Title	Spatial Bioeconomics for seafood and marine ecosystem conservation
Author(s)	Sumaila, Ussif Rashid
Description	Invited Lectures
Relation	International Symposium on "Sustainability Science on Seafood and Ocean Ecosystem Conservation". 7 November 2009. Hakodate, Japan.
Issue Date	2009-11-07
Doc URL	https://hdl.handle.net/2115/39908
Type	conference presentation
File Information	Sumaila.pdf

Spatial Bioeconomics for seafood and marine ecosystem conservation

Rashid Sumaila

Fisheries Centre, University of British Columbia
Vancouver, Canada
r.sumaila@fisheries.ubc.ca

International Symposium on “Sustainability Science on Seafood and Ocean Ecosystem Conservation, Hakodate Campus of Hokkaido University, Nov. 7, 2009

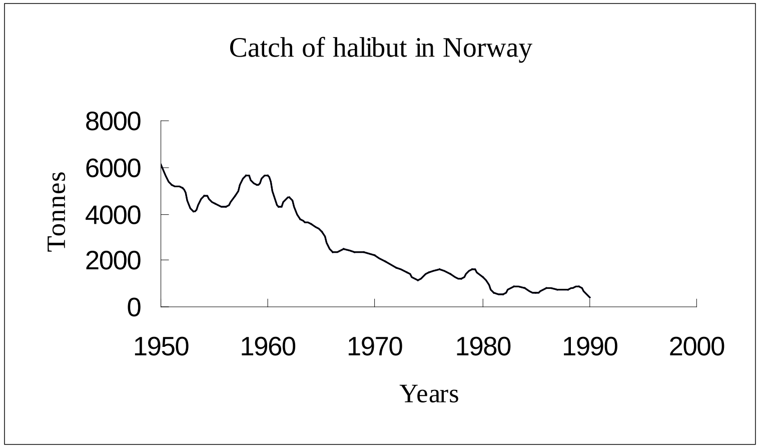
Outline of talk

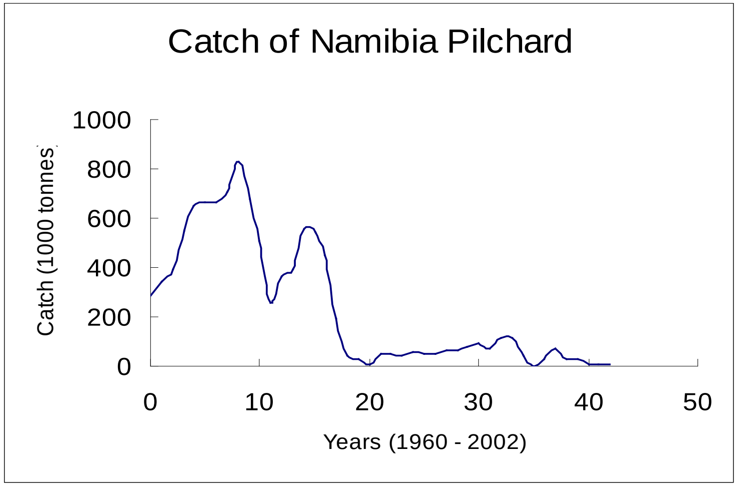
- Current state of seafood supplies (fish catch) worldwide;
- A spatial bioeconomic index for seafood and marine ecosystem conservation;
- Use index to discuss the spatial allocation of management effort and budget.

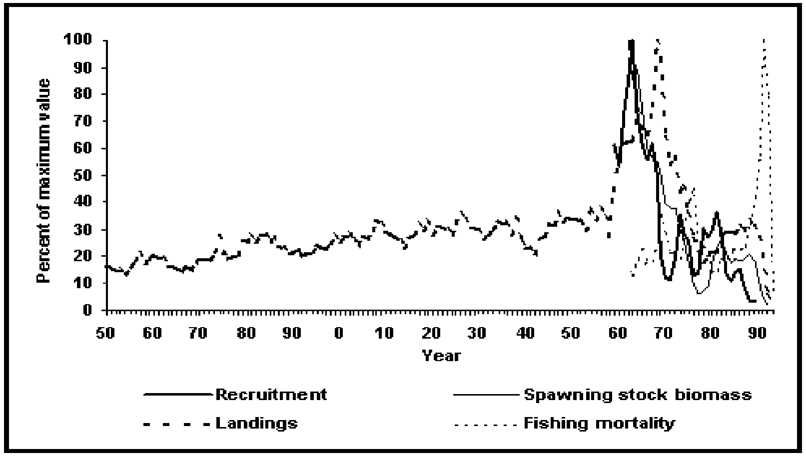
Current state of seafood supply (fish catch)

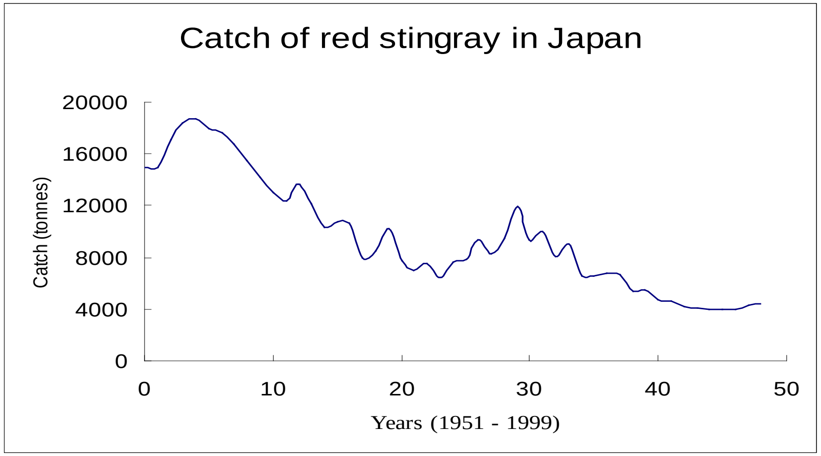
- Specific fishery level;
- Regional level; and
- Globally.

Catch trends: individual fisheries



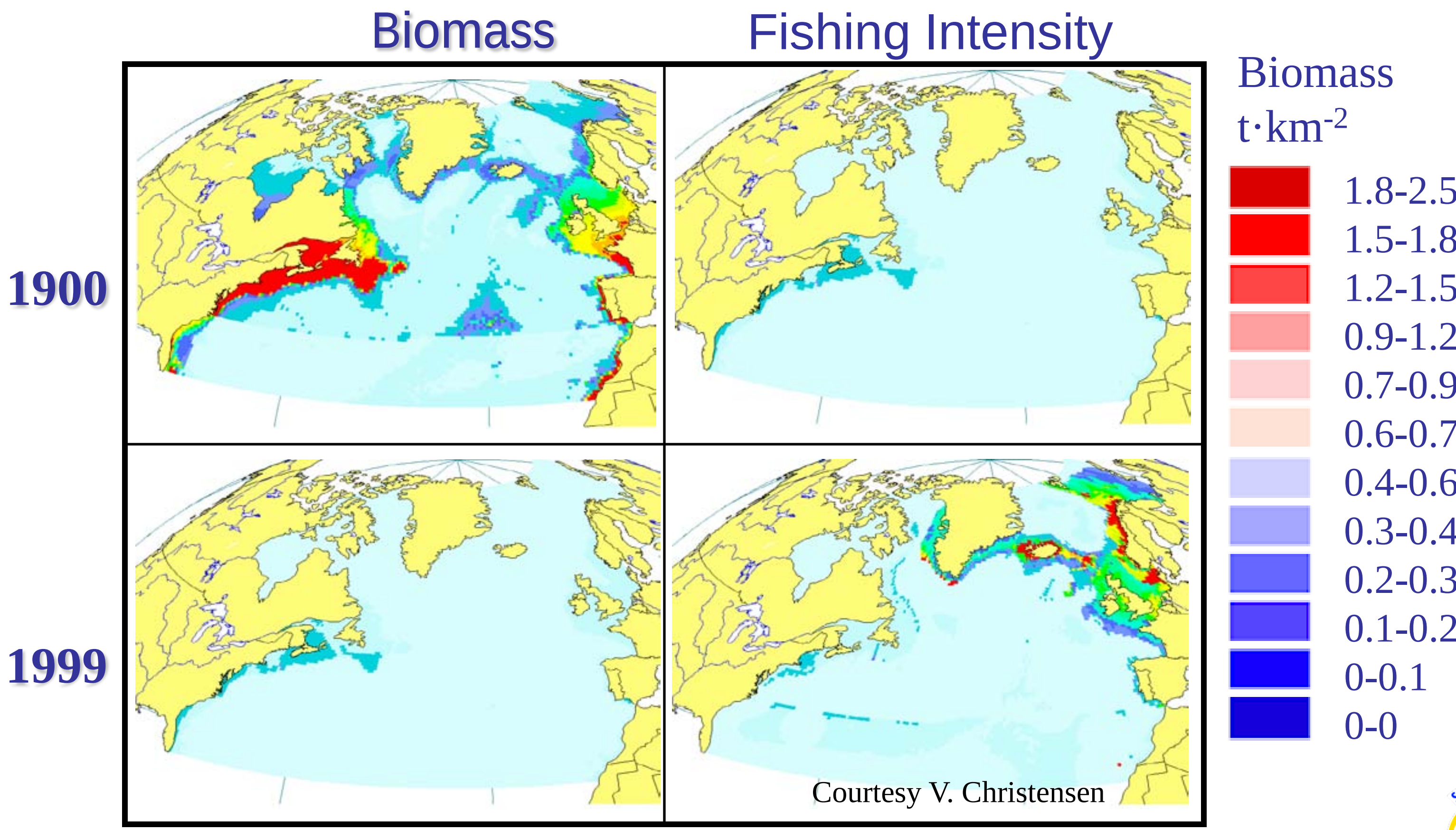


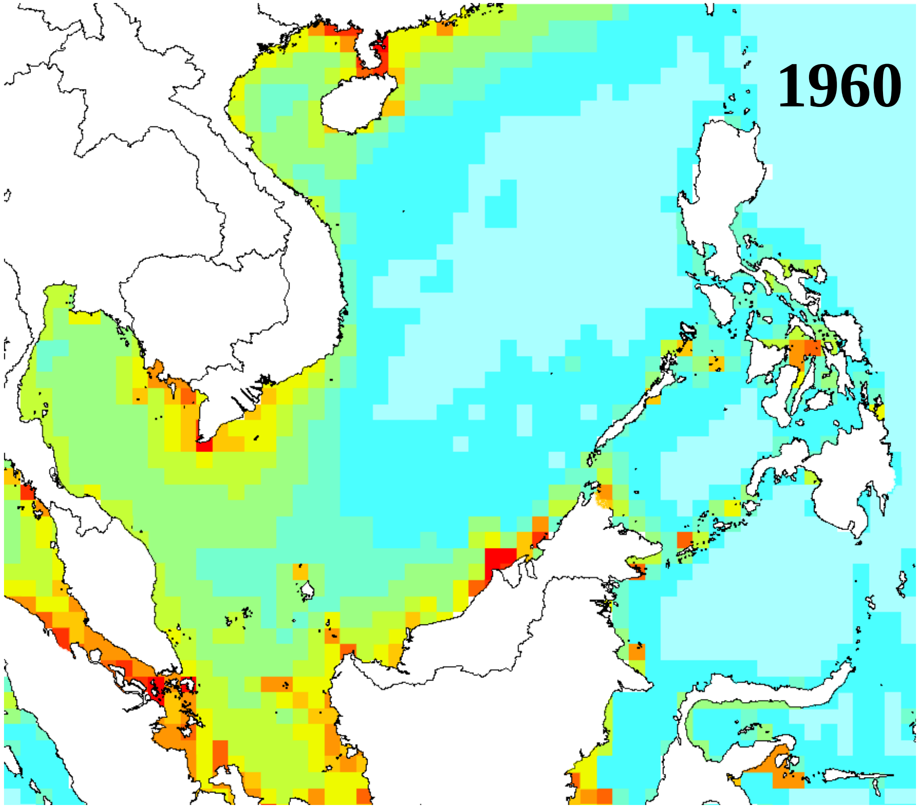




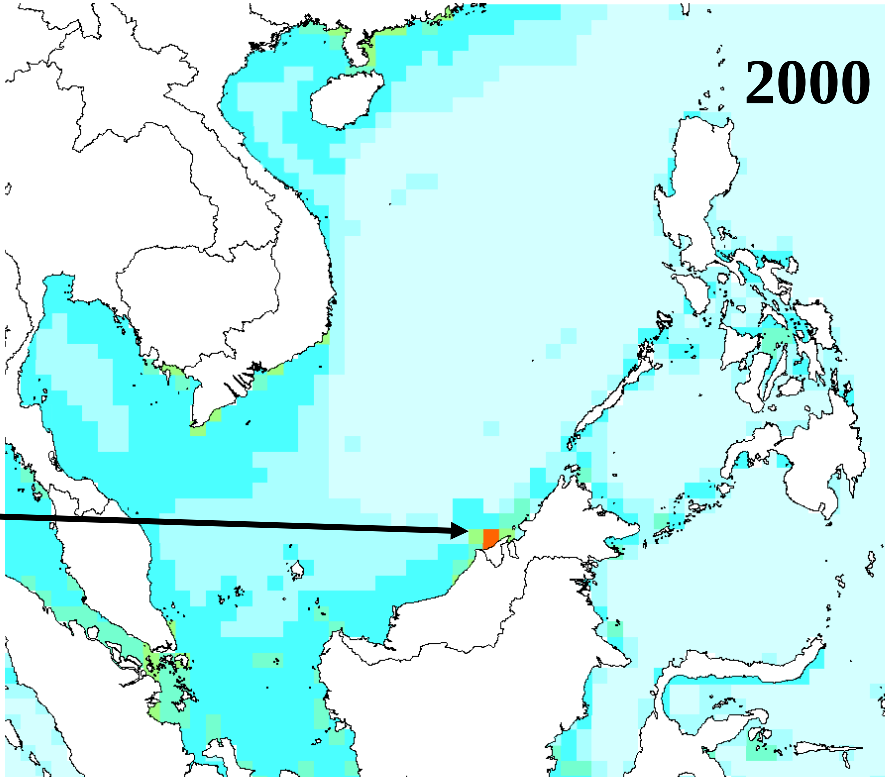
State of fisheries in the North Atlantic

- Biomass;
- Fishing intensity.





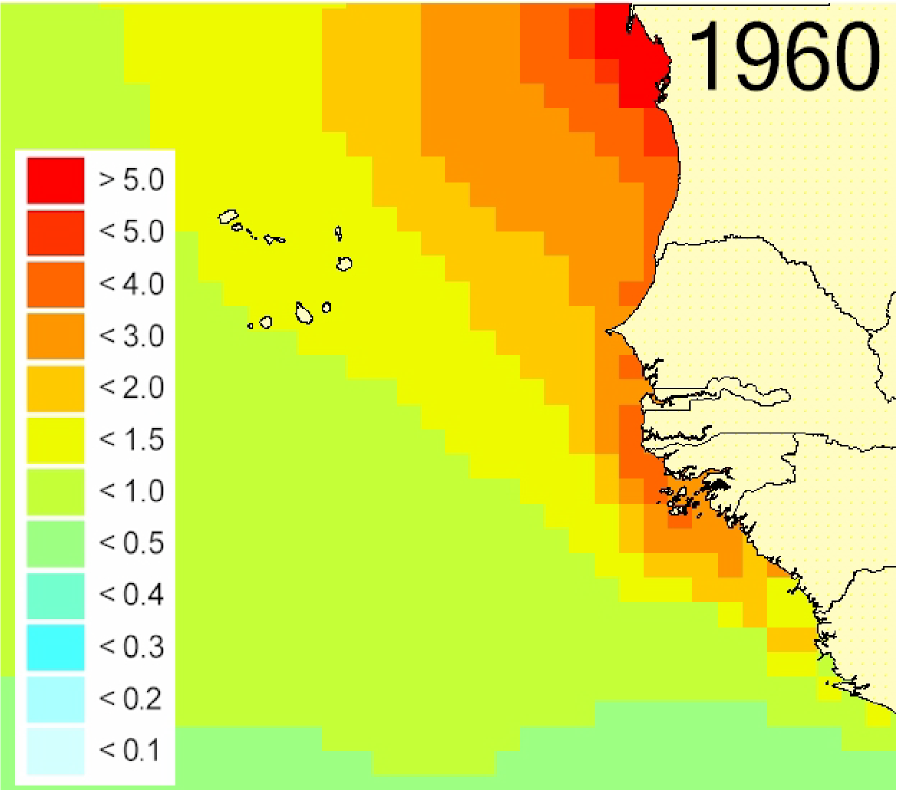
The situation is similar in Southeast Asia…

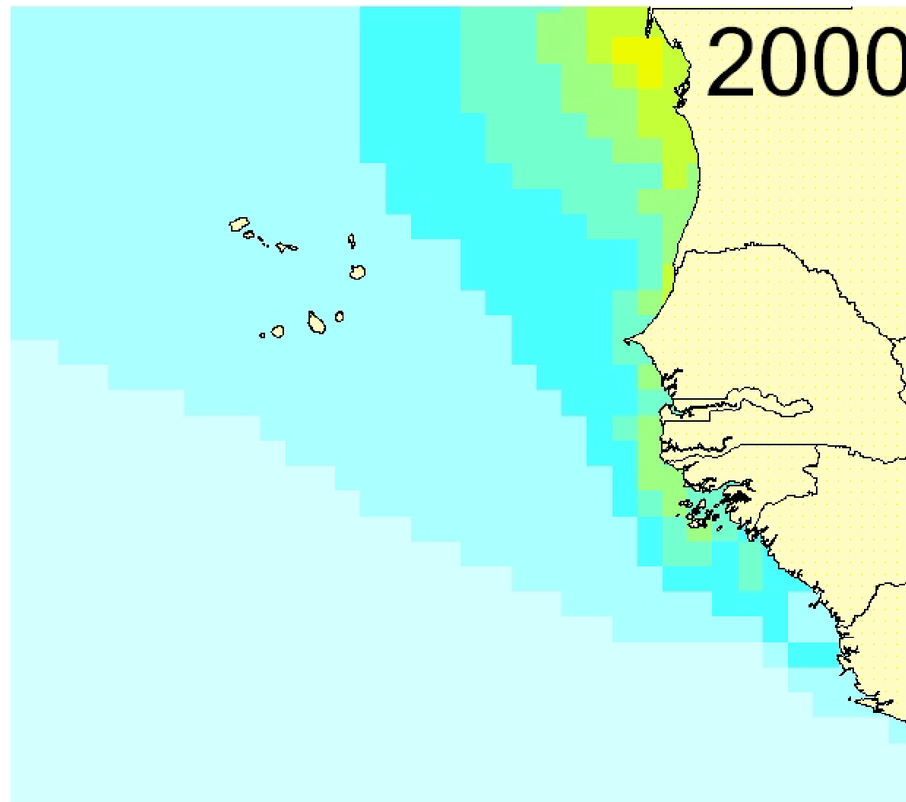


Note Brunei as exception

Christensen *et al.* (2004)

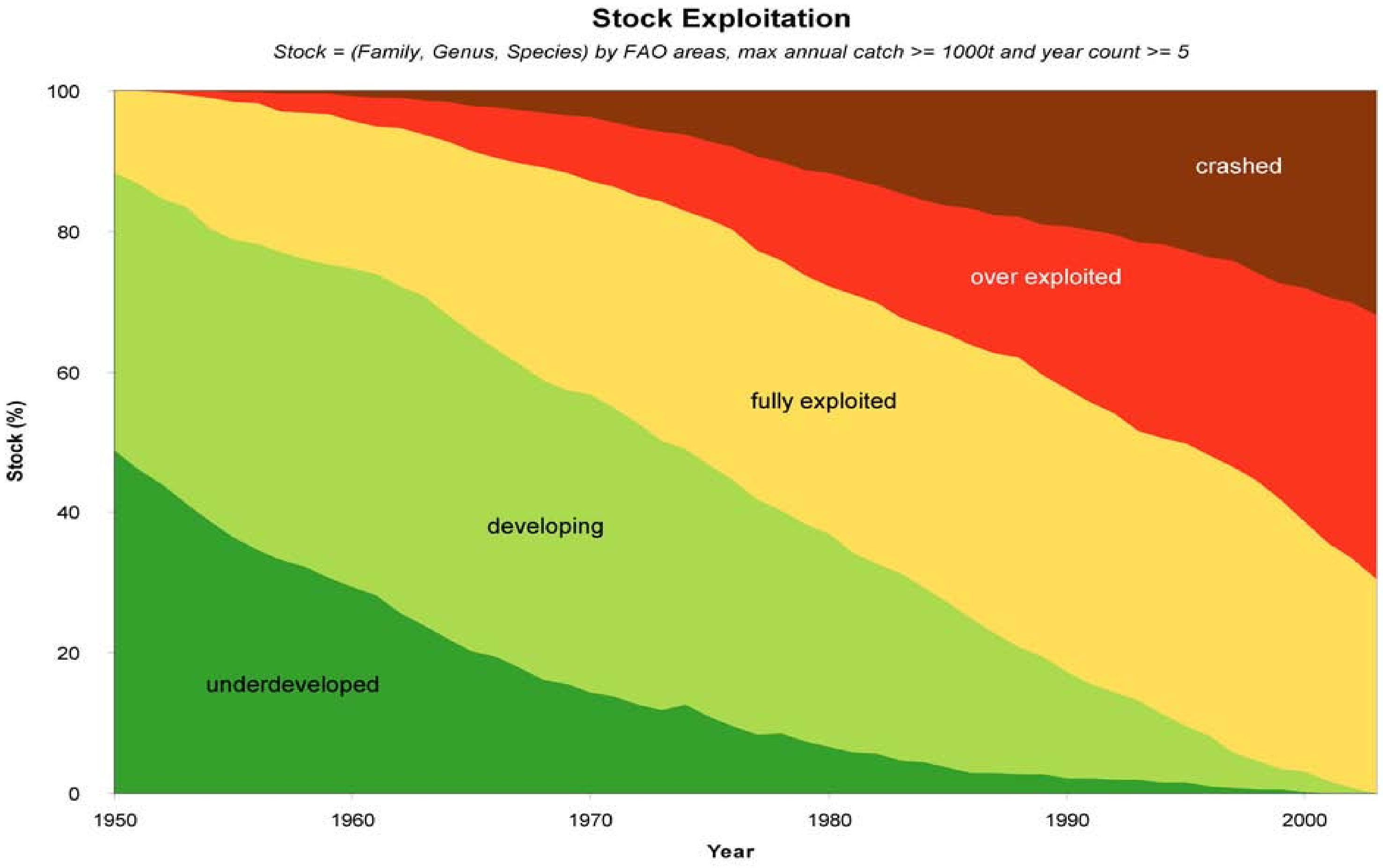
… and in Northwest Africa





Christensen *et al.* (2004)

State of fish stocks, globally



Source: Froese and Pauly (2004).

Implication

- State of world fisheries not strong at all;
- We therefore need to double our efforts to conserve seafood and marine ecosystems for the benefit of all generations.

Key conservation question

- How can economics, through integration with ecology and other disciplines, be used to help ensure seafood and marine ecosystem conservation for the benefit of both current and future generations?

“The Earth and the fullness of it belongs to every generation, and the preceding one can have no right to blind it up from posterity” (Adam Smith, 1766 Lecture on Jurisprudence).

Photo: NASA

The theoretical basis for spatial index (Clark (1973a &b in *Science; JPE*)

- Let
  - x be the biomass of fish in an ecosystem;
  - F(x) denote growth of biomass;
  - r be the intrinsic growth rate: and
  - δ_p , the private discount rate,
- then
  - if the ***average cost of fishing last unit of fish < the price per unit of fish*** the necessary & sufficient conditions for overfishing & extinction to be the private resource owner's optimal policy are:
  - **δ_p > r; δ_p > 2r**

An index for practical ocean fish management

- Simple index that can:
  - Quickly inform policy makers and managers about the most vulnerable parts of the ocean;
  - Help policy makers and managers prioritize where to use their management efforts and resources.
  - Provide information for effective spatial management of marine resources, including the establishment of MPAs;
  - Provide information on where ITQs could be used without a huge risk of facing the threat identified by Colin Clark.

The biological side to the index: Gordon-Schaefer model

$$F(X) = rx(1 - \frac{X}{K})$$

$$F'(X) = r(1 - \frac{2X}{K})$$

$$\lim_{X \to 0} F'(X) = r \qquad (1)$$

The economic side to the index

- Manager's objective functional:
  - maximize the present value (PV) of the stream of net economic returns from fishery:

$$\max PV = \int_0^\infty e^{-\delta t}(p - c(x))h(t)dt$$

– where x is the biomass, δ, the discount rate, and c(x) unit fishing cost, and h(t) is the catch in period t.

The economic side to the index cont.

- The optimal biomass, X*, is given by (Clark and Munro, 1975):

$$F'(x^*) - \frac{c'(x^*)F(x^*)}{p - c(x^*)} = \delta$$

where x* is the optimal biomass level:

- the LHS of the equation is the rate of return on a marginal investment in the resource;
- the second term on the LHS reflects the impact of investment in x on fishing cost.

$$\mathit{For}\ \mathrm{C(X^*) = 0,\ F'(X^*)} = \delta \qquad (2)$$

Bringing it all into the index

- Combining equations (1) and (2), we define our index as:

$$\theta = (1 - \frac{\delta}{r}); \theta = 1 \text{ if } \delta = 0.$$

- NB: The private owner is indifferent between ‘fish in the bank’ and ‘fish in the ocean’ when the discount rate = the intrinsic growth rate.

Putting life into the index

- Create global databases of:
  - Official discount rates;
  - Private fishers' discount rates;
  - Intrinsic growth rates of commercially exploited fish stocks;
  - catches.

Intrinsic growth rates

• Search, compile all published *r* for fish species;

• For species for which *r* is missing, we applied demographic methods (e.g., *Euler-Lotka method*) to estimate it.

• Examples of *r*:

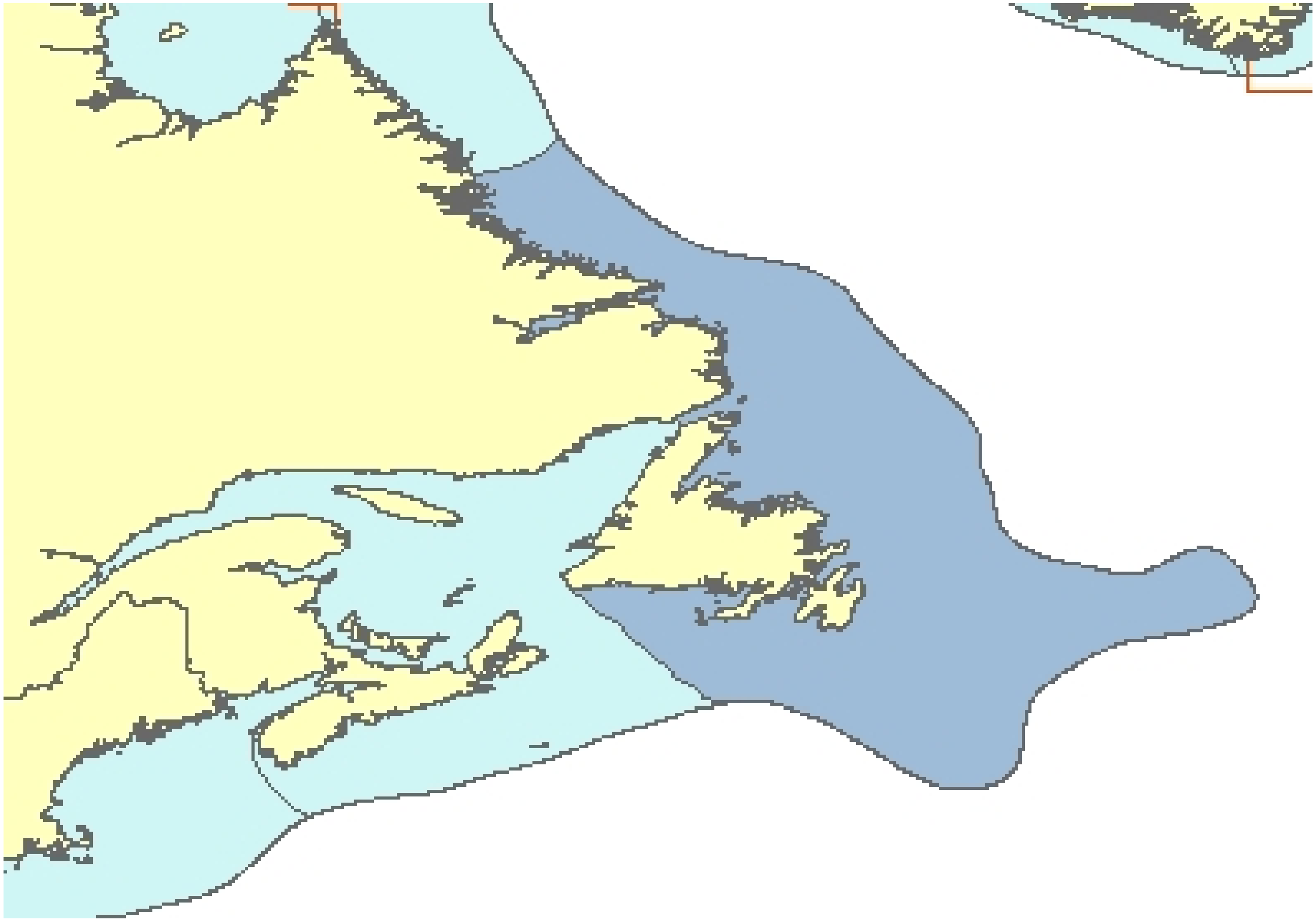
Common name	**~ r (% year^{-1})**
Orange roughy	2.5
Pacific granadier	2.5
Sablefish	2.5
Northern Bluefin tuna	10.0
Yellowtail sole	23.0
Pacific herring	23.0

Discount rate (δ)

- Obtained from published sources;
- For fishing nations without data, we assume 7% and 10% discount rates for developed and developing countries, respectively.
- Examples of discount rate (*δ)* :

Country	**Discount rate (%)**
United kingdom	3.5
France	4.0
USA	7.0
Canada	8.0
Iceland	18.0
Indonesia	24.0

Consider: Newfoundland-Labrador Shelf Large Marine Ecosystem

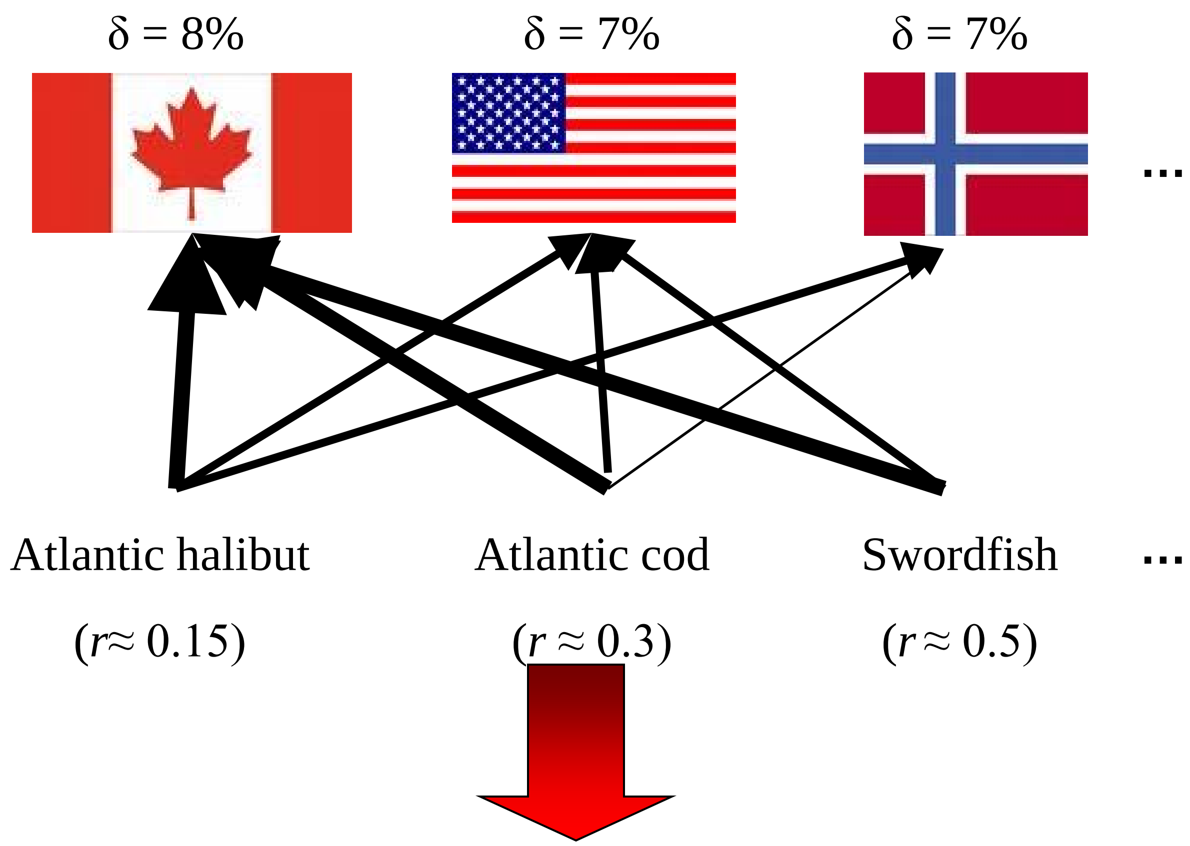


www.seaaroundus.org

Calculating spatial conservation risk index for each 30’ x 30’ cell

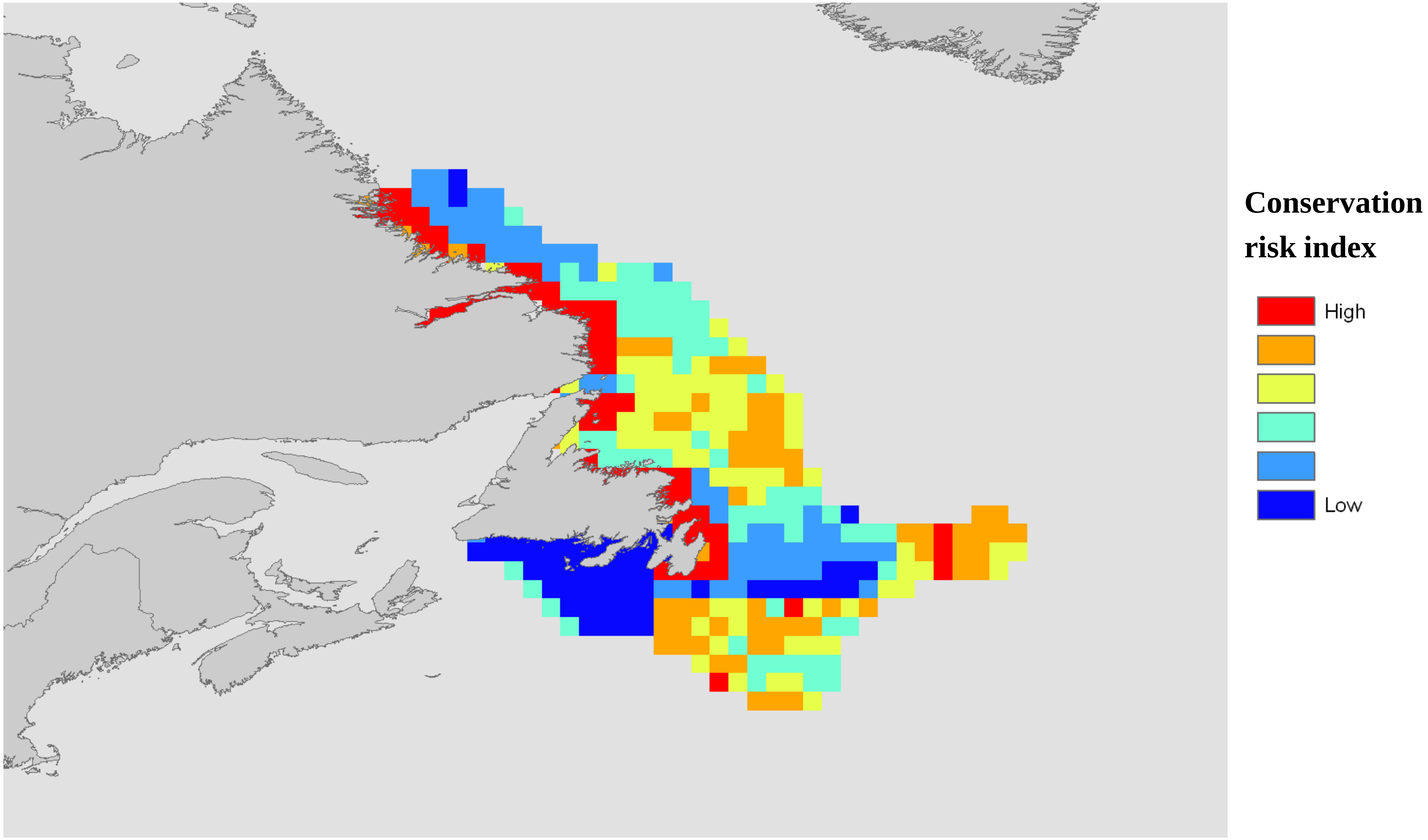
Spatial index

$(1 - \delta/r)$ *for* each link

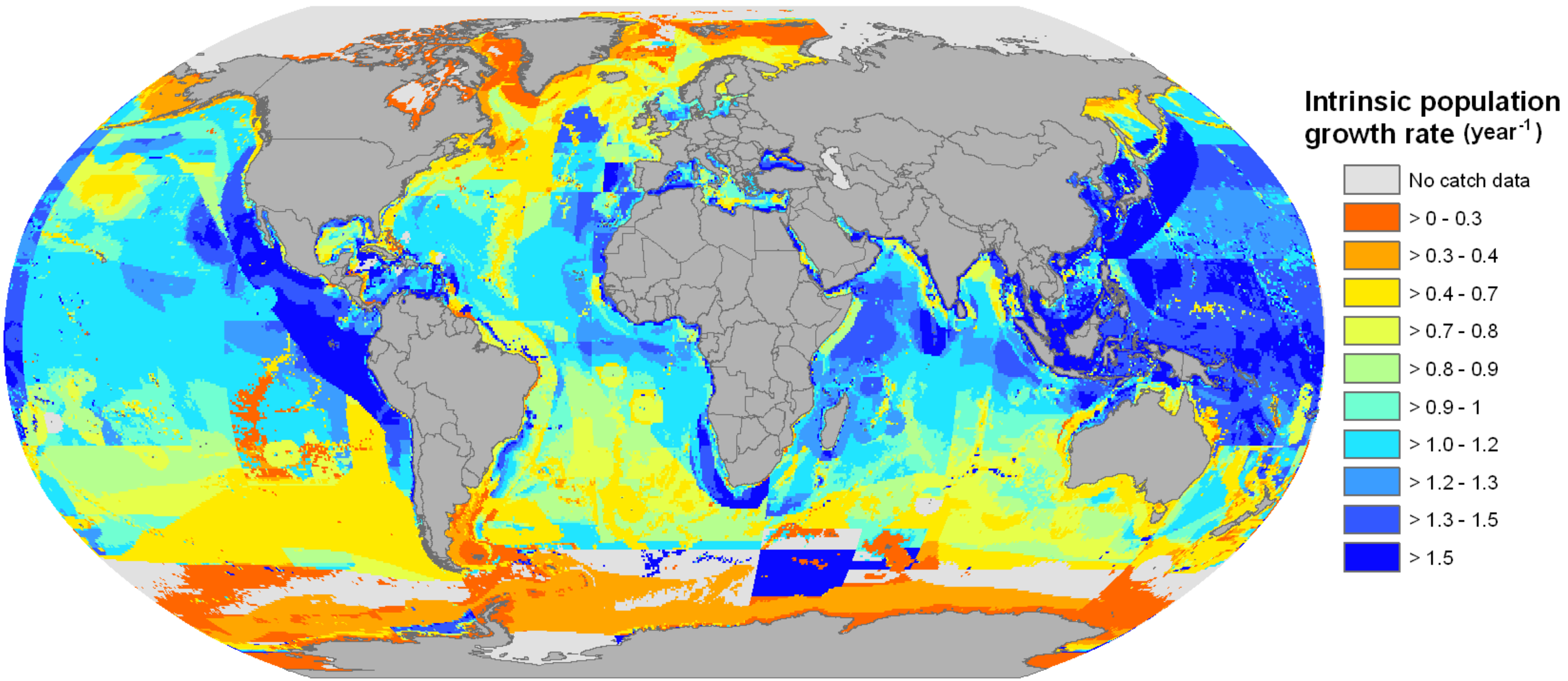


Average spatial index weighted by the catch of each link

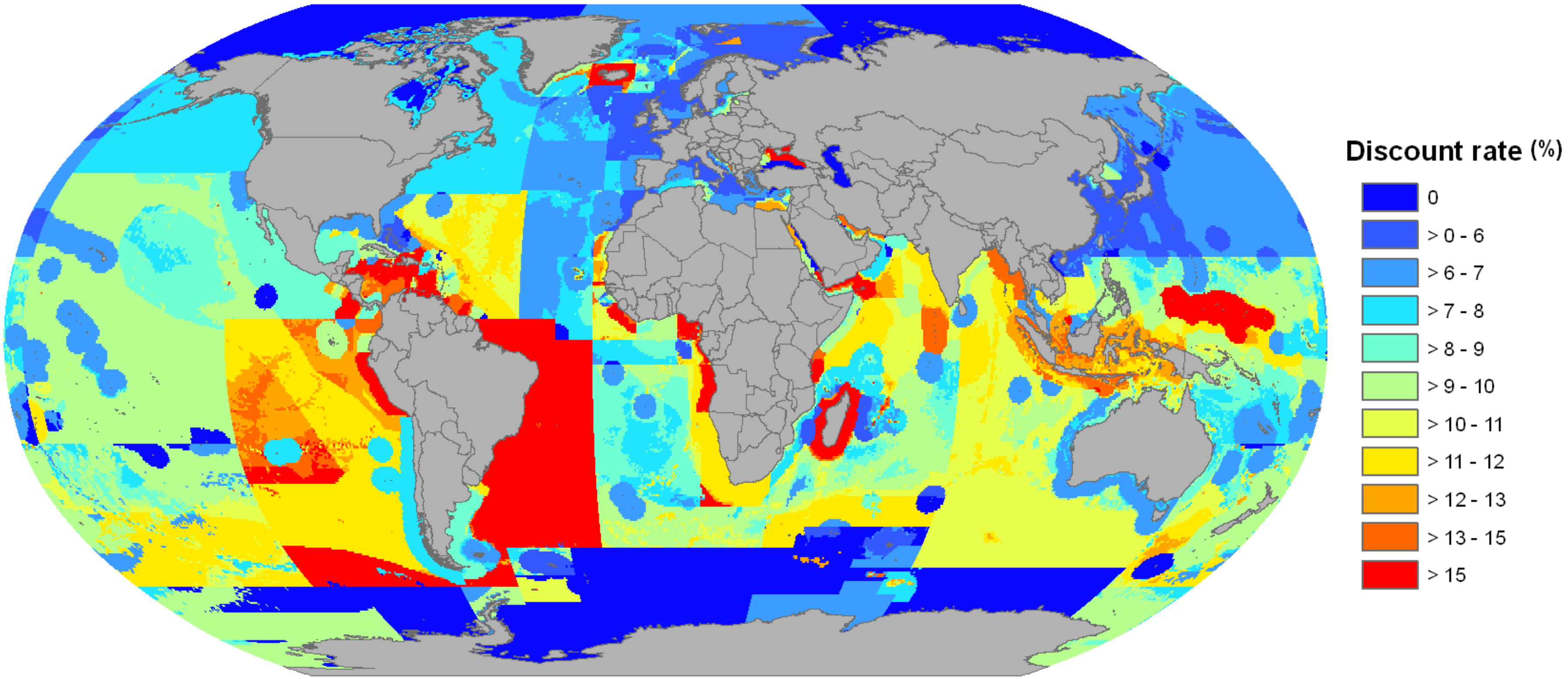
Map of indices for the Newfoundland-Labrador Shelf in the 2000s



The need for integrating ecology and economics: Mapping intrinsic growth rates

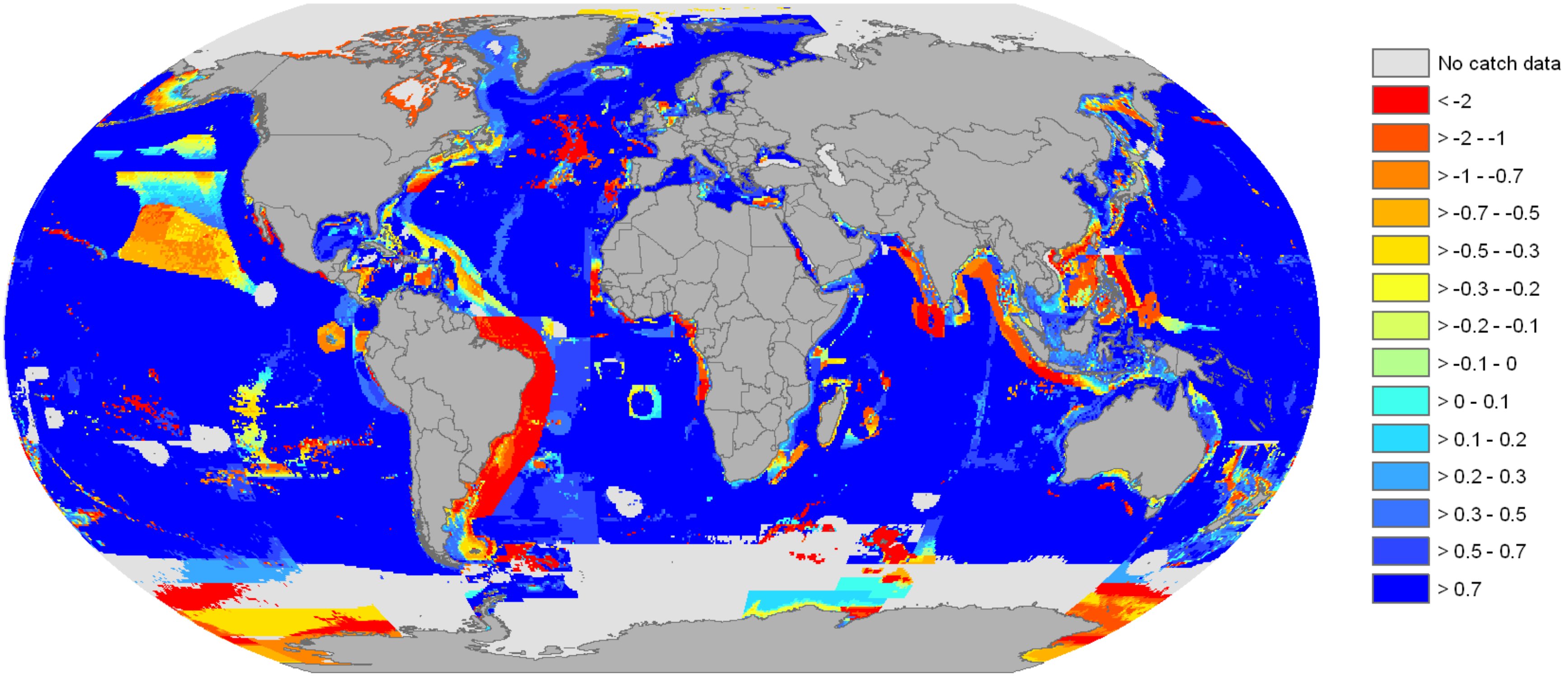


The need for integrating ecology and economics: Mapping official discount rates



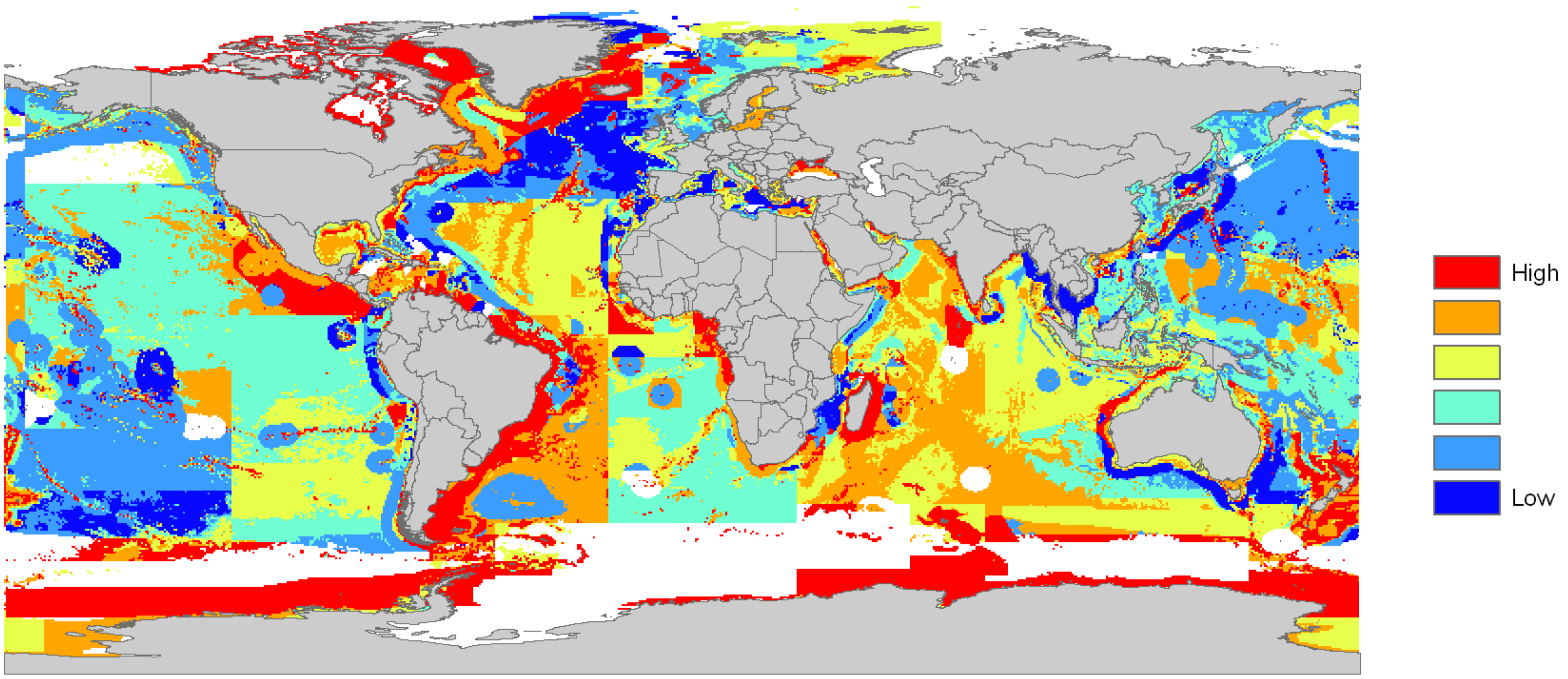
Mapping conservation risk indices

- Include all fish species.



Mapping indices globally

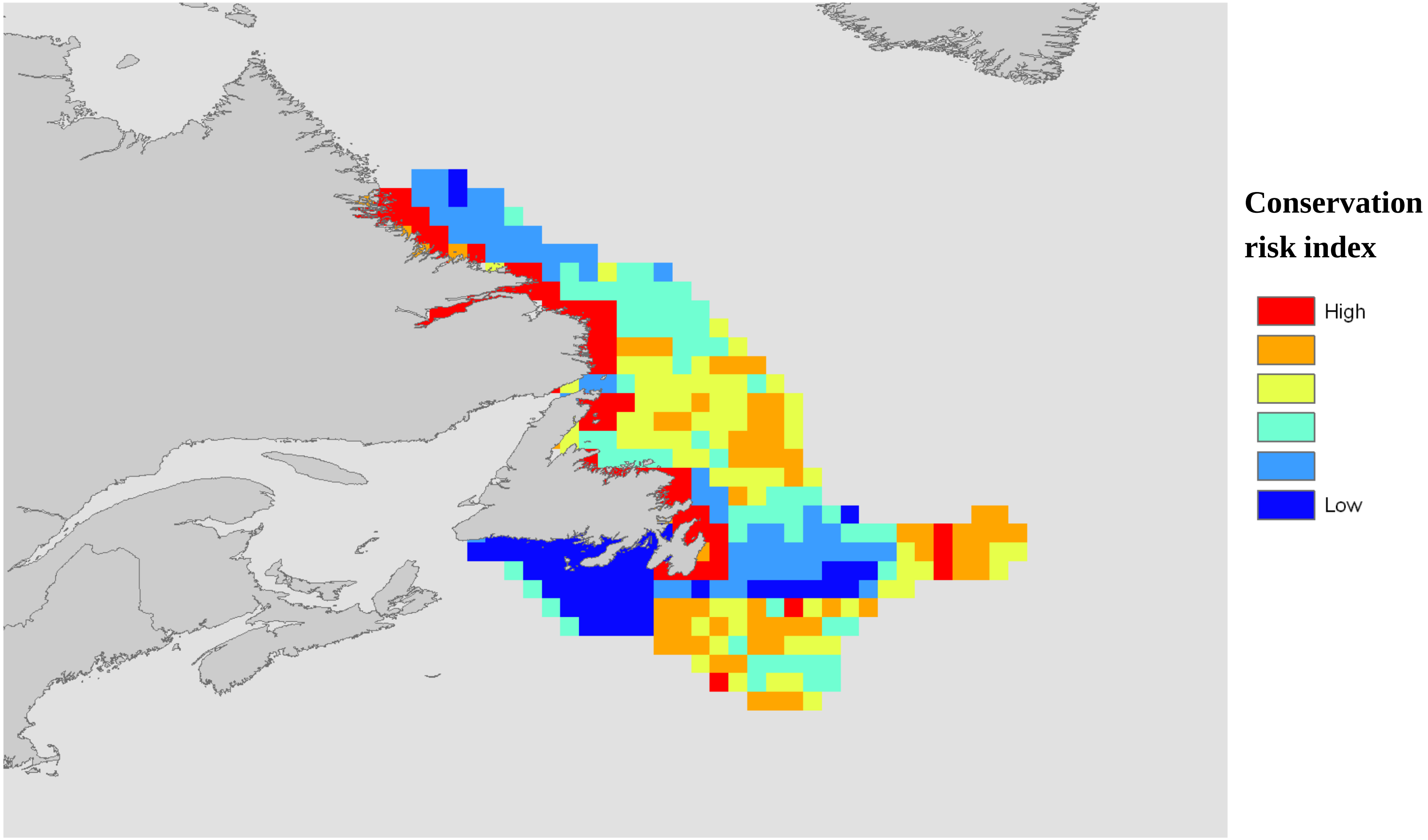
- For demersal species only.



Allocation of management effort and budget

- Reddish areas on the map indicate high risk of depletion of the fish species in the area, where the market and ecology cannot co-exist, hence, needs more management attention and resources;
- Bluish areas on the map indicate low risk of depletion. In other words, the market and ecology can co-exist, hence, can be given low priority in terms management effort and budget allocation

Map of indices for the Newfoundland-Labrador Shelf in the 2000s



Conclusion

- I have demonstrated that the current state of seafood (fisheries) worldwide is not strong at all;
- I have presented a spatial bioeconomic index to help managers conserve seafood and marine ecosystems.
- Finally, I used the index to discuss the spatial allocation of management effort and budget.

Thanks for your attention

Photo by Asep