Title of the PHD project

Ecological and evolutionary role of the local adaptation of kelps in the context of global change: consequences for aquaculture

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Recent publications of the supervisors with their PhD students:

*Name of the PhD students:

Casares* FA, **Faugeron S.** (2016). Higher reproductive success for chimeras than solitary individuals in the kelp Lessonia spicata but no benefit for individual genotypes. *Evolutionary Ecology*, 30(5), 953-972.

Montecinos* AE, Guillemin M-L, Couceiro L, Peters AF, Stoeckel S, **Valero M**. (in press) Hybridization between two cryptic filamentous brown seaweeds along the shore: Analysing pre- and post-zygotic barriers in populations of individuals with varying ploidy levels. *Molecular Ecology*, DOI: 10.1111/mec.14098

Montecinos* AE, Couceiro L, Peters AF, Desrut A, **Valero M**, Guillemin M-L. (2017) Species delimitation and phylogeographic analyses in the Ectocarpus subgroup siliculosi (Ectocarpales, Phaeophyceae). *Journal of Phycology* **53**, 17-31.

Robuchon* M, **Valero M**, Thiébaut E, Le Gall L (in press) Multi-scale drivers of community diversity and composition across tidal heights: an example on temperate seaweed communities. *Journal of Ecology.* DOI: 10.1111/1365-2745.12781.

Krueger-Hadfield* S, Roze D, Correa J, Destombe C, **Valero M** (2015) O father where art thou?; Paternity analyses in a natural population of the haploid–diploid seaweed Chondrus crispus. *Heredity* **114**, 185-194.

Summary of the PHD project:

The limits of habitats a species can occupy are generally difficult to predict, or even to characterize. This is particularly true for species with a wide distribution range, often accompanied by a range of habitats to which the species is acclimated or locally adapted. One critical aspect of local adaptation is the balance between neutral (i.e. genetic drift and gene flow) and selective forces that shape the dynamics of the genetic diversity, and ultimately the outcome of this evolutionary process. To understand how species evolve within their range, local adaptation needs to be investigated by jointly estimating adaptive divergence, gene flow and restrictions to effective dispersal, and genetic drift. The balance between these evolutionary forces is poorly studied in marine algae.

Kelps are key components of cold to temperate coastal ecosystem worldwide. They perform important ecosystem services and functions on our coasts as a habitat for marine biodiversity conservation, coastal protection and eco-tourism and as harvested species (fisheries and aquaculture). However, Several studies (including those of the sponsoring team) showed that these marine forests are currently under serious threat resulting in notable shifts of their distribution ranges (Raybaud et al. 2013 ; Assis et al. 2015 ; Araújo et al. 2016). The objective of this thesis project, financed by the European project BIODIVERSA "MARFOR" (http://marfor.eu/) and the Brittany region, is to better understand the ecological and evolutionary role of local adaptation in these species in order to propose measures regarding their cultivation while aiming at maintaining the functioning of these ecosystems in the long term. Indeed, the implementation of sustainable cultivation in these species depends not only on technical aquaculture knowledge, but also on knowledge of how environmental changes will affect the spatial and temporal distribution of genetic diversity and the processes of local adaptation. We have chosen to focus our study on several exploited and / or cultivated species of major ecological importance: Laminaria digitata (traditionally harvested in Brittany), Saccharina latissima (an emerging model for aquaculture

in Brittany and Europe) and Macroscystis pyrifera (an emerging model for aquaculture in Chile and along the Eastern Pacific coast.)

Several complementary approaches will be implemented to fulfil the objective of this PhD project.

Spatial and temporal variation of genetic diversity and life history traits (reproductive system, life span and age of reproduction) will be studied to estimate the evolution of the three kelp populations under different anthropic pressures The importance of local adaptation will be assessed not only by measuring genetic and ecological differences among populations along the species range distribution but also by cross-breeding experiments aimed at estimating the strength of reproductive barriers. These approaches will lead to the proposition of genetic improvement strategies adapted to the ecoregions where the crops grow ("landraces"). They will also determine the spatial scale at which sustainable management measures for biodiversity can be implemented.

Ecological divergence between populations occupying different habitats will be evaluated experimentally in terms of responses to abiotic factors (temperature and light) and in terms of survival, fertility and photosynthetic efficiency. As the ecophysiological and ecological characteristics of brown algae differ throughout their life cycle (in particular between gametophytes and sporophytes), these life-cycle specificities will be taken into account. Collections of gametophytes grown in Roscoff and Santiago from 10 to 20 populations for each of the three species have already been established to test local adaptation along each species range. Common protocols are being developed within BIODIVERSA-MARFOR and FONDECYT-Macrocystis to test temperature effects on reproduction and survival of gametophytes and sporophytes. These protocols will be available at the beginning of the thesis. The PHD student will thus be able to explore the role of haploid and diploid phases in ecological responses.

Population genetic tools will be used to carry out spatial and temporal analyzes. Twelve to thirty microsatellite markers (depending on the species) are commonly used by the two host teams for genotyping (Robuchon et al, 2014; Guzinski et al, 2016; Alberto et al, 2009). The microsatellite data obtained by the PhD student will be compared with previous data for temporal analyses of genetic diversity.

In order to test the importance of adaptive divergence on reproductive isolation, crosses will be carried out between genetically and ecologically differentiated populations. The two host teams have already acquired a solid experience in the production of crosses in large brown algae, in particular for the estimation of pre- or post-zygotic barriers measured in the early stages of sporophyte development (Oppliger et al. 2014).

The ideal candidate should have a Master degree and a background in evolutionary genetics and ecology and a strong interest in conservation genetics. Knowledge of the field of plant breeding would be appreciated. Deadline for application: 15th of July 2017.

Literature cited

Alberto F, Whitmer A, Coelho NC, et al. (2009) Microsatellite markers for the giant kelp Macrocystis pyrifera. Conservation Genetics 10, 1915-1917**.**

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Raybaud, V., G. Beaugrand, E. Goberville, G. Delebecq, C. Destombe, M. Valero, D. Davoult, P. Morin, and F. Gevaert. 2013. Decline in Kelp in West Europe and Climate. PLoS One **8**:e66044.

Robuchon, M., L. Le Gall, S. Mauger, and M. Valero. 2014. Contrasting genetic diversity patterns in two sister kelp species co-distributed along the coast of Brittany, France. Molecular Ecology **23**:2669-2685.