Zirfaea pilsbryi

The rough piddock

Phylum: Mollusca

Class: Bivalvia, Heterodonta, Euheterodonta

Order: Imparidentia, Myida

Family: Pholadoidea, Pholadidae, Pholadinae

Taxonomy: The taxonomies of both pholad species in this guide (*Z. pilsbryi* and *Penitella penita*) are extensive and complicated, including many synonyms and overlapping descriptions (for full list of synonymies see Kennedy 1974). *Zirfaea pilsbryi* was originally described as *Z. gabbii*, a species eventually moved to the genus *Penitella* (see *P. gabbii*, Kennedy 1974). Lowe renamed and described *Z. pilbsryi* in 1931. Thus, these three species names (*Z. pilsbryi*, *Z. gabbii*, and *P. gabbii*) and the subspecies designation, *Z. gabbii femii* (Adegoke 1967 in Kennedy 1974), are common synonyms, with descriptions that overlap and are specific to original author (see Kennedy 1974).

Description

Size: Individuals up to 150 mm in length (Ricketts and Calvin 1971; Haderlie and Abbott 1980; Kozloff 1993) and may be the largest of the boring species (Ricketts and Calvin 1971). Coos Bay (Fossil Point) specimens were approximately 75–125 mm long.

Color: White exterior, interior also white or light salmon (Turner 1954; Haderlie and Abbott 1980). Siphons gray-white to ivory, speckled with very small (1.5–2 mm) orange chitinous spots, dark red around siphonal openings and incurrent cirri (Fig. 1). Foot and mantle are ivory in color, when preserved (Turner 1954). Periostracum is dark brown (Haderlie and Abbott 1980).

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). Myoid bivalves are burrowers and borers, with long siphons and hinges with few teeth (Coan and Valentich-Scott 2007). Members of the Pholadidae bore into a variety of substrates, possess no pallets on siphon tips and have an anterior end that is pointed or curved with no notch (contrast to Teredinidae species, e.g., *Bankia setacea*, this guide) (see Plate 427F, 430D, Coan and Valentich-Scott 2007). While most pholad species are intertidal or subtidal, some can be found boring into wood at great depths (e.g., 7,250 meters *Xylophaga*, Kennedy 1974; Reft and Voight 2009; Voight 2009; Marshall and Spencer 2013).

Body: (see Plate 297, Ricketts and Calvin 1952; Fig 361, Kozloff 1993).

Color:

Interior:

Exterior:

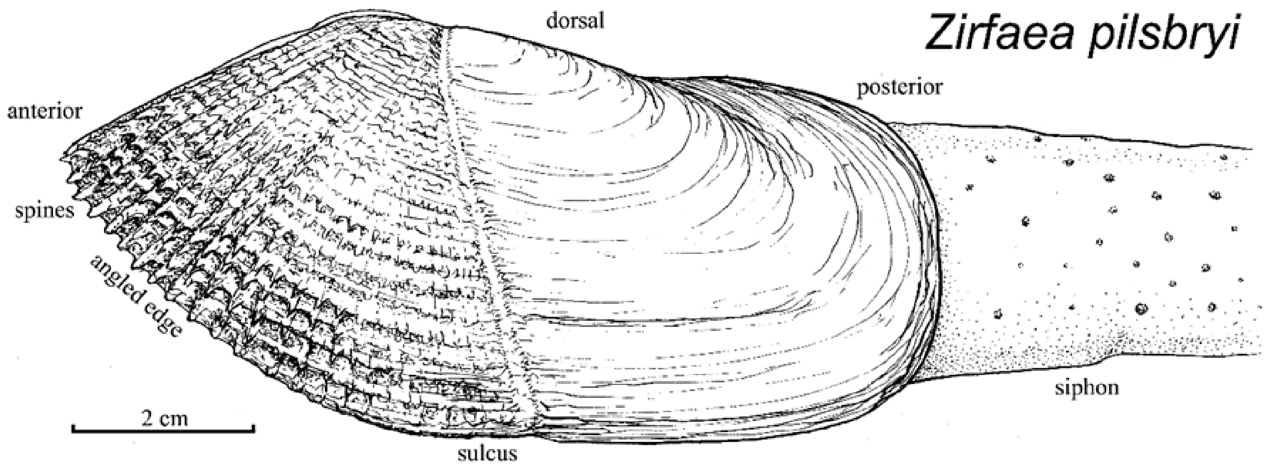
Byssus:

Gills:

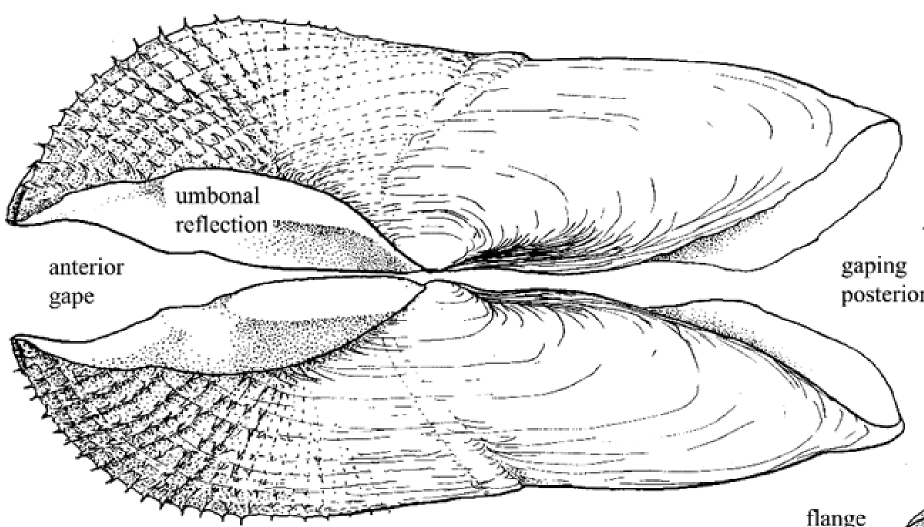
Shell: Gapes widely at both ends and valves have ventral marginal groove (Fig. 2). Anterior end has rasping ridges, but posterior is with smooth, concentric lines (Haderlie and Abbott 1980; Kozloff 1993). Anterior end of shell is not as prominently demarcated from the posterior (compare to *Penitella penita*, this guide). Shell is relatively fragile as it gains ample protection from its surrounding burrow (Ricketts and Calvin 1952).

Interior: The groove separating anterior and posterior sections of valve (or umbonal ventral sulcus) is conspicuous in juveniles, but almost disappears near ventral margin in older specimens (Kennedy 1974) (Fig. 1). Strong muscle scars present, but no hinge or

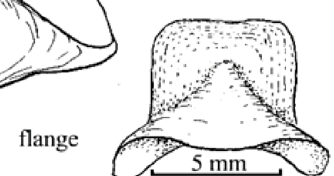
Zirfaea pilsbryi



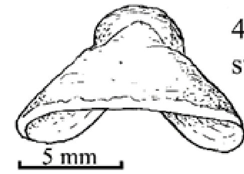
1. *Zirfaea pilsbryi* (L:93mm) x1.5:
elongate shell divided by umbonal ventral sulcus into anterior: triangular rasping surface, spined angled edge without callum; posterior truncate, with concentric striations only; siphons long, not retractible, with small chitinous patches.



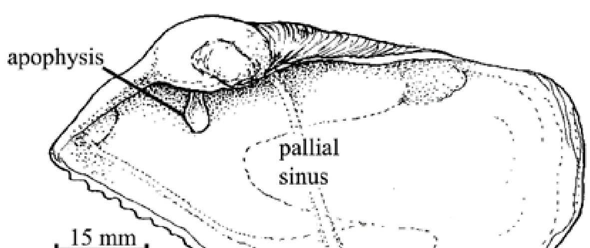
2. (Dorsal view).



4a. Mesoplax, juvenile x5.5:
strong, transverse basal flange.



4b. Mesoplax, adult x3.5:
flange obscure (Turner, 1954).



3. Interior, right valve x1:
pallial sinus broad, deep;
apophysis spoon-shaped.

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ligament (Pholadidae, Quayle 1970). Pallial sinus is broad and deep, extending nearly to umbo (Fig. 3). The apophysis (or myophore) is broad, with rounded spoon-shaped end (Fig. 3).

Exterior: Shape hard, solid, elongate, oval, but not globose. Valves divided into two regions: anterior triangular and posterior is rounded with concentric rings (Fig. 1). Anterior is triangular with rough file-like radial and concentric denticulations, which can project into spines on anterior margin (Fig. 1). Rasping portion covers half total valve area (Kozloff 1993). No callum is present (calcareous anterior accessory plate, see *Penitella penita,* this guide), only a protective membrane. Umbonal reflection is wide. The anterior ventral edge of valve is strongly angled (Fig. 1). The posterior portion is with concentric striations only and is rounded to truncate (Fig. 1). Gapes extend to the middle of the shell (Keen and Coan 1974).

Hinge:

Eyes:

Foot: Foot is round and truncate (Turner 1954).

Siphons: Fused and very long (6–8 times the shell length) and can extend 15 cm above the burrow surface (Haderlie and Abbott 1980). They are non-retractible and covered with small chitinous discs, but without papillae or pustules. No siphonoplax (flaps around siphon, see *Penitella penita*, this guide). Periostracum extends from over 1/3 shell posterior to cover part of siphons (Quayle 1970).

Burrow: *Zirfaea pilsbryi* burrows into heavy mud, clay and shale to 50 cm depths. The foot is sucker-like and attaches to the substrate so that the shell can rotate slowly and create a cylindrical burrow. Shell valves rock back and forth by contractions of anterior and posterior adductor muscles. Individuals rotate after each stroke, making a cylindrical burrow. While burrowing, individuals exude particles out the inhalant siphon by contracting their body quickly (Ricketts and Calvin 1952; Haderlie and Abbott 1980). Thirty-two movements make for one entire revolution, which takes a total of 70 minutes and after each revolution, the rotating direction alternates (MacGinitie in Ricketts and Calvin 1952). Burrows may be pear-shaped (producing *Gastrochaenolites*-type traces, Furlong et al. 2014) rather than cone-shaped, and individuals often do not fit as tightly within their burrows as other pholads (Evans and Fisher 1966). (see also **Habitat** and **Behavior.**)

Pholadidae-specific character

Mesoplax: There is only one mesoplax (or small accessory dorsal plate) present in this species. It is weak and reduced (Evans and Fisher 1966) and with a transverse basal flange that well-developed in juvenile (Fig. 4a), but becomes less obvious in adults (Fig. 4b). (Note: the mesoplax is often lost in collecting.)

Possible Misidentifications

There are several families of burrowing clams and the Pholadidae can be distinguished by their distinctively marked body areas. Members of the Teredinidae and Pholadidae can be found locally. They can be distinguished by the absence of pallets on siphon tips in the latter family as well as an anterior end that is not notched, as in the Teredinidae. The Pholadidae includes 10 species locally, within the following genera: *Barnea* (*B. subtruncata*), *Chaceia* (*C. ovoidea*), *Netastoma* (*N. rostratum*), *Parapholas* (*P. californica*), *Penitella* (five local species) and *Zirfaea* (*Z. pilsbryi*). The genus *Zirfaea* is characterized by adults that burrow into sand or mud, the absence of a callum in mature individuals, and a shell sculpture that is divided into two distinct zones (see Plates 427C, 429D, Coan and Valentich-Scott 2007). The genus *Barnea*, for example, also lacks a callum, but does not have these two distinct zones. All other local genera are characterized by the presence of a callum and all except *Netastoma* have a myopore as well. *Parapholas* species have shell sculpture with three distinct zones, where members of *Chaceia* and *Pentilla* have two.

The genus closest to *Zirfaea*, and most likely to be confused with it, is *Penitella*. As mentioned above, *Penitella*'s valves are also divided into two distinct sections, but it differs in having a calcareous anterior callum, or accessory plate (in the adult) as well as a posterior which gapes only at the end, not to the middle of the shell (it has no anterior gape) and the apophysis is narrow, not broad. No *Penitella* species has a siphon longer than its body (Evans and Fisher 1966) and all *Penitella* species have retractable siphons. There are five species of *Penitella* in our area (see Coan and Valentich-Scott 2007).

Penitella conradi is very small and is found in *Mytilus* or *Haliotus* (abalone) shells. It has a siphonoplax lined with coarse granules (*Zirfaea* has no siphonoplax) (Evans and Fisher 1966) and can bore into nephrite (Monterey, California, Wilson and Kennedy 1984). *Penitella penita* (see description in this guide) has a heavy membraneous siphonoplax, a calcified callum and a distinctive **mesoplax**. Its anterior rasping surface covers less than half the valve area (Kozloff 1974). It can be up to 70 mm in length. *Penitella fitchi* also has a heavy siphonoplax, but has a callum with a gap. This is a rare species, found low in the intertidal and up to 25 meters deep. *Penitella turnerae* is larger than *P. penita* (to 125 mm), and less common. It is stout, and like *Zirfaea* lacks a siphonoplax. It has a distinctive, rounded mesoplax, however, and its long, white, retractable siphons are tipped with solid red. Like *Zirfaea*, it has a strongly angled anterior ventral edge, but unlike *Zirfaea*, *P. turnerae* has a callum. *Penitella richardsoni* (=*gabbi*, Kennedy 1989) is also small (up to 75 mm) with a warty, creamy-lemon colored siphon and it is not common. It is different from the other members of this genus as its umbone reflection is not appressed to the anterior end, a character also found in *C. ovoidea*. *Penitella richardsoni* differs from *C. ovoidea* by having a callum that does not gap and an more elongated shell (Coan and Valentich-Scott 2007). A new species of *Penitella*, *P. hopkinsi*, was described from Alaska, but it not yet reported in our area (Kennedy and Armentrout 1989). With adult specimens, it should be easy to tell *Zirfaea* from *Penitella* by its long, non-retractable siphon and by the membraneous covering of the anterior, instead of a calcareous callum. Small shells without the callum could be young *Penitella* as well as mature *Zirfaea* and size at maturity varies greatly with environmental condition.

Zirfaea crispata is a small Atlantic species without chitinous spots on the siphons. It may have been introduced into Humboldt Bay, California with eastern oyster spat *Crassostrea* (Turner 1954), but is not currently included in local intertidal guides (see Coan and Valentich-Scott 2007).

Ecological Information

Range: Type locality is Bolinas Bay, California (Turner 1954). Eastern Pacific distribution includes the Bering Sea to Baja, California (Ricketts and Calvin 1952; Haderlie and Abbott 1980). *Zirfaea pilsbryi* is the most common fossil pholadid on the Pacific coast and dates from the Pleistocene in California and northern Baja California (for pholad palaeoecology see Kennedy 1974, 1993).
Local Distribution: Coos Bay distribution at South Slough, Fossil Point, Tillamook Bay, Netarts Bay, Yaquina Bay (Turner 1954) and Siuslaw River (Hancock et al. 1979).
Habitat: *Zirfaea pilsbryi* bores into shale, clay,

sand or mud, as soft rock, to depth of 25–35 cm (Turner 1954), where mud and clay are preferred substrates (Coan and Valentich-Scott 2007), but individuals are sometimes seen in outside rocky reefs (Ricketts and Calvin 1952). In one case, individuals were seen burrowing into wood (Emerson 1951). Substrate type (e.g., hard versus soft) has been shown to alter the piddock shell shape, size and hardness (see Tajima and Kondo 2003). Piddock burrows have the ability, particularly when individuals are present in large numbers, of compromising the stability of shorelines throughout their lifetimes (e.g., *Pholas dactylus*, *Barnea candida*, *B. parva*, Pinn et al. 2005).

Salinity:

Temperature: Cold to temperate waters.

Tidal Level: Intertidal to deep water (Quayle 1970), below -0.3 meters (Kozloff 1993)

Associates: Associates include other nestling and burrowing clams (e.g., *Penitella*, *Hiatella, Entodesma, Adula*) as well as the commensal pea crab, *Opisthopus transversus*, and the flat-worm *Cryptophallus magnus* (MacGinitie 1935; Haderlie and Abbott 1980).

Abundance: Can be quite dense in locally suitable conditions. This species is the third most abundant pholad at Fossil Point, Coos Bay (following *Penitella penita*, *P. richardsoni,* Evans and Fisher 1966).

Life-History Information

Reproduction: Spawning occurred in July in southern California (MacGinitie 1935), but little is known about the reproduction and development of this species. Breeding occurs in the congener, *Z. crispata*, in from March through October (Northumberland coast, United Kingdom, Allen 1969). Boyle and Turner (1976) described the reproduction and development of the east coast pholad, *Martesia striata.* This species spawns in February and eggs are translucent white and 45–46.8 µm in diameter (33˚C, Turner and Johnson 1968; 21˚C, Boyle and Turner 1976).

Larva: Bivalve development generally proceeds from external fertilization via broadcast spawning through a ciliated trochophore stage to a veliger larva. However, in the deep water pholad genus, *Xylophaga*, species brood larvae until late veliger stages (Kennedy 1974; Voight 2009). 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. 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 (Kabat and O’Foighil 1987; Brink 2001). (For generalized life cycle see Fig. 1, Brink 2001). Larvae of the common, local pholad, *P. penita,* are free swimming with a pelagic duration of two weeks (Haderlie and Abbott 1980). The development of other pholads (e.g., *Barnea truncata*, Chanley 1965; *Cyrtopleura costata*, Chanley and Andrews 1971; *Martesia striata*, Boyle and Turber 1976) proceeds as planktotrophic veliger larvae. After 24 hours, *M. striata* larvae are straight hinge veligers (68 µm in length and 59 µm in height, Boyle and Turner 1976). After eight days, they are umbo larvae (129–224 µm) and they are pediveligers by 28–32 days (224–236 µm) post fertilization. Metamorphosis in *M. striata* occurs after 48-53 days (see Table 1, Figure 1, Boyle and Turner 1976). (see also Campos and Ramorino 1990 for planktonic pholad larvae from Chile). The development of *Z. subconstricta* was followed by Ito (2005) where D-stage larvae were 70 µm in length and 60 µm in height and later stages were uniformly round and 150–200 µm in diameter. Metamorphosis occurred after five weeks and shells became asymmetrical once individuals were approximately 320 µm (see Fig. 1, Ito 2005).

Juvenile:

Longevity: 7–8 years (MacGinitie and MacGinitie 1947; Ricketts and Calvin 1952). The lifespan of the congener, *Z. crispata* is 5–7 years (Allen 1969).

Growth Rate: Animals grow throughout their entire life, unlike *Penitella* species (see **Behavior**). Growth rate of the congener, *Z. crispata,* is 8 mm/year (Allen 1969).

Food: A suspension feeder, *Z. pilsbryi* uses its inhalant siphon to filter food through very large gills that extend into the exposed siphon (Haderlie and Abbott 1980).

Predators: Flatworms.

Behavior: *Zirfaea pilsbryi* is unusual among pholads for its indeterminate growth, as an individual remains an active burrower for its entire life and does not stop and seal its shell with a callum when mature (MacGinitie 1935).

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