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SOUTHERN CALIFORNIA BASELINE STUDY  
BENTHIC, YEAR TWO  
FINAL REPORT  
VOLUME II, REPORT 23.0

SCIENCE APPLICATIONS, INC.

**SOUTHERN CALIFORNIA BASELINE STUDY  
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**HEALTH, ABUNDANCE AND DIVERSITY OF BOTTOMFISH AND SHELLFISH  
POPULATIONS AT PROPOSED AND EXISTING OFFSHORE DRILLING SITES  
IN THE SOUTHERN CALIFORNIA BIGHT**

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ALBUQUERQUE • ANN ARBOR • ARLINGTON • ATLANTA • BOSTON • CHICAGO • HUNTSVILLE  
LOS ANGELES • McLEAN • PALO ALTO • SANTA BARBARA • SUNNYVALE • TUCSON**

**P.O. Box 2351, 1200 Prospect Street, La Jolla, California 92037**

VOLUME II, REPORT 23.0

HEALTH, ABUNDANCE AND DIVERSITY OF BOTTOMFISH AND SHELLFISH  
POPULATIONS AT PROPOSED AND EXISTING OFFSHORE DRILLING SITES  
IN THE SOUTHERN CALIFORNIA BIGHT

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## ABSTRACT

A total of over 12,400 animals of at least 268 species of elasmobranchs, fishes, echinoderms, crustacea, and other invertebrates were enumerated and examined from 34 bottom trawl hauls (73 to 227 m deep) at four coastal and offshore sites in the Southern California OCS. Examination of the catch data indicated that the benthic fish and epibenthic invertebrate fauna had a normal community structure not dissimilar from other previously sampled coastal areas. However, there were notable differences in species composition that may be interpreted as onshore - offshore gradients. At least three southern range extensions were encountered.

Fish generally appeared healthy and contained a rather diverse and abundant load of external and internal parasites. However, histological examination revealed a high frequency of gill and liver variations in bottom fish collected near Coal Oil Point and confirmed the occurrence of "x-cell" epidermal tumors in several species at Point Conception and elsewhere in the Santa Barbara basin.

The cause of the tumors is unknown, but it is possible that the gill and liver abnormalities are in some way connected with exposure to petroleum from a nearby active seep. Additional sampling and laboratory tests are required to confirm this.

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## 23.0 HEALTH, ABUNDANCE AND DIVERSITY OF BOTTOMFISH AND SHELLFISH POPULATIONS AT PROPOSED AND EXISTING OFFSHORE DRILLING SITES IN THE SOUTHERN CALIFORNIA BIGHT

### 23.1 INTRODUCTION

As coastal waters are developed, the potential for the introduction of toxic materials into the marine environment increases. The complexity and variability of marine ecosystems and the relatively low concentrations of toxic materials make it difficult to determine biological criteria or responses that would be most sensitive and appropriate for evaluating the health of marine populations affected by toxic materials.

Recently, histological evaluation of the condition of various tissues of organisms has shown some promise as a possible approach to detecting changes in the health of fish and shellfish populations. Although the study of tissue and organ characteristics of marine fish is in its infancy, a number of researchers have already identified changes associated with exposure to oil, municipal wastewaters, chlorinated hydrocarbons, and carcinogens. Pertinent past findings are reviewed in the discussion section of this report.

One objective of this study was to evaluate the health of marine fish and shellfish populations at several southern California coastal sites at which petroleum resource development may occur. Several of the sites studied (Coal Oil Point and Point Conception) have been under development for several decades and one (Coal Oil Point) harbors active oil seeps. Therefore, a second and perhaps more important objective was to determine whether or not the health of fish and shellfish populations is now in any way different at these locations as compared to distant sites removed from active seeps or development.

Although histopathological techniques are one way to assess health, they do need to be supported by and complement other measures of the populations being investigated. Thus, a part of this study involved a semi-quantitative analysis of the variety, relative abundance, species composition, and distribution of fishes captured at each site.

### 23.2 METHODS

#### 23.2.1. Locations

Four widely separated sites (Figure II-23.0-1) were selected for assessment: Tanner Bank, a natural ridge located approximately 160 km west of San Diego; the seaward shelf of San Miguel Island located approximately 75 km southwest of Santa Barbara (50 km south of Point Conception); Coal Oil Point located approximately 16 km west of Santa Barbara; and Point Conception (Figure II-23.0-1).

The bottomfish and shellfish fauna was selected as our target biota since studies elsewhere (Mearns and Sherwood, 1974; Sherwood and Mearns, 1977) indicated these kinds of organisms are most impacted by wastewater and hydrocarbon contamination.

#### 23.2.2 Gear and gear use

The bottom macrofauna was sampled by otter trawl, although a beam-trawl and rock-dredge were used on several occasions at Tanner Bank.

The nets used were 7.6 meter (25 feet) head-rope length semi-balloon otter trawls constructed with 3.8 cm (1.5 in) stretch mesh nylon bags fitted with 1.3 cm (0.5 in) stretch-mesh nylon cod-end liners (Bascom, 1977). Because subsamples for petroleum hydrocarbon analysis were to be taken, we used untreated as well as treated nylon nets. "Treated" nets were, in fact, dipped in "Net Set", a petroleum-based primer; however, tows taken with treated nets were made with nets that had been previously subjected to numerous tows elsewhere (over 25 hours underwater) and there was little reason to believe such nets would be a source of contamination of internal tissues in intact animals.

Sampling was conducted during three cruises on board the Velero IV, a 120 ft. research vessel operated by the Allan Hancock Foundation, University of Southern California. "Winter" cruises were conducted 7-9 March and 18-20 March, 1977; the "Summer" cruise was conducted 24-29 July, 1977.

Trawl sampling was conducted both during daylight and at night. A minimum of three tows were taken at each of the four locations during winter and again during summer. Sampling depths ranged from 72 to 274 m. Attempts were made to sample within this depth range at all sites; shallow water tows at Tanner Bank and San Miguel Island were unsuccessful due to rocks.

Trawls were taken along isobaths. Target on-bottom trawl time was 20 min; however actual on-bottom time ranged from 13 to 35 min (mean 20.7 min) measured from time of bottom contact to time of lift-off by observing a tensiometer. Scope ratios used ranged from about 3.9 at 72 m to 3.1 at 220 m. Vessel speed ranged from 4 knots during gear deployment to between 2.3 and 2.5 knots during towing.

A complete log of sea, weather and sampling conditions was kept while on station and a bathythermograph was used to determine temperature profiles at each station at the time of sampling.

#### 23.2.3. On board processing of catch

Upon gear retrieval, the cod-end was hoisted aboard ship and into a large acetone-and-seawater-rinsed aluminum sorting box. Once free, the catch was examined for species and specimens required for other

From the 31 otter trawl hauls a total of over 12,400 animals were enumerated including 8383 invertebrates of 268 taxa and 4042 vertebrates comprising 58 species of 21 families of sharks, rays, and bony fishes. Of the fishes, 464 specimens of 22 species were described, fixed, and archived for possible histological examination; tissues from a total of 84 specimens representing eight species were actually selected, dissected, imbedded, sectioned, stained, and examined microscopically. Several hundred specimens were taken for tissue analyses of trace metals (Martin, et al., 1978) and for petroleum hydrocarbons (Rossi and Benson, 1978).

### 23.3.1 Catch composition

Shrimp, sea urchins, flatfish, and small rockfish dominated the total catch from the four sites (Table II-23.0-1). Seven species accounted for over 50 percent of the total specimens; the most abundant species included ocean shrimp (Pandalus jordani), an urchin (Allocentrotus fragilis), slender sole (Lyopsetta exilis), spot prawn (Pandalus platyceros), Pacific sanddab (Citharichthys sordidus), a small snail (Nassarius insculptus), and another urchin (Brissaster latifrons). The most abundant rockfish included striptail rockfish (Sebastes saxicola), splitnose rockfish (Sebastes diploproa), and shortbelly rockfish (Sebastes jordani).

Ten of the 58 species of fish were common to all four sites and appear to be prominent members of the bottomfish community. These included slender sole, Pacific sanddab, splitnose and shortbelly rockfishes, rex sole (Glyptocephalus zachirus), Dover sole (Microstomus pacificus), blacktip poacher (Xeneretmus latifrons), shortspine combfish (Zaniolepis frenata), spotfin sculpin (Icelinus tenuis), and spotted cusk-eel (Chilara taylori). Several species of fish were common and abundant at the coastal sites (Point Conception and Coal Oil Point) and San Miguel Island but were not captured at Tanner Bank: plainfin midshipman (Porichthys notatus), striptail rockfish (Sebastes saxicola), and pink seaperch (Zalembeius rosaceus). Others common elsewhere were absent at Coal Oil Point: threadfin sculpin (Icelinus filamentosus), petrale sole (Eopsetta jordani), and elasmobranchs (shark and rays).

### 23.3.2. Catch statistics

Catches from individual hauls are shown in Table II-23.0-2. A summary of catch statistics by region for 27 positive otter trawls indicates that the average haul captured 138 fish of 11 species weighing over 3.1 kg with a Shannon Weaver diversity of 1.62 and 176 invertebrates of 17 species with an average weight of 7 kg (last column, Table II-23.0-3). These values for fish are lower than overall coastal Bight averages summarized by Allen and Voglin (1976) for 10 minute on-bottom time hauls--173 specimens, 11 species with an average biomass of 7.1 kg.



Table 11.10. Summary of individual catch at all hauls from 34 trawl and dredge hauls at Tanner Bank, San Miguel Island, Coal Oil Point and Point Conception aboard the VETERO IV, March and July, 1977. RD = Rock dredge, BT = Beam trawl, UOT = untreated white nylon otter trawl, and TOT = otter trawl treated with a net preservative. NS = no sample. All weights for fish are minimum estimates (true catch weight > given value).

Velero	SAI/BLM	Date	Depth fm	Gear	On Bottom Time min	FISH		Minimum Biomass kg	INVERTEBRATES		
						Number Specimens	Species		S-W Diversity	Number Specimens	Species
TANNER BANK (817)											
25826	817-100-1	3-7-77	75	RD	21	NS	-	-	-	-	-
25827	817-100-2	3-7-77	103	RD	19	11	4	0	0.82	120	33
25828	817-100-3	3-7-77	104	UOT	23	9	3	0.3	0.68	4	1
25829	817-100-4	3-8-77	97	UOT	23	35	3	3.1	0.82	12	5
25830	817-50-1	3-8-77	50	BT	8	NS	-	-	-	-	-
25831	817-100-5	3-8-77	118	UOT	17	11	5	0.5	1.50	19	7
25832	817-100-6	3-8-77	100	UOT	35	46	9	10.0	1.48	32	8
26293	81731	7-25-77	100	UOT	22	NS	-	-	-	-	-
26294	81732	7-25-77	100	UOT	20	17	5	0.7	1.45	18	11
26295	81733	7-25-77	150	UOT	20	149	12	8.9	1.48	126	9
26297	81734	7-25-77	75	UOT	14	9	3	0.8	0.48	16+	11+
SAN MIGUEL ISLAND (805 and 806)											
25870	805-100-1	3-19-77	100	UOT	19	144	17	4.3	1.71	176	17
25871	805-100-2	3-19-77	100	UOT	17	244	16	5.8	1.82	117	7
25872	805-120-1	3-19-77	124	UOT	16	125	19	14.4	2.31	169	9
25874	806-40-1	3-19-77	41	UOT	14	NS	(lost gear)	-	-	-	-
26298	80532	7-26-77	120	UOT	20	NS	-	-	-	6	2
26299	80533	7-26-77	100	UOT	24	NS	-	-	-	6	2
26300	80534	7-27-77	105	UOT	19	11	6	0.7	1.67	134	4
26301	80535	7-27-77	150	UOT	34	4	3	2.9	1.04	1	1
26308	80536	7-28-77	120	TOT	23	184	11	4.8	1.29	954+	25+
26309	80712	7-28-77	75-68	TOT	25	462	20	24.5	1.65	662+	24+
POINT CONCEPTION (837)											
25875	837-100-1	3-20-77	100	TOT	24	196	17	9.7	2.02	1286	78
25876	837-120-1	3-20-77	120	TOT	16	138	10	6.7	1.26	189	18
25878	827-40-1	3-20-77	40	TOT	13	148	9	2.5	0.82	91	44
25879	837-75-1	3-20-77	74	TOT	16	55	10	2.0	1.76	249	56
26305	83708	7-27-77	101	TOT-1	20	201	18	2.4	2.14	705	24
26306	83709	7-27-77	75	TOT-1	27	252	15	8.9	1.62	47	25
COAL OIL POINT (801)											
25833	801-100-1	3-9-77	95	TOT	19	280	17	4.1	1.87	602	33
25835	801-75-1	3-9-77	75	TOT	18	64	11	0.6	2.0	233	16
25836	801-40-1	3-9-77	40	TOT	14	172	11	0.4	0.75	142	18
25837	801-100-2	3-9-77	101	TOT	20	337	16	9.5	1.75	525	36
26302	80143	7-27-77	100	TOT	23	47	8	0.5	1.43	1401	8
26303	80144	7-27-77	120	TOT	25	9	6	0.2	1.68	20	4
26303	80145	7-27-77	75	TOT	25	682	17	7.7	1.90	442	27

Table II-23.0-3. Summary of catch statistics from 27 otter trawl hauls taken at four sites in the Southern California Bight, winter and summer 1977; depth range 137 to 274 m.

	<u>Tanner Bank</u>	<u>San Miguel Island</u>	<u>Point Conception</u>	<u>Coal Oil Point</u>	<u>All</u>
n	(7)	(7)	(6)	(6)	(27)
Fish # Sp/Haul	5 (3-12)	16 (3-19)	12.5 (9-18)	11 (6-17)	11 (3-19)
CPUE <sup>1</sup>	17 (9-149)	144 (4-462)	172 (55-252)	172 (9-682)	138 (4-682)
SW DIV	1.45 (0.48-1.50)	1.67 (1.04-2.31)	1.69 (0.82-2.14)	1.75 (0.75-2.00)	1.62 (0.48-2.31)
Biomass	0.8 (0.3-10.0)	4.8 (0.7-24.5)	4.6 (2.0-9.7)	0.6 (0.2-9.5)	3.1 (0.2-24.5)
Inverts # Sp/Haul	9 (1-11+)	9 (1-25+)	24.5 (15-29)	17 (4-30)	17 (1-78)
CPUE <sup>1</sup>	18 (4-126)	134 (1-954)	145 (43-865+)	442 (20-595)	176 (1-1401)
Biomass	1 (<1-7)	9 (1-17.9)	6 (1-41)	41 (<1-86)	7 (<1-86.0)

<sup>1</sup> CPUE = Catch per unit effort = 1 trawl; uncorrected for variations in trawl time.

Table II-23.0-5. Summary of catches and catch ratios for conspicuous shrimp, echinoderms, and fish at four coastal sites in the Southern California Bight.

	Tanner Bank	San Miguel Island	Pt. Conception	Coal Oil Point
<u>Pandalus jordani</u>	0	0	349	1412
<u>Pandalus platyceros</u>	0	0	627	81
<u>Crangon</u> spp.	2	20	31	138
Shrimp	2	20	1007	1631
Urchins <sup>1</sup>	21	785	520	306
<u>Parastichopus californicus</u>	20	12	93	529
Starfish <sup>2</sup>	2	32	52	16
<u>Gorgonocephalus caryi</u>	0	28	0	0
Echinoderms	43	857	665	851
Shrimp % Total	4.4	2.3	60.2	65.7
Flatfish	73 (26.4%)	399 (37.5%)	486 (54%)	936 (59.4%)
Rockfish	162 (58.5%)	495 (46.6%)	228 (25.2%)	429 (27.2%)
All other fish	42 (15.2%)	169 (15.9%)	191 (21.1%)	212 (13.4%)

1 Lytechinus anamensis, Allocentrotus fragilis, and Brissaster latifrons

2 Luidia spp., Astropectin verrilli, Mediaster aequilis

seeps) were apparent aboard ship and the gear and catch contained small black particles of oil or tar. Trawls at Coal Oil Point produced average catch and variety of invertebrates, the highest average fish catch and diversity, and the highest invertebrate catch and biomass (dominated by echinoderms, prawns, shrimp, and crabs). Characteristic organisms included sea cucumbers (Parastichopus californiensis), urchins (Brissaster latifrons and Allocentrotus fragilis), large numbers of ocean shrimp and spot prawns (Pandalus jordani and P. platyceros), slender sole, Pacific sanddab, and splitnose and stripetail rockfish. Coal Oil Point produced the highest ratio of shrimp to echinoderms and the highest percentage of flatfish in the catches compared to other sites.

#### 23.3.4 Species range extensions

This study resulted in range extensions for at least three species. Spirontocaris lamellicornis, a small shrimp, was previously known to occur only as far south as central California; one specimen was caught in a trawl at Point Conception. Paraliparis albescens, a member of the snailfish family (Liparidae) was previously known from only six specimens in Monterey Bay, California; a single specimen was collected from the stomach of a rockfish taken at a depth of 183 m at Point Conception in March, 1977. This specimen (Moss Landing Marine Laboratory DB-55 (6808); final deposition, California Academy of Sciences, June, 1977) represents the only known male of the species (Anderson et al., in press). Finally, one specimen of the grunt sculpin, Rhamphocottus richardsoni, was taken at a depth of 185 m at Tanner Bank in March; this represents about a 100 km southern range extension (from Santa Monica and San Pedro Bays). Grunt sculpins are common intertidal and subtidal fish in the Pacific northwest.

#### 23.3.5 Health of fish and shellfish

The general appearance of all fishes and invertebrates was excellent and, with several notable exceptions, none of the fishes exhibited signs of fin erosion disease, lip tumors, or other abnormalities found in populations of bottomfish on the Los Angeles Orange County mainland shelf e.g., Palos Verdes and Santa Monica Bay (Mearns and Sherwood, 1977). However, large numbers of rockfish and flatfish from these trawls did exhibit a variety of conspicuous external and internal parasites, inconspicuous microscopic internal parasites, and structural and color anomalies as well as pathological tissue abnormalities apparently not caused by parasites. Two fishes bearing tumors (x-cell papillomas) were also collected at Point Conception.

##### 23.3.5.1 External parasites and anomalies

Although a quantitative analysis of parasite loads was not intended to be a central objective of this project, parasitism at all sites was too conspicuous to be ignored. A rough analysis of general types



160 170 180 190 200 ?

Figure II-23.0-2. Copepod parasite (dark lump) on the gill of a hake (Merluccius productus) 197 mm SL from the San Miguel Island, July 1977 (W77-48).

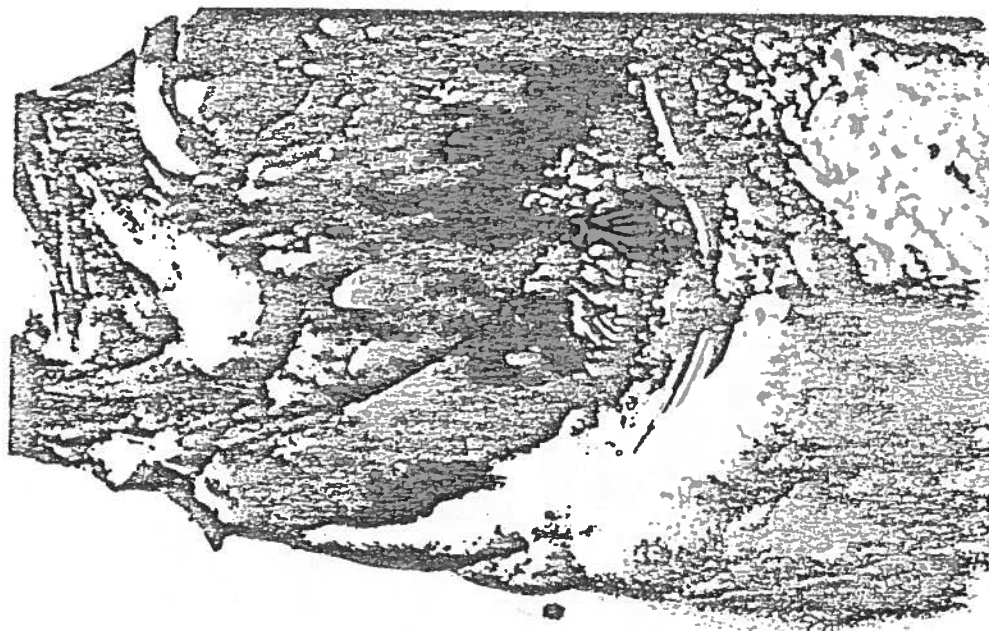


Figure II-23.0-3. Copepod parasite on the gill of a young splitnose rockfish (Sebastes diploproa, 113 mm SL) from Tanner Bank, July 1977. (S77-1).

Table II-23.0-6. Summary of occurrences of tail copepod parasites in split-nose rockfish (Sebastes diploproa) from four coastal sites. Based on shipboard examinations.

	Tanner Bank	San Miguel	Point Conception	Coal Oil Point
Total No. Parasitized	5	15	3	1
Total No. Examined	70	41	53	267
% Parasitized <sup>1</sup>	7.1	36.6	5.7	0.4

Table II-23.0-7. Occurrence of copepod eye parasites (Phrioxcephalus cinncinatus Wilson) in Pacific sanddabs (Citharichthys sordidus) from four southern California sites.

Site <sup>1</sup>	Tanner Bank	San Miguel	Point Conception	Coal Oil Point
Total No. Parasitized	0	1	2	5
Total No. Examined	9	249	158	544
% Parasitized	0	0.4	1.26	0.9

<sup>1</sup> Range of frequencies at other sites, 1974-75 was 0% in Santa Monica Bay and at Palos Verdes to 3.0% at Catalina and 5.1% at Point Loma (8.243 fish examined, Mearns and Sherwood, 1977).



Table II-23.0-8. Summary of occurrences of fin cysts in five species of rockfish from four sampling sites in the Southern California Bight. Based on external examination aboard ship.

		Tanner Bank	San Miguel	Point Conception	Coal Oil Point
<u>Sebastes elongatus</u>	N	78	13	0	0
	%	17.9	0	-	-
<u>Sebastes ensifer</u>	N	12	0	3	0
	%	25	-	0	-
<u>Sebastes rosen-</u> <u>blatti</u>	N	2	1	3	0
	%	50	0	33	-
<u>Sebastes jordani</u>	N	2	101	30	8
	%	0	1	0	0
<u>Sebastes crameri</u>	N	0	1	10	0
	%	-	0	10	-
Total, # Parasitized		18	1	2	0
	N	93	116	43	8
	%	19.4	0.9	4.7	0

Table II-23:0-9. Occurrence of diffuse pigmentation in Dover sole (Microstomus pacificus) and Rex sole (Glyptocephalus zachirus) from four southern California coastal sites.

	Tanner Bank	San Miguel	Point Conception	Coal Oil Point
<u>Microstomus pacificus</u>				
No. affected	0	7	4	5
Total Number	1	33	19	54
% affected	0	21	21	9.3
<u>Glyptocephalus zachirus</u>				
No. affected	0	9	1	5
Total Number	7	40	34	60
% affected	0	22.5	2.9	8.3

Table II-23.0-10. Number of specimens and size range (mm SL) of fishes histologically examined.

	Tanner Bank Winter Summer	San Miguel Winter Summer	Pt. Conception Winter Summer	Coal Oil Point Winter Summer
Pacific hake	-	-	- 2** (205,260)	-
<u>Rockfish</u>				
Stripetail rockfish	-	3 3* (126-134) (87-110)	4*** (101-126) (101-133)	1* (99)
Splitnose rockfish	- 3* (108-118)	-	-	3* (64-76)
<u>Epibenthic Flatfish</u>				
Pacific sanddab	- 3* (130-231)	- 3* (115-132) (93-122)	-	3 4*** (81-84) (118-162)
Slender sole	2 (N7-145)	-	3 3* (121-144) (140-170)	3 4*** (71-79) (129-156)
<u>Benthic Flatfish</u>				
English sole	-	-	-	3*** - (111-206)
Rex sole	- 3* (242-311) (169-173)	3 -	3 (104-144)	3*** - (163-212)
Dover sole	-	3*** (164-174)	3 (175-191)	3*** 6*** (162-166) (52-240)

\* Parasite damage  
 \*\* Other gross lesions  
 \*\*\* Non parasitic damage

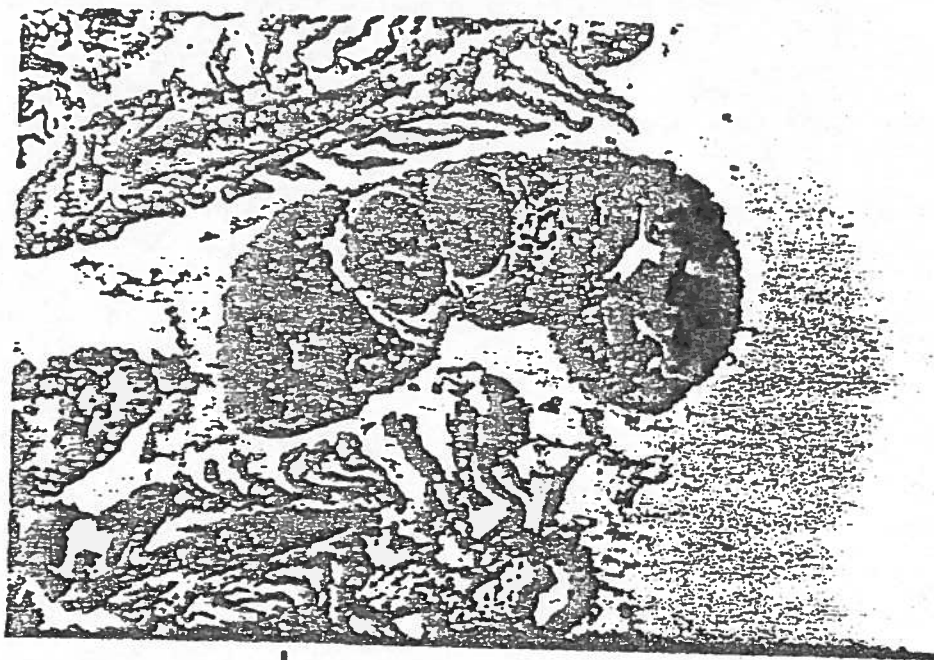


Figure II-23.0-10. Monogenetic trematodes in gills of a slender sole (*Lyopsetta exilis*, 151 mm SL) from Point Conception, July 1977 (S-77-43).

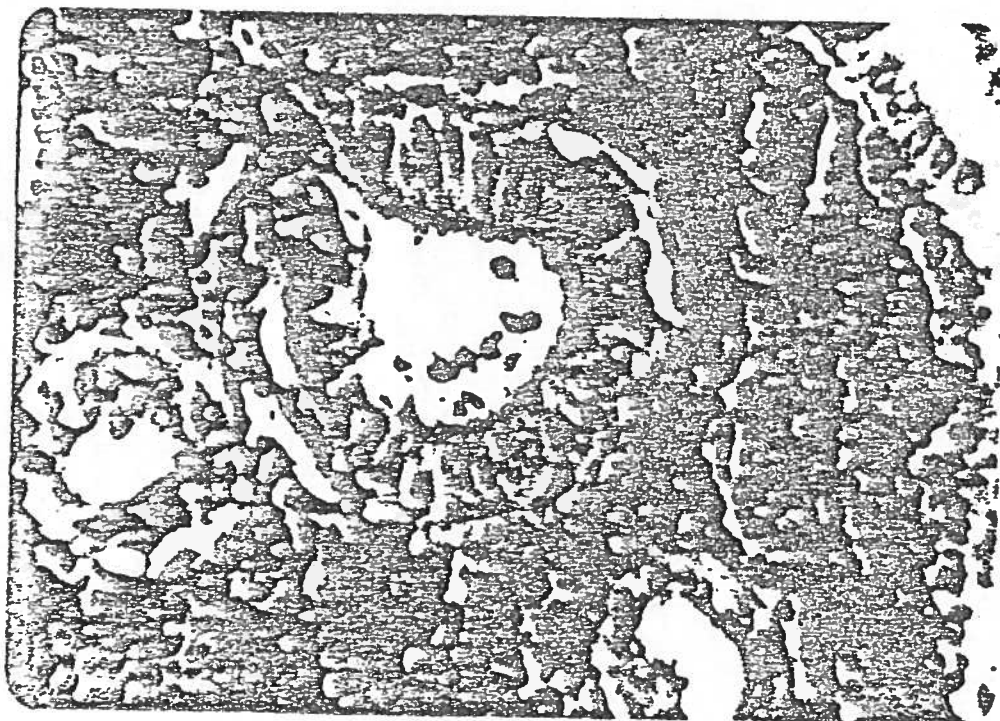


Figure II-23.0-11. Kidney tubule of a slender sole (*Lyopsetta exilis*, 137 mm SL) from Coal Oil Point with myxosporidean parasites (small dark objects inside central cavity) July 1977 (S77-24).

hyperplasia of respiratory epithelium (clubbing), sloughing of respiratory epithelium, and migration of EGC's and mucus cells to lamellae and inflammation (Figures II-23.0-13 a through c).

#### 23.3.5.2.4 Fixation problems

Due to a number of delays aboard ship, many tissues examined from winter collections and some from the summer collections were poorly fixed prior to processing for histological study and autolysis obscured what may have been more subtle cellular changes in deep internal tissues such as kidney. In addition, complete use of formalin as a fixative often resulted in loss of the epidermal layer of the skin during subsequent degasification (due to slow penetration of formalin). This precluded detail analysis of sensory tissue of the lateral line.

#### 23.3.5.3 Frequencies of liver and gill anomalies

As shown in Table II-23.0-11 (and summarized in Table II-23.0-13), liver tissue abnormalities were observed in 18 of the fish (21% of the total, 22% of those listed in Table II-23.0-9). Of these, 11 (61%) occurred at Coal Oil Point, six (33%) at Point Conception, one (6%) at San Miguel and none at Tanner Bank. Table II-23.0-12 indicates a somewhat different distribution with 29 (35%) fish showing gill damage: 20 (69%) occurred at Coal Oil Point, three (10%) at Point Conception; three (10%) at San Miguel Island, and three (10%) at Tanner Bank. However, as indicated by asterisks in Table II-23.0-8, all of the gill abnormalities at Tanner Bank, San Miguel Island, and Point Conception appeared to be host responses to parasites.

To gain a better comparison of occurrences of liver and gill anomalies, data from the previous tables were pooled by season and ecological type (Table II-23.0-13). Overall, gill damage in Coal Oil Point fish was the most frequent anomaly followed by liver damage. Benthic and epibenthic flatfish accounted for most of the liver and gill anomalies at this site.

With the exception of host tissue responses to parasites and specific cases of autolysis, all other tissues examined appeared normal.

#### 23.3.5.4 Tumors

Two first-time records of tumors in fish were made during these surveys. On March 20, 1977, a stripetail rockfish measuring 110 mm SL (130 mm TL) and bearing small tumor-like growths about the gills was caught at Point Conception Station 837, 139 m. Grossly, five small pinkish nodules were found, three on the head adjacent to the operculum, one on the left operculum and one on the isthmus of the gill (Figure II-23.0-14a). All of the tumors were approximately 2 mm

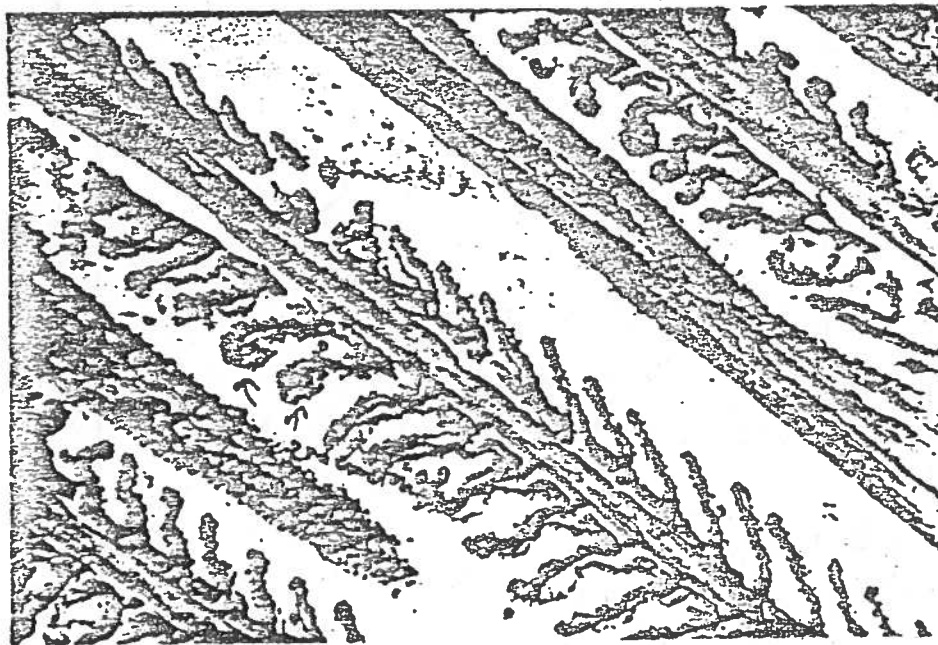
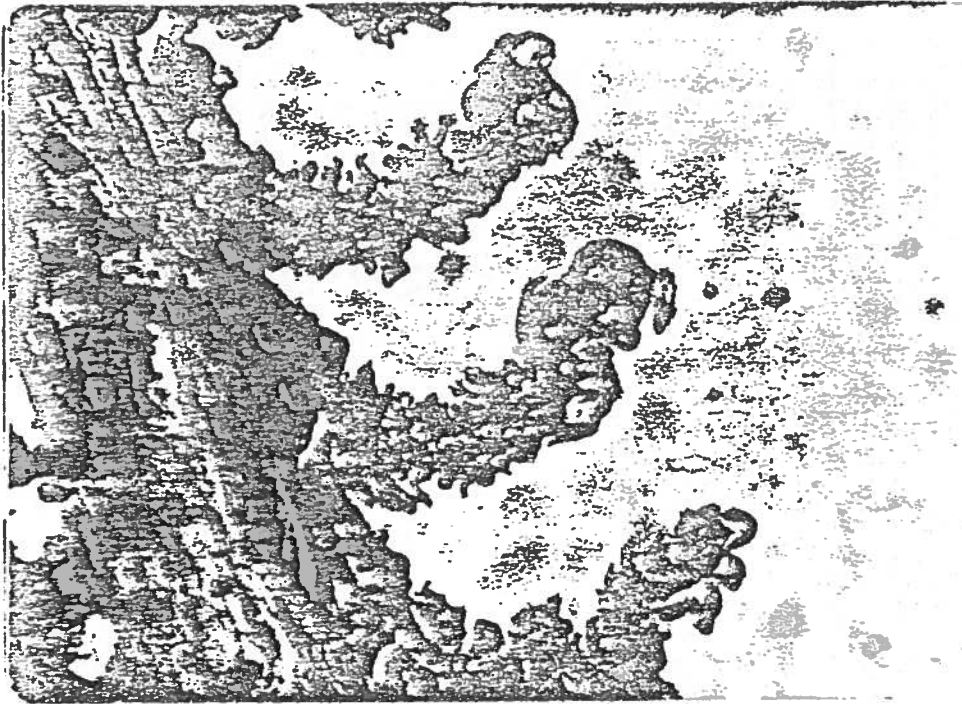


Figure II-23.0-13 (c) Abnormal gill filaments from a rex sole (Glyptocephalus zachirus) from Coal Oil Point, showing clubbing (March 1977, BLM-18).  
 (d) Abnormal gill from a Pacific sanddab (Citharichthys sordidus) from Coal Oil Point showing edematous filaments (July 1977, S77-27).



Table II-23.0-12. Occurrence of gill histopathological anomalies in fishes from four coastal sites, 1977; number affected/number examined.

	Tanner Bank		San Miguel Is.		Pt. Conception		Coal Oil Point	
	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer
Pacific hake	-	-	-	-	-	1/2*	-	-
Stripetail rockfish	-	-	0/3	0/3	0/4	1/6*	-	1/1*
Splitnose rockfish	-	0/3	-	-	-	-	-	ND/3
Pacific sanddab	-	2/3*	-	3/3*	0/3	-	0/3	4/4
Slender sole	-	0/3	-	-	0/3	1/3	0/3	4/4
English sole	-	-	-	-	-	-	3/3	-
Rex sole	-	1/3	0/3	-	0/3	-	2/3	-
Dover sole	-	-	0/3	-	0/3	-	2/3	4/6

\* Host response to parasite

ND-No data, gills removed

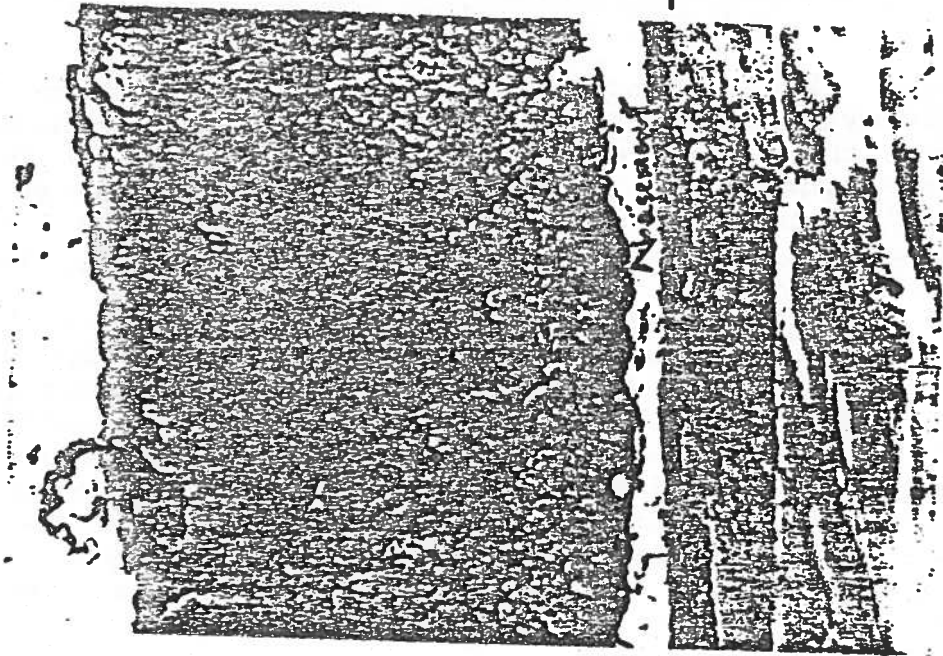
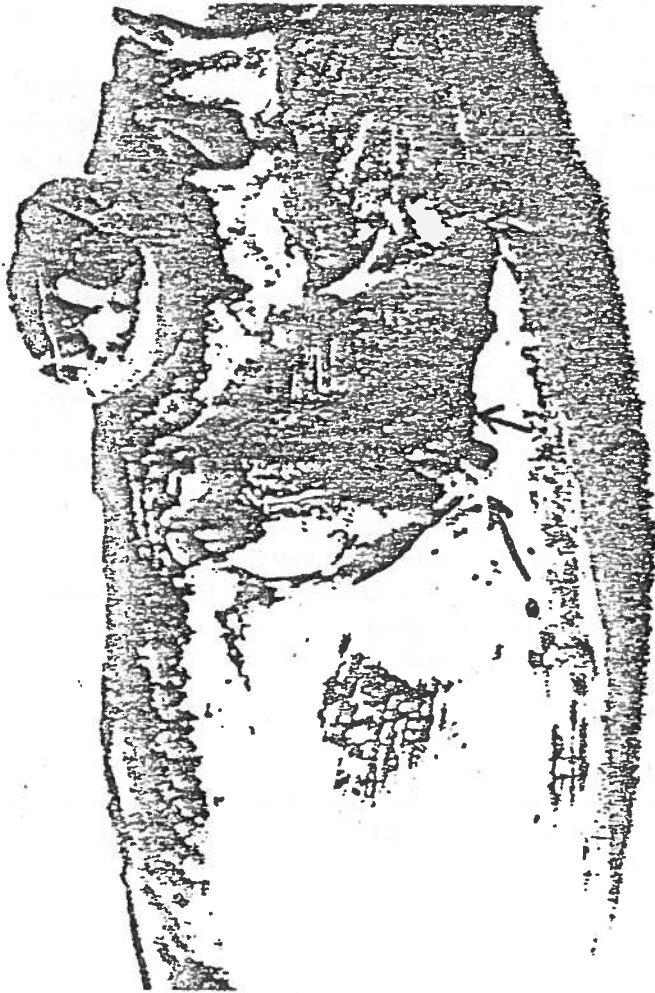


Figure II-23.0-14. "x-cell" tumors from a young (110 mm SL) stripetail rockfish (Sebastes saxicola) from Point Conception, March 1977 (BLM-13).  
 (a) Anterior portion of fish showing small flat pale-colored tumor encroaching on isthmus below gill.  
 (b) Section through tumor, basement membrane and muscle tissue, showing large tumor cells ("x-cells"), infiltrating blood vessels and normal basement tissue below.

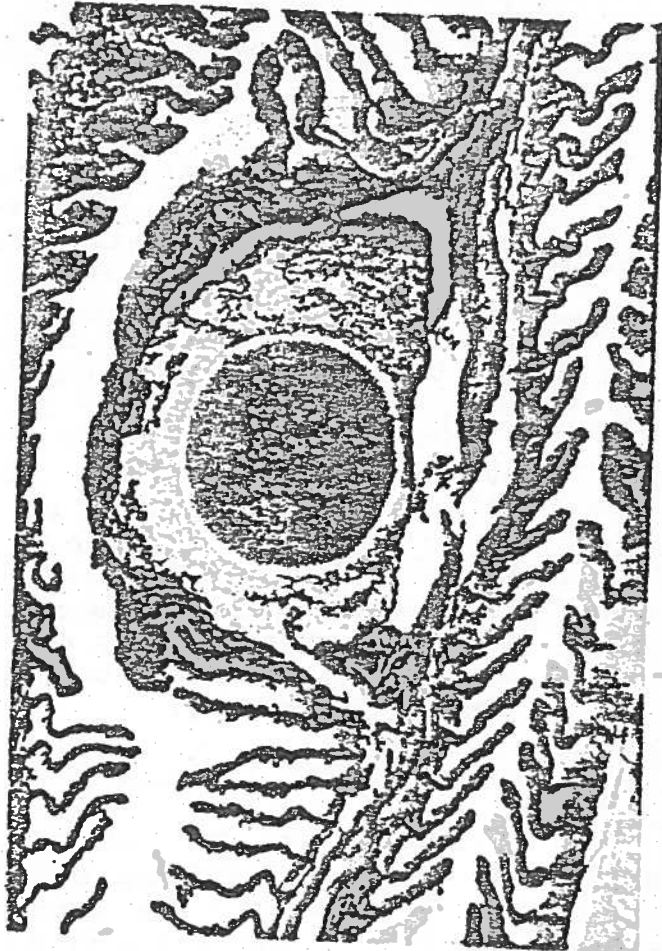
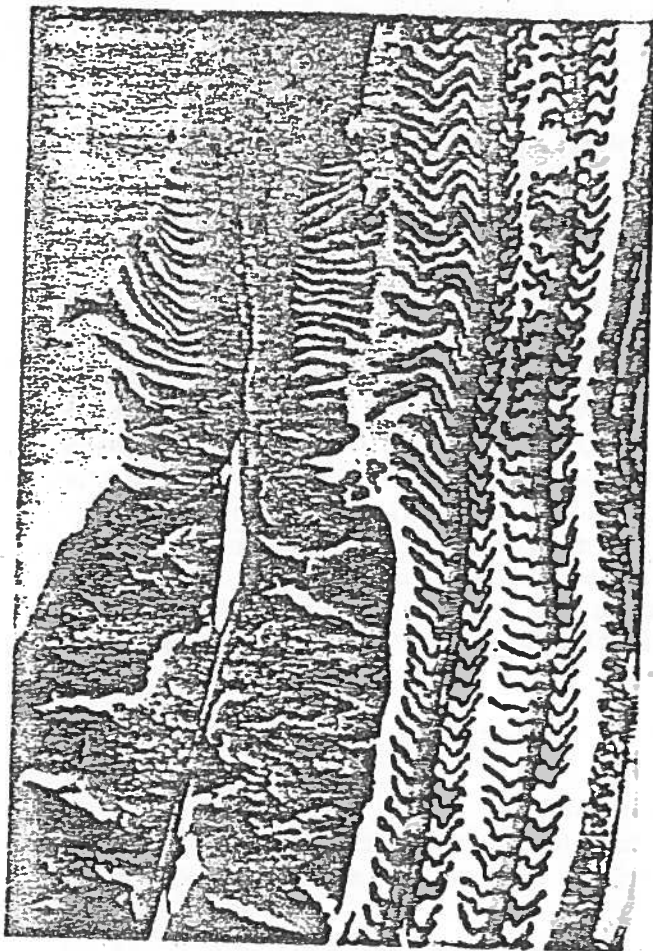


Figure II-23.0-15. Pacific hake (*Merluccius productus*, 260 mm SL) from Point Conception, July 1977, with "x-cell" tumorous growth on gill filaments (83709-1).  
 (a) Anterior portion of fish with right operculum removed; note white fungus-like growth on gill filaments.  
 (b) Low magnification section through normal and tumorous gill filament; note large mass of large "x-cells".  
 (c) Microsporidian cyst in gills of same fish.

English sole: All fish had some gill damage--either ballooning (engorged with blood) or clubbing (hyperplasia of various cells of the gill) of the gill lamellae including hypertrophic or endematous respiratory epithelium. Other tissues appeared normal.

#### 23.4.2 Summer cruise

##### 23.4.2.1 Tanner Bank

The sample from Tanner Bank consisted of three splitnose rockfish (108 to 118 mm SL), three Pacific sanddabs (130 to 231 mm SL), three rex sole (150 to 311 mm SL), and two slender sole (117 to 125 mm SL).

Splitnose rockfish: At least one fish was found with a myxosporidan parasite in cholangioles (bile ductules) of liver and probably gall bladder (probably Myxidium sp.) as this is a common genus in gall bladder and cholangiole infections in marine fish.

All three had a large unidentified parasite (probably a larval trematode but no structures present for definitive identification). This parasite infects liver, spleen, or kidney, and often is found in more than one organ. Small parasite induces only minor host response but large aggregations of the parasite (possibly sections through highly coiled parasite) induce major host response with a lot of fibrosis and encapsulation on the host's part. Size of the parasite probably makes it pathogenic especially when found in several organs.

Pacific sanddab: A myxosporidan was present in cholangioles of three fish. Two fish evidenced gill pathology including gill clubbing and ballooning in the distal regions of the gill lamellae, hypertrophy of the respiratory epithelium, migration of mucous cells and EGC's onto the gill lamellae, and many bloodcells within the mucus but exterior to the tissue (minor hemorrhages). Presence of a parasite (possibly an amoeba) was found on gills of one of the affected fish, and it was likely present (not seen in section) on the other fish as the pathology observed was very similar.

Rex sole: Parasites: one fish, trematode in kidney tubule; one fish, myxosporidan in kidney tubule; one fish, monogenic trematodes on gills (some host response such as hypertrophy and hyperplasia of respiratory epithelium near trematodes).

Slender sole: No anomalies seen in either fish.

##### 23.4.2.2 Point Conception

The sample from Point Conception consisted of six striptail rockfish (101 to 122 mm SL), three slender sole (140 to 170 mm SL), and two Pacific hake (198 to 256 mm SL).

Stripetail rockfish: Encysted trematode metacercariae found on fin and muscle of fins (base) in two fish.

#### 23.4.2.4 Coal Oil Point

The sample from Coal Oil Point consisted of six Dover sole (52 to 240 mm SL), two stripetail rockfish (99 mm SL), three splitnose rockfish (64 to 76 mm SL), four slender sole (129 to 156 mm SL), and four Pacific sanddabs (134 to 162 mm SL).

Dover sole: Four fish had damaged gills with no indication of parasites. One fish had no gills. Gill damage includes endematous condition of respiratory epithelium, clubbing and ballooning of lamellae, hyperplasia of mucous cells, and epithelial cells, migration of EGC's onto lamellae.

Two fish had myxosporians in cholangioles; one had some type of gill parasite (not identifiable because only a few), one had trematode in stomach.

Three fish had enlarged melanin-macrophage centers in livers.

Stripetail rockfish: Large unidentified parasite in spleen and kidney (same as reported elsewhere) microsporidan cysts on gills. Spleen was large upon dissection. Large M-MCs also present. Size of spleen and M-MCs may reflect presence of parasite. Trematode metacercariae encysted left pectoral.

Gills showed white cell reaction (to microsporidan?) clubbing and endema and sloughing of respiratory epithelium.

Splitnose rockfish: None had gills. Unidentified parasite present on livers, kidneys, and spleens.

Slender sole: Parasites included nematode embedded in peritoneal mesentery and tone free in peritoneal cavity, sporozoan inhabiting M-MCs, heart parasite (little host response), myxosporidan in kidney tubules, larval nematode in liver, monogenic trematodes on gills, plerocerooid in intestinal lumen, Myxosporidan in cholangioles.

All four evidenced gill damage, including edema, hypertrophy and hyperplasia of respiratory epithelium, presence of EGCs, ballooning and clubbing of lamellae.

Three fish had enlarged M-MCs.

Pacific sanddab: Two fish with myxosporidians in cholangioles (one definitely Myxidium sp.), two fish with nematodes free in body cavity, larval trematodes(?) in lamina propria of the intestine, one fish myxosporidan in kidney tubules, one fish with microsporidan cysts on gills, monogenic trematodes on most gills.

done. Gills, if not excised, should be exposed by removal or at least the bending back of the opercula. Also, muscle tissue of the body should be cut at intervals to insure fixation of the skin and muscle.

Third, the type of fixation may not be appropriate. Buffered formalin (10%) is an excellent general fixative but has several disadvantages which reduce its effectiveness under the conditions used in this study. Ten percent formalin fixes tissue quite rapidly but does not penetrate large amounts of tissue fast enough to insure good fixation throughout. Best fixation results when tissue is not more than 5 mm thick. Also, formalin does not decalcify tissues such as skin, gill, or fin thereby requiring decalcification of these tissues by solutions which can damage cellular components of the tissue. Several problems were encountered during the histological study due to the use of 10% formalin as a fixative of whole fish. The epidermal layer of the skin was often lost during the subsequent decalcification of the skin and the sensory tissues of the lateral line were not fixed before post mortem cellular lysis had occurred. This is significant because exposure to oil and pesticides has been reported to cause metaplasia and necrosis of sensory tissue in some fish (Gardner 1975). Also, the slow penetration of formalin allowed continued autolytic degeneration of some tissues after the fish were placed in the fixative. If buffered 10% formalin is to be used in the future, we recommend that the tissues intended for histological examination be excised and fixed separately. If feasible, fixing of gill, skin, and fin tissue in Bouin's fluid or adopting it as the general fixative is recommended because it has excellent fixing properties and it decalcifies tissues such as skin and gills. Disadvantages of Bouin's solutions are a) it works best on small pieces of tissue thereby requiring tissues to be excised and fixed, and, b) the additional handling required in washing the fixed tissues before storage in alcohol. If the fixation of whole animals is to be continued, Davidson's fixative (a modified formalin fixative) should be considered. This fixative has good penetrating and fixing properties, but is more expensive, has a very disagreeable odor, and tends to harden the skin of a careless user.

### 23.5 DISCUSSION AND CONCLUSIONS

This study attempted to meet a number of objectives that have rarely been attempted before at the sites chosen for this evaluation. The goal was to make as complete an evaluation as possible of the general health of the fish and shellfish fauna of Tanner Bank, the seaward side of San Miguel Island, and the mainland shelf sites of Coal Oil Point and Point Conception.



#### 23.5.2.1 Catch and species composition

No species new to the Southern California Bight were encountered during this survey. There were, however, three southern range extensions (the grunt sculpin, Ramphocottus richardsoni; a snailfish, Paraliparis albescens; and a shrimp, Spirontocaris lanellicornis) which are probably a good measure of a paucity of previous research trawl sampling at several of these sites (particularly Tanner Bank and Point Conception). In fact, the occurrence of three range extensions in only about 30 samples is a good indication that more effort may be necessary to document the occurrence of less abundant species at these sites and depths. In addition, the fact that all three extensions involve more northern species could indicate the sites and depths sampled are under more of a northern faunal influence than other southern California sites which have been more heavily sampled (as described in Allen and Voglin, 1976). However, Parrish (1971) noted that rockfish caught in longline sets off Santa Catalina Island formed what he described as a southern, deep association.

Aside from the above unusual occurrences, the bulk of the catch data suggests that all four sites are mainly occupied by a predictable bottomfish and macroinvertebrate fauna. Using recurrent group analysis techniques on over 400 otter trawl samples from the southern California mainland shelf (mainly off Los Angeles and Orange Counties), we described at least three major depth-related associations of nearshore bottomfish and associated single species and groups (Figure II-23.0-16; from Mearns et al., 1975 and Mearns, 1974). The SAI/BLM 1977 trawls sampled mainly the depth ranges occupied by Group 1 (mid depth) and Group 4 species (the boxes headed by Sebastes saxicola and Lyposetta exilis, respectively, in Figure II-23.0-16). Catch data from the four sites on species occupying these groups (and their associate species) indicate that these recurrent group species accounted for 29 to 82% of the total catches and from 55 to 91% of the total number of possible recurrent groups species (Table II-23.0-10).

Conspicuous species not represented in this recurrent group analysis included greenstriped rockfish (Sebastes elongatus) at Tanner Bank and San Miguel Island and splitnose rockfish (Sebastes diploproa) at all sites. In fact, a more recent recurrent group analysis by M. J. Allen (Scripps Institution of Oceanography, personal communication) indicates that these two species as well as green blotched rockfish (Sebastes resenblatti) may be associated with Group 4 fishes.

While species cluster techniques have not been applied to trawl caught invertebrates, past data summaries (e.g., Mearns et al., 1976) indicate that macroinvertebrates such as Parastichopus californicus, Allocentrotus fragilis, Pandalus jordani, and Pandalus platyceros are

normal and conspicuous members of the mainland shelf fauna at the depths sampled. The near-absence of larger shrimp at Tanner Bank and San Miguel Island is worthy of further documentation.

Closer inspection of Table II-23.0-10, indicates that the catches at the mainland sites (Coal Oil Point and Point Conception) had a much higher percentage of recurrent group specimens and species than the offshore sites (Tanner Bank and San Miguel Island). These observations, and other data presented above, suggest that there may be a gradient in faunal composition between the mainland sites and Tanner Bank. For example, flatfish and decapods were a much more conspicuous part of the catch at Coal Oil Point and Point Conception than at Tanner Bank and San Miguel Island (see Table II-23.0-5). A more detailed analysis of the data and additional successful samples from Tanner Bank are needed to substantiate this trend. If it is confirmed, it may simply indicate that the mainland shelf fauna is more directly dependent on a detritus and benthic infaunal food web than the offshore fauna.

Gross characteristics of the catch parameters suggest that benthic fishes and macroinvertebrates are more abundant and diverse at the mainland sites and San Miguel Island than at Tanner Bank (Table II-23.0-3). There is reason to believe this could be so because a more productive and suspended particulate dependent food web should be expected on the mainland shelf than offshore. However, additional sampling is required at Tanner Bank and San Miguel Island before such a hypothesis can be confirmed.

Overall, the catch statistics from these trawls suggested that even those sites with the largest catches (Coal Oil Point and Point Conception) produced catches well below the averages calculated from trawls of shorter duration taken mainly along coastal areas off Ventura, Los Angeles, and Orange counties (Allen and Voglin, 1976). However, the trawls reported by Allen and Voglin included many at depths shallower than 137 m; thus the difference may be due to a larger density of fish occurring shallower than 137 m. In more recent surveys to a depth of 610 m, we did conclude that fish abundance, biomass and number of species were lower below 200 m and that bottomfish abundance and biomass was low at the shallowest depths (20 m). By comparison, diversity was unaffected by depth and the largest fish occurred between 180 and 610 m (Mearns and Allen, 1977). Similar trends were found in the invertebrate catch (Word and Mearns, 1977).

#### 23.5.2.2 General health of fish

External parasites were the most conspicuous anomalies on fishes examined from these trawls. Although all fish could not be examined with equal effort (many were not), we estimate that between one and five percent of the fish had visible forms of parasitism. In fact, histological analyses revealed that nearly three-quarters of those

Table II-23.0-14. Prevalence of epidermal tumors in young Dover sole (*Microstomus pacificus*) from various regions and periods in the Southern California Bight.

Region	# fish 60-120 mm SL	# with Tumors	%	Data Source
Central Bight				
San Pedro Bay 1972-74	278	9	3.2	Sherwood and Mearns, 1975
Palos Verdes 1972-74	717	48	6.7	"
Santa Monica Bay 1971-74	52	1	1.9	"
Northern Bight				
Santa Barbara - Pt. Conception 1977	44	3	6.8	SCCWRP, in prep.
Pt. Conception (SAI) 1977	4	0	0	This Report
Coal Oil Point (SAI) 1977	8	0	0	"
San Miguel Is. (SAI) 1977	5	0	0	"
Tanner Bank (SAI)	1	0	0	"
Σ SAI/BLM	18	0	0	"

and necrosis of parenchyma cells of internal organs, pigment cell alterations, fatty metamorphosis of the liver, discoloration of various internal organs, and alterations in the ultra-structure of various parenchyma cells (Hodgins et al., 1977). Gardner (1975) reported necrosis of sensory cells, hyperplasia and metaplasia of supporting epithelial cells, and damage to blood vessels of the heart. The areas of hypertrophic nuclei and focal hepatocyte hyperplasia in the livers of the Coal Oil Point fish resembled tissue considered to be pre-neoplastic in English sole from the Duwamish River, Seattle, Washington; a population in which there was a high rate of hematoma formation (McCain et al., 1977 and Pierce et al., 1978).

Although the Coal Oil Point slender sole and Pacific sanddab did not have the same lesions as the Coal Oil Point Dover sole and rex sole, the potential for pathological changes in these species can not be disregarded since there was poor fixation and there is the possibility of abnormalities present at the ultra-structural level that were not recognized with light microscopy. Also, the differences could be attributed to differences in length of exposure, species tolerances, or acquired tolerances.

For winter specimens, parasitism was of minimal importance. With the exception of larval helminths in the stripetail rockfish from the Point Conception area, the parasites were types common to marine fishes, present at light infestations, and not believed to be detrimental to the host (Sinderman 1970). The unidentified larval helminth should be considered potentially detrimental because of its size. The absence of parasites in the Coal Oil Point sample was surprising. While effects of oil on marine teleosts are not well understood, a trend toward increased parasitism of oil-exposed teleost hosts has been noted. Personnel of NOAA, National Marine Fisheries Service, Northwest and Alaska Center, Seattle, Washington, have noted an increase in both ectoparasites and endoparasites of English sole (Parophrys vetulus) exposed to oil-soaked sediments (McCain, unpublished data). Other studies, reviewed by Hodgins et al., (1977), have indicated that exposure to crude oil and various fractions of crude oil lowers the immune resistance of many aquatic animals. Increased bacterial loads resulting in bacterial fin erosion have also been linked to exposure to crude oil (Minchew and Yarbrough 1977).

For summer specimens, fishes from all areas showed evidence of parasitism. With the exception of a few trematodes infecting the heart and the unidentified parasite of the splitnose rockfish from Tanner Bank, most of the parasites appeared well adapted, causing little harm to their host.

This report includes the first record of the occurrence of x-cell tumors in stripetail rockfish and Pacific hake. "X-cells" have previously been reported in skin papillomas of several Pleuronectid

of bottomfish and shellfish assemblages at the four sites is similar to that found elsewhere in southern California at similar depths. There are, however, some site specific differences in composition of the bottomfish and epibenthic invertebrate fauna. For instance, the mainland shelf sites appear to harbor larger populations and larger proportions of flatfish, rockfish, shrimp, and echinoderms than the offshore sites. The data suggests that oil from seeps at Coal Oil Point produced no profound inimical effects on fish and epibenthic species composition or community structure at the depths samples.

Based on external examinations, the fishes at all four sites appeared healthy and vigorous. However, many (1 to 5%) harbored an apparently normal load of visible external parasites, tumor-like cysts and color anomalies. Based on internal examination and histology, numerous fish (perhaps up to 75 percent) harbored an apparently normal load of small and microscopic parasites, dominated by trematode metacercariae, myxosporideans and microsporidians. At least three species of fish incur epidermal tumor disease(s) in the Santa Barbara Channel area. Sampling is insufficient to determine whether or not a disease epicenter exists. Based on work elsewhere, it is possible the occurrence of such tumors is not related to specific pollutant point sources. More sampling is required to confirm this locally.

Histological observations suggested that benthic-feeding fishes at Coal Oil Point suffered liver and gill tissue damage that was not as frequent or apparent at other sites and appeared unrelated to parasite burdens. Exposure to oil may be a possible factor causing these abnormalities and it would be worthwhile to reconfirm these observations, comparing these data with tissue levels of petroleum hydrocarbons and conducting experiments to confirm the relationship and determine if the pathology is reversible.

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HEALTH, ABUNDANCE AND DIVERSITY OF BOTTOM FISH  
AND SHELLFISH POPULATIONS AT PROPOSED AND  
EXISTING OFFSHORE DRILLING SITES IN THE  
SOUTHERN CALIFORNIA BIGHT

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## 23.0 HEALTH, ABUNDANCE AND DIVERSITY OF BOTTOMFISH AND SHELLFISH POPULATIONS AT PROPOSED AND EXISTING OFFSHORE DRILLING SITES IN THE SOUTHERN CALIFORNIA BIGHT

### 23.1 METHODS

At the time of collection, specimens were measured and fixed whole with body cavity slit in 10% phosphate buffered formalin. At a later time, the specimens were necropsied and samples of liver, gall bladder, spleen, intestine, gonad, heart, kidney, muscle, fin, gill, and skin (including lateral line) selected for histological examination. Selected tissues were processed using an Autotechnicon, embedded in Paraplast Plus, and sectioned at 8  $\mu$ m using an A.O. rotary microtome. Sections were stained with either hematoxylin-eosin Y or with more specialized stains (Periodic acid-Schiff's solution, and Masson's trichrome solution or May-Grunwald Giemsa), then examined using light microscopy.

### 23.2 GENERAL COMMENTS

Many of the tissues examined were fixed poorly prior to processing for histological study. It is essential that histological material be properly fixed at time of capture, as the onset of autolytic degeneration of cells can obscure many of the subtle changes that result from subacute exposure to toxic substances.

### 23.3 DESCRIPTION OF NORMAL TISSUES :

General histological descriptions of teleost tissues are available in the published literature; therefore, the following descriptions will be brief and emphasis will be on variations between species.

#### 23.3.1 Skin

The skin consists of three layers--the epidermis, dermis, and hyperdermis. The epidermal layer is composed of six to 10 layers of squamous epithelium, flattened in the outer layers. The principle cell type is the Malpighian cell. Originating in the middle layers and intermixed throughout the Malpighian cells are mucus-producing cells (Bullock and Roberts 1974; Ashley 1975). The Dover sole and rex sole also have an additional cell type in the middle and basal layers of the epidermis. These cells, called eosinophilic granular cells (EGCs), have been reported in various pleuronectid species (Bullock and Roberts 1974; Wellings *et al.*, 1976; Murchelano 1975. EGCs are occasionally seen in pathological lesions of the skin in other species (Bullock and Roberts 1974). In addition, large, mucopolysaccharide-containing cysts called multilocular cysts (Sherwood and Bendele 1975) were seen intermixed with the mucus and Malpighian cells in the Dover sole. In live teleosts, a peripheral layer called the cuticle is usually present. Composed of mucus,

they are known to phagocytize exogenous particles from the blood. Pancreatic tissue was noted along some of the major blood vessels of the rex sole and slender sole. The hepatocytes contained varying amounts of lipid and glycogen vacuolation depending upon species and age.

#### 23.3.5 Pancreas

The merocrine cells of the pancreas were found in acinar arrangements scattered throughout the mesentery tissue of the internal organs or as a hepato-pancreas in the rex sole and slender sole. Islets of Langerhans were present except in fish with a hepato-pancreas (Khalilov 1968).

#### 23.3.6 Gall bladder

The gall bladder is a sac-like structure connected to the liver. Histologically, the mucosa of the lumen is extensively folded over giving a false impression of stratification. A layer of loose connective tissue (serosa) lies between the basement membrane of the epithelial cells and the encapsulating membrane (serosa). Anderson and Mitchum (1974) have described the gall bladder of the trout which is similar to the gallbladders of the species examined.

#### 23.3.7 Kidney

The kidneys of the Dover sole, rex sole, slender sole, and Pacific sanddab were located retroperitoneally to the spine. In the stripe-tail rockfish they were located in the anterior-dorsal part of the peritoneal cavity. In the flatfish, the kidneys were fused posteriorly. Anteriorly, two slender branches formed a distinct head kidney comprised of hematopoietic tissue. The posterior kidney contained the nephrons and supporting internal tissue. M-MCs were also found in the posterior kidney. In the rockfish, the kidneys were not fused, one lying on either side of the internal organ mass. The hematopoietic tissue of the head kidney was found associated with the junction of the two kidneys. The structure of teleost kidneys has been described by Hickman and Trump (1969). Bulger and Trump (1968) described the kidney of the English sole which is representative of most flatfishes. In this study, many of the kidneys were poorly fixed.

#### 23.3.8 Intestine

The intestine was composed of four layers: the serosa, the muscularis, the lamina propria, and the mucosa (Dawes 1929; Bucke 1971; Anderson and Mitchum 1974). The mucosa, comprised of ciliated columnar epithelial cells, goblet cells, and migrating leucocytes, was highly folded. The lamina propria supported the mucosal folds and contained the vascular system. A circular and a longitudinal