REFERENCE, CORRECTION AND ADDITIONS TO THE PAPER

Wallentinus I (1999) *Sargassum muticum* (Yendo) Fensholt, 1955. *In*: Gollasch S, Minchin D, Rosenthal H & Voigt M (eds) *Exotics Across the Ocean. Case Histories on Introduced Species prepared by Members of the European Union Concerted Action on Testing Monitoring Systems for Risk Assessment of Harmful Introductions by Ships to European Waters (MAS3-CT-97-011)*. Lagos Verlag, Berlin, pp 21-30.

Correction: The year of the first record of *Sargassum muticum* from Strangford Lough, Northern Ireland, on the map (p. 21) should be 1995 as stated in the text, and not 1975.

Sargassum muticum in winter appearance with broad "leaves" and air bladders, but no slender summer shoots or receptacles. Fotö island, Göteborg, Sweden, September 2003. (*Photo*: Inger Wallentinus)

Additions (Wallentinus I (2004) Updated information since 1999 on *Sargassum muticum* (Yendo) Fensholt, 1955. http://www.aqualiens.tmbl.gu.se):

Several aspects of *Sargassum muticum* introductions were included in the review of introduced aquatic plants and marine algae in Europe (Wallentinus 2002). In a papper ranking specific traits of 113 macroalgae introduced into Europe for the three main categories: dispersal, establishment and ecological impact; *S. muticum* overall was the eight most invasive species (Nyberg and Wallentinus in press). Fletcher and Farell (1999 and references therein) discussed the role *Sargassum* *muticum* could have played as being a vector for the introduction to the North Atlantic of some epiphytic macroalgae and invertebrates. Viejo (1999) studied the mobile epifauna of *S. muticum* in N Spain in comparison with two native canopy brown algae in the intertidal and upper subtidal zone. She found that herbivorous mesograzers were very abundant, and that *S. muticum* was successfully colonized by the epifauna inhabiting local seaweeds, many using plant epiphytes as habitat and food rather than the macroalga itself, but there were also generalist mesograzers consuming the host plant itself. As a whole there was a labile association between the seaweeds and the invertebrates inhabiting them.

In the early 2000s *Sargassum muticum* had become established also in the inner part of the Oslofjord, S Norway, while there had been no confirmation of any spread in the northern parts of the country (ICES WGITMO 2002, 2004). It is now a well established member of the algal community in sheltered areas along the entire Norwegian Skagerrak coast and the species now also grows among other fucoids (ICES WGITMO 2003). In 1999, one population in the outer Oslofjord was investigated for epiphytic macroalgae (Bjaerke and Fredriksen 2003) and they found a rich macroalgal community on *S. muticum*. A total of 82 different algal taxa were identified: 34 red, 23 brown and 25 green algae and the epiphytes found included more than 25% of the total number of algal species found in the Oslofjord area.

There has not been any recent range extension of *S. muticum* on the Swedish west coast and the southernmost attached plants are still from the middle part of the province of Halland (first seen there in 1996). In 2003 large amounts of drifting plants were found as far south as in Öresund (ICES WGITMO 2004), but the low salinity may prevent it from reproducing in the area (Steen 2003a). In the northern part of the Swedish west coast it has become very abundant also in the inner archipelagoes, and in some areas there is a trend for dominance.

In Denmark its increased abundance in Limfjorden during the 1990s, when it became a dominant species, could be correlated with a corresponding decline of other perennial species such as the brown algae *Fucus vesiculosus, Halidrys siliquosa* and *Laminaria saccharina* as well as of the introduced green alga *Codium fragile* (Staehr et al. 2000) They also reported that imports of both European and Pacific oysters from France had taken place during the early 1980s, which may explain its early presence in Limfjorden (1984) compared to the much later arrival on the German North Sea coast (1988), where, however, drift plants had been seen frequently during the 1980s. Also its phenology (as a mean to interact) was thoroughly studied in Limfjorden, where *S. muticum* has invaded the habitat of and has had a negative influence, through its pseudo-perennial strategy, on the native, truely perennial fucoid *H. siliculosa* (Wernberg et al. 2000). In 1998 *S. muticum* was found attached also in the area S of the mouth of Limfjorden and drifting N of Århus (Køie et al. 2000).

In Königshafen Bay, at the German island of Sylt, the N Wadden Sea, *Sargassum muticum* (first recorded in the area in 1993) was in the mid 1990s still a prominent part of the vegetation both in the bay and outside, and outside the bay it co-occurred with the introduced green alga *Codium fragile*. The latter was previously seen also in the bay thus having become more scarce (Schories et al. 1997 and references therein). *S. muticum* has become increasingly common on Helgoland during the 1990s (Bartsch and Kuhlenkamp 2000).

In Belgium *S. muticum* was found attached in 1999 at Zeebrugge and Oostende, but later disappeared at the first site (ICES WGITMO 2001). It was speculated that oyster imports could have been the vector. Later it was reported to have disappeared also from Oostende, not seen there since 2002 (ICES WGITMO 2003).

In the UK, *S. muticum* had in 1998 extended its area into West Angle Bay on the SW coast of Wales (ICES WGITMO 1999) and the following year it was well established there and was also found on the island of Lundy and further dispersal could be predicted (ICES WGITMO 2000). In 2001 it had moved into the Menai Strait, where it was flourishing (ICES WGITMO 2002) and created great concern. In 2003 it was well established also in North Wales (ICES WGITMO 2004).

In Ireland *S. muticum* was first encountered in Strangford Lough (1995), while in the south the first plants were recorded in 2001 in Bertraghboy Bay on the W and in Kenmare Bay on the SW coast of Ireland (locally common in 2002), probably having been there for two years or more and and brought by imported oysters (ICES WGITMO 2002, 2003). A fragment was also seen in 2001 on the SE coast in Kilmar Quay, where notable stands could be seen in 2002, the vectors may either have been drift from England or visiting leisure crafts (ICES WGITMO 2003). In 2004 this population had extended along 2 km (ICES WGITMO 2004). In 2002 it had also reached the NW coast at Drumcliff Bay (ICES WGITMO 2003). Two new localities were found in 2003, in the Marine reserve at Lough Hyne on the S coast and a small population at Fanad Head, and altogether in 2003 the species occurred at six localities (ICES WGITMO 2004). Plants grow mainly on sheltered to semi-exposed shores in the mid intertidal to upper subtidal together with fucoids and *Laminaria saccharina* (Gallagher et al. 2003).

In addition to the references given in the previous paper there are more recent studies in N Spain of the ecological constraints for the establishment and abundance of *Sargassum muticum* (e.g. Fernandez 1999, Arenas and Fernandez 2000, Arenas et al. 2002, Sanchez et al. 2003). In Aramar Bay, Fernandez (1999) followed the colonization of the shore during three years after its first appearance, and in the third year all available intertidal substrate, including tide pools, were occupied, although the recruits had a high mortality rate (ca. 95%). Arenas and Fernandez (2000) found a negative biomass-density relation in the field and concluded that self-thinning is a major demographic process for *S. muticum* populations and that there was an inequal size distribution during the autumn-winter, which, however,decreased during spring and summer. A follow-up experimental study (Arenas et al. 2002) revealed that density influenced both mean size and morphology of the plants and thus induced changes in reproduction. The negative effect of density on individual plant size reduced the percentage of fertile plants and possibly their annual reproductive allocation, although these effects might be attenuated by morphological responses. Furthermore, plants became taller and thinner at higher densities as a consequence of variations in the production and growth of plant modules. They also concluded that the responses of *S. muticum* to crowding are closely linked to its ability to colonize bare space and that the massive reproductive output and very limited dispersal range account for local and dense recruitment patterns resulting in establishment of dense populations with high persistence and resistance to colonization by other species.

On the SW coast of Portugal *S. muticum* is in the early 2000s mainly found in tide pools, where they can become dominant and its demography at the southernmost distribution limit in Europe has been studied (Engelen et al. 2003).

In Venice, Italy, *S. muticum* took longer time to disperse than the introduced *Undaria pinnatifida* but in 2001 had increased and almost outcompeted the native large brown alga *Cystoseira barbata* (ICES WGITMO 2001). Boudouresque and Verlaque (2002) considered it to be among the nine most invasive species of 85 introduced macroalgae in the Mediterranean.

Steen (2003b) described that growth of *S. muticum* germlings in cultures were stimulated by high temperature and nutrient enrichment and negatively related to settlement density. At high densities some few large individuals could gain dominance and suppress many small plants and intraspecific competition occurred in stands of young germlings, with a reduced growth and competition ability of germlings at low temperatures. In another laboratory experiment, comparing the initial post-settlement period of six fucoid species, Steen and Rueness (2004) showed that at high temperatures (17°C) *S. muticum* had higher growth rates than the native species, but had a reduced survival at 7°C, compared to most of the others. They suggested that the summer reproduction, larger egg size, and a higher germling growth rate might give the introduced *S. muticum* a competitive advanged. Hwang and Dring (2002) showed that the erect "summer" branches developed after a genuine photoperiodic response and were not initiated in plants having experienced a night break (NB) regime. When plants were transferred from NB to short days (SD) conditions, erect thalli were initiated within 10 days, but once initiated under SD continued to be produced in plants transferred from SD to NB.

Dispersal distances of newly released young germlings of *S. muticum* were, together with propagules of three other macroalgal, modelled for different hydrographic regimes, considering also the heights from which the propagules were discharged and their sinking rate (Gaylord et al. 2002 and references therein). Their results indicated that it would be possible for around 10-20% of the *Sargassum* propagules to disperse more than one kilometer at currents of 10 cm s^{-1} and 1 m high waves, while at at currents of 50 cm s^{-1} and 3 m high waves they could reach more than double that distance. Thus their model predictions imply a much greater potential for longer range dispersal than has typically been assumed, which may have important implications also for understanding the demographics of algal populations.

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