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AN OTTER TRAWL SURVEY OF SANTA MONICA BAY, MAY-JUNE 1972

Alan J. Mearns
Merrill James Allen
Marjorie Sherwood

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
1500 East Imperial Highway, El Segundo, California 90245

INTRODUCTION

During 1958-63, the Bureau of Sanitation of the City of Los Angeles and the California Department of Fish and Game conducted quarterly trawls in Santa Monica Bay, California. The primary objective of the survey, which is described by Carlisle (1969), was to study the effects of the discharges of the Hyperion Sewage Treatment Plant outfalls on the fishes of the Bay. During the 6-year period, 104 fish species were captured, with annual catches fluctuating fivefold (50 to 250 fish per sample). Only minor changes in the distribution of several species could be attributed to the discharges of wastewater (261 to 283 million gallons daily) or sludge (130 to 156 tons/day) into the Bay.

It was recommended that trawl sampling be conducted at 5- to 10-year intervals to observe possible long-term trends. Therefore, a trawl program was again initiated in 1970 by the staff of the Hyperion Treatment Plant. In 1971, biologists from the Southern California Coastal Water Research Project assisted in three surveys, which were summarized by the Project in its 3-year report (1973). These surveys indicated (1) that no substantial changes in the abundance of bottom fish had occurred since the 6-year trawl study, and (2) that bottom fish distributions appeared to have some relationship to the dissolved oxygen (D.O.) concentrations and temperature of bottom water.

To further investigate this second finding, the Coastal Water Project and Hyperion conducted one additional survey in the spring of 1972. The objectives of the survey were (1) to obtain data needed in determining the influences of D.O., temperature, and salinity on the distributions of bottom fish and (2) to extend observations on normal and diseased fish to areas not sampled in the previous surveys. The results of this survey are described in this memorandum.

METHODS

The 1972 survey of Santa Monica Bay was conducted between 23 May and 2 June aboard the R/V Marine Surveyor, City of Los Angeles. All hauls were made with a Wilcox trawl (manufactured in Mystic, Connecticut) with a 24-ft headrope and 1-1/2-in. stretch mesh cod end. The otter boards measured 12-1/4 by 24 in. and were attached to the headrope and footrope with 31-ft leg lines. Bridles were attached, and the net was towed single-warped for 10 min. (bottom-time) at 1.5 kn. The trawl net and towing speed were identical to that used in the 1958-63 survey except that the cod-end mesh in the earlier study was 1/4- and 1/2-in.

Trawls were conducted at 34 stations, ranging in depth from 18 to 200 m and covering most of Santa Monica Bay from Malibu on the northwest to Redondo Canyon on the south (Figure 1). Fish and invertebrates were sorted, counted, and measured on board ship. The standard length of fishes in small catches was determined to the nearest millimeter; specimens in large catches were measured to the nearest centimeter. All specimens were examined for external signs of disease and parasites. A number of photographs were taken of diseased fish, and internal organ imprints and smears of several species were made for future reference. In addition, specimens of Dover sole were frozen for analyses of pesticide and trace element content.

Bottom water D.O., temperature, and salinity were measured at the end of the trawl transect after 30 of the 40 hauls, using submerged probes attached to a Martek analyzer. Unfortunately, the first day of measurements indicated that D.O. was not correctly recorded on the instrument; we subsequently measured D.O. chemically from bottle samples using the modified Winkler titration method.

RESULTS

Bottom Water Data

Table 1, which lists the water quality data taken in the survey, shows the marked discrepancy in the D.O. values obtained by the Martek analyzer and by Winkler titration. Readings were taken by both methods after 14 of the trawls: With a few exceptions, the Martek analyzer was producing readings about 4 mg/L below those obtained by titration (Figure 2). We assumed that the data obtained by titration were approximately correct and plotted bottom D.O. contours from these values.

Figure 3 shows that bottom water D.O. values were low at mid-depths (61 m) at the north and south edges of Santa Monica Bay, and, with one exception, apparently high in both shallow and deeper water. Several of the D.O. values from the deepest waters were much higher than expected based on previous observations (which had indicated that D.O. generally decreases with depth into Santa Monica Bay.) Low D.O. at mid-depths is usually indicative of intrusions or mixing of saline, cold basin waters. However, the waters at three of the four stations where D.O. was lowest were not unusually cold or saline

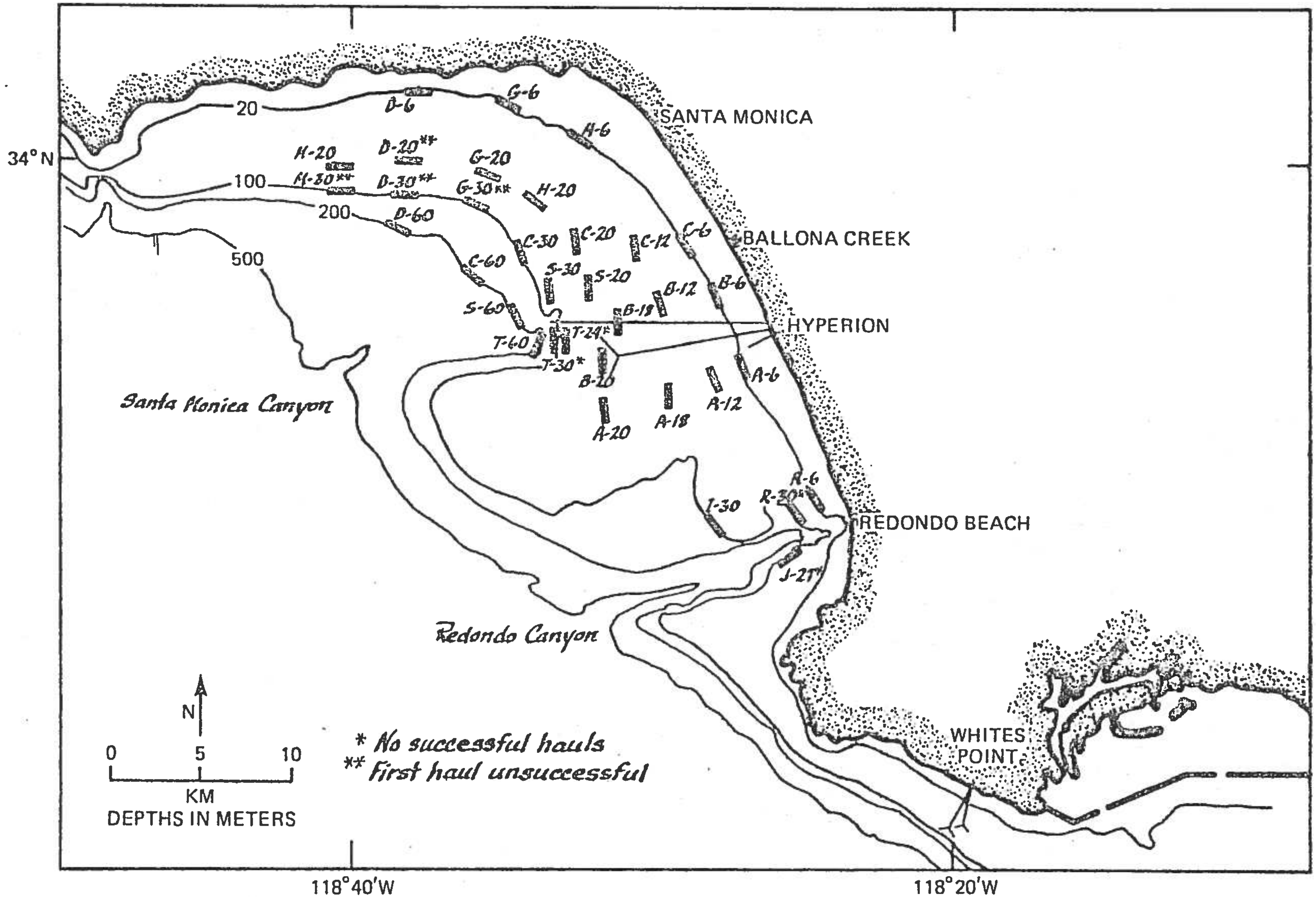

Figure 1. Stations trawled, Santa Monica Bay survey, May-June 1972.

Table 1

HAUL AND STATION CHARACTERISTICS, SANTA MONICA BAY SURVEY, MAY–JUNE 1972

Station	Latitude	Longitude	Depth (m)	Date	Time of Day	Dir. of Haul	Bottom Physical Measurements: Depth of Measurement (m)	Temp. (°C)	Salinity	Dissolved O_2: Martek	Chem.	No. of Indiv.	No. of Species	Shannon-Weaver Diversity
A-6	33°54'30"	118°26'50"	18	5/24/72	0930	S	18.5	15	33.3	3.3	7.6	3	2	0.63
A-12	33°54'10"	118°28'10"	36	5/23/72	1015	S	38	11.5	34.4	1.0	4.5*	157	11	1.60
A-18	33°53'40"	118°30'20"	55	5/23/72	1100	N	51	11	35.0	1.2	4.7*	178	11	1.81
A-20	33°53'30"	118°31'20"	61	6/01/72	0950	S	61	10.5	32.9	3.9	7.6	14	3	1.00
B-6	33°56'00"	118°27'30"	18	5/24/72	0847	S	19	15	33.3	2.9	6.4*	90	9	1.13
B-12	33°55'50"	118°29'00"	36	5/23/72	0940	S	41	12	34.0	1.6	5.1*	231	17	2.11
B-18	33°55'10"	118°30'50"	55	5/23/72	1140	N	54	11	35.5	1.1	4.6*	167	9	1.40
B-20	33°54'30"	118°31'20"	61	6/01/72	0920	S	62	10	34.0	–	4.2	57	5	1.09
C-6	33°57'30"	118°28'50"	18	5/23/72	0835	N	20	14	33.2	2.8	6.3*	78	8	1.00
C-12	33°57'30"	118°30'20"	36	5/23/72	0905	N	41	12	34.0	2.2	5.7*	236	14	1.51
				5/26/72	0830	N	40	11	33.0	1.0	4.5	241	12	1.42
C-20	33°57'30"	118°32'20"	61	5/26/72	0930	N	66	–	–	0.8	5.0	98	10	1.38
C-30	33°57'20"	118°34'00"	91	6/02/72	1100	S	66	11.5	32.8	0.0	5.1	202	20	2.09
C-60	33°57'00"	118°35'30"	182	6/01/72	1100	N	–	–	–	–	3.6	45	8	1.84
D-6	34°01'50"	118°37'30"	18	5/25/72	1015	N	18	14	33.2	3.0	8.2	90	10	1.59
D-20	34°00'00"	118°37'30"	61	5/26/72	1130	N	–	–	–	–	–	6**	4	1.33
				5/26/72	1155	S	58	11	33.0	1.0	5.0	291	16	1.92
D-30	33°59'10"	118°37'30"	91	5/26/72	1300	S	70	11	34.0	1.4	4.5	35	10	2.02
				6/01/72	1130	N	–	–	–	–	–	1**	1	0.00
D-60	33°58'30"	118°38'00"	182	6/01/72	1200	N	–	–	–	–	7.0	15	6	1.68
G-6	34°01'20"	118°34'10"	18	5/25/72	0940	N	20	13	32.7	1.2	5.2	131	7	1.04
G-20	33°59'40"	118°35'10"	61	5/26/72	1050	N	–	–	–	–	–	160	13	1.98
G-30	33°58'50"	118°35'40"	91	6/02/72	0930	N	–	11	33.0	–	–	6**	2	0.45
				6/02/72	1010	S	–	–	–	–	–	84	10	1.86
H-6	34°00'40"	118°32'30"	17	5/25/72	0910	N	18.5	14	32.9	5.0	5.5	124	8	1.01
H-20	33°59'00"	118°33'40"	55	5/26/72	1010	N	54	11	34.0	0.6	4.6	337	13	1.14
I-30	33°50'00"	118°28'00"	91	5/24/72	1315	N	85	10	34.4	0.4	3.9*	23	6	1.30
J-27	33°49'00"	118°25'30"	82	5/24/72	1145	S	–	–	–	–	–	1**	1	0.00
M-20	33°59'50"	118°40'00"	61	5/25/72	1120	S	59	11	33.5	1.2	4.0	127	10	1.90
M-30	33°59'20"	118°40'00"	91	5/25/72	1145	S	–	–	–	–	–	1**	1	0.00
				5/25/72	1220	N	82	11	33.5	1.4	5.2	59	9	0.80
R-6	33°50'40"	118°24'20"	18	5/24/72	1020	S	19	12	33.2	–	–	51	4	0.36
R-30	33°50'40"	118°24'50"	91	5/24/72	1100	S	53	11	33.5	–	4.5	14**	4	1.03
S-20	33°56'00"	118°31'20"	61	5/23/72	1212	N	50	11	35.5	1.2	–	310	12	1.30
S-30	33°55'50"	118°33'00"	91	5/31/72	1100	N	65	11	32.5	2.6	4.6	27	6	1.27
S-60	33°55'50"	118°34'20"	182	5/31/72	1200	S	–	–	–	–	–	209	15	2.11
T-24	33°55'00"	118°32'40"	73	6/02/72	1245	N	–	–	–	–	–	17**	4	1.00
T-30	33°55'00"	118°33'00"	91	5/31/72	0930	N	–	–	–	–	–	1**	1	0.00
				5/31/72	1015	S	–	–	–	–	–	4**	2	0.00
T-60	33°55'10"	118°34'10"	182	5/31/72	1300	S	–	–	–	–	8.0	17	5	1.40

* Hypothetical chemical measurement based on actual Martek measurement plus a correction factor of 3.5 ± 3.
** Trawl unsuccessful (net twisted or ripped).

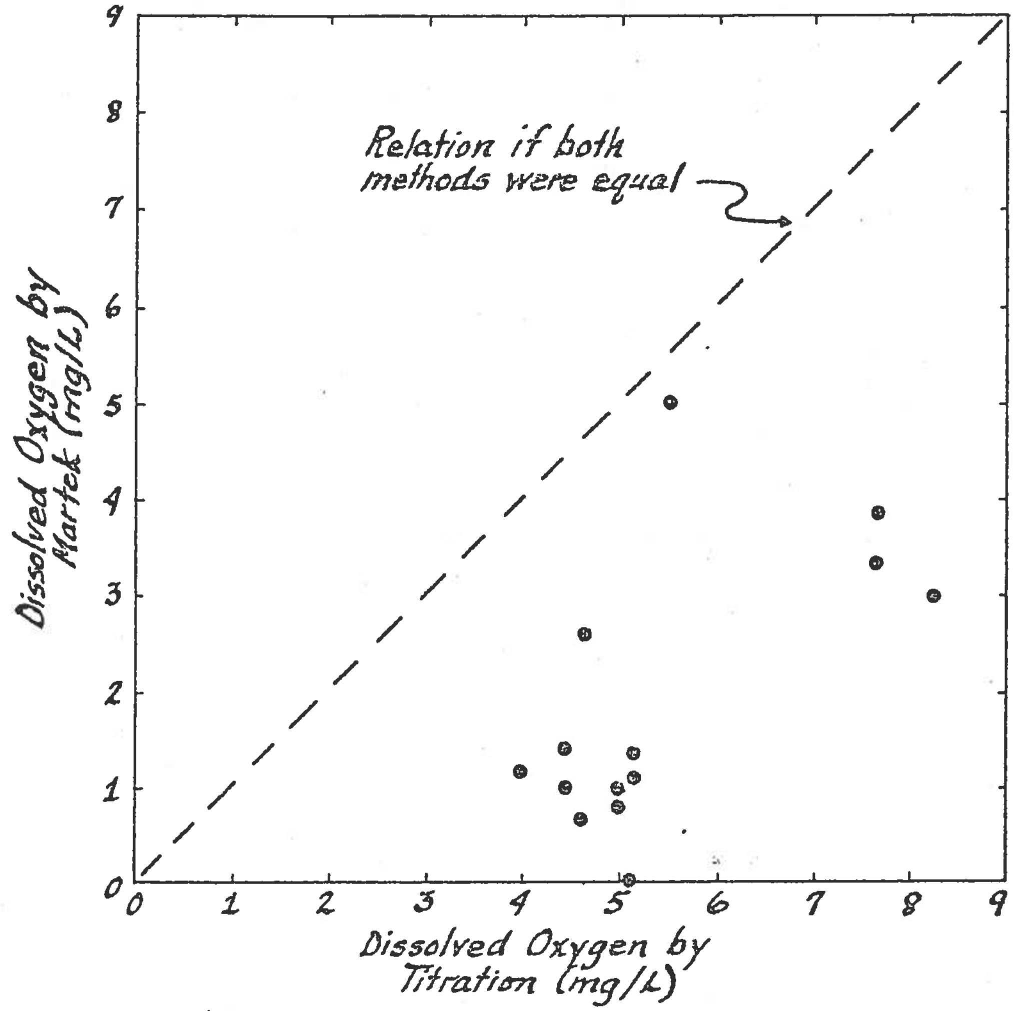

Figure 2. Comparison of dissolved oxygen data obtained by modified Winkler titration and Martek analyzer, Santa Monica Bay, May-June 1972.

(Figure 3). Instead, low temperatures and high salinity were recorded at stations in the central part of the Bay, near the wastewater outfalls.

There are two possible explanations for the observed pattern in D.O., temperature, and salinity. The first is that the bottles used to obtain the water samples at the deeper stations were accidentally triggered in surface waters before reaching bottom. Salinity data support this hypothesis.

A second explanation is that D.O. values at sites in Redondo Canyon (Stations I-30 and J-27, Figure 1) and off Malibu (Station M-20) resulted from oxygen consumption at or near

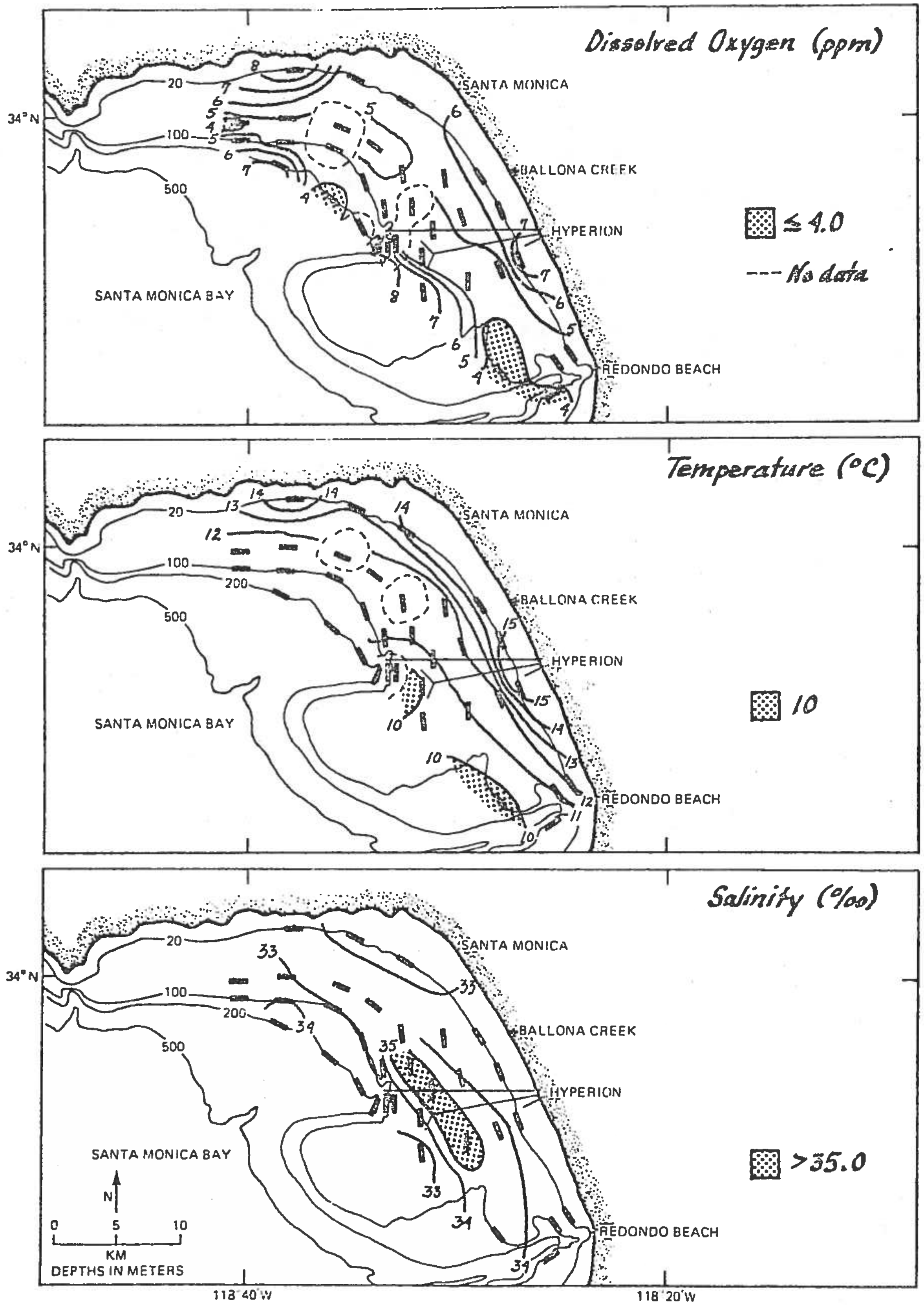

Figure 3. Dissolved oxygen, temperature, and salinity, Santa Monica Bay, May-June 1972.

Table 2

SUMMARY OF CATCH STATISTICS, SANTA MONICA BAY SURVEY, MAY-JUNE 1972

Sample Category	N	Median Catch/haul	Species/haul $\bar{X}$		Species/haul S.E.	Shannon-Weaver Diversity/haul $\bar{X}$		Shannon-Weaver Diversity/haul S.E.	Total Catch	Total Species
All Samples	40	68.5	7.98	±	0.77	1.21	±	0.10	3,938	53
Successful Samples	31	98.0	9.64	±	0.75	1.44	±	0.08	3,887	53

these sites. The problem is not at all clear and needs to be investigated further by taking a series of bottom water samples throughout the Bay and in all Canyon areas.

It does appear that inshore waters (18 m) were warm, well oxygenated, and of low salinity and mid-depth bottom waters were cool and poorly oxygenated.

Population and Community Parameters

Forty hauls were made at the 34 stations. Nine hauls were considered unsuccessful because the net was twisted or torn when recovered; these hauls are identified in Figure 1 and Table 1.

A summary of the catch statistics is given in Table 2. A total of 3,887 specimens were taken in the 31 successful hauls; the median fish per sample was 98. The number of fish captured in all 40 hauls, was 3,938, with a median of 69 fish per haul. These catches are low but within the range of values (means) reported by Carlisle (1969) for the 1958-63 survey. Catches in 1971 were about twice as high using similar gear (Southern California Coastal Water Research Project 1973).

Catch per haul (summarized on Figure 4) in the successful hauls ranged from 3 to 337 fish. Highest catches occurred in the north central part of the Bay between the 36- and 61-m contours. Catches decreased to the south and inshore and offshore of this area.

A total of 53 species, representing 15 families, were taken in the survey in the 31 successful hauls (Table 3), and the 9 unsuccessful hauls added no new species to this list. Species per haul (summarized on Figure 4) in the successful catches ranged from 2 to 20. The 31 successful hauls yielded a mean of 9.6 ± 0.8 species/haul, and the total 40 hauls yielded a mean of 8.0 ± 0.8 species/haul.

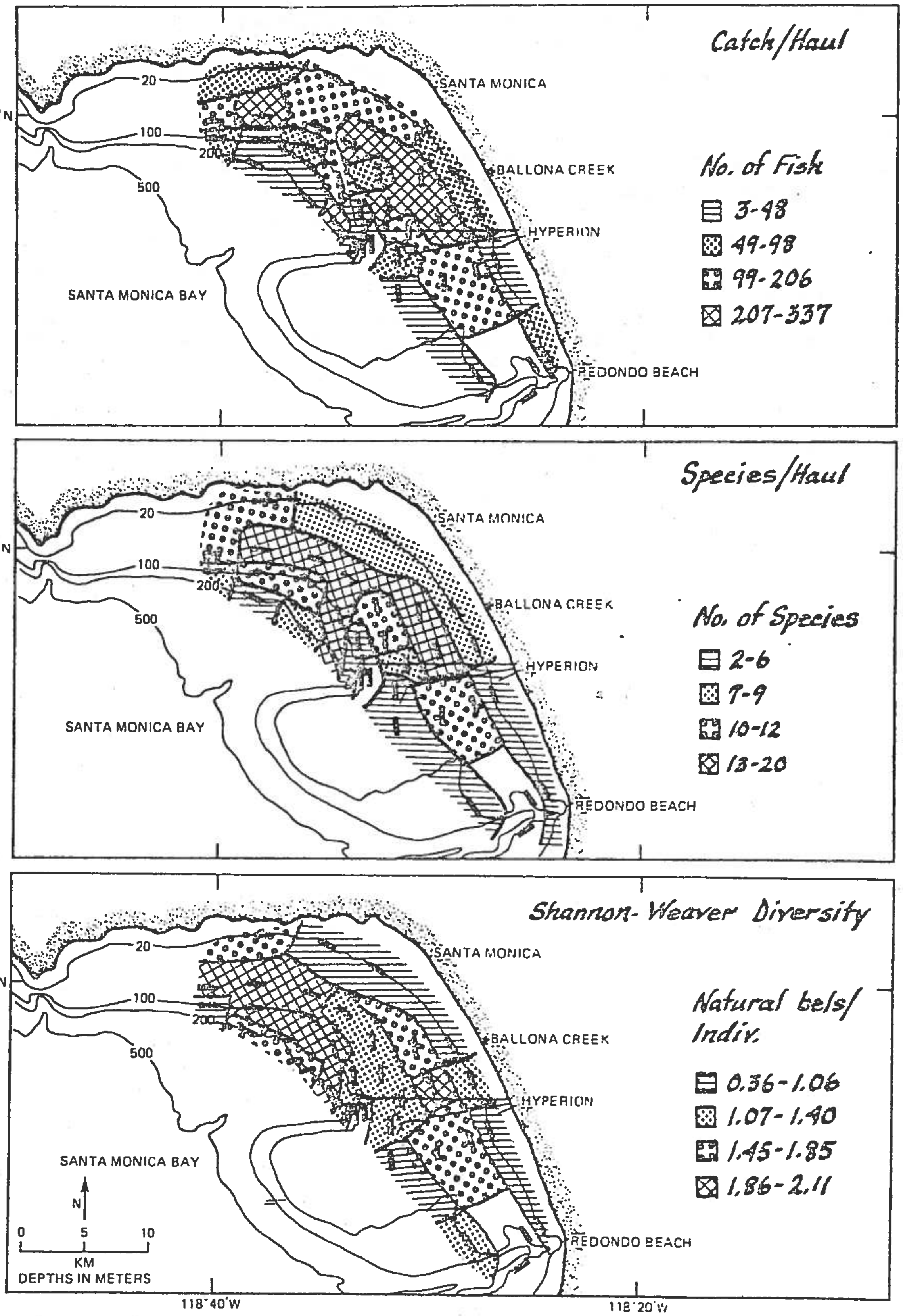

Figure 4. Catch per haul, species per haul and Shannon-Weaver diversity, Santa Monica Bay, May-June 1972.

Table 3

FISHES TAKEN, SANTA MONICA BAY SURVEY, MAY-JUNE 1972

Species	Common Name	Species	Common Name
Chimaeridae		Sebastes miniatus	Vermilion Rockfish
Hydrolagus colliei	Ratfish	Sebastes rosenblatti	Greenblotched Rockfish
Batrachoididae		Sebastes rubrivinctus	Flag Rockfish
Porichthys myriaster	Specklefin Midshipman	Sebastes saxicola	Stripetail Rockfish
Porichthys notatus	Plainfin Midshipman	Sebastes semicinctus	Halfbanded Rockfish
Ophidiidae		Sebastes vexillaris	Whitebelly Rockfish
Chilara taylori	Spotted Cusk-eel	Hexagrammidae	
Zoarcidae		Oxylebius pictus	Painted Greenling
Aprodon cortezianus	Bigfin Eelpout	Zaniolepis frenata	Shortspine Combfish
Lycodopsis pacifica	Blackbelly Eelpout	Zaniolepis latipinnis	Longspine Combfish
Maynea californica		Cottidae	
Sciaenidae		Artedius notospilotus	Bonehead Sculpin
Genyonemus lineatus	White Croaker	Chitonotus pugetensis	Roughback Sculpin
Embiotocidae		Icelinus quadriseriatus	Yellowchin Sculpin
Embiotoca jacksoni	Black Perch	Icelinus tenuis	Spotfin Sculpin
Hypsurus caryi	Rainbow Seaperch	Agonidae	
Phanerodon furcatus	White Seaperch	Agonopsis sterletus	Southern Spearnose Poacher
Rhacochilus toxotes	Rubberlip Seaperch	Odontopyxis trispinosa	Pygmy Poacher
Zalembius rosaceus	Pink Seaperch	Xeneretmus latifrons	Blacktip Poacher
Gobiidae		Xeneretmus triacanthus	Bluespotted Poacher
Coryphopterus nicholsi	Blackeye Goby	Bothidae	
Lepidogobius lepidus	Bay Goby	Citharichthys sordidus	Pacific Sanddab
Stromateidae		Citharichthys stigmaeus	Speckled Sanddab
Icichthys lockingtoni	Medusafish	Pleuronectidae	
Scorpaenidae		Eopsetta jordani	Petrale Sole
Sebastes auriculatus	Brown Rockfish	Glyptocephalus zachirus	Rex Sole
Sebastes babcocki	Redbanded Rockfish	Lyopsetta exilis	Slender Sole
Sebastes chlorostictus	Greenspotted Rockfish	Microstomus pacificus	Dover Sole
Sebastes crameri	Darkblotched Rockfish	Parophrys vetulus	English Sole
Sebastes dalli	Calico Rockfish	Pleuronichthys coenosus	C-O Sole
Sebastes diploproa	Splitnose Rockfish	Pleuronichthys decurrens	Curlfin Sole
Sebastes elongatus	Greenstriped Rockfish	Pleuronichthys verticalis	Hornyhead Turbot
Sebastes flavidus	Yellowtail Rockfish	Cynoglossidae	
Sebastes levis	Cow Rockfish	Symphurus atricauda	California Tonguefish

The most abundant fish (Table 4) was the speckled sanddab, followed by the yellowchin sculpin and the plainfin midshipman. California tonguefish, slender sole, English sole, and Pacific sanddabs were less abundant in the catches than in 1958-63 (Carlisle 1969). A more discrete analysis of both data sources is required to determine the role of the seasons in the abundance of these species.

The most frequently occurring species (Table 5) were the plainfin midshipman, the speckled sanddab, and the Dover sole.

Four species taken in May-June 1972 had not been noted in Santa Monica Bay surveys since regular monitoring began in 1957. These were the medusafish, the eelpout _Maynea californica_, the redbanded rockfish, and the greenblotched rockfish. The medusafish is usually associated with jellyfish, which are pelagic rather than demersal creatures: Our medusafish specimen was probably caught at the end of the trawl, as the net was pulled up from the bottom. The other unusual finds may also be a reflection of sampling factors:

A. The eelpout _Maynea california_ has only been taken two other times since it was originally described in 1915. However, this species may actually occur more frequently off southern California and simply have been misidentified in the past.

B. As the greenblotched rockfish (_Sebastes rosenblatti_) has only recently been distinguished from the pink rockfish (_S. eos_) and the greenspotted rockfish (_S. chlorostictus_) by Chen (1971), it may also have been present in the past but misidentified (of the three species, the greenblotched is the one most frequently taken in recent surveys).

C. The redbanded rockfish has been taken only once before in southern California--in the early 1900's. This species is common off northern California and may indeed be rare in southern California waters. However, its rareness could be a function of our sampling method--the fish may inhabit deep rocky bottoms where the trawl net cannot be used.

Shannon-Weaver diversity (summarized on Figure 4) averaged 1.44 $\pm$ 0.08 natural bels/individual for the 31 successful hauls and 1.21 $\pm$ 0.1 for all 40 hauls. Diversity values for successful hauls ranged from 0.04 to 2.11

Table 6 shows the species caught at each station in the May-June 1972 survey. Figure 5 shows the recurrent groups of fishes identified in the data from 1969-72 surveys of the southern California area (303 otter trawl samples, including those discussed here, taken in 1969-72 between Port Hueneme and Newport Beach; Southern California Coastal Water Research Project 1973).

Table 4

SPECIES MOST ABUNDANT, SANTA MONICA BAY SURVEY, MAY-JUNE 1972

Species	Abundance
Speckled Sanddab	1,162
Yellowchin Sculpin	1,012
Plainfin Midshipman	431
Stripetail Rockfish	366
Dover Sole	234
California Tonguefish	192
Pink Seaperch	70
Hornyhead Turbot	69
Splitnose Rockfish	61
Pygmy Poacher	54

Table 5

SPECIES MOST FREQUENTLY TAKEN, SANTA MONICA BAY SURVEY, MAY-JUNE 1972

Species	Frequency of Occurrence (Number of Samples)
Plainfin Midshipman	27
Speckled Sanddab	26
Dover Sole	26
Stripetail Rockfish	20
Yellowchin Sculpin	18
California Tonguefish	17
Pygmy Poacher	16
Pink Seaperch	15
Hornyhead Turbot	15
Pacific Sanddab	9
Curlfin Sole	9

TABLE 6

CATCH PER SPECIES PER HAUL, SANTA MONICA BAY SURVEY, MAY-JUNE 1972. SPECIES ARE LISTED ACCORDING TO THE RECURRENT GROUPS IN FIGURE 5; BOXES MARK THE PRESENCE OF ALL GROUP MEMBERS IN A SINGLE COLLECTION

Species	A 6	A 12	A 10	A 20	B 6	B 12	B 18	B 20	C 6	C-12 Haul 1	C-12 Haul 2	C 20	C 30	C 60	D 6	D-20 Haul 2	D-20 Haul 1	D-10 Haul 2	D-10 Haul 1	D 60	G 6	G 20	G-10 Haul 1	G-10 Haul 2	H 6	H 20	I 10	J 27	M 20	M-10 Haul 1	M-10 Haul 2	R 6	R 10	S 29	S 39	S 60	T 24	T-32 Haul 1	T-32 Haul 2	T 65	Total*
White Croaker					1																																				1 (1)
White Seaperch					4				1						1						1				2																[illegible]
Speckled Sanddab	2	69	61	6	65	41	41	32	57	83	125	10	70		43	15					90	26	11	1	89	14	1					47		89	2		19				1,1[illegible] ([illegible])
California Tonguefish		2	2		6	10	1		10	6	22	1			12	38					15	11			9	8			29					2							[illegible] (17)
Hornyhead Turbot		2	1		4	4			4	2	1				13		1				12	3	1		15	3	1														[illegible]
English Sole			1				1	2								7							2		1				1												[illegible]
Curlfin Sole			3		4				2			2	6		12	10										1						1					1				21 (1[illegible])
Yellowchin Sculpin		42	20			69	81	1	1	96	61	61	27		5	45					11	54			6	240			14					176							[illegible]
Longspine Combfish		1	15			7				1	3					2										1			1												33 (9)
Pygmy Poacher		3	2		3	7	1		2	3	1	5	8		1	2					1	3				5								7							[illegible] (16)
Pacific Sanddab							1						4			2		2				1	5			2			5					2							24 ([illegible])
Dover Sole		17	32	2		4	13	5		1	4	2	11	6		22	2	3	3			11	8			4	13		24		1			4	3	11			2	6	234 (26)
Plainfin Midshipman		12	8	6		36	20	17	1	27	11	4	26		1	67	2	12				20	35	5		18			15	2	49		2	13	16		5	1			431 (27)
Pink Seaperch						26				9	2	1	1		12	2		1				3	3		1	1			3		2			3							70 (16)
Shortspine Combfish																		2	1																	2	1				6 (4)
Stripetail Rockfish		2	33			5	6			2	3	10	32	4		84	1		4			22	5			19			31				9	19	4	42					366 (20)
Slender Sole														14					3																	14				2	33 (4)
Rex Sole														3					3														1			7					14 (4)
Blackbelly Eelpout																											4	1					2			24				1	32 (5)
Blacktip Poacher														9								1	9				1				1					13				6	43 (7)
Ratfish													1																												1 (1)
Specklefin Midshipman	1				2					1																															4 (3)
Spotted Cusk-eel													2			1																				1					4 (3)
Bigfin Eelpout																																				1					1 (1)
Maynea californica																																				2					2 (1)
Black Perch															1						1																				2 (2)
Rainbow Seaperch																																2									2 (2)
Rubberlip Seaperch						1																																			1 (1)
Blackeye Goby													3																												3 (1)
Bay Goby						1				1	1					1													2												6 (5)

*Number in parentheses is number of hauls in which species was taken (frequency of occurrence).

Table 6 (continued)

Species	A 6	A 12	A 18	A 20	B 6	B 12	D 10	D 20	C 6	C-12 Haul 1	C-12 Haul 2	C 20	C 30	C 60	D 6	D-20 Haul 2	D-20 Haul 1	D-30 Haul 2	D-30 Haul 1	D 60	G 6	G 20	G-30 Haul 1	G-30 Haul 2	H 6	H 20	I 30	J 27	M 20	M-30 Haul 1	M-30 Haul 2	R 6	R 30	S 20	S 30	S 60	T 24	T-30 Haul 1	T-30 Haul 2	T 60	Total*
Medusafish																															1										1 (1)
Brown Rockfish						1																																			1 (1)
Redbanded Rockfish																																				1					1 (1)
Greenspotted Rockfish													2					1													1				1						7 (4)
Darkblotched Rockfish														1																						1					2 (2)
Calico Rockfish													1																												1 (1)
Splitnose Rockfish														6																						53				2	61 (1)
Greenstriped Rockfish																		1																							1 (1)
Yellowtail Rockfish						3																																			3 (1)
Cow Rockfish													1					1																		4					6 (3)
Vermilion Rockfish		2				6				2															1									2							13 (5)
Greenblotched Rockfish													1	2				3		1											1					13					21 (6)
Flag Rockfish													3																												3 (1)
Halfbanded Rockfish													1					5													2										8 (3)
Whitebelly Rockfish																	1																								1 (1)
Painted Greenling						1																																			1 (1)
Bonehead Sculpin					1																																				1 (1)
Roughback Sculpin		3				1				2	3	2																						1							12 (6)
Spotfin Sculpin													1																												1 (1)
Southern Spearnose Poacher																										1															1 (1)
Bluespotted Poacher													1						1			2	5				1				1				1				2		14 (8)
Petrale Sole																																		1							1 (1)
C-O Sole																																1									1 (1)

*Number in parentheses is number of hauls in which species was taken (frequency of occurrence).

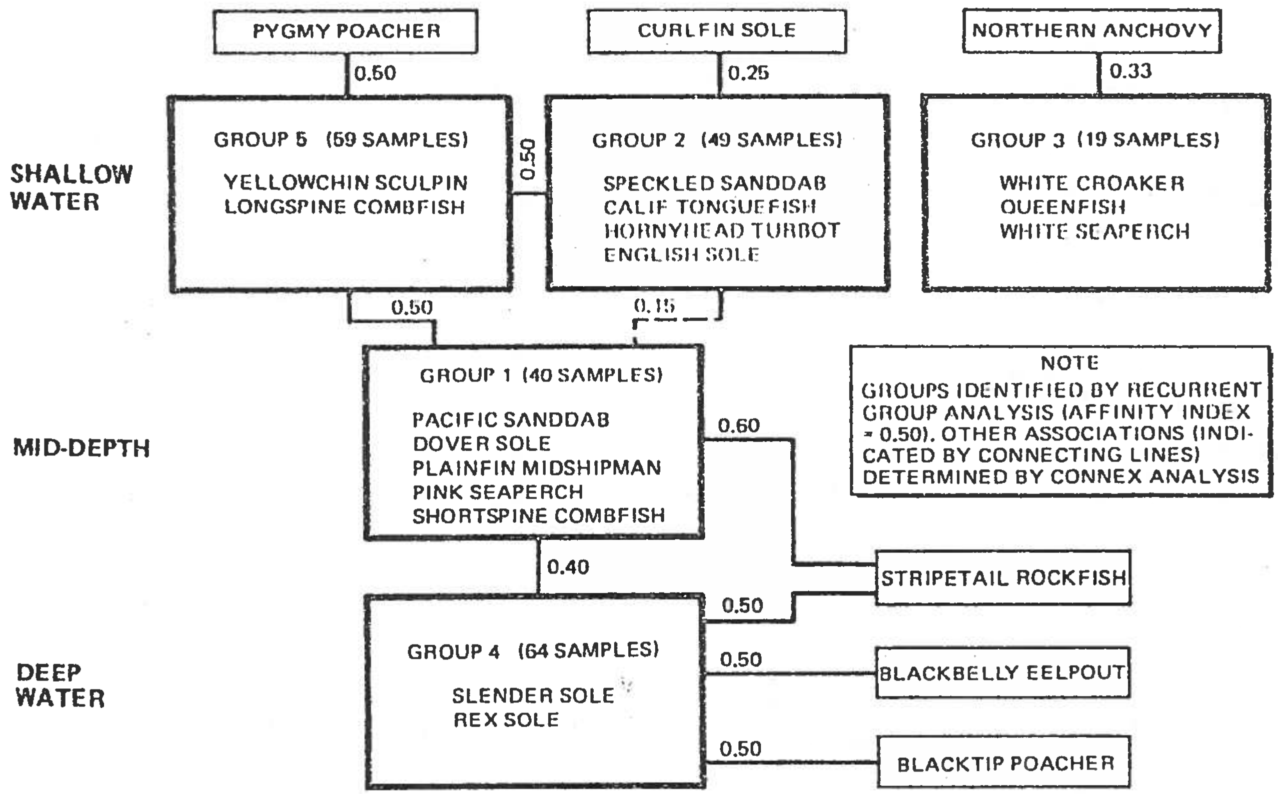

Figure 5. Species associations of southern California nearshore demersal fishes, 1969-72.

To facilitate the identification of these groups in the data from the May-June 1972 survey, the species in Table 6 are arranged according to the previously identified recurrent groups.

All group members of 4 out of 5 groups were collected in the May-June 1972 survey. Since the queenfish was not taken in the survey, Group 3 was not found, although both the white croaker and the white seaperch were present. The northern anchovy, a close associate of this group, was also not found in the survey.

The most frequently occurring group was Group 5, composed of the yellowchin sculpin and the longspine combfish, which appeared at seven stations (Figure 6). Group 4, composed of the slender sole and rex sole, was found at three 200-m stations. Group 2, which consists of the speckled sanddab, California tonguefish, hornyhead turbot, and English sole, was present at Stations H-6 and A-18. Group 1, composed of the Pacific sanddab, Dover sole, plainfin midshipman, pink seaperch, and shortspine combfish, appeared at only one station, D-30.

Figure 6 shows the species numerically dominant in the catch at each station. The speckled sanddab was dominant at 13 stations, mostly near shore and to the south of the outfalls. The yellowchin sculpin was dominant at seven stations offshore but still on the shelf. The plainfin midshipman was dominant at five stations along the edge of the shelf.

Comparison of Figures 4 and 6 suggests a direct relation between number of fish and number of species and an inverse relation between these parameters and diversity. Diversity was highest at the stations where complete recurrent group associations were found. The role of species dominances in affecting this diversity/species group relation is complicated, but it is being investigated more thoroughly because both diversity and species associations are low at the stations around the wastewater discharge site.

Physical/Biological Relationships

The data from the May-June 1972 surveys revealed a few general relationships between the fish catches and the depth and bottom water quality. There were more fish and more species of fish per sample at depths of 36 to 61 meters than at shallower or deeper depths (Figure 7). Diversity, however, increased with depth. As noted earlier, inshore catches were dominated by a few species, and this factor, along with the relatively small number of individuals in the nearshore catches, may account for the low diversities. The high standard errors (± 2 S.E.$_{\bar{x}}$) shown in Figure 7 reflect high variances resulting from the skewed distributions of the parameters. Thus, there is some question about the significance of these differences: They may be indicative of

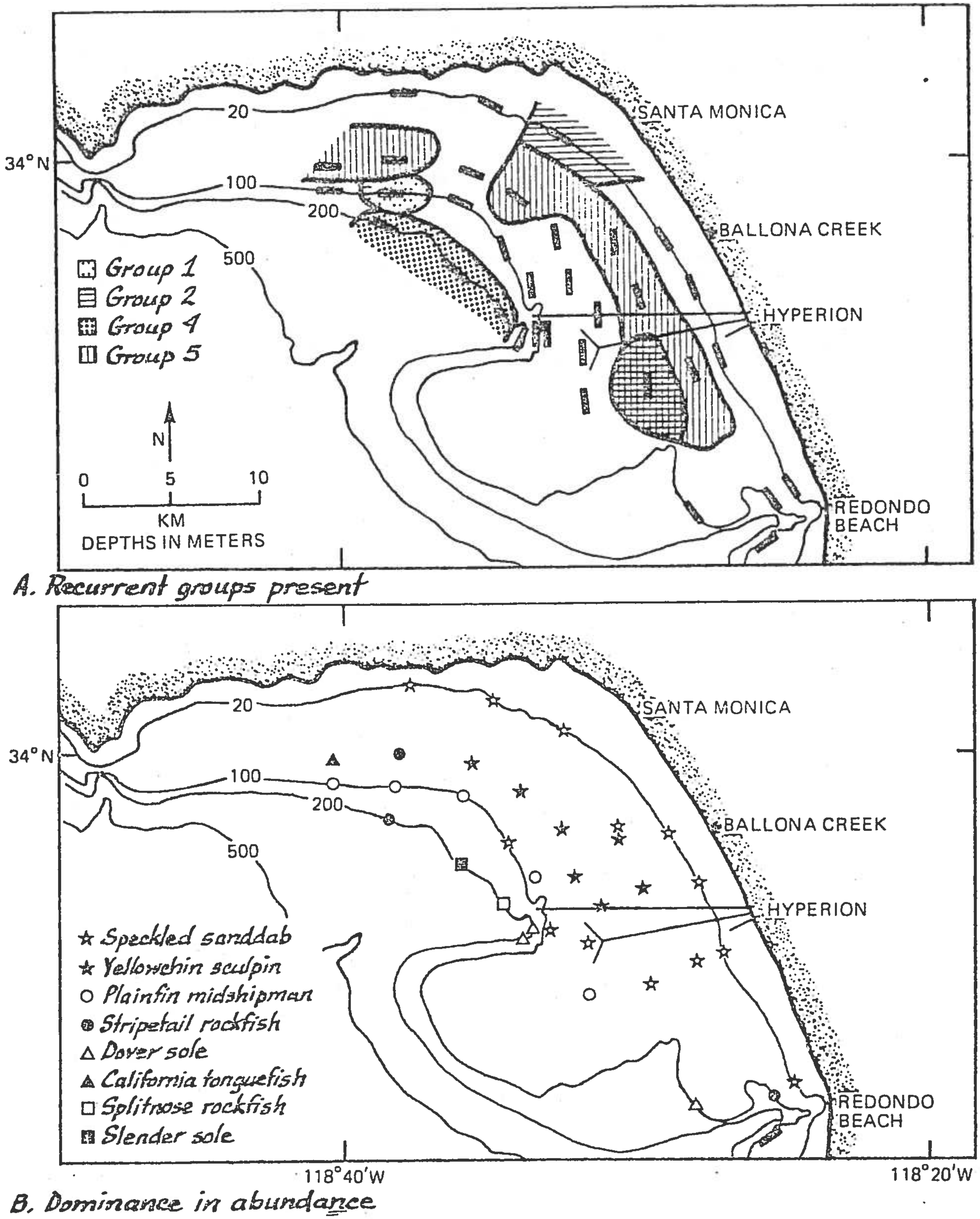

Figure 6. Recurrent groups present and dominance in abundance, Santa Monica Bay, May-June 1972. Recurrent groups are shown on Figure 5.

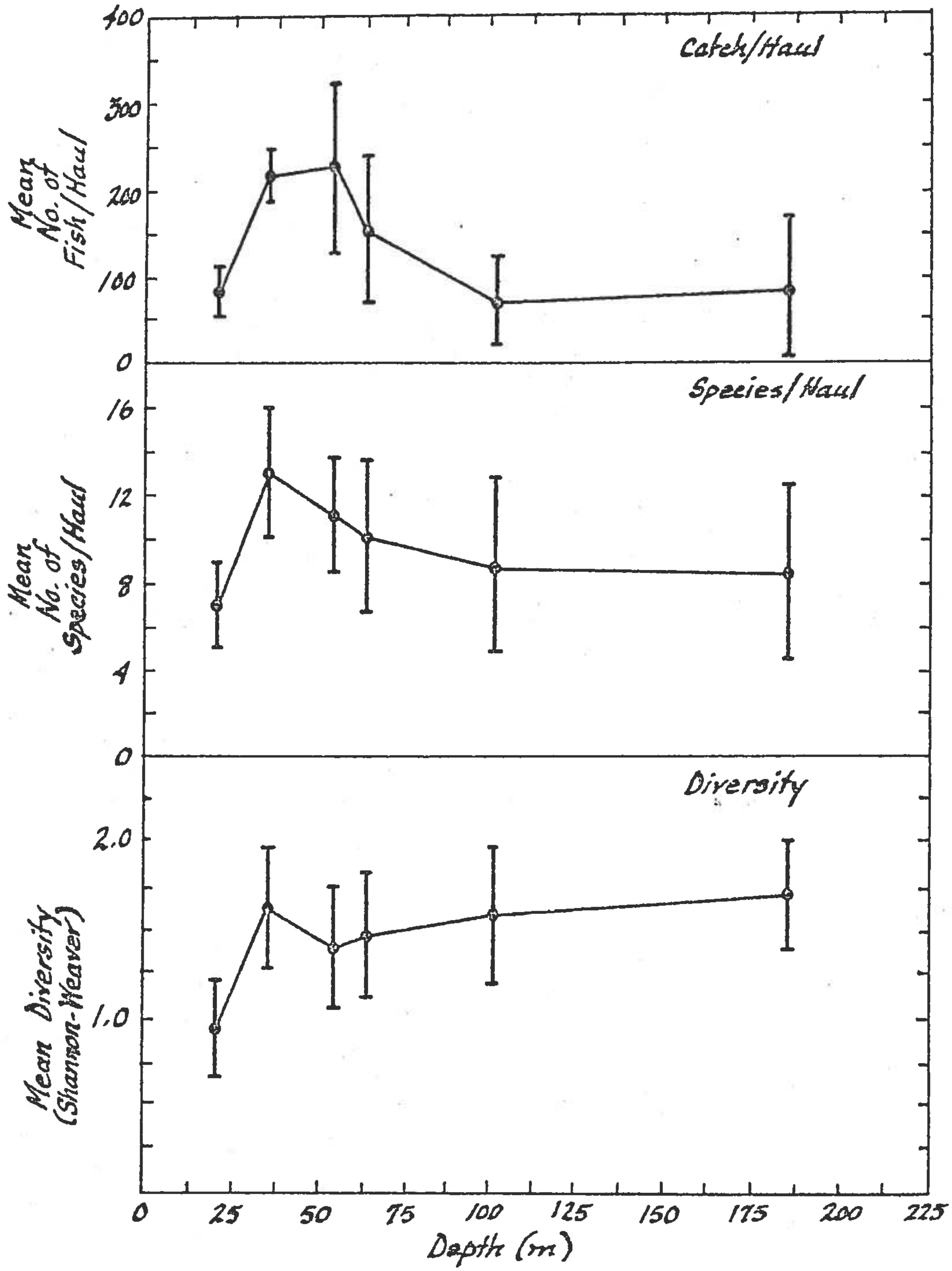

Figure 7. Catch, species, and diversity per haul (±2 S.E.$_{\bar{x}}$) with depth, Santa Monica Bay, May-June 1972.

trends only. The same comments apply to possible relationships between the abundance of fish and bottom water D.O. and temperature (Figure 8).

In general, the largest and most varied catches were taken at depths of 36 to 61 m in bottom water with temperatures of 11 to 12°C and D.O. concentrations of 4.5 to 5.5 mg/L. Warm, well-oxygenated, inshore water was not associated with high catches, or high diversity, of bottom fishes: Apparently, factors other than D.O. are limiting for these fishes. However, D.O. may be a limiting factor to some species in deeper parts of Santa Monica Bay. This possibility should be examined in future surveys.

Diseased and Anomalous Fishes

During the May-June 1972 trawls in Santa Monica Bay, we noted eroded fins on individuals from three species: Dover sole, slender sole, and greenblotched rockfish. Overall incidence of fin erosion in the Dover sole was 1.3 percent. (It should be noted that there were no successful hauls at Station T-30, where a number of Dover sole with fin erosion were collected in fall 1971.)

The 228 Dover sole collected in the 31 successful hauls fell into four population subgroups (Figure 9). All individuals with eroded fins, however, were part of the third size grouping, consisting of fish approximately 150 to 219 mm in standard length. These fish are slightly larger than the Palos Verdes Dover sole most severely affected with fin erosion and were collected close to the two major canyons in the Bay (Figure 10).

Overall incidence of fin erosion in slender sole was 9.1 percent and in the greenblotched rockfish, 9.5 percent. Considering the disease data on all three of these species, it appears that fin erosion was enhanced at the sludge discharge site.

We found external tumors on individuals from four species: Dover sole (Figure 10); hornyhead turbot, *Pleuronichthys verticalis*; speckled sanddab, *Citharichthys stigmaeus*; and longspine combfish, *Zaniolepis latipinnis* (Table 7). Overall incidence of tumors in Dover sole was 1.8 percent. All these individuals were found in the second size grouping (Figure 9), which consists of fish approximately 90-159 mm in standard length. Overall incidence of tumors in the speckled sanddab was 0.1 percent; in the hornyhead turbot, 1.4 percent; and in the longspine combfish, 3.3 percent. Two of the tumor-bearing fishes (the sanddab and the turbot) were caught at Station H-6 off Santa Monica Pier; this site should be investigated in more detail in future surveys.

A detailed analysis of diseased Dover sole from Santa Monica Bay and other southern California sites indicates that the tumor

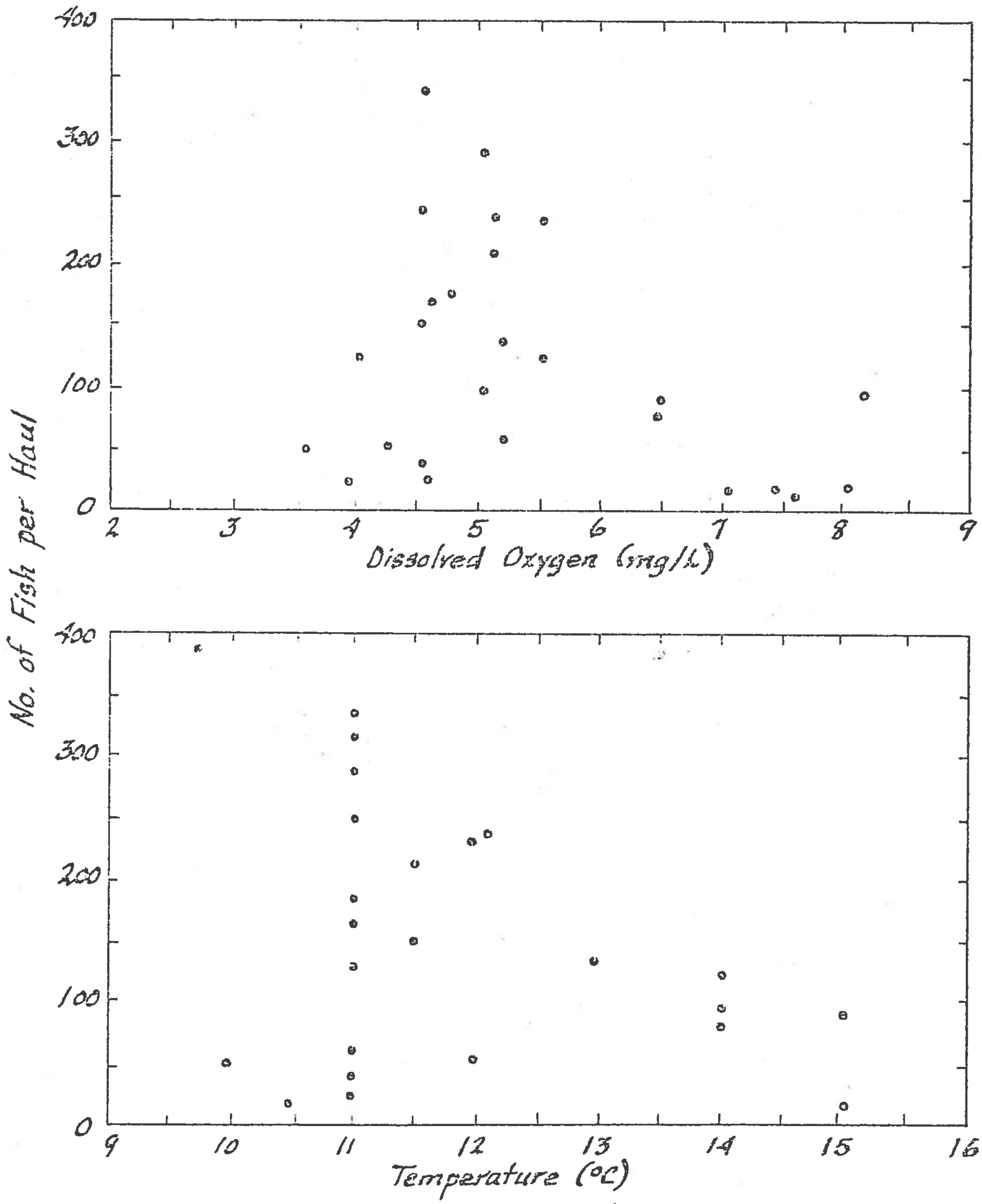

Figure 8. Catch per haul versus temperature and dissolved oxygen, Santa Monica Bay, May-June 1972.

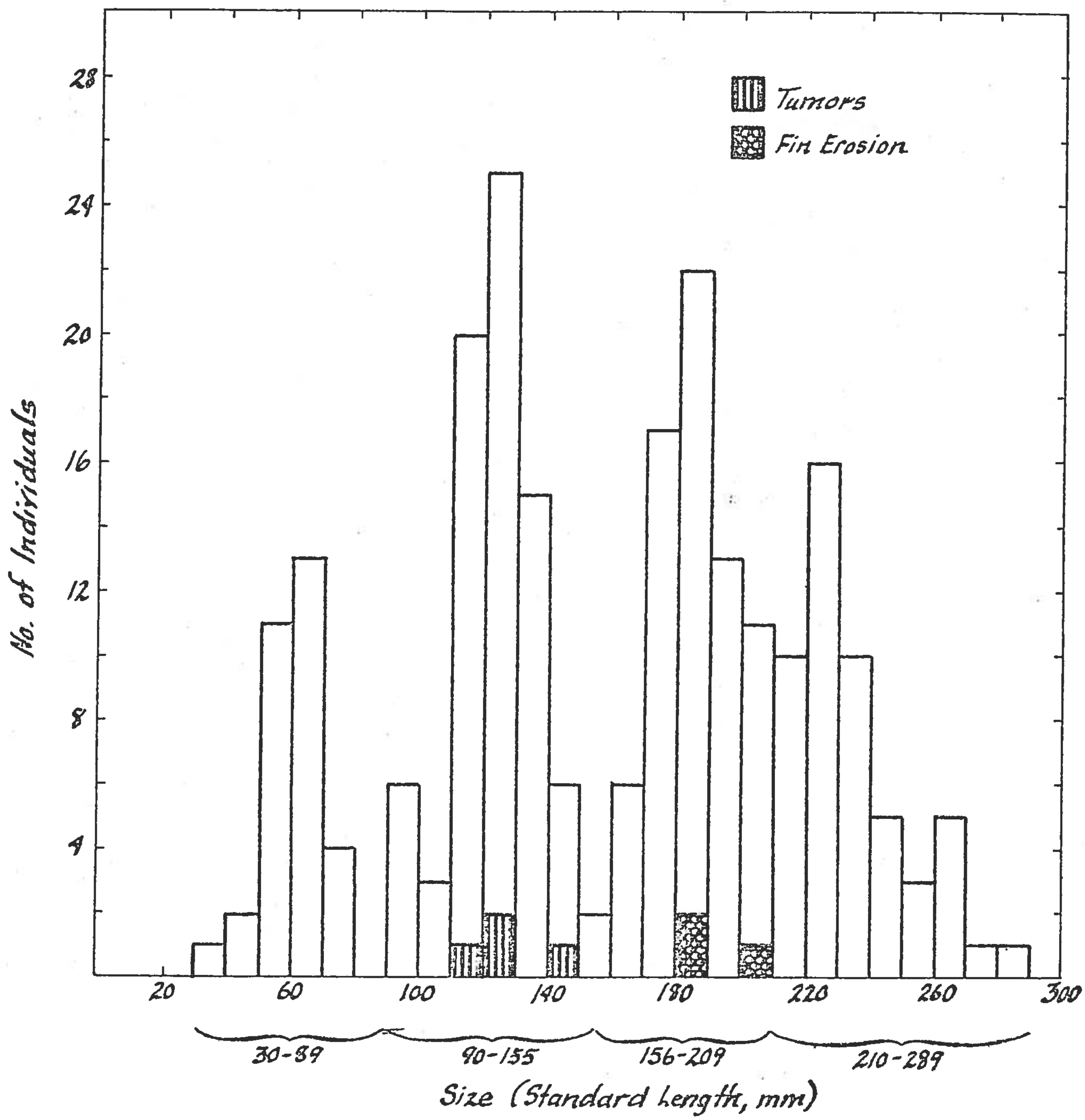

Figure 9. Prevalence of disease in Dover sole captured in Santa Monica Bay, May-June 1972.

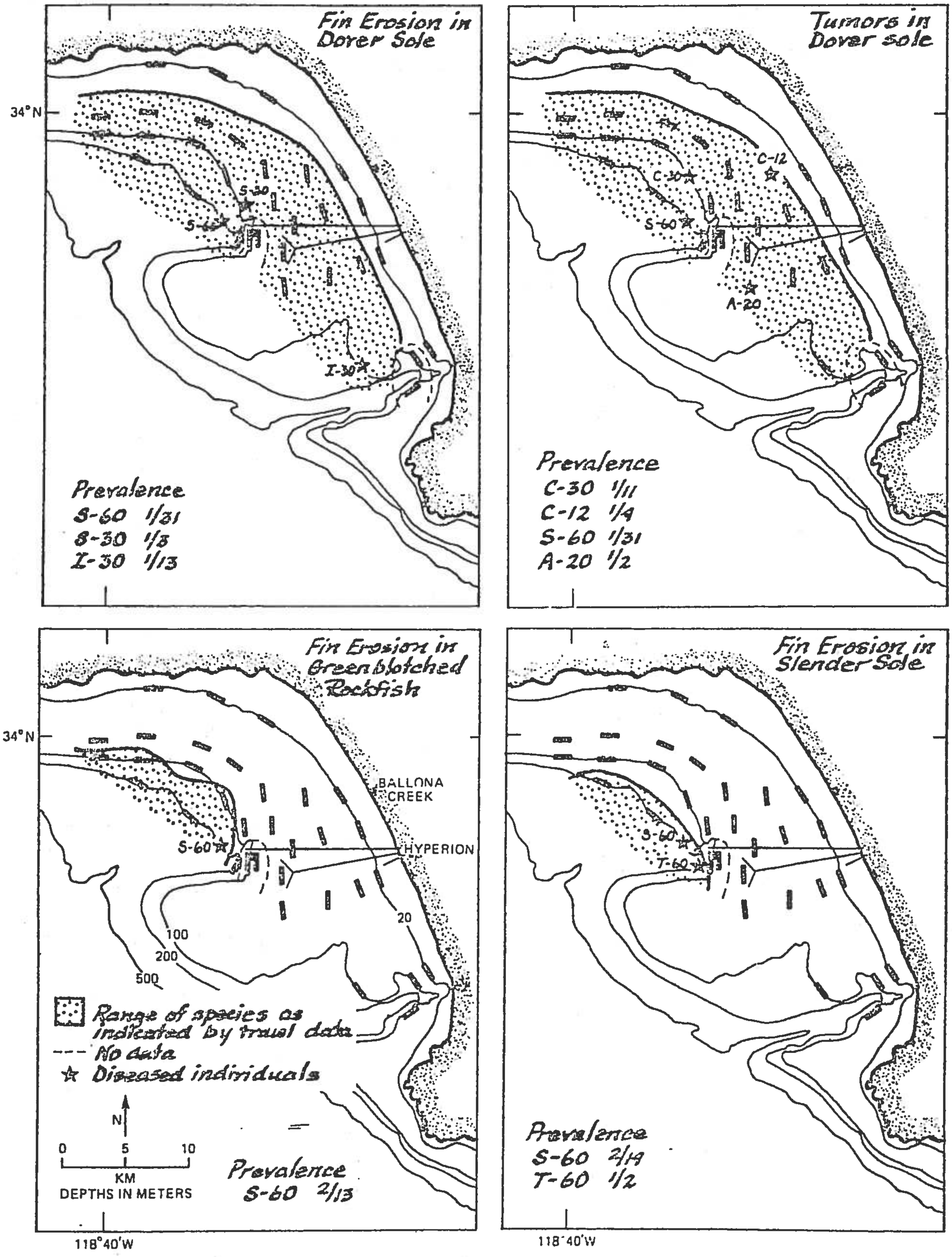

Figure 10. Prevalence of fin erosion and tumors in Dover sole and fin erosion in greenblotched rockfish and slender sole, Santa Monica Bay, May-June 1972.

Table 7

PREVALENCE OF FIN EROSION AND TUMORS IN SANTA MONICA BAY FISHES, MAY-JUNE 1972

Species	Total No. of Indiv.	Fin Erosion No. of Indiv.	Fin Erosion %	Tumors No. of Indiv.	Tumors %
Dover sole	234	3	1.3	4	1.8
Slender sole	33	3	9.1	-	
Greenblotched rockfish	21	2	9.5	-	
Speckled sanddab	1,162	-		1	0.1
Longspine combfish	33	-		1	3.3
Hornyhead turbot	69	-		1	1.4

syndrome is not restricted to wastewater discharge sites and clearly involves the early life history of the Dover sole (Mearns and Sherwood, in press).

SUMMARY AND CONCLUSIONS

In general, the temperature and D.O. of bottom water in Santa Monica Bay decreased with increasing distance from shore. Several deep stations showed increased D.O. and decreased salinity; however, we suspect that these values were the result of sampling problems (temperature data for these stations, taken by probe, suggest that D.O. should have been lower and salinity, higher).

Catches in the May-June 1972 survey were smaller than those in 1971 (Table 8), but the differences were within the year-to-year variability noted in the 1958-63 survey (Carlisle 1969). Median catch per haul data for 1971-72 suggest a strong seasonal effect, with small catches in the late spring and large catches in the fall and winter. In his summary of the 1958-63 survey data, Carlisle did not present or discuss seasonal fluctuations, except those in the speckled sanddab population.

Data on community parameters (including diversity, species association, dominance, and disease frequencies) suggest that, in 1972, the effects of wastewater discharges were confined to an area in a radius of 2 to 3 km around the wastewater discharge points. The area in which benthic fish community structure is influenced by the outfalls appeared to be about the same in 1972 as it was in 1958-63, with perhaps a tendency for a shift of influence to the north of the sludge outfall. A more detailed examination of the distribution of individual species is required to confirm and further define these effects. This is now underway at the Coastal Water Project.

Table 8

COMPARISON OF TRAWL CATCH STATISTICS FOR SURVEYS OF SANTA MONICA BAY, 1971* AND 1972

Date	Depth Range (m)	No. of Hauls	Total No. of Species	Total No. of Indiv.	Median Catch/Haul	Species/Haul		Shannon-Weaver Diversity/Haul	
						Mean	S.E.	Mean	S.E.
2/71	18-183	15	40	3,005	169	9.4	0.5	1.35	0.08
5-6/71	18-183	6	25	962	108	8.3	0.8	1.03	0.17
9/71	18-183	28	54	4,389	132	10.4	0.7	1.39	0.10
5-6/72**	18-182	31	53	3,887	98	9.6	0.8	1.44	0.08

*The 1971 surveys are described in the Coastal Water Project's 3-yr report (1973).
**Successful hauls only.

Finally, data on metals and chlorinated hydrocarbons in fish from Santa Monica Bay were taken during these surveys and reported by the Project (1973). These data suggest that concentrations of metals in Dover sole from the north, central, and southern portions of the Bay were normal (de Goeij et al., in press). PCB and DDT concentrations in muscle tissue of Dover sole taken near the outfalls were somewhat higher than those in specimens from other parts of the Bay: A marked increase in trace organic concentrations in fish from the south end of the Bay showed the influence of the Whites Point discharge off Palos Verdes.

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