How will Fisheries and Managers Adapt to Climate Change?

Andrew A. Rosenberg,
University of New Hampshire

What do we have to adapt to?

- Changes in distribution
  (e.g., Hanneson 2007 Marine Policy, Roessig et al. 2004 Rev. Fish Bio Fisheries)
- Changes in productivity
  (e.g. Brander 2007 PNAS, Stenevik and Sundby 2007 Marine Policy, Portner et al. 2001 Cont. Shelf Res.)
- Changes in species composition
  (Brunel and Boucher 2007 Fish. Oceanog., Edgar et al. 2008 Con Bio.)
- Changes in variability
  (e.g. Eide 2008 Climatic Change, Zeeberg et al 2008 Fish Res.)
- Changes in resilience
  (e.g. Watters 2003 Can. J. Fish)

The History of Fishing

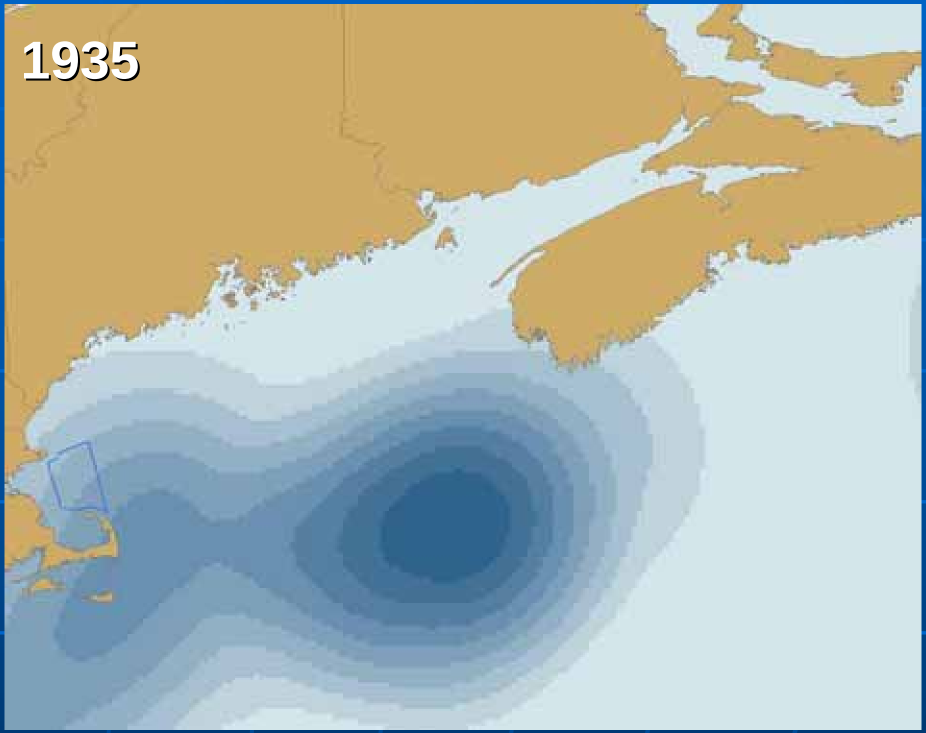
Expansion to new areas, gears and products resulting in profound changes in exploitation

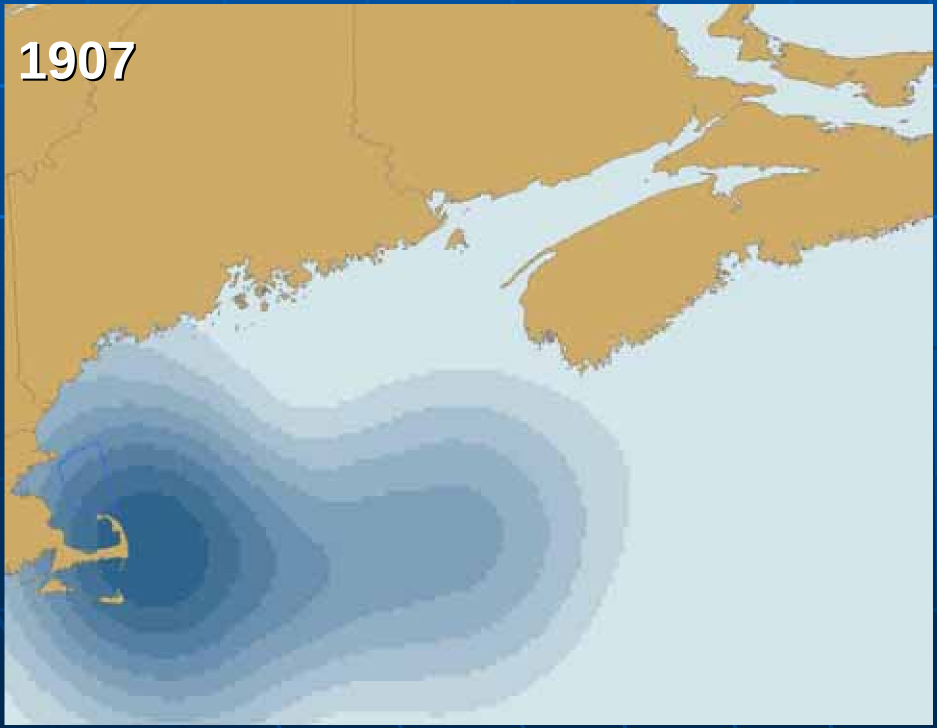
(and overexploitation)

This history gives good indications for adaptation of fisheries policy to climate change

Localized Fishery Expansion

Change in Relative Concentration of Fishing Effort





Analysis by S. Claesson, UNH

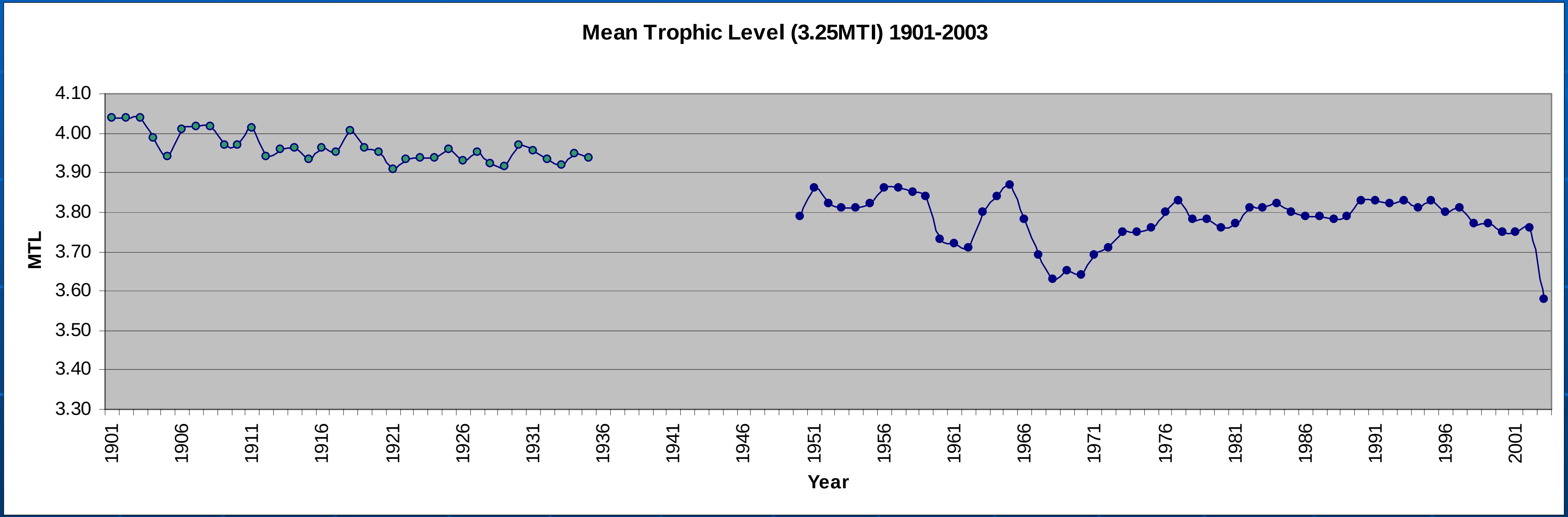
Changing Target Species

Analysis by S. Claesson, UNH

Mean Trophic Levels from Statistical Bulletin Landing Data (1901-1935)

and

LME Northeast US Continental Shelf Landings (1950-2003)



Trophic Level: Position in the food chain, determined by the number of energy-transfer steps to that level. A number indicating the position of a species within an ecosystem. By definition, plants have a TL = 1, herbivores TL = 2, and so on, up to a TL = 5 in killer whales.

Biomass Depletion and Shifting Baselines

The Scotian Shelf

REVIEWS REVIEWS REVIEWS

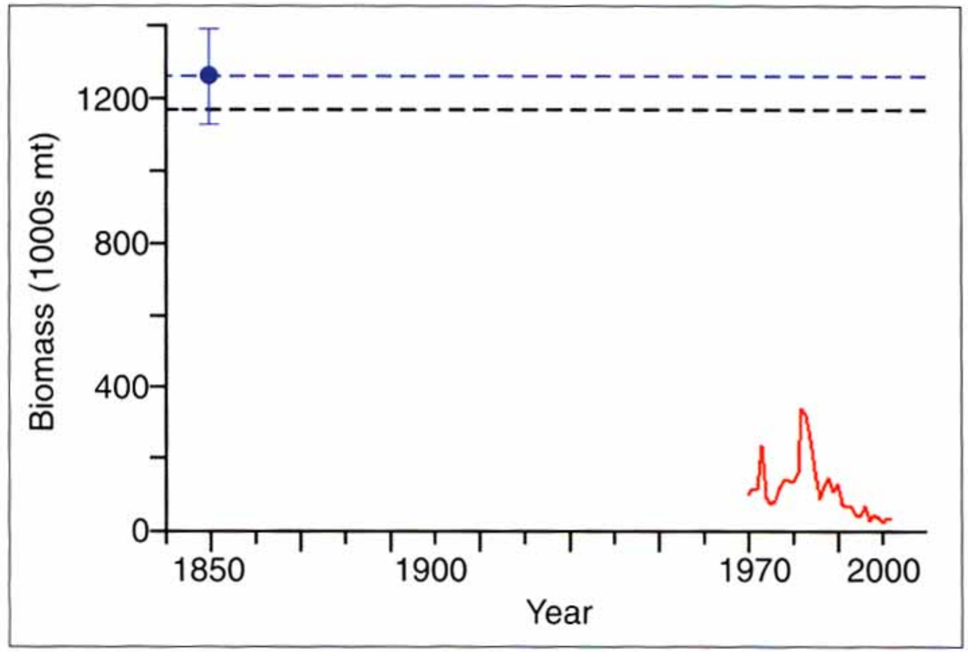
The history of ocean resources: modeling cod biomass using historical records

Andrew A Rosenberg, W Jeffrey Bolster, Karen E Alexander, William B Leavenworth, Andrew B Cooper, Matthew G McKenzie

In a nutshell:

Rosenberg et al. 2005

Biomass Estimate of Total Cod late 1990s: **50,000 metric tons**



Biomass estimates for Scotian Shelf Cod: ● *this study, with confidence interval (1852);* – – – *estimated carrying capacity of this marine ecosystem from late 20th century data (Myers et al. 2001);* —— *total biomass estimates from 1970 to 2000 for cod, 4X,4VsW (Mohn 1998; Canada DFO 2000; Fanning 2003).*

Biomass Estimate of Adult Cod 1852: **1.26 million metric tons**

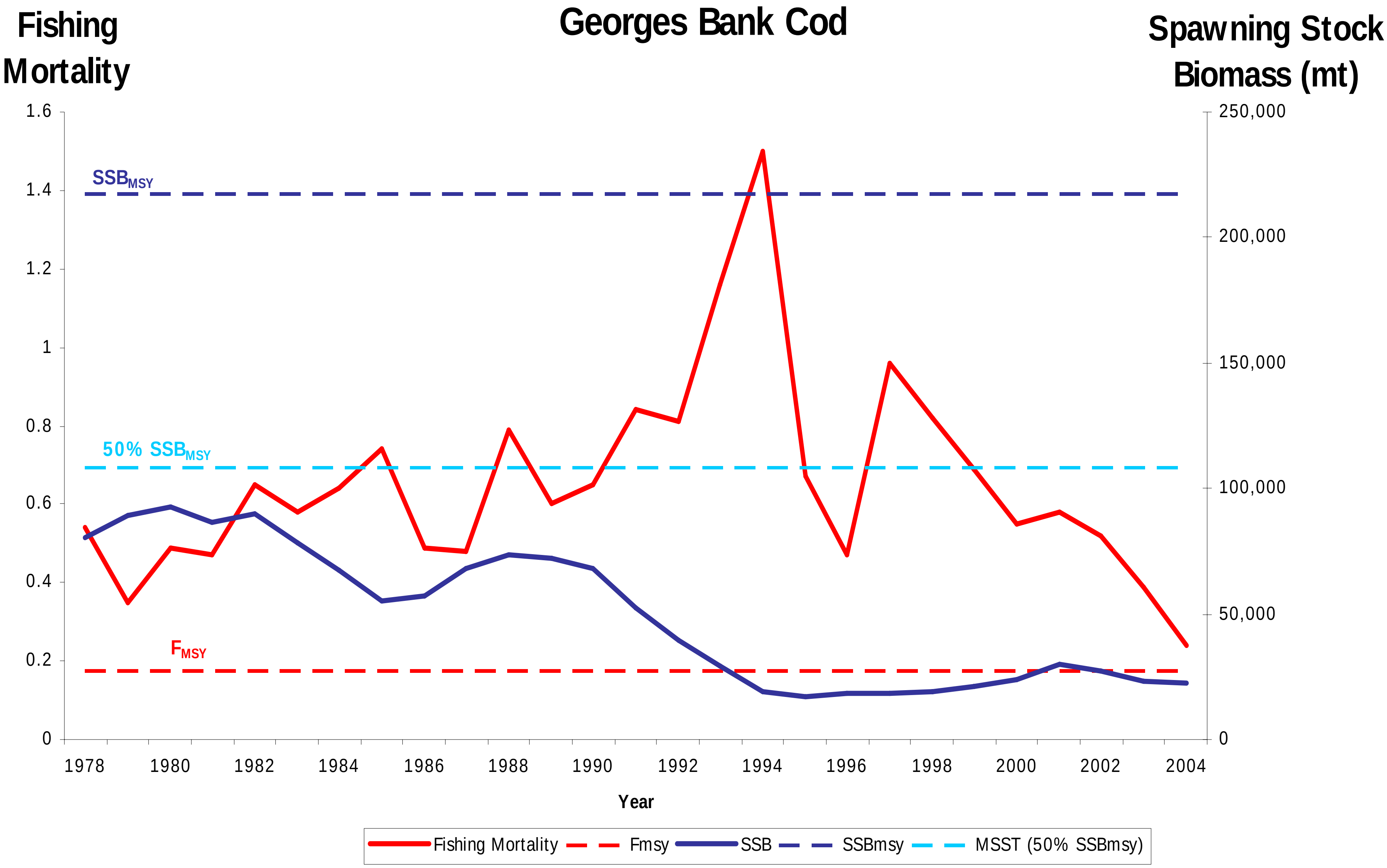
Changing Productivity

Principal and tributary waters.	Annual catch.
MAINE.	*Pounds.*
Saint John River	20, 000
Saint Croix River, Schoodic Lake and tributaries	45, 000
Denny's River	50, 000
Cobscook River	25, 000
Machias and East Machias Rivers	125, 000
Tunk, Narragaugus, Harrington, Pleasant, Indian, and Chandler's Rivers	135, 000
Union River	25, 000
Penobscot River: Gray's or Walker's Pond, Alamoosook, Toddy, Craig, and other ponds, Pushaw River, Passadumkeag River, Piscataquis, Pleasant, Sebec River and ponds, Mattawamkeag and Salmon Rivers	700, 000
Pemaquid, Muscongus, Saint George Rivers, &c	450, 000
Damariscotta River	1, 500, 000
Sheepscott River	50, 000
Kennebec River: Androscoggin River, Little Androscoggin River and Thompson Lake, Weld Pond, Ellis and Bear Branch, Umbagog, Richardson, Molechunkemunk River, Moostocmaguntic, Rangeley, and other lakes, Eastern River, Cobbossecontee River and Lake, Sebasticook River, Messalonskee River and Belgrade Lake, Wisserunset, Sandy, Carrabasset, and Dead Rivers, Moosehead Lake, Moose River	1, 290, 000
Presumpscot River: Sebago, Long Lake, &c., Songo River, Crooked River	18, 000
Saco River, Little Ossipee River	16, 500
Mousam River	10, 000
York River	5, 000
Piscataquis River	85, 000

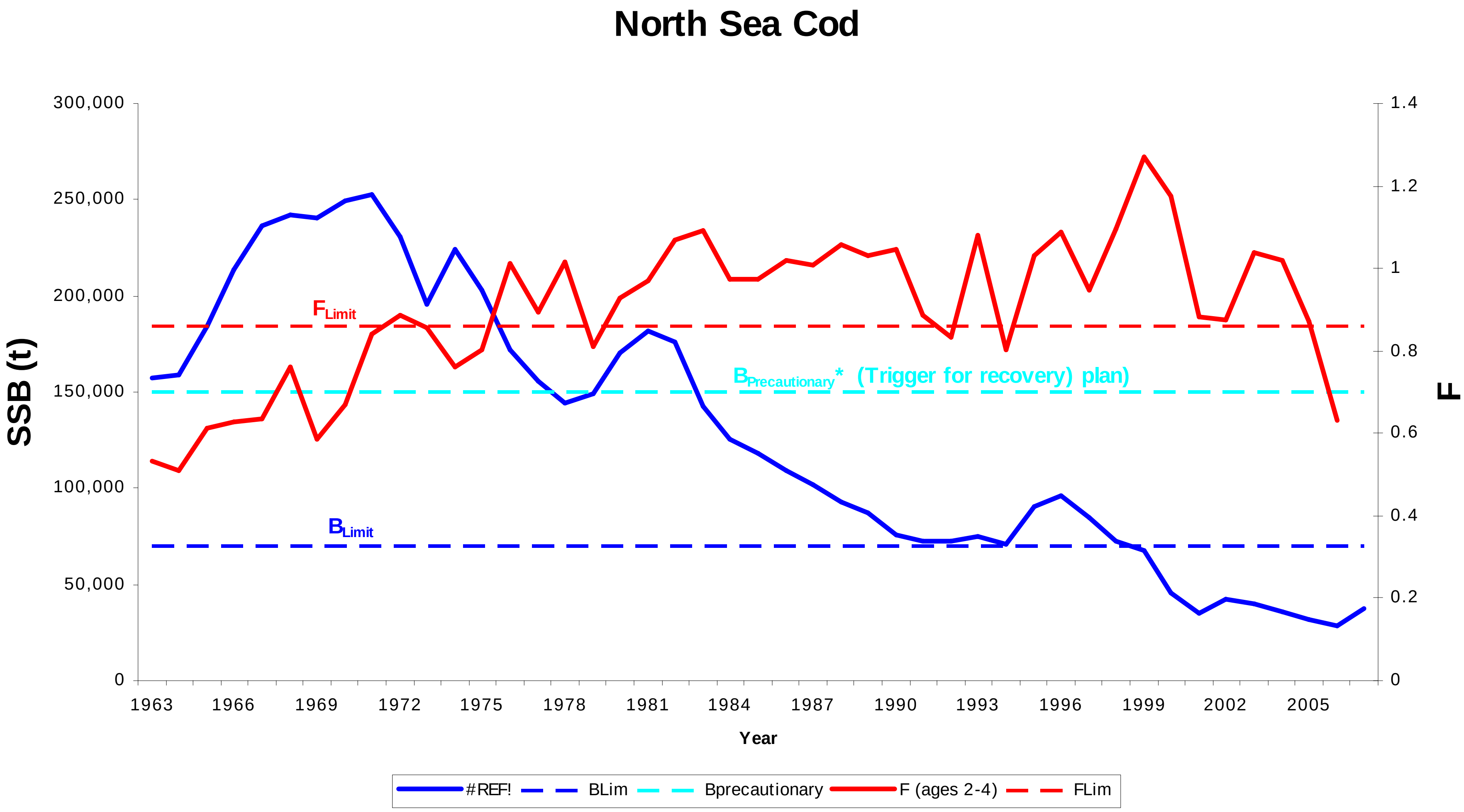
Left: Maine's River Fisheries in 1882, USFC Report, 1883. 4,549,500 pounds. Photo: Waldoboro alewife fishery, 1874, from Bunting, "A Day's Work, Part I."

From W. Leavenworth, UNH

If management continues on a course of reducing flexibility, both *management and fisheries will fail*



If fisheries are to be flexible, *overcapacity is intolerable*

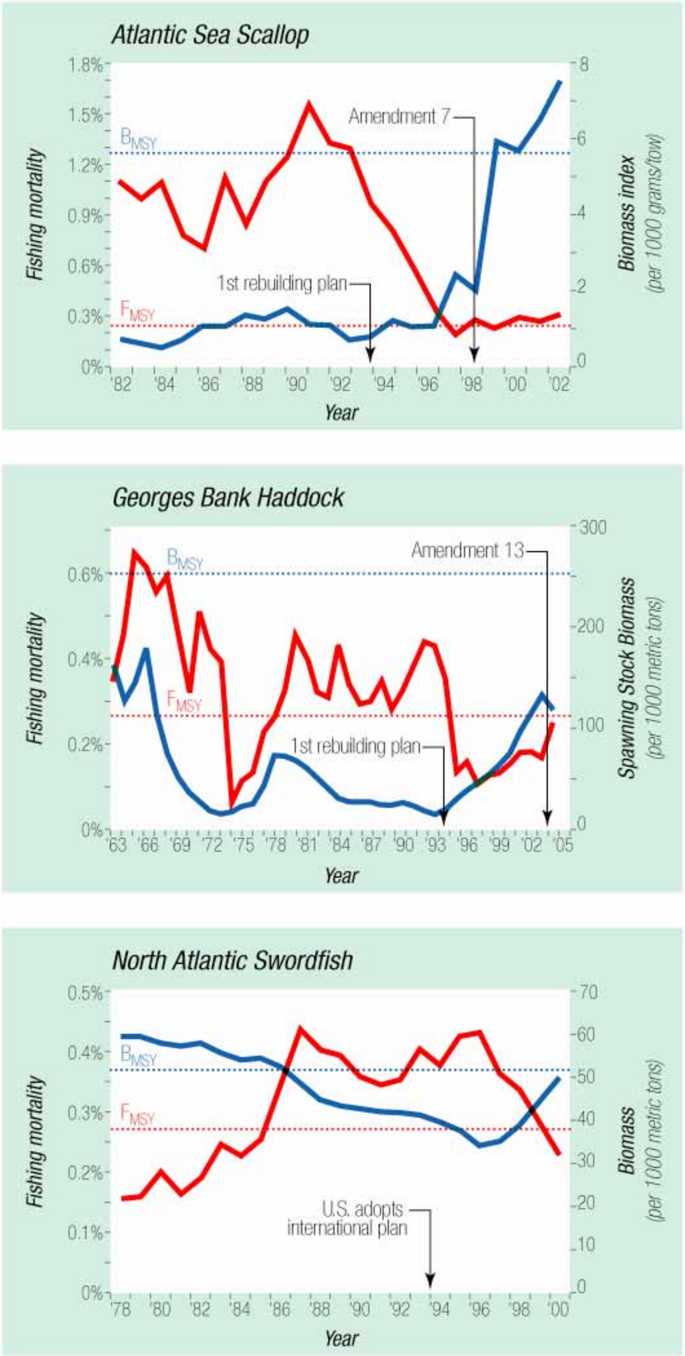


Example – North Sea cod recovery plan

- From 1991 the biological advice was that seen in isolation cod should not be caught or a zero TAC
- TACs were set – to protect industry and to enable mixed fisheries to continue
- Indications of extensive black landings and high-grading as a response to reduced TACs
- The fishing mortality remained high – even increased – and the stock continued going down

Political Pressure to Keep Fishing

Figure 5: Examples Of Stocks Showing Rebuilding Progress



When fishing pressure is reduced, stocks can recover

Rosenberg et al. 2006. Frontiers in Ecol. Env.

LENFEST OCEAN PROGRAM

Evidence for ecosystem effects

- Large declines in overall abundance of many stocks are have been documented
- Effects of fisheries removals can cascade through marine ecosystems.
- Both fishing down the food web (sequential depletion) and fishing through the food web (sequential addition) occur.
- Regime shifts can be caused by physical forcing, fishing, or a combination of both.
- Shifting baselines alter perceptions of marine ecosystems, masking the extent of ecosystem change.
- Realizing that there is a theoretical limit to the productivity that can be taken from the oceans and that we may currently be at or approaching that limit,

National Academy of Sciences 2006. Dynamic Changes in Marine Ecosystems: Fishing, Food Webs, and Future Options

Lessons Learned for Adapting to Climate Change

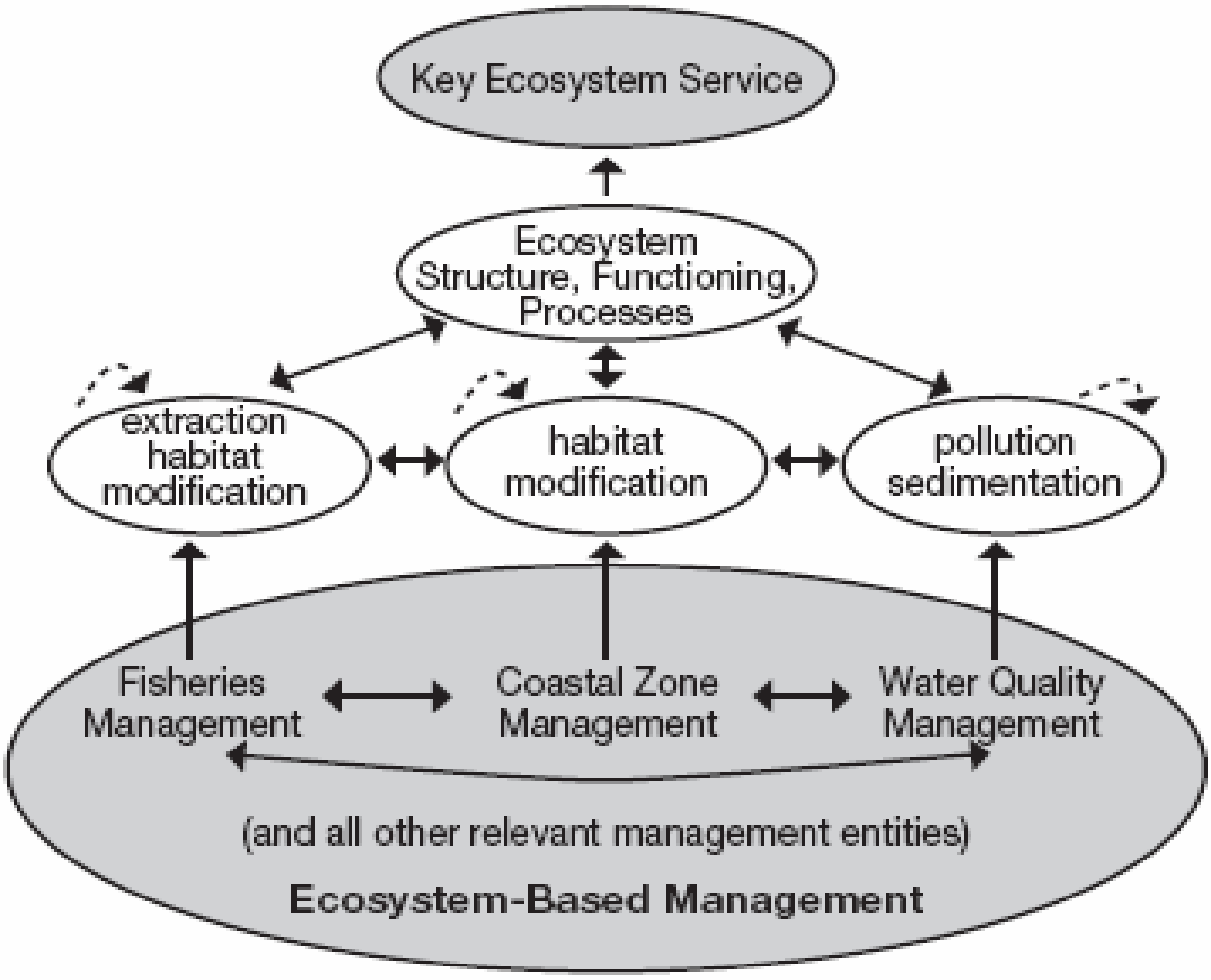
- Beware the false dichotomy between environmental changes or fishing effects. *Both are inevitably affecting resources*
- As species composition, ranges and productivity shift, fisheries will adapt to those changes, *very rapidly*
- If management continues on a course of reducing flexibility, both *management and fisheries will fail*
- If fisheries are to be flexible, *overcapacity is intolerable*

Five Features of EBM

1. Focus on the ability of the ecosystem to support human well-being through the provision of ecosystem services.
   - **Services occur at multiple scales**
   - **Services are not independent between scales**
     - **e.g., Nutrient cycling, natural hazard protection, fish production**
2. Natural boundaries are most relevant to the conservation of ecosystem services
   - There are multiple boundaries that are hierarchical
   - All boundaries are leaky not absolute

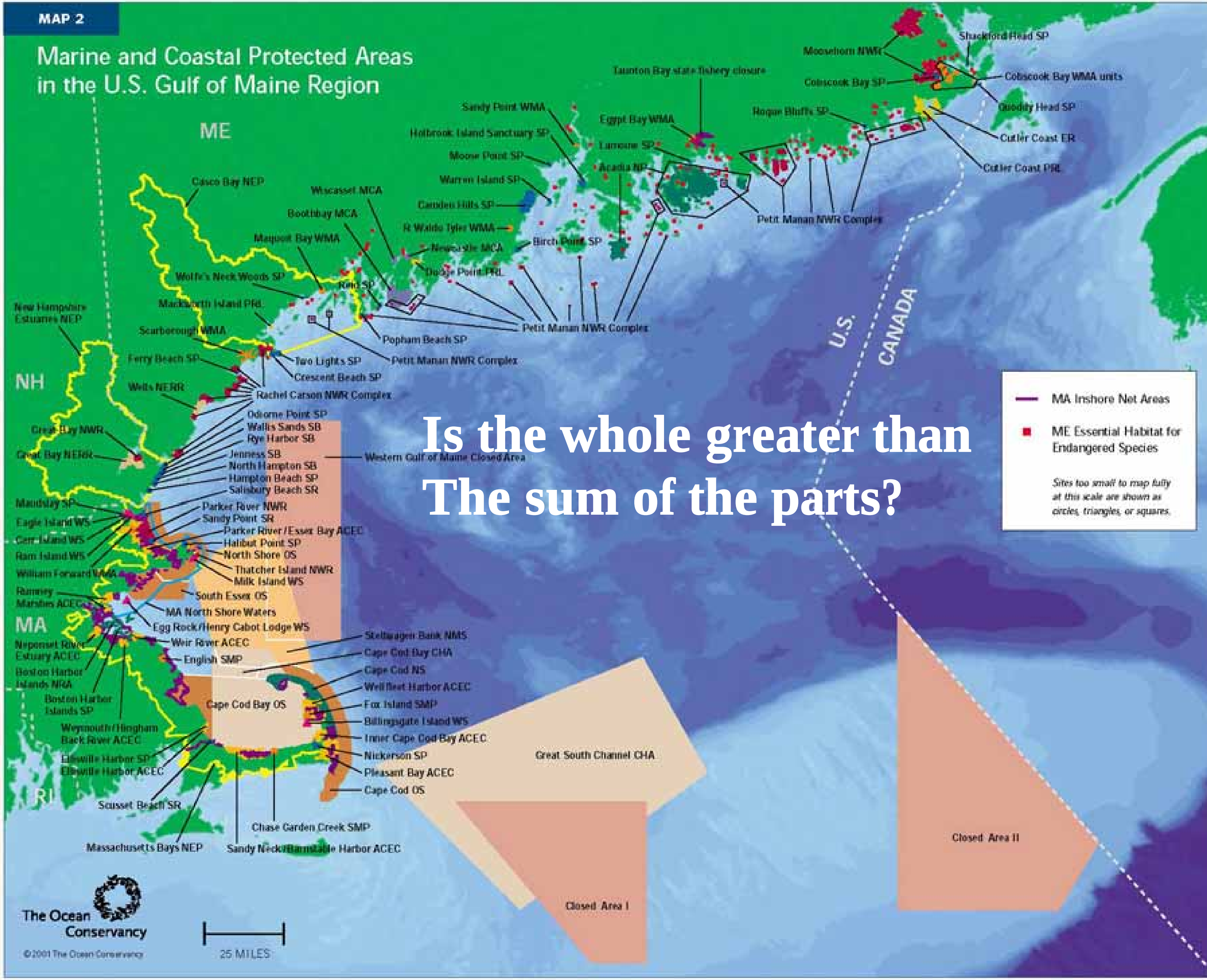
3. Various sectors of human activity interact so management should be integrated
   - Interactions local and at larger scales
4. Impacts of human activities on an ecosystem are often cumulative across both time and space - and scale
5. Tradeoffs in services among sectors must be made and should be explicit – locally and LME wide

It is ecosystems that will undergo changes, not just individual stocks, so *an ecosystem-based approach is essential*



Rosenberg & MacLeod 2005

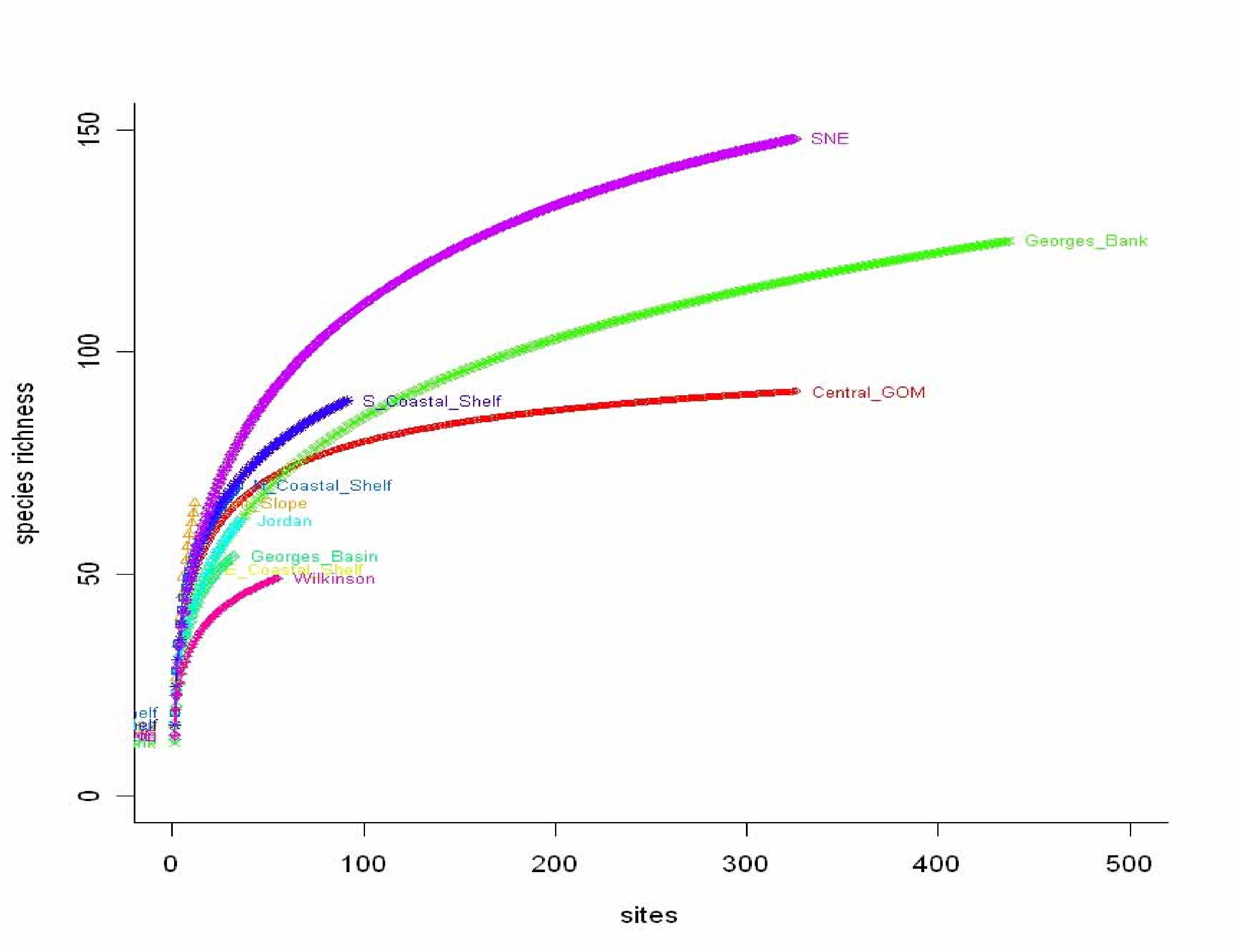
Is the whole greater than The sum of the parts?



Community properties are area based

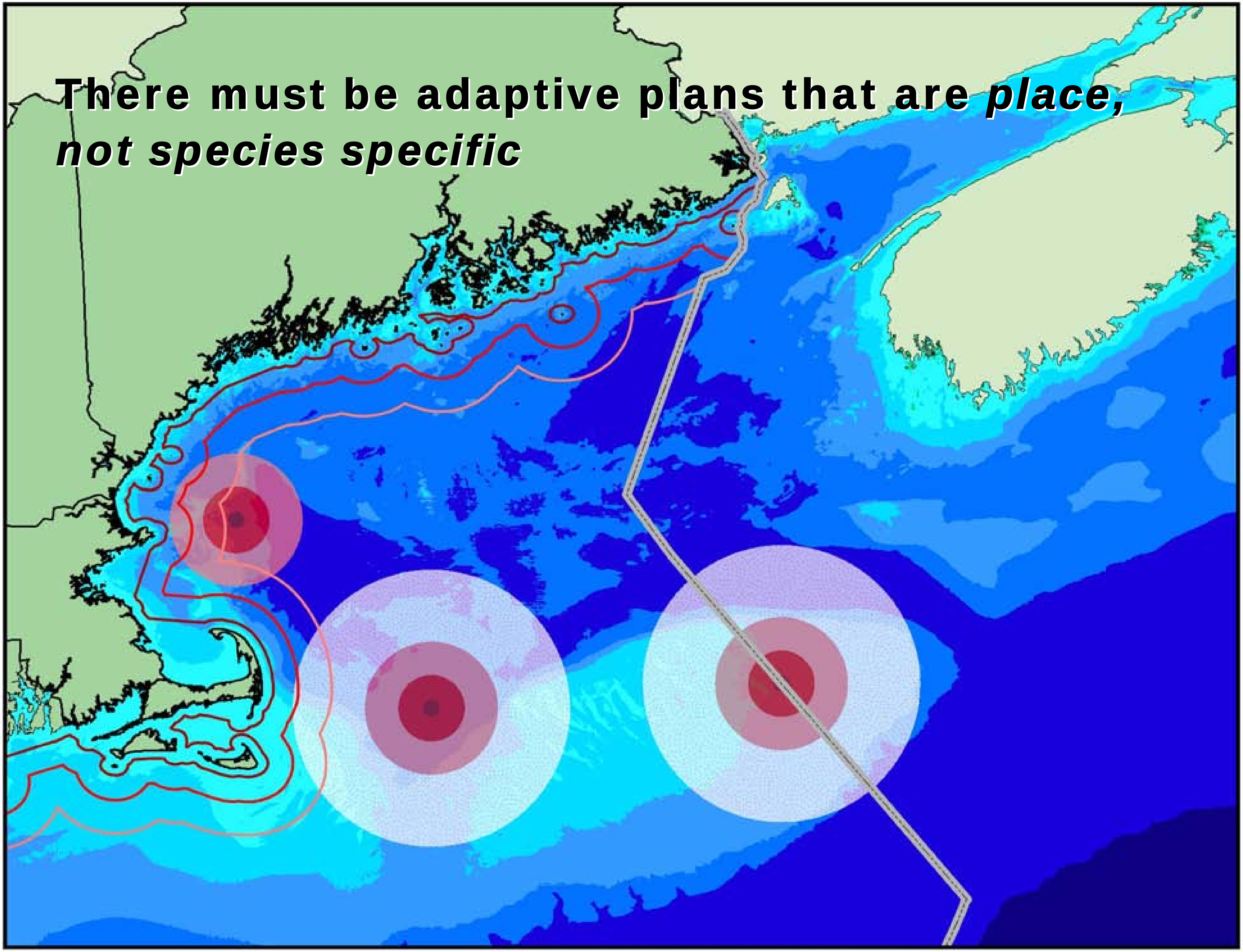
Species Richness from trawl survey data

Higher richness from north to south



Analysis by J.M.L Cournane, UNH

There must be adaptive plans that are *place, not species specific*

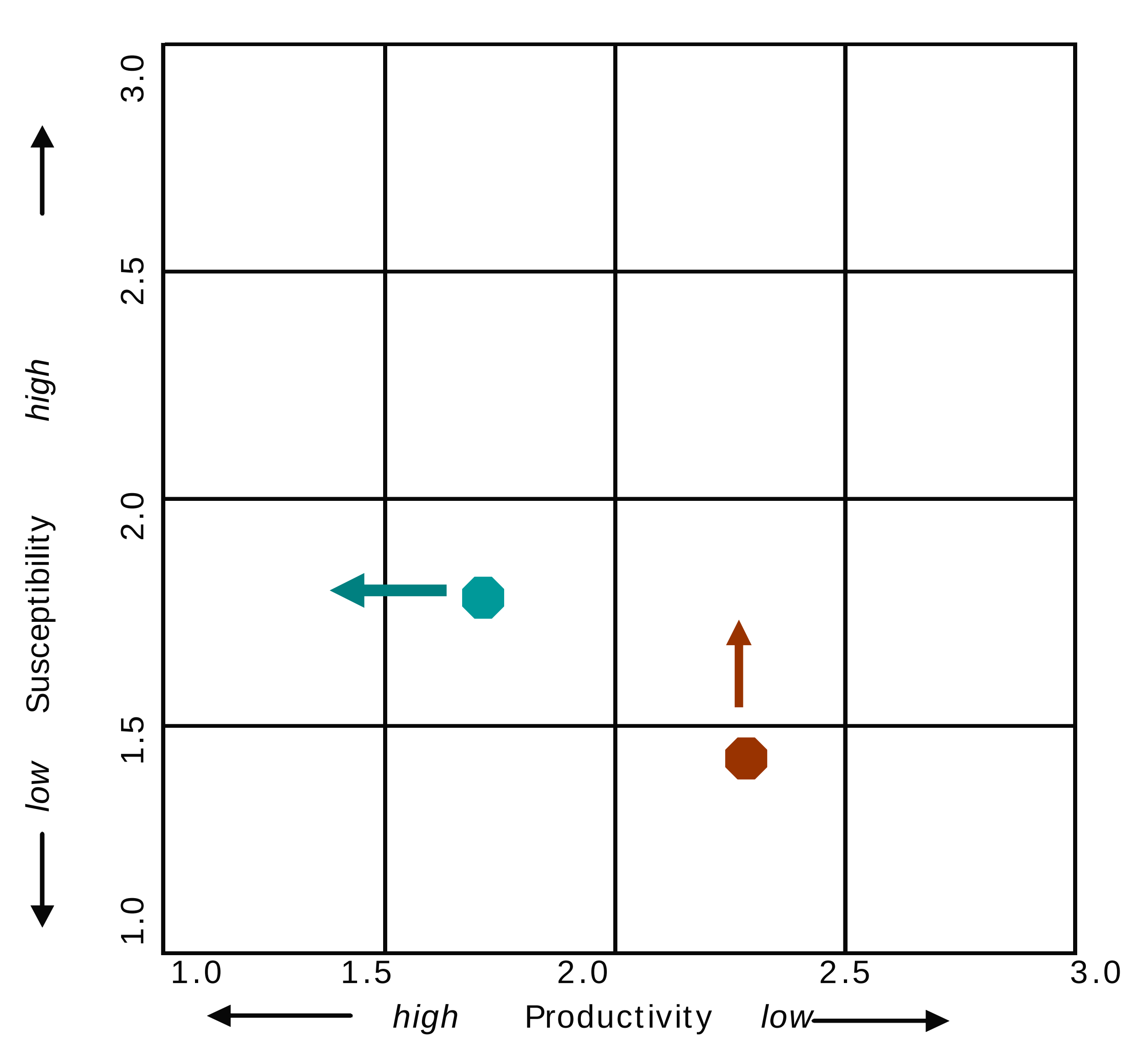


US Fisheries Law 2007 amendments

- A Council must:
  - establish a mechanism for specifying annual catch limits …… at a level such that overfishing does not occur in the fishery, including measures to ensure accountability;
  - develop annual catch limits for each of its managed fisheries that may not exceed the fishing level recommendations of its scientific and statistical committee or the peer review process

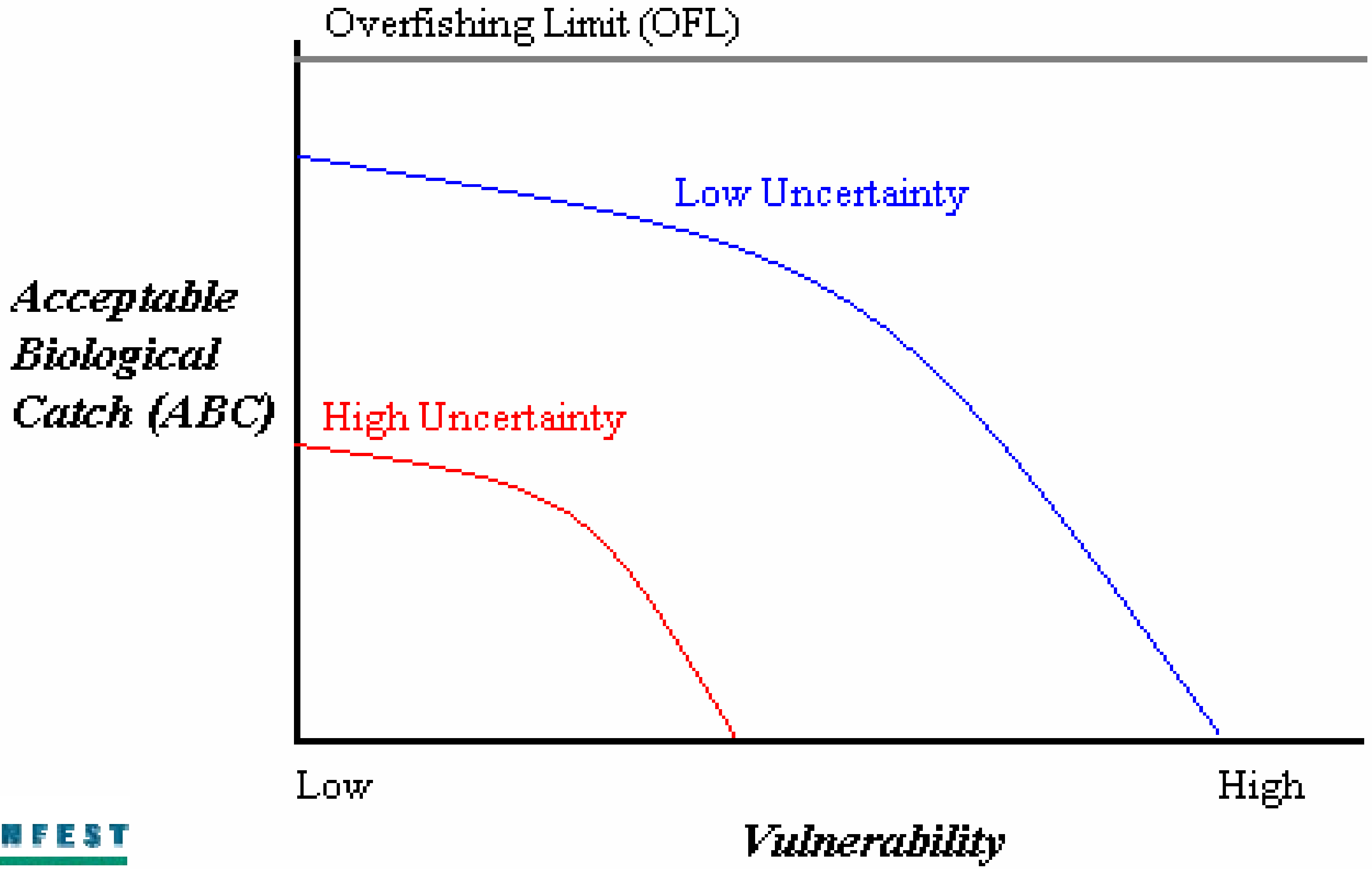
Shifts Due to Climate, in Productivity and Susceptibility Expected for Species within regions

Productivity and Susceptibility Analysis



Adapted from Hobday

Precautionary Measures to Prevent Overfishing



LENFEST OCEAN PROGRAM

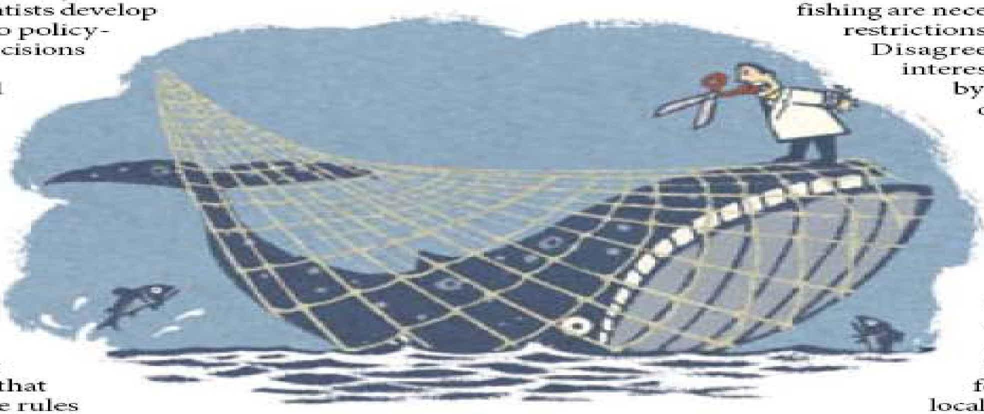
Fishing for certainty

Science advisers should have confidence in their data, or risk being drowned-out by more dogmatic stakeholders.

Andrew A. Rosenberg

Policy-makers receive formal and informal advice from all quarters: scientific, legal, political and public. Each piece of advice is considered mandatory by the giver, and it often conflicts with other advisers' points of view. Uncertainty is a feature of all advice, but is usually only acknowledged by the scientific adviser.

I have worked as a scientist, policy-maker and adviser, mostly managing marine resources. As an ecologist specializing in fisheries population dynamics, I naively assumed that scientists develop advice that is passed on to policy-makers who then make decisions in the light of it.



When in 1995 I moved into the policy-making side of things, managing fisheries in the northeastern United States, I learned that advice comes from all directions. Scientists would present data with many caveats; others would give advice based mainly on opinion. Fishermen coming to the microphone in a public meeting might categorically state that the science was wrong, the rules wouldn't work and everyone would go out of business. Scientists tended to emphasize their uncertainty, and would be unwilling to speculate.

As scientists, we learn to analyse uncertainty and we explore decision-making in the light of that uncertainty. This is important, but we must also recognize that the precautionary approach will be adopted only slowly in policy-making. Uncertainty undermines political will in environmental decision-making. Officials are more likely to support a vociferous interest group that is apparently certain of the dire economic consequences of new restrictions, than scientists who advocate caution and prioritize the environment.

Over time, I learned that the solution for an adviser is not to hide careful analyses of uncertainty, but to distinguish the almost certain from the less certain. For example, it became clear in the 1980s that overfishing in New England, the North Sea and many other areas was critically depleting resources. Exploitation of species such as cod was removing 60–70% of the standing stock every year. Unfortunately, the debates were too often about whether the sustainable exploitation rate should be 20 or 25%. The conclusion drawn by many in industry and politics was that the science was uncertain. Hearing people say in debates, "fisheries science is not an exact science," made me wonder which other field they were comparing fisheries to, and indeed what an exact science is.

There is little uncertainty that overfishing was, and in many cases still is, occurring and that exploitation needed to be reduced by half or more. Emphasizing what we don't know often drowns out what we do know. In the event, strong action in New England reduced exploitation rates on some stocks, such as haddock, down to reasonable levels. As scientists predicted, the stocks began to recover. On other stocks such as cod, exploitation has remained relatively high, and they have not recovered. There is little mystery, and very slow progress is being made. Unfortunately, the fish may not wait for us to learn our lesson.

"Emphasizing what we don't know often drowns out what we do know."

Statements of policy are still a far cry from implementing policy. It is easier to agree to the general principle of ending overfishing and rebuilding resources than it is to put the principle into effect. Few argue that overfishing and resource depletion is a good thing; many argue about whether their fishing activity, their business or their recreation really contributes to overfishing.

For example, the United States' Marine Mammal Protection Act of 1972 is a strong mandate to protect all marine mammals; its reauthorization in 1994 was passed unanimously by the US Senate. But in the northeastern United States, protection of whales from entanglement in fishing gear — one of the main causes of death in whales in coastal waters — means that restrictions on fishing are necessary. Implementing these restrictions caused huge controversy. Disagreement between different interest groups was exemplified by the elected official who opposed the restriction, telling me to, "go save the whales somewhere else".

Political decision-making inevitably leans towards minimizing the impacts of policies on constituents who are most affected. The public cares about the general outcome, such as saving whales, but is unlikely to change its political view or support for an official because of local issues such as catch quotas or protected areas; fishermen will because the issue is immediate and vital to them.

In the 1990s, when I was a senior manager of the US National Marine Fisheries Service, I viewed my job as maximizing conservation without someone higher in the policy-making structure taking away my authority. Each decision was a judgement call about how far I could go, and without a doubt my judgment was imperfect. Science led my logic. I would start by asking: what do we know, and what does that mean we should do? In every case, I would then have to consider: what can be done, given the forces at play? As an adviser, I learned that adhering closely to the scientific advice is always the best course — as long as you can save some fish in the process. ■

Andrew A. Rosenberg is professor of natural resources at the Institute for the Study of Earth, Oceans and Space, Morse Hall 142, Durham, New Hampshire 03824, USA.

For more essays and information see http://nature.com/nature/focus/arts/scipol/index.html.

More Lessons…

- It is ecosystems that will undergo changes, not just individual stocks, so *an ecosystem-based approach is essential*
- There must be adaptive plans that are *place, not species specific*
- *Precautionary buffers* must be in place because of increased uncertainty about productivity

From Robert Wilson: The Hidden Assassins (2006)

“You’re smiling, Javier…. I’m impressed

‘I’m solitary but not depressed’, said Falcon.

‘That’s not bad going for a middle-aged homicide detective’, said Pablo.

‘Being a homicide detective isn’t such a problem for me. There aren’t that many murders in Seville and I crack most of them, so my work with the homicide squad actually gives me the illusion that problems are being resolved. And, as you know, an illusory state can contribute to sensations of well-being,’ said Falcon.
‘If I were trying to resolve something like global warming, or the oceans’ dwindling fish stocks, then I’d probably
be in much worse mental shape.’