A Global Comparison Of Marine Ecosystem Response To Fishing Using A Suite Of Ecological Indicators

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A comparative approach

- 19 ecosystems are included in the comparative approach.
  - temperate, tropical, upwelling, and high latitude ecosystems,
  - span different socioeconomic situations,
  - vary in ecosystem structure, environmental forcing, and include
  - a range of exploitation histories.
- This represents a beginning of a global comparative analysis and diagnosis of ecosystem status.
  - Examined via a range of indicators reflecting fishing, environmental pressures and ecology

IndiSeas1 culminated in a suite of papers

ICES Journal of Marine Science volume 67

Shin, Y-J., and Shannon, L. J. 2010. **Using indicators for evaluating, comparing and communicating the ecological status of exploited marine ecosystems. 1. The IndiSeas project.** – ICES Journal of Marine Science, 67: 686–691.

Shin, Y.-J., Shannon, L.J., Bundy, A., Coll, M., Aydin, K., Bez, N., Blanchard, J.L., Borges, M.F., Diallo, I., Diaz, E., Heymans, J.J., Hill, L., Johannesen, E., Jouffre, D., Kifani, S., Labrosse, P., Link, J.S., Mackinson, S., Masski, H., Möllmann, C., Neira, S., Ojaveer, H., Ould Mohammed Abdallahi, K., Perry, I., Thiao, D., Yemane, D., and Cury, P.M. 2010. **Using indicators for evaluating, comparing and communicating the ecological status of exploited marine ecosystems**. Part 2: Setting the scene. ICES Journal of Marine Science, 67: 692-716

Shin, Y.-J., Bundy, A., Shannon, L.J., Simier, M., Coll, M., Fulton, E.A., Link, J.S., Jouffre, D., Ojaveer, H., Mackinson, S., Heymans, J.J., and Raid, T. 2010. **Can simple be useful and reliable? Using ecological indicators to represent and compare the states of marine ecosystems**. ICES Journal of Marine Science, 67: 717-731.

Blanchard, J. L., Coll, M., Trenkel, V. M., Vergnon, R., Yemane, D., Jouffre, D., Link, J. S., et al. 2010. **Trend analysis of indicators: a comparison of recent changes in the status of marine ecosystems around the world**. ICES Journal of Marine Science, 67: 732–744.

Bundy, A., Shannon, L.J., Rochet, M.-J., Neira, S., Shin, Y.-J., Hill, L., and Aydin, K. 2010. **The Good(ish), the Bad and the Ugly: a tripartite classification of ecosystem trends.** ICES Journal of Marine Science, 67: 745-768.

Coll, M., Shannon, L. J., Yemane, D., Link, J. S., Ojaveer, H., Neira, S., Jouffre, D., et al. 2010. **Ranking the ecological relative status of exploited marine ecosystems**. ICES Journal of Marine Science, 67: 769–786.

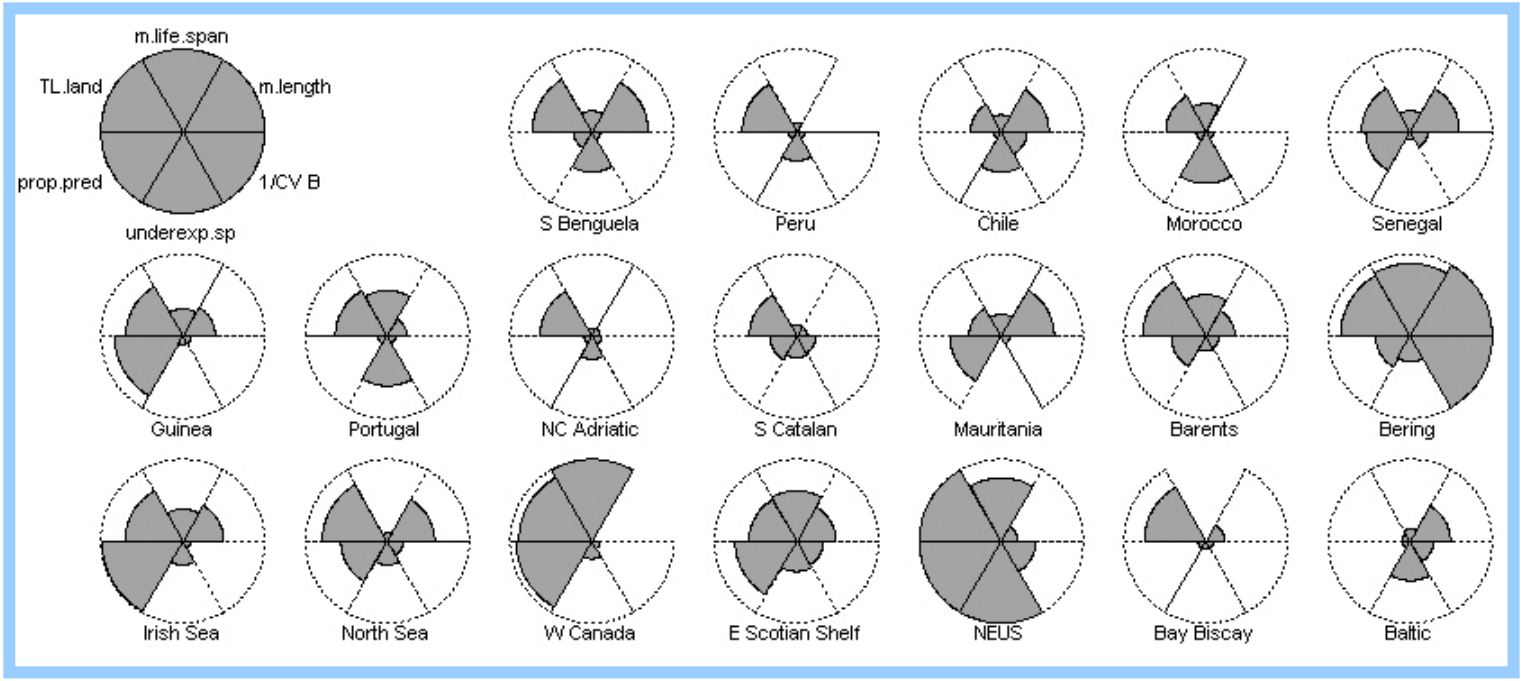
Link, J. S., Yemane, D., Shannon, L. J., Coll, M., Shin, Y-J., Hill, L., and Borges, M. F. 2010. **Relating marine ecosystem indicators to fishing and environmental drivers: an elucidation of contrasting responses.** ICES Journal of Marine Science, 67: 787–795.

Jouffre, D., Borges ,M.F., Bundy, A., Coll, M., Diallo, I., Fulton, E.A., Guitton, J., Labrosse, P., Abdellahi, K.o.M;, Masumbuko, B., Thiao, D. 2010. **Estimating EAF indicators from scientific trawl surveys: theoretical and practical concerns.** ICES Journal of Marine Science, 67: 796-806.

Scientific Indicator (Common name)	States	Trends	Data source
Mean length of the community **(Fish size)**	X	X	Mean length distribution of the fish caught in research surveys
Trophic level of the landings **(TL of the catch)**	X	X	Reported catches (landings) i.e. retained species
Proportion of predatory fish in the community **(Proportion of table fish)**	X	X	Surveyed species, weighted by biomass estimated per species in research surveys
Mean life span **(Mean life span)**	X	X	Fixed life span assumed per species, annual biomass estimated for surveyed species
Proportion of underexploited species **(Proportion of underexploited species)**	X		FAO database and local stock assessment reports; includes only those retained species included in the FAO database
1/coefficient of variability of total biomass **(Stability of biomass)**	X		Biomass indices from research surveys over the last ten years
Total biomass index **(Fish biomass)**		X	Combined biomass index for surveyed species
1/Proportion of biomass exploited [biomass/catch] **(Inverse fishing pressure)**		X	Biomass of surveyed species; catch data; estimated for retained species

8 Indicators were selected, using specific criteria, for comparison across the 19 ecosystems: 6 were used to described the state of the ecosystems, and 6 to describe trends in the ecosystems.

Can simple be useful and reliable? Using ecological indicators to represent and compare the states of marine ecosystems (Shin et al. 2010)



QUESTION: Is it acceptable to directly compare ecosystems of different types by simply using a common set of indicators?

OBJECTIVE: Checking whether reference levels for these indicators are similar across ecosystems = min requirement for a comparative analysis

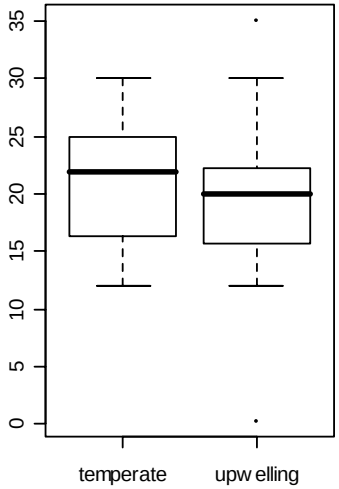
METHOD: Defining reference levels (ecosystem overexploitation) by means of an expert survey of scientists

RESULTS

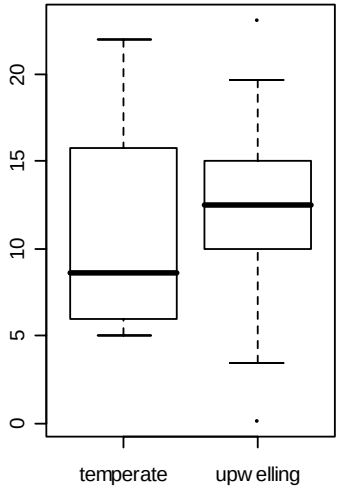
36 questionnaires filled for upwelling (17), temperate (17), high latitude (2) ecosystems

→ Comparison of the Ref Levels (RL) for upwelling and temperate ecosystems

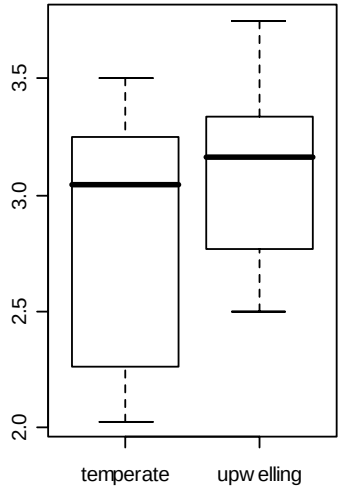
Mean length



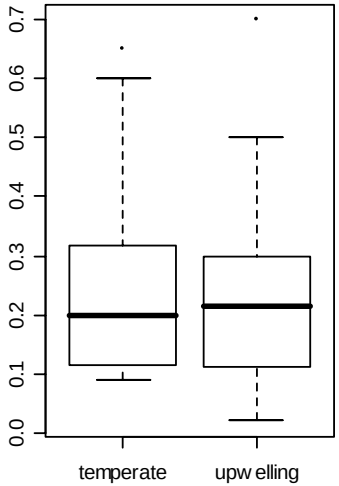
Mean life span



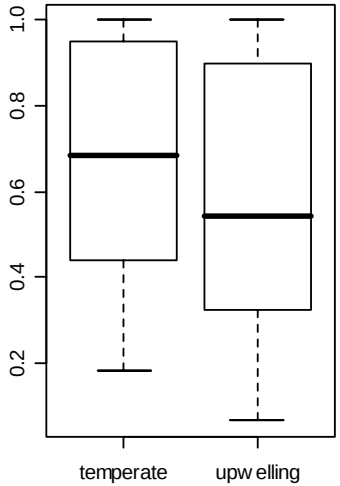
TL landings



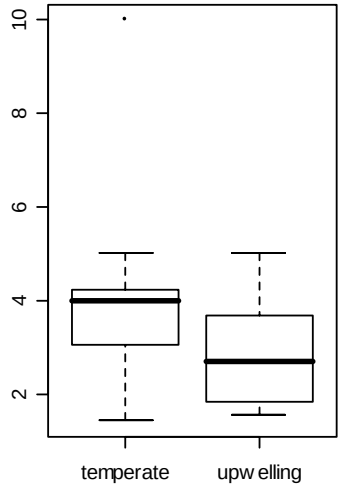
Proportion predators



Prop. under mod. expl. stocks



1/CV biomass

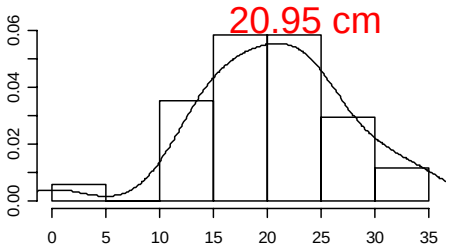


<u>Kolmogorov-Smirnov test:</u>

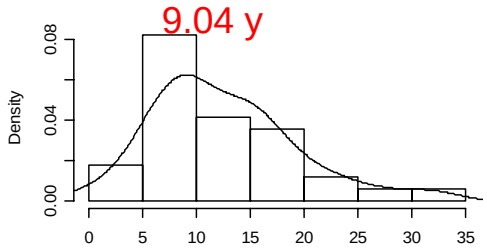
No significant differences detected between upwelling and temperate ecosystems at 5% risk level

→ It suggests that the 6 indicators can potentially be used for direct comparison of the status of exploited marine ecosystems in upwelling and temperate waters.

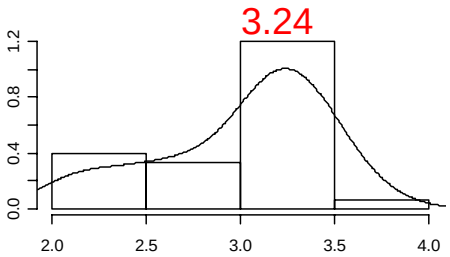
Distribution of the Ref Levels (RL) produced by the expert survey



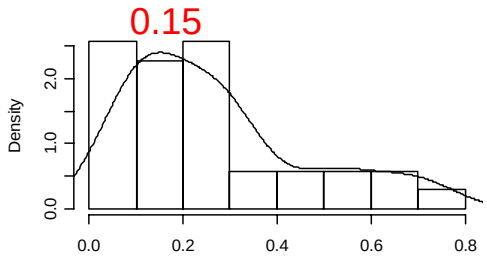
RL mean length



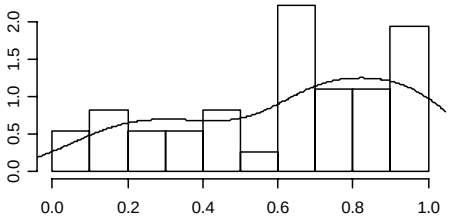
RL mean life span



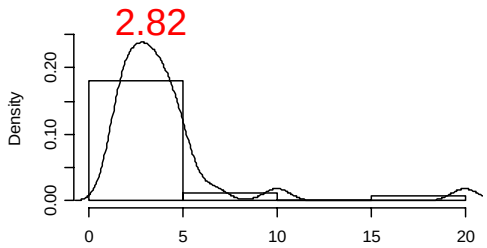
RL TL landings



RL proportion predators



RL prop under-mod expl species



RL 1/CV Biomass

→Flat distribution indicates no consensus reached among experts (prop of under to moderately explpoited species)

→ Unimodal distributions obtained for the other 5 indicators

→ For 7 ecosystems (37% of the 19 ecosystems in IndiSeas), at least half the indicator values were below these expert RL modes:

Bay Biscay, Sahara Coastal, Humboldt N, Adriatic NC, Catalan S, Portuguese EEZ, Baltic Sea

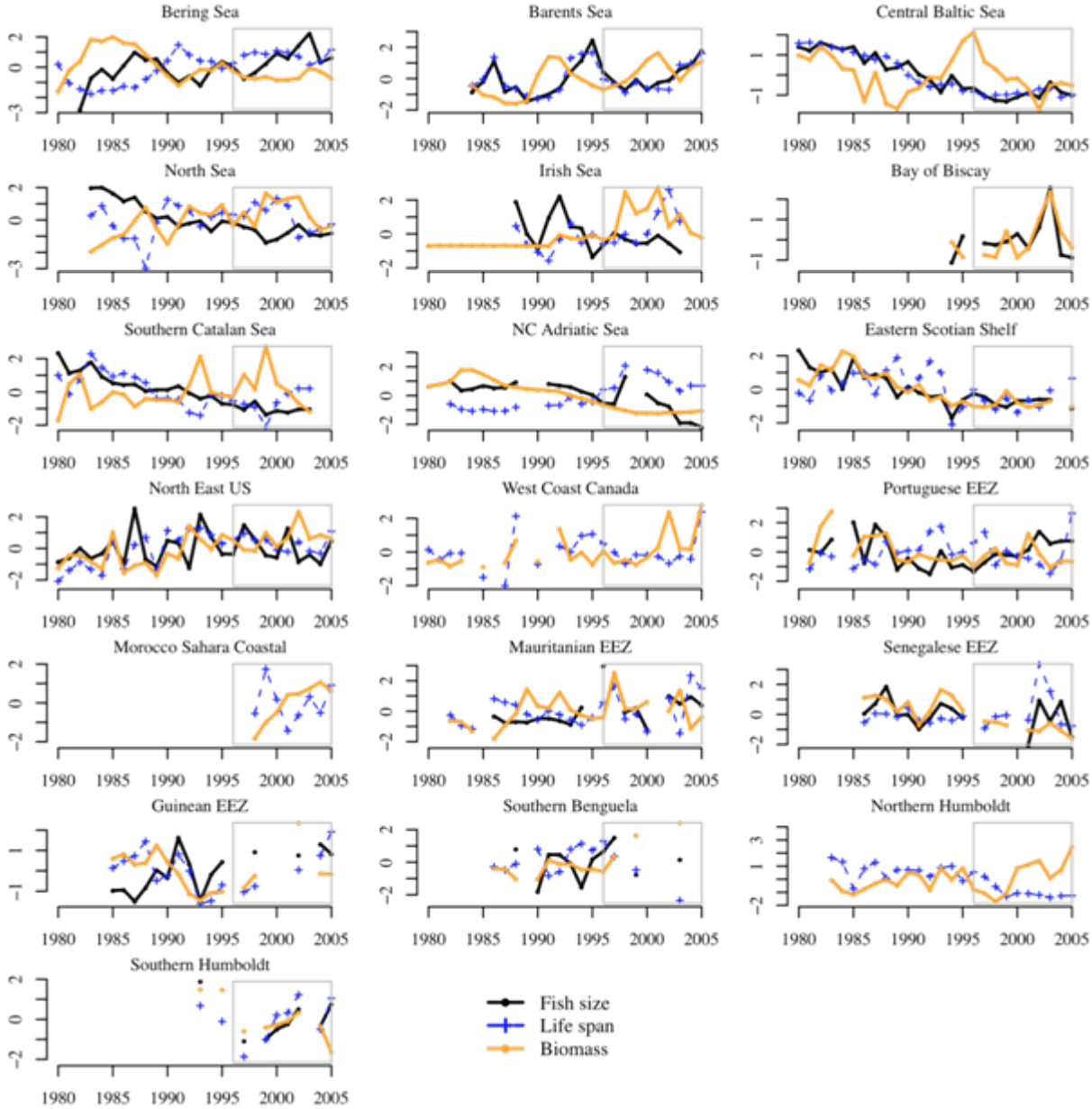
Trend analysis of indicators: a comparison of recent changes in the status of marine ecosystems around the world

Blanchard JL, Coll M, Trenkel VM, Vergnon R, Yemane D, Jouffre D, Link JS & Shin YJ.

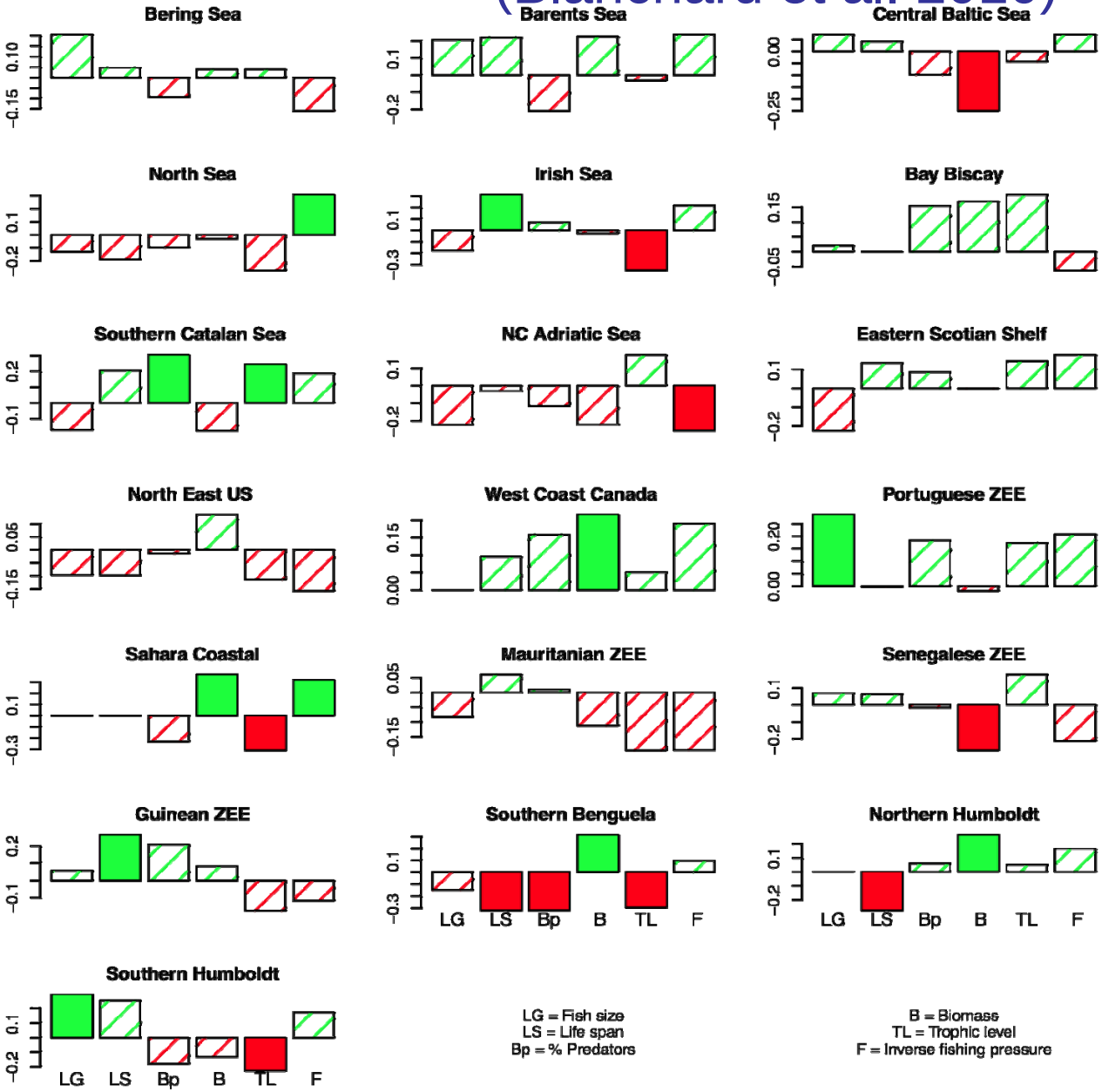
ICES J Mar Sci 2010

Objectives:

- explore the recent changes of ecosystem indicators using both linear and non-linear statistical methods for quantifying trends
- compare and contrast trends in indicators across ecosystems
- address the redundancies and/or complementarities of indicators by looking at similarities in their temporal dynamics.



Recent linear trends in ecosystem indicators around the world (Blanchard et al. 2010)



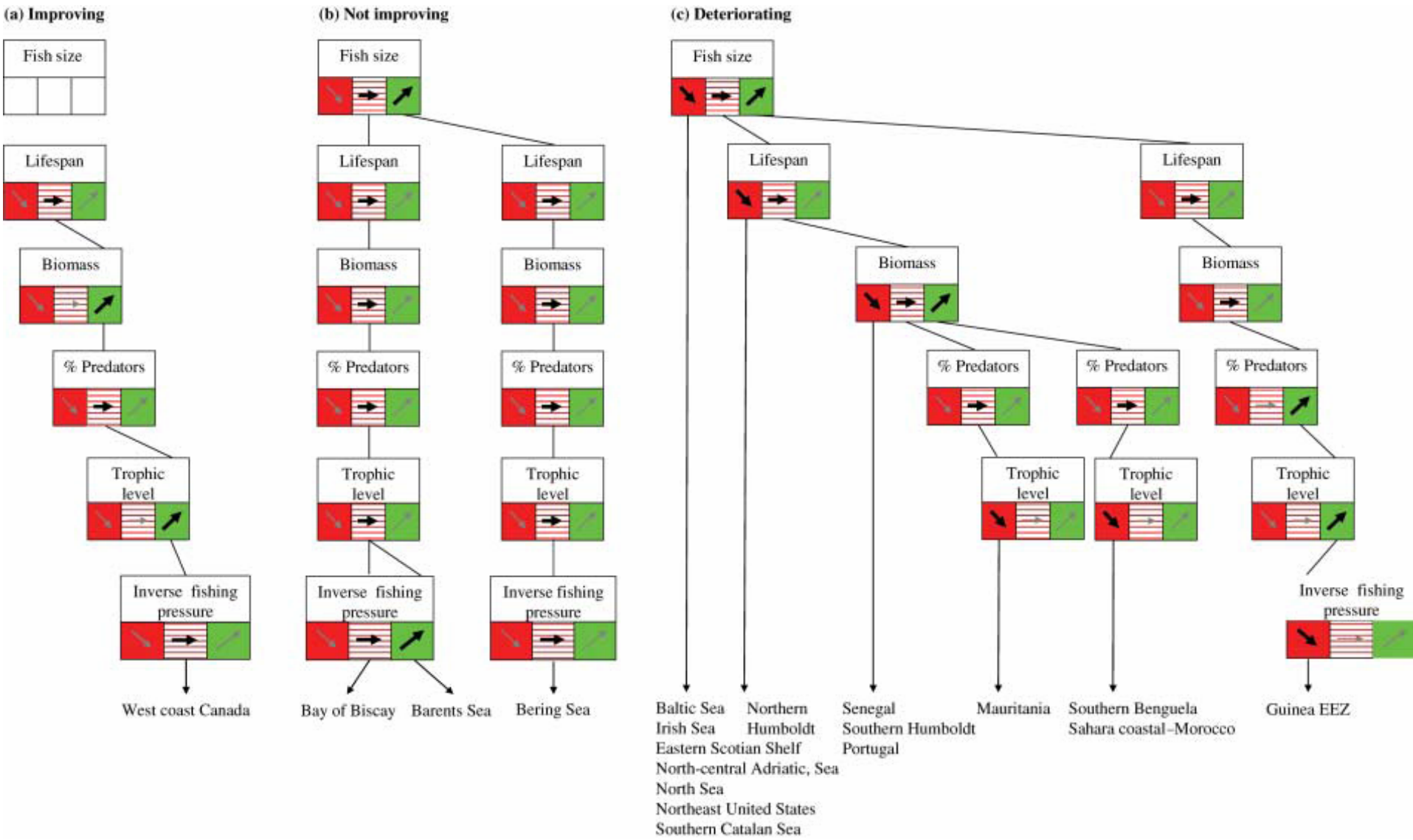
1996-2005

Left to right:

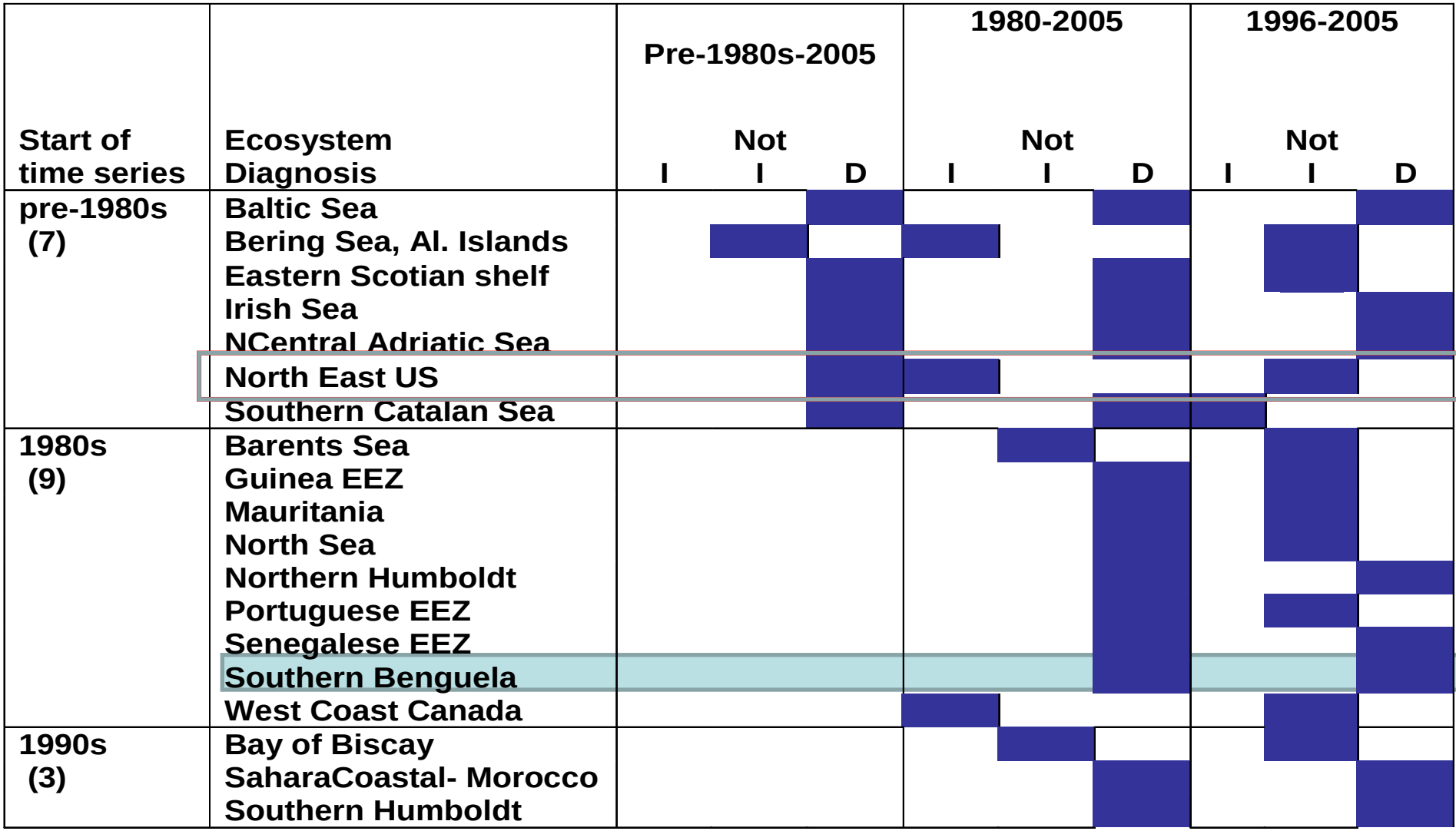
- mean size
- mean life span
- % predators
- total biomass
- mean trophic level of catch
- 1/exploitation index

No general pattern across ecosystems or indicators

The Good(ish), the Bad and the Ugly: a tripartite classification of ecosystem trends (Bundy et al. 2010)



Indicator trends over time (Bundy et al. 2010)



Ranking the ecological relative status of exploited marine ecosystems

Marta Coll, Lynne J. Shannon, Dawit Yemane, Jason S. Link, Henn Ojaveer, Sergio Neira, Didier Jouffre, Pierre Labrosse, Johanna J. Heymans, Elizabeth A. Fulton, and Yunne-Jai Shin

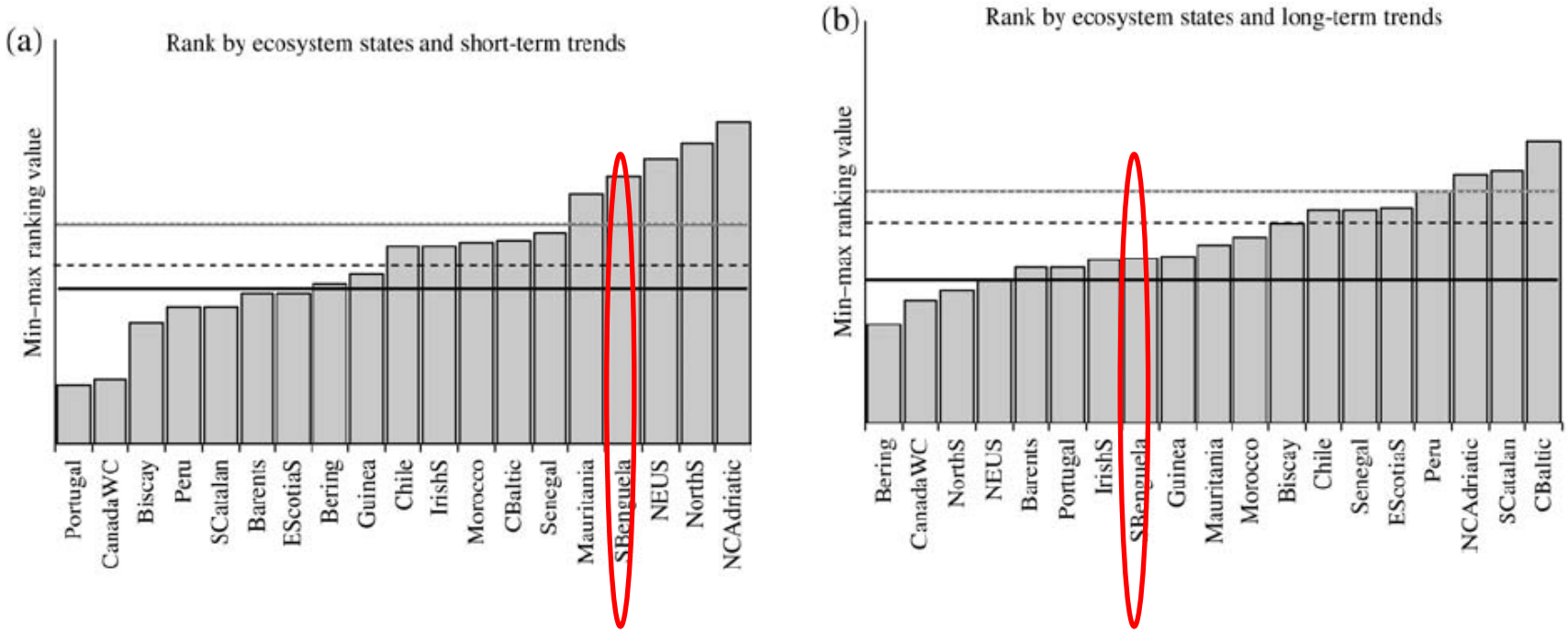
- A set of simple, data-based ecological indicators was used to rank exploited **ecosystems** regarding fishing impacts with respect to their **status (most recent three years), trends (short and long term), and ecosystem EAF attributes;**

- Expected theoretical changes in indicators with respect to increasing fishing impacts were considered;

- Systems were classified into nine potential categories according to whether they were **most, moderately, or least impacted**, and whether they were **becoming more or less impacted, or remaining stationary;**

- The responses of ecological indicators to **additional environmental and socio-economic explanatory factors** were tested.

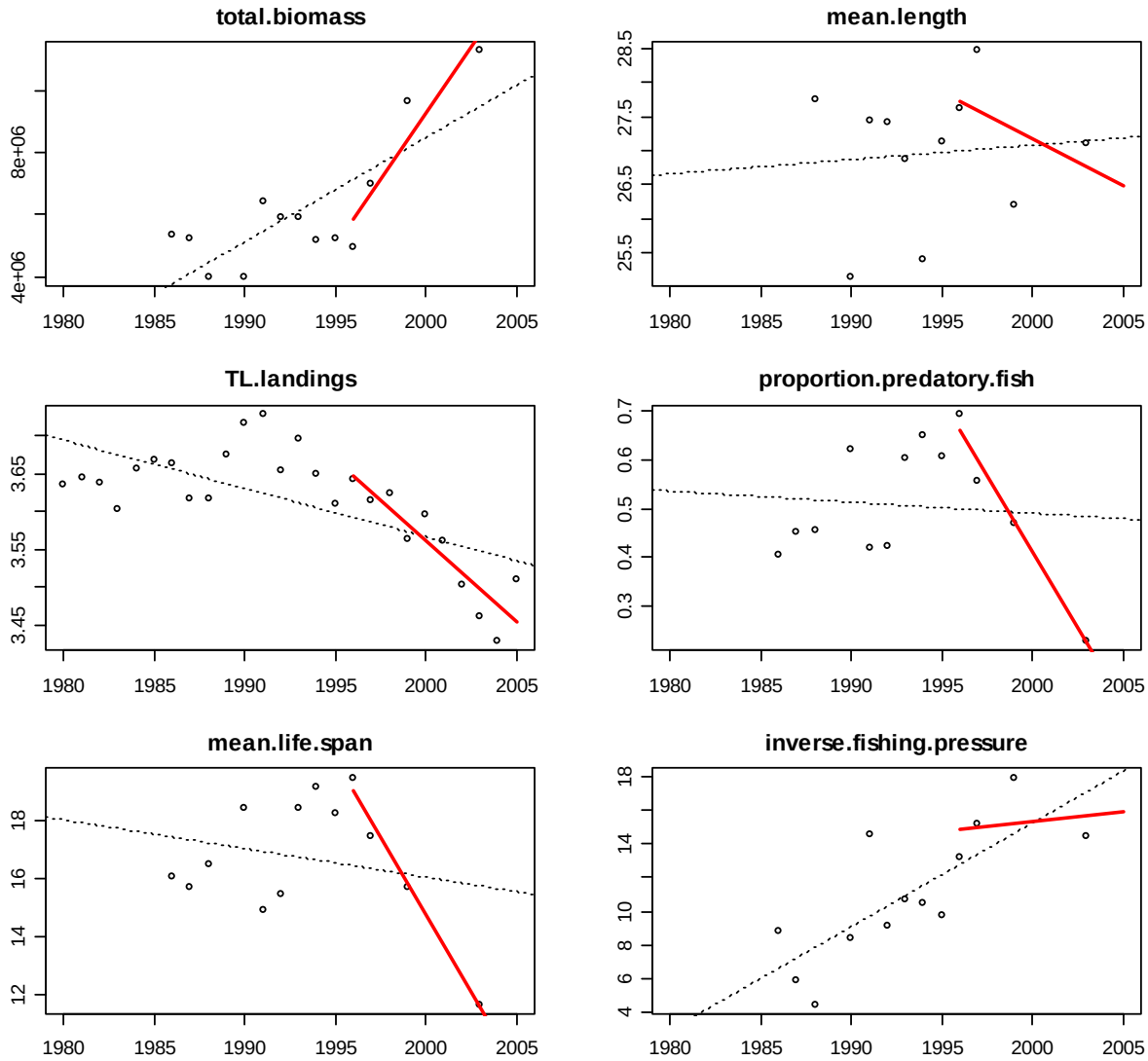
Ranking of ecosystems using short- and long-term trends and states differed because of differences in trends: it is important to analyse both states and trends in ecosystem analyses (Coll et al. 2010)

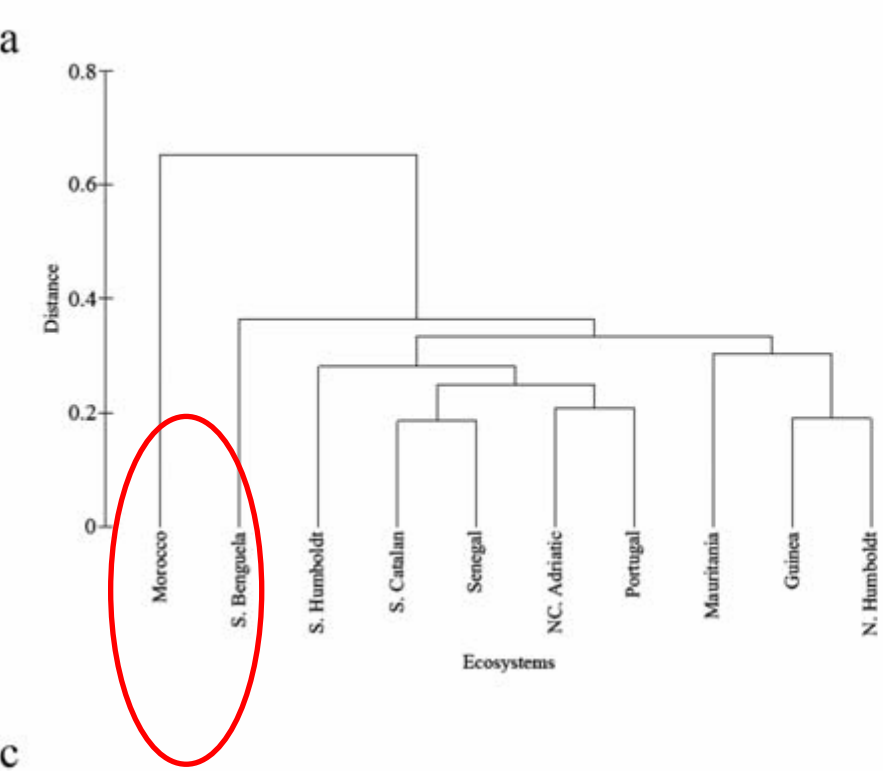


The number of ecosystems classified as "unclear or intermediately impacted" increased recently, the proportion of ecosystems classified as "less strongly impacted" was maintained, but more cases fall within the category "more strongly impacted" in terms of long-term trends and states

Indicator trends over time:

S Benguela




a
0.8
0.6
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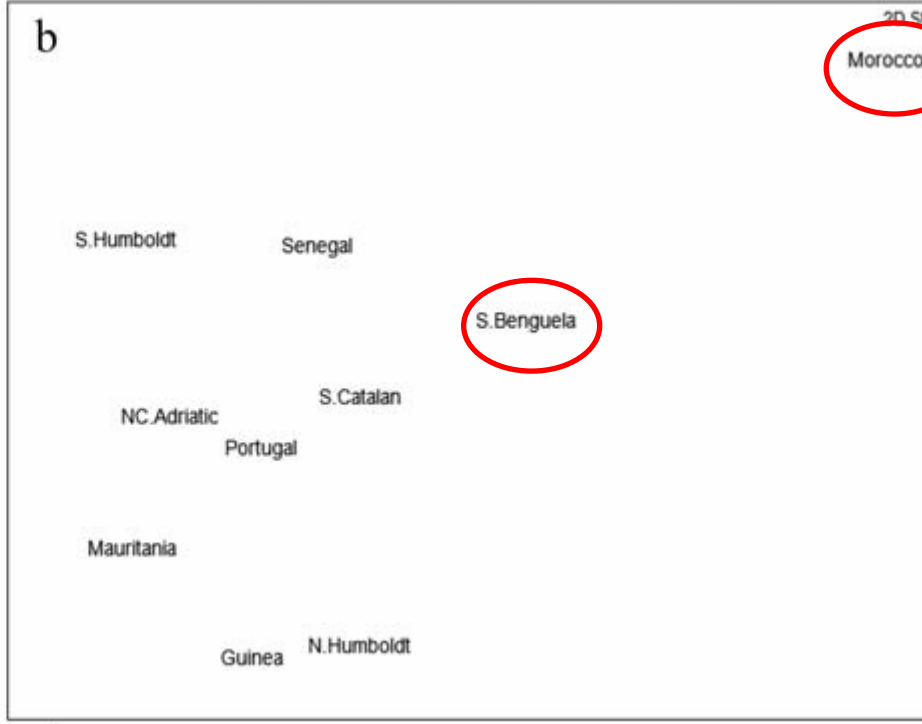
Distance
Morocco
S. Benguela
S. Humboldt
S. Catalan
Senegal
NC. Adriatic
Portugal
Mauritania
Guinea
N. Humboldt
Ecosystems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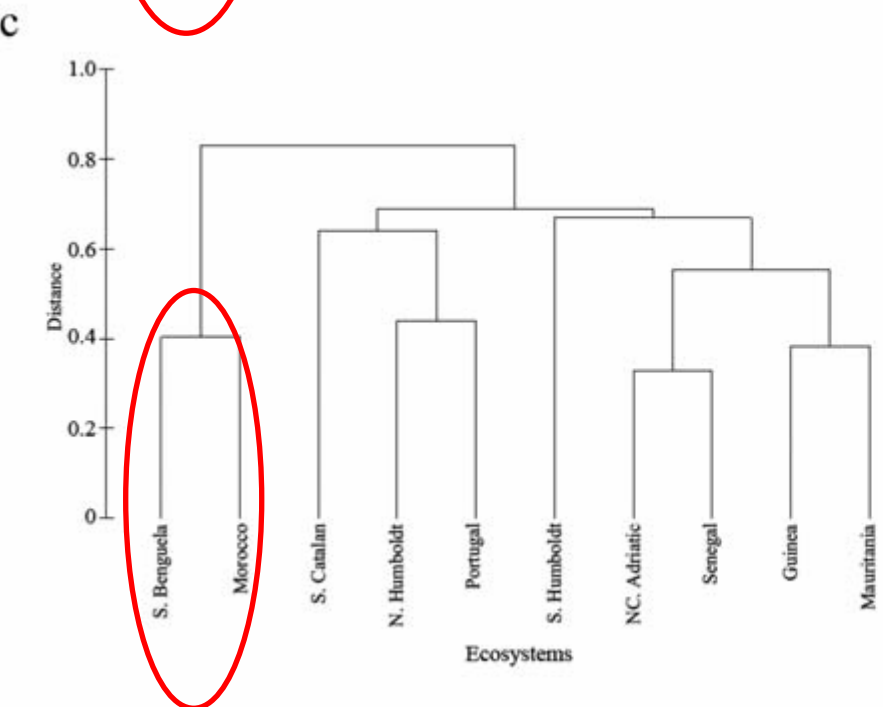
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Portugal
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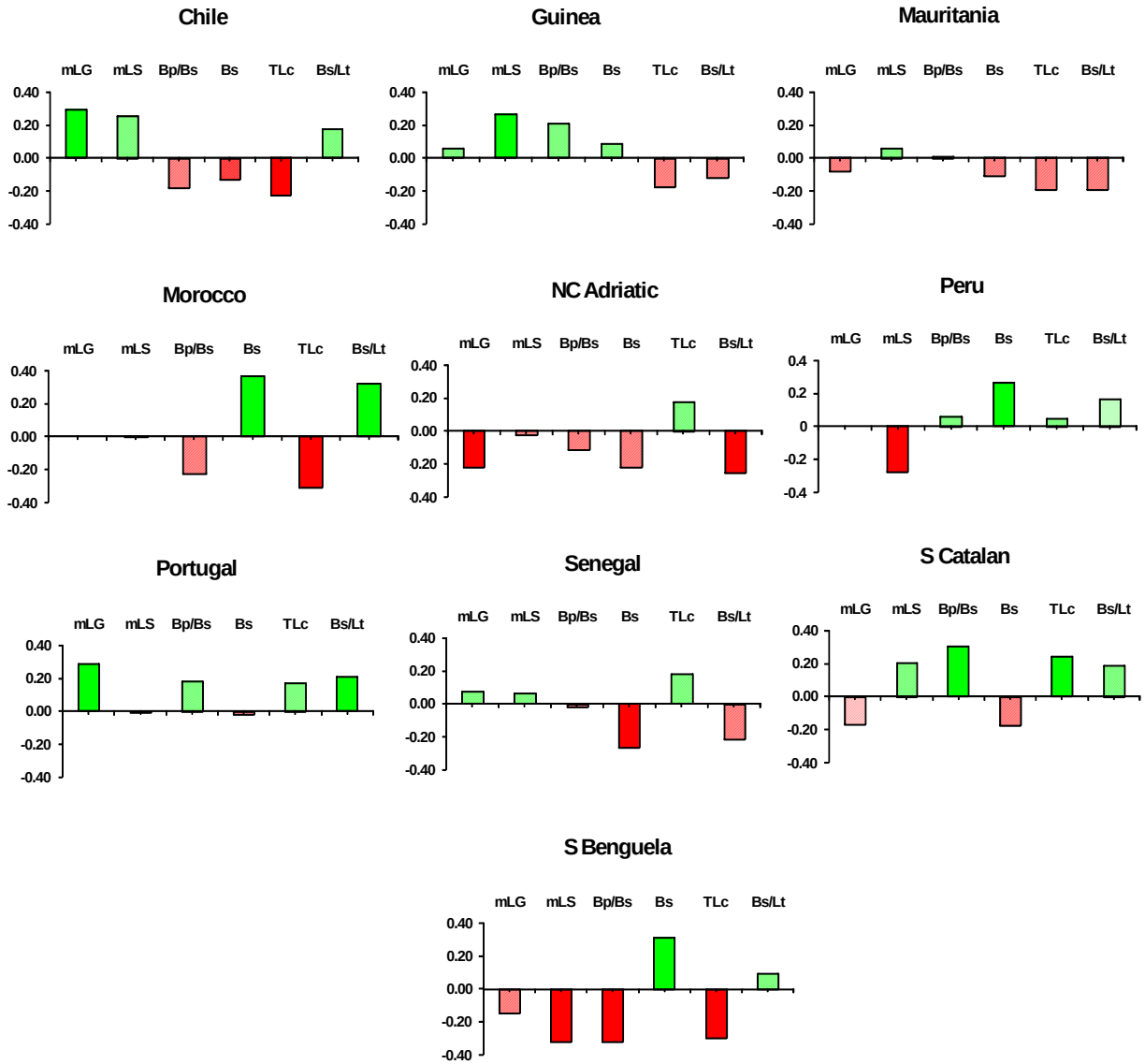
NC. Adriatic
Senegal
Guinea
Mauritania
Ecosystems


d
S.Benguela
NC.Adriatic
N.Humboldt
Mauritania
Senegal
Morocco
Guinea
S.Humboldt
Portugal

Slopes of linear trends fitted for 1996-2005



A closer look at the southern Benguela

- mean life span, trophic level of landings & % predatory fish in the fish community declined from 1980–2005
- mean length of fish in demersal trawl surveys, fish biomass and inverse fishing pressure (biomass/landings) increased over this period
- mean fish size of the demersal community declined 1996-2005
- From indicator trends (1980-2005), S. Benguela classified as ‘‘not improving” or ‘‘deteriorating”,
- Coll et al. (2010) ranked the 19 ecosystems, classifying the Southern Benguela as being in an unclear (1980–2005) or undesirable (1996–2005) ecosystem state.
- S Benguela consistently ranked amongst the most heavily impacted ecosystems, at least partly due to temporary upsurge of low trophic level, small pelagic fish in the early 2000s (not directly related to fishing intensity but the situation warrants careful monitoring)

Ecosystem Diagnoses

- Consistent patterns observed across ecosystems, methods and indicators (state or trend):
  - 10 ecosystems identified as in a deteriorating/impacted state
  - 4 ecosystems identified as in less impacted/improving/non-deteriorating state
  - 5 ecosystems with mixed results due to difference in methodologies
- All showed some form of prominence of primarily human and most showed some form of secondarily environmental driver

Ecosystem type, fisheries enforcement, primary production, sea temperature, and fishing type were important variables explaining the ecological indicators (Coll et al. 2010)

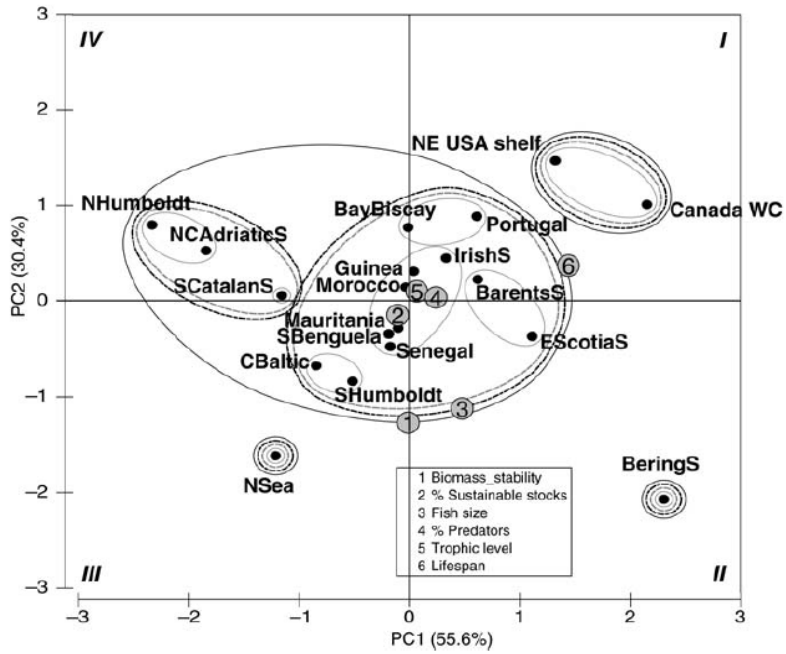
Correlations with BIO-ENV:

State ecological indicators & abiotic data
r = 0.285, p = 0.048 (fisheries type & enforcement)

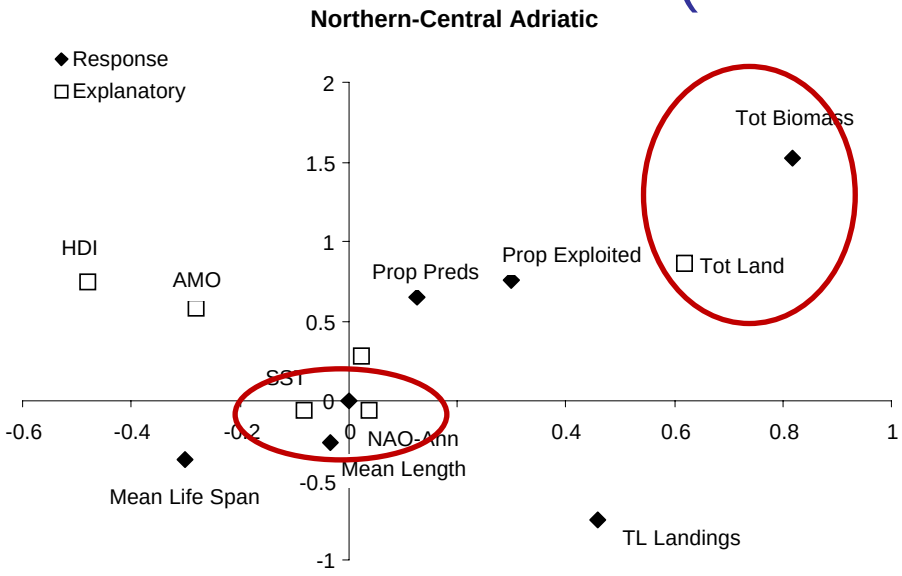
Short-term trend ecological indicators & abiotic factors
r = 0.448, p = 0.01 (ecosystem type, fisheries type, & landed catches)

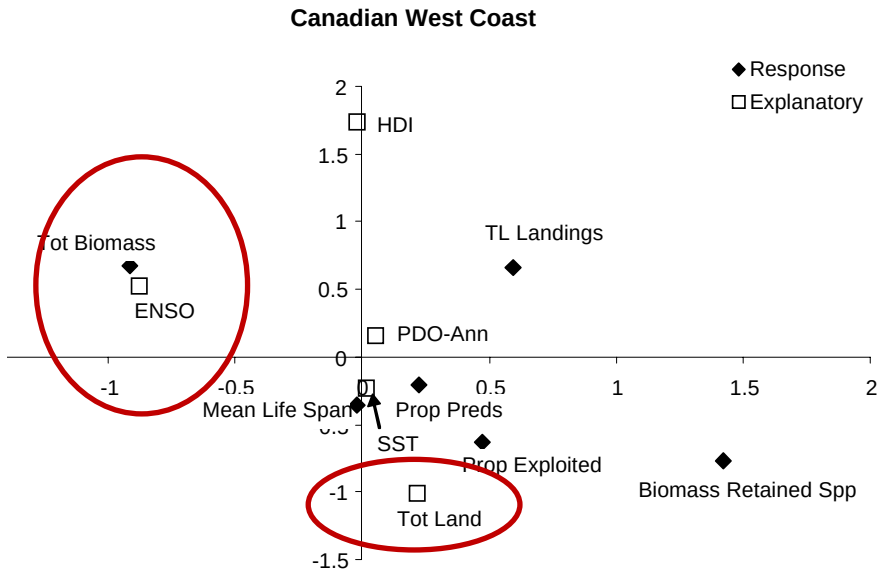
Long-term trend ecological indicators & abiotic indicators
r = 0.376, p = 0.01 (ecosystem type, fisheries type, & landed catches)

The results reflect different changes and processes in the ecosystems, demonstrating that information on ecological, environmental, and fishery histories is crucial to interpreting indicators correctly, while disentangling the effects of fishing and of the environment.



Relating marine ecosystem indicators to fishing and environmental drivers: an elucidation of contrasting responses (Link et al. 2010)





Multiple, MV analyses to partition explanable variance of responses into those factors driven by humans and the environment

Results showed that either fishing (Landings) or human populations (HDI) were the primary driver
Some form of environmental driver was secondarily important in most ecosystems, except those largely driven by environmental processes

Conclusions

- Multiple indicators required to avoid spurious conclusions based upon inherent ecosystem dynamics and complexities
- Multiple analyses similarly useful to confirm results
- A comparative approach provides a robust framework with which to evaluate the effects of fishing and other drivers
- Across a wide range of ecosystems, fishing is a prominent driver and environmental drivers can also be important, depending on local conditions.

IndiSeas 2

GOAL: evaluate the status of the world's exploited marine ecosystems subject to multiple drivers in a changing world.

- further develop and expand the suite of ecosystem indicators,
- expand the number and range of ecosystems included in the analysis
- add climate/environmental, biodiversity/ conservation and socio-economic indicators
- develop reference points for the suite of indicators
- test indicator responsiveness and performance

Acknowledgements

Thank you!