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Study of *Gelidium sesquipedale* overexploitation effects on *Sargassum muticum* proliferation of in El Jadida area, Morocco

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ABSTRACT: The proliferation of harmful algae in a marine environment is practically linked to human activities that are to be by overexploitation or pollution. Characteristics of the brown alga *Sargassum muticum* promote her ability to adapt and endure the harsh conditions in different parts of its distribution. This study indicates that the overexploitation of the red algae *Gelidium sesquipedale* causes an imbalance in the marine environment will be colonized by invasive alga *S. muticum*. Therefore, we must act quickly and rationally manage natural seaweed fields to avoid the invasion of the environment by harmful species.

KEYWORDS: harmful algae, human activities, invasion, pollution.

1 INTRODUCTION

Biological invasions in coastal marine habitats have been recognized as one of the main causes of biodiversity decline and changes in native populations, community dynamics, and major ecosystem processes (Grosholz 2002).

In certain number of marine sites, a higher biomass and more frequent harmful algae coincided with dramatic declines in commercial stocks of other species very important economic interest. We quote here the example of *Gelidium sesquipedale* (Clemente) Thuret which quantities collected decline each year leaving space either case to the new Japanese *Sargassum muticum* (Yendo) Fensholt species.

The Japanese seaweed *Sargassum muticum* was accidentally introduced into African waters and discovered for the first time in coastal waters Doukkala at African level (Sabour & al, 2013).

Algal blooms are a natural phenomena regulated by a certain number of environmental factors. However, overfishing accentuates the problem of harmful algal blooms by weakening the growth of other algae species. In association with abiotic factors, collectors' algae influence the development of algal biomass. Thus, when the activity is accentuated by poaching or increased fishing, harmful algal blooms easily. At present, the adverse effects of overfishing on the life cycle of algae contaminate coastal ecosystems, causing problems of coastal water quality and habitat loss.

The general objective of this research is to provide information needed to understand the linkages between Harmful Algal Blooms (*Sargassum muticum* case) and overexploitation of algae (*Gelidium sesquipedale* case) and present scientific evidence that the red algae overuse could contribute to the worsening of harmful algal blooms.

2 MATERIALS AND METHODS

2.1 *SARGASSUM MUTICUM* DESCRIPTION

Sargassum muticum (Yendo) Fensholt is a Japanese seaweed class Phaeophyceae. In her country, it is present on the coast bathed by the warm waters of the current "Kuroshio" south and east "Tsushima" west (Critchley, 1983) and in China Sea. It is located on semi-beaten quiet mode, at the infralittoral superficial. The first proliferation observed (Sabour & al., 2013) on the Moroccan Atlantic coast in the coastal Doukkala.

Like all algae of the genus Sargassum, *Sargassum muticum* is fixed by a basal disc and carries air-carrying vesicles pedicelled. The frond has a complex morphology resembling that of higher plants (Fig. 1). Seaweed has one or more principal axes from which primary and secondary branches are born. Of these branches, there foliaceous organs sometimes with a rib nickname, cylindrical containers pruned tip and pedicellate, aerocystes, pedicelled and spherical vesicles located in the lateral position.

Its systematic classification is as follows: Class: Phaeophyceae, Subclass: Cyclosporeae, Order: Fucales, Family: Sargassasseae, Genre: Sargassum, Species: muticum.

2.2 STUDY AREA

This part of research was conducted in the area of Sidi Bouzid Moroccan Atlantic coast.

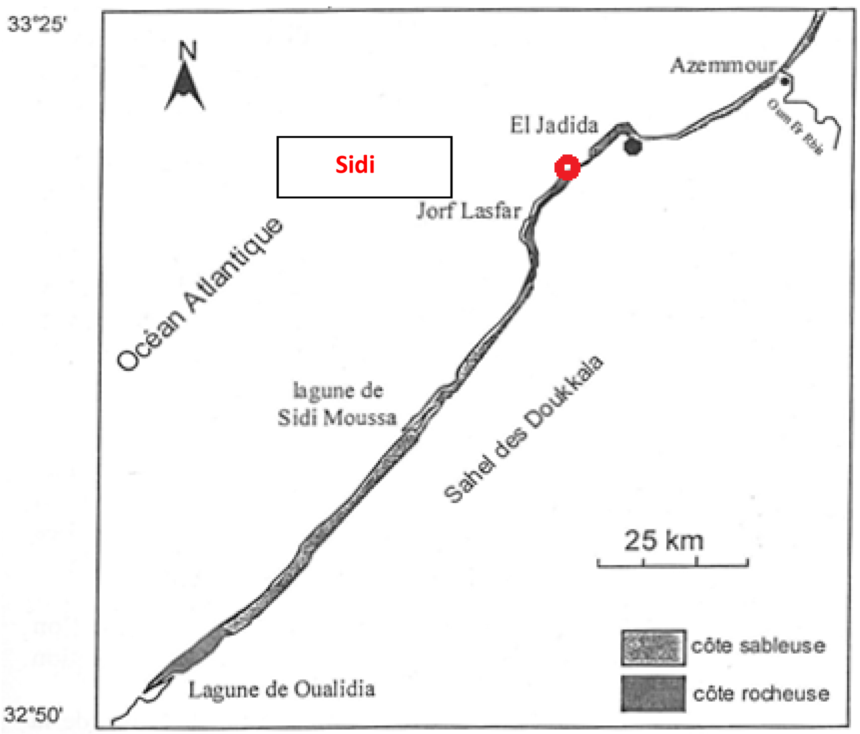

Fig. 1. Location of sampling site

2.3 SAMPLING METHODS

Sampling of this kind was carried out along an annual cycle from January 2013 until December 2013. We file randomly on a different point quadrat covering the entire study site. Determining the coordinates of each sampling point was determined by GPS (Garmin 72) and a photo was taken for verification of coverage of the species *Sargassum muticum* and *Gelidium sesquipedale*.

2.4 Parameters studied

During this research we determined the abundance of *Sargassum muticum* species in the study station. The study of the ecology of this species has also been started in this part of research.

The parameters taken into account are the index of overall algal cover (% of plant cover occupied by the reference species) (RR) according to the scoring grid below (Table 1). The principle of this grid is based on the disappearance of the reference species under the effect of increasing of eutrophication level and on species richness. At the monitoring station, each color corresponds to a state defined by the level of eutrophication, bad to very good for a given species.

Table 1. Classification grid of recovery algae index present in the quadrats

Percentage	Cover index	Qualification
0-5%	1	**Bad**
5-25%	2	**Mediocre**
25-50%	3	**Medium**
50-75%	4	**Good**
75-100%	5	**Very good**

-**Very good**: the reference species dominate (≥ 75%), opportunistic algae blooms may be present very locally. Diversity is satisfactory.

-**Good**: the reference species dominate (50-75%), opportunistic algae proliferate locally with the possibility of exceptional anoxic crises. Diversity is satisfactory.

-**Medium**: the reference species no longer dominate (between 5 and 50%) but are present, opportunistic species proliferates locally with local but recurrent anoxic crises. Diversity is satisfactory.

-**Mediocre**: the reference species are very poorly represented (<5%), opportunistic species do not dominate continuously but their abundance can lead to general anoxia. Diversity is reduced.

-**Bad**: the reference species are absent, only opportunistic species can grow with general and recurrent anoxic crises. Species richness is low.

3 Results

3.1 Morphology

The *S. muticum* plant, illustrated in Figure 2, is attached to the substratum by a perennial, conical, discoid holdfast up to 5 cm diameter. Occasionally smaller plants may be found attached to, or fused into, the holdfast of an adult plant. Germlings can settle simultaneously and their holdfasts can fuse, and one plant may become dominant and retard the development of the other plants by shading.

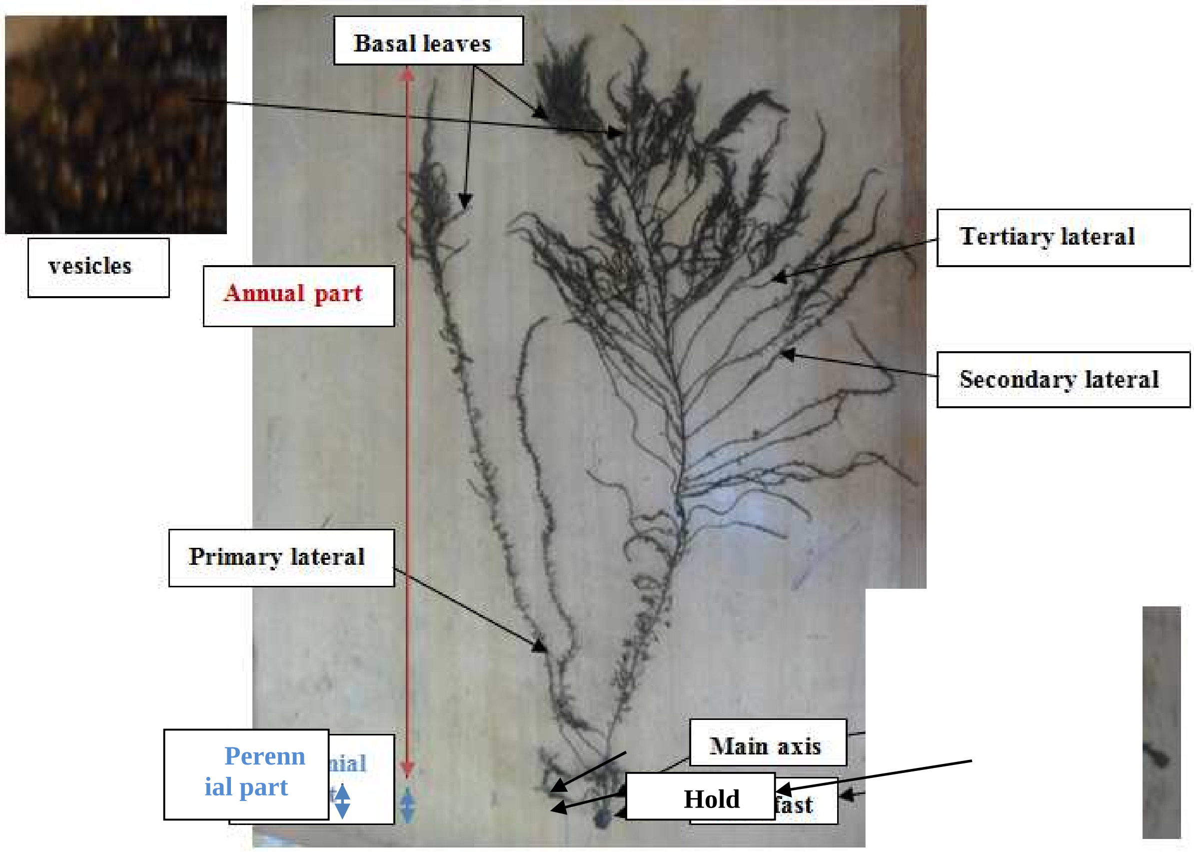

Fig. 2. The plant structure of Sargassum muticum.
(Nomination by Wernberg M., & al., 1998)

Thallus is more than 1 m high. Holdfast complanate discoid in shape, up to 1,5 cm diameter. Stem solitary on the hodfast, upriht, terete, 2-3 mm in diameter, up to 2 cm high, usually unbranched, sometimes once or twice branched in the upper part. Several main branches issued spirally from the terminal part of the stem. Main branch angular 2 mm wide. Lateral branches numerously developed. Leaves arranges spirally with a phyllotaxis of 215 on the main branch. Its leaves on lower part long of the main branch obovoid to long elliptical usually 2-3 cm and 3-4 mm wide. with entire or slightly serrulate margin. Midrib absent (Belsher T., 1989).

It's leaves on the upper part of the branch becoming smaller, cuneate or sometimes slightly hemiphyllous, with dentation in distal part. Cryptostomata Scattered on leaves and vesicles. Vesicles shortly stipitate. spherical or pyriform in shape up to 3 mm in diameter, with round or mucronate apex. Vesicles formed abundantly on lower part of lateral branches. Plant monoecious. Male and female conceptacles mixed in an androgynous receptacle. Receptaclie terete, shortly stipitate, tapering upwards, 10-12 mm long and 1 mm in diameter. Maturation period is in winter to early summer. This species grows on rocks rather protected from wave action in a zone from lower intertidal to upper subtidal (Belsher T., 1989).

3.2 *SARGASSUM MUTICUM* COVERAGE VARIATION

The figure below shows that the coverage (%) of *S. muticum* in the site of Sidi Bouzid reaches a maximum during June and it decreases from July. However, a very significant increase was noticed in the coverage of this species from August.

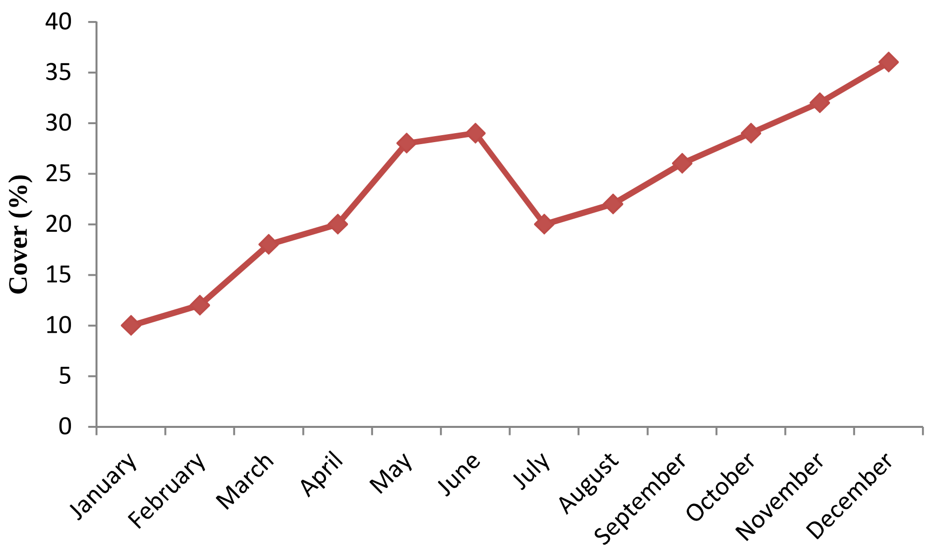

Fig. 3. Monthly change Sargassum muticum coverage

There is a very significant increase in this species coverage in August and September. This meant that there was correlation between the exploitation of *Sargassum muticum* and *Gelidium sesquipedale*.

3.3 CHANGE IN *GELIDIUM SESQUIPEDALE* COVERAGE

The evolution of *Gelidium sesquipedale* coverage in Sidi Bouzid site shows that it is high during April, May and June, then relapse during the collection of marine algae (July, August and September).

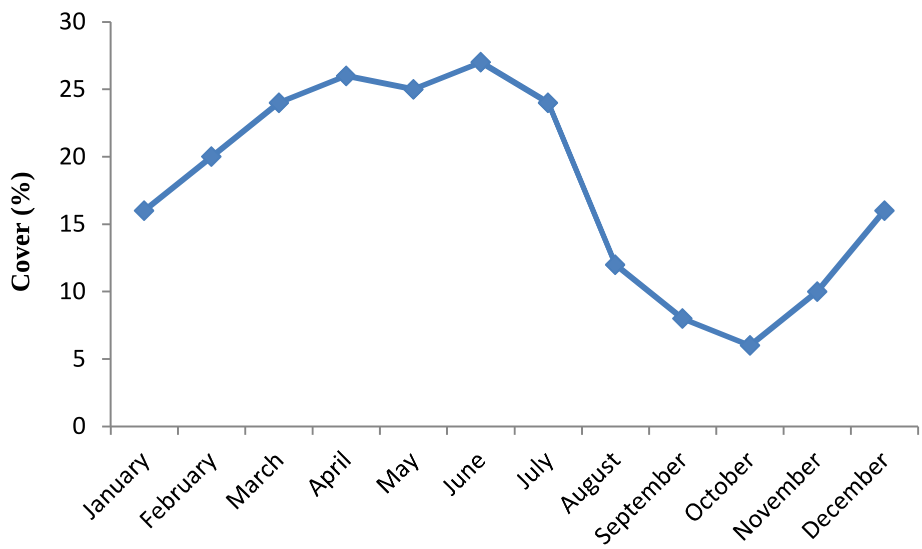

Fig. 4. Monthly change Gelidium sesquipedale coverage

3.4 COMPARISON BETWEEN *G.SESQUIPEDALE* AND *S. MUTICUM*

From the graph below, the decrease in coverage *G. sesquipedale* during and after the licensing campaign for the collection of this species promotes increasing coverage in *S. muticum*.

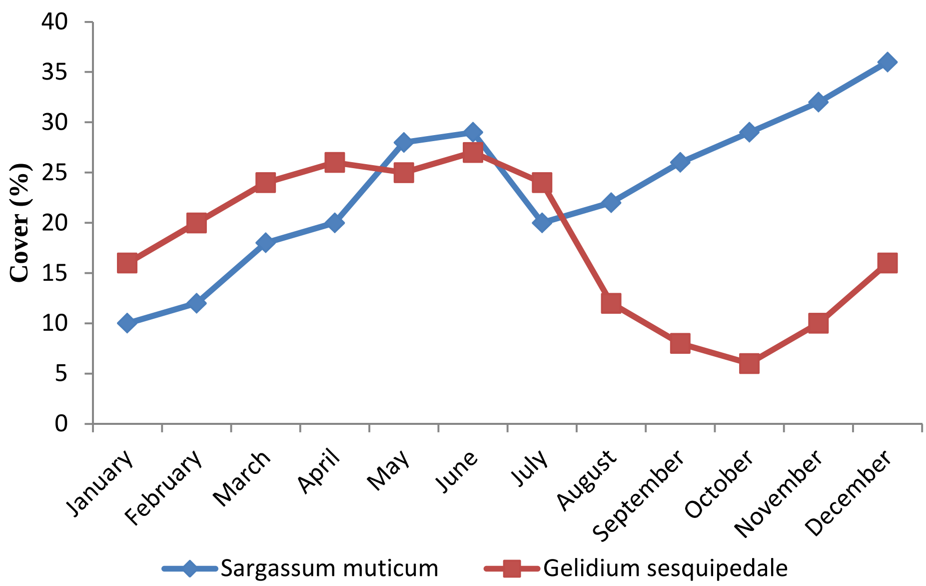

Fig. 5. Monthly coverage of Gelidium sesquipedale and Sargassum muticum in Sidi Bouzid station

4 DISCUSSION

The exploitation of *Gelidium* began to El Jadida in 1949, especially for the species *G. sesquipedale* that was abundant rejected wreck by the sea or on the rocks of mediolittoral. Today, during harvest periods, these are some thousands of needy trackside dwellers and hundreds of boats which carry an algal biomass exceeding 14000 tones defined by MPM (2010), generating a turnover exceeding 30 million dirham.

This species has an interesting agar yield of around 25-30% of the dry weight. It is the only Moroccan marine life; the law tries to protect the intense destructive exploitation. Today, it appears that the intrusion of Japan *Sargassum* in the area of predilection of *Gelidium* may represent a real threat to the latter. This is what we can call duel to the death; where *Gelidium sesquipedale* would hardly be able to push in its natural environment.

Various original morphological characters of *Sargassum muticum* were highlighted: free frond clustering, with marginal proliferations of the stud or branches from the trunk. These characteristics raise the problem of the determination of this polymorphic species. Fertile branches detached from the thallus may remain up to three months, even in difficult conditions of salinity and preserve their germination potential. Furthermore, *Sargassum muticum* has the opportunity to multiply vegetatively. Indeed, seaweed can regenerate a new frond from a single fragment with a meristem or a perennant basal disk. This vegetative propagation is related to the production of the apex phytohormones to the frond base. Dispersal of *Sargassum* may therefore be short distance through the zygotes and long distance through the fertile branches and vegetative multiplication. The presence of the dispersion promotes floats (Loraine I, 1989).

A study conducted by Levavasseur (1988) compared the pigment composition and photosynthetic activity of *Sargassum muticum* with other algal species present in our communities. The main results are as follows:

-In the spring at least, *Sargassum muticum* has a chlorophyll a among the highest; it seems that the fast-growing algae contain more chlorophyll than slow growth.

-In addition, *Sargassum muticum* would be less sensitive than other algae in summer photo-destruction of pigments.

-*Sargassum muticum* has a significant photosynthetic activity. The presence of aerocystes allows fronds grow well in the middle and even spread to the water surface, which allows them to capture the maximum of light energy.

The perennial holdfast, main stalk and basal leaves have the ability to regenerate rapidly when fronds are lost by natural senescence, physical damage or grazing, particularly in warmer waters (Davison D.M., 1996). If a primary lateral is damaged, one of the secondary laterals can effectively replace it. Herbivorous grazing damage has been observed to initiate the rapid maturation of the secondary lateral (Withers & al., 1975). Abscised laterals can continue to grow and become fertile while free-floating (Fletcher, 1975; Tsukidate, 1984). If receptacles are damaged, they can also regenerate and the process is most rapid in mature, zygote bearing receptacles (Hales & Fletcher, 1992).

Sargassum muticum semble donc être parmi les algues dont les potentialités physiologiques sont les plus aptes à assurer une forte productivité photosynthétique.

S. muticum is tolerant of a wide range of temperatures, 5 - 30^{o}C (Norton, 1977). It can survive short periods of freezing temperatures (Norton, 1977). High water temperatures are favorable for growth and this encourages southward spread while lower water temperatures tend to limit its spread north (Norton, 1977). It is tolerant of a wide range of salinities, 6.8 – 34 ‰, but at reduced salinities, growth rates are reduced (Norton, 1977). The ideal growth conditions are thought to be a temperature of 25^{o}C and a salinity of 34 ‰ (Eno & Clark, 1995).

So with all these features, *Sargassum muticum* can develop in different environments even under difficult conditions. According to our results, the overexploitation of *Gelidium sesquipedale* promotes the location of *Sargassum muticum* in areas of *G. sesquipedale* reduced abundance. We have shown that the *S. muticum* maximum coverage was reached after increasing collection of *G. sesquipedale* during July, August and September (the period allowed for collection).

Sargassum muticum colonizes the lower part of the intertidal zone to the mean low water springs in sheltered areas where water remains at low tide. It attaches to solid substrates in place or mobile: rocks, pebbles, shells. In the Thau lagoon, for example, she has three habitat types: hard subtrats, shellfish growing tables (pillars, ropes, shells). Soft bottoms where it binds to harsh elements such as dead shells, pieces of plastic or scrap (Boudouresque & al., 1985). In Sidi Bouzid, *S. muticum* is fixed on rocks in sheltered areas at low tide. After a few months, *S. muticum* deprives other species of food and growth in the region of its hooking and it may even be a cover avoiding any passing light to other species.

Upwelling phenomena present in Sidi Bousid also promote the rapid growth of *Sargassum muticum*. This species competes with *Gelidium sesquipedale* for food, as *S. muticum* is a hardy species to the harsh conditions that favor its rapid growth over *G. sequipedale*.

But one may wonder why *Sargassum muticum* does not proliferate as much in its original environment, in Japan. In fact, the average length is 1.20 m in Japan while it can go up to more than 10 m on the Atlantic coast. The internodes between two branches are shorter and less long secondary branches in Japan (Loraine I., 1989).

One can think of a phenomenon of competition between species, an equilibrium not being reached in France is being established in Japan, but other factors may be involved. This is why the physical and chemical characteristics of water have been a comparison between the Bay of Mangoku-ura Japan and the Thau lagoon (David, 1985). The temperature criteria and meet the salinity requirements of *Sargassum muticum* in both cases, temperatures being slightly more favorable to Thau and salinity somewhat more favorable in Japan. But nitrogen levels are still significantly higher than in Japan, especially for NH_4 and NO_2. Chemical analysis of composition shows that a Japan alga has nitrogen twice. This could be the nitrate nitrogen which constitutes a limiting factor of Japan *Sargassum muticum* NH_4 and NO_2 not being assimilated (David, 1985).

In Morocco, all the conditions listed above are present and especially in the coastal upwelling where Doukkala recognized at Sidi Bouzid gives an immense richness with nutrients by upwelling from the bottom to the area rich in mineral element. Also, pollution is a major cause for *S. muticum* rapid growth.

5 CONCLUSION

Following this study, the overexploitation of *Gelidium sesquipedale* promotes attachment and growth of harmful algae *Sargassum muticum*. The different characteristics of *Sargassum muticum* gave a clearer understanding the success than meets this alga on our shores. We can mention a few points that are all favorable to its growth factors:

-Very rapid growth,

- A high reproductive capacity with an effective sexual reproduction and the possibility of vegetative propagation,

- An effective dispersion by fertile branches or not with floats, a great capacity for attachment to any single mobile solid object,

- A good photosynthetic activity.

Therefore, we must make a great attention to *G. sesquipedale* exploitation to avoid the proliferation of harmful algae in the Moroccan Atlantic coast. Since the *S.muticum* invasion is at its beginning, an effective fight against this species.

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