Case Study: Acid Rain in Europe
Case Study: Fisheries

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What is this and where is it?

Name the ***species*** of fish and the exact location (building, room)

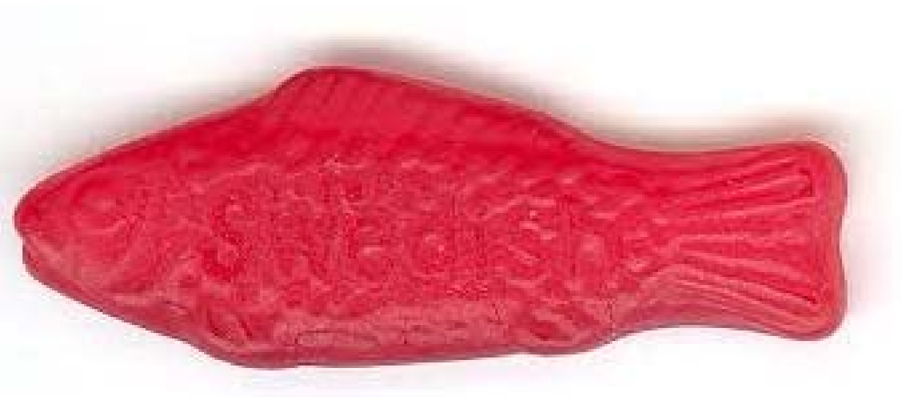
Prize: honor, glory, extra Swedish fish (Hint: it is not in Sweden).

Bonus points for its nickname.

Questions raised in quizzes

- Why is it “salience” not “relevance”?
- Discussion starters:
  - Should you make your model more legitimate in the eyes of a decision-maker who has already made up his/her mind?
  - What if you have a better model but the current one is “good enough”?
  - Suggestion: use online discussion forum…

Running themes: Sweden, Fish



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First, Sweden…..the RAINS case

What is acid rain?

- Natural pH of rain: 5-7 (due to equilibrium with CO_2, natural acids/bases)
- Acid rain: Rain with pH <5
- Causes damage to ecosystems
- Pollutants of concern: Sulfur and nitrogen oxides

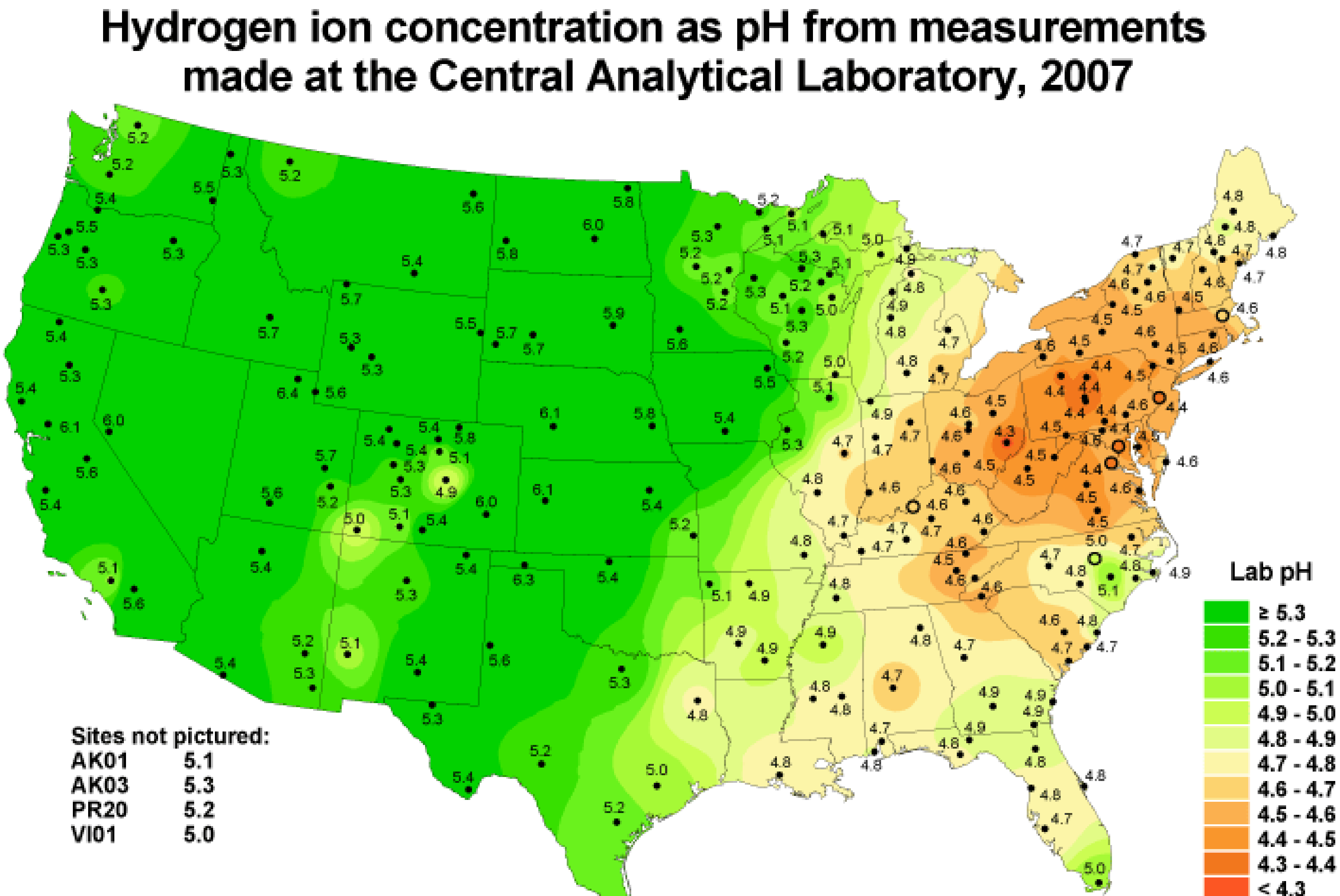
What's the problem?

Local air pollution (c. 1950) becomes a problem….

Solution = dilution! (Build high smokestacks)

This leads to long-range transport, and thus problems beyond jurisdictions (esp. in Europe)

PRECIPITATION PH OVER THE UNITED STATES



National Atmospheric Deposition Program/National Trends Network
http://nadp.sws.uiuc.edu

Figure by the National Atmospheric Deposition Program. This image is in the public domain.

European Acid Rain

Domestic portion of the sulfur deposition in European countries according to model calculations with a 10-year average meteorology*

Country	1980	1988
Albania	21	22
Austria	18	10
Belgium	51	46
Bulgaria	66	68
Czechoslovakia	53	54
Denmark	43	33
Finland	34	25
France	55	34
East Germany	72	76
Greece	42	40
Hungary	60	58
Ireland	40	36
Italy	75	68
Luxembourg	21	23
Netherlands	29	27
Norway	9	5
Poland	51	55
Portugal	46	44
Romania	11	11

Country	1980	1988
Spain	76	78
Sweden	20	13
Switzerland	16	11
Turkey	24	30
U.S.S.R	62	58
United Kingdom	83	83
West Germany	47	42
Yugoslavia	38	46

*Calculations based on results from the co-operative programme for monitoring and evaluation of the long-range transmission of air-pollutants in Europe (EMEP).

Image by MIT OpenCourseWare.

Acid Politics in Europe

- Led by Nordic countries (esp. Sweden)
- Research by Svante Oden (Swedish scientist, 1967) shows precipitation becoming more acidic, took concerns to the public in newspaper article
- Sweden takes its concerns to Organization for Economic Co-operation and Development (OECD)
- Acid rain comes onto the political agenda around the time of the 1972 Stockholm Conference on the Human Environment (first major environmental summit)

Acid politics as East-West issue

- United Nations Economic Commission for Europe takes over
- In 1975, Soviet premier Brezhnev called for east-west cooperation on "environment, energy or transport"
- Acid rain was convenient at the time
- Led to 1979 Convention on Long-Range Transboundary Air Pollution

Convention on Long-Range Transboundary Air Pollution

- "LRTAP" [or, "CLRTAP" in Europe]
- Historic agreement: called the first international treaty on air pollution, first east-west environmental treaty
- No requirements initially, but set in motion scientific cooperation through Co-operative Programme for the Monitoring and Evaluation of the Long-Range Transmission of Air Pollutants in Europe (EMEP)
- EMEP centers: one in West (Oslo), one in East (Moscow)

First effort to regulate sulfur

- 1985 Sulfur Protocol
- "30%" club: countries agree to reduce emissions (or their transboundary fluxes) 30% from 1980-1993

LRTAP Sulfur Science: General Impressions

- "When this convention came about, certainly it was scientific findings that were in the bottom."
- "…the internalization of science as an important component in development of an agreement [has] mostly…become manifest during this decade"
- [from interviews with LRTAP delegates, 1998]

Sulfur (1985): Influence of Assessment

- Agenda-setting
  - Bringing acidification to public opinion
  - Acceptance of transboundary nature of problem
- Identification of Sources
  - Justifying decisionmaking
  - Identifying the culprits
- Handling uncertainty
  - Parties stalled negotiations by citing uncertainty
- **Little science, but it seemed to work**

Sulfur (1994): Increasing influence of assessment

- Shifting debate from basic controversies to application of information
  - Critical loads = a common language of evaluation
  - …to critical levels
- Providing evidence to justify decision making
- Debate over modeling methods and uncertainties, not substantive issues
- "by the time you got to the second [sulfur protocol] we were getting sophisticated in how you design the protocol to take into account scientific things you knew" [Interview, 1998]

The progress of LRTAP Assessment

- "Over the 20 years that the convention has existed, it has built up quite a network and support system to develop good scientific work. There's the EMEP process, and the working group on effects, and the…integrated assessment modeling done through IIASA, which has matured over that period of time." [Interview, 1998]
- "The LRTAP process integrated knowledge-building exercises artfully with the task of negotiating international regulations" (Levy, 1995)

Use of Models in LRTAP

- 3 potential integrated assessment models being developed c. 1985
- "RAINS" developed by IIASA is chosen
- Generally viewed as a successful use of modeling in policy/negotiations; also, one of the first (Hordijk, 1991)
- RAINS allows scenario and optimization analysis

RAINS modeling

- 4 components:
  - Energy use
  - Costs
  - Dispersion
  - Effects

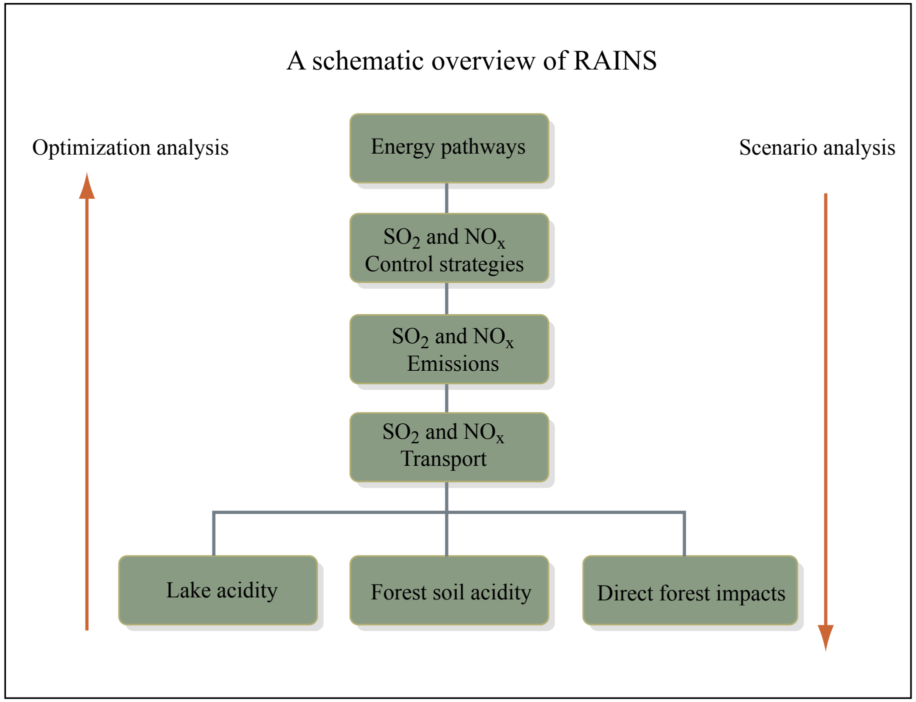


Image by MIT OpenCourseWare.

RAINS scenarios during 1994 Sulfur negotiations

Scenario	Emissions reduction (Percent)*	Annual costs (Billions of Deutsche marks)	Ecosystem protection (percent of area)
1994 reduction plans	29	15	78
Best available technology	83	82	97
60-percent flat rate	58	34	86
60-percent gap closure	59	26	93
Second sulfur protocol	53	29	90

**Relative to 1980 levels*

Scenarios considered during the negotiations over the second sulfur protocol

Image by MIT OpenCourseWare. After Tuinstra, Hordijk & Amann, 1999.

Why was RAINS so credible? (Tuinstra, 1999)

- Trust in institutions that conducted modeling
- Close relationship between modelers and policy
- Conducted within LRTAP framework
- Used data provided by countries
- 3 different models used/compared: not one solution

- Anything surprising here?

Questions

- What are the limits to complexity of a model used in international negotiations?

“Dependable Dynamism”?

- “The developments following the 1987 signing [of the Montreal Protocol] illustrated the wisdom of designing the treaty as a flexible instrument. By providing for periodic integrated assessments -- the first of which was advanced . . . in response to the rapidly changing science -- the negotiators made the accord adaptable to evolving circumstances. In effect, the protocol became a dynamic process rather than a static solution” (Benedick, 1998, p. 319).

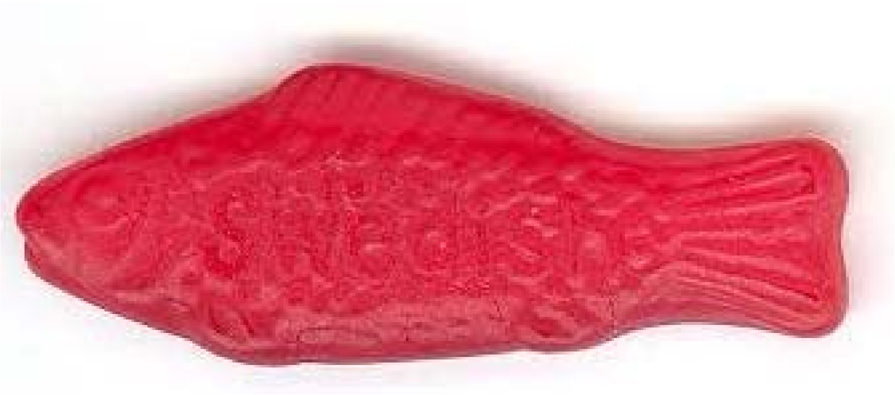
How does adapatability help?

- Not the "final" decision: lowering the threshold of scientific credibility
- Can compromise across time
- But, not too fluid that decisions can be taken back at any time: "dependable"

More questions

- Was RAINS' success more about the process than the model?
- Can you imagine a situation where a RAINS-like model would fail to influence policy? What would it look like?
- Can you draw any lessons from this case for the type of modeling you do?

In Sweden they are just "Fish"



Photograph by Slowking Man on wikimedia commons; this photograph is in the public domain.

Fisheries….

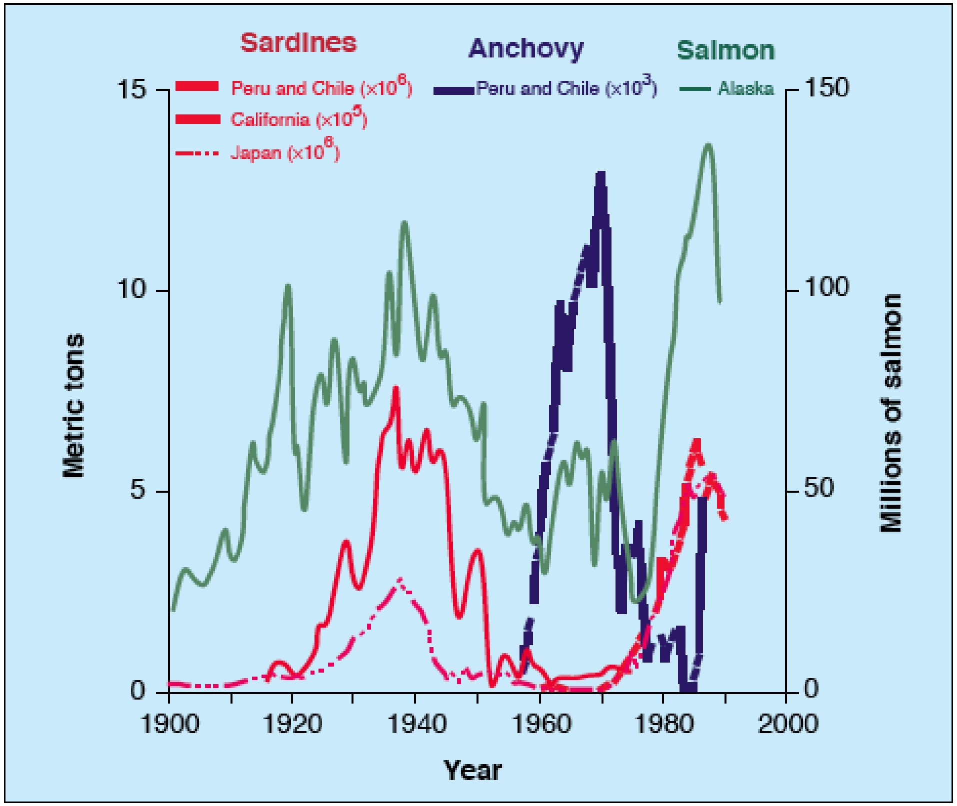
What is this and where is it?

Massachusetts State House
House of Representatives Chamber
"The Sacred Cod"

FYI for your entertainment: Tour the State House, weekdays 10-3, 617-727-3676

Prize winners?

What’s the issue?



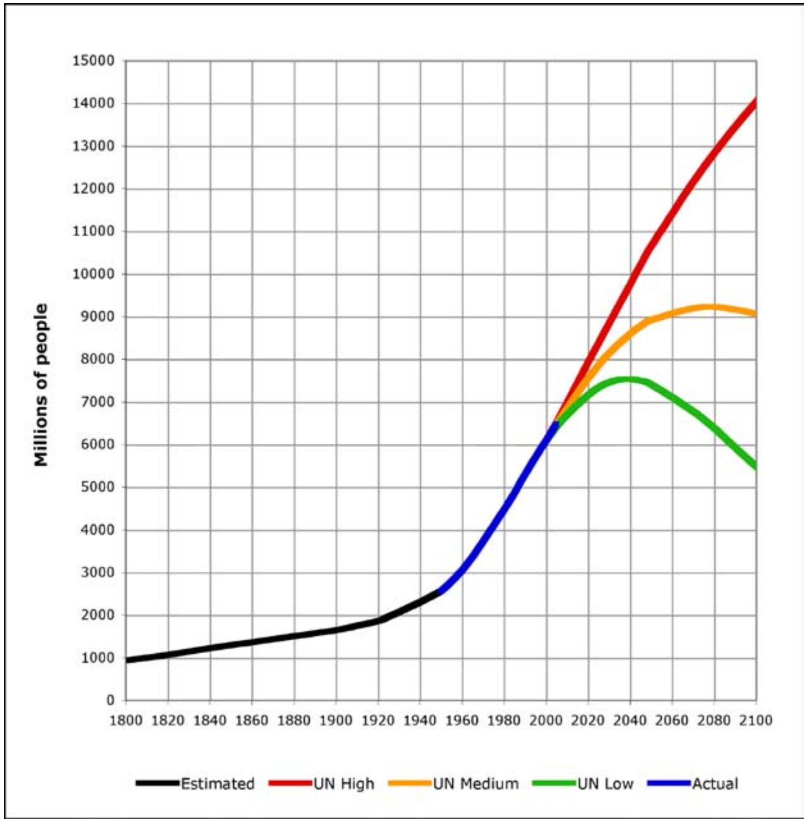
Source: Botsford, Louis W., Juan Carlos Castilla, et al. "The Management of Fisheries and Marine Ecosystems." *Science* 277, no. 5325 (1997): 509-15.

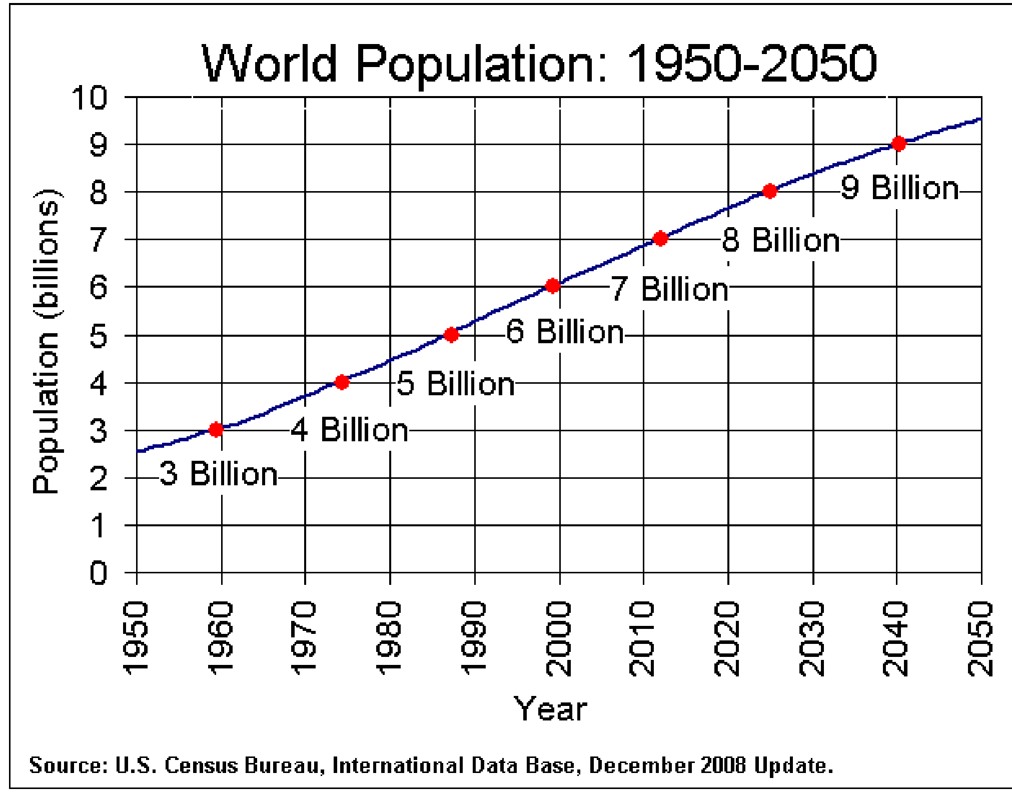
Source: Botsford, 1997

Fisheries Management

- *"In the most common institutional format for fisheries management, fisheries scientists formulate potential management actions based on these estimates, then provide them to fishery managers, who weigh their sociopolitical consequences in deciding which to implement."* (Bosford, 1997)
- Recent example: EU fisheries management

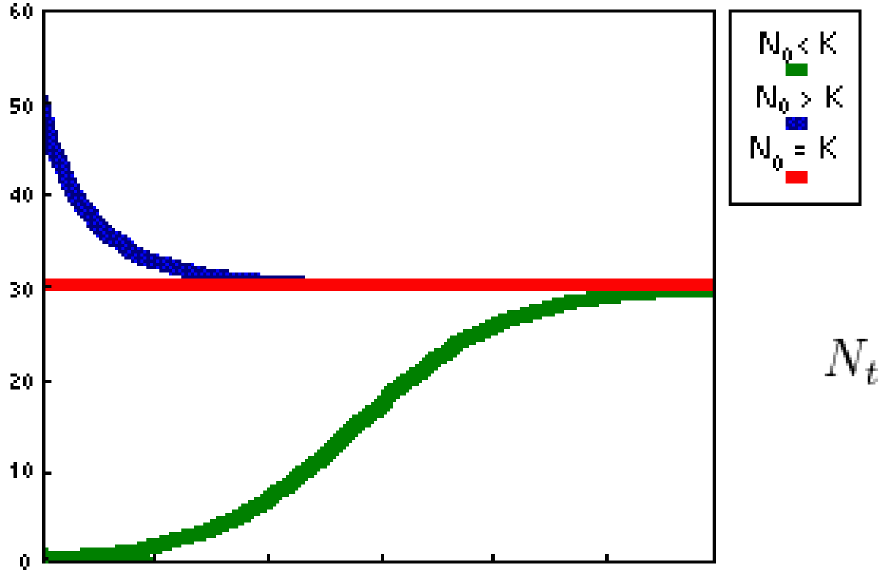
Population: Exponential model





Logistic model of population growth

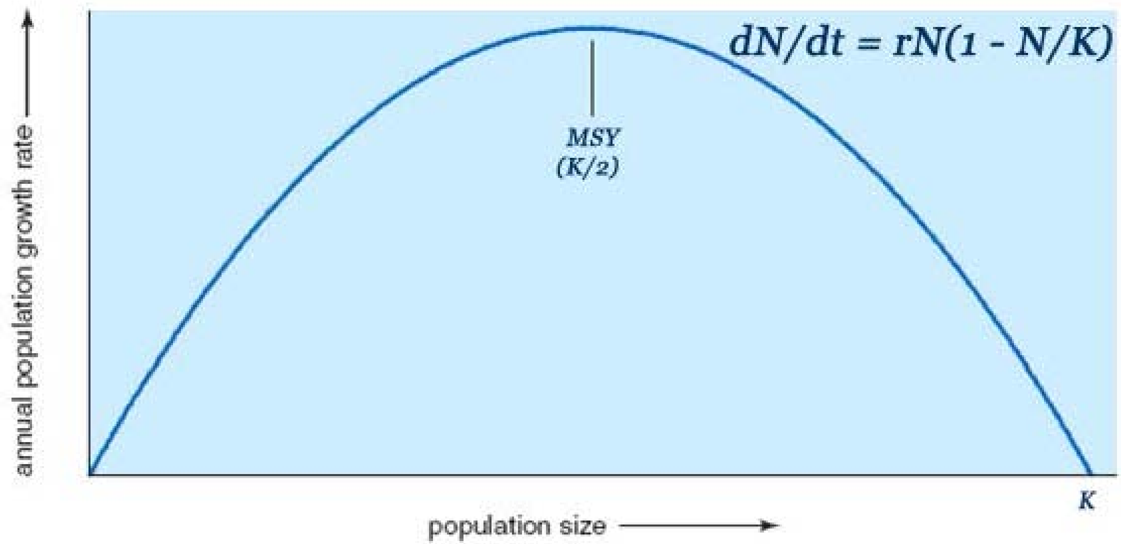
- $$\frac{dN}{dt} = rN\left(1 - \frac{N}{K}\right)$$ where r is maximum growth rate and K is carrying capacity



Courtesy of Alexei Sharov. Used with permission.

$$N_t = \frac{K}{1 + \frac{K - N_0}{N_0} e^{-rt}}$$

Maximum sustainable yield (MSY)



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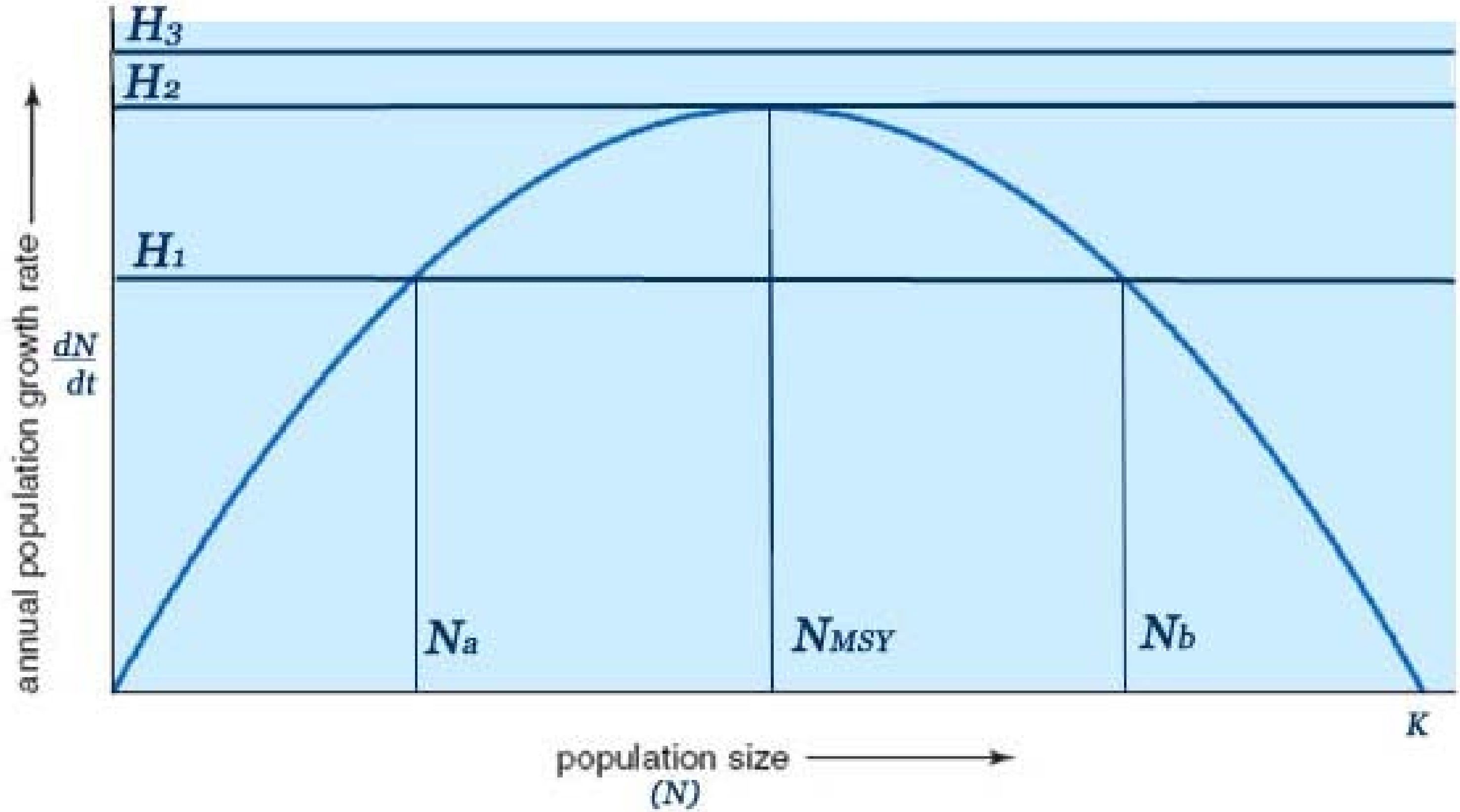
$$\frac{dN}{dt} = rN(1 - \frac{N}{K}) - H$$

Where H represents "Harvesting"

At MSY: dN/dt is maximum [differentiate, set equal to 0 → N=K/2

Influence of harvest rate: Perils of Quantitative Management



What is adaptive management?

- Formalization of “learning by doing”
- Management policies chosen to test uncertainties: policy as experimentation

ISO 14000 general principles for environmental management

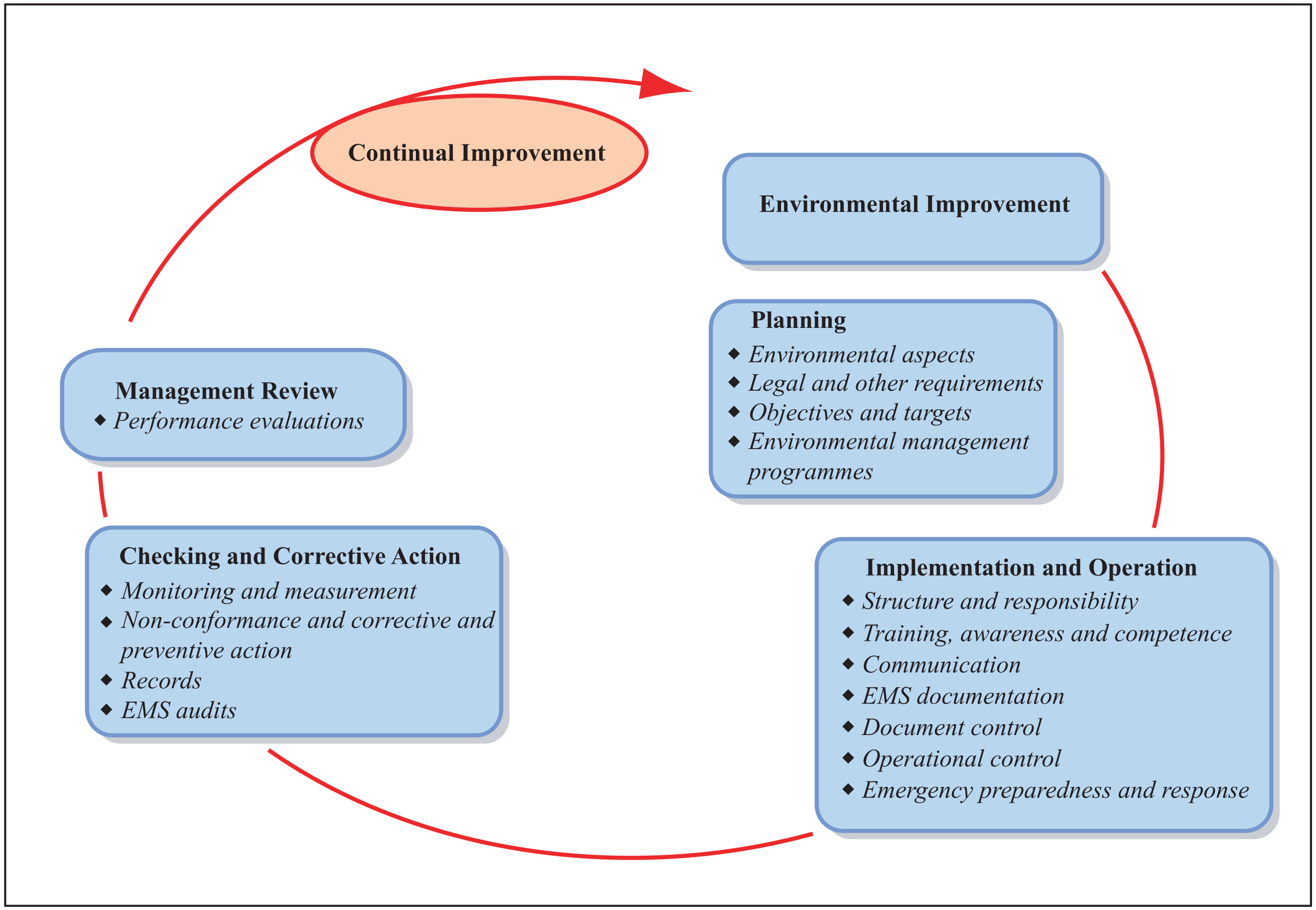
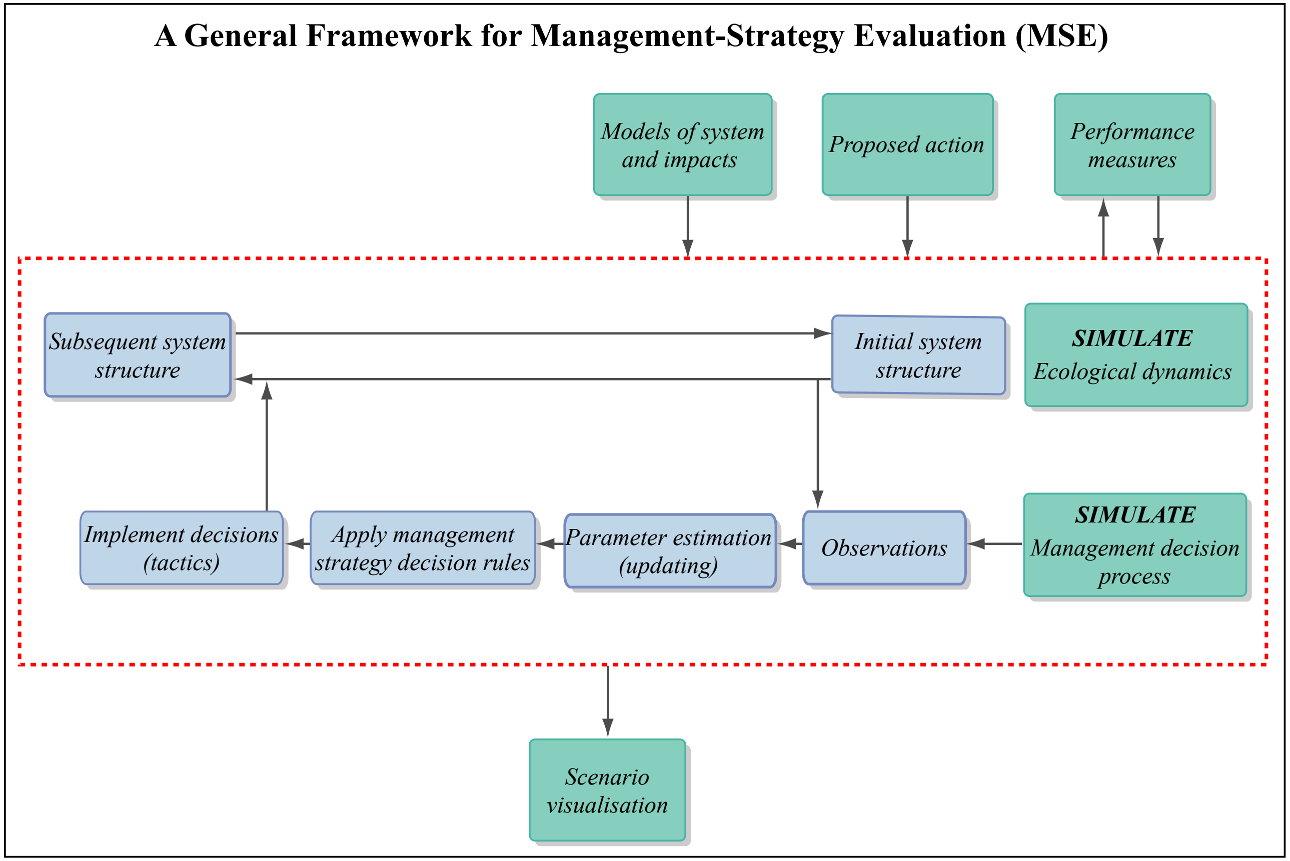


Image by MIT OpenCourseWare. After Sainsbury et al., 2000.

Management strategy evaluation



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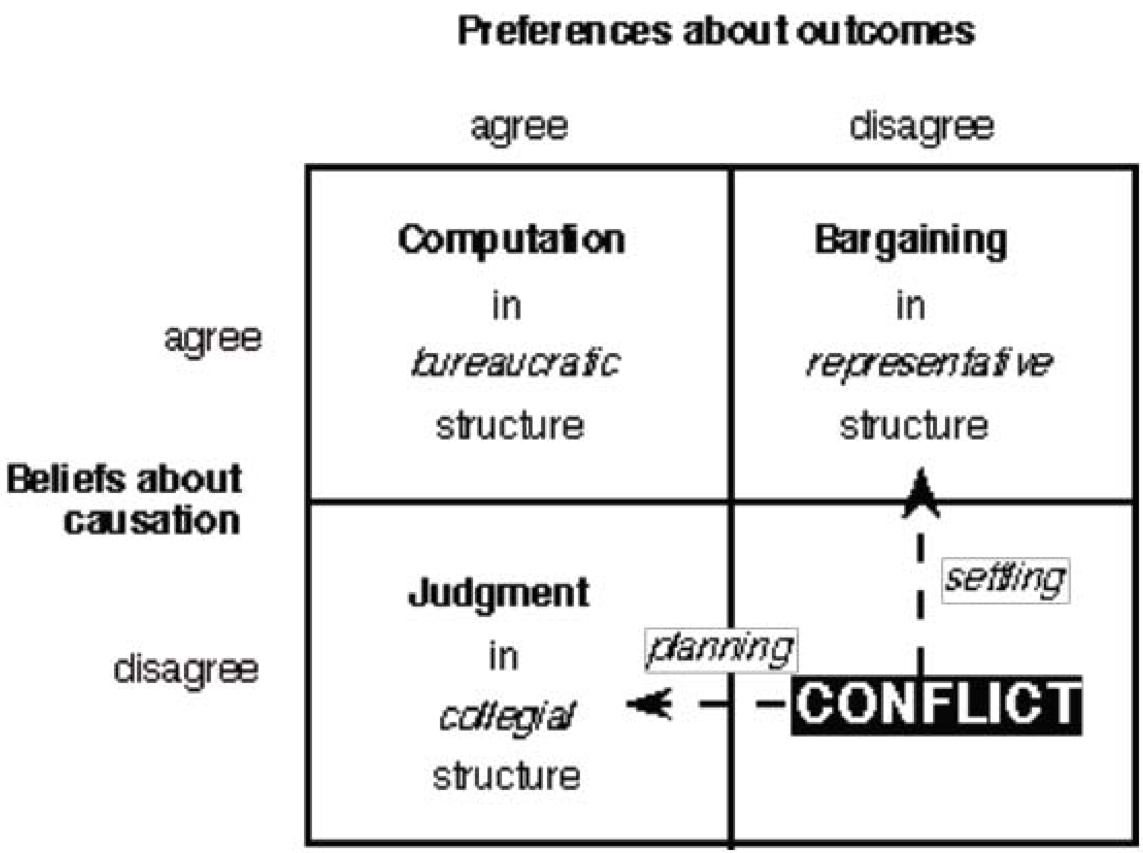
Adaptive Management in Conservation

Ref: Conservation Measures Partnership

each mode of learning	makes observations...	and combines them...	to inform activities...	...that accumulate into usable knowledge	*example*
LABORATORY EXPERIMENTATION	controlled observation to infer cause	replicated to assure reliable knowledge	enabling prediction, design, control	**theory** (it works, but range of applicability may be narrow)	*molecular biology & biotechnology*
ADAPTIVE MANAGEMENT (QUASI-EXPERIMENTS IN THE FIELD)	systematic monitoring to detect surprise	integrated assessment to build system knowledge	informing model-building to structure debate	**strong inference** (but learning may not produce timely prediction or control)	*Green Revolution agriculture*
TRIAL & ERROR	problem-oriented observation	extended to analogous instances	to solve or mitigate particular problems	**empirical knowledge** (it works but may be inconsistent & surprising)	*Learning by doing in mass production*
UNMONITORED EXPERIENCE	casual observation	applied anecdotally	to identify plausible solutions to intractable problems	**models of reality** (test is political, not practical, feasibility)	*most statutory policies*

Source: Table 1 in Lee, Kai N. "Appraising Adaptive Management."
Conservation Ecology 3, no. 2 (1999): 3.

Strategies for moving forward



Courtesy of The Resilience Alliance. Used with permission.
Source: Table 1 in Lee, Kai N. "Appraising Adaptive Management."
Conservation Ecology 3, no. 2 (1999): 3.

From Lee, 1999

Importance of model simulations….

- Purpose of modeling in AM is **not to build realistic representations**, but to develop **simplifications** for specific purposes
- Used to explicitly describe components of management and relationships, articulate assumptions, incorporate level & types of uncertainty
- Quantitative modeling can investigate **propagation** of uncertainties
- Role of models in **problem clarification, policy screening, identification of key knowledge gaps**

(Schreiber et al 2004; Walters, 1997)

Modeling in adaptive management practice

- Low success rate: of 25 planning exercises, 7 large-scale management experiments, and 2 "well-planned" ones (Walters, 1997)
- Why so low? Specific barriers for modeling:
  - Problems of scale and complexity
  - Reasons for distrusting detailed models as much or more as simple ones: concentration of interactions, overparameterization (cf. Oreskes), propagating feedbacks

Walters, 1997

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