
Macoma balthica

Phylum: Mollusca
Class: Bivalvia; Heterodonta
Order: Veneroida
Family: Tellinidae

Taxonomy: Originally described as a member of the genus *Tellina*, *Macoma balthica* was the name of the Atlantic species. Our west coast clam was originally called *M. inconspicua* (Broderip and Sowerby 1829), but they are now generally considered to be the same species (e.g., Vassallo, 1969, 1971; Haderlie and Abbott 1980). An extensive taxonomic history has yielded many synonyms for *M. balthica*. Some ambiguity exists whether individuals from the southernmost reaches of the distribution on east and west sides of the Atlantic should be considered the same species (Beukema and Meehan 1985) and some researchers (e.g., Meehan 1985; Kamermans et al. 1990; Luttikhuizen et al. 2012; Sanier et al. 2015) consider these allopatric populations to be subspecies (eastern Atlantic *Macoma balthica balthica* and western Atlantic *Macoma balthica rubra*) that have been reproductively isolated for 2–3.5 million years (Luttikhuizen et al. 2012; Saunier et al. 2015). *Macoma petalum* populations in San Francisco Bay, once recognized as distinct species from *M. balthica* (Vainola 2003), are now believed to be genetically identical to *Macoma balthica* (the circum-Arctic species) (Brusati and Grosholz 2007). However, these may yet prove different species and their taxonomy awaits further study (Coan and Valentich-Scott 2007; Brusati and Grosholz 2007). Thus, the description below considers them together as is done in current local intertidal guides (e.g. Coan and Valentich-Scott 2007). (see Vainola 2003 for molecular systematics of *M. balthica* species complex.)

Description

Size: Individuals averaging 30–35 mm in length (Oldroyd 1924), but usually under 30 mm (Coan 1971) and rarely more than 45 mm (Coan 1971; Cardoso et al. 2003). Smallest adults are 2 mm (Caddy 1969). Body proportions are generally 27 in length, 22 in

height, and 11 mm in diameter (Oldroyd 1924). The illustrated specimen (from Coos Bay) is 17.5 mm long.

Color: Distinct color is reddish, pale rose or white and is sometimes bluish or yellow (Oldroyd 1924; see Plate 17, Kozloff 1993). Coos Bay specimens are usually pink inside and out, but individuals from British Columbia, Canada can have pink or yellow interiors (Quayle 1970).

General Morphology: Bivalve mollusks are bilaterally symmetrical with two lateral valves or **shells** that are hinged dorsally and surround a mantle, head, **foot** and viscera (see Plate 393B, Coan and Valentich-Scott 2007). Among the bivalves, the Heterodonta are characterized by **ctenidia** (or gills) that are eulamellibranchiate, fused mantle margins and the presence of long **siphons**. Veneroid bivalves have well-developed hinge teeth and members of the family Tellinidae have short lateral hinge teeth (when present – see **Possible Misidentifications**), shells with external striations or ribs, and deep pallial sinuses (Coan and Valentich-Scott 2007). When holding closed shell in both hands with the hinged area up and the ligaments toward you, the right valve is in the right hand (Fig. 3) (Keen and Coan 1974).

Body:

Color:

Interior: Ligament is short, but strong, partially sunken, seated on a stout callus (Dunnill and Ellis 1969), but not on a nymph (Tellinidae, Coan and Valentich-Scott 2007).

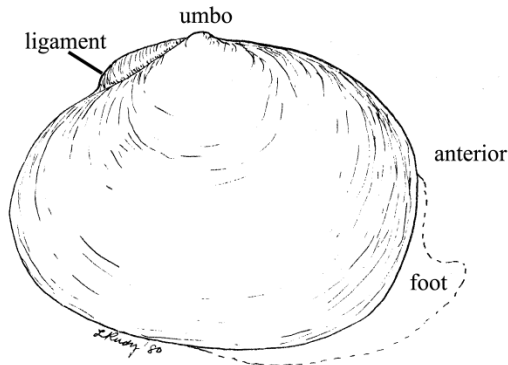
Exterior:

Byssus:

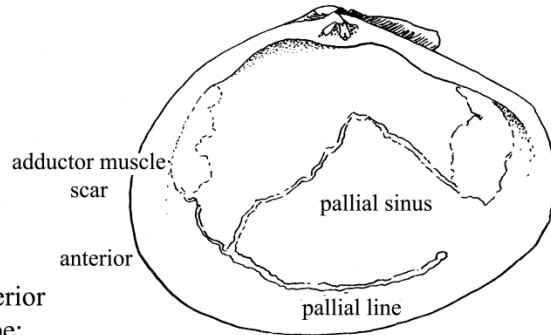
Ctenidia:

Shell: The shell shape is regularly oval, round, thick, with equal valves, umbos low, almost central, and usually worn (Fig. 1). The dorsal margin is arched, the ventral margin is slightly contracted (Oldroyd 1924), and there is no posterior dorsal flange (posterior to

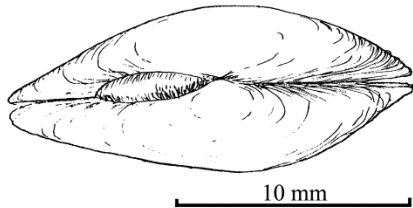
Macoma balthica



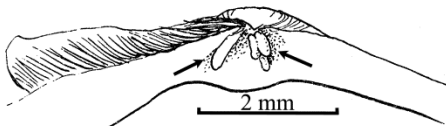
1. *Macoma balthica*, exterior, right valve (L:17.5mm,D:7.5mm,H:14mm) x4: shell regular, oval; valves equal; umbos low, almost central; anterior and posterior ends rounded: no flange, bend or gape; exterior color pink; ligament external, short, strong.



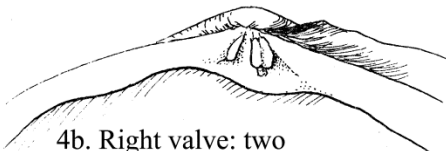
2a. Interior, right valve: pallial line narrow, faint; pallial sinus ends 3/4 of way to anterior adductor muscle scar; sinuses in both valves similar; interior pink.



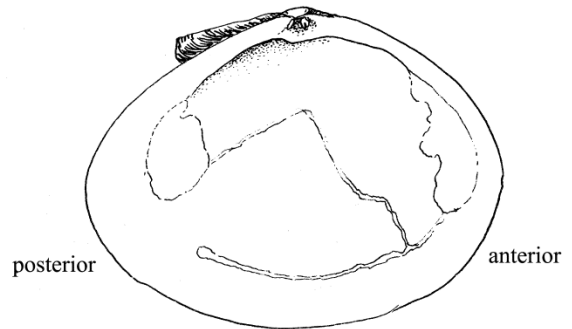
3. (Dorsal view) x4: valves not bent.



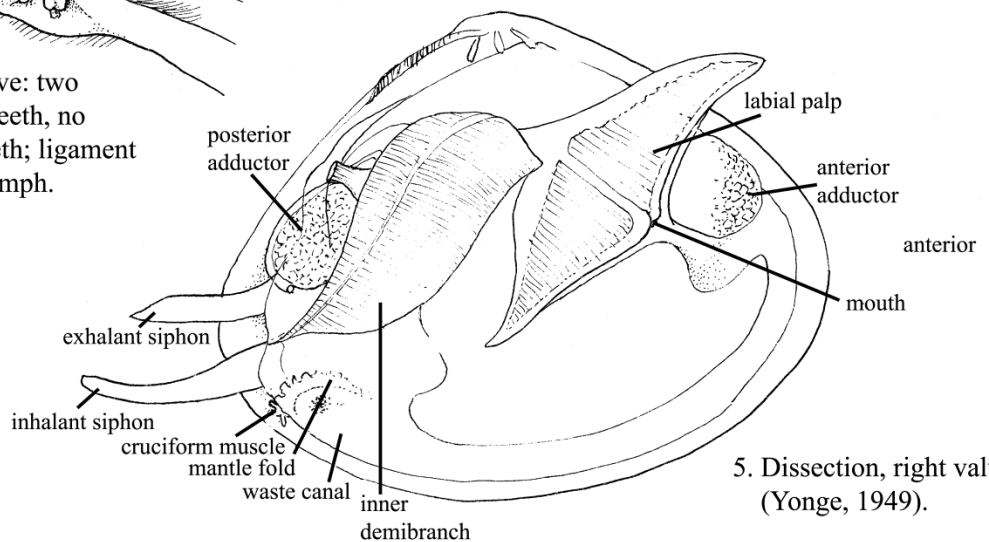
4a. Left valve x12: two cardinal teeth, no lateral teeth.



4b. Right valve: two cardinal teeth, no lateral teeth; ligament not on nymph.



2b. Left valve



5. Dissection, right valve: (Yonge, 1949).

ligament). Valves do not gape (Tellinidae, Keen 1971) and the posterior end is rounded. Shell usually heavy, but bay specimens sometimes thin (Coan 1971).

Interior: Pallial line is narrow and faint. The pallial sinus is large (see Plate 422, Coan and Valentich-Scott 2007) and equal among valves. The sinus ends $\frac{3}{4}$ of the way to anterior adductor muscle scar in both valves (Figs. 2a, 2b), and does not reach the muscle scar (Fig. 2b) (Coan and Valentich-Scott 2007).

Exterior: Periostracum is thin, silky, not shiny (Coan 1971), and a trace is visible only ventrally. Shell sculpture consists of fine concentric growth lines only (Figs. 1, 3) (Dunnill and Ellis 1969).

Hinge: The hinge area has no lateral teeth (*Macoma*, Coan and Valentich-Scott 2007). Two cardinal teeth exist in each valve (Figs. 4a, 4b), one stout, bifid, and the other single and fragile (Dunnill and Ellis 1969).

Eyes:

Foot:

Siphons: The siphons are long, separate, and mobile (Kozloff 1993). Inhalant siphons are four times the shell length, when extended. Exhalant siphons held vertically above surface are 1.5 cm. Siphons bear large palps, for sorting fine particles (Fig. 5) (Yonge 1949). (For diagrams of siphon development, see Figs. 3, 6, Caddy 1969.)

Burrow:

Possible Misidentifications

Tellinids can be distinguished from other small or young bay clams (i.e., Mactridae: *Tresus*; Veneridae: *Protothaca*, *Saxidomus*; Myidae: *Mya*, *Cryptomya*) an external ligament, an ovate shell, an inconspicuous nymph (or supporting projection for the external ligament), sometimes reddish hue and lateral teeth as well as a shell with ribs or striations (no radial pattern) and shells that never gape. Lateral teeth may or may not be present in the Tellinidae (Coan 1971). Myids have a hinge with a spoon-shaped chondrophore (left valve) and a projecting tooth (right valve) (see *Mya arenaria*, this guide). Venerids have three cardinal teeth in each valve. Mactrids have an internal ligament, A-shaped cardinal teeth, and gaping valves (Coan and Valentich-Scott 2007). The

Tellinidae has around 16 species distributed between two genera locally – *Tellina* and *Macoma*. These genera can be differentiated by the hinge teeth, *Tellina* species have a hinge with lateral teeth, while *Macoma* species do not. *Macoma* species have shells that are also more rounded and inflated than *Tellina*, and are smooth, white, often chalky. They are characterized by having a ovate shell consisting of two equal valves, a dark and deciduous periostracum, two cardinal teeth, the absence of lateral teeth and a pallial sinus that is deeper on the left valve (Scott and Blake 1998; Arruda and Domaneschi 2005). *Macoma* species may also have a more northern geographic distribution while *Tellina* are elongate, relatively compressed, conspicuously sculptured, brightly colored, and usually warm water dwellers (Coan 1971). Eleven species in the infaunal genus *Macoma* (Luttikhuisen et al. 2012) are reported locally (although 30 have been identified in the northeastern Pacific, Dunnill and Ellis 1969), but only seven are described in local keys (e.g. Coan and Valentich-Scott 2007), the four most common species of *Macoma* in our area are *M. balthica*, *M. nasuta*, *M. inquinata*, and *M. secta* (Kabat and O’Foighil 1987).

Two species, *M. secta* and *M. indentata* have a posterior dorsal flange extending from posterior end to the external ligament, this is absent in other *Macoma* species. The former species is called the sand clam and has a quadrate and truncate posterior. The latter is elongate, has a pointed posterior, unique muscle scars, is relatively rare and small (to 2.5 cm) and occurs from Trinidad, California southward. *Macoma secta*, also has a white shell, with a yellowish epidermis. Its right valve is more inflated than the left, and it can be large (to 120 mm) and is more common in clean sand, not in estuarine mud.

The morphology of the pallial sinus differentiates the other species. In species without a posterior dorsal flange, *M. acolasta* and *M. yoldiformis*, the anterior ventral edge of the pallial sinus is detached for a portion of the distance to the posterior adductor muscle scar. *Macoma acolasta* also has a rounded posterior, rather than pointed as in *M. yoldiformis* and is rare, sand-dwelling, and

occurs from Bodega Bay, California, southward. *Macoma yoldiformis* is elongate, inflated, and thin, with the pallial sinus detached from the pallial line. Although the range of this clam is from Vancouver south to Baja California, it is not included in Puget Sound or British Columbia work (Dunnill and Ellis 1969). It can be found in silt in low intertidal of protected bays (Coan and Valentich-Scott 2007).

Macoma inquinata, *M. nasuta* and *M. balthica* (see descriptions in this guide) are all species with an anterior ventral edge of pallial sinus that is not detached and they tend to be larger (up to 110 mm) than *M. acolasta* or *M. yoldiformis* (less than 30 mm). *Macoma balthica* has a pinkish hue and a pallial sinus that ends $\frac{3}{4}$ of the way to anterior adductor muscle scar and is generally more oval than *M. nasuta* or *M. inquinata* (compare Fig. 1 *M. balthica*, with Fig. 1 *M. nasuta*, this guide) (Kozloff 1993). In *M. inquinata*, the pallial sinus does not reach the ventral end of the anterior adductor muscle and the shell is chalky white with a fibrous olive green periostracum. *Macoma nasuta*, on the other hand, is not as round and heavy as *M. inquinata* and its pallial sinus reaches and joins the anterior adductor scar above its base (left valve). (Its right valve may be more like *M. inquinata*'s). Furthermore, its siphons are orange and its shell posterior is bent to the right. *Macoma inquinata* can also bend slightly posteriorly, and may be confused with the thinner *M. nasuta*, without investigations of the other aforementioned features. (see Plate 422 for diagrams of these distinguishing characteristics in *Macoma*). *Macoma balthica* and *M. inquinata* are generally smaller than *M. nasuta* (up to 5 cm), with mature *Macoma balthica* rarely exceeding 25 mm in length (Dunnill and Ellis 1969), but could be confused with the young of some of these larger clams. Molecular differences have been documented within the *M. balthica* complex (see Vainola 2003) as well as morphological differences between the eastern (*Macoma balthica balthica*) and western (*Macoma balthica rubra*) Atlantic populations or subspecies. In particular, populations from southeastern United States estuaries exhibited larger shells and higher siphon height, which may correspond to

deeper burying depths to avoid higher water temperatures in this region (Kamermans et al. 1990).

(The following species may be present locally, but are not included in local dichotomous keys). *Macoma expansa*, is a rare, usually offshore species (to 50 mm) whose pallial sinuses are perpendicular to the pallial line. *Macoma elimata* is found in 15–476 meters of water. *Macoma incongrua* is a generally northern species which can be found to 33°N latitude, intertidally to 36 meters. It has somewhat inflated valves, is usually 30–40 mm long, and almost round in outline (Dunnill and Ellis 1969). *Macoma calcarea* is found from 35 meters and lower, from 37° northward. Other northern subtidal species include the large *M. brota* and *M. lipara* (Dunnill and Ellis 1969).

Ecological Information

Range: Type locality is the Baltic Sea.

Macoma balthica is present in the North Pacific and North Atlantic, in both European and North American waters. In Europe, distribution includes the White Sea, Pechora Sea, Wadden Sea, and southern coastal France. North American distribution includes the Gulf of St. Lawrence and Hudson Bay, south to Virginia as well as the Alaskan coast to San Francisco, but rarely further south to San Diego (Coan 1971). This species was possibly introduced to San Francisco from the Atlantic coast (Coan and Valentich-Scott 2007). However, some hybridization between populations has been observed where they meet at the Baltic Sea (Luttikhuisen et al. 2012). Local genetic population structure with depth has been determined in the Gulf of Gdańsk in Poland (Becquet et al. 2013).

Local Distribution: Coos Bay sites at the South Slough channel and airport spoil islands. Oregonian distribution in Siletz, Nestucca, Siuslaw, Netarts, Tillamook Bays and generally all bays within close proximity to the open coast (Hancock 1979; Kozloff 1993).

Habitat: Offshore and bay mud (Kabat and O'Foighil 1987). Often in very fine and sometimes black, foul mud. Currents largely determine distribution, as they affect the settlement of sediment and degree of shelter. Although coarseness of sediment was found

to not be a determining factor in distribution (see Vassalio 1969), individuals may prefer fine sediment, which increases the density of their food supply (e.g., micro-organism populations, Newell 1963). *Macoma balthica* recruitment was negatively effected by suction dredging, presumably due to the reduction and subsequent lack of accumulation of fine-grained sediment (Piersma et al. 2001).

Salinity: Collected at salinities of 30 and also found in brackish water (Vassalio 1969). Individuals found where salinity is as low as 5 (Jansson et al. 2013). Along the York River in the Chesapeake Bay, higher abundance, predation and food availability was found upriver (salinity 5–10) than downriver (salinity 15–19), although recruitment was lowest upriver (Seitz 2011).

Temperature: *Macoma balthica* prefers cold to temperate waters and has a low tolerance to elevated temperatures (Wadden Sea, Beukema et al. 2009). Increases in seawater temperature and mild winters alter the onset of spawning and associated recruitment timing among *Macoma balthica* (Phillipart et al. 2003) and their predators in the Wadden Sea (Dekker and Beukema 2014). Increases in water temperature have also been shown to reduce body mass, which usually decreases in winter, but to a greater degree during mild versus cold winters (Honkoop and Beukema 1997).

Tidal Level: Intertidal and subtidal (Kabat and O'Foighil 1987). Individuals found at + 0.3 m (Coos Bay, Shore Acres) and down to 37 m (Coan 1971). An apparent correlation between clam size and depth distribution was reported, with the smallest animals closest to surface (Vassalio 1969), where distance from surface can be determined by siphon length (Vassalio 1971).

Associates: In San Francisco Bay, California associates include the whelk, *Busycotypus*, the gastropod *Nassarius*, capitellid and nereid polychaetes, the amphipod, *Ampelisca*, and bivalves, *Gemma* and *Mya* (Vassalio 1969). Individuals are sometimes host to gymnophallid trematode (metacercariae) parasites (e.g. *Gymnophallus somateriae*, *Lacunovermis conspicuus*, *Meiogymnophallus multigemmulus*, Swennen 1969; Ching 1973) as well as a protist parasite, *Perkinsus*

chesapeaki (Coss et al. 2001; Burreson et al. 2005).

Abundance: Adults most abundant in the upper intertidal zone (1.3–2.6 m) (San Francisco Bay, California, Vassalio 1969), where they compose 55% of the total invertebrate community. Density may be determined by currents, fineness of deposits and micro-organism food (Haderlie and Abbott 1980). Individuals not very common in Puget Sound, Washington (Kozloff 1993), but quite common at many stations in Coos Bay, OR. Pelagic larval abundances as high as 12,000 larvae/m³ were reported in the Baltic Sea (Jansson et al. 2013). Larval abundance (determined by single step nested multiplex PCR) in Isefjord, Denmark showed two peaks, one in the July and another at the end of August (Larsen et al. 2007). Juvenile densities of up to 5,000 individuals/m² where reported in June in the Thames estuary, England (Caddy 1969). Adult density correlates with egg size, where populations that are more dense produce smaller eggs (e.g., 224 individuals/m² produce eggs that are 100.5 µm whereas five individuals/m² produce eggs that are 108.5 µm in diameter, Luttikhuizen et al. 2011).

Life-History Information

Reproduction: Reproduction and development has been described for *M. balthica* (Europe, Caddy 1967, 1969; Lammens 1967). Egg size correlates with adult density (see **Abundance**) and ranges from 100.5–108.5 µm in diameter (Wadden and North Seas, Luttikhuizen et al. 2011). In the Netherlands, oocytes measured 97 µm and spawning occurred in short burst throughout March–April (at 10°C, Caddy 1967). Research on the effects of ocean acidification has found that reduction in pH (e.g. 7.5) negatively effects fertilization, and causes slower growth, and delayed metamorphosis, which occurs at smaller sizes and reduces pelagic survival (Van Colen et al. 2012; Jansson et al. 2013; Jansson et al. 2015).

Larva: Bivalve development generally proceeds from external fertilization via broadcast spawning through a ciliated trochophore stage to a veliger larva. Bivalve veligers are characterized by a ciliated velum

that is used for swimming, feeding and respiration. The veliger larva is also found in many gastropod larvae, but the larvae in the two groups can be recognized by shell morphology (i.e. snail-like versus clam-like). In bivalves, the initial shelled-larva is called a D-stage or straight-hinge veliger due to the “D” shaped shell. This initial shell is called a prodissoconch I and is followed by a prodissoconch II, or shell that is subsequently added to the initial shell zone (see Fig. 1, Caddy 1969). Finally, shell secreted following metamorphosis is simply referred to as the dissoconch (see Fig. 2, Brink 2001). Once the larva develops a foot, usually just before metamorphosis and loss of the velum, it is called a pediveliger (see Fig. 1, Caddy 1969; Kabat and O’Foighil 1987; Brink 2001). (For generalized life cycle see Fig. 1, Brink 2001). Some bivalve species (e.g. *Mytilus edulis*), including *M. balthica*, have two dispersal periods. The initial larval dispersal and settlement into the benthos, where larvae are 200–500 µm, is followed by potential dispersal from the benthos by thread drifting on long hyaline threads when young clams are 5–12 mm (Beukema and Vlas 1989). In *M. balthica*, advanced veliger larvae have a yellow shell that is 245–350 µm in length and is with red umbo and small prodissoconch II (Kabat and O’Foighil 1987; Brink 2001). Veliger shell shape in *M. balthica* is broadly rounded (see Fig. 4, Brink 2001). *Macoma nasuta* and *M. secta* are also known to have free swimming veliger larvae (Marriage 1954; Rae 1978, 1979; Brink 2001). Planktonic duration is probably 2–5 weeks and larvae settle at sizes between 300–330 µm. Significant research has been conducted on recruitment, growth, and general biology of *Macoma balthica* in the Dutch Wadden Sea. These studies found that larval recruitment is most successful in summers following severe winters due to reduced predation pressure from populations negatively influenced by cold temperature (e.g., *Crangon crangon*, *Carcinus maenas*, Beukema et al. 1998; Dekker and Beukema 2014; Dekker and Beukema 2014). Conversely, increases in winter temperatures reduce reproductive output and increase juvenile mortality suggesting that *Macoma balthica* populations will suffer with a warming climate (Wadden

Sea, Philippart et al. 2003; Beukema et al. 2009). Highest recruitment was observed after cold winters and recruitment reportedly failed altogether after mild winters in the Wadden Sea (Honkoop et al. 1998) (see also **Temperature**).

Juvenile:

Longevity: Up to 30 years (Cardoso et al. 2003). Five years was reported from Rand Harbor, Massachusetts and up to 25 years in the Gulf of Finland (Gilbert 1973).

Growth Rate: Individual age is often estimated by the external rings on the shell as the rings are produced each winter when growth slows. However, these growth rings are likely overestimates of actual age and, thus, underestimates of growth rates (Cardoso et al. 2003). Seasonal growth was observed in European populations, where growth rate correlates to food supply (e.g. chlorophyll and unicellular algae) and ranged from 5–7 mm and 10–25 mm/year in the western Wadden Sea (see Fig. 5, Beukema et al. 2002). Growth measured in the same region was 0.009–0.011 mm/day from March through April and reduced to 0.001–0.002 mm/day from July to September (Cardoso et al. 2003). Average maximum length was greater for North American populations than European (Gilbert 1973) and may be evidence for two sibling species (Kamermans et al. 1990). Growth rate depends on season and food availability in San Francisco Bay, California (Thompson and Nichols 1988) and is relatively constant throughout the year in Massachusetts, though slightly accelerated in the summer.

Food: A suspension feeder that also feeds on mud surface bacteria and detritus as well as on planktonic organisms at high tide (Braefield and Newell 1961; Newell 1963; Vassalio 1969; Oldroyd 1924). Thus, *M. balthica* switches between suspension and deposit feeding modes depending on local habitat (Tornroos et al. 2015). Individuals compete for food with the amphipod, *Ampelisca*. Each individual feeds in a 4 cm area (Braefield and Newell 1961) and an increase in individual weight between late winter and early summer is dependent on algal feeding in the Wadden Sea (Beukema et al. 2014).

Predators: Predators include shorebirds (e.g., eiders *Somateria mollissima*, oystercatchers *Haematopus ostralegus*, red knots *Calidris canutus*, Beukema et al. 2010) and starry flounder (Vassalio 1969; Cardoso et al. 2003). Predators of newly settled spat include, *Ampelisca* (Vassalio 1969) and top down predation on young *M. balthica* by the shrimp, *Crangon crangon* and the shore crab, *Carcinus maenas* have a negative effect on populations (Dekker and Beukema 2014).

Behavior: *Macoma balthica* is essentially static and a slower burrower than some other *Macoma* species (Yonge 1949), requiring 2½ minutes to bury itself (Braefield and Newell 1961). U-shaped tracks in mud suggest movement toward and away from the sun (Braefield and Newell 1961).

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