



International Institute for  
Applied Systems Analysis  
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science for global insight

# **Future Oceans**

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## Meeting the Challenges of Securing Aquatic Food Resources

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IIASA, International Institute for Applied Systems Analysis

# Aquatic Food Resources

- Key source of animal protein for a large fraction of humankind
- Many economies and communities, in particular in developing nations and coastal regions, depend on fisheries
- Rampant overfishing on open-access ocean fisheries is causing serious problems
- Impacts of catches on freshwater systems are still underestimated

Seafood is the primary source of animal protein for more than

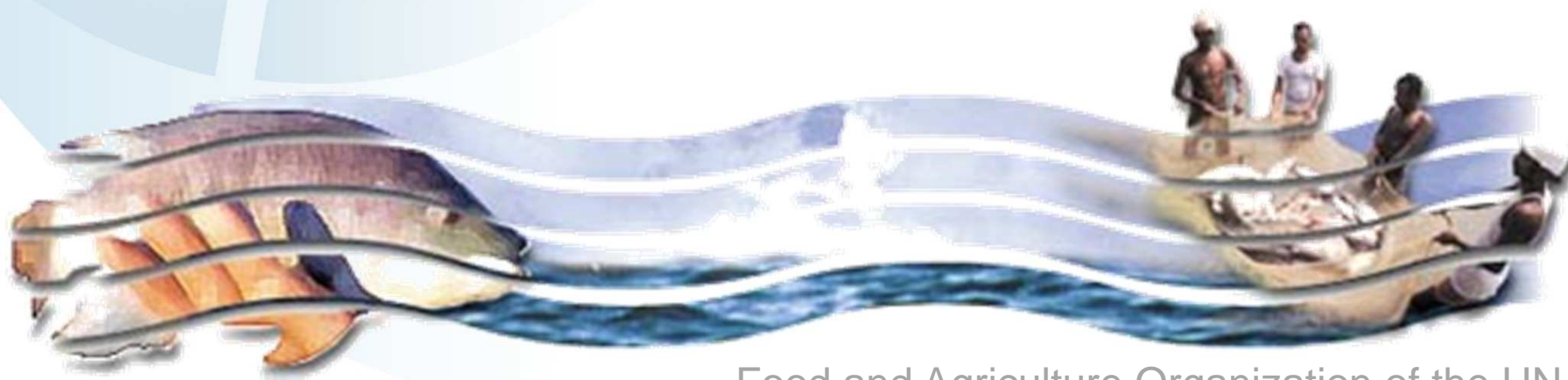
**1 billion people**



Food and Agriculture Organization of the UN

Fishing, aquaculture, and related industries support the livelihoods of

**700 million people**



Food and Agriculture Organization of the UN

# Only 2%

of motorized fishing boats  
are of industrial size



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Total annual revenue

**US\$225 billion**



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Total annual production

**155 million tonnes**



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Average annual per capita fish supply

19 kg



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Production growth in past 50 years

480%

*“Conquering the blue continent”*



Food and Agriculture Organization of the UN

Today, aquaculture supplies

**40%**

of total production; in China even

**65%**



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During the past 30 years  
capture production has **plateaued**,  
while aquaculture production has risen

**12-fold**



Food and Agriculture Organization of the UN

Of our oceans' fish stocks,

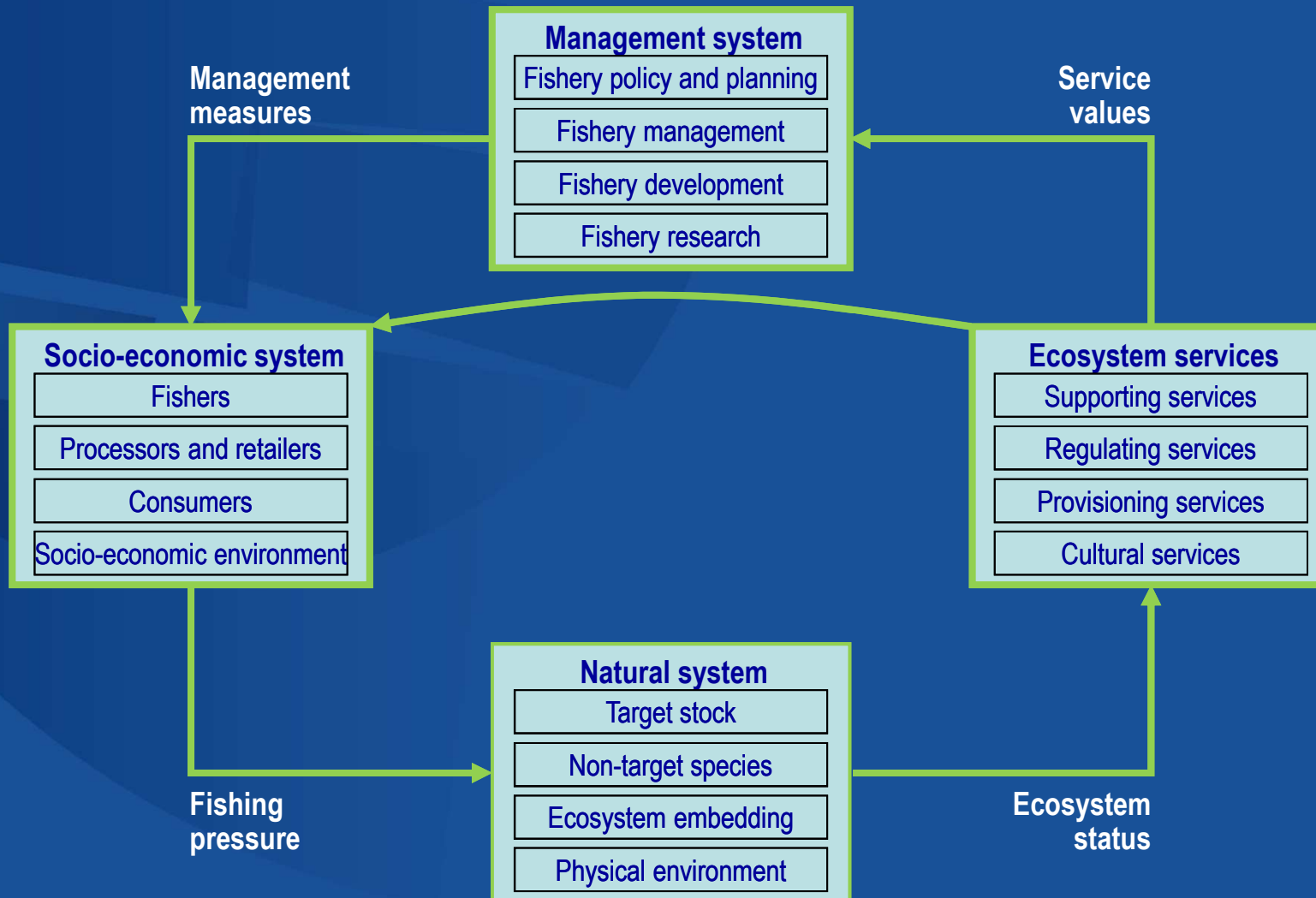
**50%** are fully exploited

**25%** are overexploited



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# Fishery Systems



# IIASA's Main Contributions

- Process-based models

Needed for coping with uncertainties, nonlinearities, and regime shifts

- Fisheries-induced evolution

Needed for overcoming a blind spot of contemporary fisheries management

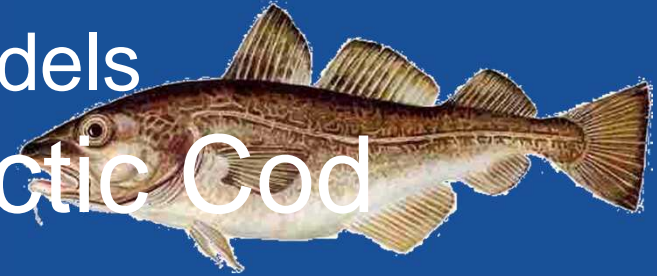
- Integrative assessments

Needed for facilitating transparent stakeholder reconciliation through quantitative socioeconomic analyses

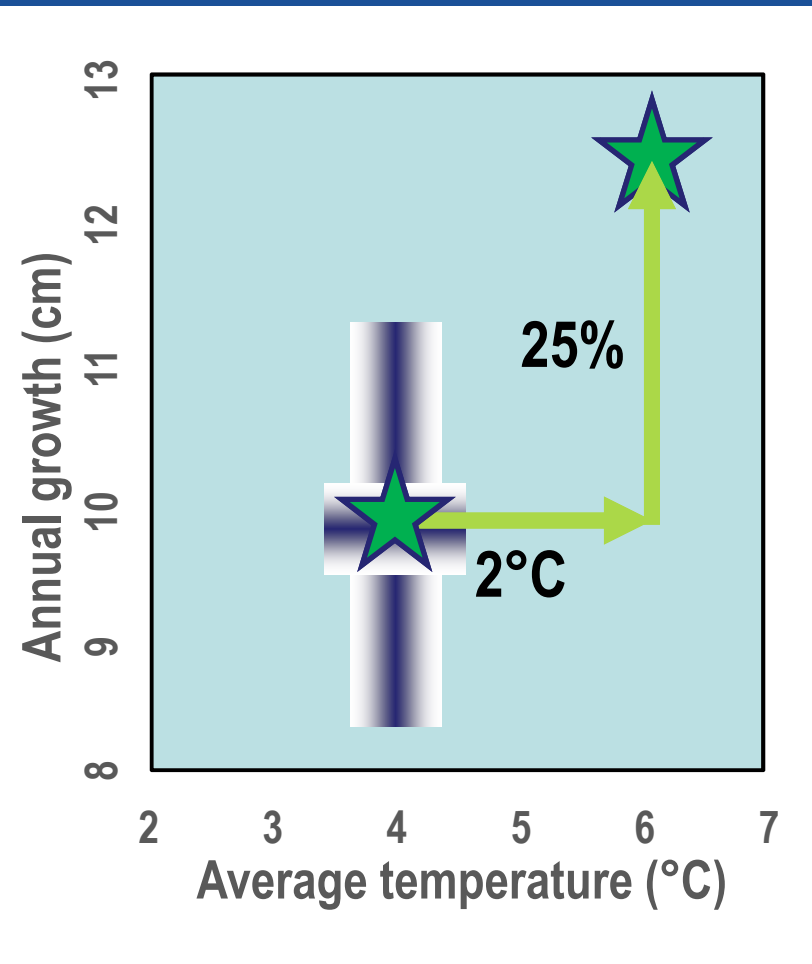


# Example 1: Process-Based Models

## Growth of Northeast Arctic Cod

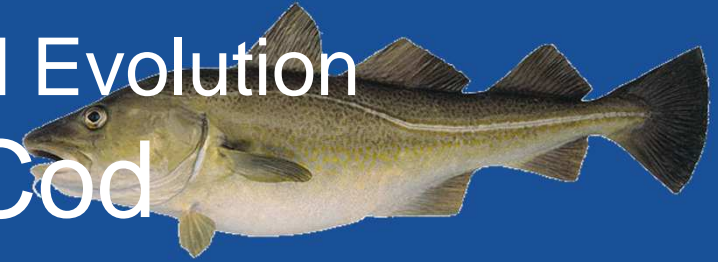


- Very valuable European stock
- Standard statistical models are problematic when used for extrapolation
- Standard age-based models are not suitable when growth is variable
- Growth turns out to vary with temperature and stock size
- A 2°C rise in temperature is expected to cause a 25% rise in growth



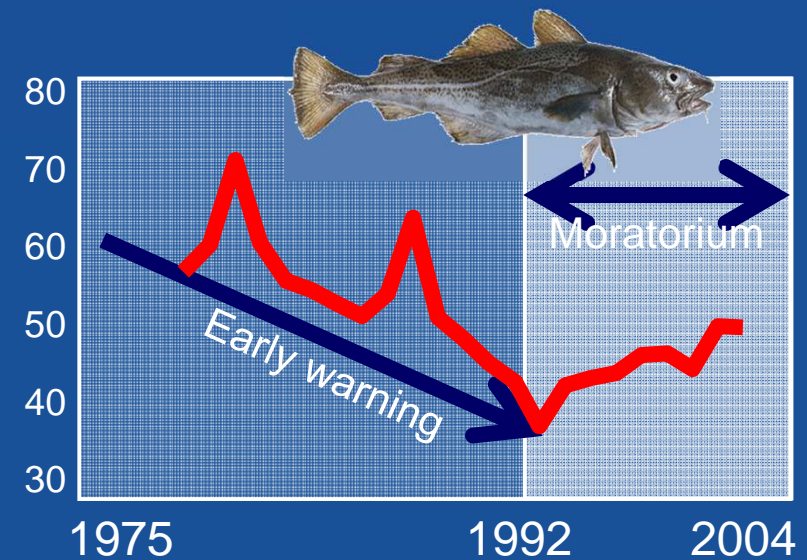
# Example 2: Fisheries-Induced Evolution

## Collapse of Northern Cod



- Stock collapsed in 1992 and has not recovered since
- Heavy exploitation favors earlier maturation at smaller size
- We have documented a 15% drop in age at maturation and a 30% drop in size at maturation
- Such evolutionary impacts of fishing are very slow and difficult to reverse

Size at 50% maturation probability at age 5 (cm)

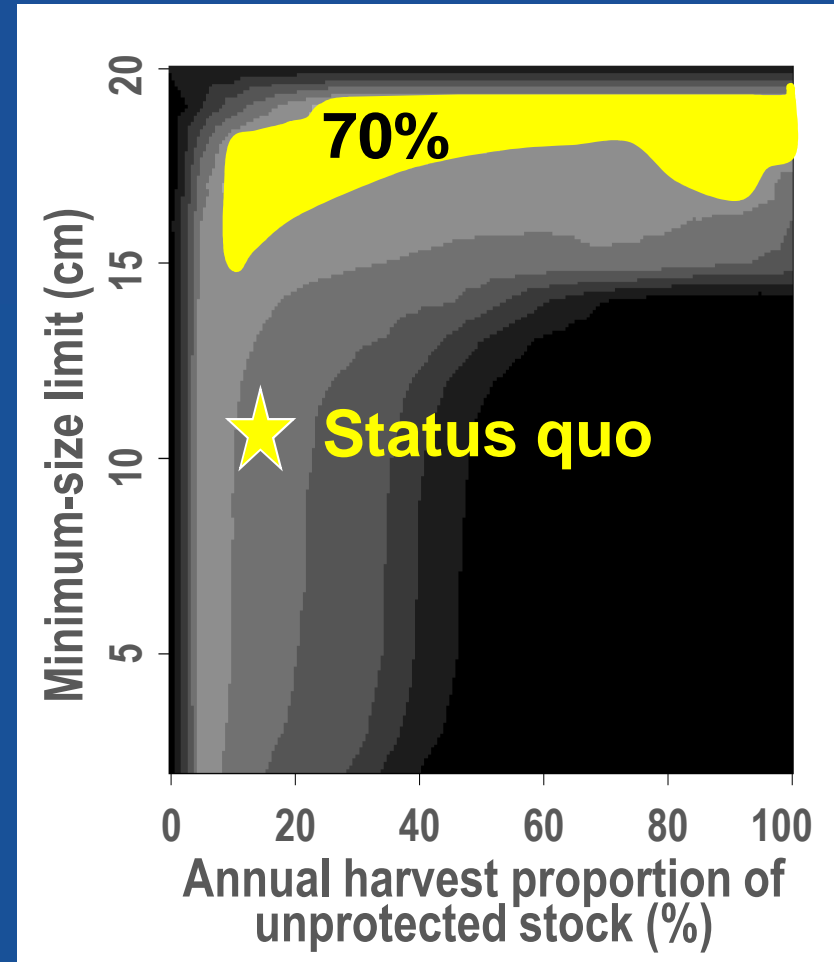


*Nature* 428:932

# Example 3: Integrative Assessments: Management of Barents Sea Capelin

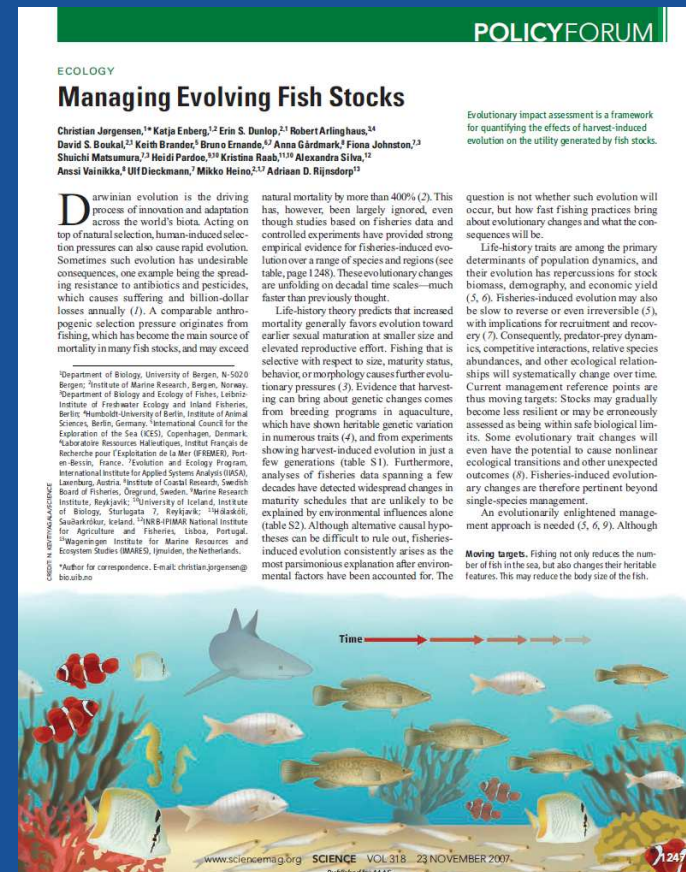


- Largest capelin stock in the world; was largest Norwegian fishery; collapsed in 1986
- Our assessment accounts for yields, profits, employment, and ecological impact
- Our assessment also accounts for differential preferences among five types of stakeholders
- Maximum joint satisfaction is high, and is best achieved through minimum-size limits



# Improving Fishing Policies

- International expert group on “Fisheries-induced Evolution”
- Part of the scientific advice by the International Council for the Exploration of the Sea (ICES)
- New tool: Evolutionary Impact Assessments (EvoIA)
- Monitoring maturation evolution has become a binding EU requirement
- At IIASA, further integration of process-based, evolutionary, and socioeconomic perspectives



Science 318:1247

Science 320:48