

# CIESM ATLAS OF EXOTIC MACROPHYTES IN THE MEDITERRANEAN SEA

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## Abstract

The CIESM Atlas of Exotic Species covers the marine macrophytes. A total of 110 species (22 Chromobionta, 71 Rhodobionta, 16 Chlorobionta and 1 Magnoliophyta) are listed. Several other exotic species only known on the NE Atlantic coast are listed in the Annex. The kinetics of species introduction into the Mediterranean Sea is exponential since the late 19<sup>th</sup> century. As far as the number of introduced macrophytes is concerned, the main donor area is the Indo-Pacific region, and the main vectors of introduction are the shellfish aquaculture, followed by the ship traffic and the Suez Canal. Diagnostic features, biological information, references and a distribution map are given for each species.

**Keywords :** *Algae, Species Introduction, Suez Canal, Aquaculture.*

The CIESM Atlas of Exotic Species is the first attempt to provide a comprehensive, group by group, survey of recent marine "immigrants" in the Mediterranean Sea, which is witnessing drastic and rapid changes in its biota. The present volume, which follows the publication of the first three Atlases (Fish, Crustaceans decapods/stomatopods and Molluscs), covers the marine macrophytes. As far as Macrophytes are concerned, the Mediterranean is the sea harbouring the greatest number of exotic species worldwide. In this volume, we drew a list as broad as possible of the exotic macroflora on the basis of recent checklists and unpublished data [1-6], considering as "exotic" a species being a relative newcomer to the Mediterranean Sea (e.g.: not having appeared before 1869, date of the opening of the Suez Canal, for species originating from the Red Sea). Several species reported before this date and assumed to be native by some authors [2] (e.g.: *Asparagopsis taxiformis*) have nevertheless been included because recent and fast changes in their Mediterranean distribution give evidence to a recent introduction of either a cryptic species similar to the Mediterranean one or an exotic genotype from remote population. A total of 110 species (22 Chromobionta, 71 Rhodobionta, 16 Chlorobionta and 1 Magnoliophyta) constitute the main core of this CIESM Atlas. Considering the high risk of secondary introduction into the Mediterranean Sea of exotic species present on the NE Atlantic coast, 12 other exotic species until now unknown in the Mediterranean are briefly listed in the Annex. Each species is classified within the following categories according to the likelihood of being introduced: very high (introduction with no doubts); high (introduction likely); medium (introduction debatable). Presumed not-established and established species in the basin are distinguished as having either only one record in the scientific literature, or self-maintaining populations (minimum of two published records from either different localities or in different periods).

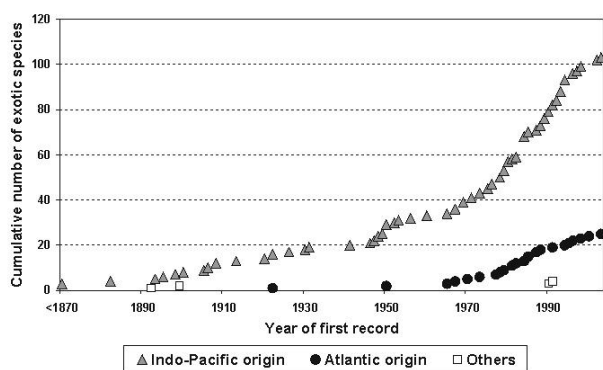


Fig. 1. Arrivals of exotic macrophytes species in the Mediterranean through the late 19<sup>th</sup> and the 20<sup>th</sup> century according to the first year of collection (by default, year of publication).

In the Mediterranean Sea, the introduction of macrophytes may result from a variety of causes (vectors): transportation of species on the hulls of ships and offshore structures (fouling) (e.g.: *Antithamionella* spp.), deballasting of waters and solid matters transported by ships, opening of the Suez Canal (e.g.: *Stypopodium schimperi*), importations of aquaculture species from native regions, then transfers between basins (e.g. the exotic flora introduced along with the importation of *Crassostrea gigas*

from Japan in the 1970s), accidental escapes from public and private aquaria (e.g. *Caulerpa taxifolia*), and releases of species used as packing material of fishing baits (e.g. *Fucus spiralis*). Lastly, some epiphytic species have certainly arrived on their exotic host (e.g.: *Acrochaetium* spp.). Once introduced, an exotic species can spread by one or several of the previous vectors but also via other human activities as fishery and ship traffic, entangled with the anchorages and fishing engines (e.g. *Caulerpa* spp.). Transportation of fixed organisms on ship hulls is certainly the most ancient vector of species introduction in the marine realm. The relative importance of this vector has actually decreased with time and, nowadays, one might suppose that most of the macrophytes that were potential candidates for introduction via fouling have been already introduced. Ballast waters seem to play a minor role as a vector for introduction of macrophytes but not as a secondary dispersal vector (e.g. *Caulerpa* spp.). The main vector of introduction is shellfish aquaculture, followed by ship traffic and the Suez Canal. Multiple introductions via different vectors (e.g. fouling, ballast waters and aquaculture) are probable for several species (e.g.: *Codium fragile*).

The kinetics of species introduction into the Mediterranean Sea is exponential since the beginning of the late 19<sup>th</sup> century, and the main donor area is the Indo-Pacific region (Fig. 1). The marked upsurge in the introductions in the 1970s results from accidental introductions along with massive importations of Japanese Oysters from Asia. This exponential trend was probably also accentuated by the intensification of research efforts in marine invasions since the *Caulerpa taxifolia* event. In the future new records will need to be added to those presented in this volume. These changes will be documented in the electronic version of this Atlas, to be found on the CIESM website at <w.w.w.ciesm.org/atlas/macrophytes.html>.

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