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DISEASE RESPONSES IN SOUTHERN CALIFORNIA COASTAL FISHES

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ABSTRACT

The nearshore demersal fish communities of southern California have been extensively monitored by public and private agencies since 1969. The Southern California Coastal Water Research Project has assembled and analyzed much of the data in order to evaluate the health of local populations. One approach has been to investigate the frequency of diseased or anomalous specimens. Diseases with external symptoms may be easily observed and quantified in the field, and the presence of diseased individuals in a given habitat may be indicative not only of the health of the population but also of an imbalance in the community.

A number of disease conditions were recorded during the trawl surveys. Of these, only fin erosion in the Dover sole (*Microstomus pacificus*) appeared to be directly related to wastewater discharge sites. At present, there are no direct links between the identifiable field effect and the suspected causes. A laboratory program has been designed to determine the role of microorganisms and physical/chemical factors in the disease response.

The biological effects of toxic substances have been studied at the organism, tissue, cellular, and subcellular levels. Although a number of measurement indices have been proposed, it has often been difficult to select an experimental test response that can explain and predict field conditions. Disease is one response that may serve to tie the experimental and the descriptive together in investigations of fish populations and communities.

In planning an experimental program based on disease response, it is important to select a response that may result from exposure to toxic conditions in the environment as opposed to a syndrome that may be developmental, hereditary, or density dependent. Such a selection can be made on the basis of an adequate supply of survey data close to and distant from the regions of concern and on a comparison of the frequency, geographical and temporal distributions, size range, gross characteristics, histology, and bacteriology of affected and nonaffected specimens. This paper illustrates analyses involved in the identification of a disease response appropriate for toxicity testing.

The demersal fish communities of southern California have been extensively monitored by private and public agencies since 1969 (table 1). The Southern California Coastal Water Research Project, as part of its overall program, has assembled, analyzed, and added to these data in attempting to determine the effects of man's activities on the ecology of the coastal waters. The Project's primary study area, stretching from Point Conception to the U. S. - Mexico border, contains discharge facilities that contribute approximately 1.4×10^9 cu m of treated municipal wastewaters, 0.25×10^9 cu m of discrete industrial wastes, and 7.7×10^9 cu m of returned cooling waters (reference 1) to the coastal waters each year. One of our major objectives has been to distinguish population and community variations caused by human activities from those resulting from natural fluctuations. The trawling surveys were conducted off the coasts of Ventura, Los Angeles, and Orange Counties at depths of 10 to 400 m. Although a variety of gear and vessels were used, all surveys were performed with small otter trawls.

Table 1. Agencies contributing trawl data on southern California demersal fish communities.

Agency and sampling area	Sampling frequency	Sampling period, 1973	No. of samples, 1973
CITY OF LOS ANGELES			
Santa Monica Bay	irregularly	Apr	9
LOS ANGELES COUNTY SAN. DIST.			
Palos Verdes	biannually	Mar, Jun	63
S. Catalina I.	biannually	Jun	21
ORANGE CO. SAN. DIST.			
San Pedro Bay	quarterly	Feb, May, Sep	24
OCCIDENTAL COLLEGE*			
Palos Verdes	—	Oct	1
COASTAL WATER PROJ.			
Dana Point	quarterly	Feb, May, Aug	24
Santa Monica Bay	annually	Sep	9
Palos Verdes	annually	Sep	9
San Pedro Bay	annually	Sep	9

**Occidental College also samples other southern California areas on a continuous basis; however, data from these trawls were not considered here.*

External diseases were grouped into several general categories:

- Fin erosion, seen most frequently in the Dover sole (*Microstomus pacificus*) (figure 1), white croaker (*Genyonemus lineatus*), and rex sole (*Glyptocephalus zachirus*).
- Tumors, most common in the Dover sole (figure 2) and white croaker.
- Exophthalmia.
- Ambicoloration.
- Structural deformities.
- Parasites.

In a September, 1973, synoptic survey in which Santa Monica Bay, the Palos Verdes shelf, and San Pedro Bay were trawled using one vessel and one set of gear, approximately 2.5 percent of the fishes collected were obviously diseased or anomalous.

In 169 trawl samples taken by public and private agencies from Point Dume to Dana Point, California, in 1973, fin erosion was found in five times as many species as the tumor diseases. The 20 species with fin erosion and the four species with tumor-like growths (table 2) can be generally grouped as follows:

	Number of Species with Disease	
Type of Fish	Fin Erosion	Tumors
Right-eyed flounders	7	1
Tonguefishes	1	1
Rockfishes	4	–
Perches	2	1
Croakers	1	1
Eelpouts	1	–
Cusk-eels	1	–
Sablefishes	1	–
Combfishes	1	–
Midshipmen	1	–

The number of species affected with a disease can help to define its nature in that an environmental disease is likely to appear in more species than a disease that is developmental or related to population density.

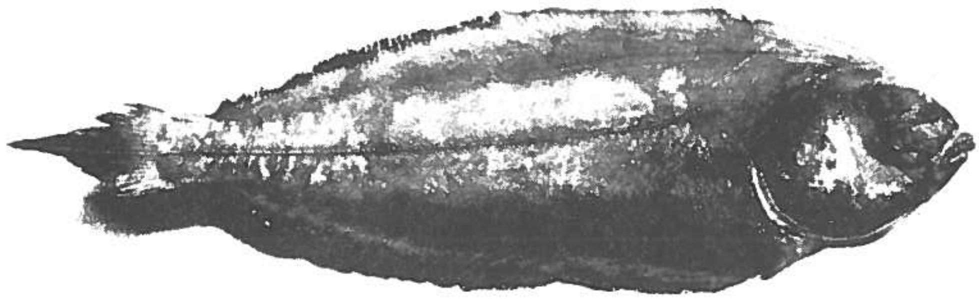

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Figure 1. Severe fin erosion in the Dover sole, *Microstomus pacificus.*

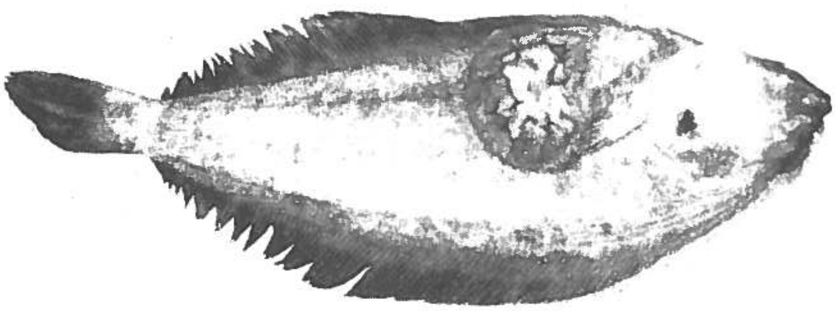

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Figure 2. Epidermal papilloma on the blind side of the Dover sole.

Table 2. Species with fin erosion and tumors collected in southern California coastal waters, 1973.

Species	Common Name
FIN EROSION	
Porichthys notatus	Plainfin midshipman
Chilara taylori	Spotted cusk-eel
Lycodopsis pacifica	Blackbelly eelpout
Genyonemus lineatus	White croaker
Cymatogaster aggregata	Shiner perch
Phanerodon furcatus	White seaperch
Sebastes elongatus	Greenstriped rockfish
Sebastes jordani	Shortbelly rockfish
Sebastes miniatus	Vermilion rockfish
Sebastes rubrivinctus	Flag rockfish
Anoplopoma fimbria	Sablefish
Zaniolepis frenata	Shortspine combfish
Eopsetta jordani	Petrale sole
Glyptocephalus zachirus	Rex sole
Lyopsetta exilis	Slender sole
Microstomus pacificus	Dover sole
Parophrys vetulus	English sole
Pleuronichthys decurrens	Curlfin sole
Pleuronichthys verticalis	Hornyhead turbot
Symphurus atricauda	California tonguefish
TUMORS	
Genyonemus lineatus	White croaker
Cymatogaster aggregata	Shiner perch
Microstomus pacificus	Dover sole
Symphurus atricauda	California tonguefish

The synoptic survey of 1973 provided a means to compare disease incidences in different areas without the influence of gear variations. There was a distinct elevation in both the number of species with fin erosion and in the frequency of fin erosion in Dover sole and rex sole captured off the Palos Verdes Peninsula (table 3). This pattern alone suggests that the fin erosion disease was the result of a very localized and circumscribed event and that it was location-dependent (figures 3 and 4). The incidences of tumor-bearing Dover sole, however, were comparatively low in all three areas (figure 5).

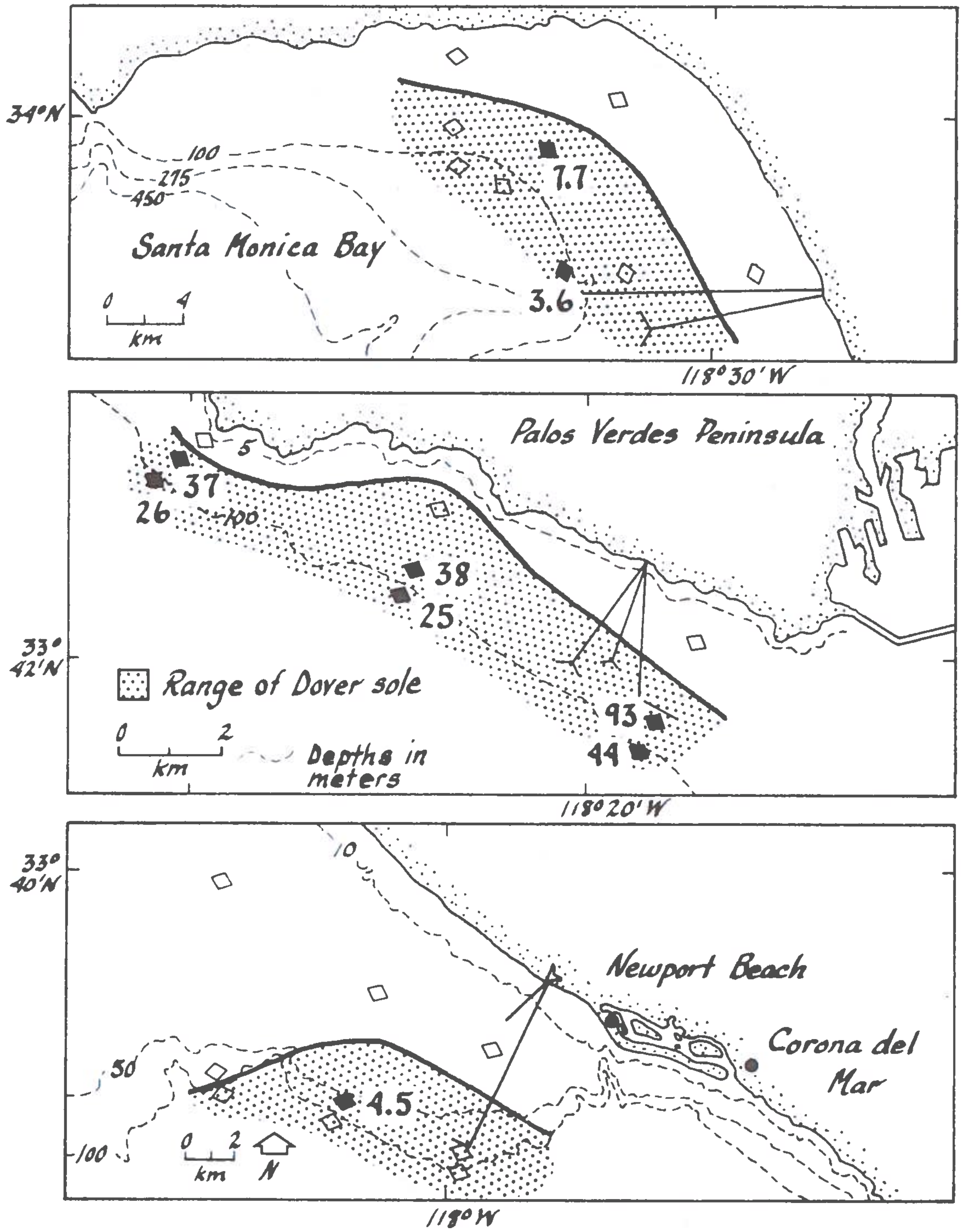


Figure 3. Geographical distribution of fin erosion in Dover sole, September 24-26, 1973 (numbers are percentages).

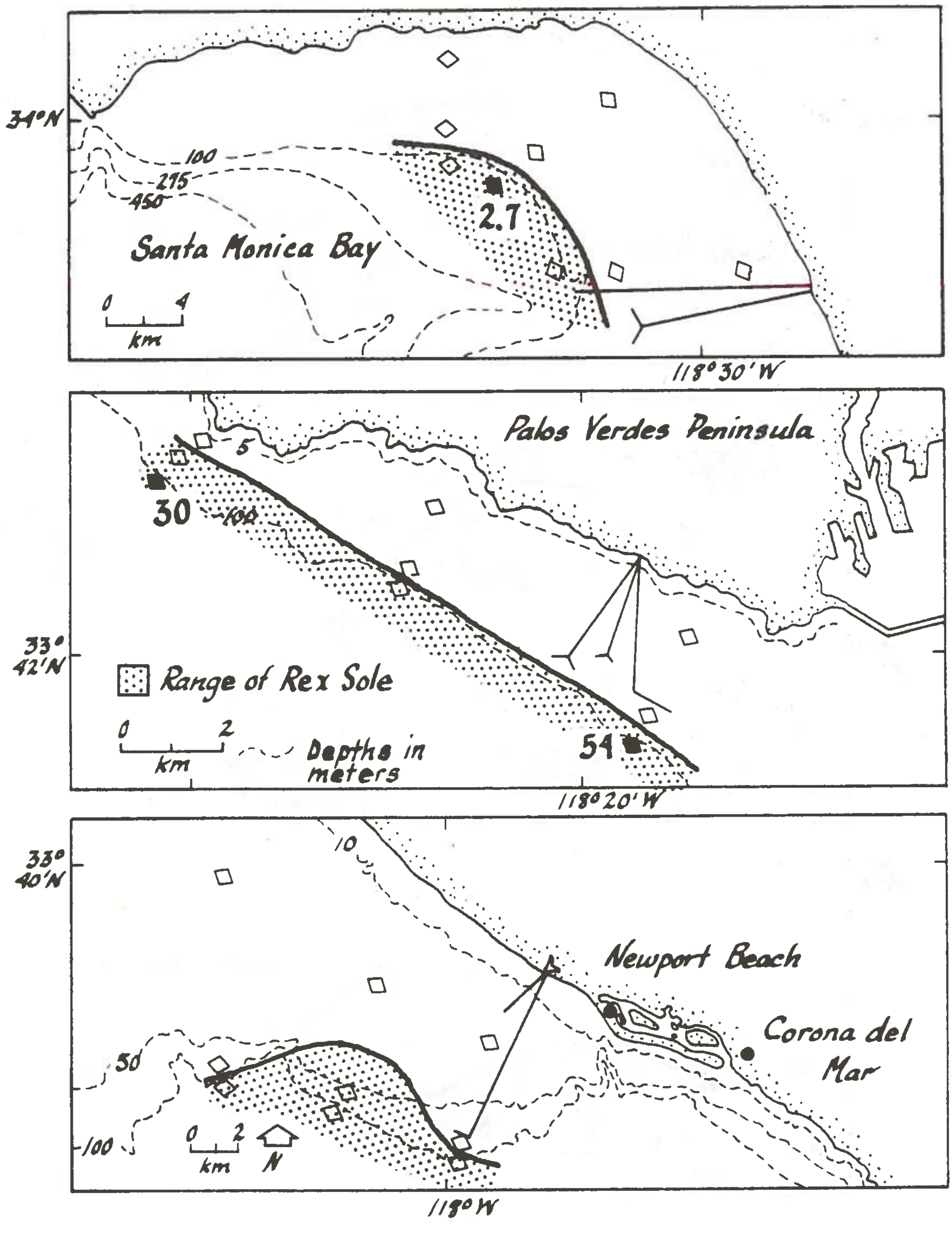


Figure 4. Geographical distribution of fin erosion in rex sole, September 24-26, 1973 (numbers are percentages).

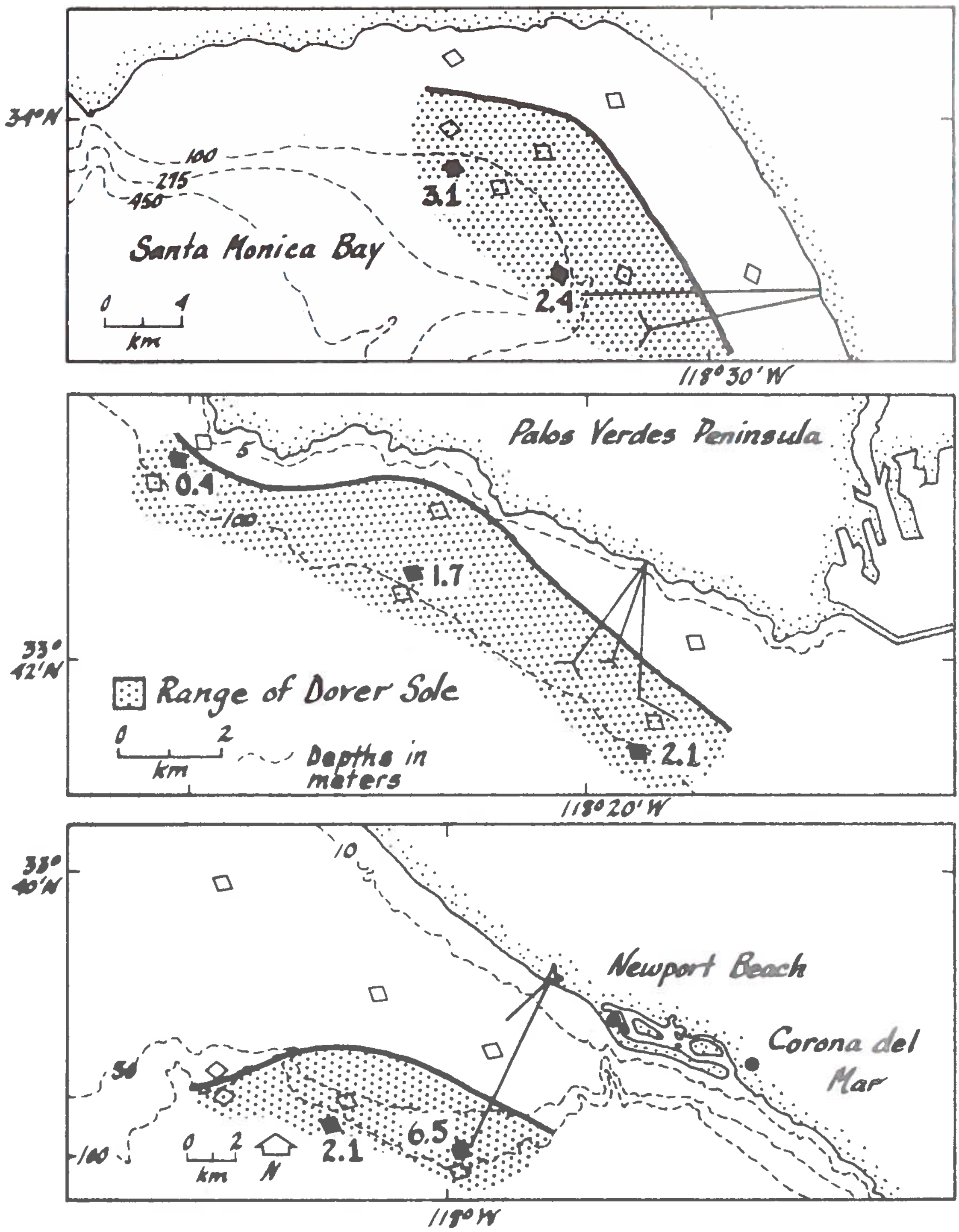


Figure 5. Geographical distribution of tumors in Dover sole, September 24-26, 1973 (numbers are percentages).

Table 3. Species with fin erosion and tumors collected in a synoptic trawl survey of three southern California localities, September 24-26, 1973.

Area and species	Total No. of fish	Fin erosion No.	Fin erosion %	Tumors No.	Tumors %
SANTA MONICA BAY					
Dover Sole	239	5	2.1	4	1.7
Slender sole	196	8	4.1		
Rex sole	57	1	1.8		
PALOS VERDES SHELF					
Dover sole	651	238	37	4	0.6
Rex sole	71	24	34		
Curlfin sole	208	1	0.5		
Shortbelly rockfish	69	1	1.4		
White croaker	195	2	1.0		
SAN PEDRO BAY					
Dover sole	256	4	1.5	4	1.6
California tonguefish	297	1	0.3		
Plainfin midshipman	103	1	1.0		

Studies in northern California and the Pacific Northwest have shown fish size and age to be important in the investigation of fish diseases. Off Palos Verdes, where the incidence of Dover sole with fin erosion was high, affected individuals ranged in size from 70 to 240 mm S.L. while apparently healthy specimens ranged from 40 to 280 mm (figure 6). Santa Monica Bay Dover sole with fin erosion (collected in the same survey) were in a more restricted size range (120 to 200 mm). Off Orange County, individuals with fin erosion also appeared generally restricted to the larger size classes, greater than 160 mm. Standardized seasonal trawl surveys conducted off Orange County in 1973 revealed that the number and size range of Dover sole with fin erosion increased in association with an influx of subadults into the area in May, 1973, and decreased with the migration of subadults offshore in September (figure 7). Therefore, migration of larger diseased individuals could account for the occurrence of Dover sole with fin erosion in San Pedro and Santa Monica Bays. A disease that is location-dependent would tend to be centered in one area and prevalent in individuals of many sizes. A developmental disease would more likely affect fish in the same size range in each area.

Tumor-bearing Dover sole were found predominately in the 70 to 130 mm S.L. size range in each survey area. Studies of tumor-bearing flatfish in northern California and the Pacific Northwest have shown that, in these areas, young fish one to two years old also have

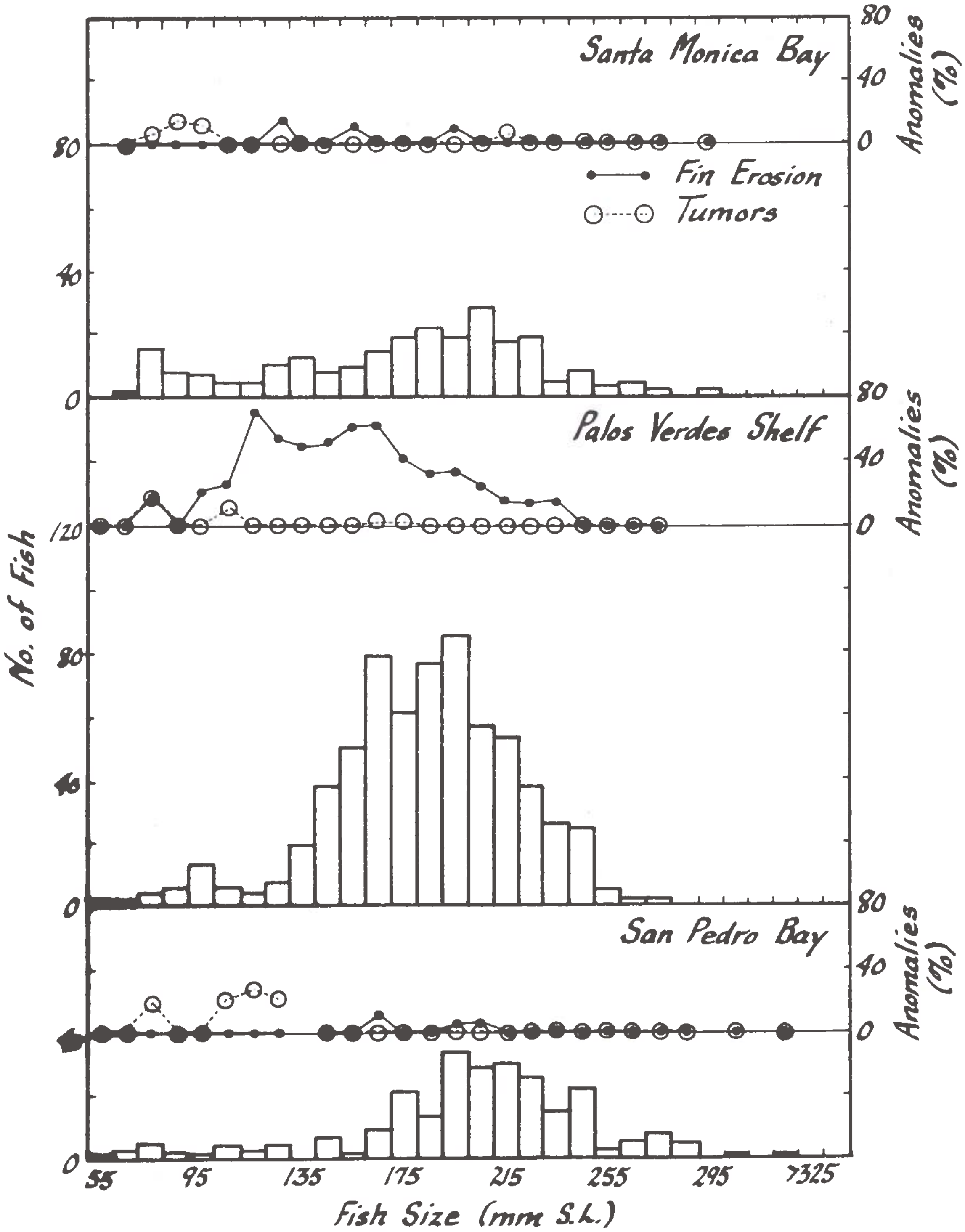


Figure 6. Prevalence of fin erosion in Dover sole captured in three locations off southern California in a synoptic trawl survey, September, 1973.

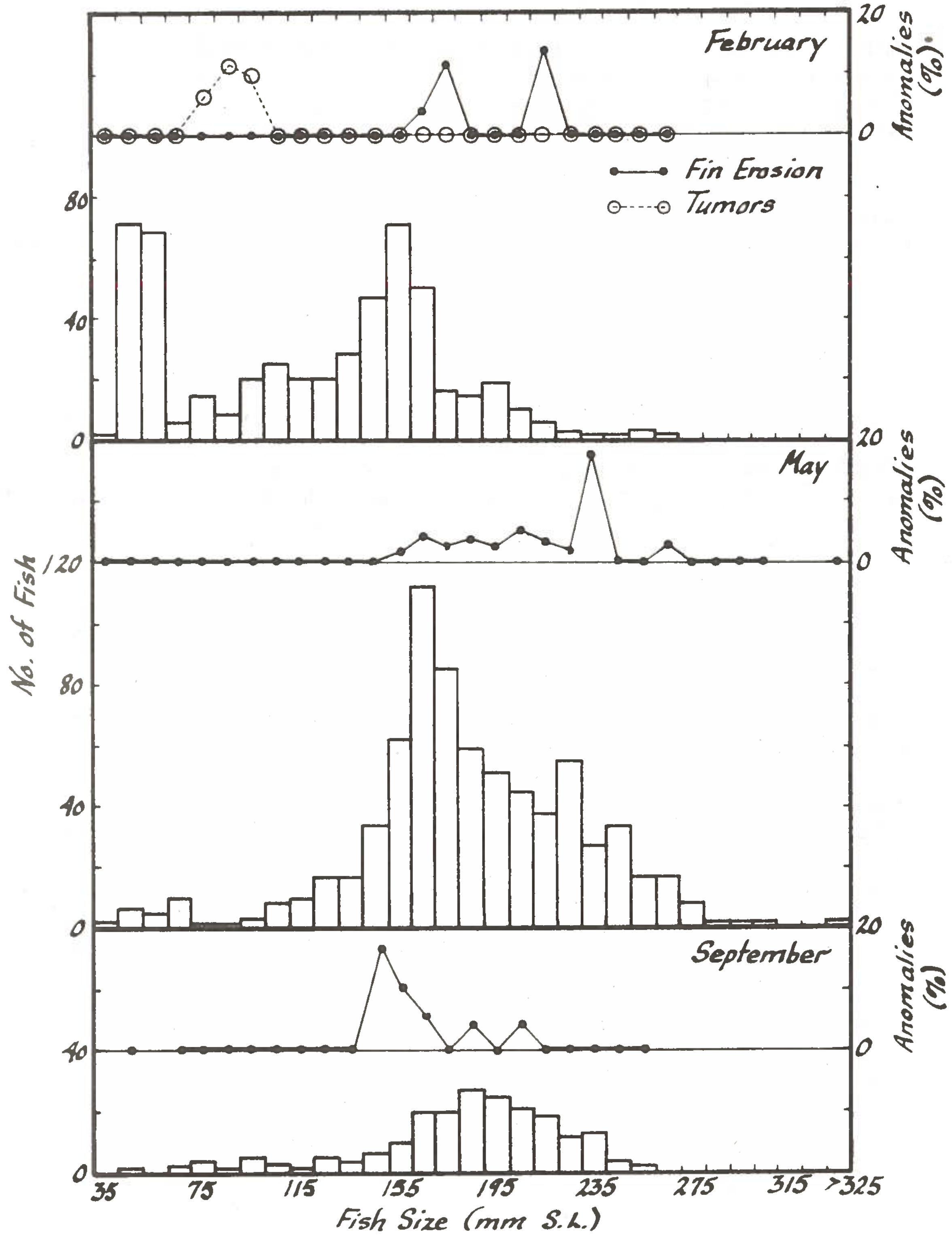


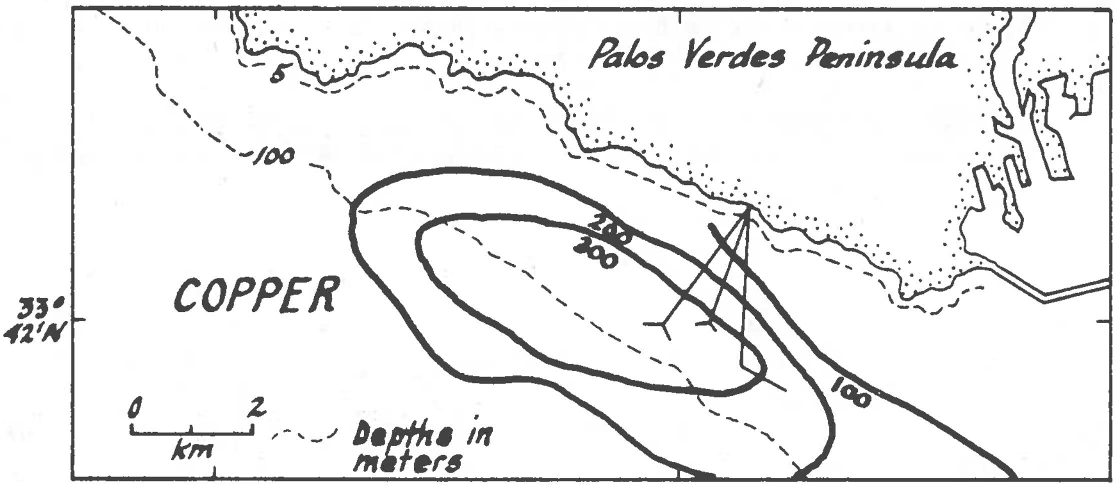
Figure 7. Prevalence of fin erosion in Dover sole captured in San Pedro Bay trawl surveys, 1973.

the highest incidence of tumors (references 2 and 3). In southern California, prevalence of tumor-bearing specimens less than 130 mm S.L. were 5.7 percent in Santa Monica Bay (N = 53), 4.3 percent on the Palos Verdes shelf (N = 46), and 13 percent in San Pedro Bay (N = 30).

It therefore appears that fin erosion in the Dover sole and several other species in a location-dependent disease, occurring primarily on the Palos Verdes shelf. In contrast, the tumor syndrome in the Dover sole seems more like a developmental disease with an incidence that may be influenced by factors that change or modify population structure.

Histopathological analysis of the fin erosion disease in the Dover sole (reference 4) showed early changes to involve fraying of the fins followed by denuding of the tips of the fin rays. A characteristic black line formed along the edge of the eroding fins. Later, degeneration of the bony rays and fin thickening due to fibroplasia in the skin between and around the fin rays also occurred; in some cases, the entire fin was gone. Lymphocytic infiltration was sparse or absent, and application of various histological stains failed to demonstrate bacterial, fungal, or protozoal organisms associated with the fin lesions. No differences between the viscera of affected and nonaffected fish were noted, but the gills of some affected Dover sole had a mildly hyperplastic respiratory epithelium. Light microscopy also revealed that apparently unaffected individuals had microscopic symptoms of the disease.

The histopathological data suggested that the disease was the result of external infection or irritation and was not systemic in nature. The fact that the most severe lesions were found on the midportion of the dorsal and anal fins suggested that their development might be associated with movement and contact of these fins with the bottom sediment. The bottom sediment could cause the initial damage by extreme pH, high hydrogen sulfide content, or high trace metal content; any of these conditions could cause coagulation of the protective mucus on the skin and subsequent cellular necrosis of the fins. The undulation of the middle portion of the dorsal and anal fins during swimming, and the use of these fins for burrowing into the sediment, could cause this portion of the fish's skin to lose mucus rapidly and thus predispose the underlying epidermal cells to the chemical irritants in the sediments or to bacterial attack. A study of contamination of the surface sediments off the Palos Verdes Peninsula (reference 1) showed higher concentrations of most trace metals measured (except iron and manganese) in the sediments to the northwest of the northernmost outfall. The highest concentrations of copper in this area, for example, were approximately 10 times those observed near shore or 6 to 10 km southeast of the outfall (figure 8). Concentrations of total DDT and PCB in the surface sediments were highest both near the outfalls and to the northwest (figure 8). Measurement of trace metals in Dover sole liver and total DDT and PCB in flesh revealed that, although sediment DDT values were reflected in tissue levels, metal concentrations were not (reference 1).



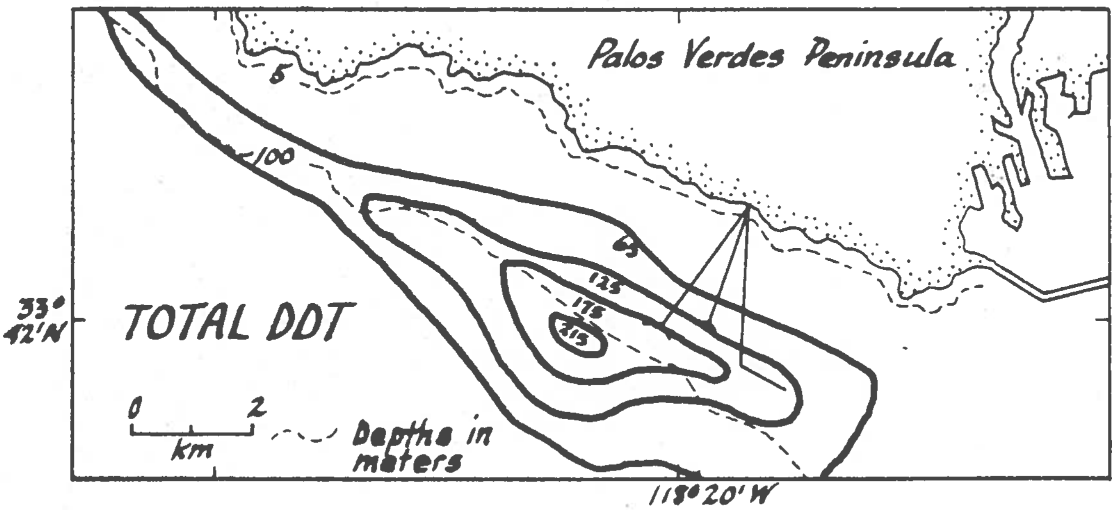


Figure 8. Geographical distribution of copper (mg/dry kg, May, 1970) and total DDT (mg/dry kg, June, 1972) in surface sediments on the Palos Verdes shelf.

Two major processes function in the occurrence of diseased individuals in a natural community—initiation and maintenance. The specific factors responsible for initiating the Dover sole fin erosion disease are unknown at this time and require further field and laboratory investigations. The great abundance of Dover sole with eroded fins off the Palos Verdes Peninsula suggests that the disease is being maintained in the population through high survival. Not much is known about southern California Dover sole populations, but the species now dominates trawl catches in the Palos Verdes area.

The importance of the fin erosion disease is not its impact on the Dover sole population of the Southern California Bight, which appears to be slight, but its potential use as an indicator of a toxic environment.

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SHERWOOD

DISCUSSION

AUSTIN: Have you ever found any thick growths, called microsporidia, on the surface of the fish? They look like little black dots.

SHERWOOD: No. However, the bottom (or blind) sides of the Dover sole off Palos Verdes have dark spots, or diffuse pigmentation, while the Dover sole from Catalina Island are white on the blind side. We haven't been able to associate the color difference with any parasitic agent as yet.

AUSTIN: I'm not sure what type of parasites they are. We get them in the Long Island area. The older the fish gets, the bolder the black spots get.

QUESTION: Has there been any chemical analysis made on the black fins? I'm wondering about the possibility of sulfide through implantation.

SHERWOOD: We have looked at DDT in the flesh, as well as at metals in the liver. So far, we've found that the fish tissue concentrations reflect sediment concentrations of DDT. The metals in the liver don't reflect sediment concentrations. We haven't yet looked at the concentrations in the fins themselves.

QUESTION: What is the depth level of the outfalls?

SHERWOOD: The Whites Point outfalls are at about 50 to 60 m; the Hyperion five-mile outfall is at 60 m, and the seven-mile outfall is at 100 m.

QUESTION: Is there a corresponding disease in invertebrates in the area you've been studying?

SHERWOOD: We haven't really looked at invertebrate diseases yet. With respect to fish, we do know that the Palos Verdes area has the largest number of species that do have fin erosion. In some catches of Dover sole, as many as 90 percent have eroded fins. The rex sole is next in frequency, with prevalence of fin erosion in some catches as high as 50 percent.

AUSTIN: On the East Coast, fish have parasites that erode their gills. We find a number of isopods in the gills up to a certain size of fish. After that you never find fish with parasites at all. I think the fish die—they don't have any more gills, and can't breathe. Maybe you're dealing with a similar situation. The fish that have the parasites die.

SHERWOOD: It is a possibility. The California Department of Fish and Game has done some trawling at deeper depths off the Palos Verdes Peninsula, and even with larger trawl net mesh sizes, they have found very few large Dover sole. So we really don't know whether or not Dover sole are maturing in the area.