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Mollusca: Bivalvia

Laura A. Brink

The bivalves (also known as lamellibranchs or pelecypods) include such groups as the clams, mussels, scallops, and oysters. The class Bivalvia is one of the largest groups of invertebrates on the Pacific Northwest coast, with well over 150 species encompassing nine orders and 42 families (Table 1). Despite the fact that this class of mollusc is well represented in the Pacific Northwest, the larvae of only a few species have been identified and described in the scientific literature. The larvae of only 15 of the more common bivalves are described in this chapter. Six of these are introductions from the East Coast. There has been quite a bit of work aimed at rearing West Coast bivalve larvae in the lab, but this has lead to few larval descriptions.

Reproduction and Development

Most marine bivalves, like many marine invertebrates, are broadcast spawners (e.g., *Crassostrea gigas, Macoma balthica,* and *Mya arenaria,*); the males expel sperm into the seawater while females expel their eggs (Fig. 1). Fertilization of an egg by a sperm occurs within the water column. In some species, fertilization occurs within the female, with the zygotes then

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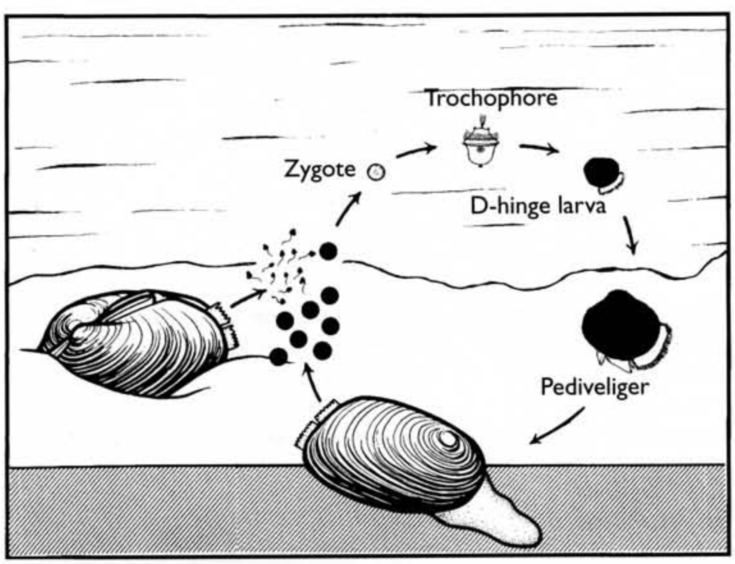

Fig. 1. Generalized life cycle of marine bivalves (not to scale).

Table 1. Species in the class Bivalvia from the Pacific Northwest (local species list from Kozloff, 1996). Species in bold indicate larvae described in this chapter.

Order, Family	*Species*	*Life History*[1]	*References for Larval Descriptions*
Nuculoida			
Nuculidae	*Nucula tenuis*		
	Acila castrensis	FSP	Strathmann, 1987; Zardus and Morse, 1998
Nuculanidae	*Nuculana hamata*		
	Nuculana minuta		
	Nuculana cellutita		
Yoldiidae	*Yoldia amygdalea*		
	Yoldia scissurata		
	Yoldia thraciaeformis		Hutchings and Haedrich, 1984
	Yoldia myalis		
Solemyoida			
Solemyidae	***Solemya reidi***	FSP	Gustafson and Reid, 1986
Arcoida			
Glycymerididae	*Glycymeris subobsoleta*		
	Glycymeris corteziana		
Philobryidae	*Philobrya setosa*		
Mytiloida			
Mytilidae	***Mytilus californianus***	FSV	Lutz et al., 1982; Shaw et al., 1988; Strathmann, 1987; Martel et al., 2000
	***Mytilus trossulus* (*edulis*)**	FSV	Stafford, 1912; Sullivan, 1948; Rees, 1950; Loosanoff et al., 1966, Chanley and Andrews, 1971; Bayne, 1971; Epifanio et al., 1975; De Schweintiz and Lutz, 1976; Le Pennec, 1980
	Crenella decussata		Shaw et al., 1988; Martel et al., 2000
	Lithophaga plumula		
	Adula californiensis	FSV	Morris et al., 1980
	Adula falcata		
	Adula diegensis	FSV	Lough and Gonor, 1971; Strathmann, 1987
	Modiolus modiolus	FSV	Rees, 1950; Chanley and Andrews, 1971; De Schweinitz and Lutz, 1976
	Modiolus rectus		
	Musculista senhousia		
	Musculus niger		
	Musculus discors		
	Musculus taylori		
	Dacrydium pacificum		
	Megacrenella columbiana		
Limoida			
Limidae	*Limatula subauriculata*		
Ostreoida			
Pectinidae	*Patinopecten caurinus*	FSV	Bronson et al., 1984; Strathmann, 1987
	Chlamys hastata	FSV	Strathmann, 1987Hodgson and Bourne, 1988
	Chlamys rubida		
	Chlamys behringiana		
	Hinnites gigantea	FSV	Bronson et al., 1984; Strathmann, 1987
	Delectopecten randolphi		
	Delectopecten vancouverensis		
	Parvamussium alaskensis		

Order, Family	*Species*	*Life History*[1]	*References for Larval Descriptions*
Anomiidae	*Pododesmus cepio*	FSV	Leonard, 1969; Strathmann, 1987
Ostreidae	***Ostrea lurida***	BV	Hori, 1933; Hopkins, 1936; Loosanoff et al., 1966; Strathmann 1987
	Ostrea conchaphilia		
	Crassostrea virginica	FSV	Sullivan, 1948; Loosanoff et al., 1966; Chanley and Andrews, 1971; Epifanio et al., 1975; Lutz et al., 1982
	Crassostrea gigas	FSV	Loosanoff et al., 1966; Epifanio et al., 1975; Le Pennec, 1980; Pauley et al., 1988
Veneroida			
Lucinidae	*Lucina tenuisculpta*		
	Lucinoma annulata		
Thyasiridae	*Thyasira cygnus*		
	Thyasira gouldii	BV or BJ ?	Blacknell and Ansell, 1974, 1975
	Thyasira barbarensis		
	Axinopsida serricata		
	Axinopsida viridis		
	Conchocele bisecta		
Ungulinidae	*Diplodonta orbellus*		
	Diplodonta impolita		
Chamidae	*Chama arcana*		
	Pseudochama exogyra		
Kelliidae	***Kellia suborbicularis***	BV	Lebour, 1938 a,b; Rees, 1950; Strathmann, 1987
	Rhamphidonta retifera		
	Odontogena borealis		
Lasaeidae	*Lasaea subviridis*	BV	Strathmann, 1987
Galeommatidae	*Scintillona bellerophon*		
Montaculidae	*Pseudopythina rugifera*	BV	Strathmann, 1987
	Pseudopythina compressa		
	Mysella tumida	BV	O'Foighil, 1985; Strathmann, 1987
Turtoniidae	*Turtonia minuta*		Matveeva, 1976
Carditidae	*Glans carpenteri*	BJ	Morris et al., 1980
	Miontodiscus prolongatus		
	Cyclocardia ventricosa		
	Cyclocardia crebricostata		
	Crassicardia crassidens		
Astartidae	*Astarte esquimalti*		
	Astarte compacta		
	Astarte undata		
	Tridonta alaskensis		
Cardiidae	*Nemocardium centrifilosum*		
	Clinocardium nuttalli	FSV	Gallucci and Gallucci 1982; Strathmann, 1987
	Clinocardium blandum		
	Clinocardium cliatum		
	Clinocardium californiense		
	Clinocardium fucanum		
	Serripes groenlandicus		
Mactridae	*Mactra californica*		
	Spisula falcata		

table continues

Order, Family	*Species*	*Life History*[1]	*References for Larval Descriptions*
	Tresus nuttalli	FSV	Morris et al., 1980
	Tresus capax	FSV	Bourne and Smith, 1972a,b; Strathmann, 1987
Cultellidae	*Siliqua patula*	FSV	Breese and Robinson, 1981; Lassuy and Simons, 1989; Morris et al., 1980
	Siliqua lucida		
	Siliqua sloati		
Solenidae	*Solen sicarius*		
Tellinidae	*Tellina bodegensis*		
	Tellina carpenteri		
	Tellina modesta		
	Tellina nuculeoides		
	Macoma balthica	FSV	Sullivan, 1948; Strathmann, 1987
	Macoma calottensis		
	Macoma eliminata		
	Macoma nasuta	FSV	Marriage, 1954; Rae, 1978, 1979
	Macoma secta	FSV	Marriage, 1954; Rae, 1978, 1979
	Macoma yoldiformis		
Psammobiidae	*Gari californica*	FSV	Strathmann, 1987
Scrobiculariidae	*Semele rubropicta*		
	Cumingia californica		
Solecurtidae	*Tagelus californianus*		
Corbiculidae	***Corbiucla fluminea***	BJ	Kennedy and Van Huekelem, 1985; Kennedy et al., 1991
Veneridae	*Protothaca staminea*	FSV	Marriage, 1954; Nickerson, 1977; Chew and Ma, 1987; Strathmann, 1987
	Protothaca tenerrina		
	Humilaria kennerlyi		
	Tapes philippinarum	FSV	Bourne, 1982; Strathmann, 1987
	Psephidia ovalis		
	Psephidia lordi	BV	Strathmann, 1987
	Transenella confusa		Gray, 1982
	Transenella tantilla	BG	Strathmann, 1987
	Lyocyma fluctuosa		
	Saxidomus giganteus	FSV	Fraser, 1929; Breese and Phibbs, 1970; Nickerson, 1977; Strathmann, 1987
	Compsomyax subdiaphana		
Petricolidae	*Petricola carditoides*		
	Petricola pholadiromis	FSV	Chanley and Andrews, 1971
Cooperellidae	*Cooperella subdiaphana*		
Thraciidae	*Thracia beringi*		
	Thracia curta		
	Thracia trapezoides		
	Thracia challisiana		
Myoida			
Myidae	***Mya arenaria***	FSV	Stafford, 1912; Sullivan, 1948; Marriage, 1954; Loosanoff et al., 1966; Chanley and Andrews, 1971; Savage and Goldberg, 1976; Lutz et al., 1982
	Mya truncata		
	Cryptomya californica		
	Platyodon cancellatus		
	Sphenia ovoidea		

Order, Family	*Species*	*Life History*[1]	*References for Larval Descriptions*
Hiatellidae	***Hiatella arctica***	FSV	Lebour, 1938b; Sullivan, 1948, Rees, 1950, Savage and Goldberg, 1976
	Panope abrupta	FSV	Marriage, 1954; Goodwin, 1973; Strathmann, 1987
	Panomya chrysis		
Pholadidae	*Barnea subtruncata*		
	Zirfaea pilsbryii		
	Penitella conradi		Wilson and Kennedy, 1984
	Penitella gabbii		
	Penitella penita	FSV	Morris et al., 1980
	Penitella turnerae		
	Netastoma rostrata		
Xylophagaidae	*Xylophaga washingtona*		
Teredinidae	***Teredo navalis***	FSV	Sullivan, 1948; Loosanoff et al., 1966; Chanley and Andrews, 1971; Culliney, 1975; Quayle, 1992
	Bankia setacea	FSV	Quayle, 1953, 1959, 1992; Townsley et al., 1966; Haderlie, 1983
Pholadomyoida			
Lyonsiidae	*Lyonsia californica*	FSV	Strathmann, 1987
	Entodesma pictum		
	Mytilimeria nuttalli	FSV	Yonge, 1952; Strathmann, 1987
	Agriodesma saxicola		
Pandoridae	*Pandora bilirata*		
	Pandora filosa		Thomas, 1994
	Pandora punctata		
	Pandora wardiana		
	Pandora glacialis		
Septibranchida			
Cuspidariidae	*Cardiomya oldroydi*		
	Cardiomya pectinata	BEC	Gustafson et al., 1986; Strathmann, 1987
	Cardiomya planetica		
	Cardiomya californica		
	Plectodon scaber		

[1]Life History: FSV, free-spawning veliger larvae; FSP, free-spawning periclymmna larvae; BV, brooded to veliger; BJ, brooded to juvenile; BEC, benthic egg capsule.

expelled into the surrounding water column. After fertilization of the egg, the zygote first develops into a planktonic trochophore and then into a shelled veliger larva with a ciliated velum used for swimming and respiration. This planktonic larval stage can last from a few days to months, depending on the species. Just prior to metamorphosis the foot develops, at which time the larva is called a pediveliger. After settling on the bottom, loss of the ciliated swimming velum takes place and the post-larval bivalve is able to dig and crawl around using its now fully functional foot. At this stage, these post-larval individuals are referred to as "spat," or juveniles.

In contrast, some bivalve species brood their larvae either within the mantle cavity or attached to the external shell surface (Strathmann, 1987). The developmental stage at which these larvae are released is species specific; some species release their young at the early veliger stage (i.e., *Kellia suborbicularis,* at ca 72 µm; Strathmann, 1987), but others retain the larvae until they are ready to live as juveniles on the bottom (i.e., *Corbicula fluminea*, at ca 210 µm; V. Kennedy, pers. comm.).

Finally, some species in the orders Nuculoida and Solemyoida produce non-feeding (lecithotrophic) larvae with unique morphology, the periclymma larva (see Fig. 3). The larvae are barrel-shaped with prominent apical tufts and are propelled by cilia. The outer cellular body, or test, is ovoid and completely surrounds the shell. The test is cast off at metamorphosis when the juvenile clam begins its benthic existence. Two local species with this mode of development have thus far been described (*Acila castrensis* and *Solemya reidi*).

Occasionally post-settlement-sized "larvae" are found in plankton samples, especially those samples taken near the bottom. These are individuals that have already metamorphosed and taken up residence on the bottom. Non-planktonic individuals are occasionally found in plankton samples for one of three reasons: (1) They were stirred up from the bottom by the currents. (2) They are byssus thread drifters. Byssus thread drifting occurs when post-settlement bivalves extend a byssus thread and the drag on the thread causes the individual to become resuspended in the water column. This is a common way for post-larval bivalves (and occasionally gastropods) to further their dispersal (Lane et al., 1985; Martel and Chia, 1991; Cummings et al., 1993). (3) Less likely, these individuals have not found suitable settlement sites and are able to delay metamorphosis (Bayne, 1965).

Identification and Description of Local Taxa

Sampling of bivalve larvae is best accomplished with a plankton net that has a mesh size small enough to retain the smallest larvae one wishes to study. Larvae smaller than about 100 μm are nearly impossible to identify without the aid of a scanning electron microscope. The larval shells are surprisingly strong and thus can be sampled either by a towed plankton net or through an electric or gas-powered pump with minimal damage to the shells. For short-term storage (on the order of months), 5% formalin buffered with calcium carbonate works well for preservation; buffering prevents low pH that causes shells to dissolve. If longer storage is necessary (months to years), 70% ethanol is recommended to prevent shell loss.

Because plankton samples are typically kept in buffered formalin, the bodies of the bivalve larvae are often shriveled while the shell has remained intact. For some larvae, shell color is helpful for identification. Depending on how long the sample has been stored, however, this color may not have survived, and shell shape is the primary tool for identification, not shell or body color. Color characteristics can be useful as a backup to help confirm an identification

Use cross-polarized light to view larvae. Place a polarizing filter below the stage on the microscope and a second filter between the sample and the lens of the microscope. Rotate one of the filters until the background becomes dark and the bivalve shells "light up." The crossed polarization causes birefringence due to the microcrystalline aragonitic structure of the larval shells (Gallager et al., 1989) and dramatically aids finding and identifying larvae within a sample.

At all developmental stages (veliger or pediveliger) regardless of size, the shape of the umbo is most useful for identification (Fig. 2). The umbo can take on a variety of shapes and sizes, most of which are species-specific. Prior to the development of the umbo, during the early veliger or D-hinge stage, larvae can be extremely difficult to differentiate and, without the use of scanning electron microscopy, probably cannot be taken down to species. Aside from the umbo, the length and slope of the shoulders can also be helpful in identification. The shoulders typically become prominent during the veliconcha stage.

Periclymma Larvae

There are probably 12 local bivalve species that produce periclymma larvae. The larvae of two of these species have been described, and illustrations of several additional periclymma are available (Fig. 3).

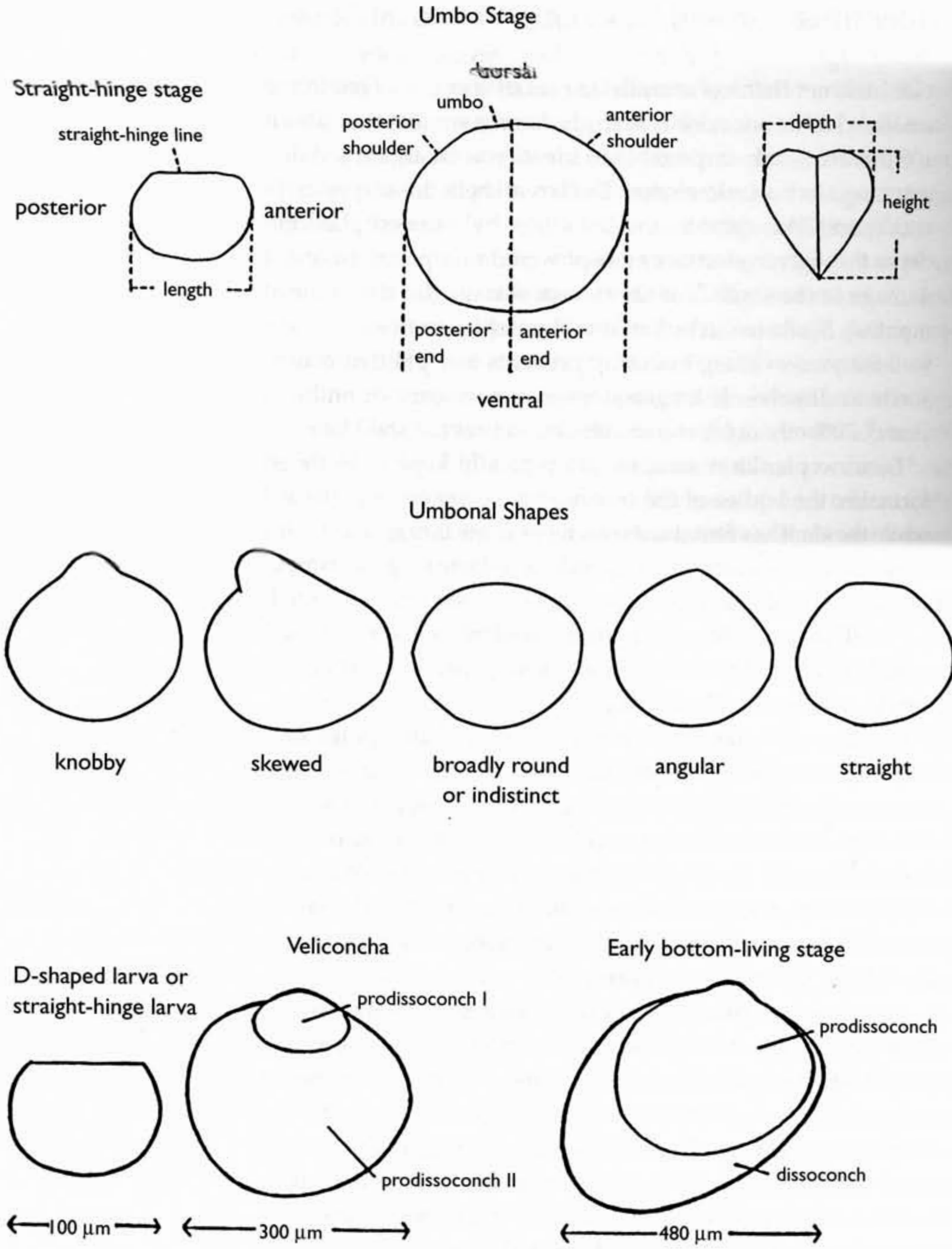

Fig. 2. Terminology used to describe dimensions and shapes of bivalve larvae. The posterior end of the larval shell is typically blunter and shorter than the anterior end and has a higher shoulder. (Adapted from Chanley and Andrews, 1971; Rees, 1950)

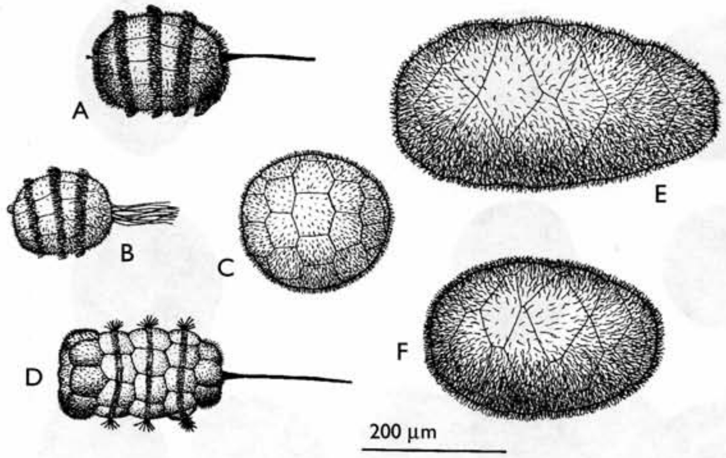

Fig. 3. Periclymma larvae. (A) ***Acila castrensis***. (B) ***Nucula*** *proxima*. (C) ***Nucula*** *delphinodonta*. (D) ***Yoldia*** *limatula*. (E) ***Solemya reidi***. (F) ***Solemya*** *velum*. Local genera and species are in bold. (From Zardus and Morse, 1998, Fig. 54)

Key to bivalve periclymma larvae

1a. Test with 3 transverse bands of cilia and apical tuft of accessory cilia. Late-stage larvae laterally compressed with shell development. Test shed at metamorphosis (Fig. 3A) .... *Acila castrensis*

1b. Test entirely covered with cilia. Length varies, 360–440 μm (Fig. 3E) .... *Solemya reidi*

Veliger Larvae

The subtle differences in larval shell shape between bivalve species do not lend themselves to the normal dichotomous key. What works better is a pictorial guide. We have modeled this identification guide after Chanley and Andrews's (1971) guide to the bivalve larvae of the Virginia coast. Because of the difficulty in distinguishing straight-hinge or D-larvae, this section describes only larvae in which the umbo has become rounded. Use this section as follows: (1) Use the ocular micrometer on the dissection microscope to determine the length of the larva in question. (2) Find this length in Fig. 4. (3) Match the shape of the specimen's larval shell. (4) Find details of the selected species in the following descriptions.

The correct identification of larval bivalves takes considerable time and patience. Differences in shell shape among species are in most cases extremely subtle. It is particularly important to remember that few of the bivalve species common to the Pacific Northwest coast have published descriptions of their larvae (see Table 1).

Bankia setacea, **Feathery Shipworm** (Order Myoida, Family Teredinidae). Characteristic dark rim around the margin of the

Fig. 4 (overleaf). Comparative drawings of 15 species of larval bivalves.

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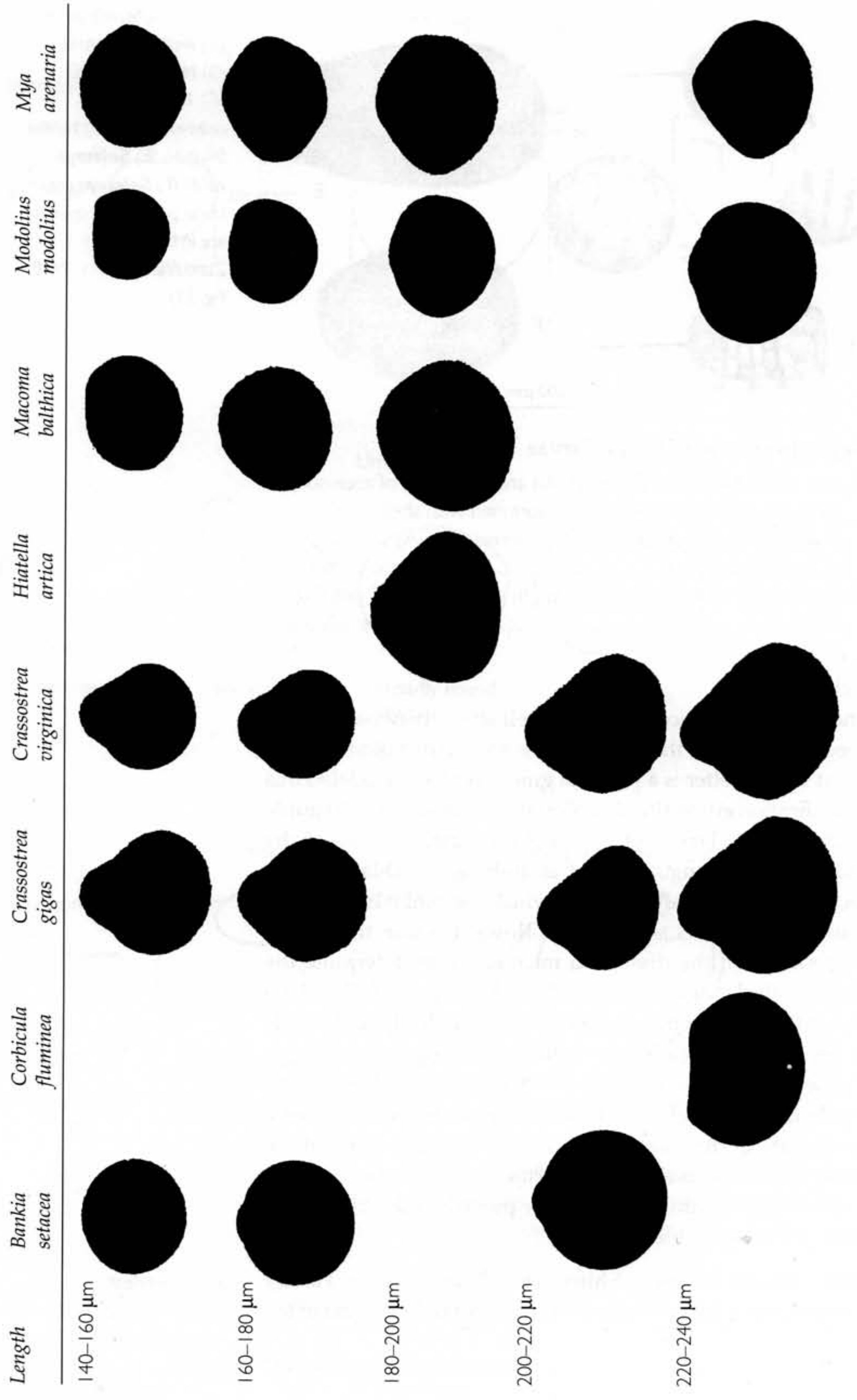
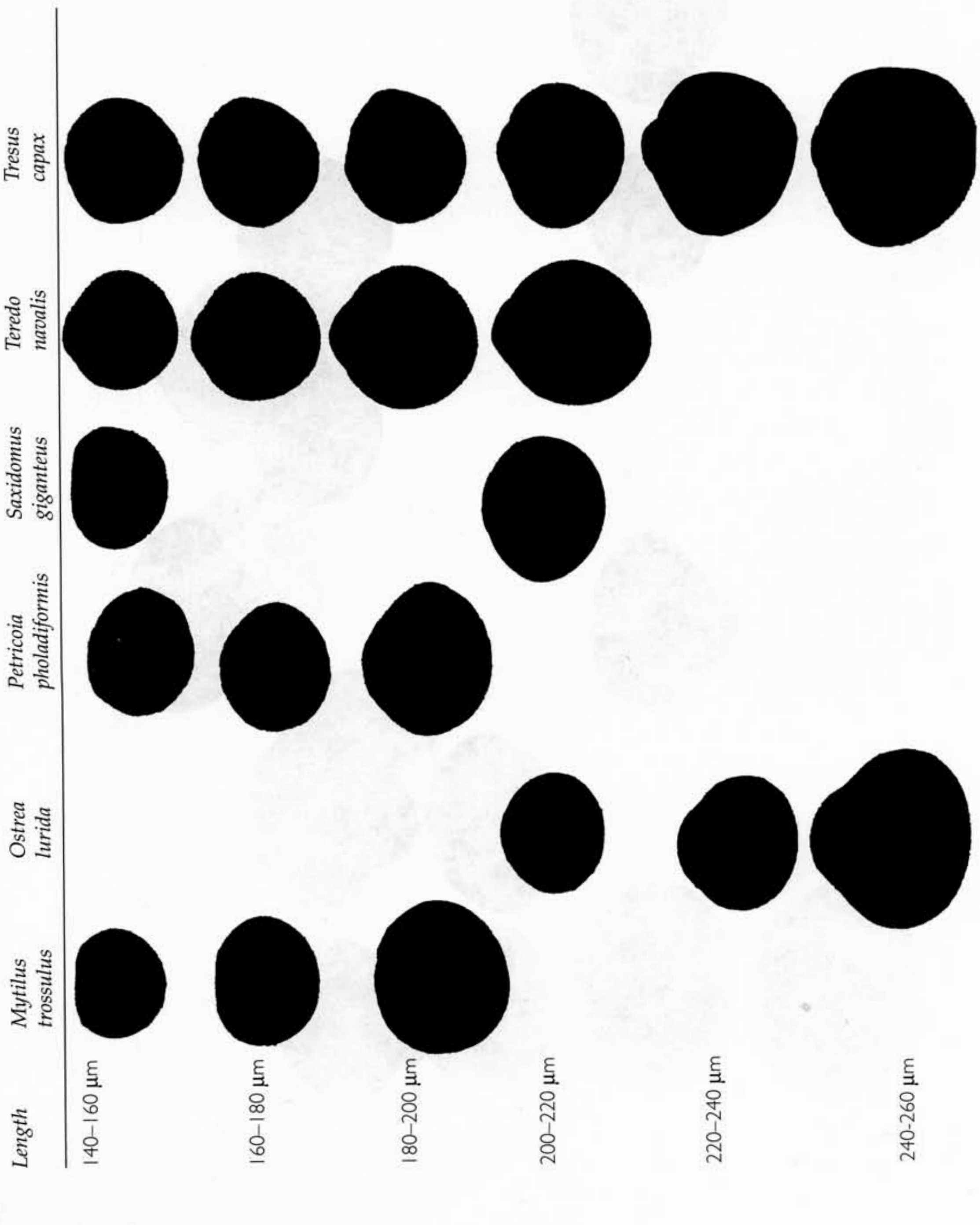
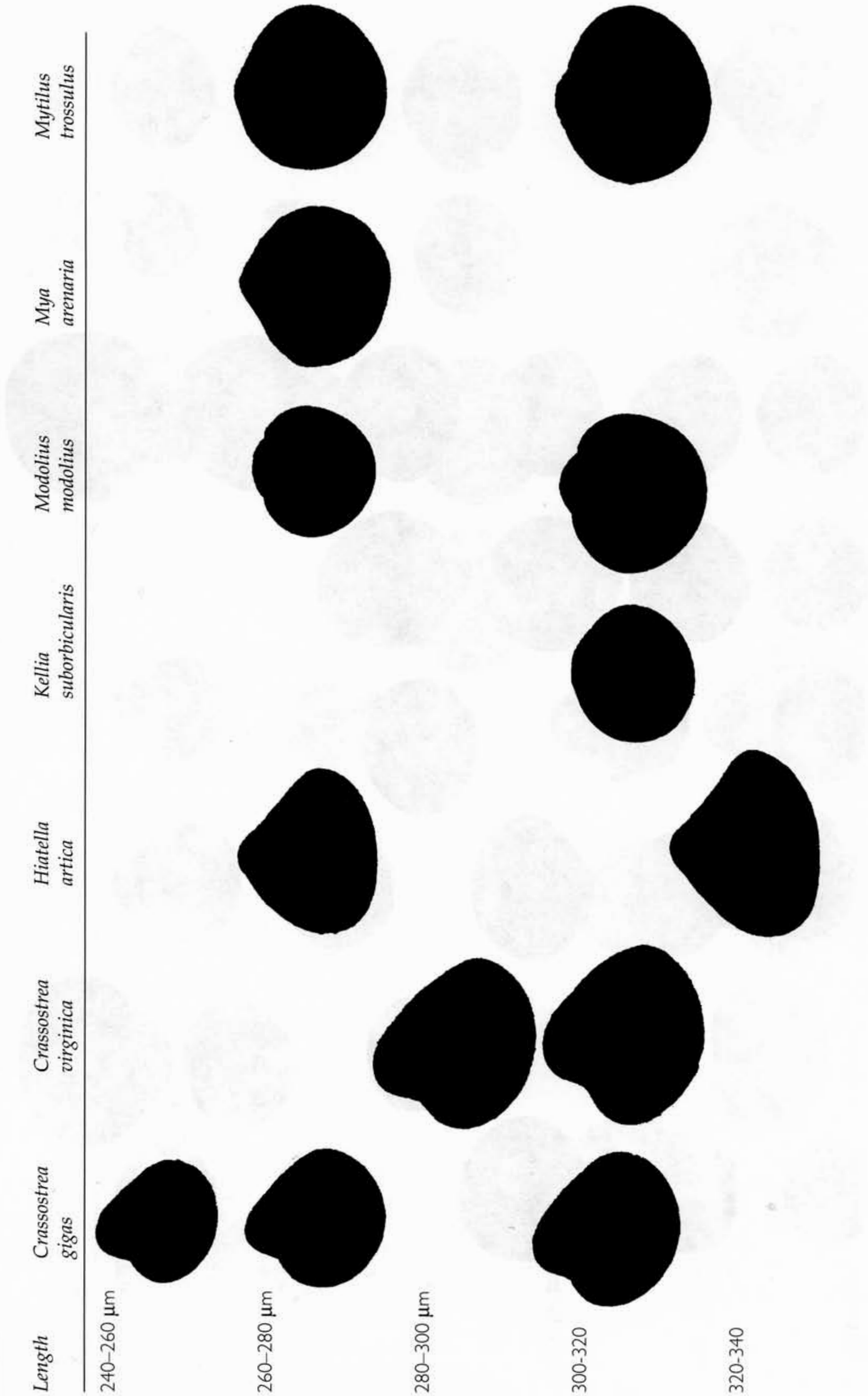
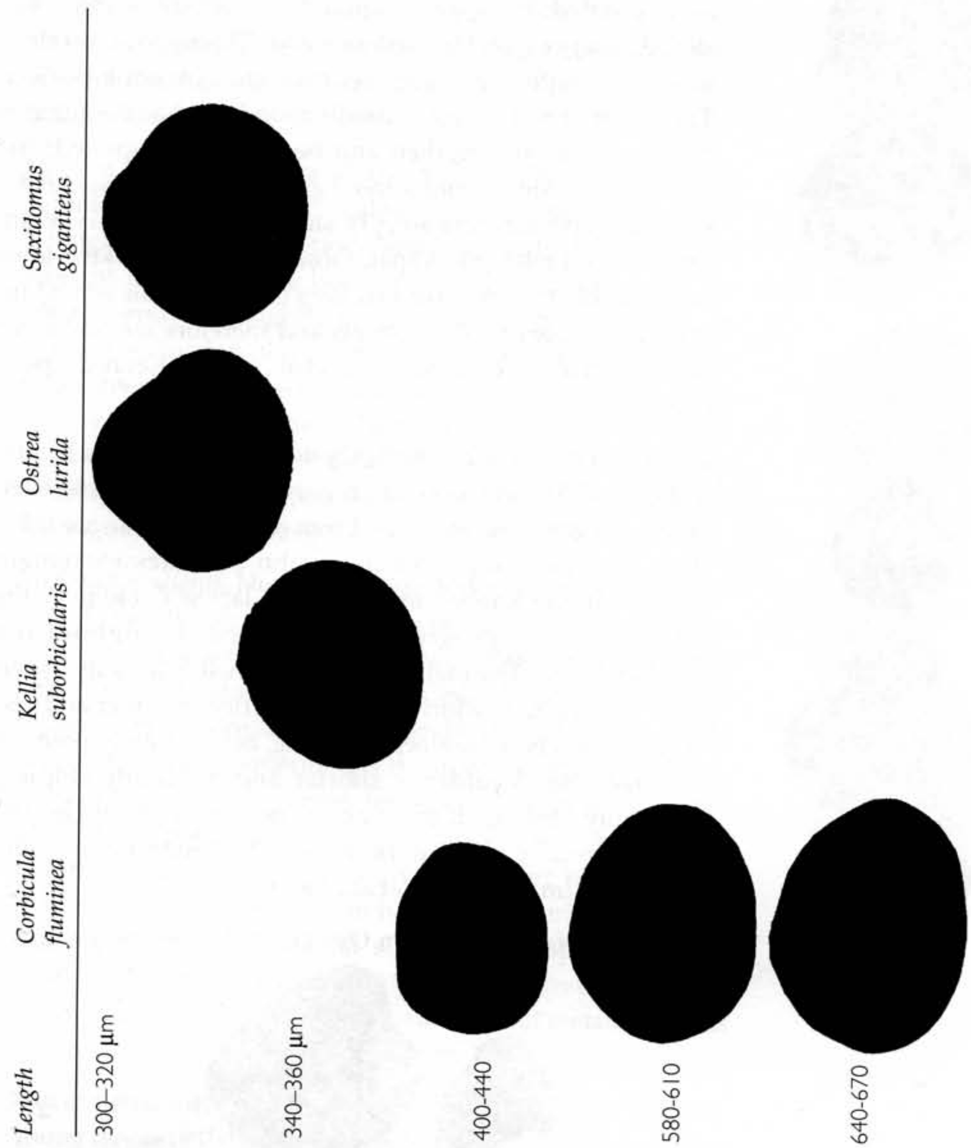
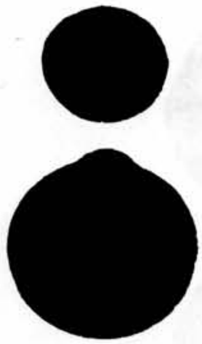

Length
140–160 µm
160–180 µm
180–200 µm
200–220 µm
220–240 µm
Bankia setacea
Corbicula fluminea
Crassostrea gigas
Crassostrea virginica
Hiatella artica
Macoma balthica
Modolius modolius
Mya arenaria

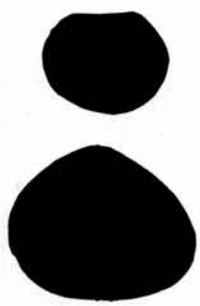

Length
Mytilus trossulus
Ostrea lurida
Petricoia pholadiformis
Saxidomus giganteus
Teredo navalis
Tresus capax
140–160 µm
160–180 µm
180–200 µm
200–220 µm
220–240 µm
240-260 µm


Length
Crassostrea gigas
Crassostrea virginica
Hiatella artica
Kellia suborbicularis
Modolius modolius
Mya arenaria
Mytilus trossulus
240–260 µm
260–280 µm
280–300 µm
300-320
320-340

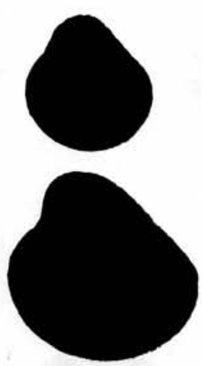

Length
Corbicula fluminea
Kellia suborbicularis
Ostrea lurida
Saxidomus giganteus
300–320 µm
340–360 µm
400-440
580-610
640-670



larval shell; at a length of ca 140 µm, a dark line appears just inside the edge of the shell and runs parallel to the rim of the shell. Before the appearance of the knobby umbo at ca 150 µm, the shell is nearly round and the shoulders are gradually sloping. The shell gets progressively yellower in color throughout the larval period. The shell becomes as tall if not taller than it is long; the shell depth becomes nearly as great as the length. Size at metamorphosis, ca 245 µm (Quayle, 1953).

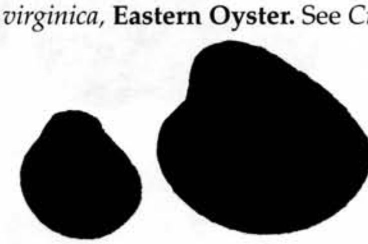


Corbicula fluminea, **Asiatic Freshwater Clam** (Order Veneroida, Family Corbiculidae). Larvae are brooded within the adult clam until ca 210 µm length. Upon release the spat have a long, straight umbo, a steeply sloping posterior shoulder, and rounded posterior end; the anterior end is slightly longer and more pointed; the anterior shoulder is steeply sloping but slightly longer than the posterior end. Throughout development, the length of the umbo shortens and remains indistinct. The posterior end remains broadly rounded while the anterior end continues to lengthen and become more pointed; the anterior shoulder becomes more gradually sloping while the posterior end remains steeply sloping. Because larvae are brooded and released as spat, those caught in plankton tows are probably byssus thread drifters or individuals stirred up from the bottom by the currents and therefore are no longer considered true larvae (Kennedy et al., 1991; V. Kennedy, pers. comm.)

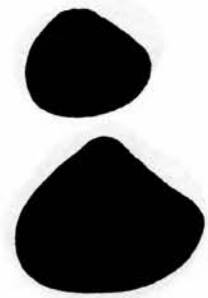


Crassostrea gigas, **Giant Pacific Oyster** (Order Osteoida, Family Ostreidae). These larvae are nearly indistinguishable from larvae of *Crassostrea virginica*. From early on, larvae are taller than they are long, and the umbo becomes extremely prominent and knobby in even small larvae (~140 µm); the umbo becomes progressively skewed throughout the planktonic life. The main body of the shell is initially round until ca 200 µm, at which time the anterior shoulder and end lengthen and become steeply sloping, being slightly pointed; the posterior shoulder is shorter and gradually sloping, eventually coming off the umbo at nearly a right angle. The shell is typically rather dark in color. Metamorphosis occurs at 275–330 µm (Loosanoff et al., 1966).

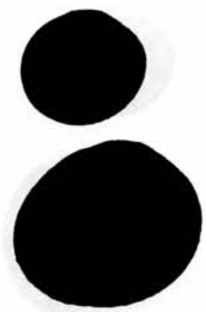
Crassostrea virginica, **Eastern Oyster.** See *Crassostrea gigas*.



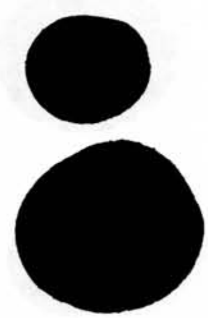
Hiatella arctica, **Arctic Saxicave, Little Gaper, Red Nose** (Order Myoida, Family Hiatellidae). Larvae of this species have a distinct shape: the umbo is angular and slightly knobby; the posterior shoulder is long and steeply sloping; the bottom half of the posterior end is rather squared-off. The anterior shoulder is also long and steeply sloping, but less so than the posterior end. The anterior end comes to a distinct point halfway down the height of the shell. Metamorphosis is believed to occur at ca 345 µm (Rees, 1950).



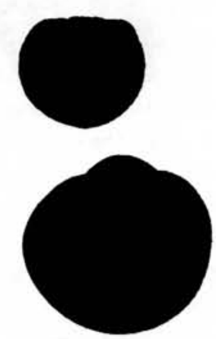
Kellia suborbicularis, **North Atlantic Lepton** (Order Veneroida, Family Kelliidae). Larvae of this species are large and easily recognized by their very short, straight umbo. The posterior end is broadly rounded with a long, steeply sloping shoulder. The anterior end is also broadly rounded but is slightly longer and skewed toward the anteroventral margin of the shell. Size at metamorphosis is believed to be ca 370 µm (Rees, 1950; Strathmann, 1987).



Macoma balthica, **Balthica Macoma** (Order Veneroida, Family Tellinidae). These larvae retain a rather indistinct shape throughout the larval period. Young larvae (<160 µm) have a straight hinge and the body is broadly rounded with the anterior end only slightly longer than the posterior end. As the larvae develop, the anterior end lengthens and becomes more steeply sloped while the posterior end remains much shorter and more rounded. The result is a larval shell slightly skewed in the direction of the anterior end. The umbo remains broadly rounded and indistinct throughout development. Average size at metamorphosis is 255 µm (Sullivan, 1948).



Modiolus modiolus, **Northern Horse Mussel** (Order Mytiloida, Family Mytilidae). Straight-hinge larvae of *M. modiolus* are indistinguishable from *Mytilus trossulus* (*edulis*) straight-hinge larvae. At ca 170 µm, the umbo of *M. modiolus* becomes broadly rounded. At this size, the posterior end is short and also broadly rounded, while the anterior end is longer and slightly pointed. As size increases, the umbo becomes more prominent and knobby. The posterior shoulder is short and the posterior end is rather squared off; the anterior shoulder is longer and gradually sloping. The bottom half of the anterior end slopes sharply toward the ventral margin. This species is best distinguished from *M. trossulus* by the size of the umbo, which is longer and wider than in *M. trossulus*. Size at metamorphosis is ca 300 µm. (De Schweinitz and Lutz, 1976).



Mya arenaria, **Soft-shell Clam** (Order Myoida, Family Myidae). Young larvae (<150 µm) have a broadly rounded umbo with a short, gradually sloping posterior shoulder and a longer, more steeply sloping anterior shoulder and end. As development proceeds, the umbo becomes angled and the shoulders become straighter and more steeply sloping. Both ends are pointed but the anterior end is slightly longer. Larvae retain this general shape throughout development. Metamorphosis occurs at 170–230 µm (Chanley and Andrews, 1971).

Mytilus trossulus (edulis), **Blue Mussel** (Order Mytiloida, Family Mytilidae). This larva retains its straight hinge much longer than other larvae, until almost 220 µm. At this point, the umbo becomes broadly rounded and the anterior end begins to lengthen and become more pointed. Eventually a small, knobby umbo develops. The posterior end is short but steeply sloping; the anterior end is longer but slopes more gradually down to a point. The bottom half of the anterior end slopes steeply toward the ventral margin. Compare *Modiolus modiolus*. Metamorphosis occurs at 215–305 µm (Chanley and Andrews, 1971).

Martel et al. (2000) provide a description of characteristics that can be used to differentiate between settling and early postlarval stages (e.g., prior to dissoconch secretion) of *Mytilus trossulus* and *M. californianus*. In addition, they suggest that the following characteristics can also be used to separate *M. galloprovincialis* (a species found in southern California) from *M. californianus*. *M. californianus* displayed 1) a shallower, flatter umbo (i.e., the PI curve was more pronounced, see Fig. 5), 2) the umbo was less conspicuous, barely extending above the larval hinge and only weakly curved (Fig. 5), and 3) wider separation between the provincular lateral teeth (Fig. 5).

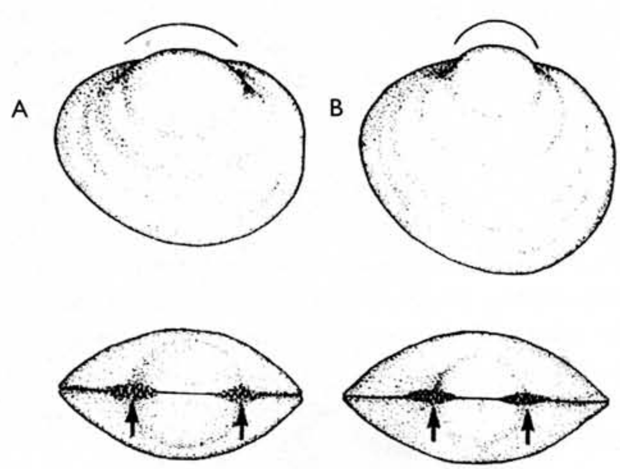
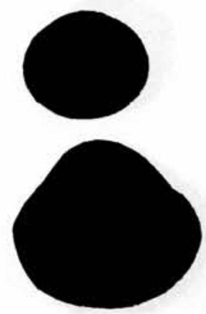
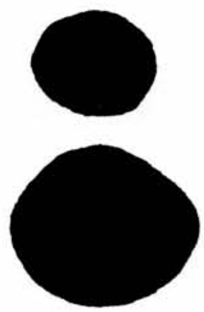


Fig 5. Settling and early postlarval stages of (A) *Mytilus californianus* and (B) *M. trossulus* (Martel at al., 2000). The curved line above the upper figures indicates the length of the prodissoconch curve (the PI curve). Note the higher and more pronounced umbo displayed by *M. trossulus* and the closer spacing between the provincular lateral teeth (arrows) relative to *M. californianus*.

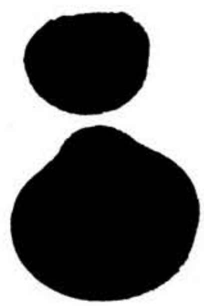
Ostrea lurida, **Native Pacific Oyster** (Order Ostreoida, Family Ostreidae). Larvae are brooded until 165–189 µm (Strathmann, 1987). Larvae less than ca 200 µm have a straight hinge, with the main body of the shell broadly rounded with ends of roughly equal length. At 200 µm, the umbo first becomes apparent and is initially just a rounded hump atop the valves. The anterior end begins to lengthen, and the anterior shoulder gets progressively longer and more steeply sloping while the posterior shoulder becomes shorter and less steeply sloping. The anterior end is longer than the posterior end. The umbo, like that of *Crassostrea*, becomes prominent and knobby in shape throughout development, although it does not become skewed. Metamorphosis occurs at ca 320 µm (Hori, 1933).



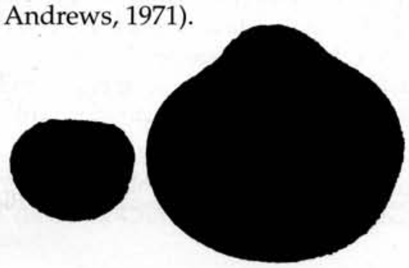
Petricola pholadiformis, **False Angle Wing** (Order Veneroida, Family Petricolidae). Larvae are free-swimming. Total length is 60–185 µm. Straight-hinge stage ends at ca 105 µm length, at which time a broadly rounded umbo develops. The anterior end is slightly longer than posterior. The ends of the shell are nearly equally rounded. The shoulders are straight and slope steeply. There is no distinctive color, though the margin is dark. The eye spot is not pigmented. The shell is heavier than in most clams. Metamorphosis occurs at ca 175 µm (Chanley and Andrews, 1971).

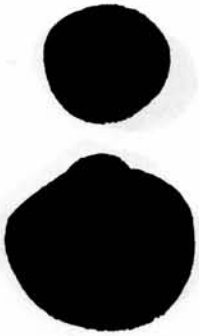


Saxidomus giganteus, **Butter Clam** (Order Veneroida, Family Veneridae). Rather indistinct larvae with a straight hinge until ca 160 µm. At this point, the anterior end is slightly longer and more pointed than the broadly rounded posterior end. As development proceeds, the umbo becomes broadly rounded as do both ends, with the anterior end being only slightly longer than the posterior end. The larvae are noticeably longer than they are tall and as a result have a rather squat appearance. Metamorphosis occurs at ca 230 µm (Breese and Phibbs, 1970).



Teredo navalis, **Common Shipworm** (Order Myoida, Family Teredinidae). Larvae have a distinct walnut-shaped (oval) shell, being as tall if not taller than long and with considerable depth. The larvae have a knobby umbo and virtually no shoulders. The ends are of equal length and rounded. The shell is usually a dark brown, golden color. Metamorphosis is at 190–200 µm (Chanley and Andrews, 1971).





Tresus capax, **Alaskan Gaper** (Order Veneroida, Family Mactridae). In small larvae with straight umbos (<140 μm), the anterior end is slightly longer and pointed, and the posterior end is short and more broadly rounded. The bottom half of the anterior end slopes sharply toward the ventral margin. As size increases, the umbo becomes progressively more angled but never becomes conspicuous. The posterior end becomes rather squared off, while the anterior end becomes more pointed. The anterior shoulder is longer than the posterior shoulder. Metamorphosis occurs at 270 μm (Bourne and Smith, 1972a,b).

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