Semibalanus cariosus

A thatched barnacle

Phylum: Arthropoda, Crustacea

Class: Multicrustacea, Hexanauplia, Thecostraca, Cirripedia

Order: Thoracica, Sessilia, Balanomorpha

Family: Balanoidea, Archaeobalanidae, Semibalaninae

Taxonomy: *Semibalanus cariosus* originally belonged to the genus *Balanus.* Members of the genus *Semibalanus*, which was described (initially as a subgenus) by Pilsbry in 1916, differ from *Balanus* species with the presence of membranous bases (Newman and Ross 1976). Thus, a common known synonym for *S. cariosus* is *B. cariosus*.

Description

Size: Individuals typically up to 75 mm in diameter (Henry 1940) and 80 mm in height. Size is highly variable, especially in cylindrical specimens on vertical surfaces, but is not limited by mechanical factors of a wave swept environment (Denny et al. 1985). For example, individuals from Puget Sound, Washington can grow to 100 mm high while only 15 mm in diameter (Pilsbry 1916).

Color: Shell dirty white, gray with round or uncrowded specimens chalky white. Tergum beak can be purple (Pilsbry 1916) and cirri are brown to almost black.

General Morphology: Members of the Cirripedia, or barnacles, can be recognized by their feathery thoracic limbs (called cirri) that are used for feeding. There are six pairs of cirri in *S. cariosus*. Sessile barnacles are surrounded by a **shell** that is composed of a flat **basis** attached to the substratum, a **wall** formed by several articulated **plates** and movable **opercular valves** including **terga** and **scuta** (Newman 2007).

Shell:

Shape: Conical when isolated (Fig. 2), but can be cylindrical if crowded (see Fig. 108, Kozloff 1993).

Basis: Calcareous and flat, attached to hard substrate, rendering *S. cariosus* a sessile, or attached barnacle (Balanomorpha). Basis in *S. cariosus* is membraneous, in contrast to most barnacles which have calcareous bases (Cornwall 1951) and base forms unique starry pattern (Fig. 1), especially in juveniles (Fig. 3) (Ricketts and Calvin 1971).

Wall: Formed by plates and is thick when isolated, but thinner when crowded. The internal surface is usually with faint ribs or wrinkled texture (Cornwall 1951) (Fig. 4).

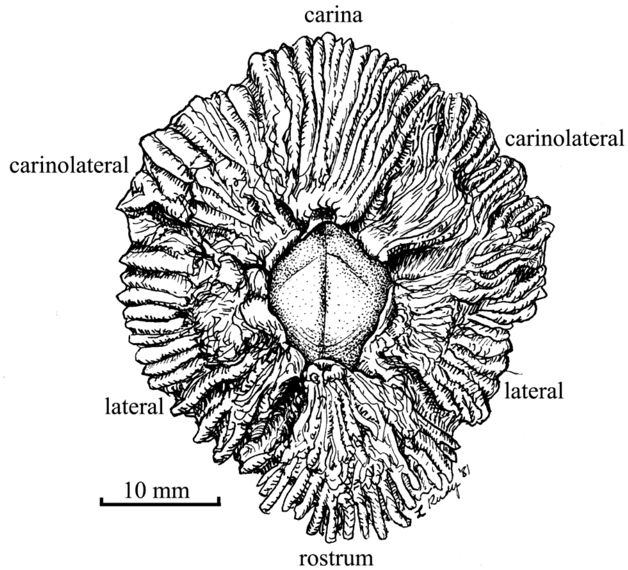
Longitudinal Tubes: Within walls, tubes are irregular (Fig. 4) and with cross-septa. They are sometimes filled with powder (Pilsbry 1916).

Plates: Six, unequal and calcareous plates bear narrow longitudinal spines, giving specimens a unique thatched appearance (Fig. 1). Each plate is composed of parietes (exposed triangular part), alae (overlapping plate edges) and radii (the plate edge marked off from the parietes by a definite change in direction of growth lines) (Newman 2007). The plates themselves include the rostrum, opposite it the carina and between the carina and rostrum are the four side plates, the carinolateral and rostrolateral plates (see Fig. 3, *Balanus glandula,* this guide). When crowded, cylindrical specimens often lack spines (Cornwall 1977). Rostrum overlaps adjacent lateral plates (see Plate 213, Newman 2007). Radii narrow (Cornwall 1951).

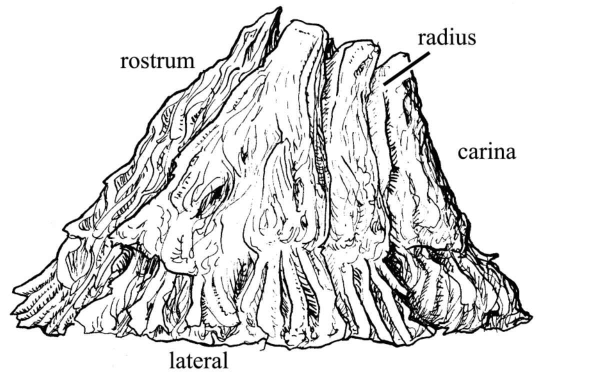
Opercular Valves: Thin (Henry 1942) valves consist of two pairs of movable plates inside the wall, which close the aperture: the tergum and the scutum (Figs. 5, 6).

Scuta: Exterior with low growth ridges, the lower ridges are fringed with mem-

Semibalanus cariosus

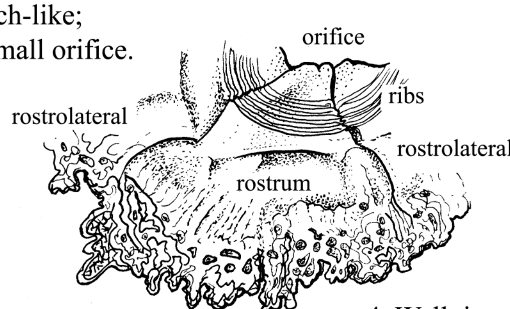


1. *Semibalanus cariosus* (dorsal view, L: 40mm W: 35mm) x2: many long spines: thatch-like; six plates: rostrum overlaps laterals; small orifice.

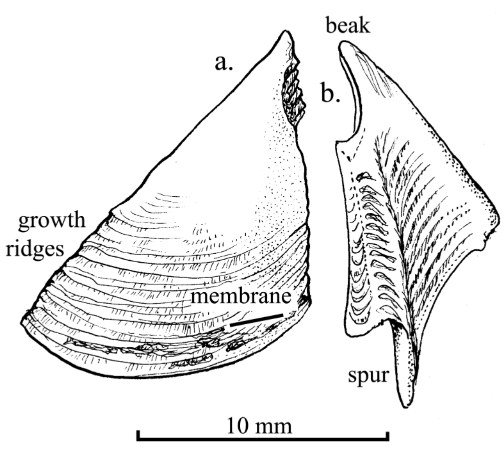


2. Lateral view: conical shape; thick wall; narrow radii .

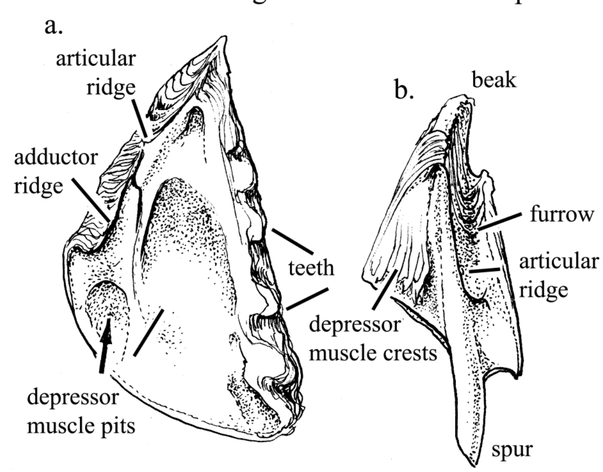
3. Young (dorsal view) x2: star-shaped border; prominent ribs, few in number.



4. Wall, interior (posterior view): basal edges: rostral and lateral plates.



5. Opercular valves, exterior right x4:
a. scutum: low growth ridges, lower ones membranous; weak longitudinal striations
b. tergum: narrow, beaked; long spur.



6. Opercular valves, interior x4:
a. scutum: small, reflexed articular ridge; sharp, high adductor ridge; deep depressor muscle pit; coarse teeth on occludent margin
b. tergum: narrow furrow; long, acute articular ridge; spur on raised ridge; strong depressor muscle crests.

Hiebert, T.C. 2015. *Semibalanus cariosus. In:* Oregon Estuarine Invertebrates: Rudys' Illustrated Guide to Common Species, 3rd ed. T.C. Hiebert, B.A. Butler and A.L. Shanks (eds.). University of Oregon Libraries and Oregon Institute of Marine Biology, Charleston, OR.

brane and usually with a weak longitudinal striation. Interior a small, well-reflexed articular ridge is present, which is continued as a sharp, high, curved adductor oblique coarse teeth (Henry 1940) (Figs. 5a, 6a).

Terga: Very narrow and beaked, with narrow furrow, and long and acute articular ridge. Very narrow and long spur (Pilsbry 1916) that continue as a raised ridge on the inside with strongly developed depressor muscle crests (Figs. 5b. 6b).

Aperture: The shell opening, from which the cirri emerge when feeding, is controlled by movement of the terga and scuta in conjunction with adductor and depressor muscles. The aperture is small in conical specimens and large in cylindrical ones (Henry 1940), the aperture can be deeply toothed (Fig. 1).

Cirri: Six pairs of conspicuous feathery feeding appendages.

Possible Misidentifications

There are three groups (i.e. superorders) of cirripeds including the Rhizocephala (parasites among crustaceans), the Acrothoracica (shell-less burrowing forms) and the Thoracica. The Thoracica contains 1,000 species worldwide including the monophyletic taxa, Lepadomorpha, the stalked barnacles, and the Balanomorpha, or sessile barnacles (Perez-Losada et al. 2008; Chan et al. 2014). Among the sessile forms, there are four families represented locally. The family Chthamaloidea includes members of the genus *Chthamalus,* which has alae on its rostral plates, not radii. The family Tetraclitoidea has one species locally, *Tetraclita rubescens,* the southern thatched barnacle, that is superficially similar to *S. cariosus*. However, it is characterized by a wall that is composed of four plates (rather than six in the *S. cariosus*). *Tetraclita rubescens* occurs as far north as Monterey Bay, California (Newman 2007).

The remaining two families include the Balanidae and Archaeobalanidae. Balanidae encompasses the genera *Megabalanus*, *Paraconcavus*, and *Menesiniella* (each with one local species), *Amphibalanus* (three local species) and *Balanus* (four local species). The Archaeobalanidae includes the genera *Armatobalanus*, *Conopea*, *Hesperibalanus* and *Semibalanus* (each with one local species). An isolated *S. cariosus*, is with splinter -like spines, nearly black cirri and is not likely to be confused with another barnacle. It has a thatched appearance, being irregularly ribbed and its walls have uneven, longitudinal tubes (Pilsbry 1916). However, where it is crowded or eroded, these spines may be worn off or not developed, and the barnacle would have to be distinguished from other common barnacles by its tergum and scutum, and by its unique and unusual membraneous base. *Semibalanus cariosus* have terga with a long pointed spur, quite different from either *B. crenatus* or *B. glandula*. *Semibalanus cariosus* commonly co-occurs with *B. crenatus*, *B. glandula*, as well as with *Chthamalus dalli*. Juvenile *S. cariosus* will show a typical heavy ribbing and starry outline, which would distinguish it from young *B. crenatus* or *B. glandula*. Generally, these latter two species are found higher in the intertidal than is *S. cariosus*, which occurs mostly subtidally.

Balanus crenatus may be easily confused with the ubiquitous *B. glandula*, but is generally found lower in the intertidal. *Balanus glandula* has no longitudinal wall tubes (except when young) and it differs in the structure of terga and scuta: the tergum is very wide and has longer spurs and the scutum has no adductor ridge. *Balanus crenatus*, on the other hand, has a shell wall with a single row of uniformly spaced tubes (Newman 2007). *Balanus trigonus* is a lower intertidal species with a southern distribution (to Monterey Bay, California). *Balanus nu-*

bilus, the giant acorn barnacle, reaches 100 mm in diameter, and has a shell aperture that is relatively large and flaring (Newman 2007). *Balanus nubilus*, would be most likely to be confused with *S. cariosus* at subtidal levels. Both species, as juveniles, have strong ribs: *S. cariosus* has the characteristic starry border (Figs. 1, 3), however, that *B. nubilus* lacks. Both species have a tergal plate with a long spur, but that of *S. cariosus* is pointed, while it is truncate in *B. nubilus* (compare Figs. 5, 6 with Figs. 3b, 4a in *B. nubilus,* this guide). The cirri of *S. cariosus* are also conspicuous and almost black.

Ecological Information

Range: Type locality is the Kurile Islands. Known range includes the Bering Sea south to Morro Bay, California (Newman and Abbott 1980) and Japan. (For range map see Newman and Abbott 1980, p 507.)
Local Distribution: Outer rocky coasts and protected sites in Oregon Bays. In Coos Bay, also found on floating docks in the Charleston Marina.
Habitat: Hard surface needed for attachment (i.e. rock, shell, wood). Southern specimens prefer protected spots, including deep crevices and overhanging ledges, in the presence of a strong current (Ricketts and Calvin 1971). Puget Sound individuals live exclusively in oceanic conditions. In Coos Bay *S. cariosus* occurs on floating docks (subtidally) just below the water line, versus *B. glandula* that clusters at the water line (e.g. on floats) (Kozloff 1993). An ecosystem engineer, groups of *S. cariosus* (coupled with *Mytilus trossulus*) create necessary microhabitats for other marine invertebrate species (Harley 2011).
Salinity: Collected at salinities of 30 and prefers full-strength seawater.
Temperature: Occurs in temperate waters, with optimal feeding temperatures from 15 to 20 degrees C (Nishizaki and Carrington 2014).
Tidal Level: From high in splash zone (e.g. OIMB Boat House, Coos Bay) to more protected areas farther up bay. Also occurs in the low intertidal zone and subtidally (e.g. floating docks in Charleston). Upper intertidal limit may be determined by desiccation and by substrate temperature as *S. cariosus* and *B. glandula* individuals showed a negative correlation in abundance with substrate temperature in the mid-intertidal (Salish Sea, Washington, Harley 2011). Predation by sea stars may determine lower vertical limit (Cochran et al. 1968).
Associates: Commonly grows below *B. glandula*, a barnacle that is often found growing on *S. cariosus.* Often grows on and amongst *Mytilus californianus*, with *Littorina scutulata* (outer coast) and with *B. crenatus* and the goose barnacle, *Lepas pectinata pacifica* and with masses of tube worms (e.g. *Eudistylia*). Also co-occurs with the barnacles, *Chthamalus dalli* and *Pollicipes polymerus* (outer coast) (Henry 1942).
Abundance: Most common barnacle of low estuarine zone, where the tall and crowded variety can be as dense as 15,000 individuals per square meter (Ricketts and Calvin 1971). The highest density observed locally, at the OIMB Boat House, Coos Head was 270 individuals per 20 square centimeters (Holden 1968).

Life-History Information

Reproduction: Cirripeds usually brood their eggs and *S. cariosus* broods in the winter with larvae hatching in the spring and summer (Newman and Abbott 1980). In Vladivostok, Russia, spawning occurs once a year in November, larvae hatch in March and settlement occurs from April–May (Koch 1989). Individuals are hermaphroditic and self-fertilization is possible (e.g. in isolated individuals), but not common (MacGinitie and MacGinitie 1949;

Yonge 1963). Eggs and embryos are retained in ovisacs within the mantle cavity and are discharged as nauplii after four months (Høeg et al. 1987; Arnsberg 2001). For detailed reproductive anatomy see Høeg et al. (1987).

Larva: Cirriped broods hatch as nauplius larvae and undergo 4–6 naupliar stages, each larger and more setose than the last (Høeg et al. 1987; Arnsberg 2001; Chan et al. 2014). For naupliar setal formulae and antenna morphology, see Branscomb and Vedder 1982. Larvae molt to the second naupliar stage shortly after hatching (Branscomb and Vedder 1982). The generalized cirriped nauplius has a triangular or shield-shaped carapace with frontolateral horns and a conspicuous naupliar eye (Fig. 1, Arnsberg 2001; Figs. 22.1–22.2, Chan et al. 2014). In *S. cariosus*, the nauplius is large and bulky. Naupliar stages 2–3 have a long dorsal thoracic spine and approximate naupliar sizes are 350 µm (stage II), 350 µm (stage III), 450 µm (stage IV), 550 µm (stage V) and 650 µm (stage VI) (Fig. 14, Arnsberg 2001). The final larval stage in cirripeds is called a cyprid, a non-feeding stage that attaches to a substrate by its antennae, secretes a cement and builds the adult calcareous shell (Ricketts and Calvin 1971). Cyprids are oblong and composed of a bivalve shell, six thoracic appendages, a pair of compound eyes and a conspicuous lipid reserve anteriorly (Fig. 3, Arnsberg 2001; Figs. 22.2–22.3, Chan et al. 2014). Cyprids prefer rough surfaces for settlement (Yonge 1963). Cyprid larvae in *S. cariosus* are found in plankton in the spring and summer. They are large (960–1200 µm) and with smooth carapace, bear no pigment spots (compare to *Balanus crenatus*, this guide), and are angular both anteriorly and posteriorly (Fig. 15, Arnsberg 2001). Cyprids tend to settle into dark crevices from April–June (San Juan Archipelago, Washington, Høeg et al. 1987). Like other marine invertebrate larvae, the cyprid larvae of *S. cariosus* and *B. glandula* become concentrated in convergence zones over internal waves, which provides a mechanism for shoreward transport of larvae prior to settlement (Shanks and Wright 1987).

Juvenile: Usually up to 10 mm, juveniles are star-shaped and with 2–3 prominent ribs on carina, one on carinolateral and three or four on lateral and rostrum. Orifice very small (Henry 1940) and surrounded by numerous fine setae in newly metamorphosed individuals. Young juveniles occurs from May to November (Puget Sound, Washington, Høeg et al. 1987).

Longevity: Longevity ranges from three years in low intertidal (Ricketts and Calvin 1971) to 10–15 years (Newman and Abbott 1980).

Growth Rate: Cirriped body growth occurs in conjunction with molting (Kuris et al. 2007). Shell growth depends on barnacle density (e.g. crowded individuals tend to be tall and columnar).

Food: Filter and suspension feeder, eating plankton and detritus that is strained by cirri.

Predators: Heavily preyed upon by sea stars (e.g *Pisaster*), particularly in its lower range (Cochran 1968). Other predators include the nemertean *Emplectonerna gracile,* birds (e.g. *Larus glaucescens*, *Haematopus bachmani*, *Corvus caurinus*, Wootton 1997), and the whelk, *Nucella freycineti* (Noda 2004). Three snail species, *Thais emarginata*, *Thais canaliculata* and *Thais lamellosa* are also common predators of *B. glandula* and *S. cariosus* (Washington, Connell 1970; Sebens and Lewis 1985). Furthermore, it has been suggested that predation by this genus of drilling gastropods has driven the evolution of balanomorph barnacle plate morphology (Palmer 1982).

Behavior: Barnacles detect changes in light with photoreceptors in simple eyes and in *S.*

cariosus, the medial ocellus contains 6–9 photoreceptors (Millecchia and Gwilliam 1972). Furthermore, cirral beating in *S. cariosus* appears to be photoperiodic, where cirral activity is higher at night than during the day (Takeda et al. 1998).

Bibliography

1. ARNSBERG, A. J. 2001. Arthropoda, Cirripedia: The Barnacles. *In:* An identification guide to the larval marine invertebrates of the Pacific Northwest. A. L. Shanks (ed.). Oregon State University Press.
2. BRANSCOMB, E. S., and K. VEDDER. 1982. A description of the naupliar stages of the barnacles *Balanus glandula* (Darwin), *Balanus cariosus* (Pallas), and *Balanus crenatus* (Bruguiere) (Cirripedia, Thoracica). Crustaceana. 42:83-95.
3. CHAN, B. K. K., J. T. HØEG, and R. KADO. 2014. Thoracica, p. 116-124. *In:* Atlas of crustacean larvae. J. W. Margtin, J. Olesen, and J. T. Høeg (eds.). Johns Hopkins University Press, Baltimore.
4. COCHRAN, T. 1968. Effects of predation upon the intertidal cirriped population. Vol. Summer, Book 1. OIMB (ed.), Charleston, OR.
5. COCHRAN, T., M. PATTERSON, H. HOLDEN, and S. STRASSER. 1968. Factors involved in the distribution of three intertidal species of barnacle, Coast Guard Station, Charleston, Oregon. Vol. Summer Book 1. OIMB (ed.), Charleston, OR.
6. CONNELL, J. H. 1970. A predator-prey system in the marine intertidal region. I. *Balanus glandula* and several predatory species of Thais. Ecological Monographs. 40:49-78.
7. CORNWALL, I. E. 1951. Arthropoda: Cirripedia. *In:* Canadian Pacific Fauna. University of Toronto Press for the Fisheries Research Board of Canada, Toronto.
8. —. 1977. The Barnacles of British Columbia. British Colonial Provincial Museum, Victoria.
9. DENNY, M. W., T. L. DANIEL, and M. A. R. KOEHL. 1985. Mechanical limits to size in wave-swept organisms. Ecological Monographs. 55:69-102.
10. HARLEY, C. D. G. 2011. Climate change, keystone predation, and biodiversity loss. Science. 334:1124-1127.
11. HENRY, D. P. 1940. The Cirripedia of Puget Sound with a key to the species. University of Washington Publications in Oceanography. 4:1-48.
12. —. 1942. Studies on the sessile Cirripedia of the Pacific coast of North America. University of Washington Publications in Oceanography. 4:95-134.
13. HOLDEN, B. 1968. Distributions of three species of barnacles, *Balanus cariosus*, *Balanus glandula* and *Mitella polymerus*. Vol. Summer Book 1. OIMB (ed.), Charleston, OR.
14. HØEG, J. T., P. L. LIIG, R. R. STRATHMANN, and D. S. WETHEY. 1987. Phylum Crustacea, class Maxillopoda, subclass Cirripedia, p. 370-392. *In:* Reproduction and development of marine invertebrates of the northern Pacific coast. M. F. Strathmann (ed.). University of Washington Press, Seattle.
15. KOCH, O. M. 1989. Reproduction of the barnacle *Semibalanus cariosus* in the Sea of Japan. Biologiya Morya:40-48.
16. KOZLOFF, E. N. 1993. Seashore life of the northern Pacific coast: an illustrated guide to northern California, Oregon, Washington, and British Columbia. University of Washington Press, Seattle.
17. KURIS, A. M., P. S. SADEGHIAN, J. T. CARLTON, and E. CAMPOS. 2007. Decapoda, p. 632-656. *In:* The Light and Smith manual: intertidal invertebrates from central California to Oregon. J. T. Carlton (ed.). University of California Press, Berke-

ley, CA.
18. MACGINITIE, G. E., and N. MACGINITIE. 1949. Natural history of marine animals. McGraw-Hill Book Co., New York.
19. MILLECCHIA, R., and G. F. GWILLIAM. 1972. Photoreception in a barnacle: electrophysiology of the shadow reflect pathway in *Balanus cariosus*. Science. 177:438-440.
20. NEWMAN, W. A. 2007. Cirripedia, p. 475 -484. *In:* The Light and Smith manual: intertidal invertebrates from central California to Oregon. J. T. Carlton (ed.). University of California Press, Berkeley.
21. NEWMAN, W. A., D. P. ABBOTT, R. H. MORRIS, and E. C. HADERLIE. 1980. Cirripedia: The Barnacles. *In:* Intertidal invertebrates of California. Stanford University Press, Stanford, California.
22. NEWMAN, W. A., and A. ROSS. 1976. Revision of the balanomorph barnacles including a catalog of the species. San Diego Society of Natural History, San Diego.
23. NISHIZAKI, M. T., and E. CARRINGTON. 2014. Temperature and water flow influence feeding behavior and success in the barnacle *Balanus glandula*. Marine Ecology Progress Series. 507:207-218.
24. NODA, T. 2004. Large-scale variability in recruitment of the barnacle *Semibalanus cariosus*: its cause and effects on the population density and predator. Marine Ecology Progress Series. 278:241-252.
25. PALMER, A. R. 1982. Predation and parallel evolution: recurrent parietal plate reduction in Balanomorph barnacles. Paleobiology. 8:31-44.
26. PEREZ-LOSADA, M., M. HARP, J. T. HOEG, Y. ACHITUV, D. JONES, H. WATANABE, and K. A. CRANDALL. 2008. The tempo and mode of barnacle evolution. Molecular Phylogenetics and Evolution. 46:328-346.
27. PILSBRY, H. A. 1916. The sessile barnacles (Cirripedia) contained in the collections of the U.S. National Museum; including a monograph of the American species. U.S. National Museum Bulletin. 93:1-366.
28. RICKETTS, E. F., and J. CALVIN. 1971. Between Pacific tides. Stanford University Press, Stanford, California.
29. SEBENS, K. P., and J. R. LEWIS. 1985. Rare events and population structure of the barnacle *Semibalanus cariosus* (Pallas, 1788). Journal of Experimental Marine Biology and Ecology. 87:55-65.
30. SHANKS, A. L., and W. G. WRIGHT. 1987. Internal-wave-mediated shoreward transport of cyprids, megalopae, and gammarids and correlated longshore differences in the settling rate of intertidal barnaces. Journal of Experimental Marine Biology and Ecology. 114:1-13.
31. TAKEDA, S., Y. SHIMOKAWA, and O. MURAKAMI. 1998. Daily activity of the barnacle, *Semibalanus cariosus* (Pallas). Crustaceana. 71:299-311.
32. WOOTTON, J. T. 1997. Estimates and tests of per capita interaction strength: diet, abundance, and impact of intertidally foraging birds. Ecological Monographs. 67:45-64.
33. YONGE, C. M. 1963. The Sea shore. Atheneum, New York.

Updated 2015
T.C. Hiebert