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at The Salton Sea Symposium, January 13-14, 2000,
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sponsored by the Salton Sea Authority.

Invertebrates of the Salton Sea: A Scanning Electron Microscopy Portfolio

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ABSTRACT

The last detailed examination of the biota of the Salton Sea was carried out in the 1950s.A biotic inventory is currently being conducted by researchers at SDSU and other universities. We are attempting to document all invertebrates in the Salton Sea with scanning electron microscopy (SEM) and light microscopy (LM). General morphology and ultrastructure of representatives of 11 major taxonomic groups of invertebrates are demonstrated in this portfolio of images and brief descriptions. Forms illustrated include different stages of their development of both planktonic and benthic organisms.

Planktonic Invertebrates

1. Larvae of barnacle, *Balanus amphitrite saltonensis.* Found in greatest abundance in near shore waters in January through April. Adult forms live attached to hard substrates. Extensive deposits of barnacle shell form major structural habitats for other invertebrates in the Sea.

2. Larvae of pile worm, *Neanthes succinea.* Most abundance in March, scarce in summer, increase starting in November. Prey for fish and birds feeding in water column.

3. Rotifer, *Brachionus rotundiformis.* Most numerous organism in the summer zooplankton. Play an important role in nutrient cycling. Prey for copepods and fish.

4. Cyclopoid copepod, *Apocyclops dengizicus.* Dominates summer zooplankton. Food for small fish. Feeds on algae, protozoans and rotifers.

Benthic Invertebrates

5. Adult pile worm. Major item in diet of several fish and eared grebes. Most abundant in winter on mud at a depth of 5-8 m. Estimated biomass is 13.2 million kg for the entire sea in late fall.

6. Polychaete worm, *Streblospio benedicti.* First found in the Salton Sea in January 1999.

7. Amphipod, *Gammarus mucronatus.* Lives in algal mats, among living barnacles, in the barnacle sand along the shoreline and within soft sediments. Food item of eared grebes and other bird species that feed in shallow water.

8. Amphipod, *Corophium sp.* Lives in small tubes on submerged rocks.

9. Harpacticoid copepod, *Cletocampus deitersi.* Abundant among algae and detritis debris on rocks and also present in the mud.

10. Ostracod, *Cyprideis beaconensis.* Lives in algal mats and in the sediments. Swim up into the water column between aquatic plants.

11. Flatworm (Turbellaria), an unidentified species lives in the sediments.

12. Round worms (Nematoda). Several species have been found in sediments.

Other Important Invertebrates and Figures

13. *Ephydra sp. (* Ephydridae, Diptera).

14. *Trichocorixa reticulata* (Corixidae, Hemiptera)

15. Barnacle and Polychaete Larvae Abundances 1997-1998

16. Brachionus and Copepod Abundances 1997-1998

Planktonic Organisms

Benthic Organisms

Other Important Invertebrates

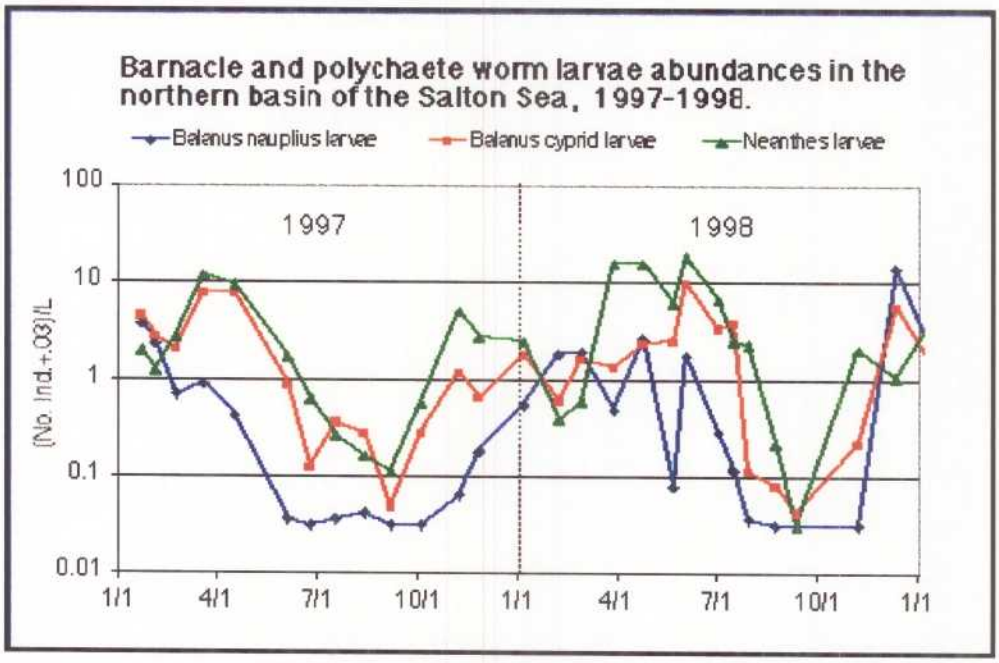

Fig. 15. Barnacle and Polychaete Larvae Abundances 1997-1998

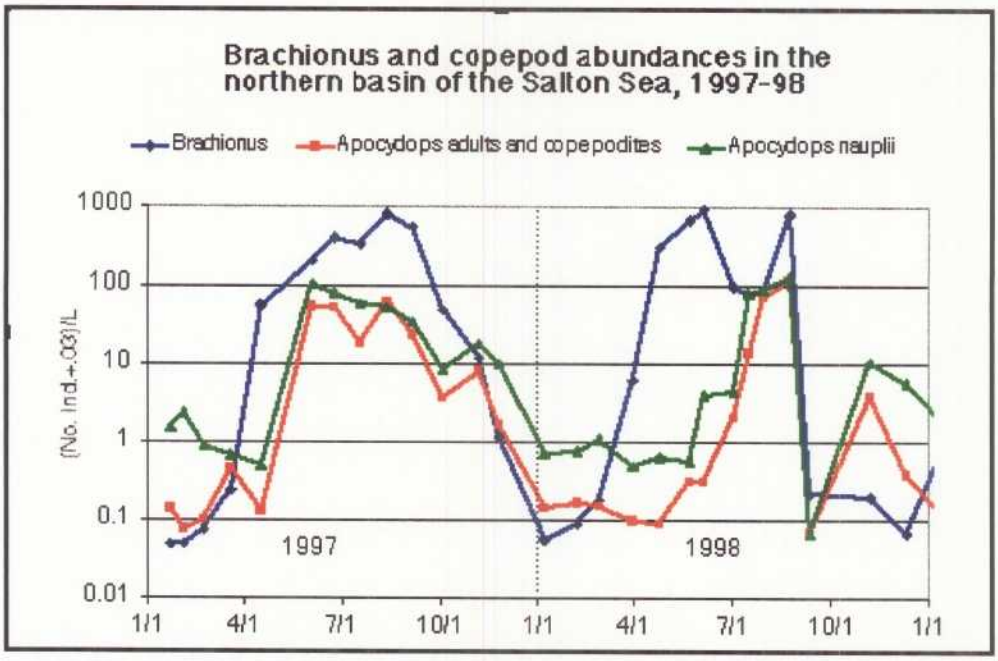

Fig. 16. Brachionus and Copepod Abundances 1997-1998

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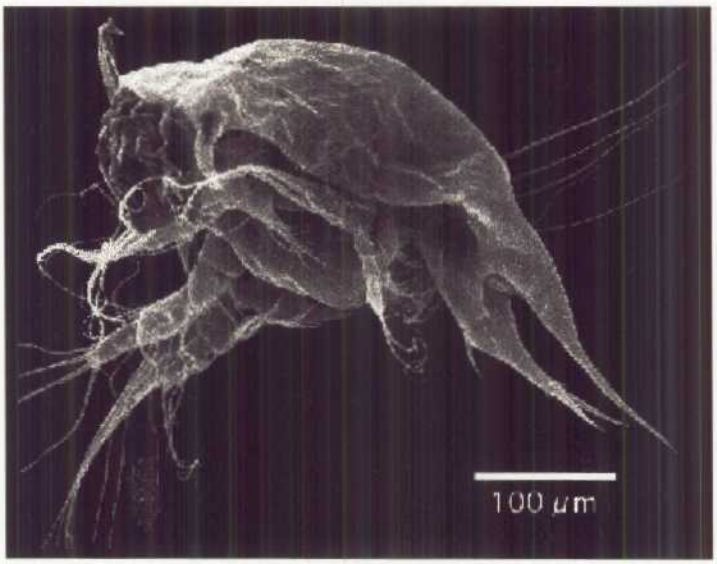
Planktonic Invertebrate Organisms of the Salton Sea

[Click on genus and species name to reach larger images]

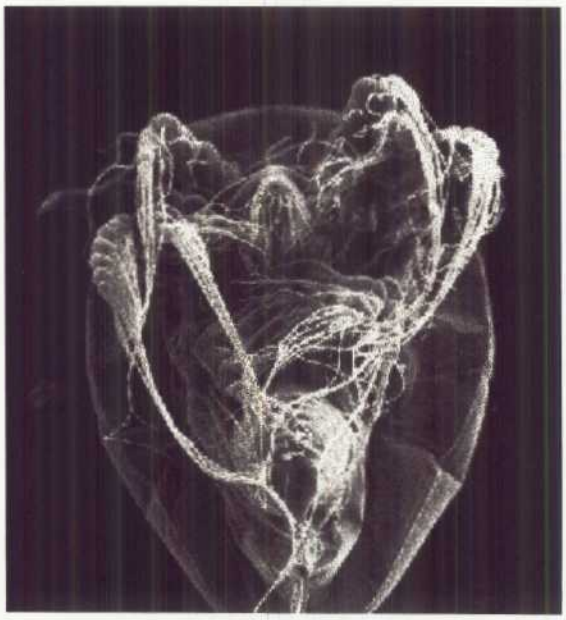
Balanus amphitrite saltonensis (larvae)

(Balanidae, Cirripedia)

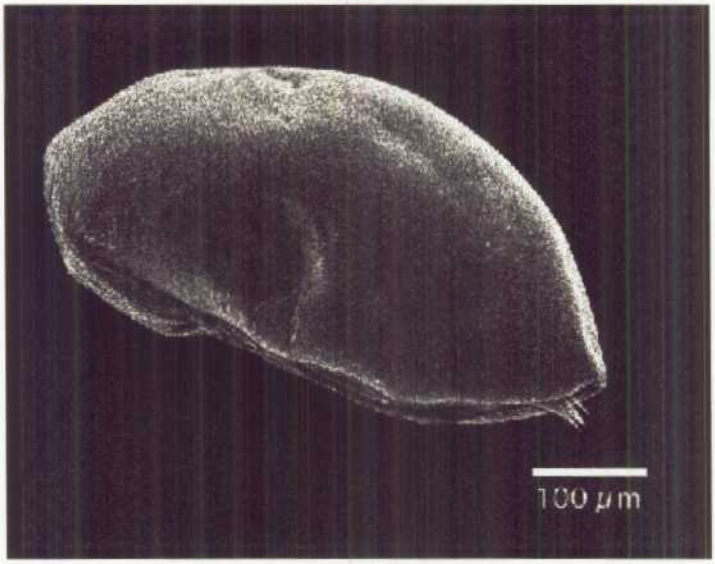
This barnacle has a worldwide distribution in warm temperate and tropical waters. The Salton Sea is the only inland saline lake in the world from which a barnacle has been reported. Assemblages of live adults and extensive deposits of barnacle shell form major structural habitats for other invertebrate species in the Sea. Beginning as a nauplius (a,b), it develops into the cyprid form (c) which than settles on a hard substrate as an adult barnacle.



a. nauplius



b. nauplius



c. cypris form

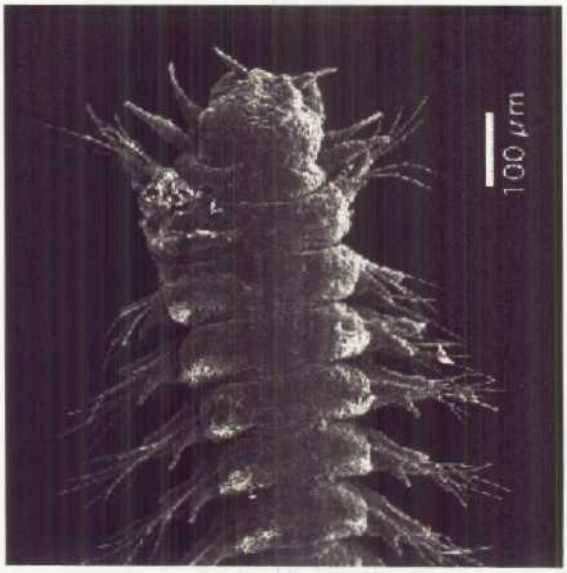
Fig. 1. Larvae of barnacle, *Balanus amphitrite saltonensis.* Found in greatest abundance in near shore waters in January through April. Adult forms live attached to hard substrates. Extensive deposits of barnacle shell form major structural habitats for other invertebrates in the Sea.

Neanthes succinea (larvae)

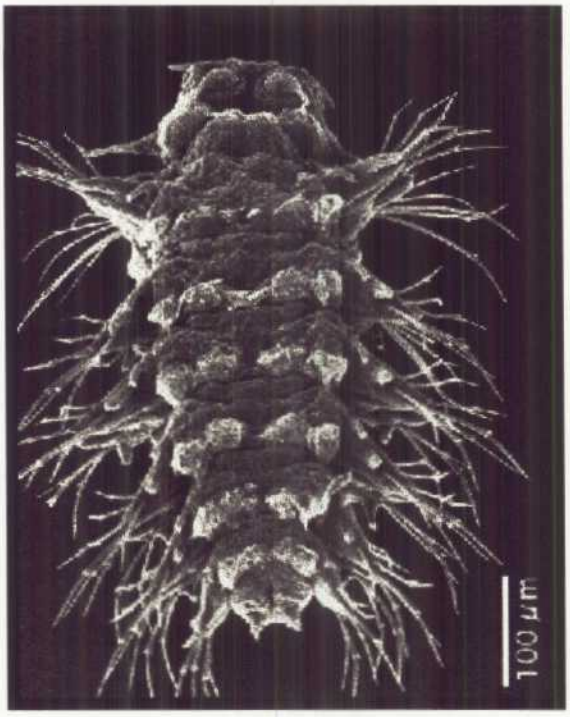
(Nereidae, Polychaeta)

Early stages in the development of this pile worm, from eggs to the nine-segmented larvae, are planktonic. They are most abundant in the Salton Sea in spring and fall (see Graph. I).

Light microscopy: a - trochophore (to be added), b - nectochaete, c - setiger juvenile



b - nectochaete



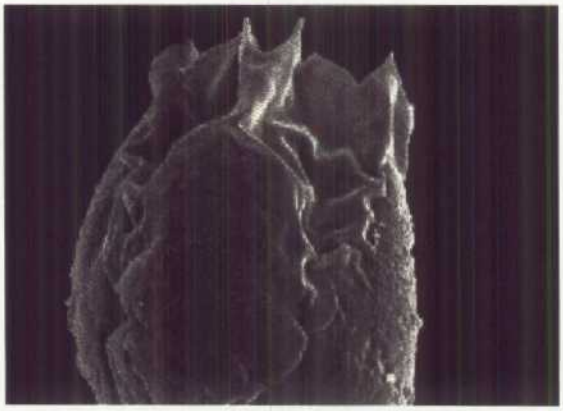
c - setiger juvenile

Fig 2. Larvae of pile worm, *Neanthes succinea*. Most abundance in March, scarce in summer, increase starting in November. Prey for fish and birds feeding in water column.

Brachionus rotundiformis

(Brachionidae, Rotifera)

In earlier publications this rotifer was referred as *Brachionus plicatus*, but it is now considered to be a distinct form. It is strictly planktonic organism that reproduces by parthenogenesis. This allows it to increase in abundance very rapidly (see graph. I). It is the most numerous organism in the summer zooplankton.



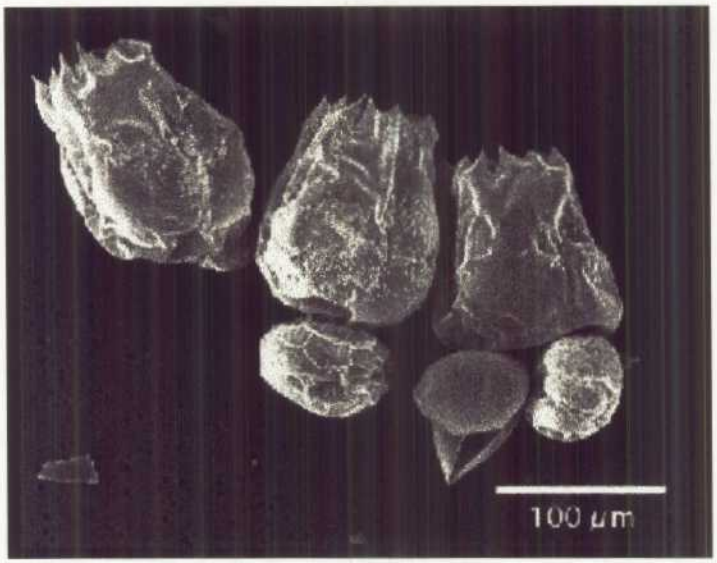
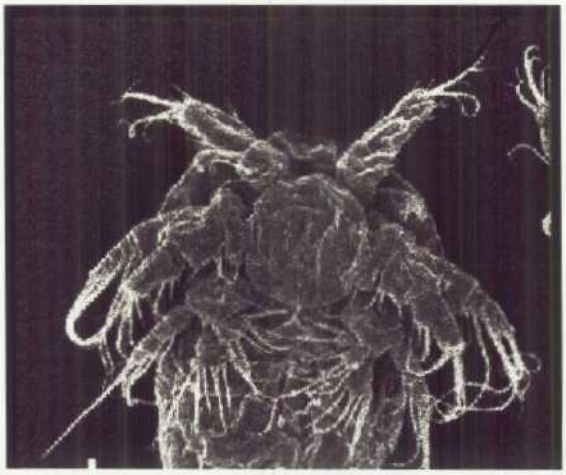


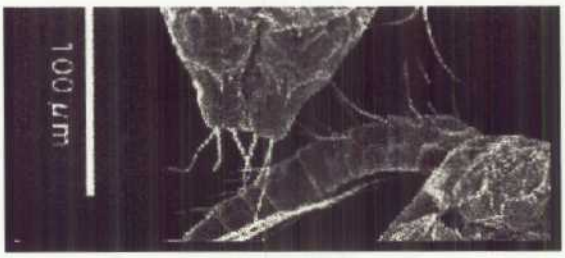
Fig. 3. Rotifer, Brachionus rotundiformis. Most numerous organism in the summer zooplankton. Play an important role in nutrient cycling. Prey for copepods and fish.

Apocyclops dengizicus

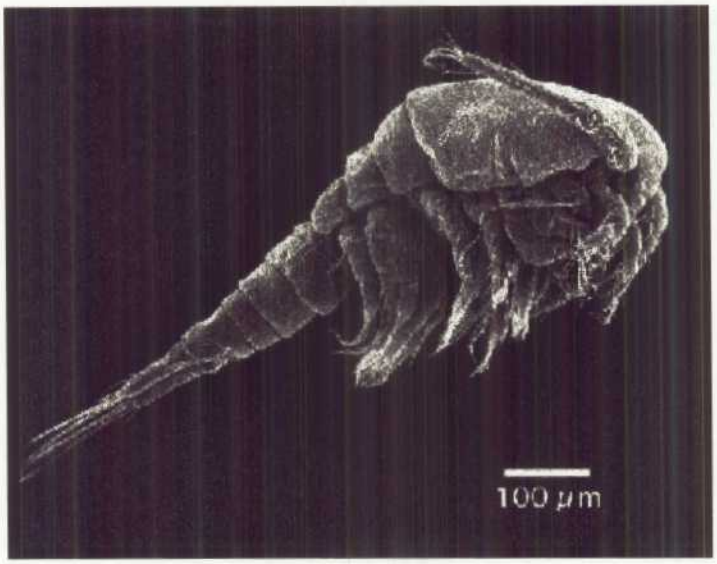
(Cyclopidae, Copepoda)

This is the only cyclopoid copepod reported from the Salton Sea (Dexter, 1993). It is present in the Salton Sea year round, but most abundant in the summer (see graph I). *A. dengizicus* has a generation time as brief as 2 weeks. Other places that it is found is inland saline lakes in Australia, Africa, Asia, and the Carribean.





Nauplius, ventral view



Adult, ventrolateral view

Fig. 4. Cyclopoid copepod, *Apocyclops dengizicus*. Dominates summer zooplankton. Food for small fish. Feeds on algae, protozoans and rotifers.

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Benthic Organisms

[Click on genus and species name to reach larger images]

Neanthes succinea

(Nereidae, Polychaeta)

Adults of this worm dominate oxygenated offshore sediments and are abundant along the shoreline in a variety of substrates. It is a cosmopolitan benthic species being able to survive in a wide range of salinity: from fresh water estuaries to sea waters (Wu et al., 1985). *N. succinea* was first recorded in the Salton Sea in 1935 (Hartman, 1936).

It is the most important link between the detritus in the sediments and higher trophic levels (fish and birds). Due to its abundance and high caloric value, this polychaete is a major food item for fish at the Salton Sea.

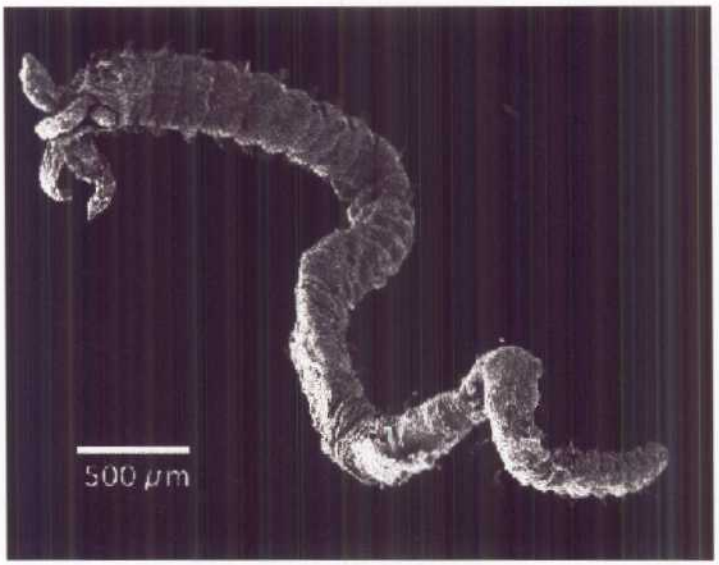
Scanning electron microscopy: dorsal view ventral view

Fig. 5. Adult pile worm. Major item in diet of several fish and eared grebes. Most abundant in winter on mud at a depth of 5-8 m. Estimated biomass is 13.2 million kg for the entire sea in late fall.

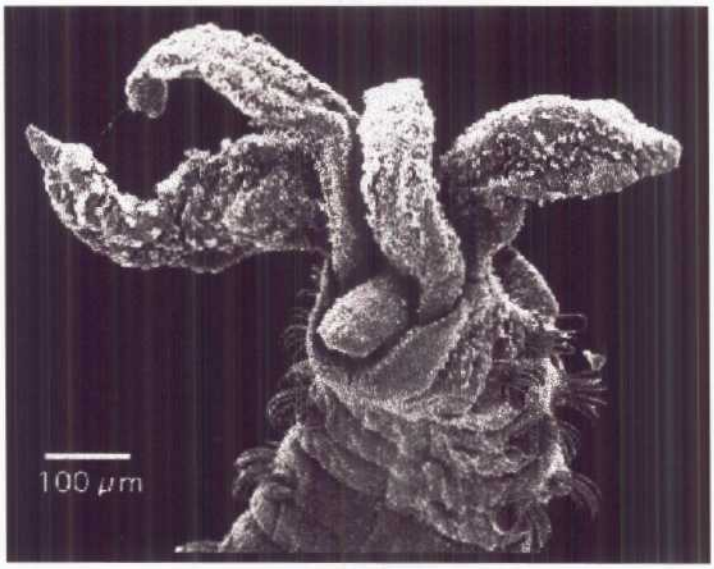
Streblospio benedicti

(Spionidae, Polychaeta)

The presence of the polychaete family Spionidae was first found in the Salton Sea in January 1999 by D.Dexter. This tiny worm (4 mm as adult) inhabits the upper layer of muddy substrates throughout the world. It is found occupying dead barnacle shell along the rocky shoreline, among algae, and in muddy substrates of both shoreline and deeper Salton Sea sediments.



General view



Ventrolateral view of anterior end with branchia (B), palp(P), and notopodium (N) with setae (S).

Fig. 6 Polychaete worm, *Streblospio benedicti.* First found in the Salton Sea in January 1999.

Gammarus mucronatus

(Gammaridae, Amphipoda)

This amphipod was probably introduced into the Salton Sea in 1957. Gammarus is most abundant in algae-covered rock, common in barnacle-covered rock, and rare in soft sediments. Several generations are produced yearly.

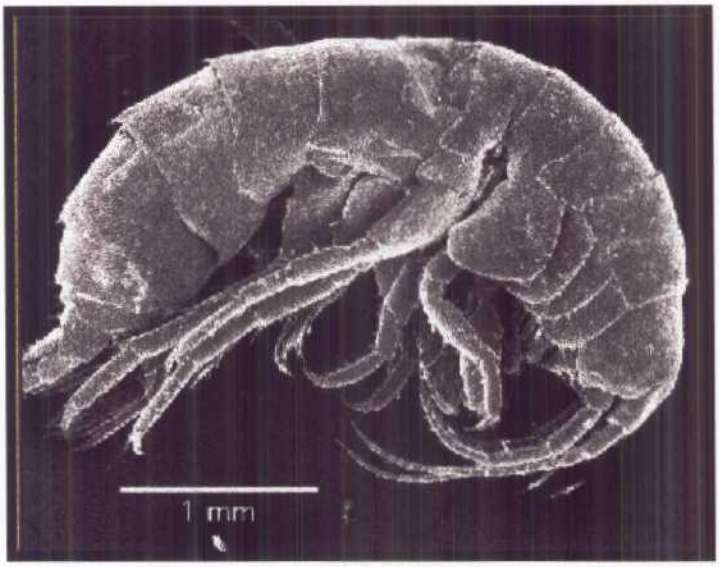
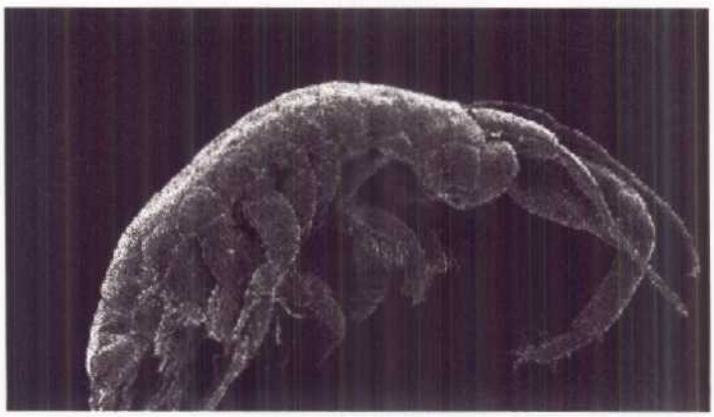


Fig. 7. Amphipod, *Gammarus mucronatus*. Lives in algal mats, among living barnacles, in the barnacle sand along the shoreline and within soft sediments. Food item of eared grebes and other bird species that feed in shallow water.

Corophium louisianum

(Corophiidae, Amphipoda)

This amphipod is a tube-dwelling species. It lives in u-shaped silky tubes which it secretes from glands in its legs and attaches to sediments, rocks and dead barnicle shells. Most species of *Corophium* are deposit feeders. It uses the long hairs on its anterior legs to filter food from the water. It was first collected in the Salton Sea by SDSU scientists in 1991 (Simpson et al., 1998).



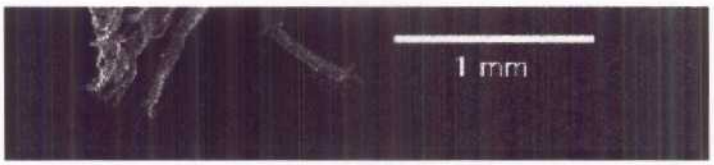
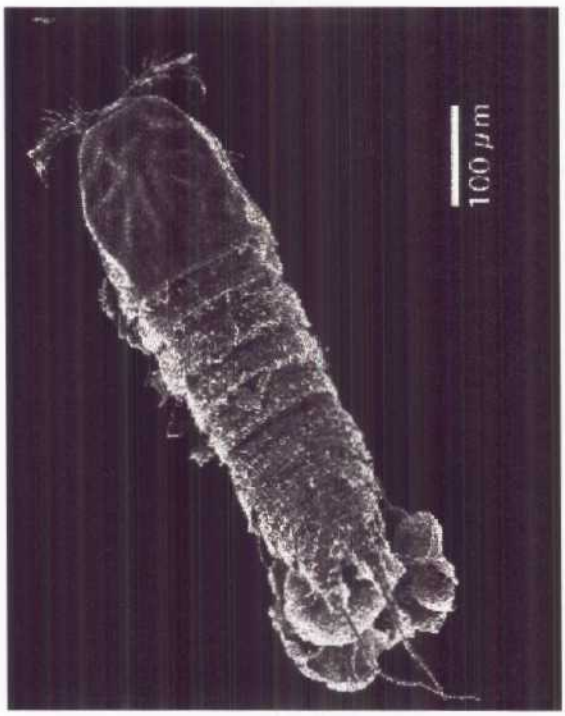


Fig. 8. Amphipod, *Corophium sp.* Lives in small tubes on submerged rocks.

Harpacticoid copepod, *Cletocampus deitersi.*

It is a harpacticoid copepod which is reported from 5 continents (North and South America, Asia, Australia, Africa) in waters of varying salinity. It was first discovered at the Salton Sea in 1990 by an SDSU scientist (Dexter, 1995). Very abundant among algae, detrital debris on rocks and in muddy sediments. It is also occurs in low numbers in the plankton. Harpacticoid copepods are an important food source for fish larvae and juveniles.



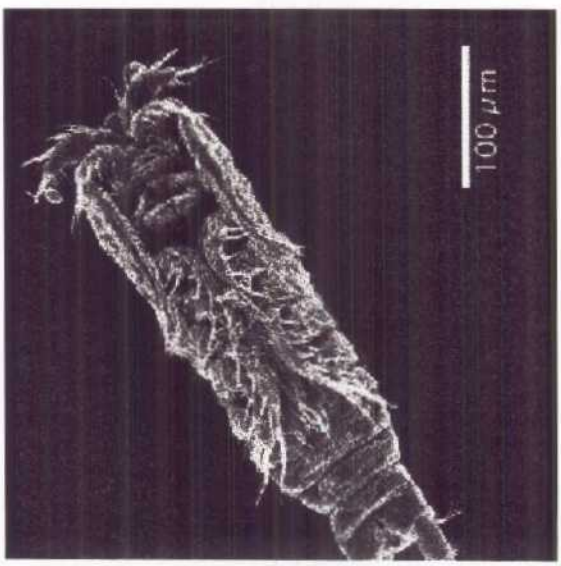


Fig. 9. Harpacticoid copepod, *Cletocampus deitersi.* Abundant among algae and detritis debris on rocks and also present in the mud.

Cyprideis beaconensis

(Ostracoda)

At the Salton Sea these small crustaceans live in algal mats and in the sediments. They are found associated with macroalgae growing on rocks near the shore. The most distinctive feature of the Ostracoda is the calcareous bivalved carapace which totally envelops the body and limbs. Various appendages protrude from the carapace and are used for locomotion, feeding and reproduction.

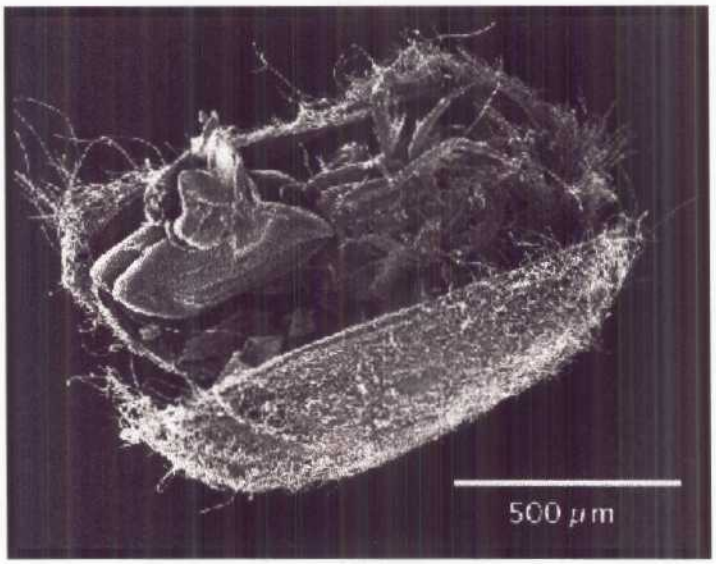


Fig. 10. Ostracod, *Cyprideis beaconensis.* Lives in algal mats and in the sediments. Swim up into the water column between aquatic plants.

Turbellaria

An unidentified species of turbellarian flatworm was found in benthic samples by M.A. Tiffany in 1997. In early December, 1999, a high abundance of this turbellarian was found in the sediments along southeastern shoreline.

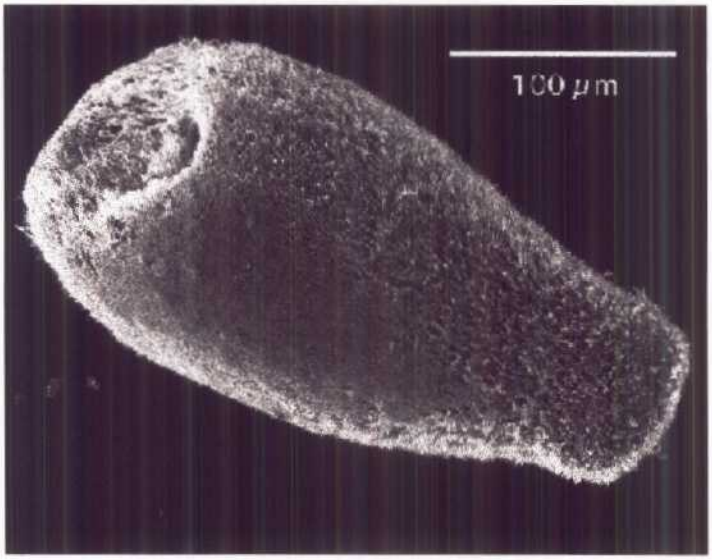
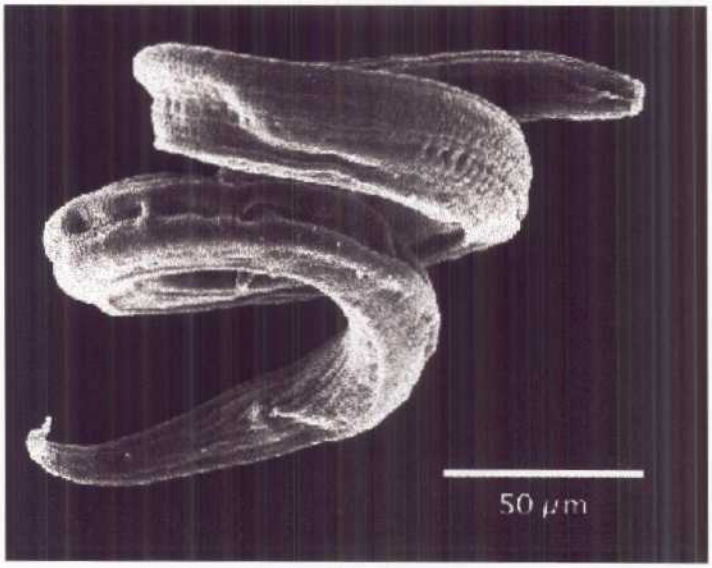


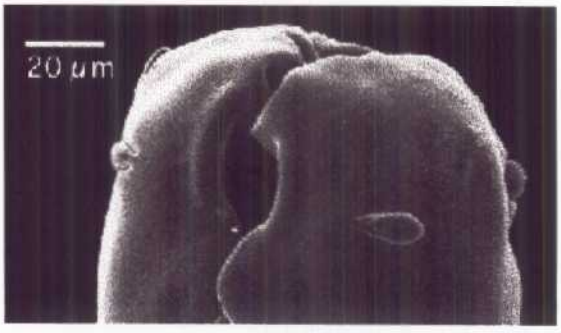
Fig. 11. Flatworm (Turbellaria), an unidentified species lives in the sediments.

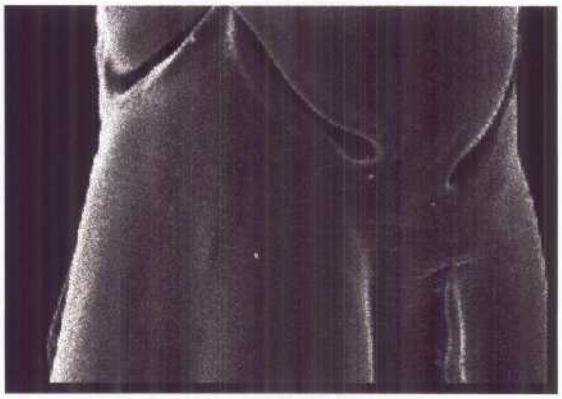
Nematoda

Several species of roundworms have been found in algal mats, barnacle communities and sediments. They are important in the recycling of organic matter and bacteria. a - general view, b - cephalic part, c - caudal part, male, d - buccal area, d - caudal part

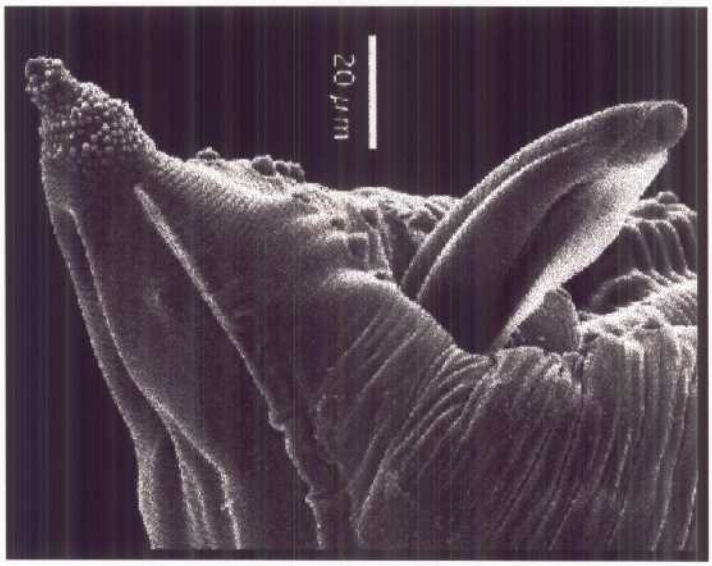


a - general view

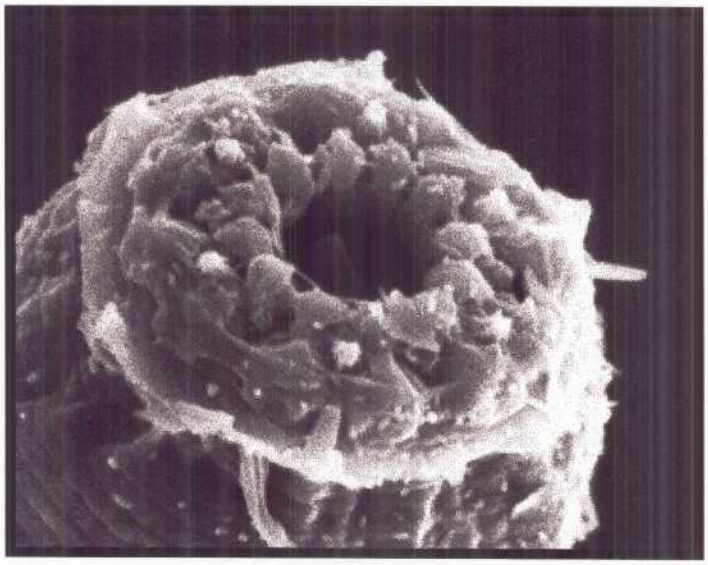




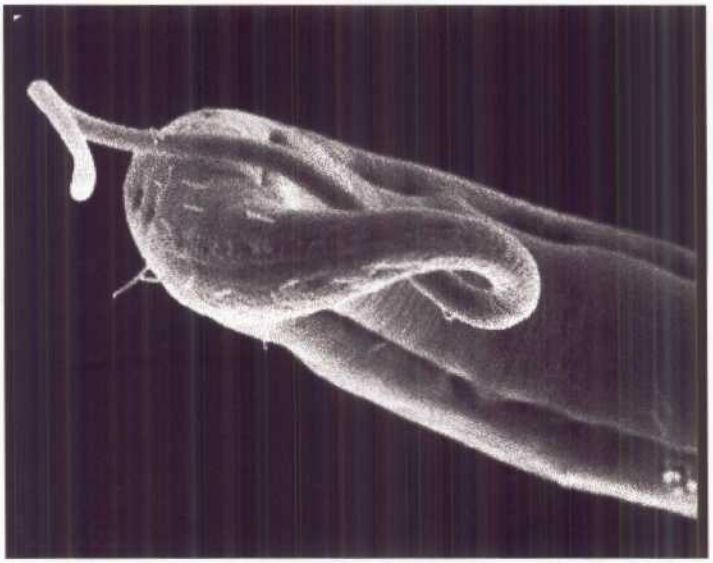
b - cephalic part



c - caudal part, male



d - anterior end



e - posterior end

Fig. 12. Round worms (Nematoda). Several species have been found in sediments.

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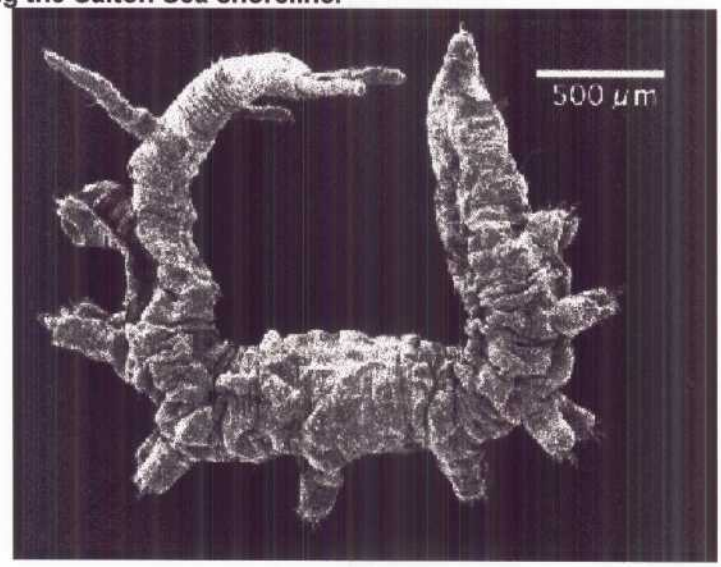
Other Important Invertebrates

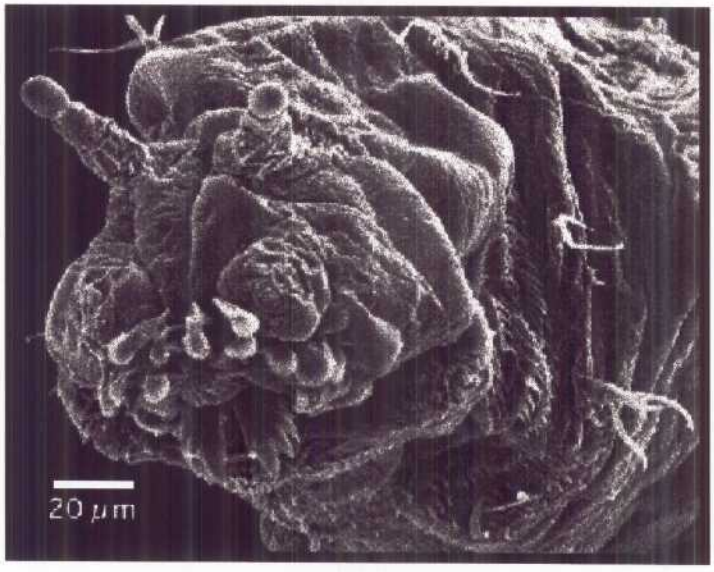
[Click on genus and species name to reach larger images of that parasite]

Ephydra sp. (Ephydridae, Diptera)

Larvae and adults of these brine flies are abundant in hypersaline ponds isolated from main body of the Salton Sea. Larvae feed on algae. Both larvae and adult flies are probably significant food items for some of the birds feeding along the Salton Sea shoreline.



General view. B- breathing tube, C - cephalic segment, P - projection .



Facial mask. A - antennae, C- comb-like structure, H- hook, M - mandible, S - sensory plate, Sc- sclerite.

Fig. 13. *Ephydra sp. (* Ephydridae, Diptera)

Trichocorixa reticulata (Corixidae, Hemiptera)

The distribution of this aquatic insect includes the southern United States, Carribean Islands, the west coast of the Americas from Peru to northern California, where it is found in a wide range of salinities. At the Salton Sea it occurs mainly in protected embayments or isolated pools at the fringe of the lake, where salinity is usually higher than the main body of the lake but where fish are scarce or absent. In tropical regions this species reproduces continuously, but in colder regions produces only 2-3 generations per year.

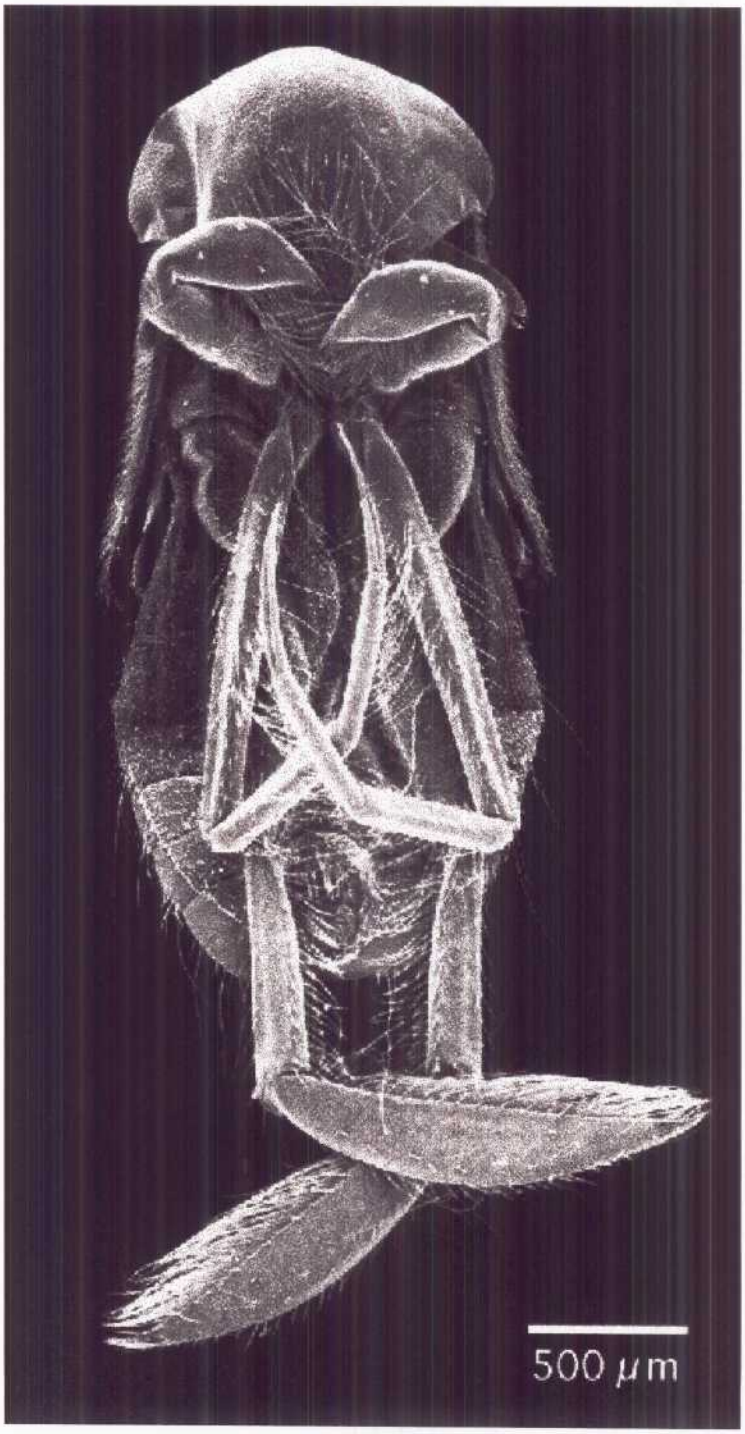


Fig. 14. *Trichocorixa reticulata* (Corixidae, Hemiptera)