Impacts of Marine and Lagoon Aquaculture on Macrophytes in Mediterranean Benthic Ecosystems

Charles-François Boudouresque1*, Aurélie Blanfuné1, Gérard Pergent1, Christine Pergent-Martini2, Michèle Perret-Boudouresque1 and Thierry Thibaut1

1 Aix Marseille Univ., Université de Toulon, CNRS, IRD, MIO UM 110, Marseille, France, 2 Università di Corsica Pasquale Paoli, Corte, France

The direct and indirect impact of fish farms, shellfish aquaculture, and extensive forms of aquaculture such as seeding of juvenile sea urchins, on macrophytes (seaweeds and seagrasses), is reviewed in Mediterranean benthic ecosystems. Fish farms constitute a source of organic matter and nutrients (food and fecal pellets) that causes the extirpation of *Posidonia oceanica* seagrass meadows beneath and near to farm facilities. In addition to direct effects, the nitrogen enrichment of macrophytes tissues increases the grazing pressure by herbivorous fishes and sea urchins. In some cases, the impact can continue to increase several years after the cessation of farming activities. Natural restoration of extirpated seagrass meadows is generally unlikely at the human time scale. Shellfish aquaculture is the cause of the main flow of introduced macrophytes in the Mediterranean; the main vector is the importation of oyster spat from Japan and Korea. North-eastern Pacific seaweeds are now the dominant biotic component of some Mediterranean lagoons (e.g., Thau, Mar Piccolo, and Venice lagoons). In addition to direct effects, mussel aquaculture can constitute a source of larvae that flow with currents, the adults of which can overwhelm seaweed forests (e.g., *Carpodesmia mediterranea*). Shellfish aquaculture is also a source of fecal pellets, resulting in changes in bottom macrophytes, and a vector of diseases of metazoans, the extirpation of which may change the functioning of recipient macrophyte ecosystems. The edible sea urchin *Paracentrotus lividus* is sometimes erroneously considered as in decline due to over-harvesting. However, its abundance in the second half of the 20th century was probably a consequence of human impact (overfishing of its predatory fish, organic pollution. This man-induced proliferation resulted in the extirpation of seaweed forests (e.g., *Carpodesmia* spp., *Treptacantha* spp. – formerly *Cystoseira* spp. – *Sargassum* spp.; many species are endemic), which play a key role in Mediterranean coastal ecosystems. Therefore, the attempts to restore sea urchin abundance, via seeding of juveniles from hatcheries, has further artificialized the habitats rather than contributing to the restoration of natural ecosystems. Good practices guidelines are proposed aimed at minimizing the impact of aquaculture on macrophytes.

Keywords: aquaculture, fish farms, macrophytes, mediterranean, *Paracentrotus lividus*, shellfish culture