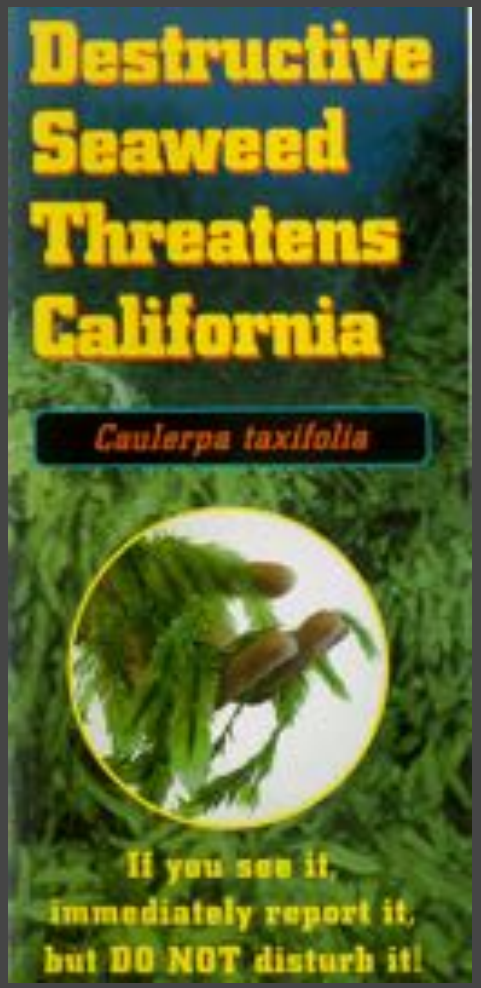
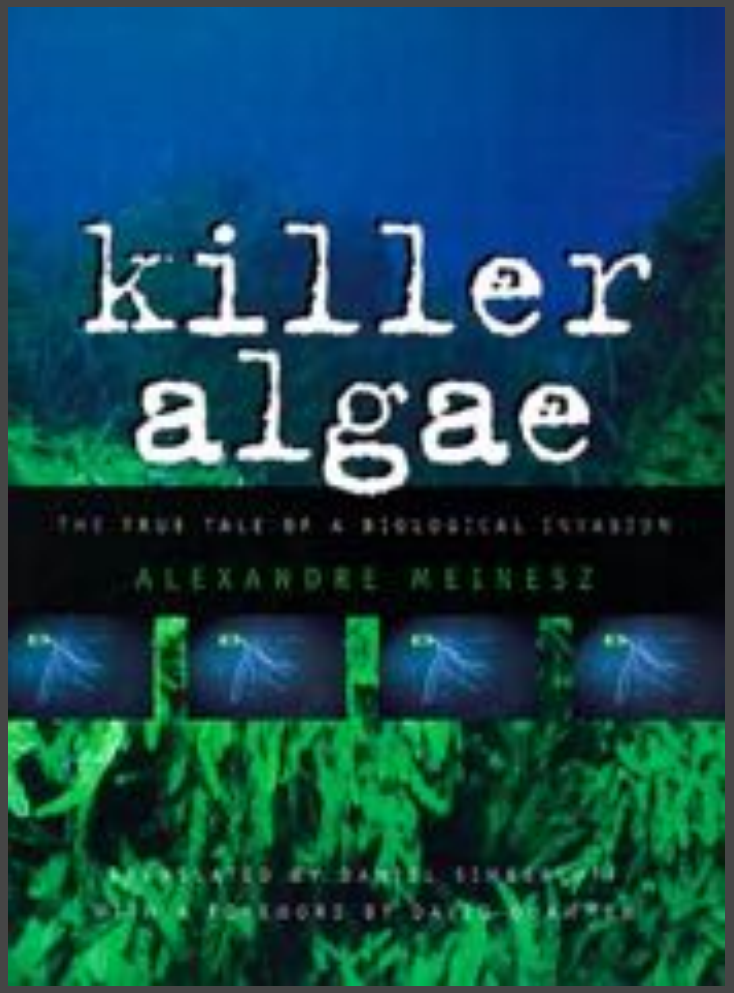
SEAWEEDS AND BIOINVASIONS





Little is known about invasive algae

- Lack of historic knowledge of marine flora
- Sea is a cryptic medium
- Known consequences of marine plants is lower than terrestrial

The latest assessment* of marine plants includes 189 exotic species:

100 Rhodophyta

42 Brown algae

21 Chlorophyta

15 Phytoplankton

11 Higher plants

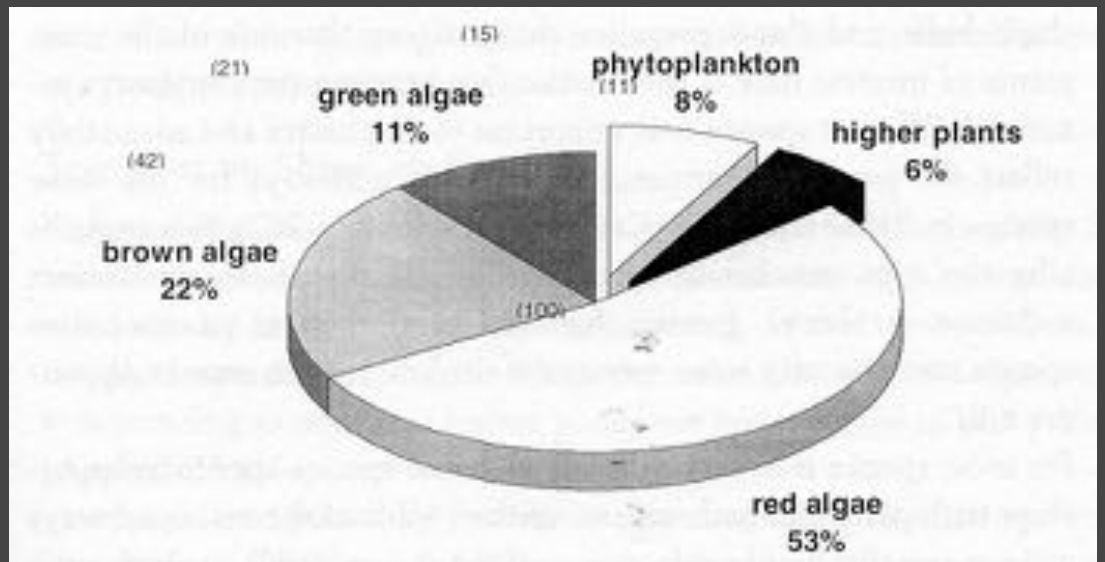
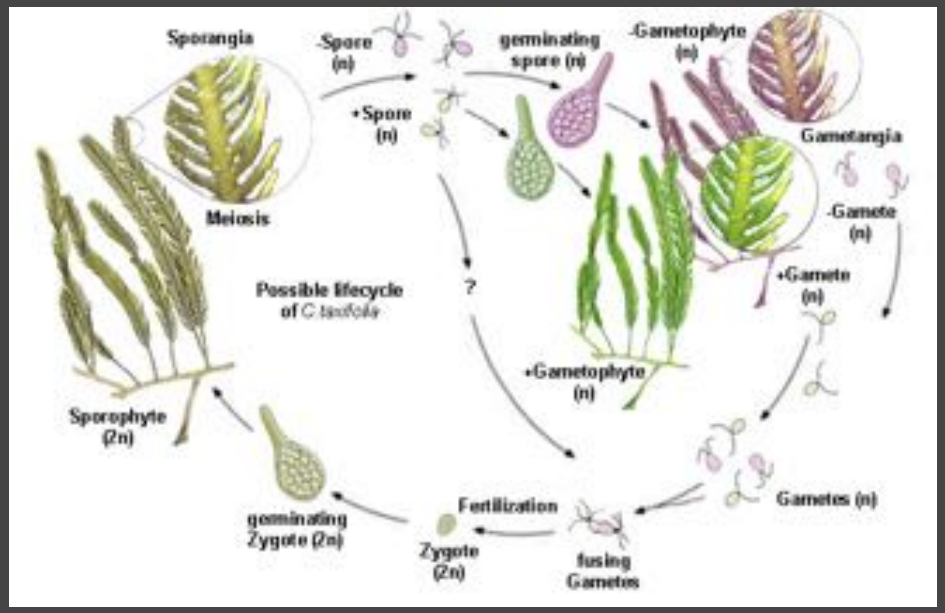


FIGURE 8.1. Number and percentage of nonnative species of marine plants, presented by systematic groups.

*Ribera 2003: Pathways of biological invasions of marine plants

An invasive species is defined as a species that fulfills all of the four following criteria

- it colonizes a new area where it was not previously present
- the extension of its range is linked to human activity
- there is a geographical or genetic discontinuity between its native area and the new area
- finally, new generations of the non-native species are born *in-situ* without human assistance, thus constituting self-sustaining populations: the species is established, i.e. naturalized.



Fragments of *C.taxifolia* drifting in Mediterranean waters

The two additional questions which warrant mentioning are:

- **why do some species become invasive and others not? and also,**
- **is it possible to predict the invasiveness of an introduced species?**

Several common features of invasive plants:

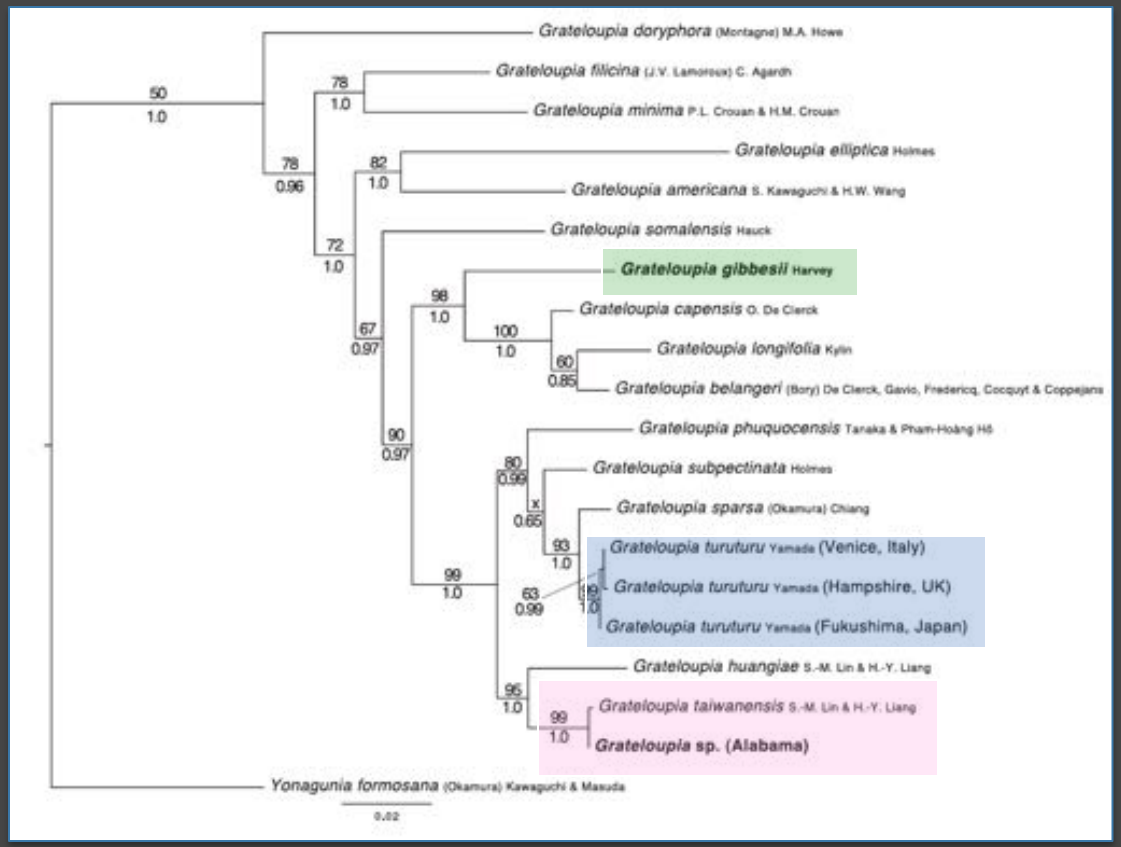
- vegetative reproduction is usually the commonest, and often the only method of reproduction
- vegetative reproduction is prolific
- habitat requirements are flexible
- they tolerate the stresses of environmental fluctuations and extremes
- there is a similarity between the native and recipient habitat
- they are free from predators and diseases typical of their native range

Sequencing of the *rbc*L Marker Reveals the Non-native Red Alga *Grateloupia taiwanensis* (Halymeniaceae, Rhodophyta) in Alabama

MICHAEL S. DE PRIEST AND JUAN M. LOPEZ –BAUTISTA

Gulf of Mexico Science 2012(1-2):7-13

- *Grateloupia* contains species that are known to be aggressively invasive, most notably *Grateloupia turuturu* Yamada
- *G. turuturu*, along with several other *Grateloupia* species, has been introduced in Italy, New Zealand, Great Britain, France, and the Atlantic coast of the United States
- Due to the difficulty and cost of stopping an invasive marine algal species—for example, the 2000 accidental introduction of the green alga *Caulerpa taxifolia* in California—efforts to prevent species introductions or to detect the presence of a potential species are imperative for conservation of native diversity



A very special *Grateloupia* from Alabama

Dissimilar to other Grateloupia from the Atlantic (*G. gibbesii* 6%)

However, 99.9% identical to *G. taiwanensis* from Taiwan

The first non-native species in the Gulf of Mexico, detected with molecular methods (by UA! Yay!!!)

Invasive features

From Asian origins

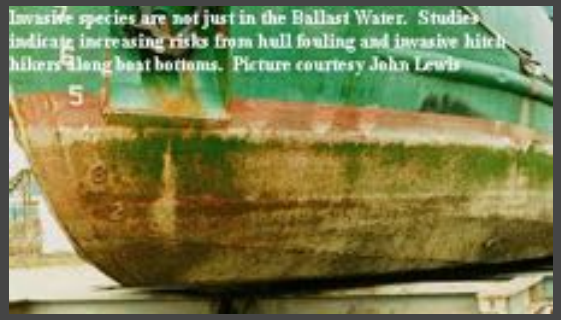
Main Pathways: patterns of invasion for marine plants

1. Marine Transport
2. Aquaculture Activities
3. Research Activities
4. Aquarium Trade
5. Fishing Activities
6. Opening Marine Canals

1. Marine Transport by ships is the greatest mechanism of global dispersal

•Transport on Ship's Hulls

- 39 marine plants (mostly Rhodophyta) have been dispersed by hull fouling. Many are small filamentous but some like Japanese *Undaria pinnatifida* (1 m length) have been observed on hulls
- In the Mediterranean many exotics are Ceramiaceae



This transport is probably the mechanism of transoceanic dispersal of *Codium fragile* subsp. *tomentosoides*

Native from Japan, found in Holland in 1900 and later in NY in 1957

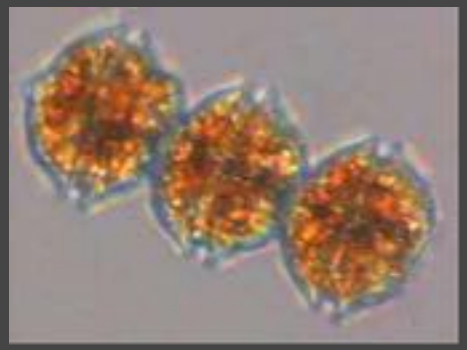
This invasive *Codium* is the cause for ecological and economic problems in the NE USA, reducing the abundance of local flora and natural fish refuges, deterring sea urchins, seashell industries, and attaching to anything!

"Dead man's fingers"

• Transport through Ships' Ballast

Volume of ballast water released into USA waters every year: 79 million metric tons

- 25 nonnative marine plants transported by this method
- 16 are phytoplankton (probably much more)
- 317 species recorded upon arrival from ballast water from Japanese ships in Oregon



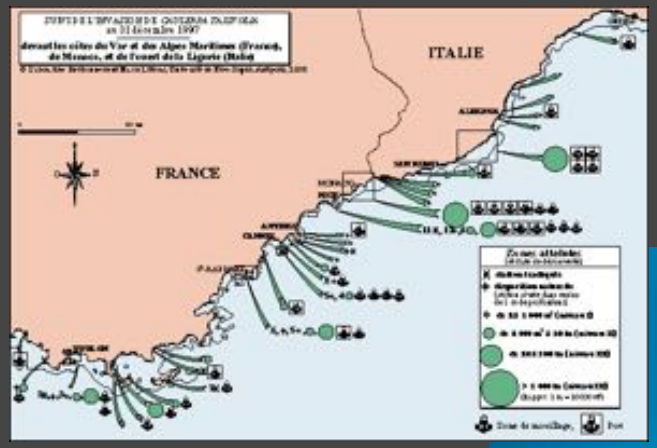
Common ballast water algae:
- Plankton species
- Resistance structures of life cycle (cysts, zygospores)
- Plants with vegetative reproduction (*Sargassum muticum)*

Sargassum muticum an invasive seaweed native from Japan, found in US west coast in 1945; recently in the North Atlantic in 1973; first seen in Denmark in 1984

• Transport by other parts of a Ship

Transport by adhesion to the propeller or anchor.

- Important in marginal rather than remote dispersal
- The dissemination of *Caulerpa taxifolia* across the Mediterranean is an example



2. Aquaculture Activities: 64 species were introduced

•Release into the Open Sea for Aquaculture purposes

- 15 nonnative species of marine plants (11 red and 4 brown algae) are used in aquaculture for experiments of as exploited resource
- *Laminaria japonica* (Japan) was introduced to China (1925) and Korea (1997). China is now the world's largest producer of *L. japonica*

•Escapes from controlled cultures

- *Undaria pinnatifida* escaped from culture in French Atlantic. Researchers thought this species will not survive and complete its life cycle because of water temperatures WRONG! Some did and now is a wild species

•Associated species with aquaculture transfer

- Accidental transfer of epibiota: Japanese oyster *Crassostrea gigas* transferred 29 red algae
- Sites of shellfish culture carry a high risk of transfer, they are "HOT SPOTS" in terms of number of exotic species! ……. Port of Mobile!!!!

3. Research Activities

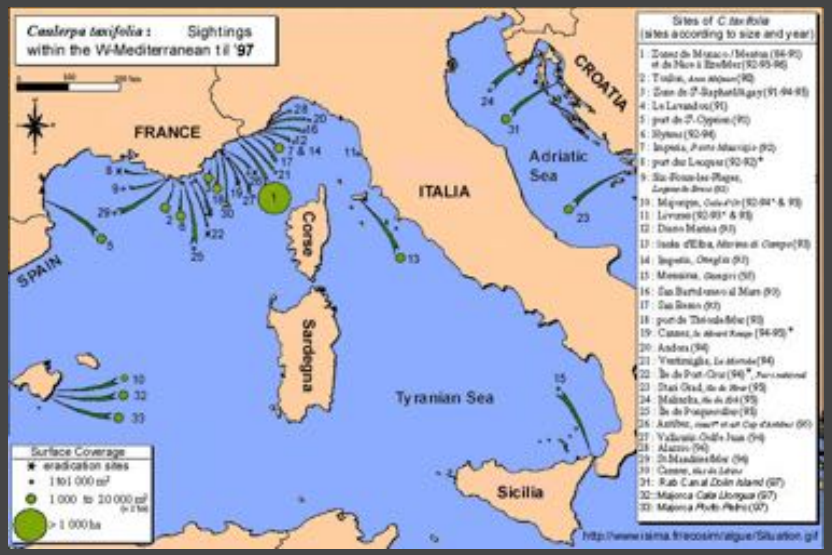
- Few species associated with this pathway
- Escapes from Laboratories
- Accidental release from discards

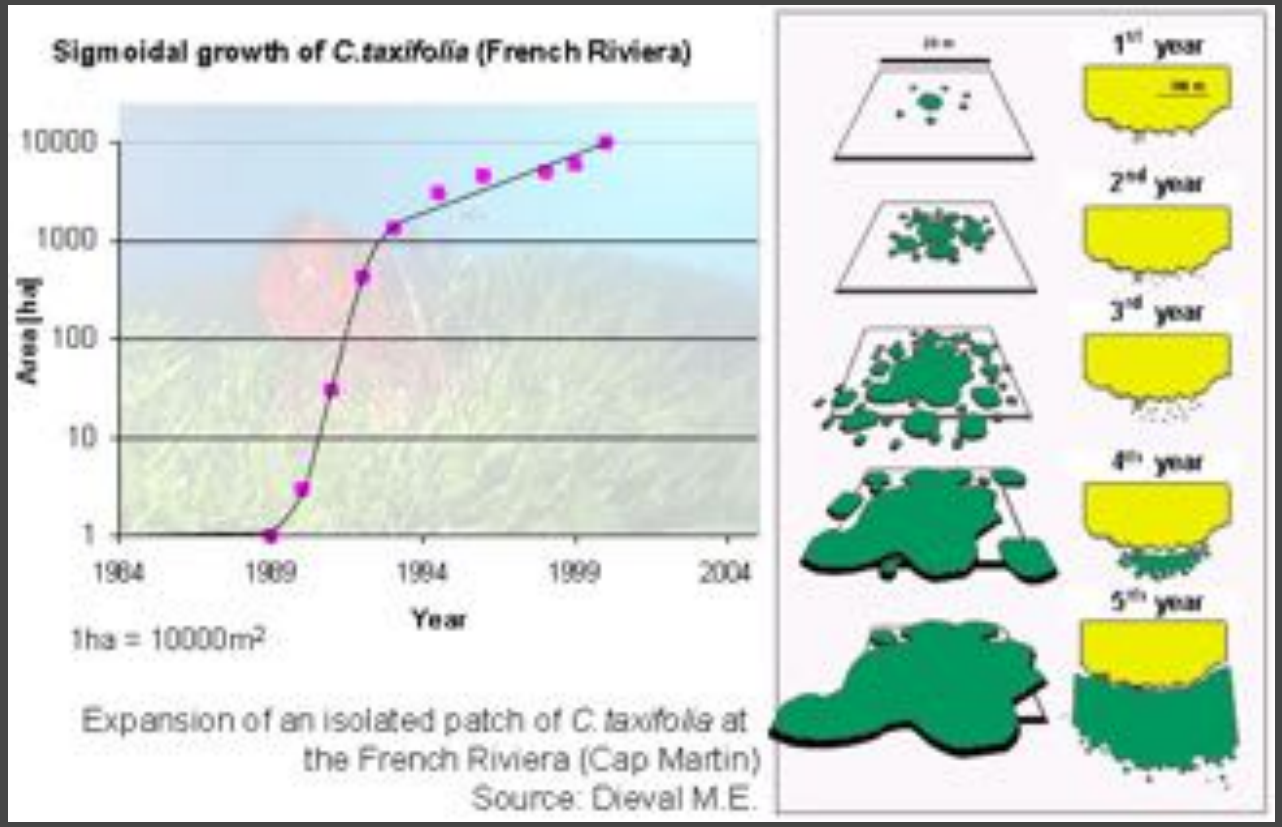
4. Aquarium Trade: Escapes from Public of Private Aquaria

In the Mediterranean Sea, the tropical alga *Caulerpa taxifolia* has been one of the most spectacular marine invasions; recorded since 1984 on the coasts of Monaco

- Today *C. taxifolia* is found along the coasts of five countries in the Northern Mediterranean (Monaco, France, Italy, Spain and Croatia) and 6,000 hectares have been affected by this invasion
- With genetic markers was detected that invasive samples have the same origin: the Wilhelma Zooligish-Botanischer Garden of Stuttgart (Germany)

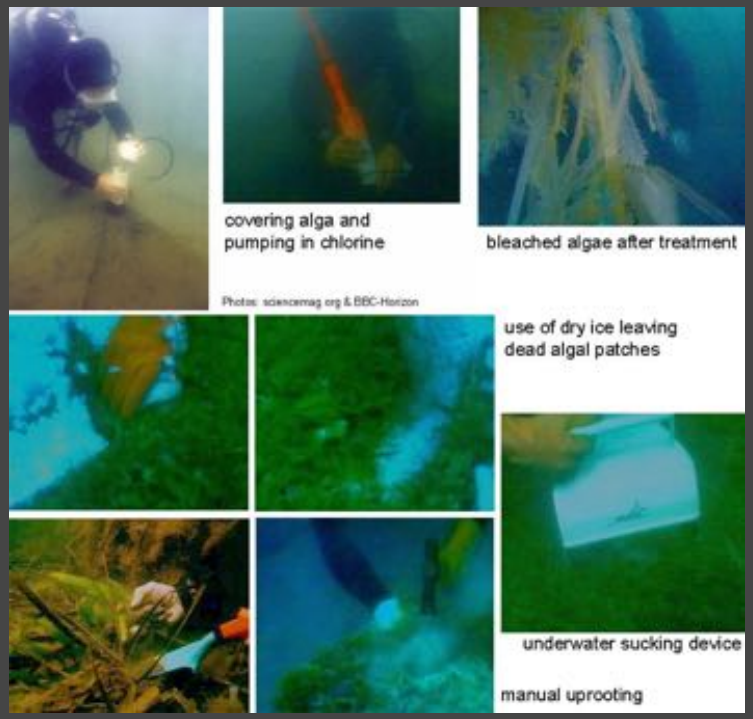
In 1980 this strain was given to the Tropical Aquarium of Nancy (French Atlantic coast) and from here to the Aquarium of Monaco (Mediterranean coast)


Caulerpa taxifolia : Sightings within the W-Mediterranean til '97
FRANCE
SPAIN
ITALIA
CROATIA
Adriatic Sea
Corse
Sardegna
Tyranian Sea
Sicilia
Surface Coverage
eradication sites
1 to 1 000 m²
1 000 to 10 000 m²
> 1 000 ha
Sites of C.taxifolia (sites according to size and year)
http://www.rama.free.com/algue/Situation.gif

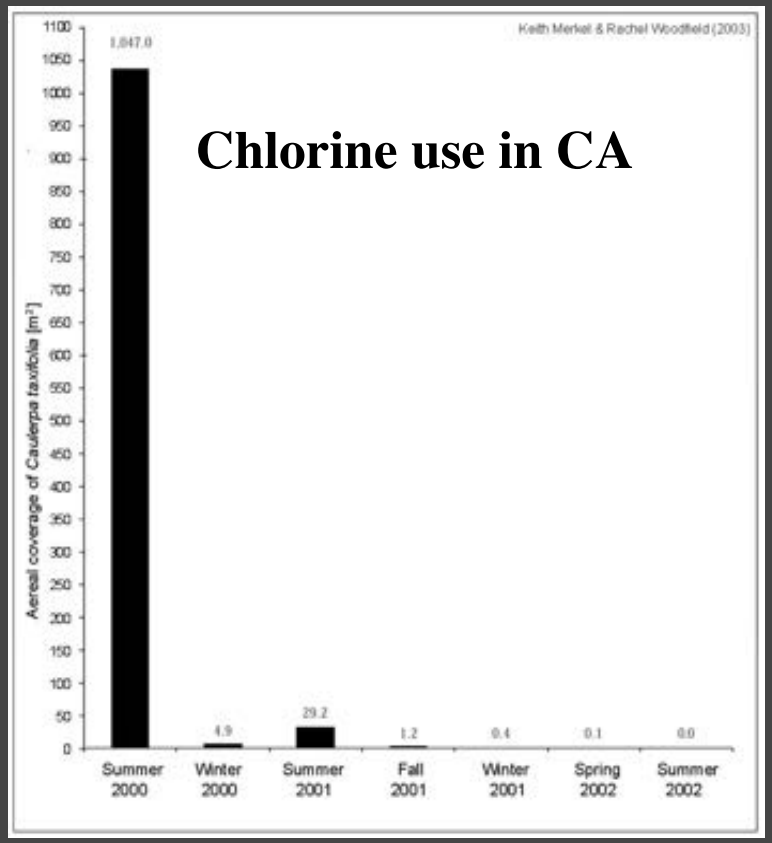

Sigmoidal growth of C.taxifolia (French Riviera)
10000
1000
100
10
1
Area [ha]
1984
1989
1994
1999
2004
Year
1ha = 10000m²
1st year
2nd year
3rd year
4th year
5th year
Expansion of an isolated patch of C. taxifolia at the French Riviera (Cap Martin)
Source: Dieval M.E.

- *C. taxifolia* colonize almost any surface down to 100 m depth
- Decreases diversity, density and biomass (especially of fish)
- Toxic substances can be magnified by grazers (mollusks) then to humans
- Impoverishment of local marine flora and invertebrates

•Possible control by manual uprooting, ascoglossan grazers, chemical (chlorine)



In 2000 *C. taxifolia* was reported on Australia, Southern Florida (Atlantic coast) (probably from native pantropical populations), and California coast



5. Fishing Activities: involves 6 species

Transport by fishing nets: *Codium fragile* subsp. *tomentosoides*

The use of plants to packing for bait, fish, and shellfish: *Fucus spiralis* and *Codium fragile* subsp. *tomentosoides*

***Codium fragile* meadow**

6. Opening Marine Canals

The best example: the opening in 1869 of the Suez Canal, linking two biogeographic marine provinces separated by several millions of years: the Mediterranean Sea and the Red Sea

- Some 200-300 species from the Red Sea have colonized the Mediterranean (15 red, 4 brown, 4 green algae and 1 higher plant)
- The Panama Canal, which links the Pacific and Atlantic Oceans, has resulted in the passage of a very limited number of euryhaline marine species

Summary notes:

a) Shellfish transport is main dispersal pathway for exotic species (30%) followed by ship fouling (24%) and then ballast (16%)

b) Oldest transport vector for marine plants: ship's hulls

c) The Mediterranean Sea contains the highest number of reported exotic marine plant species, followed by the European Atlantic coast

d) The rate of introduction of marine plants is increasing

e) The increasing rate of species introductions is linked to economic interests

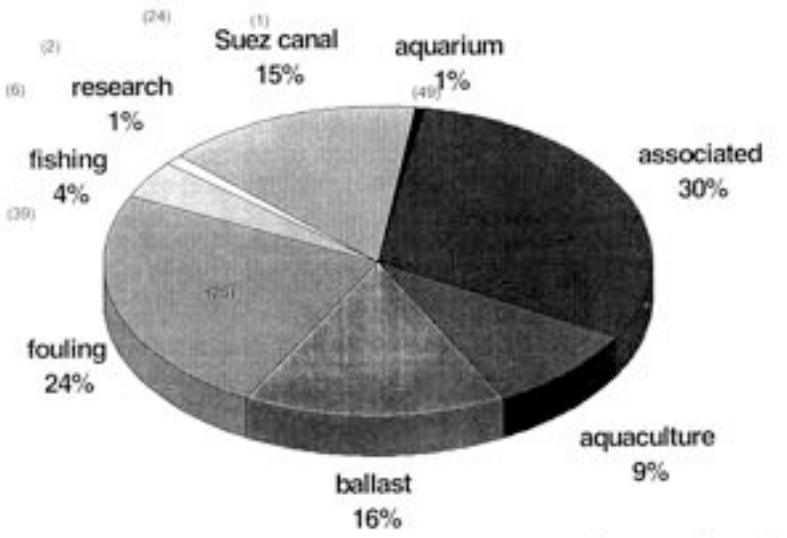


FIGURE 8.2. Number and percentage of nonnative species of marine plants introduced by each pathway.

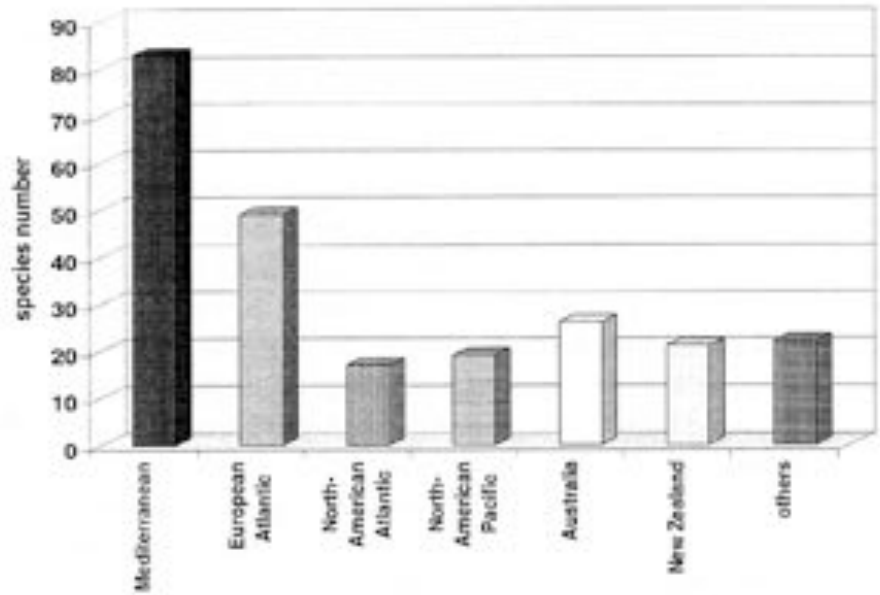


FIGURE 8.4. Diversity of nonnative species of marine plants in each geographical area.

Required readings for next class:

- Ribera 2003: Pathways of biological invasions of marine plants

- DePriest, M. and J. Lopez-Bautsita. In Press. Sequencing of the rbcL marker reveals the non-native red alga *Grateloupia taiwanensis* (Halymeniaceae, Rhodophyta)in Alabama. *Gulf of Mexico Science*, 2012 (1-2):7-13

Further reading:

- DePriest, M., Bhattacharya, D. and J. Lopez-Bautista. 2013. The plastid genome of the red macroalga *Grateloupia taiwanensis* (Halymeniaceae). PLoS ONE8(7)

- DePriest, S., Bhattacharya, D., and J. Lopez-Bautista. 2014. The mitochondrial genome of *Grateloupia taiwanensis* (Halymeniaceae, Rhodophyta) and comparative mitochondrial genomics of red algae. Biol. Bull. 227(2)