A surf clam (*Spisula solida*)

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

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The surf clam *Spisula solida*.
Photographer: Bob Williams
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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	Marisa Sabatini	**Refereed by**	This information is not refereed.
Authority	(Linnaeus, 1758)		
Other common names	-	**Synonyms**	-

Summary

Description

Spisula solida can reach lengths up of 5 cm. It has a triangular outline with rounded corners. Fine concentric lines and grooves are grouped close together on either side of the beaks. The outer shell surface is brownish or yellowish-white. The shell is white on the inside. The three cardinal teeth of the left valve are fused and short, extending only half way to the inner hinge plate rim, whereas the right valve has two short cardinal teeth. The left valve has single, elongate, anterior and posterior lateral teeth and the right valve has paired anterior and posterior lateral teeth.

Recorded distribution in Britain and Ireland

Recorded at scattered locations around the coasts of Britain and Ireland.

Global distribution

Spisula solida is distributed from subarctic Iceland and Norway as far south as Portugal and Morocco but is not found in the Mediterranean.

Habitat

Spisula solida is a burrowing bivalve occasionally found at low water but more usually in the sublittoral. It prefers sandy beds with continually moving water and avoids mud and stagnant water.

Depth range
5-50 m

Identifying features

- Sub triangular shell.
- Coarse concentric sculpturing with distinct growth lines.
  The three cardinal teeth of the left valve are fused and short, extending only half way to the inner hinge plate rim, whereas the right valve has two short cardinal teeth.
- Lateral teeth are serrated or ridged.
- The left valve has single, elongate, anterior and posterior lateral teeth and the right valve has paired anterior and posterior lateral teeth.
- Solid umbones on the midline.

Additional information
Spisula solida may be confused with *Spisula elliptica*, however the latter is smaller and more delicate. *Spisula elliptica* is also narrower relative to its length. *Spisula solida* may also be confused with *Mactra stultorum* but the cardinal teeth of the latter are smooth rather than ridged. **Please note:** the biology of *Spisula solida* is poorly known and information on closely related species has been used where appropriate.

Listed by

Further information sources

Search on:

NBN WoRMS

Biology review

Taxonomy

Phylum	Mollusca	Snails, slugs, mussels, cockles, clams & squid
Family	Mactridae	
Genus	Spisula	
Authority	(Linnaeus, 1758)	
Recent Synonyms	-	

Biology

Typical abundance	High density
Male size range	<5cm
Male size at maturity	~2.5cm
Female size range	~2.5cm
Female size at maturity	
Growth form	Bivalved
Growth rate	See additional information
Body flexibility	None (less than 10 degrees)
Mobility	
Characteristic feeding method	Active suspension feeder, Active suspension feeder
Diet/food source	
Typically feeds on	Phytoplankton (i.e. diatoms)
Sociability	
Environmental position	Infaunal
Dependency	No information found.
Supports	No information found
Is the species harmful?	No

Biology information

Abundance and biomass

The abundance of *Spisula solida* varies with location. For example, the following abundances and biomass were reported:

- 0-240 ind./m□ (0-2046 g/m□) at R&#248de Klit Sand (Denmark) (Kristensen, 1996);
- 0-45 ind./m□ (0-632 g/m□) at Horns Reef (Denmark) (Kristensen, 1996); whereas
- 2000 ind./m^2 in Start Bay (UK) (Ford, 1925).

In Danish waters the average biomass of *Spisula solida* was 265 g/m□ in the R&#248de Klit Sand 103 g/m□ at Horns Reef (Kristensen, 1996). In Waterford Harbour, (Ireland) the maximum biomass was 600 g/m^2 (Fahy *et al*., 2003).

Growth

The growth of *Spisula solida* is rapid during its first two years and then slows down (Gaspar *et al*., 1995; Kristensen, 1996). This rapid increase in size was reported in Waterford Harbour where the number of *Spisula solida* per kg declined rapidly between the ages of 2-3 (769 - 227 ind./kg) (Fahy *et* *al*., 2003). Over the following three years this figure halved again to 101 ind./kg (Fahy *et al*., 2003).

Growth can be influenced by environmental factors, particularly density. For instance, Weinberg & Hesler (1996) compared growth curves of *Spisula solidissima* in two areas off the New Jersey and Dekmarva coasts (U.S.) and the Long Island and South New England coasts (U.S.) following a hypoxic event, which resulted in mortalities in the southernmost in 1976. Both growth and maximum shell length declined in Long Island/South New England, whereas in New Jersey/Dekmarva growth and shell length remained constant and had not been affected by the hypoxia. Weinberg & Hesler (1996) suggested that following the hypoxia, the first clams to recolonize grew more rapidly in the presence of a good food supply and without competitors.

Growth rates
Clear shell sculpture marks occur on *Spisula solida*, suggesting annual rings, but their interpretation is not straight forward (Fahy *et al*., 2003). The shell surface of *Spisula solida* also exhibits some disturbance lines, that are impossible to distinguish from annual growth lines therefore internal bands are used (Gaspar *et al*., 1995). Taylor *et al.* (1969,1973; cited in Fahy *et al*., 2003) described the shells of the superfamily Mactracea. Their shells are composed of two layers of aragonite: a white, opaque, outer layer, consisting of crossed lamellar crystalline structure, which is separated by the pallial myostracum from a grey, somewhat translucent, inner layer. The white outer shell layer and the chondrophore are streaked periodically with dark lines (internal growth lines). This structure confirms the presence of true annuli, which external sculpture alone might not indicate. During winter, wide growth increments are deposited, which is characteristic of rapid shell growth whilst narrow spaced dark zones are formed in summer (Gaspar *et al*., 1995).

The maximum length of *Spisula solida* (5 cm) from Irish waters is similar to that of northern European stocks but growth rates appear to vary geographically. Dimensions attained by Irish *Spisula solida* differ from those reported from other northern European stocks of the species. In the Danish North Sea, individuals between 2-3 years reached a length of 35 mm. Meixner (1994; cited in Fahy *et al*., 2003) reported that *Spisula solida* 35 mm in length from the German North Sea similarly averaged 2.5 years old while in Waterford Harbour individuals were 5.27 years at the same length (Fahy *et al*., 2003).

Habitat preferences

Physiographic preferences	Open coast, Offshore seabed, Strait / sound
Biological zone preferences	Lower eulittoral, Lower infralittoral, Sublittoral fringe, Upper infralittoral
Substratum / habitat preferences	Fine clean sand, Gravel / shingle, Mixed, Pebbles
Tidal strength preferences	Moderately Strong 1 to 3 knots (0.5-1.5 m/sec.), Strong 3 to 6 knots (1.5-3 m/sec.), Weak < 1 knot (<0.5 m/sec.)
Wave exposure preferences	Exposed, Moderately exposed, Sheltered, Very exposed
Salinity preferences	Full (30-40 psu)
Depth range	5-50 m
Other preferences	No text entered
Migration Pattern	Non-migratory / resident

Habitat Information

Kristensen (1996) reported that *Spisula solida* showed a preference for grain sizes that ranged between 2-3 mm. The population of *Spisula solida* in Waterford Harbour, (Ireland) conformed to the grain size preference above. *Spisula solida* can be found at depths of 50 m (Schlieper *et al.*, 1967). But in the North Sea, *Spisula solida* is restricted to depths of about 10-15 m (Theede *et al.*, 1969). Whereas, in Portuguese waters, *Spisula solida* is more common in greater abundances at depths between 5-13 metres (Gaspar *et al.*, 1999).

Life history

Adult characteristics

Reproductive type	Gonochoristic (dioecious)
Reproductive frequency	Annual protracted
Fecundity (number of eggs)	No information
Generation time	Insufficient information
Age at maturity	1 year
Season	February - June
Life span	5-10 years

Larval characteristics

Larval/propagule type	-
Larval/juvenile development	Planktotrophic
Duration of larval stage	No information
Larval dispersal potential	See additional information
Larval settlement period	Insufficient information

Life history information

Longevity
The life expectancy of *Spisula solida* is up to approximately ten years (Fahy, 2003).

Sexual maturity
Spisula solida reaches sexual maturity during its first year, which is a function of age, not of size (Gaspar & Monteiro,1999; Fahy *et al.*, 2003).

Gametogenesis
The sexes of *Spisula solida* are separate and there are no records of hermaphrodites (Gaspar & Monteiro, 1999). Male and female white clams are distinguishable externally since the colour of the gonad in this species is reddish in the females and yellowish-orange in the males (Gaspar & Monteiro, 1999). Both sexes show a synchrony in gametogenic development and spawning.

Gaspar & Monteiro (1999) observed that gametogenesis in *Spisula solida* began when the seawater temperature started to decrease (late September). Gaspar *et al.* (1999) concluded that the initiation of gametogenesis in *Spisula solida* was a response to falling temperature and that spawning occurred when the temperature began to rise rather than occurring at a fixed temperature. The maturation of the gonad continued until late January when the water temperature was at its lowest (Gaspar & Monteiro, 1999). In Danish waters specimens of *Spisula solida* were sexually inactive from July-Sept. The first ripe stage of gonads was reached in December, and all individuals were ripe by January (Gaspar & Monteiro, 1999).

Spawning
Spawning begins in February (Gaspar & Monteiro, 1999). Gaspar & Monteiro (1999) noted that 75% of a studied population were in the spent stage of their gametogenic cycle by June (Gaspar & Monteiro, 1999).

Dispersal
Ford (1925) suggested that *Spisula solida* can be moved along by water movement (bed load transport) along the sea bottom to another position on the seabed. Therefore, in the course of time considerable mixing could easily bring together individuals of different ages and origins (Ford, 1925).

Recruitment
In Ireland the recruitment of *Spisula solida* is irregular with 1 year old clams out numbering all the other year classes (Fahy *et al.*, 2003). The reasons for this are unknown. However, irregular settlement rather than erratic gamete production might be the explanation for the occasional strong representation of a year class in Waterford Harbour clam population (Fahy, 2003).

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	Low

Removal of the substratum would also remove the entire population of *Spisula solida* and so intolerance has been assessed as high with a high recoverability.

	Intolerance	Recoverability	Sensitivity	Confidence
Smothering	Intermediate	High	Low	Moderate

Spisula solida is a fast burrowing bivalve. If *Spisula solida* were covered by sediments it would be able to reposition itself within the sediment. The location of the Waterford clam bed (Ireland) was examined in 2001. Fishermen compared the areas of the clam bed that provided the heaviest catches in two years. It was concluded that the location of the heaviest catches had moved slightly to the north-west of the harbour as part of the existing bed had silted up. This reduced the numbers of *Spisula solida* and the size of the clam patch (Fahy *et al.*, 2003). However, intolerance has been assessed as intermediate to reflect the reduction in the size of the clam bed and *Spisula* numbers. Recoverability is assessed as high.

	Intolerance	Recoverability	Sensitivity	Confidence
Increase in suspended sediment	Low	Very high	Very Low	Very low

Levels of suspended sediment are likely to be most relevant to feeding. An increase in suspended sediment is likely to increase the rate of siltation (see smothering above) and the availability of food as *Spisula solida* is a suspension feeder. However, if the level of suspended sediment become too high it could cause the feeding structures to become clogged. It is unlikely that mortality would occur, therefore intolerance has been assessed as low with a very high recoverability.

	Intolerance	Recoverability	Sensitivity	Confidence
Decrease in suspended sediment	Low	Immediate	Not sensitive	

Levels of suspended sediment are likely to be most relevant to feeding. A decrease in suspended sediment is likely to decrease the availability of food for suspension feeding bivalves. Mortality is unlikely to occur within 1 month (see benchmark) and so intolerance is assessed as low. When suspended sediment levels return to normal, so too should food availability and feeding.

	Intolerance	Recoverability	Sensitivity	Confidence
Dessication	Intermediate	High	Low	Very low

Spisula solida can be found occasionally in the intertidal. A change in desiccation at the benchmark level would affect *Spisula solida* at the upper limit of their distribution and may cause mortalities. Therefore intolerance is assessed as intermediate with a high recoverability.

	Intolerance	Recoverability	Sensitivity	Confidence
Increase in emergence regime	Intermediate	High	Low	Very low

An increase in emergence at the benchmark level, would most likely to reduce the upper limits of *Spisula solida* and a portion of the population may be lost. Therefore intolerance is assessed as intermediate with high recoverability a recoverability.

	Intolerance	Recoverability	Sensitivity	Confidence
Decrease in emergence regime	Tolerant*	Not relevant	Not sensitive*	

A decrease in emergence at the benchmark level would benefit individuals of*Spisula solida* allowing them to colonize further up the shoreline. Therefore, *Spisula solida* is tolerant* of this factor.

Increase in water flow rate	Intermediate	High	Low	Moderate

Spisula solida is found in areas ranging from strong to weak water flow. The increased water flow rate at the benchmark level would change the sediment characteristics in which the species lives. The substrata may be disturbed and the sediment on the seabed may erode. This scouring of sand and gravel causes coarse sediments to become unstable and difficult to burrow. Additionally, an increase in water flow may interfere with feeding and respiration. Increased water flow may also lead to the dislodgement and abrasion of *Spisula solida*. However, the worn appearance of *Spisula solida* shells indicate that they inhabit areas of considerable water movement. A proportion of the population of *Spisula solida* may also be transported to another position on the seabed (bedload transport). Increased water flow may also prevent the settlement of larvae and juveniles decreasing the recruitment to an area (Hiscock, 1983). Therefore intolerance is assessed as intermediate with a high recoverability.

Decrease in water flow rate	Intermediate	High	Low	Low

Spisula solida is found in areas ranging from strong to weak water flow. A decreased water flow rate may lower the dispersion of planktonic larvae and recruitment from other areas would be minimal. A decrease in water flow at the benchmark level would also result in increased deposition of fine suspended sediment (Hiscock, 1983), changing the sediment characteristics of the habitat in which the species lives. This may cause the substratum to become too muddy for *Spisula solida* which prefers sandy sediments and mixed sediments and avoids muddy sediments. Some mortality is, therefore, expected and an intolerance of intermediate is recorded. Recoverability is assessed as high

Increase in temperature	Tolerant	Not relevant	Not sensitive	Low

Schlieper *et al.* (1967) state that the upper temperature tolerance of *Spisula solida* is 30°C. Fahy *et al.* (2003) stated that the optimum condition of *Spisula solida* occurred at low temperature. However, *Spisula solida* does occur in areas as far south as Portugal and Morocco and is unlikely to be affected by an increases in temperature experienced in British and Irish waters. Therefore, *Spisula solida* would probably be tolerant of an increase in temperature at the benchmark level.

Decrease in temperature	High	High	Moderate	Moderate

Fahy *et al.* (2003) stated that the optimum condition of *Spisula solida* occurred at low temperatures. *Spisula solida* also occurs as far north as sub-arctic Iceland and Norway. Therefore, *Spisula solida* would probably be tolerant of an increase in temperature at the benchmark level. However, the *Spisula solida* population of Red Wharf Bay, Anglesey was reported to demonstrate 'exceptionally heavy mortality' as a result of the 1962/63 winter (Crisp, 1964). Futhermore, the clam disappeared from the entire German Bight above the 20 m depth contour line during the 1995/96 winter where water temperatures at the sea bottom dropped to 0°C (M. Ruth, pers. comm.). Therefore, *Spisula solida* is probably highly intolerant of an acute temperature change, at the benchmark level.

Increase in turbidity	Low	Very high	Very Low	Low

Spisula solida does not require light and therefore the effects of increased turbidity on light attenuation are not directly relevant. An increase in turbidity may affect primary production in the water column and therefore reduce the availability of food. A turbidity increase for a year (see benchmark) would reduce the availability of food that would probably affect growth and fecundity and an intolerance of low is recorded. As soon as light levels return to normal, primary production will increase and hence recoverability is recorded as very high.

Decrease in turbidity Tolerant Not relevant Not sensitive Low

Spisula solida does not require light and therefore the effects of increased turbidity on light attenuation are not directly relevant. A decrease in turbidity would increase primary production in the water column and food availability. Therefore it is likely that *Spisula solida* would be tolerant of a decrease in turbidity.

Increase in wave exposure Intermediate High Low Moderate

Spisula solida occurs in wave exposed to wave sheltered areas. This suggests that the species would be tolerant of a certain degree of sediment mobility associated with strong wave action. An increase in wave exposure (at the benchmark level) would place the majority of the population in areas frequently subject to strong wave action and the species may be affected in several ways. Strong wave action may cause damage or withdrawal of the siphons, resulting in loss of feeding opportunities and compromised growth. Furthermore, individuals may be dislodged by scouring from sand and gravel mobilized by increased wave action. Breon (1970; cited in Chícharo *et al.*, 2002) reported that *Spisula subtruncata*, a species with a depth distribution similar to *Spisula solida*, exhibited increased burrowing activity when disturbed by wave action. Therefore intolerance is assessed as intermediate with a high recoverability.

Decrease in wave exposure Intermediate High Low Moderate

Spisula solida occurs in wave exposed to wave sheltered areas. Decreased wave exposure at the benchmark level is likely to result in the establishment of more stable muddy sediment habitats. It is likely that this would result in mortality of *Spisula solida*. *Spisula solida* may also probably suffer increased competition from species better adapted to life in low energy environments. Intolerance is therefore assessed as intermediate with a high recoverability.

Noise Not relevant Low

No information was found concerning the effects of noise on *Spisula solida.*

Visual Presence Not relevant Low

Spisula solida probably has little visual acuity and has been recorded as not sensitive to this factor.

Abrasion & physical disturbance Intermediate High Low Low

The worn appearance of *Spisula solida* shells indicate that they inhabit areas of considerable water movement showing some tolerance for the effects of water movement on their robust shells (Ford, 1925).
Fishing for demersal species will disturb the surface layer of sediment and any protruding or shallow burrowing species. In Portugal, *Spisula solida* is caught at a depth of 7-9 m with a tooth dredge that can penetrate the sediment to a depth of 50 cm. Gaspar *et al.* (2002) noted that 93% of the uncaught *Spisula solida* were undamaged after experimental trawls, as they were well protected by their thick shells, and only 1% of the uncaught *Spisula solida* died (Gaspar *et al.*, 2002).

The impacts caused by a fishing dredge significantly increased the number of exposed *Spisula solida* clams and the abundance of potential predators (Chícharo *et al.*, 2002). The impact of the dredge increased the time needed for *Spisula solida* to rebury, which rendered them vulnerable to predation for longer periods (Chícharo *et al.*, 2002). Under controlled conditions, it took *Spisula solida* three minutes to rebury themselves when displaced to the surface.

However under trawling/dredging conditions it took *Spisula solida* nine minutes to rebury back into the sediments (Chícharo *et al.*, 2002). Chícharo *et al.* (2002) stated that only 6% of *Spisula solida* not caught by the dredge were damaged and 94% were classified as having none or slight damage. Therefore intolerance has been assessed as intermediate as mortality may occur and recoverability has been assessed as high.

Displacement	Intermediate	High	Low	Moderate

Spisula solida can burrow back down into the sediment very rapidly in its preferred substrata when it is displaced to the surface, therefore it is probably relatively tolerant of displacement. *Spisula solida* are subject to considerable water movements that cause displacement, which can carry individuals to another position where they will once again settle (Ford, 1925). This can be seen when different morphologies of *Spisula solida* occur in the same area. It is unlikely that mortalities will occur as *Spisula solida* has a thick solid shell and individual *Spisula solida* are often found with a worn appearance that is consistent with such activity (Ford, 1925).

The impacts caused by a fishing dredge significantly increased the number of exposed *Spisula solida* clams and the abundance of potential predators (Chícharo *et al.*, 2002). The impact of the dredge increased the time needed for *Spisula solida* to rebury and rendered them vulnerable to predation for longer periods (Chícharo *et al.*, 2002). Under controlled conditions it took *Spisula solida* three minutes to rebury when displaced however under trawling/dredging conditions it took *Spisula solida* nine minutes to rebury back into the sediments (Chícharo *et al.*, 2002).

However such displacement could result in a loss of recruitment, increased predation and loss of mature individuals which will affect the viability of a population. Therefore intolerance is assessed as intermediate with a high recoverability.

Chemical Pressures

	Intolerance	Recoverability	Sensitivity	Confidence
Synthetic compound contamination	Intermediate	High	Low	Very low

Effects of synthetic contamination on bivalves are listed below.

- The burrowing and avoidance behaviour in the bivalves *Tellina tenuis*, *Abra alba* and *Limecola balthica* becomes impaired when they are exposed to phenol but no deaths occurred. Impairment of burrowing can leave bivalves vulnerable to predation and wave action (Møhlen & Kiørboe, 1983).
- High levels of tributyl tin (TBT), was implicated in slow growth and shell malformation 'balling' in the oyster *Magallana gigas* and larval mortality in *Mytilus edulis* (Beaumont *et al.*, 1989) reducing recruitment levels. When exposed to 1-3 µgTBT/l *Cerastoderma edule* and *Scobicularia plana* suffered 100% mortality after two and ten weeks respectively (Beaumont *et al.*, 1989).

There is also evidence that TBT causes recruitment failure in bivalves, either due to reproductive failure or larval mortality (Bryan & Gibbs, 1991). No information could be found on the effects of synthetic chemicals on *Spisula solida*. However, given the likely effects of TBT on bivalves, an intolerance of intermediate has been suggested, albeit with very low confidence.

Heavy metal contamination	Intermediate	High	Low	Very low

Many bivalve species accumulate heavy metals in their tissues, far in excess of environmental levels. Examples of the sub-lethal effects of heavy metals include: siphon retraction, valve closure, inhibition of byssal thread production, disruption of burrowing behaviour, inhibition of respiration, inhibition of filtration rate, inhibition of protein synthesis and suppressed growth (see review by Aberkali & Trueman, 1985). Bryan (1984), suggested that Hg was the most toxic metal to bivalve molluscs in experimental studies while copper (Cu), cadmium (Cd) and zinc (Zn) were the most problematic for bivalves in the field. For example:

- exposure to 15 parts per billion (ppb) of copper was found to produce deformed embryos in *Crassostrea virginica*and 33 ppb proved lethal to their larvae (Bryan, 1984).
- adults, on the other hand could withstand exposure to such levels, although through the immobilization of copper, they become green and unpalatable (Bryan, 1984);
- exposure to 100 ppb of cadmium for 15 weeks induced poor conditions and mortalities in adult *Crassostrea virginica* (Bryan, 1984).

No information specifically concerning the effects of heavy metal contamination on *Spisula solida* was found. However, the above evidence suggests that they may demonstrate sub-lethal effects, and in some cases, mortalities due to heavy metal contamination. Therefore, an intolerance of intermediate has been suggested, albeit with very low confidence.

Hydrocarbon contamination	Intermediate	High		Low

The effects of oil on invertebrate molluscs include:

- substantially reduced feeding rates and / or food detection ability probably due to ciliary inhibition;
- an increase in energy expenditure and a decrease in feeding rate, resulting in less energy available for growth and reproduction; and
- reduced infaunal burrowing rates at sublethal concentrations (Suchanek, 1993).

Spisula solidissima, a relative of *Spisula solida*, was exposed to oil during the North Cape oil spill on the coast of Rhode island (USA) (McCay *et al.*, 2003). The number of bivalve mortalities was estimated by impact assessment modeling of acute toxicity. Results showed that *Solida solidissima* comprised of 97% of the total loss of bivalve production from the spill affected area with up to 40% mortality. It is probable that hydrocarbons would have a similar effect on *Spisula solida*, however no specific information could be found concerning the effects of hydrocarbons on *Spisula solida*. Therefore, an intolerance of intermediate has been suggested, albeit with low confidence.

Radionuclide contamination		Not relevant		Not relevant

No information was found on the effects of radionuclides on *Spisula solida*.

Changes in nutrient levels	Intermediate	High	Low	Low

Increased nutrients are likely to enhance ephemeral algal and phytoplankton growth, increase organic material deposition and enhance bacterial growth. At low levels, an increase in phytoplankton may increase food availability for *Spisula solida*. However, increased levels of nutrients (beyond the carrying capacity of the environment) may result in eutrophication, algal blooms and reductions in oxygen concentrations that can cause hypoxia. Rosenberg & Loo (1988) reported mass mortalities of the bivalves *Mya arenaria* and *Cerastoderma edule* following a eutrophication event in Sweden, however no direct causal link was established. *Spisula* sp. were reported to accumulate algal toxins (e.g. saxitoxin and neosaxitoxin) in their tissues, and to retain toxins for long periods of time, ranging from months to over three years (see review by Landsberg, 1996). However, Landsberg (1996) found no evidence of resultant neoplasias (cancers) in *Spisula* sp. and did not report evidence of mortalities in *Spisula* sp. induced by algal blooms. However, Mahoney & Steimle (1979) reported mass mortalities of *Spisula solidissima* off the coast of New Jersey, due to of bottom water oxygen deficiency, as a result of the decay of a bloom of the dinoflagellate *Ceratium tripos* (see oxygenation below). Therefore, while *Spisula* sp. May be relatively tolerant of algal toxins, algal blooms may indirectly cause mortality due to hypoxia. Therefore, a dramatic increase in nutrient levels may cause some mortality of *Spisula solida*, and an intolerance of intermediate has been reported.

Increase in salinity High High Moderate Low

Spisula solida is typically found in full salinity conditions. *Spisula solida* exhibited the lowest salinity tolerance of excised gill tissues compared to the other species tested. After 24 hours, ciliary activity of 4 to 8 mm² gill pieces was observed in salinities that ranged from 15 to 50 parts per thousand (Theede, 1965; reported in Kinne, 1971b). The whole animal is likely to tolerate changes in salinity for longer, since it can isolate itself from its surroundings by closing its valves. However, at the benchmark level, an acute change for a period of 1 week or a chronic change for a year is likely to result in mortality. Therefore, an intolerance of high has been recorded.

Decrease in salinity High High Moderate Low

Spisula solida exhibited the lowest salinity tolerance of excised gill tissues compared to the other species tested. After 24 hours, ciliary activity of 4 to 8 mm² gill pieces was observed in salinities that ranged from 15 to 50 parts per thousand (Kinne, 1971b). The whole animal is likely to tolerate changes in salinity for longer, since it can isolate itself from its surroundings by closing its valves. *Spisula solida* is typically found at full salinities (Theede *et al.*, 1969) and is likely to be intolerant of a decrease in salinity. Distributionally, *Spisula solida* extends into the Kattegat (Sweden) but does not enter the brackish waters of the Baltic Sea as the salinity is lower (Theede et al., 1969). At the benchmark level, an acute change for a period of 1 week or a chronic change for a year is likely to result in mortality. Therefore intolerance has been assessed to be high with a high recoverability.

Changes in oxygenation High High Moderate High

Diaz & Rosenberg (1995) list *Spisula solida* as sensitive to hypoxic events. *Spisula solida* exhibited the fastest declines in ciliary movement in excised gill tissue, compared to other species tested at oxygen concentrations of 0.21 mg/l (Theede *at al.*, 1969). Excised gill tissues of *Spisula solida* showed irreversible damage after 4 days under anoxic conditions after which ciliary movement completely stopped. The tolerance of the whole animal is likely to be longer, since it can shut itself off from the surrounding water by closing its valves.
Decay of an immense bloom of the dinoflagellate *Ceratium tripos* caused severe hypoxia over a 13,000 km² in the New York bight in 1976 (Mahoney & Steimle, 1979). The oxygen levels dropped 2ml/l (2.8 mg/l) over a wide area, and to as low as 0.1 ml/l (0.14 mg/l) in the worst affected areas, with an associated increase in hydrogen sulphide levels. *Spisula solidissima* was the most affected species and exhibited an estimated 69% mortality (Mahoney & Steimle, 1979).

Overall, the above evidence suggests that Spisula solida and related species are relatively intolerant of hypoxic conditions. Therefore, a change in oxygenation at the benchmark level would probably cause the population of *Spisula solida* to collapse and recoverability would be reliant on outside recruitment. Therefore intolerance is assessed as high with a high recoverability.

Biological Pressures

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

A number of organisms have been found living on and in individual specimens of *Spisula solida*

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- The gregarine *Nematopis schneideri* utilizes *Spisula solida* as an intermediate host (Lauckner, 1983).
- The ciliate *Thigmorphyra bivalviorum* was found on the gills of *Spisula solida* (Fenchel, 1965). However no information on their effects on *Spisula solida* could be found.
- The pea crab *Pinnotheres pisum* lives inside the shells of living bivalves. Møller Christensen (1962;cited in Lauckner, 1983) found an ovigenous female in *Spisula solida*. Berner (1952; cited in Cheung, 1967) noted that there was a partial or complete cessation in the production of gametes in those individuals that were infected with *Pinnotheres pisum* that averaged 1 cm or more in carapace length (CL). Smaller crabs very seldom affect bivalves in the manner above.

Therefore, intolerance is assessed as intermediate to reflect the cessation in the production of gonads, with a high recoverability.

	Intolerance	Recoverability	Sensitivity	Confidence
Introduction of non-native species		Not relevant		Low

There is no information on the effects of non-native species on *Spisula solida*.

	Intolerance	Recoverability	Sensitivity	Confidence
Extraction of this species	Intermediate	High	Low	Moderate

Spisula solida is fished commercially. The impacts caused by a fishing dredge significantly increased the number of exposed *Spisula solida* clams and the abundance of potential predators (Chícharo *et al.*, 2002). The impact of the dredge increased the time needed for *Spisula solida* individuals to rebury rendering them vulnerable to predation for longer.

Since 1992 a fishery for *Spisula solida* has taken place in Danish waters. Catches and landings were high in some years but totally absent in others during a ten year fishing period between 1992 and 2002 (Jensen *et al.*, 2003). From 1992 to 1995 the fishery continued without any decrease in cpue (M. Ruth, pers. comm.). However, *Spisula solida* disappeared from the entire German Bight above the 20 m depth contour line during the 1995/96 winter where water temperatures at the sea bottom dropped to 0°C (M. Ruth, pers. comm.). 1995 also saw the fishery ending due to bad weather conditions (M. Ruth, pers. comm.). In April 1996, when the fishery tried to start again, no living *Spisula solida* were found (M. Ruth, pers. comm.). The suction dredging gear was subsequently modified to access *Spisula solida* living at greater depths.

Because the clams are fished commercially, at least some of the population will be removed and, therefore, intolerance has been assessed as intermediate. Even if the clams are not caught, the dredging will at the very least leave the clams more susceptible to predation. Recoverability will probably be high.

	Intolerance	Recoverability	Sensitivity	Confidence
Extraction of other species	Intermediate	High	Low	Very low

No specific information was found concerning the effects of the extraction of other species on *Spisula solida*. Any extraction of other species using fishing gear that penetrates the seabed such as scallop dredging is likely to cause forced disturbances (as above) or remove species as bycatch. Therefore intolerance has been assessed as intermediate with a high recoverability.

Additional information

Recoverability
Spisula solida can live up to 10 years. No information was found concerning the fecundity of *Spisula solida*. However, when *Spisula solida* occur they occur in high abundances (Fahy, 2003). Growth is rapid during the first 2 years although it takes 2-3 years for *Spisula solida* to reach sexual maturity. Recruitment of *Spisula solida* can be irregular (Fahy et al., 2003). Gaspar *et al.* (1996 cited in Gaspar & Monteiro, 1999) noted that in Portuguese waters, there were large yearly fluctuations in the recruitment of a number of species including *Spisula solida*. The dispersal potential of *Spisula solida* is also variable as it is reliant on water movement. Ford (1925) suggested that *Spisula solida* can be moved along by water movement to the sea bottom to another position on the seabed. Therefore, in the course of time considerable mixing could easily be bring together individuals of different ages and origins (Ford, 1925). Although no information was found on the mortality rates of *Spisula solida*, mortality is probably greatest during the early post larval period when *Spisula solida* are much smaller and more fragile. Therefore with the available information the recoverability of *Spisula solida* has been assessed as high, although further information is required.

Importance review

Policy/legislation

- no data -

Status

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

Non-native

Native	-		
Origin	-	Date Arrived	-

Importance information

Spisula solida is a potentially important commercial bivalve species, although it is under-exploited in the United Kingdom, compared to continental Europe and the USA.

European Union regulations
A minimum size limited of 2.5 cm for *Spisula solida* clams was imposed by European Union Council Regulation 850/98, Annex XII (Fahy *et al*., 2003). However Fahy *et al.* (2003) suggested that bars on a clam dredge should be a minimum 11 mm apart, which corresponds to an age of three years.

Fisheries information
Commercial fishing methods screen *Spisula* catches so that the smaller and younger individuals are not retained by the dredge (Fahy *et al*., 2003). The largest of certain medium age groups will be retained and probably the oldest groups are representative of the size range within the population (Fahy *et al*., 2003). *Spisula solida* is harvested in Waterford Harbour (Ireland). The harvesting of *Spisula solida* was irregular and sporadic as the principle dealers landed 400 tonnes of *Spisula solida* in 1996, no landings were traced from 1997 or 1998 and only 6 tonnes was harvested in 1999 (Fahy *et al*., 2003). In 2000, 338 tonnes of *Spisula solida* was landed, however, in the following two years the numbers of *Spisula solida* dropped further as the calm bed started to become barren (Fahy *et al*., 2003). Kristensen (1996) stated that a biomass of less than 200 g/m^2 was not considered worth fishing. Kristensen (1996) also suggested that an exploitation rate should range from 10-15%. Fahy *et al.* (2003) suggested likely that the above exploitation rate of *Spisula solida* was exceeded whenever surf clam patches were harvested in Ireland.

Food source
Spisula solida is an important component of the diet of many flat fishes.

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