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An Ecosystem Approach to Marine Aquaculture – Are we Already There?

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Outline

- Legal drivers in the US
- The nature of the beast – Aquatic organisms under culture, relative to fisheries and terrestrial agriculture - Resilience and sustainability of the ecosystem
- Technology, regulation, certification as drivers for change – the scope for continuous improvement – Trade-offs

U.S. National Aquaculture Act of 1980



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“It is, therefore, in the national interest, and it is the national policy, to encourage the development of aquaculture in the United States”.

However! Do so under provisions of other environmental laws:

Marine Mammal Protection Act
Clean Water Act
Endangered Species Act
NEPA, MSA, and so on...





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Marine aquaculture is regulate using environmental and social laws!

Industry must comply with laws protecting:

- Fisheries
- Habitat
- Marine Mammals
- Endangered Species
- Water quality-clean water
- Air quality
- Food safety and quality
- Truth in marketing
- And so on....





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Also! Because our society has strong environmental and social values!

Industry must sell products and get permission to operate that:

- Minimizes impacts on the Environment
 - Maximizes positive impacts on the Economy
 - Is "fair" and "honest"
 - That follows laws
 - Produce healthy local food
 - That benefits society
 - Looks after animal welfare...
-
- And we import the majority of our seafood....

Legal drivers



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Aquaculture

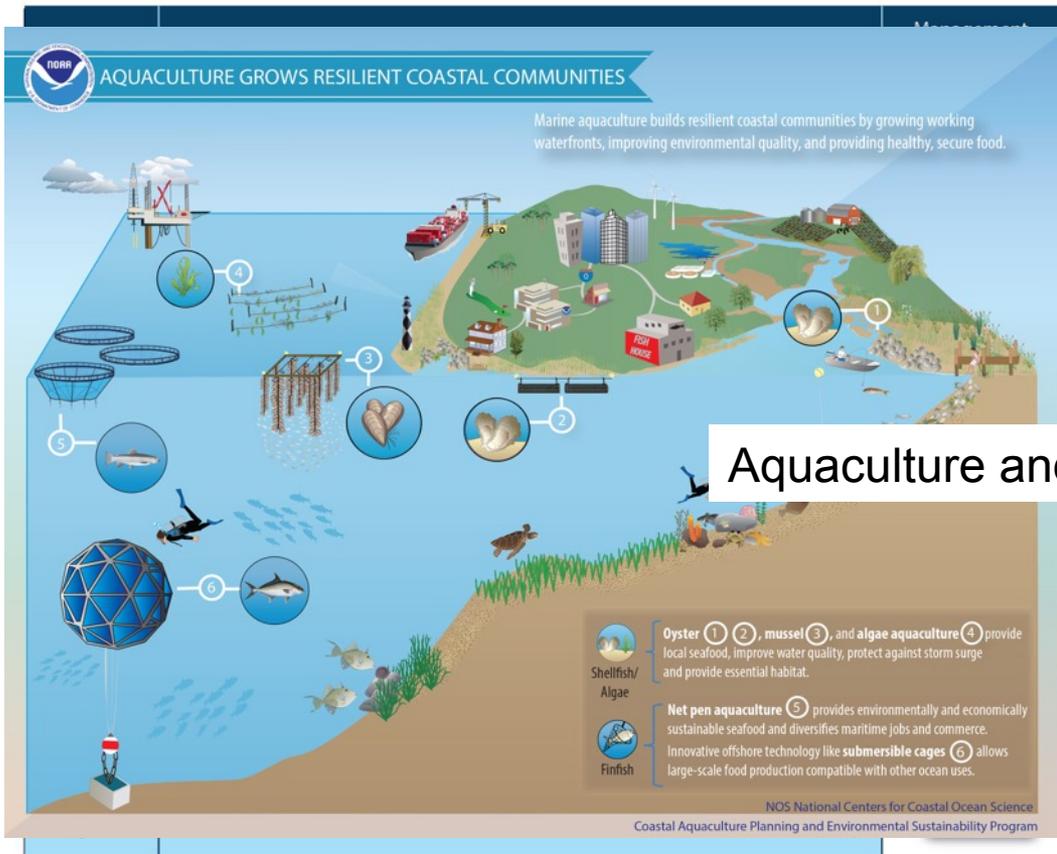
The Magnuson-Stevens Fishery Conservation and Management Act (MSA), has provisions related to:

- 1) integrating ecosystem considerations into fishery conservation and management actions,
- 2) minimizing the impacts of fishing on ecosystem components, and
- 3) conserving important ecosystem components from non-fishing threats

What about activities which are actually produce seafood and are restorative?



NOAA Fisheries defines Ecosystem Based Aquaculture Management as a systematic approach to Aquaculture management in a:



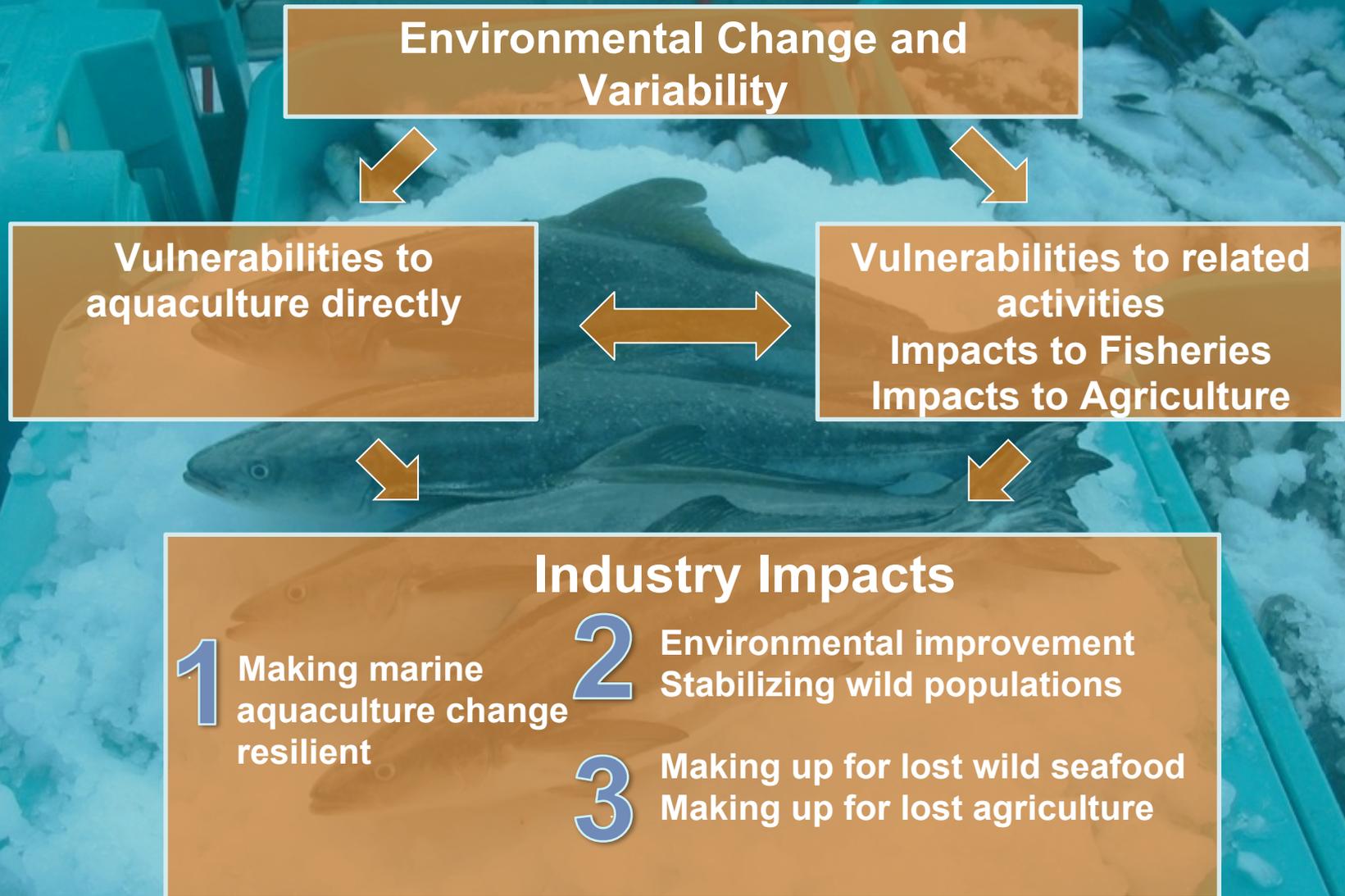
Aquaculture and

- (1) geographically specified area that contributes to the
- (2) resilience and sustainability of the ecosystem;
- (3) recognizes the physical, biological, economic, and social interactions among the affected fishery-related components of the ecosystem, including humans; and seeks to
- (4) optimize benefits among a diverse set of societal goals.

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2) Resilience and sustainability of the ecosystem



2) Resilience and sustainability of the ecosystem

Impacts to aquaculture production due to environmental change (e.g., ocean acidification impacts on shellfish aquaculture).

- More hatcheries
- Feed choice
- Engineering solutions
- Species selection
- Genetic selection
- Resiliency through application of science and technology.



2) Resilience and sustainability of the ecosystem

Potential for aquaculture of shellfish and seaweed (algae) to mitigate impacts of climate change (e.g., sequestering carbon, bioextraction),



Resiliency through intelligent use
of aquaculture/ecosystem
synergy

2) Resilience and sustainability of the ecosystem

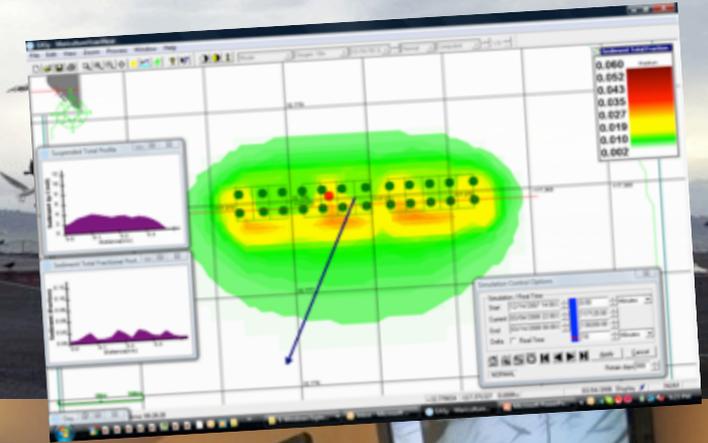
Use of aquaculture to recover or enhance wild populations impacted by climate change – Aquaculture as a tool to improve resiliency of Wild Fisheries

- Abalone restoration
- Alaskan King Crab
- Salmon
- Corals?
- Pacific Cod?



2) Resilience and sustainability of the ecosystem

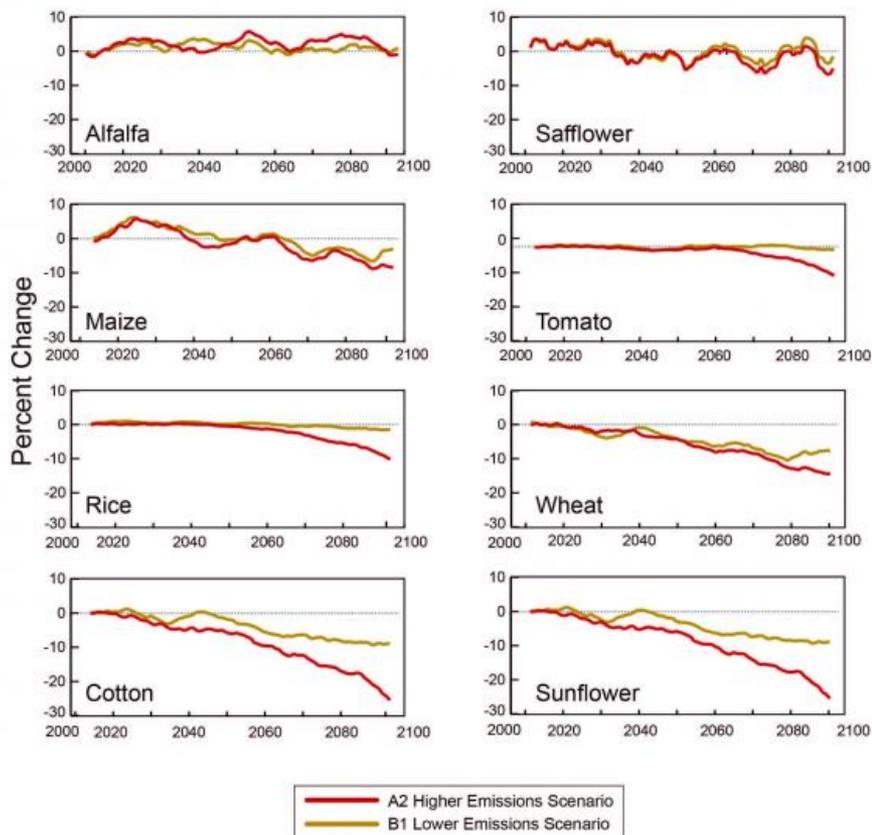
Use of marine aquaculture to make up the potential seafood deficit due to loss of wild fisheries impacted by climate change – improve resiliency of seafood supply.



2) Resilience and sustainability of the ecosystem

Use of marine aquaculture to make up potential food deficits due to impacts of change on agriculture inputs. Aquaculture as a way to improve resiliency in the food production system?

Crop Yield Response to Warming in California's Central Valley

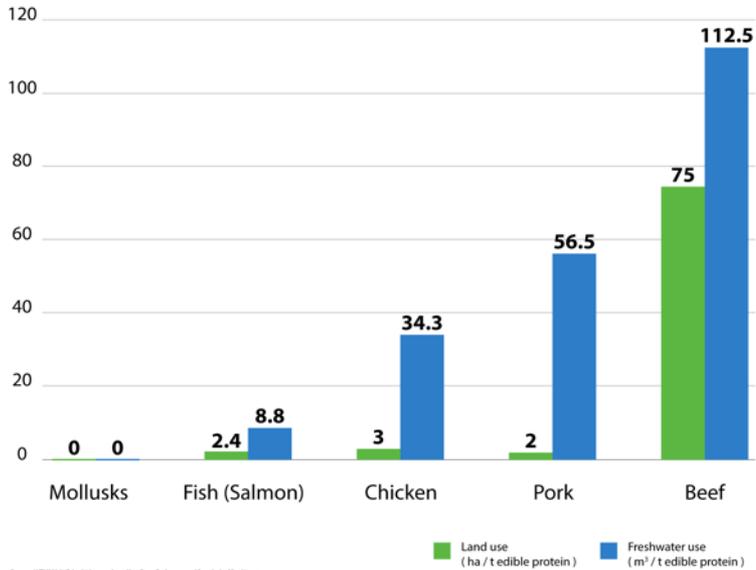


Limiting resources for food production

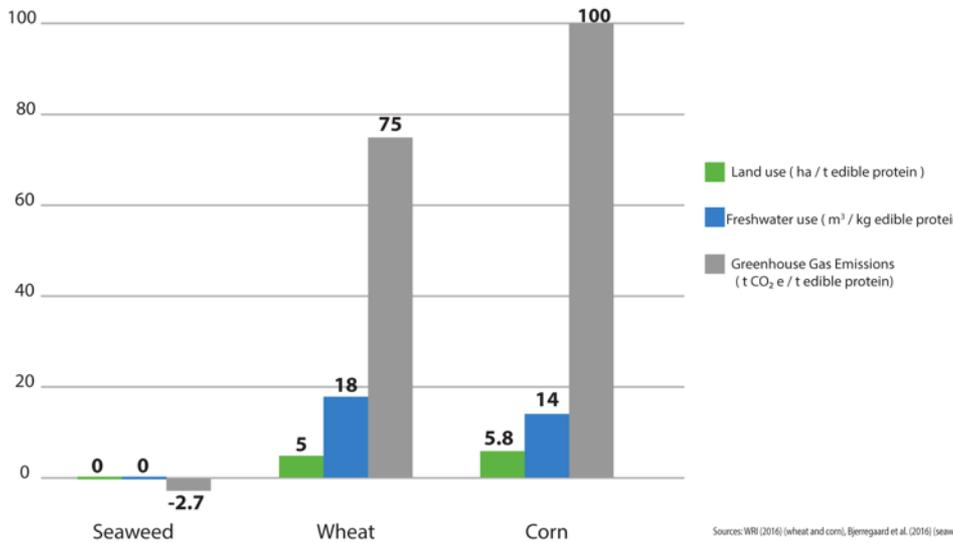
- Farm land
- Freshwater
- P and other nutrients
- Weather
- Green house gas
- Energy use

None are limited or are buffered in the marine environment

Resiliency through Social and Economic forces

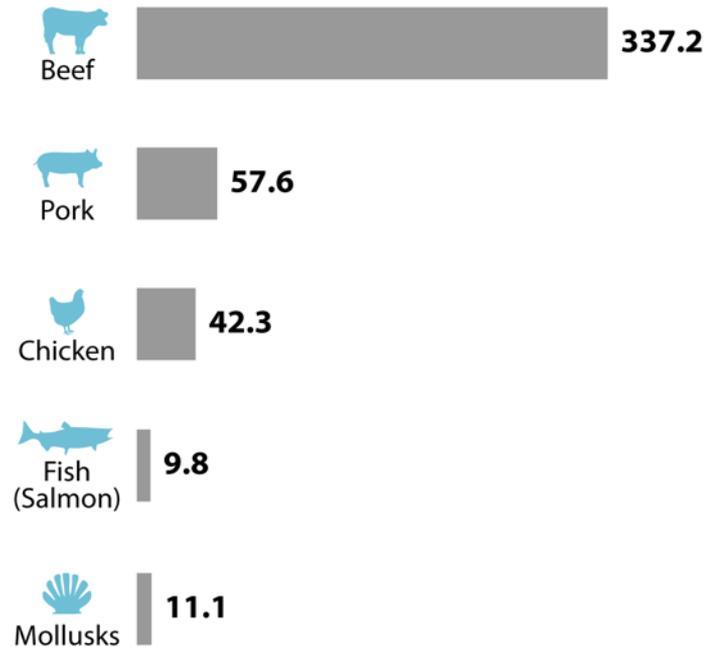


Sources: WRI (2014) (fish, chicken, pork, and beef), mollusks assumed from lack of feed input.



Sources: WRI (2016) (wheat and corn), Bjenegaard et al. (2016) (seaweed)

Terrestrial vs ocean-based agronomy in terms of water use, green house gasses and land use. Resiliency through efficiency.



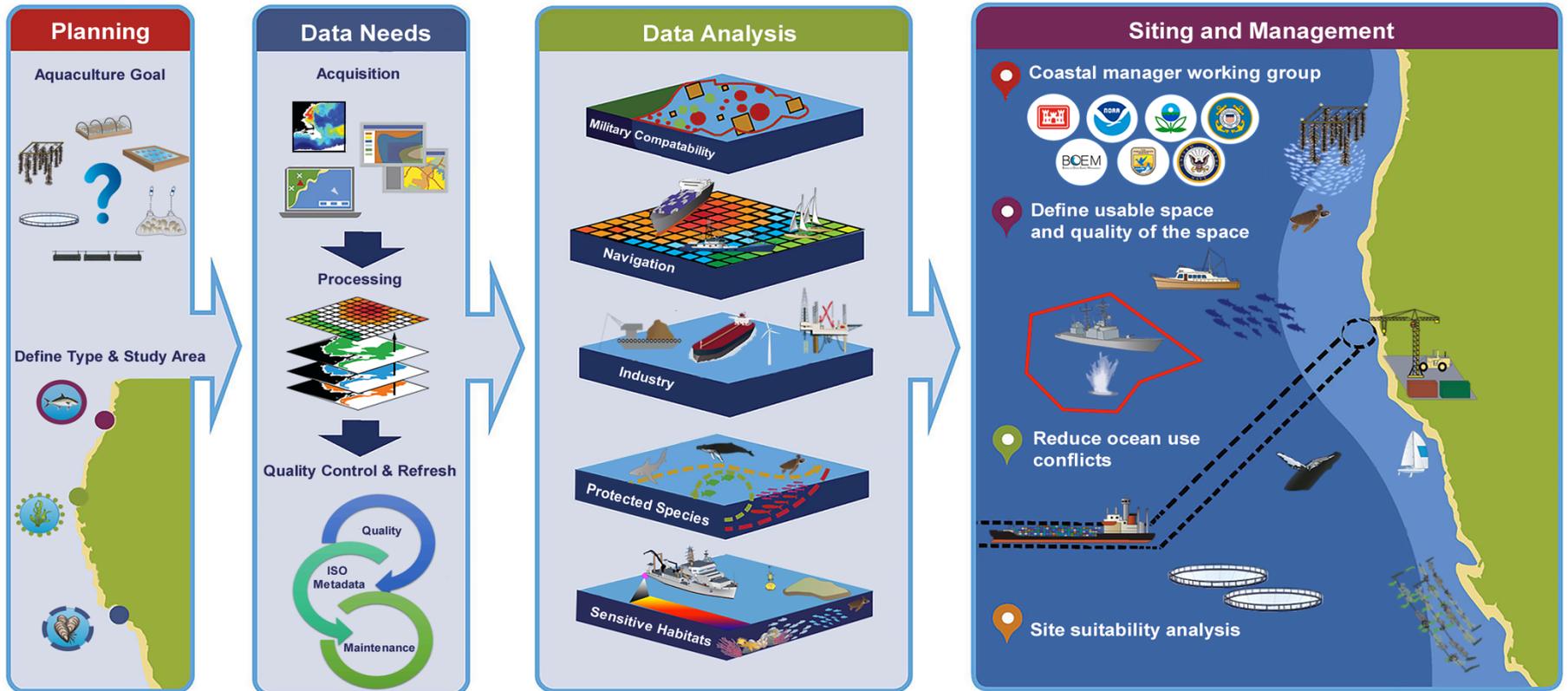
Sources: WRI (2014) (mollusks, chicken, pork, and beef) and Pahlow et al. (2015) Tons CO₂e/T edible protein

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3) ...the physical, biological, economic, and social interactions among the components of the ecosystem (including humans)

Coastal Aquaculture Siting



NOS National Centers for Coastal Ocean Science
Coastal Aquaculture Siting and Sustainability

Some graphics courtesy of IAN, UMCES, NCCOS BioGeo, and the Marine-life Data and Analysis Team (MDAT)



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FIGURES

nature
COMMUNICATIONS

ARTICLE
DOI: 10.1038/ncomms1476a OPEN

Marine spatial planning makes room for offshore aquaculture in crowded coastal waters

“We identify >250,000 MSP solutions that generate significant seafood supply and billions of dollars in revenue with minimal impacts (often < 1%) on existing sectors and the environment.”

Dealing with Trade-offs

...optimize benefits among a diverse set of societal goals

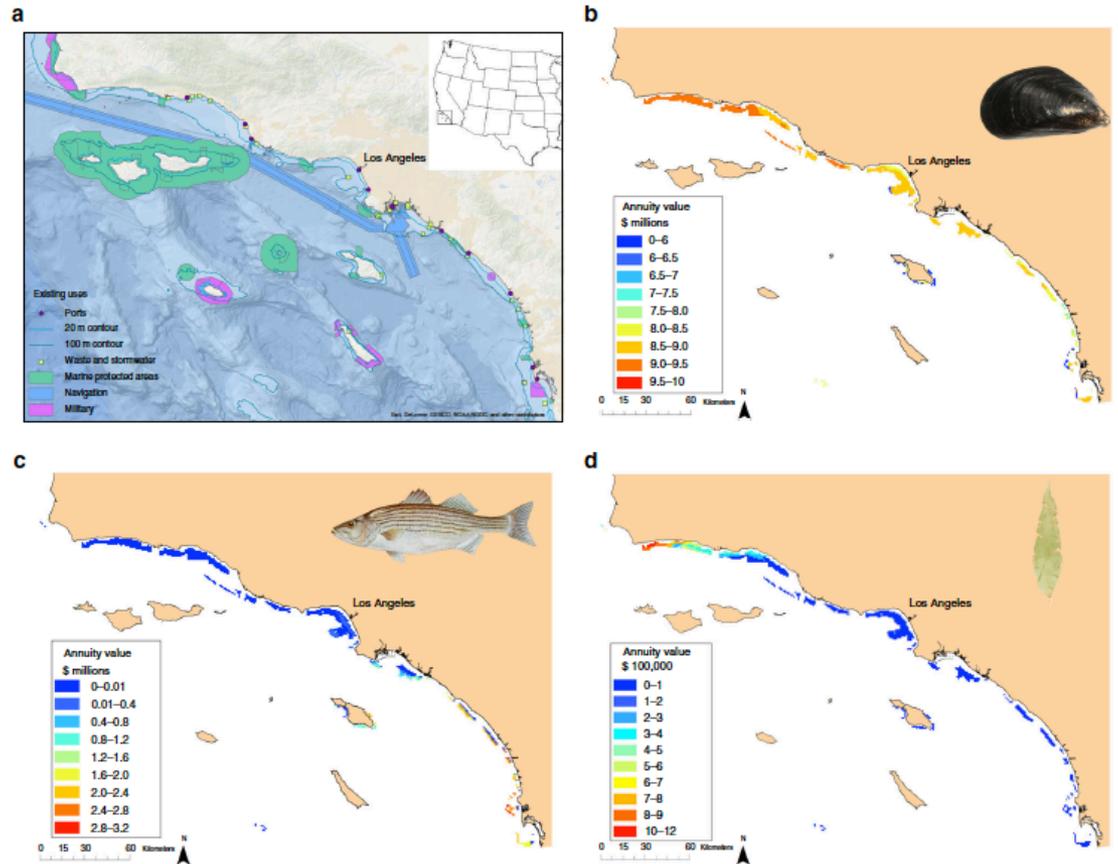
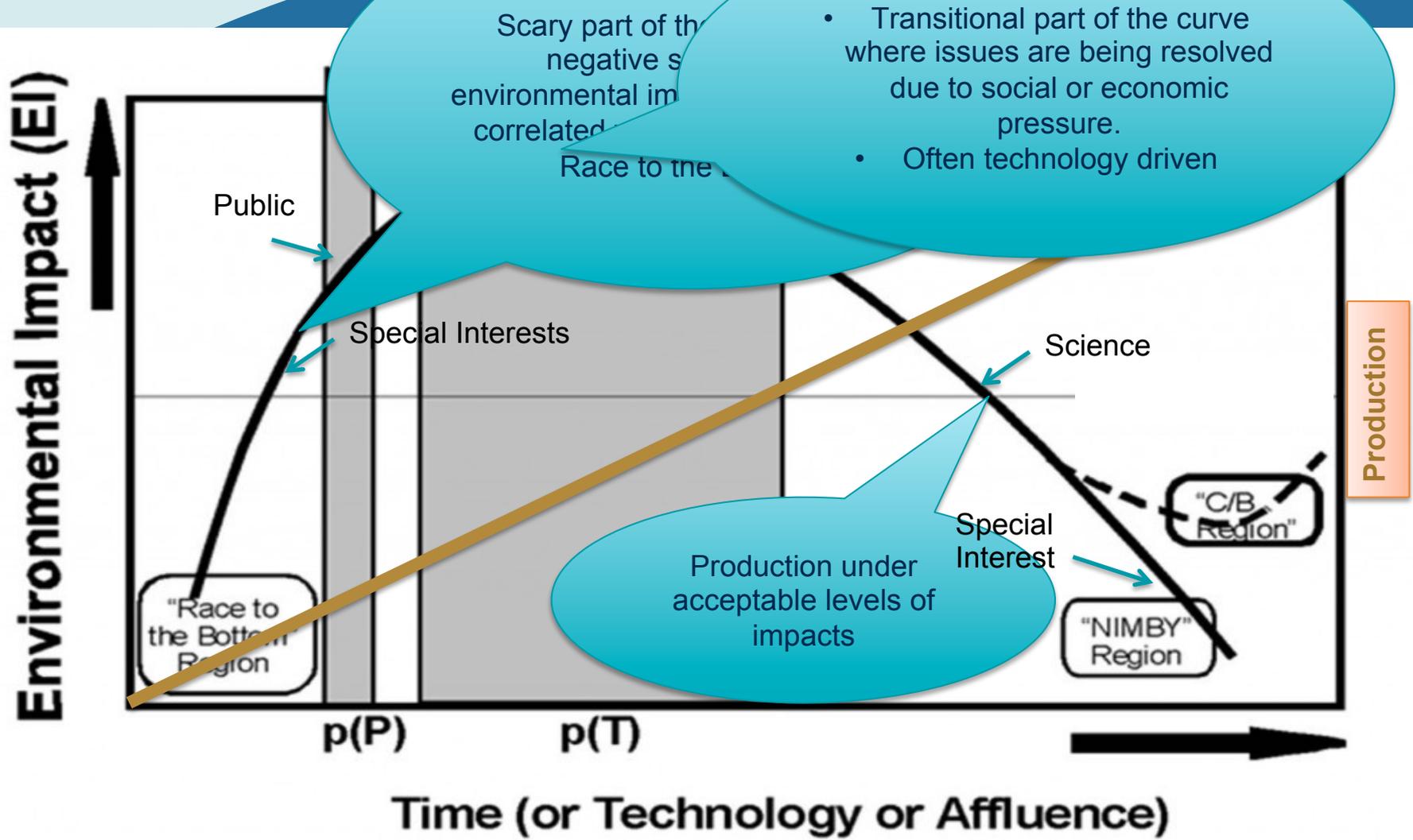


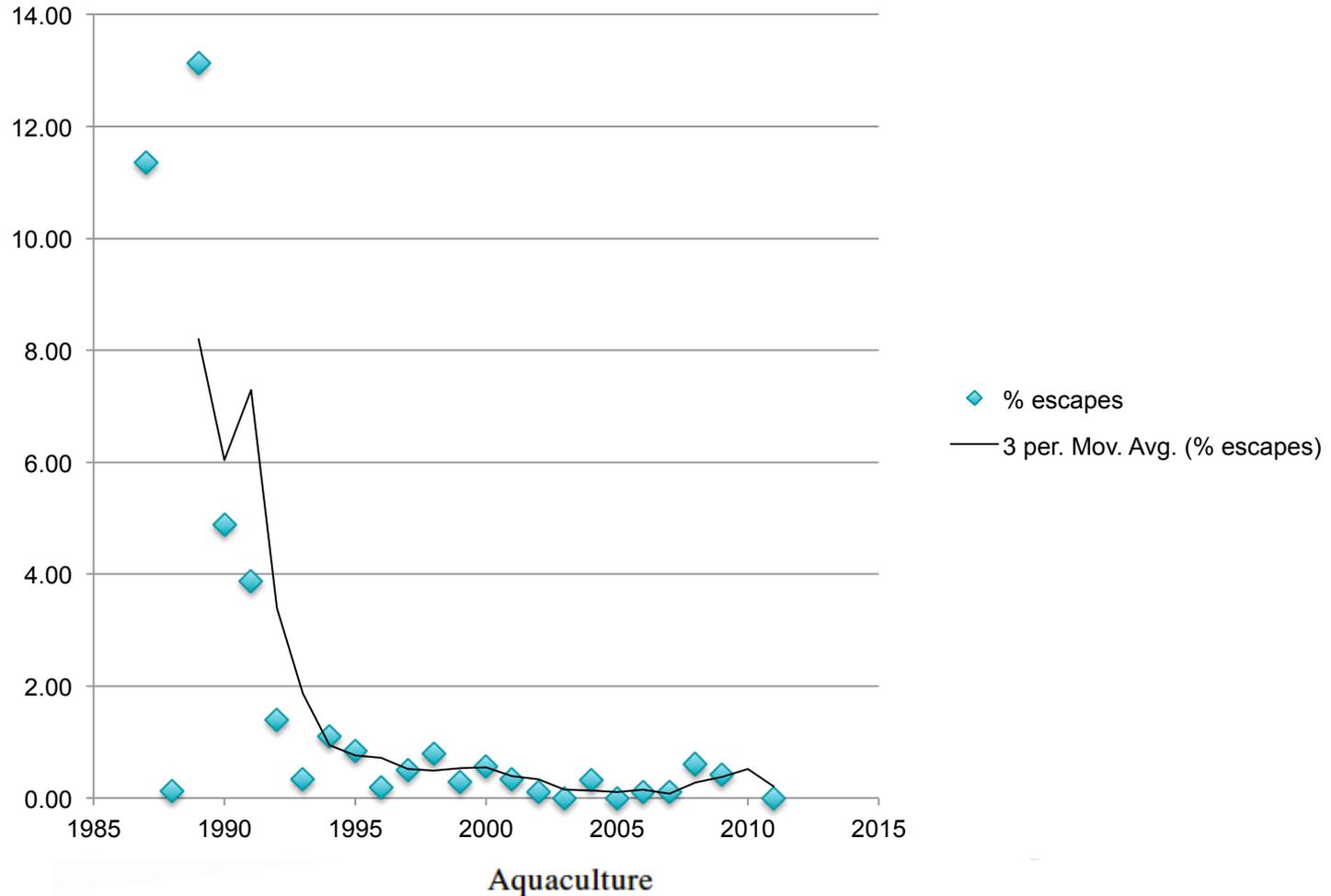
Fig. 1 Study domain, spatial constraints, and potential value for aquaculture development in the SCB. Potential annuity (\$/year) in each developable site for (b) mussel, (c) finfish, and (d) kelp aquaculture sectors. Mussel image in b from <https://commons.wikimedia.org/wiki/File:HPIM1476a.jpg>

A Paradigm for Change: Inverted "U"



Examples from Aquaculture

% Escapes from BC farms



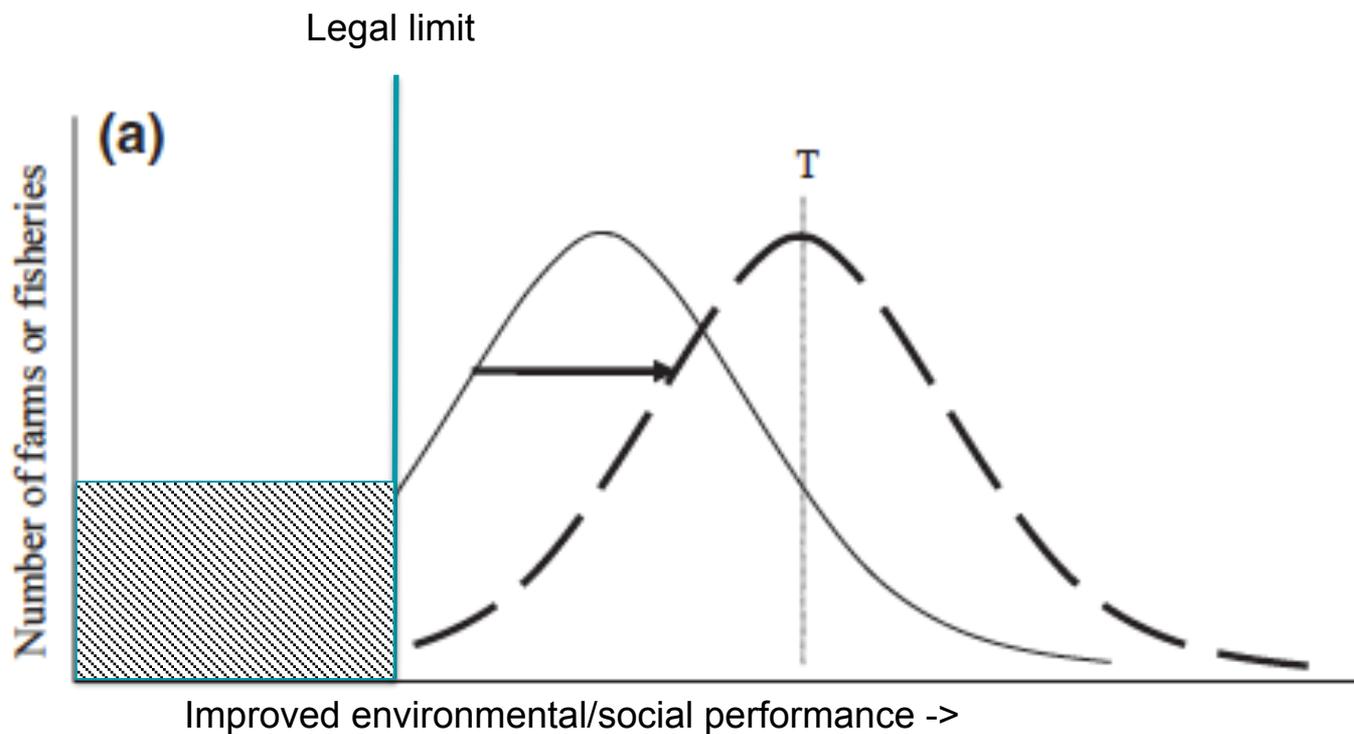
Seen time
and time
again as
industries
mature

Source: Norwegian Directorate of Fisheries (2008).



Pulling, Pushing and Creating Change

Limits can truncate the industry cutting off the lowest performers and may push the industry



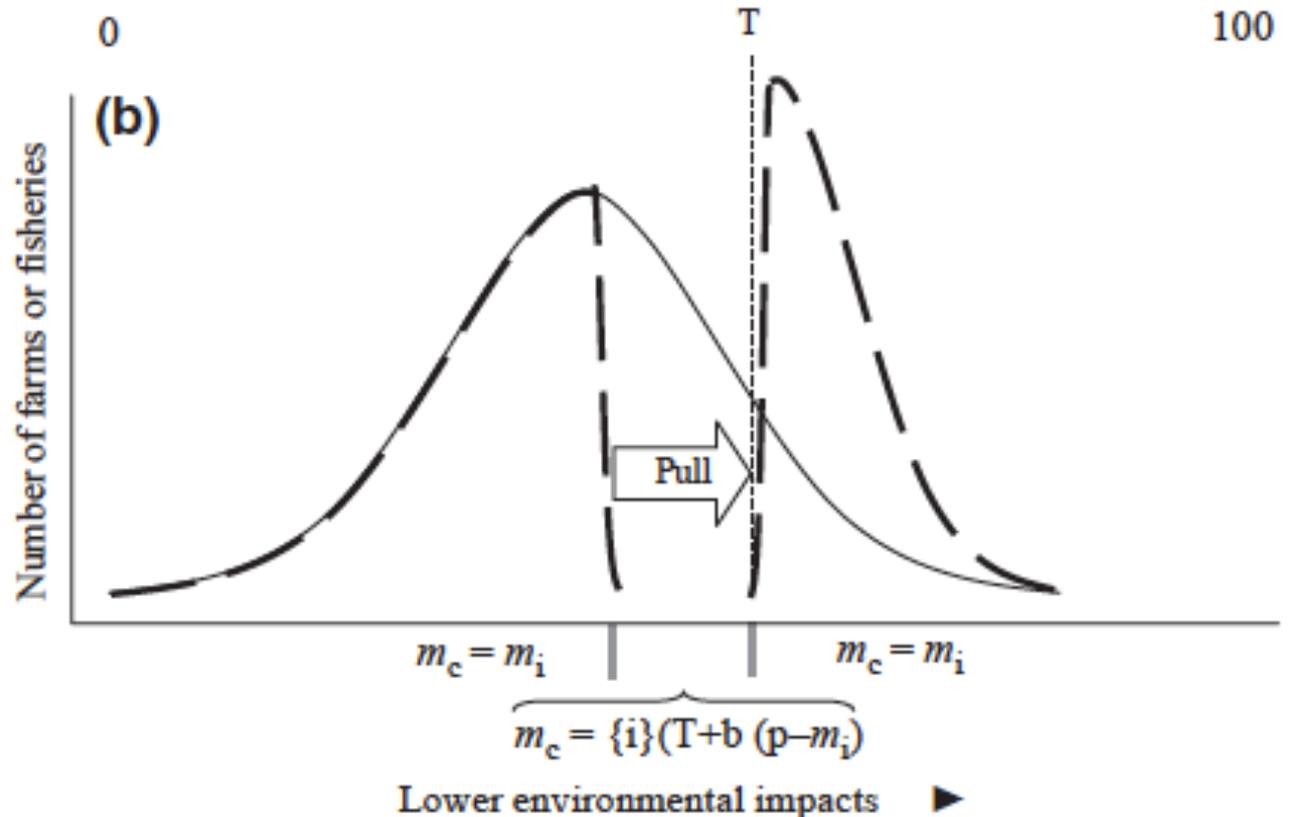
However - Limits are not set this way – they depend on what is being protected



Pulling, Pushing and Creating Change



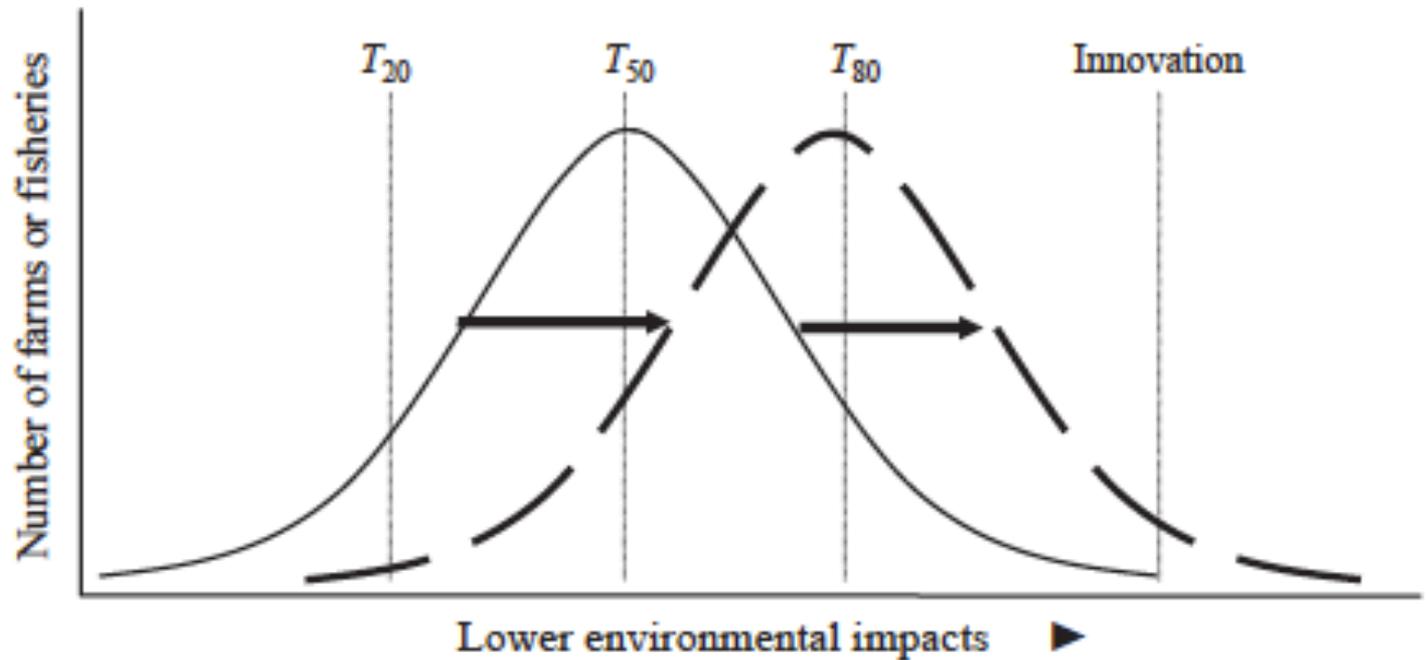
BMP's and certification schemes tend to pull the best farms and can split the industry unless the whole industry can make the bar



Pulling, Pushing and Creating Change



Innovation (structural change) tends to move the whole industry to higher standards if economic gain and environmental gain are both achieved



Questions?

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