The Economics of Sustainable Aquaculture

Marine Policy Center
Woods Hole Oceanographic Institution

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Economic Sustainability

the allocation of scarce resources in such a way as to generate economic profits that are available for investments in physical capital, knowledge, and technology – these investments endow future generations with the *capacity* to be at least as well off as the current generation

Weak sustainability – allows irreversible changes

Strong sustainability – does not allow such changes

Translation:

- prices need to reflect **all** costs of production
- adequate investments in knowledge, physical capital, and technology

Sustainable Agriculture

. . . practices that meet current and future societal needs for food and fibre, for ecosystem services, and for healthy lives, and that do so by maximizing the net benefit to society when all costs and benefits of the practices are considered. . .

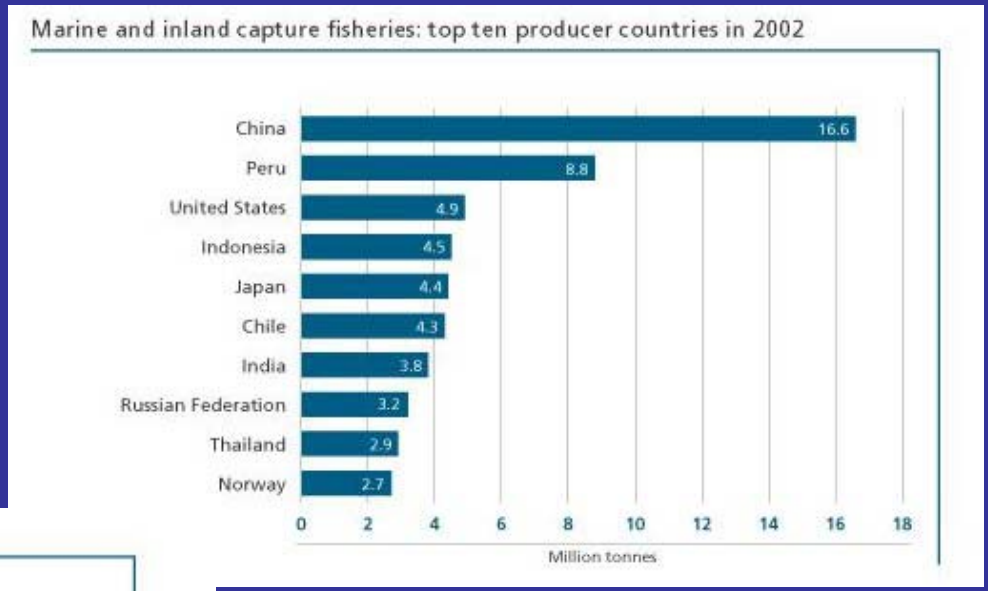
If society is to maximize the net benefits of agriculture, there must be a fuller accounting of both the costs and the benefits of alternative agricultural practices, and such an accounting must become the basis of policy, ethics, and action.

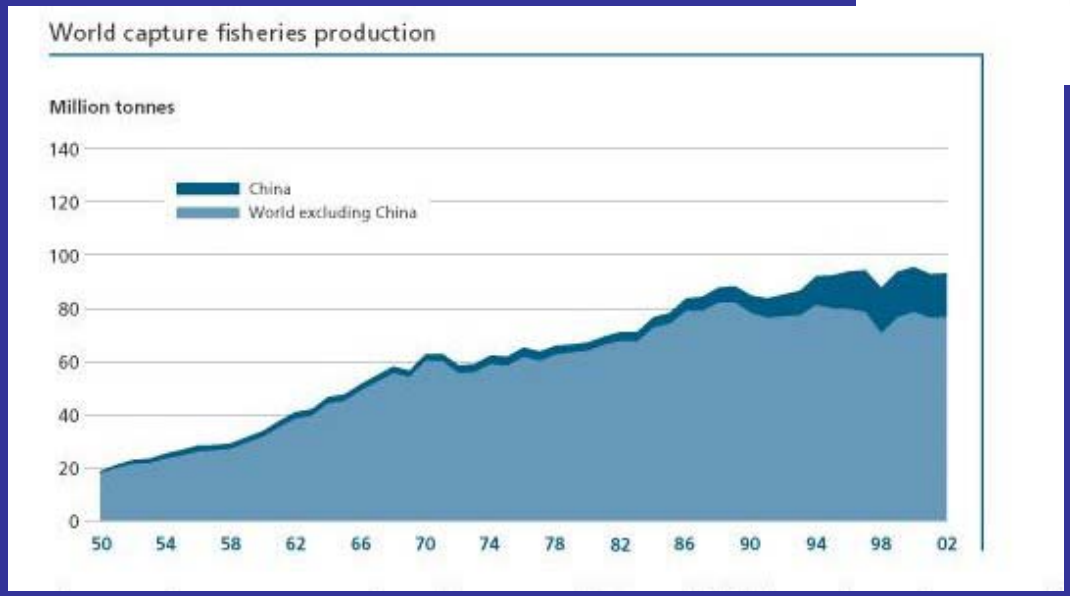
Tilman *et al*. (2002)

Science Paper Approach

- Compile recent economic data on aquaculture production and trade.
- Review the prospects for the growth of marine aquaculture in the United States across major product markets.
- Identify general classes of both *positive* and *adverse* effects resulting from marine aquaculture.
- Characterize the extent to which existing and potential operations lead to these effects.
- Identify empirical estimates from the literature of the economic benefits and costs of these effects.
- Characterize institutional measures for encouraging growers to conduct their operations in a way that increases the potential for sustainable marine aquaculture.
- Present evidence from the literature of the success or failure of the implementation of these measures.
- Identify productive directions for future economic research efforts.

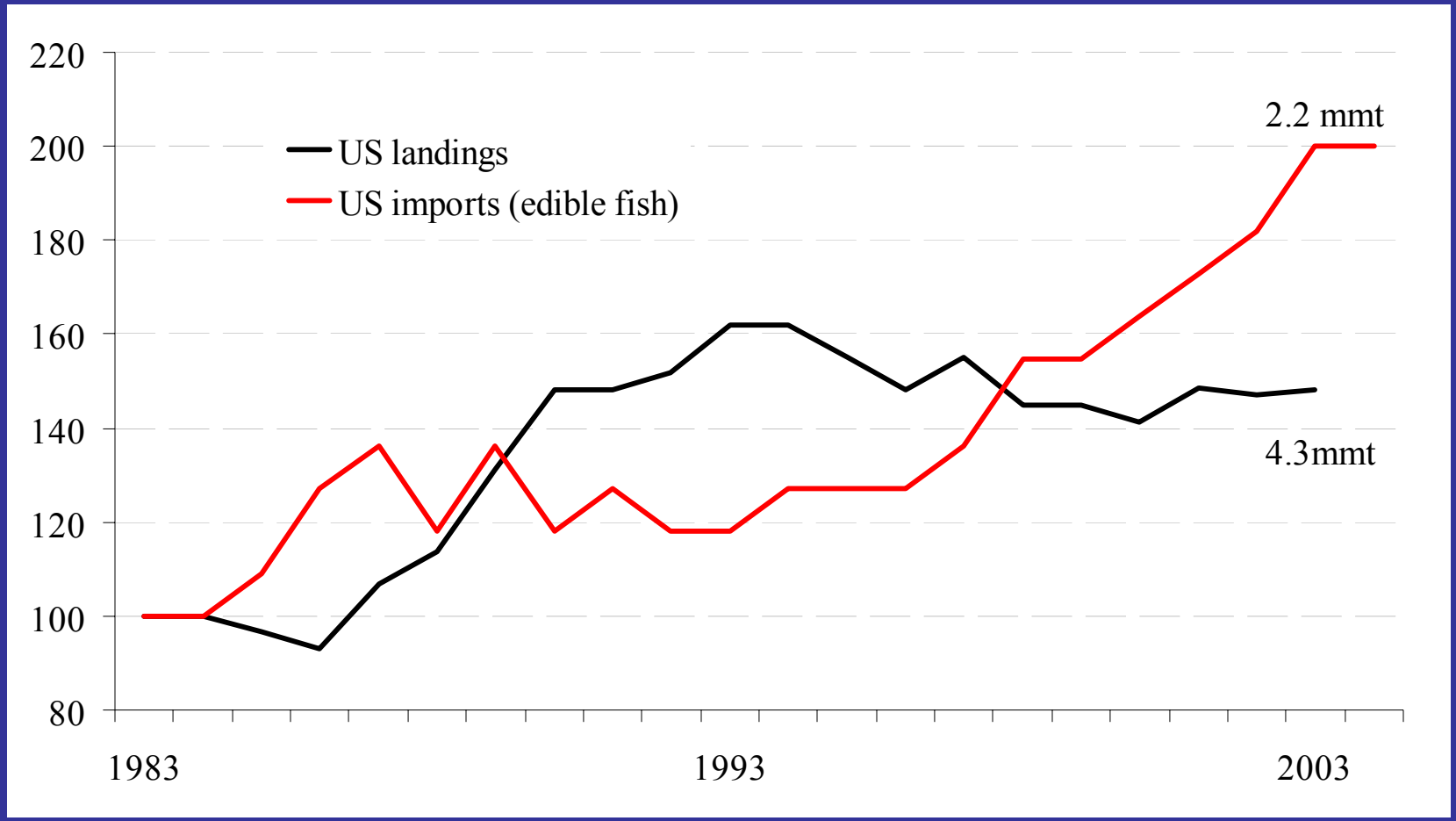
World Capture Fisheries



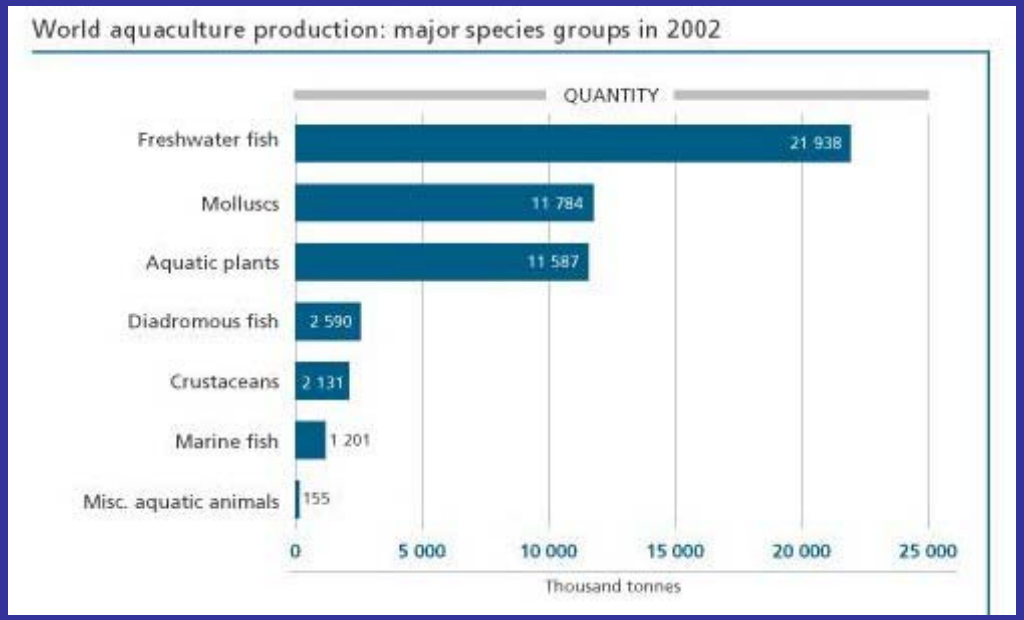


Source: FAO 2005

US Landings and Imports (index)

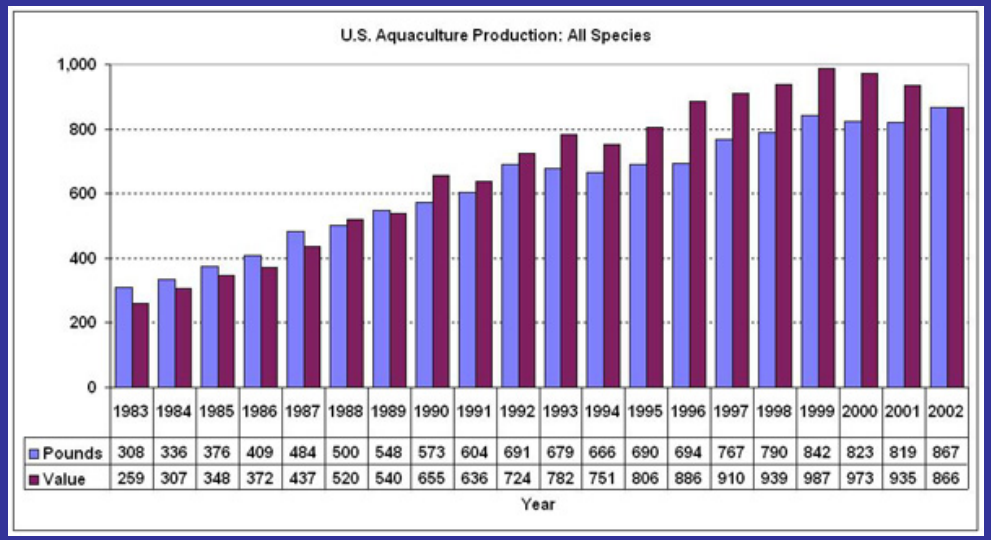


World and US Aquaculture Production

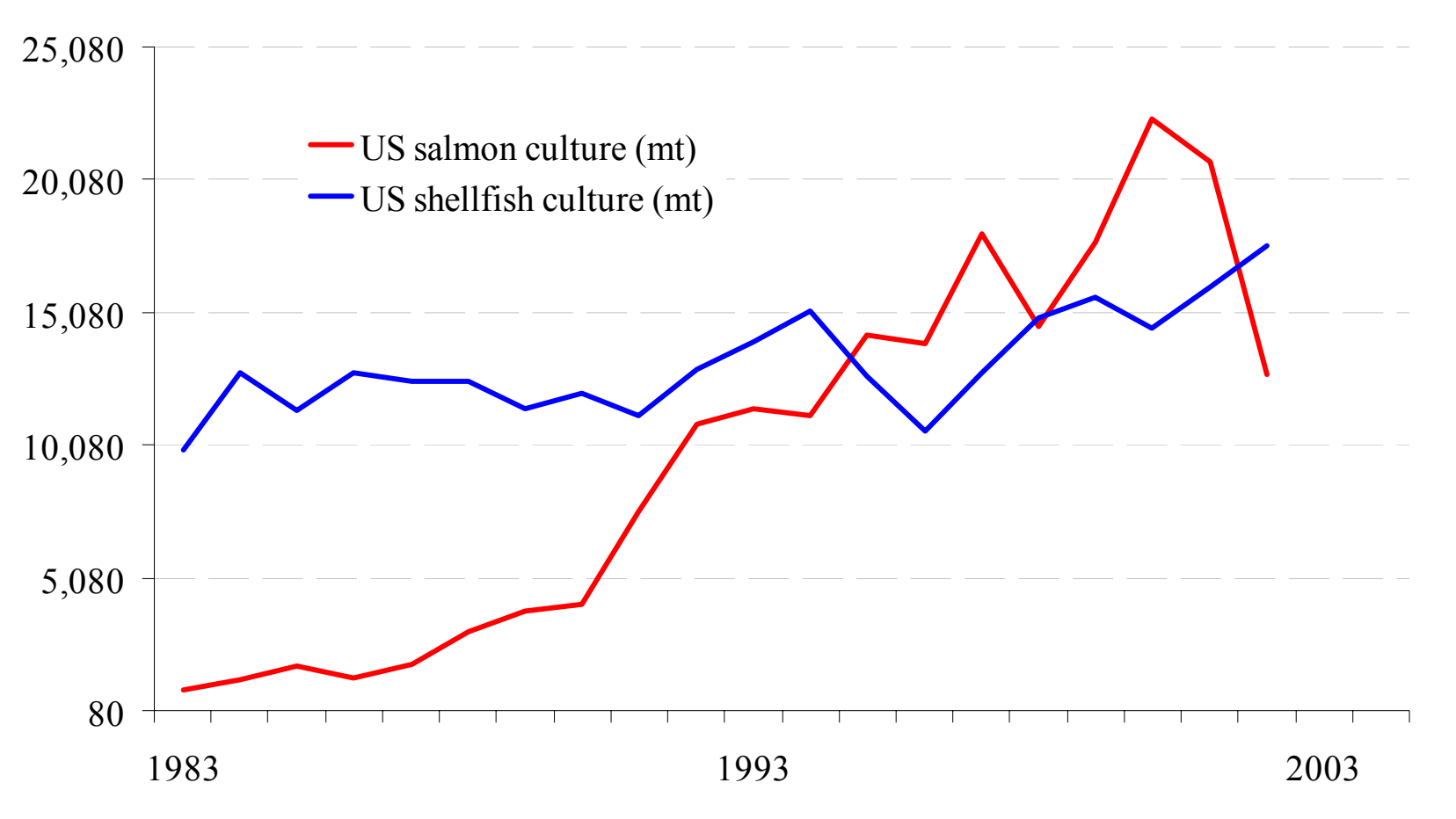


Source: FAO 2005

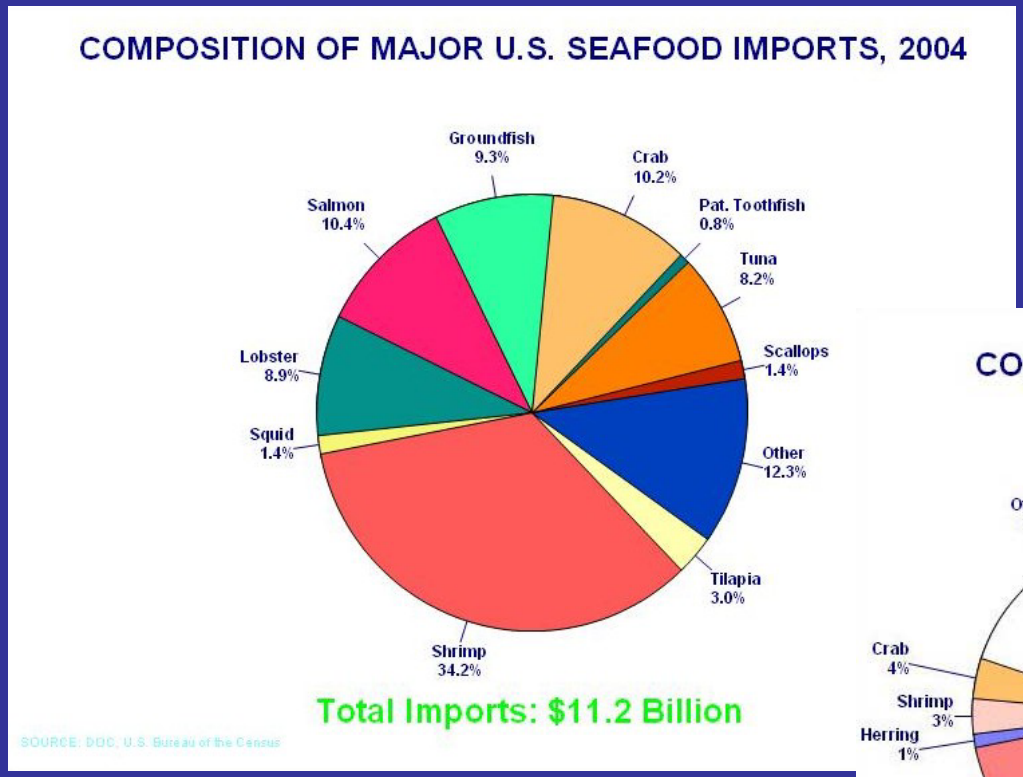
Source: MSU 2006

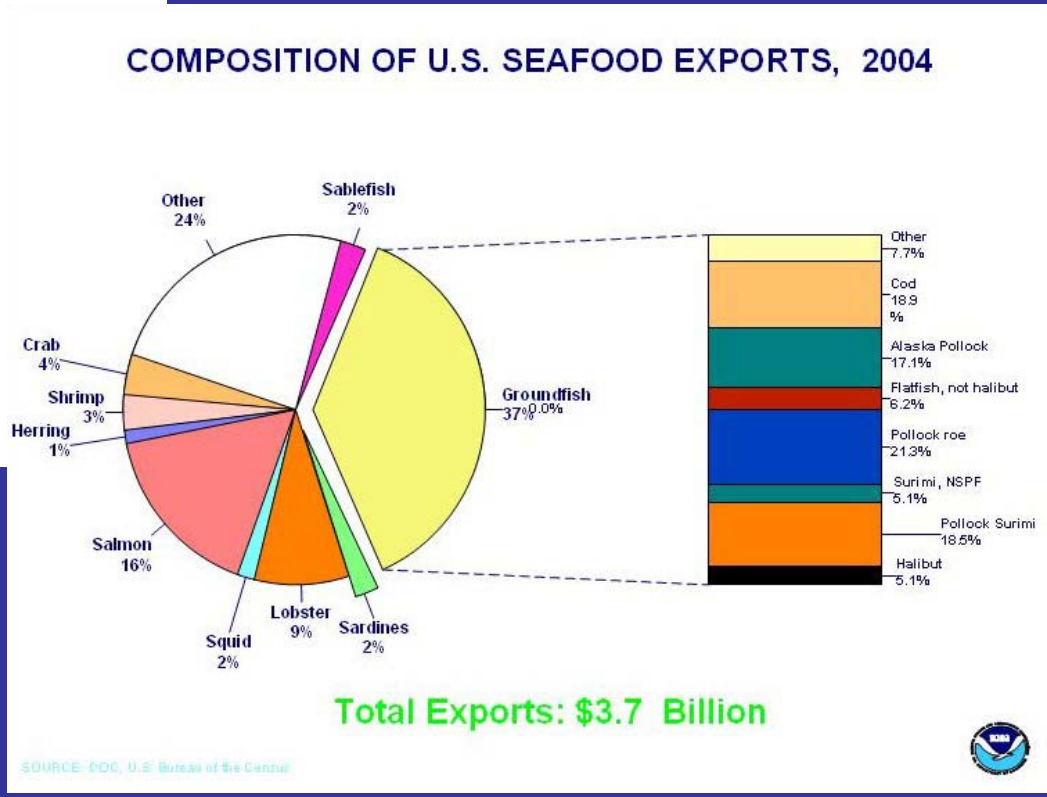


US Marine Aquaculture Production (mt)



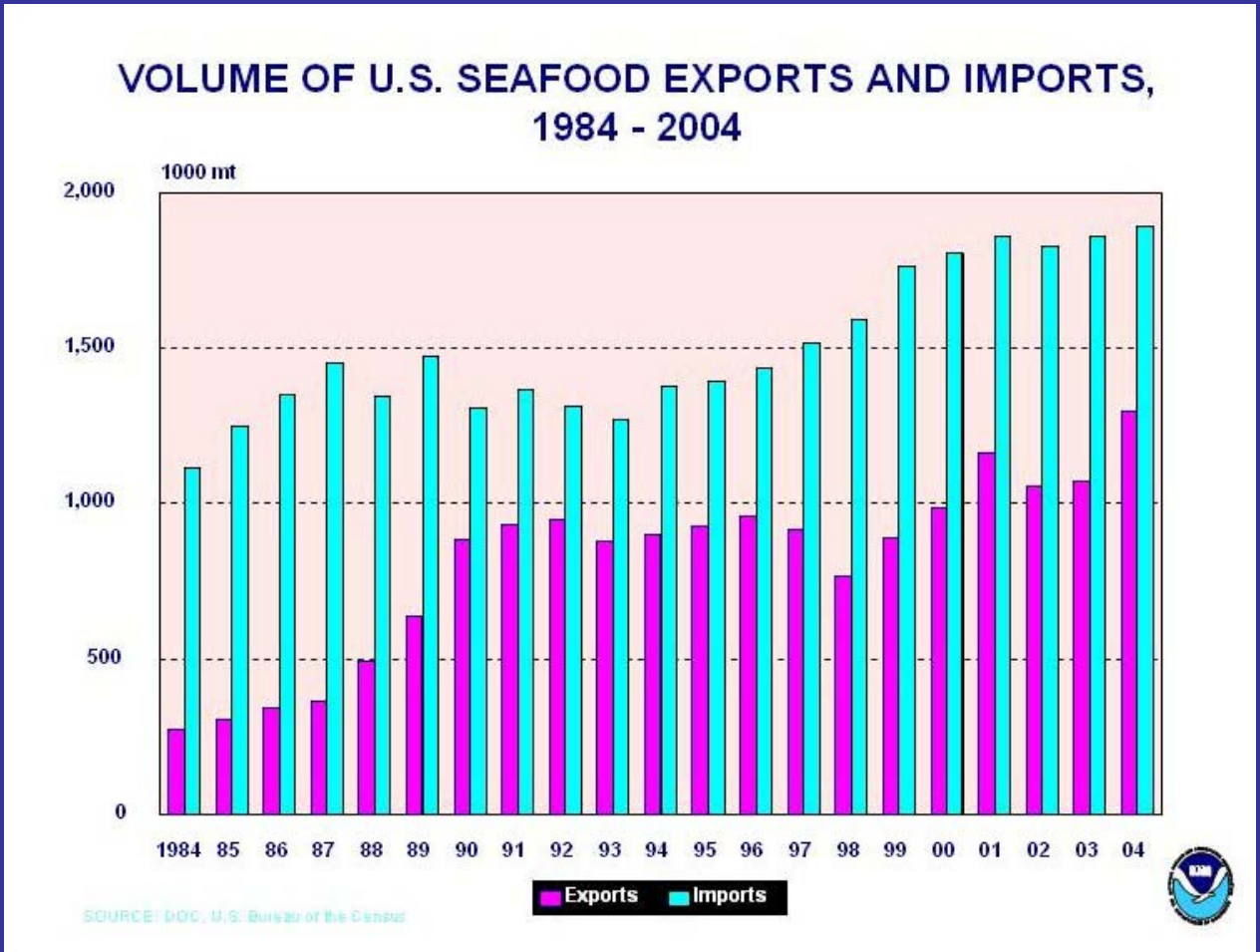
US Seafood Exports and Imports





Source: NOAA 2005

US Seafood Exports and Imports

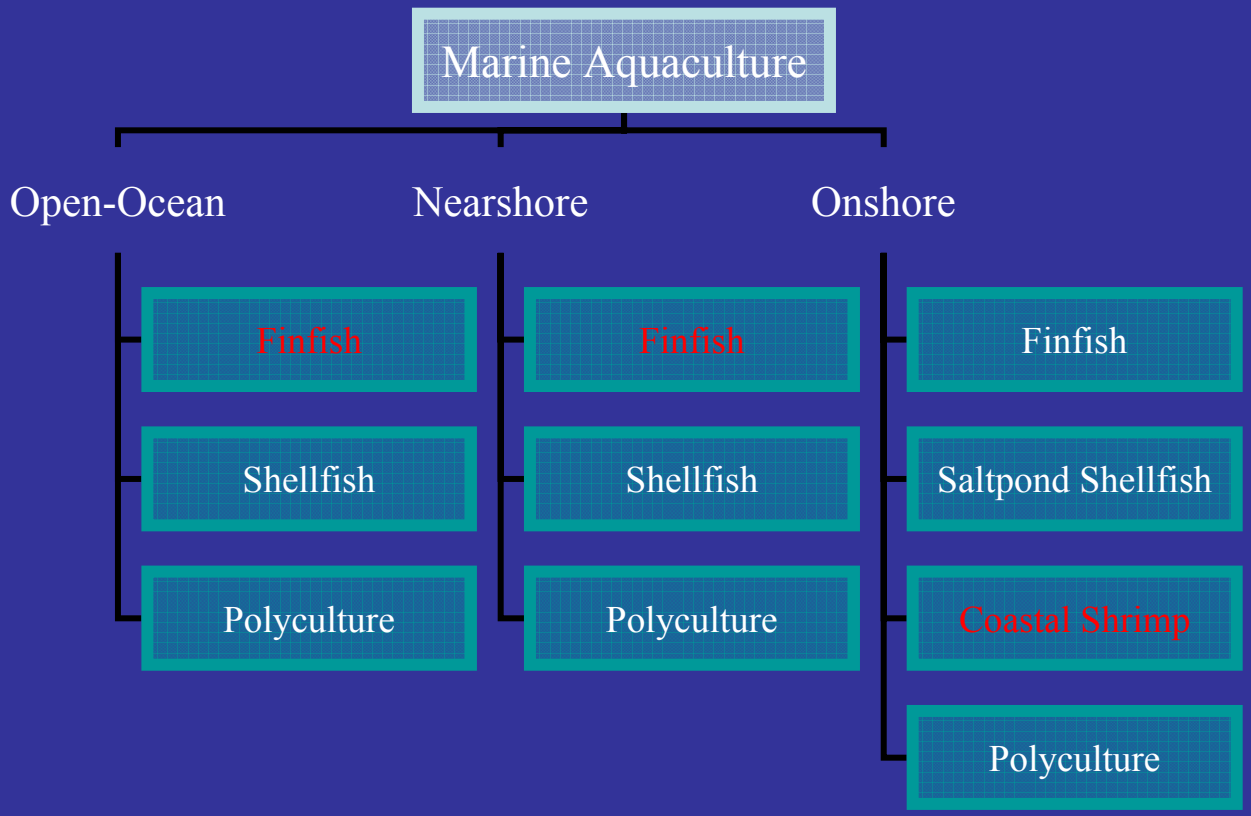


Source: NOAA 2005

Growth Prospects – US

- Consumption growth likely to match population: 6.2 mt/y by 2025
- Capture fisheries not likely to increase
- Need additional 1.8 mt/y from aquaculture and net imports
- Possible 3x increase in US aquaculture production (achievable at historical growth rates)

Types of Marine Aquaculture



Adverse Effects

- Displacement of competing uses
- Pollution inputs and habitat/ecosystem modification
- Release of farmed fish/genetic mixing
- Disease and parasites
- Depletion of forage (reduction) fish stocks

Adverse Effects: Competing Uses

- Economic significance:
  - High in some nearshore and onshore locations, minimal offshore
  - Not all aquaculture requires exclusive use of ocean space
  - Use value of some parts of the ocean is low
- Sustainability:
  - Ensure that net benefits from aquaculture exceed those from competing uses

Adverse Effects: Pollution

- Economic significance:
  - 130 kg N, 25 kg P per ton of farmed fish
  - Eutrophication; modification of benthic environment
  - High in some nearshore (finfish) and onshore (shrimp) locations, probably minimal offshore
  - Variability and uncertainty (nutrient input not always bad!)
- Sustainability:
  - Significant challenge for nearshore finfish farming
  - Can be managed by operational protocols

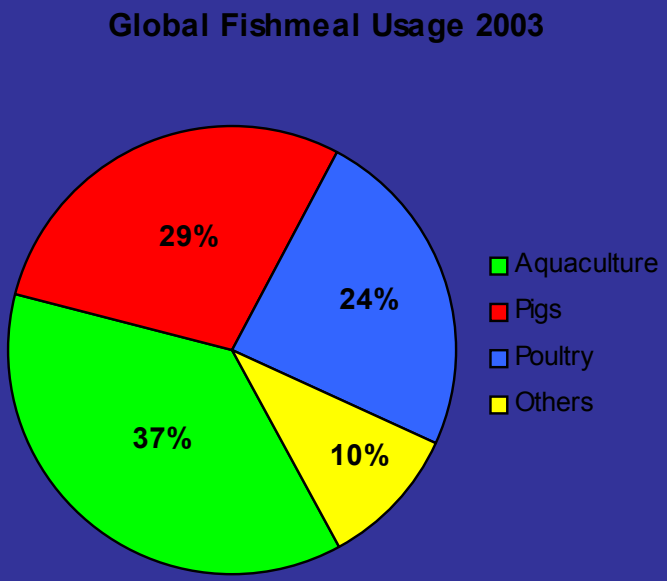
Adverse Effects: Escapes

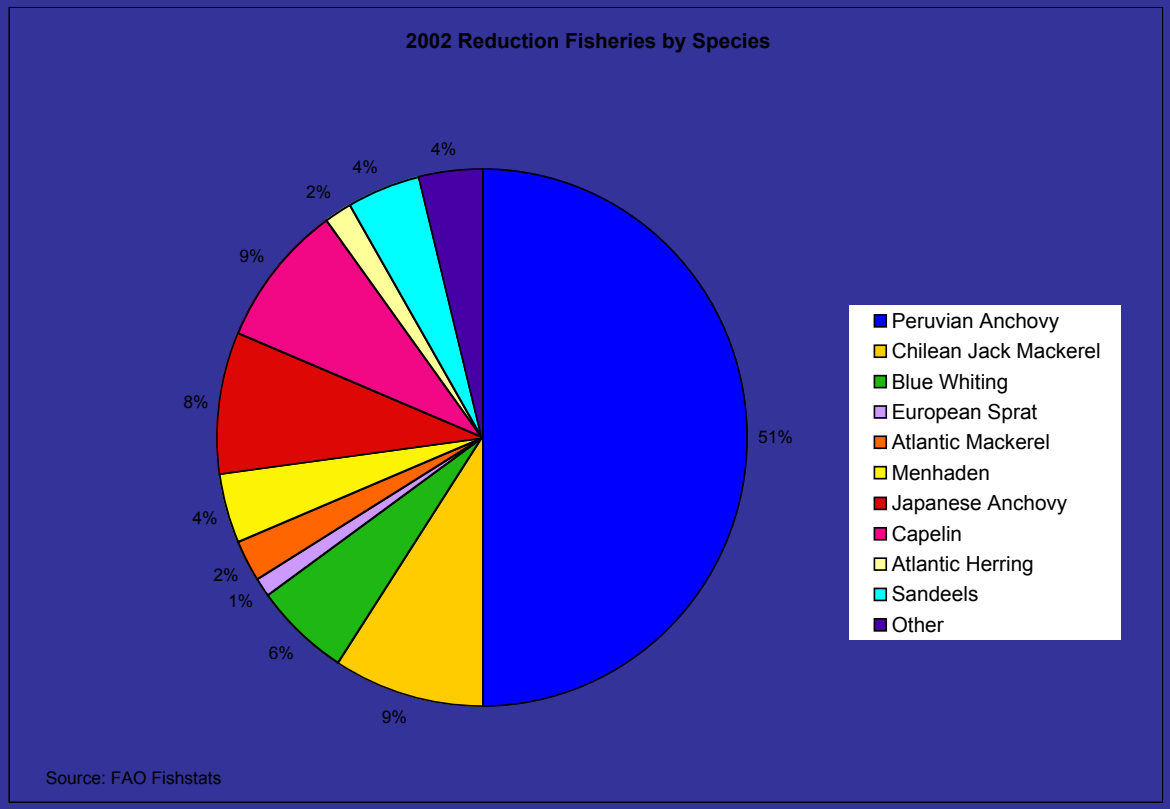
- Economic significance:
  - Potentially high (also direct cost), especially for finfish
  - Effects are location-specific; high degree of uncertainty
- Sustainability:
  - Potentially significant challenge for finfish
  - Can be managed by use of sterile fish, operating protocols, design of containment systems

Adverse Effects: Disease & Parasites

- Economic significance:
  - Potentially high (also direct cost), for both finfish and shellfish
  - High degree of uncertainty
- Sustainability:
  - Potentially significant challenge for both finfish and shellfish
  - Requires regulation and R&D (same is true of terrestrial farming)

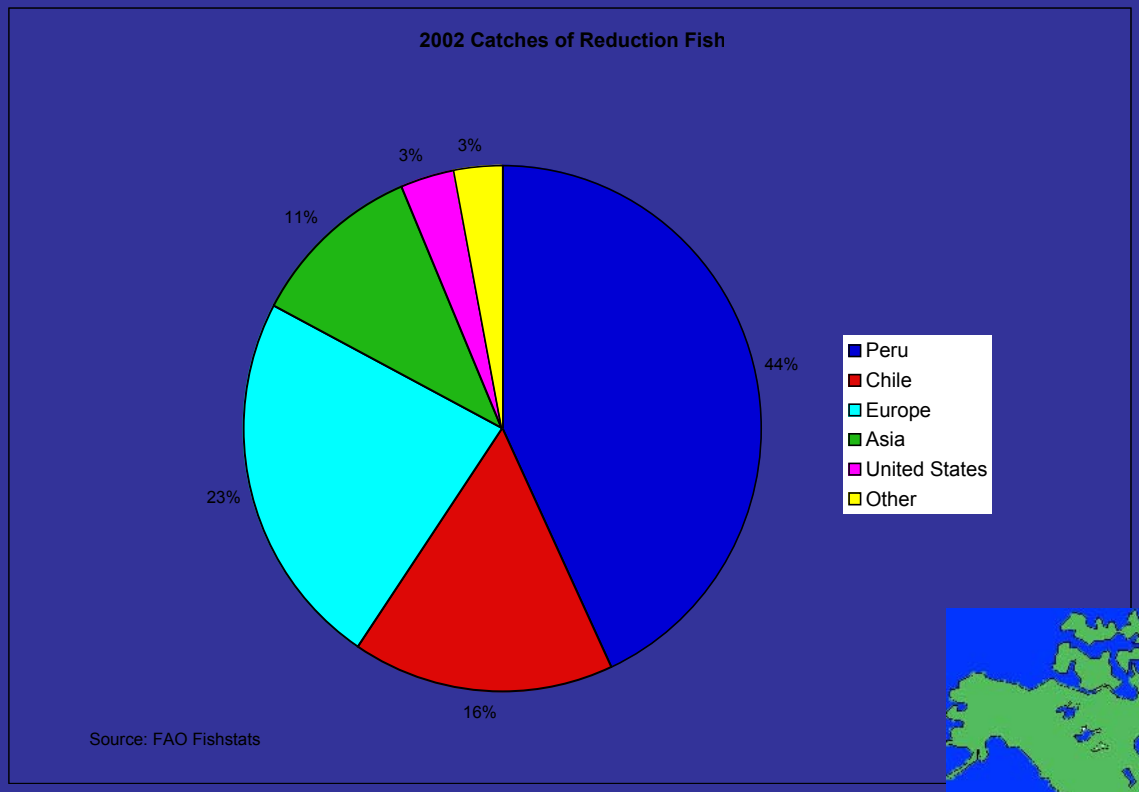
Adverse Effects: Forage Fish





27 mt/y from capture fisheries

Adverse Effects: Forage Fish



Adverse Effects: Forage Fish

- Economic significance:
  - Carnivorous finfish only; 2.5 to 5 kg wild per kg farmed product
  - Potentially high; international
  - Related to management of forage fish stocks, feed development efforts
- Sustainability:
  - Potentially very significant: projected demand 45 mt/y by 2015
  - Can be ensured via management of forage fish stocks; most significant stocks are (at least) fully exploited and probably not managed optimally today
  - Equity vs. sustainability concerns

Positive Effects

- Increased seafood supply
  - Minor significance for US (but important globally)
- Economic growth and development
  - Significant for (small) local communities only
- Relaxing pressure on wild capture fish stocks
  - Could be significant for certain species (temporary?)
- Removal of excess nutrients from coastal waters
  - Significant locally
- Effective Marine Protected Areas
  - Significance uncertain

Conclusions

Principal challenges to sustainability, ranked (roughly) by likely severity:

- Forage fish depletion (carnivorous finfish)
- Pollution input, habitat/ecosystem effects (nearshore finfish, coastal ponds)
- Disease and parasite problems
- Escapes and genetic mixing

Measures to Ensure Sustainability

- Carnivorous fish feeds
  - Ensure proper management of forage fish stocks
  - Better utilize capture fishery byproducts (processing waste)
  - Develop alternatives to fish meal, oil
- Pollution/disease/genetic mixing
  - Zoning
  - Regulation of operating practice
  - R&D
- General
  - “Sustainable harvest” certification/labeling?
  - Eliminate effective fuel subsidies

Focal Issues for Sustainability

- Nearshore finfish culture
  - disease transmission to wild stocks
  - escapement and interbreeding effects on wild stocks
  - overexploitation of forage fish stocks
  - organic pollution
  - use conflicts
- Open-ocean finfish culture
  - escapement and interbreeding
  - overexploitation of forage fish stocks
- Finfish ranching
  - depletion of natural stocks
  - use conflicts

Typology of Economic Effects (Draft)

	Positive	Negative	Indeterminate
Direct Economic Effects	• Increase in seafood output • Decrease in seafood price • Increase in demands for factors from other industries • R&D and technology investments	• Administrative costs of providing access • Ineffective regulations • Industry concentration (if monopolistic)	• Employment for currently unemployed workers • Increase in seafood quality
External Effects	• Organic nutrient inputs (up to a threshold) • Nutrient removal (shellfish)	• Displacement of more productive ocean uses • Eutrophication • Chemical pollution • Pharmaceutical pollution • Escapement • Ecosystem disruption • Protected species takings • Growth overfishing of ranched stocks	• Bioaccumulation of carcinogens in fish • Overexploitation of forage fish stocks
Distributional Effects	• Employment opportunities in a new industry • Redeployment of unused capital from the fishing industry • Rents accrue to the public as the owner of "ocean space"	• Local communities left out of industry • Reorganization of local market structure • Loss of access to local seafood protein (forage fish)	• Reduction of trade deficit

Assessment of Effects (Draft)

Note: all effects are negative unless preceded by "+". "Z" = zero, "M" = moderate, "S" = significant.	Offshore Finfish	NearshoreFinfish	Land Based Finfish	Nearshore Mollusks	Offshore Mollusks	Offshore Fish Ranching	Nearshore Fish Ranching	Coastal Marine Shrimp	Polyculture
Organic Pollution and Eutrophication	M	S	M	Z	Z	Z	M	S	M
Chemical and Pharmaceutical Pollution	Z	M	M	Z	Z	Z	Z	S	Z
Habitat Modification	Z	Z	Z	Z	Z	Z	Z	S	Z
Disease Transmission to Wild Stocks	S	S	Z	M	M	Z	Z	Z	M
Escapements and Interbreeding	S	S	Z	M	M	Z	Z	Z	M
Exploitation of Forage Fish Stock	S	S	S	Z	Z	S	S	Z	Z
Takings of Protected Species	M	M	Z	Z	M	M	M	Z	M
Direct Depletion of Natural Stocks	Z	Z	Z	Z	Z	S	S	Z	Z
Bioaccumulation of Carcinogens	S	S	S	Z	Z	M	M	Z	Z
Increased Productivity from Nutrient Input	+M	+S	Z	Z	Z	Z	Z	Z	+M
Nutrient Removal	Z	Z	Z	+S	+M	Z	Z	Z	+M