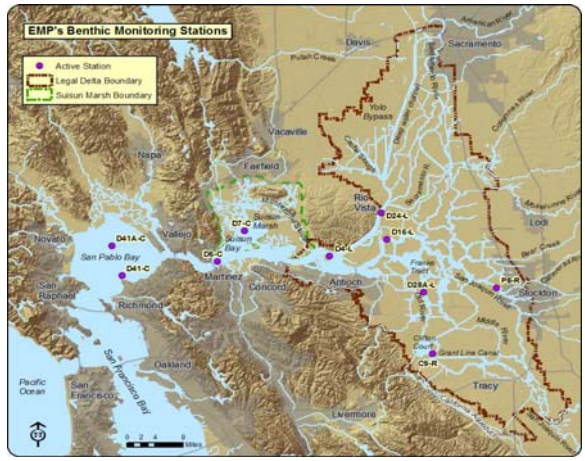
Benthic BioGuide





The Benthic BioGuide is funded by the California Interagency Ecological Program (IEP) for the purpose of providing a comprehensive source for biological, ecological and identification information for common and important benthic invertebrates of the upper San Francisco Estuary (SFE).

The Benthic BioGuide is a living document that is constantly being updated as new information becomes available. The initial idea was hatched by Cindy Messer and a poster paper was produced by Rachel Barnett and Sabrina Bell for the "2007 State of the San Francisco Estuary Conference". During summer and fall of 2011, Wyatt Floerke and Bill Templin, worked on this version of the BioGuide for the first 10 (of 40) most common species. If you have information to contribute, please contact Karen Gehrts.

Species comprising the Benthic BioGuide were selected because of their high abundance in the estuary as collected from the IEP Environmental Monitoring Program (EMP). Information for individual species in the Benthos BioGuide is compiled in a Species Summary Page which includes information on classification, identification, species status in the SFE, environmental requirements, reproduction, food web, occurrence in the upper SFE, and behavior. The species represented are as follows:

	Genus species	***Common Name***
1.	*Corbula amurensis*	*Asian Clam, Chinese Clam, Overbite clam*
2.	*Corbicula fluminea*	*Asian clam, Asiatic Clam*
3.	*Gammarus daiberi*	*Gammarid Amphipod*
4.	*Americorophium spinicorne*	*Gammarid Amphipod*
5.	*Corophium alienense*	*Gammarid Amphipod*
6.	*Monocorophium acherusicum*	*Gammarid Amphipod, slender tube*
7.	*Americorophium stimpsoni*	*Gammarid Amphipod*
8.	*Ampelisca abdita*	*Gammarid Amphipod*
9.	*Varichaetadrilus angustipenis*	*Tubificid Worm*
10.	*Laonome species A*	*Polychaete Worm*

References
Internet Links
Additional Pictures
Glossary

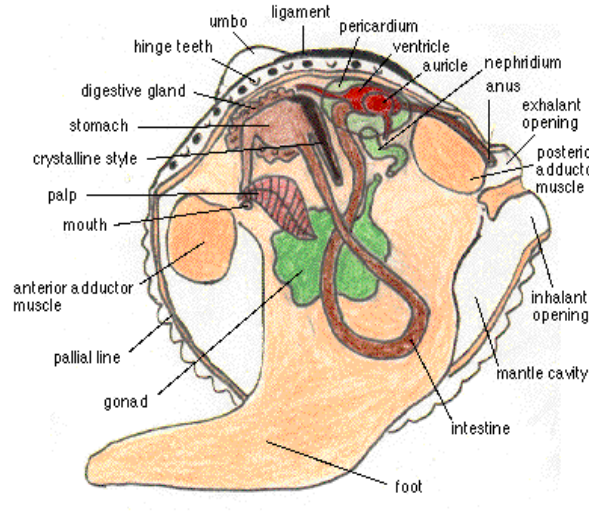
Corbula amurensis
Schrenck, 1861
Asian clam, Chinese clam, Overbite clam

Reference Collection Code: 6890

Photo courtesy of Luis A. Solórzano

Taxonomic Identification

Phylum: Mollusca
Class: Bivalvia
Subclass: Heterondonta
Order: Myoida
Superfamily: Myoidea
Family: Corbulidae
Genus: *Corbula*
Species: *amurensis*



General Clam Illustrated by: © Spineless Productions, Inc.

Life Stages

Egg → trochophore larvae→veliger →spat → adult

Reproduction

Individuals are dioecious. Gametogenesis usually occurs in fall. Fertilized eggs are released into water (16-20°C) and settlement occurs after 30 to 40 days. They may have several reproductive events depending on environmental conditions.

Behavior

They are infaunal burrowers, leaving one third to one half of the shell exposed for feeding purposes. They move vertically to utilize the sediment-water interface.

Food Web

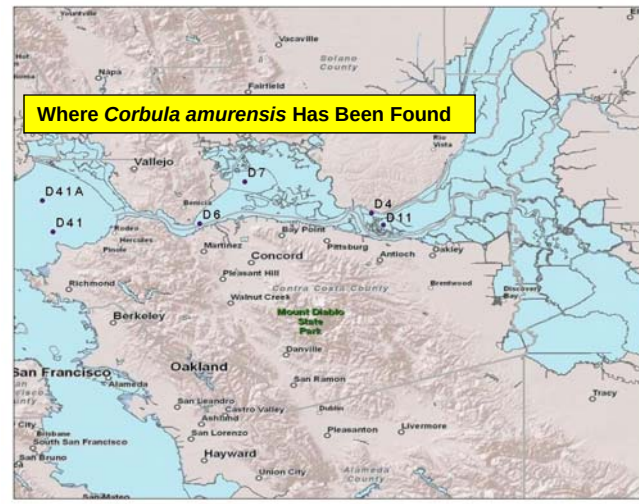
They filter feed on diatoms and nauplii of copepods. Their predators include diving birds (ie scaups and scoters), dungeness crabs and white sturgeon.

Identification

Small clam (maximum size = 27.5mm). The shell is thin and ovate, white, tan or yellow in color. Shell is inequivalve with the left valve being smaller, flat and drawn into the larger more swollen right valve. There is a prominent external keel and umbonal keel on the posterior end of the left valve extending to the ventroposterior margin. Fine striae are present on older specimens. The siphons are brown. The incurrent siphon bears pinnate tentacles, the excurrent siphon has non-pinnate tentacles which bear two long medial filaments. The entire mantle is fringed with papillae. The pallial sinus is very small.

Environmental Requirements in San Francisco Estuary

Their habitat is predominantly subtidal and intertidal mudflats. Their preferred substrate consists of all sediment types, but are most abundantly found in muddy sand bottoms. The salinity levels are best from freshwater (<1ppt) to saline (32.6 ppt). And their ideal temperature range is 8°C to 23°C.



Maps done by Edmund Yu

Species Status in San Francisco Estuary

It was first discovered in the estuary around 1986. It started out native to China, Japan and Korea but was spread to the estuary by ballast water. *Corbula* have caused significant reduction in phytoplankton in the San Francisco Estuary since its introduction.

Corbicula fluminea
Müller, 1774
Asian clam, Asiatic Clam

Reference Collection Code: 6730

Photo courtesy of Noel Burkhead - USGS

Taxonomic Identification

Phylum: Mollusca
Class: Bivalvia
Subclass: Heterodonta
Order: Veneroida
Suborder: Sphaeriacea
Superfamily: Corbiculoidea
Family: Corbiculidae
Genus: Corbicula
Species: fluminea

Life Stages

Larvae → Juvenile → Adult

Reproduction

Individuals are viviparous. Although uncommon, they can be hermaphroditic and are capable of self-fertilization. Sperm are released into the water, caught by another clam, and brooded in the gills. The clams release benthic pediveliger larvae or planktonic veligers that become benthic within 48 hours. There are typically two spawning periods per year between spring and fall.

Behavior

Corbicula clogs water intake pipes, affecting power, water, and other industries. In 1980, the costs of correcting this problem were estimated at 1 billion dollars annually. Juveniles are weak-swimmers, and are pushed to the bottom of the water column where intake pipes are usually placed. They are pulled inside the intakes, where they attach, breed, and die, clogging the pipes.

Food Web

Corbicula is known to filter-feed on bacteria and phytoplankton in the water column and pedal-feed on benthic bacteria. Predators of *Corbicula* include humans, fish, birds, raccoons, crayfish, and flatworms.

Environmental Requirements in San Francisco Estuary

Although *Corbicula* is mainly a freshwater organism, it can be found as far west as Martinez, tolerating saline levels as high as 17 ppt. *Corbicula* has low tolerance of cold temperatures, and requires well-oxygenated waters. It prefers fine, clean sand, clay, and coarse sand substrates.

Species Status in San Francisco Estuary

It was first reported in the Delta in 1945 and widespread by 1948. *Corbicula* is native to China, Korea and the Ussuri Basin in southeastern Siberia and possibly Japan. It is the third most abundant benthic organism in the Delta. Although non-threatening to humans, it alters benthic substrate, competes with native species for resources and is considered an economic pest of water delivery systems.

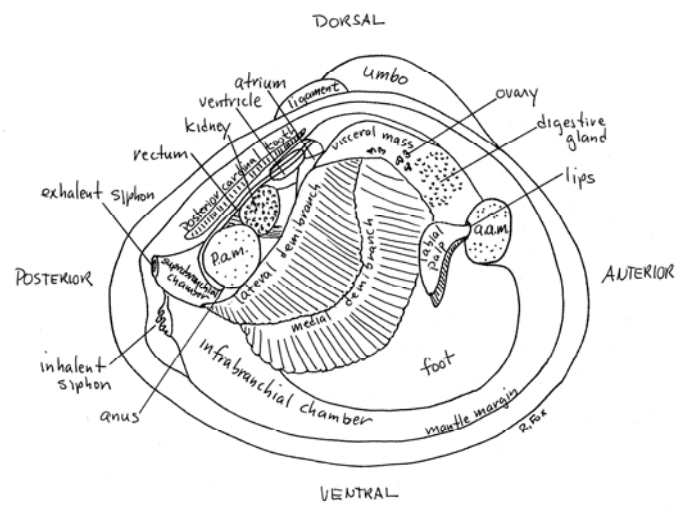
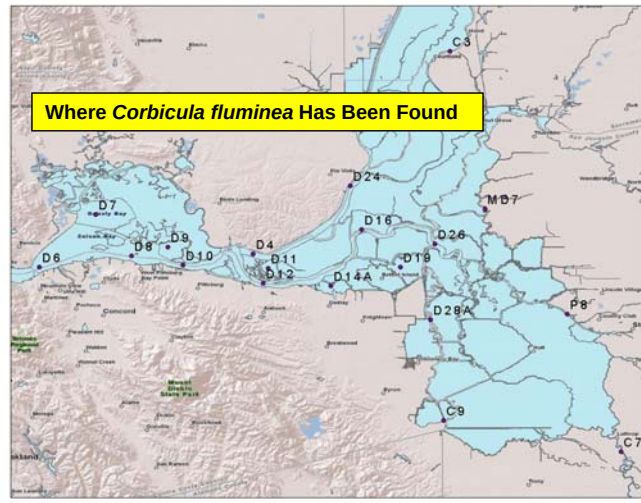


Figure 3. *Corbicula fluminea*. View of right side of undissected clam. Right valve and mantle lobe removed.

Illustration courtesy of Richard Fox

Identification

Corbicula is a freshwater clam that can reach 50 mm in length. The shell is ovate and deep at the hinge. The exterior of the shell is normally a yellow-green to brown in color with thick, concentric rings. The inside of the shell is layered with polished, white to light blue, light purple or deep royal blue nacre. They have three cardinal teeth in each valve with two lateral serrated teeth in each side of the right valve and only one in each side of the left valve.



Maps done by Edmund Yu

Gammarus daiberi
Bousfield, 1969
Gammarid Amphipod

Reference Collection Code: 4750

Photo courtesy of California Academy of Sciences

Taxonomic Identification

Phylum: Arthropoda
Subphylum: Mandibulata
Class: Crustacea
Subclass: Malocostraca
Order: Amphipoda
Family: Gammaridae
Genus: *Gammarus*
Species: *daiberi*

Life Stages

Egg → Larvae → Adult

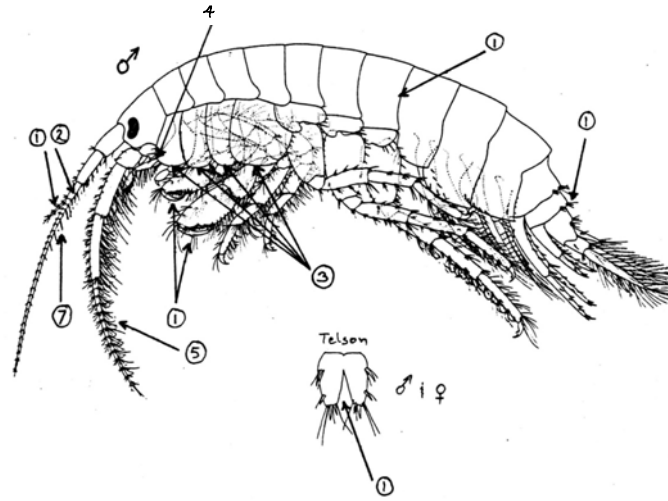


Illustration courtesy of Dot Norris

Reproduction

Gammarus reach sexual maturity in about 30 days. The average clutch size of females increases with size of individual. Their highest reproduction potential occurs in spring and summer months with a short time required for maturation and incubation and continuous reproduction. Reproductive activity remains constant until *G. daiberi* enters into overwintering cycle.

Behavior

There is some debate as to the behavior of *Gammarus.* It is thought to be more pelagic than benthic because anecdotal evidence says that more will be captured with a zooplankton tow (through a boat wake) than with a dredge (WC Fields, PC). R. Stewart contends that they are more benthic than pelagic, as she finds them attached to numerous items such as SCUFA probes and plants (R. Stewart, PC).

Food Web

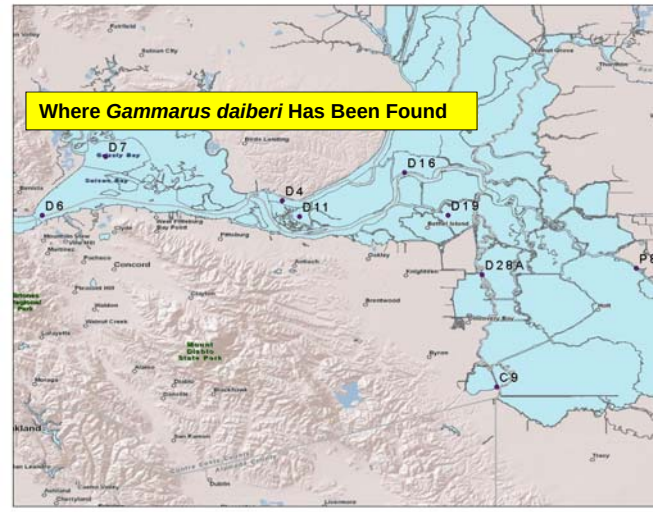
Isotopic analysis of *G. daiberi* indicates that they are phytoplankton eaters. Depending on the availability and quality of food, they have also been known to be scavengers, predators, omnivores and even cannibals. Fish are their main predators.

Identification

The telson of *Gammarus* is cleft and its first antennae accessory flagellum is larger than 4 articles. The urosome has bundles of articulate spines and the pleonites are lacking posterdorsal teeth. Gnathopod 1 is always smaller than gnathopod 2. The third segment of antennae 1's length is less than 3 times the width. On coxal plates 1 to 4, the lower margins have no setae. But coxal plate 1 has 5-8 setae at aterovential angles. For males, antennae 2 has curly setae. The urosome lateral spines are found alone or in clusters of 2. On antennae 1, the basal flagellar segments setae are longer than twice the width of respective segments

Environmental Requirements in San Francisco Estuary

Its preferred habitat is predominantly subtidal and sometimes intertidal mudflats. *Gammarus* is commonly found in substrate of all sediment types, but most abundantly muddy sand bottoms. It works best in salinity of freshwater (<1ppt) to saline (32.6 ppt) and a temperature range of 8°C to 23°C.



Maps done by Edmund Yu

Species Status in San Francisco Estuary

Gammarus was first introduced around 1986 from China, Japan and Korea. Though non threatening to humans, *Gammarus* has caused significant reduction in phytoplankton density in the San Francisco Estuary since its arrived.

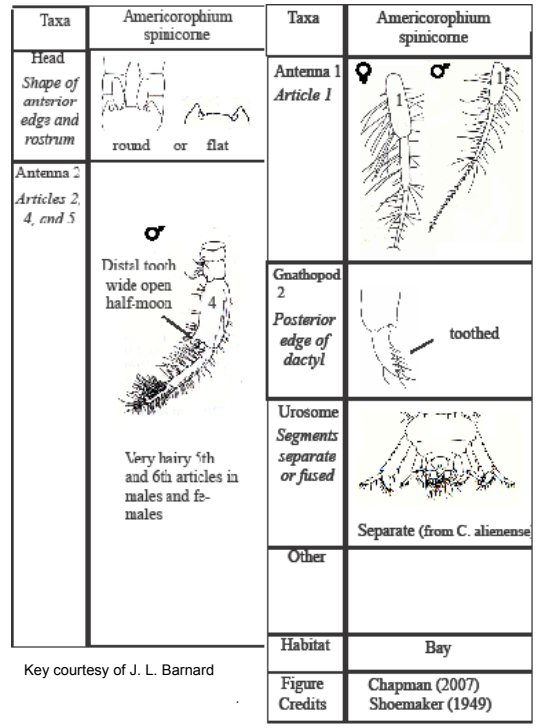
Americorophium spinicorne
Stimpson, 1857
Gammarid Amphipod

Reference Collection Code: 4610

Photo courtesy of California Academy of Sciences

Taxonomic Identification

Phylum: Arthropoda
Subphylum: Mandibulata
Class: Crustacea
Subclass: Malocostraca
Order: Amphipoda
Family: Corophiidae
Genus: *Americorophium*
Species: *spinicorne*



Key courtesy of J. L. Barnard

Life Stages

Egg → Larvae → Adult

Reproduction

Internal fertilization is the general rule in crustacea. Females of *A. spinicorne* protect their eggs and young by brooding them in their marsupium. Typically, one brood is produced in a lifetime.

Behavior

Corophium is an interesting beast, living in the littoral, but belonging to open-water food webs. They burrow when sediment is soft in order to escape predators and find food. They frequently crawl along the bottom as well using their paraeopods and antennae.

Food Web

Isotopic analysis of *A. spinicorne* indicates that they are phytoplankton eaters. Depending on the availability and quality of food, they have also been known to be scavengers, predators, omnivores and even cannibals. Fish are their sole predators.

Identification

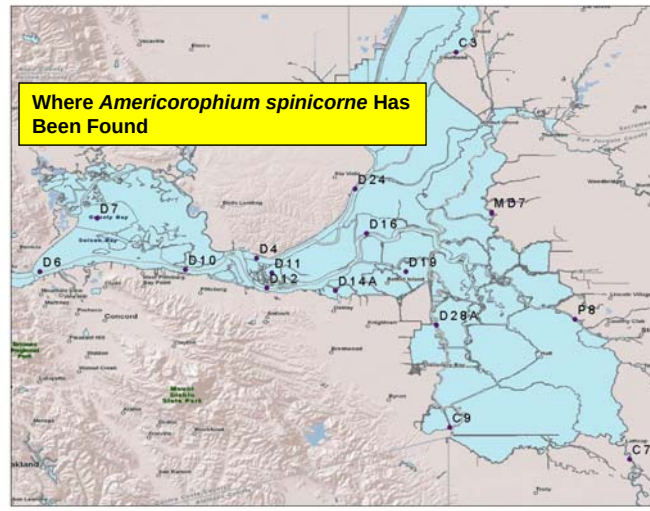
It is the largest species of *Americorophium* on the west coast at 6-10mm. Its complexion is clear with dark brown markings on antennae and thoracic segments. The first antenna reaches to middle of fifth segment of second antenna, while the flagellum is located on joints 14-16 on males and 11 on females. The second antenna is longer than the body on and the fourth joint has a large half moon tooth.

Environmental Requirements in San Francisco Estuary

A. spinicorne was originally found upstream of tidal freshwater in the Snake river watershed in Idaho (Thorp and Covich, 2001). They favor areas of heavy silting, but mainly sand, muddy beaches and log booms. Commonly found in brackish to freshwater of salinities from 0.02ppt-33.6ppt. Their ideal temperature is 10-22.8 C.

Species Status in San Francisco Estuary

A. spinicorne is native to other parts of the US, but transplanted into the San Francisco Estuary.



Maps done by Edmund Yu

Corophium alienense
Chapman, 1988
Gammarid Amphipod

Reference Collection Code: 4550

Photo Courtesy of Rachel August

Taxonomic Identification

Phylum: Arthropoda
Subphylum: Mandibulata
Class: Crustacea
Subclass: Malocostraca
Order: Amphipoda
Family: Corophiidae
Genus: *Corophium*
Species: *alienense*

Life Stages

Egg → Larvae → Adult

Reproduction

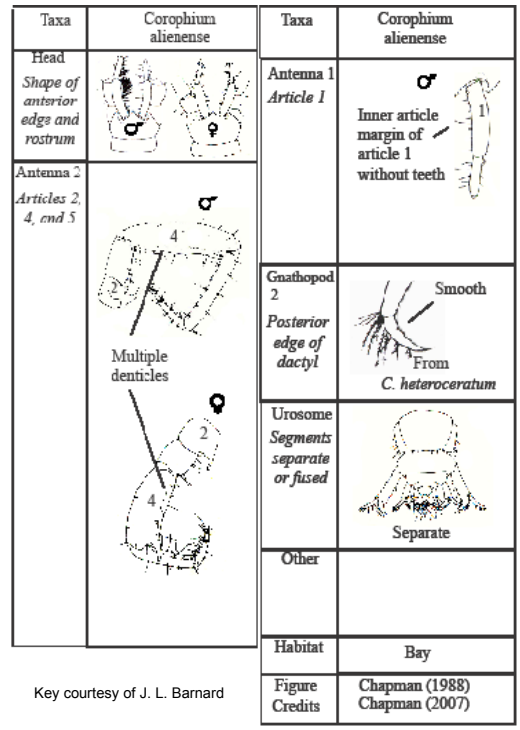
Internal fertilization is the general rule in crustacea. Females of *C. alienense* carry their young in their brooding chamber, or marsupium, until they are developed enough to be released. Typically, one brood is produced in a lifetime.

Behavior

There is very little information on *C. aliensense* but they are presumed to burrow in the muddy substrata and it is also assumed that males guard their mates like most amphipoda.

Food Web

Isotopic analysis of *C. alienense* indicates that they are phytoplankton eaters. Depending on the availability and quality of food, they have also been known to be scavengers, predators, omnivores and even cannibals. Their sole predators are fish.



Key courtesy of J. L. Barnard

Identification

The urosome segments are uncoalesced. The head and rostrum are obvious and the inferior lateral sinus is quite large. Antenna 1 is elongated and usually exceeds antenna 2's peduncular segment 4. Segment 5 of antenna 2 has a weak median tooth and posterodistal process. The gland cone is rather prominent in *C. alienense.*

Environmental Requirements in San Francisco Estuary

Little is actually known about the environmental requirements of *C. alienense.* But based on where they have been found (i.e. Suisun and San Pablo Bays) they prefer a more saline environment and lower temperatures.

Maps done by Edmund Yu

Species Status in San Francisco Estuary

C. alienense is virtually unknown outside of the San Francisco Estuary, but is very similar to another species (*S. triangulopedarum)* from the western North Pacific. Thus this species is most likely native to that area, and was introduced into the San Francisco Estuary.

Monocorophium acherusicum Costa, 1857 Gammarid Amphipod, slender tube amphipod

Reference Collection Code: 4530

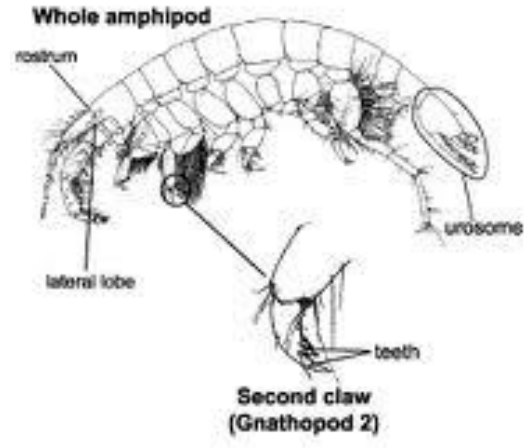
Photo courtesy of Academy of Sciences

Taxonomic Identification

Phylum: Arthropoda
Subphylum: Mandibulata
Class: Crustacea
Subclass: Malocostraca
Order: Amphipoda
Family: Corophiidae
Genus: *Monocorphium*
Species: *acherusicum*

Life Stages

Egg → Larvae → Adult



Picture courtesy of www.marine.csiro.au

Reproduction

Internal fertilization is the general rule in crustacea. Females of *M. acherusicum* carry their young in their brooding chamber, or marsupium, until they are developed enough to be released. Typically, one brood is produced in a lifetime.

Identification

It is known as a dorso-ventrally flattened amphipod and has a rostrum that is fairly short. It's second walking leg is rather hairy and it's second claw has two teeth on the tip. The urosome is composed of three fused segments. Mandibular palp segment 1 has an unproduced distal shelf.

Behavior

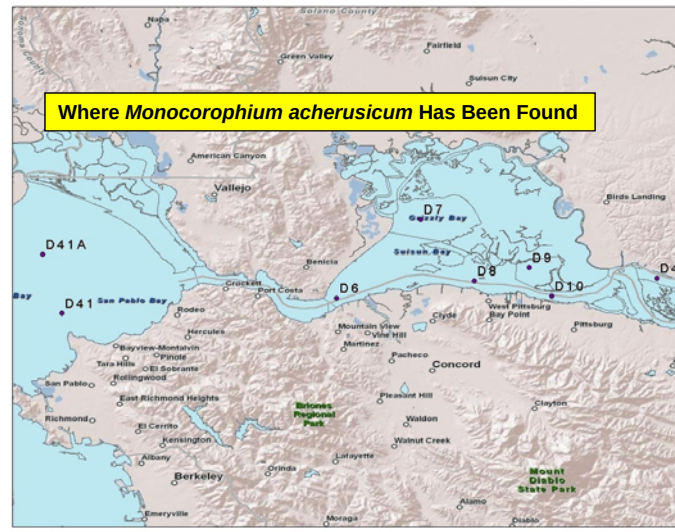
Monocorohium is typically found at an altitude of 0 to 345 meters (0 to 1,132 feet). It burrows when sediment is soft to escape predators and find food. They frequently crawl along the bottom as well by using their paraeopods and antennae.

Food Web

Isotopic analysis of *M. acherusicum* indicates that they are phytoplankton eaters. Depending on the availability and quality of food, they have also been known to be scavengers, predators, omnivores and even cannibals. They are mainly preyed on by fish.

Environmental Requirements in San Francisco Estuary

Little is actually known about the environmental requirements of *Monocorophium.* However, based on where they have been found (i.e. Suisun and San Pablo Bays) they prefer a more saline environment and lower temperatures.



Maps done by Edmund Yu

Species Status in San Francisco Estuary

M. acherusicum was introduced to the estuary from the North Atlantic, but the exact year of the introduction is unknown.

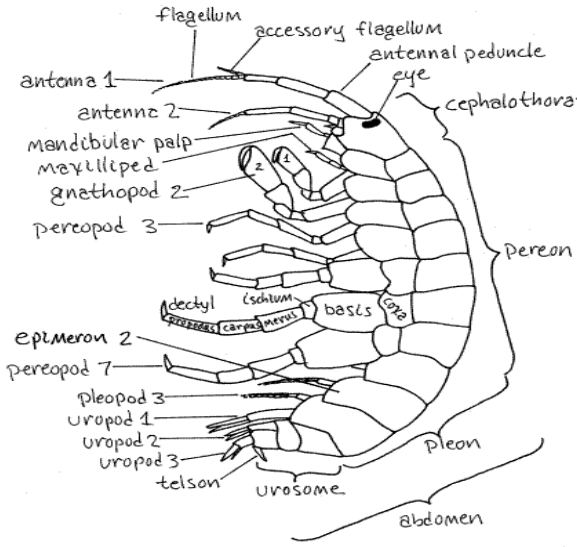
Americorophium stimpsoni
Shoemaker, 1941
Gammarid Amphipod

Reference Collection Code: 4630

Photo courtesy of California Academy of Sciences

Taxonomic Identification

Phylum: Arthropoda
Subphylum: Mandibulata
Class: Crustacea
Subclass: Malocostraca
Order: Amphipoda
Family: Corophiidae
Genus: *Americorophium*
Species: *stimpsoni*



General Amphipod from Holsinger

Life Stages

Egg → Larvae → Adult

Reproduction

Females of *A. stimpsoni* carry their young in their brooding chamber, or marsupium, until they are developed enough to be released. Typically, one brood is produced in a lifetime.

Behavior

Americorophium is an interesting beast, living in the littoral, but belonging to open-water food webs. It's usually inhabits the intertidal zone along the edge of the water, and is most comfortable in a depth of 1-6 meters (3-20 feet). It has been known to burrow when sediment is soft to escape predators and find food. They frequently crawl along the bottom as well using their paraeopods and antennae.

Food Web

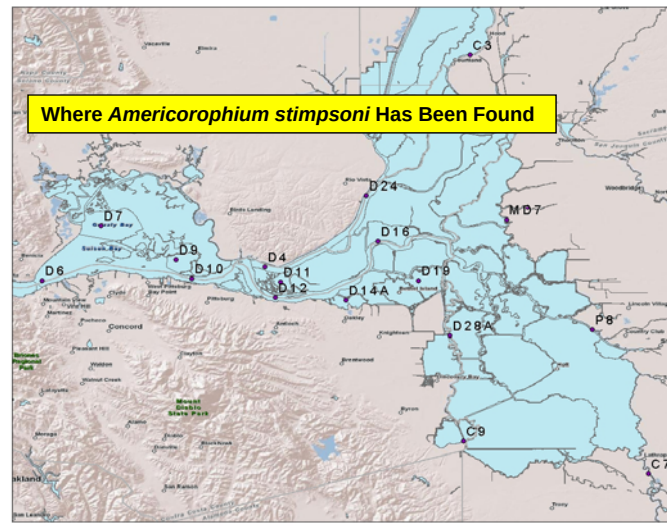
Isotopic analysis of *A. stimpsoni* indicates that they are phytoplankton eaters. Depending on the availability and quality of food, they have also been known to be scavengers, predators, omnivores and even cannibals. Predators include fish and themselves.

Identification

Antenna 2 is powerful and similar in both sexes. The urosome segments are unfused, while the head and rostrum are flat, rounded and weakly produced. The antennal sinus is rather large. The gland cone is short and the mandiublar lobes are quite pronounced.

Environmental Requirements in San Francisco Estuary

Little is actually known about the environmental requirements of *A. stimpsoni.* But based on their preferred habitat deeper in the delta, they favor a more fresh water environment and warmer temperatures.



Maps done by Edmund Yu

Species Status in San Francisco Estuary

A. stimpsoni was introduced to the estuary. It was first collected by EMP in 1981.

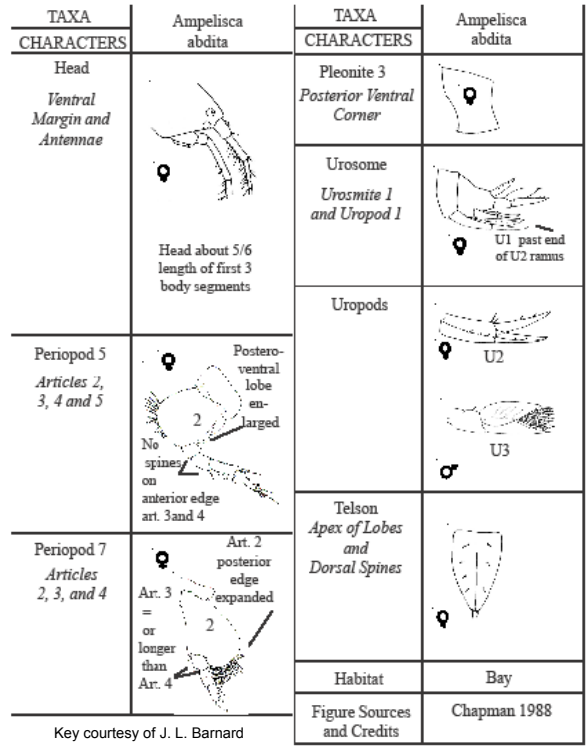
Ampelisca abdita
Mills 1964
Gammarid Amphipod

Reference Collection Code: 4510

Photo courtesy of California Academy of Sciences

Taxonomic Identification

Phylum: Arthropoda
Subphylum: Mandibulata
Class: Crustacea
Subclass: Malocostraca
Order: Amphipoda
Family: Ampeliscidae
Genus: *Ampelisca*
Species: *abdita*



Key courtesy of J. L. Barnard

Life Stages

Egg → Larvae → Adult

Reproduction

Internal fertilization is the general rule in crustacea. Females of *A. abdita* carry their young in their brooding chamber, or marsupium, until they are developed enough to be released. Typically, one brood is produced in a lifetime.

Behavior

This amphipod has been known to construct membranous tubes out of sediment across the substrate, usually 3 to 4 cm long. They feed from the openings of these tubes, only leaving to mate.

Food Web

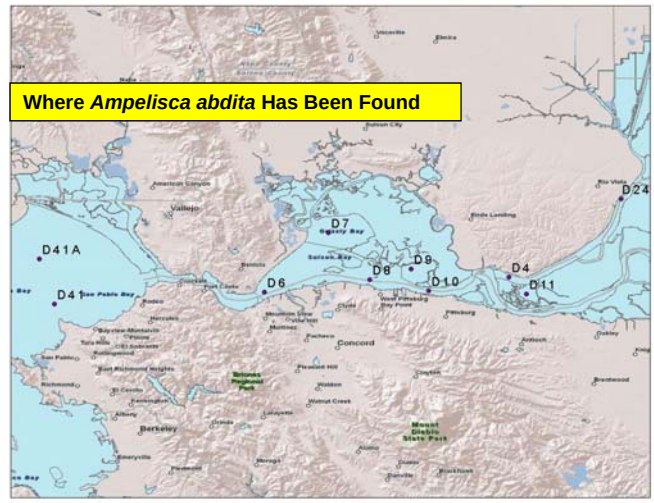
Isotopic analysis of *A. abdita* indicates that they are phytoplankton eaters. Depending on the availability and quality of food, they have also been known to be scavengers, predators, omnivores and even cannibals. Their predators include bottom feeding fish, such as flounder or catfish.

Identification

A. abdita carries a distinct pink coloration. The eyes are much smaller than other gammarids and are bright red. They lack gnathopods completely. Pereopod 5 article 2 has an enlarged posterioventral lobe and pereopod 7 article 2 has an expanded posterior edge.

Environmental Requirements in San Francisco Estuary

A. abdita prefers to live in a substrate consisting of subtidal muds or silty sands. It works best in more marine waters, but can tolerate low levels of salinity as well. It can survive a temperature range 0°C to 25°C.



Maps done by Edmund Yu

Species Status in San Francisco Estuary

A. abdita was accidentally introduced to the estuary when seed oysters were first imported from the east coast, although the exact year is unknown.

Varichaetadrilus angustipenis Brinkhurst and Cook 1966 Tubificid Worm

Reference Collection Code: 2730

Photo courtesy of Caily Nelson

Taxonomic Identification

Phylum: Annelida
Class: Oligochaeta
Order: Tubificida
Family: Tubificidae
Genus: *Varichaetadrilus*
Species: *angustipenis*

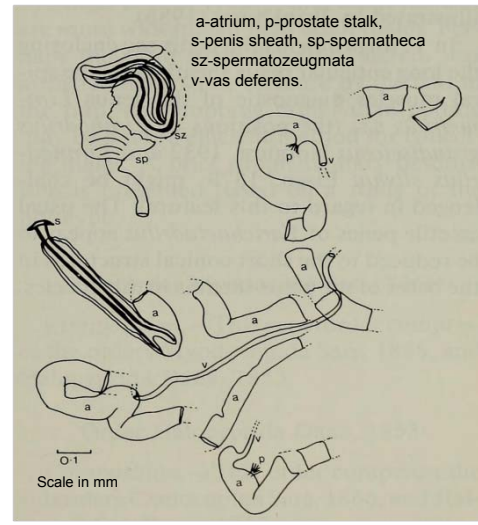


Diagram courtesy of Brinkhurst

Life Stages

Egg → Juvenile → Adult

Reproduction

V. angustipenis is hermaphroditic and cross-fertilization occurs. The sperm is passed from partner into the spermathecae. They have two types of sperm which form a mix called spermatozeugmata. The clitellum secretes a cocoon carrying the unfertilized eggs, which the sperm enter and fertilize. Eventually, the worm releases the cocoon and young emerge. There is no larval stage for the progeny.

Behavior

Food Web

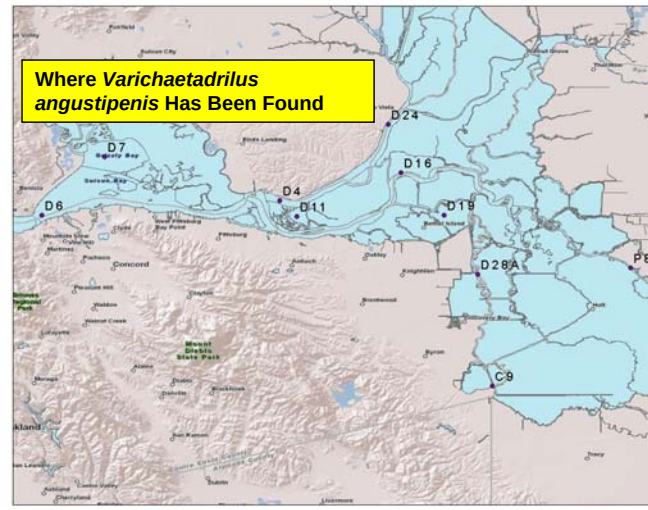
Tubificids subsist on heterotrophic bacteria and have selective ingestion and digestion. They are constantly ingesting sediment which is rich in nutrients and bacteria, and often their own feces. They are commonly preyed on by various species of fish, crabs, and birds.

Identification

Tubes of most tubificids are probably temporary. The first 10-12 segments of body are wider than the rest. There is a small, protruding appendage known as a cuticular penis sheath. The setae are long-hair like bristles that start on segment II and continue down the length of the body. All of the reproductive organs are sited on segments X and XI. Their red blood cells assist in the uptake of oxygen through their posterior body wall. Fragmented male ducts and spermatheca of *V. angustipenis* drawn with the aid of a drawing tube from a paratype in the author's collection.

Environmental Requirements in San Francisco Estuary

Little is actually known about the environmental requirements of *V. angustipenis.* But based on their preferred habitat in the more eastern part of the delta, they favor a more fresh water environment and warmer temperatures.



Maps done by Edmund Yu

Species Status in San Francisco Estuary

It's not known whether or not *Varichaetadrilus* is native or introduced, but Wayne C. Fields is working on a paper with M. Wetzel to clarify.

Laonome species A
Polychaete Worm

Photo courtesy of Naoaki Ikemiyagi

Reference Collection Code: 3450

Taxonomic Identification

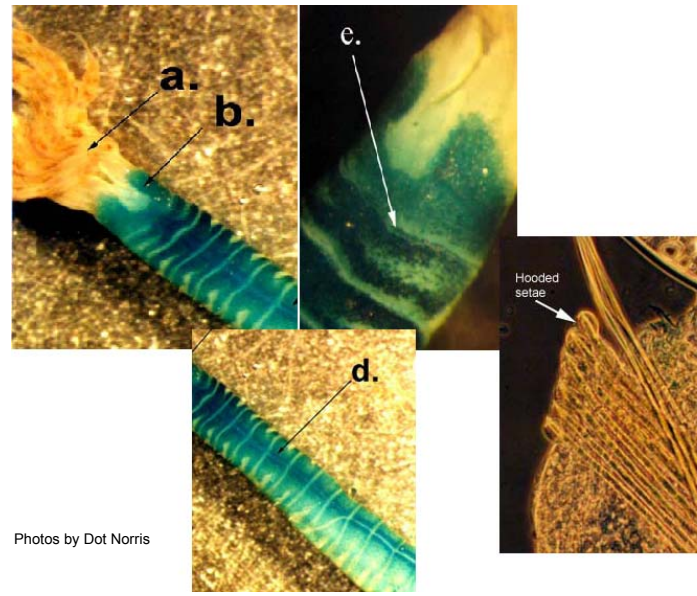
Phylum: Annelida
Class: Polychaeta
Order: Sabellida
Family: Sabellidae
Genus: *Laonome*
Species: *species A*

Life Stages

Egg → Juvenile → Adult

Reproduction

This organism is a spawn with sedentary larvae.



Photos by Dot Norris

Behavior

Laonome is a tube-dweller that commonly projects its feathery tentacles, or cirri, to obtain food and oxygen.

Food Web

Studies of sabellidae show that virtually all are capable of suspension feeding. Their diet consists mainly of uni-cellular algae, dinoflagellates, and small larval invertebrates.

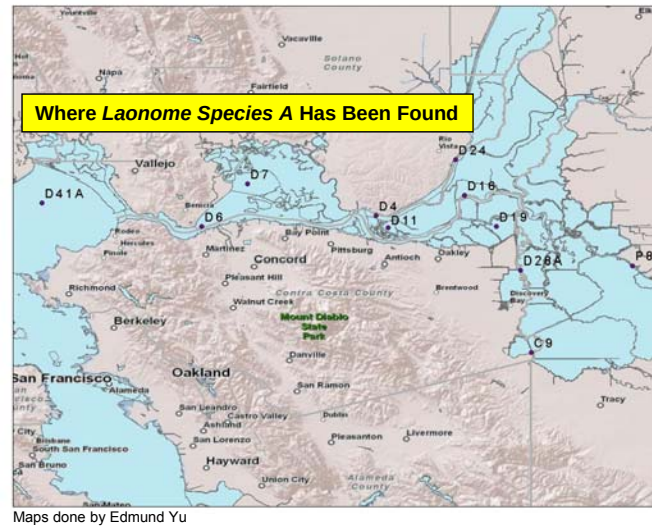
Identification

The crown has about 6 radioles, free to base with pigment and no eyes (a). The collar lacks setae with two long ventral lobes (b.) and two small dorsal lobes with shallow incisions. The inferior neurosetae is broadly hooded with small mucron. The methyl green staining of ventrum is nearly solid except at the margins of the collar and around the setae. It also reveals a non-staining, thin, longitudinal line going through setiger 4 and intersecting the anal groove on setiger 8 (d). The dorsal staining is speckled while a ring of non-staining glandular tissue is located between the collar and the first setiger (e).

Environmental Requirements in San Francisco Estuary

Laonome has a wide ranger of environmental tolerances. The EMP has collected this species throughout the delta (i.e. South Bay and San Pablo Bay).

Species Status in San Francisco Estuary



Maps done by Edmund Yu

References

Arthropoda-

Barnard, J. L. (1954). Amphipoda of the family Ampeliscidae collected in the eastern Pacific Ocean by the Velero III and Velero IV, Allan Hancock Pacific Expeditions 18: 1-137.

Blake, J. A. (1996). Family Spionidae Grube, 1850: including a review of the genera and species from California and a revision of the genus Polydora Bose, 1802. Taxonomic Atlas of the Benthic Fauna of the Santa Maria Basin and Western Santa Barbara Channel. Santa Barbara, CA, Santa Barbara Museum of Natural History. 6: 418.

Bousfield, E.L. and P.M. Hoover. (1997). The amphipod superfamily Corophioidea on
the Pacific Coast of North America, Part V. Family Corophiinae, new subfamily. Systematics and distributional ecology. Amphipacifica 2(3): 67-139.

Carlton, J. T. (1979). Introduced invertebrates of San Francisco Bay, pp.427-444 in: T. J. Conomos, Ed., San Francisco Bay: The Urbanized Estuary.
Pacific Division, AAAS, San Francisco.

Chapman, J. W. and J. A. Dorman (1975). "Diagnosis, systematics and notes on Grandidierella japonica (Amphipoda: Gammaridea) and its introduction to the Pacific coast of the United States." Bulletin of the Southern California Academy of Sciences 74(3): 104-108.

Chapman, J. W. (1988). Invasions of the Northeast Pacific by Asian and Atlantic Gammaridean amphipod crustaceans, including a new species of Corophium. J. Crust. Biol. 8(3): 364-382.

Chapman, J.W. and J.T. Carlton. (1991). A test of criteria for introduced species: the global invasion by the isopod Synidotea laevidorsalis (Miers, 1881). J. Crust. Biol.11(3): 386-400.

Coffman, W. P. and L. C. Ferrington, Jr. (1996). Chironomidae. An Introduction to the Aquatic insects of North America. R. W. Merritt and K. W. Cummins. Dubuque, Iowa, Kendall/Hunt Publishing Company: 635-754.

Cohen, A. N. and J. T. Carlton (1995). Nonindigenous Aquatic Species in a United States Estuary: A case study of the biological invasions of the San Francisco Bay and Delta. Washington D. C., United States Fish and Wildlife Service.

Dixon, I. M. T. and P. G. Moore (1997). A comparative study on the tubes and feeding behavior of eight species of corophioid Amphipoda and their bearing on phylogenetic relationships within the Corophioidea. Philosophical Transactions of the Royal Society
of London 352(1349): 93-112.

Mills, E. L. (1967). "The biology of an ampeliscid amphipod crustacean sibling species pair." Journal Fisheries Research Board of Canada 24(2): 305-355.
Ruppert, E. E. and R. D. Barnes (1994). Invertebrate Zoology. 6th Edition. New York, Saunders College Publishing.

Sieg, J. and R.N. Winn. (1981). The Tanaidae (Crustacea: Tanaidacea) of California, with a key to world genera. Proc. Biol. Soc. Wash. 94(2): 315-343.
Smith, R. I. and J. T. Carlton. (1975). Light's Manual: Intertidal Invertebrates of the Central California Coast, 3rd Ed. UC Press, Berkeley. 716 p.

Thorp, J.H., and A.P. Covich (2010) Ecology and Classification of North American Freshwater Invertebrates. San Francisco, Academic Press, Aquatic Ecology Series, Third Edition. 1021 p.

Watling, L. 1991. Revision of the cumacean family Leuconidae. J. Crust. Biol. 11(4):569-582.

Mollusks-

Burch, J. B. (1975). Freshwater Sphaericean Clams (Mollusca: Pelecypoda) of North America. Malacological Publications, Hamburg, MI. 96 p.

Carlton, J.T., J.K. Thompson, L.E. Schemel, and F.H. Nichols (1990) "Remarkable invasion of San Francisco Bay (California, USA) by the Asian clam Potamocorbula amurensis. I. Introduction and dispersal" Marine Ecology Progress Series, 66: 81-94

Coan, E.V. (2002). The Eastern Pacific recent species of the Corbulidae (Bivalvia). Malacologia 44(1): 47-105

Cohen, A. N. and J. T. Carlton (1995). Nonindigenous Aquatic Species in a United States Estuary: A case study of the biological invasions of the San Francisco Bay and Delta. Washington D. C., United States Fish and Wildlife Service.

Eng, L. L. (1977). Population dynamics of the asiatic clam, Corbicula fluminea (Muller), in the concrete-lined Delta-Mendota Canal of central California. Proc. 1st Int. Corbicula Symp., Texas Christian Univ., Ft. Worth, Texas, Oct 13-15. pp.39-68.

McMahon, R. F. (1999). Invasive Characteristics of the Freshwater Bivalve Corbicula fluminea. Nonindigenous Freshwater Organisms: vectors, biology, and impacts. R. Claudi and J. H. Leach. Boca Raton, Fl., Lewis Publishers: 315-343.

Nichols, F.H., J.K. Thompson, and L.E. Schemel (1990) "Remarkable invasion of San Francisco Bay (California, USA) by the Asian clam Potamocorbula amurensis. II. Displacement of a former community" Marine Ecology Progress Series 66: 95-101.
Nichols, F.H., and J.K. Thompson, (1985) "Time scales of change in the San Francisco benthos" Hydrobiologia 129(1): p. 121-138.

Nicolini, M. H. and D. L. Penry (2000). Spawning, fertilization, and larval development of Potamocorbula amurensis (Mollusca: Bivalvia) from San Francisco Bay, California. Pacific Science 54(4): 377-388.

Penry, D. L. (2000). Digestive kinematics of suspension-feeding bivalves: modeling and measuring particle processing in the gut of Potamocorbula amurensis. Marine Ecology Progress Series 197: 181-192.

Rosenblum, S. E. and T. M. Niesen (1985). "The spawning cycle of soft-shell clam, Mya arenaria, in San Francisco Bay." Fishery Bulletin 83(3): 403-412.
Ruppert, E. E. and R. D. Barnes (1994). Invertebrate Zoology. 6th Edition. New York, Saunders College Publishing.

Smith, R. I. and J. T. Carlton. (1975). Light's Manual: Intertidal Invertebrates of the Central California Coast, 3rd Ed. UC Press, Berkeley. 716 p.

Thompson, J.K. (2005) "One Estuary, One Invasion, Two Responses: Phytoplankton and Benthic Community Dynamics Determine the Effect of an Estuarine Invasive Suspension-Feeder" p.291-316, In: Dame, F.F., and S. Olenin (Eds.) (1990) "The Comparative Roles of Suspension-Feeders in Ecosystems" Proceedings of the NATO Advanced Research Workshop on The Comparative Roles of Suspension-Feeders in Ecosystems, Nida, Lithuania, October 4-9, 2003. NATO Science Series: IV: Earth and Environmental Services Volume 47, 2005, DOI: 10.1007/ 1-4020-3030-4

Thorp, J.H., and A.P. Covich (2010) Ecology and Classification of North American Freshwater Invertebrates. San Francisco, Academic Press, Aquatic Ecology Series, Third Edition. 1021 p.

Vincent, B., G. Desrosiers, et al. (1988). "Orientation of the infaunal bivalve Mya arenaria L. in relation to local current direction on a tidal flat." Journal of Experimental Marine Biology and Ecology 124: 205-214.

Worms-

Blake, J. A. (1996). Family Spionidae Grube, 1850: including a review of the genera and species from California and a revision of the genus Polydora Bose, 1802. Taxonomic Atlas of the Benthic Fauna of the Santa Maria Basin and Western Santa Barbara Channel. Santa Barbara, CA, Santa Barbara Museum of Natural History. 6: 418.

Block, E. M., G. Moreno, et al. (1982). "Observations on the life history of Limnodrilus hoffmeisteri (Annelida Tubificidae) from the Little Calumet River in temperate North America." International Journal of Invertebrate Reproduction 4: 239-247.

Brinkhurst, R. O. (1986). Guide to the freshwater aquatic microdrile oligochaetes of North America. Can. Spec. Pub. Fish. Aquat. Sci. 84: 259 pp.

Brinkhurst, R. O. (1986). Taxonomy of the genusTubificoides Lastockin (Oligochaeta:Tubificidae): species with bifid setae. Can. J. Zool. 64: 1270-1279.

Castellato, S. (1984). "Life-cycle and karyology of Branchiura sowerbyi Beddard (Oligochaeta, Tubificidae)." Hydrobiologia 115: 65-69.

Cohen, A. N. and J. T. Carlton (1995). Nonindigenous Aquatic Species in a United States Estuary: A case study of the biological invasions of the San Francisco Bay and Delta. Washington D. C., United States Fish and Wildlife Service.

Dauer, D. M. (1997). "Functional morphology and feeding behavior of Marenzelleria viridis (Polychaeta: Spionidae)." Bulletin of Marine Science 60(2): 512-516.

Fauchald, K. and P. A. Jumars, Eds. (1979). The diet of worms: a study of polychaete feeding guilds. Oceanography and Marine Biology Annual Review, Aberdeen University Press.

Learner, M. A., G. Lochhead, et al. (1978). "A review of the biology of British Naididae (Oligochaeta) with emphasis on the lotic environment." Freshwater Biology 8: 357-375.39.

Leppakoski, E. and S. Olenin (2000). "Non-native species and rates of spread: lessons from the brackish Baltic Sea." Biological Invasions 2: 151-163

Levin, L. A. (1982). "Interference interactions among tube-dwelling polychaetes in a dense infaunal assemblage." Journal of Experimental Marine Biology and Ecology 65: 107-119.

Light, W. J. (1978). Spionidae (Polychaeta: Annelida). Invertebrates of the San Francisco Bay Estuary System, W.L. Lee, Ed. Boxwood Press, Pacific Grove, CA 93950. 211 p.

Pennak, R. W. (1978). Freshwater Invertebrates of the United States, 2nd Ed. John Wiley & Sons, New York. 803 p

Rouse, G. W. and K. Fitzhugh (1994). "Broadcasting fables: Is external fertilization really primitive? Sex, size, and larvae in sabellid polychaetes." Zoologica Scripta 23(4): 271-312.

Rouse, G. W. and F. Pleijel (2001). Polychaetes. Oxford, Oxford University Press

Rudy, P. Jr., and L. H. Rudy. (1983) Oregon Estuarine Invertebrates. FWS/OBS LC 83-600-712. U.S. Fish and Wildlife Service. 225 p.

Ruppert, E. E. and R. D. Barnes (1994). Invertebrate Zoology. 6th Edition. New York, Saunders College Publishing.

Shaffer, P. L. (1983). "Population ecology of Heteromastus filiformis (Polychaeta: Capitellidae). Netherlands Journal of Sea Research 17(1): 106-125.

Smith, R. I. and J. T. Carlton. (1975). Light's Manual: Intertidal Invertebrates of the Central California Coast, 3rd Ed. UC Press, Berkeley. 716 p.

Thorp, J.H., and A.P. Covich (2010) Ecology and Classification of North American Freshwater Invertebrates. San Francisco, Academic Press, Aquatic Ecology Series, Third Edition. 1021 p.

Internet Links

Corbula amurensis:
http://www.exoticsguide.org/species_pages/c_amurensis.html
http://toxics.usgs.gov/highlights/invasives/
http://nas.er.usgs.gov/queries/SpecimenViewer.aspx?SpecimenID=52545

Corbicula fluminea:
http://nas.er.usgs.gov/queries/factsheet.aspx?speciesid=92
http://www.issg.org/database/species/ecology.asp?fr=1&si=537
http://webs.lander.edu/rsfox/invertebrates/corbicula.html

Gammarus daiberi:
http://nas.er.usgs.gov/queries/factsheet.aspx?SpeciesID=25
http://www.eol.org/pages/1023113
http://www.itis.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=93779

Americorophium spinicorne:
http://www.eol.org/pages/345022
http://www.itis.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=656746

Corophium alienense:
http://nas.er.usgs.gov/queries/factsheet.aspx?speciesid=15
http://animaldiversity.ummz.umich.edu/site/accounts/classification/Corophium_alienense.html

Monocorophium acherusicum:
http://www.eol.org/pages/318058
http://www.itis.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=656756

Americorophium stimpsoni:
http://www.eol.org/pages/1024518
http://www.slosea.org/initiatives/is/invertdata.php?viewline=5

Ampelisca abdita:
http://nas.er.usgs.gov/queries/factsheet.aspx?SpeciesID=9
http://www.marinespecies.org/aphia.php?p=taxdetails&id=158020

Varichaetadrilus angustipenis:
N/A

Laonome Species A:
N/A

Additional Pictures

Corbula amurensis:
http://www.science.calwater.ca.gov/stage/images/clam_03_lg.jpg

Corbicula fluminea:
http://www.jaxshells.org/821aa.jpg
http://news.bbc.co.uk/olmedia/1865000/images/_1867191_asianclam300.jpg

Gammarus daiberi:
http://images.marinespecies.org/thumbs/29961_gammarus.jpg

Americorophium spinicorne
http://nas.er.usgs.gov/XIMAGESERVERX/2009/20090317163300.jpg
http://bcbiodiversity.lifedesks.org/pages/19610

Corophium alienense:
N/A

Monocorophium acherusicum:
http://bcbiodiversity.lifedesks.org/pages/19612

Americorophium stimpsoni:
N/A

Ampelisca abdita:
N/A

Varichaetadrilus angustipenis:
N/A

Laonome Species A:
N/A

Glossary

Concentric: Having a common center

Diatoms: microscopic unicellular marine or freshwater colonial alga having cell walls impregnated with silica

Dioecious: Characterized by species in which the male and female reproductive organs occur on different individuals; sexually distinct

Equivalve: Having the valves equal in size and from, as in most bivalve shells.

Gametogenesis: The formation or production of gametes

Gnathopod: A modified appendage to assist in feeding

Hermaphroditic: having both male female reproductive organs

Infauna: Aquatic animals that live in the substrate of a body of water, especially in a soft sea bottom.

Marsupium: A temporary egg pouch in various fishes and crustaceans

Nacre: the technical name for mother-of-pearl

Nauplii: The free-swimming first stage of the larva of certain crustaceans, having an unsegmented body with three pairs of appendages and a single median eye.

Ovate: Shaped like an egg; oval

Papillae: A small part projecting from the surface of an organism

Pediveliger: The third and final free swimming stage of a mollusk, prior to settlement or attachment to a substrate

Peduncular: A stalk-like bundle of nerve fibers connecting different parts of the brain

Pinnate: Like a feather in appearance

Rami: upward portions on both sides of the mandible

Striae: A narrow band of color or a ridge, groove, or similar linear mark, usually occurring in a parallel series

Telson: The rearmost segment of the body of certain arthropods.

Umbonal: A knoblike protuberance arising from a surface, as the prominence near the hinge of a bivalve shell or the projection at the scale tip of a seed-bearing cone.

Veliger: A larval stage of a mollusk characterized by the presence of a velum

Viviparous: Giving birth to living offspring that develop within the mother's body