POLLUTION RELATED ALTERATIONS OF SOUTHERN CALIFORNIA DEMERSAL FISH COMMUNITIES

M. James Allen
Southern California Coastal Water Research Project
El Segundo, California

Abstract. Demersal fish communities in southern California show altered trophic structure, diversity, and species composition near wastewater discharge pipes. Although one recurrent group is attracted to the pipe, others lose some species or feeding types in outfall areas. Species feeding types on polychaetes or plankton are often more abundant, whereas species feeding on small epibenthic crustaceans are frequently absent. A fin erosion disease found in Dover sole (*Microstomus pacificus*) living near outfalls suggest toxic or irritational properties of the sediments. Outfall pipes attract hard bottom and schooling species that prey upon soft-bottom species.

INTRODUCTION

Municipal wastewater treatment plants discharge about one billion gallons of wastewater per day into the ocean off southern California. Three major sanitation districts in the Los Angeles area discharge 84 percent of this effluent from outfall pipes resting on the bottom at 60 to 100 meter depths. For the past seven years the Coastal Water Research Project has studied the effects of wastewater pollution on marine life in southern California (SCCWRP 1973; Mearns *et al*. 1976). In addition to other problems we have examined the effects of wastewater pollution on demersal fish communities. Fishes in these communities commonly occur on the soft-bottom (composed of sandy to silty sediments) habitat, the major bottom habitat in deep-water in this area. This paper summarizes the types of pollution related alterations that we have identified in southern California demersal fish communities.

MATERIALS AND METHODS

The Coastal Water Research Project, often in association with the Los Angeles County Sanitation Districts, City of Los Angeles Bureau of Sanitation, and County Sanitation Districts of Orange County, have collected some 800 otter trawl samples of demersal fishes and invertebrates throughout southern California to depths of 200 meters since 1971. Samples were collected with a 7.6 m (headrope) otter trawl with 1.25 cm cod-end mesh; trawls were towed for ten minutes at 4.6 km per hour (2.5 knots) along isobaths. Fishes and invertebrates were identified to species, measured, weighed, and examined for external diseases. We used additional samples methods including hook-and-line (Allen et al. 1975) and remote observational methods (i.e., photographs, movies, and video tapes) (Allen et al. 1976; SCCWRP 1977) to sample species that might be missed by trawling. Data from an additional 1700 trawl samples collected in southern California since 1912 have also been examined.

We defined fish communities by recurrent group analysis (Fager 1957, 1963) using data sets of 303 samples (SCCWRP 1973) and 448 samples (Mearns et al. 1976) and from this data I have described a resource partitioning model of these communities (Allen, in preparation). We analyzed the distribution of these communities and fish abundance, diversity, biomass, and numbers of species for regional and temporal variation and alterations occurring near discharge areas.

RESULTS

Demersal Fish Fauna and Communities

An average 10-minute otter trawl with a 7.6 m (25 ft) net in southern California captures about 175 fish representing 11 species and weighing 7.1 kg; average Brillouin and Shannon-Weaver diversities are 1.28 and 1.36, respectively (Allen and Voglin 1976). Some 2,500 samples have yielded 197 species of fish and nearly 400 species of invertebrates. Approximately 12 to 15 percent of the fish species are important members of soft-bottom communities. Six to seven recurrent groups containing two to eight species per group occur in one of three major depth zones (i.e., approximately 10-60, 50-140, or 100-400 m) (Figure 1). Most communities are composed of bottom fishes such as flatfishes (Pleuronectidae, Bothidae, and Cynoglossidae) and scorpaeniform fishes (Scorpaenidae, Cottidae, Agonidae, and Hexagrammidae). At shallow depths recurrent groups of schooling perciform fishes (Embiotocidae and Sciaenidae) are also found in addition to the bottom fish communities. Species in these communities generally represent one of 12 major feeding guilds (Allen, in preparation); species within a guild generally displace each other by depth and are found in different communities.

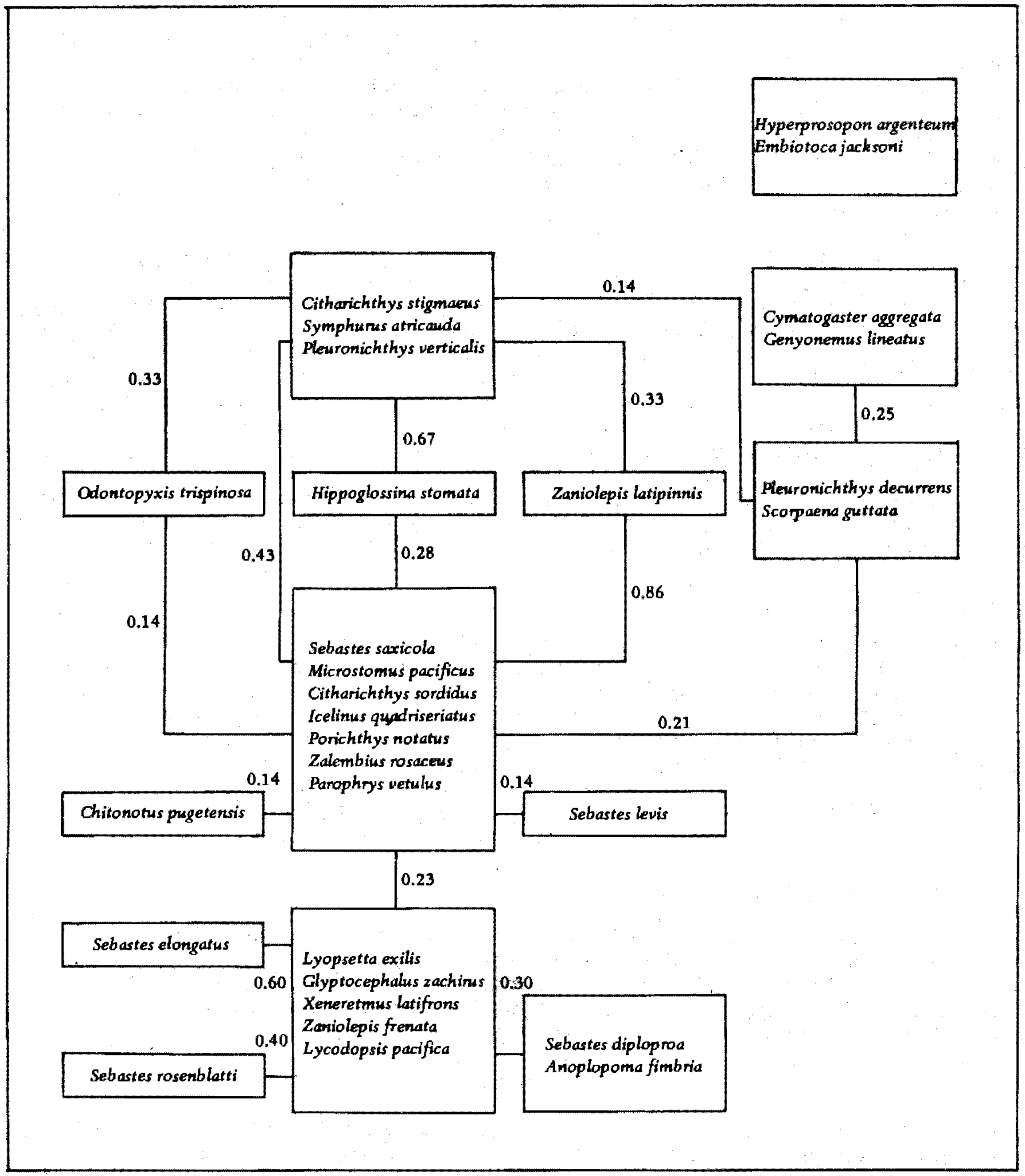
Effects on Fish Abundance, Diversity, and Biomass

Fish abundance and diversity is generally depressed in the immediate vicinity of outfall pipes (Mearns et al. 1976; Allen and Voglin 1976). Areas of enhanced abundance and biomass generally surround this region. On the Palos Verdes shelf an area of depressed average fish abundance occurs over an area of about 10.5 sq km and depressed numbers of species over an area of 19.5 sq km near the White's Point outfall. When the County Sanitation Districts of Orange County discontinued use of a shallow (15 m) outfall and began discharging through a deep (60 m) diffuser in San Pedro Bay, fish abundance increased 100 percent at the new outfall and decreased 50 percent at the old. While previous trawl surveys (1963 to 1974) revealed low fish abundance and diversity near the Hyperion 7-mile sludge pipe in Santa Monica Bay (Allen and Voglin 1976), a recent trawl and video tape examination of the sludge field indicated high fish abundance, biomass, and diversity (SCCWRP 1977) on the sludge deposits.

Effects of Fish Communities

A number of recurrent groups are incomplete in the immediate vicinity of the discharges, losing some but not all species. Some species were not found at all near the Los Angeles County Sanitation Districts' White's Point outfall on the Palos Verdes shelf, although it falls within their

Fig. 1. Recurrent groups of demersal fishes collected in 344 trawl samples in southern California at depths to 200m, June 1972 to December 1973.



normal depth range--the most obvious cases include the hornyhead turbot (Pleuronichthys verticalis) and the California tonguefish (Symphurus atricaudus). The plainfin midshipman (Porichthys notatus) and yellowchin sculpin (Icelinus quadriseriatus), both important community members, occur less than 25 percent of the time near the outfall.

The decreased occurrence of some species may be related to the increased occurrence of a potential competitor--for example, the hornyhead turbot drops out in an area where the congeneric curlfin sole (Pleuronichthys decurrens) is abundant and the pink seaperch (Zalembius rosaceus) occurs less frequently in areas where the shiner perch (Cymatogaster aggregata) occurs frequently.

While some species may be replaced by ecologically similar species, other species are not. A low abundance of suitable food organisms may account for the decreased occurrence of some species (i.e., cottids and agonids may occur in low frequency here because of a low abundance of small epibenthic crustacea). Alternatively, a rapid sedimentation rate from sewage particles may make the bottom unsuitable for small bottom-living fishes. Other species (such as the California tonguefish which probably locates polychaetes and bivalves by chemoreception) may avoid the area because of chemical properties of the sediments.

Certain species appear to occur more frequently or more abundantly near outfalls; these include the shiner perch, white croaker (Genyonemus lineatus), English sole (Parophrys vetulus), and Dover sole (Microstomus pacificus). All of these species feed on bottom dwelling organisms, presumably finding an abundance of polychaetes in the organically rich discharge sediments. An additional species, the Pacific electric ray (Torpedo californica) is generally abundant in outfall areas presumably feeding on the schooling shiner perch and white croaker. The shiner perch and white croaker are wide-ranging opportunistic species.

Small plankton-feeding rockfishes are frequently the most abundant species near the outfalls at middepths (i.e., 60 m) (Allen 1975), polychaete feeding flatfishes generally very abundant near outfalls at greater depths.

Effects of Outfall Pipes

The outfall pipes themselves, being hard substrate habitats, effect soft bottom fishes by attracting hard bottom organisms to the area (Allen et al. 1976). Deep-water outfall pipes generally have forests of sea anemones (Metridium senile); these forests and the ballast associated with the pipe provide refuge for a number of rockfishes (Sebastes spp.) that feed on bottom organisms. In addition, many schooling species such as bocaccio (Sebastes paucispinis) and shortbelly rockfish (Sebastes jordani) use the pipe as a point of reference for schools; larger species such as the bocaccio may prey frequently on perches and croakers found over the soft bottom.

Fish Diseases

A fin erosion disease that affects a number of species (particularly the Dover sole) on the Palos Verdes Shelf (Mearns and Sherwood 1976) is probably related to toxic or irritational properties of the sediment. Other diseases (papillomas in Dover sole and white croaker and tail erosion in white croaker) are apparently unrelated to outfall conditions.

DISCUSSION

In general, the wastewater discharge affects demersal fish communities by altering their trophic structure, diversity, and species composition. Depending upon the chemical and physical properties of the effluent discharged, the abundances of certain species may be enhanced or depressed.

Although a community composed of shiner perch and white croaker are apparently attracted to outfall conditions, other communities are often incomplete in outfall areas relative to areas distant from outfalls. Community members that drop out in these areas are sometimes replaced by ecologically similar species; when no replacement occurs the structure of the community (in terms of number of coexisting feeding guilds) has been simplified. Species are not replaced when food availability, habitat conditions, and chemical properties of the sediments are unsuitable. The organically rich sediments (and their associated polychaete populations) generally attract bottom-feeding fishes, although plankton-feeding rockfishes are often abundant near the discharge areas. A fin erosion disease in Dover sole appears to be related to physical or chemical properties of the sediments in these areas. The pipes themselves attract hard bottom organisms and schooling species to the area; among both groups are species that prey upon soft bottom species.

LITERATURE CITED

Allen, M. J. 1975. Regional variation in the structure of fish communities. Annual Report for the Year Ended 30 June 1975, p. 99-102. Southern California Coastal Water Research Project.

Allen, M. J., J. B. Isaacs, and R. M. Voglin. 1975. Hook-and-line survey of demersal fishes in Santa Monica Bay. TM 222. Southern California Coastal Water Research Project. 23 pp.

Allen, M. J., H. Pecorelli, and J. Word. 1976. Marine organisms around outfall pipes in Santa Monica Bay. J. Water Pollut. Control Fed. 48(8): 1881-93.

Allen, M. J. and R. Voglin. 1976. Regional and local variation of bottom fish and invertebrate populations. Annual Report for the Year Ended 30 June 1976, p. 217-221. Southern California Coastal Water Research Project.

Fager, E. W. 1957. Determination and analysis of recurrent groups. Ecology. 38:586-595.

Fager, E. W. 1963. Communities of organisms. In M. N. Hill (editor), The Sea, Vol. 2, p. 415-437. John Wiley and Sons, N. Y.

Mearns, A. J., M. J. Allen, L. S. Word, J. Q. Word, C. S. Greene, M. J. Sherwood, and B. Myers. 1976. Quantitative responses of demersal fish and benthic invertebrate communities to coastal municipal wastewater discharges. Final Report to Environmental Protection Agency, Grant R801152. Southern California Coastal Water Research Project. Vol. 1, 67 pp.; Vol. 2, 179 pp.

Sherwood, M. J. and A. J. Mearns. 1974. Disease responses in southern California coastal fishes. Proceedings of the Conference on Marine Biology in Environmental Protection. Report NUC TP 443, Naval Undersea Center, San Diego, California.

Southern California Coastal Water Research Project. 1973. The ecology of the Southern California Bight: Implications for Water Quality Management. TR 104. Southern California Coastal Water Research Project, 531 pp.

Southern California Coastal Water Research Project. 1977. Interim report on the effects of sludge in Santa Monica Bay. TM 228. Southern California Coastal Water Research Project, 56 pp.