Ricardo Melo (rmelo@ciencias.ulisboa.pt)

Monitorização da zona costeira para a DQA

Revisitação crítica (II)

Seaweeds as indicators

- Seaweeds respond directly to the abiotic and biotic aquatic environment and thus might be proper indicators of change in the environment
  - thus, they were proposed as a quality element for classification of marine coastal areas
  - specific indices to assess the ecological status of macroalgal communities were developed
    - based on the taxonomic composition of the communities
    - assume that sensitivity to anthropogenic disturbances differs among species
    - a distinction between perennial and opportunistic species is adopted
    - changes in abundance of opportunistic versus perennial algae are interpreted as a deterioration of the environmental quality
      - caused by anthropogenic pressures?

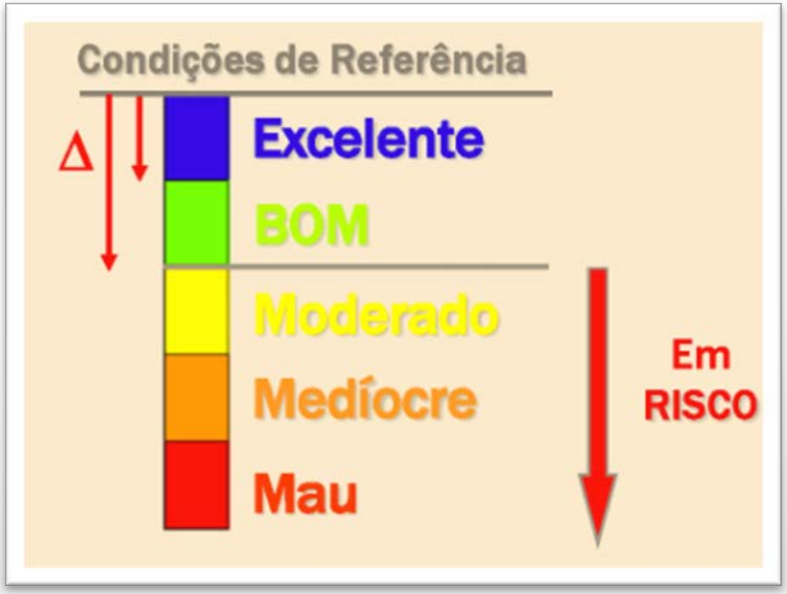
Mercado 2011

Apresentação em 19 julho 2010 – ARHs

DQA (1)

- Elementos de qualidade biológica (BQE)
  - Macroalgas
    - Comunidades intertidais maduras e perenes
    - Florescimentos em sistemas desequilibrados
    - Dependentes da existência de substrato duro
  - Angiospérmicas, plantas (vegetação)
    - Em Portugal, presentes apenas em Águas de Transição
    - Sapais (salgados)
    - Pradarias de ervas marinhas (sebas)

DQA (2)



Abreviaturas usadas:

- Directiva Quadro da Água – DQA
- Massa de água - WM
- Águas costeiras – CW
- Águas de transição – TW
- Lagoas costeiras – CW-L
- Elemento de qualidade biológica – BQE
- Estado de qualidade ecológica - EQS

Macroalgas – Águas Costeiras

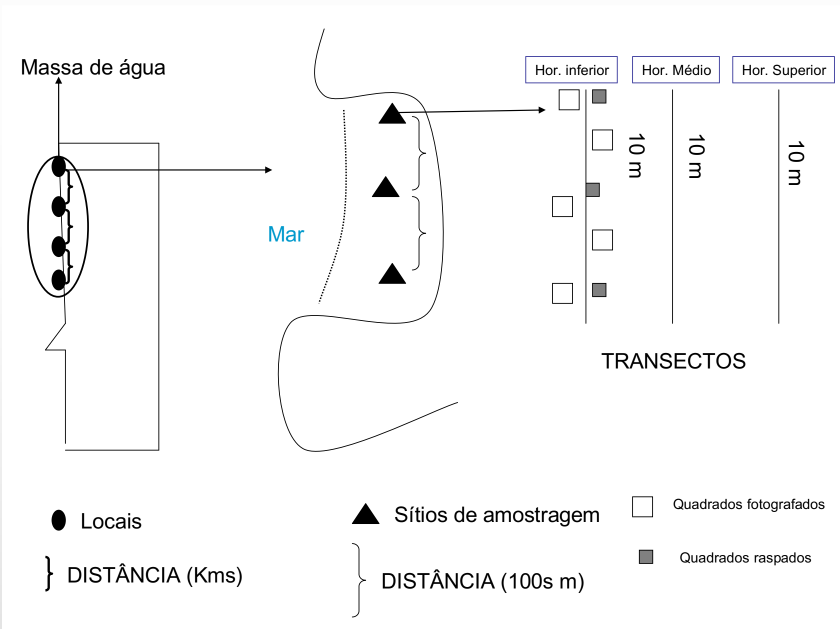
Comunidade intertidal, exposição elevada, Cabo Raso

Comunidade dominada por algas verdes ulvóides, Papoa, Peniche

DQA Macroalgas (CW)

- DQA estipula:
  - Composição taxonómica corresponde totalmente - ou quase - à condição não perturbada
  - Não há alterações detectáveis na abundância de macroalgas devidas a pressão antropogénica
  - EQS Elevado => todos os taxa sensíveis devem estar presentes
- Problemas:
  - Espécies sensíveis?
    - Quais são? Em que situações?
    - Tendem a ser menos abundantes => podem não estar presentes mesmo em condições pristinas
  - Variabilidade natural elevada da composição
    - Constância a nível de grupos funcionais dominantes

Desenho da amostragem



Monitorização Macroalgas CW

P-MarMAT – Valores de referência e limites

Riqueza **spp.**	Proporção **verdes**	Proporção **vermelhas**	Rácio ESG	Proporção oportunistas	Descrição da costa	Cobertura oportunistas
25	10	70	2.5	10	7	10

Table 2.3.9: Candidate metrics comprising the P-MarMAT, their boundaries, and conversion of sum of scores in EQR and EQS classes.

Quality	Bad	Poor	Moderate	Good	High
Species Richness (*)	0 - 5	5 - 8	9 - 16	17 - 24	> 24
Proportion of Greens	40 - 100	30 - 40	20 - 30	10 - 20	0 - 10
Proportion of Reds	0 - 30	30 - 45	45 - 55	55 - 70	70 - 100
ESG Ratio	0 - 1	1 - 1.5	1.5 - 2	2 - 2.5	> 2.5
Proportion of Opportunists	40 - 100	30 - 40	20 - 30	10 - 20	0 - 10
Shore Descriptions	-	15 - 18	12 - 14	8 - 11	1 - 7
Coverage of Opportunists (%) (*)	70 - 100	30 - 70	20 - 30	10 - 20	0 - 10
(*) factor of 2					
Sum of scores	0 - 7	8 - 14	15 - 21	22 - 28	29 - 36
EQR	0 - 0.2	0.2 - 0.4	0.4 - 0.6	0.6 - 0.8	0.8 - 1
EQS	Bad	Poor	Moderate	Good	High

WFD IC Tech. Report Part 3 Ago 2008-Draft, págs. 189, 193

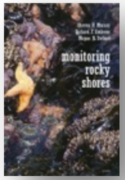
Programa(s) de monitorização

1

- Objetivos
  - Identificar a presença ou efeitos da atividade humana, existente ou potencial, num sistema biológico

- Requisitos comuns
  - Deve ser executado durante períodos longos
  - Deve ter em conta a variabilidade natural do sistema
  - Deve usar os melhores princípios, desenhos experimentais e conceitos ecológicos disponíveis
  - Deve recolher dados de maneira consistente e bem documentada (continuidade, confiabilidade)
  - Deve permitir a deteção das alterações e impactos com base estatística

Âmbito espacial e temporal



- Para poder lidar com a variabilidade natural dos sistemas intertidais complexos, uma abordagem regional é claramente um requisito!*
- Financiamento para estudos de âmbito alargado (espaço, tempo, comunidades) é difícil de manter
  - Devem cobrir a longevidade dos organismos dominantes e a duração dos ciclos dos fatores ambientais importantes
  - Escala temporal dos ciclos naturais em sistemas biológicos marinhos ~ 1 - várias dezenas de anos

Mas…

"The most formidable challenge for any successful field-monitoring program is to design an approach that can separate effects of human perturbations from those occurring naturally in the biological system."

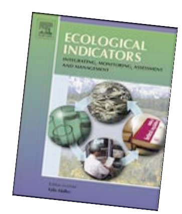
Murray et al. 2006

Evaluating ecological states of rocky intertidal communities (1)

- "…analyses based on biological data can be difficult to interpret, particularly when the effects of multiple potential stressors need to be considered in a setting of large natural biological variation."

- "…coastal managers rarely have access to temporal data sets with the history neededto evaluate community state in the context of natural community dynamics."

Murray et al. 2016

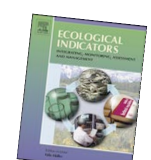


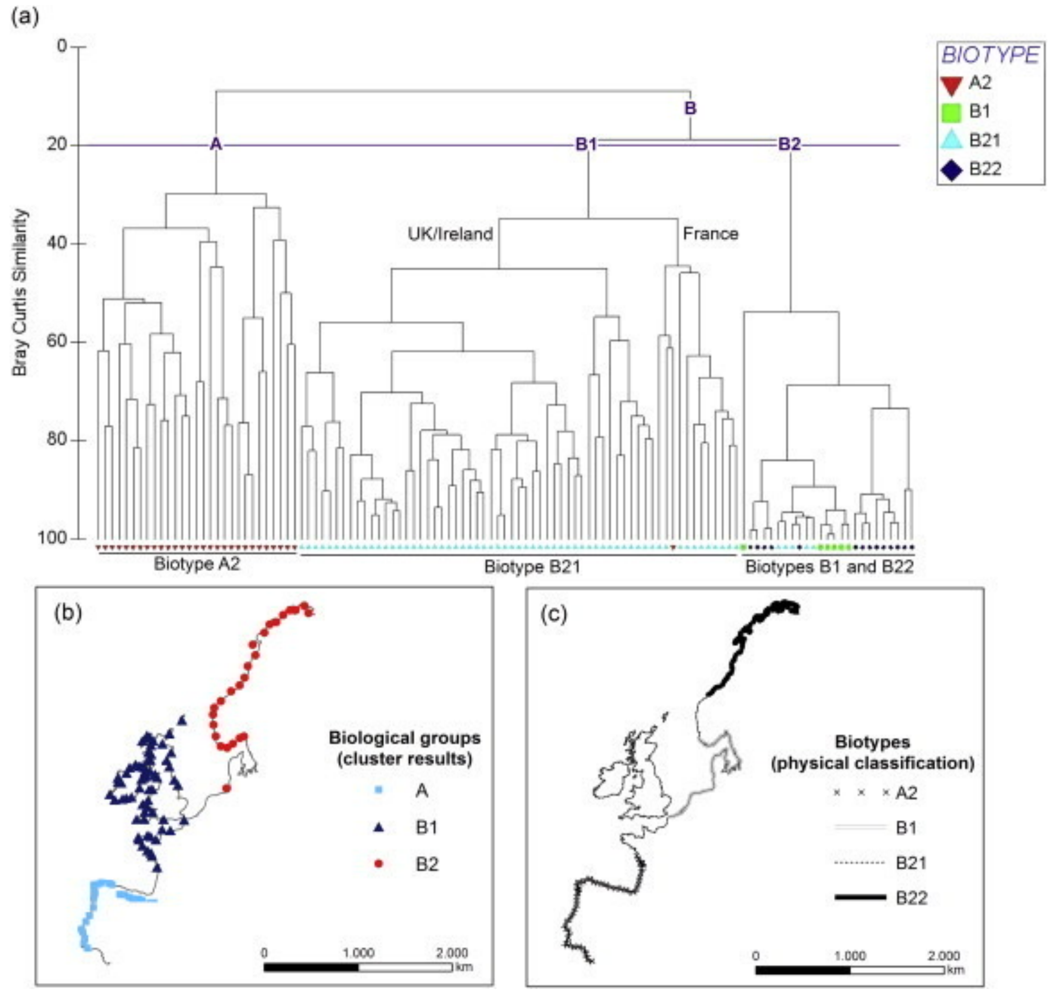
Evaluating ecological states of rocky intertidal communities (2)

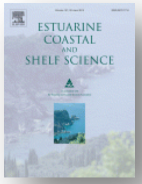
- “Biotic indices that translate complex ecological data into simpler metrics are sometimes used as communication tools for representing community states.”

- However, for rocky coastal environments, these efforts remain on-going and a consensus has yet to be achieved on which rocky intertidal population and community responses serve to consistently differentiate natural from anthropogenic stress across different types ofshores and geographic regions, an important property of a widely useful index”

Murray et al. 2016







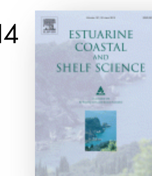
Ramos et al. 2014

Biologia vs. oceanografia no Atlântico NE

A latitudinal gradient in the distribution of macroalgae species was found. One northern and one southern group, separated at Brittany, were distinguished. The ecological meaning of the physical classification was demonstrated.

Biotypes			
A2	B1	B21	B22
Corall. – crust 8.44	*Ascophyllum nodosum* 1.78	*Fucus serratus* 4.49	*Alaria esculenta* 2.03
Corallina/Ellisolandia 8.43	*Ceramium* spp. 1.78	*Ulva* spp. 4.49	*Ascophyllum nodosum* 2.03
Ulva spp. 7.96%	*Chondrus crispus* 1.78	*Chondrus crispus* 4.40	*Chordaria flagelliformis* 2.03
Caulacanthus ustulatus 6.81	*Cladophora* spp. 1.78	*Corall. – crusts* 4.35	*Corall. – crusts* 2.03
Ceramium spp. 6.28	*Corallina/Ellisolandia* 1.78	*Mastocarpus stellatus* 4.24	*Fucus serratus* 2.03
Halopteris scoparia 4.84	*Corall. – crusts* 1.78	*Cladophora* spp 4.06.	*Fucus vesiculosus* 2.03
Bifurcaria bifurcata 4.32	*Delesseria sanguinea* 1.78	*Ceramium* spp. 4.06	*Laminaria digitata* 2.03
Osmundea pinnatifida 4.08	*Dumontia contorta* 1.78	*Fucus vesiculosus* 3.80	*Laminaria hyperborea* 2.03
Dictyota dichotoma 3.98	*Fucus serratus* 1.78	*Fucus spiralis* 3.77	*Palmaria palmata* 2.03
Chondracanthus acicularis 3.92	*Fucus spiralis* 1.78	*Corallina/Ellisolandia* 3.65%	*Pelvetia canaliculata* 2.03
Asparagopsis armata 3.04	*Fucus vesiculosus* 1.78	*Laminaria digitata* 3.39	*Phycodrys rubens* 2.03
Chondrus crispus 2.79	*Hildenbrandia rubra* 1.78	*Palmaria palmata* 3.05	*Polysiphonia* spp. 2.03
Gelidium spinosum 2.49	*Monostroma grevillei* 1.78	*Pelvetia canaliculata* 3.04	*Porphyra* spp. 2.03
Plocamium cartilagineum 2.29	*Porphyra linearis* 1.78	*Ectocarpus* spp. 3.03	*Scytosiphon lomentaria* 2.03
Chondria coerulescens 2.07	*Porphyra purpurea* 1.78	*Ascophyllum nodosum* 2.84	*Saccharina latissima* 1.90
Leathesia spp. 2.06	*Porphyra* spp. 1.78	*Osmundea pinnatifida* 2.64	*Desmarestia aculeata* 1.88
Colpomenia spp. 1.75	*Porphyra umbilicalis* 1.78	*Lomentaria articulata* 2.45	*Chorda filum* 1.88
	Prasiola stipitata 1.78	*Polysiphonia* spp. 2.32	*Corallina/Ellisolandia* 1.88
	Ulothrix spp. 1.78	*Dictyota dichotoma* 2.32	*Cystoclonium purpureum* 1.88
	Ulva spp. 1.78	*Leathesia* spp. 1.87	*Dictyosiphon foeniculaceus* 1.88
	Urospora spp. 1.78	*Osmundea hybrida* 1.79	*Ectocarpus* spp. 1.88
			Fucus spiralis 1.88
			Membranoptera alata 1.88
			Odonthalia dentata 1.88
			Plumaria plumosa 1.88
			Porphyra umbilicalis 1.88
			Ptilota gunneri 1.88
Cum. contribution: 75.6	Cum. contribution: 37.3	Cum. contribution: 70.1	Cum. contribution: 52.9

Ramos et al. 2014



Taxa de referência - para monitorizar no futuro

List of taxa ordered by their contribution to similarity into biotypes and the cumulative contribution (Cum. contribution), according to results of the SIMPER analysis. Taxa that appeared in all the groups were Chondrus crispus and taxa belonging to the family Corallinaceae, both Corallina/ Ellisolandia and crustose macroalgae (i.e. Litophyllum, Mesophyllum, etc.). Biotype A2 had a remarkably different seaweed composition.

Conceito: espécies indicadoras (1)

Indicator species: One or more taxa selected based on its sensitivity to an environmental attribute, and then assessed to make inferences about that attribute. Commonly used in the context of wildlife conservation, habitat management and ecosystem restoration

Umbrella species: A species that requires a large area of suitable habitat to maintain a viable population, and whose requirements for persistence are believed to encapsulate those of an array of associated species. Umbrella species usually have very large home ranges. As indicator species, umbrella species are used most for conservation applications and management of protected areas

Keystone species: A species on which the health of the ecosystem depends, due to its strong interactions with other species in that ecosystem. As indicator species, keystone species are used most for monitoring habitat quality, restoration success and protected areas management

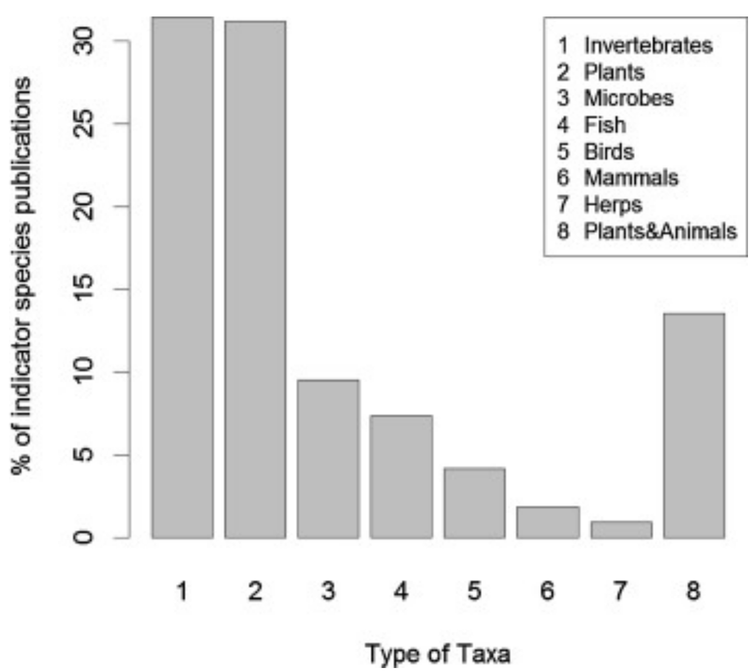
Flagship species: A species that can easily attract public support based on its charismatic qualities and its conservation status. As indicator species, flagship species are used most for identifying and monitoring conservation status of the species

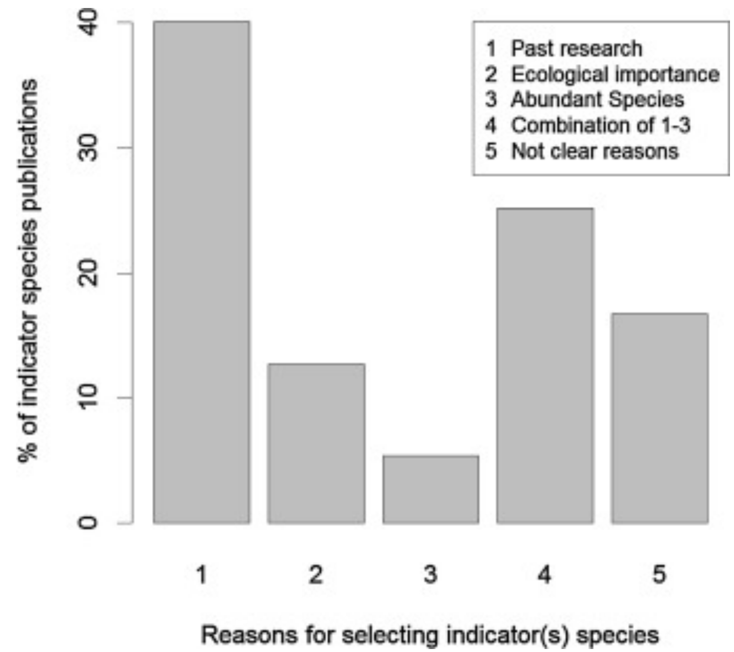
Ecosystem engineer: A species that causes physical changes in biotic or abiotic materials, thereby modulating the availability of resources to other species. As indicator species, ecosystem engineers are used most for ecosystem restorations and conservation

Foundation species: A species that defines much of the structure of a community by creating locally stable conditions for other species, and by modulating and stabilizing fundamental ecosystem processes. As indicator species, foundation species are used most for monitoring ecosystem changes

Siddig et al. 2016

Conceito: espécies indicadoras (2)





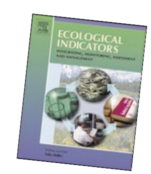
Siddig et al. 2016

Evaluating ecological states of rocky intertidal communities (3)

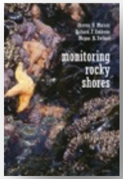
By their nature, rocky intertidal communities offer several challenges to evaluators of community state and to index development:

1. These communities occupy heterogeneous habitats with considerable spatial and temporal variation in key abiotic environmental drivers
   - This can lead to multiple possible community structures that change over time, even for habitat patches within the same physical site, complicating efforts to evaluate ecological state
2. Rocky shore communities are simultaneously subjected to significant physical (e.g., wave action, sand scour, substratum instability, aerial emersion) and biological (e.g., predation) natural processes, whose effects are often difficult to differentiate from all but the most severe anthropogenic (e.g., poor water quality, trampling, harvesting) impacts
3. The rocky intertidal zone is strongly influenced by tides, where submersion and emersion regimes limit the shore positions that can be occupied by most species
   - This produces well known, vertical patterns of species abundances on the shore and makes it essential that community data used to determine and compare the ecological states of sites are obtained from samples taken over equivalent intertidal positions
4. The composition, orientation (slope, aspect) and relief (rugosity) of the rocky sub-stratum itself has a strong influence on species distributions and abundances, within and among

Murray et al. 2016



Unidades biológicas

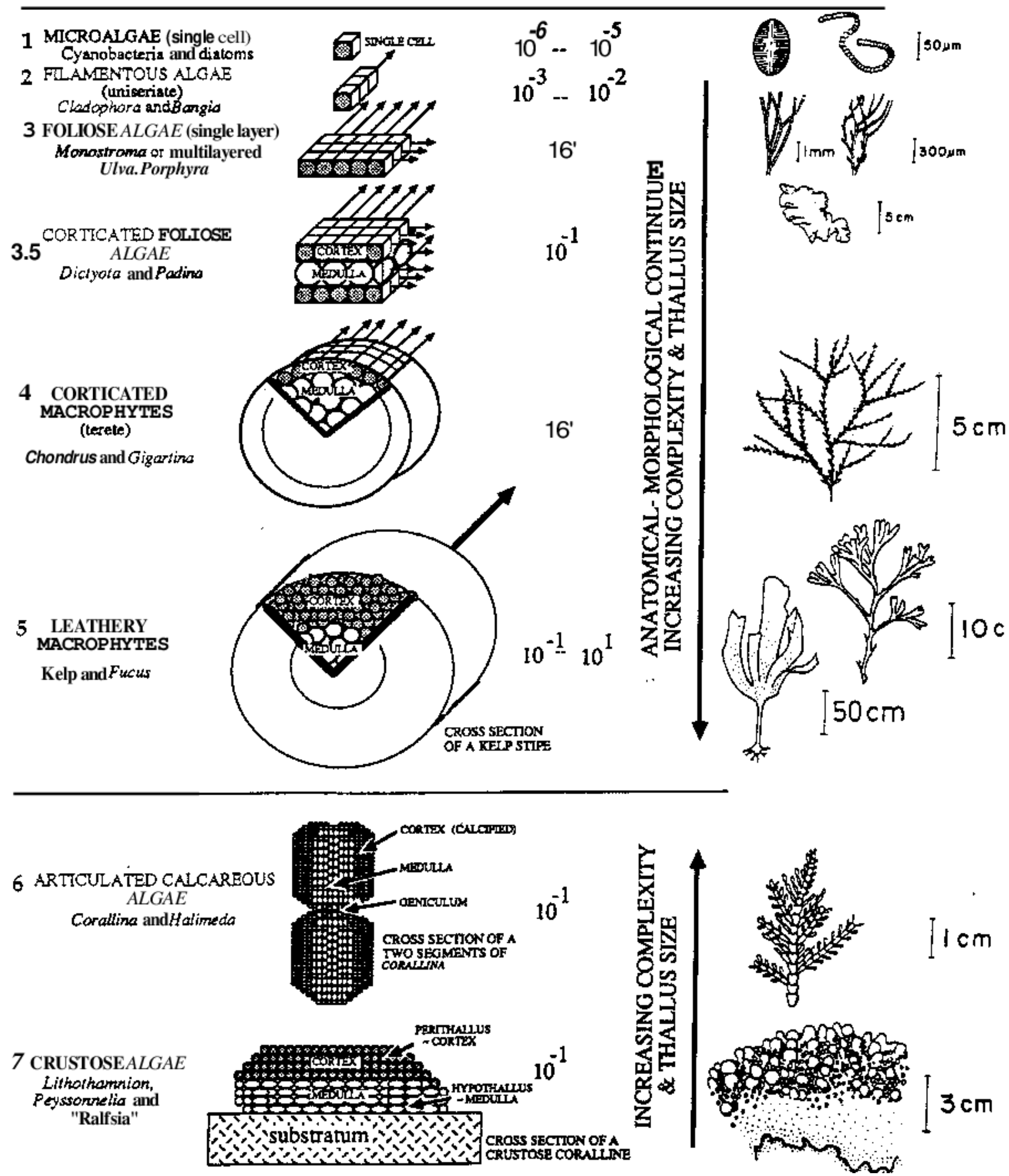


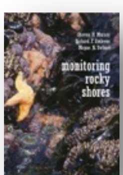
- Amostragem ao nível das espécies
  - do indivíduo
  - grupos taxonómicos supra-específicos
    - Género, família, filo…
    - Grupos (morfo-)funcionais

Catalogue of Life

Grupos funcionais

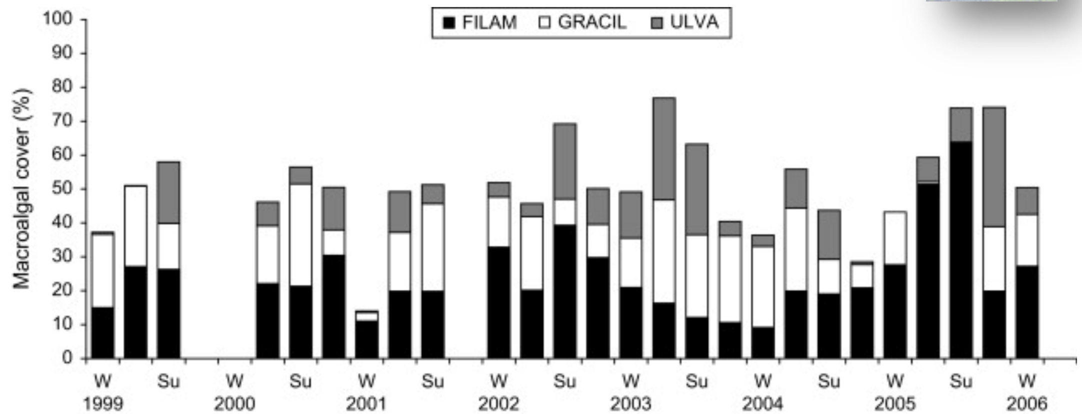
Steneck & Dethier 1994v



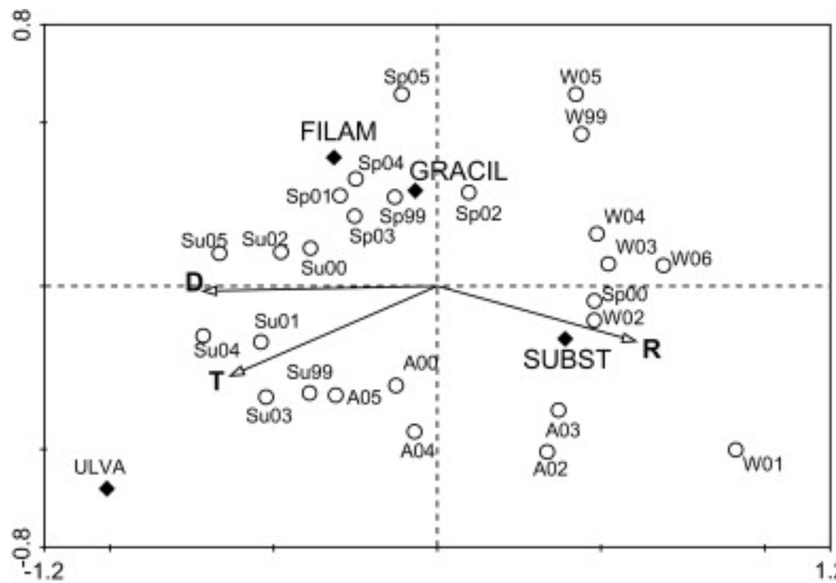


Long-term abundance patterns of macroalgae in relation to environmental variables in the Tagus estuary

Variation of macroalgal percent cover (FILAM – small (<10 cm) filamentous group, includes eight species; GRACIL – corticated terete macrophyte group, includes Gracilaria gracilis; ULVA – foliose group, includes Ulva spp.; and SUBST – bare substrate without algal cover), in Ponta do Destrói oyster reef, Tagus Estuary, throughout the study period (W = winter; Sp = spring; Su = summer; and A = autumn).



Canonical correspondence analysis (CCA) ordination of macroalgal cover in relation to the environmental variables. ULVA, GRACIL, FILAM and SUBST scores (the value of each category on an ordination axis) are indicated by diamonds, samples by circles (letters as above), and arrows represent environmental variables (T = average between samples of mean daily air temperatures; D = average daylight hours between samples; and R = total accumulated daily rainfall between samples)



Green tides (1)

- Massive proliferations of ephemeral macroalgae that replace the pre-existing macrophyte communities

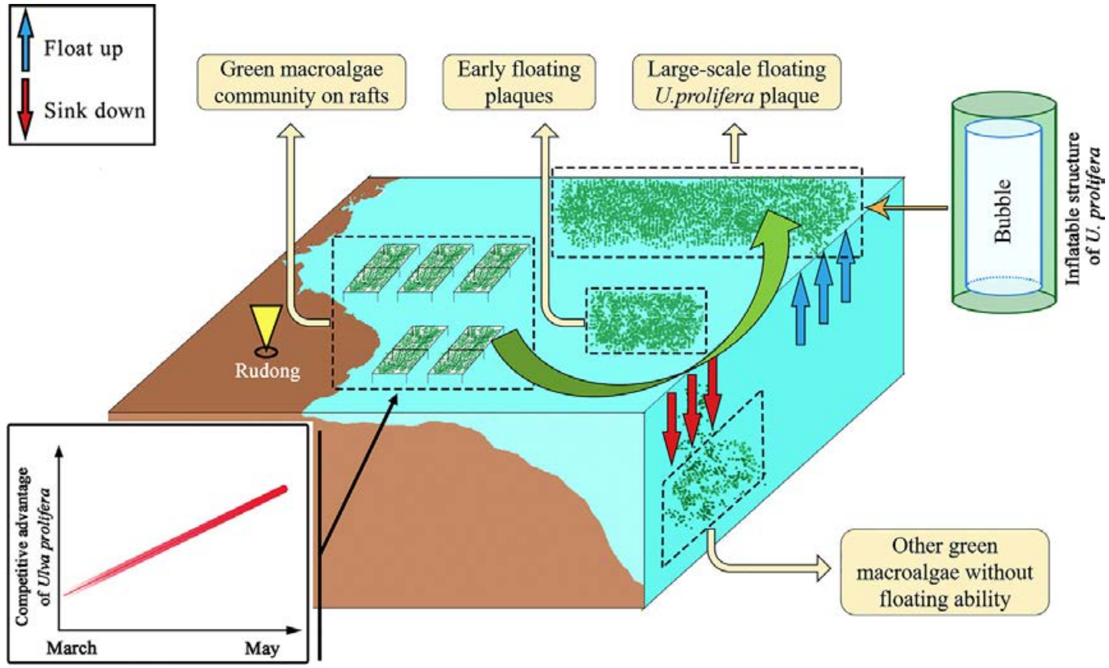
- The physiological performance of the algae forming green tides is often invoked to explain its explosive proliferation and capacity for replacing the native macrophyte communities
  - it is normally accepted that the fast growth macroalga have higher capacity for nutrient assimilation than perennial species, consequently green-tides are associated to nutrient pollution

- The relationship between nutrient uptake capacity and dominance patterns of species of opportunistic macroalgae was not clear in the few studied cases
  - Liu et al. (2009) found that the proliferation of ~~Enteromorpha~~ Ulva prolifera off the China coast was due to a combination of favourable oceanic conditions related to temperature, wind, and currents
  - the occurrence of these green tides could not be explained solely from the eutrophication prevalent in the region

Mercado 2011

Ulva prolifera from *Pyropia* aquaculture rafts implicated for the green tide in the Yellow Sea

The physiological characteristics of *Ulva prolifera* and *Blidingia* sp. during two pre-bloom stages (March & May) were compared to evaluate the competitive advantage of *U. prolifera* on *Pyropia* aquaculture rafts in Subei Shoal. (1) Compared to *Blidingia* sp., *U. prolifera* had a lower growth rate, chlorophyll content, photosynthetic efficiency, and antioxidant capacity in March. (2) In May, various indicators of *U. prolifera*'s physiological function improved significantly, while the antioxidant capacity of *Blidingia* sp. decreased significantly. Large lipidic globules in *U. prolifera* cells became scattered small lipidic globules in May, which indicated a decrease in lipid membrane peroxidation. (3) In *U. prolifera*, the ratio of buoyancy to gravity of per unit volume was 1.73, and the bubbles inside the thalli provided 60% of the total buoyancy. Buoyancy generated by the inflatable structure of *U. prolifera* allowed this species to float after being separated from the rafts.



Hao et al. 2020

Ulva microscopic propagules

(A) *Ulva* individuals grown from the microscopic stage after 5-day's culture at 20 °C under 100 μmol photons m^{-2} s^{-1}. The arrows respectively showed the rhizoid. (B) The rhizoid attached on small sand particles. (C) The basal of an *Ulva* germling with new branches. (D) *Ulva* germlings grown for 10-days in petri dishes.

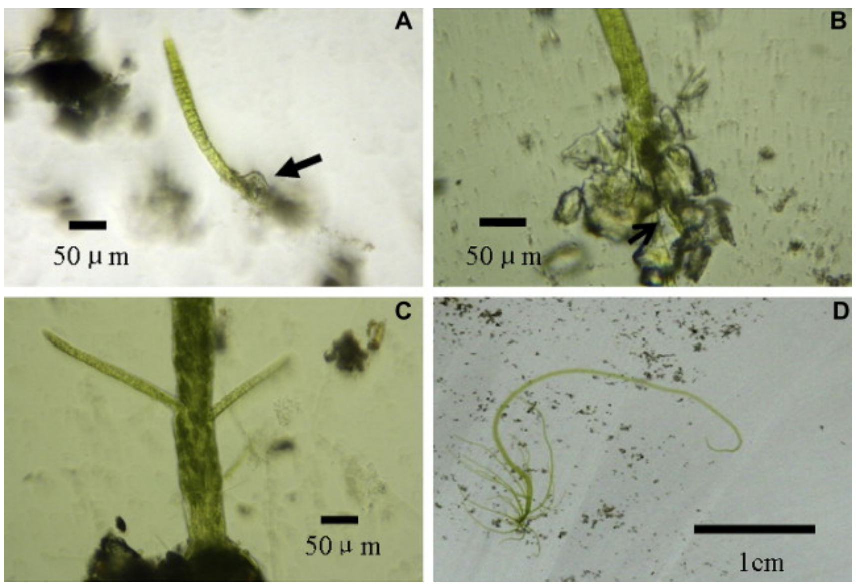
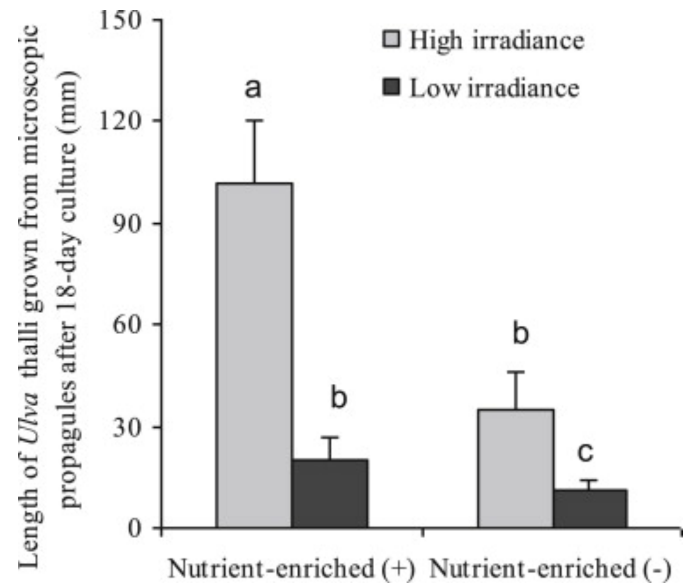


Fig. 8. Length of *Ulva* microscopic propagule germlings grown at 20 °C under 100 μmol photons m^{-2} s^{-1} after 18-day's culture. High and low irradiances refer to 145 and 50 μmol photons m^{-2} s^{-1}, respectively. Nutrients were supplemented to reach the levels of 200 μM NH_4^+ and 20 μM PO_4^{3-} in nutrient-enriched group. Means and SE are shown (n = 20). Values with statistically significant differences ($P < 0.05$) are indicated by different letters.



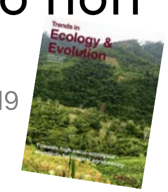
Liu et al 2012

“Biology pulses with metaphors…”

“Many biological metaphors, such as ‘adaptation’, ‘advertising’, ‘competition’, ‘defense’, ‘function’, and ‘selection’ make it harder rather than easier to envision that these processes are not consciously goal-directed” [Olson et al. 2019]

- Metaphor - analogical projections of ideas to situations in which they do not literally apply
- Semantics - how words correspond to the world, one of the central efforts of science
- Teleology - imputing goal-directed agency to non-sentient systems

Olson et al. 2019



Algumas vantagens

Olson et al. 2019

Expressiveness

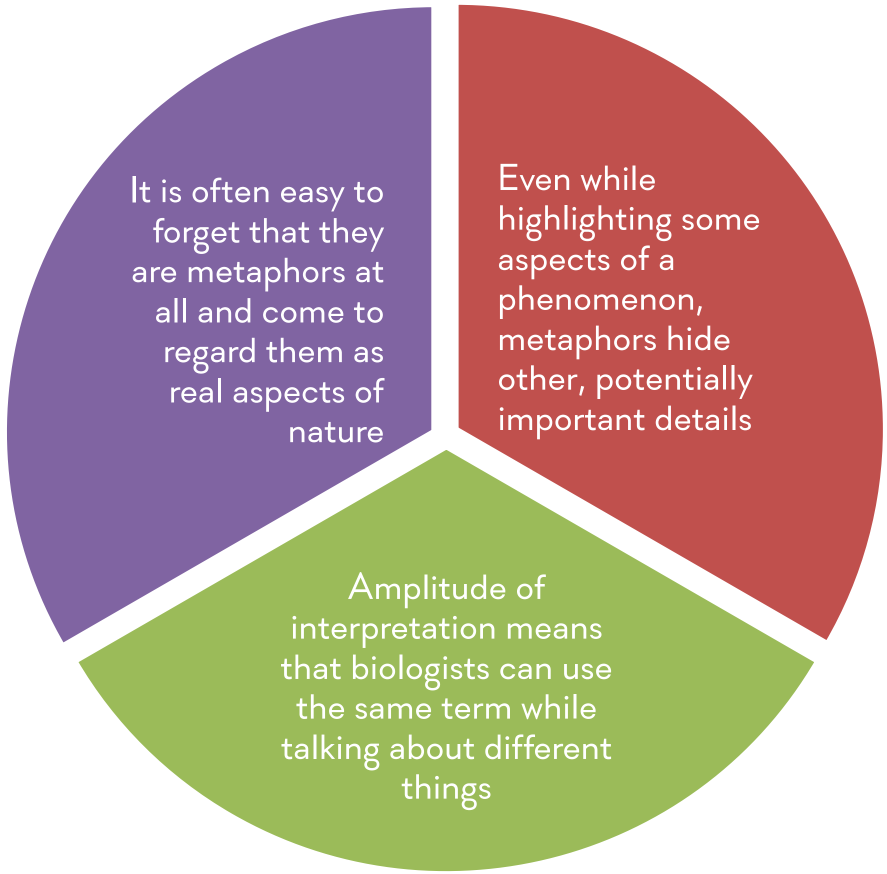
Metaphors are not simply verbal models but cognitive tools that evoke thinking about possible attributes and relations of novel entities or phenomena

Vagueness

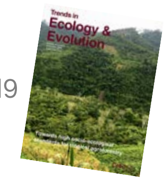
Because they can be interpreted in many ways, scientific metaphors group a vast array of phenomena under a single evocative label

The vagueness of metaphors is thus one of their virtues, allowing them to foster cross-pollination among biological perspectives

Algumas desvantagens



Olson et al. 2019



Referências

1. Hao Y, Qu T, Guan C, Zhao X, Hou C, Tang X & Wang Y (2020). Competitive advantages of *Ulva prolifera* from *Pyropia* aquaculture rafts in Subei Shoal and its implication for the green tide in the Yellow Sea. Marine Pollution Bulletin 157: 111353. https://doi.org/10/ghpv8j
2. Liu F, Pang SJ, Zhao XB & Hu CM (2012). Quantitative, molecular and growth analyses of Ulva microscopic propagules in the coastal sediment of Jiangsu province where green tides initially occurred. Marine Environmental Research 74: 56–63. https://doi.org/10/fx23nj
3. Mercado JM (2011). Physiological basis for the use of seaweeds as indicators of anthropogenic pressures: The case of green tides. In S-K Kim (Ed.), Handbook of Marine Macroalgae (pp. 106–115). John Wiley & Sons, Ltd. http://onlinelibrary.wiley.com/doi/10.1002/9781119977087.ch5/summary
4. Murray SN, Ambrose R, Dethier MN (2006) Monitoring Rocky Shores. University of California Press
5. Murray SN, Weisberg SB, Raimondi PT et al. (2016). Evaluating ecological states of rocky intertidal communities: A Best Professional Judgment exercise. Ecological Indicators 60: 802–814. https://doi.org/10/f75s9b
6. Olson ME, Arroyo-Santos A, Vergara-Silva F (2019) A User's Guide to Metaphors In Ecology and Evolution. Trends in Ecology & Evolution 34: 605–615. https://doi.org/10/gfzhvz
7. Ramos E, Puente A, Juanes JA et al. (2014) Biological validation of physical coastal waters classification along the NE Atlantic region based on rocky macroalgae distribution. Estuarine, Coastal and Shelf Science 147: 103–112. https://doi.org/10.1016/j.ecss.2014.05.036
8. Siddig AAH, Ellison AM, Ochs A et al (2016) How do ecologists select and use indicator species to monitor ecological change? Insights from 14 years of publication in Ecological Indicators. Ecological Indicators 60: 223–230. https://doi.org/10/f75rzm
9. Sousa-Dias A, Melo RA (2008) Long-term abundance patterns of macroalgae in relation to environmental variables in the Tagus estuary (Portugal). Estuarine, Coastal and Shelf Science 76: 21–28. https://doi.org/10.1016/j.ecss.2007.05.039
10. Steneck R, Dethier M (1994) A functional group approach to the structure of algal-dominated communities. Oikos 69: 476–498. http://bit.ly/33TEAti

Obrigado pela atenção!