Marine organisms around outfall pipes in Santa Monica Bay

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The major wastewater discharge pipes in southern California empty into the ocean at depths of 60 to 100 m. For this reason it is thought that deepwater organisms would be the first to be affected by wastewater pollution. A major problem in studying the effects of wastewater pollution on deepwater marine life is the difficulty in directly observing the organisms in their natural environment. One way of solving this problem is to send submersibles with human passengers to the bottom to investigate the marine life that is actually found in the vicinity of the pipe. Submersibles have been used to study wastewater effects at Howe Sound, British Columbia,[1] and at Oxnard, California.[2] Several sanitation districts in southern California have used submersibles in the past to investigate the structure of the discharge pipes, but there has been little effort to determine what organisms are actually found around the pipes. The objective of this study is to identify the larger species of marine life that are associated with the 8,000- and 11,000-m wastewater discharge pipes of the Hyperion Treatment Plant (Los Angeles City Sanitation District) and note observable discharge pipe effects.

Discharge Pipe Characteristics and Study Area

The Hyperion Treatment Plant of the Los Angeles City Sanitation District has two currently operating wastewater discharge pipes that empty into the ocean: An 8,000-m (5 mile) effluent pipe; and an 11,000-m (7 mile) sludge pipe (Table I, Figure 1). The 8,000-m pipe is approximately 3.66 m (12 ft) in diameter and is made of reinforced concrete. It has two 1,220 m diffuser legs that form a wye-structure with respect to the main pipe, both of which discharge at a depth of 60 m. On each diffuser leg a series of 83 diffuser ports ranging in size from 0.170–0.205 m (6.75 to 8.25 in.) are alternately placed 14.63 m apart on each side of the pipe along the springline. A 0.403 m (16 in.) port at the end of each diffuser leg has been plugged. The pipe is kept in place by large rock ballast in shallow water (to about 15 m) and a gravel ballast in deeper water. Completed in 1959, this pipe has been discharging from 1961 to the present. About 889,475 cu m/day (235 mgd) primary and 378,500 cu m/day (100 mgd) secondary effluent is currently being discharged from this pipe.

The 11,000-m pipe is approximately 0.61 m (2 ft) in diameter and is covered externally with a gunnite layer over coal tar enamel. It extends to the edge of Santa Monica Canyon at a depth of 100 m and has a single 0.504 m (20 in.) opening at the end through which 18,925 cu m/day (5 mgd) of sludge and effluent are discharged. The end structure includes the sled which was used to drag the pipe to its present position. Because the end of the pipe rotated when it was laid, this sled is upside down. The pipe is held in place by large concrete anchor blocks that have been placed periodically along the pipe from 20 to 35 m. The pipe bends downward as it goes over the edge of Santa Monica Canyon, and is buried where it crosses the canyon edge.

The bottom of Santa Monica Bay consists of an olive green sand from shallow water to about 30 m.[3] At depths greater than this it consists of a silty sand or sandy silt. The nearest rocky bottom is about

TABLE I.—Characteristics of the Hyperion Wastewater Discharge Pipes Currently in Operation

Characteristic	5-Mile Pipe (Effluent)	7-Mile Pipe (Sludge)
Total length (m)	8,000	11,000
Diffuser leg lengths (m)	1,220	—
Number of discharge ports	83/diffuser leg	1 (end)
Discharge port diameter (m)	0.170–0.205	0.504
Depth of discharge (m)	60	100
Pipe diameter (m)	3.66	0.61
Pipe construction materials	Reinforced concrete	Steel (external coating of gunnite on coal tar enamel
Discharge quantity (mgd)		
Primary	235	—
Secondary	100	5 (incl. sludge)
Date of completion	1959	1957
Dates of operation	1961 to present	1961 to present

2 km to the southwest of the end of the south diffuser leg. The soft-bottom fish and invertebrate fauna in Santa Monica Bay have been described in a variety of studies.[4–9] Hard substrate organisms found associated with artificial reefs in shallow water in Santa Monica Bay have also been described.[10]

Methods. Color photographs of marine organisms around the discharge pipes were taken from June 6 to July 2, 1974, by Harry Pecorelli while scuba diving at depths of 10 to 30 m and in deeper water, from the two-man submersible "Snooper" owned by Undersea Graphics, Inc., Torrance, Calif. Seven regions were sampled along the pipes, four along the 8,000-m pipe, and three along the 11,000-m pipe (Figure 1). These regions represent three major depth zones: (1) shallow—10 to 30 m; (2) mid-depth—40 to 50 m; and (3) deep—60 m (8,000-m pipe) or 60 to 100 m (11,000-m pipe). One region was sampled along each diffuser leg of the 8,000-m pipe at 60 m.

The marine organisms observed in each of 399 photographs of the discharge pipes were identified to species when possible and notes were taken concerning the location of the organisms with respect to the pipes. No attempt was made to estimate abundances of organisms although general abundance patterns for each species were noted.

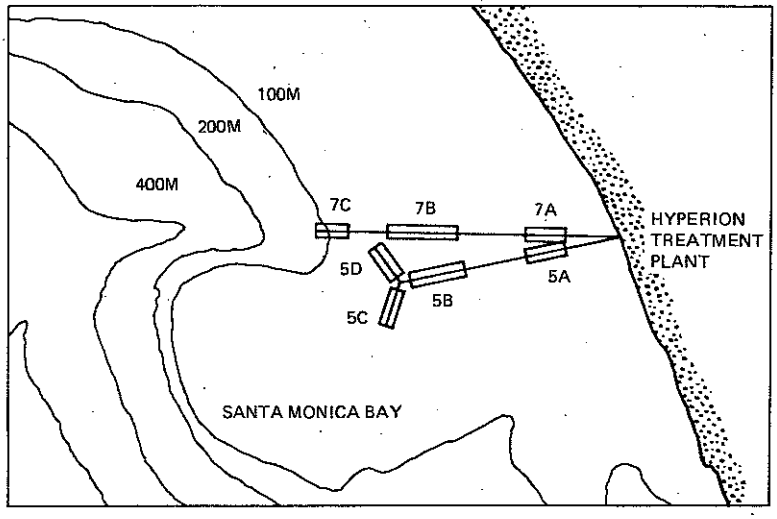

FIGURE 1.—Regions along the Hyperion 11,000-m and 8,000-m discharge pipes photographed by two-man submarine and scuba diver.

Results. At least 100 species of marine organisms were observed in the photographs (Tables II and III). Of these, 3 were algae, 66 were invertebrates, and 31 were fishes. The class Osteichthyes (bony fishes) contained the most species (30), followed by Gastropoda (15) and Anthozoa (10). Sixteen of the fish species were in the family Scorpaenidae (i.e. *Scorpaena guttata, Sebastes* spp.—Rock fishes).

Region 5A (Depth: 10–30 m). The aggregate anemone, *Corynactis* sp., which is attached to the pipe was the most frequently observed organism in shallow water along the 8,000-m pipe (Region 5A—Table IV, Figure 2). Other common sessile organisms attached to the pipe in this region included the gorgonians *Muricea* sp. and *Lophogorgia chilensis,* hydroids which include unidentified species and *Aglaophenia* sp., unidentified serpulid polychaetes and unidentified ectoprocts. Organisms frequently observed attached to the ballast rocks included unidentified hydroids and the algae including *Rhodymenia pacifica, Iridaea splendens, Gigartina corymbifera,* and other red algaes that were not identifiable. Unidentified tube anemones (Ceriantharia) were frequently observed in the gravel ballast and surrounding soft-bottom areas. The most frequently observed motile organisms included crabs (*Cancer anthonyi, Cancer productus,* and *Loxorhynchus grandis*), starfish (*Pisaster brevispinis*), sea cucumbers (*Parastichopus parvimensis*), and the giant keyhole limpet (*Megathura crenulata*). The crabs and *Pisaster brevispinis* were found on the pipe, ballast, and sand, while *Parastichopus parvimensis* was observed only on the ballast and the giant keyhole limpet only on the pipe.

Region 5B (Depth: 40–50 m). The aggregate anemone, *Corynactis* sp. was again the most frequently observed organism at middepths along the 8,000-m pipe (Region 5B—Table V, Figure 3), and again was confined to the pipe. Other common sessile organisms attached to the pipe included the gorgonians *Muricea* sp. and *Lophogorgia chilensis,* the sea anemone *Metridium senile,* and unidentified hard corals (Madreporaria). *Metridium senile* was found on the pipe from about 50 m and deeper and appears to replace the gorgonians as the dominant large sessile suspension-feeders. Sea cucumbers (*Parastichopus californicus*) were commonly observed along the ballast and Kellet's whelk (*Kelletia kelleti*) were observed on the soft-bottom. Shortbelly rockfish (*Sebastes jordani*), a small water-column feeding rockfish, formed rather dense schools near the pipe and ratfish (*Hydrolagus colliei*), a bottom feeder, was commonly observed swimming near the ballast and the pipe.

Region 5C (Depth: 60 m). The sea anemone, *Metridium senile,* was the most frequently observed organism along the south diffuser leg of the 8,000-m pipe (Region 5C—Table VI, Figures 4 & 5). Dense forests of this large (about 0.6 m tall) white sea anemone were found predominately attached to the pipe, but also attached to ballast rocks. They were densely clustered around the diffuser ports. The aggregate anemone, *Corynactis* sp., was the only other sessile organism commonly observed here. The sea cucumber, *Parastichopus californicus,* was observed on the pipe, along the ballast, and on the soft-bottom. Unidentified gastropods were observed on the ballast and soft-bottom. Rockfishes were very common. The shortbelly rockfish (*Sebastes jordani*), vermilion rockfish (*Sebastes miniatus*), blue rockfish (*Sebastes mystinus*), and bocaccio (*Sebastes paucispinis*), all water-column feeders, were always seen in the water column. The shortbelly rockfish, a small species, and bocaccio, a large species, both formed dense schools. Vermilion rockfish were observed in the lower parts of the bocaccio schools or cruising slightly above the sea anemones as were the blue rockfish. Olive rockfish (*Sebastes serranoides*), which behave similarly, although possibly including more bottom food in their diet, were also observed cruising slightly above the anemones or resting on the bottom. The flag rockfish (*Sebastes rubrivinctus*), cow rockfish (*Sebastes levis*), and sword-

TABLE II.—Marine Organisms Observed near the Hyperion 8,000- and 11,000-m Wastewater Discharge Pipes, June–July, 1974*

Species	Common Name
Rhodophyta	
Rhodophyceae	
Gigartina corymbifera	Red alga
Iridaea splendens	Red alga
Rhodophyceae, unid.**	Red alga
Rhodymenia pacifica	Red alga
Porifera	
Porifera, unid.	Sponge
Cnidaria	
Hydrozoa	
Aglaophenia sp.	Hydroid
Hydroid unid.	Hydroid
Scyphozoa	
Pelagia sp.	Jellyfish
Anthozoa	
?*Acanthoptilum*, sp.	Sea pen
Actinaria, unid.	Sea anemone
Ceriantharia unid.	Tube anemone
Corynactis sp.	Sea anemone
Eugorgia rubens	Gorgonian
Lophogorgia chilensis	Gorgonian
Madreporaria, unid.	Hard coral
Metridium senile	Sea anemone
Muricea sp.	Gorgonion
Pennatulacea, unid.**	Sea pen
Stylatula sp.	Sea pen
Annelida	
Polychaeta	
?*Diopatra* sp.	Polychaete
Phyllochaetopterus sp.	Polychaete
Polychaete tubes, unid.	Polychaete
Serpulidae, unid.	Polychaete
Telepsavus costarum	Polychaete
Arthropoda	
Crustacea	
Balanus sp.	Barnacle
Cancer antennarius	Rock Crab
Cancer anthonyi	Yellow Crab
Cancer productus	Crab
Cancer sp. **	Crab
Cirripedia, unid.**	Barnacle
Loxorhynchus grandis	Sheep Crab
Mursia gaudichaudii	Crab
Paguridae, unid.	Hermit crab
Panulirus interruptus	California Spiny Lobster
Scalpellum sp.	Barnacle
Mollusca	
Gastropoda	
Aegires albopunctatus	Sea slug
Bursa californica	California Frog Shell
Calliostoma gloriosum	Snail
Conus californicus	California Cone
Crassispira semiinflata	Snail
Doridoidea	Sea slug
Gastropod, unid.**	Snail
Gastropod, unid.	*Ocenebra*-like snail
Mollusca (continued)	
Gastropod eggs, unid.**	Gastropod eggs
Hermissenda crassicornis	Sea slug
Kelletia kelleti	Kellet's Whelk
Kelletia kelleti, eggs	Kellet's Whelk, eggs
Megasurcula carpenteriana	Snail
Megathura crenulata	Giant Keyhole Limpet
Nassarius sp.	Snail
Naticidae, unid.	Moon snail
Neverita alta	Snail
Nudibranchia?, unid.**	Sea slug
Opisthobranchia eggs, unid.**	Sea slug, eggs
Terebra sp.	Snail
Tritonia diomedea	Sea slug
Pelecypoda	
Anomiidae, unid.	Jingle
Hinnites multirugosus	Rock Scallop
?*Macoma* sp.	Clam
Pelecypoda, unid.	Clam
Solemya sp.	Clam
Zirfaea sp.	Clam
Cephalopoda	
Octopus sp.	Octopus
Ectroprocta	
Ectoprocta, unid.	Moss animal
Echinodermata	
Asteroidea	
Asteriinae, unid.	Starfish
Astropectin verrilli	Sand star
?*Henricia* sp.	Star
Luidia foliolata	Star
Mediaster aequalis	Bat starfish
Patiria miniata	Star
Pisaster brevispinis	Starfish
Pisaster giganteus	Giant Spined Starfish
Pisaster ochraceus	Common Starfish
Pisaster sp.**	Starfish
Echinoidea	
Lytechinus ?anamesus	Sea urchin
?*Stronglyocentrotus* sp.	Sea urchin
Holothuroidea	
Holothuroidea, unid.	Sea cucumber
Parastichopus californicus	Sea cucumber
Parastichopus parvimensis	Sea cucumber
Chordata	
Ascidiacea	
Styella sp.	Sea squirt
Chondrichthyes	
Hydrolagus colliei	Ratfish
Osteichthyes	
Chitonotus pugetensis	Roughback Sculpin
Citharichthys stigmaeus	Speckled Sanddab
Coryphopterus nicholsi	Blackeye Goby

TABLE II.—(*Continued*)

Species	Common Name
Chordata (continued)	
Cymatogaster aggregata	Shiner Perch
Embiotocidae, unid.**	Perch
Hippoglossina stomata	Bigmouth Sole
Icelinus tenuis	Spotfin Sculpin
Lepidogobius lepidus	Bay Goby
Microstomus pacificus	Dover Sole
Neoclinus uninotatus	Onespot Fringehead
Osteichthys, unid.**	Fish
Oxylebius pictus	Painted Greenling
Pleuronectiformes, unid.**	Flatfish
Pleuronichthys coenosus	C-O Sole
Pleuronichthys sp.**	Turbot
?Rathbunella sp.	Ronquil
Scorpaena guttata	California Scorpionfish
Scorpaenichthys marmoratus	Cabezon
Sebastes auriculatus	Brown Rockfish
Sebastes ?dalli	Calico Rockfish
Sebastes ensifer	Swordspine Rockfish
Chordate (continued)	
Sebastes flavidus	Yellowtail Rockfish
Sebastes goodei	Chilipepper
Sebastes jordani	Shortbelly Rockfish
Sebastes levis	Cow Rockfish
Sebastes miniatus	Vermilion Rockfish
Sebastes mystinus	Blue Rockfish
Sebastes paucispinis	Bocaccio
Sebastes rubrivinctus	Flag Rockfish
Sebastes saxicola	Stripetail Rockfish
Sebastes semicinctus	Halfbanded Rockfish
Sebastes serranoides	Olive Rockfish
Sebastes sp.**	Rockfish
Sebastes vexillaris	Whitebelly Rockfish
Zalembius rosaceus	Pink Seaperch

* Common names of fishes are from Bailey *et al.*[11]
** Unidentifiable species, although not necessarily different from those identified in the photographs.

spine rockfish (*Sebastes ensifer*) were generally solitary and found near the bottom. The flag rockfish and cow rockfish have vertical light and dark bars allowing

TABLE III.—Minimum Number of Identifiable Species in Each Class of Organisms Observed in Photographs of the Discharge Pipes

Class	Minimum Number of Identifiable Species
Rhodophyceae	3
Porifera	1
Hydrozoa	2
Scyphozoa	1
Anthozoa	10
Polychaeta	5
Crustacea	9
Gastropoda	15
Pelecypoda	6
Cephalopoda	1
Ectoprocta	1
Asteroidea	9
Echinoidea	2
Holothuroidea	3
Ascidiacea	1
Chondrichthyes	1
Osteichthyes	30
Total	100

TABLE IV.—Marine Organisms Appearing in 5% or More Photographs Taken at Region 5A

Species	Common Name	Frequency of Occurrence (%)
1. *Corynactis* sp.	Sea anemone	67.1
2. *Muricea* sp.	Gorgonian	28.6
3. Hydroid, unid.	Hydroid	24.3
4. *Cancer anthonyi*	Yellow Crab	20.0
5. Rhodophyceae, unid.	Red alga	14.3
6. *Rhodymenia pacifica*	Red alga	14.3
7. *Lophogorgia chilensis*	Gorgonian	14.3
8. Serpulidae, unid.	Polychaete	10.0
9. Ceriantharia, unid.	Tube anemone	10.0
10. *Pisaster brevispinis*	Starfish	8.0
11. *Aglaophenia* sp.	Hydroid	8.0
12. *Iridaea splendens*	Red alga	7.1
13. *Megathura crenulata*	Giant Keyhole Limpet	7.1
14. *Parastichopus parvimensis*	Sea cucumber	7.1
15. *Gigartina corymbifera*	Red alga	5.7
16. Ectoprocta, unid.	Moss animal	5.7
17. *Cancer productus*	Crab	5.7
18. *Loxorhynchus grandis*	Sheep Crab	5.7

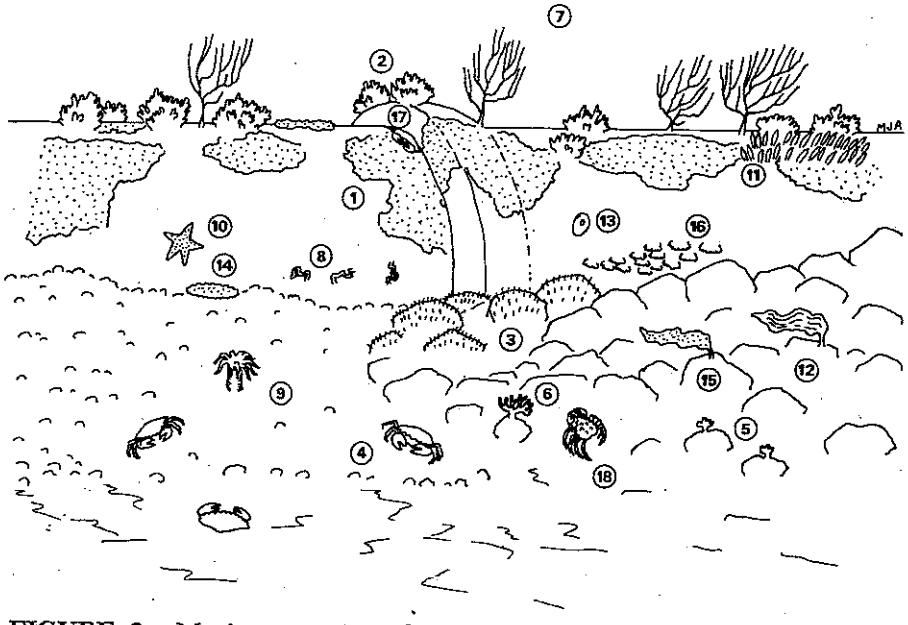

FIGURE 2.—Marine organisms found in 5 percent or more photographs taken at Region 5A. Numbers correspond to species shown in Table IV. Large rock ballast can be seen along the bottom of the pipe to the right.

them to blend into the anemone forests like zebras. The flag rockfish tended to be found among anemones along the ballast whereas the cow rockfish was also found among anemones on the pipe. The swordspine rockfish were found on the pipe or near the pipe-ballast interface.

Region 5D (Depth: 60 m). As on the south diffuser leg, the sea anemone, *Metridium senile*, was the most frequently observed organism along the north diffuser leg of the 8,000-m pipe where it forms dense clusters around the diffuser ports (Region 5D—Table VII, Figure 6). The aggregate anemone, *Corynactis* sp., was again the only other sessile suspension feeder found on the pipe, although sea pens (Pennatulacae, unid.), also sessile suspension feeders, were observed on the soft-bottom. Sea cucumbers, *Parastichopus californicus*, were frequently seen on the pipe, ballast, and soft-bottom, while starfish (Asteriinae, unid.) were seen near and on the plug at the end of the diffuser leg. Kellett's whelk (*Kelletia kelleti*) were observed on the gravel ballast and soft bottom. Among fishes aggregating or schooling in the water column, shortbelly rockfish (*Sebastes jordani*), vermilion rockfish (*Sebastes miniatus*), and bocaccio (*Sebastes paucispinis*) were common. Cow rockfish (*Sebastes levis*) and flag rockfish (*Sebastes rubrivinctus*) were again common among the *Metridium senile*. Whitebelly rockfish (*Sebastes vexillaris*) were also common along the ballast and on the pipe near the plug at the end of the diffuser leg. Unidentified

TABLE V.—Marine Organisms Appearing in 5% or More Photographs Taken at Region 5B

Species	Common Name	Frequency of Occurrence (%)
1. *Corynactis* sp.	Sea anemone	43.0
2. *Muricea* sp.	Gorgonian	26.7
3. *Sebastes jordani*	Shortbelly Rockfish	25.6
4. Madreporaria, unid.	Hard Coral	16.3
5. *Metridium senile*	Sea anemone	15.1
6. *Parastichopus californicus*	Sea cucumber	8.1
7. *Hydrolagus colliei*	Ratfish	7.0
8. *Lophogorgia chilensis*	Gorgonian	5.8
9. *Kelletia kelleti*	Kellet's Whelk	5.8

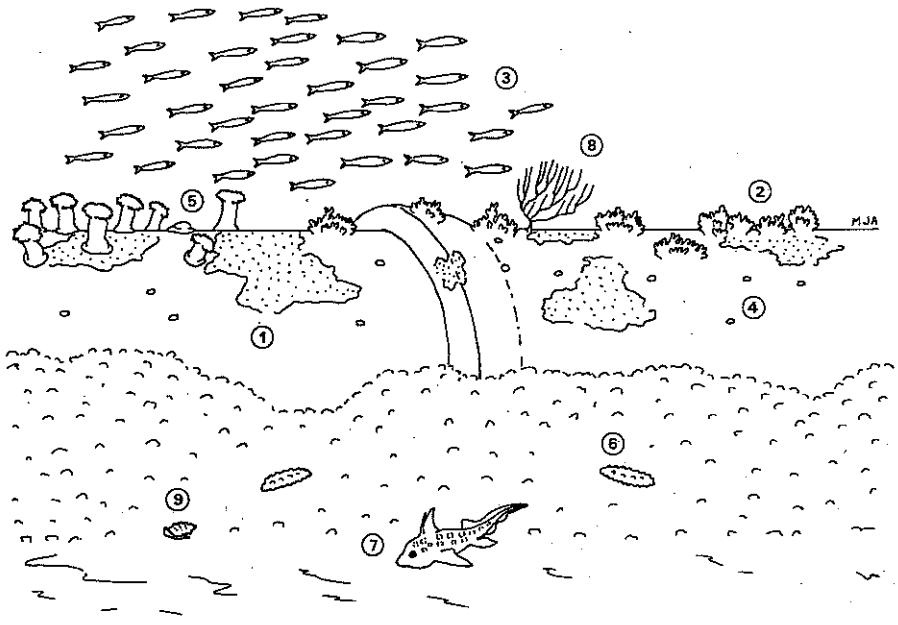

FIGURE 3.—Marine organisms found in 5 percent or more photographs taken at Region 5B. Numbers correspond to species shown in Table V.

rockfish (*Sebastes* sp.) were frequently noted in photographs along this leg.

Region 7A (Depth: 10–30 m). The shallow region, region 7A, along the 11,000-m pipe resembled the shallow region along the 8,000-m pipe. The aggregate anemone, *Corynactis* sp., was again the most frequently observed organism attached to the pipe (Table VIII, Figure 7). Other suspension-feeders included the gorgonian *Lophogorgia chilensis*, and rock scallop (*Hinnites multirugosus*), both attached only to the pipe, and unidentified hydroids and sponges, which were observed on the pipe, and anchor blocks. Gastropods were often observed in this region; Kellett's whelk (*Kelletia kelleti*) was common on the soft-bottom and clusters of its eggs were attached to rocks, while the snails, *Megasercula carpenteriana*, *Crassispira semiinflata*, and *Terebra* sp. were common on the soft-bottom near the pipe. Brown rockfish (*Sebastes auriculatus*) and California spiny lobster (*Panulirus interruptus*) were commonly seen in crevices supplied by the concrete anchor blocks, although the brown rockfish were also noted swimming slightly above the pipe or resting in the *Lophogorgia chilensis*. Debris of human origin such as basketballs and diving fins were also noted in this region.

Region 7B (Depth: 40–50 m). The gorgonian, *Lophogorgia chilensis*, was the most common organism attached to the 11,000-m pipe at middepth (Region 7B—

TABLE VI.—Marine Organisms Appearing in 5% or More Photographs Taken at Region 5C

Species	Common Name	Frequency of Occurrence (%)
1. *Metridium senile*	Sea anemone	88.7
2. *Corynactis* sp.	Sea anemone	62.3
3. *Parastichopus californicus*	Sea cucumber	50.9
4. *Sebastes jordani*	Shortbelly Rockfish	18.9
5. *Sebastes rubrivinctus*	Flag Rockfish	15.1
6. *Sebastes miniatus*	Vermilion Rockfish	13.2
7. *Sebastes mystinus*	Blue Rockfish	13.2
8. *Sebastes serranoides*	Olive Rockfish	9.4
9. *Sebastes paucispinis*	Bocaccio	7.5
10. Gastropoda, unid.	Snail	5.7
11. *Sebastes levis*	Cow Rockfish	5.7
12. *Sebastes ensifer*	Swordspine Rockfish	5.7

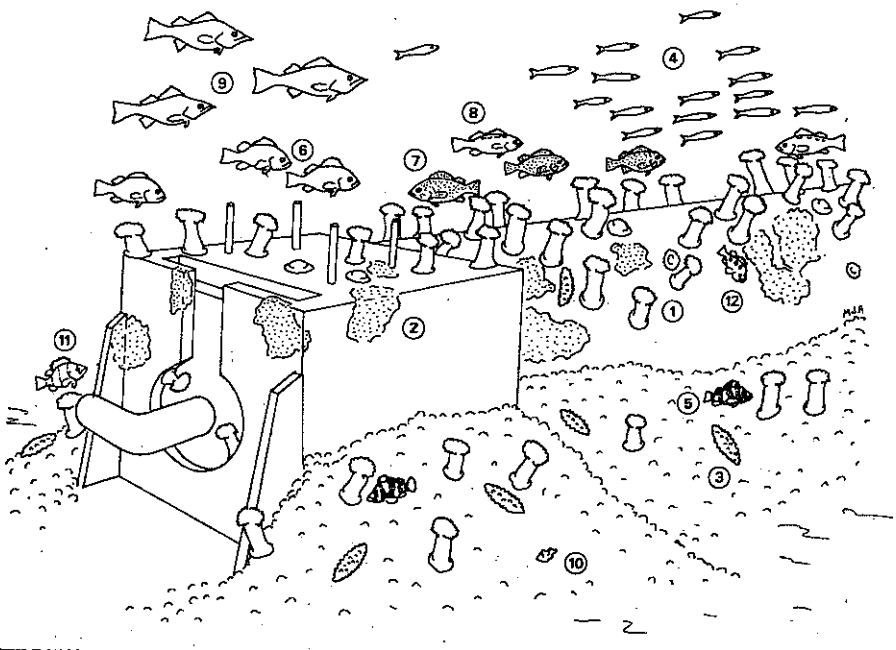

FIGURE 4.—Marine organisms found in 5 percent or more photographs taken at Region 5C. Numbers correspond to species shown in Table VI. Elbow pipe extends from end of pipe which at one time diverted effluent flow to the north.

Table IX, Figure 8). Suspension-feeding hard corals (Madreporaria, unid.), and *Corynactis* sp. were also common along the pipe and tube anemones (Ceriantharia, unid.) were common in the soft-bottom. The gastropods *Megasercula carpenteriana,*

FIGURE 5.—Ballast near base of south diffuser leg of Hyperion 8,000-m effluent pipe at 60 m depth with sea anemones (*Metridium senile*) on ballast and bocaccio (*Sebastes paucispinis*), vermilion rockfish (*Sebastes miniatus*), and cow rockfish (*Sebastes levis*) swimming above. Photographed by Harry Pecorelli.

TABLE VII.—Marine Organisms Appearing in 5% or More Photographs Takes at Region 5D

Species	Common Name	Frequency of Occurrence (%)
1. *Metridium senile*	Sea anemone	66.7
2. *Parastichopus californicus*	Sea cucumber	41.0
3. *Corynactis* sp.	Sea anemone	23.1
4. *Sebastes jordani*	Shortbelly Rockfish	20.5
5. *Sebastes miniatus*	Vermilion Rockfish	20.5
6. *Sebastes levis*	Cow Rockfish	17.9
7. *Sebastes paucispinis*	Bocaccio	12.8
8. *Sebastes vexillaris*	Whitebelly Rockfish	10.3
9. Pennatulacea, unid.	Sea pen	7.7
10. Asteriinae, unid.	Starfish	5.1
11. *Kelletia kelleti*	Kellet's Whelk	5.1
12. *Sebastes* sp.	Rockfish	5.1
13. *Sebastes rubrivinctus*	Flag Rockfish	5.1

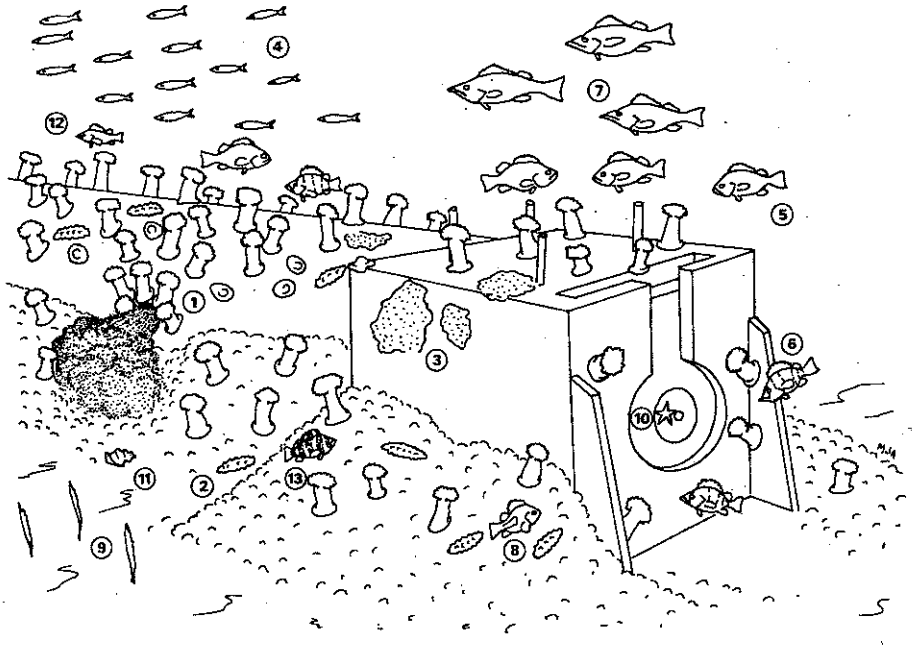

FIGURE 6.—Marine organisms found in 5 percent or more photographs taken at Region 5D. Numbers correspond to species shown in Table VII. Diffuser port can be seen discharging effluent.

Kelletia kelleti, and *Terebra* sp. were common over the soft-bottom areas around the pipe as was the sand star, *Astropectin verrilli*. *Astropectin verrilli* was also more frequently encountered on the north side of the pipe. Unidentified rockfishes (*Sebastes* sp.), vermilion rockfish (*Sebastes miniatus*), and olive rockfish (*Sebastes serranoides*), were seen cruising slightly above and near the pipe, while shortbelly rockfish (*Sebastes jordani*) were occasionally seen in small schools near the pipe. Pink seaperch (*Zalembius rosaceus*) were observed in small groups hovering very close to, almost resting on, the pipe, while painted greenling (*Oxylebius pictus*) were noted resting on the pipe or concrete anchor blocks. Large clusters of beer cans cluttered the north side of the pipe in this region.

Region 7C (Depth: 60–100 m). The 11,000-m pipe in deepwater, Region 7C, is covered almost entirely by the sea anemone (*Metridium senile*) (Table X, Figures 9 & 10). Some of these sea anemones, still attached to the pipe, mark it even at the edge of the canyon where the pipe is buried by sediments. This anemone is common on the sled and near the end of the pipe where the sludge is discharged. The starfishes, *Astropectin verrilli* and

TABLE VIII.—Marine Organisms Appearing in 5% of More Photographs Taken at Region 7A

Species	Common Name	Frequency of Occurrence (%)
1. *Corynactis* sp.	Sea anemone	34.1
2. *Kelletia kelleti*, eggs	Kellet's Whelk	19.5
3. *Sebastes auriculatus*	Brown Rockfish	19.5
4. Hydroid, unid.	Hydroid	17.1
5. *Lophogorgia chilensis*	Gorgonian	17.1
6. *Kelletia kelleti*	Kellet's Whelk	14.6
7. Porifera, unid.	Sponge	9.8
8. *Megasercula carpenteriana*	Snail	9.8
9. *Crasssispira semiinflata*	Snail	7.3
10. *Terebra* sp.	Snail	7.3
11. *Hinnites multirugosus*	Rock Scallop	7.3
12. *Panulirus interruptus*	California Spiny Lobster	7.3

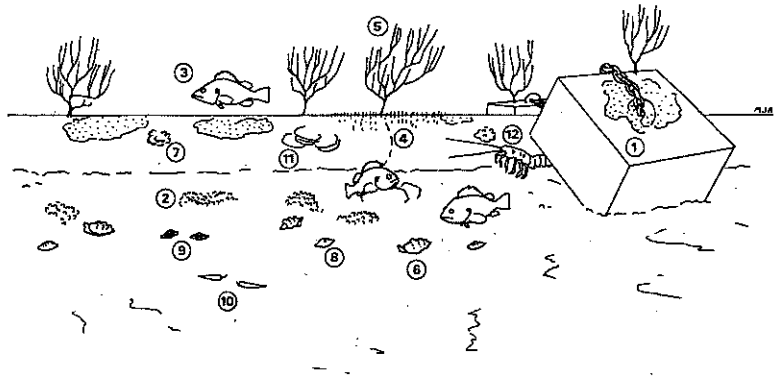

FIGURE 7.—Marine organisms found in 5 percent or more photographs at Region 7A. Numbers correspond to species shown in Table VIII. The concrete anchor blocks with connecting chain help to hold the pipe down.

Luidia foliolata, were very common on the surrounding soft-bottom and were even found in the sludge near the end of the pipe. The gastropods, *Kelletia kelleti, Megasercula carpenteriana,* and *Terebra* sp., were also common on the soft-bottom. Schools of the larger rockfish, bocaccio (*Sebastes paucispinis*) and vermilion rockfish (*Sebastes miniatus*) were common near the end, although individual bocaccio were also noted cruising along the pipe. Schools of the smaller shortbelly rockfish (*Sebastes jordani*), were also frequently observed above the pipe. Individual cow rockfish (*Sebastes levis*) occurred near the *Metridium* and Dover sole (*Microstomus pacificus*) were noted on the soft-bottom and on the pipe, particularly near the region where it is buried.

TABLE IX.—Marine Organisms Appearing in 5% or More Photographs Taken at Region 7B

Species	Common Name	Frequency of Occurrence (%)
1. *Lophogorgia chilensis*	Gorgonian	56.6
2. Madreporaria, unid.	Hard coral	32.1
3. *Corynactis* sp.	Sea anemone	28.3
4. *Megasercula carpenteriana*	Snail	17.0
5. *Sebastes* sp.	Rockfish	15.1
6. *Sebastes miniatus*	Vermilion Rockfish	13.2
7. *Kelletia kelleti*	Kellet's Whelk	11.3
8. *Terebra* sp.	Snail	9.4
9. *Parastichopus californicus*	Sea cucumber	9.4
10. *Sebastes serranoides*	Olive Rockfish	9.4
11. Ceriantharia, unid.	Tube anemone	7.5
12. *Astropectin verrilli*	Sand star	7.5
13. *Zalembius rosaceus*	Pink Sea Perch	7.5
14. *Sebastes jordani*	Shortbelly Rockfish	5.7
15. *Oxylebius pictus*	Painted Greenling	5.7

Comparison of the two pipes. Major differences between the two pipes with respect to their suitability as a habitat to marine organisms appears related to the relative diameters of the two pipes, difference in length (and hence depth of discharge), and possibly construction materials. These include the following. (a) The 8,000-m pipe is 3.66 m (12 ft), outside diameter, whereas the 11,000-m pipe is 0.61 m (2 ft), outside diameter. This provides a greater surface area on top of the pipe (between the spring lines on each side of the pipe) for attachment of sessile organisms on the 8,000-m pipe relative to that on the 11,000-m pipe. Sessile organisms were seldom observed below the springline. (b) The 11,000-m pipe discharges in deeper water than does the 8,000-m and hence differs somewhat in the organisms found on and around it. The aggregate anemone, *Corynactis* sp., commonly found in all other regions on both pipes, was not noted in the deep region along the 11,000-m pipe. Flag

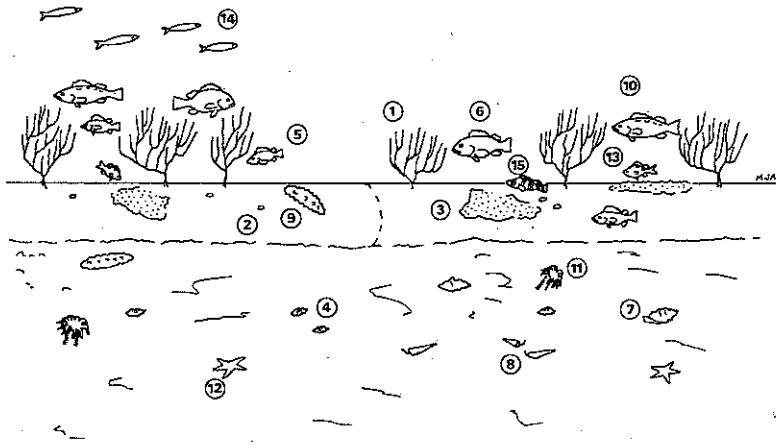

FIGURE 8.—Marine organisms found in 5 percent or more photographs taken at Region 7B. Numbers correspond to species shown in Table IX.

rockfish (*Sebastes rubrivinctus*), a species commonly associated with the sea anemone, *Metridium senile*, was also not noted at these depths. (c) The 8,000-m pipe is made of reinforced concrete, while the surface of the 11,000-m pipe is a layer of gunnite over coal tar enamel. Bushy gorgonions, *Muricea* sp. are commonly found on the 8,000-m pipe but only infrequently found on the 11,000-m pipe. As there appears to be sufficient available surface area on the top of the pipe that is not occupied by other large organisms this may be related to the materials with which the 11,000-m was constructed.

In addition, the soft-bottom to the north of the 11,000-m pipe has finer sediments, more human debris, and more sand stars, *Astropectin verrilli*, than to the south, an observation that has been confirmed by dragging a television camera on a sled across the pipe from north to south. Fishes and other motile organisms were most concentrated along the concrete anchor blocks that were periodically placed along this pipe and along the large rock ballast of the 8,000-m pipe.

SUMMARY AND CONCLUSIONS

A general description of the marine life along the outfall pipes can be summarized as follows:

1. The outfall pipes are a hard substrate habitat in a region that is dominated by a soft-bottom habitat; they therefore have many organisms that normally live only on rocky bottoms. These rocky bottom organisms are often very different from those found on soft-bottoms and generally do not stray far from a hard substrate habitat. The outfall pipes are like rock fences that cut 8,000 and 11,000 m across a sandy or muddy plateau.

2. Sessile suspension feeding organisms such as sea anemones and gorgonians are

TABLE X.—Marine Organisms Appearing in 5% or More Photographs Taken at Region 7C

Species	Common Name	Frequency of Occurrence (%)
1. *Metridium senile*	Sea anemone	45.6
2. *Astropectin verrilli*	Sand star	45.6
3. *Sebastes paucispinis*	Bocaccio	19.3
4. *Luidia foliolata*	Star	14.0
5. *Sebastes levis*	Cow Rockfish	12.3
6. *Sebastes minatus*	Vermilion Rockfish	12.3
7. *Kelletia kelleti*	Kellet's Whelk	7.0
8. *Megasercula carpenteriana*	Snail	7.0
9. *Sebastes jordani*	Shortbelly Rockfish	7.0
10. *Microstomus pacificus*	Dover sole	7.0
11. *Terebra* sp.	Snail	5.3

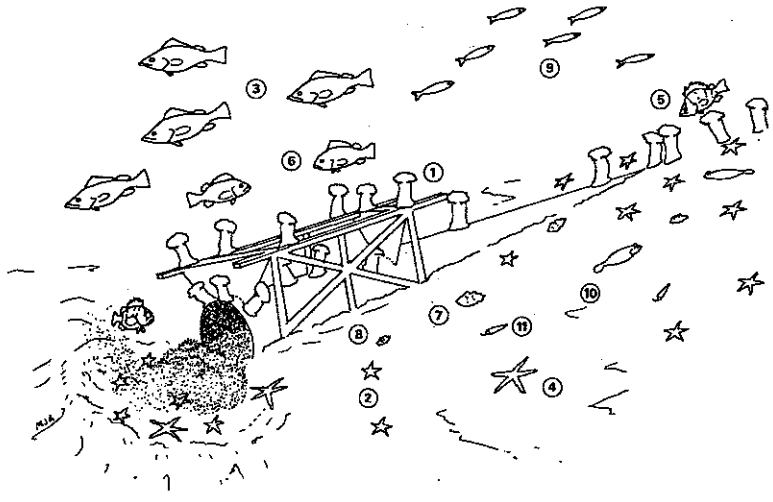

FIGURE 9.—Marine organisms found in 5 percent or more photographs taken at Region 7C. Numbers correspond to species shown in Table X. The sled used to drag the pipe to its present position is still attached to pipe. Since the pipe rotated when it was set, the runners are on the upper side.

common along both pipes at all depths. Among the larger species, gorgonians dominated the pipe in shallow water to about 50 m, where they were replaced by the large white sea anemone, *Metridium senile*, which was commonly found to 100 m.

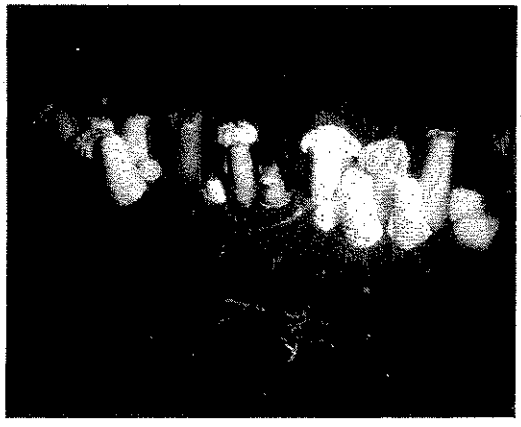

FIGURE 10.—Section of the Hyperion 7-mile sludge pipe at 60 m depth with sea anemones (*Metridium senile*), and Dover sole (*Microstomus pacificus*) on the pipe and sand stars (*Astropectin verrilli*) on the silt near the pipe. Pipe diameter 0.6m. Photographed by Harry Pecorelli.

This anemone was densely concentrated near the diffuser ports along the 8,000-m effluent pipe and near the end of the 11,000-m sludge pipe.

3. Water-column fishes were not abundant in shallow water near either pipe, but were abundant at greater depths. In general, the larger species were found near the ends of the pipes although this may be due to depth preferences of the species. It may be that they concentrate around any hard substrate at these depths, rather than to the outfall specifically. Schools and aggregations of these species may congregate there, using the pipes as points of reference, and, in addition, may find an abundance of food there.

4. The large rock ballast in shallow water on the 8,000-m pipe and the concrete anchor blocks on the 11,000-m pipe provide a suitable habitat for bottom-dwelling rockfishes, crabs, and lobsters that require crevices for refuge. Ballast rocks, although dropped almost 20 yr ago are relatively free of sediments and are covered with hydroids.

5. Differences in the marine life between the two pipes appear to be related to the differences in the diameters, depths of

discharge, and possibly construction materials of the two pipes. The 8,000-m pipe has a considerably greater diameter, providing more surface area for sessile organisms. The 11,000-m pipe discharges at a greater depth, resulting in a loss of species that are more common in shallower waters. The 11,000-m pipe also is constructed of different materials which may affect the abundance of attached organisms (such as some gorgonians).

6. The life on these pipes is similar to that found on other outfall pipes in southern California, although it is uncertain whether control rocky bottoms at greater depths have the same species.

7. To the north of the 11,000-m pipe, the sediment was finer and human debris and sand stars, *Astropectin verrilli*, were more abundant, suggesting a unidirectional current pattern with eddies resulting from the pipe structure.

In general then, these wastewater discharge pipes attract rocky bottom organisms characteristic of given depths and thus associations are formed that are very different from surrounding soft-bottom areas. Wastewater effects upon these organisms cannot be completely determined without comparable studies on similar hard bottoms at the same depths, although large sea anemones are concentrated near the discharge openings.

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