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PUGET SOUND INTERIM STUDIES

ECOLOGICAL AND DISEASE STUDIES OF DEMERSAL FISHES NEAR METRO OPERATED SEWAGE TREATMENT PLANTS ON PUGET SOUND AND THE DUWAMISH RIVER

by

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INTRODUCTION

During 1975 the Fisheries Research Institute (FRI) conducted ecological and disease studies on the demersal fishes near METRO-operated sewage outfalls and in the Duwamish River. This study has operated under the auspices of the METRO-funded Puget Sound Interim Studies (PSIS) program, and will continue through February 1977. This one-year progress report presents the results of the ecological and disease studies for 1975.

The ecological studies are divided into two separate programs: (1) An outfall study and (2) a Duwamish River study. The objectives of the outfall study are: (1) To investigate the effects of sewage effluent on demersal fish community structure, (2) to investigate the relationship between sewage outfalls and disease incidence and parasite infestation levels, and (3) to provide baseline data for the analysis of the effects of future sewage treatment procedures on demersal fishes. To satisfy these objectives a sampling program was designed to collect data on species composition, distribution, and abundance as well as disease and parasite incidences in the vicinity of two METRO sewage outfalls (West Point and Alki Point facilities) and at a control site (Point Pully). This approach will allow comparisons between the outfall and control sites, as well as between-year comparisons at outfall sites where previous data exist (Moulton, et al., 1974; Miller, et al., 1975), and should permit an evaluation of the effects of sewage disposal on demersal fish community structure and "health".

The principal objective of the Duwamish River study is to provide data on the river location and monthly occurrence of disease and parasite infestation incidences on flatfish species--in particular the abundant starry flounder (Platichthys stellatus). Additional data are collected on the distribution and relative abundance of non-flatfish species.

The purpose of the pathological part of this investigation is to characterize the histopathological, microbiological, and physiological properties of the significant marine fish diseases associated with METRO sewage outfalls. In addition, attempts are being made to identify the etiological agent(s) of each disease.

METHODS AND MATERIALS

Ecological Studies

1. *Outfall Study*

1.1 *Sampling Plan.* The outfall study sampling program is conducted near METRO-operated sewage outfalls located at West Point and Alki Point, and at Point Pully which serves as a control site (Fig. 1). Initiation of monthly sampling was originally scheduled for February 1975 at all three sites. However, because of contractual difficulties, gear problems, and site evaluation, a finalized sampling plan was not in full operation until June. Prior to June, irregular sampling was conducted at each site with all gear types (Table 1) and these data are included in this report.

Beach seine operations were initiated in February on the south-facing beaches at West Point and Point Pully, and in April at Alki Point. Immediate sampling problems were encountered with the 37-m beach seine which necessitated shifting our sampling to the north beaches at West Point and Alki Point. In the case of West Point, this move seemed justified since studies by the Applied Physics Laboratory (1975) and Evan-Hamilton, Inc. (1974), had shown that effluent from the outfall

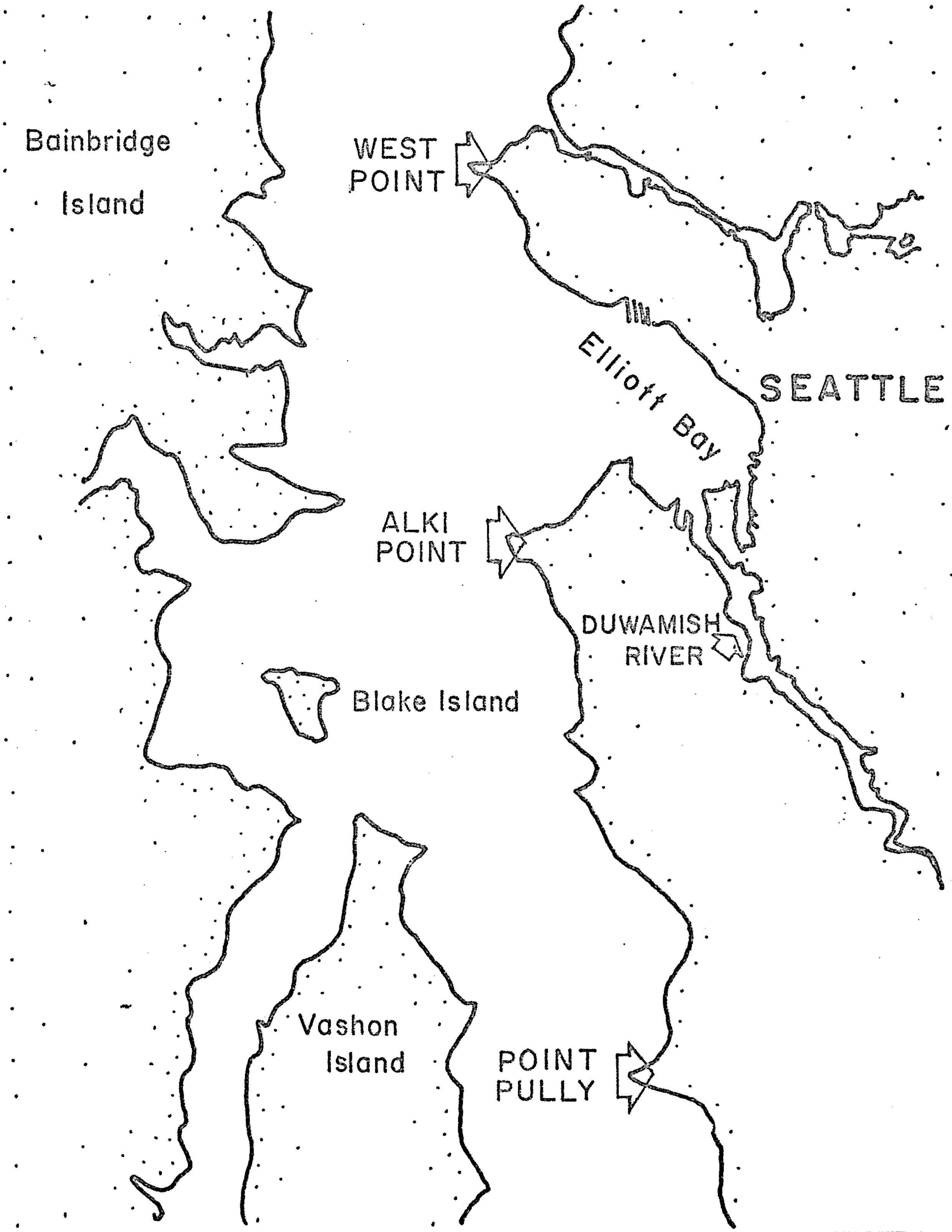


Fig. 1. Central Puget Sound showing outfall and Duwamish River study sites.

Table 1. Sampling conducted during 1975. C indicates sampling completed; P indicates a partial sample obtained; dash (--) indicates no sampling conducted; N indicates sampling conducted on the north side of the point; and S indicates sampling conducted on the south side of the point.

	Beach seine			Otter trawl			
Month	West Pt.	Alki Pt.	Pt. Pully	West Pt.	Alki Pt.	Pt. Pully	Duwamish River
February	CS	--	CS	--	--	--	C
March	--	--	CS	PS	--	--	C
April	PS	CS	CS	CS	CS	CS	C
May	CN	--	CS	CS	CS	CS	C
June	CN	CN	CS	CN	CS	CS	C
July	CN	PN	CS	CN	CS	CS	C
August	CN	CN	CS	CN	CS	CS	C
September	CN	CN	CS	CN	CS	CS	C
October	CN	CN	CS	CN	CS	CS	C
November	CN	PN	CS	PN	CS	CS	C
December	CN	PN	CS	--	CS	CS	--

reached both the north and the south beaches. No difficulties were encountered at Point Pully and all subsequent sampling has been continued on the south beach since the north beach is not satisfactory for seining.

Otter trawl sampling was begun in March at West Point and in April at Alki Point and Point Pully. Initially, all sampling was confined to the south side of each point; however, after changing the West Point beach seine site to the north beach, it was decided to shift the otter trawling as well. Since the Alki Point outfall is relatively small and the sphere of its influence not clear, it seemed wise to continue otter trawling on the south shore where the outfall was located and where previous sampling had been conducted (Miller, et al., 1974).

The finalized sampling plan for the outfall study involves beach seining (37-m and 9-m nets) and otter trawling at all sites once each month. At West Point all sampling is confined to the north shore and beach (Fig. 2), except for 9-m beach seine samples which are also taken on the south beach. At Alki Point, all otter trawling is conducted on the south shore, and all beach seine operations are confined to the north beach (Fig. 3). At Point Pully, all sampling is exclusively confined to the south shore and beach (Fig. 4).

1.2 *Sampling Gear and Methods*

1.21 *Beach Seine.* Three different types of beach seines are utilized for sampling littoral fishes in the sand/eelgrass habitat which characterizes the beaches at all three sampling sites. All beach seine operations are confined to the lowest tidal series each month and include sampling with all three types of gear. A 9-m beach seine is used for

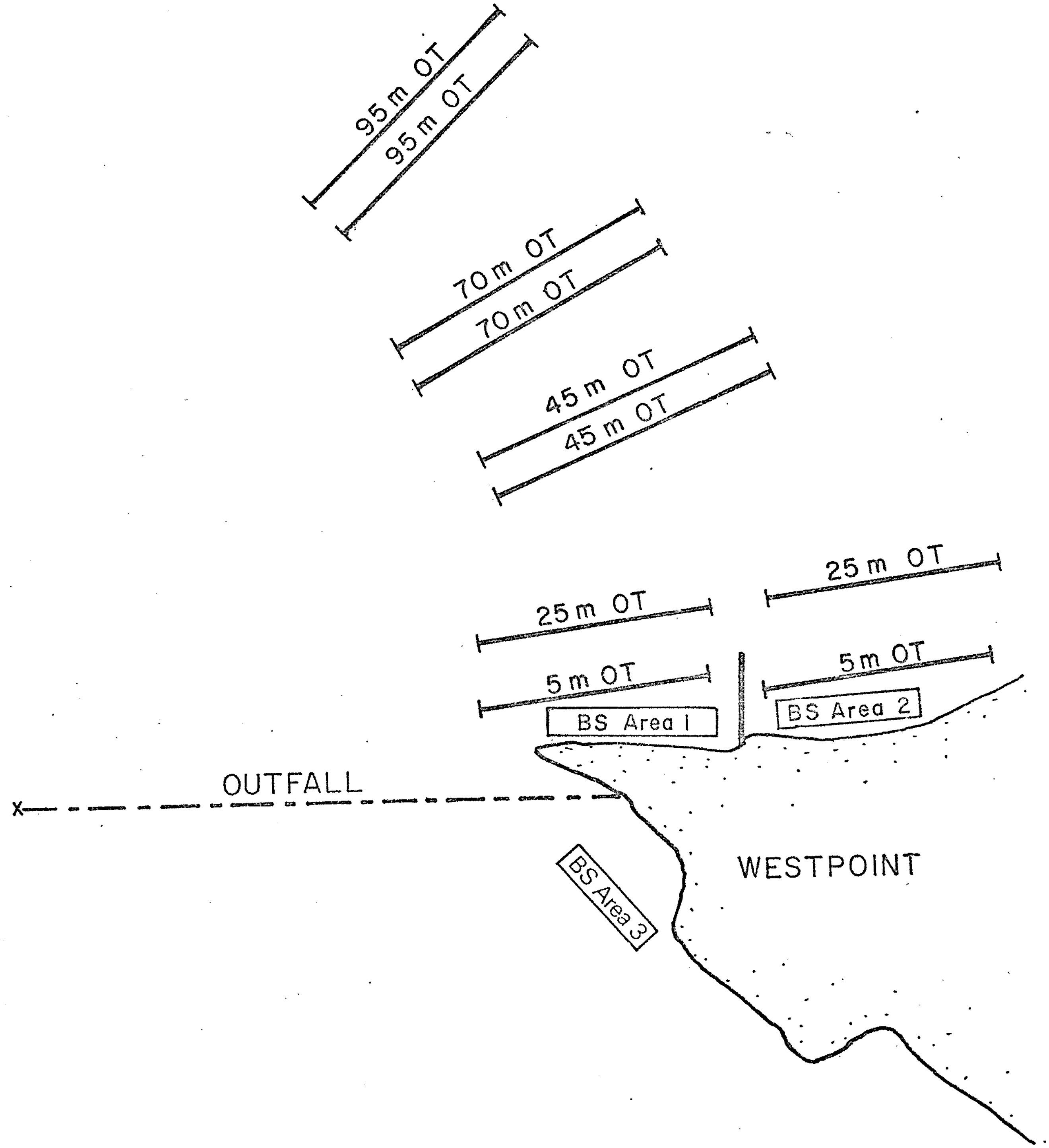


Fig. 2. West Point study site showing beach seine (BS) and otter trawl (OT) sampling stations (depth in meters).

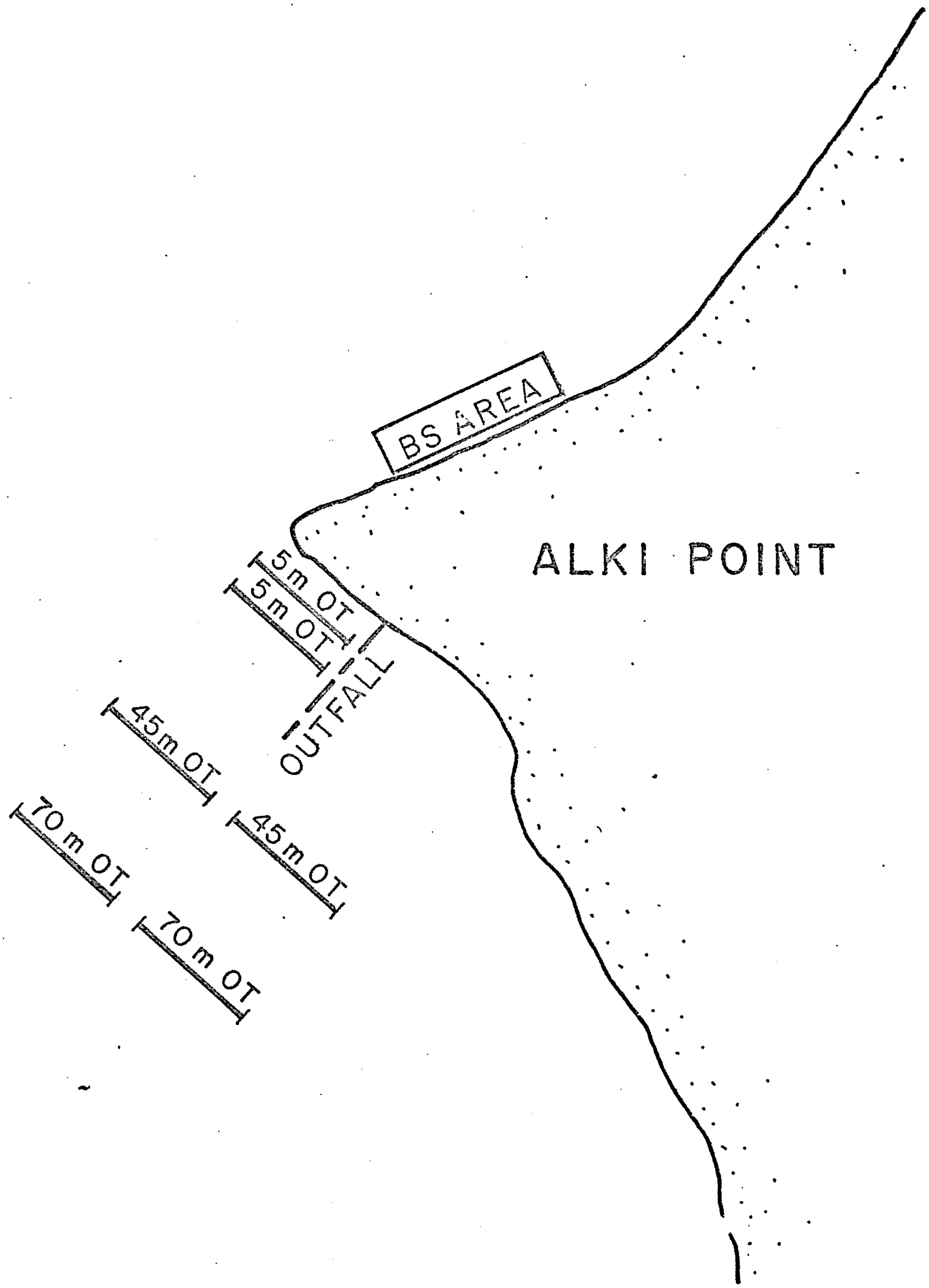


Fig. 3. Alki Point study site showing beach seine (BS) and otter trawl (OT) sampling stations (depth in meters).

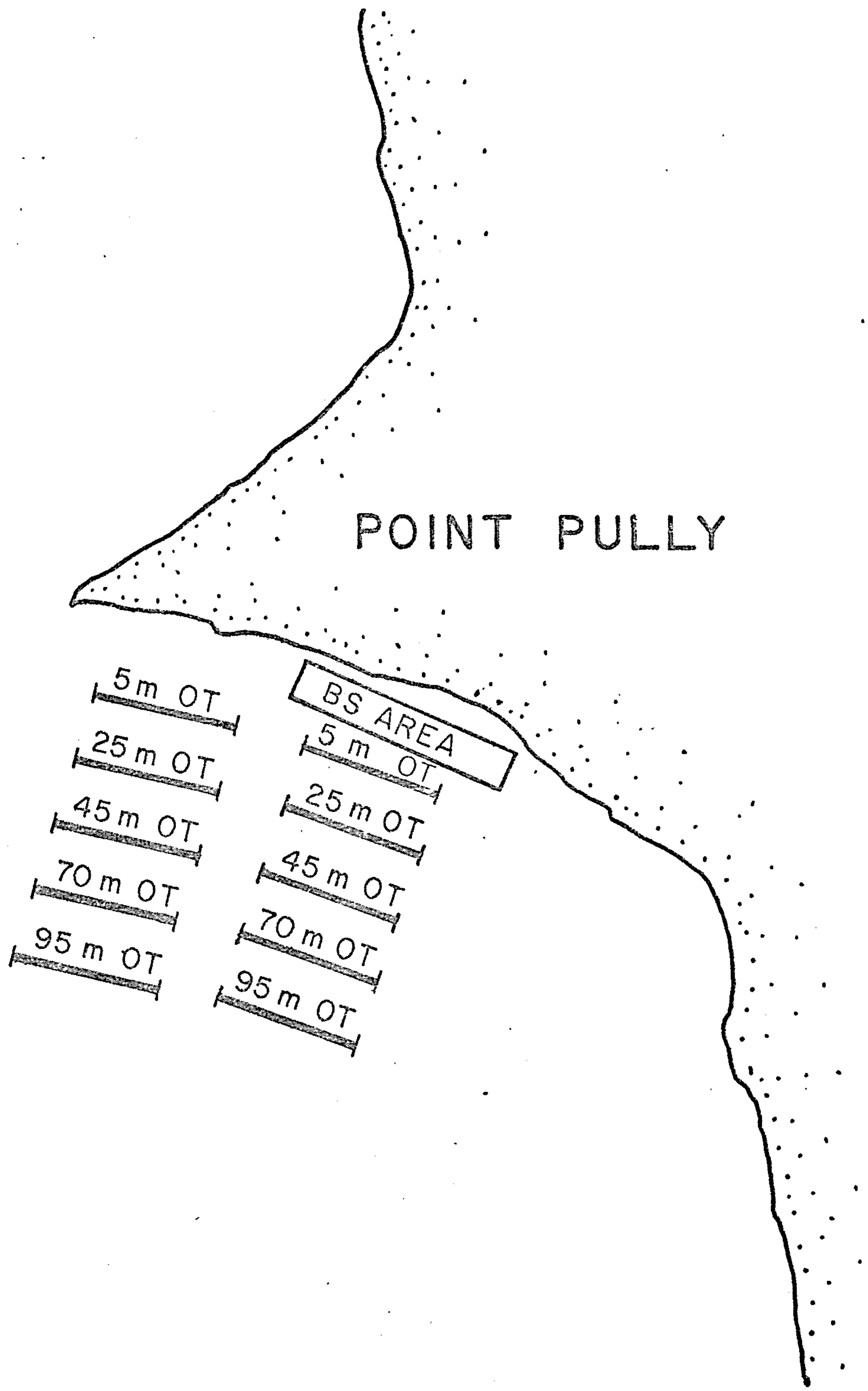


Fig. 4. Point Pully study site showing beach seine (BS) and otter trawl (OT) sampling stations (depth in meters).

sampling in shallow water less than one meter deep. This net has 9-mm mesh in the wings, a 6-mm mesh bag, and is fished with a 6.5-m check cord which serves to maintain a constant mouth opening. The 9-m net is set perpendicular to the beach and is pulled parallel to shore by two men for a distance of 30 m. Generally, 3-5 replicates are made if time permits. Although this small net samples only a narrow strip of beach near the water line, it is extremely effective at capturing newly metamorphosed and juvenile flatfishes as well as small eelgrass-associated species.

Two 37-m beach seines are utilized for sampling the bottom and surface waters of the littoral zone out to a distance of 30 m. Both 37-m nets have 18-m wings of 29-mm mesh and a 0.6m x 2.4m x 2.3m bag lined with 6-mm mesh. One net is equipped with seven floats and thus serves as a floating net which samples the surface water layer of the littoral zone. The other 37-m net is a sinking net which samples the bottom of the same region fished by the floating net. The nets are set in an identical manner and replicates are taken if time permits and catches are not too large. The 37-m nets are set parallel to shore at a distance of 30 m using a small skiff and are retrieved at a rate of about 10 m/min. Lines attached to poles at the end of each wing are initially retrieved from a distance of 40 m apart. After 20 m of line have been retrieved, the net opening is closed to approximately 12 m and retrieval of the net is completed. The 37-m nets sample a more extensive area than the 9-m net. At West Point and Point Pully, they appear to sample an area that is contiguous with the shallow (5-m) otter trawl station.

Because of extensive eelgrass beds at our Alki Point station, the 37-m sinking and floating nets could not be used properly. Experimentation showed that the net worked satisfactorily when three floats were attached just above the bag; consequently, this method was adopted.

All specimens collected are bagged by haul, held on ice, and returned to the lab for further processing.

1.22 *Otter Trawl.* A 5-m (footrope) otter trawl is used to sample demersal fishes at depths of 5, 25, 45, 70, and 95 m, at West Point and Point Pully, while only the 5-m, 45-m, and 70-m depths are sampled at Alki Point. Replicate 5-min tows are made at each depth. In some months, replicate series of 4-7 tows are made at a particular depth in order to investigate the reliability of our sampling. Catches are bagged separately by haul, placed on ice, and returned to the lab for processing.

1.23 *Drop Net.* An important microhabitat for fishes in the areas where we beach-seine is eelgrass (Zostera marina). For the most part, eelgrass-associated fishes have not been carefully studied as a group in Puget Sound. Therefore, a 3m x 3m drop net patterned after that used by Adams (1974) is being developed for sampling those fishes closely associated with eelgrass beds. We hope to have this net operational by March 1976.

1.24 *Twenty-Four Hour Studies.* At West Point, quarterly 24-hour studies are being conducted. During each 24-hour study period, samples are taken with the 37-m beach seine, 5-m otter trawl, and a 46-m trammel net. A series of beach seine and otter trawl hauls is made every four hours, and two trammel nets are set and retrieved at dusk and dawn. Sampling of this nature will permit us to investigate: (1) Diel changes in the distribution of individual species near the METRO outfall, and

(2) the influx of larger predatory fishes (e.g., cod, hake, and dogfish) which are not captured during normal daytime sampling.

1.3 *Field Collection Information.* For all types of sampling, the location, date, time, weather conditions, tidal height, and other relevant environmental data are recorded in the field. Water samples for dissolved oxygen and salinity are taken during beach seining and trawling operations each month. Water samples taken during beach seining are from shallow water less than 1.5 m deep. During trawling bottom water samples are taken at depths of 5 m, 45 m, and 95 m. In addition, bathythermograph tracings are made at the 45-m and 95-m depths. All salinity and dissolved oxygen determinations are made by the METRO water quality laboratory. All physical-chemical and environmental data are transferred to computer-format forms for keypunching.

1.4 *Laboratory Processing.* Laboratory catch processing includes: Identification; enumeration by species; external sexing whenever possible; and examination for tumors, external nematode parasites, fin erosion, and other abnormalities. Total lengths to the nearest millimeter and total weights to the nearest 0.1 gm are taken for all specimens. Individuals from all species, with emphasis on the flatfishes, are preserved for later stomach analysis. Otoliths are removed from English sole, rock sole, and C-O sole in order to study growth rates. In addition, otoliths are removed from several other species in order to gather general life history information. All biological data are compiled on computer-format forms for later keypunching.

2. *Duwamish River Study*

2.1 *Study Site, Sampling Gear, and Methods.* Sampling in the Duwamish River during 1975 was the continuation of a study conducted during 1974 (Miller, et al., 1975). Monthly samples of demersal fishes were obtained at each of eight stations located in the lower river (Fig. 5). Single 5-min tows were made at each station using a 5-m (footrope) otter trawl outfitted with 6-mm cod end mesh lining. Each haul was bagged separately, held on ice, and later returned to the laboratory for further processing.

2.2 *Laboratory Processing*. Laboratory processing involved identification and enumeration of all individuals collected. External determination of sex was made whenever possible. Total lengths were taken to the nearest millimeter for all fishes. Total weights were taken to the nearest 0.1 gm for flatfish species only. All fish were carefully examined for tumors, fin erosion, and external nematodes. In addition, otoliths were removed from approximately 50 "normal" and all diseased (i.e., fish with fin erosion and/or tumors) starry flounder in order to determine growth rates for normal and diseased starry flounder residing in the river. All data were compiled on computer-format forms and later keypunched for data storage and retrieval.

Pathology Studies

Specimens from normal and diseased fish were obtained and returned to the laboratory for further analyses. The specimens included live and/or freshly dead fish, fish blood, fish tissue, and microbial isolates.

For histopathological examination of a diseased fish, the fish was photographed, autopsied, and all abnormalities recorded. The diseased tissue and major internal organs were preserved in either 10% Formalin in phosphate buffered saline, or Bouin's fixative. Paraffin-embedded or frozen tissue was sectioned with a microtome, and the sections were

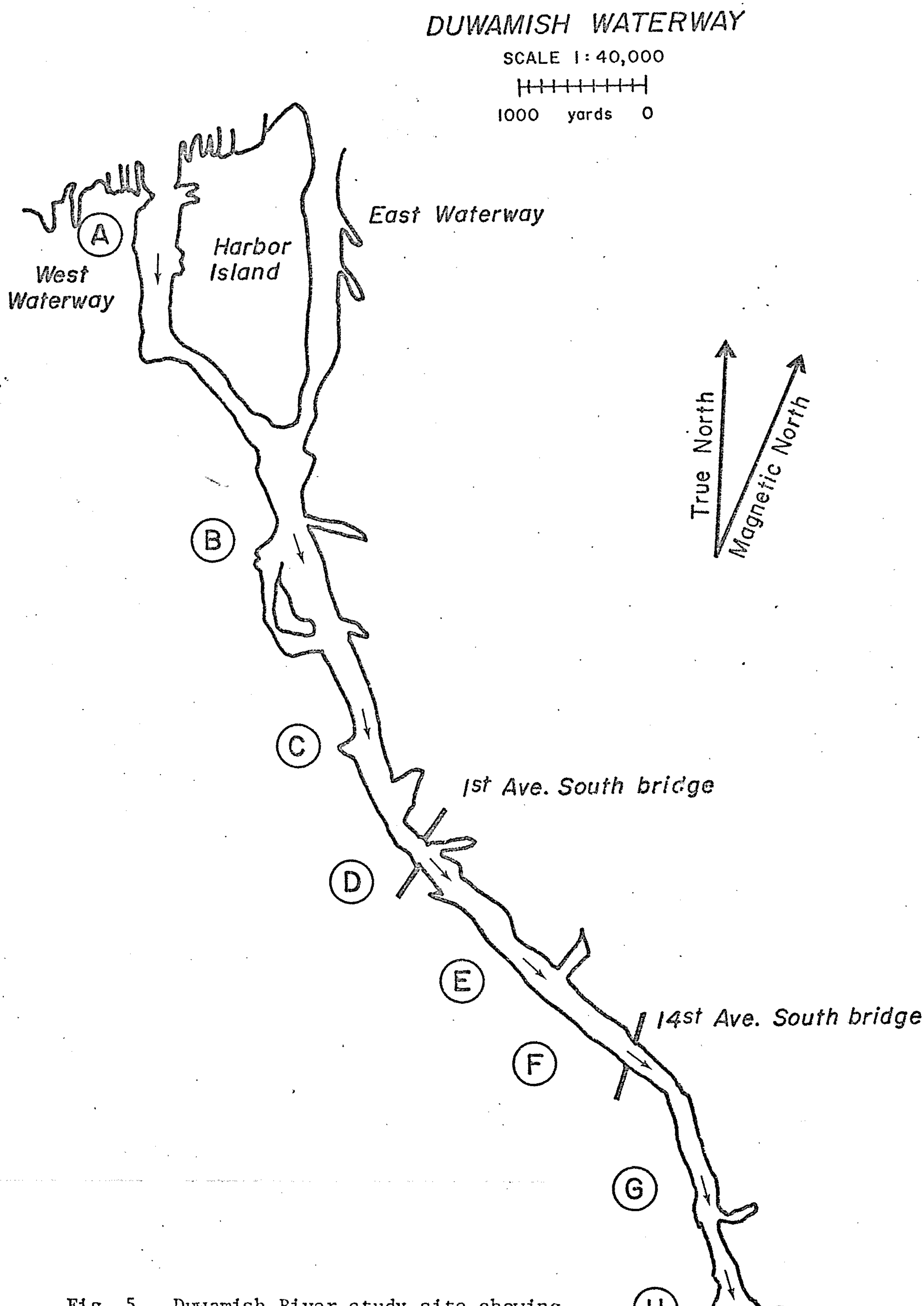


Fig. 5. Duwamish River study site showing otter trawl sampling stations A-H.

stained by a variety of methods including hemotoxylin and eosin, Oil-Red-O, Gomori's iron reaction, Masson's trichrome, Armed Forces Institute of Pathology lipofuscin stain, and May-Grunwald-Giemsa.

Microbiological procedures were designed to isolate disease-associated bacteria, fungi, and viruses, and to determine total bacterial "loads" of fish from various areas. Bacteria and fungi were isolated from the surface of diseased animals using a sterile cotton swab and storing the used swab in a tube containing sea water with 0.5% peptone kept at 0°C until returned to the laboratory 4 to 8 hours later. The swabs were agitated in the storage medium in order to remove most of the attached microorganisms, an aliquot of this medium was diluted with an appropriate volume of seawater-peptone, and 0.05 ml of the suspension was spread on the surface of agar medium in a petri dish. Types of agar media employed were Trypicase Soy Agar (TSA), Ordal's Seawater Cytophaga Agar (OSCA), Brain Heart Infusion Agar, and Potato Dextrose Agar with penicillin and streptomycin (for growth of fungi). When bacterial colonies had formed, representative ones were picked, colony purified, and stored in tubes containing OSCA.

Because preliminary attempts to isolate fungi from marine fish yielded very few fungal cultures, efforts to isolate and characterize fungi were terminated.

Virus isolation procedures involved preparing homogenates of fresh and/or frozen-and-thawed diseased tissue, and inoculating fish cell cultures with filtered or unfiltered homogenates. Cell cultures used included explant cultures of English sole fin tissue, a cell line derived from an epidermal papilloma from an English sole, and a cell line derived from chinook salmon embryonic tissue. Following their inoculation, cultures were periodically examined for cellular changes.

Determinations of total surface-associated bacteria were performed by aseptically excising a 1 cm^2 piece of skin from either a starry flounder or an English sole, and placing the skin into a tube containing 10 ml of seawater-peptone and 1 cm^3 of sterile, acid washed sand. The tube was stored at 0°C until returned to the laboratory 4 to 8 hours later. The tubes were shaken vigorously, an aliquot of the medium was serially diluted, and appropriate dilutions were spread on the surface of the TSA and OSCA-containing petri dishes with a sterile glass "rake". The total number of bacteria per 1 cm^2 of skin was calculated as follows: Bacteria/cm^2 = (Reciprocal of dilution)(Bacterial colonies/Dish). Fish used for these determinations were taken from the otter trawl net as soon as it was brought aboard in order to reduce the amount of surface-to-surface contact between fish.

Attempts to induce one of the fish diseases under study, fin erosion, were initiated by exposing English sole and starry flounder to Duwamish River bottom sediment. Normal-appearing experimental fish were captured near the Nisqually River and held in four 80-gal. flow-through seawater aquaria at METRO's West Point facilities. Bottom sediment was obtained from the Duwamish River near the 16th Avenue Bridge with a grab. Control bottom sediment was taken from the Nisqually River. Two aquaria received Duwamish River sediment and two had Nisqually River sediment. Between 10 and 15 flatfish were kept in each aquarium. The fish were fed weekly and examined individually for disease signs once a week.

Chemical analyses of normal and diseased fish were performed in cooperation with other individuals, agencies, and private laboratories. Blood serum samples were analyzed for 14 compounds and enzymes by National Health Laboratories, Seattle, Washington. Fish tissues were, or are being, analyzed for PCBs by Dr. Spiros Pavlou of the University of Washington and by Dr. Virginia Stout of the Pacific Utilization Research Center, Seattle, and for PCBs, DDTs, and heavy metals by the Southern California Coastal Water Research Project.

In order to characterize liver abnormalities in Duwamish River starry flounder and English sole, it was necessary to estimate the prevalence of this condition in addition to establishing its histopathological properties. Random samples of 25 to 50 fish of both species captured during regular monthly sampling cruises of the Duwamish River were weighed, and the livers were examined for gross pathology, excised, weighed, and in most cases examined histologically. The liver-somatic index (liver weight/body weight) was calculated for each fish in order to determine if livers with pathology also had a greater mass. As a means of finding if liver abnormalities were present at other sampling sites of the METRO study and in the Nisqually River (a "control" site for starry flounder), fish samples were examined in the same manner as for the Duwamish River.

RESULTS

Ecological Studies

1. *Outfall Study*

1.1 *Physical Data.* The surface temperature at the beach seining sites was lowest in the fall, winter, and early spring; increased through late spring and early summer; and then decreased during late summer and early fall (Fig. 6a). Point Pully and Alki Point were highest in surface temperature in July. The low July value at West Point was probably due to instrumental or reading error. At 5 m, temperature at all three sites was highest in July and remained relatively high through October before fall declines (Fig. 7a). Bottom temperature at all three sites followed quite similar patterns at both 45 m and 70-95 m (Figs. 8a, 9a). Temperature was highest in June and remained relatively high until late fall.

Salinity patterns at the surface (beach seine sites) were similar to those at the 5-m trawl depth (Figs. 6a, 7b). Salinity was lowest in the early summer and late fall, presumably because these were periods of highest runoff. West Point salinity at 5 m was quite erratic compared to the other two sites. Salinity fluctuated less at 45 m and 70-95 m than at the shallower stations (Figs. 8b, 9b). At 45 m and 70-95 m, salinity was slightly higher in summer and fall compared to the rest of the year.

The surface water at the beach seine sites was supersaturated with oxygen from March through September and remained relatively high in oxygen content throughout the year (Fig. 6c). The percent saturation of dissolved oxygen was relatively high throughout the year at all bottom sampling sites (Figs. 7c, 8c, 9c). Oxygen content appears to be lowest in the late summer and fall. Dissolved oxygen was most erratic at West Point at 45 m.

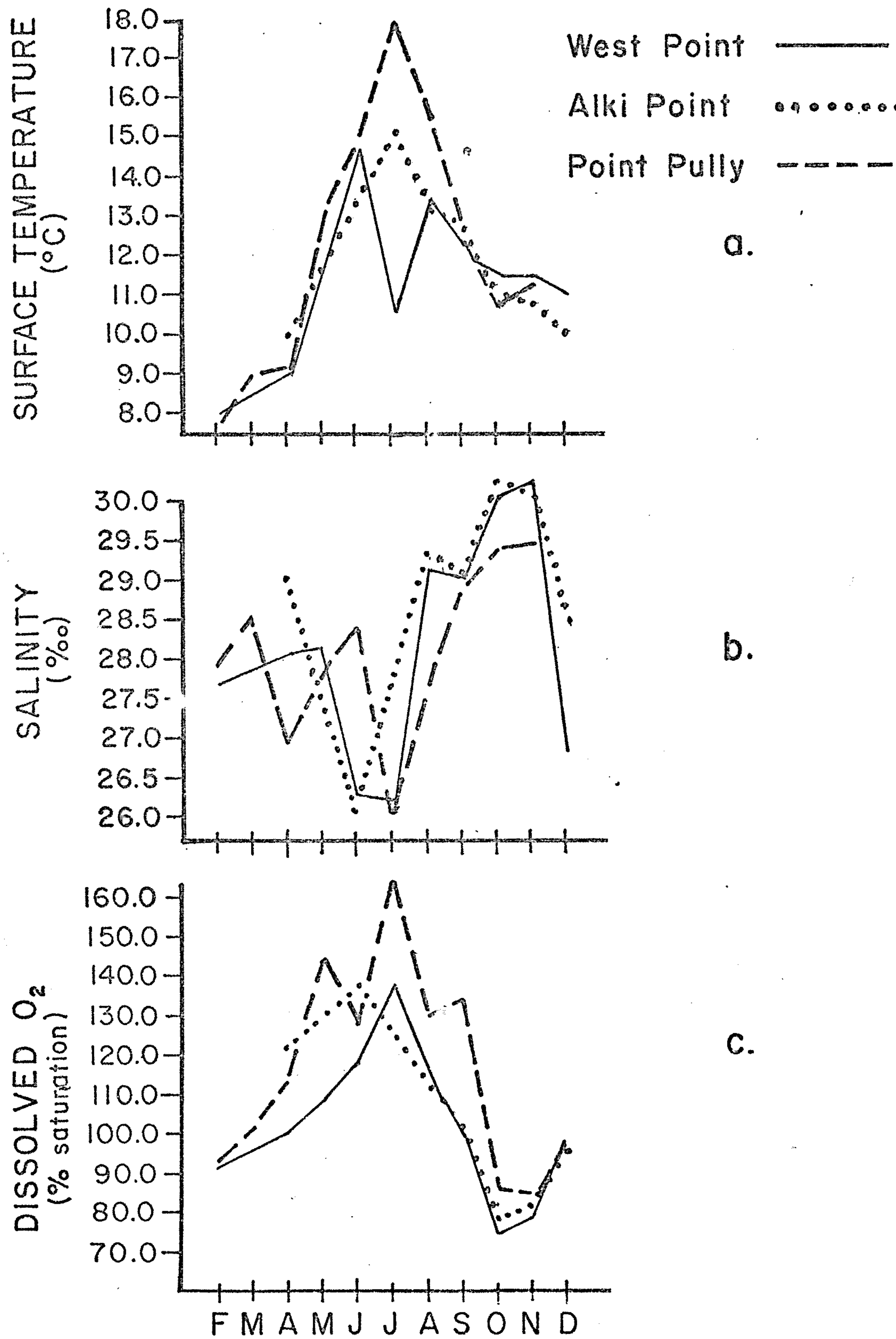


Fig. 6. Surface water temperature (6a), salinity (6b), and dissolved oxygen (6c) from beach seine areas at West Point, Alki Point, and Point Pully.

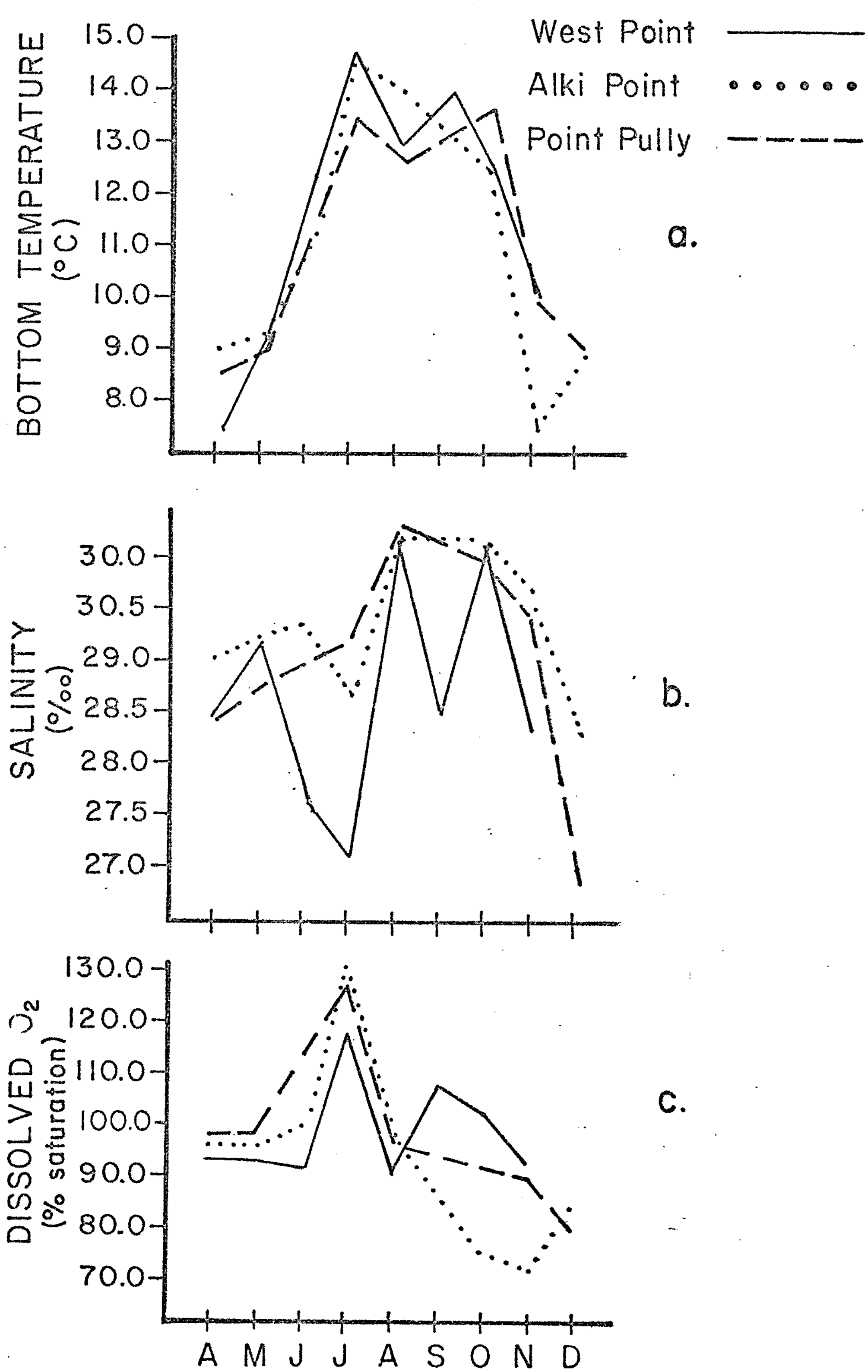


Fig. 7. Bottom water temperature (7a), salinity (7b), and dissolved oxygen (7c) from 5-m otter trawling stations at West Point, Alki Point, and Point Pully.

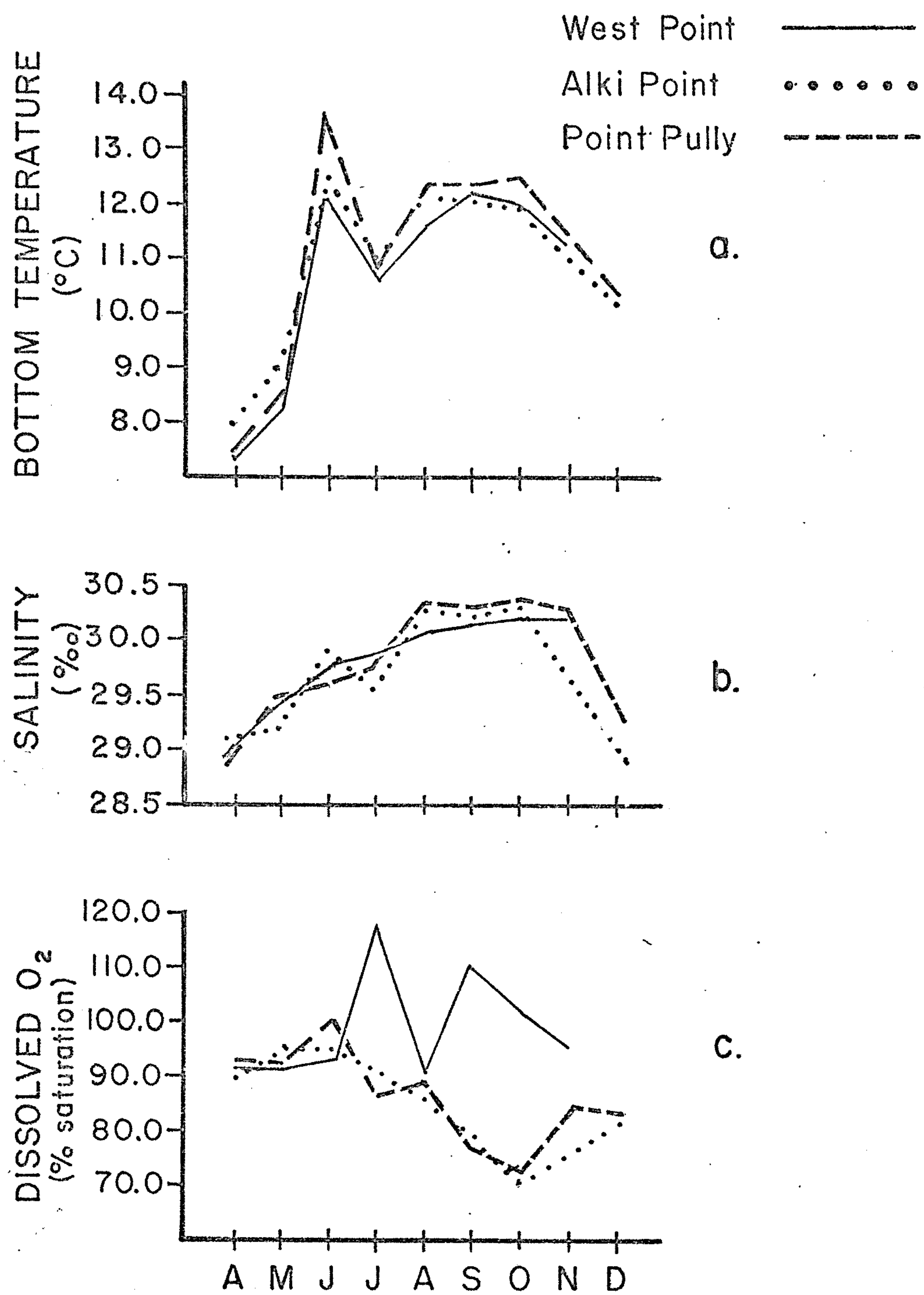


Fig. 8. Bottom water temperature (8a), salinity (8b), and dissolved oxygen (8c) from 45-m otter trawling stations at West Point, Alki Point, and Point Pully.

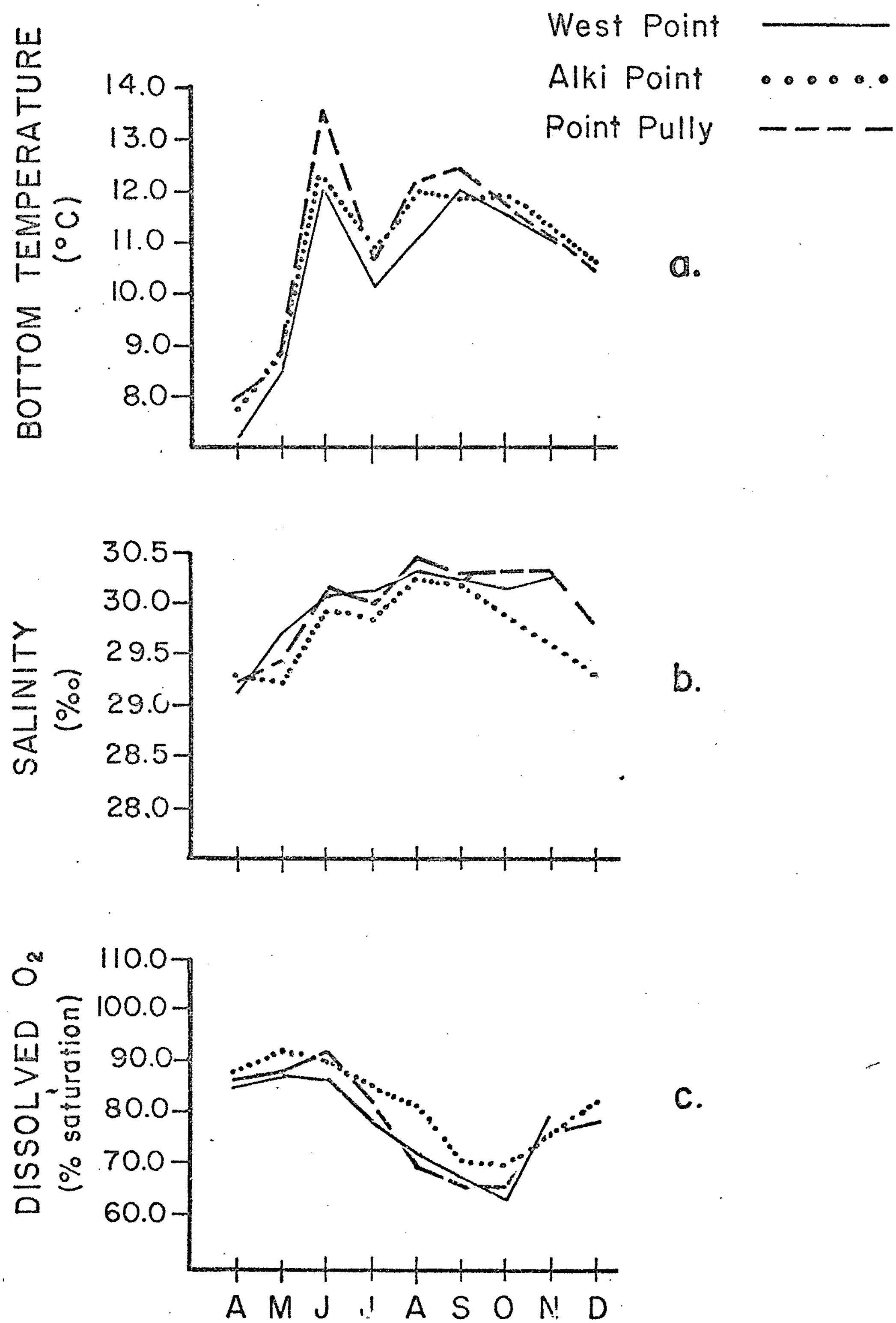


Fig. 9. Bottom water temperature (9a), salinity (9b), and dissolved oxygen (9c) from 70-95-m otter trawling stations at West Point, Alki Point, and Point Pully.

1.2 *Catch Results*

1.21 *West Point*

1.21a *General Catch Results.* A total catch of 66 species comprising 15,912 individuals was captured at West Point during sampling in 1975 (Table 2). The vast majority of the total catch (95.1%) was collected with the 37-m beach seine. The species most frequently (> 70% samples) collected with the beach seine gear were: Pacific tomcod juveniles, shiner perch juveniles and adults, striped seaperch juveniles and adults, Pacific staghorn sculpin juveniles and adults, rock sole juveniles and adults, and English sole juveniles and adults (Table 2). The species most frequently (> 70% samples) collected with the 5-m otter trawl were: Ratfish juveniles and adults, northern ronquil adults, roughback sculpin juveniles and adults, rex sole juveniles and adults, rock sole adults, Dover sole juveniles and adults, English sole juveniles and adults, and C-O sole adults (Table 2). The overall ten most abundant species collected with the 37-m beach seine gear comprised 95.6% of the total beach seine catch (Table 3). The three most abundant species were Pacific tomcod, shiner perch, and English sole. In a similar fashion, the otter trawl catch was dominated by ten species comprising approximately 90% of the total catch (Table 3). Ratfish, English sole, and rock sole were the three most abundant species collected.

1.21b *Seasonal Patterns of Species Richness and Abundance.*

Beach Seine (37-m Net). Both species richness (total number of species occurring in paired replicate hauls) and mean abundance (mean number of fish per haul) with the 37-m beach seine varied seasonally (Fig. 10a). The lowest values for both mean density and species richness occurred in April. Species richness rapidly increased over the

Table 2. List of species collected in vicinity of West Point during 1975. "F" (frequent) indicates species occurred in > 70% of samples; "C" (common) indicates species occurred in 30-70% of samples; "R" (rare) indicates species occurred in < 30% of samples.

		Beach seine			Otter trawl depths				
Species	Total number	9m net	37m[a] net	37m[b] net	5m	25m	45m	70m	95m
Spiny dogfish	9		R	R					
Ratfish	829		R			R	C	F	F
Pacific herring	331	R	C	C					
Chum salmon	91	R	R	C					
Coho salmon	165		C	R					
Chinook salmon	23		R	C					
Dolly Varden	1		R						
Surf smelt	54		R	C					
Longfin smelt	2		R						
Midshipman	1					R			
Pacific tomcod	4,686	C	F	C	R	R	C	R	R
Walleye pollock	6		R				R	R	R
Pacific hake	1								R
Red brotula	1								R
Blackbelly eelpout	51		R			R	C	C	R
Tube-snout	4				R				
Threespine stickleback	22	R	R	C					
Bay pipefish	1			R					
Shiner perch	4,149	C	F	C	R	R	R	R	R
Striped seaperch	104		F	R	R	R			
Pile perch	33		C	R		R	R		
Northern ronquil	37		R	R		R	F	R	
Snake prickleback	77		C	R		R			
Penpoint gunnel	2	R				R			
Saddleback gunnel	3	R	R						
Pacific sandlance	240	R	R	R					

a--37m sinking beach seine.
b--37m floating beach seine.

Table 2, cont'd

Species	Total number	Beach seine 9m net	37m[a] net	37m[b] net	Otter trawl depths 5m	25m	45m	70m	95m
Brown rockfish	33					C	C		
Copper rockfish	1					R			
Quillback rockfish	48					C	C	R	C
Painted greenling	1					R			
White spotted greenling	2		R						
Padded sculpin	58	R	C	R		R	R		
Silverspotted sculpin	2			R	R				
Roughback sculpin	88		R		R	F	C	R	R
Sharpnose sculpin	42	C		R					
Buffalo sculpin	66	C	C	C	R				
Pacific staghorn sculpin	197	F	F	C	R		R		
Great sculpin	2		R						
Manacled sculpin	1					R			
Sailfin sculpin	5		R			R	R		
Tidepool sculpin	27	R	R	C					
Red Irish lord	1					R			
Slim sculpin	5						R	R	R
Tadpole sculpin	1					R			
Grunt sculpin	1					R			
Cabezon	2		R			R			
Northern spearnose poacher	3					R	R		
Sturgeon poacher	50		C	R		R	C	R	
Gray starsnout	2							R	
Spinycheek starsnout	2						R	R	
Pygmy poacher	4					R			
Blacktip poacher	7							R	R
Bluespotted poacher	23	R					R	C	R

a--37m sinking beach seine.
b--37m floating beach seine.

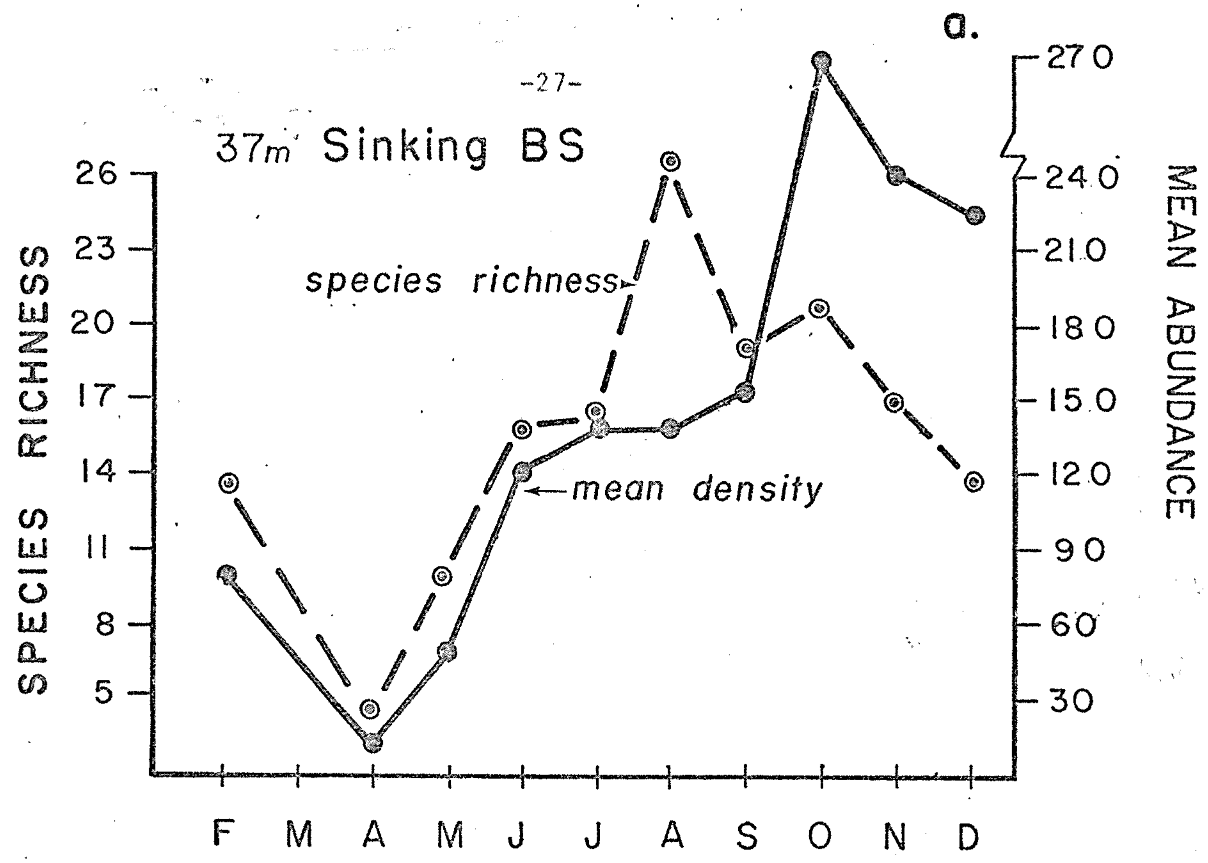
Table 2, cont'd

Species	Total number	Beach seine 9m net	37m[a] net	37m[b] net	Otter trawl depths 5m	25m	45m	70m	95m
Tidepool snailfish	1					R			
Pacific sanddab	64		R		R	R	C		
Speckled sanddab	36		C		C	C			
Rex sole	41						C	F	C
Butter sole	2		R						
Rock sole	1,074	R	F	C	F	F	F		
Slender sole	48	R	C			R	C	C	C
Dover sole	160		R			R	F	F	F
English sole	2,689	F	F	F	F	F	F	R	C
Starry flounder	21	R	C	C					
C-O sole	68		C		F	C			
Sand sole	20	R	R	R	C	R			
Hybrid sole	1		R						
Total number of individuals	15,912	623	12,050		549	571	1,042	618	459
Total number of species	66								

a--37m sinking beach seine.
b--37m floating beach seine.

Table 3. Abundance of the 10 most dominant species collected by beach seine (37-m net) and otter trawl at West Point during 1975.

	Beach seine			Otter trawl		
Rank	Species	Total	% Total	Species	Total	% Total
1	Pacific tomcod	4,452	36.9	Ratfish	827	25.5
2	Shiner perch	3,893	32.3	English sole	791	24.4
3	English sole	1,697	14.1	Rock sole	636	19.6
4	Rock sole	530	4.4	Pacific tomcod	164	5.1
5	Pacific herring	300	2.5	Shiner perch	130	4.0
6	Pacific sand lance	183	1.5	Dover sole	126	3.9
7	Coho salmon	165	1.4	Roughback sculpin	78	2.4
8	Pacific staghorn sculpin	129	1.1	Pacific sanddab	62	1.9
9	Striped seaperch	96	0.8	C-O sole	59	1.8
10	Chum salmon	77	0.6	Rex sole	41	1.3
	TOTAL	11,522	95.6% (11,522/12,050)	TOTAL	2914	89.9% (2914/3239)



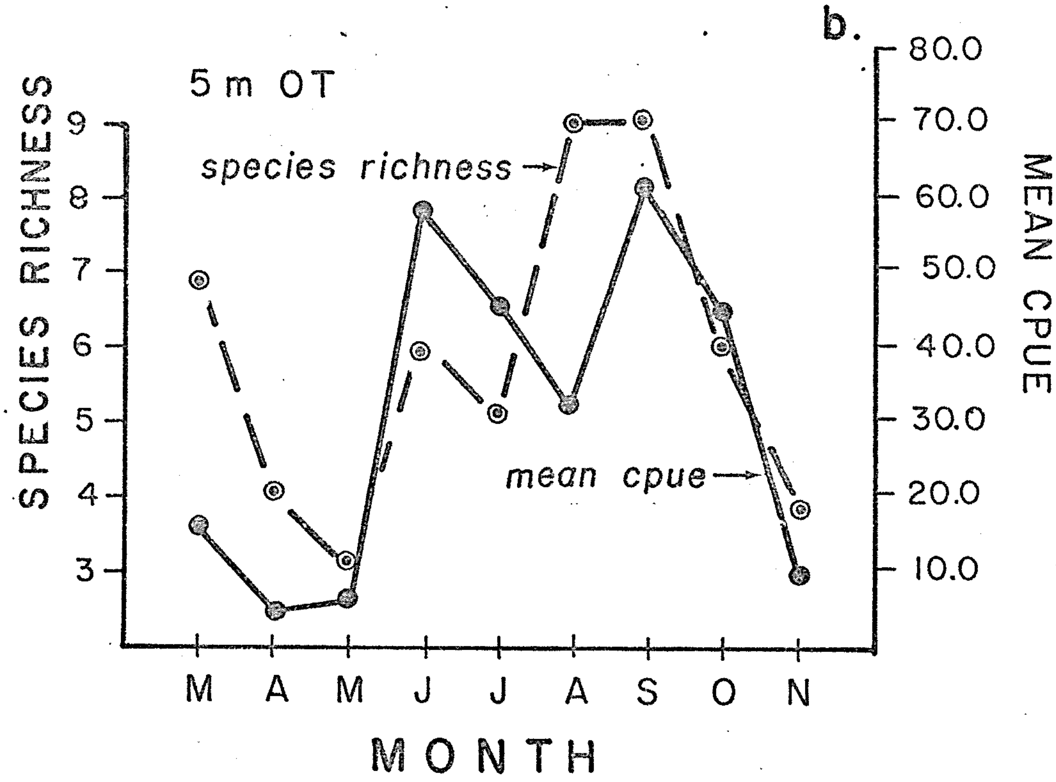


Fig. 10. Species richness, mean abundance (BS), and mean CPUE (OT) for 37-m beach seining (10a), and 5-m otter trawling (10b) stations at West Point.

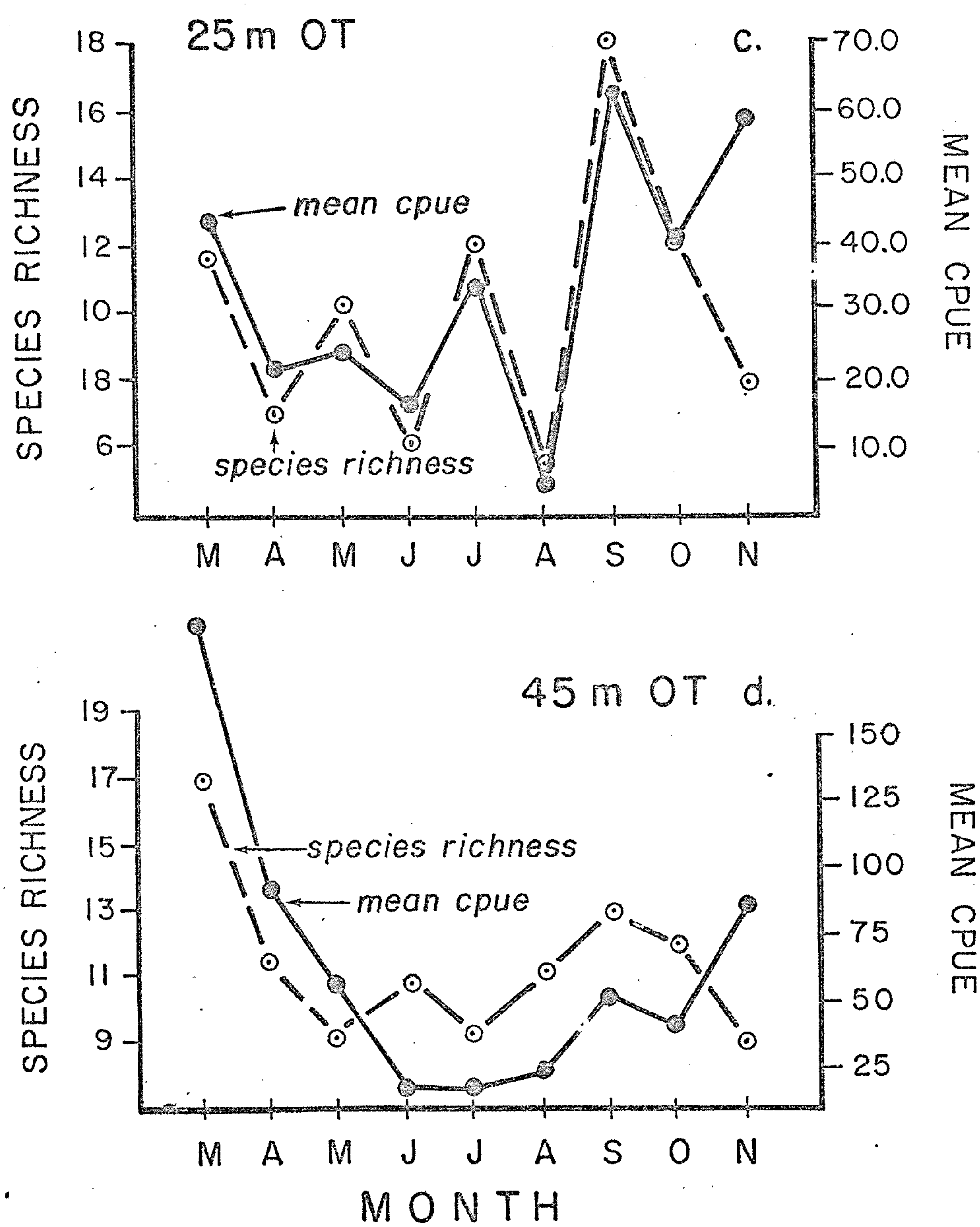


Fig. 10. Species richness and mean CPUE for 25-m (10c) and 45-m (10d) otter trawling stations at West Point.

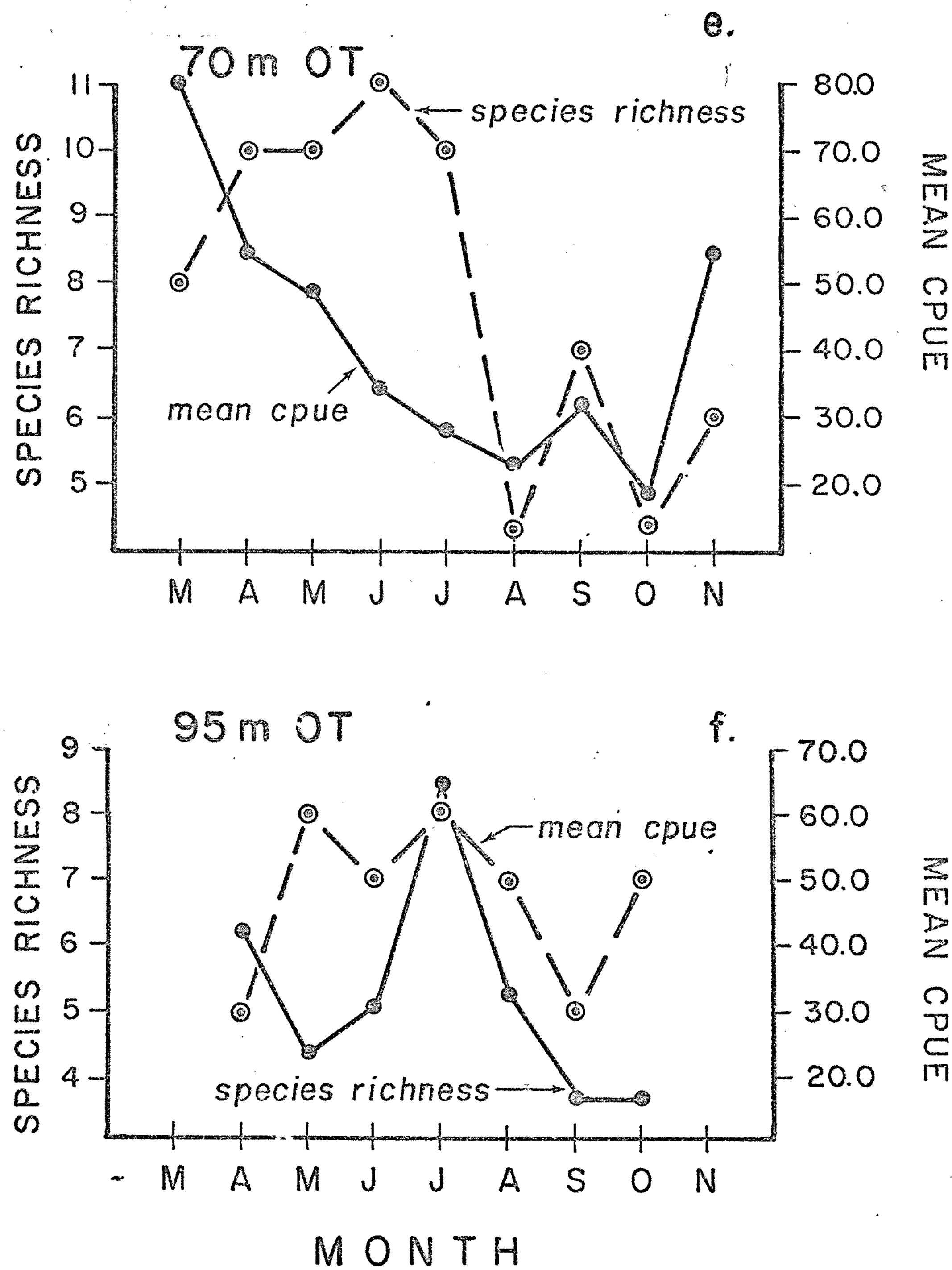


Fig. 10. Species richness and mean CPUE for 70-m (10e) and 95-m (10f) otter trawling stations at West Point.

next several months and reached a maximum in August (mid-summer) followed by a late-year decline. Mean abundance increased in a similar manner, achieved a slightly later peak (October), and then decreased during the winter months (October-December).

Otter Trawl. At 5 m, species richness and mean catch per unit effort (CPUE) followed the same general patterns during the year (Fig. 10b). Minimum monthly values of both indices occurred in March, followed by a gradual spring and summer increase. Species richness and CPUE decreased abruptly after September.

At 25 m, monthly variations in species richness and CPUE also followed each other closely during the year (Fig. 10c). Monthly fluctuations were erratic and no clear trend in the data was evident. The lowest values for richness and CPUE occurred in August (mid-summer), and the highest in September (late summer).

The patterns of species richness and CPUE at 45 m during the year were just the inverse of those at 5 m (Fig. 10d). Both indices peaked in March and then rapidly declined through June. In subsequent months, both CPUE and richness increased, although richness declined again late in the year. In large part, the summer (July-September) decline at 45 m was the result of a seasonal movement by rock sole and English sole into shallower water. This general onshore movement was reflected in the summer increase at 5 m (Fig. 10b).

At 70 m, species richness reached a peak during spring (April-June) followed by an abrupt drop in mid-summer (Fig. 10e). In subsequent months, species richness fluctuated erratically. The trend for CPUE at 70 m was considerably different from that for species richness. The peak CPUE occurred in March, declined gradually over the next several months, and achieved a minimum in October. In November, CPUE increased dramatically and probably represented the onset of a mid-winter peak.

Data at 95 m (Fig. 10f) were much less complete, but showed a summer (July-August) peak for CPUE. Maximum species richness, however, was reached in spring (April-June) and remained high through the summer months, declining after September. The spring-summer (April-August) decline in CPUE at 70 m corresponded closely with the mid-summer peak which occurred at 95 m. This peak was largely due to an offshore movement of ratfish from shallower water.

1.21c *Relative Seasonal Abundance of Dominant Species*

Beach Seine (37-m Net). Relative monthly abundance of the dominant species in the 37-m beach seine catches fluctuated considerably during 1975 (Table 4a). The most abundant species, Pacific tomcod, dominated the catch from September to November, but was rarely collected early in the year. This may be an artifact of our sampling plan, however, since months of absence and/or low abundance correspond to daytime sampling and months of high abundance correspond to nighttime sampling. Shiner perch were relatively abundant in February but uncommon during spring (April-July). During the summer months of July-September, adults and newly born juveniles became increasingly abundant. A similar increase in abundance was observed over this period for adult and juvenile striped seaperch and pile perch. Typically, all three species of surf perches mate and give birth to their offspring in shallow water during the summer months. Although abundance of striped seaperch and pile perch declined markedly after August, shiner perch continued to dominate the catch for the remainder of the year. English sole occurred in all months and were abundant from

Table 4a. Relative monthly abundance of the five most dominant species collected with the sinking 37-m beach seine at West Point during 1975.

Rank	Species	Feb.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1.	Pacific tomcod	8.1%	0.0%	0.0%	0.0%	0.3%	0.3%	32.9%	54.2%	15.7%	6.1%
2.	Shiner perch	12.7	0.0	1.7	0.4	17.7	13.6	39.0	35.1	56.3	32.0
3.	English sole	51.2	72.7	46.1	59.1	30.6	41.6	9.5	6.7	8.5	44.6
4.	Rock sole	0.6	0.0	0.0	28.9	25.8	23.8	4.3	0.9	10.1	11.9
5.	Pacific herring	0.0	0.0	0.0	0.0	0.0	0.0	8.9	0.1	2.2	0.0
	TOTAL	72.6	72.7	47.8	88.4	74.4	79.3	94.6	97.0	92.8	94.6

Table 4b. Relative monthly abundance of the five most dominant species collected at West Point during 1975 otter trawling at 5 m.

Rank	Species	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.
1.	English sole	19.4%	33.3%	33.3%	57.9%	52.6%	62.1%	75.2%	24.6%	9.1%
2.	Rock sole	29.0	33.3	33.3	36.1	43.2	22.7	14.4	20.9	63.6
3.	C-O sole	35.5	22.2	33.3	3.4	1.1	3.0	3.2	24.7	9.1
4.	Shiner perch	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.9	0.0
5.	Speckled sanddab	6.4	0.0	0.0	0.0	2.1	4.5	2.4	0.0	0.0
	TOTAL	90.3	88.8	99.9	97.4	99.0	92.3	95.2	91.1	81.8

Table 4c. Relative monthly abundance of the five most dominant species collected at West Point during 1975 otter trawling at 45 m.

Rank	Species	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.
1.	English sole	30.5%	37.7%	29.1%	24.2%	12.5%	13.0%	13.3%	11.1%	1.1%
2.	Rock sole	31.8	55.1	46.4	12.2	20.8	8.7	7.6	44.4	68.9
3.	Pacific tomcod	0.8	0.0	0.9	0.0	0.0	23.9	57.1	14.8	13.7
4.	Shiner perch	17.2	3.9	0.0	0.0	0.0	0.0	0.0	0.0	5.7
5.	Pacific sanddab	9.3	1.7	11.8	6.1	4.2	0.0	0.9	0.0	0.0
	TOTAL	89.6	98.4	88.2	42.5	37.5	45.6	78.9	70.3	89.4

Table 4d. Relative monthly abundance of the five most dominant species collected at West Point during 1975 otter trawling at 25 m.

Rank	Species	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.
1.	Rock sole	35.5%	39.5%	64.7%	30.0%	52.0%	33.3%	14.7%	16.8%	20.6%
2.	English sole	16.7	0.0	0.0	56.6	20.0	25.0	20.9	56.6	15.5
3.	Roughback sculpin	22.2	39.5	7.8	0.0	2.7	16.7	3.1	7.2	0.0
4.	Pacific tomcod	0.0	0.0	0.0	0.0	0.0	0.0	33.3	0.0	0.0
5.	Shiner perch	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	48.2
	TOTAL	74.4	79.0	72.5	86.6	74.7	75.0	72.0	80.6	84.3

Table 4e. Relative monthly abundance of the five most dominant species collected at West Point during 1975 otter trawling at 70 m.

Rank	Species	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.
1.	Ratfish	54.1%	73.5%	73.4%	69.5%	62.9%	83.3%	71.6%	70.0%	83.3%
2.	Dover sole	8.2	5.8	10.2	4.3	11.1	10.4	10.4	13.3	5.6
3.	Rex sole	1.1	1.7	1.0	5.8	7.4	4.2	10.4	10.0	5.6
4.	English sole	24.7	0.8	0.0	4.3	1.8	0.0	0.0	0.0	0.0
5.	Bluespotted poacher	5.9	3.3	7.2	0.0	5.6	0.0	1.5	0.0	0.0
	TOTAL	94.0	85.1	91.8	83.9	88.8	97.9	93.9	93.3	94.5

Table 4f. Relative monthly abundance of the five most dominant species collected at West Point during 1975 otter trawling at 95 m.

Rank	Species	Apr.	May	June	July	Aug.	Sep.	Oct.
1.	Ratfish	55.2%	79.2%	80.0%	77.6%	85.5%	79.4%	50.0%
2.	Dover sole	3.5	9.4	10.8	8.0	3.2	11.8	14.7
3.	English sole	0.0	1.9	1.5	4.8	0.0	2.9	5.9
4.	Slender sole	0.0	1.9	1.5	2.4	4.8	0.0	2.9
5.	Quillback rockfish	0.0	1.9	0.0	2.4	1.6	0.0	11.7
	TOTAL	58.7	94.3	93.8	95.2	95.1	94.1	85.2

February to mid-summer. Relative abundance decreased from September to November; however, much of this apparent decline was due to increasing numbers of Pacific tomcod and shiner perch rather than an actual decrease in absolute abundance of English sole. Rock sole were absent early in the year but became very abundant during late spring and summer (June-August). Pacific herring were absent from the catch until September but thereafter occurred in relatively large numbers.

Otter Trawl. At the 5-m otter trawling depth, the dominant species in order of abundance were English sole, rock sole, C-O sole, shiner perch, and speckled sanddab (Table 4b). English and rock sole were consistently abundant in all months sampled, although English sole generally predominated. C-O sole were equally abundant with the former two species from March through May; however, their numbers declined abruptly in June and remained low until late in the year. Shiner perch were collected only in October but occurred in very large numbers on that occasion. Speckled sanddab occurred sporadically over much of the year. In all months, these five species comprised more than 80% of the catch.

The dominant species at 25 m were also rock and English sole (Table 4c). Rock sole comprised more than 30% of the catch between March and August but dropped off substantially thereafter. English sole showed a markedly increased abundance in June and remained dominant for the rest of the year. Roughback sculpin were very abundant in March and April, but occurred only sporadically in subsequent months. Both Pacific tomcod and shiner perch were sampled in large numbers, but each occurred on only a single occasion. Overall, these five species totaled 70% or more of the catch in all months.

At 45 m, English and rock sole were again the dominant species (Table 4d). English sole abundance was highest during the spring and early summer and decreased subsequently. Rock sole were most abundant during spring and fall but were considerably less abundant between June and September. Prior to August, Pacific tomcod were rare; however, they were abundant in later months particularly August and September. Shiner perch occurred early in the year during March and April, but were absent thereafter until November. Pacific sanddab were consistently present from March to July, but absent throughout the remainder of the year.

Ratfish were the overwhelmingly dominant fishes at 70 m (Table 4e). In every month they comprised at least 50% of the total catch and in most months considerably more. Dover sole was the other consistently occurring species, and was especially abundant from July to October. Prior to May, rex sole occurred but in low numbers. Subsequently, they increased in abundance and from September to November were equally abundant with Dover sole. English sole were collected occasionally before July, but were absent during the remainder of the year. Bluespotted poachers also occurred frequently, but only in low numbers and sporadically.

At 95 m, ratfish also dominated the catch (Table 4f). In each month they represented at least 50% of the total catch. Dover sole was the only other species which occurred consistently in all months. Abundance of Dover sole generally increased throughout the year. The only other commonly occurring species were English sole, slender sole, and quillback rockfish; however, their occurrence was erratic and their abundance usually low.

1.21d *Diel Variations in Catch*

Beach Seine. In September, comparable low tide series occurred both during the day and at night at West Point. This fortuitous situation was utilized to examine diel changes in catch with the 37-m beach seine during the same season and under similar tidal conditions. The most striking difference between day and night catches was in total abundance; however, species richness also increased at night (Table 5). The greatly increased catch at night was primarily due to large numbers of shiner perch, Pacific tomcod, and Pacific herring. Whether these species actually move into shallow water at night or simply become more vulnerable to the gear is not clear. The catch of several other species including snake prickleback, blackbelly eelpout, Dover sole, and slender sole was considerably greater at night than in the daytime. Generally, these species are rarely encountered in beach seine sampling; in particular, the latter three species are characteristically found in deeper water during the day.

Trammel Net. During November, a 24-hour sampling study was conducted at West Point. A portion of this study included sampling at dusk with a 45.8-m trammel net. Results from a single set suggest that certain large predatory fishes are moving inshore at night, including Pacific hake, walleye pollock, Pacific cod, and spiny dogfish (Table 6). The capture of sturgeon poachers, large adult English sole, Pacific sanddabs, and slender sole, which generally occur in deeper water, indicates that these species may also be moving onshore at night.

Table 5. Day versus night catch during September 1975 at West Point with 37-m sinking beach seine.

Species	Day 1	Day 2	Night 1	Night 2
Pacific herring	1	1	283	25
Chinook salmon	0	1	0	0
Coho salmon	0	1	4	4
Surf smelt	5	11	0	0
Walleye pollock	0	0	1	0
Pacific tomcod	1	0	825	236
Blackbelly eelpout	0	0	19	3
Shiner perch	16	41	1,022	178
Striped seaperch	11	0	13	2
Pile perch	0	0	3	2
Snake prickleback	0	0	41	2
Penpoint gunnel	1	0	1	0
Saddleback gunnel	0	1	0	0
Padded sculpin	1	0	1	1
Buffalo sculpin	1	0	4	5
Pacific staghorn sculpin	5	6	3	2
Tidepool sculpin	0	0	2	1
Sturgeon poacher	0	2	2	1
Butter sole	0	0	0	1
Rock sole	25	34	69	12
Slender sole	0	0	3	2
Dover sole	0	0	29	0
English sole	40	94	117	56
Starry flounder	1	1	0	0
Sand sole	0	1	0	0
Speckled sanddab	1	0	0	0
Total number of individuals	109	194	2,442	533
Total number of species	13	12	19	17

Table 6. Number of individuals and total-length range for species collected with 45.8-m trammel net during 24-hour study at West Point (November 4-5, 1975).

Species	Total number	Range of total lengths (mm)
Spiny dogfish	9	725-883
Ratfish	2	318-346
Pacific cod	2	460-476
Walleye pollock	19	291-468
Pacific tomcod	15	204-282
Pacific hake	5	392-484
Shiner perch	1	150
Striped seaperch	2	280-337
Quillback rockfish	1	160
Brown rockfish	1	214
Copper rockfish	2	262-265
Pacific staghorn sculpin	6	175-316
Sturgeon poacher	5	183-216
Pacific sanddab	5	127-190
Slender sole	4	148-228
English sole	16	232-390
Total No. Indiv.	95	
Total No. Species	16	

1.22 *Alki Point*

1.22a *General Catch Results.* A total catch of 65 species of fishes comprising 11,201 individuals was collected with all gear types during 1975 (Table 7). Most individuals (8,940/11,201 = 79.8%) were collected with the 37-m beach seine. The species most frequently (> 70% of samples) captured with the beach seine gear were: Pacific tomcod juveniles, tubesnout juveniles and adults, shiner perch juveniles and adults, penpoint gunnel adults, padded sculpin juveniles and adults, Pacific staghorn sculpin juveniles and adults, rock sole juveniles and adults, English sole juveniles and adults, and C-O sole adults. In contrast, the species most frequently (> 70% of samples) occurring in otter trawl samples were: Ratfish juveniles and adults, roughback sculpin juveniles and adults, rock sole adults, English sole juveniles and adults, and C-O sole adults.

The ten most abundant species collected with the 37-m beach seine totaled 96.2% of the entire 1975 beach seine catch; however, three species were actually the overwhelming dominants--shiner perch, striped seaperch, and tubesnout (Table 8). Similarly, the ten most abundant species from otter trawl samples comprised 80% of the 1975 catch (Table 8). The dominant species were rock sole, English sole, striped seaperch, and ratfish (46.8% of total otter trawl catch).

1.22b *Seasonal Patterns of Species Richness and Abundance*

Beach Seine (37-m Net). Species richness (total number of species occurring in paired replicate hauls) and mean abundance (mean number of fish per haul) followed somewhat different patterns during 1975 (Fig. 11a). Species richness reached a peak in early summer (June), declined until

Table 7. List of species collected in vicinity of Alki Point during 1975. "F" (frequent) indicates species occurred in > 70% of samples; "C" (common) indicates species occurred in 30-70% of samples; "R" (rare) indicates species occurred in < 30% of samples.

Species	Total number	Beach seine net		Otter trawl depths		
		9m	37m*	5m	45m	70m
Ratfish	152				C	F
Pacific herring	13	R	R			
Chum salmon	41		R			
Coho salmon	3		R			
Chinook salmon	15	R	R			
Rainbow trout	1		R			
Surf smelt	1		R			
Midshipman	8				C	R
Northern clingfish	2	R	R			
Pacific cod	7		R		R	
Pacific tomcod	485	C	F	R	C	C
Walleye pollock	23		R	R	R	R
Pacific hake	3					R
Blackbelly eelpout	5				R	R
Tube-snout	1,524	C	F	C		
Threespine stickleback	2	R	R			
Bay pipefish	29	C	C			
Shiner perch	3,752	R	F	R	R	R
Striped seaperch	2,015	R	F	C		R
Pile perch	75	R	F	R		R
Northern ronquil	26				C	R
Snake prickleback	4		R			
Penpoint gunnel	99	F	F	R	R	
Crescent gunnel	12	R	R	R		
Saddleback gunnel	23	C	C			
Brown rockfish	19		R	R	C	R
Sharpchin rockfish	1				R	

*37-m floating beach seine (see Materials & Methods).

Table 7, cont'd

Species	Total number	Beach seine net 9m	Beach seine net 37m*	Otter trawl depths 5m	Otter trawl depths 45m	Otter trawl depths 70m
Copper rockfish	3		R			
Quillback rockfish	20		R		C	R
Redstripe rockfish	5				R	
Painted greenling	2			R	R	
White spotted greenling	2		R			
Padded sculpin	307	C	F	C	R	
Smoothhead sculpin	5	R	R			
Silverspotted sculpin	46	R	C	R		
Roughback sculpin	73		R	R	F	R
Sharpnose sculpin	68	C	R			
Buffalo sculpin	68	C	C	R		
Roughspine sculpin	1			R		
Northern sculpin	8				R	
Red Irish lord	8		R	R		
Spotfin sculpin	22				C	R
Pacific staghorn sculpin	109	C	F		R	
Great sculpin	12	R	R			
Sailfin sculpin	20		R		R	R
Tidepool sculpin	19	C	C			
Threadfin sculpin	1					R
Slim sculpin	10			R	R	R
Cabezon	6		R	R		
Northern spearnose poacher	5				R	
Sturgeon poacher	28		C	R	R	R
Gray starsnout	2			R		R
Pygmy poacher	24				C	R
Blacktip poacher	4					R
Bluespotted poacher	29				R	C
Pacific sanddab	8				R	

*37-m floating beach seine (see Materials & Methods).

Table 7, cont'd

Species	Total number	Beach seine net 9m	Beach seine net 37m*	Otter trawl depths 5m	Otter trawl depths 45m	Otter trawl depths 70m
Speckled sanddab	61	R	C	R		
Rex sole	11				R	C
Rock sole	719	C	F	F	F	R
Slender sole	26		R		R	C
Dover sole	58		R		R	F
English sole	910	F	F	F	F	C
Starry flounder	2		R			
C-O sole	154		F	F	R	
Sand sole	5			R		
Total No. Indiv.	11,201	717	8,940	721	472	351
Total No. Species	65					

*37-m floating beach seine (see Materials & Methods).

Table 8. Abundance of the 10 most dominant species collected by beach seine (37-m net) and otter trawl at Alki Point during 1975.

	Beach seine			Otter trawl		
Rank	Species	Total number	% Total	Species	Total number	% Total
1	Shiner perch	3697	41.3	Rock sole	286	18.4
2	Striped seaperch	1774	19.8	English sole	237	15.3
3	Tubesnout	1454	16.3	Striped seaperch	203	13.1
4	English sole	590	6.6	Ratfish	152	9.8
5	Rock sole	427	4.8	Pacific tomcod	93	6.0
6	Pacific tomcod	310	3.5	C-O sole	74	4.8
7	Padded sculpin	121	1.4	Roughback sculpin	64	4.1
8	Pacific staghorn sculpin	88	0.9	Dover sole	57	3.7
9	C-O sole	80	0.8	Padded sculpin	47	3.0
10	Pile perch	64	0.7	Northern ronquil	26	1.7
	TOTAL	8605	96.2% (8605/8942)	TOTAL	1239	80.0% (1239/1547)

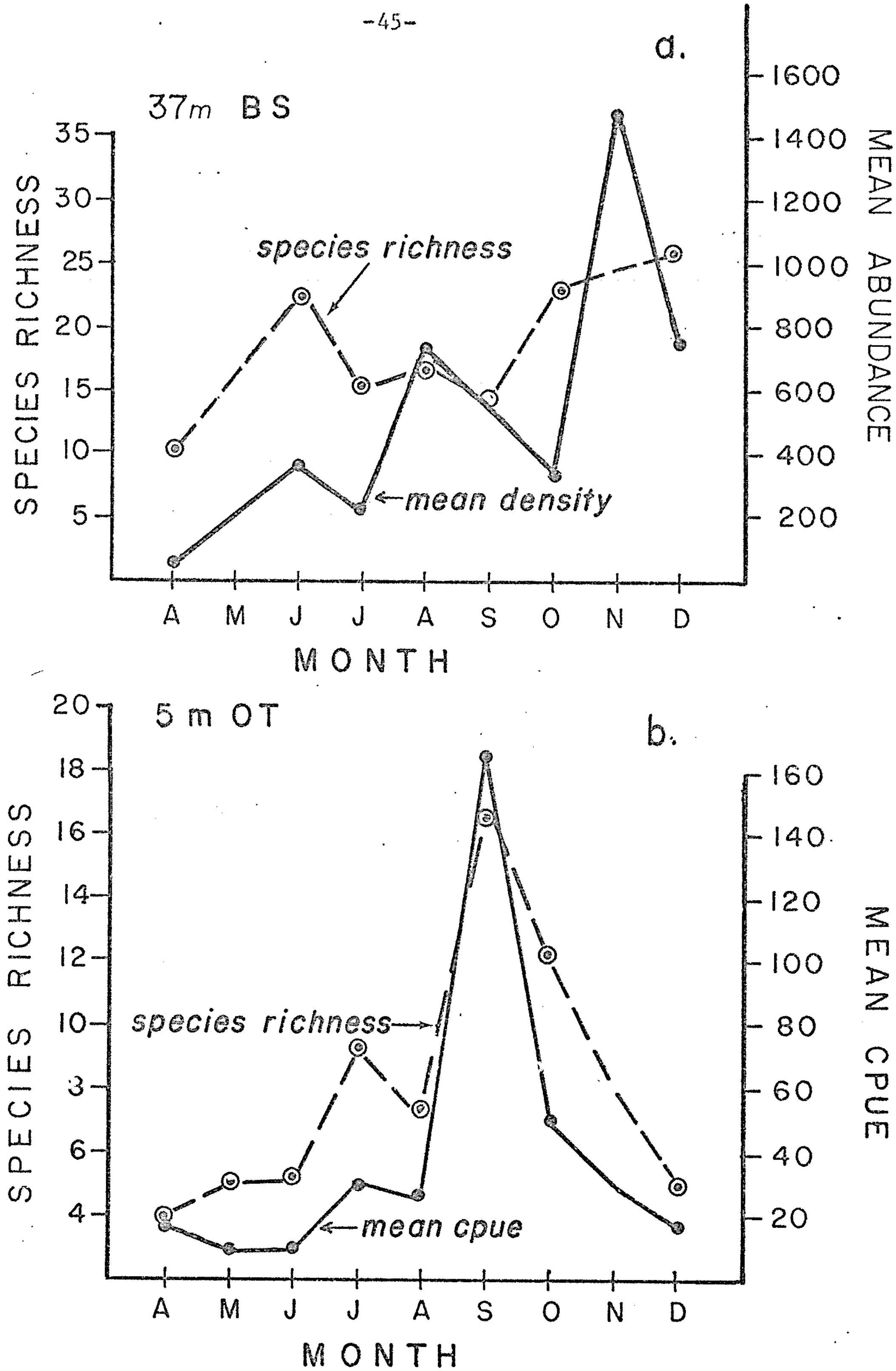


Fig. 11. Species richness and mean abundance (BS) or mean CPUE (OT) for 37-m beach seining (11a) and 5-m otter trawling stations (11b) at Alki Point.

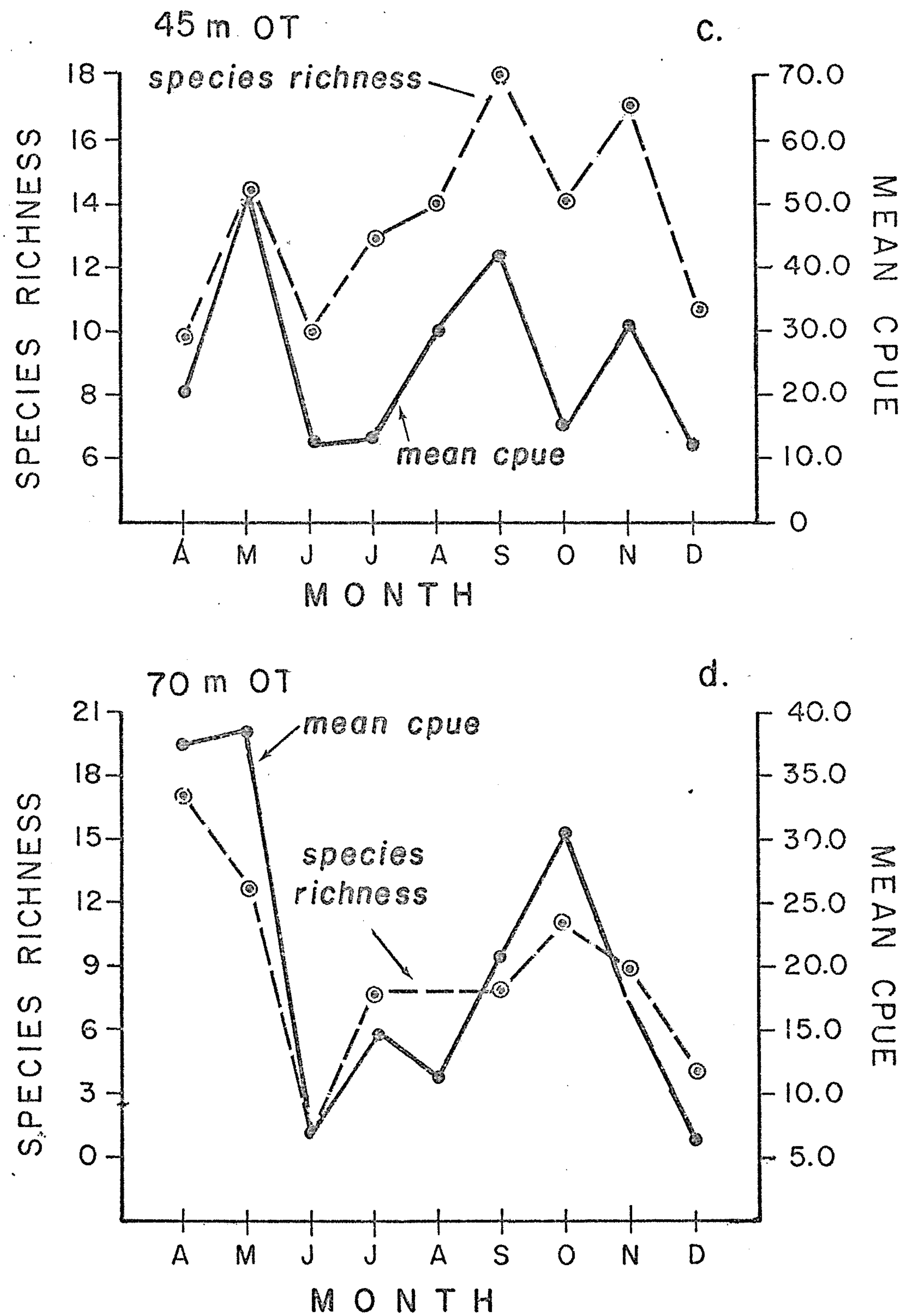


Fig. 11. Species richness and mean CPUE for 45-m (11c) and 70-m (11d) otter trawling stations at Alki Point.

August, and then increased again late in the year. In contrast, mean abundance generally increased throughout the year from a minimum value in April. A gradual increase was observed through mid-summer (August), a decline until October, and then an abrupt rise in November.

Otter Trawl. At 5 m, the species richness and mean CPUE followed much the same trends (Fig. 11b). Both indices increased gradually from April through August but rose abruptly to peaks in September. In subsequent months, both species richness and CPUE dropped to lows in December.

Species richness and mean CPUE were both erratic at 45 m (Fig. 11c). Species richness peaked in May, dropped off in June, but then rose to an annual maximum in September followed by another drop late in the year. The overall peak species richness seemed to occur in late summer and early fall. CPUE followed a similar pattern, although the highest peak occurred in May.

At 70 m, seasonal trends in species richness and mean CPUE were similar (Fig. 11d). Both measures reached peak values in April-May, and were followed by drastic declines in June. From the June low point, both species richness and CPUE gradually increased until October, but dropped off again in November-December.

1.22c *Relative Seasonal Abundance of Dominant Species*

Beach Seine (37-m Net). The five most abundant species collected with the 37-m beach seine were: Shiner perch, striped seaperch, tubesnout, English sole, and rock sole (Table 9a). Although shiner perch were not abundant in April (1.3%), they consistently occurred in large numbers during the remainder of the year. Relative abundance of striped seaperch showed a marked seasonal peak from June (21.4%) to

Table 9a. Relative monthly abundance (percentage) of the five most dominant species collected with the 37-m beach seine at Alki Point during 1975.

Rank	Species	Apr.	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	Shiner perch	1.3%	33.5%	15.4%	38.9%	34.7%	40.8%	51.9%	42.8%
2	Striped perch	2.6	21.4	21.7	49.8	55.2	5.4	2.6	6.6
3	Tube-snout	0.0	1.5	1.2	2.1	2.9	25.8	33.1	13.9
4	English sole	22.6	7.7	19.1	0.9	0.5	5.7	3.7	17.6
5	Rock sole	8.0	21.0	13.3	5.9	2.8	2.6	0.8	3.1
	TOTAL	34.5%	85.1%	70.7%	97.6%	96.1%	80.3%	92.1%	84.0%

Table 9b. Relative monthly abundance (percentage) of the five most dominant species collected at Alki Point during 1975 otter trawling at 5 m.

Rank	Species	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	Striped perch	0.0%	0.0%	0.0%	0.0%	52.7%	39.2%	38.3%	0.0%	0.0%
2	Rock sole	40.5	57.8	35.0	32.5	23.6	20.6	18.1	46.7	21.1
3	English sole	16.2	15.7	45.0	50.0	14.5	13.5	14.9	3.2	5.2
4	C-O sole	40.5	15.7	10.0	6.4	0.0	3.6	5.3	11.3	57.8
5	Padded sculpin	0.0	0.0	0.0	1.6	1.8	10.2	8.5	3.2	0.0
	TOTAL	97.2%	89.2%	90.0%	90.5%	92.6%	87.1%	85.1%	64.4%	84.1%

Table 9c. Relative monthly abundance (percentage) of the five most dominant species collected at Alki Point during 1975 otter trawling at 45 m.

Rank	Species	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	Rock sole	47.5%	35.6%	8.7%	11.5%	16.7%	10.5%	12.1%	3.3%	0.0%
2	English sole	23.7	33.6	26.1	15.4	8.3	1.2	6.1	3.3	4.7
3	Pacific tomcod	0.0	0.0	0.0	7.7	8.3	15.3	30.3	49.2	4.7
4	Roughback sculpin	15.3	4.8	21.7	7.7	13.3	5.9	3.0	3.3	4.7
5	Northern ronquil	3.4	0.0	0.0	7.7	13.3	4.7	12.1	3.3	0.0
	TOTAL	89.9%	74.0%	56.5%	50.0%	59.9%	37.6%	63.6%	62.4%	14.1%

Table 9d. Relative monthly abundance (percentage) of the five most dominant species collected at Alki Point during 1975 otter trawling at 70 m.

Rank	Species	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	Ratfish	15.7%	37.9%	100.0%	51.7%	41.6%	61.9%	41.3%	35.3%	25.0%
2	English sole	40.7	8.9	0.0	3.4	0.0	0.0	7.9	8.8	0.0
3	Dover sole	10.5	12.7	0.0	17.2	20.8	11.9	6.3	23.5	25.0
4	Pacific tomcod	0.0	3.8	0.0	0.0	8.3	2.3	28.6	0.0	0.0
5	Slender sole	3.9	13.9	0.0	0.0	8.3	4.8	0.0	8.8	0.0
	TOTAL	79.8%	77.2%	100.0%	72.3%	79.0%	80.9%	84.1%	76.4%	50.0%

September (55.2%). After September their abundance declined considerably. Tubesnout were present in low abundance (1.2%-2.9%) through September, but increased dramatically during the last three months of the year. English sole appeared to follow a cycle of high abundance (22.6%) in April, low abundance in the summer, and increased abundance late in the year. Rock sole were most abundant during June (21.0%) and July (13.3%), but dropped off substantially thereafter.

Otter Trawl. At 5 m, the five dominant species were striped seaperch, rock sole, English sole, C-O sole, and padded sculpins (Table 9b). Striped seaperch were absent prior to late summer; however, they dominated the catch from August (52.7%) to October (38.3%). This marked August-October peak was due to offshore emigration by young-of-the-year fish born in early summer. Rock sole were consistently abundant (18.1%-57.8%) during all months and showed no evident seasonality. In contrast, English sole relative abundance peaked strongly in June-July (45%-50%), and then gradually declined from August (14.5%) to December (5.2%). C-O sole were abundant in April (40.5%) but decreased to a low in mid-summer. Relative abundance gradually increased from September to November and reached an annual maximum in December (57.8%). Prior to July, padded sculpins were absent from the catch; however, they became increasingly abundant during the summer months and reached a peak in September (10.2%).

At 45 m, the dominant species were rock sole, English sole, Pacific tomcod, roughback sculpin, and northern ronquil (Table 9c). Both English sole and rock sole dominated in April and May. After May, the relative abundance of both species dropped substantially, although rock sole were generally the more abundant species. Roughback sculpin were most abundant from April (15.3%) to June (21.7%), but were consistently present in all months. Pacific tomcod were absent before June and then gradually increased from July (7.7%) through November (49.2%). Relative abundance of northern ronquil was sporadic and followed no clear cycle. Maximum relative abundances occurred in August (13.3%) and October (12.1%).

Ratfish totally dominated the catch at 70 m (Table 9d). Other abundant species were English sole, Dover sole, Pacific tomcod, and slender sole. In all months except April, ratfish comprised the largest fraction of the catch. From June (100%) to September (61.9%) they were particularly abundant. English sole were exceptionally abundant in April (40.7%), but only occurred sporadically in later months. Dover sole were consistently present in all months except June. Pacific tomcod were relatively abundant in October (28.3%) but occurred only sporadically in other months. Relative abundance of slender sole was generally erratic with the highest abundance occurring in May.

1.23 *Point Pully*

1.23a *General Catch Results.* A total of 22,345 individuals in 70 species was collected at Point Pully in 1975 (Table 10). English sole was the only species commonly (present in 30-70% of samples) or frequently (present in > 70% of samples) caught at all depths. Other species caught in the beach seine and at all trawl depths were ratfish, Pacific tomcod, quillback rockfish, roughback sculpin, and rock sole. Ten species comprised 96.2% of the overall beach seine catch (Table 11), with shiner perch, Pacific herring, English sole, and rock sole the dominant species (83.8% of the total catch). Ten species comprised 78.8% of the overall otter trawl catch (Table 11), with rock sole, English sole, ratfish, and roughback sculpin the dominant species (64.3% of the total catch). The largest number of species and

Table 10. List of species collected in the vicinity of Point Pully during 1975. "F" (frequent) indicates species occurred in > 70% of samples; "C" (common) indicates species occurred in 30-70% of samples; "R" (rare) indicates species occurred in < 30% of samples.

		Beach seine			Otter trawl depths				
Species	Total number	9m net	37m[a] net	37m[b] net	5m	25m	45m	70m	95m
Spiny dogfish	3		R						
Ratfish	289		R		R	F	C	F	F
Pacific herring	2,284		R	R			R	R	
Chum salmon	35			R					
Coho salmon	21		R	R					
Chinook salmon	13		R						
Cutthroat trout	8		R	R					
Dolly Varden	1			R					
Surf smelt	2		R						
Plainfin midshipman	35			R		R	R	R	R
Pacific cod	1						R		
Pacific tomcod	422	C	C	R	R	R	C	R	R
Walleye pollock	41		R				R	R	R
Red brotula	1								R
Blackbelly eelpout	4						R	R	R
Tube-snout	174	R	R	R	R				
Threespine stickleback	4	R	R	R					
Bay pipefish	37	C	R	C	R	R			
Shiner perch	10,787	F	F	C	R	R			
Striped seaperch	1,024	R	F	C	R	R			
Pile perch	237		C		R	R	R		
Northern ronquil	30					R	F	R	R
Snake prickleback	15		R	R					
Penpoint gunnel	36	R	R	R	R				
Crescent gunnel	6		R						

a--37m sinking beach seine.
b--37m floating beach seine.

Table 10, cont'd

Species	Total number	Beach seine 9m net	37m[a] net	37[b] net	Otter trawl depths 5m	25m	45m	70m	95m
Saddleback gunnel	24	R	R	R					
Pacific sand lance	208	R	R	R					
Brown rockfish	51		R		R	C	C	R	
Copper rockfish	4		R			R	R		
Quillback rockfish	44		R		R	R	C	C	R
Redstripe rockfish	8						R	R	
Kelp greenling	1					R			
Whitespotted greenling	1	R							
Painted greenling	1					R			
Padded sculpin	218	C	C	C	R	R			
Scalyhead sculpin	1				R				
Silverspotted sculpin	9	R	R	R	R				
Roughback sculpin	161		C		R	F	F	R	R
Sharpnose sculpin	8	R							
Buffalo sculpin	7	R	R	R	R				
Soft sculpin	2								R
Red Irish lord	2		R						
Northern sculpin	2						R		
Spotfin sculpin	24					R	C	R	R
Pacific staghorn sculpin	536	F	F	F	R	R			
Sailfin sculpin	22		R	R			R		
Tidepool sculpin	7	R	R	R					
Tadpole sculpin	1				R				
Slim sculpin	13					R	C	R	
Grunt sculpin	3					R	R		
Cabezon	4		R						
Manacled sculpin	2				R				

a--37m sinking beach seine.
b--37m floating beach seine.

Table 10, cont'd

Species	Total number	Beach seine 9m net	Beach seine 37m[a] net	Beach seine 37[b] net	Otter trawl depths 5m	25m	45m	70m	95m
Northern spearnose poacher	10		R		R		R		
Sturgeon poacher	18	R	R			R	R		
Grey starsnout	2							R	
Pygmy poacher	10					R	R	R	
Blacktip poacher	7							R	
Bluespotted poacher	25		R				R	C	R
Showy snailfish	1								R
Pacific sanddab	62		R		R	R	F		
Speckled sanddab	50		C	R	C	C	R		
Petrale sole	1							R	
Rex sole	24						C	C	R
Rock sole	1,764	R	F	C	F	F	F	R	R
Slender sole	83		R				C	F	C
Dover sole	68		R			R	C	C	C
English sole	2,948	F	F	F	F	F	F	C	C
Starry flounder	28	R	C	R	R				
C-O sole	361		F	C	C	R	R		
Sand sole	9	R	R			R	R		
Total number of individuals	22,345	854	16,392	2,823	569	445	893	182	297
Total number of species	70								

a--37m sinking beach seine.
b--37m floating beach seine.

Table 11. Abundance of the ten most dominant species collected by beach seine (37-m net) and otter trawl at Point Pully during 1975.

	Beach seine			Otter trawl		
Rank	Species	Total	% Total	Species	Total	% Total
1	Shiner perch	10,594	55.1	Rock sole	667	27.9
2	Pacific herring	2,281	11.9	English sole	471	19.7
3	English sole	2,136	11.1	Ratfish	271	11.3
4	Rock sole	1,098	5.7	Roughback sculpin	128	5.4
5	Striped seaperch	967	5.0	Slender sole	70	2.9
6	Pacific tomcod	346	1.8	Dover sole	63	2.6
7	Pacific staghorn sculpin	329	1.7	Pacific sanddab	58	2.4
8	C-O sole	315	1.6	Tube-snout	54	2.3
9	Pile perch	215	1.1	Pacific tomcod	53	2.2
10	Pacific sand lance	204	1.1	Striped seaperch	48	2.0
	TOTAL	18,485	96.2% (18,485/19,215)	TOTAL	1883	78.8% (1883/2390)

individuals (89.8%) were caught in the shallow beach seine areas. For otter trawling both CPUE and species richness were greatest at 45 m. CPUE was lowest at 70 m while species richness was lowest at 95 m.

1.23b *Seasonal Patterns of Species Richness and Abundance*

Beach Seine (37-m Net). Both species richness and mean abundance (mean number of fish per haul) were lowest in late winter and early spring, and both exhibited a large increase from late spring through early fall (Fig. 12a). Low values in August were probably caused by sampling problems. Species richness reached a high in November and mean abundance in October before winter declines.

Otter Trawl. The 5-m depth otter trawl species richness and mean CPUE followed the same seasonal patterns as the beach seine, but with much lower values (Fig. 12b). Both species richness and CPUE rose from May low values to October highs before sharp winter declines.

The 25-m catches were more variable, but indicate a high winter species richness and CPUE as opposed to the low 5-m values (Fig. 12c).

Species richness and CPUE at 45 m followed a pattern similar to that at 25 m but with higher values (Fig. 12d). CPUE was highest in April and declined during the spring and summer to a low in July before rising somewhat erratically again through November. Species richness was highest in December. The 45-m catches, like those at 25 m, seem to be inversely related to the beach seine and 5-m catches.

Species richness and CPUE at 70 m were characterized by high spring values followed by declining summer values with both reaching low points in August and rising again through the late summer and fall (Fig. 12e). There is some indication of a winter decline.

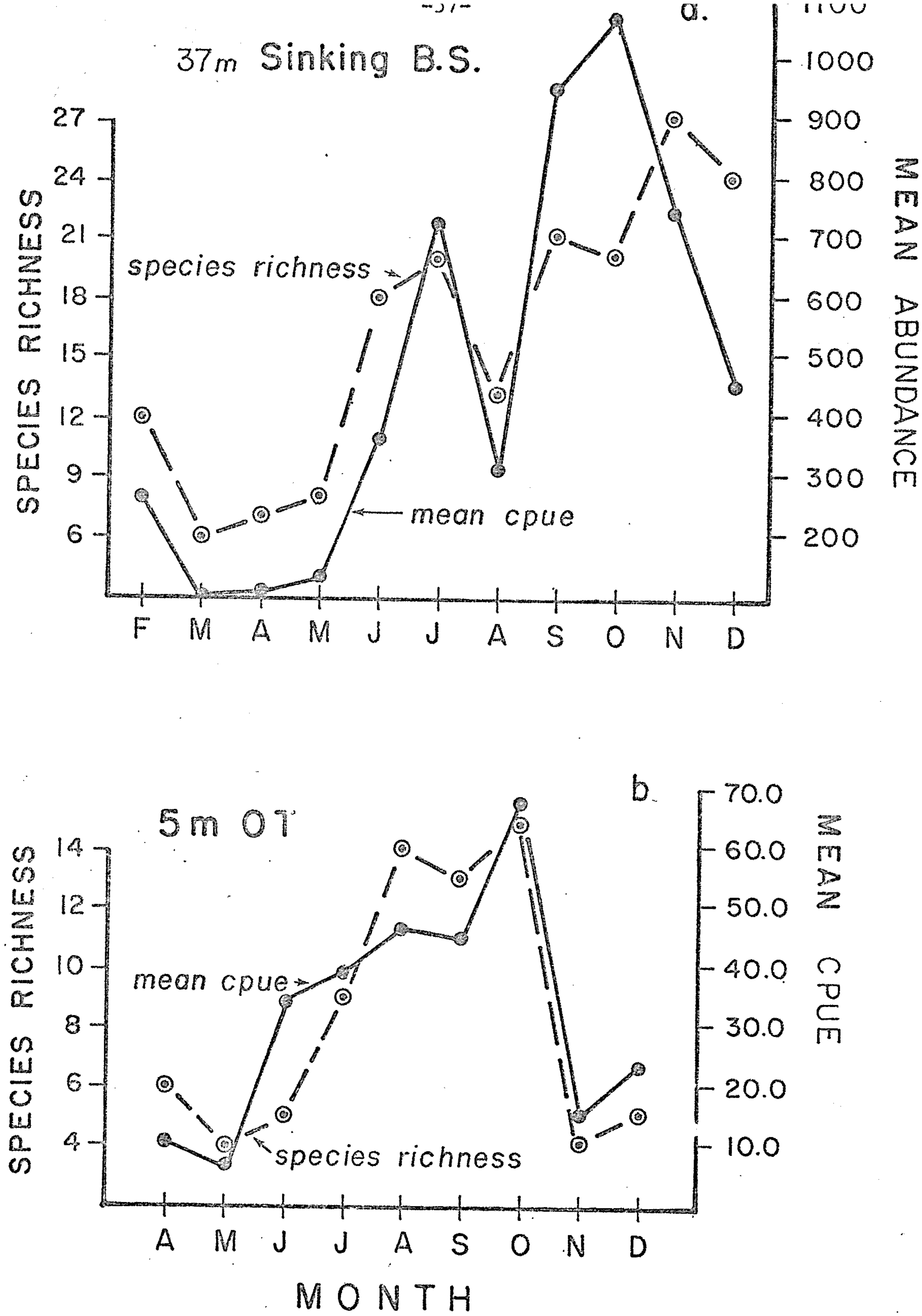
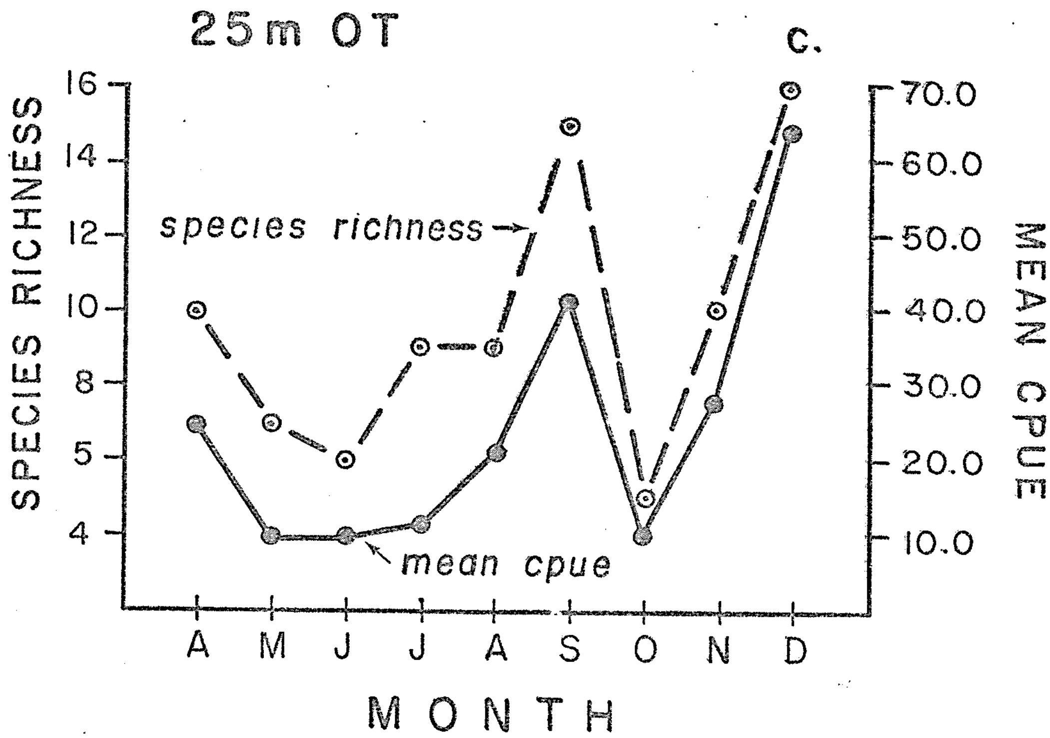


Fig. 12. Species richness and mean abundance (BS) or mean CPUE (OT) for 37-m beach seining (12a) and 5-m (12b) otter trawling stations at Point Pully.



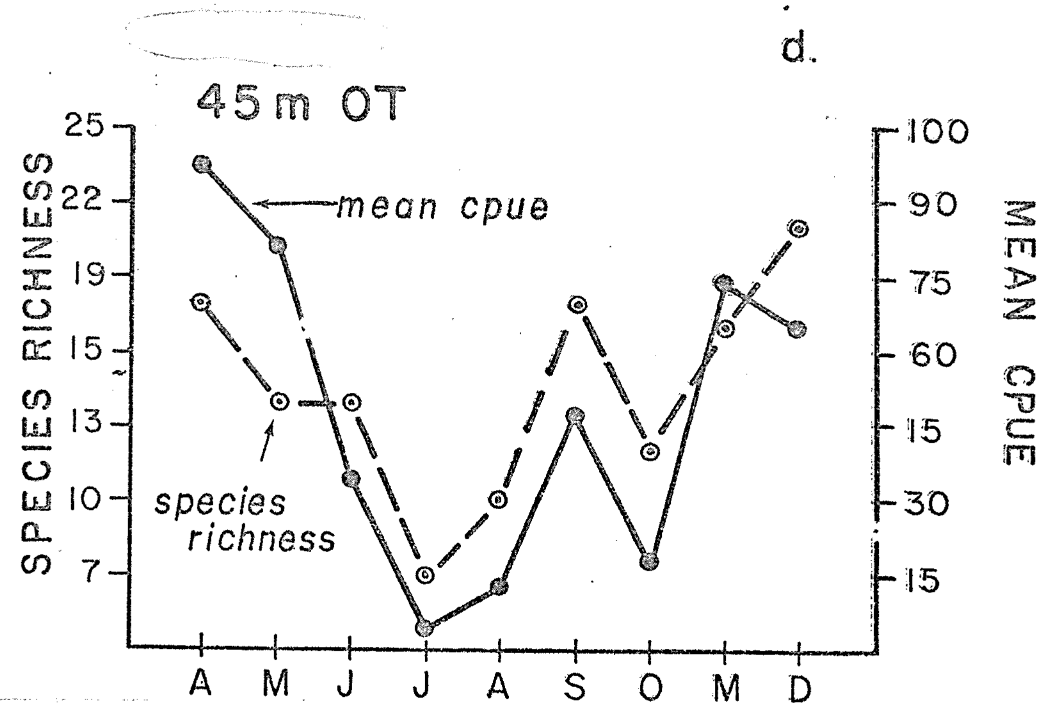


Fig. 12. Species richness and mean CPUE for 25-m (12c) and 45-m (12d) otter trawling stations at Point Pully.

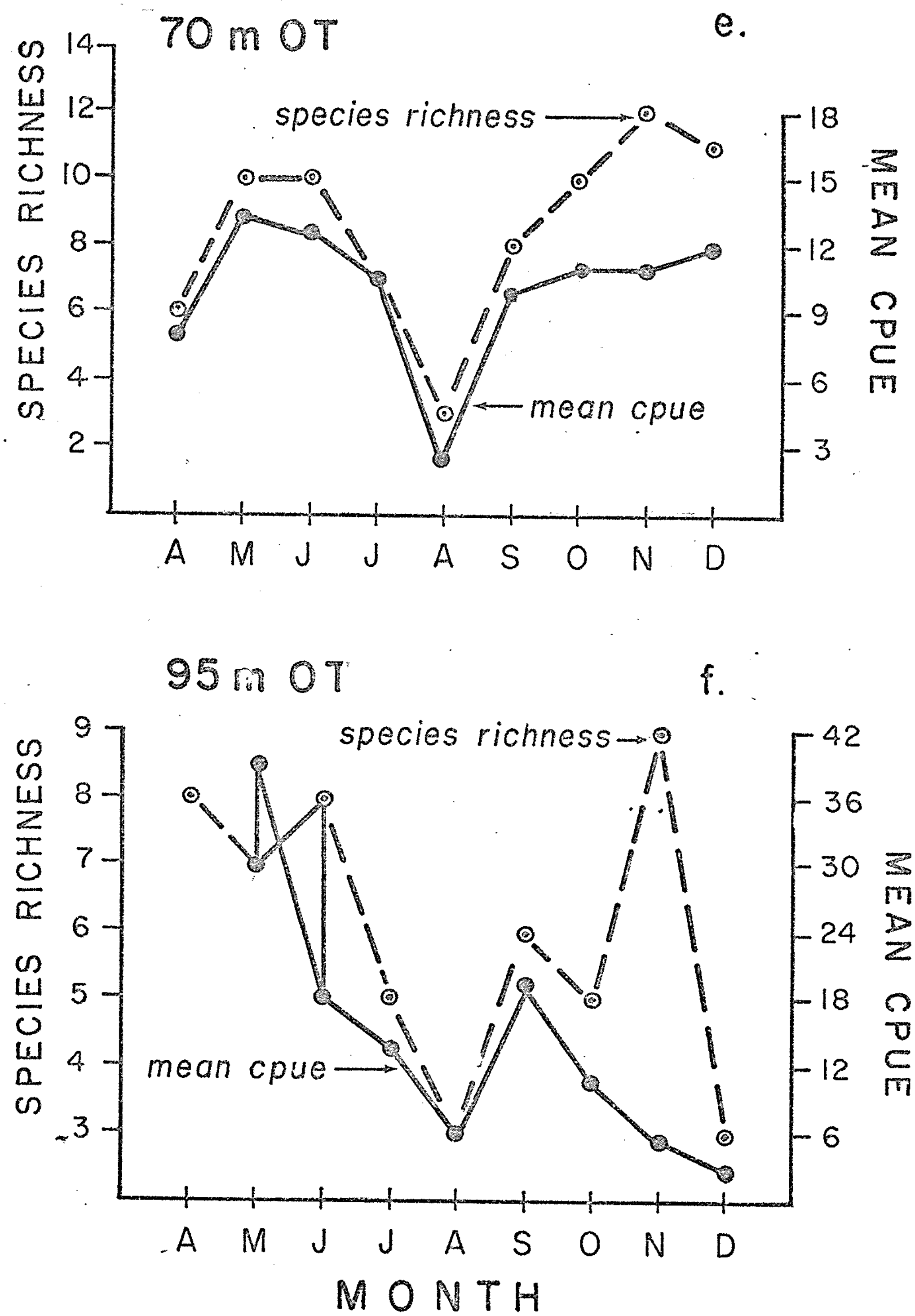


Fig. 12. Species richness and mean CPUE for 70-m (12e) and 95-m (12f) otter trawling stations at Point Pully.

The 95-m species richness and CPUE were somewhat similar to those at 70 m and 45 m (Fig. 12f). From high values in the spring, both species richness and CPUE declined in the early summer to August lows. Both then increased, although somewhat erratically, before fall and winter declines.

1.23c *Relative Seasonal Abundance of Dominant Species*

Beach Seine (37-m Net). Shiner perch dominated the beach seine catch most of the year (Table 12a). Adults were present in high numbers in June and July. Newly released young appeared first in great numbers in August and dominated the catch for the remainder of the year. Pacific herring were ranked high in dominance only because of a large catch of juveniles in September. English sole and rock sole were consistently present in the beach seine catches throughout the year. Greatest numbers were caught in June through November. In June and July nearly all the recently metamorphosed English sole obtained by beach seine were caught with the 9-m fine mesh net. Large numbers of these 0 age English sole were first caught with the 37-m net in August when they made up 76.1% of the English sole catch and 29.8% of the total catch. Large numbers were caught through October. By November most juvenile English sole had moved to deeper waters, but adults were present in considerable numbers through the remainder of the year. Adult striped seaperch were present in high numbers in May through July. Newly released young first appeared in July and were present in moderate numbers through the rest of the year.

Otter Trawl. Rock sole and English sole dominated the 5-m depth otter trawl catch through most of the year (Table 12b). Tubesnout were present in late summer and fall, dominating the catch in October. Juvenile striped seaperch and padded sculpin were seasonally present only in the three-month late summer, early fall period.

Table 12a. Relative monthly abundance of the five most dominant species collected with the sinking 37-m beach seine at Pt. Pully in 1975.

Rank	Species	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	Shiner perch	72.4%	0.0%	4.3%	2.1%	38.5%	67.1%	27.3%	50.5%	63.0%	55.9%	41.4%
2	Pacific herring	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28.1	0.2	0.0	0.1
3	English sole	10.2	23.8	30.4	13.3	11.6	7.6	39.2	5.9	21.2	13.2	16.9
4	Rock sole	6.2	14.3	17.4	37.8	18.7	9.9	24.2	2.3	6.8	4.7	11.1
5	Striped seaperch	0.0	0.0	0.0	19.6	8.2	7.9	3.5	3.1	1.3	10.7	5.8
	TOTAL	88.8	38.1	52.1	72.8	77.0	92.5	94.2	89.9	92.5	84.5	75.3

Table 12b. Relative monthly abundance of the five most dominant species collected at Pt. Pully during 1975 at 5 m.

Rank	Species	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	Rock sole	22.7%	28.6%	44.9%	36.7%	30.1%	36.0%	17.9%	30.0%	52.1%
2	English sole	4.5	28.6	49.3	48.1	10.8	29.2	14.9	63.3	21.7
3	Tube-snout	0.0	0.0	0.0	0.0	11.8	1.1	29.1	0.0	6.5
4	Striped seaperch	0.0	0.0	0.0	0.0	32.3	6.7	7.5	0.0	0.0
5	Padded sculpin	0.0	0.0	0.0	0.0	1.1	6.7	20.1	0.0	0.0
	TOTAL	27.2	57.2	94.2	84.8	86.1	79.7	89.5	93.3	80.3

Table 12c. Relative monthly abundance of the five most dominant species collected at Pt. Pully during 1975 at 25 m.

Rank	Species	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	Rock sole	42.0%	45.0%	20.0%	21.7%	26.2%	21.7%	25.0%	57.9%	41.9%
2	English sole	10.0	5.0	50.0	17.4	31.0	24.1	20.0	12.3	21.7
3	Roughback sculpin	10.0	20.0	10.0	26.1	16.7	26.5	35.0	10.5	1.6
4	Pacific tomcod	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.3
5	Ratfish	10.0	15.0	5.0	8.7	7.1	3.6	5.0	0.0	0.8
	TOTAL	72.0	85.0	85.0	73.9	81.0	75.9	85.0	80.7	82.3

Table 12d. Relative monthly abundance of the five most dominant species collected at Pt. Pully during 1975 at 45 m.

Rank	Species	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	Rock sole	45.4%	53.0%	4.3%	33.3%	7.4%	25.3%	13.9%	53.4%	17.6%
2	English sole	19.4	28.0	55.1	0.0	14.8	15.8	27.8	22.3	11.5
3	Roughback sculpin	6.6	5.5	14.5	0.0	7.4	1.1	0.0	11.5	3.8
4	Pacific sanddab	2.0	4.9	4.3	0.0	25.9	12.6	8.3	5.4	1.5
5	Walleye pollock	0.0	0.0	0.0	0.0	0.0	3.2	0.0	0.0	20.6
	TOTAL	73.4	91.4	78.2	33.3	55.5	58.0	50.0	92.6	55.0

Table 12e. Relative monthly abundance of the five most dominant species collected at Pt. Pully during 1975 at 70 m.

Rank	Species	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	Ratfish	25.0%	14.8%	12.0%	42.9%	40.0%	38.9%	0.0%	4.5%	25.0%
2	Slender sole	0.0	14.8	24.0	14.3	40.0	5.6	18.2	27.3	12.5
3	Bluespotted poacher	12.5	3.7	12.0	9.5	20.0	22.2	22.7	0.0	8.3
4	Dover sole	25.0	7.4	16.0	9.5	0.0	5.6	9.1	0.0	12.5
5	Quillback rockfish	12.5	18.5	8.0	4.8	0.0	0.0	4.5	4.5	4.2
	TOTAL	75.0	59.2	72.0	81.0	100.0	72.3	54.5	36.3	62.5

Table 12f. Relative monthly abundance of the five most dominant species collected at Pt. Pully during 1975 at 95 m.

Rank	Species	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	Ratfish	63.4%	74.4%	63.9%	81.5%	58.3%	79.5%	57.1%	10.0%	60.0%
2	Dover sole	14.1	7.7	8.3	3.7	33.3	2.6	0.0	10.0	0.0
3	Slender sole	2.8	12.8	11.1	0.0	0.0	5.1	19.0	20.0	20.0
4	Rex sole	8.5	0.0	0.0	3.7	0.0	7.7	0.0	10.0	0.0
5	English sole	7.0	1.3	2.8	0.0	0.0	0.0	4.8	10.0	0.0
	TOTAL	95.8	96.2	86.1	88.9	91.6	94.9	80.9	60.0	80.0

The 25-m depth was dominated by rock sole, English sole, and roughback sculpin (Table 12c). Rock sole were dominant in the fall, winter, and spring. Lower summer abundance coincided with larger catches of rock sole at 5 m and in the beach seine. English sole were dominant in June and August with greatest numbers being caught in late summer. Roughback sculpin were most abundant in summer and early fall. Pacific tomcod were only present in December. Ratfish were most abundant in spring and summer.

The catch at 45 m was dominated by rock sole and English sole (Table 12d). Rock sole were more abundant at this depth than at any other in the early spring (April and May) and late summer (September) through winter. Although rock sole were ranked high in the July relative abundance, very few fish were caught. As with the 25-m catch, lower summer abundance of rock sole at 45 m coincided with larger catches at 5 m and in the beach seine. English sole were also least abundant in the summer. Fall increases coincided with offshore migration, particularly of juveniles. Roughback sculpin were present in moderate numbers most of the year. Pacific sanddab were also present most of the year and dominated the catch in August. Walleye pollock were only present in considerable numbers in December when they dominated the catch.

The catches at 70 m were small with ratfish dominating most of the year (Table 12e). Ratfish were least abundant in the fall (October and November). Slender sole were present most of the year and were most abundant in the spring and fall. Bluespotted poacher, Dover sole, and quillback rockfish were present most of the year with all being most abundant in the spring.

Ratfish overwhelmingly dominated the catch at 95 m (Table 12f). They were most abundant in the spring and early summer. Dover sole and slender sole were present in moderate numbers only in the spring. Rex sole were present in small numbers sporadically throughout the year. English sole were caught in small numbers in the spring and fall.

1.23d *Diel Variations in Beach Seine Catch.* Beach seining was conducted at the lowest tides of each month. Since low tides occur during the day from March through September and at night from October through February, beach seine sampling of necessity was conducted about half the year at night and half during the day. At Point Pully, the switch from night to day in March coincided with a drop in total catch to the lowest level of the year, whereas the day to night switch in October resulted in the highest catch of the year.

In general, species richness and CPUE seemed to be higher at night. In September there was a low tide series at night nearly equal in height to one in the day; sampling was conducted during both the day and night low tide series. More than three times as many individuals were caught at night as in the day, and species richness was also higher at night (Table 13). The most obvious difference was the large catch of juvenile Pacific herring at night. Other species with much larger catches at night were shiner perch, Pacific tomcod, English sole, and pile perch. Striped seaperch was the only species much more abundant during the day than at night. Increase in abundance at night for some species may be partly attributable to increased efficiency of the net during darkness.

1.3 *Disease Incidence Results*

1.31 *West Point.* Percent incidence of tumorous English sole varied by month and age during 1975 (Table 14). The general pattern of

Table 13. Day versus night catch during September 1975 at Point Pully with the 37-m sinking beach seine.

	Day		Night	
	1	2	1	2
Pacific herring	1		1,864	408
Coho salmon			1	1
Pacific tomcod	2	2	48	39
Walleye pollock			1	
Threespine stickleback	1			
Tubesnout				5
Bay pipefish		3		
Shiner perch	524	811	798	1,954
Striped seaperch	82	125	15	29
Pile perch			66	75
Snake prickleback			1	2
Penpoint gunnel	1	1	1	2
Saddleback gunnel		1	2	
Pacific sand lance			1	
Brown rockfish	1			1
Padded sculpin	26	29	18	33
Silverspotted sculpin	1	1		
Roughback sculpin			1	
Buffalo sculpin				1
Red Irish lord			1	
Pacific staghorn sculpin	10	16	24	20
Sailfin sculpin			1	
Tidepool sculpin			1	
Cabezon	1			
Sturgeon poacher			1	
Pacific sanddab	1		1	
Speckled sanddab	1	3		
Rock sole	35	42	40	72
Slender sole			1	1
Dover sole		1		1
English sole	83	83	128	180
Starry flounder	1			1
C-O sole	1	4	1	5
Sand sole	1			1
Total No. Indiv.	773	1,122	3,376	2,830
Total No. Species	18	14	23	20

Table 14. Percent incidence of tumor-bearing English sole (Parophrys vetulus) collected at West Point during 1975. 37-m and 9-m beach seine catches are combined.

	Beach seine			Otter trawl		
Month	Age 0	Age I	Age II+	Age 0	Age I	Age II+
February	0.0 (0/10)	18.4 (7/38)	0.0 (0/40)	NO SAMPLING		
March	NO SAMPLING			0.0 (0/0)	8.7 (2/23)	0.0 (0/130)
April	3.2 (1/31)	100.0 (1/1)	100.0 (1/1)	0.0 (0/13)	2.5 (1/40)	0.0 (0/105)
May	0.0 (0/42)	0.0 (0/3)	0.0 (0/13)	0.0 (0/0)	20.0 (1/5)	0.0 (0/44)
June	0.0 (0/129)	0.0 (0/33)	0.0 (0/52)	0.0 (0/0)	3.2 (1/31)	0.0 (0/72)
July	0.0 (0/144)	0.0 (0/11)	0.0 (0/24)	0.0 (0/3)	0.0 (0/14)	0.0 (0/58)
August	0.0 (0/235)	7.1 (1/14)	0.0 (0/15)	0.0 (0/6)	0.0 (0/14)	0.0 (0/30)
September	7.0 (12/171)	17.6 (3/17)	0.0 (0/7)	7.7 (3/39)	2.5 (1/40)	0.0 (0/58)
October	4.2 (7/165)	3.3 (6/180)	0.0 (0/85)	6.3 (1/16)	2.6 (1/39)	0.0 (0/49)
November	7.8 (4/51)	0.0 (0/0)	0.0 (0/0)	0.0 (0/0)	0.0 (0/0)	0.0 (0/0)
December	9.5 (8/84)	10.4 (8/77)	0.0 (0/73)	NO SAMPLING		

abundance of tumor-bearing fish was similar to that reported previously at West Point (Miller, et al., 1974, 1975). Percent incidence of age 0 tumor-bearing fish ranged from 3.2% in April to 9.5% in December. Juvenile English sole settled onto the beach beginning in February, but the largest influx occurred between June and October. Except for a lone occurrence in April, tumor-bearing fish were not detected prior to September. Between September and December the percent incidence of age group 0 fish was highest and ranged from 4.2% to 9.5%. Incidence of tumor-bearing age I fish was highest during the early portion of the year and then later declined. Only a single fish older than two years was observed with a tumor.

Percent incidence of external nematodes (Philometra) on English sole and rock sole fluctuated considerably during 1975 (Table 15). Externally evident parasites were not detected on individuals less than 150 mm in total length for either species. Monthly incidences for English sole ranged from 3.7% in June to 14.1% in September, but failed to follow any clear seasonal pattern. Incidences of rock sole infestation varied from 1.6% in August to 15.0% in December. In general, external nematode incidences were high early in the year, declined during late spring and summer, and then gradually increased through the end of the year for both species.

1.32 *Alki Point.* Settlement of young-of-the-year (age group 0) English sole at Alki Point was very limited during 1975. Tumor-bearing age group 0 fish were absent prior to October but occurred in small numbers from October to December (Table 16). These incidence levels, however, should be viewed with some caution since the sample sizes are very small. Even though the data are incomplete, it is apparent that the

Table 15. Percent incidence of Philometra-infested English sole (Parophrys vetulus) and rock sole (Lepidopsetta bilineata) collected at West Point during 1975. Beach seine and otter trawl catches are combined.

	English sole		Rock sole	
	Total length		Total length	
Month	< 150 mm	≥ 150 mm	< 150 mm TL	≥ 150 mm TL
February	0.0 (0/47)	0.0 (0/41)	0.0 (0/0)	0.0 (0/1)
March	0.0 (0/31)	5.5 (7/126)	0.0 (0/2)	10.6 (11/104)
April	0.0 (0/54)	12.1 (17/140)	0.0 (0/79)	12.3 (19/154)
May	0.0 (0/56)	7.8 (4/51)	0.0 (0/36)	5.3 (3/62)
June	0.0 (0/153)	3.7 (6/164)	0.0 (0/10)	3.4 (4/117)
July	0.0 (0/152)	5.9 (6/102)	0.0 (0/23)	6.2 (9/145)
August	0.0 (0/249)	4.7 (3/64)	0.0 (0/22)	1.6 (1/86)
September	0.0 (0/247)	14.1 (12/85)	0.0 (0/22)	8.9 (8/90)
October	0.0 (0/191)	3.9 (13/334)	0.0 (0/20)	8.0 (6/75)
November	0.0 (0/13)	10.3 (3/29)	0.0 (0/19)	9.7 (3/31)
December	0.0 (0/88)	8.2 (12/146)	0.0 (0/23)	15.0 (6/40)

Table 16. Percent incidence of tumor-bearing English sole (*Parophrys vetulus*) collected at Alki Point during 1975. 37-m and 9-m beach seine catches are combined.

	Beach seine			Otter trawl		
Month	Age 0	Age I	Age II+	Age 0	Age I	Age II+
April	0.0 (0/19)	0.0 (0/2)	0.0 (0/0)	0.0 (0/1)	33.3 (1/3)	0.0 (0/40)
May		NO SAMPLING		0.0 (0/0)	0.0 (0/15)	0.0 (0/29)
June	0.0 (0/29)	8.1 (3.37)	15.4 (2/13)	0.0 (0/0)	0.0 (0/3)	0.0 (0/17)
July	0.0 (0/90)	6.6 (2/30)	0.0 (0/2)	0.0 (0/0)	0.0 (0/14)	0.0 (0/22)
August	0.0 (0/30)	0.0 (0/0)	0.0 (0/0)	0.0 (0/0)	0.0 (0/4)	0.0 (0/9)
September	0.0 (0/9)	0.0 (0/0)	0.0 (0/0)	0.0 (0/2)	0.0 (0/10)	0.0 (0/35)
October	10.0 (2/20)	0.0 (0/5)	0.0 (0/18)	8.3 (1/12)	0.0 (0/3)	0.0 (0/6)
November	9.1 (4/44)	3.6 (1/28)	0.0 (0/39)	0.0 (0/0)	0.0 (0/0)	0.0 (0/7)
December	6.6 (4/61)	1.9 (2/106)	0.0 (0/98)	0.0 (0/0)	0.0 (0/0)	0.0 (0/3)

general pattern of abundance of tumor-bearing young-of-the-year is similar to that observed at West Point. The incidence of tumorous one-year-old fish was low and sporadic, but generally was highest from April to July. Only two fish more than two years of age were found with tumors.

The incidence of nematode-infested rock sole and English sole was generally high throughout the year (Table 17). Incidences ranged from 10.0% to 40.0% for English sole and 2.9% to 18.2% for rock sole. No individuals less than 150 mm in total length had externally detectable parasites. No clear seasonal cycles are apparent in the data; however, infestation levels for rock sole are lowest during summer and fall and highest early in the year.

1.33 *Point Pully*. Tumor-bearing age 0 English sole were observed in the beach seine catches only in late summer and fall and in the otter trawl catches in fall (Table 18). The highest incidence was in October when 14.7% of the age 0 English sole caught by beach seine had tumors. Tumor-bearing one-year-old English sole were caught most months. The highest incidences were in spring and summer for both the beach seine and the otter trawl. Very few tumor-bearing English sole over two years old were caught.

Incidence of externally observable infestation by the nematode Philometra was high throughout the year for both English sole and rock sole (Table 19). English sole had the highest incidence in fall and spring, with April being the peak month when 46.7% of the fish ≥ 150 mm in length were infested. Incidence of infestation in rock sole was consistently higher throughout the year than in English sole. The highest incidence was in December when 55.5% of the rock sole ≥ 150 mm

Table 17. Percent incidence of *Philometra*-infested English sole (*Parophrys vetulus*) and rock sole (*Lepidopsetta bilineata*) collected at Alki Point during 1975. Beach seine and otter trawl catches are combined.

	English sole		Rock sole	
	Total length		Total length	
Month	< 150 mm	≥ 150 mm	< 150 mm	≥ 150 mm
April	0.0 (0/32)	40.0 (16/40)	0.0 (0/9)	11.9 (5/42)
May	0.0 (0/10	14.7 (5/34)	0.0 (0/10)	5.3 (2/38)
June	0.0 (0/36)	10.0 (6/60)	0.0 (0/6)	14.4 (24/167)
July	0.0 (0/101)	14.0 (8/57)	0.0 (0/25)	14.8 (8/54)
August	0.0 (0/33)	10.0 (1/10)	0.0 (0/1)	0.9 (1/106)
September	0.0 (0/11)	24.4 (11/45)	0.0 (0/6)	7.6 (8/105)
October	0.0 (0/32)	21.8 (7/32)	0.0 (0/3)	3.4 (1/29)
November	0.0 (0/50)	14.7 (10/68)	0.0 (0/21)	2.9 (1/34)
December	0.0 (0/85)	23.5 (14/183)	0.0 (0/5)	18.2 (8/44)

Table 18. Percent incidence of tumor-bearing English sole (<u>Parophrys vetulus</u>) collected at Pt. Pully during 1975. Dash (--) indicates that no sampling was conducted. 37-m and 9-m beach seine catches are combined.

Month	Beach seine			Otter trawl		
	Age 0	Age I	Age II+	Age 0	Age I	Age II+
February	0.0 (0/9)	6.3 (3/48)	13.3 (2/15)	--	--	--
March	0.0 (0/2)	0.0 (0/2)	0.0 (0/2)	--	--	--
April	0.0 (0/7)	20.0 (1/5)	0.0 (0/0)	0.0 (0/1)	0.0 (0/10)	0.0 (0/41)
May	0.0 (0/8)	0.0 (0/7)	0.0 (0/13)	0.0 (0/0)	20.0 (4/20)	0.0 (0/31)
June	0.0 (0/60)	23.5 (8/34)	0.0 (0/45)	0.0 (0/0)	18.5 (5/27)	0.0 (0/57)
July	0.0 (0/145)	18.5 (12/65)	0.0 (0/44)	0.0 (0/0)	7.1 (2/28)	0.0 (0/15)
August	0.0 (0/343)	21.2 (11/52)	0.0 (0/8)	0.0 (0/0)	11.1 (1/9)	0.0 (0/17)
September	6.3 (13/207)	7.9 (10/126)	0.0 (0/45)	0.0 (0/3)	4.5 (1/22)	0.0 (0/36)
October	14.7 (50/340)	6.3 (9/144)	2.1 (2/97)	13.3 (2/15)	0.0 (0/13)	0.0 (0/7)
November	4.2 (1/24)	1.4 (1/71)	0.0 (0/102)	6.7 (1/15)	10.0 (3/30)	0.0 (0/15)
December	12.5 (2/16)	6.3 (2/32)	0.0 (0/106)	0.0 (0/6)	5.3 (1/19)	0.0 (0/32

Table 19. Percent incidence of *Philometra*-infested English sole (*Parophrys vetulus*) and rock sole (*Lepidopsetta bilineata*) collected at Point Pully during 1975, beach seine and otter trawl catches combined.

	English sole		Rock sole	
	Total length		Total length	
Month	< 150 mm	≥ 150 mm	< 150 mm	≥ 150 mm
February	0.0 (0/28)	16.7 (3/18)	5.6 (1/18)	33.3 (7/21)
March	0.0 (0/4)	0.0 (0/2)	0.0 (0/1)	0.0 (0/1)
April	0.0 (0/18)	46.7 (21/45)	7.1 (2/28)	35.2 (32/91)
May	0.0 (0/32)	27.1 (13/48)	0.0 (0/27)	35.2 (51/145)
June	0.0 (0/69)	15.9 (23/145)	0.0 (0/32)	38.3 (54/141)
July	0.0 (0/147)	12.7 (19/150)	0.0 (0/30)	46.5 (73/157)
August	0.0 (0/371)	18.6 (11/59)	0.6 (1/160)	41.2 (47/114)
September	0.0 (0/283)	16.6 (26/157)	2.0 (1/49)	38.2 (58/152)
October	0.0 (0/367)	12.9 (32/249)	1.4 (1/73)	44.5 (65/146)
November	0.0 (0/71)	25.8 (48/186)	0.0 (0/46)	40.8 (60/147)
December	0.0 (0/34)	37.3 (66/177)	0.0 (0/64)	55.5 (81/146)

in length were infested and the lowest in February when 33.3% were infested.

2. *Duwamish River Study*

2.1 *General Catch Results.* A total of 8,483 individuals in 29 species were collected in the Duwamish River during 1975 (Table 20). The most frequently captured species ($\geq$ 70% of samples) were Pacific staghorn sculpin and English sole. Commonly occurring species (30%-70% of samples) included the Pacific herring, longfin smelt, Pacific tomcod, shiner perch, snake prickleback, padded sculpin, rock sole, starry flounder, and sand sole. Overall, the ten most abundant species accounted for nearly 98% of the year's catch (Table 21) with snake prickleback, English sole, and longfin smelt the most abundant species.

2.11 *Seasonal Patterns of Species Richness and Abundance.* Species richness and abundance (catch per haul), for all stations and months combined, exhibited marked seasonal variation during 1975 (Fig. 13). Catch per haul was lowest during late winter and early spring (March-April), but increased rapidly during late spring (May-June) and summer (July-September) with the exception of a slight decline in July. After peaking in late summer, catch per haul dropped abruptly late in the year (October and November). Species richness followed similar though less marked seasonal changes. Catch per haul and species richness varied considerably between stations on a seasonal basis (Figs. 14a-14g). Catch per haul at lower river stations (A through D) generally was less than at upper river stations (E-G), whereas species richness tended to be highest at mid-river stations (C through F).

2.12 *Relative Seasonal Abundance of Dominant Species.* Relative seasonal abundance of the 5 dominant species (all stations combined)

Table 20. List of species collected in Duwamish River, all stations combined, during 1975. "F" (frequent) indicates species occurred in > 70% of samples; "C" (common) indicates species occurred in 30-70% of samples; "R" (rare) indicates species occurred in < 30% of samples.

Species	Total number	Frequency of occurrence
Spiny dogfish	1	R
Ratfish	1	R
Pacific herring	70	C
Coho salmon	11	R
Longfin smelt	1473	C
Eulachon	2	R
Pacific cod	1	R
Pacific tomcod	610	C
Tubesnout	1	R
Shiner perch	190	C
Striped seaperch	3	R
Pile perch	10	R
Snake prickleback	1969	C
Saddleback gunnel	1	R
Bay goby	13	R
Padded sculpin	49	C
Roughback sculpin	7	R
Buffalo sculpin	8	R
Pacific staghorn sculpin	888	F
Prickly sculpin	2	R
Sturgeon poacher	1	R
Pygmy poacher	3	R
Rock sole	116	C
Slender sole	8	R
Dover sole	69	R
English sole	1561	F
Starry flounder	1314	C
Sand sole	98	C
English sole x starry flounder hybrid	3	R
Total No. Individuals	8483	
Total No. Species	29	

Table 21. Abundance of 10 most dominant species collected in the Duwamish River in 1975.

Rank	Species	Total	% Total
1	Snake prickleback	1969	23.2
2	English sole	1561	18.4
3	Longfin smelt	1473	17.4
4	Starry flounder	1314	15.5
5	Pacific staghorn sculpin	888	10.5
6	Pacific tomcod	610	7.2
7	Shiner perch	190	2.2
8	Rock sole	116	1.4
9	Sand sole	98	1.2
10	Pacific herring	70	0.8
	Total	8289	97.7% (8289/8483)

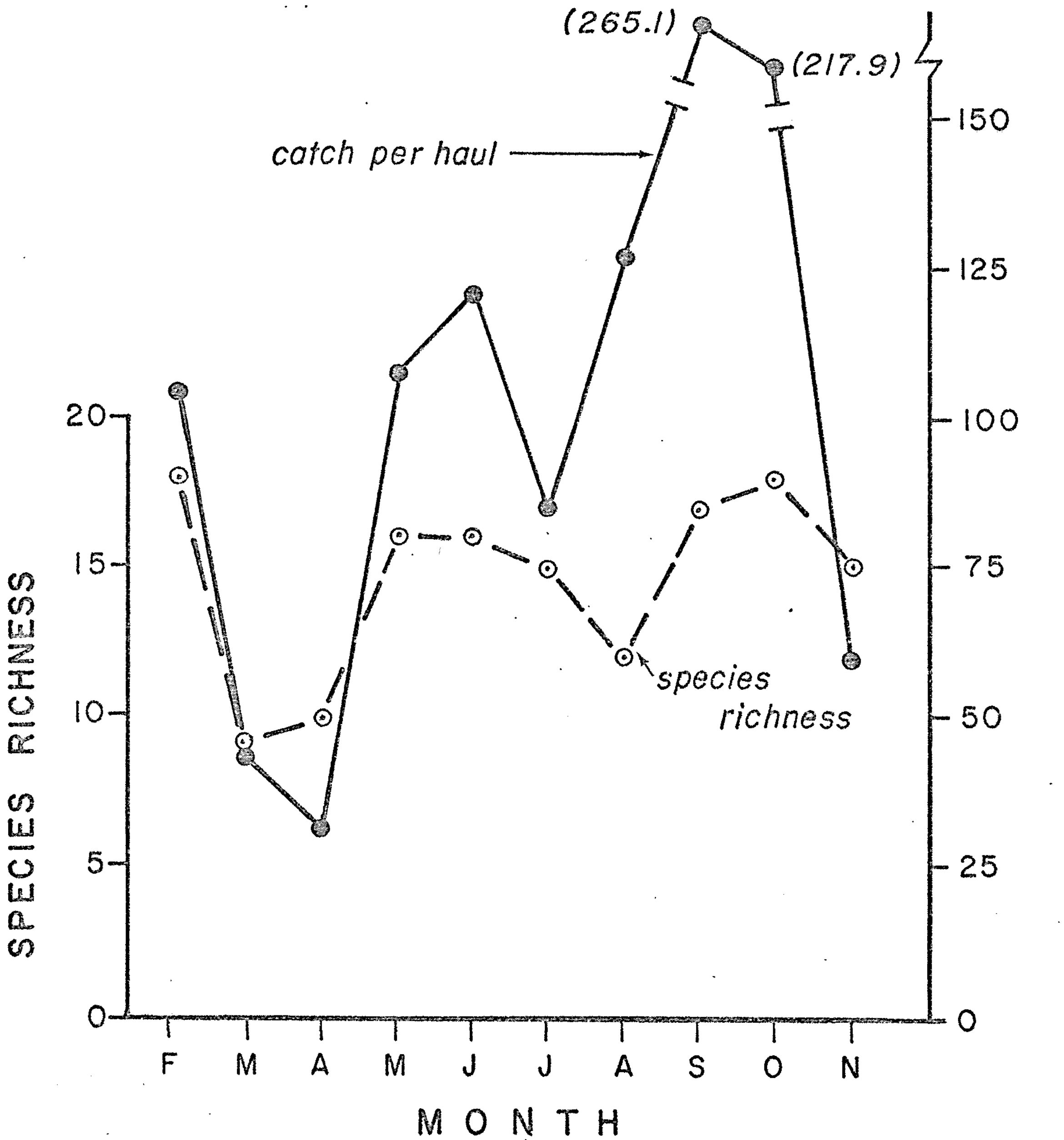


Fig. 13. Species richness and catch per haul from the Duwamish River for all stations combined.

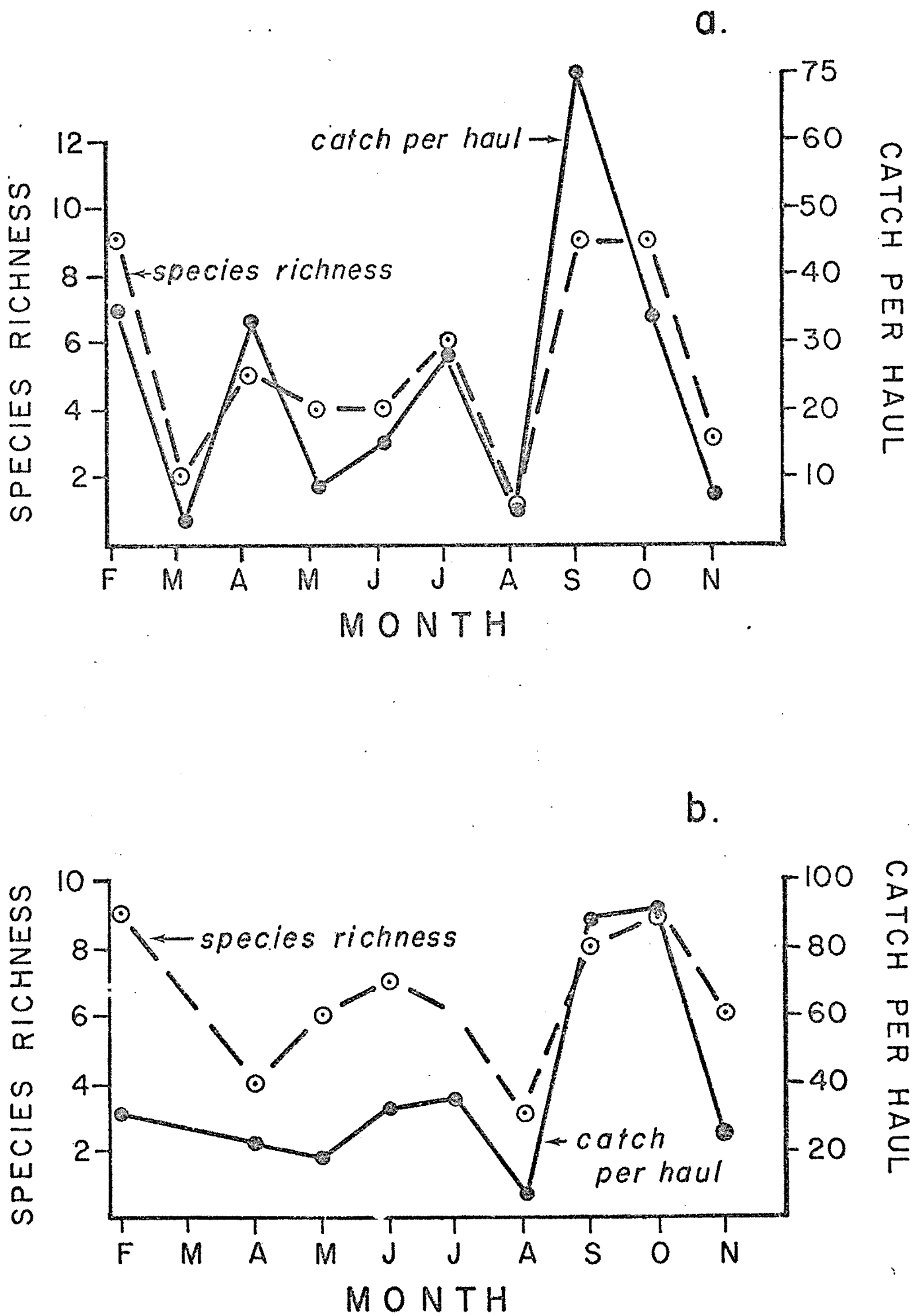
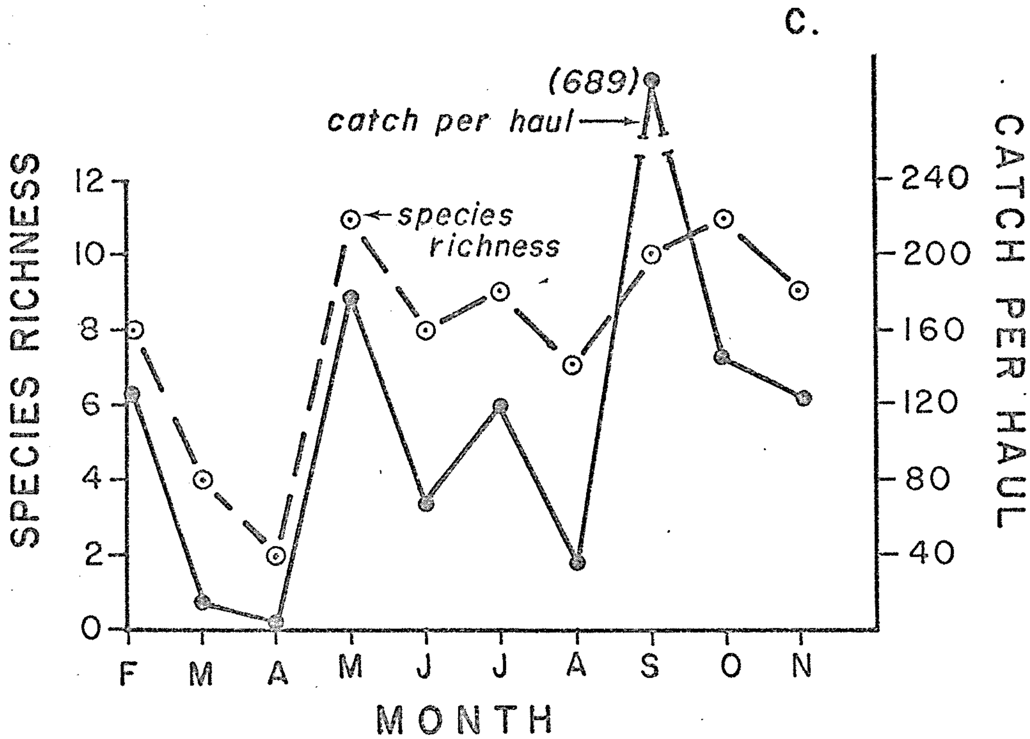


Fig. 14. Species richness and catch per haul for Station A (14a) and Station B (14b) from the Duwamish River.



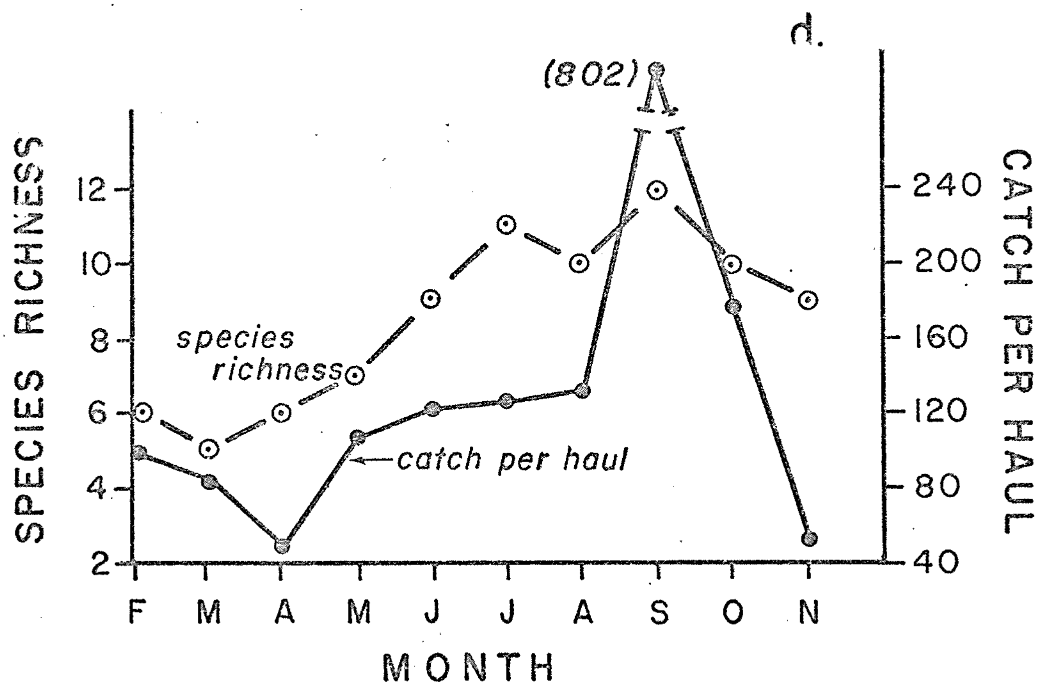


Fig. 14. Species richness and catch per haul for Station C (14c) and Station D (14d) from the Duwamish River.

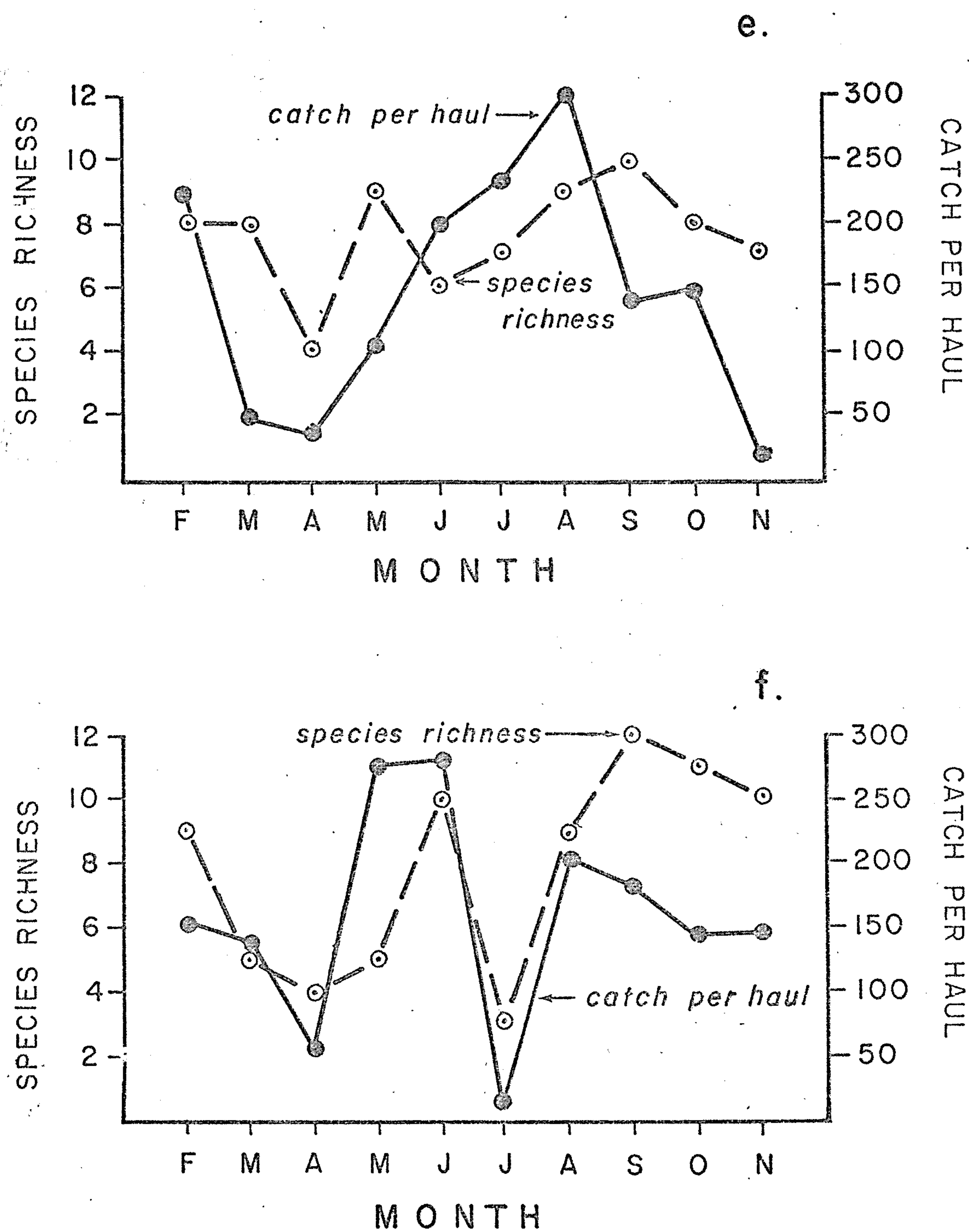


Fig. 14. Species richness and catch per haul for Station E (14e) and Station F (14f) from the Duwamish River.

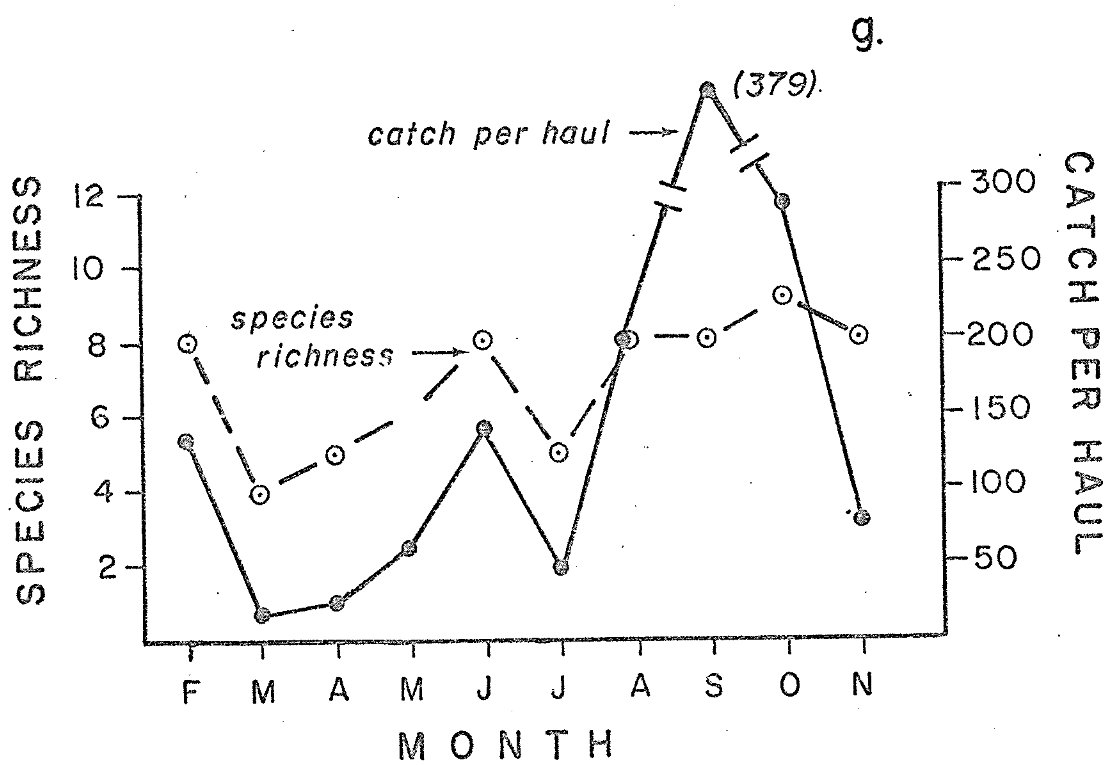


Fig. 14. Species richness and catch per haul for Station G (14g) from the Duwamish River.

fluctuated greatly during 1975 (Table 22). Snake prickleback, the most abundant species, was largely absent prior to May, but dramatically increased in late spring and summer. In contrast, English sole generally comprised a major portion of the catch in all months, especially during the spring (April-June). Longfin smelt were markedly seasonal as were starry flounder. Smelt (mostly juveniles) were only a small fraction of the catch ($< 5\%$) before July, but increased considerably during the remainder of the year. Starry flounder, however, were dominant in the winter, spring, and early fall, but were less important during the summer. Pacific staghorn sculpin were consistently found in all months but never dominated the catches (4-20%). Relative abundance of dominant species by station (A-G) is presented in Tables 23a-23g.

2.2 *Disease Incidence Results*

2.21 *Tumor Disease.* Incidence of tumor-bearing starry flounder varied by month and size of fish (Table 24). Size classes (total length intervals) were utilized because preliminary age-growth data indicated wide variability in growth rates of individual fishes found in the river. Fishes bearing early developmental stage tumors (AEN, angioepithelial nodules) were found only during October, whereas fishes with later developmental stage tumors were sampled in all months except August. The incidence of EP (epithelial papilloma) tumor-bearing fishes increased rapidly in fall (October-November) and remained high through winter and spring (February-June) (Table 24). During the summer months, the incidence of EP tumor-bearing individuals was only sporadic. Most tumor-bearing individuals were in the 100-149 mm total length size range. Smaller (50-99 mm total length) tumor-bearing individuals were found only in November, and larger tumor-bearing individuals (150-199 mm total

Table 22. Relative monthly abundance of the five most dominant species collected in the Duwamish River during 1975.

Rank	Species	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov
1	Snake prickleback	1.2%	0.0%	0.0%	12.5%	47.8%	27.1%	55.1%	22.6%	19.0%	10.9%
2	English sole	7.7	16.4	38.5	37.9	26.3	29.9	17.1	12.2	12.2	18.5
3	Longfin smelt	41.5	4.6	4.1	4.0	0.5	13.6	3.6	37.3	15.8	2.3
4	Starry flounder	32.0	61.9	35.8	28.3	5.9	5.7	3.5	3.0	18.1	20.4
5	Pacific staghorn sculpin	4.6	10.4	11.9	10.4	9.4	6.9	9.2	8.2	15.0	21.1
	TOTAL	87.0%	93.3%	90.3%	93.1%	89.9%	83.2%	88.5%	83.3%	80.1%	73.2%

Table 23a. Relative monthly abundance of the five most dominant species collected at Station A in the Duwamish River during 1975.

Rank	Species	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.
1	English sole	8.8%	66.6%	66.6%	50.0%	73.3%	25.0%	0.0%	5.3%	44.1%	0.0%
2	Rock sole	38.2	33.4	18.1	0.0	13.3	3.6	0.0	10.6	20.6	40.0
3	Pacific tomcod	14.7	0.0	0.0	0.0	0.0	0.0	0.0	24.0	2.9	
4	Pacific staghorn sculpin	8.8	0.0	3.0	0.0	0.0	0.0	0.0	4.0	8.8	0.0
5	Snake prickleback	0.0	0.0	0.0	0.0	0.0	3.6	0.0	54.7	0.0	0.0
	TOTAL	70.5%	100.0%	87.7%	50.0%	86.6%	32.2%	0.0%	99.8%	76.4%	40.0%

Table 23b. Relative monthly abundance of the five most dominant species collected at Station B in the Duwamish River during 1975.

Rank	Species	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.
1	Snake prickleback	0.0%	0.0%	0.0%	23.5%	9.4%	20.0%	28.6%	46.6%	44.4%	26.3%
2	English sole	16.6	0.0	80.9	0.0	31.3	31.4	14.3	4.5	10.0	0.0
3	Rock sole	3.3	0.0	9.5	52.9	34.4	31.4	57.1	5.7	2.2	26.3
4	Pacific tomcod	16.6	0.0	0.0	5.9	0.0	0.0	0.0	21.6	16.7	10.5
5	Pacific staghorn sculpin	16.6	0.0	0.0	5.9	3.1	2.9	0.0	9.1	13.3	26.3
	TOTAL	53.1%	0.0%	90.4%	88.2%	78.2%	85.7%	100.0%	87.5%	86.6%	89.1%

Table 23c. Relative monthly abundance of the five most dominant species collected at Station C in the Duwamish River during 1975.

Rank	Species	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.
1	Longfin smelt	72.8%	0.0%	0.0%	10.1%	0.0%	12.8%	6.1%	82.3%	32.8%	3.3%
2	English sole	1.6	45.5	66.6	68.5	33.3	46.2	51.5	2.9	22.6	32.0
3	Snake prickleback	7.2	0.0	0.0	8.4	31.8	23.9	30.3	5.1	10.9	27.9
4	Pacific staghorn sculpin	4.0	9.1	33.4	6.2	9.1	3.4	0.0	5.1	17.1	20.5
5	Pacific tomcod	10.4	0.0	0.0	1.7	15.1	7.7	3.0	0.0	6.1	2.5
	TOTAL	96.0%	54.6%	100.0%	94.9%	89.3%	94.0%	90.9%	95.4%	89.5%	86.2%

Table 23d. Relative monthly abundance of the five most dominant species collected at Station D in the Duwamish River during 1975.

Rank	Species	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.
1	English sole	16.5%	40.0%	60.4%	40.2%	42.1%	50.4%	35.6%	14.2%	16.6%	30.2%
2	Snake prickleback	0.0	0.0	0.0	20.6	37.2	28.8	33.3	13.6	26.9	18.9
3	Pacific tomcod	2.1	0.0	0.0	3.7	5.8	8.8	6.1	28.1	12.6	9.4
4	Longfin smelt	30.9	1.2	6.3	11.2	1.7	0.0	10.6	15.6	19.4	0.0
5	Pacific staghorn sculpin	1.0	11.8	14.6	11.2	6.6	3.2	8.3	8.9	14.3	20.8
	TOTAL	50.5%	53.0%	81.3%	86.9%	93.4%	91.2%	93.9%	80.4%	89.8%	79.3%

Table 23e. Relative monthly abundance of the five most dominant species collected at Station E in the Duwamish River during 1975.

Rank	Species	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.
1	Snake prickleback	0.0%	0.0%	0.0%	9.5%	57.1%	33.9%	62.9%	24.6%	61.8%	5.3%
2	English sole	11.2	10.6	8.6	59.0	40.4	15.4	18.2	32.6	21.5	31.6
3	Longfin smelt	55.8	4.3	0.0	0.0	0.0	28.3	14.0	2.2	0.0	0.0
4	Starry flounder	25.9	63.8	74.3	15.2	1.0	5.6	1.3	2.2	0.7	5.3
5	Pacific staghorn sculpin	2.7	6.4	14.3	5.7	0.0	7.3	3.3	15.2	5.6	36.8
	TOTAL	95.6%	85.1%	97.2%	89.4%	98.5%	90.5%	99.7%	76.8%	89.6%	79.0%

Table 23f. Relative monthly abundance of the five most dominant species collected at Station F in the Duwamish River during 1975.

Rank	Species	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.
1	Starry flounder	55.9%	81.6%	60.4%	56.7%	8.3%	0.0%	2.8%	9.4%	9.7%	26.3%
2	Snake prickleback	0.7	0.0	0.0	12.7	54.8	81.8	44.4	33.7	9.7	0.7
3	Pacific staghorn sculpin	9.2	8.8	17.0	9.4	14.1	9.1	12.1	20.4	16.1	17.4
4	Pacific tomcod	1.4	0.0	0.0	0.0	2.8	0.0	27.0	19.3	35.6	33.3
5	English sole	0.7	2.2	20.6	19.2	14.4	9.1	6.3	9.9	18.9	11.1
	TOTAL	67.9%	92.6%	98.0%	98.0%	94.4%	100.0%	92.6%	92.7%	90.0%	88.8%

Table 23g. Relative monthly abundance of the five most dominant species collected at Station G in the Duwamish River during 1975.

Rank	Species	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.
1	Snake prickleback	0.0%	0.0%	0.0%	12.9%	51.4%	4.2%	63.9%	52.2%	40.7%	1.2%
2	Starry flounder	51.1	52.9	56.0	45.2	15.4	37.5	7.6	2.9	11.3	52.4
3	Pacific staghorn sculpin	2.2	29.4	12.0	35.4	18.3	29.1	14.4	5.5	7.8	20.2
4	English sole	7.3	0.0	0.0	1.6	6.3	14.6	9.0	14.2	12.7	13.1
5	Longfin smelt	29.9	5.8	24.0	0.0	1.4	0.0	0.9	20.1	10.6	0.0
	TOTAL	90.5%	88.1%	92.0%	95.1%	92.8%	85.4%	95.8%	94.9%	83.1%	86.9%

Table 24. Percent incidence by month (all stations combined) of tumor-bearing starry flounder (<u>Platichthys stellatus</u>) collected in the Duwamish River during 1975.

Total length (mm): Month	50-99	100-149	150-199	200-249	≥ 250
February	53.8 (7/13)	16.7 (11/66)	2.1 (2/92)	0.0 (0/75)	0.0 (0/10)
March	0.0 (0/0)	18.0 (11/61)	1.0 (1/97)	0.0 (0/25)	0.0 (0/2)
April	0.0 (0/0)	22.5 (9/40)	0.0 (0/24)	0.0 (0/8)	0.0 (0/1)
May	0.0 0/0	30.6 (34/111)	0.0 (0/54)	0.0 (0/40)	0.0 (0/8)
June	0.0 (0/0)	20.0 (3/15)	6.3 (1/16)	0.0 (0/18)	0.0 (0/4)
July	0.0 (0/0)	11.1 (1/9)	0.0 (0/12)	0.0 (0/10)	0.0 (0/3)
August	0.0 (0/0)	0.0 (0/10)	0.0 (0/14)	0.0 (0/6)	0.0 (0/0)
September	0.0 (0/1)	20.0 (1/5)	0.0 (0/13)	0.0 (0/27)	0.0 (0/8)
October	46.7 (42/90)	29.1 (32/110)	2.4 (2/85)	0.0 (0/30)	0.0 (0/0)
November	23.1 (3/13)	37.0 (10/27)	0.0 (0/38)	0.0 (0/19)	0.0 (0/0)

length) occurred only sporadically through the year. No fishes larger than 200 mm total length were observed with tumors.

Tumor-bearing starry flounder were confined exclusively to the upper river (Stations E through H), generally following the same distributional pattern as non-tumor-bearing individuals (Table 25). The smallest (50-99 mm TL) tumorous fishes, and the only AEN tumor-bearing fishes were found at the highest two stations (G and H). Larger (> 150 mm TL) tumor-bearing individuals were found throughout the upper river. Both AEN and EP stage tumors occurred most commonly on the "eyed" side of individual starry flounder (Table 26).

2.22 *Fin Erosion Disease.* Starry flounder with fin erosion were sampled in all months during 1975 (Table 27). The incidence of fin-eroded fish did not follow any evident seasonal pattern. Incidences were lowest in early summer (July-August), but starry flounder were also least abundant during that period. Relatively few fish less than 150 mm in total length, and no fish less than 100 mm TL were afflicted with the disease. Generally, fishes ranging from 150-250 mm TL were the most commonly diseased (Table 27). Starry flounder with the fin erosion disease were more widely distributed in the river than tumor-bearing individuals, but were usually confined to the middle and upper river. No diseased individuals were captured in the lower river (Stations A and B) (Table 28). Generally, the highest incidences for all size classes occurred at the middle river stations (D through F). Typically, the dorsal, anal, and caudal fins of individual fishes were the most frequently diseased (Table 29). Less commonly afflicted were the pectoral and pelvic fins. Consistently, the "blind" pectoral fin was more frequently diseased than the "eyed" pectoral fin.

Table 25. Percent incidence by station (all months combined) of tumor-bearing starry flounder (*Platichthys stellatus*) collected in the Duwamish River during 1975.

Total length (mm): Station	50-99	100-149	150-199	200-249	≥ 250
E	0.0 (0/0)	19.6 (9/46)	0.0 (0/62)	0.0 (0/56)	0.0 (0/11)
F	33.3 (2/6)	28.3 (49/173)	1.4 (2/143)	0.0 (0/96)	0.0 (0/15)
G	44.7 (17/38)	10.1 (10/99)	5.5 (3/54)	0.0 (0/25)	0.0 (0/2)
H	45.8 (33/72)	32.3 (33/102)	2.3 (2/86)	0.0 (0/16)	0.0 (0/0)

Table 26. Number of tumors on the eyed and blind sides of individual starry flounder (<u>Platichthys stellatus</u>) collected in the Duwamish River during 1975.

	Eyed side	Blind side	Both sides	Number of fish afflicted
February	21	1	13	20
March	14	3	38	12
April	7	4	12	9
May	20	5	37	34
June	3	2	2	4
July	1	0	0	1
August	0	0	0	0
September	0	0	1	1
October	99	27	86	76
November	11	2	15	13
Total	176	44	204	170
Percentage of total	41.5	10.4	48.1	

Table 27. Percent incidence by month (all stations combined) of fin erosion on starry flounder (Platichthys stellatus) collected in the Duwamish River during 1975.

Total length (mm): Month	50-99	100-149	150-199	200-249	≥ 250
February	0.0 (0/13)	7.6 (5/66)	15.2 (14/92)	13.3 (10/75)	30.0 (3/10)
March	0.0 (0/0)	8.2 (5/61)	14.4 (14/97)	52.0 (13/25)	50.0 (1/2)
April	0.0 (0/0)	10.0 (4/40)	12.5 (3/24)	12.5 (1/8)	0.0 (0/1)
May	0.0 (0/0)	0.0 (0/111)	20.4 (11/54)	17.5 (7/40)	50.0 (4/8)
June	0.0 (0/0)	0.0 (0/15)	0.0 (0/16)	11.1 (2/18)	0.0 (0/4)
July	0.0 (0/0)	0.0 (0/9)	16.6 (2/12)	0.0 (0/10)	33.3 (1/3)
August	0.0 (0/0)	0.0 (0/10)	0.0 (0/14)	66.6 (4/6)	0.0 (0/0)
September	0.0 (0/1)	0.0 (0/5)	23.1 (3/13)	57.1 (16/28)	5.5 (1/8)
October	0.0 (0/90)	0.9 (1/110)	9.4 (8/85)	26.6 (8/30)	0.0 (0/0)
November	0.0 (0/13)	7.4 (2/27)	2.6 (1/38)	0.0 (0/19)	0.0 (0/0)

Table 28. Percent incidence by station (all months combined) of fin erosion on starry flounder (Platichthys stellatus) collected in the Duwamish River during 1975.

Total Length (mm): Station	50-99	100-149	150-199	200-249	≥ 250
C	0.0 (0/0)	0.0 (0/1)	25.0 (2/8)	21.4 (3/14)	0.0 (0/14)
D	0.0 (0/0)	5.9 (1/17)	9.3 (4/43)	25.6 (11/43)	0.0 (0/2)
E	0.0 (0/0)	2.2 (1/46)	12.9 (8/62)	12.5 (7/56)	27.3 (3/11)
F	0.0 (0/6)	4.6 (8/173)	21.0 (30/143)	39.6 (38/96)	33.3 (5/15)
G	0.0 (0/38)	3.0 (3/99)	13.0 (7/54)	4.0 (1/25)	50.0 (1/2)
H	0.0 (0/72)	1.0 (1/102)	8.1 (7/86)	6.3 (1/16)	0.0 (0/0)

Table 29. Frequency of fin erosion by month (all stations combined) and by fin on individual starry flounder (*Platichthys stellatus*) collected in the Duwamish River during 1975.

Month	Dorsal	Anal	Caudal	Eyed pectoral	Blind pectoral	Eyed pelvic	Blind pelvic	Number of fish afflicted
February	20	15	6	0	1	0	0	42
March	29	12	9	0	8	4	2	64
April	5	5	2	1	2	1	0	16
May	29	12	9	0	8	4	2	42
June	2	0	0	0	0	0	0	2
July	2	1	1	0	0	0	0	4
August	3	2	2	0	0	0	0	7
September	10	13	4	0	1	0	1	29
October	13	8	3	0	3	1	0	28
November	4	3	2	0	0	1	1	11
Total	117	71	38	1	23	10	6	245
Percentage of total	44.0	26.7	14.3	0.4	8.6	3.8	2.3	

2.23 *Parasitic Nematodes (Philometra).* Both English sole and rock sole from the Duwamish River were infested with nematode parasites (Tables 30, 31). Externally evident nematodes were only found on fishes exceeding 150 mm in total length. English sole infestation was consistent (7.9-18.2%) throughout the year and exhibited no apparent seasonal pattern (Table 30). In contrast, rock sole infestation was sporadic with parasitized individuals only observed in August and September. Infestation of both species was not related to location (station) in the river (Table 31).

Pathology Studies

Three pathological conditions of flatfish were investigated: The previously observed fin erosion and epidermal papilloma, and a recently discovered liver disease. The pathological characteristics of each disease will be reported separately below.

1. *Fin Erosion.*

1.1 *Gross Pathology.* Although both starry flounder and English sole had fin erosion, the gross pathology of the disease differed somewhat between the two species. The earliest visually recognizable signs of the disease in both species were absent, fused, or deformed fin rays; and the presence of hemorrhagic or dull gray granulosis tissue extending from the fins to the body in a spiderlike patterns (Fig. 15).

The more advanced fin erosion lesions appeared to be of two basic types, known as chronic fibrosing and acute necrotizing fin erosion. Starry flounder with advanced lesions had the chronic fibrosing form

Table 30. Percent incidence by month of *Philometra*-infested English sole (*Parophrys vetulus*) and rock sole (*Lepidopsetta bilineata*) collected in the Duwamish River during 1975. Dash indicates no fishes were collected.

	English sole		Rock sole	
	Total length		Total length	
Month	< 150 mm	≥ 150 mm	< 150 mm	≥ 150 mm
February	0.0 (0/10)	13.5 (7/52)	0.0 (0/9)	0.0 (0/6)
March	0.0 (0/7)	10.8 (4/37)	0.0 (0/1)	0.0 (0/1)
April	0.0 (0/3)	11.1 (9/81)	0.0 (0/9)	0.0 (0/1)
May	0.0 (0/5)	16.4 (46/280)	0.0 (0/1)	0.0 (0/9)
June	0.0 (0/8)	10.7 (23/215)	0.0 (0/10)	0.0 (0/5)
July	--	10.6 (19/179)	0.0 (0/3)	0.0 (0/7)
August	0.0 (0/26)	10.9 (15/137)	0.0 (0/1)	10.0 (1/10)
September	0.0 (0/25)	7.9 (10/203)	0.0 (0/4)	15.8 (3/19)
October	0.0 (0/29)	18.2 (33/181)	0.0 (0/9)	0.0 (0/4)
November	0.0 (0/4)	11.9 (10/84)	0.0 (0/4)	0.0 (0/3)

Table 31. Percent incidence by station of *Philometra*-infested English sole (*Parophrys vetulus*) and rock sole (*Lepidopsetta bilineata*) collected in the Duwamish River during 1975. Dash indicates no fishes were collected.

	English sole		Rock sole	
	Total length		Total length	
Station	< 150 mm	≥ 150 mm	< 150 mm	≥ 150 mm
A	0.0 (0/7)	14.1 (9/64)	0.0 (0/29)	0.0 (0/11)
B	0.0 (0/3)	3.7 (2/54)	0.0 (0/19)	12.9 (4/31)
C	0.0 (0/5)	14.6 (45/308)	--	0.0 (0/5)
D	0.0 (0/15)	8.1 (31/382)	0.0 (0/4)	0.0 (0/8)
E	0.0 (0/58)	17.9 (53/295)	--	0.0 (0/3)
F	0.0 (0/12)	15.8 (27/171)	--	12.5 (1/8)
G	0.0 (0/11)	9.4 (13/138)	--	--

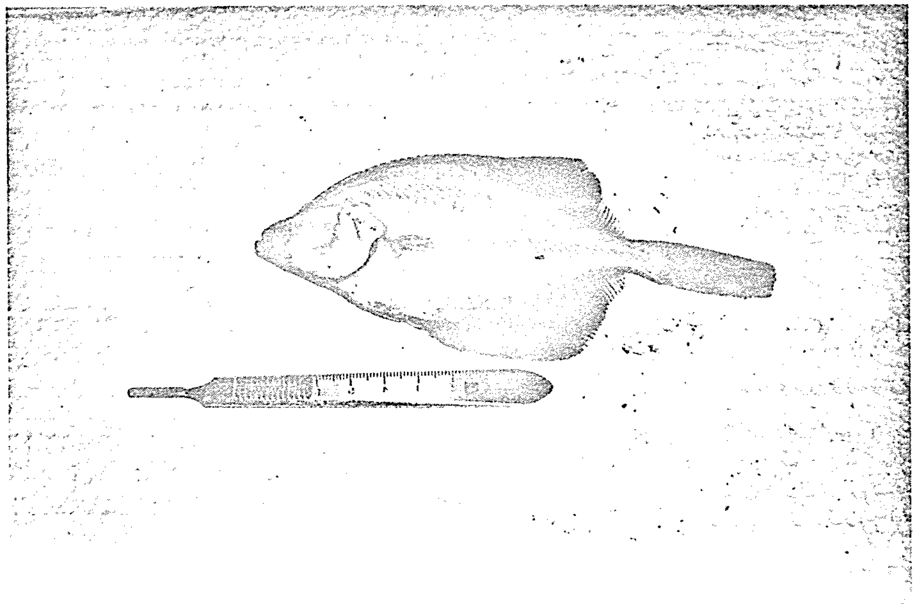


Fig. 15. Starry flounder with an early form of fin erosion. Granulosis tissue is located on the body surface near the anal fin.

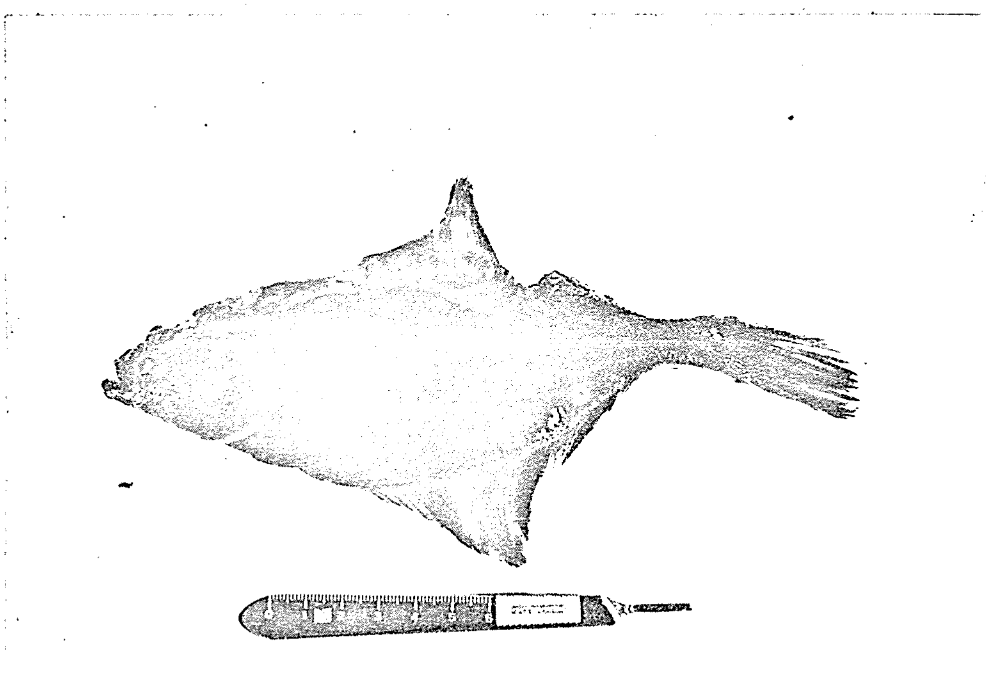


Fig. 16. Starry flounder with an advanced form of chronic fibrosing fin erosion. Sheets of fin tissue extend onto the body surface near the dorsal fin, and an indentation into the body exists near the posterior portion of the dorsal fin.

which consisted of partial or complete destruction of fins, leaving the residual fin tissue retracted, thickened, flaccid, and fibrotic (Fig. 16); and in some cases "flaps" or sheets of this tissue extended out onto the body and were attached by a permanent union (Fig. 17). Extensive amounts of scar tissue were often associated with the residual fin tissue. Generally, the epithelial surface was without any ulceration. Occasionally, starry flounder have been observed to have such advanced cases of fin erosion that they have indentations into the body, suggesting erosion of the larger bones connected to the fin rays had occurred (Fig. 16).

English sole with both forms of fin erosion have been captured. The acute necrotizing form had much less residual fin tissue associated with the lesions (Fig. 18). Tissue flaps or sheets are seldom observed. Denuded fin rays are often present, as well as less scar tissue and more ulcerations than in the chronic form.

1.2 *Histology.* Histological examination of fin tissues in various stages of fin erosion has demonstrated that one of the most predominant features of this disease is bone resorption. In the early lesions, fin rays are observed in the process of resorption and replacement of bone by fibrosis and granulosis tissue (Fig. 19). This resorption occurs in the absence of any apparent damage to the adjacent epithelium. As this process of bone resorption continues, the fin tissue loses its structure and collapses into a series of folds onto the body surface and forms the thickened residual fin tissue and tissue "folds" mentioned above.

In the advanced stages of chronic fibrosing fin erosion, bone resorption and resulting fibrosis is accompanied by epidermal and mucous cell hyperplasia, formation of cysts lined by epidermal or mucous cells, sclerosis of small blood vessels in the fin web, and accumulations of

Fig. 17. Starry flounder with a "flap" of fin-derived tissue.

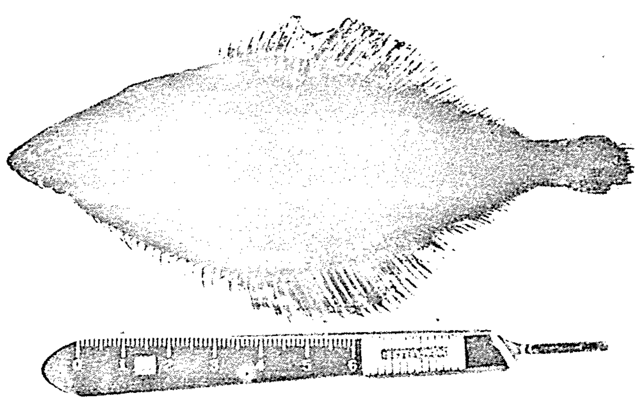


Fig. 18. English sole with acute necrotizing fin erosion of the anal and caudal fins induced by experimental exposure to Duwamish River bottom sediment.

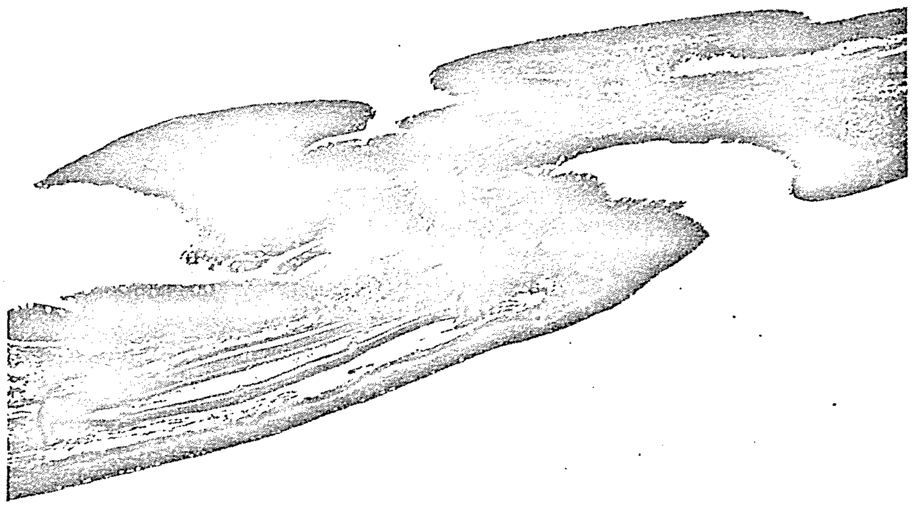


Fig. 19. A section of fin tissue from a starry flounder with fin erosion. Normal-appearing bone spicules (lower left) are being resorbed and replaced by fibrosis and granulosis. Fin tissue which has lost fin ray (upper right) has collapsed and folded back onto itself.

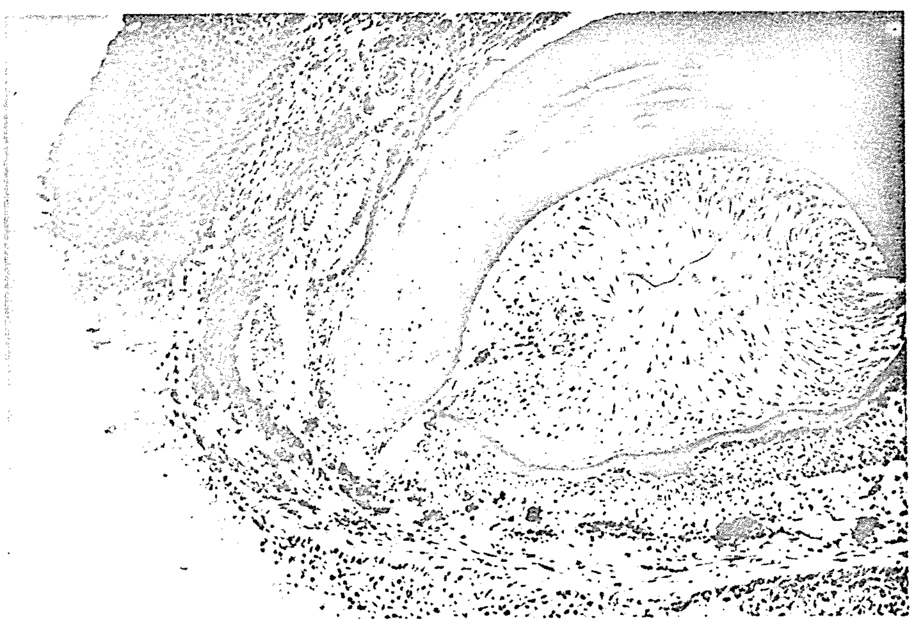


Fig. 20. A transverse section of fin tissue from a starry flounder with fin erosion. Bone spicules are being resorbed unequally, with accumulations of melanophores at the edge of the resorbing spicule.

melanophores at sites of tissue destruction (Fig. 20). Not observed are marked infiltrations of inflammatory cells, such as leukocytes, and no intracellular microorganisms, such as bacteria.

1.3 *Microbiology.* Attempts were made to isolate microorganisms from fin lesions and internal organs of fish with fin erosion. In addition, several normal fish of each species were examined in the same manner. A total of 232 bacterial isolates were selected at random from 30 different starry flounder and English sole. The fish were captured from the Duwamish River, Point Pully, Alki Point, and West Point; fish from the latter three areas served as non-fin-erosion controls. Fourteen of the isolates were from internal organs and tissues of fin-eroded fish, including kidney, liver, spleen, and blood. Only two of these isolates could be grown on available bacteriological media after the initial isolation, and both of these were from blood.

The remaining 218 bacterial isolates were taken from the surface of fin lesions and normal fins, characterized by several taxonomic tests, and were divided into 50 subgeneric taxonomic groups. No one group was consistently associated with fin lesions. Nevertheless, 20 of the isolates from groups which had several members from different fin-eroded fish and few or no members from normal fish were selected for further study. These 20 bacterial cultures are being tested with additional, more specific taxonomic tests, and approximately five of these will be tested for their ability to induce fin erosion in the laboratory.

Since no individual bacteria or group of bacteria appeared to be routinely associated with fin erosion, it is possible that several different bacteria may cause the disease through an accumulative effect. As a means of evaluating that possibility, quantitative bacterial isolations were performed using 1-cm^2 pieces of skin from fish captured in the Duwamish River, Alki Point, and West Point. Duwamish River starry flounder and English sole had approximately $7x10^4$ bacteria/cm^2. English sole from West Point and Alki Point had about $7x10^3$ and $2x10^4$ bacteria/cm^2, respectively.

Efforts to routinely isolate fungi and virus from fin erosion lesions were unsuccessful. Fewer than five fungal isolates were obtained from several different fish. No virus was cultured from eroded fin tissue.

1.4 *Disease Induction.* In an attempt to determine if fin erosion in the Duwamish River is caused by environmental contaminants, normal-appearing English sole from the Nisqually River were exposed to bottom sediment from the Duwamish River. The experiment was performed in four flow-through seawater aquaria located at West Point using Nisqually River sediment in control aquaria. Two aquaria had Duwamish River sediment and two had control sediment; each had 15 fish. By one month after the initiation of the test, two of 30 fish in aquaria with Duwamish River sediment had fin erosion, and none of the control fish had the disease. The induced fin erosion resembled the acute necrotizing form described above to occur in English sole in the Duwamish River (Figs. 18 and 21).

Currently, a similar experiment is being performed using starry flounder from the Nisqually River. The experimental conditions are exactly the same, except that each aquarium has ten fish. At one month of exposure, no fin erosion has been observed.

1.5 *Chemical Tests.* Polychlorinated biphenyls (PCBs) are a known contaminant of fish and bottom sediments from the Duwamish River (Pattie,

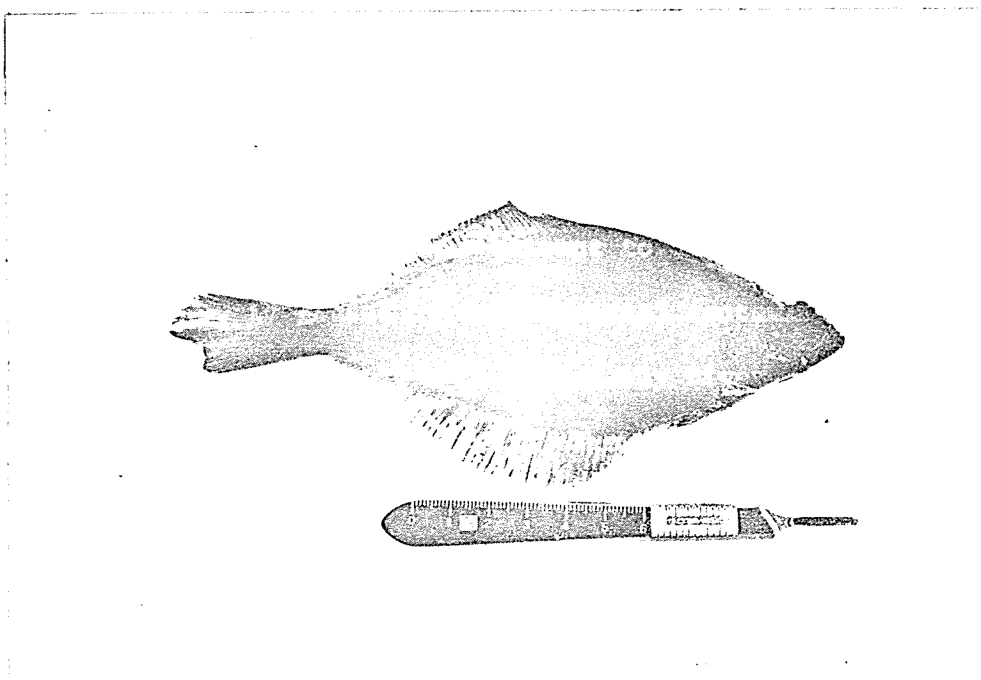


Fig. 21. An English sole with experimentally induced fin erosion of the caudal fin. This fish was one of two that developed fin erosion while in contact with Duwamish River bottom sediment for 30 days.

1975; Pavlou, et al., 1973). Whole English sole have been analyzed and found to contain high levels of PCBs. The livers of starry flounder were analyzed for PCB levels in cooperation with Dr. Spyros Pavlou, Department of Oceanography, University of Washington. Preliminary data showed that livers of fish from the Duwamish River had PCB concentrations of approximately 5.2 ppm wet liver weight (range, 3.8 to 10.7 ppm), while livers from control starry flounder taken from Hood Canal had levels averaging about 0.9 ppm wet liver weight.

Additional cooperative efforts to analyze PCB levels in Duwamish River starry flounder have been undertaken with Dr. Virginia Stout of Pacific Utilization Research Center, and with Marjorie Sherwood of Southern California Coastal Water Research Project (SCCWRP). The specimens have been collected and are awaiting analysis. SCCWRP will also be analyzing for DDT and heavy metals.

Because fin erosion could be only one sign of a systemic disease syndrome, blood samples were collected from starry flounder with and without fin erosion from the Duwamish River and from normal-appearing starry flounder from the Nisqually River. The samples were analyzed by National Health Laboratories for concentrations of calcium, sodium, potassium, phosphorus, glucose, urea nitrogen, uric acid, cholesterol, total protein, albumin, bilirubin, alkaline phosphatase, and lactic dehydrogenase. There were no significant differences between the values for serum from fish with fin erosion and from normal-appearing fish from the Duwamish River. However, the levels of cholesterol and potassium were each about four times higher in Duwamish River fish than in Nisqually River fish. Duwamish River starry flounder averaged 553 mg% cholesterol and 1.55 meq/liter potassium. Nisqually River fish averaged 144 mg% cholesterol and 0.4 meq/liter potassium.

2. *Skin Tumors*

2.1 *Gross Pathology.* Three main types of skin tumors were observed--the angioepithelial nodule (AEN), the epidermal papilloma (EP), and the angioepithelial polyp (AEP). AEN were 1 to 5 mm in diameter, hemispherical, pink to red, smooth surfaced, sessile lesions which were located anywhere on the external surfaces of young-of-the-year fish. EP were circular, 0.5 to 5 cm in greatest dimension, and varied in thickness from about 0.5 to 1.5 cm (Fig. 22). EP were brown to black, depending upon the amount of melanin in the stroma. Their outer and cutaneous surfaces were cauliflower-like in appearance. AEP were grossly similar to EP except that they were flatter.

Previous laboratory and field experiments have demonstrated that the AEN, EP, and AEP are different stages of the same disease. AEN progress to EP, and AEP are derived from either the AEN or EP (McArn, et al., 1968).

2.2 *Histology.* Microscopically, the bulk of the AEN consisted of a central mass of vascular connective tissue which was capped by a thin layer of hyperplastic epidermis. EP consisted of a relatively sparse branching fibrovascular stroma, which supported a thick layer of hyperplastic cells of epidermal origin. A tumor-specific cell, known as the "X cell", was seen in both stromal and epidermal spaces. X-cells had an eosinophilic cytoplasm, and a pale nucleus with a prominent eosinophilic nucleolus. AEP were composed mostly of vascular connective tissue containing a few X-cells. The vascular core of the AEP was covered by a thin layer of epithelium. Descriptions of AEN, EP, and AEP

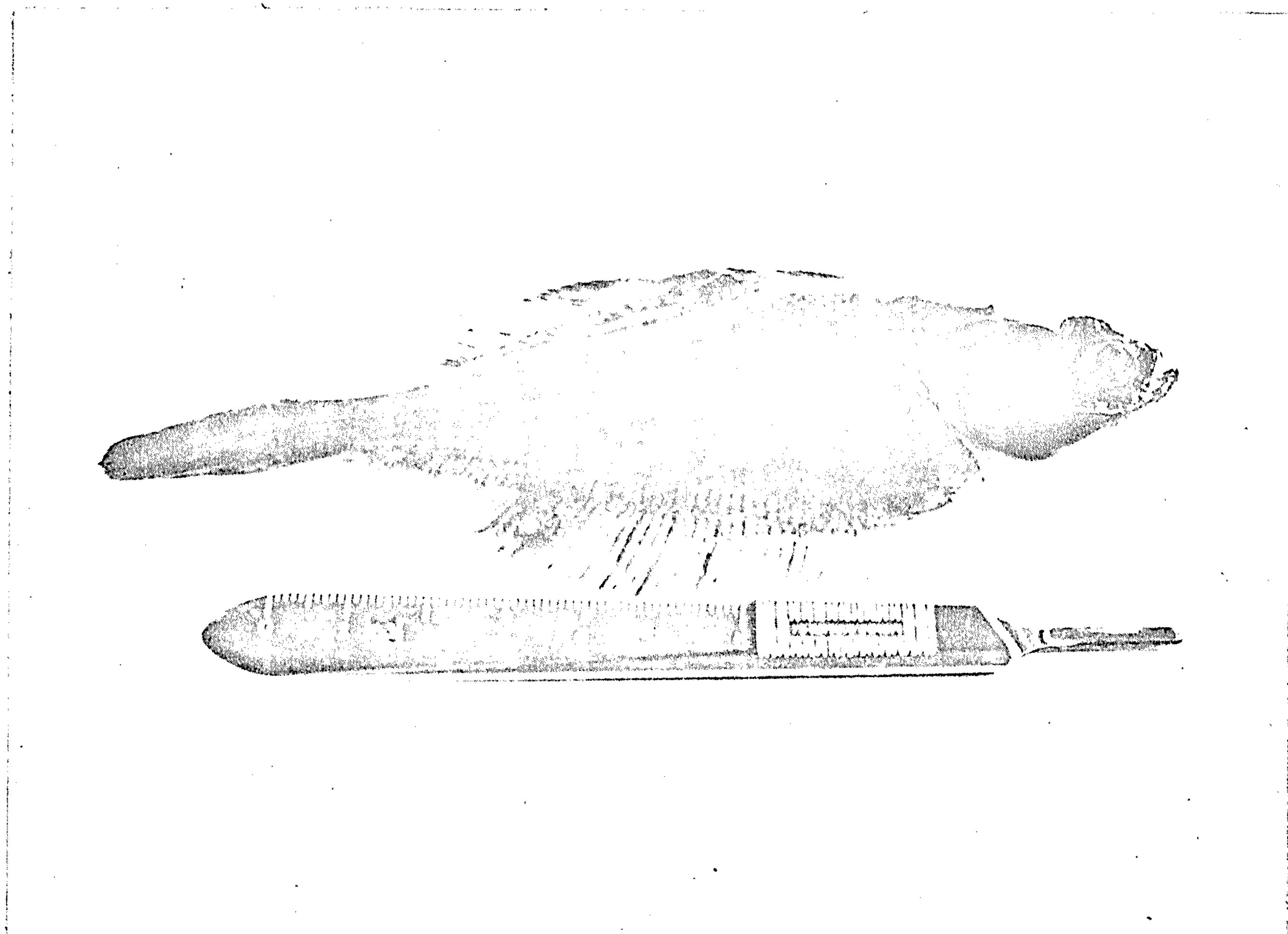


Fig. 22. An English sole from the Duwamish River with four epidermal papillomas.

of Puget Sound flounder have been published (Miller and Wellings, 1971; McArn, et al., 1968).

No intracellular bacteria or fungi were observed, although virus-like particles have been previously reported to be observed with the electron microscope in X-cells.

2.3 *Microbiology*. Several attempts were made to isolate bacteria, fungi, or virus from skin tumors. The only microorganisms isolated were bacteria from the surface of tumors, and these were not considered to be significantly different from normal skin flora.

3. *Liver Disease*. As a part of our investigation of fin erosion in the Duwamish River, we examined the internal organs of several normal-appearing and fin-eroded starry flounder and English sole. A high percentage of both types of starry flounder were observed to have yellow-colored livers, in contrast to the brown to reddish brown livers of starry flounder from other areas of Puget Sound. When examined histologically, the yellow livers were obviously abnormal; they had lost normal liver structure, the hepatocytes were vacuolated, and they had a variety of other abnormalities which will be described in detail below. Although the livers of English sole from the Duwamish River had been examined and did not appear to have any gross pathology, it seemed unlikely for one of the two most common flatfish species to have a liver disease and the other not to have such a disease. Subsequent histological examination of several English sole livers revealed that this species also had similar liver abnormalities.

Investigations of this liver condition have mainly involved determining (1) the frequency and distribution of the disease, (2) the histopathological characteristics of the disease, and (3) the liver weight versus total body weight of diseased fish compared to normal-appearing fish from control areas.

3.1 *Incidence.* Preliminary estimates of the frequency of liver abnormalities in starry flounder and English sole in the Duwamish River, based on careful visual and histological examination, were approximately 90% for each species. Some liver abnormalities observed in Duwamish River fish have been observed in the same species captured at West Point and the Nisqually River; however, the incidence at these locations was less than 1.0%.

3.2 *Gross Pathology.* The most obvious macroscopic sign of liver pathology was unusual liver color. Generally, normal starry flounder had brown to red-brown livers, while abnormal fish had livers that were yellowish-tan to yellow to greenish brown. English sole had two main normal liver colors, depending upon the time of year they were sampled. In the summer, their color ranged from brown to red-brown. In winter, normal livers were pale salmon. Abnormal English sole livers had a broader range of colors than did starry flounder; they ranged from black to tan to cream to yellow, and in some cases each of these colors had black spots about 0.2 mm to 1 mm in diameter. Occasionally, livers of both species had a mottled appearance. Other gross features of abnormal livers were: (1) They appeared to be larger than normal livers, and (2) they were more fragile and would tear more easily during excision.

To test if abnormal livers were larger than normal livers, liver-somatic indices for 218 starry flounder and English sole from the Duwamish and Nisqually rivers, West Point, and Alki Point were determined. Starry flounder had average indices of 2.42, and 1.07 from the Duwamish and Nisqually rivers, respectively. English sole had average indices of 2.40, 1.63, and 1.31 from the Duwamish River, Alki Point, and West Point, respectively. These data suggest that Duwamish River starry flounder and English sole have larger livers than individuals of the same species in control areas.

3.3 *Histopathology.* The histopathology of abnormal livers from starry flounder and English sole was somewhat similar, although English sole seemed to be affected more severely (Fig. 23). The most commonly observed histologic features of abnormal livers were vacuolated hepatocytes, loss of normal liver structure, focal necrosis, fibrosis, cellular hypertrophy (Fig. 24), congestion of erythrocytes in blood vessels, and focal areas of compact cell masses (identified as melanin-macrophage centers) distinguishable by their inability to be stained by basophilic stains and by the presence of hemosiderin (a breakdown product of blood cell necrosis).

Generally, abnormal liver color correlates well with at least three of the above histopathological conditions--loss of structure, vacuolated hepatocytes, and fibrosis. Also, some livers with normal coloration have been shown by histologic examination to be abnormal.

Occasionally, nematodes were observed both macroscopically and histologically in the livers of starry flounder and English sole from the Duwamish River. These parasites were present in both abnormal and normal-appearing livers.

Fig. 23. Normal liver from control starry flounder (Nisqually delta). The two-cell thick anastomosing lamina of the hepatocytes are arranged radially around the portal vein. The dark staining cells surrounding the portal vein (upper center) are pancreatic tissue. Cellular area to the right of the portal vein and nearly surrounded by pancreatic tissue is a melanin-macrophage center.

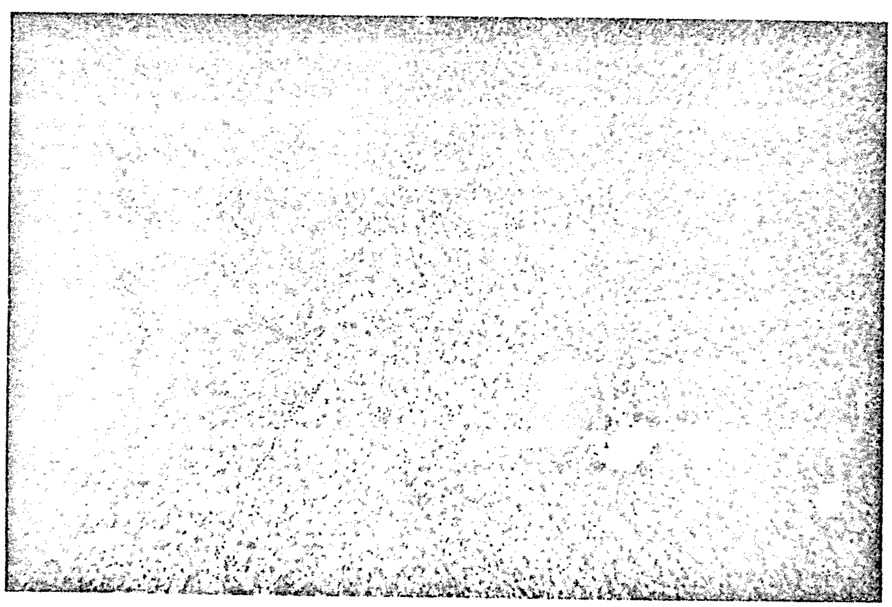


Fig. 24. Section of abnormal liver of English sole from the Duwamish River. On the left is extensive fibrosis; in the center, vacuolated hepatocytes with complete loss of tissue structure, surrounding a darker staining melanin-macrophage center.

DISCUSSION

Ecological Studies

1. *Outfall Study*

1.1 *Comparison of Outfall Study Sites, 1975*

1.11 *General Catch Results*

Sampling during 1975 demonstrated little difference in overall species composition and relative abundance of demersal fishes at West Point, Alki Point, and Point Pully. At all three sites the vast majority of numbers of fishes were taken with the beach seine gear. In general, species richness and CPUE at all three localities were higher at the 45-m otter trawling depth than at other depths.

Beach Seine. The total beach seine catches at all three study sites were dominated by three or four species. Shiner perch were particularly abundant at all three beaches, but especially at Point Pully where this species comprised 55.1% of the entire 1975 catch. Striped seaperch were also extremely abundant at Point Pully and Alki Point, but were uncommon at West Point. The large numbers of juvenile and adult surfperch at Alki Point and Point Pully suggest that both areas are important nursery grounds for this species. The suitability of these two beaches as nursery areas may be associated with the relatively extensive eelgrass beds which occur there in shallow water.

The absence of large numbers of striped seaperch and pile perch at West Point is probably related to the lack of adequate nursery areas rather than the presence of METRO's sewage outfall. Pacific tomcod was the most abundant species captured at West Point, yet was conspicuously less numerous at the other two locations. The reasons for this are not clear. Similarly, tubesnout were extremely abundant at Alki Point but relatively uncommon at West Point and Point Pully. The abundance of tubesnout and the relatively large numbers of padded sculpin at Alki Point are most likely associated with the extensive eelgrass beds located there.

Rock sole and English sole ranked high in abundance at all three sites but were somewhat more numerous at Point Pully. Although not especially numerous at Alki Point and Point Pully, C-O sole were notably less abundant at West Point.

Juvenile coho and chum salmon occurred much more frequently at West Point than either of the other sites, although not in particularly great numbers. Most of these juvenile salmonids were collected in relatively few beach seine hauls during the spring, and thus it is likely that more intensive sampling during this period might have demonstrated their heavy exploitation of the nearshore environment around West Point. During this phase of their early life history, juvenile salmonids (< 70 mm TL) are largely feeding on epibenthic invertebrate prey (Kaczynski, et al., 1973) and growing very rapidly. Therefore, the concern exists that these transient species, although only in the vicinity of the West Point outfall for a relatively short period, may be affected. Previous studies by the Applied Physics Laboratory (1975) and Evan-Hamilton, Inc. (1974), have demonstrated that sewage effluent from the METRO outfall reaches into shallow water where these juvenile salmonids and other species are sampled.

Otter Trawl. Ten species dominated the overall 1975 otter trawl catches at West Point (89.9%), Alki Point (80.0%), and Point Pully (78.8%).

Rock sole, English sole, and ratfish were typically the most abundant species at all three sites. At Alki Point, striped seaperch were also very abundant; however, nearly all of these perch captured during trawling were young-of-the-year juveniles which had begun to move offshore into deeper water late in the year (September-November). At Point Pully and Alki Point rock sole and English sole were the two dominant species. At West Point, however, ratfish were the dominant fish followed by English sole. The relatively greater abundance of ratfish at West Point is significant since they are most abundant at a depth range (70-95 m) which includes the reported average depth of sewage discharge by the METRO-operated outfall (Environmental Quality Analysts, Inc., 1974).

1.12 *Seasonal Patterns*

Beach Seine. Species richness exhibited somewhat different patterns at each outfall study site. Point Pully and Alki Point were characterized by spring-summer (June-September) and late year (October-November) peaks, whereas West Point had only a single peak in August. Species richness was greater at Alki Point and West Point than at Point Pully during the spring-summer peak. In contrast, the fall peak was higher at Alki Point than at Point Pully. In general, species richness at Alki Point fluctuated less widely.

Mean abundance (average number of fish per beach seine haul) followed different patterns at each site as well. Point Pully exhibited summer and fall peaks (as with species richness), whereas at Alki Point and West Point, abundance gradually increased through the year reaching a maximum level in the fall. Late year peaks at West Point and Point Pully were higher than at Alki Point. As with species richness, mean abundance fluctuated less widely at Alki Point than at the other two locations.

Otter Trawl. Similar seasonal patterns of species richness and mean CPUE at all three study sites were exhibited at 5 m. In general, a spring (April-June) low was followed by a summer-fall (July-October) maximum and a late year decrease to pre-summer levels. The pattern was much more erratic at West Point than at Point Pully, and the summer-fall peak was of greater magnitude at Point Pully. At Alki Point the summer peak was more abrupt and of shorter duration than at either West Point or Point Pully.

At 25 m, the trends were much more erratic. Generally, the patterns at West Point and Point Pully were similar (trawling at 25 m was not conducted at Alki Point). At both locations, species richness and CPUE showed similar trends through the year. Late summer peaks in both indices occurred at both sites and reached roughly the same level.

At 45 m, the seasonal variations in species richness and CPUE were erratic at Alki Point, but very comparable at West Point and Point Pully. At Alki Point peaks occurred in the spring (May), summer (August-September), and late in the year (November). In contrast, seasonal peaks of species richness and CPUE occurred in the winter (January-March) at Point Pully and West Point, followed by a spring and summer decline. Both indices gradually increased through the latter portion of the year at both locations. This spring-summer decline at 45 m corresponds with the spring-summer increases observed at 5 m. Closer examination of the data indicated that these concurrent changes are caused by an onshore movement of adult rock sole and English sole to shallower water. Reasons for this apparent seasonal change in depth distribution are not clear but are probably related to dissolved oxygen levels near the bottom during spring and summer.

At 70 m and 95 m, seasonal patterns of species richness and CPUE were generally comparable at all three sites. Generally, species richness and mean CPUE were highest in winter and fall and lowest during late spring and summer.

1.13 *Disease Incidences.* Data collected in 1975 suggest that there is no obvious relationship between the incidence of tumor-bearing fishes and METRO outfalls. The incidence of tumor-bearing young-of-the-year English sole followed a similar pattern at West Point, Alki Point, and Point Pully. At all three sites, tumor-bearing age group 0 fish were absent (except for one fish at West Point in April) until September or October when relatively large numbers were collected. Tumor-bearing individuals first occurred in September at West Point and Point Pully and in October at Alki Point. Since the influx of age group 0 English sole was not prevalent at Alki Point, the incidences observed there should be viewed with caution. Influxes were similar at West Point and Point Pully and incidences from those sites are more directly comparable. In September, the incidence of tumor-bearing 0 group English sole was nearly the same at both localities. In October, the incidence at Point Pully increased sharply and declined at West Point. In November, the incidence was highest at West Point and in December it was highest at Point Pully. Tumor-bearing age I fish were encountered throughout the year at both West Point and Point Pully, although the greatest numbers of diseased fish occurred early and late in the year. Incidences were more sporadic at West Point and generally higher at Point Pully.

The incidence of Philometra-infested English sole was sporadic at all localities and did not exhibit any clear seasonal periodicity. No English sole less than 150 mm TL were observed with externally visible parasites. Monthly incidences were much higher at Point Pully and Alki Point than at West Point. The monthly incidence of infestation ranged only from 3.7% to 14.1% at West Point, but from 10.0% to 40.0% and 12.9% to 46.7% at Alki Point and Point Pully, respectively.

The incidence of Philometra-infested rock sole appeared to exhibit a seasonal pattern at West Point and Alki Point. Generally, the incidences were highest in the fall and winter and lowest in the summer. In contrast, the incidence at Point Pully was consistently high in all months, except in March when only a single individual was collected. The ranges of monthly incidence were very similar at West Point (1.6-15.0%) and Alki Point (0.9-18.2%). Omitting the March sample at Point Pully, incidences were considerably higher than at the other locations and ranged from 33.3% (February) to 55.5% (December).

Although there is no apparent relationship between Philometra infestation of English sole or rock sole and the METRO outfalls, there seems to be a trend toward increasingly higher parasite incidences as one progresses further south in Puget Sound. Data collected by Moulton, et al. (1974), from south Puget Sound and southern Hood Canal support this hypothesis of increasing Philometra infestation from north to south in Puget Sound.

1.2 *Diel Variations in Catch.* Trammel net sampling during the November 24-hour study and the day-night beach seine studies in September demonstrated that several species normally found in deeper water during the day move into shallower water at night. The reasons for these movements are not clear, although feeding is suspected. This general phenomenon has been reported previously at West Point (Miller, et al, 1974) and elsewhere (Cooney, 1967; Zebold, 1970). Several of the species sampled with the trammel net, such as Pacific cod, hake, walleye pollock, and spiny dogfish, are not normally considered to be in the vicinity of the METRO outfall. Our data, however, clearly show that these large predatory forms are in the area at night. The presence of these species in the area--presumably feeding on benthic invertebrates--and their high position in the trophic system, emphasize the possibility that they may be subject to possible contamination by METRO outfall discharges.

2. *Duwamish River Study*

2.1 *Comparison of Catch Results, 1974-1975.* Overall abundance for all stations combined followed similar seasonal cycles in 1974 and 1975. In both years abundance was lowest in winter, increased in spring and summer, and decreased late in fall. Species richness followed a similar cycle as well; however, maximum species richness occurred later in 1975 than in 1974.

In both 1974 and 1975, English sole and starry flounder exhibited complementary patterns of distribution in the river. English sole were typically more abundant in the lower river (Stations A, B, C, D), whereas starry flounder were more abundant in the upper river. The distribution of starry flounder in particular reflects their tolerance, and perhaps preference, for waters of reduced salinity. Conversely, the distribution of English sole probably reflects an intolerance of reduced salinity. The seasonal cycles of abundance of longfin smelt and snake prickleback were also remarkably similar during both years. Longfin smelt were largely absent through the winter and spring, but rapidly increased in abundance during the summer and early fall. The snake prickleback was markedly abundant from late spring through summer, but much less prevalent in fall and virtually absent in the winter. The seasonal cycle of longfin smelt is clearly reproductive in nature; however, the cyclical pattern of abundance of snake prickleback is not at all clear.

In the Duwamish River, salinity and temperature have a significant effect on the distribution and abundance of individual species of fish. Starry flounder, longfin smelt, and Pacific staghorn sculpin are euryhaline and therefore are capable of higher intrusion up the river. Most other species collected are considered stenohaline and are confined to the lower river where the salinity of the bottom water is higher. It was impossible to select precise sampling dates and times for comparison during the study; thus, apparent seasonal and spatial variations in abundance and distribution and the effects of tidal variation were not possible to analyze.

2.2 *Disease Incidences.* The occurrence of tumor-bearing starry flounder by station and time of year was quite similar in 1974 and 1975. In general, very few early developmental stage tumors (AEN) were observed on fishes--only later stage tumors, suggesting that diseased fish migrate into the Duwamish from other areas. Tumor-bearing fishes were confined to the upper river and generally followed the same pattern of distribution as non-diseased fishes. The distribution of both normal and diseased starry flounder is probably a function of salinity tolerances and preference and suggests that both normal and diseased fish respond in a similar fashion to these factors.

The absence of any large (> 200 mm total length) starry flounder with tumors suggests either that mortality of diseased fish is exceptionally high or that they emigrate from the river into Elliott Bay. Other studies have also shown that tumor incidence in flatfish populations declines with age (Miller and Wellings, 1971; Angell, et al., 1975), most likely due to mortality during the first and second years of life.

The seasonal occurrence of starry flounder with fin erosion followed similar patterns in 1974 and 1975. Fin erosion incidence was generally highest in winter and early spring, as well as late in the year. In both years, the incidence declined markedly in the summer months. Reasons for the low summer incidence are not clear; however, abundance of starry flounder is known to decline also during the summer. As in 1974, starry flounder with the fin erosion anomaly were restricted largely to upper river stations. This is in accord with the distributions of both normal and tumor-bearing individuals, and seems related to salinity tolerances or preferences.

Fin erosion diseases have been observed on fishes associated with sewage outfalls in both Southern California (Mearns and Sherwood, 1974) and the New York Bight (Mahoney, et al., 1973). In Southern California, Dover sole are most commonly afflicted with the disease, although it has been reported in other species as well. In the New York Bight, fin erosion was found among 22 species of fishes, particularly on summer flounder, winter flounder, bluefish, and weakfish.

The fin erosion disease of Dover sole in Southern California is restricted primarily to larger individuals (100-220 mm total length) (Sherwood and Bendele, 1974). Similarly, we have observed fin erosion only on starry flounder exceeding 100 mm in total length. Most commonly, however, the disease occurs on individuals greater than 150 mm in total length. Reasons for the absence of fin erosion on smaller fishes are not clear; however, it may be that the disease requires a long developmental period prior to becoming externally apparent, or that extended exposure to the disease-causing agent is required.

Mearns and Sherwood (1974) have suggested that the fin erosion disease of Dover sole is somehow sediment-related. They presented data showing that fins known to be intimately associated with sediments (dorsal, anal, and caudal fins) were most frequently eroded, and that the "blind" pectoral fin was more commonly eroded than the "eyed" pectoral. These observations agree with our observations of starry flounder in the Duwamish River. In both instances, the data support the hypothesis that fin erosion is sediment-related.

Pathology Studies

Of the three marine fish diseases associated with METRO's West Point sewage outfall or the Duwamish River, fin erosion and liver disease appear to be the most pollution-related. Both of these conditions are found almost exclusively in the Duwamish River. Epidermal papillomas of flounder are found both in the estuary and near the West Point sewage outfall, but the prevalence at either site is not significantly higher than in other areas of Puget Sound with minimal sewage contamination. The cause of these skin tumors is not known.

1. *Fin Erosion.* As indicated above, fin erosion of marine flatfishes has been reported to be associated with sewage outfalls in the Los Angeles area of the Southern California Bight (Mearns and Sherwood, 1974) and in the New York Bight (Mahoney, et al., 1973; Ziskowski and Murchelano, 1975).

The gross and histopathological characteristics of fin erosion in these two areas resemble most closely the acute necrotizing fin erosion observed in English sole in the Duwamish River. Common gross features are loss of fins, denuded fin rays, and thickened residual fin tissue (Murchelano, 1975; Klontz and Bendele, 1973). Histologically, similarities include fibrosis, epidermal hyperplasia, and accumulation of melanophores.

Several possible causes of fin erosion have been suggested. Investigators studying fin erosion in the New York and Southern California bights have suggested that the disease is localized in the fins, and that the condition may be caused by the direct action of chemical irritants (Murchelano, 1975; Mearns and Sherwood, 1974), or a combination effect of pollutants and bacteria (Mahoney, et al., 1973).

The causes of fin erosion in the Duwamish River are not yet known. Two types of experimental data suggest that the disease may be one sign of a systemic rather than a local disorder. The first type of data is the high frequency of liver abnormalities in fish species which develop fin erosion. The second data are the results of blood serum analyses showing that Duwamish River starry flounder have concentrations of cholesterol and potassium about four times higher than control starry flounder from the Nisqually River. The high levels of cholesterol and potassium may reflect liver malfunction and cellular damage, respectively.

Because starry flounder with fin erosion have been examined that had no detectable liver abnormalities, the relationship between these two conditions is not yet understood. Nevertheless, Couch (1975) performed experiments using spot (Leiostomus xanthurus) exposed to Aroclor 1254 (a PCB) in sea water demonstrating that the treated fish developed liver pathology very similar to that described above for Duwamish River fish. In addition, PCB-exposed spot had a very high frequency of fin erosion and resulting death. Unfortunately, a description of the gross or histological properties of this fin erosion has not yet been published.

Recent reports have shown that the sediments, fish, and invertebrates of the Duwamish River contain high levels of PCBs. Since 1972, samples of English sole and Pacific staghorn sculpin have been collected twice a year from six estuaries in Washington State, including the Duwamish River, and analyzed for PCBs. Only the Duwamish River fish have had detectable PCB levels; through November 1974, these levels in the English sole have averaged about 1700 ppb (Pattie, 1975). PCB analyses of Duwamish River sediments performed in 1973 demonstrated highest concentrations in samples at the mouth of the river (about 2000 ppb, dry weight) and decreasing levels in samples taken farther upstream (333 ppm, dry weight, in an area where high frequencies of fin erosion were observed) (Pavlou, 1973). In a similar study performed in 1975, PCB levels of 70 and 330 ppb, dry weight, were found in sediment taken near the mouth of the Duwamish River (Musgrove, et al., 1975). In the same study, cottid fishes captured at the same sites had PCB levels of 470 and 840 ppb, wet weight.

Regardless of whether fin erosion is the result of a systemic or a localized reaction to PCB exposure, the results of one disease induction experiment performed at West Point suggest that English sole may develop a form of fin erosion as a result of contact with Duwamish River bottom sediment. Additional experiments of a similar nature are being performed in order to confirm this single observation.

The occasional observation of fin-eroded fish in which the bone resorption process had extended into the larger bones proximal to the fin bones could be another indication of the systemic nature of this disease. However, widespread bone resorption should be accompanied by hypercalcemia, and calcium analyses performed on blood serum from starry flounder did not show any differences between fin-eroded and normal-appearing fish.

The relationship between fin erosion and bacteria has not been established. Histological data reported by investigators of this disease in the New York and the Southern California bights, as well as our work with Duwamish River fish, showed that bacteria were not located within diseased tissue and that there was minimal leukocytic infiltration of diseased areas (Klontz and Bendele, 1973; Murchelano, 1975). Thus, bacteria do not appear to be the primary cause of fin erosion, although, as Murchelano (1975) stated, "The inflammatory responses of fishes to microbes vary extensively, however, and some bacteria and fungi elicit no detectable cellular response."

In early attempts to isolate disease-associated bacteria from diseased fins, it was noticed that surface swabbings of Duwamish River fish yielded considerably more bacteria than did similar swabbings of fish from control sampling areas. This observation was tested by performing quantitative determinations of the amount of surface bacteria on starry flounder and English sole from these areas. The results showed that Duwamish River fish had between 5- and 10-fold more bacteria per cm^2 than did fish from Alki Point and West Point, respectively. Therefore, bacteria may participate in the pathogenesis of acute necrotizing fin erosion in a secondary manner because of proportionately more bacteria on the skin surface. For example, PCBs may remove protective mucus (Couch, 1975) and expose the epidermis to bacterial action.

The chronic fibrosing form of fin erosion, which appears to be peculiar to the Duwamish River, seems likely to be caused by systemic disorder. Support for this assumption comes from the observation that bone resorption occurs in the early stages of chronic fin erosion without any detectable damage to the adjacent epithelium.

2. *Tumors*. Skin tumors found on flounder in the Duwamish River and near the West Point sewage outfall resembled skin tumors found in other parts of Puget Sound. All three stages of the tumor were observed, and in general the tumors appeared to be histologically similar to flounder skin tumors from other areas.

The causes of flounder skin tumors are not known. Since virus-like particles have been observed in tumor cells with the electron microscope, there is a possibility that they might be virally caused. However, repeated attempts to isolate virus or to transmit the disease in vitro or in vivo were unsuccessful. In addition, other microorganisms are neither observed in, nor isolated from, tumor tissue.

Chemical contaminants of the marine environment cannot be ruled out as a cause of these tumors. Since skin tumors are found on flounder in relatively pristine waters, some of these chemicals may come from natural sources (e.g., natural oil seeps, products of plant metabolism). Additional man-made pollution may augment this natural tumor induction, although such a possibility has not yet been proven.

3. *Abnormal Livers.* One of the most striking characteristics of abnormal livers from starry flounder and English sole from the Duwamish River was accumulation of lipids in the hepatocytes. This phenomenon probably contributed to loss of liver structure, focal necrosis, and increased liver-somatic indices. The fibrotic areas observed in several livers were probably the result of tissue-repair mechanisms at the site of necrosis.

A variety of toxic substances when exposed to fish, birds, and mammals will produce liver abnormalities similar to those observed in Duwamish River flounder. One group of toxins, the chlorinated hydrocarbons (e.g., DDT, PCBs, endrin, and chlordane), are especially noted for their ability to cause abnormal accumulation of lipid in the livers of fish (Couch, 1975), mammals (Koller and Zinkl, 1973), and birds (Platonow, 1972). As mentioned above, Duwamish River flounder have high levels of PCBs. Whether PCBs contribute to, or are the cause of, liver abnormalities in these fish must await further investigation.

The high level of serum cholesterol in Duwamish River starry flounder (four times higher than in Nisqually River starry flounder) is another suggestion of liver pathology in these fish. Such a condition, which is probably caused by an interference with lipid metabolism in the liver, can be caused by several factors. For example, rats and rabbits exposed to Aroclor 1254 develop elevated cholesterol levels (Koller and Zinkl, 1973).

Bacterial, viral, and fungal infections are also known to cause liver abnormalities in fish. So far, however, histopathological and microbiological evidence does not indicate the presence of a systemic microbial infection in starry flounder or English sole in the Duwamish River.

SUMMARY

Ecological Studies

1. As yet, no obviously significant pollution-related disturbance of demersal fishes has been found to be correlated with METRO's sewage outfalls at West Point and Alki Point.

2. Seasonal patterns of species richness and CPUE were similar at both outfall sites and the control site.

3. In general, species richness and CPUE were highest at the 45-m otter trawling depth at all sites.

4. Large numbers of both juvenile and adult surfperch at Alki Point and Point Pully suggest that these beaches are important nursery grounds.

5. Suitability of the above-noted nursery grounds is probably related to eelgrass beds which occur at both sites.

6. Juvenile coho and chum salmon were sampled more frequently at West Point than other sites; thus, concern exists that these transient species may be affected by METRO outfall discharge.

7. Ratfish tended to be more dominant in deeper water near the METRO outfall at West Point than at Alki Point or Point Pully.

8. In late spring and early summer, English sole and rock sole migrated from deeper to shallower water, possibly in response to reduced dissolved oxygen levels in deeper water and higher temperatures in shallower water.

9. Nighttime sampling suggests that several species normally collected in deeper water during the daytime, or not normally collected at all, enter shallow water at night. Reasons for this movement are not clear, but during this period in shallow water they may be subject to contamination from METRO outfall discharge.

10. Tumor-bearing English sole occurred at both outfall sites as well as at the control site.

11. The incidence of Philometra-infested rock sole and English sole at the outfall study sites followed a marked north-south gradient. The highest incidence was found at Point Pully (control site), followed by Alki Point and West Point in descending order of number of occurrences.

12. Five species of fish generally dominated (> 90% of catch) in the Duwamish River; however, their relative abundance varied markedly with the seasons.

13. Incidence of tumor-bearing starry flounder in the Duwamish River was related to location (station), time of year, and size of fish. Tumor-bearing individuals were captured exclusively in the upper river, particularly at stations F through H. Tumor incidences were highest in the winter, spring, and autumn and lowest in the summer. Tumor incidences were highest for those individuals less than 150 mm TL (total length).

14. Tumors on starry flounder were more frequent on the "eyed" than the "blind" side of individual fish.

15. Fin erosion of starry flounder was most prevalent for individuals in the 150-249 mm TL size class, and occurred most frequently on those fins associated with the sediment.

Pathology Studies

1. As yet, no significant pollution-related marine fish diseases have been found near METRO's West Point sewage outfall.

2. Two diseases, possibly interrelated, were found in starry flounder and English sole in the Duwamish River--fin erosion and a liver disease.

3. Two basic types of fin erosion were observed: Chronic fibrosing fin erosion, found in starry flounder and some English sole; and acute necrotizing fin erosion, found in English sole.

4. A characteristic common to both types of fin erosion was resorption of fin rays associated with fibrosis, granulosis, and loss of fin tissue structure.

5. The chronic form resulted in retracted and thickened residual fin tissue, often with "flaps" or sheets of tissue extended out onto the body.

6. The acute form often had denuded, exposed fin rays and varying amounts of ulcerated epidermis.

7. Of the 232 bacterial isolates from the surface and the internal organs or fin-eroded and normal fish, no disease-specific bacteria were found.

8. Fungi were not commonly associated with fin erosion, and no viruses were isolated from diseased fin tissue.

9. A form of fin erosion was induced in 2 of 30 English sole experimentally exposed to Duwamish River bottom sediment, while 30 fish from the same lot exposed to control sediment were normal.

10. Skin tumors (epidermal papillomas) found on flounder from the Duwamish River and West Point were grossly and histopathologically similar to skin tumors found on flounder from other parts of Puget Sound.

11. Approximately 90% of the starry flounder and English sole examined in the Duwamish River had liver abnormalities.

12. The liver disease was characterized by liver discoloration, loss of normal liver structure, hepatocytes with large lipid vacuoles, fibrosis, and increased liver size.

13. Chemical analyses of blood serum from Duwamish River starry flounder showed that these fish had concentrations of cholesterol and potassium four times higher than fish from a control area, which also suggests the existence of liver disease in Duwamish River flounder.

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Appendix 1. Scientific and common names of species collected in the vicinity of outfall study sites and in the Duwamish River during 1975.

Scientific name	Common name
Squalus acanthias	spiny dogfish
Hydrolagus colliei	ratfish
Clupea harengus pallasi	Pacific herring
Oncorhynchus keta	chum salmon
O. kisutch	coho salmon
O. tshawytscha	chinook salmon
Salmo clarki	cutthroat trout
Salvelinus malma	Dolly Varden
Hypomesus pretiosus	surf smelt
Spirinchus thaleichthys	longfin smelt
Thaleichthys pacificus	eulachon
Porichthys notatus	plainfin midshipman
Gobiesox maeandricus	northern clingfish
Gadus macrocephalus	Pacific cod
Merluccius productus	Pacific hake
Microgadus proximus	Pacific tomcod
Theragra chalcogramma	walleye pollock
Brosmophycis marginata	red brotula
Lycodopsis pacifica	blackbelly eelpout
Aulorhynchus flavidus	tubesnout
Gasterosteus aculeatus	threespine stickleback
Syngnathus griseolineatus	bay pipefish
Cymatogaster aggregata	shiner perch
Embiotoca lateralis	striped seaperch
Rhacochilus vacca	pile perch
Ronquilus jordani	northern ronquil
Lumpenus sagitta	snake prickleback
Apodichthys flavidus	penpoint gunnel
Pholis laeta	crescent gunnel
P. ornata	saddleback gunnel
Ammodytes hexapterus	Pacific sand lance
Lepidogobius lepidus	bay goby
Sebastes auriculatus	brown rockfish
S. caurinus	copper rockfish
S. maliger	quillback rockfish
S. proriger	redstripe rockfish
S. zacentrus	sharpchin rockfish
Hexagrammos decagrammus	kelp greenling
H. stelleri	whitespotted greenling
Oxylebius pictus	painted greenling

Appendix 1, cont'd

Scientific name	Common name
Artedius fenestralis	padded sculpin
A. harringtoni	scalyhead sculpin
A. lateralis	smoothhead sculpin
Blepsias cirrhosus	silverspotted sculpin
Chitonotus pugetensis	roughback sculpin
Clinocottus acuticeps	sharpnose sculpin
Enophrys bison	buffalo sculpin
Gilbertidia sigalutes	soft sculpin
Hemilepidotus hemilepidotus	red Irish lord
Icelinus borealis	northern sculpin
I. filamentosus	threadfin sculpin
I. tenuis	spotfin sculpin
Leptocottus armatus	Pacific staghorn sculpin
Myoxocephalus polyacanthocephalus	great sculpin
Nautichthys oculofasciatus	sailfin sculpin
Oligocottus maculosus	tidepool sculpin
Psychrolutes paradoxus	tadpole sculpin
Radulinus asprellus	slim sculpin
Rhamphocottus richardsoni	grunt sculpin
Scorpaenichthys marmoratus	cabezon
Synchirus gilli	manacled sculpin
Cottus asper	prickly sculpin
Agonopsis emmelane	northern spearnose poacher
Agonus acipenserinus	sturgeon poacher
Asterotheca alascana	gray starsnout
A. infraspinata	spinycheek starsnout
Odontopyxis trispinosa	pygmy poacher
Xeneretmus latifrons	blacktip poacher
X. triacanthus	bluespotted poacher
Liparis florae	tidepool snailfish
L. pulchellus	showy snailfish
Citharichthys sordidus	Pacific sanddab
C. stigmaeus	speckled sanddab
Eopsetta jordani	petrale sole
Glyptocephalus zachirus	rex sole
Isopsetta isolepis	butter sole
Lepidopsetta bilineata	rock sole
Lyopsetta exilis	slender sole
Microstomus pacificus	Dover sole
Parophrys vetulus	English sole
Platichthys stellatus	starry flounder
Pleuronichthys coenosus	C-O sole
Psettichthys melanostictus	sand sole