Editorial

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Phycomorph: macroalgal development and morphogenesis

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Macroalgal cultivation holds great economic potential as an additional source of food, fuel and chemicals (Buchholz et al. 2012, Loureiro et al. 2015). Currently, 19 million tonnes of macroalgal biomass with an estimated value of US$ 5.7 billion are annually collected through aquaculture for consumption or industrial raw material (FAO 2012). However, the production could be increased, especially in Europe, by more appropriate and efficient macroalgal cultivation techniques. To match these actual demands in aquaculture, a step-change in the knowledge of fundamental macroalgal biology is required. Orchestrated projects that unify scientists from various disciplines (including the expertise gained from flowering plants) should aim to unravel the rules that underpin the multiple processes in algal development and morphogenesis. In fact, with the emerging model systems of *Ectocarpus*, *Chondrus* and *Ulva* along with suitable genetic toolkits (Cock et al. 2010, Collén et al. 2013, Charrier et al. 2015, Oertel et al. 2015, Wichard et al. 2015), phycologists are now able to obtain new knowledge about macroalgal development to apply, for example, to aquaculture maintenance and control or to food-processing industries.

The recently funded European Cooperation in Science and Technology (COST) Action PHYCOMORPH (FA1406) “Advancing knowledge on seaweed growth and development” is the outcome of the establishment of a European interdisciplinary network integrating unique expertise, currently scattered worldwide. The principal objective of PHYCOMORPH is to increase fundamental knowledge about macroalgal growth, development and reproduction, and thus to improve sustainable seaweed aquaculture (Charrier 2017). This will be achieved by combining our understanding of many biological processes that control macroalgal development with the know-how of research and development organisations dedicated to knowledge transfer and the creation and/or support of innovative seaweed industries (Figure 1, http://www.phycomorph.org/ and http://www.cost.eu/COST_Actions/fa/FA1406).

To track the history of this volume, we need to go back to London, where the 6th European Phycological Congress (EPC 6) was held in August 2015. Bénédicte Charrier (Station Biologique Roscoff, CNRS U MPC, France), Chair of the COST Action, introduced the network at EPC 6, where one session was devoted to the objectives of PHYCOMORPH. There, after discussing with Matthew Dring, editor-in-chief of *Botanica Marina*, the idea of preparing together a special issue as an important part of building up a new community was born.

This special issue dedicated to macroalgal growth, development and reproduction includes three review articles and nine research articles. They present a broad view of exciting topics, including studies on the main tasks of the Phycomorph project, i.e. (i) fertility induction, (ii) reproduction and initiation of new generations, (iii) fostering adult growth as well as (iv) the development of novel technical tools (Figure 1). This volume covers brown (*Fucus, Laminaria, Padina*), red (*Furcellaria, Hydrolithon*) and green (*Ulva*) macroalgae, including both laboratory and field studies. In the following paragraphs, we briefly highlight a few contributions:

Liu and co-workers review the current knowledge on reproductive strategies and trade-offs of reproductive effort in macroalgae, including the importance of environmental control mechanisms and molecular perspectives on fertility regarding, for example, phytohormones. Improved determination of these signal molecules in red seaweeds is reviewed by Mori et al. In their contribution, they show recent advances in simultaneous profiling of multiple phytohormones based on analysis using liquid chromatography coupled with mass spectrometry upon solid phase extraction of those molecules.

Another class of signal molecules, morphogenetic compounds, were investigated by Weiss and co-workers. In this study, various *Maribacter* species (Bacteroidetes) induce rhizoid and cell wall formation in standardized cultures of *Ulva mutabilis* Føyn via waterborne molecules.

Morphological features were also investigated by Lubsch and Timmermans. Quantification of mechanical stress resistance of the *Laminaria* thallus revealed a toughness gradient from young to old tissues. The authors discuss their findings not only in the context of
mechanical properties in mariculture applications, but also regarding morphological responses to changing environmental conditions.

Inspired by research on terrestrial plants, Shefer et al. report a novel methodology for carbohydrate-based phenotyping of *Ulva fasciata* Delile using near-infrared spectrometry. The authors summarize the strength of this high-throughput tool to rapidly select high-carbohydrate-content thalli for further application in marine biorefineries.

On a microscopic level, the mesoalgal community and small structures on the algal surface were investigated by Fricke et al. using confocal laser scanning microscopy combined with a non-destructive approach that even allows them to visualize species-specific interactions. Using transmission electron microscopy and tubulin immunofluorescence, Katsaros et al. studied the changes in cell structure and microtubule organisation during gametogenesis of *U. mutabilis*.

Several field studies were conducted to assess changes in morphology and reproduction under variable environmental conditions. Martins et al. highlight the importance of understanding the seasonal drivers for growth and reproduction of life-cycle stages of kelps. Bürger and co-workers show the variations of morphology and density of the calcareous algae *Padina pavonica* (Linnaeus) Thivy along a depth gradient. Two contributions are focusing on aspects of macroalgal development following prolonged environmental contaminant exposure: Lauze and Hable showed the impact of polychlorinated biphenyls and metals on the reproductive capacity and morphology of *Fucus vesiculosus* (Linnaeus). Finally, a review by Kersen et al. about the biotechnological applications of *Furcellaria lumbricalis* (Hudson) J.V. Lamouroux and its future domestication under open marine conditions in the Baltic Sea completes this special issue.

We would like to take the opportunity to thank all the authors that participated in this volume for their enthusiastic collaboration. We hope that the readership will be inspired by this volume to further build a new community and their skills in the field of macroalgal development. Several articles are based upon work from COST Action FA1406 supported by COST. In particular, research students or early stage researchers benefited from the networking through short-term scientific missions (STSMs). We trust that this volume becomes the first of many contributions within a growing research network of “Phycomorphers”.

### References


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