Sand gaper (*Mya arenaria*)

MarLIN – Marine Life Information Network
Biology and Sensitivity Key Information Review

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A selection of adult *Mya arenaria*.
Photographer: Dr Matthias Strasser
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See online review for distribution map

Distribution data supplied by the Ocean Biogeographic Information System (OBIS). To interrogate UK data visit the NBN Atlas.

Researched by	Dr Harvey Tyler-Walters	**Refereed by**	Dr Matthias Strasser
Authority	Linnaeus, 1758		
Other common names	-	**Synonyms**	-

Summary

Description

Mya arenaria is a large long-lived bivalve. The shell is dirty white or fawn in colour with a fawn or light yellow periostracum. Large specimens may reach 12 -15 cm in length. The shell is oval in outline, marked by conspicuous concentric lines with dissimilar valves, the right being slightly more convex than the left, and slightly anterior beaks (umbones). The shell gapes posteriorly. The shell hinge bears no teeth but the left valve bears a large spoon shaped chondrophore to which the ligament is attached. However, there is considerable variation in shell outline, texture and thickness. The interior of the shell is white with a deep pallial sinus, and anterior and posterior adductor muscle scars. The foot is small and muscular and the mantle edges are fused except at the pedal gape and ends of siphons. The exhalent and inhalent siphons are fused along their length, contractile, and capable of considerable extension to reach the surface (about 20cm or up to 40cm in large specimens) where they leave a characteristic 'key-hole' shaped opening in the sediment.

Recorded distribution in Britain and Ireland

Found on all British coasts but is not recorded from the Isles of Scilly.

Global distribution

Found on the European coast from the White Sea to northern Norway, in the Baltic Sea and

Wadden Sea to Portugal as well as the Black Sea. Reported from Labrador to Georgia in the W. Atlantic and from North Sound, Alaska to California in the E. Pacific.

Habitat

Mya arenaria lives in burrows up to 50 cm deep in sand, mud, sandy mud, and sandy gravels from the mid shore to the shallow sublittoral, sometimes to a depth of 192 m. Often abundant on estuarine flats where it can survive at salinities as low as 4-5 psu.

Depth range

Intertidal to 192 m

Identifying features

- Shell gapes posteriorly.
- Shell oval, rounded and slightly elongate in outline.
- Pallial sinus deep and not confluent with pallial line.
- Anterior adductor scar long and thin, posterior adductor short and fat.
- Hinge without teeth.
- Ligament both external and internal and attached to a large, spoon shaped chondrophore borne on the left valve.
- Burrow opening characterised by 'key-hole' shaped opening left by siphons.

Additional information

Common names include, the 'sand gaper', 'soft clam', 'soft-shelled clam', 'steamer clam' and the 'nannynose'. The literature on *Mya arenaria* is extensive and this Key Information review is based upon more detailed reviews by Clay (1966), Newell & Hidu (1986) and Strasser (1999).

Listed by

Further information sources

Search on:

NBN WoRMS

Biology review

Taxonomy

Phylum	Mollusca	Snails, slugs, mussels, cockles, clams & squid
Order	Myida	Gapers, piddocks, and shipworms
Family	Myidae	
Genus	Mya	
Authority	Linnaeus, 1758	
Recent Synonyms	-	

Biology

Typical abundance	See additional information
Male size range	60 -100mm
Male size at maturity	>20mm
Female size range	>20mm
Female size at maturity	
Growth form	Bivalved
Growth rate	See additional text
Body flexibility	None (less than 10 degrees)
Mobility	
Characteristic feeding method	Active suspension feeder
Diet/food source	
Typically feeds on	Phytoplankton, small zooplankton, benthic diatoms, suspended particulates and dissolved organic matter.
Sociability	
Environmental position	Infaunal
Dependency	Independent.
Supports	Host several cercariae and other parasites (see Gibbons & Blogoslawski, 1989 for review), but not recorded within UK and Europe (Strasser *pers comm.*).
Is the species harmful?	No Edible

Biology information

Mya arenaria populations demonstrate pronounced patchiness, e.g. in the Dutch Wadden Sea its abundance varies from high to low. Patchiness seems to be typical in *Mya arenaria* and has been reported from Sweden and North America (Strasser *et al.*,1999; Strasser *pers. comm.*).

Growth rates: *Mya arenaria* generally grows fastest in its first years with growth rate decreasing with age, although linear rates of growth have also been reported (Strasser, 1999). Growth is rapid in favourable conditions but rates vary with location, e.g. *Mya* sp. grew to 51 mm in 6-7 years in Alaska, but this size was attained in 1.5 years in Connecticut (Brousseau & Baglivo, 1987).

Similarly, marketable size (4-5 cm long) was reached within 1.5 years in Chesapeake Bay, but took 5 years in New Brunswick, Canada. Growth rates are affected by population density, sediment type, salinity, emergence time, water flow rates, disturbance, latitude and pollution (Newell & Hidu, 1986; Strasser, 1999).

Seasonal growth rates: growth is generally greatest in late spring and early summer and slowest in cold winters e.g. in New England (Newell & Hidu, 1986). Rapid growth is correlated with the phytoplankton bloom and therefore food availability but may also be affected by temperature and spawning (Stickney, 1964; Brousseau, 1979; Newell & Hidu, 1986).

Habitat preferences

Physiographic preferences	Strait / sound, Sea loch / Sea lough, Ria / Voe, Estuary, Enclosed coast / Embayment
Biological zone preferences	Lower circalittoral, Lower eulittoral, Lower infralittoral, Mid eulittoral, Sublittoral fringe, Upper circalittoral, Upper infralittoral
Substratum / habitat preferences	Coarse clean sand, Fine clean sand, Mixed, Mud, Muddy gravel, Muddy sand, Sandy mud
Tidal strength preferences	Moderately Strong 1 to 3 knots (0.5-1.5 m/sec.), Weak < 1 knot (<0.5 m/sec.)
Wave exposure preferences	Exposed, Moderately exposed, Sheltered, Very sheltered
Salinity preferences	Full (30-40 psu), Low (<18 psu), Reduced (18-30 psu), Variable (18-40 psu)
Depth range	Intertidal to 192 m
Other preferences	No text entered
Migration Pattern	Non-migratory / resident

Habitat Information

The southern distribution of *Mya arenaria* may be restricted by a limit of 28 °C for both adults and larvae (Newell & Hidu, 1986; Strasser, 1999). Various authors suggested that the northern distribution was limited by critical spawning temperature of 10-12 °C and 12-15 °C required for larval development, however, Strasser (1999) noted some exceptions and concluded that this hypothesis needed further examination.

Distribution: *Mya arenaria* is found most abundantly in intertidal and shallow subtidal areas but can reach 192 m depth in the subtidal (Strasser, 1999). The majority of clams >50 mm are found in sediment between 15 - 20 cm deep in the Wadden Sea, but may burrow up to 40 cm deep. As they grow adults live deeper in the sediment, their siphons growing accordingly and large clams establish a permanent burrow. Young clams (up to 50 mm) can burrow again if disturbed. However the foot becomes much reduced and shorter in larger specimens. With increasing size it becomes more difficult for exposed specimens to raise the shell into position and therefore. if disturbed, fewer large than small individuals manage to reburrow. For example, 62% of small clams (35-50mm), 39% of medium sized (51-65 mm) and only 21% of large clams (66-75 mm) had reburrowed within 48 hours (Pfitzenmeyer & Drobeck, 1967).

Mya arenaria grows faster in fine rather than coarse sediments and fastest in sand or sandy mud.

The clam has difficulty burrowing in sediments larger than 0.5 mm (coarse sand). Areas with fast currents support highest densities and growth rates whereas excessive silt reduces growth rates (Newell & Hidu, 1986). Densities of adults vary between years and location, e.g. Clay (1966) reported adult densities between ca 5 /m^2 to 300 /m^2 in the UK and Strasser *et al.* (1999) reported abundances between 0-243 individuals /m^2 (with a mean of 11.8 individuals /m^2) in the Wadden Sea. Strasser *et al.* (1999) concluded that the Wadden Sea population is greatest at the mid to low tidal level and resulted from larval settlement. Its patchy distribution and dominance of single year classes being due to wind direction during peaks of larval settlement, and when juvenile predation is low. Clams that survive the first year may reach several years of age but mass mortalities may occur at any time, due to indeterminate causes (Strasser *et al*, 1999).

Global distribution: *Mya arenaria* became extinct on the east coasts of the Pacific and Atlantic during the glaciations of the Pleistocene. It subsequently colonized the European coast between the 13 th and 17 th centuries, possibly introduced by the Vikings (as food or bait) (Eno *et al.*, 1997; Eno *et al.*, 2000; Strasser, 1999). *Mya arenaria* has been reported from Kamchatka to southern Japan and China, however these records may have been confused with *Mya japonica* (Strasser, 1999). Strasser (1999) also regarded additional records from Iceland, the Mediterranean and Florida as dubious. *Mya arenaria* probably invaded the Pacific east coast as a by-product of oyster transplants but was later intentionally introduced as a commercial fishery. It was probably introduced into the Black Sea around 1960 as larvae in the ballast waters of Baltic Sea tankers (Strasser, 1999) . Strasser (1999) notes that although introduction may have been effected by man its present distribution is also the result of significant natural expansion.

Life history

Adult characteristics

Reproductive type	Gonochoristic (dioecious)
Reproductive frequency	Annual protracted
Fecundity (number of eggs)	>1,000,000
Generation time	2-5 years
Age at maturity	Depends on growth
Season	See additional text
Life span	10-20 years

Larval characteristics

Larval/propagule type	-
Larval/juvenile development	Planktotrophic
Duration of larval stage	11-30 days
Larval dispersal potential	Greater than 10 km
Larval settlement period	Insufficient information

Life history information

A lifespan of 10-12 years was considered normal, although a maximum of 28 years was recorded in the Bay of Fundy (Strasser, 1999). Commito (1982) suggested that *Mya* sp. delayed reproduction

until its fourth year, preferring rapid growth to reach a depth refuge. Strasser (1999) reported that first reproduction usually occurred at a size of about 20 -50 mm, which corresponds to an age of about 1-4 years depending on growth conditions.
Spawning: Spawning occurs once or twice annually, usually starting in spring and can occur between March and November depending on locality. In European waters larvae are usually found in May and June but sometimes as late as October. Annual spawning was reported in the Wadden Sea, on the west coast of Sweden, the east coast of Denmark and the Black Sea whereas biannual spawning was reported in Oslofjord and the south coast of England (Warwick & Price, 1976; Strasser, 1999; and see Brousseau,1987 and Clay, 1966 for reviews).
Both temperature and food availability affect gametogenesis and spawning. Critical spawning temperatures of 10-12 °C were suggested by Nelson (1928) however, peak spawning occurs in Massachusetts at 4-6 °C (Brousseau, 1978a). Peaks of larvae have been observed at 20°C and second spawnings once temperature had dropped below 25 °C (Newell & Hidu, 1986). Optimum larval growth has been reported between 17 -23 °C in the laboratory (Stickney, 1964) and slow growth between 12-15 °C (Loonsanoff & Davis, 1963). Strasser (1999) suggested that further study was required.
Fecundity: Males usually spawn first, releasing a pheromone which stimulates females to spawn (Newell & Hidu, 1986). Fecundity varies with location and size e.g. 120,000 eggs from a 60 mm clam, 3 million from a 63 mm clam and 1-5 million eggs in an individual have been reported (Strasser, 1999).
Fertilization: fertilization is external. Eggs are 66µm in diameter and can be carried many miles by the current (Newell & Hidu, 1986).
Larval stages: larval life lasts about 2-3 weeks, but can be extended, in the laboratory to up to 35 days in unfavourable conditions, most not metamorphosing until 200µm in length (Loosanoff & Davis, 1963; Strasser, 1999).
Recruitment: recruitment in bivalve molluscs is influenced by larval and post-settlement mortality. *Mya arenaria* demonstrates high fecundity, increasing with female size, with long life and hence high reproductive potential. The high potential population increase is offset by high larval and juvenile mortality. Juvenile mortality reduces rapidly with age (Brousseau, 1978b; Strasser, 1999). Larval mortality results from predation during its pelagic stages, predation from suspension feeding macrofauna (including conspecific adults) during settlement and deposition in unsuitable habitats. Mortality of the juveniles of marine benthic invertebrates can exceed 30% in the first day, and several studies report 90% mortality (Gosselin & Qian, 1997). Larval supply and settlement is often dependant on currents and timing of the phytoplankton bloom and may be sporadic in bivalves (see *Cerastoderma edule* reproduction) and differs consistently between sites. Recruitment is affected by adult population density, settlement intensity (in some but not all cases), post-settlement and juvenile predation, active and passive transport, and bedload transport or sediment erosion (Olafsson *et al*., 1994). For example:

- in New Hampshire densities of spat ranged from 21 -8,200 /m^2 from 1975-1980 depending on the year (Newel & Hidu, 1986);
- adults (up to 25 mm and occasionally 40 mm) and large numbers of juveniles were subject to bedload sediment transport (up to 790 individuals /m /day in sheltered sites and 2,600 individuals /m /day in exposed) in Nova Scotia;
- in the above population bedload transport in exposed conditions accounted for 10 fold increase in clam density in September followed by a significant decrease by November and complete removal of newly settled spat (Emerson & Grant, 1991);
- Brousseau (1978b) estimated that 0.1% of egg production survived to successful settlement;
- Newell & Hidu (1986) suggested that <1% of settled spat must mature and reproduce in

order to sustain the population;

- high larval and juvenile mortality decreases with age and size levelling off towards age of first reproduction, with estimates of 88% mortality at 2-4.9 mm falling to <10% at >30 mm, and is highest in summer when predators are most abundant (Brousseau, 1978b; Strasser, 1999);
- high densities of settling spat on a shallow exposed shore in southern Sweden in summer were swept away by storms in autumn and early winter (Olafsson *et al.*,1994);
- predation was blamed for a reduction in newly settled spat from $6000/m^2$ to zero in the subtidal in Virginia (Lucy, 1976 cited by Newell & Hidu, 1986);
- Strasser *et al.*, (1999) noted that sites of high adult densities do not deter settling spat or prevent successful recruitment, but the presence of *Arenicola marina* may prevent development to adulthood due to bioturbation.

Sensitivity review

This MarLIN sensitivity assessment has been superseded by the MarESA approach to sensitivity assessment. MarLIN assessments used an approach that has now been modified to reflect the most recent conservation imperatives and terminology and are due to be updated by 2016/17.

Physical Pressures

	Intolerance	Recoverability	Sensitivity	Confidence
Substratum Loss	High	High	Moderate	High

Loss of substratum would entail loss of the population of *Mya arenaria*.
Recovery is dependant on recolonization by juveniles, perhaps transported by bedload transport, and successful recruitment of spat. Strasser *et al.* (1999) noted that population densities in the Wadden Sea were patchy and dominated by particular year classes. *Mya arenaria* has a high fecundity and reproductive potential but larval supply is sporadic and juvenile mortality is high, so that although, large numbers of spat may settle annually, successful recruitment and hence recovery may take longer than a year. Beukema (1995) reported that a population of *Mya arenaria* in the Wadden Sea, drastically reduced by lugworm dredging took about 5 years to recover. Therefore a recovery of high has been recorded.

	Intolerance	Recoverability	Sensitivity	Confidence
Smothering	Intermediate	High	Low	Moderate

Emerson *et al.* (1990) examined smothering and burrowing of *Mya arenaria* after clam harvesting. Significant mortality (2 -60%) in small and large clams occurred only at burial depths of 50 cm or more in sandy substrates. However, they suggested that in mud clams buried under 25cm of sediment would almost certainly die. Dow & Wallace (1961) note that large mortalities in clam beds have resulted from smothering by blankets of algae (*Ulva* sp.) or mussels (*Mytilus edulis*). In addition clam beds have been lost due to smothering by 6 cm of sawdust, thin layers of eroded clay material, and shifting sand (moved by water flow or storms) in the intertidal. Therefore, *Mya arenaria* is probably of intermediate intolerance to smothering by 5cm of sediment (the benchmark level), although it should be noted that intolerance would also depend on the nature of the smothering material.
Given the patchy nature of populations and the sporadic nature of recruitment a recoverability of high has been recorded (see additional information below).

	Intolerance	Recoverability	Sensitivity	Confidence
Increase in suspended sediment	Intermediate	High	Low	High

Newell & Hidu, (1986) point out that because adults occupy permanent burrows they are vulnerable to smothering as a result of e.g. coastal engineering works but they also point out that clams continue filtration even when suspended solid concentrations exceed 300mg/l. Grant & Thorpe (1991) noted that in short term exposures to suspended sediment between 0 -2000 mg/l resulted in reduced oxygen consumption and respiration with increasing sediment concentration, pseudofaeces production being initiated at 100-119 mg/l. This results in rejection of particulates as pseudofaeces and loss of energy as mucus. However, *Mya arenaria* was unable to obtain adequate nutrition at particle loads of 100-200 mg/l and metabolised protein. Grant & Thorpe (1991) suggested, therefore, that prolonged exposure to concentrations >100 mg/l for > 2 weeks would result in reduced condition and reduced growth, increased mortality and decline of the fishery. Therefore, an intolerance of intermediate to siltation has been recorded. Given the patchy nature of populations and the sporadic nature of recruitment a recoverability of high has been recorded (see additional information below).

Decrease in suspended sediment

Dessication	Intermediate	High	Low	Very low

The burrowing habit of *Mya arenaria* protects it from the risk of desiccation. However, juveniles, and adults removed from the sediment are likely to be highly intolerant of the effects of desiccation, especially as the siphons can not be enclosed in the shell, forcing the shell to gape. Given the patchy nature of populations and the sporadic nature of recruitment a recoverability of high has been recorded (see additional information below).

Increase in emergence regime	Intermediate	High	Low	Low

Increased emergence will result in increased drainage of the sediment and reduced time for *Mya arenaria* to feed. High shore populations are likely to be most vulnerable. Overall increased emergence may reduce the extent of the population towards the top of the shore. However, given this species wide range of habitat preference decreased emergence is unlikely to adversely affect the population. Given the patchy nature of populations and the sporadic nature of recruitment a recoverability of high has been recorded (see additional information below).

Decrease in emergence regime

Increase in water flow rate	Intermediate	High	Low	Moderate

Changes in the water flow rate will affect the hydrodynamics of the shore, sediment grain size and distribution. Shifting sands and erosion result in the loss of soft-shell clam beds in the intertidal due to smothering (see above) or loss of intertidal habitat (Dow & Wallace, 1961). Given the patchy nature of populations and the sporadic nature of recruitment a recoverability of high has been recorded (see additional information below).

Decrease in water flow rate

Increase in temperature	Low	Very high	Very Low	Moderate

The southern distribution of *Mya arenaria* may be restricted by a limit of 28 °C for both adults and larvae (Newell & Hidu, 1986; Strasser, 1999). Clams did not survive temperatures higher than 28 °C in Chesapeake Bay, and 24 hr LT_{50} for adults were 32.5 °C and 34.4 °C in larvae Stickney (1964) found that all larvae died after 14 days at 28°C. However, clams from the high intertidal survived higher temperatures (>25 °C) than clams from the mid tidal level (Kennedy & Mihursky, 1972). Growth, burrowing, and pumping rates are affected by temperature. Over-wintering *Mya arenaria* survived temperatures as low as -2°C in Alaska, persisted in the St. Lawrence estuary exposed to freezing winter air temperatures, and survived 60 days of ice in the severe 1995/1996 winter in the Wadden Sea (Strasser, 1999). However, severe winters have been known to cause mortality (Rasmussen, 1973; Strasser, 1999). Overall, *Mya arenaria* is tolerant of a wide range of temperatures (eurythermal) although at its upper thermal limit a small increase in temperature (1 °C) results in substantial mortality (Anonymous, 1996). This species burrowing habit removes it from the direct influence of extreme temperatures, especially the deep dwelling adults. Therefore, a low intolerance to temperature change is reported, although populations at the edge of its range or at high tidal level are likely to be more intolerant. Similarly, juveniles dwelling near the surface are likely to be more vulnerable to extremes of temperature. It is likely that individuals affected by temperature change would recover within a few weeks of a return to original temperature regime.

Decrease in temperature

Increase in turbidity	Low	Immediate	Not sensitive	Moderate

Changes in light attenuation are likely to affect phytoplankton, benthic diatom and algal productivity and therefore affect food availability for the soft-shell clam. However *Mya arenaria* is unlikely to be affected directly.

Decrease in turbidity

Increase in wave exposure	Intermediate	High	Low	Low

Increased wave exposure in the long term is likely to alter the sediment grain size, and erode finer sediments, while decreased wave exposure is likely to increase the deposition of finer sediments. Overall, changes in wave exposure may increase or decrease the available habitat for *Mya arenaria*. Therefore an intolerance of intermediate has been recorded.
Given the patchy nature of populations and the sporadic nature of recruitment a recoverability of high has been recorded (see additional information below).

Decrease in wave exposure

Noise	Tolerant	Not relevant	Not sensitive	Not relevant

This species probably responds to local vibration, especially in the vicinity of the siphonal opening, withdrawing its siphons in response to potential predators, however it is unlikely to respond to noise pollution.

Visual Presence	Tolerant	Not relevant	Not sensitive	Not relevant

The siphons bear sensory tentacles that are probably light sensitive and responsive to shading, so that siphons withdraw to avoid predators, however, the visual range is probably extremely limited and this species is unlikely to respond to visual disturbance.

Abrasion & physical disturbance	Intermediate	High	Low	Low

Up to 50% of juveniles and 20% of un-harvested clams have been reported to be killed by shell breakage or smothering by tailings resulting from hydraulic dredging for clams. However, abrasion due to a passing scallop dredge (see benchmark) may kill a few individuals where the sediment is penetrated. *Mya arenaria* can occupy burrows of 15-20 cm deep and up to 40 cm deep so that adults are likely to survive, while young adults and juveniles may be lost. Therefore, an intolerance of intermediate has been recorded. A recoverability of high has been recorded (see additional information below).

Displacement	Intermediate	High	Low	Moderate

Clams can not burrow unless they are submerged. Small clams could re-burrow in ca. 5 min whereas older clams (>5cm) took >10 hrs. Pfitzenmeyer & Droebeck (1967) reported that 62% of small clams (35-50 mm), 39% of medium sized (51-65 mm) and only 21% of large clams (66-75 mm) had reburrowed within 48 hours. Emerson *et al.* (1990) noted that large clams could not burrow unless their anterior edge was in contact with the sediment and that small clams were held in suspension, but suggested that this would not result in significant mortality. Clams took longer to burrow in mud. Disturbed clams that re-buried themselves often burrowed to shallower depths than before the disturbance. Hence increasing their susceptibility to predation from shorebirds, and crabs. Together with the increased risk of predation, desiccation and temperature extremes while exposed at the sediment surface this may result in increased mortality. Therefore, an intolerance of intermediate has been recorded. Given the patchy nature of populations and the sporadic nature of recruitment a recoverability of high has been recorded (see additional information below).

Chemical Pressures

	Intolerance	Recoverability	Sensitivity	Confidence
Synthetic compound contamination	Intermediate	High	Low	Low

Mya arenaria has been shown to accumulate Tributyl tin (TBT) with a concentration factor of 539,690 (Bryan & Gibbs, 1991). Bouchard *et al.* (1999) reported that 8.1 x 10^{-7}M dibutyltin and 4.5 x 10^{-6} tributyltin resulted in 50% reduction of phagocytic activity in haemocytes, resulting in immunosuppression, and presumably a higher susceptibility to disease. However, little other information regarding the toxicity of TBT in the soft-shell clam was found. Bivalve mollusc larvae have been shown to be sensitive to TBT. Bryan & Gibbs (1991) reported evidence for the correlation between TBT contamination and recruitment failure in a number of bivalve species. Lack of recruitment in affected population would result in a significant decline in the population due to natural mortality of the adults alone. Newell & Hidu (1986) reported that *Mya arenaria* accumulated pesticides, however, no information concerning toxicity was given. Therefore, an intolerance of intermediate has been recorded. Given the patchy nature of populations and the sporadic nature of recruitment a recoverability of high has been recorded (see additional information below).

Heavy metal contamination	Intermediate	High	Low	Moderate

The embryonic and larval stages of bivalves are the most intolerant of heavy metals (Newell & Hidu, 1986; Bryan, 1984). Bryan (1984) suggested that mercury (Hg) was the most toxic, but that Cu, Cd and Zn may be the most problematic in the field. Eisler (1977) exposed *Mya arenaria* to a mixture of heavy metals in solution at concentrations equivalent to the highest recorded concentrations in interstitial waters in the study area. At 0 °C and 11 °C (winter temperatures)) 100% mortality occurred after4-10 weeks. At 16-22 °C (summer temperatures) 100% mortality occurred after 6-14 days, indicating greater intolerance at higher temperatures. Eisler (1977) reported the following LC_{50} in mg/l:

- 0.035 Cu;
- 0.15 Cd;
- 1.55 Zn;
- 8.8 Pb;
- 300 Mn; and
- >50 for Ni.

In Eisler's study (1977) the *Mya arenaria* accumulated Pb > Cu and Zn > Mn > Ni. Therefore an intolerance of intermediate has been recorded. Given the patchy nature of populations and the sporadic nature of recruitment a recoverability of high has been recorded (see additional information below).

Hydrocarbon contamination	High	Moderate	Moderate	Moderate

A spill of fuel oil and jet fuel contaminated sediments in Long Cove, Maine. Small clams close to the surface were killed first but as the oil penetrated the sediment larger clams were killed. Subsequent weathering removed oils from the surface of the sediment, but oil accumulated between 15-25 cm in the sediment for at least 6 years, varying in depth between 2-15 cm below the surface depending on location. *Mya arenaria* spat attempting to recolonize the affected area survived near the surface, even in the presence of 250 ppm of hydrocarbons. As the juveniles grew they burrowed deeper and died once they contacted the oil layer (Dow, 1978; Johnston, 1984). *Mya arenaria* was excluded from polluted sediments in an estuarine mudflat affected by petrochemical effluents, and did not appear until 2.5-4 km from the outfalls (moderate pollution) (McLusky, 1982). Therefore an intolerance of high has been recorded. Given the patchy nature of populations, the sporadic nature of recruitment, and the extended recoverability in oil contaminated sediments, as in the example above, a recoverability rank of moderate has been recorded (see additional information below).

Radionuclide contamination Not relevant Not relevant

Insufficient information

Changes in nutrient levels Intermediate High Low Moderate

No information regarding the direct effects of nutrients on *Mya arenaria* was found. However, increased nutrients are likely to enhance ephemeral algal and phytoplankton growth, increased organic material deposition and bacterial growth. At low levels increase phytoplankton and benthic diatoms may increase food availability for benthic infauna, including *Mya arenaria*. The presence of algal mats may act as refuges from predators (Newell & Hidu, 1986). However, increased levels of nutrient (beyond the carrying capacity of the environment) may result in eutrophication, algal blooms and concomitant reductions in oxygen concentrations and hypoxia e.g. in the Kattegat (Rosenberg & Loo, 1988) (see oxygenation below). Eutrophication is often associated with the growth of blankets of algae (*Ulva* sp.) or mussels (*Mytilus edulis*). Large-scale mortalities due to smothering by algal mats were reported by Dow & Wallace (1961). Mussels beds form on the surface of the sediment, and in high enough densities may deprive the infaunal clams of food and eventually of oxygen. In the long term, bio-deposition by the mussels and sedimentation between the mussels raises the height of the sediment, preventing the clams from reaching the surface, therefore destroying the clam bed (Dow & Wallace, 1961). Therefore, an intolerance of intermediate has been recorded at the level of the benchmark, although intolerance to severe nutrient enrichmant and eutrophication may be higher.
Given the patchy nature of populations and the sporadic nature of recruitment a recoverability of high has been recorded (see additional information below).

Increase in salinity Low Immediate Not sensitive Moderate

Mya arenaria tolerates a wide range of salinities and is a euryhaline osmoconformer (Strasser, 1999). Like several bivalves it can regulate cell volume to some extent by mobilising its amino acid pool (Newell & Hidu, 1986). The lowest salinity at which *Mya arenaria* occurred in the Baltic was 4.5-5.0 psu and lower limits of 4 psu and 5 psu have also been reported from the west Atlantic coast (Strasser, 1999). Larvae are more intolerant of low salinity than adults and grow optimally between 16-32 psu (Stickney, 1964). Salinity tolerance is correlated with temperature, the clams tolerating lower salinities at lower temperature and being able to acclimate to decreasing salinities more rapidly at higher temperatures (Newell & Hidu, 1986). High mortalites (98%) were reported due to freshwater runoff after hurricane Agnes in Chesapeake Bay when salinities dropped to 2 psu (Shaw & Hammons, 1974). However, in St Lawrence Bay clams survived 1.5 days at 1 psu at low temperatures (Newell & Hidu, 1986). *Mya arenaria* also persists in areas that reach >35 psu (Strasser, 1999). Therefore, given its wide salinity tolerance and widespread distribution from the subtidal to estuaries *Mya arenaria* is probably tolerant of changes in salinity at the benchmark level and an intolerance of low has been recorded. Populations in the upper intertidal or the upper reaches of estuaries and juveniles living on the surface and shallow depth in the sediment are probably more vulnerable to changes in salinity. Newell & Hidu (1986) reported laboratory studies that demonstrated acclimation from 30 - 22 psu with 60 hrs at 4°C and 10 hours at 10°C. Therefore, recovery from salinity stress is likely to be rapid, within a few days and a recoverability of immediate has been recorded.

Decrease in salinity

Changes in oxygenation	Low	Immediate	Not sensitive	High

Mya arenaria tolerates low oxygen concentration and the presence of hydrogen sulphide for several days or weeks. Fifty percent mortality was observed after 21 days at 10 °C exposed to 0.15 ml O_2/l (0.21 mg/l) in the presence of H_2S (Theede *et al.* 1969). At 0.5-1.0 ml O_2/l (0.7-1.4mg/l), 8% survived in sediment for 32 days and 54% survived for 43 days (Rosenberg *et al.*, 1991). Rosenberg & Loo (1988) reported mass mortalities of *Mya arenaria* and *Cerastoderma edule* in the 1980s in the Kattegat, which were associated with eutrophication and resultant low oxygen concentrations over several years (often <1 ml O_2/l). However, *Mya arenaria* species is probably tolerant of 2mg/l for a week and a rank of low intolerance has been given. Anaerobic metabolism allows bivalves to maintain important metabolic function while emersed or under hypoxic conditions but may deplete energy reserves and result in an 'oxygen debt' on return to normal conditions. Therefore, recovery on return to normoxic conditions may take several hours or even days.

Biological Pressures

	Intolerance	Recoverability	Sensitivity	Confidence
Introduction of microbial pathogens/parasites	Intermediate	High	Low	High

Several parasites occur in *Mya arenaria*, e.g. cercaria of *Himasthla leptosoma*, the nemertean parasite *Malacobdella* sp. and the copepod *Myicola metisciensis* may be commensal (Clay, 1966). The protozoan, *Perkinsus* sp. related to the species responsible for 'Dermo' disease in oysters, has recently been isolated from *Mya arenaria* in Chesapeake Bay, USA (McLaughlin *et al.*, 2000, summary only). *Mya arenaria* is also known to suffer from cancers, disseminated neoplasia and gonadal tumours. Disseminated neoplasia has been reported to occur in 20% of the population in north eastern United States and Canada, and caused up to 78% mortalities in New England (Brousseau & Baglivo, 1991; Landsberg, 1996). Presumably gonadal tumours reproduce reproductive capacity. The occurrence of gonadal tumours in *Mya arenaria* was related to the occurrence of the blooms of the toxigenic dinoflagellate *Alexandrium* spp. Lansberg (1996) reported a correlation between the occurrence of gonadal tumours and neoplasia in bivalves and paralytic shellfish poisoning due to the accumulation of toxins released by toxigenic dinoflagellate blooms. Therefore an intolerance of intermediate has been recorded. However, so far there have been no records of parasites or disease in the UK or Europe (Strasser, *pers comm.*). Given the patchy nature of populations and the sporadic nature of recruitment a recoverability of high has been recorded (see additional information below).

Introduction of non-native species	Intermediate	High	Low	Very low

The American hard-shelled clam *Mercenaria mercenaria* colonized the niche left by *Mya arenaria* killed after cold winter of 1947 and1962/63 in Southampton Water (Eno *et al.* 1997). The *Mya arenaria* populations had not recovered in this area by 1997 (Eno *et al.*, 1997). Therefore, the above non-native species may compete with *Mya arenaria* for suitable habitat and an intolerance of intermediate has been reported. Given the patchy nature of populations and the sporadic nature of recruitment a recoverability of high has been recorded (see additional information below).

Extraction of this species	Intermediate	High	Low	Low

Removal of *Mya arenaria* will remove a high proportion of the population, either removed by harvesting or killed in the process. For example, up to 50% of juveniles and 20% of un-harvested clams have been reported to be killed by shell breakage or smothering by tailing by hydraulic dredging for clams (Emerson *et al.*, 1990). Disturbed clams that re-buried themselves

often burrowed to shallower depths than before the disturbance, hence increasing their susceptibility to predation from shorebirds, and crabs (Emerson *et al.*, 1990). Together with the increased risk of predation, desiccation and temperature extremes while exposed at the sediment surface this may result in increased mortality and an intolerance of intermediate has been recorded.
Given the patchy nature of populations and the sporadic nature of recruitment a recoverability of high has been recorded (see additional information below).

Extraction of other species	High	High	Moderate	High

Oyster dredging removed most fauna except *Abra tenuis*, *Cerastoderma edule* and *Mya arenaria*, which were probably displaced (Gubbay & Knapman, 1999). Mechanical harvesting (dredging) for *Arenicola marina* resulted in drastic reduction in the population *Mya arenaria* in the Wadden Sea (Beukema, 1995). Some clams were harvested by bait diggers, but most of mortality resulted from broken shells and predation on those individuals (especially large clams) that could not burrow before the tide receded. As a result the population of *Mya arenaria* became very low between 1979-1986, and the population took about 5 years to recover its original density (Beukema, 1995). Therefore ,an intolerance of high has been recorded together with a recoverability of high.

Additional information

Recoverability:
Strasser *et al.* (1999) noted that population densities in the Wadden Sea were patchy and dominated by particular year classes. *Mya arenaria* has a high fecundity and reproductive potential but larval supply is sporadic and juvenile mortality is high, so that although, large numbers of spat may settle annually, successful recruitment and hence recovery may take longer than a year. Beukema (1995) reported that a population of *Mya arenaria* in the Wadden Sea, drastically reduced by lugworm dredging took about 5 years to recover.

Importance review

Policy/legislation

- no data -

Status

National (GB) importance	-	**Global red list (IUCN) category**	-

Non-native

Native	Non-native		
Origin	Northern America	**Date Arrived**	1899

Importance information

Mya arenaria is a dominant member of the benthic infauna (Warwick & Price 1978; Strasser, 1999) and an important food source for numerous species in benthic ecosystems including man. In North America the soft-shell clam is an important commercial fishery (Strasser,1999; Anonymous, 1996). However, in Chesapeake Bay, for example, the abundance has decreased recently, possibly due to intense fishing pressure, habitat loss or declining water quality (Anonymous, 1996). Fowler (1999) noted that *Mya arenaria* is rarely collected for food or bait in the UK.

Mya arenaria is an important food source for numerous organisms. The most important juvenile predators are crabs, (e.g. the green crab *Carcinus maenas*, which dig pits to reach clams living in the top 14 cm), shrimp *Crangon crangon*, shorebirds, nereids (sandworms), nemerteans and flatfish (*Pleuronectes platessa*, *Platichtys flesus*). Adults are preyed on by crabs (as above), oystercatchers (*Haematopus ostralegus*) and curlew (*Numenius arquata*) and wintering sea ducks in the Baltic Sea (Emerson *et al.*, 1990; Strasser, 1999).

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