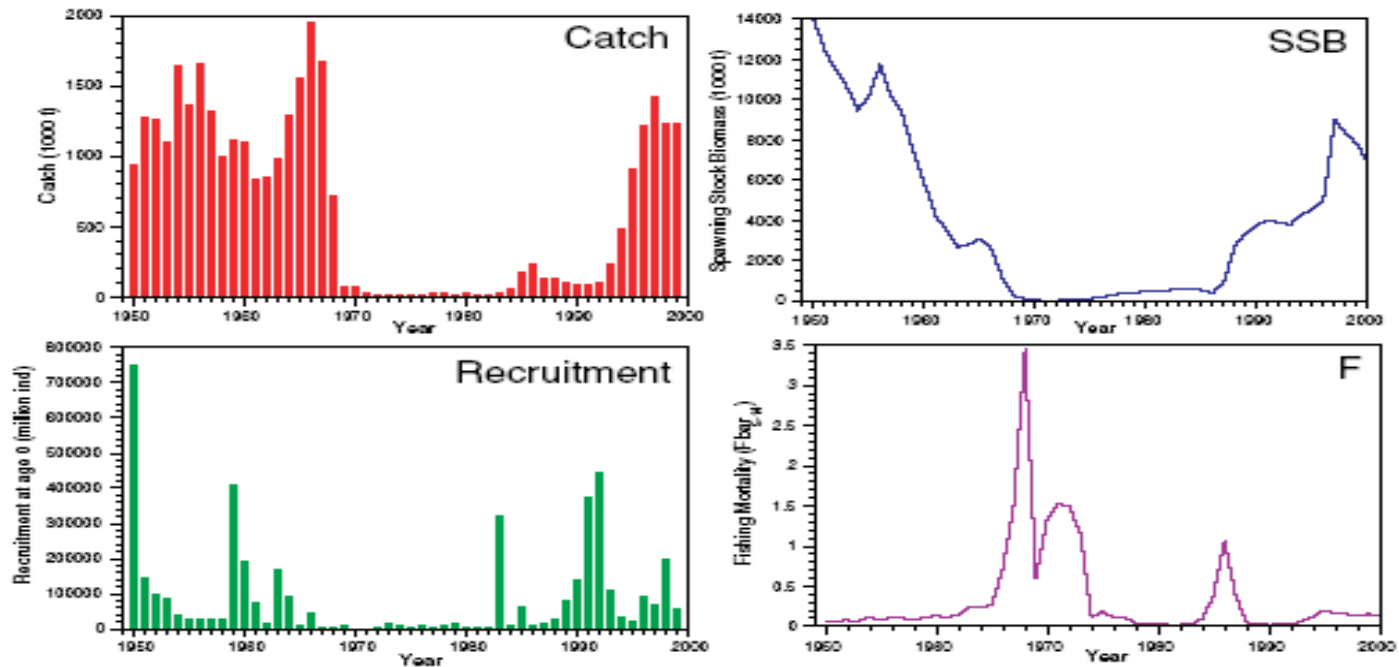
Indications of this renewed migration pattern discernible 5 years earlier

Is there a 30 years cycle in North Atlantic climate oscillations?

Collapse of herring stocks

(Source: ICES)

Norwegian Spring Spawning Herring

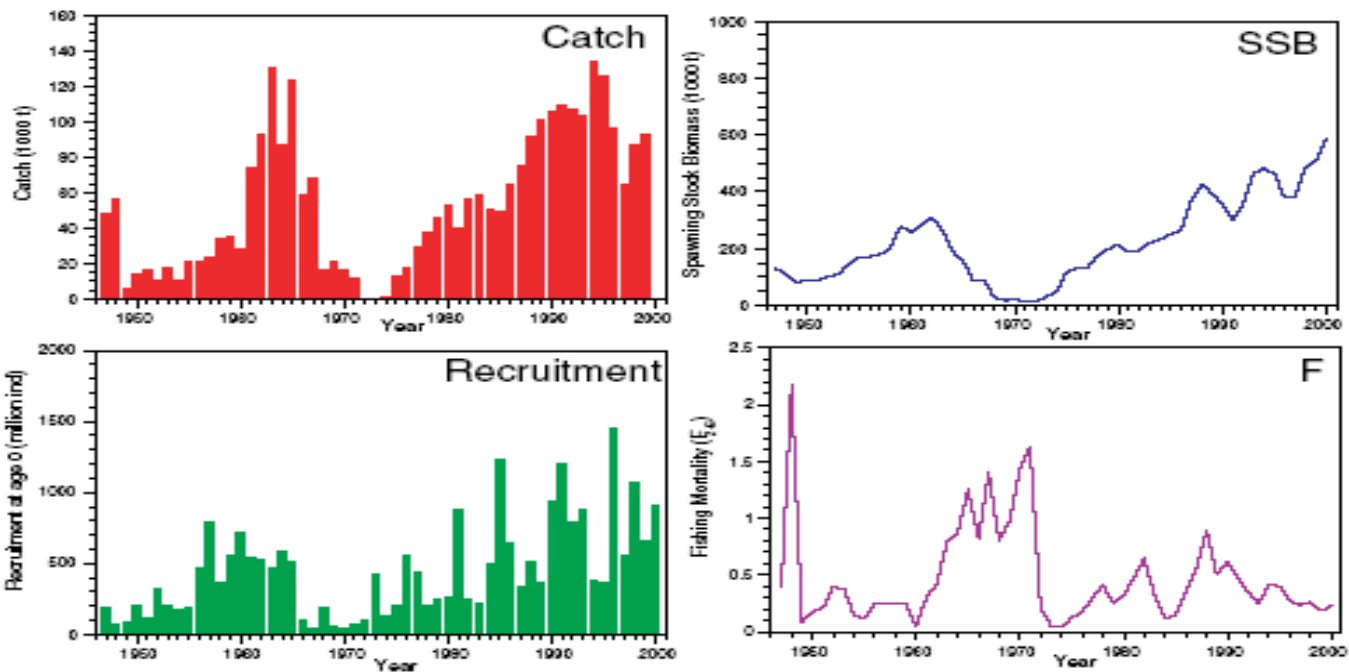


Other herring stocks suffered the same fate because of new fishing techniques and climate change

Collapse of herring stocks

(Source: ICES)

Icelandic Summer Spawning Herring



Present state of the herring stocks

(Source: Marine Research Institute, Reykjavik)

- **Icelandic spring-spawners**

Almost extinct since 1970

(Maybe an off-spring of the Norwegian stock)

- **Icelandic summer-spawners**

Spawning stock ≈ 0.4 Mt; Recommended catch ≈ 80 kt/year

Declined from equilibrium of 0.6 Mt because of an infection

(Endangered in the 1970s, rebuilt by strict TAC regulations)

- **Norwegian spring-spawners**

Spawning stock ≈ 4 Mt; Recommended catch ≈ 300 kt/year

Declining but relatively stable for the last 20 years

(Migrating again after decades of stagnation)

Why did the herring stocks collapse?

- **Mismanagement: Open access, overfishing, low recruitment (“tragedy of the commons”)**
- **Technical revolution: Sonar, power block, larger boats and purse seines**
- **Climate change: Lower ocean temperature, sea ice, reduced plankton production**
- **Harvesting immature herring**
- **Economic opportunism: Short-term demand for meal and oil supplied without foresight**

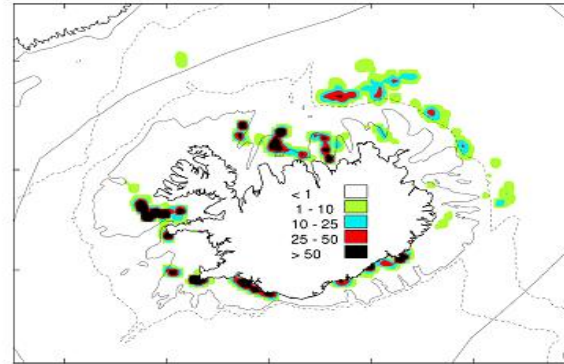
Other competing pelagic stocks

(Source: Marine Research Institute, Reykjavik)

- **Capelin**
- **Blue whiting**
- **Mackerel**

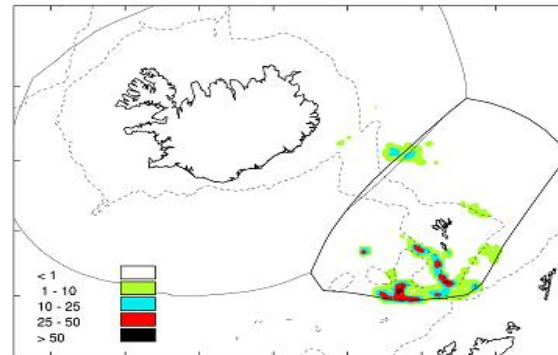


The capelin saved the Icelandic economy by replacing herring after the collapse in 1968



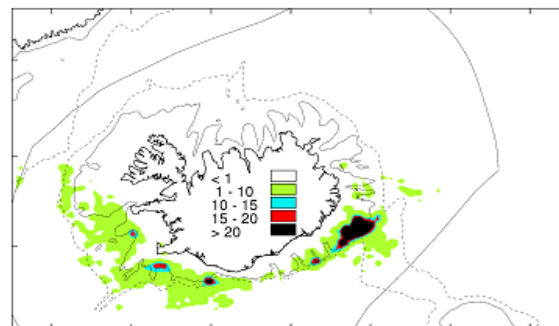
Loðna. Veidisvæði við Ísland vertíðina 2014/2015. Dekkstu svæðin sýna mestan afla (tonn/sjm²).

Capelin. Icelandic fishing grounds in 2014/2015 fishing season. Dark areas indicate highest catch (tonnes/nmi²).



Kolmunnir. Veidisvæði íslenskra skipa árið 2014. Dekkstu svæðin sýna mestan afla (tonn/sjm²).

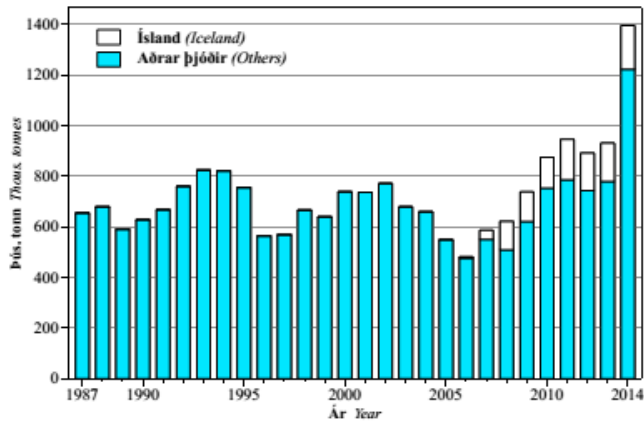
Blue whiting. Fishing grounds of the Icelandic fleet in 2014. Dark areas indicate highest catch (tonnes/nmi²).



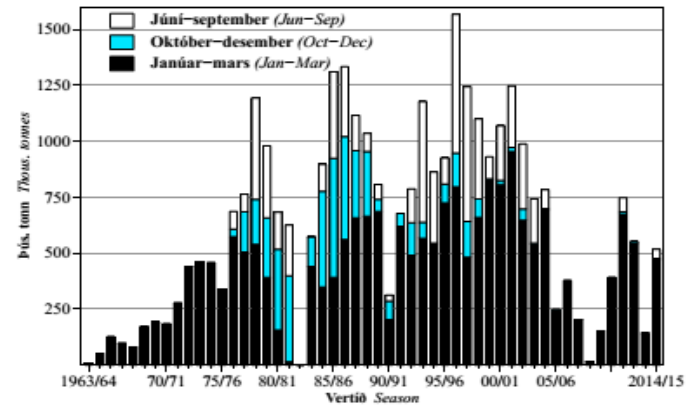
Makrill. Veidisvæði íslenskra skipa árið 2014. Dekkstu svæðin sýna mestan afla (tonn/sjm²).

Mackerel. Fishing grounds of the Icelandic fleet in 2014. Dark areas indicate highest catch (tonnes/nmi²).

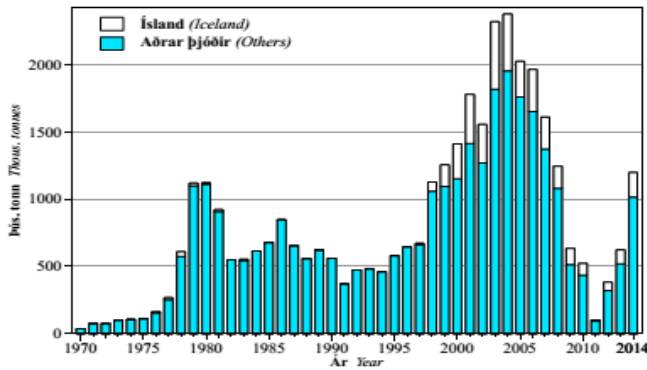
State of other stocks



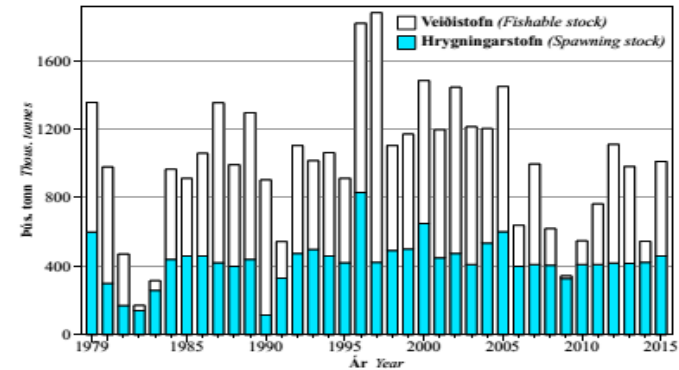
Mackerel: Catches from the Northeast Atlantic
Stock size in 2015 3.6 Mt



Icelandic capelin: Landings split between seasons



Blue whiting: Catches from the Northeast Atlantic
Stock size in 2015 3.3 Mt

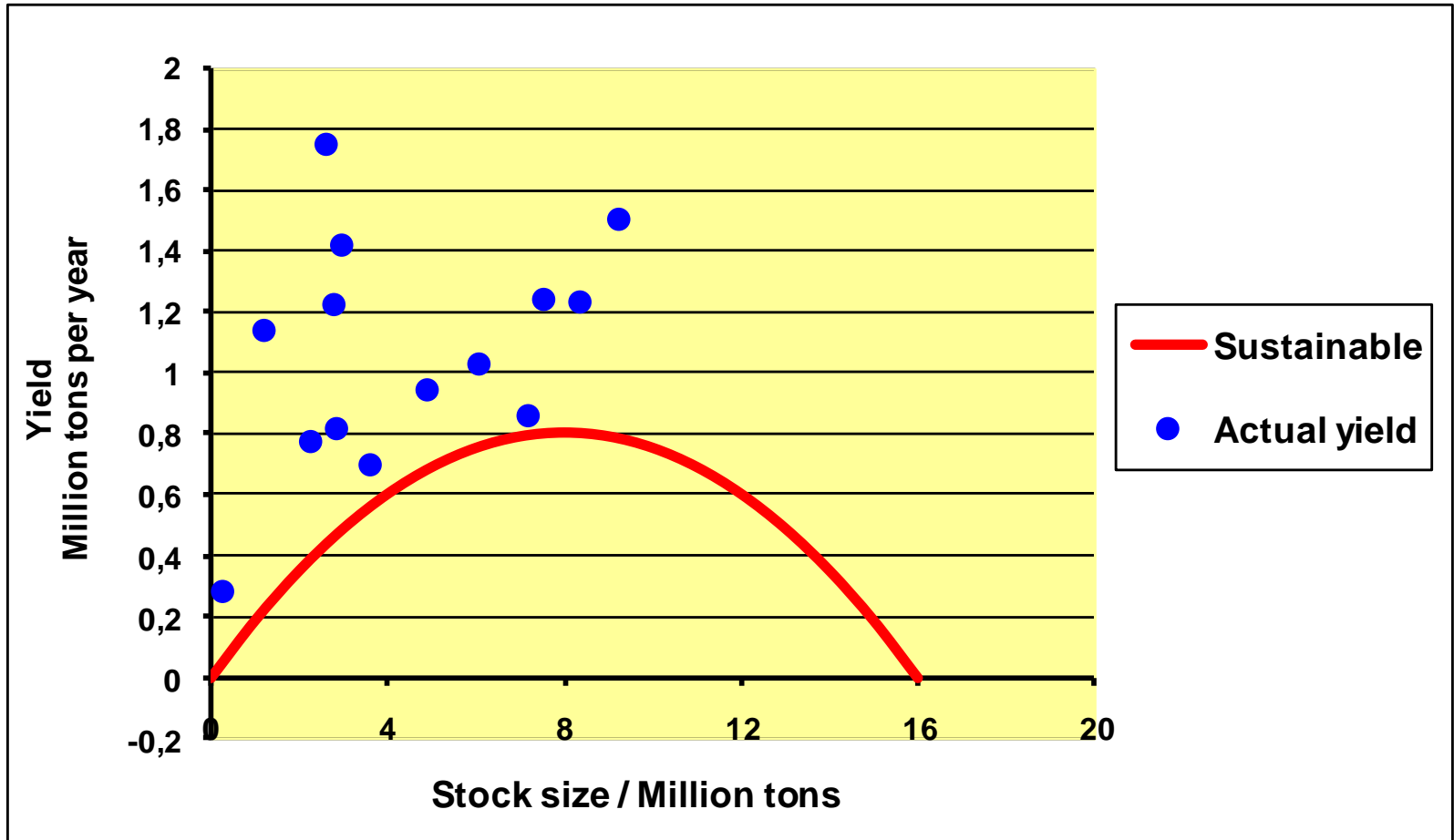


Icelandic capelin: Stock size

Successful management despite disputes over quota allocation between countries

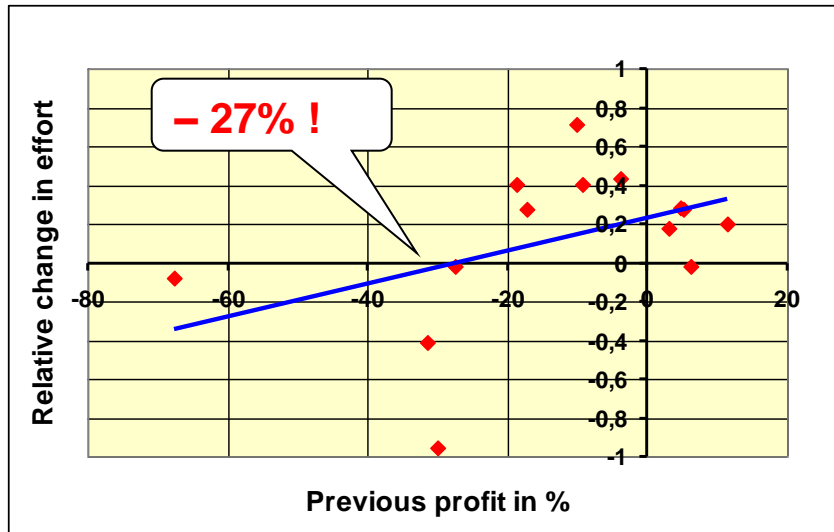
Model of overfishing 1955-1968

Schaefer's growth $G=0,2 S(1-S/16)$



(Sigurdsson, 2010)

Model of fleet dynamics 1955-1968



Model: $\frac{\Delta E}{E} = k(P - P_0)$

Estimation:

$$\frac{\Delta E}{E} = 0,233 + 0,0086 \times P$$

(0,123) (0,0050)

$$R = 0,44$$

Slope: $k = \underline{0,0086}$ **Marginal profit:** $P_0 = -0,233/0,0086 = \underline{-27\%}$

Fishing continued with increasing effort (10 times in this period) despite losses because of subsidies and negative real interest rate in government controlled banks and funds.

(Sigurdsson, 2006)

Increasing fishing capacity

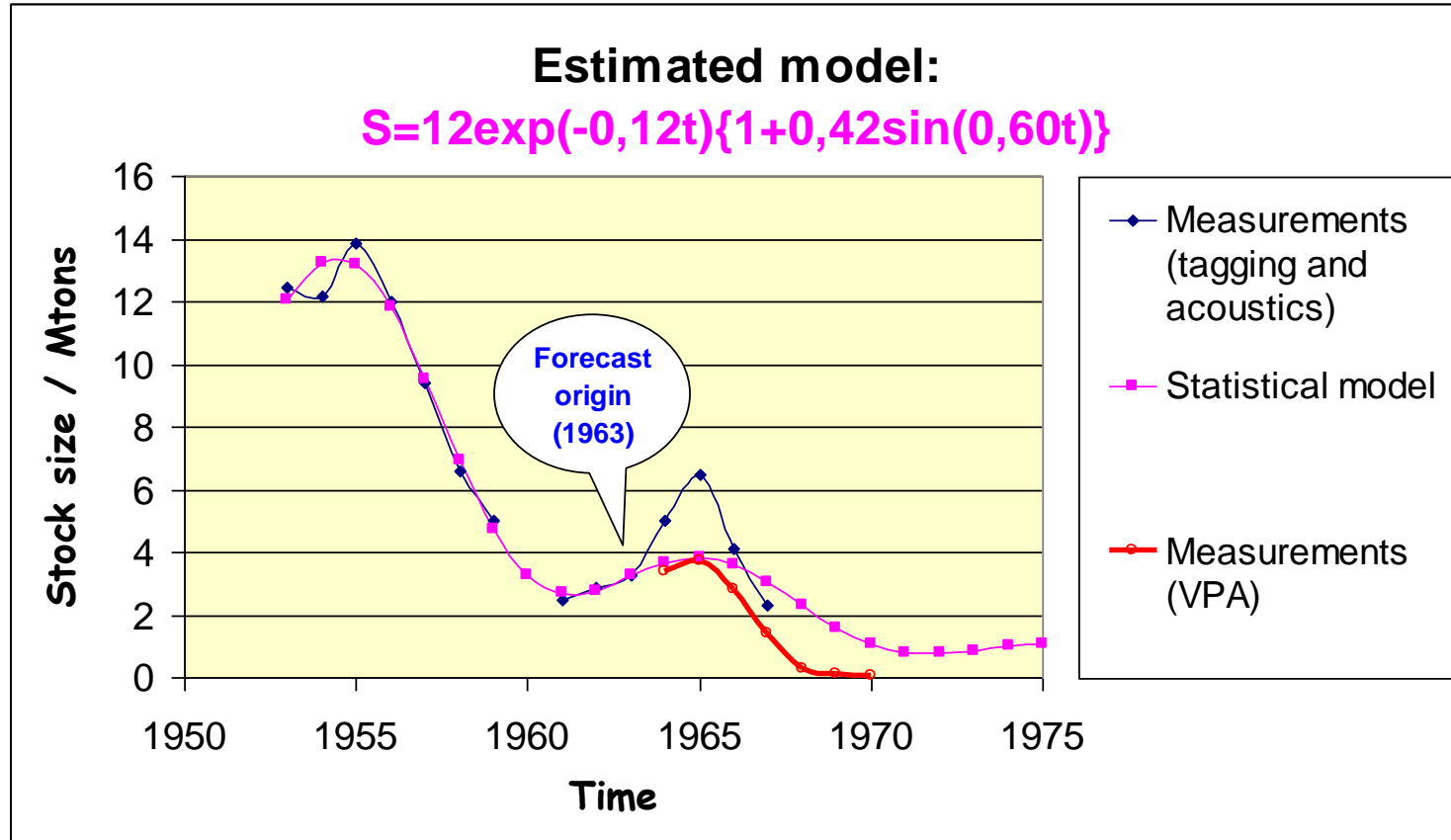


**Typical boat in the 1930s:
50 GT, purse seine, 2 skiffs,
(Photos: K. Gudjonsson; G. Asgeirsson)**

**New boat in the 1960s:
500 GT, ring net, sonar, powerblock
(Photo: J.A. Hedinsson)**



Model of the collapse



Easy to predict the past ! Time series too short and recognized too late.

(Sigurdsson, 2006)

CONCLUSIONS

- **Collapse predictable after 1970 by time series analysis from 1964**
- **Theoretically preventable by effort and catch limitations before 1960
- but practically impossible in an open access international fishery**
- **Tough lesson that lead to better management of other species**

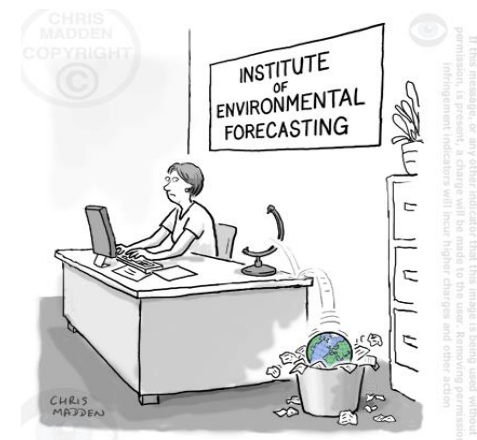
We have learned from history !

- **Continuous collection of biological and oceanographic data vital background**
- **Fish stocks compete and replace each other in varying oceanic conditions**
- **Statistical models useful forecasting tools but**
- **Warnings:**

„Prediction is very difficult, especially if it´s about the future.“ (Niels Bohr)

„An economist is an expert who will know tomorrow why the things he predicted yesterday didn´t happen today.“ (Evan Esar)

„I never think of the future, it comes soon enough.“ (Albert Einstein)



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