Emodnet Project Final Report

Integrating biological traits of European Macroalgae into the World Register of Marine Species

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01/10/2013 – 31/05/2014

1. List of the targeted traits and their definitions.

We selected 21 biological traits related to 5 categories (morphofunctional growth form, reproductive biology, ecology, ecophysiology and biogeography) relevant for macroalgae and as compatible as possible with a generalised trait classification for marine organisms. Non-relevant traits, e.g. traits relevant to other taxonomic groups but no to seaweeds (e.g. feeding mechanism, sociability …), were excluded and seaweed specific traits, e.g. those related to reproductive biology and morphofunctional growth form, were included.

Below we concisely describe the major trait categories and refer to Table 1 for detailed trait definitions and accompanying literature references:

Morphofunctional growth form

Here we list a description of the thallus based on the concept of morphofunctionality. This concept was introduced by Littler & Littler (1979), and states that morphology is related to a certain ecological niche. All terms used to describe the growth form of a seaweed thallus as well as mode of calcification are newly introduced regarded to the previous pilot projects (See table 1). Values measuring the diameter or height of a thallus refer to the maximum value found in the literature.

Reproductive biology

Here we describe the typical life cycle of seaweeds. Most seaweeds have a biphasic lifecycle in which they alternate between diploid sporophytic and haploid gametophytic phases. However, monophasic diploid life cycles are also encountered (e.g. Fucales). Furthermore, the typical life cycle of many seaweeds is complemented or at least partially replaced by asexual reproduction (See fig. 1). All terms used, with the exception of 'asexual reproduction', are newly introduced and unique with respect to the previous pilot projects (See table 1).

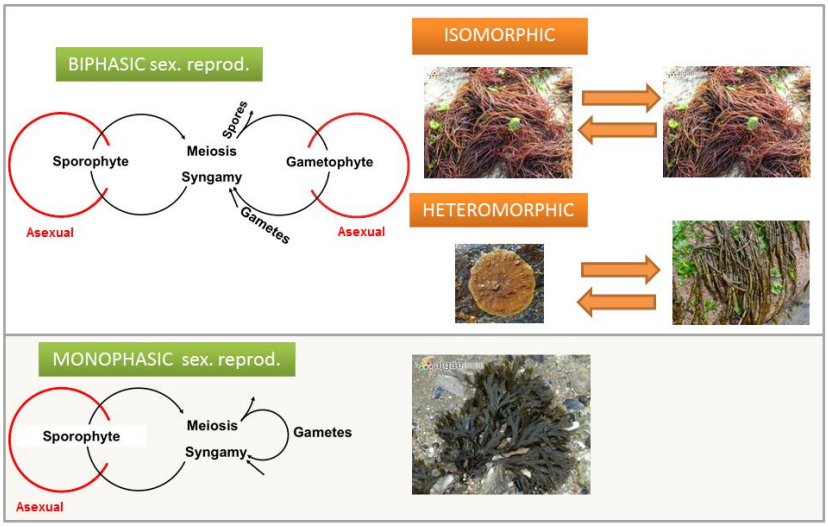

Figure 1. : Biphasic and monophasic sexual reproduction

Ecology

Ecological traits list relate to the habitat of the seaweed with respect to tidal zonation, various degrees of exposure, and substrate, were recorded. Where possible we included data on seasonality, even though these characters have not been consistently recorded in the literature for a large number of smaller taxa. In addition, it should be noted that seasonality as a character may display considerable variation, even along the European coastline. Data on seasonality used in the database are derived from the British Seaweed Flora (several volumes) and a recent guide to the macroalgae of the Western Mediterranean Sea (Rodriguez-Prieto et al. 2013). Terms 'endophytic' and 'endozoic' under the trait 'Substrate' are newly added regarding the previous pilot projects. In the few instances where seaweed species are known to form blooms this has been indicated.

Ecophysiology

Here we document whether ecophysiological data is available or not (See table 1). We defined ecophysiological data as data related to the interrelationship between an organism's physical functioning and its environment. We thereby excluded studies which are in principal of a biochemical nature with little or no relevance to the ecology of the organisms. For example, studies screening for biologically active secondary metabolites have been excluded, whereas studies linking secondary metabolites to grazing resistance have been included.

Biogeography

Data related to the distribution of the taxa are listed here (See table 1). Algaebase served as a primary source of information to characterize the species' distributions. Distributions were classified according the ecoregions defined by Spalding et al. (2007). Non-indigenous species are flagged as 'introduced', whereas seaweed genera confined to European waters and not found anywhere else in the world are flagged as 'endemic'. Note that introduced is a species trait while endemic refers to genera, which implies that one cannot make statements about the endemic nature of specific species in case the genus is distributed outside European waters also.

Table 1 : Targeted traits with their scores and definitions

Group in Access (Tab/References)		Trait name	Trait score or value	Definition	Reference
1	**Morpho-functional growth form**	Growth form	crustose	forming a firm to hard crust or layer on the substrate	Womersley (1987)
			branched	forming main and lateral branches (and branchlets)	Womersley (1987)
			spheric	thallus approximating the shape of a sphere	Womersley (1987)
			cushion-like	thallus approximating the shape of a cushion	Womersley (1987)
			foliose	leaf-like	Womersley (1987)
			filamentous	thallus existing out of a branched or unbranched row of cells joined end to end	Womersley (1987)
			discoid	forming a flattend disc with a rounded outline	Womersley (1987)
			pinnate	thallus with lateral segments arranged along each side of an axis or branch	Womersley (1987)
			siphonous	filamentous, tubular, multinucleate and with a few cross-walls, if any	Brodie & Maggs (2007)
			erect	upright	pers. comm. O. De Clerck
			prostrate	thallus trailing on the sustrate	pers. comm. O. De Clerck
			saccate	inflated, or sac-like thallus	pers. comm. O. De Clerck
			capitate	ending in a distinct compact head	Google
		Thallus value		maximum value observed for the regarding thallus feature	
		Unit	mm	unit used to describe the regarding thallus feature	
			cm		
			m		
		Calcification	calcified articulated	segmented thallus that is encrusted or impregnated with lime	Womersley (1987)
			calcified non-articulated	non-segmented thallus that is encrusted or impregnated with lime	Womersley (1987)
			non-calified	not encrusted or impregnated with lime	Womersley (1987)
		Life span	perennial	a thallus or a part thereof with a lifespan exceeding one year	Womersley (1987)
			annual	a thallus which survives only one growing season	Womersley (1987)
		Memo	maerl	Unattached, branched corallines, living or dead that develops as a result of fragmentation or envelopment of a stone or other object	Irvine & Chamberlaine (1994), Womersley IIIB (1996)
2	**Reproductive biology**	Life cycle	Haplontic	when the haploid phase is prominent and the diploid phase only consists of the zygote cell	Womersley (1987)
			Diplontic	when the diploid phase is prominent and the haploid phase consists only of the gametes	Womersley (1987)
			Diplohaplontic	free-living gametophyte and sporophyte phases	Womersley (1987)
			Direct	reproduction of the same phase of the life history by means of asexual spores or propagules	Womersley (1987)
2	**Reproductive biology**	Lifecycle type	isomorphic	organisms with the gametophyte and sporophyte of similar morphology and size	Womersley (1987)
			heteromorphic	organisms with the gametophyte and sporophyte of	Womersley (1987)

				different morphology and size	
		Form gametes	oogamous	having a reproduction involving a large non-motile female gamete (egg cell) and a small motile male gamete (sperm cel or equivalent)	Womersley (1987)
			isogamous	having morphologically identical (usually motile) gametes	Womersley (1987)
			anisogamous	having motile male and female gametes with different morphology	Womersley (1987)
		Asexual reproduction	yes	reproduction without the fusion of gametes or meiosis, therefore recycling the same life stage	Brodie & Maggs (2007)
			no		
		Arrangement gametophytes	Dioecious	When male and female reproductive structures are fomed on the same individual	Brodie & Maggs (2007)
			Monoecious	When male and female reproductive structures are fomed on seperate individuals	Brodie & Maggs (2007)
			Mixed	When there are dioecious and momoecious individuals in one species	pers. comm. O. De Clerck
		Spawning method	fertilization on female gametophyte	female gamete retained on the female gametophyte (e.g. all Rhodophyta)	pers. comm. O. De Clerck
			fertilization in the water column	fertilisation with gametes released in the water column	pers. comm. O. De Clerck
3	**Ecology**	Zonation	subtidal	living in the region of the shore that is mostly submerged and only the upper layer is exposed during extreme low tides	Womersley (1987)
			intertidal	living in the region of the shore between extreme low and high tides	Womersley (1987)
		Substrate	epilithic	living attached to rocks or stones	Womersley (1987)
			epizoic	living attached to an animal	Womersley (1994)
			epiphytic	living attached to a plant, but not parasitic	Womersley (1987)
			endophytic	living within the thallus of a host plant	Brodie & Maggs (2007)
			endozoic	living within the thallus of a host animal	Brodie & Maggs (2007)
			unattached		
		Habitat	sheltered	occurring at calm places, places protected to billow	pers. comm. O. De Clerck
			exposed	occurring at unprotected places	pers. comm. O. De Clerck
			semi exposed	occurring at semi-protected places	pers. comm. O. De Clerck
		Seasonality	summer	season in which the macroscopic phase can be observed	pers. comm. O. De Clerck
			autumn		
			winter		
			spring		
3	**Ecology**	Blooming	yes	episode of intense growth and mass proliferation of the thallus	pers. comm. O. De Clerck
			no		

4	**Eco-physiology**	Eco-physiological data	available	data related to the study of the interrelationship between an organism's physical functioning and its environment	pers. comm. O. De Clerck
			not available		
5	**Biogeography**	Non-native	Yes	a genus with at least some of its species introduced into European waters	pers. comm. O. De Clerck
			No		
		Endemic	Yes	a genus endemic to European waters	pers. comm. O. De Clerck
			No		
		Distribution	Southern Ocean	approximate distribution of the European members of the genus according to Spalding's eco-region classification (2007)	Spalding (2007)
			Arctic		
			Temperate Northern Pacific		
			Tropical easern Pacific		
			Temperate South Pacific		
			Temperate Southern Africa		
			Western Indo-Pacific		
			Temperate Australasia		
			Central Indo-Pacific		
			Eastern Indo-pacific		
			Tropical Atlantic		
			Temperate Northwest Atlantic		
			Northern European Sea		
			Lusituania		
			Mediterranean		
			Black Sea		
			Cosmopolitan		

2. Number of genera with trait data entered

Because identification of macroalgae to species level is not straightforward and surprisingly little consensus is found on the number of species present in many genera, the collected trait data is attributed to genus level, and not to species level.

Filtering unicellular and non-marine genera from the European Register of Marine Species (ERMS) resulted in 516 genera of marine macroalgae. For these genera we filled in the traits as complete as possible for all 21 biological traits. To cope with a possible loss of variation due to attributing the trait data to genus level (see above), we divided 72 genera in subgroups. We created subgroups based on morphological similarity of species and based on the life phases of the biphasic life cycles (sporo- and gametophyte). We tried to document each trait for every subgroup made. We divided the species of 7 genera in morphologically similar subgroups (See table 2 & tab 'Subgroups' in the Excel file 'Overview table'), and 65 genera were divided in subgroups depending on their life phase (sporophyte/gametophyte) (See table 3). We described both the sporophyte and gametophyte for 34 genera of these 64. For the other 30 genera, we described 1 life phase and added a short note about the other life phase. The remaining 444 genera were not divided in subgroups.

44 genera (9%) were classified as non-prior. These include cases where names are currently regarded as a taxonomic synonym, genera for which no reliable literature available, or unduly obscure taxa. The traits of non-prior genera are not or only incompletely documented.

In total we made 564 unique descriptions of genera or subgroups.

Table 2: Genera divided in subgroups based on morphological similarity

Genus	# Subgroups
Codium	3
Desmarestia	2
Fucus	8
Petalonia	2
Ptilothamnion	2
Stragularia	2
Tiffaniella	2

Table 3: Genera divided in subgroups base on their heteromorphic generations

Genera				
Ahnfeltia	*Pikea*	*Mastocarpus*	*Ganonema*	*Monostroma*
Bangia	*Gloiosiphonia*	*Erythrodermis*	*Helminthocladia*	*Myriogloea*
Porphyra	*Plagiospora*	*Turnerella*	*Liagora*	*Saccharina*
Asparagopsis	*Schimmelmannia*	*Alaria*	*Nemalion*	*Chlorothrix*
Bonnemaisonia	*Thuretella*	*Ecklonia*	*Atractophora*	*Grania*
Derbesia	*Acrodiscus*	*Undaria*	*Naccaria*	*Meredithia*
Pseudopringsheimia	*Cutleria*	*Chorda*	*Scytosiphon*	*Pseudobryopsis*
Gomontia	*Arthrocladia*	*Halosiphon*	*Sphaerococcus*	*Wildemania*

Cladosiphon	*Porphyropsis*	*Laminaria*	*Carpomitra*	*Pseudothrix*
Papenfussiella	*Porphyrostromium*	*Phyllariopsis*	*Nereia*	*Pyropia*
Sphaerotrichia	*Schmitzia*	*Saccorhiza*	*Sporochnus*	*Fredericqia*
Spermatochnus	*Halarachnion*	*Galaxaura*	*Ulothrix*	*Giraudia*
Acrosymphyton	*Neurocaulon*	*Tricleocarpa*	*Kornmannia*	

3. References used for trait data

We used 515 references which we collected in an EndNote database. Every reference is linked to the Excel and Access database by a unique call number. We included the corresponding pdf for 240 references. The reference we used the most is Algaebase (Guiry, M.D. & Guiry, G.M., 2014). Algaebase was our starting point for most of the genera; by means of the distribution indicated on Algaebase, we had a first view of which (region specific) literature could be relevant in documenting our traits.

See - 'Algenmatrix_Library_FINAL.enl' for the EndNote format
- tab 'Literature' in the Excel file 'Overview table_FINAL'.

4. Problems encountered whilst documenting the trait information.

The main problem we encountered while entering the data was the lack of an interface with on one hand an overview of the genera and traits that are already completed and on the other hand the genera and traits that still had to be processed. We handled this issue by making our own form in Access.

As previously mentioned, we encountered the risk of losing variation by working on genus level which we handled by creating subgroups.

5. My findings in general about the trait documentation in general and recommendations for the future.

We think it would be very useful, more than the template that was provided, to provide a universal user-friendly interface which can be used to give in data for different kind of taxa.