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Scale effects on food-web indicators – impacts at Biogeographic Region level

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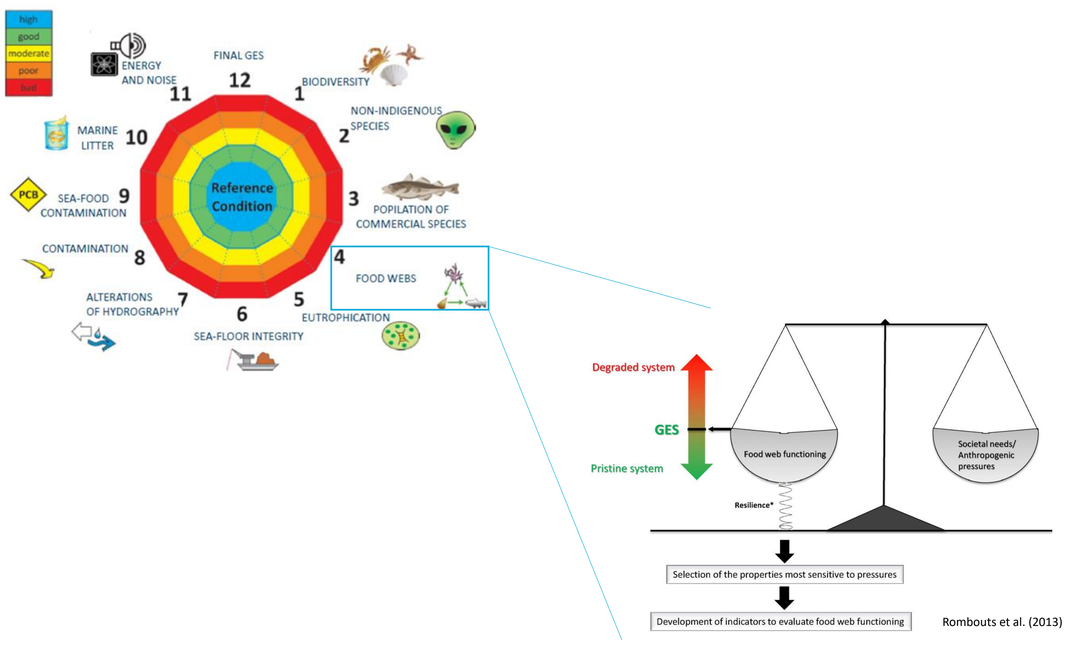
Introduction



Rombouts et al. (2013)

D4 implementation pointed out several issues such as problematic metrics, scarcity of operational indicators, use of dissimilar methodologies and lack of data. Indicators should link pressure to ecosystem state at the appropriate spatial and temporal resolution. However, the environment is exposed to multiple pressures, such as natural and anthropogenic variability, that also vary in temporal and spatial resolution, therefore optimization is required. This work tested spatial and temporal scales used to implement Food-web indicators in the Celtic Seas and the Bay of Biscay and Iberian Coast.

What scales significantly explain Food-web indicators?

We hypothesized that scales can affect the detection of pressures on the environment and GES assessment, having implications in management. Results contribute to the definition of parameters and optimization of D4 in the MSFD, increasing its coherence and promoting advancements.

Methods

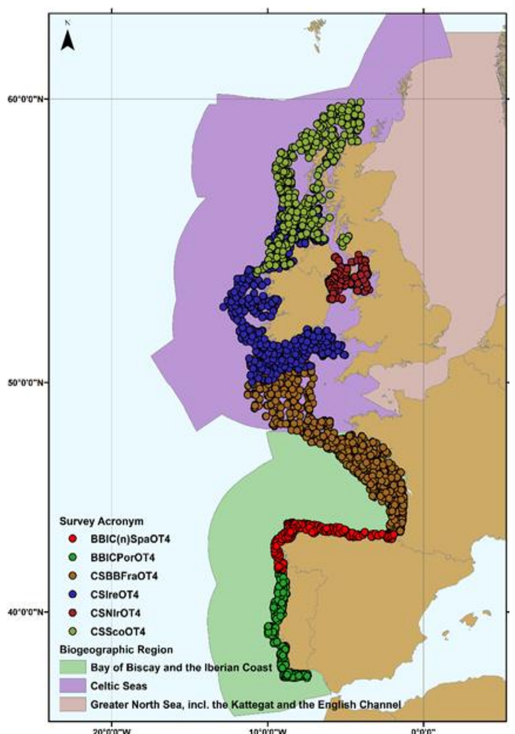


Figure 1 - Biogeographic Regions under study in North East Atlantic Ocean; areas covered by each survey used in the North East Atlantic (Shapefiles source: (OSPAR, 2017)).

MSFD Food-web indicators were assessed, using Groundfish Survey Monitoring and Assessment Data Products. Data products based on Database of Trawl Surveys (DATRAS) and maintained by International Council for Exploration of the Seas (ICES).

D4 - Food-web includes criteria such as

D4C1 Trophic guild species diversity and
D4C2 Abundance across trophic guild, and secondary:
D4C3 Trophic guild size distribution and
D4C4 Trophic guild productivity (European Commission, 2017).

Descriptor 4 commonly used Indicators

- Mean Trophic Level (MTL)
- Mean Trophic Index (MTI) TL<3.25
- Mean Trophic Index (MTI) TL>4
- Large Fish Indicator (LFI)
- Mean abundance (MATG)

Spatial scales	Temporal scales
100 km2 Squares (n=862)	Year (n=10)
1000 km^2 Squares (n=604)	
ICES Rectangles (n=172)	2 Years (n=5)
Sector and Strata (n=91)	
Sector (Country level demarcations) (n=41)	3 Years (n=3)
Strata (Depth) (n=4)	
Marine Sub-units (MSU) (n=6)	
Biogeographic Region (BR) (n=2)	5 Years (n=2)

- Food web indicators analysed using Generalized Linear Models (GLMs) - gamma distribution with a log-link function.
- Goodness of fit was assessed for each scale and the explanatory deviance was compared.
- LFI performance was assessed using latitude as a covariate, since LLF´s is a consequence of environmental.
- *p-values* were based on a Chi-squared test and were used to evaluate:
  (1) the significance of scale in comparison with the null model and
  (2) the contribution for explaining deviance.
- Each scale was nested within its corresponding biogeographic unit.

Results

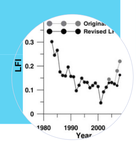
Spatial scales ranged from 0.03% to 26.04% of deviance explained, and were more important than temporal scales, that ranged from 0.03% to 5.35% of deviance explained. MTI (TL>4) and LFI were largely affected by scales, while MATG was less. MTL, MTI (TL>3.25) were not significantly explained by scales.

MTI – TL>4

- ***Spatial scales:*** MSU, Strata, Sector, Sector/Strata and ICES Squares nested within BR ($p<0.05$).
- Sector/Strata's and ICES Squares explained 17.06 and 15.41% of deviance.
- CS units (2.13) were significantly higher than BBIC (1.94).
- ICES rectangles: BBIC MSUs exhibited differences between several units. In the CS, only one deep-sea unit was significantly higher.
- Although ICES rectangles consisted in significantly relevant spatial scale, Sector/Strata explained higher deviance.
- ***Temporal scales:*** deviance explained increased by downsizing scales, but no significant differences were found, showing that temporal scales do not improve MTI (TL>4) prediction.

LFI

- ***Spatial scales:*** BR, MSU, Strata, Sector and Sector/Strata's nested in BRs, all in interaction with latitude
- Deviance explained ranged from 1.39% using BR as predictor to 26.04% using Sector/Strata, nested within BR.
- LFI was higher in the Celtic Seas than in BBIC (BBIC: 0.29; CS: 0.33).
- LFI was more variable in BBIC than in the CS.
- Reporting at Sector/Strata's scale level explained higher deviance values, with 26.04%.
- ***Temporal scales:*** Yearly scales, nested within BR: explained higher deviance results (5.35%).
- Similar patterns in the two regions: low LFI in 2002, increase in 2008, decrease in 2010 and subsequent increase in 2011 and 2013.



MATG

- MATG was less explained by scales, ranging between 0.03 and 0.34% of explained deviance (factor such as trophic guild explains 35.19%).
- ***Spatial scales:*** BR, MSU, Strata, Sector and Sector/Strata, nested within BR.
- Sector/Strata explained highest deviance values (0.34%).
- MATG for BBIC was significantly higher than CS (BBIC: 0.29; CS: 0.27).
- Strata explained less deviance than MSU - scales based on depth are poor predictors.
- ***Temporal scales***: 5 and 3-Years, nested within BR.
- Explained a low value of existing deviance (0.03%).

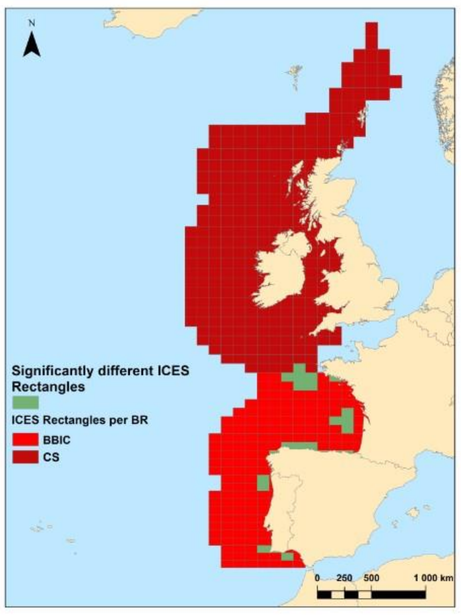


Figure 2– ICES rectangles assessment, showing significantly different MTI (TL>4) results in each Biogeographic Region (BBIC: Bay of Biscay and Iberian Coast and CS: Celtic Seas).

Discussion

- When established, thresholds are not considering Food- webs spatial and temporal natural variability within the Biogeographic Level, as required by the MSFD.
- Spatial scales have a wider effect when compared to temporal ones:
  - Temporal scales analysis can improve if seasonal datasets are added to current assessment.
  - Indicators may benefit from higher sampling effort; however, its improvement would largely benefit from an assessment that covers smaller size spatial scales.
- MTL and MTI (TL>3.25) models require the addition of more factors to disclose scale effects.
- MTI (TL>4) and LFI are largely explained by spatial scales; ICES rectangles for MTI (TL>4) and Sector/ Strata for LFI
- MATG is marginally explained by scales and scales differ among BR: Sector/ Strata in BBIC and Sector CS.
- Celtic Seas present consistently less variance than Bay of Biscay.
- To properly manage the marine environment, monitoring programs need to consider adequate spatial scales for each indicator, so that natural variability is assessed and can be clearly distinguished from anthropogenic effects.

References: Adams et al., 2017; Bergström et al., 2016; Bradter et al., 2013; Greenstreet et al., 2011 ; Moriarty et al., 2017, 2019; OSPAR, 2017; Östman et al., 2017; Rombouts et al., 2013; R Core Team, 2019; Shephard et al., 2011; Zuur et al., 2009
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