NOBANIS – Invasive Alien Species Fact Sheet

Sargassum muticum

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Species description

Scientific name: *Sargassum muticum* (Yendo) Fensholt, Sargassaceae, Fucales, Phaeophyceae, Heterokonta (Infrakingdom)
Synonyms: *Sargassum kjellmanianum* f. *muticum* Yendo
Common names: Japanese seaweed, Japanese brown alga, Japweed, Wire weed, Strangle weed (GB), Japanischer Beerentang (DE), Butblæret Sargassotang (DK), Sargassolevä (FI), Japansk drivtang (NO), Sargassosnärja (SE).

Fig. 1. *Sargassum muticum*, photo by Cecilia Nyberg.

Species identification

Sargassum muticum is a large brown seaweed, varying in colour from dark brown to pale, yellowish brown depending on the season and the growing conditions. *S. muticum* has regularly alternating lateral shoots or branches, on a central perennial stem. It attaches to the substrate with a disc-shaped holdfast. It has numerous small 2–3 mm round or pear-shaped air-bladders which sit on small stems and cause the alga to stand upright in the water or float if parts of the alga are detached from the basal stem. *S. muticum* has a frond which may be 75–120 cm long in its native range, but normally reaches a length of 1.5–2 m in Swedish waters, 6–7 m in French waters, and up to 8.5 m in Norwegian waters. Lateral branches detach in the summer or autumn, leaving a short perennial basal stem to overwinter (Wallentinus 1999). During the summer, cigar-shaped reproductive receptacles develop in the areas where the annual shoot or “branch” attaches to the stem, but may also sit on top of the branch.

Native range
Sargassum muticum is native to the north-western Pacific, and is found in the coastal waters of Japan, China, Russia, and Korea.

Alien distribution

History of introduction and geographical spread
Sargassum muticum was first observed as established outside of its native range in British Columbia, Canada in 1944. At present, *Sargassum muticum* is established in North America on the eastern Pacific coast from south-eastern Alaska in the north to Baja California, Mexico in the south (Wallentinus 1999).

Although it was first observed in European waters off the south coast of England in 1973, it was probably introduced to European waters in the 1960s, possibly with Pacific oysters imported for aquaculture to France. *S. muticum* is now present along most of the Atlantic coast, from Portugal in the south to Norway in the north, as well as in the North Sea area, including Skagerrak and Kattegat (Wallentinus 1999, Staehr *et al.* 2000). It was introduced to l’Etang de Thau in the Mediterranean in 1980 with imports of Japanese oysters or by small pleasure boats, and to the lagoon outside Venice in 1992 (Wallentinus 1999, Ribera Siguan 2002).

The first record of Japanese seaweed in Nordic waters is from the Nissum Bredning, in the Limfjord, Denmark, in 1984 (Christensen 1984). In Norway *S. muticum* was found drifting the same year (Rueness 1985) and attached in 1988 (Rueness 1989). In Sweden drifting *S. muticum* specimens were recorded in 1985, and attached ones in 1987 along the Skagerrak coast (Karlsson 1988). *S. muticum* spread to Helgoland, Germany in 1988 and reached the island of Sylt in 1993 (Kornmann & Sahling 1994).

S. muticum has the potential to continue to spread throughout European waters as it has the ability to disperse through drifting specimens or fertile branches over long distances. Potential areas that may be colonized by *S. muticum* include all of the Danish North Sea coast, the Faroe Islands, southern Iceland, the Hebrides, Shetland, the Orkneys, the Norwegian northwest and north coasts, as well as the entire coastlines of England, Wales, Scotland, and Ireland (Wallentinus 1999). *S. muticum* may have the potential to establish in the entire Kattegat and perhaps the Kiel Bight in the south-western Baltic Sea (Karlsson & Loo 1999). It is, however, more difficult to predict how far into the brackish Baltic Sea area (in this context refers to the oceanographic definition of the Baltic Sea, which does not include Kattegat and the Belt Sea) it may progress since different tolerance limits to salinity have been reported in the literature, and it is not clear what effect low salinity has on reproduction (Karlsson & Loo 1999, Wallentinus 1999). Reproduction (fertilization) seems to be the stage least tolerant to low salinities, and thus the limiting factor for its dispersal into the Baltic.

Pathways of introduction
S. muticum was probably introduced to Europe in the late 1960s through the import of Pacific oysters (*Crassostrea gigas*) to France from Japan or possibly Canada (to where it had been previously introduced), either as epiphytes, growing on the shells of the oysters, or as packing material (Farnham 1994). Secondary spread in Europe from the U.K. south to the Netherlands and into the North Sea probably occurred through drifting specimens or branches (Karlsson 1997). The

introduction of *S. muticum* to Denmark possibly occurred through oyster import to the Limfjord, where oysters imported from France were re-laid at Nissum Bredning during the 1960s and 70s. Dispersal with ships, including pleasure boats, is also a possibility through entanglement in anchor chains or propellers or hull fouling (Wallentinus 1999).

Alien status in region

In Denmark the Japanese seaweed is well established in the Limfjord, where it has become the most conspicuous and abundant macroalga present (Staehr *et al*. 1998, 2000). It is also found on the Danish Skagerrak and northern Kattegat coasts (Nielsen 1994). In Norway it is present along the Skagerrak and North Sea coasts to north of the Sognefjord at about 62° N (Anonymous 1997). In Swedish waters, *S. muticum* is established along the Kattegat and Skagerrak coasts from the province of Halland and northwards to the Norwegian border (Karlsson 1997). In 2005, however, the known range of the species “jumped” about 120 km to the south, when two attached individuals were found growing in Helsingborg, in the northern Öresund (Hellfalk *et al.* 2005).

In the Limfjord the rate of spread of *S. muticum* has been estimated to be 10 kilometres per year (Staehr *et al.* 1998). Its expansion along the Swedish coast has also been very rapid (Karlsson *et al.* 1995). Between June 1994 and 1995 the estimated biomass increased ten times (Karlsson 1996).

In Königshafen Bay in the northern Wadden Sea, at the German island of Sylt, *S. muticum* was in the mid-1990s still a prominent part of the vegetation both in the bay and outside. Outside the bay it co-occurs with the introduced green alga *Codium fragile* (Schories *et al.* 1997). *S. muticum* is still expanding in the Wadden Sea (Buschbaum 2005). On the German island of Helgoland *S. muticum* has become increasingly common during the 1990s (Bartsch & Kuhlenkamp 2000).

As noted above, it is not known if *S. muticum* can become established in the Baltic Sea area, as it may not be able to reproduce at low salinities.

The species has not been reported from Iceland, Greenland, or the Faroe Islands. It is not found in the brackish Baltic Sea area. (Table 1).

Country	**Not found**	**Not established**	**Rare**	**Local**	**Common**	**Very common**	**Not known**
Denmark					X		
Estonia	X						
European part of Russia	X						
Finland	X						
Faroe Islands	X						
Germany				X			
Greenland	X						
Iceland	X						
Latvia	X						
Lithuania	X						
Norway					X		
Poland	X						
Sweden				X			

Table 1. The frequency and establishment of *Sargassum muticum*, please refer also to the information provided for this species at www.nobanis.org/search.asp. Legend for this table: **Not**

found – The species is not found in the country; **Not established –** The species has not formed self-reproducing populations (but is found as a casual or incidental species); **Rare –** Few sites where it is found in the country; **Local –** Locally abundant, many individuals in some areas of the country; **Common –** Many sites in the country; **Very common –** Many sites and many individuals; **Not known –** No information was available.

Ecology

Habitat description

The preferred habitat of Japanese seaweed is sheltered hard-bottoms, but it may also attach to hard substrates on soft-bottoms, such as stones or shells. Direct wave exposure is not beneficial for the species, but *S. muticum* tolerates currents. *S. muticum* is often found in shallow waters, in the lower intertidal and upper subtidal zones, but depths of 6–15 m are not uncommon in Swedish waters (Karlsson *et al.* 1995). In Norway it is reported to be found in the lower intertidal and down to about 10 m depth, and it seems to be most frequently established in areas with reduced wave influence and limited amounts of other macroalgal vegetation (Steen & Rueness 2004). In the sedimentary tidal zone of the Wadden Sea, the seaweed occurs on mussel beds together with other alien species such as Pacific oysters (*Crassostrea gigas*) and American slipper limpets (*Crepidula fornicata*) (Buschbaum 2005).

Eutrophic conditions favour the growth of *S. muticum* (Wallentinus 2002).

S. muticum tolerates a wide range of abiotic conditions and is thus considered highly invasive (Nyberg & Wallentinus 2005). Although a salinity of 34 ‰ is considered optimal for growth (Eno *et al*. 1997), germlings (Hales & Fletcher 1989) and mature individuals (Steen 2004) have been reported to survive laboratory experiments with salinities down to 5–6 ‰. Drifting *S. muticum* individuals found at the southernmost distribution limit in the Kattegat have been fully fertile (Karlsson 1997). Failure to reproduce may prevent its establishment in brackish areas, since, according to laboratory experiments, fertilization may not take place at salinities below 16 ‰ (Steen 2004). Low temperature and ice-scour, which are more frequent in the Baltic Sea area than in western waters, may be another inhibiting factor. Observations in Swedish waters, however, indicate that *S. muticum* has survived long periods with water temperatures of -1.4°C (Karlsson 1988). Lack of suitable hard substrates may also limit its expansion (Staehr *et al.* 2000). It has been estimated that the hypothetical northern limit for its distribution along the western coast of Norway might be at about 66°N. A further spread northwards will be limited by low summer temperatures, as *S. muticum* requires a temperature of more than 8°C for at least four months to reproduce (Steen & Rueness 2004).

Reproduction and life cycle

Sargassum muticum is monoecious and self-fertile. Reproduction occurs in spring, summer and early autumn depending on water temperature. Cigar-shaped reproductive receptacles which produce both eggs and spermatozoids are formed on top of the branches or where the branches attach to the stem. After fertilization, the embryos or germlings detach from the receptacles and reattach to any available hard surface. As germlings settle only a few meters from the mother alga, *S. muticum* is dependent on drifting with water currents for spread. *S. muticum* does not reproduce vegetatively (Wallentinus 1999, 2005).

Dispersal and spread

S. muticum has a rapid growth rate (maximum growth in the field has been observed at 2–4 cm/day), high fecundity (large production of propagules), and a long life span. It has the ability to reproduce from drifting fertile individuals or branches, which because of the buoyancy provided by the air vesicules are able to drift long distances, and rapidly colonize new areas. This combination is thought to be one of the reasons for its successful invasion of North American and European waters (Wernberg-Møller *et al.* 1998, Wallentinus 2002, Nyberg & Wallentinus 2005). Failed eradication attempts may also be explained by these traits. In many cases removal has actually enhanced dispersal by dislodging large numbers of fronds full of viable germlings.

The primary vector of introduction of *S. muticum* to a new area, *e.g.* to Northern Europe, has probably been the transfer of oysters or mussels for aquaculture; *Sargassum* has traditionally been used as packaging material and is furthermore often found as a fouling organism on shells. Secondary dispersal with currents, through drift of fertile individuals or branches, has then contributed to its further spread within the area. *Sargassum* may also be spread by ships and pleasure boats (entangled on the vessel itself or *e.g.* on ropes and fishing gear or, less likely, as hull fouling). *Sargassum muticum* is also sold for use in salt water aquariums (Wallentinus 2002).

Impact

Affected habitats and indigenous organisms
The introduction and rapid expansion of Japanese seaweed is one of the most dramatic changes of the vegetation of the upper sublittoral zone in modern times, and this large alga undoubtedly plays an important structuring role in the upper algal belt (Karlsson *et al.* 1995). Critchley *et al.* (1990) listed potential effects and problems associated with the establishment of Japanese seaweed, including replacement of native species, increase of filamentous epiphytic algae, changes in composition of flora and fauna, increased sedimentation, interference with coastal fisheries, large accumulations of drift algae, blocking of narrow sounds and harbours, and interference with recreational activities.

S. muticum is a strong competitor with native flora for space and light through its fast growth, high fertility, high biomass, and high densities which can prevent settlement and development of other algae (Critchley *et al.* 1986, Staehr *et al.* 2000). Studies in Norway have shown that the species is able to grow considerably faster than most of the indigenous brown algal species, thus being a strong competitor to the native algal flora (Steen & Rueness 2004). The expansion of *S. muticum* in the Limfjord has lead to reductions in slow growing seaweeds, particularly fucoids and kelps such as *Laminaria saccharina*, *Fucus vesiculosus*, *Codium fragile* and *Halidrys siliquosa* (Staehr *et al.* 2000). Leathery and coarse branched algae, such as *Macrocystis pyrifera* and *Rhodomela larix*, have also been negatively affected through competition with *S. muticum* (Staehr *et al.* 2000, Wallentinus 2002). Japanese seaweed can also invade beds of eelgrass (*Zostera marina*), which serve as important nursery areas for fish and marine invertebrates. Replacement of *Z. marina* and a drastic reduction in the kelp *Laminaria digitata* by Japanese seaweed have been documented in the 1990s on the French Atlantic coast (Givernaud *et al.* 1991, Cosson 1999).

This replacement of native flora by a faster growing macroalga may lead to a large increase in the biomass input and thus of detritus in systems which have been invaded by *S. muticum*. Because *S. muticum* also undergoes a faster and more complete decomposition than that of the native flora it has replaced, it has increased the turnover and regeneration of nutrients in Limfjorden, Denmark, and thus altered the nutrient cycle (Pedersen *et al.* 2005).

Due to its height, ”bushy” structure and high densities, *S. muticum* may also have physical effects on its local environment, such as effects on sedimentation and light penetration (Rueness 1985), water movement, and oxygen levels. Densities of *S. muticum* may be quite high, 130–300 individuals/m^2 have been observed in European waters (Ambrose & Nelson 1982, Boudouresque *et al.* 1985, Fernández *et al.* 1990).

Oxygen free conditions and development of hydrogen sulphide caused by stagnation of water movement in dense stands of *S. muticum* have been observed even where natural water movement is high (Bohuslän, Sweden) (Karlsson *et al*. 1995). Areas with naturally poor water exchange, including harbours *etc*., are of course more susceptible.

S. muticum may provide additional habitat space for epibiota (organisms living on the surface of *S. muticum*). In the Limfjord, studies have shown that although the introduction of *S. muticum* has not caused major changes in the community structure of the epibiota, the abundance or standing stock of epibiota has increased (Wernberg *et al.* 2004). Dense stands of *S. muticum* may provide protection for animals and attract settlement of invertebrates which may attract fish and other predators (Wallentinus 1999). A survey at Sylt showed that in the Wadden Sea the number of species associated with *S. muticum* was much higher than on other macroalgae. More than 80 species of algae and invertebrates were found associated with this seaweed, including species that otherwise are rare or absent in the Wadden Sea. At Helgoland, by contrast, *S. muticum* showed little difference in associated organisms to similar macroalgae such as *Halidrys siliquosa* (Buschbaum 2005, Buschbaum *et al.* 2006).. In Norway it has been observed that the morphology of the species, with its lateral branches lifted in an upright position due to the small air-bladders, contributes to establishing a three-dimensional habitat for many epiphytic algae and smaller animals. *S. muticum* has, *e.g.*, more epiphytic algae than the native *Fucus serratus* or *Zostera marina* (Bjærke & Fredriksen 2003).

Genetic effects
No genetic effects have been observed.

Human health effects
No effects on human health have been observed.

Economic and societal effects (positive/negative)
Drifting individuals or mats of *S. muticum* can cause problems for coastal and recreational fishing by becoming entangled in fishing lines and nets, as well as in boat propellers. In Sweden catches of eel (*Anguilla anguilla*) may have been negatively influenced in some areas (Koster archipelago) through interference with fishing gear (Karlsson *et al.* 1995). *S. muticum* also causes problems for aquaculture by growing on and fouling ropes and fish pens, as well as on the shells of cultured shellfish.

S. muticum can also cause clogging of intake pipes to waterworks and industrial plants using seawater for cooling. Large populations have been found *e.g.* at the Ringhals nuclear power plant in the province of Halland. Fouling by *S. muticum* on wharfs, buoys and pontoons is a problem in harbours.

In the Mediterranean dense growths of *S. muticum* in or near aquaculture facilities may reduce light and impede water circulation, and thus limit oyster growth. It may also, through its weight and dense growth, impede handling of ropes and cages used in aquaculture (Verlaque 2001).

Rotting mats of *S. muticum* which are washed ashore onto beaches may cause a strong odour, which is considered a nuisance and an eyesore. Dense stands of *S. muticum* may hinder recreational use of waters for *e.g.* swimming, boating and fishing.

Sargassum muticum may have a positive commercial value for the alginate industry.

Management approaches

Prevention methods
Proper quarantine treatment of organisms used in aquaculture is essential in reducing the risks of introduction and spread of *S. muticum* and other fouling organisms commonly found on oysters and mussels. Only the release to natural waters of second generation introduced species should be allowed, in accordance with the ICES Code of Practice for Aquaculture (Wallentinus 1999, ICES 2004).

Eradication, control and monitoring efforts
Attempts have been made to eradicate Japanese seaweed by manual removal in England in the 1970s. This was, however, a total failure (Farnham 1980). In Strangford Lough, Northern Ireland, tonnes of seaweed have been harvested each year in an attempt to at least restrict its further dispersal (Boaden 1995). However, this measure was not successful and *S. muticum* is now distributed at numerous locations throughout Ireland (Kraan 2006).

Other methods tested include trawling, cutting and suction, as well as chemical methods (herbicides). The latter has failed due to a lack of selectivity and the large doses needed. Whatever method is chosen, the alga seems to regrow quickly, and removal will most likely have to be carried out repeatedly, maybe even indefinitely (Eno *et al*. 1997).

Biological control agents have also been tested but have been found to be ineffective as most species studied are not specific to *Sargassum muticum* (Critchley *et al.* 1986).

At present, it would seem that once the species has become established, the only option available is repeated manual removal. This is, however, something that may at most be carried out for particularly valuable and spatially limited areas, such as aquaculture sites, protected or recreational areas. With mechanical removal there is also a risk that the procedure may actually increase dispersal if *S. muticum* individuals or branches are dislodged and carried by currents to new areas. This risk emphasizes the importance of monitoring and early detection, where the goal would be to quickly identify and eradicate new infestations outside the present distribution limits of the species.

S. muticum has now been present in Nordic waters for more than twenty years, and it seems definitely to have become a permanent member of the macroalgal flora. This species, which has its origin in warmer waters, has already survived several severe winters, and even if local populations should be wiped out, there will be many opportunities for recruitment through drifting individuals from North Sea populations.

Information and awareness
Sargassum muticum is featured on the ISSG *100 of the World’s Worst Invasive Alien Species* list and information about this species is found in publications and on the ISSG web site. Fact sheets on *Sargassum muticum* to raise public awareness have been produced by various organizations and are listed as links in the section: References and other resources.

Knowledge and research
Research on the ecological effects of *Sargassum muticum* is currently in progress in Europe, *e.g.* in Denmark, Germany, France, Spain, the U.K., and Norway. The *AquAliens* research program studies the ecological effects of alien macroalgae, including *S. muticum*, in Swedish waters.

Recommendations or comments from experts and local communities
See prevention methods.

References and other resources

Contact persons

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Links

AlgaeBase, Information on taxonomy, distribution and bibliography of *Sargassum muticum*

Alien Species in Swedish Seas (Främmande arter i svenska hav), Fact Sheet on *Sargassum muticum* (pdf, in Swedish)

AquAliens, Research on aquatic alien species; where and why they pose a threat to ecosystem functions and economy (in Swedish)

Aquascope, Learn more about the Sea, Tjärnö Marine Biological Laboratory, Strömstad, Sweden

Aquatic alien species in German inland and coastal waters - database

Global Invasive Species Database, Fact Sheet on *Sargassum muticum*

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