Caulerpa taxifolia

Taxon	Family / Order / Class / Phylum
Caulerpa taxifolia (M. Vahl) C. Agardh, 1817	Caulerpaceae / Bryopsidales / Bryopsidophyceae / Chlorophyta

COMMON NAMES (English only)
Caulerpa
Killer alga

SYNONYMS
Fucus taxifolius Vahl, 1802

SHORT DESCRIPTION
A green macroalga with upright leaf-like fronds arising from creeping stolons. The fronds are compressed laterally and the small side branchlets are constricted at the base (where they attach to the midrib of each frond), are opposite in their attachment to the midrib and curve upwards and narrow towards the tip. Frond diameter is 6-8 mm and frond length is usually 3-15 cm in the shallows, 40-60 cm in deeper waters.

Close-up of *Caulerpa taxifolia*
Photo: www.iptek.net.id

BIOLOGY/ECOLOGY

Dispersal mechanisms
Fragments are transported by anchors or nets, or with natural currents.

Reproduction
Sexual reproduction remains unknown, because only male gametes are formed. It also reproduces vegetatively via fragmentation. During summer (June to September) the thallus of the aquarium strain attains extreme growth rates of up to 32mm of new stolon per day and a new frond every other day (month of August), resulting in frond densities of approximately 5000 fronds/m^2

Known predators/herbivores
Marine herbivores such as fish, sea urchins, gastropods.

Resistant stages (seeds, spores etc.)
The alga can survive out of water and under humid conditions for up to 10 days.

HABITAT

Native (EUNIS code)
A2 Littoral sediments, A4: Sublittoral sediments. Marine sublittoral soft.

Habitat occupied in invaded range (EUNIS code)
A2: Littoral sediments, A3: Sublittoral rock and other hard substrata, A4: Sublittoral sediments. Marine sublittoral, dense coverage between depths of 1 to 35m, small patches as far down as 100m. On a wide variety of substrates, including sandy bottoms, rocky outcroppings, mud, sheltered bays, seagrass meadows, and artificial substrates (concrete jetties, metal buoys, rubber bumpers, pipes, plastic lines, ship and nylon ropes).

Habitat requirements
It is able to withstand severe nutrient limitation as well as eutrophic or polluted conditions.

DISTRIBUTION

Native range

Caribbean coasts, Gulf of Guinea, Red Sea, East African coast, Maldives, Seychelles, northern Indian Ocean coasts, southern China Sea, Japan, Hawaii, Fiji, New Caledonia and tropical/sub-tropical Australia.

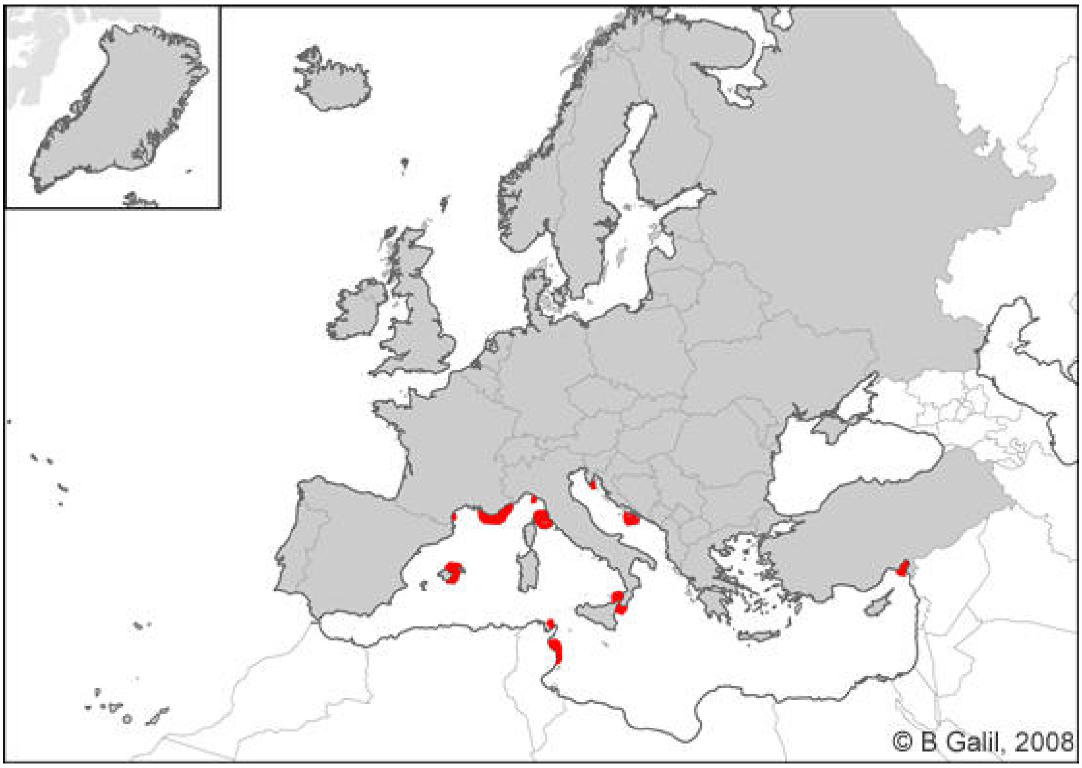
Known Introduced Range

Mediterranean Sea.

Trend

In 1984 a patch about $1m^2$ was discovered at the base of the Oceanographic Museum in Monaco. In 1989 the area affected extended to 1 ha. In 1990 the alga spread along the south-eastern coast of France, and by the following year it was found near the Spanish border. In 1992 the alga was found along the Ligurian coast, and off the Balearic Island of Majorca (Spain). In 1994, it spread to Elba and Messina in the strait of Sicily (Italy). In 1995 it was reported from Croatia, in the Adriatic Sea. In 2000 it was sighted at Sousse (Tunisia). By the end of the 1990s it was dominating large patches along the Mediterranean coastline.

MAP (European distribution)



Legend

	Known in country		Known in CGRS square		Known in sea

INTRODUCTION PATHWAY

Widely available through the aquarium trade, it was unintentionally introduced into the Mediterranean in 1984, by the Musée Océanographique de Monaco with aquaria outflow. Secondary spread takes place by shipping and currents.

IMPACT

Ecosystem Impact

Its rapid spread, high growth rate, and its ability to form dense meadows (up to 14,000 blades per m^2) on various infralittoral bottom types, especially in areas plagued by higher nutrient loads, leads to formation of homogenized microhabitats and replacement of native algal species. It reduces species richness of native hard substrate algae by 25-55%, and, under certain conditions, outcompetes *Cymodocea nodosa* and *Posidonia oceanica*. The alga's dense clumps of rhizomes and stolons form an obstruction to fish feeding on benthic invertebrates. Caulerpenyne, the most potent of the endotoxins protecting this macroalgae against epiphytes and herbivores, is toxic to molluscs, sea urchins, herbivorous fish, at least during summer and autumn.

Health and Social Impact

Economic Impact

MANAGEMENT

Prevention

Legislation on controlling practices of aquarium trade, shipping, and mariculture is necessary.

Mechanical

Manual uprooting, different underwater suction devices, physical control with dry ice, hot water jets and underwater welding devices to boil the plant have been suggested. Except for a few failed eradication attempts made at the onset of the invasion, no control strategy has been established.

Chemical

Intervention utilizing household bleach (chlorine) and other chemicals (Cu and Al salts) have been suggested to halt the spread of this invasive species.

Biological

Studies were conducted on biocontrol via potential predator ascoglossans (Mollusca).

REFERENCES

Boudouresque CF, Bellan-Santini D, Belsher T, Duclerc J, Durand-Clement M, Francour P, Harmelin-Vivien M, Henocque Y, Meinesz A, Pesando D, Pietra F, Verlaque M (1992) The introduction of the green alga *Caulerpa taxifolia* into the Mediterranean: the repercussions for the indigenous communities. Mésogée 52:88-89

Boudouresque CF, Meinesz A, Ribera MA, Ballesteros E (1995) Spread of the green alga *Caulerpa taxifolia* (Caulerpales, Chlorophyta) in the Mediterranean: possible consequences of a major ecological event. Scientia Marina 59(Suppl. 1):21-29

www.algaebase.org

OTHER REFERENCES

Bellan-Santini D, P.M. Arnaud, G. Bellan, Verlaque M (1996) The influence of the introduced tropical alga *Caulerpa taxifolia*, on the biodiversity of the Mediterranean marine biota. Journal of the Marine Biological Association of the United Kingdom 76:235-237

Boudouresque CF, Meinesz A, Verlaque M, Knoepffler-Peguy M (1992) The expansion of the tropical alga *Caulerpa taxifolia* (Chlorophyta) in the Mediterranean. Cryptogamie, Algologie 13(2):144-145

Ceccherelli G, Cinelli F (1997) Short-term effects of nutrient enrichment of the sediment and interactions between the seagrass *Cymodocea nodosa* and the introduced green alga *Caulerpa taxifolia* in a Mediterranean bay. Journal of Experimental Marine Biology and Ecology 217:165-177

Ceccherelli G, Cinelli F (1998) Habitat effect on spatio-temporal variability in size and density of the introduced alga *Caulerpa taxifolia*. Marine Ecology Progress Series 163:289-294

Ceccherelli G, Cinelli F (1999a) A pilot study of nutrient enriched sediments in a *Cymodocea nodosa* bed invaded by the introduced alga *Caulerpa taxifolia*. Botanica Marina 42:409-417

Ceccherelli G, Cinelli F (1999b) Effects of *Posidonia oceanica* canopy on *Caulerpa taxifolia* size in a north-western Mediterranean bay. Journal of Experimental Marine Biology and Ecology 240:19-36

Ceccherelli G, Cinelli F (1999c) The role of vegetative fragmentation in the dispersal of the invasive alga *Caulerpa taxifolia* in the Mediterranean. Marine Ecology Progress Series 182:299-303

Chisholm JRM, Jaubert JM (1999) Comments on the article of Olsen et al. (1998): Mediterranean *Caulerpa taxifolia* and *Caulerpa mexicana* (Chlorophyta) are not conspecific. Journal of Phycology 35: 438-440

Chisholm JRM, Jaubert JM, Giaccone G (1995) *Caulerpa taxifolia* in the northwest Mediterranean: introduced species or migrant from the Red Sea? Compte Rendu Hebdomadaire des Séances de l'Académie des Sciences. Paris. Série *D* 318D:1219-1226

de Vaugelas J, Meinesz A, Coquillard P, Hill D (1997) A computer simulation to evaluate the impact of *Caulerpa taxifolia* on Mediterranean biodiversity. Vie et Milieu 47(4):397-400

de Villèle X, Verlaque M (1995) Changes and degradation in a *Polidonia oceanica* bed invaded by the introduced tropical alga *Caulerpa taxifolia* in the north western Mediterranean. Botanica Marina 38:79-87

Delgado O, Rodríguez-Prieto C, Gacia E, Ballesteros E (1996) Lack of severe nutrient limitation in *Caulerpa taxifolia* (Vahl) C. Agardh, an introduced seaweed spreading over the oligotrophic northwestern Mediterranean. Botanica Marina 39:61-67

Ferla S, Tomasello A, Ferreri B, Fradà Orestano C, Calvo S (1994) Preliminary notes on epiphyte macroflora of *Caulerpa taxifolia* in the Straits of Messina. Giornale Botanico Italiano 128:1096-1098

Ganteaume A, Gobert J, Malestroit P, Ménager V, Francour P, Boudouresque C-F (1998) *In vitro* consumption of *Caulerpa taxifolia* (Chlorophyta) by accustomed and non-accustomed *Paracentrotus lividus* (Echinoid): seasonal variations. Journal of the Marine Biological Association of the United Kingdom 78:239-248

Jaubert JM, Chisholm JRM, Passeron-Seitre G, Ducrot D, Ripley HT, Roy L (1999) No deleterious alterations in *Posidonia* beds in the Bay of Menton (France) eight years after *Caulerpa taxifolia* colonization. Journal of Phycology 35:1113-1119

Jousson O, Pawlowski J, Zaninetti L, Meinesz A, Boudouresque C-F (1998) Molecular evidence for the aquarium origin of the green alga *Caulerpa taxifolia* introduced to the Mediterranean Sea. *Marine Ecology Progress Series* 172:275-280

Longpierre S, Robert A, Levi F. Francour P (2005) How an invasive alga species (*Caulerpa taxifolia*) induces changes in foraging strategies of the benthivorous fish *Mullus surmuletus* in coastal Mediterranean ecosystems. Biodiversity Conservation 14:365-376

Meinesz A, Boudouresque C-F (1996) Sur l'origine de *Caulerpa taxifolia* en Méditerranée. Compte Rendu Hebdomadaire des Séances de l'Académie des Sciences. Paris. Série D 319:603-613

Meinesz A, Hesse B (1991) Introduction et invasion de l'algue tropicale *Caulerpa taxifolia* en Méditeranée nord-occidentale. Oceanologia Acta 14:415-426

Meinesz A, Benichou L, Blachier J, Komatsu T, Lemée R, Molenaar H, Mari X (1995) Variations in the structure, morphology and biomass of *Caulerpa taxifolia* in the Mediterranean Sea. Botanica Marina 38:499-508

Meinesz A, de Vaugelas J, Hesse B, Mari X (1993) Spread of the introduced tropical green alga *Caulerpa taxifolia* in northern Mediterranean waters. Journal of Applied Phycology 5:141-147

Meusnier I, Valero M, Olsen J, Stam W (2004) Analysis of rDNA ITS1 indels in *Caulerpa taxifolia* (Chlorophyta) supports a derived, incipient species status for the invasive strain. European Journal of Phycology 39:83-92

Sant N, Delgado O, Rodríguez-Prieto C, Ballesteros E (1996) The spreading of the introduced seaweed *Caulerpa taxifolia* (Vahl) C. Agardh in the Mediterranean Sea: testing the boat transportation hypothesis. Botanica Marina 39:427-430

Thake B, Herfort L, Randone M, Hill G (2003) Susceptibility of the invasive seaweed *Caulerpa taxifolia* to ionic aluminium. Botanica Marina 46:17-23

Verlaque M, Fritayre P (1994) Modifications des communautés algales méditerranéennes en présence de l'algue envahissante *Caulerpa taxifolia* (Vahl) C. Agardh. Oceanologica Acta 17:659-672

Zuljevic A, Antolic B (2000) Synchronous release of male gametes of *Caulerpa taxifolia* (Caulerpales, Chlorophyta) in the Mediterranean Sea (Research Note). Phycologia 39:157-159

Author: B.S. Galil

Date Last Modified: November 6th, 2006