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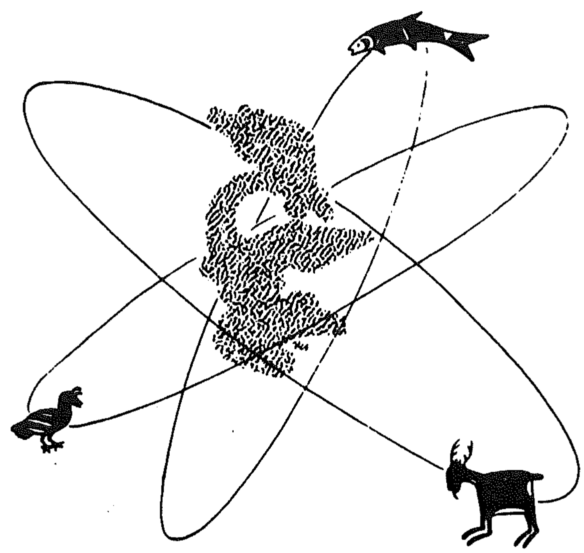

RESEARCH SECTION

Oregon Department of Fish and Wildlife

Identification, Distribution, and Notes on
Food Habits of Fish and Shellfish in
Tillamook Bay, Oregon

JOB COMPLETION REPORT

PROJECT TITLE: Identification, distribution, and notes on food habits of fish and shellfish in Tillamook Bay, Oregon

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INTRODUCTION

Human activities in estuaries have increased in recent years and will probably continue to expand in the future. Many of these activities will occur along shorelines or in shallow waters. Shallow areas are often necessary for many important species as nursery grounds, feeding areas, or resting areas. Misuse of estuaries has reduced productivity for fish and shellfish and diversity for human use. The potential for further losses has prompted the formation of local, regional, or state groups to plan for proper management of the irreplaceable estuarine resources. These groups need inventories of the basic biological and physical parameters in each estuary to make sound land-use decisions.

This is a study of the species composition, spatial and temporal distribution, and relative abundance of the fish in Tillamook Bay, Oregon. Other information includes distribution and abundance of shellfish, and distribution of birds, harbor seals, ghost shrimp, and eel grass. Food habits of several fish species are also examined.

STUDY AREA

Tillamook Bay is located on the north coast of Oregon approximately 50 miles south of the Columbia River. It is the third largest estuary in Oregon with 3,355 total hectares and 1,685 hectares in tideland (Oregon Division of State Lands 1973). Five major streams enter Tillamook Bay: the Miami, Kilchis, Wilson, Trask, and Tillamook rivers. The average annual run-off, per 100,000 m^3 for those streams, respectively, are 217.0, 456.2, 1,294.7, 863.1, and 335.4. The bay lies on a northwest to southeast line and is approximately 9.6 km long and 4.8 km wide.

For the purposes of this report, we divided the bay into lower, middle, and upper sections (Fig. 1). The lower and middle sections were divided between Hobsonville Point and the Ghost Hole. The middle and upper sections were divided between Sibley Sands and Pitcher Point Channel. Although no clear-cut lines were drawn as boundaries there are general differences in substrate, vegetation, depth, and salinities from one end of the bay to the other.

Lower Bay

The lower bay habitat ranges from jetty rock to large, well-sorted sand flats with salinities similar to open ocean. The main navigation channel is located in this area with a width of 61 m and depth of 5.5 m (mean lower low water). The substrate consists of well-sorted sand, rock, and shell. The finer sediments do not settle in this area because of relatively high current velocities (U. S. Army Corps of Engineers 1974). Sampling stations in this habitat type were Buoy 8, Buoy 11, and the Garibaldi boat basin.

The Crab Harbor station was located in a sandy channel approximately 4.6 m deep with adjacent sandy shorelines. The Range Finders station was a shallow, sandy habitat. Kincheloe Point and Hobsonville Point were cobble shoreline stations in the lower bay. Garibaldi Flat was a shallow, sandy shoreline that becomes steep-banked at low tide. Eel grass and other marine vegetation are

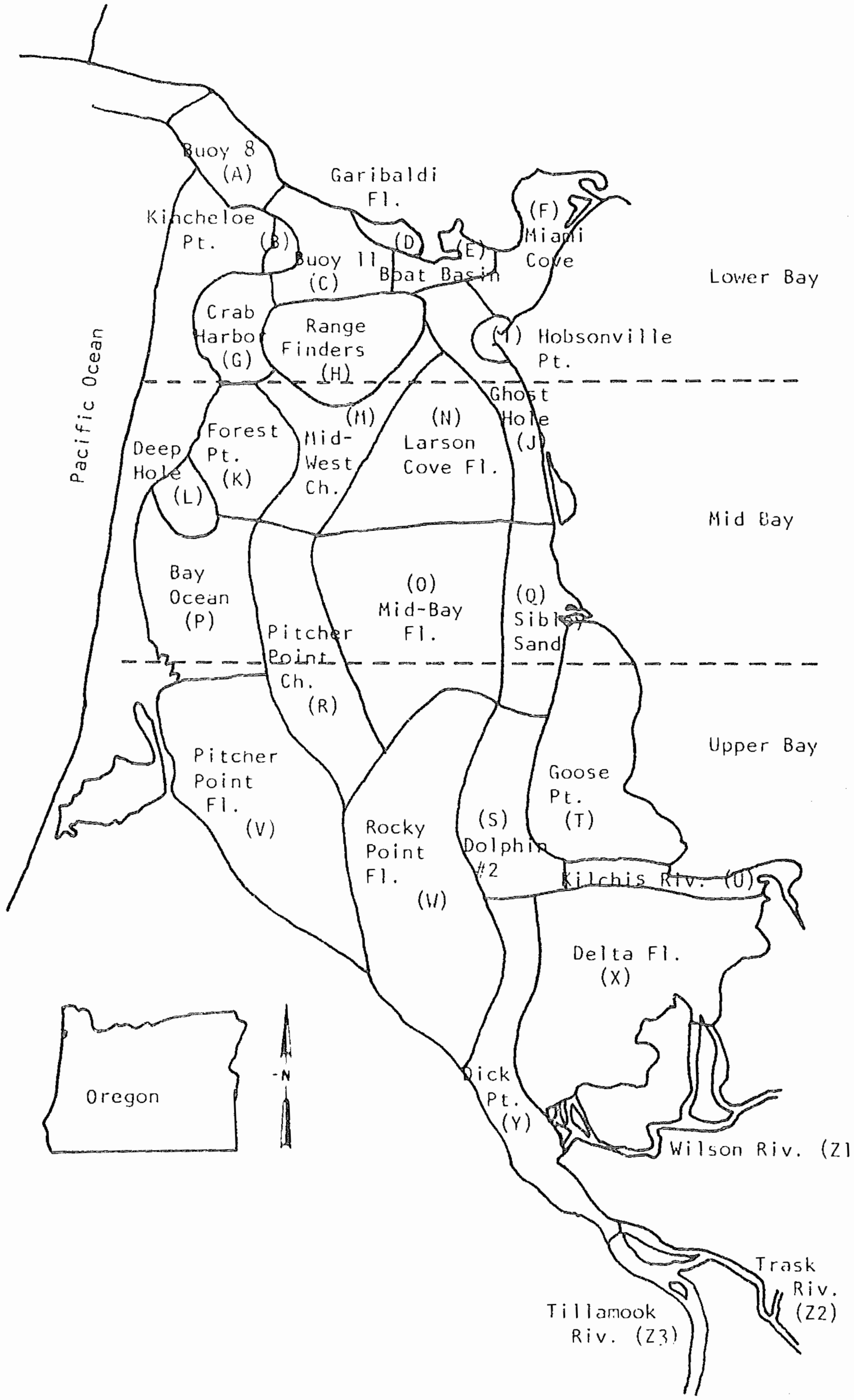

Fig. 1. Sampling station locations, names, and letter designations in Tillamook Bay, Oregon.

associated with each of the last three areas. Another shallow area station with dense eel-grass beds was Miami Cove; the substrate there is sandy silt. The north and south jetties were composed of large rock.

Mid Bay

The mid-bay area consists of moderately well-sorted, sandy silt on the flats and a mixture of rock and shell in some of the lower channeled areas. The major eel-grass beds of the bay are in this large section and aid deposition of finer particles (U. S. Army Corps of Engineers 1974). This is also the transitional zone between the more saline lower bay and the less saline upper bay.

This section has two channels which traverse its length on both sides of the bay. A great amount of leaves and other upland debris are deposited in these channels during winter run-off. The Mid-West channel station was approximately 5.5 m deep and consisted mainly of sand. The Ghost Hole and Sibley Sands stations were located in the east channel. The Ghost Hole substrate is mostly cobble and shell and has long been known as a sport fishing area for fall chinook salmon. The Bay Ocean, Mid-Bay Flat, and Larson Cove Flat stations were located on dense, eel-grass flats.

A unique area on the west side of this section was the Deep Hole station. The Deep Hole is a dredge barrow site approximately 304.8 m long and 182.9 m wide with a maximum depth of 13.7 m. The substrate is fine silt. This area is the site of an experimental artificial reef which was installed by the Oregon Department of Fish and Wildlife. Forest Point was located on a shallow, mid-bay sand flat.

Upper Bay

The upper bay is an area of relatively low tidal currents and salinity. The substrate consists of sandy silt of finer particle size (U. S. Army Corps of Engineers 1974). This section is much shallower than the others and is mostly exposed at low tides.

The southern portion of the two bay channels were sampled at Pitcher Point Channel, Dolphin #2, and Dick Point stations. Rocky Point Flat, Goose Point, and Pitcher Point Flat stations were areas of fine silty sand. Eel-grass beds are located on the latter two flats. The tidewater of the Kilchis, Wilson, Trask, and Tillamook rivers are included in this portion. Dick Point, Delta Flat, and the lower reaches of the four rivers are areas where coarse grained sand is deposited.

METHODS AND MATERIALS

Equipment

This project was conducted over a 2-year period, May 1974 to May 1976. A 6.1 m fiberglass dory was used exclusively the first year, but because of shallow water in upper Tillamook Bay, a 4.3 m tri-hull craft was used in conjunction with the dory during the second year of sampling. This enabled us to sample the entire bay at lower tides.

We used a small trawl (tri-net) of 3.81 cm (stretched) mesh in the wing and body and 3.175 cm mesh in the codend with a 6.35 mm liner. The bridles, from wings to otter doors, were 4.72 m long. The dandyline, from otter doors to the single warp, was 8.23 m long. The footrope was 6.1 m and we wrapped it with 1.588 cm chain and attached a 5.5 m "tickler" chain to the wings to move fish off the bottom. The trawl had a vertical opening of approximately 2.13-2.44 m and a horizontal opening of about 2.13 m when fishing. We estimated these openings while scuba diving.

The trawl was set in the same manner as a side trawler, over the starboard side of the boat while making a large clockwise semi-circle. When the otter doors were out, we shot the single warp to trawling distance and attached it to a towing bit. Two men worked the trawl.

We used a beach seine 45.72 m long by 3.05 m deep with a bag measuring 3.05 by 3.05 m and 1.27 cm mesh throughout. We anchored one end of it on the beach and laid out the rest of the net while proceeding in a large semi-circle back to the beach. The seine was then hauled onto the beach. Four men normally were needed to effectively use the seine.

A smaller beach seine, 22.86 m long and 1.27 cm mesh was used in the upper bay during the second year.

We also used monofilament gill nets with variable mesh of 2.54 to 10.16 cm, and 30.48 m in length. The net was composed of four 7.62 m long panels of 2.54, 5.08, 7.62, and 10.16 cm (stretched measure), respectively. This gear was only used periodically during the first year.

Sampling

Captured fish were identified and counted in the field when possible. Those of unsure identity were determined in the laboratory using keys (Carl, Clemens, and Lindsey, 1959; Hart 1973; Miller and Lea 1972). We recorded a limited number of lengths to separate adults from juveniles. During scuba dives, we noted fish species and relative numbers. Most captured fish were released alive after identification and data collection.

We selected 28 sampling stations in Tillamook Bay, on the basis of habitat type, from aerial photographs and by on-site inspection of the areas. We sampled 25 locations with the trawl and 12 with the seine. During the first year, May 1974 to May 1975, the trawl stations and four seine stations were sampled twice per month at high tide and once per month at low tide. That frequency was reduced to once per month each at high and low tides during the second sampling year when the other eight seine stations were added. The reduction in sampling frequency was due to limited manpower. Each trawl tow was about 5 minutes duration. Several other sites were sampled periodically with seine, gill nets, and by scuba.

During the summer of 1974, we cooperated with department shellfish biologists on a subtidal clam survey. Shellfish personnel laid out 609.60 m of transect lines 15.24 m apart in several locations of the lower bay. They dove along these transects and, at 15.24 m intervals, observed clam species present and relative abundance.

We collected a water sample near the bottom of each trawl station with a Kemmerer bottle. At each seine station, we dipped a collection bottle into the surface water. We determine salinities in the laboratory with Kahlsico hydrometers of 0.995-1.011, 1.010-1.021, and 1.020-1.031 specific gravity range, respectively. In October of 1975, we obtained a Hydrolab surveyor model 6-D to measure salinity, temperature, and dissolved oxygen.

We retained some fish after capture for stomach content analysis. Oregon State University personnel cooperated with us by examining several species in the summer of 1974 (Flynn and Frolander 1975) and over a 6-month period from November 1975 through April 1976 (Toner 1976).

The Oregon Department of Fish and Wildlife and Oregon State University (Margaret Toner) conducted a study of food habits for five species of fish in Tillamook Bay from July 1, 1975, to June 30, 1976. The five species collected for this study were chinook salmon, surf smelt, rockfish, English sole, and starry flounder.

The purpose of the study was to identify food organisms and preferred foods for five fish species in Tillamook Bay, to identify food organisms consumed from different areas in the bay, and to determine differences in food habits over an annual period.

We captured all fish except adult rockfish with beach seines or the small trawl. Scuba gear and spear gun were used to capture adult rockfish near the rocky areas down bay.

All fish except adult rockfish were measured and preserved upon capture. Adult rockfish were measured and stomach contents examined at the field laboratory after spearing. All other specimens were preserved in jars containing a 10% formalin solution. To stop the digestive process, chinook salmon, larger surf smelt, and adult starry flounder were injected with formalin upon capture, then placed in the 10% formalin solution.

The stomach of each specimen was removed to the junction of the pyloric caeca and the contents were transferred to a watch glass. The organisms were examined under a binocular scope, identified, and counted. Stomach fullness was estimated and recorded.

RESULTS

Gear Selection and Limitations

During the 2 years of study, 1,438 samples or observations were made with all types of gear. These samples included 1,049 trawl sets, 356 seine sets, 21 gill-net sets, and 12 scuba observations. The majority of the trawl sets (857) were made at high tide due to the shallow water and exposed flats at low tide. The beach seine stations were sampled 170 times at high tide and 186 at low tide.

The seine and trawl captured nearly equal numbers of species. The trawl caught 47 species and the seine 46. Thirty-nine of these species were caught by both types of gear. The seine captured seven species not found in the trawl, while the trawl captured eight species lacking in seine hauls. We caught 12 species with the gill nets, but only one was unique to this gear. We observed or captured 18 species while scuba diving, including three species not caught using other methods.

The seine seemed to be more efficient than the trawl. Of 11 species compared, all but Dungeness crab and saddleback gunnel had a higher probability of capture and ~~all but crab a better~~ catch/haul with the seine (Table 1). The average number of all species per set was also higher for the seine than the trawl. The seine was obviously more efficient on pelagic species since it fished from the surface to a depth of 3 m. In steep-banked areas such as Crab Harbor and Kincheloe Point, the seine captured only pelagic species until it approached the beach. The trawl, on the other hand, fished from the bottom up to an effective height of 1.5 or 1.8 m and; therefore, was expected to be more efficient on bottom species such as English sole and starry flounder. The reason it was not may be that the trawl sampled open water areas and the seine the more productive shoreline areas.

Table 1. Seine and trawl catch/effort and probability of capture for 11 species in Tillamook Bay from May 1974-April 1976.

	Catch/effort		Probability of capture	
	Seine	Trawl	Seine	Trawl
Herring	46.68	0.02	0.14	0.01
Chum salmon	2.30	<0.01	0.13	<0.01
Chinook salmon	14.47	<0.01	0.43	<0.01
Surf smelt	81.00	0.24	0.47	0.03
Rockfish sp.	2.38	0.05	0.10	0.03
Shiner perch	63.47	1.27	0.40	0.14
Saddleback gunnel	0.39	0.62	0.11	0.17
Pacific staghorn sculpin	4.57	0.83	0.43	0.24
English sole	6.96	2.75	0.40	0.38
Starry flounder	1.46	0.96	0.37	0.28
Dungeness crab	1.82	9.76	0.21	0.51
Average number of species per set	4.53	2.27		

The weather made sampling difficult during frequent winter storms and during late afternoon in summer when strong northwesterly winds prevailed. During windy weather we could not set the seine properly if at all. We had to set the trawl with the wind which was sometimes against the tidal current. This may have resulted in "flying the net" and, therefore, a reduced catch.

We were not always successful in collecting fish with our sampling gear during slack water. Fish may have been hidden or "buried in" at that time. However, while diving during strong tidal flows, we observed crabs "sanded in" and inactive. DeWess and Gotshall (1974) noted that fishing success decreased during strong tidal currents, suggesting that fish forage during slack water.

We had difficulty fishing gill nets in the current where they filled with floating algae and debris, becoming visible to fish. Gill nets were more selective to pelagic species; but when they did fish near or on the bottom, crabs ate captured fish and became entangled in the net, adding further to sampling problems.

Quality of scuba observations was influenced by water turbidity. During months of rough and turbid water, diving and identification of species was difficult.

Temperature and Salinity

Water temperatures in Tillamook Bay ranged from a high of 21.1 C during July to a low of 5.0 C in January. Previous temperature extremes for the estuary were between 2 C and 21 C (U. S. Army Corps of Engineers 1974). Salinities ranged from freshwater, 0 °/oo, in the upper portion of the estuary to 35 °/oo in the lower bay.

Temperature and salinity fluctuations were more noticeable in the upper bay and were modified by ocean conditions in the lower bay. These fluctuations were closely related to meteorological conditions in the area. Over 70% of the average annual rainfall occurs from November through March (Corps of Engineers 1974), causing these extremes.

Water temperature and salinity variations were most apparent in bay channels (Tables 2 and 3). Bottom high tide salinities for down bay, mid bay, and up bay were 15-35 °/oo, 5-35 °/oo, and 0-35 °/oo, respectively. Low tributary flows during late summer resulted in saliniity intrusion into the bay as far up as Dick Point, 12.9 km above the Tillamook Bay entrance, where salinities during September averaged 26.5 °/oo (Fig. 2). Salinity intrusion was less marked during the winter when average salinities of greater than 25 °/oo occurred up bay only as far as the Deep Hole station (Fig. 3). Water temperature extremes were greatest up bay with higher highs and lower lows than down bay (Fig. 4 and 5). Water temperature and salinity fluctuations were less pronounced over tidal flats where mixing is more thorough, thus modifying differences from surface to bottom.

We took salinity and water temperature readings monthly from both the surface and bottom of the Deep Hole (Table 4). The Deep Hole was stratified throughout the year with the denser saline water near the bottom. Tidal mixing in the hole appeared slight during winter months of high runoff. Currents within the hole, even during periods of peak winter flooding, showed significant differences from surface (47.5 cm/sec) to bottom (18 cm/sec) (Hancock 1975). A temperature turnover occurred during November and April. This turnover between warmer and cooler water was caused by colder winter freshets flowing over denser saline water on the bottom.

On the basis of circulation patterns and salinity changes from surface to bottom, Tillamook Bay is classified as a two-layered system during the high run-off periods from November through March and as a well-mixed, vertically homogenous system during low flow periods from April through October (Burt and McAllister 1959). Based on the same system, the up-bay portion of the estuary appears to fluctuate between completely mixed and relatively stratified depending upon runoff quantities and tidal action (U. S. Army Corps of Engineers 1974).

Table 2. Mean monthly high-tide water temperatures from selected channel stations in Tillamook Bay, Oregon, May 1974-April 1976.

	Water temperature (C)					
Month	Buoy 8	Buoy 11	Ghost Hole	Sibley Sands	Dolphin #2	Dick Point
May	10.85	10.85	10.00	10.55	11.40	12.80
June	9.60	11.85	10.70	12.20	13.60	16.10
July	12.65	12.65	12.20	13.50	14.35	16.65
August	11.85	11.85	11.85	12.50	13.60	16.30
September	10.70	11.10	11.30	12.10	12.80	16.30
October	11.20	11.10	11.00	10.80	11.10	11.20
November	10.90	11.10	11.30	11.30	11.10	9.45
December	10.00	10.00	9.90	9.45	9.15	7.95
January	9.05	9.15	9.05	9.05	8.35	7.40
February	7.80	7.80	8.50	8.60	8.05	7.80
March	8.90	8.70	8.70	8.70	8.35	8.15
April	8.80	8.90	9.05	9.60	9.60	10.85

Table 3. Mean monthly high-tide salinities from selected channel stations in Tillamook Bay, Oregon, May 1974-April 1976.

	Salinity ‰					
Month	Buoy 8	Buoy 11	Ghost Hole	Sibley Sands	Dolphin #2	Dick Point
May	30.2	29.9	29.7	21.8	14.8	3.4
June	33.0	30.3	30.6	30.5	25.1	17.4
July	30.7	30.6	30.8	28.7	26.2	19.5
August	32.3	31.9	32.3	31.8	30.4	23.7
September	32.6	32.5	32.6	32.1	31.5	26.5
October	29.7	29.8	30.3	24.9	23.9	16.5
November	32.8	32.8	32.5	28.9	28.2	22.3
December	28.1	28.0	29.0	25.7	20.5	4.1
January	29.9	29.8	28.0	21.0	15.4	3.2
February	15.3	18.9	26.7	25.0	21.9	9.4
March	27.8	27.8	27.6	25.4	12.5	4.6
April	26.0	25.9	25.2	22.7	18.9	3.8

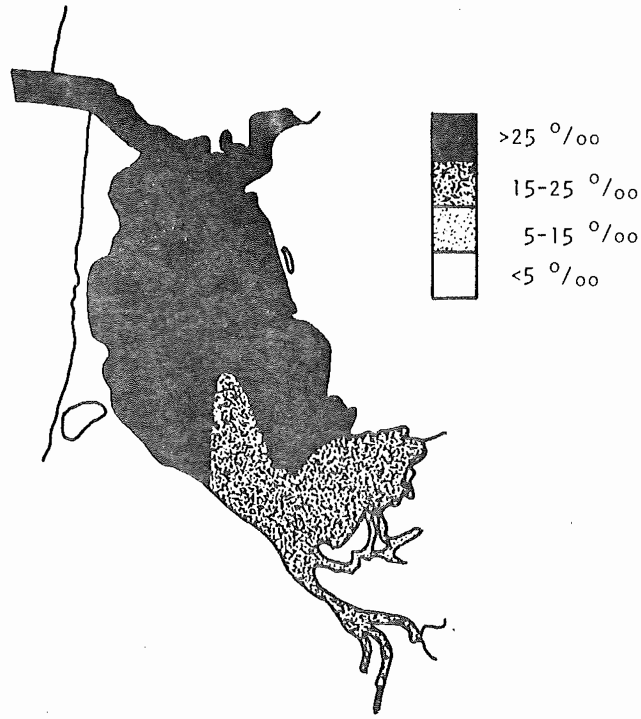

Fig. 2. Summer salinity intrusion into Tillamook Bay, Oregon.

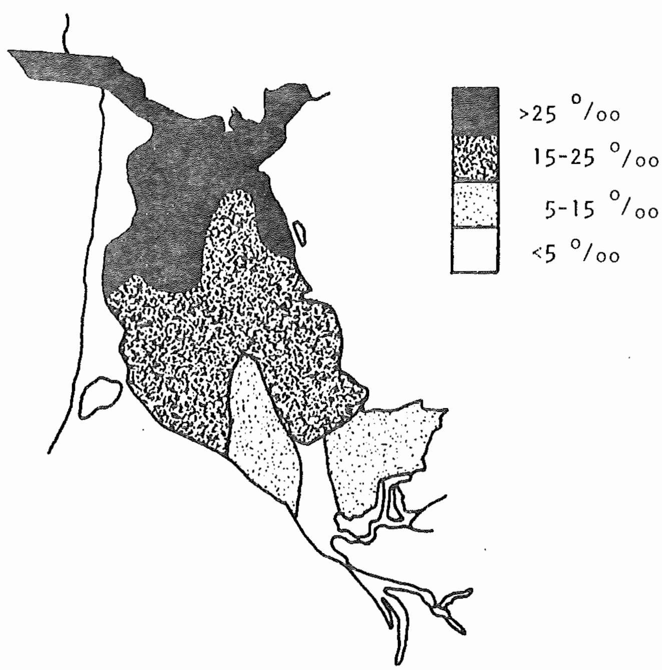

Fig. 3. Winter salinity intrusion into Tillamook Bay, Oregon.

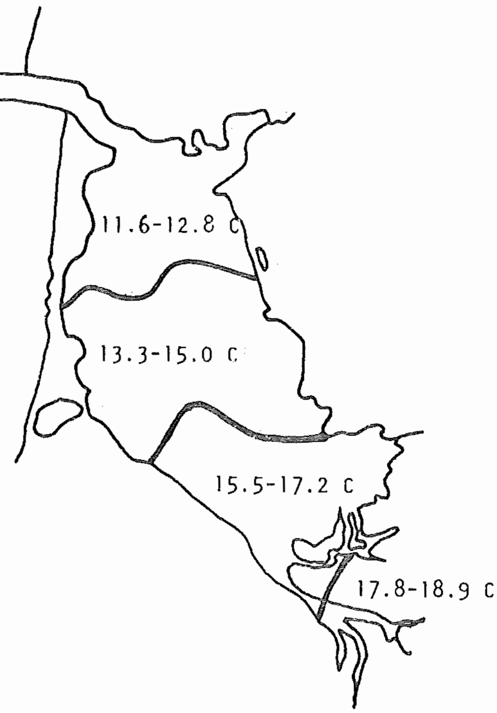

Fig. 4. Summer water temperature patterns in Tillamook Bay, Oregon.

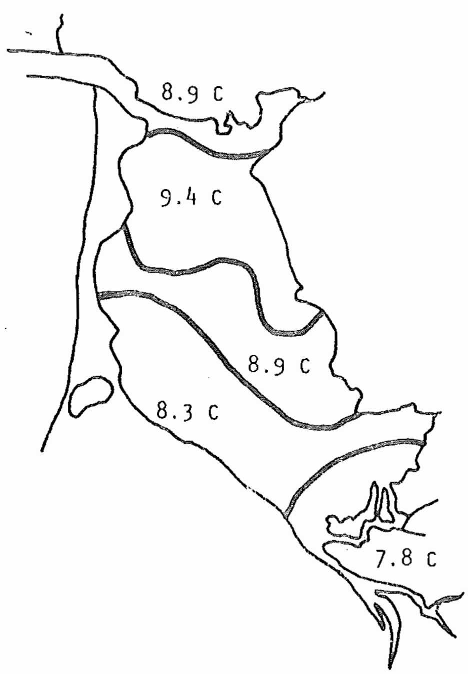

Fig. 5. Winter water temperature patterns in Tillamook Bay, Oregon.

Table 4. Mean monthly high-tide water temperatures and salinities from the Deep Hole station in Tillamook Bay, Oregon, May 1974-April 1976.

	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
	Water temperature (C)											
Surface	14.05	12.50	15.00	11.10	14.45	11.65	9.15	9.20	6.85	7.95	8.50	10.00
Bottom	10.55	9.70	12.95	11.55	12.40	11.10	11.65	10.15	8.80	8.50	8.50	9.60
	Salinity (°/oo)											
Surface	19.9	28.0	27.7	32.5	31.4	29.0	19.6	19.9	19.9	19.2	19.1	21.3
Bottom	30.4	33.2	30.4	33.1	32.3	31.7	31.5	28.6	29.4	25.1	26.2	26.2

Species Diversity

The average monthly number of species/set was used as an index of species diversity. This index had to be separated into species caught by trawl and by seine, since the two types of gear displayed different efficiencies.

Seasonally, the most species/set were caught in Tillamook Bay in the summer months, June, July, and August (Fig. 6). Highest monthly average catches were 7.6 and 3.7 species/set for seine and trawl, respectively. Much lower average catches of 1.6 and 1.1 species/set for seine and trawl were made in the winter.

Distributionally, the most species/seine set were caught in the lower bay (Table 5). However, the trawl caught the most species in mid bay, possibly because of the variety of fish inhabiting dense eel-grass beds in this section. In the lower bay, the most diverse catches by seine were at Hobsonville Point and Garibaldi Flat, whereas the Boat Basin area yielded the most diverse catch for the trawl. In the mid-bay section, the most diverse catches were at the edge of the Deep Hole for the seine and at Larson Cove Flat for the trawl. In the upper bay, Pitcher Point Channel yielded the most diverse catches by seine, while Goose Point and Pitcher Point Flat had the most species/set for the trawl.

Several other factors were examined to show their relationship to species diversity. A tidal comparison shows that more species were caught per set during low tide as opposed to high tide (Fig. 7). The increased catch and resultant greater species diversity may reflect a greater concentration of fish due to the reduction in total water volume at low tide.

As stated earlier there were six substrate types in Tillamook Bay. Cobble habitat yielded the most diverse catches by the seine, while the fine silt bottom found only in the Deep Hole provided the greatest species variety in trawl catches. Eel grass proved to be an important factor in fish diversity when species caught in each set were examined.

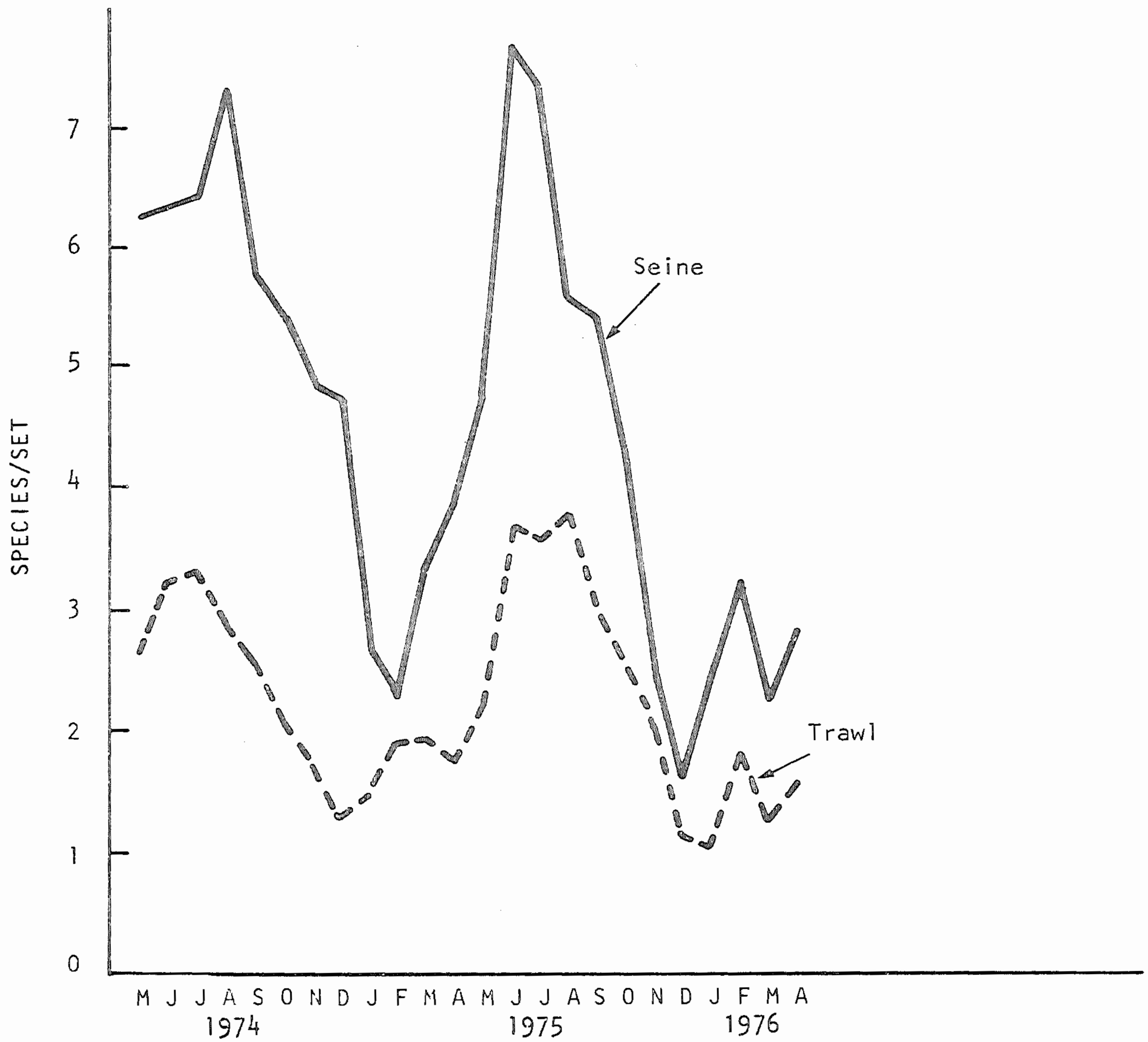

Fig. 6. Mean number of species/set for trawl and seine by month, May 1974-April 1976.

Table 5. Average number of species/set for each station and bay section.

Station	Species/set by station		Bay section	Average species/set	
	Seine	Trawl		Seine	Trawl
Buoy 8	--	1.8			
Kincheloe Pt.	4.9	--			
Buoy 11	--	2.0			
Garibaldi Fl.	6.1	--	Lower	5.3	2.1
Boat Basin	--	3.2			
Miami Cove	--	2.6			
Crab Harbor	3.6	1.6			
Range Finders	--	1.1			
Hobsonville Pt.	6.6	--			
Ghost Hole	--	3.1			
Forest Pt.	--	1.6			
Deep Hole	4.0	2.9			
Mid-West Ch.	--	2.2			
Larson Cove Fl.	--	3.7	Mid	3.0	2.6
Mid-Bay Fl.	--	2.5			
Bay Ocean	3.5	3.0			
Sibley Sands	2.1	1.8			
Pitcher Pt. Ch.	4.8	2.1			
Dolphin #2	3.4	1.8			
Goose Pt.	2.8	3.1			
Kilchis River	--	2.2			
Pitcher Pt. Fl.	2.4	3.1	Upper	2.8	2.0
Rocky Pt. Fl.	4.2	1.9			
Delta Fl.	--	1.6			
Dick Pt.	3.6	2.0			
Wilson River	2.7	1.6			
Trask River	1.6	1.6			
Tillamook River	2.6	1.4			

Species Composition

A total of 126,389 fish representing 56 species were caught with the seine, trawl, and gill nets in 2 years of sampling (Table 6). Two of the species, northern anchovy and surf smelt composed almost 52% of the total catch. However, it was difficult to gain perspective regarding the catch by species since gear efficiency was unknown. Juvenile rockfish caught in the nets were listed only by genus *Sebastes*, although we observed numerous adult black and blue rockfish along the jetties while diving. These adults were not included in the total number. Juvenile greenling were also listed by genus alone *(Hexagrammos)* because the two species caught, rock and kelp, were difficult to separate as juveniles.

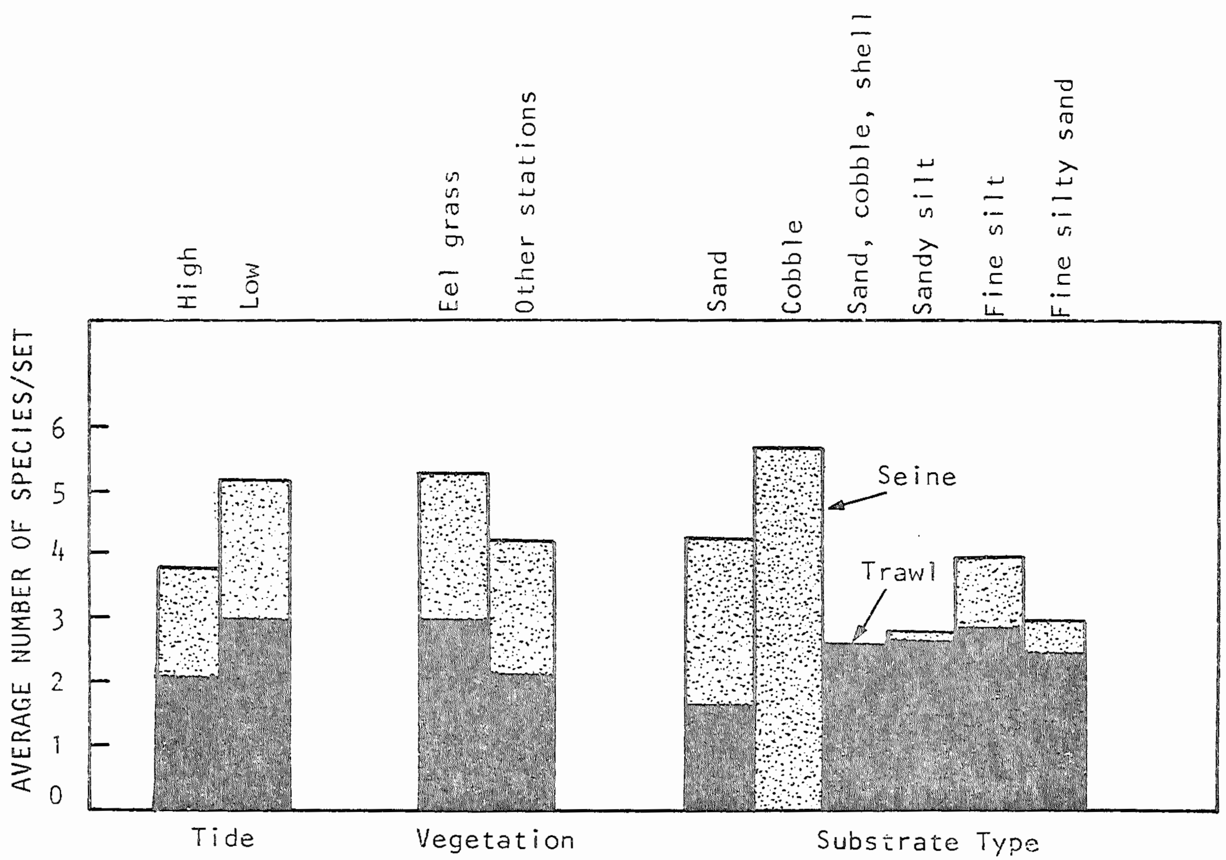

Fig. 7. Average number of species caught/set compared to tide, vegetation, and substrate type.

Table 6. Species composition and relative abundance of fish caught in Tillamook Bay.

Common name	Scientific name	Percentage of total	Total number
Northern anchovy	*Engraulis mordax*	28.17	35,610
Surf smelt	*Hypomesus pretiosus*	23.80	30,085
Shiner perch	*Cymatogaster aggregata*	18.95	23,952
Pacific herring	*Clupea harengus pallasi*	13.17	16,641
English sole	*Parophrys vetulus*	4.24	5,365
Chinook salmon	*Oncorhynchus tshawytscha*	4.02	5,077
Pacific staghorn sculpin	*Leptocottus armatus*	1.98	2,499
Starry flounder	*Platichthys stellatus*	1.21	1,529
Rockfish sp.	*Sebastes* sp.	0.71	901
Chum salmon	*Oncorhynchus keta*	0.65	825
Saddleback gunnel	*Pholis ornata*	0.63	794
Buffalo sculpin	*Enophrys bison*	0.53	671
Threespine stickleback	*Gasterosteus aculeatus*	0.24	308
Pacific sand lance	*Ammodytes hexapterus*	0.22	284
Greenling sp.	*Hexagrammos* sp.	0.18	228
Topsmelt	*Atherinops affinis*	0.15	192
Bay pipefish	*Syngnathus griseolineatus*	0.15	187
Tubesnout	*Aulorhynchus flavidus*	0.12	147
Cabezon	*Scorpaenichthys marmoratus*	0.13	166
Sand sole	*Psettichthys melanostictus*	0.09	113
Coho salmon	*Oncorhynchus kisutch*	0.07	88
Padded sculpin	*Artedius fenestralis*	0.07	86
Steelhead trout	*Salmo gairdneri*	0.06	74
Pacific tomcod	*Microgadus proximus*	0.05	65
Prickly sculpin	*Cottus asper*	0.05	62
Cutthroat trout	*Salmo clarki*	0.05	59
Pile perch	*Rhacochilus vacca*	0.04	54
Snake prickleback	*Lumpenus sagitta*	0.04	51
Lingcod	*Ophiodon elongatus*	0.03	37
Striped seaperch	*Embiotoca lateralis*	0.03	42
Sharpnose sculpin	*Clinocottus acuticeps*	0.02	26
Penpoint gunnel	*Apodichthys flavidus*	0.02	26
Pacific sanddab	*Citharichthys sordidus*	0.02	27
Tubenose poacher	*Pallasina barbata*	0.02	23
American shad	*Alosa sapidissima*	0.01	15
Ringtail snailfish	*Liparis rutteri*	0.01	15
Red Irish lord	*Hemilepidotus hemilepidotus*	0.01	12
White seaperch	*Phanerodon furcatus*	0.01	8
Walleye surfperch	*Hyperprosopon argenteum*	0.01	7
Longfin smelt	*Spirinchus thaleichthys*	0.01	7
Tidepool sculpin	*Oligocottus maculosus*	<0.01	6
Wolf-eel	*Anarrhichthys ocellatus*	<0.01	4
Arrow goby	*Clevelandia ios*	<0.01	3
Redtail surfperch	*Amphistichys rhodoterus*	<0.01	2
Slipskin snailfish	*Liparis fucensis*	<0.01	2
Red gunnel	*Pholis schultzi*	<0.01	2
High cockscomb	*Anoplarchus purpurescens*	<0.01	2
Silver surfperch	*Hyperprosopon ellipticum*	<0.01	2
Pacific lamprey	*Entosphenus tridentatus*	<0.01	1
Longnose skate	*Raja rhina*	<0.01	1
Green sturgeon	*Acipenser medirostris*	<0.01	1
Sablefish	*Anoplopoma fimbria*	<0.01	1
Pricklebreast poacher	*Stellerina xyosterna*	<0.01	1
Butter sole	*Isopsetta isolepis*	<0.01	1
Silverspotted sculpin	*Blepsias cirrhosus*	<0.01	1
Big skate	*Raja binoculata*	<0.01	1
		Total	126,389

The 11 most abundant species accounted for 97% of the total catch. These were the fish selected for distribution and abundance analysis in this report because of their apparent numerical or known economic importance. The other 46 species, although not caught as often, are important to the estuarine ecosystem.

Distribution and Abundance of Major Fin Fish Species

Catch data shown for the major fin fish species cover both years of the study. Comparison of catch among species or by area and time must be tempered by the fact that gear efficiency was not determined for any species at any time or place. We did not attempt to statistically test the data presented, but will do so where practical in the final report.

Northern anchovy

Northern anchovy was the most numerous species caught, representing over 28% of the total catch. However, they were only caught during January, March, and June through September and were found in the bay in large numbers only during August and September. The catch/effort for those 2 months were 544 and 507 fish, respectively (Fig. 8), the highest for any species. Fish in the August-September catches averaged 95 to 105 mm in length (Fig. 9) and were nearly 1-year old (Hart 1973). Although anchovies were observed throughout the bay during August and September, they were only caught at the seining sites down bay (Fig. 10). The trawl was ineffective at capturing anchovies. The most productive sampling station was Kincheloe Point (B) with 467 fish/set over 2 years (Fig. 11).

Surf smelt

Surf smelt was the second most numerous species, 24% of the total catch, and was captured every month for 2 years. The highest catches were made during July and August, although large numbers were also taken in June and September. Their spatial distribution showed no discernable trend over an annual period (Fig. 12), but catch/effort data over 2 years indicated they were most abundant along shoreline areas down bay (Fig. 13). Greatest catches were made at Kincheloe Point (B), 237.3 fish/set, for the seine, and at the Mid-West Channel (M), 1.7 fish/set, for the trawl.

Their monthly abundance was greatest from June through September (Fig. 8). These fish were probably first year adults entering the estuary to spawn. Juveniles first appeared in the catch in December (Fig. 14). The trawl catch/effort increased on these juveniles during February and March because they were too small or weak to avoid the net.

Shiner perch

Shiner perch was another seasonally abundant species. During the winter months, the few that were caught inhabited the shoreline areas in the lower and middle bay (Fig. 15). Spring distribution seemed spotty, but by summer shiner perch inhabited the entire bay. Good catches were made throughout the bay with both types of gear, although the seine was more efficient. While we

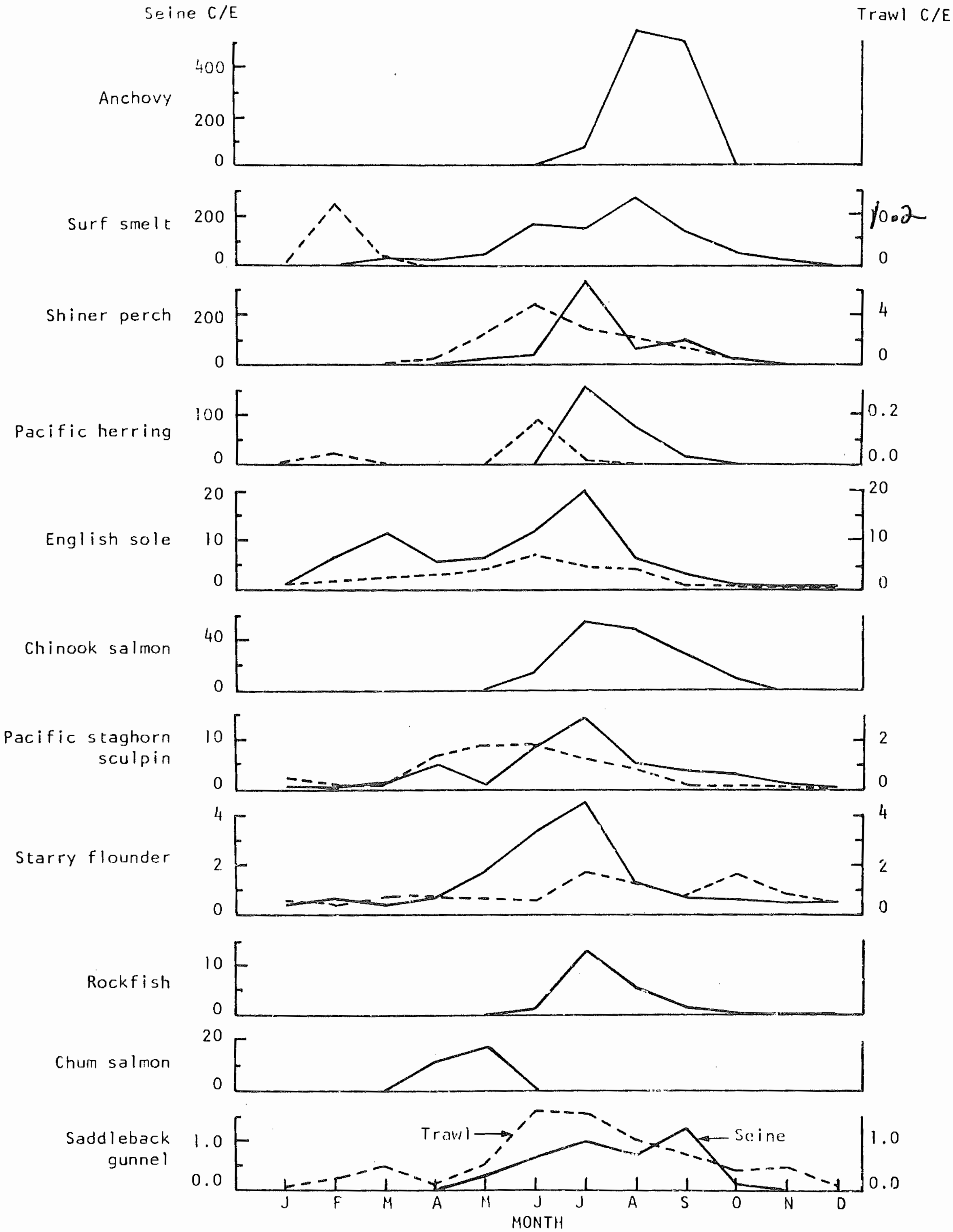

Fig. 8. Monthly catch/effort of the 11 most abundant species taken by seine and trawl (2 years combined).

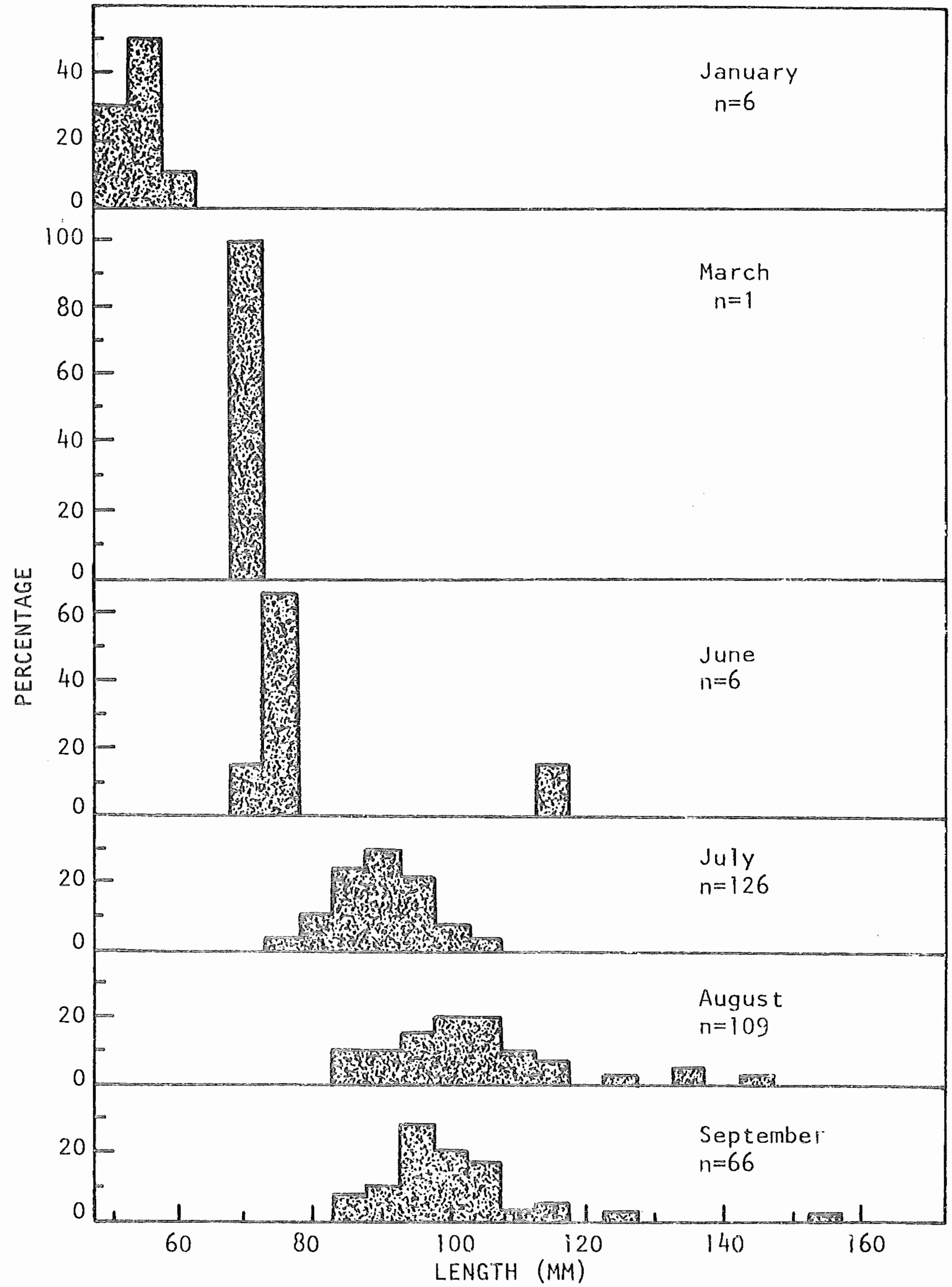

Fig. 9. Length frequency of anchovy by month in Tillamook Bay.

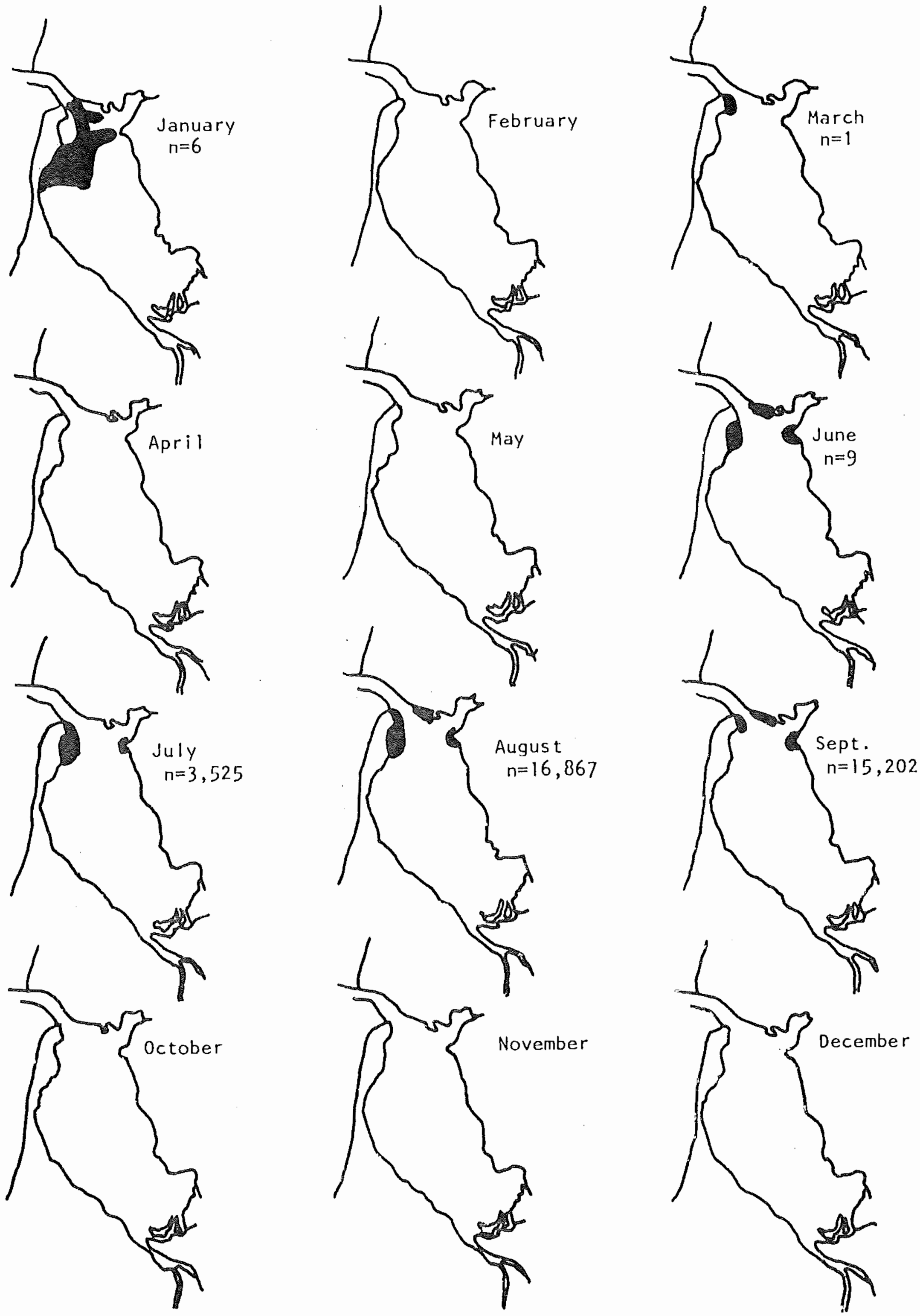

Fig. 10. Monthly catches and distributions of northern anchovy in Tillamook Bay (2 years combined).

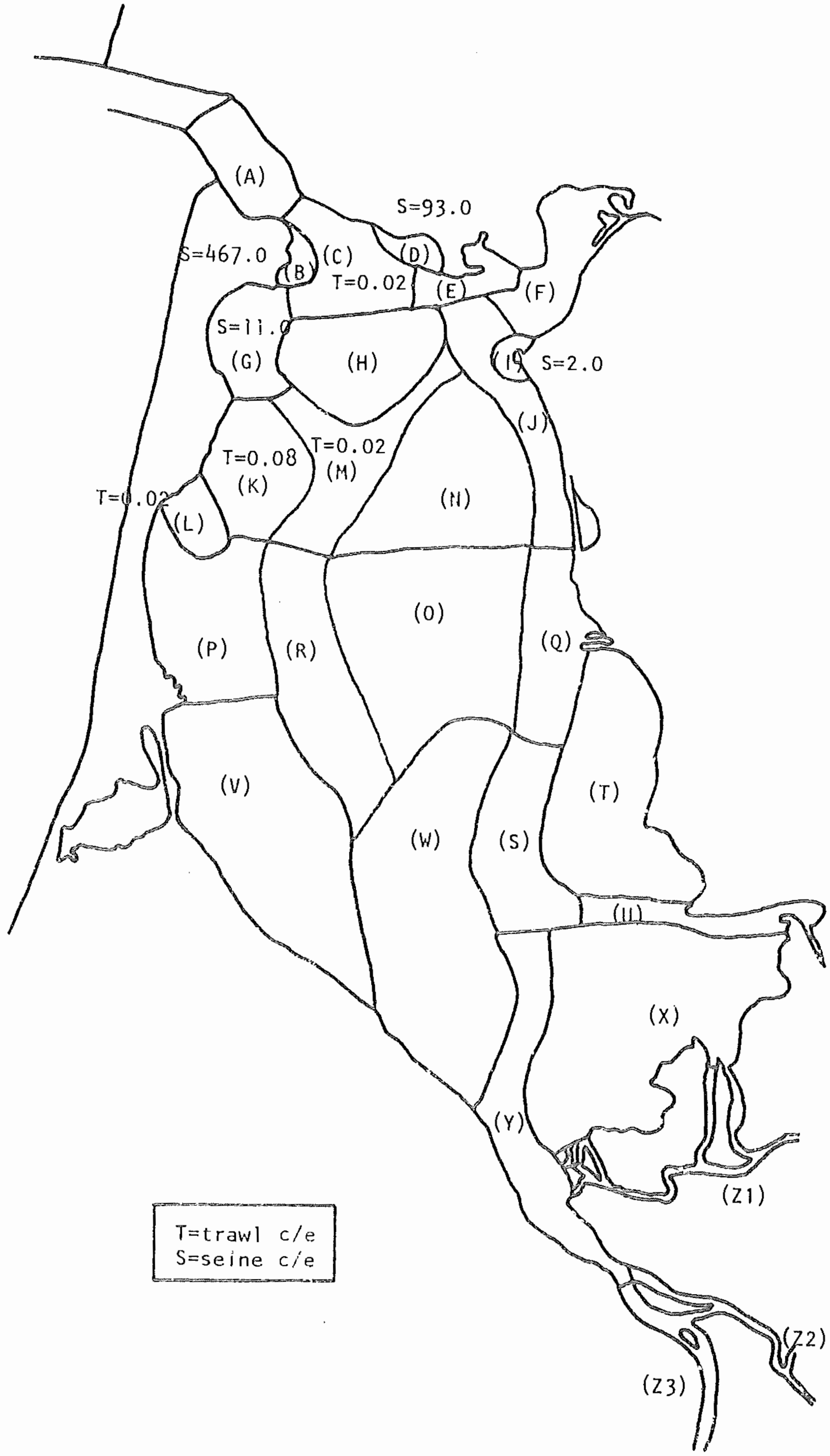

Fig. 11. Catch/set of anchovy by sampling station in Tillamook Bay (2 years combined).

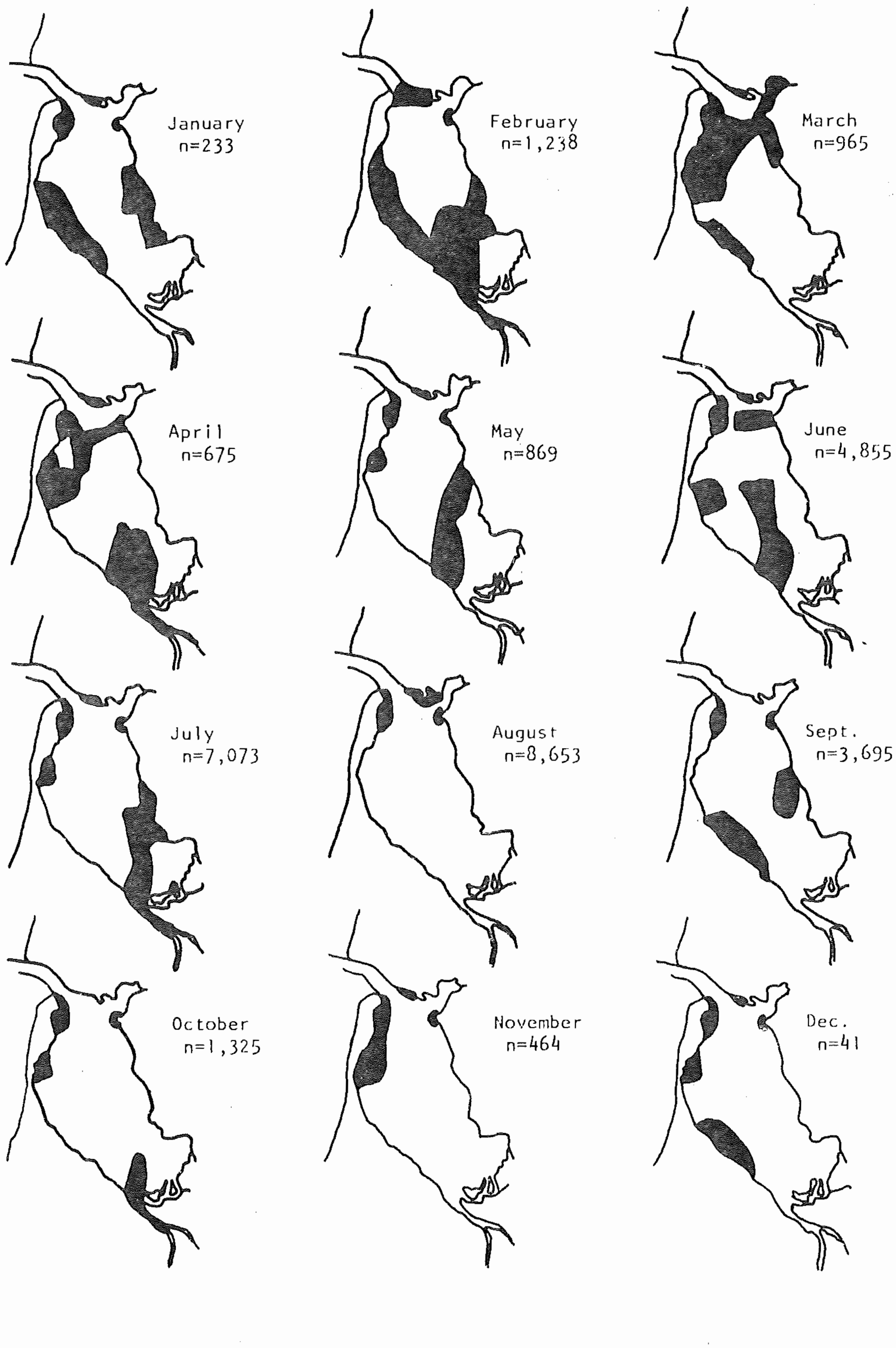

Fig. 12. Monthly catches and distributions of surf smelt in Tillamook Bay (2 years combined, May 1974-April 1976).

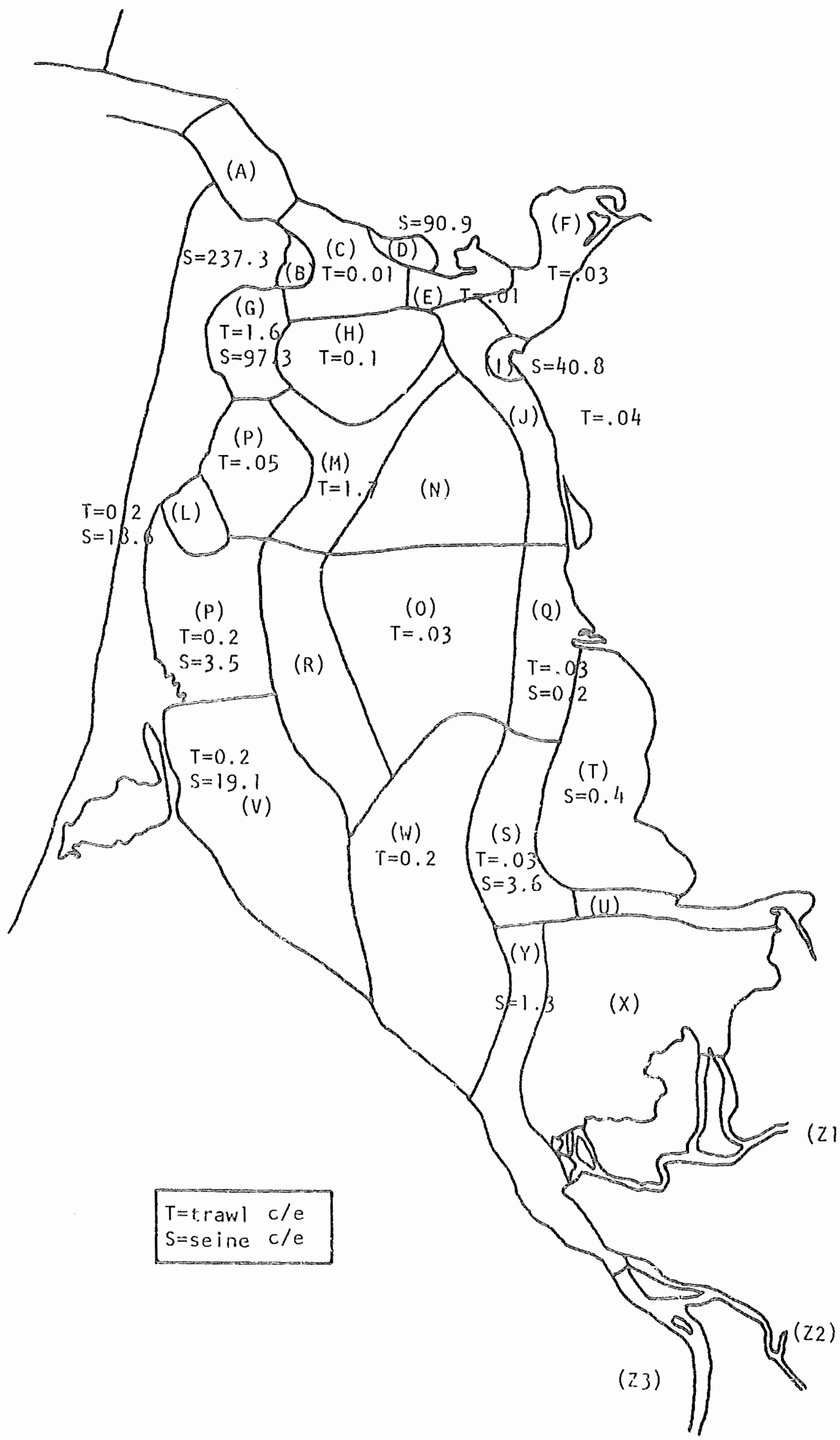

Fig. 13. Catch/set of surf smelt by sampling station in Tillamook Bay (2 years combined).

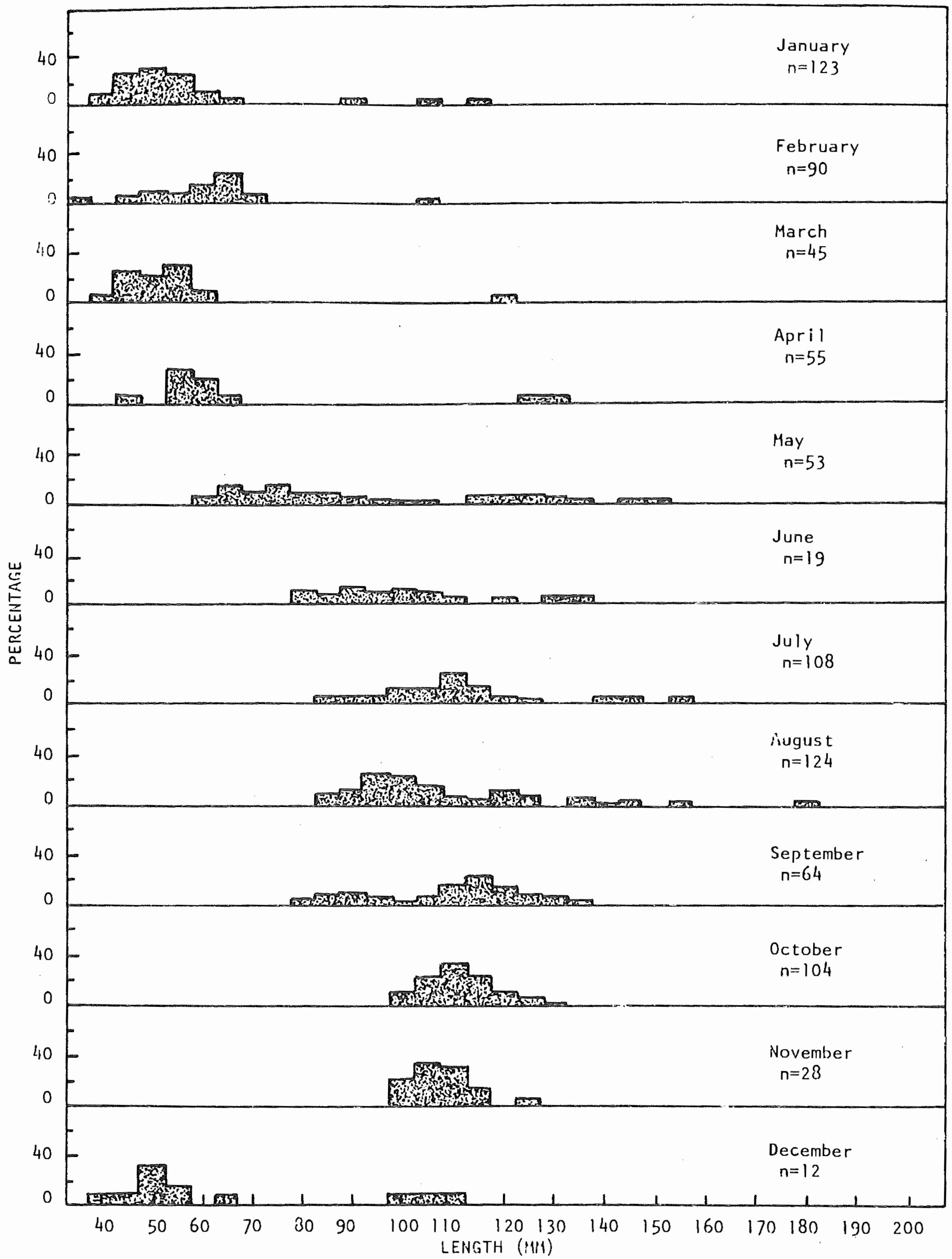

Fig. 14. Length frequency of surf smelt, by month, in Tillamook Bay.

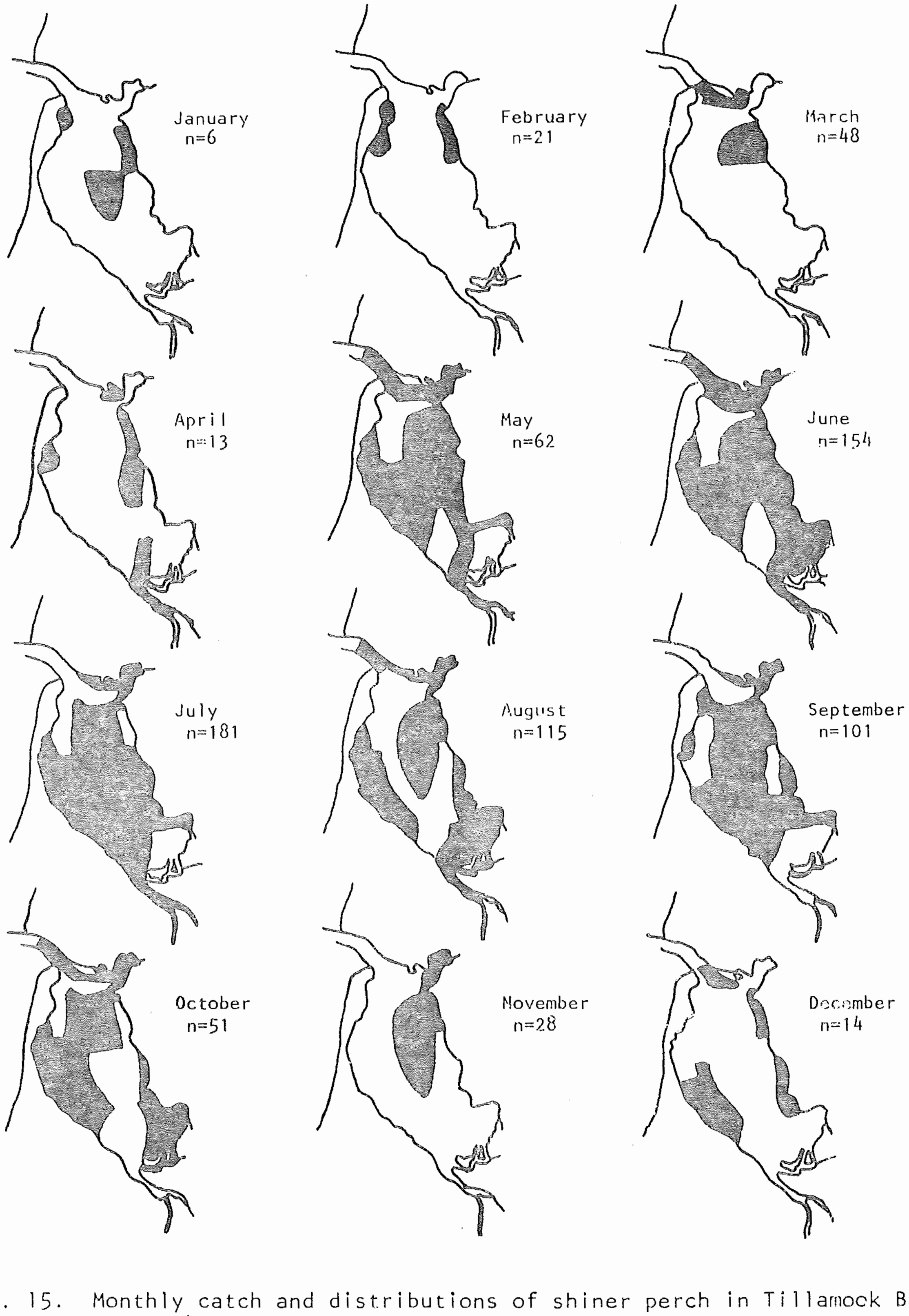

Fig. 15. Monthly catch and distributions of shiner perch in Tillamock Bay (2 years combined).

caught large numbers of shiner perch at Pitcher Point Channel (R), we only sampled there a few times when this species was most abundant. Of the stations having the most representative sampling, the highest catches were made with the seine at Garibaldi Flat (D) at low tide, 93.8 fish/set, and with the trawl at the Boat Basin (E), 8.3 fish/set (Fig. 16). The high sand flat represented by the Range Finders station (H) was the only site where shiner perch were not caught during the 2-year sampling effort.

Shiner perch entered the bay in May as adults and abundance peaked in July (Fig. 8) after spawning, when both juveniles and adults were present. Adults started leaving in August and were nearly gone by September, while the juveniles were abundant until the end of October (Fig. 17).

Pacific herring

Although we caught very few, sport and commercial fishermen normally caught adult Pacific herring in Tillamook Bay from January through March (Cummings and Berry 1974). Our gear was unable to sample the rock and piling habitat where herring spawned during this period. Our catches were composed of juveniles resulting from those spawnings (Fig. 18). Juveniles started appearing in the June catches, abundance peaked in July, and the catch declined in September (Fig. 8).

Juvenile herring were mainly caught at the down bay seine stations during the summer months (Fig. 19). Greatest seine catches were made at Crab Harbor (G), 172.9 fish/set, while trawl catches peaked at Buoy 8 (A), 0.2 fish/set (Fig. 20).

English sole

We found English sole in Tillamook Bay throughout the year. Juveniles were caught throughout the bay, except in the Wilson, Trask, and Tillamook rivers. The winter distribution within the bay was highly variable but was generally in lower and mid-bay areas (Fig. 21). As spring and summer progressed, sole distributed into the upper bay as well. Most stations accounted for good catches of English sole with greatest abundance occurring at Garibaldi Flat (D), 19.2 fish/set, and Pitcher Point Channel (R), 18.3 fish/set, for seine catches, and Larson Cove Flat (N), 11.2 fish/set for trawl catches (Fig. 22). Delta Flat (X) and Kilchis River (U) stations seemed to be poor areas for English sole.

English sole first appeared in Tillamook Bay as 20-30 mm juveniles in November and December (Fig. 23), and increased in abundance until June and July (Fig. 8). Emigration from the bay began in late summer and most were gone by November. A small portion, however, did not leave until late winter or early spring of their second year. These data agree with Westrheim's (1955) findings in Yaquina Bay. The occurrence of 20 mm fish from November through June may indicate a long spawning period for this species.

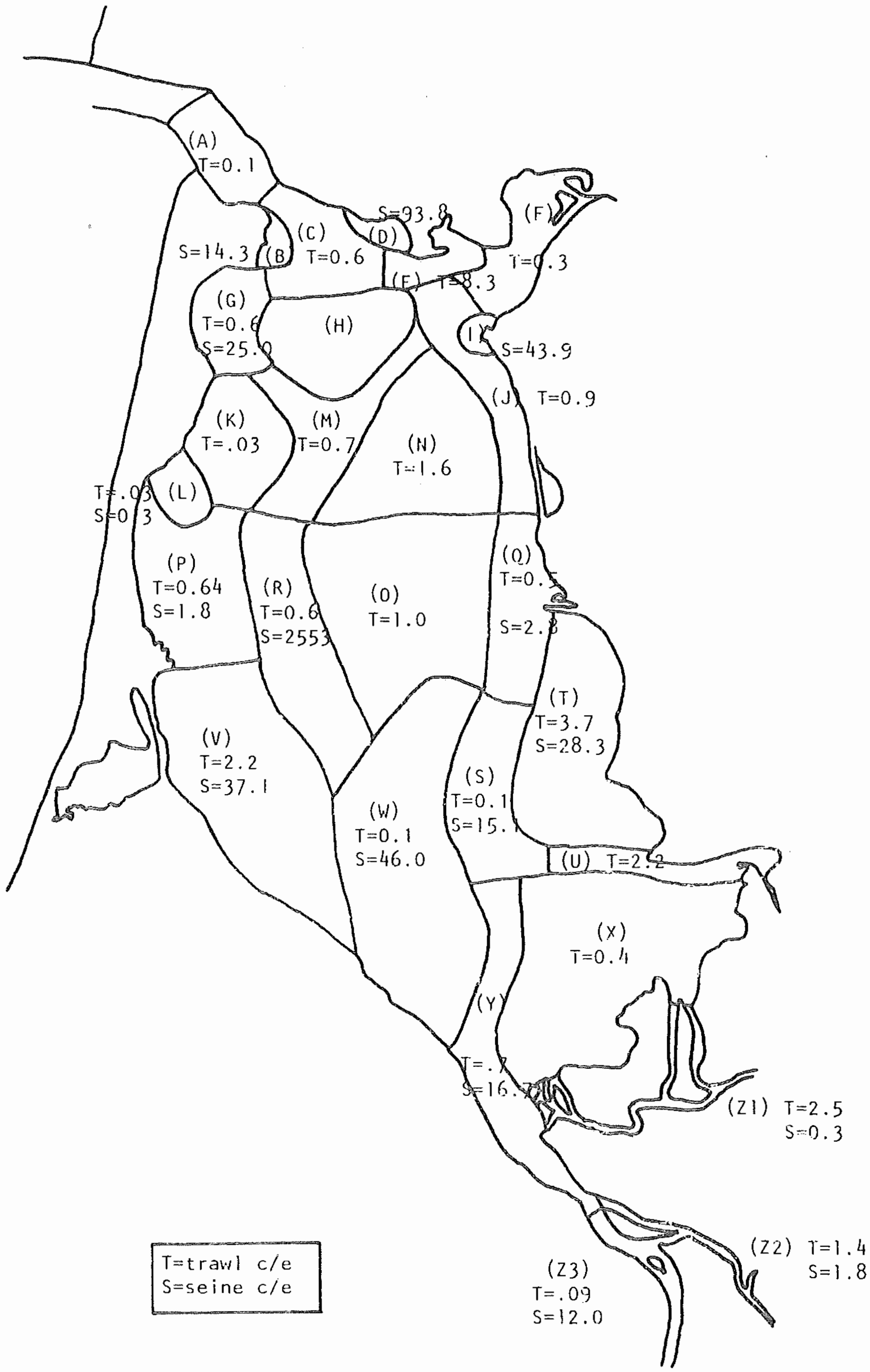

Fig. 16. Catch/set of shiner perch by sampling station in Tillamook Bay (2 years combined).

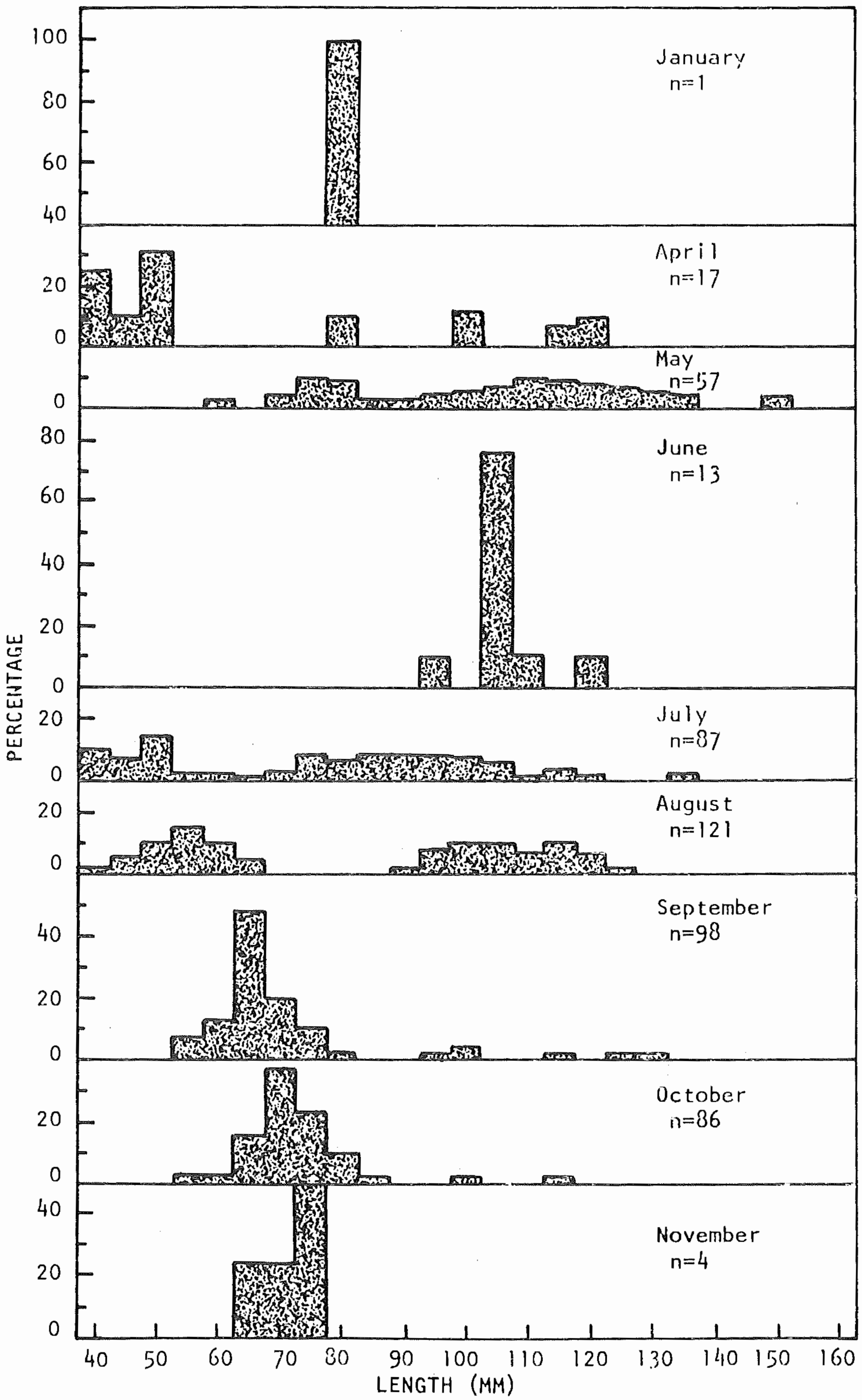

Fig. 17. Length frequency of shiner perch in Tillamook Bay.

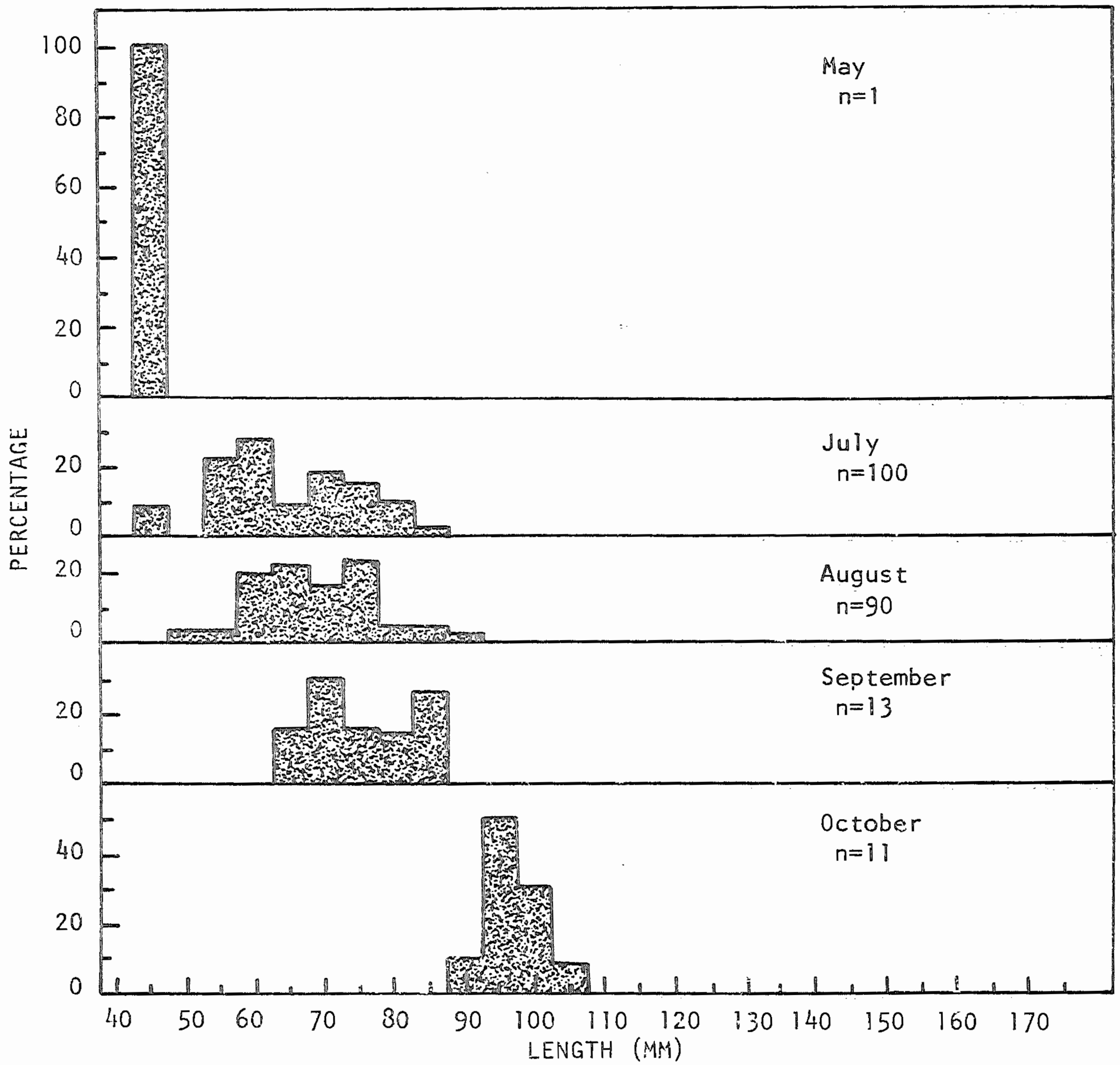

Fig. 18. Length frequency of Pacific herring in Tillamook Bay.

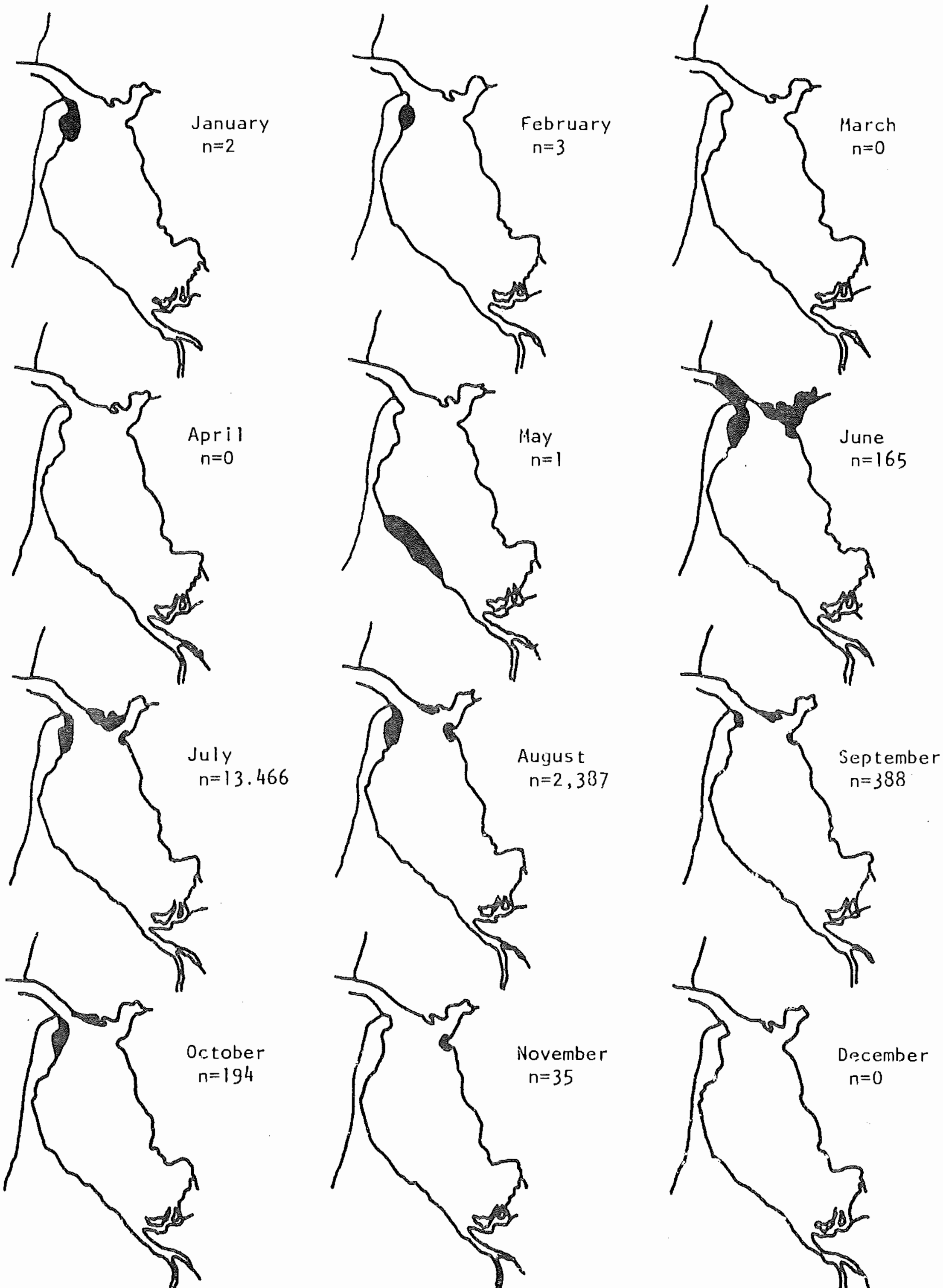

Fig. 19. Monthly catches and distributions of Pacific herring in Tillamook Bay (2 years combined).

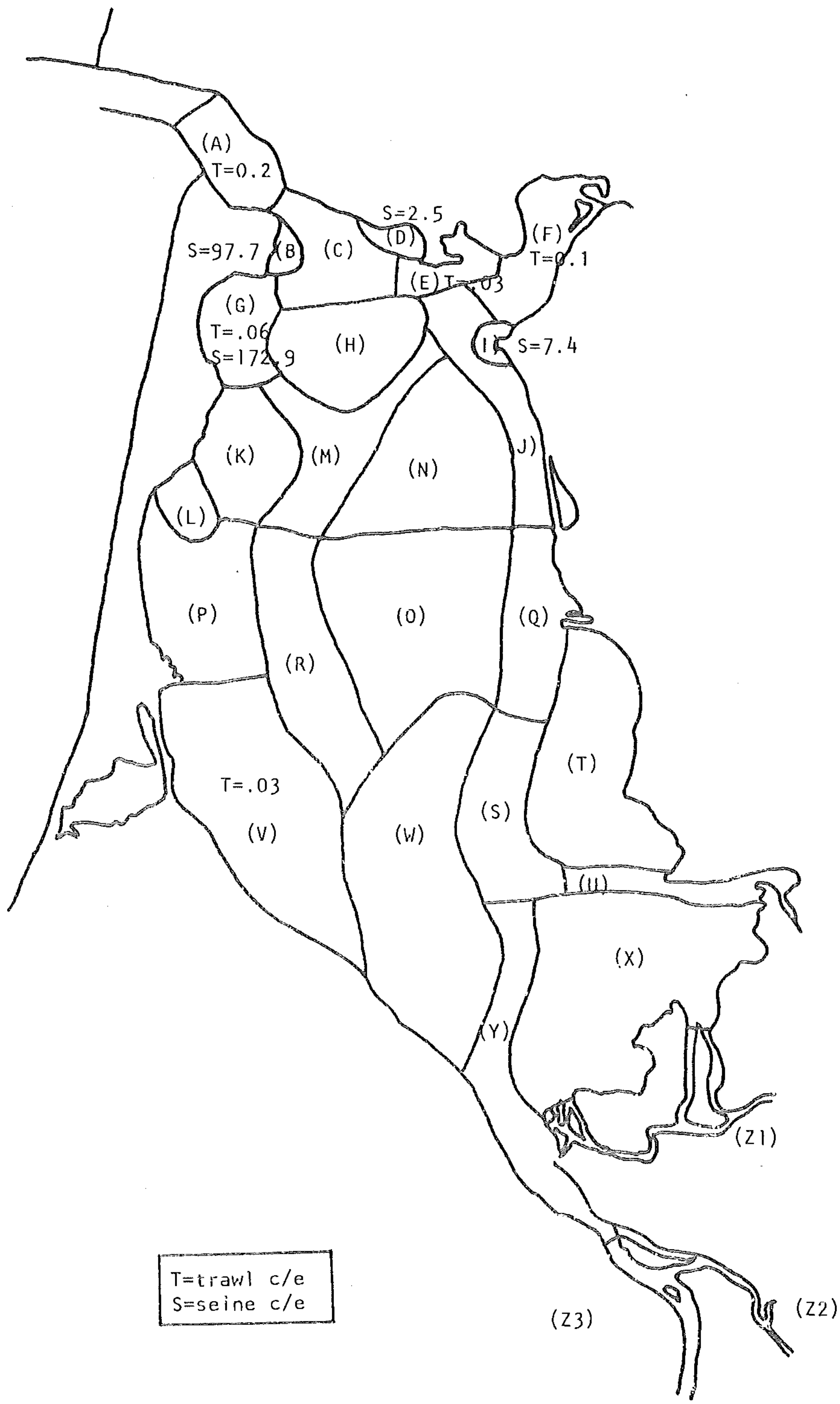

Fig. 20. Catch/set of Pacific herring by sampling station in Tillamook Bay (2 years combined).

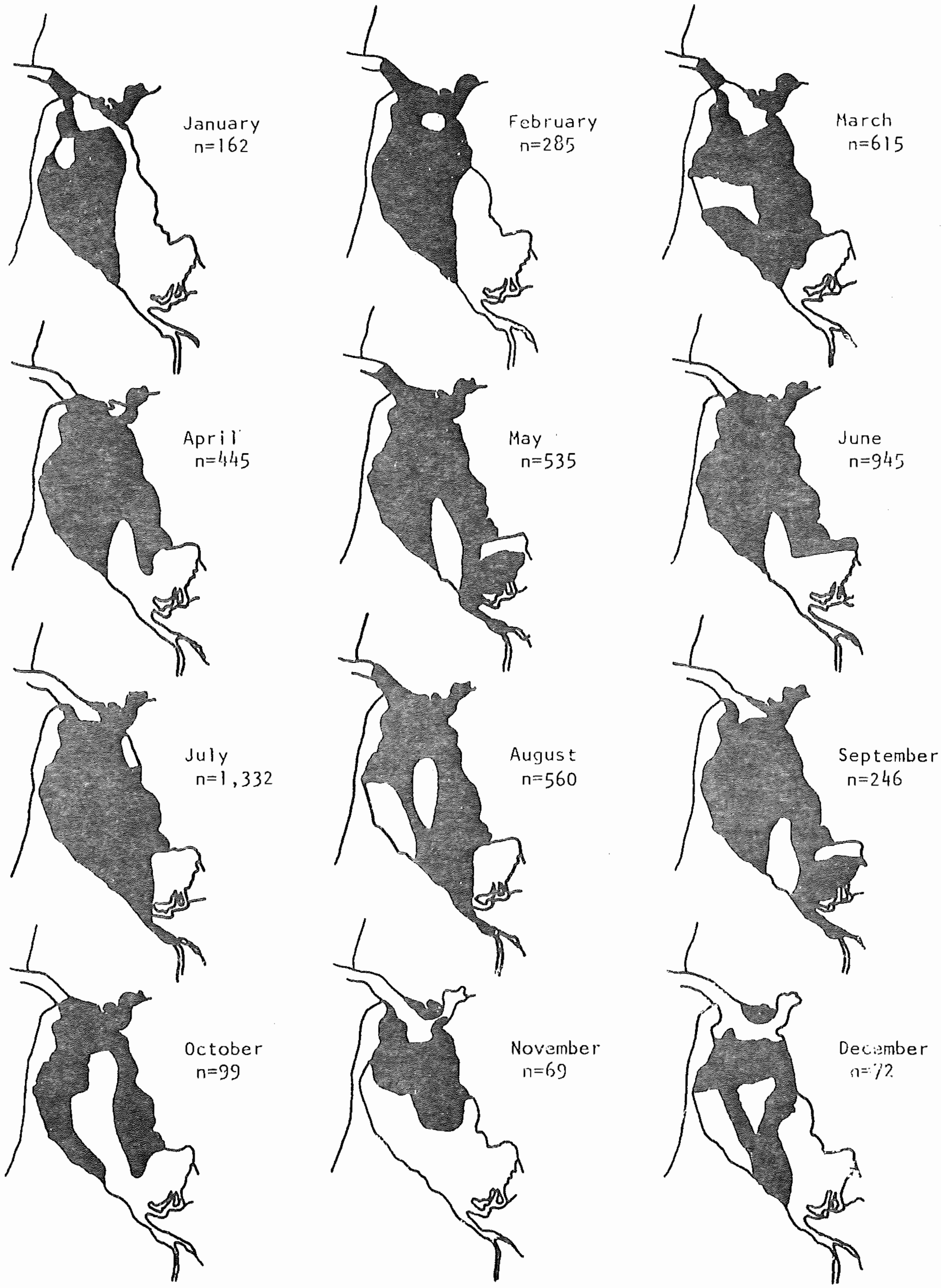

Fig. 21. Monthly catches and distributions of English sole in Tillamook Bay (2 years combined).

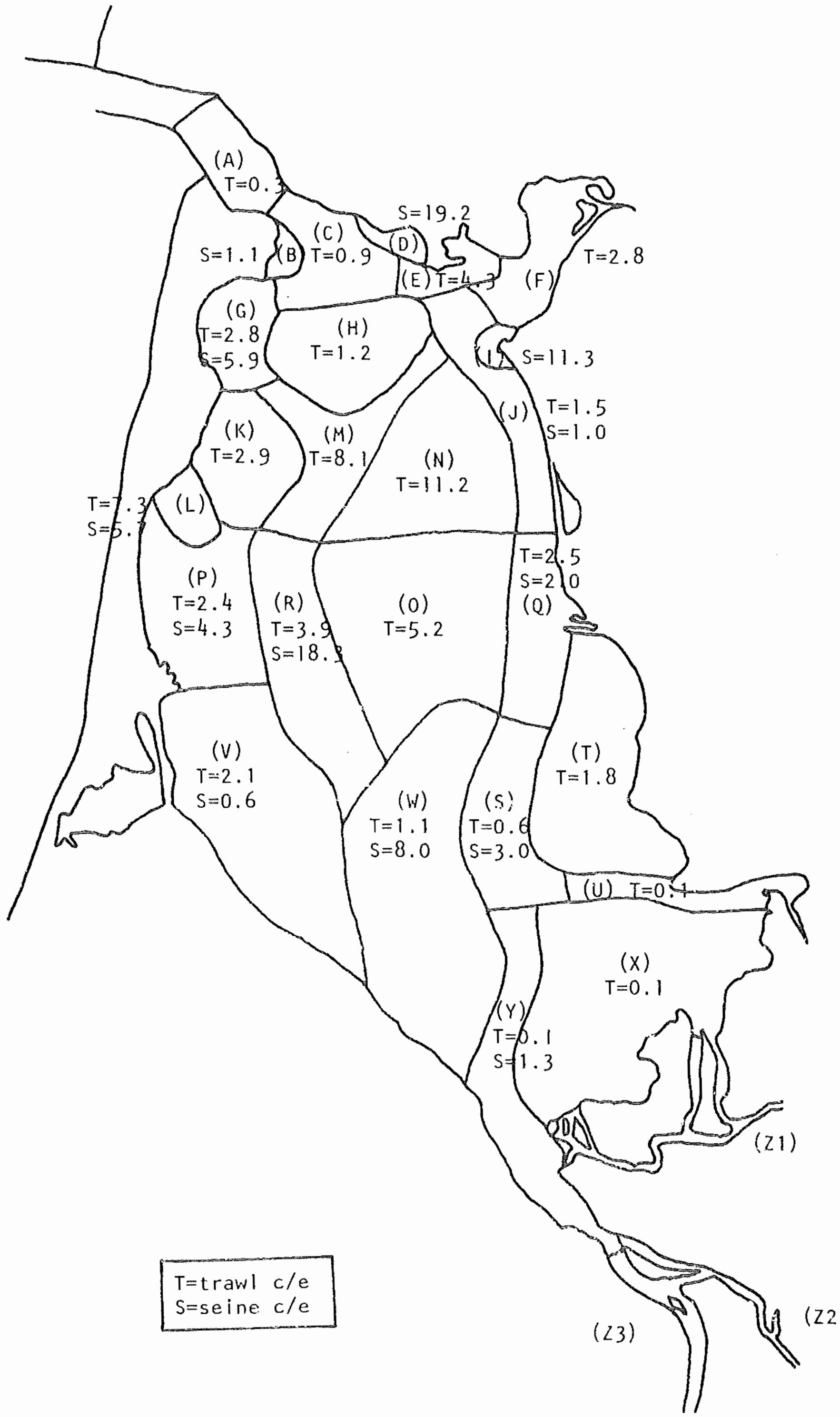

Fig. 22. Catch/set of English sole by sampling station in Tillamook Bay (2 years combined).

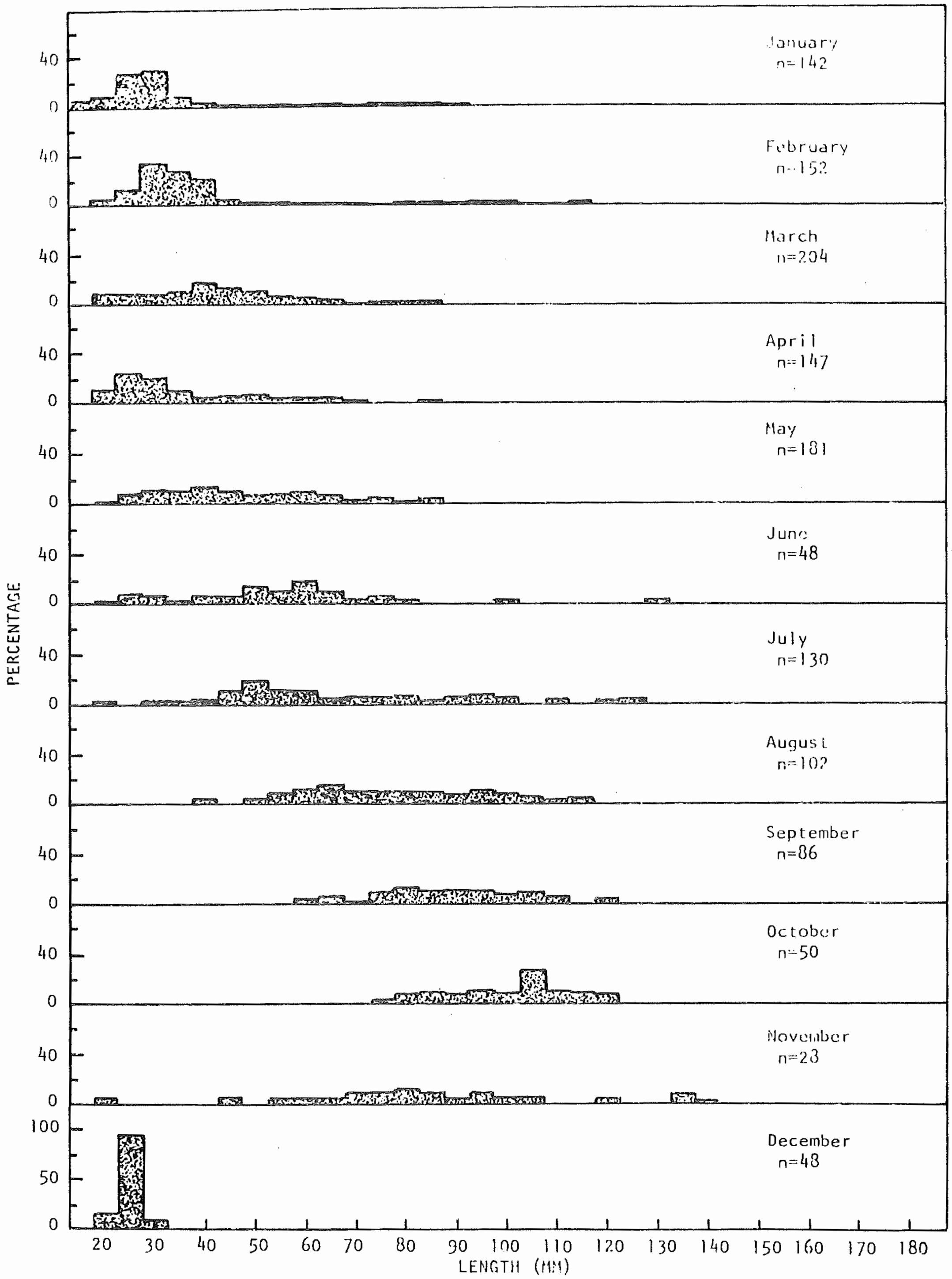

Fig. 23. Length frequency of English sole in Tillamook Bay.

Chinook salmon

The distribution of juvenile chinook salmon in Tillamook Bay varied during the year, but they generally were found in shoreline areas (Fig. 24). This distribution could have been influenced by gear in that the seine was the most effective and it only sampled the shoreline. The most productive areas for catching juvenile chinook were the rocky habitats of Hobsonville Point (I) and Kincheloe Point (B) with 31.5 and 25.2 fish/seine set, respectively, in the lower bay (Fig. 25).

Juvenile chinook were found in the bay beginning in June, peaked in July, and continued into November (Fig. 8). In August most of the fish ranged from 85 to 100 mm long; by November they ranged from 110 to 135 mm (Fig. 26).

Few chinook were caught in January and February, but two groups were represented. The first were newly emerged chinook, probably too weak to withstand the winter runoff or forced downstream for other reasons. These were probably the emergent fry that move directly downstream and into the ocean that Reimers (1973) refers to as Type-1 fish, and which generally do not contribute to adult returns. The other groups of juvenile chinook caught during January, February, and possibly March were larger, ranging in length from 130 to 180 mm. These may be either juvenile fall chinook of Type-5 (Reimers 1973) that remain in tributaries throughout the year and into the following spring; or they may be juvenile spring chinook salmon migrating to the ocean during their second spring.

The Oregon Department of Fish and Wildlife released approximately 169,000 fall chinook salmon fingerlings into Trask River tidewater on August 5, 1974, and another 120,000 smolts at the Trask River Hatchery on November 1, 1974. Some marked juvenile fall chinook salmon from the August release were captured in the lower bay only 2 days later. Catches indicated these fish remained in the bay for several months. We seined some juvenile chinook salmon, of those released from the hatchery in November, in the lower bay 4 days later. This group of fish had left the bay by December.

Adult fall chinook salmon began entering the bay in August. A 1974 angler survey (Cummings 1975) showed large numbers of fall chinook salmon in the lower bay, upper bay, and tidewater during September and October. By November, it appeared most adults had moved up through the bay and were in tidewater or the stream above.

Sportsmen begin to catch adult spring chinook salmon in May and catches usually peak in June (Gaumer, Demory, and Osis 1973).

Pacific staghorn sculpin

Although Pacific staghorn sculpin are not of any economic importance, they are an important food source for many other fish and wildlife. While not the most abundant fish species caught, they were one of the most frequently caught. They inhabited every station from the rivers to the bay entrance at some time during each year (Fig. 27). The most productive areas seemed to be the tide flats rather than the channels. Rocky Point Flat (W) was the most productive

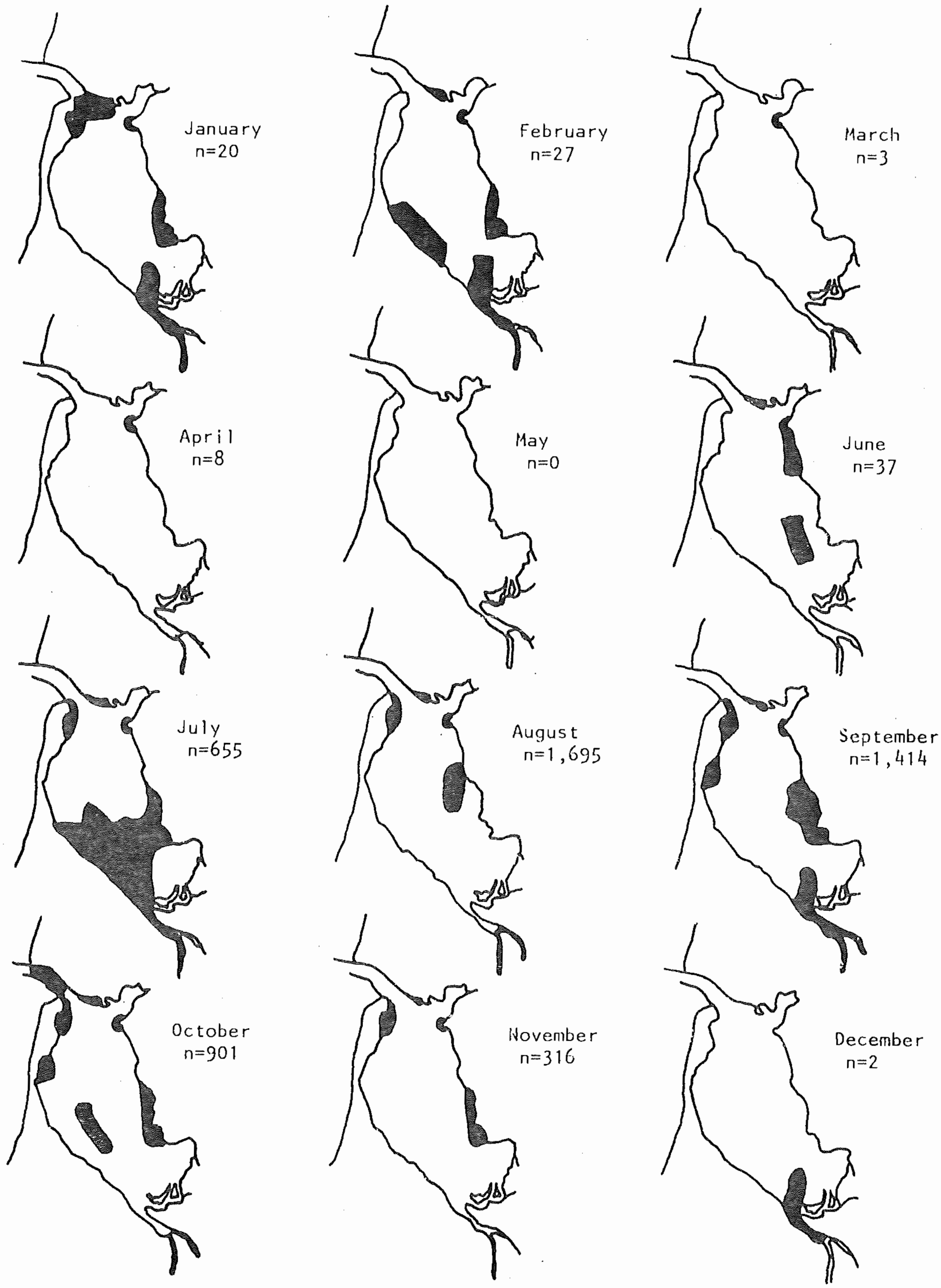

Fig. 24. Monthly catches and distributions of chinook salmon in Tillamook Bay (2 years combined).

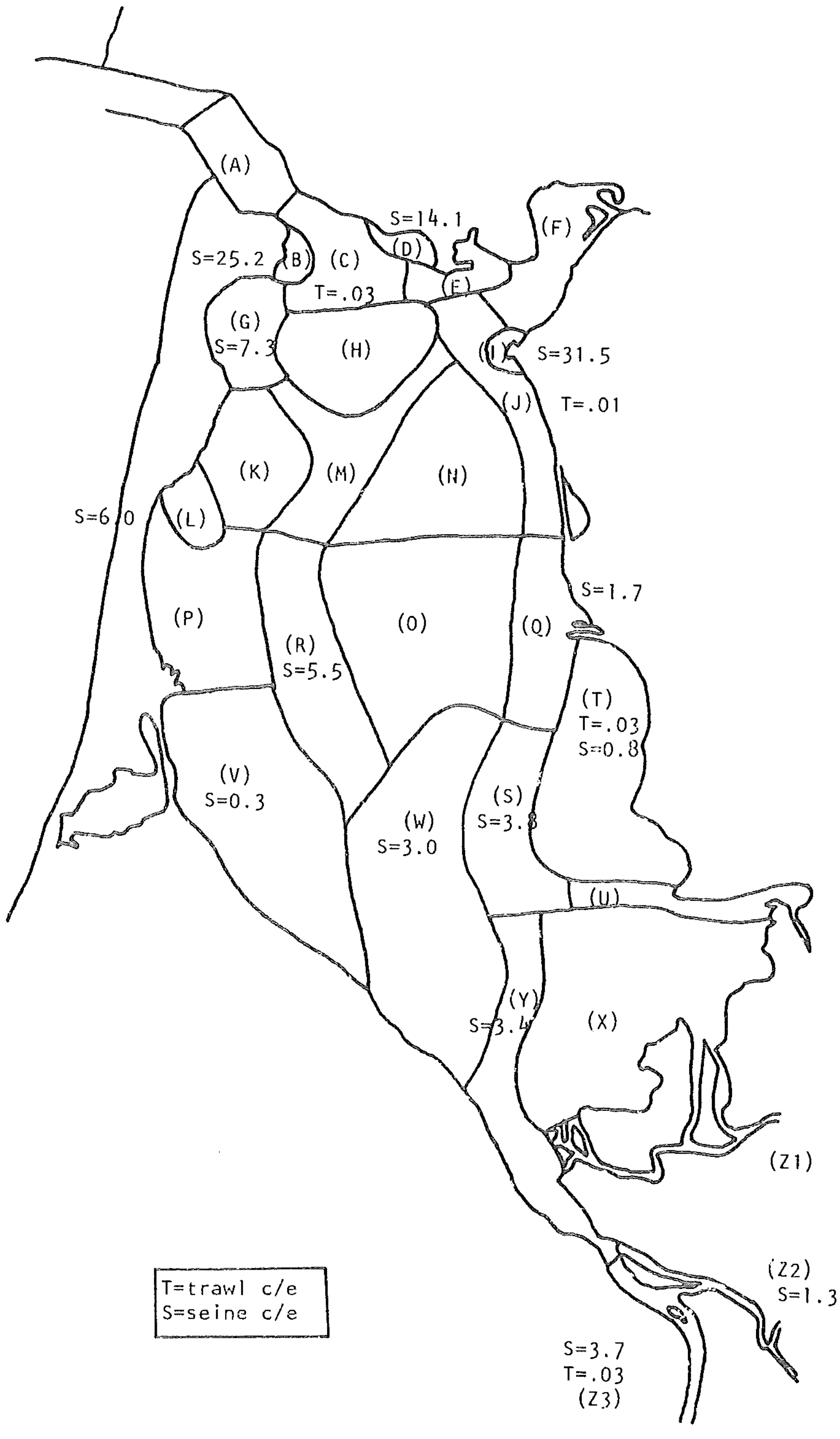

Fig. 25. Catch/set of chinook salmon by sampling station in Tillamook Bay (2 years combined).

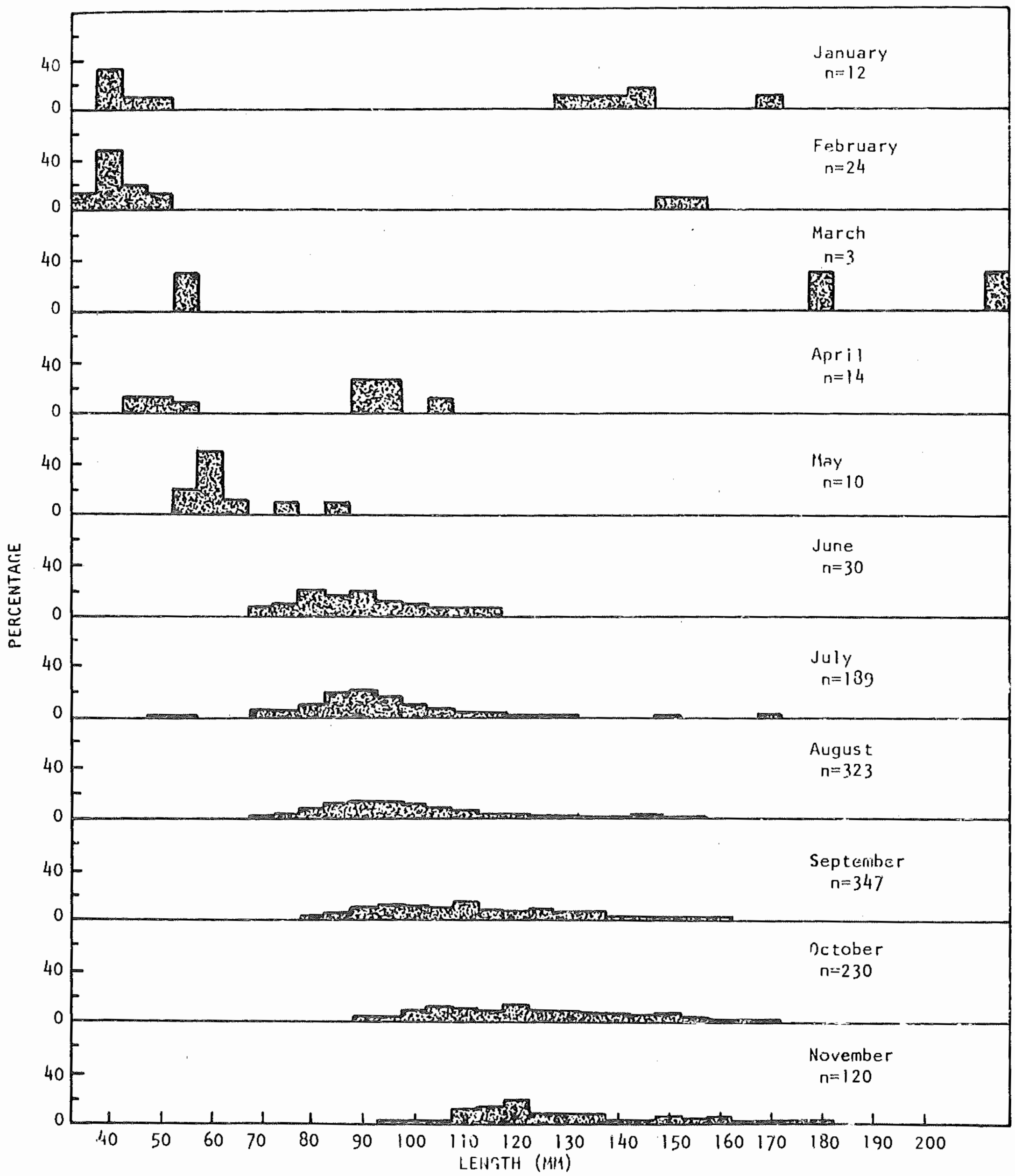

Fig. 26. Length frequency of chinook salmon in Tillamook Bay.

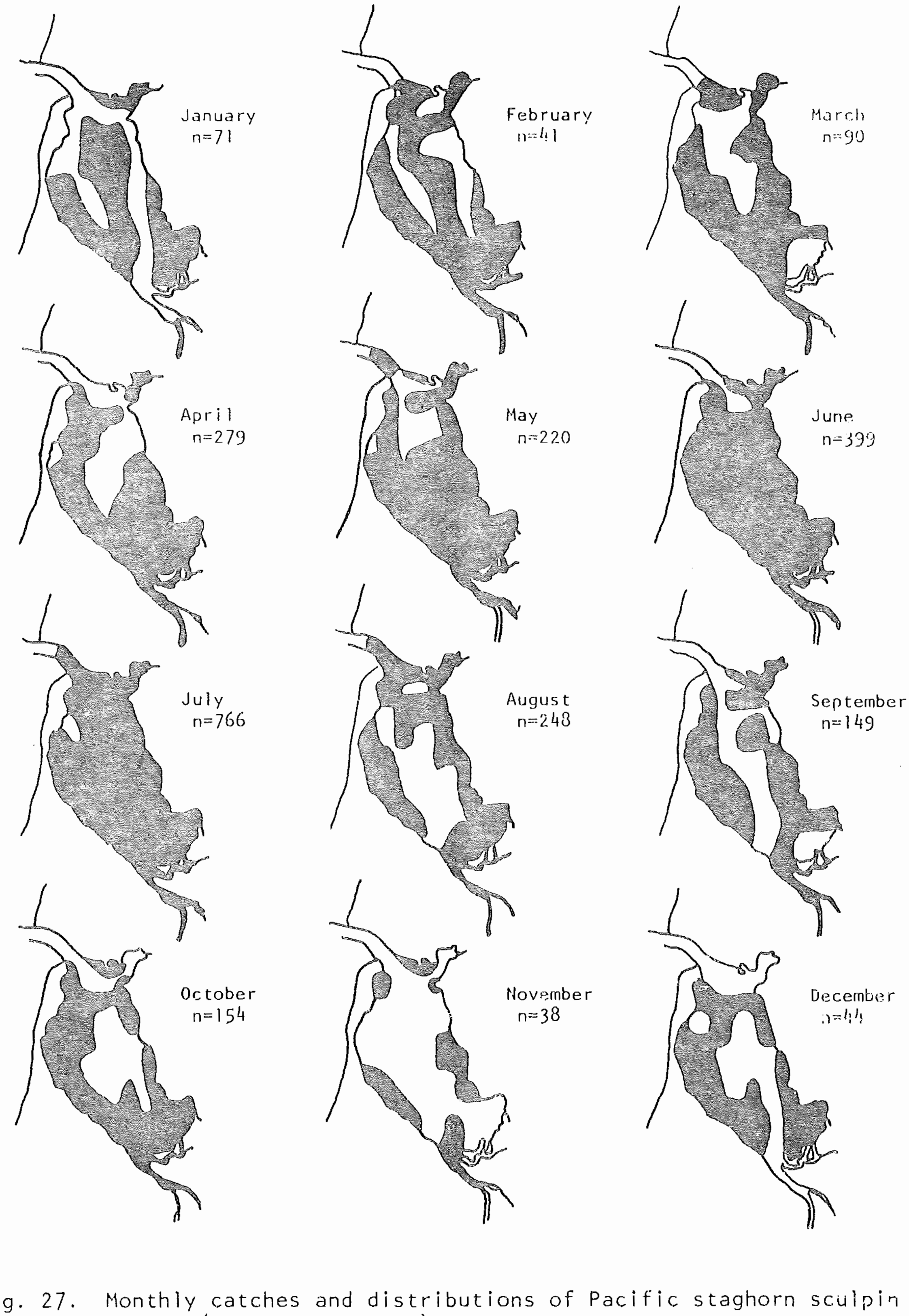

Fig. 27. Monthly catches and distributions of Pacific staghorn sculpin in Tillamook Bay (2 years combined).

for the seine with an average of 42.8 fish/set, and trawling at Goose Point (T) accounted for nearly 4 fish/set (Fig. 28).

Pacific staghorn sculpin, like most of the species caught, were most abundant during the summer months (Fig. 8). Catches peaked in July and were lowest from November through February.

Spawning must have taken place sometime in the late fall since the first juveniles appeared in December at a length of 20 to 45 mm (Fig. 29). Some juveniles were caught in the bay throughout the year. Although some adults also inhabited the bay throughout the year, most appeared to enter in July and stay until the end of November.

Starry flounder

Starry flounder were caught at every station in Tillamook Bay except at Buoy 8 (A). They were most consistently caught in upper bay stations (Fig. 30). In three areas, Dick Point (Y), Tillamook River (Z3), and Trask River (Z2), they were caught during every month of the year. Tillamook, Trask, and Wilson rivers (Z1) provided the best trawl catches with as many as six fish/set (Fig. 31). Another upper bay area, Rocky Point Flat (W), was the most productive for the seine with 9.8 flounder/set.

Seasonally, starry flounder were most abundant in the summer and fall (Fig. 8). Catches peaked in July for both seine and trawl.

Catches were predominantly juveniles throughout the sampling period. Adults were concentrated in the down-bay seine areas. In the 1972 resource survey, recreational fishermen caught most of their adult starry flounder in the spring along the Ghost Hole shoreline (Gaumer, Demory, and Osis 1973).

Rockfish

Juvenile rockfish (*Sebastes* sp.) of unidentified species were caught from June through November in lower and mid-bay areas (Fig. 32); none were taken in the other months. Abundance peaked in July (Fig. 8). We believe these fish were either black or blue rockfish, but positive identification was not possible. The juveniles rearing in the bay during these summer months ranged in length from 50 to 80 mm (Fig. 33). Areas with cobble or shell were the main sites of capture, although the Deep Hole (1) and Larson Cove Flat (N) were also occupied consistently. Rockfish were caught best in the seine at Kincheloe Point (B) with 10.7/set and in the trawl at the Boat Basin (E) with 0.3/set (Fig. 34).

Sport fishermen caught adult black rockfish from March through October (Gaumer, Demory, and Osis 1973). They caught adults mostly on the north jetty during this period, but some were caught as far up bay as the Ghost Hole shoreline in June and July. Anglers also caught blue rockfish on the north jetty. We saw many schools of both black and blue rockfish adults during the spring and summer while scuba diving along the jetties.

From our observations, adult rockfish had not taken up residence in the bay except along the jetty rocks in the extreme lower bay. An experimental

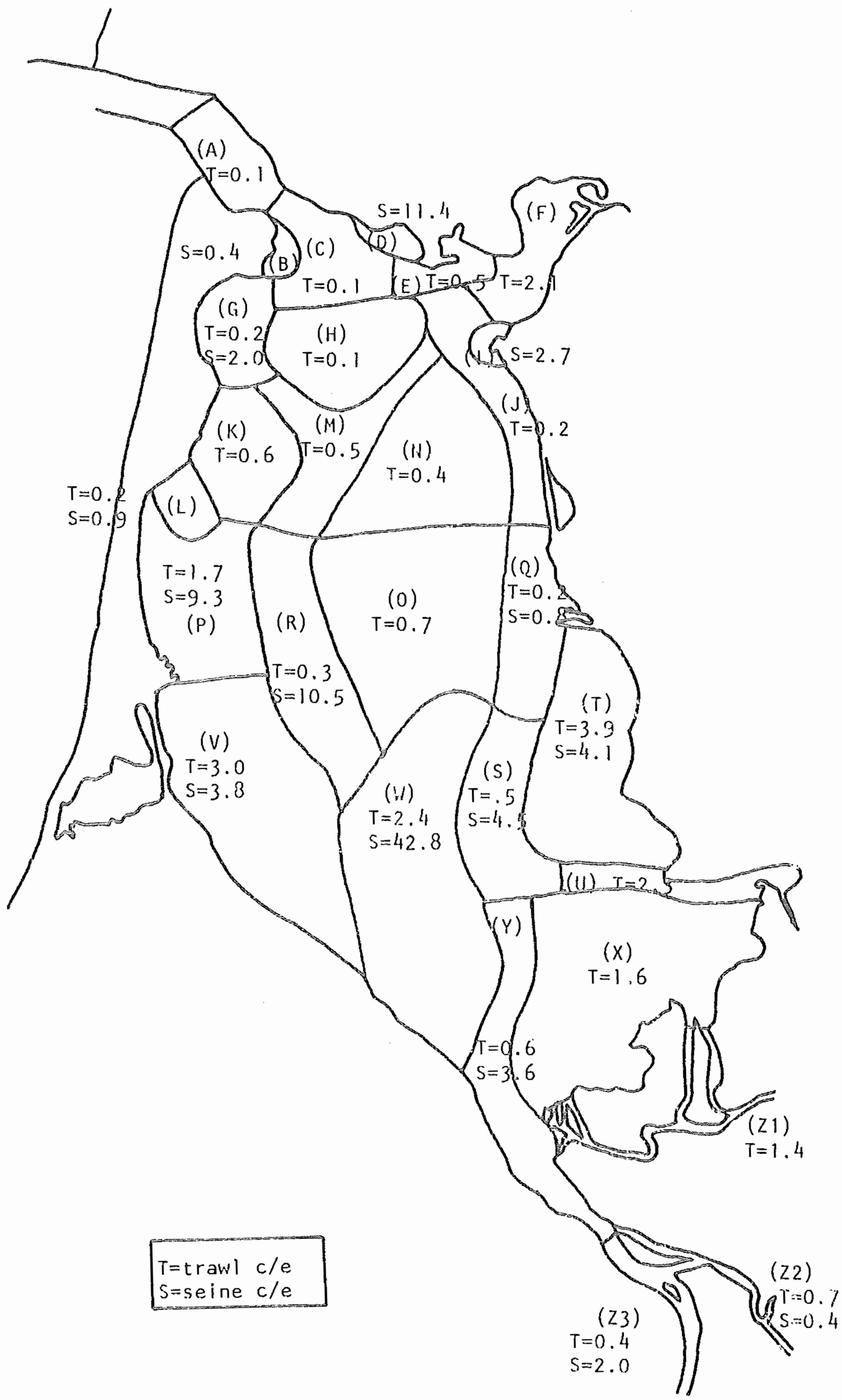

Fig. 28. Catch/set of Pacific staghorn sculpin by sampling station in Tillamook Bay (2 years combined).

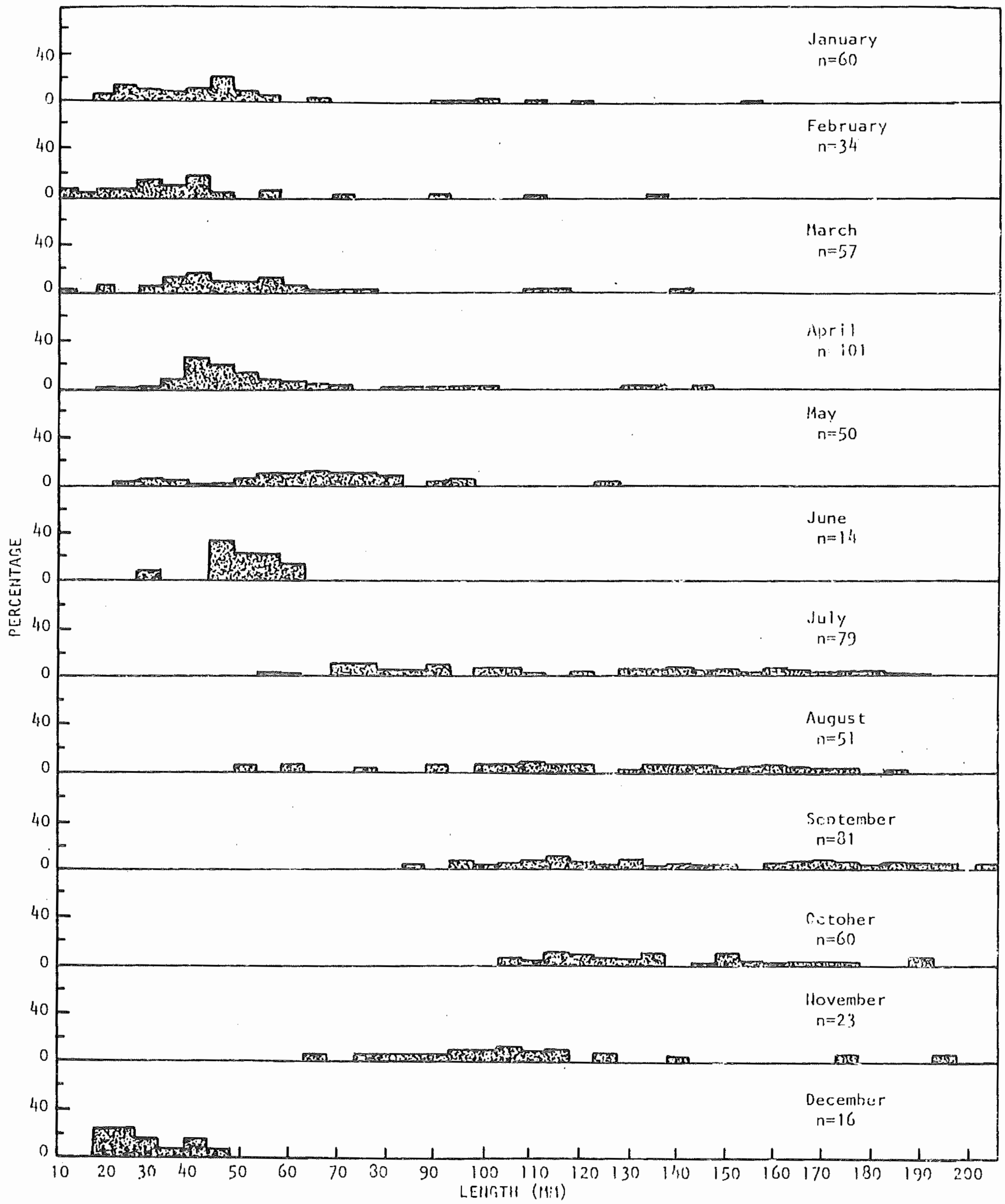

Fig. 29. Length frequency of staghorn sculpin in Tillamook Bay.

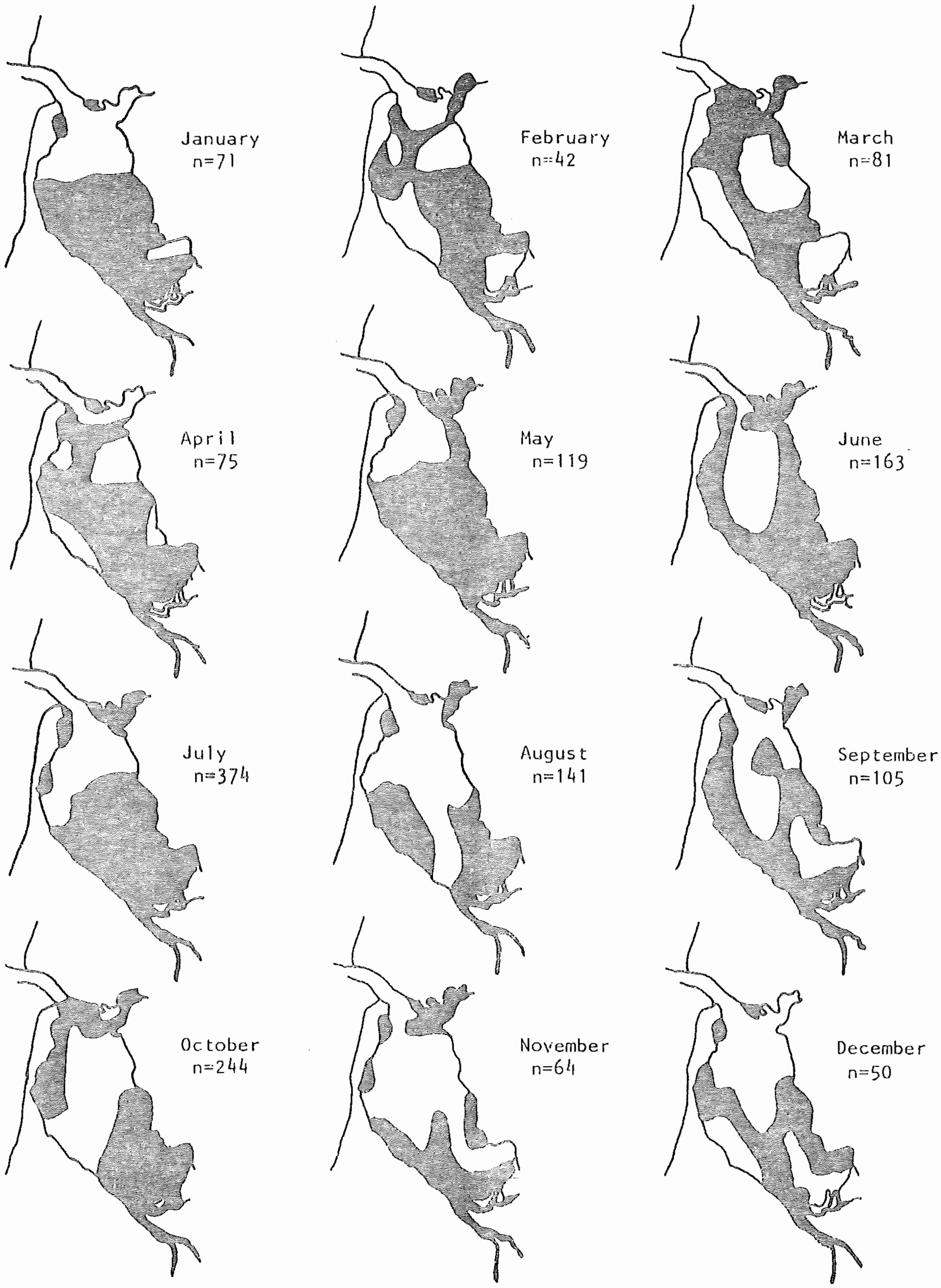

Fig. 30. Monthly catches and distributions of starry flounder in Tillamook Bay (2 years combined).

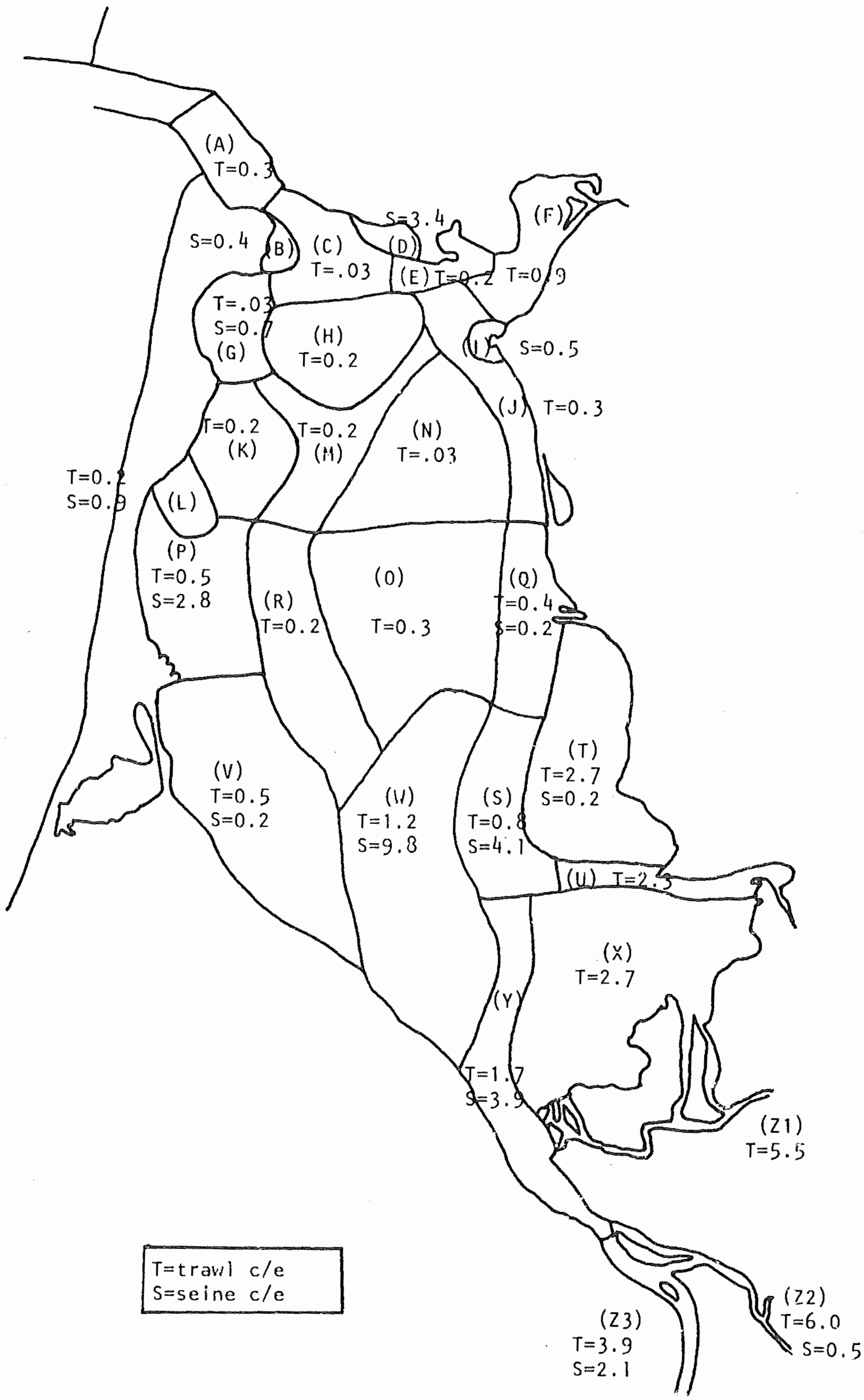

Fig. 31. Catch/set of starry flounder by sampling station in Tillamook Bay (2 years combined).

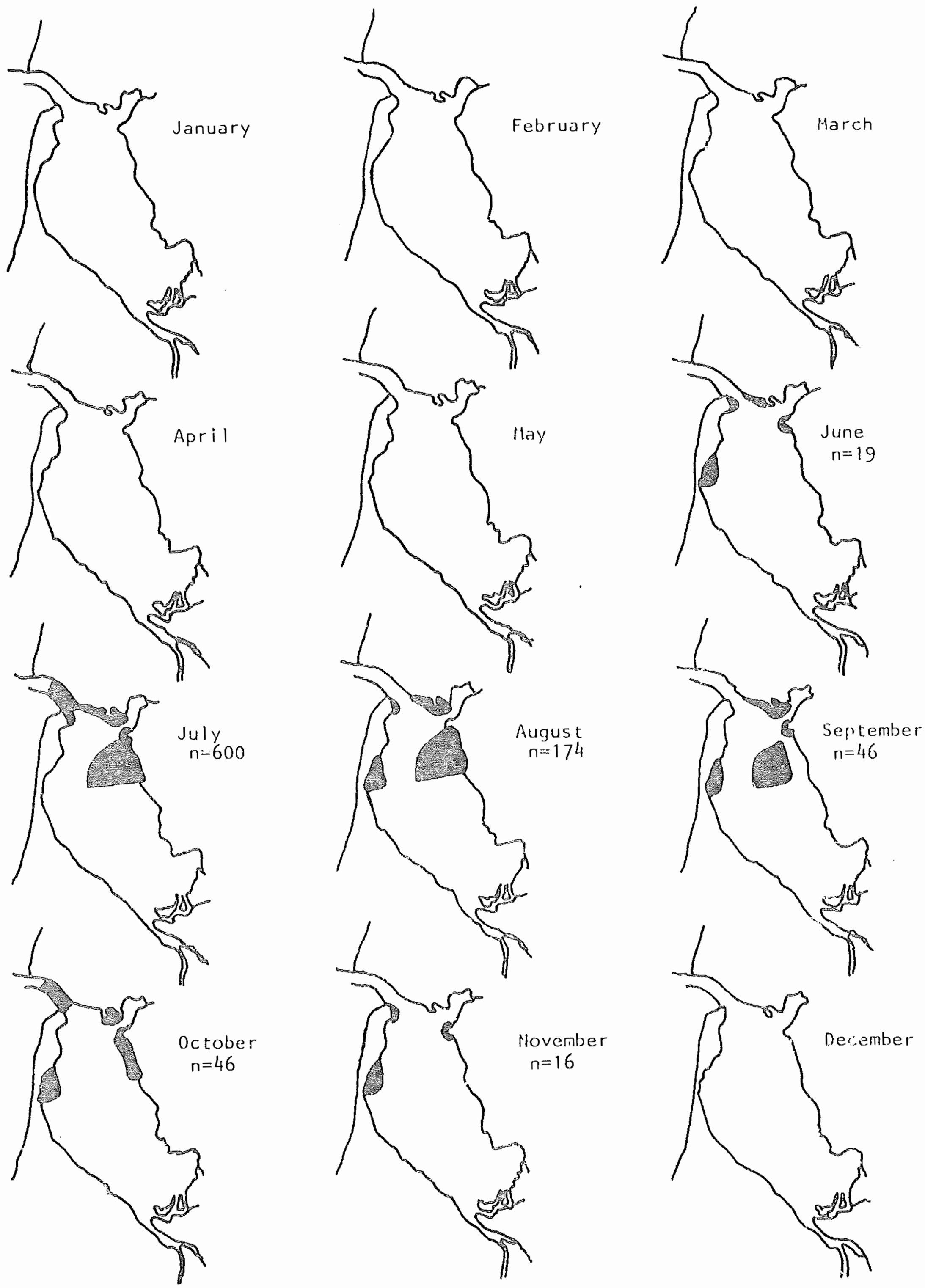

Fig. 32. Monthly catches and distributions of juvenile rockfish in Tillamook Bay (2 years combined).

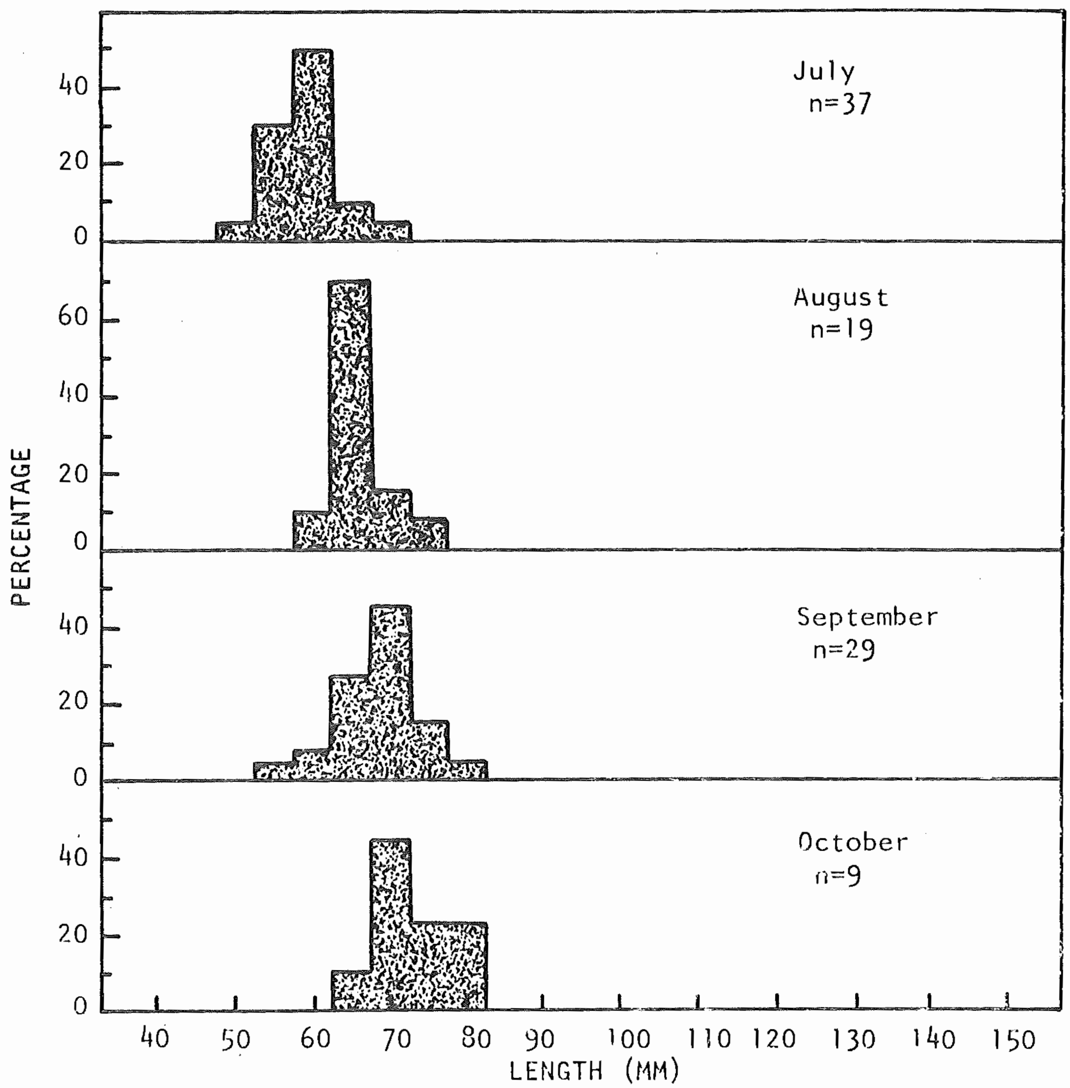

Fig. 33. Length frequency of chum salmon in Tillamook Bay.

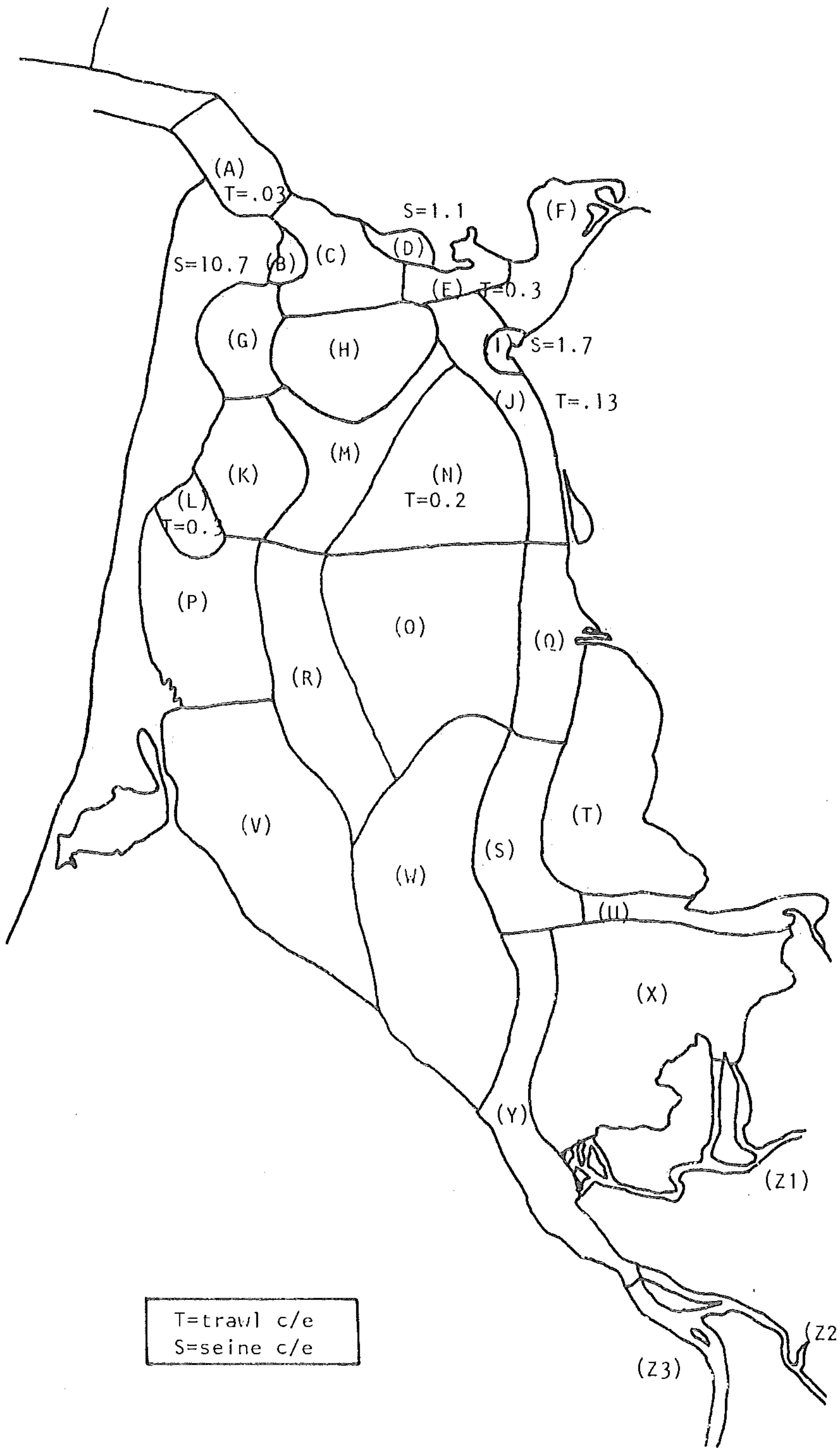

Fig. 34. Catch/set of rockfish by sampling station in Tillamook Bay (2 years combined).

artificial reef of old tires was placed in the Deep Hole in an effort to provide the juveniles, known to inhabit that area, with a permanent residence.

Chum salmon

Juvenile chum salmon migrated through the bay to the ocean from February until July using the main channel and the shoreline areas (Fig. 35). The most productive area was Dolphin #2 (S) with 10.3 fish/seine set (Fig. 36). Although more fish were caught in April, catch/effort indicated abundance peaked during May (Fig. 8). These juveniles grew substantially during their emigration; modal length increased from 40 mm in February to 65 mm in June (Fig. 37).

Only four adult chum salmon were caught during the normal fall spawning migration. All were caught in November with either the seine or the gill net.

Saddleback gunnel

Saddleback gunnel was another of the common species that has no economic importance. They were distributed throughout the estuary from the lower bay to the rivers. During the winter and early spring they tended to inhabit lower and mid-bay areas, and during the summer and fall, they extended their distribution into the lower portions of the rivers (Fig. 38). The most productive areas appeared to be eel grass, especially Larson Cove Flat (N), with 2.1 fish/trawl set (Fig. 39). It was the only species examined for catch/effort where the trawl had higher values than the seine. Although saddleback gunnel inhabited the bay during an entire year, they were most abundant during summer and early fall months (Fig. 8).

Environmental Relationships

Salinity and temperature

Salinity seemed to have an influence on some species while not on others. Pacific herring and surf smelt were found in relatively high salinities (Fig. 40). Juvenile chinook salmon, migrating from the rivers to the ocean, seemed to prefer high salinities while holding in the estuary. On the other hand, juvenile chum salmon, making the same fresh- to saltwater migration, appeared to make the transition by holding in lower salinity water for a short time. Starry flounder is another species that apparently prefers low salinities. The other species examined did not appear to have any salinity preference and were caught in high as well as low salinities. Trawl-caught Pacific staghorn sculpin and English sole, however, showed slight preferences for fresh and saltwater, respectively.

Water temperature may have been the controlling influence for those species that did not exhibit a salinity preference (Fig. 40). For the 10 species examined, fish appeared to prefer water temperatures above 12.8 C. The notable exception was chum salmon which were found in greater numbers between temperatures of 7.4 and 13.3 C.

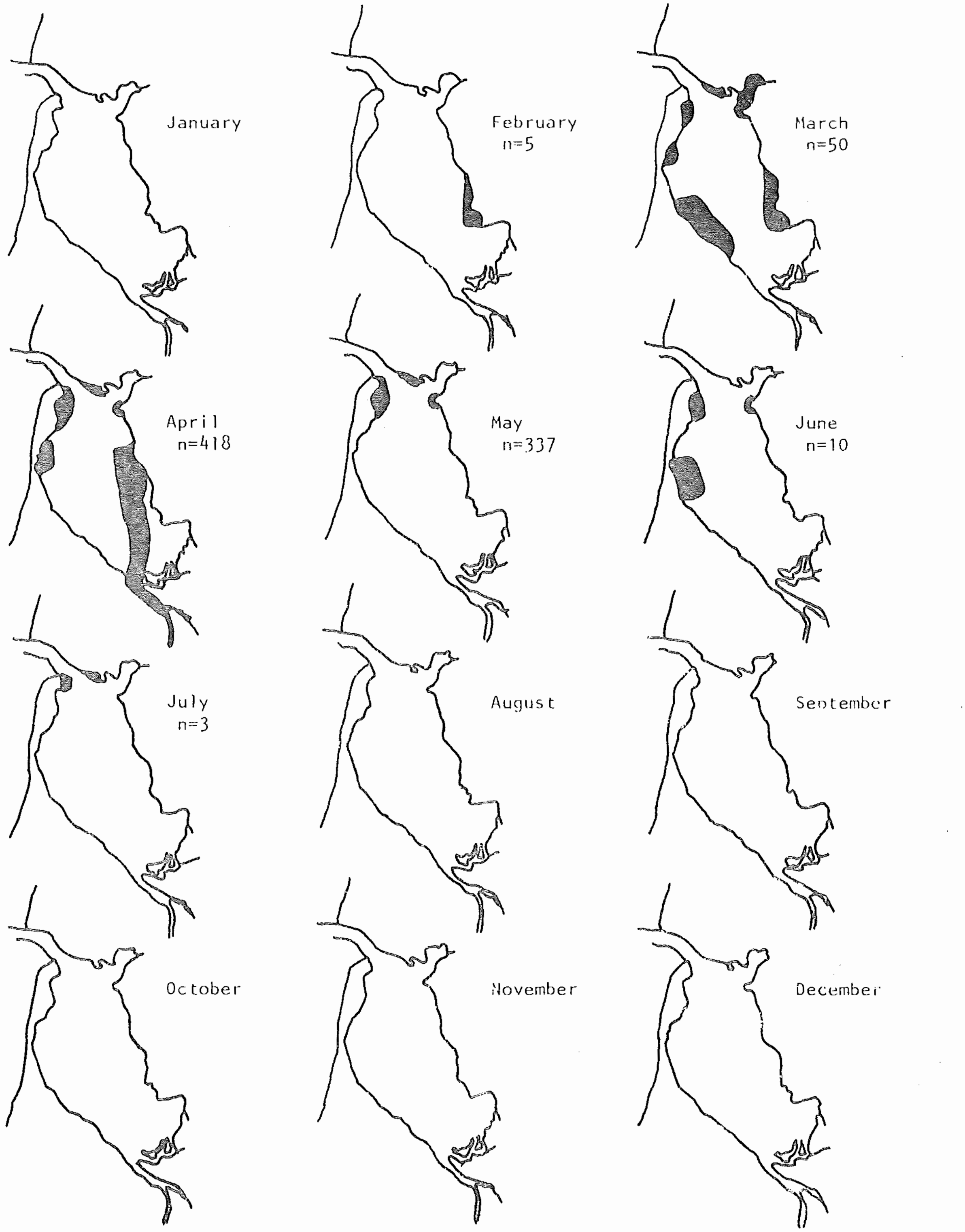

Fig. 35. Monthly catches and distributions of chum salmon in Tillamook Bay (2 years combined).

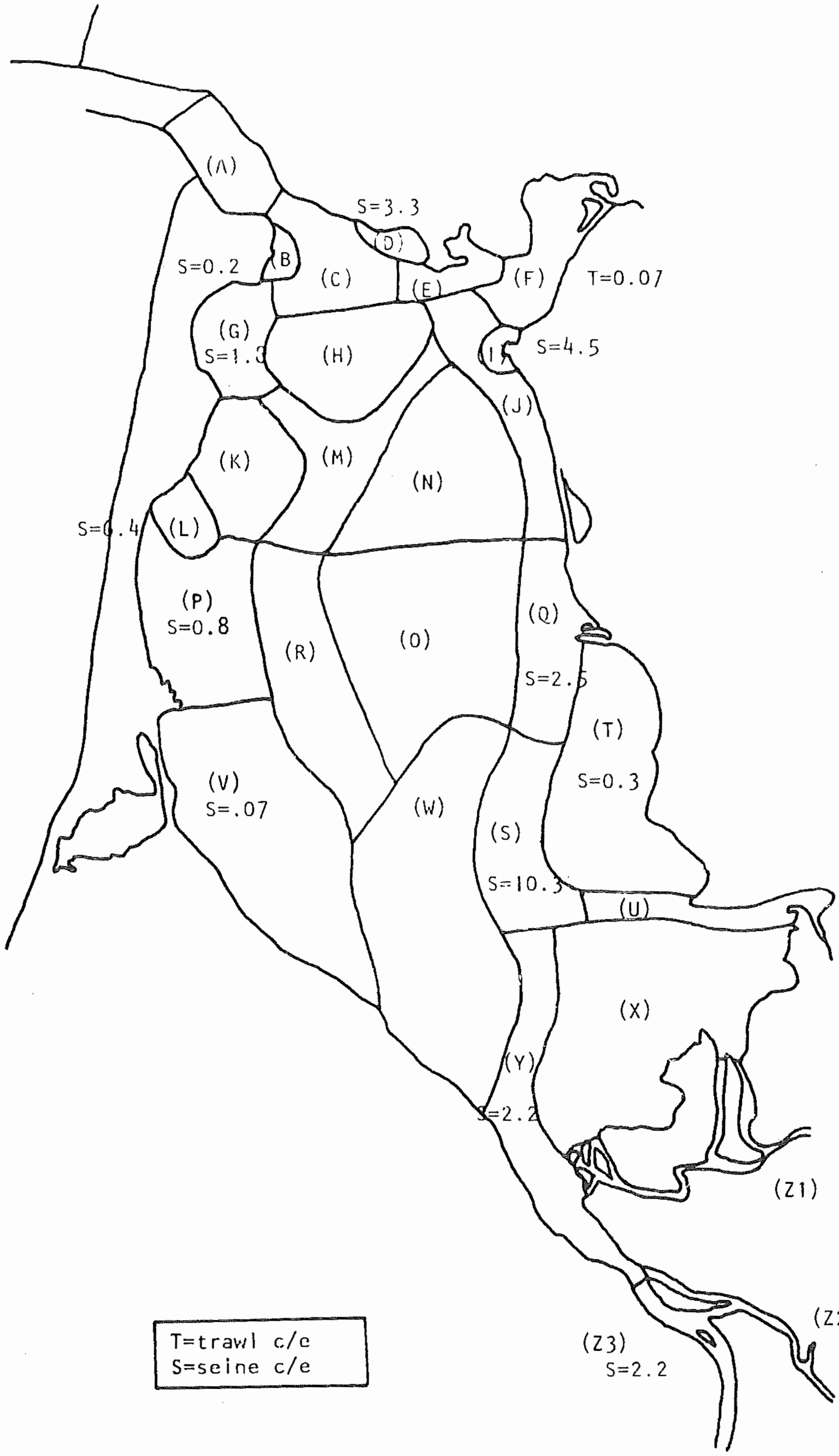

Fig. 36. Catch/set of chum salmon by sampling station in Tillamook Bay (2 years combined).

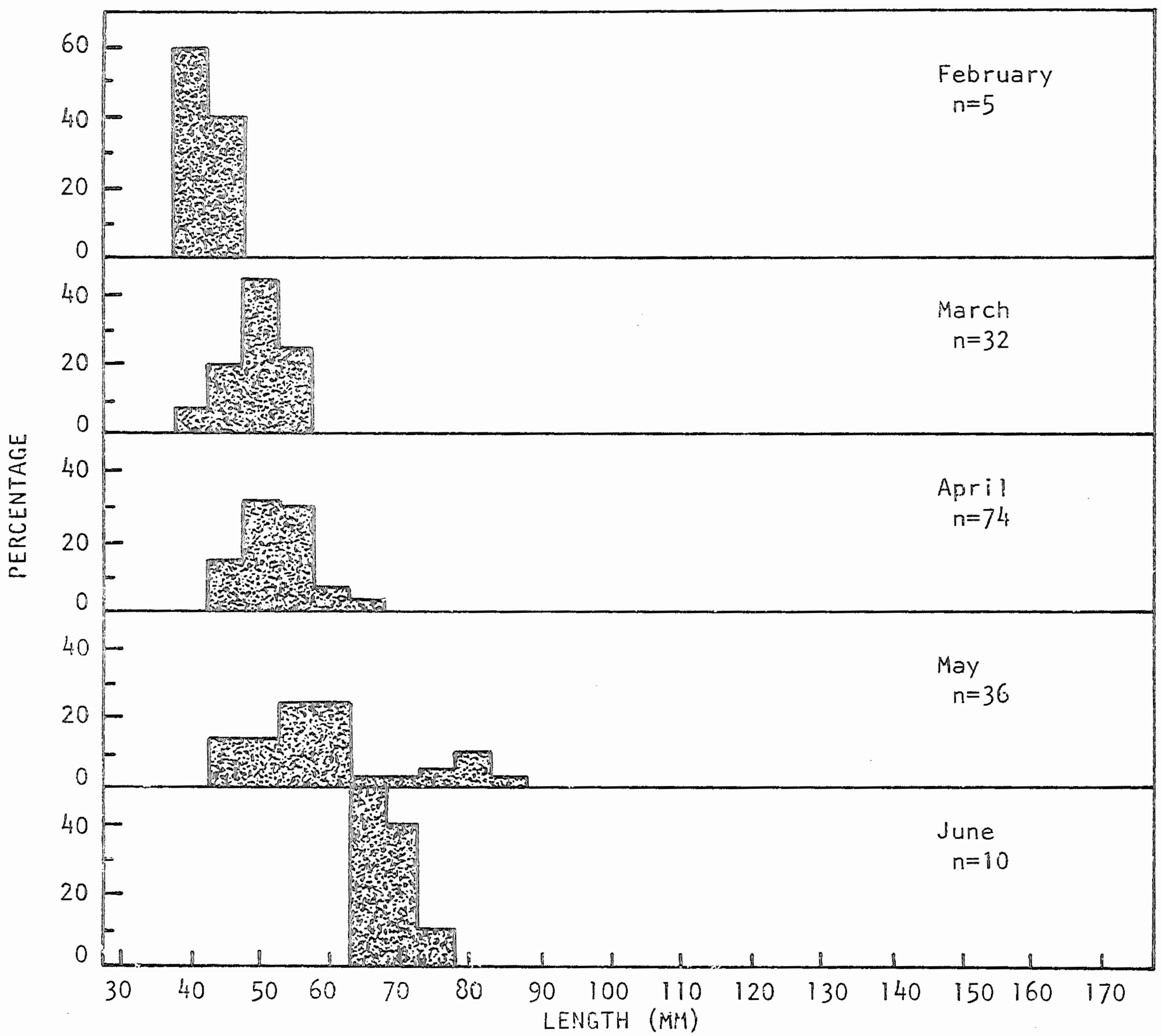

Fig. 37. Length frequency of chum salmon in Tillamock Bay.

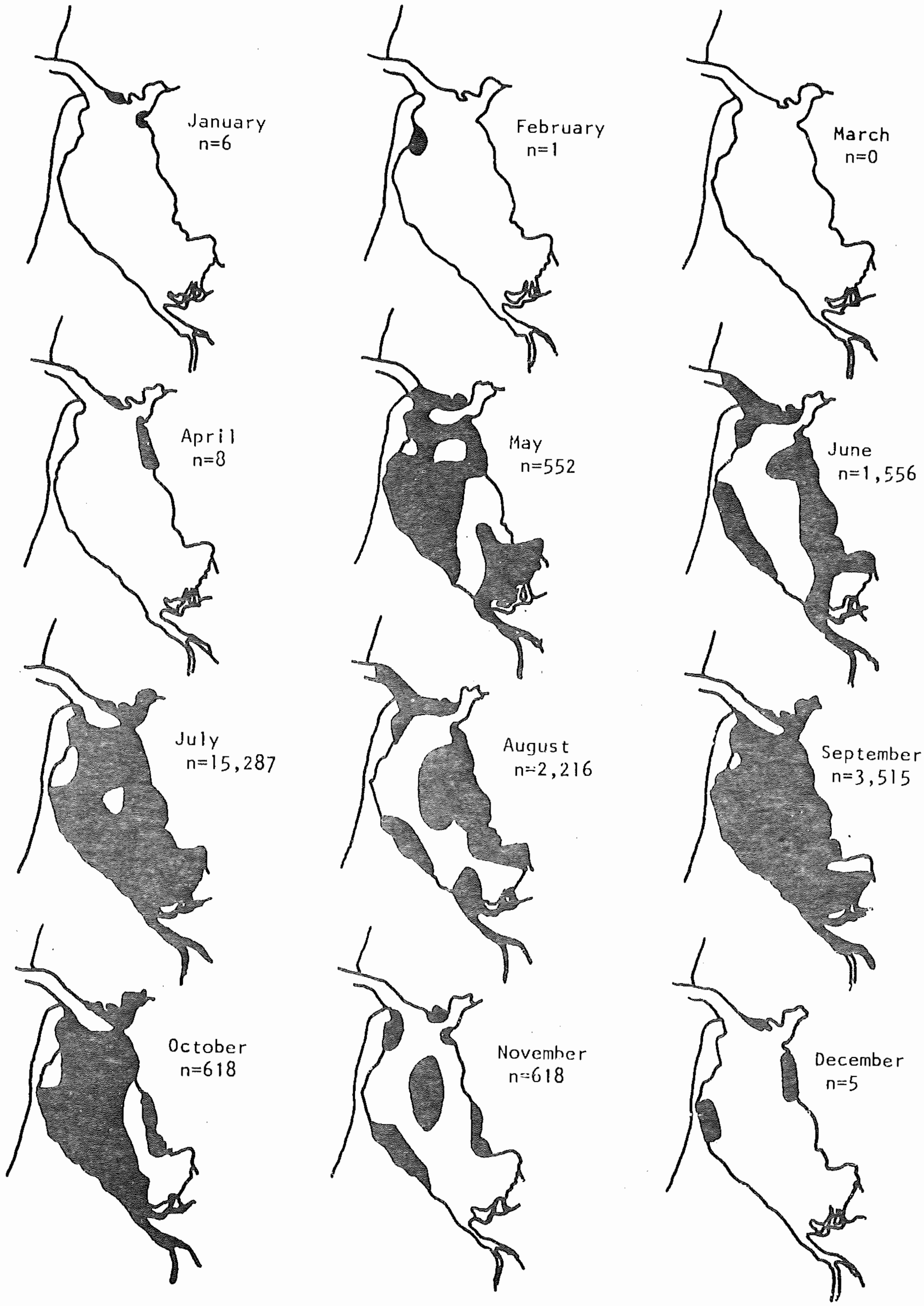

Fig. 38. Monthly catches and distributions of saddleback gunnel in Tillamook Bay (2 years combined).

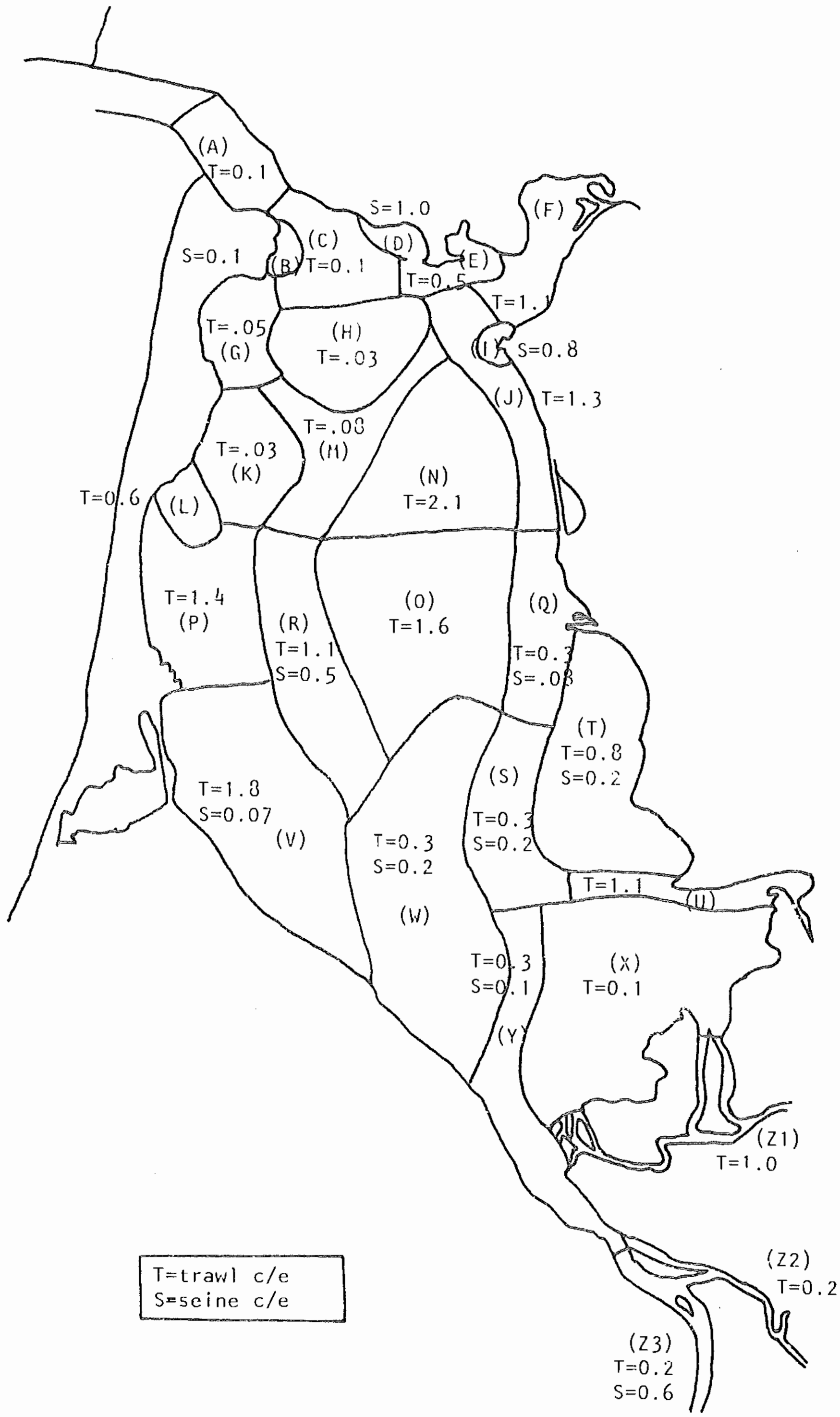

Fig. 39. Catch/set of saddleback gunnel by sampling station in Tillamook Bay (2 years combined).

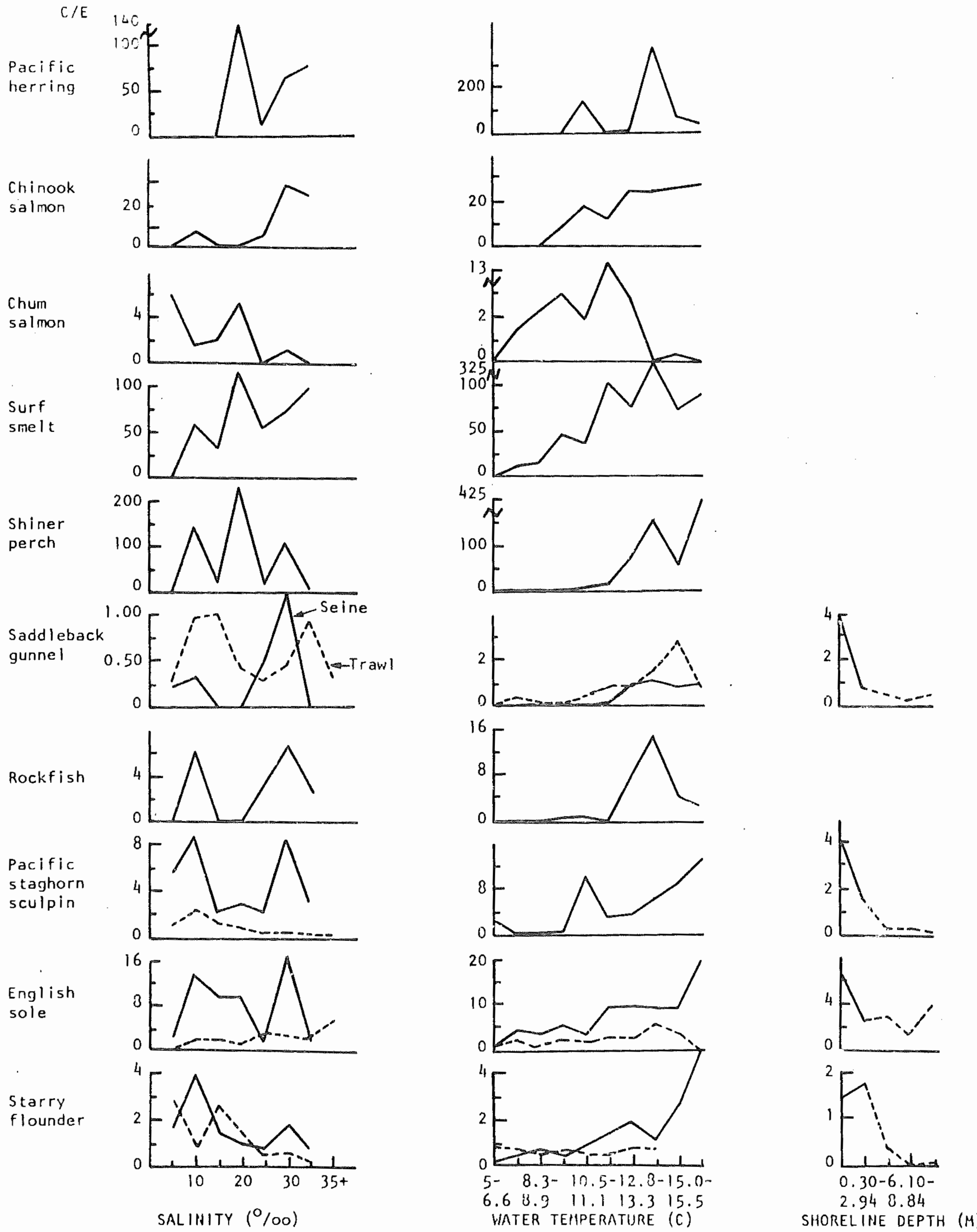

Fig. 40. Species distribution by salinity, water temperature, and depth.

Depth

It was difficult to examine depth as a factor affecting fish distribution. The major species were generally caught most efficiently by the seine which only sampled the shoreline. Three of the four species examined showed a preference for shoreline areas although this may still be just a reflection of gear type (Fig. 40). Starry flounder showed a preference for shallower areas also, although not shoreline areas. English sole was the only species examined that was caught at the greatest depths in any abundance.

Substrate type

As described earlier, there were six substrate types in the study area (Fig. 41). Each of the major fish species was examined to determine if it preferred a given substrate. Trawl and seine catches were again analyzed separately. Sandy shoreline habitats were preferred areas for Pacific herring, starry flounder, saddleback gunnel, and English sole (Fig. 42). Starry flounder, along with Pacific staghorn sculpin, also preferred the deeper sandy areas. Cobble beaches were inhabited by rockfish, chinook salmon, and surf smelt. Trawl-caught shiner perch were captured in the deeper habitat combination of sand, cobble, and shell while saddleback gunnel showed a preference for the sandy silt areas. Catches of saddleback gunnel and English sole also indicated they liked the fine silt of the Deep Hole. Fine silty sand areas up bay were good sites to catch shiner perch and Pacific staghorn sculpin.

Eel grass

The dominant vegetation in Tillamook Bay was eel grass, *Zoxtera marina* (Fig. 43). Eel grass appeared to influence species distribution. Generally pelagic species were less abundant and most bottom-dwelling species were more abundant in eel-grass beds (Fig. 42). Trawl-caught starry flounder and seine-caught saddleback gunnel were taken best in areas not having eel grass.

Another thin-bladed species of eel grass *(Z. noltii)* was found in Tillamook. The discovery of *Z. noltii* was the first reported occurrence of this species in Oregon. This species occurs on tide flats farther up Tillamook Bay than *Z. marina*.

Food Habits

We examined stomachs from 71 juvenile starry flounder of which 22 were empty. Over all, corophid (53.6%) and gammarid amphipods (13.6%) were the most preferred food items, followed by juvenile clams (11.5%) and polychaetes (10.0%) (Table 7). Corophid amphipods and polychaetes were the main food items for starry flounder up bay, especially in the rivers, while gammarid amphipods and juvenile clams were the most preferred food items down bay. We observed no seasonal differences in the feeding habits of starry flounder in the bay.

We examined stomachs from nine juvenile and 50 adult rockfish. A high incidence of empty stomachs was recorded in the adults due mainly to an inadequate job of spearing which spilled stomach contents and caused regurgitation. Juvenile rockfish fed mainly on decapod larvae (43.0%), harpacticoid (21.1%) and cyclopoid (10.5%) copepods, barnacle nauplius (13.2%), and unspecified copepods (5.3%). Adult rockfish preferred decapod larvae (36.8%),

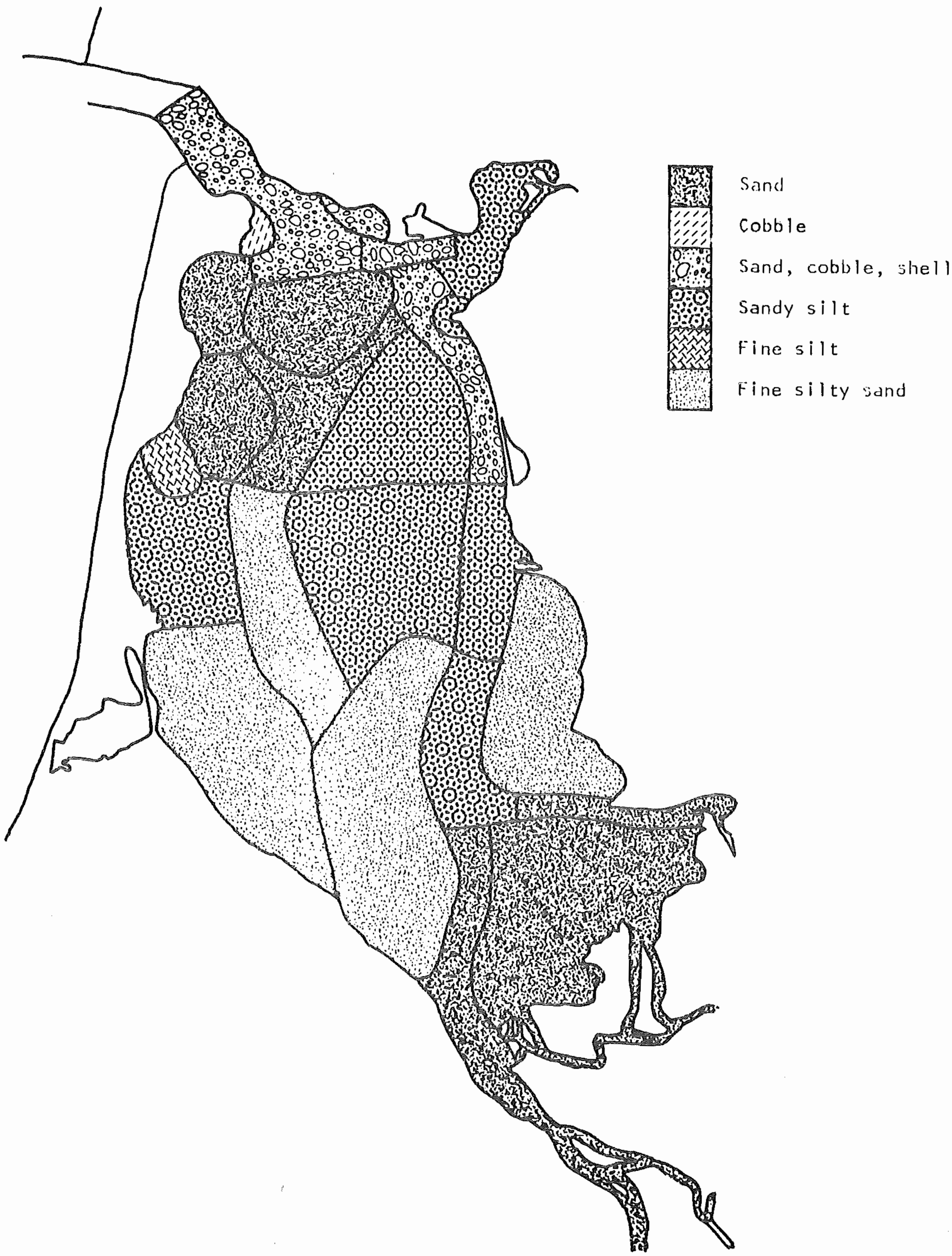

Fig. 41. Distribution of sediment types in Tillamook Bay.

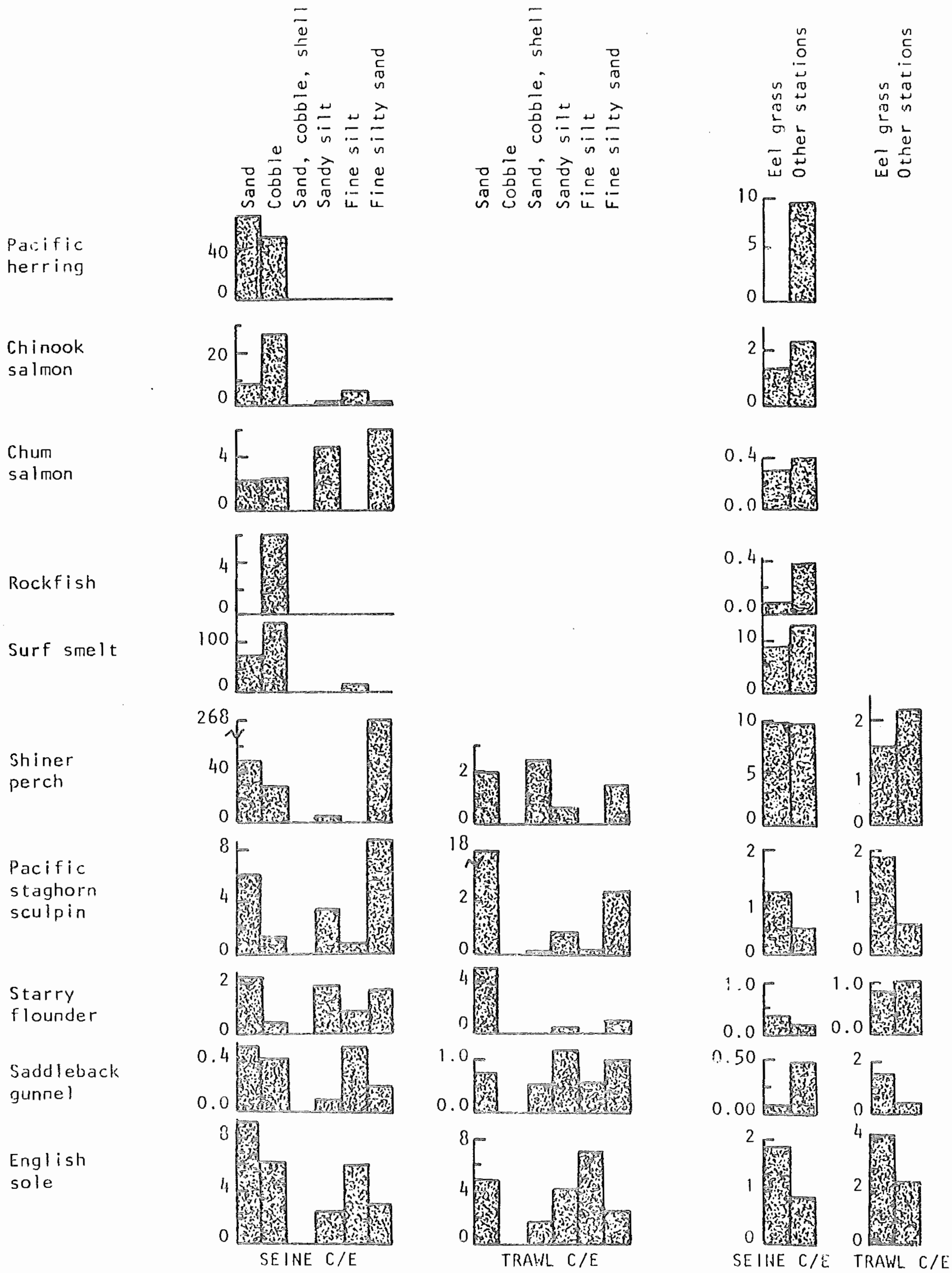

Fig. 42. Species abundance (catch/effort) by substrate type and vegetation for seine and trawl.

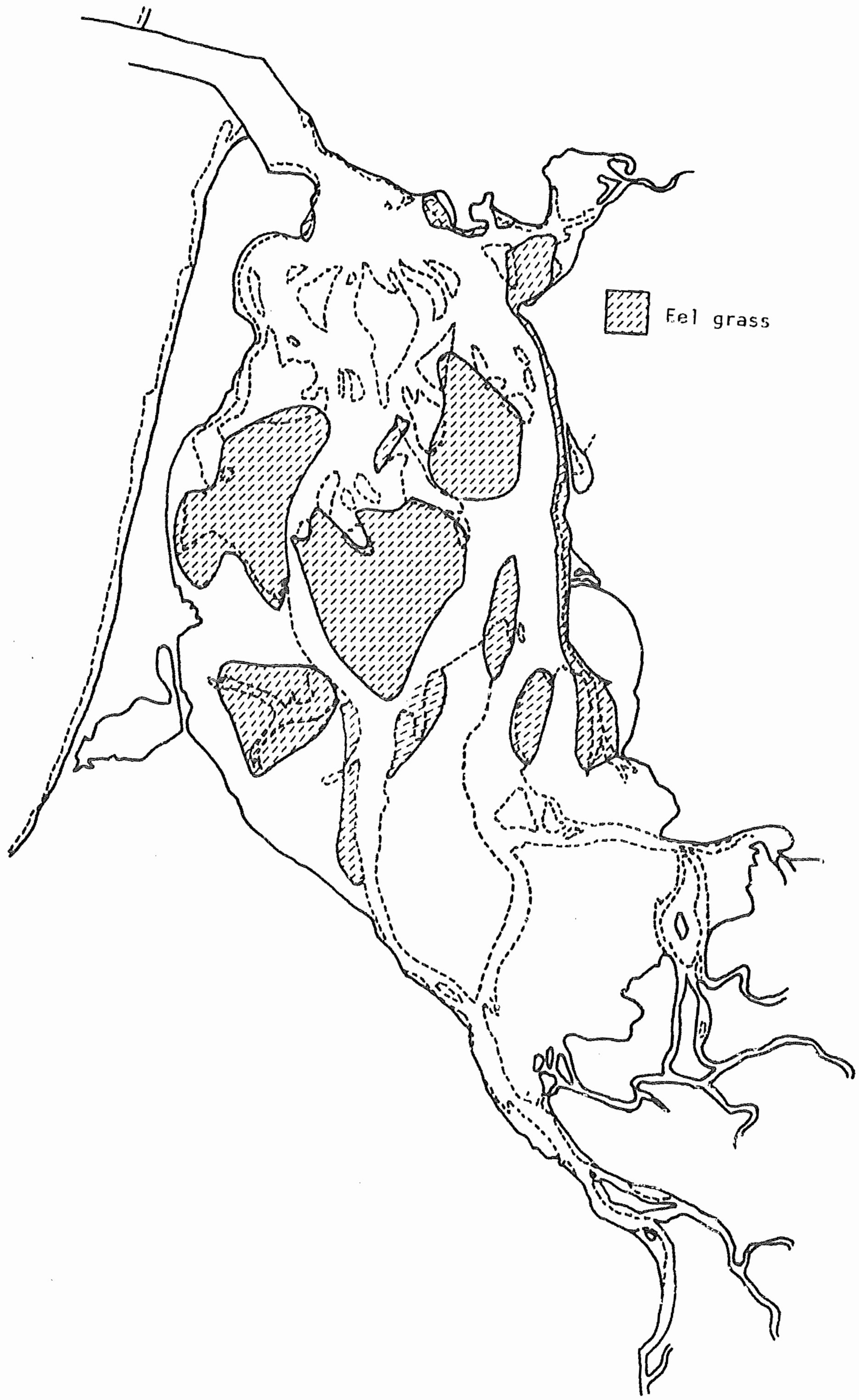

Fig. 43. Eel grass areas in Tillamook Bay.

Table 7. Food organisms from stomach contents of selected species in Tillamook Bay from July 1975-June 1976.

	Starry flounder		Rockfish		Chinook		English sole		Surf smelt		Preferred foods in bay	
	Juvenile	Adult	Juvenile	Adult	Juvenile	Adult	Juvenile	Adult	Juvenile	Adult	Total	Percentage
Total stomachs	71		9	50	68		69		85	46	398	
Empty stomachs	22			17	1		7		16	2	65	
% empty stomachs	30.9		0	34.0	1.5		9.8		18.8	4.3		16.3
1. Epibenthic organisms												
A. Amphipod, Gammarid	116		2		65		99		70	60	412	2.5
B. Amphipod, Corophid	456		1		66		80		117	61	781	4.7
C. Copepod, unspecified			6							75	81	0.5
D. Copepod, Harpacticoid			24				132		1,275	179	1,610	9.6
E. Copepod, Cyclapoid			12				7		52	3	74	0.4
F. Copepod, Calanoid			5						2,494	1,728	4,227	25.3
G. Cummacean					43		44		15	7	109	0.7
H. Isopod	15			11	28		2			1	57	0.3
I. Polychaete	85				16		85		63	68	317	1.9
J. Nematode	35				8		93			62	198	1.2
K. Ostracod					1						1	
L. Tanadacea	21				2		97				120	0.7
M. Mysid					1				4	3	8	
2. Lg. planktonic organisms												
N. Decapod, adult	4			30	2		1			6	43	0.3
O. Decapod, larvae	2		49	50	255				2,834	2,445	5,634	33.8
P. Fish, juvenile & larval				44	48				17	5	114	0.7
Q. Euphausids									3	2	5	
3. Small planktonic												
R. Barnacle Nauplius			15						56	83	154	0.9
S. Barnacle Cypris									115	27	142	0.9
4. Miscellaneous												
T. Clam siphons	18						178				196	1.2
U. Clams, juv.	98			1			220		21	14	354	2.1
V. Diptera	1				873						874	5.2
W. Coleoptera					1						1	
X. Arachnid					11						11	
Y. Gastropod, larvae									13	14	27	0.1
Z. Larvacean									437	697	1,134	6.8
Total Food Items	851		114	136	1,420		1,038		7,586	5,540	16,684	
Preferred Food Items (%)	B-53.6		0-43.0	0-36.8	V-61.8		U-21.2		0-37.4	0-44.1		0-33.8
	A-13.6		D-21.1	P-32.4	0-18.0		T-17.1		F-32.9	F-31.2		F-25.3
	U-11.5		R-13.2	N-22.1	B- 4.6		D-12.7		D-16.5	Z-12.6		D- 9.6
	I-10.0		E-10.5	H- 8.1	A- 4.6		A- 9.5		Z- 5.8	D- 3.2		Z- 6.8
	J- 4.1		C- 5.3	U- .74	P- 3.4		L- 9.3		B 1.5			V- 5.2

juvenile and larval fish (32.4%), and decapod adults (22.1%). All fish were captured in down bay areas. Rockfish were sampled only in the summer, spring, and fall months.

We examined 68 juvenile chinook salmon and only one fish had an empty stomach. The most important food item was diptera larvae and adults (61.8%) and decapod larvae (18.0%). Diptera and corophid amphipods were the main foods up bay while decapod larvae, gammarid amphipods, and juvenile fish (herring and smelt) were the most preferred foods down bay. There was relatively no variation in the seasonal feeding habits of chinook up bay; however, chinook feeding in the lower bay showed a definite preference for decapod larvae and juvenile fish, from summer through fall, when those food items were most abundant.

We examined 69 juvenile English sole and found only seven empty stomachs. The English sole fed on juvenile clams (21.2%), juvenile clam siphons (17.1%), harpacticoid copepods (12.7%), gammarid amphipods (9.5%), and tanaids (9.3%). The fish were most often captured in the lower bay and no seasonal variance in food habits was observed.

We examined 131 surf smelt, 85 juveniles and 46 adults, and found only 18 empty stomachs. Juvenile surf smelt fed on decapod larvae (37.4%), and calanoid (32.9%) and harpacticoid (16.5%) copepods. Adult surf smelt preferred decapod larvae (44.1%), calanoid copepods (31.2%), and larvaceans (12.6%).

The five food items in the bay most commonly eaten by all five species combined were as follows: decapod larvae (33.8%), calanoid copepods (25.3%), harpacticoid copepods (9.6%), larvaceans (6.8%), and diptera (5.2%). These percentages are based on the total number of organisms rather than volume or weight. Although copepods represent a high percentage of the total food organisms consumed by the species studied, they would be rated at a much lower percentage if either weight or size were the measured factor.

Crustaceans were the dominant food organisms consumed by all of the fish species in this study with the exception of English sole and chinook salmon. English sole preferred juvenile clams and juvenile clam siphons while chinook preferred diptera. See material in appendices for more detailed results of food habit studies.

Shellfish

Dungeness crab

During the winter and spring months, crab distribution was mainly limited to the lower half of the bay (Fig. 44). From June through October they extended into the upper bay, including the Tillamook (Z3) and Trask rivers (Z2). The Wilson River (Z1) was the only station where crab were not caught. It appeared from the trawl catches that crab preferred the deeper channels rather than the flats (Fig. 45). The most consistent and productive station was the Boat Basin (E) at 56.6 crab/trawl set, where the discharge from the shrimp and fish plants was an attractant.

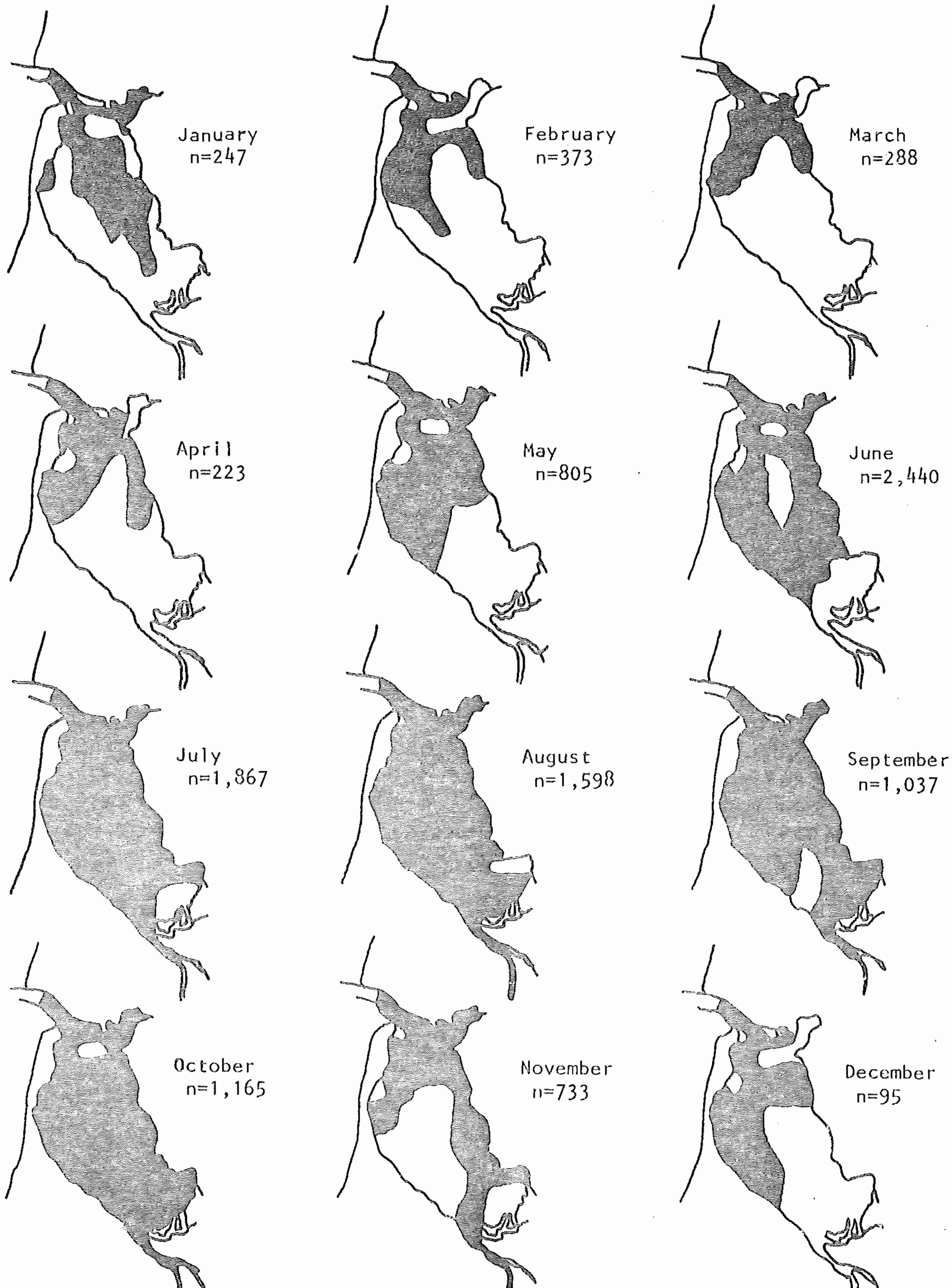

Fig. 44. Monthly catches and distributions of Dungeness crab in Tillamook Bay (2 years combined).

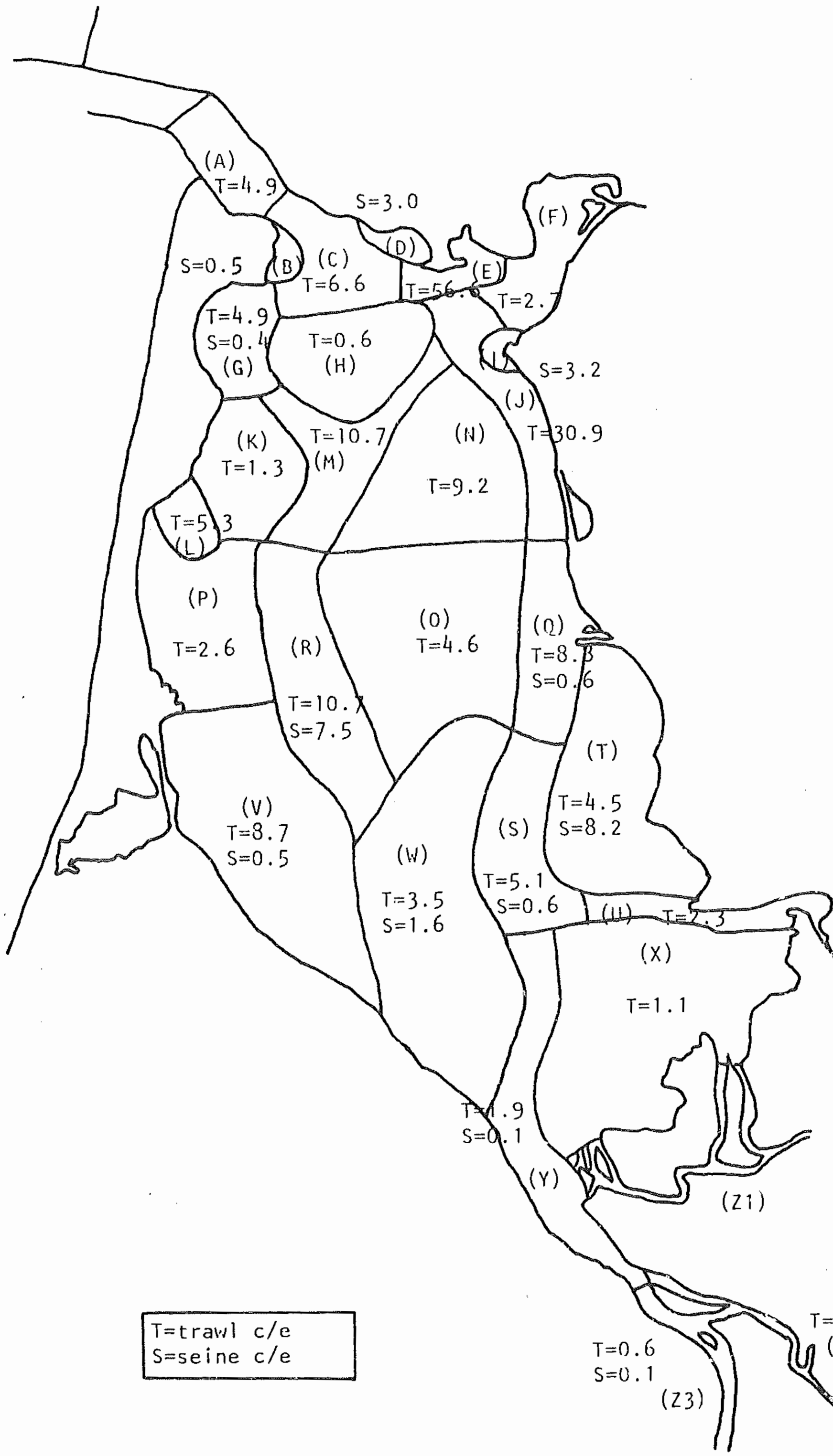

Fig. 45. Catch/set of Dungeness crab by sampling station in Tillamook Bay (2 years combined).

Crab abundance was high from June through October with the peak catch/effort in June (Fig. 46). Most of the crab left the bay in December. Very few of the crab caught during the survey were of legal size. Lack of legal size crab could be the result of sampling gear deficiencies or pots and rings in high crab use areas. Those of legal size were all caught in the lower half of the bay.

Environmentally, crab prefer salinities above 20 $^{o}/oo$, water temperatures between 12.8 C and 15.5 C, and depths between 3.05 and 6.10 m (Fig. 47).

Clams

The clam survey indicated that there were several productive beds in Tillamook Bay. Shellfish biologists made over 840 subtidal observations (Gaumer and Lukas 1975) and over 770 intertidal observations (Gaumer, personal communication) during 1975 and 1976. They observed five major clam species: cockle, gaper, littleneck, butter, and softshell clams.

Gapers and cockles were scattered throughout the lower half of the bay (Fig. 48). The survey indicated that littleneck and butter clams were limited to the very productive beds along the Ghost Hole, Hobsonville Point, and Garibaldi Flat. Softshell clams were distributed in the upper half of the bay and upper Miami Cove.

Oysters

More than 80% of the oysters produced in Oregon are grown in Tillamook Bay (Gaumer, Demory, and Osis 1973). The Pacific oyster *(Crassostrea gigas)*, and the smaller variety, Kumamoto oyster, are the two main types grown. According to landing statistics, 142,144 pounds of oysters were harvested in 1975 with a value to the fishermen of $280,180.

Currently three oyster companies have commercial leases on the bay. Fig. 49 shows the present distribution of oysters in Tillamook Bay and indicates the leased areas and potential growing areas. Approximately 50% of the potential growing areas are leased, but only a small portion of the leased area is presently being used for oysters. Tillamook Bay has the potential for producing many more oysters than at present. Current threats to the Tillamook Bay oyster industry are an increasing siltation problem and the undermining of oyster beds by ghost shrimp.

Ghost shrimp

Ghost shrimp *(Callianassa* sp.) are excellent fishing bait and of significant importance to the northern Oregon coast as well as certain parts of Washington. Five people commercially harvest ghost shrimp from Tillamook Bay. The predicted harvest for 1976 was approximately 780,000 shrimp which could represent a value of $20,000 to the commercial fisherman and $32,000 to the retail market.

Stomach analysis indicates that ghost shrimp are an important food source for most fish inhabiting Tillamook Bay. Larval and adult ghost shrimp represent 8% of all food items consumed by the five species of fish examined.

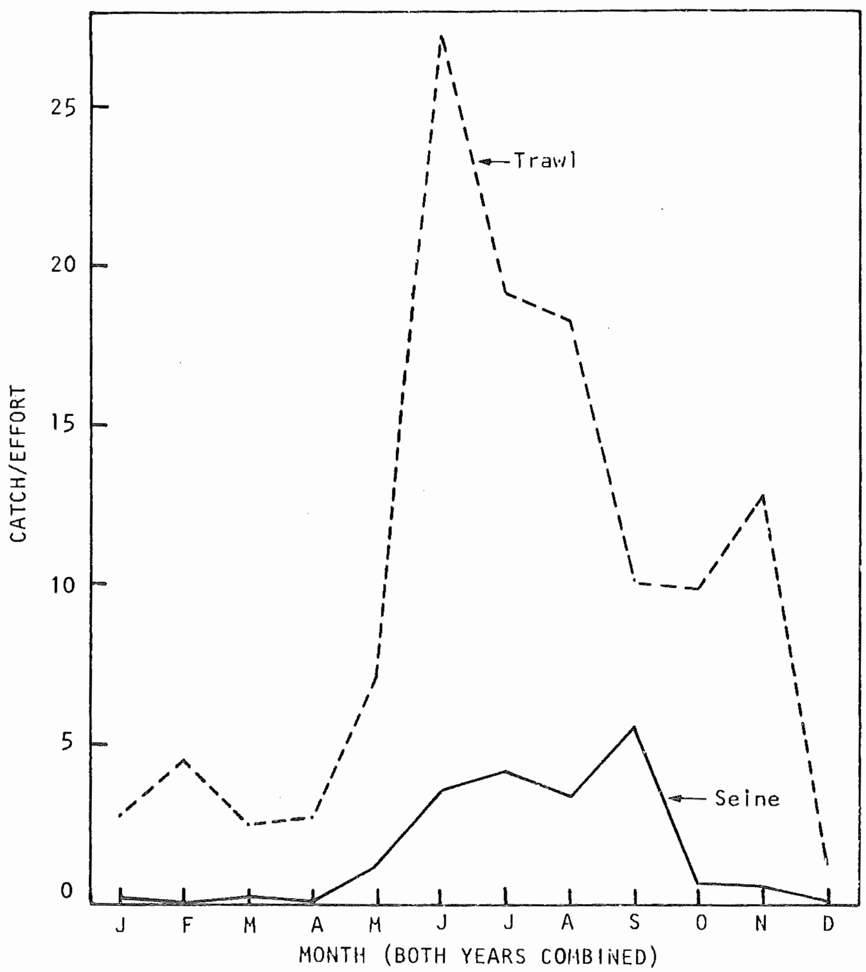

Fig. 46. Monthly catch/effort of Dungeness crab in Tillamook Bay.

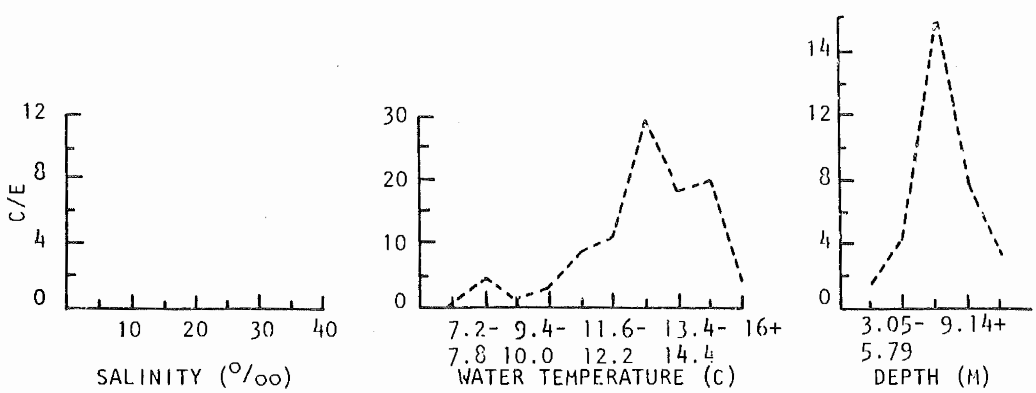

Fig. 47. Catch/effort of Dungeness crab by salinity, water temperature, and depth.

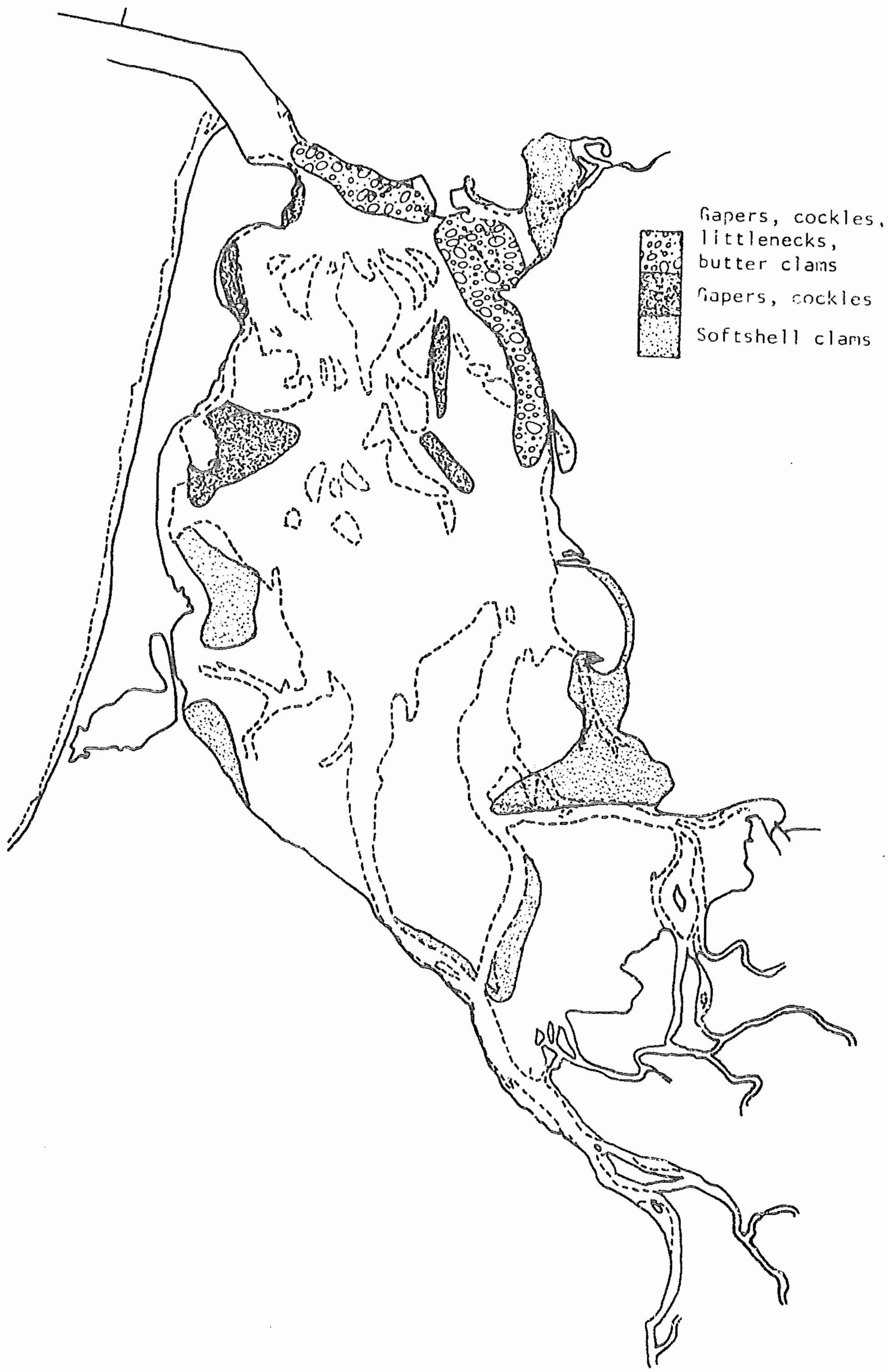

Fig. 48. Identified clam beds in Tillamook Bay.

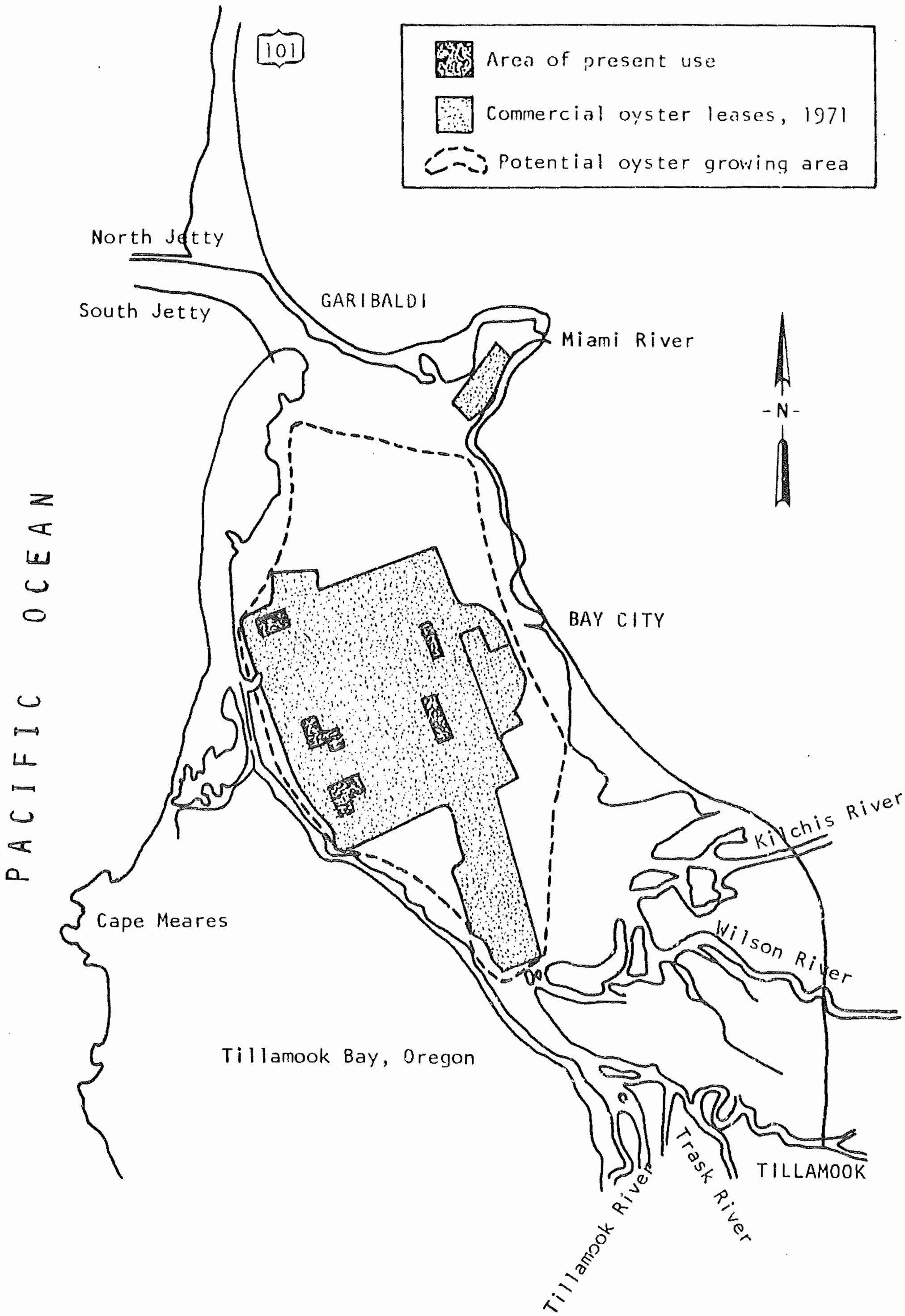

Fig. 49. Oyster distribution in Tillamook Bay.

We noted general distribution and relative abundance of ghost shrimp in terms of low, medium, and high densities (Fig. 50). Highest concentrations were generally found in the lower and mid-bay sections. The upper distributional limit was the area around Dick Point. No accurate method has yet been established for estimating numbers of ghost shrimp in Tillamook Bay; however, some Tillamook Bay residents believe as many as 1 or 2 tons/acre exist in certain high density areas (Sam Hays, personal communication 1976). All five commercial harvesters of ghost shrimp believe that there has been no decline in the population of shrimp since they began pumping.

Ghost shrimp are harvested commercially by means of a motor-driven pump taken to the beds in a small skiff. A large number of local residents pump shrimp for their own personal use as fishing bait. These people harvested shrimp by means of a hand-operated shrimp pump available at local sporting good stores.

The oyster fishery on Tillamook Bay is of much greater economic importance than the shrimp fishery. Oyster plant owners have expressed concern that ghost shrimp provide a threat to their industry since they tend to undermine the oyster beds. Rearing of oysters therefore is difficult, if not impossible, in areas of shrimp concentrations. This conflict between two industries deserves close attention in the future.

We believe that the commercial harvesting of ghost shrimp as fishing bait has not yet begun to reach its full potential due to relatively low demand at present. Increased harvest might benefit both industries by providing a greater economic return from shrimp and thereby giving oysters a firmer substrate.

Harbor Seals

The only large mammals of importance observed have been harbor seals, which seemed to be present in some numbers at all times in Tillamook Bay.

Accurate estimates of the seal population in Tillamook Bay is impossible. However, we counted over 200 seals at one "hauling out" area on several occasions. Largest concentrations were seen on sand bars at low tide on the west side of the lower bay near Crab Harbor (Fig. 51). Counts of over 100 were common in this area at low tide. In April 1976, approximately 12 seals were seen on a small "haul out" near the Range Finders. They appeared to be using these sand bars for resting purposes only.

Seals appeared to be feeding throughout the bay at high tide, however; concentrations of 15 to 20 seals were seen, apparently feeding, around the perimeter of the Deep Hole. Other apparent feeding areas are Crab Harbor and the Ghost Hole. We have seen seals as far as 1.6 km up the various rivers throughout the year, but especially during the fall and early winter, when seals appeared to be following salmon and steelhead up the rivers.

In March 1976, we observed a Steller Sea lion at Buoy 8. The sea lion was apparently feeding on herring, which were spawning in the area at the time.

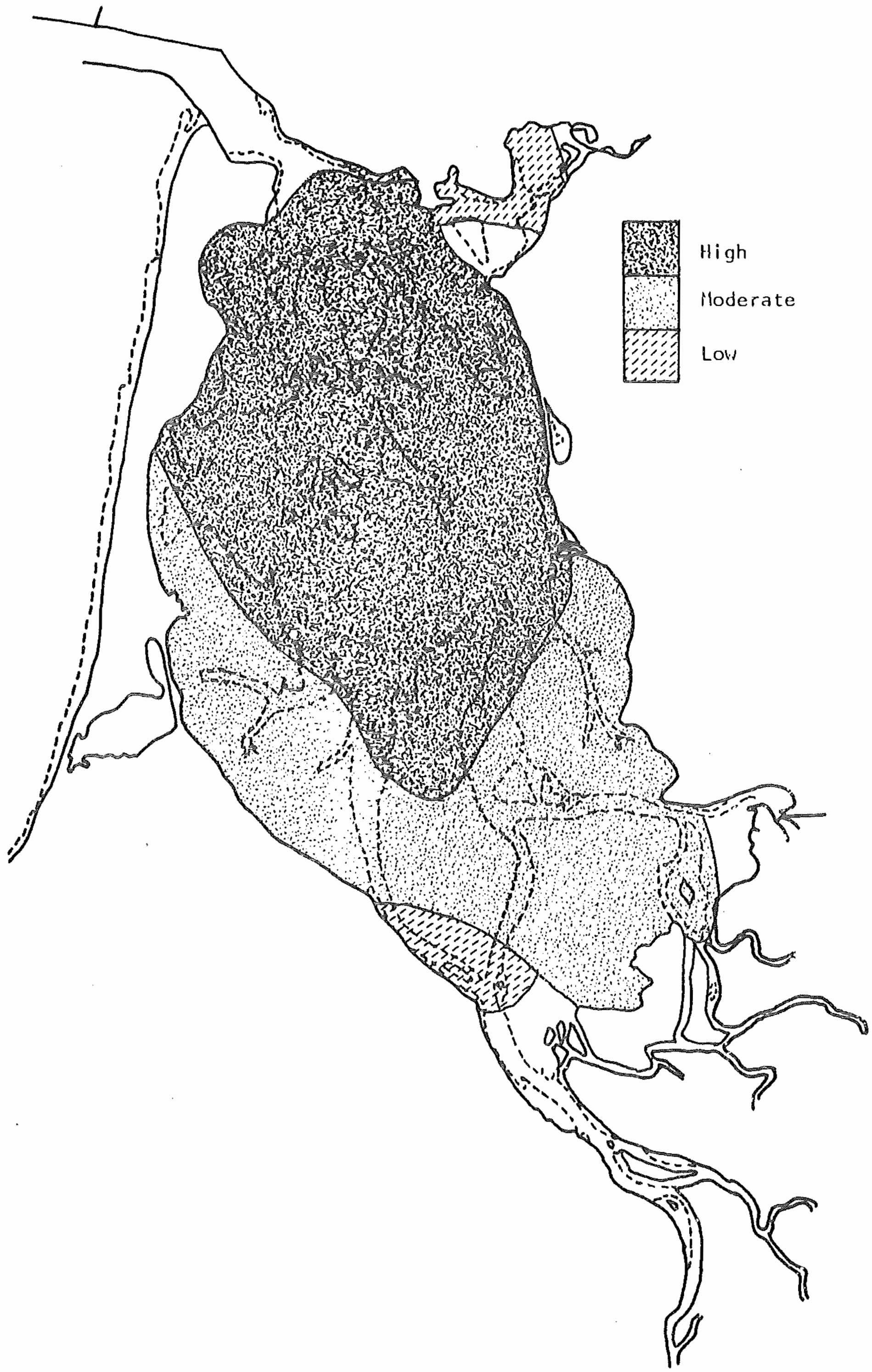

Fig. 50. Ghost shrimp distribution and concentrations in Tillamook Bay. High: greater than 10 holes/0.836 m^2; moderate: 1-10 holes/0.836 m^2; low: less than 1 hole/0.836 m^2.

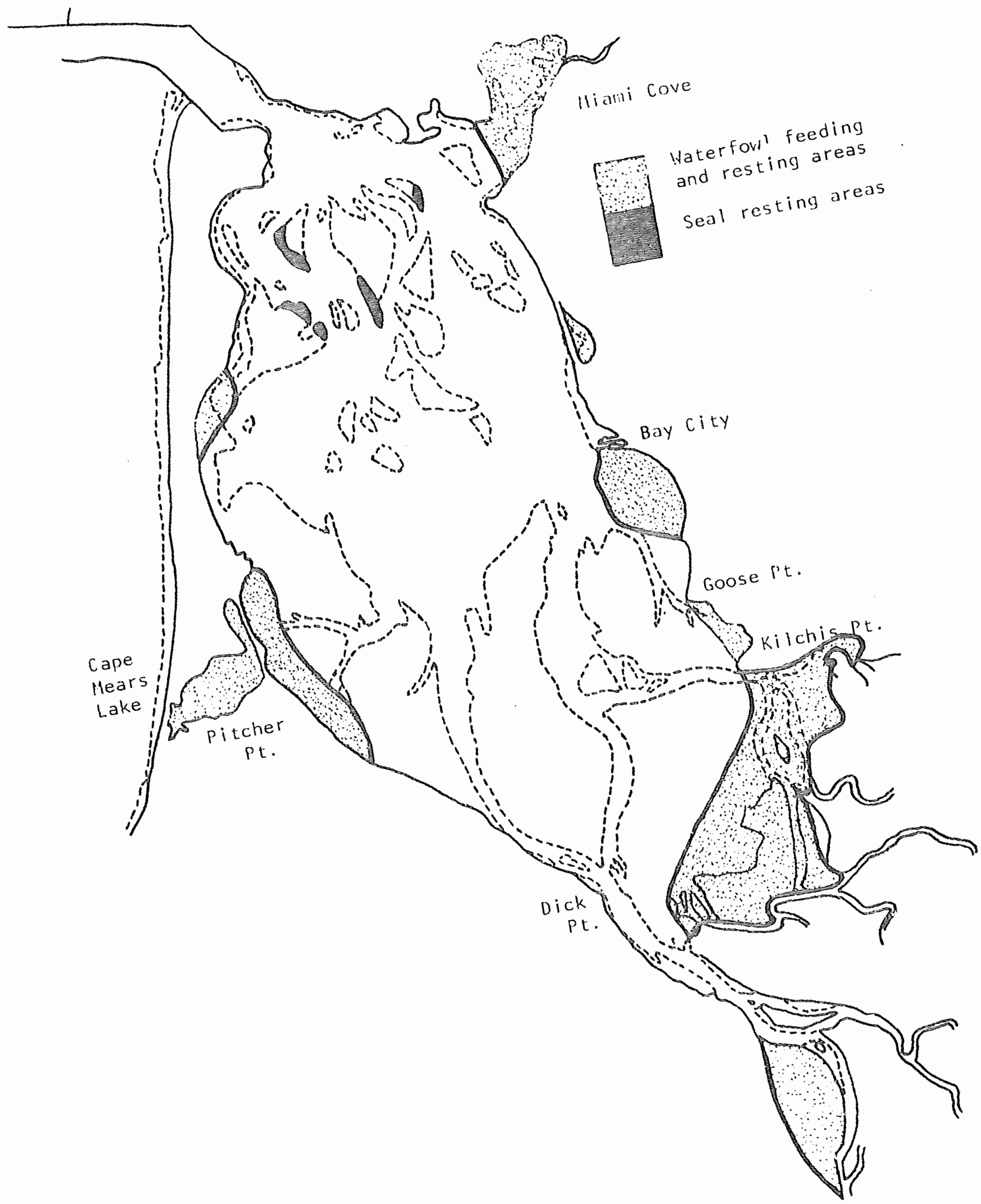

Fig. 51. Waterfowl feeding and resting areas, and seal resting areas in Tillamook Bay.

Birds

Certain species of birds such as gulls, herons, crows, mergansers, grebes, kingfishers, etc. are permanent residents of the bay, while migratory birds show definite seasonal trends. A cooperative effort between the Oregon Department of Fish and Wildlife and the Portland Audubon Society accounted for 155 species of birds using the Tillamook Bay area in an 8-month study period.

We saw turkey vultures in the upper bay only during the summer months. Adult common murres with young appeared on the bay in early spring and left in the fall. Brown pelicans appeared in early summer, gradually increased in numbers to about 300 birds in July, and left by the end of October. Band-tailed pigeons arrived in the spring and used the bay's two flyways in large numbers from July through September. Large numbers of ducks appeared on Tillamook Bay in mid-August and increased until a maximum population was reached about December. Widgeons, green-winged teal, mallards, and pintail were first to arrive in the fall while the diving types such as bufflehead, canvasback, scaup, and goldeneye arrived in November and December. Black brant arrived in December, abundance peaked in February, and most left the bay by April 1.

Barview Rocks near the north jetty is a unique area which provides both shelter and a resting area for several unusual species of birds. Up to 100 cormorants have been seen sitting on the rocks at one time. Several black oystercatchers were frequently seen feeding near the waterline of these rocks. At least five harlequin ducks were commonly seen on or near the rocks; however, up to 40 were counted in this area at one time.

Miami Cove served as both a resting and feeding area for many species of waterfowl (Fig. 51). Many heron used the shallow areas to catch fish, especially at low tide. The many pilings along the northeast shoreline provided excellent resting areas for gulls, cormorants, heron, and brown pelicans. Many widgeons used Miami Cove as a feeding area, and this cove, as well as Pitcher Point Flat, were the only places on the bay where canvasback were consistently seen during the winter months.

Herring spawned along the rocks from Barview to the Coast Guard pier near Garibaldi in early March. Thousands of birds, mostly gulls, concentrated in this area and were seen feeding on the herring spawn.

Hobsonville Point, as well as the Goose Point area, were the only two places on the bay where band-tailed pigeons concentrated in significant numbers to drink brackish water. Approximately 50 birds used Hobsonville Point and 350 birds used the Goose Point flyway.

The Deep Hole, located near the Bay Ocean spit, was a resting area for both dabbling and diving ducks because it is sheltered from the northwest and southwest winds. Many juvenile fish reared in this area and, therefore, loons, grebes, and mergansers fed here. The loons and grebes were observed in the largest concentrations in the spring.

Larson Cove was important the year round as a feeding area for great blue heron at low tide stages. Five common egrets frequented this area in early winter. Hundreds of crows and gulls were seen feeding on the eel-grass flats in or surrounding Larson Cove at low tide. Widgeon and bufflehead were the most common waterfowl using this sheltered cove as a resting area during stormy weather. Upon occasion canvasback used this area also.

Many species of waterfowl almost exclusively used the delta area between Goose Point, Kilchis Point, and Dick Point for a feeding area. However, when heavily hunted or harassed they tended to seek sanctuary along the west side of the bay from Dick Point to Cape Mears Lake. They rafted up in huge flocks of a thousand or more in this area which is protected from the the southwest wind by Cape Mears. During calm weather and at low tide, pintail, and widgeon were found feeding on the mud flats adjacent to Bay City. Hundreds of diving ducks including canvasback, scaup, bufflehead, and goldeneye used Pitcher Point Flat for a feeding area during the winter months.

The farm field adjacent to the Tillamook River on the west side opposite our trawl station was an important feeding and resting area in the winter months. We estimated up to 7,000 ducks were there during the months of January and February.

A pair of eagles nested annually in the trees near Dick Point. Both the young and the adults were seen hunting for food from the river-delta area to Pitcher Point Cove.

We identified approximately 30 species of shorebirds using the bay during the study period. At low-tide, shorebirds were found almost anywhere on the bay, while they concentrated along shorelines at high tide. The beach along Bay Ocean spit was one of the major feeding areas observed for shorebirds. Gravel bars and pilings in the delta area between Wilson River and the Kilchis River served as resting areas for large concentrations of shorebirds as well as gulls.

A list of all birds sighted on Tillamook Bay is included in Table 8.

SUMMARY

Basic knowledge of the biological resources in estuaries has been needed by resource agencies and planners for proper management. This survey to determine species composition, spatial and temporal distribution, and relative abundance of the fish and crabs in Tillamook Bay, Oregon, was intended as an initial response to this need. The inventory also included shellfish, birds, and harbor seals. Food habits of certain fish were also examined.

Tillamook Bay was partitioned into 28 stations, representing variations in substrate, depth, vegetation, salinity, and water temperature. Gear used in this study included a small otter trawl, 45.7 m beach seine, 22.9 m beach seine, gill nets, and scuba gear. The trawl was most effective in capturing bottom fish and crabs, while beach seines were most effective for collecting pelagic fish. We used gill nets to a limited extent with poor results. We used scuba to capture rockfish along jetties, observe bottom types, and examine clam populations.

Table 8. Birds reported from the Tillamook Bay area from August 1, 1975 to April 30, 1976.

Common name	Scientific name[1]
Loons	
Arctic loon	*Gavia arctica*
Common loon	*Gavia immer*
Red-throated loon	*Gavia stellata*
Grebes	
Red-necked grebe	*Podiceps grisegena*
Horned grebe	*Podiceps auritus*
Eared grebe	*Podiceps caspcus*
Western grebe	*Aechmophorus occidentalis*
Pied-billed grebe	*Podilymbus podiceps*
Shearwaters	
Sooty shearwater	*Puffinus griseus*
Pelicans	
Brown pelican	*Pelecanus occidentalis*
Cormorants	
Double-crested cormorant	*Phalacrocorax auritus*
Brandt's cormorant	*Phalacrocorax penicillatus*
Pelagic cormorant	*Phalacrocorax pelagus*
Herons & Bitterns	
Great blue heron	*Adea herodias*
Common egret	*Casmerodius albus*
Green heron	*Butorides virescens*
Swans, Geese, & Ducks	
Whistling swan	*Olor columbianus*
Canada goose	*Branta canadensis*
White fronted goose	*Anser albifrons*
Mallard	*Anas platyrhynchos*
Pintail	*Anas acuta*
Green-winged teal	*Anas carolinensis*
Blue-winged teal	*Anas discors*
Cinnamon teal	*Anas cyanoptera*
European widgeon	*Mareca penelope*
American widgeon	*Mareca americana*
Northern shoveler	*Spatula clypeata*
Canvasback	*Aythya valisineria*
Greater scaup	*Aythya marila*
Bufflehead	*Bucephala albeola*
Harlequin duck	*Histrionicus histrionicus*
White-winged scoter	*Melanitta deglandi*

Table 8 (Continued)

Common name	Scientific name
Surf scoter	*Melanitta perspicillata*
Common scoter	*Oidemia nigra*
Ruddy duck	*Oxyura jamaicensis*
Hooded merganser	*Lophodytes cucullatus*
Common merganser	*Mergus merganser*
Red-breasted merganser	*Mergus serrator*
Black brant	*Branta nigricans*
Oldsquaw	*Clangula hyemalis*
Vultures, Hawks, Eagles, and Owls	
Turkey vulture	*Cathartes aura*
Short-eared owl	*Asio flammeus*
Red-tailed hawk	*Buteo jamaicensis*
Marsh hawk	*Circus cyaneus*
Goshawk	*Accipiter gentilis*
Merlin	*Falco columbarius*
Sharp-shinned hawk	*Accipiter striatus*
Peregrine falcon	*Falco peregrinus*
Osprey	*Pandion haliaetus*
American kestrel	*Falco sparverius*
Rails and Coots	
American coot	*Fulica americana*
Oystercatchers	
Black oystercatcher	*Haematopus bachmani*
Plovers, Turnstones, and Surfbirds	
Semipalmated plover	*Charadrius semipalmatus*
Snowy plover	*Charadrius alexandrinus*
Killdeer	*Charadrius vociferus*
American golden plover	*Pluvialis dominica*
Black-bellied plover	*Squatarola squatarola*
Surfbird	*Aphriza viragata*
Ruddy turnstone	*Arenaria interpres*
Black turnstone	*Arenaria melanocephala*
Snipes, Sandpipers, Curlews, and Godwits	
Common snipe	*Capella gallinago*
Whimbral	*Numenius phaeopus*
Spotted sandpiper	*Actitis macularia*
Wandering tattler	*Heteroscelus incanum*
Greater yellowlegs	*Totanus melanoleucus*
Lesser yellowlegs	*Totanus flavipes*
Red knot	*Calidris canutus*
Pectoral sandpiper	*Erolia melanotos*

Table 8. (Continued)

Common name	Scientific name
Baird's sandpiper	*Erolia bairdi*
Least sandpiper	*Erolia minutilla*
Dunlin	*Erolia alpina*
Short-billed dowitcher	*Limnodromus griseus*
Long-billed dowitcher	*Limnodromus scolopaceus*
Western sandpiper	*Ereunetes mauri*
Marbled godwit	*Limosa fedoa*
Sanderling	*Crocethia alba*
Rock sandpiper	*Erolia ptilocnemis*
Sharptailed sandpiper	*Erolia acuminata*
Buff breasted sandpiper	*Tryngites subrutieollis*
Phalaropes	
Northern phalarope	*Lobipes lobatus*
Gulls	
Glaucous-winged gull	*Larus glaucescens*
Western gull	*Larus occidentalis*
Herring gull	*Larus argentatus*
California gull	*Larus californicus*
Ring-billed gull	*Larus delawarensis*
Mew gull	*Larus canus*
Bonapartes gull	*Larus philadelphia*
Heerman's gull	*Larus heermanni*
Black-legged kittiwake	*Rissa tridactyla*
Thayer's gull	*Larus argentatus thayeri*
Little gull	*Larus minutus*
Terns	
Arctic tern	*Sterna paradisara*
Caspian tern	*Hydroprogne caspia*
Auks and Murres	
Common murre	*Uria aalge*
Pigeon guillemot	*Cepphus columba*
Marbled murrelet	*Brachyramphus marmoratum*
Tufted puffin	*Launda cirrhata*
Pigeons and Doves	
Band-tailed pigeon	*Columba fasciata*
Rock dove	*Columba livia*
Mourning dove	*Zenaidura macroura*
Nighthawk	
Common nighthawk	*Chordeiles minor*
Swift	
Vaux's swift	*Chaetura vauxi*

Table 8. (Continued)

Common name	Scientific name
Hummingbirds	
Rufous hummingbird	*Selasphorus rufus*
Kingfishers	
Belted kingfisher	*Megaceryle alcyon*
Woodpeckers	
Common flicker	*Colaptes cafer*
Downy woodpecker	*Dendrocopos pubescens*
Flycatchers	
Western flycatcher	*Empidonax difficilis*
Western wood pewee	*Contopus sordidulus*
Swallows	
Violet-green swallow	*Tachycineta thalassina*
Tree swallow	*Tridoprocne bicolor*
Barn swallow	*Hirundo rustica*
Cliff swallow	*Petrochelidon pyrrhonota*
Purple martin	*Progne subis*
Crows and Jays	
Steller's jay	*Cyanocitta stelleri*
Common raven	*Corvus corax*
Common crow	*Corvus brachyrhychos*
Chickadees	
Black-capped chickadee	*Parus atricapillus*
Chestnut-backed chickadee	*Parus rufescens*
Common bushtit	*Psaltriparus minimus*
Wrentits	
Wrentit	*Chamara fasciata*
Wrens	
Winter wren	*Troglodytes troglodytes*
Bewick's wren	*Thryomanes bewicki*
Long-billed marsh wren	*Telmatodytes palustris*
Thrushes	
Hermit thrush	*Hylocichla guttata*
Swainson's thrush	*Hylocichla ustulata*
Varied thrush	*Ixoreus naevius*
American robin	*Turdus migratorius*
Kinglets	
Golden-crowned kinglet	*Regulus satrapa*
Ruby-crowned kinglet	*Regulus calendula*

Table 8. (Continued)

Common name	Scientific name
Pipits	
Water pipet	*Anthus spinoletta*
Waxwings	
Cedar waxwing	*Bombycilla cedrorum*
Shrikes	
Northern shrike	*Lanius excubitor*
Starlings	
Starling	*Sturnus vulgaris*
Vireos	
Warbling vireo	*Vireo gilvus*
Warblers	
Yellow-rumped warbler	*Dendroica*
Wilson's warbler	*Wilsonia pusilla*
Weaver Finches	
House sparrow	*Passer domesticus*
Meadowlarks, Blackbirds, and Cowbirds	
Western meadowlark	*Sturnella neglecta*
Red-winged blackbird	*Agelaius phoeniceus*
Brewer's blackbird	*Euphagus cyanocephalus*
Brown-headed cowbird	*Molothrus ater*
Tanagers	
Western tanager	*Piranga ludoviciana*
Grosbeaks, Finches, Sparrows, and Buntings	
House finch	*Carpodacus mexicanus*
Pine siskin	*Spinus pinus*
American goldfinch	*Spinus tristis*
Red crossbill	*Loxia curvirostra*
Rufous-sided towhee	*Pipilo erythrophthalmus*
Dark-eyed junco	*Junco oreganus*
Savannah sparrow	*Passerculus sandwichensis*
Chipping sparrow	*Spizella passerina*
White-crowned sparrow	*Zonotrichia leucophrys*
Golden-crowned sparrow	*Zonotrichia atricapilla*
Fox sparrow	*Passecella iliaca*
Song sparrow	*Melospiza melodia*
Grouse	
Ruffed grouse	*Bonasa umbellus*

[1]*Peterson's Field Guide Birds of North America.*

In 2 years of sampling, 126,389 fish were caught including 56 species; however, the 11 most abundant species accounted for 97% of the catch. The lower portion of Tillamook Bay was the most productive for fish and crabs with highest catch rates for six of the major species. These included northern anchovy, surf smelt, chinook salmon, Pacific herring, juvenile rockfish, and Dungeness crab. On the other hand, starry flounder, Pacific staghorn sculpin, and chum salmon were more frequently caught in the upper bay. The other species examined, shiner perch, English sole, and saddleback gunnel, were caught in quantity throughout the bay. English sole, however, were not caught in the rivers. The months of June, July, and August were the most productive with more species per set than during other months. July was the month of highest abundance for shiner perch, Pacific herring, English sole, chinook salmon, Pacific staghorn sculpin, starry flounder, and juvenile rockfish. Saddleback gunnel and Dungeness crab were most abundant in June, while May and August were peak months for catches of chum salmon and northern anchovy, respectively.

Salinity seemed to have an influence on some species and not others. Those species that seemed to be attracted to high salinities were surf smelt, Pacific herring, English sole, juvenile rockfish, juvenile chinook salmon, and Dungeness crab. Low salinities may have been preferred by chum salmon, starry flounder, and Pacific staghorn sculpin. Water temperatures above 12.8 C appeared to be preferred by most species, with the exception of chum salmon.

Water depth was another factor examined. Shallow shoreline areas seemed to be the most productive for all species except starry flounder and Dungeness crab. English sole showed some abundance at greater depths also.

There were more species of fish caught per set on rocky substrate than any other type; that was the preferred habitat for chinook salmon, surf smelt, and juvenile rockfish. Sand was the most popular substrate for Pacific herring, Pacific staghorn sculpin, English sole, and starry flounder. Chum salmon and shiner perch preferred fine sandy silt, while saddleback gunnel preferred a coarser sand silt substrate.

Eel grass had a positive effect on the distribution of Pacific staghorn sculpin, saddleback gunnel, and English sole. This vegetation had little effect on the other species.

In cooperation with Oregon State University, we examined 398 stomachs of five species containing 16,684 food organisms. The preferred food for starry flounder was corophid amphipods. Chinook salmon preferred diptera, and English sole ate mostly juvenile clams. Decapod larvae were the preferred food item for both surf smelt and rockfish.

Subtidal and intertidal observations for clams indicated five species inhabit Tillamook Bay. They are littleneck, gaper, butter, cockle, and softshell clams. The major clam beds were located along Ghost Hole, Hobsonville Point, and Garibaldi Flat for the first four species. Softshell clam beds were distributed in the upper bay and Miami Cove.

Ghost shrimp inhabited nearly the entire bay, with their greatest concentration in the lower and middle bays. Oysters are grown in Tillamook Bay by commercial farmers. The area utilized is only a fraction of the total area suitable for oyster farming. A major problem confronting the oyster growers was the soft substrate caused by burrowing ghost shrimp.

Harbor seals were seen throughout the bay, but their resting areas were concentrated on sand bars near Crab Harbor and the Range Finders.

In cooperation with the Portland Audubon Society, we identified 155 species of birds. Heavy concentrations of waterfowl used the bay during fall and winter. Major areas of use included Miami Cove, Larson Cove, Goose Point, Delta Flat, Deep Hole, Pitcher Point Flat, and fields adjacent to Tillamook River.

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APPENDICES

Appendix A

Analysis of Stomach Content of Various Species of Fish in June-July 1974 at Tillamook Bay, Oregon

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Nine species of fish collected in Tillamook Bay were examined for stomach content to determine their feeding habits. These included three species of juvenile salmon: Chinook (which were emphasized), Chum and Silver. Other fish examined were Pacific Herring, Surf Smelt, English Sole, Northern Anchovy, Shiner Perch and Black Rockfish. The data are presented in Table 1 and summarized in Table 2.

Stations where specimens were collected included four seaward stations: Crab Harbor, Kincheloe Point, Garibaldi Flat and Hobsonville Point. These stations are all near the mouth of the estuary. The only Chum Salmon examined were collected at the Bay Ocean station which is farther south in the estuary. On 20 July 9 Chinook were collected at Dolphin #3 and Wilson River Mouth stations which are located even farther up the estuary.

Fish were collected for stomach analysis on 8 sampling dates, 22 May, 7, 21 June and 3, 19, 20, 23 July. Most fish were caught by beach seine, but some were collected by trawl on several occasions.

Fish were dissected and the contents of the stomach and intestine were identified and counted. At times the material in the intestine was digested to the extent that numbers were impossible to determine and only the type of organisms was recorded. For this report the content of stomach and intestine were combined in order to list animals present and total numbers when possible. Stomach content will refer to stomach and intestine combined unless specified separately.

In analysis of the results stomach contents were combined into 5 basic food categories (Table 2). Some overlap between epibenthic and planktonic organisms is unavoidable since some epibenthic organisms (for example harpacticoid copepods, amphipods, and cumaceans) swim above the bottom and often are found in plankton samples.

Oncorhynchus tshawytscha - Chinook Salmon

A total of 93 juvenile native Chinook were examined for stomach content. Specimens were collected from six stations on six dates from 21 June to 23 July. They ranged in fork length from 53-157 mm, with an average of 95.1 mm. Chinook showed a definite preference for large food items. These included *Ulva*-like green algae in the stomachs of more than 25% of the Chinook examined. The algae was not digested. More than 25% consumed large fish larva. The presence of 4 seed pods, 2 rocks, feathers, a leaf and a piece of string are also indications that largeness is their main desirability. Epibenthic organisms were present in most of the stomachs (72). These were mainly gammerid amphipods (mostly *Anisogammarus* sp.) and corophid amphipods, of which two species were present. *Corophium salmonis* was more abundance than

Corophium spinicorne. Cumaceans and isopods also were present in fairly large numbers. Insects and insect larva were the next most abundant food item, being present in 63 of the stomachs. Insects were present in varying numbers from 1-72 except for one specimen which contained 239 insects. Most of the insects were adult. Species were not identified. Large planktonic organisms ranked next in importance. Fish larvae were present in 26 of the stomachs, including 21 Pacific Herring, 2 Rockfish (*Sebastes* sp.), 1 sculpin and 2 unidentified. Herring larvae were present in the stomachs on five of the six collection dates at the four seaward stations. They were present more often in stomachs from Hobsonville Point and Crab Harbor than from the other stations. The size of the Chinook which ate herring varied from 70-126 mm. Of the 21 herring found in the Chinook, many were more than 1/3 the length of the Chinook itself, measuring 35-50 mm. Decapod larvae were present in 24 of the stomachs. Of these 12 were *Callianassa* larvae, 5 were *Upogebia* larvae and 9 were unidentified. *Callianassa* larvae were usually present in the stomachs in small numbers, but two stomachs contained totals of 303 and 192 animals of this genus. *Upogebia* larvae were present in the stomachs in small numbers and this category was only recorded once in the collected plankton samples. Small planktonic organisms were present in the stomachs on only 8 occasions. Of these, four, containing calanoid copepods, were caught at Crab Harbor on 19 July.

Oncorhynchus keta - Chum Salmon

Only three juvenile Chum were captured, all from the Bay Ocean station on 7 June. Fork lengths ranged from 63-82 mm. All 3 stomach contained insects and insect larva. One stomach also contained 1 Surf Smelt, 1 unidentified fish larva and 10 *Callianassa* larvae.

Oncorhynchus kisutch - Coho Salmon

Only two juvenile Coho were captured. They were taken at Crab Harbor on 3 July and Hobsonville Point on 19 July. They were older juveniles as their fork lengths were 111 mm and 154 mm. One had an empty stomach, but contained 1 pelecypod and a few crustacean remains in its intestine. The other contained 1 fish larva, 1 decapod larva and 5 amphipods, *Anisogammarus* sp.

Clupea harengus pallasi - Pacific Herring

Stomach contents of 41 Pacific Herring were examined. They were collected at the four seaward stations on six dates between 21 June and 23 July. Fork lengths ranged from 36-154 mm with an average of 74.4 mm. Sand was present in varying degrees in more than 25% of the stomachs examined, suggesting they might have been disturbed by the beach seining. Herring showed a definite preference for small planktonic organisms, which were present in all but 2 of the stomachs. These 2 contained digested crustacean pieces which might also have been planktonic. Larvae of *Callianassa* were present in 10 stomachs. One specimen from Crab Harbor on 3 July contained several hundred *Callianassa* larvae combined with small planktonic organisms. Fish larvae were present in 2 stomachs. Epibenthic organisms were consumed by 19 herring: 15 had eaten harpacticoid copepods, the other 4 ate amphipods. No insects were found.

Hypomesus pretiosus - Surf Smelt

Stomach contents were examined from 28 Surf Smelt. They were collected at four seaward stations on eight dates from 7 June to 23 July. Fork lengths ranged from 77-163 mm with an average of 98.2 mm. All of the stomachs contained small planktonic organisms, with barnacle cypris and calanoid copepods being the dominant forms. Fish collected on 23 July contained several hundred small plankton. Epibenthic organisms were present in 22 of the stomachs. Of these, 20 contained harpacticoid copepods. A few decapod larva and insects were present. More than 50% of the Surf Smelt had empty stomachs and a smaller number also had an empty intestine.

Parophrys vetulus - English Sole

Stomach contents from 10 English Sole were examined from Garibaldi Flat and Crab Harbor on three dates, 21 June, 3 July and 23 July. Fork lengths ranged from 45-87 mm. All 10 contained harpacticoid copepods, and 9 contained cumaceans. Other epibenthic forms were present in 5 or fewer of the stomachs. Small planktonic organisms were found in 7 stomachs and 6 of these contained calanoid copepods. Two types of crustaceans were consumed only by the English Sole: tanaids were found in 3 stomachs and ostracods were found in 2 stomachs.

Engraulis mordax - Northern Anchovy

Stomachs of 5 Northern Anchovy were examined. They were collected at Hobsonville Point and Crab Harbor on 25 June and 19 and 20 July. Fork lengths ranged from 87-129 mm. Planktonic and epibenthic forms were both present in the stomachs examined, with calanoid copepods being present in more stomachs (3). Four of the five contained digested phytoplankton.

Cymatogaster aggregata - Shiner Perch

Five Shiner Perch were examined which were collected on dates ranging from 22 May to 23 July. Of these, 4 were collected at Hobsonville Point. Fork lengths ranged from 46-110 mm. Epibenthic organisms, both harpacticoid copepods and gammerid amphipods were present in four of the Shiner Perch. Zooplankton was found in 2 specimens and a single insect was present.

Sebastes melanops - Black Rockfish

Five Black Rockfish were examined. All were captured at Kincheloe Point on 25 June and 3 and 19 July. Fork lengths ranged from 57-73 mm. Of the 5 fish examined, 4 had empty stomachs and gut contents were determined from the intestine. Only epibenthic organisms were found, mainly harpacticoid copepods.

Summary:

Juvenile Chinook from samples taken in Tillamook Bay, Oregon in June-July 1974 fed indiscriminantly on large items. Those with food value were primarily epibenthic amphipods. Juvenile English Sole, Shiner Perch and Black Rockfish also ate epibenthic animals predominately. Pacific Herring and Surf Smelt proved to be planktivores. Juvenile Chum and Coho Salmon and Northern

Anchovy were only captured in small numbers, but all consumed a broad diet of epibenthic and planktonic food. In the anchovy this included phytoplankton. A large percentage of Surf Smelt and Black Rockfish had empty stomachs which indicates they may vomit during seining. Sand present in many Pacific Herring stomachs is also an indication that the contents were disturbed at this time.

Analysis of Zooplankton from 1/2 Meter Net Samples in June-July 1974 at Tillamook Bay, Oregon

Zooplankton samples were collected with a 1/2 meter net at the four seaward stations in the bay, Crab Harbor, Kincheloe Point, Garibaldi Flat and Hobsonville Point, on five sampling dates: 21, 25 June and 3, 19, 23 July. A total of 20 samples were analyzed for species identification and frequency of occurrence (Table 3).

Two calanoid copepods, *Acartia clausi* and *Acartia longiremis*, were the only organisms present in all samples. *Acartia clausi* is a very abundant form in many temperate estuaries, and is probably an important food source for certain fish larvae and juveniles. *Arcatia longiremis* is abundant in the nearshore ocean and its continual presence during this period indicates that offshore water is regularly present in the estuary. Salinities taken at these stations during this period have a wide range, 7 ^{o}/oo to 33 ^{o}/oo, showing that offshore and estuarine waters are often mixed in the bay.

Organisms present which show evidence of oceanic water within the estuary are the calanoid copepods, *Corycaeus affinish*, *Ctenocalanus vanus*, *Eucalanus bungii* and *Rhincalanus nasutus*. Two calanoid copepods *Heterorhabdus* sp. and *Scolecithricella* sp. which were present at Kincheloe Point on 25 June, are indicators of northern open ocean water masses. Salinities on this date all measured 33 ^{o}/oo which is typical of ocean water for this area. These two species have not been encountered in Yaquina Bay in a decade of weekly studies (OSU Department of Oceanography unpublished data). Otherwise, the samples are very comparable to samples taken during this season in Yaquina Bay.

Eurytemora americana, found in 90% of the samples, is a strictly estuarine species, and often develops into large populations. It is a potential food source for fish larvae and juveniles.

Other organisms found to be abundant were two neritic calanoid copepods, *Centropages abdominalis* and *Pseudocalanus* sp., and *Oithona similis*, which is a cosmopolitan species of cyclopoid copepod.

Callianassa larvae were present in 75% of the samples. These appear to be an important planktonic crustacean food source for juvenile fish, as they were occasionally found in large numbers in Chinook Salmon and Pacific Herring. Several other decapod larvae and other forms such as barnacle, pelecypod and polychaete larvae are meroplanktonic and are numerous in the plankton during larval stages before becoming benthic in existence. Barnacle cypris were one of the most abundant forms, being present in 85% of the samples. They were important food items for Pacific Herring and Surf Smelt.

Small planktonic forms were an important food, particularly for Pacific Herring, Surf Smelt, English Sole and Northern Anchovie.

Harpacticoid copepods were present in 80% and gammerid amphipods in 55% of the samples. They commonly swim above the bottom and overlap both planktonic and epibenthic habitats. Harpacticoid copepods were found to be important food items for most of the species examined: Pacific Herring, Surf Smelt, English Sole, Shiner Perch and Black Rockfish. Gammerid amphipods, along with corophid amphipods were particularly important food items for the Chinook, English Sole and Shiner Perch.

Note: Samples were collected by Adrian Matson, who periodically assisted the Oregon Fish Commission with beach seining and trawling. Fish and their stomach contents, and zooplankton samples were identified by Joan Flynn, School of Oceanography, Oregon State University, with the support of the Sea Grant College Program.

Table 1. Food items consumed by fish caught with beach seine in June-July, 1974 at Tillamook Bay, Oregon.

	Oncorhynchus tshawytscha[1] Chinook	*Oncorhynchus keta* Chum	*Oncorhynchus kisutch* Coho	*Clupea harengus pallasi*[2] Pacific Herring	*Hypomesus pretiosus*[3] Surf Smelt	*Parophrys vetulus*[4] English Sole	*Engraulis mordax*[6] Northern Anchovy	*Cymatogaster aggregata* Shiner Perch	*Sebastes melanops* Black Rockfish
Total Stomachs	93	3	2	41	28	10	5	5	5
Stomachs at least 1/2 empty	5		1	7	15	3	1	1	4
1. Epibenthic organisms									
Amphipod, gammerid	37		1	3	4	5	2	4	1
Amphipod, corophid	37			1	2	3	1	1	2
Copepod, harpacticoid	6			15	20	10		4	4
Cumacean	25				4	9	1	2	1
Isopod	14			2		1	1		1
Mysid larva	6			3	2	3	1		
2. Large Planktonic Organisms									
Fish larva	26	1	1	2					
Decapod larva	24	1	1	10	8		1		
3. Small Planktonic Organisms									
Barnacle cyrpis				24	19	2	2	2	
Barnacle nauplius	2			4	7				
Cladocera, *Podon leuckarti*	1			6	3				
Copepod, calanoid	6			28	15	6	3		
Gastrapod larva					4	1		1	
Pelecypod larva			1	9	11	4	2		
Polychaete larva	1				10	2			
Miscellaneous									
4. *Ulva*-like green algae	26								
5. Insect & insect larva	63	3			3			1	

[1] *Crab megalops present in 4 stomachs, roundworms in 3 stomachs, barnacle appendages in 2 stomachs, copepod nauplius, cyclopoid copepod, euphausiid larva, in 1 stomach. Seed pods present in 4 stomachs, rocks present in 2 stomachs, feathers and string in 1 stomach.*

[2] *Cyclopoid copepod present in 2 stomachs, Cladocera, Evadne nordmanni present in 1 stomach. Sand present in 10 stomachs, varying from a few grains to filling stomach.*

[3] *Aquatic mite present in 1 stomach.*

[4] *Tanaids present in 3 stomachs, ostracods present in 2 stomachs, and 1 polychaete present in 1 stomach.*

[6] *Phytoplankton present in 4 of the 5 stomachs.*

Table 2. Major categories of food items consumed by fish caught with beach seine in June-July, 1974 at Tillamook Bay, Oregon.

	Total Stomachs	Epibenthic Organisms	Large Planktonic Organisms: Fish Larva[1]	Large Planktonic Organisms: Decapod Larva[2]	Small Planktonic Organisms	*Ulva*-Like Green Algae	Insect and Insect Larva
Oncorhynchus tshawytscha Chinook	93	72	26	24	8	26	63
Oncorhynchus keta Chum	3		1	1			3
Oncorhynchus kisutch Coho	2	1	1	1	1		
Clupea harengus pallasi Pacific Herring	41	19	2	10	39		
Hypomesus pretiosus Surf Smelt	28	22		8	28		3
Parophrys vetulus English Sole	10	8			7		
Engraulis mordax Northern Anchovy	5	3		1	4		
Cymatogaster aggregata Shiner Perch	5	4			2		1
Sebastes melanops Black Rockfish	5	4					

[1] *22 Pacific herring, 2 Roclfish, Sebastes sp., 1 Sulpin, 1 Surf Smelt, 4 unidentified.*

[2] *29 Callianassa sp., 5 Upogebia sp., 12 unidentified.*

Table 3. Analysis of zooplankton from 1/2 meter net samples in June-July 1974 at Tillamook Bay, Oregon.

	June 21				June 25				July 3				July 19				July 23				Freq. of	Origin of	
	CH	KP	GF	HP	CH	KP	GF	HP	CH	KP	GF	HP	CH	KP	GF	HP	CH	KP	GF	HP	Occurrence	Population	Habitat
Copepods																							
Acartia clausi	++	+	+	+	+	+	+	++	+	+	+	+	+	+	+	+	+++	++	++	+	100	EN	P
Acartia longiremis	+	+	+	+	+	+	+	++	+	+	+	+	+	+	+	+	+	+	+	+	100	NO	P
Calanus sp.				+		+	+	+	+	+		+	+				+				45	NO	P
Centropages abdominalis	++	+	+	+	+	+	+	+		+	+	+	+	+			+	+		+	80	N	P
Corycaeus affinis																+					5	0	P
Ctenocalanus vanus						+															5	0	P
Epilabidocera amphrites					+	+															10	NO	P
Eucalanus bungii																	+				5	0	P
Eurytemora americana	++	+	++	+	+			+	+	+	+	+	+	+	++	+++	+	+	+	+	90	E	P
Harpacticoid copepod	+	++	++	+++			+	+	+	+	+	+	+	+		+	+		+	+	80	E	EB
Heterorhabdus sp.						+															5	0	P
Oithona similis	+	+	+		+	+	+	+	+	+			+	+			+		+	+	70	NO	P
Paracalanus parvus													+			+			+	+	20	NO	P
Pseudocalanus minutus	++	+	+		++	++		+		+		+	+				+	+			55	N	P
Rhincalanus nasutus										+											5	0	P
Scolecithricella sp.						+															5	0	P
Miscellaneous																							
Amphipod, corophid	+	+												+		+					20	E	EB
Amphipod, gammerid		++	+		+	+	+	+				+	+	+			+				55	E	EB
Amphipod, hyperiid																	+				5	NO	P
Barnacle cypris	+		+		+	+	+	+	+	+	+	+	+	+		+	+	+	+	+	85	E	P
Barnacle nauplius				+	+		+	+	+	+	+		+	+	+		+	+	+	+	70	E	P
Chaetognath											+			+				+			15	NO	P
Cladocera, *Evadne nordmanni*					+	+	+	+	+	+									+		35	EN	P
Cladocera, *Podon leuckarti*	+	+	+	+	+	+	+	+	+	+										+	55	EN	P
Copepod nauplius	+				+	+			+	+	+	+				+	+	+	+	+	60	ENO	P
Ctenophore, *Pleurobrachia* sp.																	+				5	NO	P
Cumacean, *Cumella vulgaris*		+	+		+								+								20	ENO	EB
Decapod larva, *Callianassa* sp.	+				+	+	+++	+	+		+	+	+	+	+	+	+		+	+	75	EN	P
Decapod, Crab megalops					+																5	EN	EB
Decapod, Crab zoea	+				+	+		+	+				+					+	+	+	45	EN	P
Decapod, Hermit crab zoea					+	+											+	+	+		25	EN	P
Decapod, Porcelain crab zoea						+											+	+			15	EN	P
Decapod, Shrimp larva													+					+			10	EN	P
Decapod larva, *Upogebia* sp.							+														5	EN	P
Fish egg					+		+		+									+			20	ENO	P
Fish larvae	+		+	+		+					++	+	+	+	+	+	+		+		60	ENO	P
Gastropod larva					+	+						+					+		+		25	EN	P
Gastropod egg case	+	+	+	+		+	+	+	+	+	+	+			+			+	+		70	EN	P
Isopod							+							+				+	+		20	ENO	EB
Hydromedusa			+		+	+	+	+	+			+	+		+		+	+			55	ENO	P
Mite, aquatic										+											5	E	EB
Mysid larva					+	+	+	+								+					25	EN	P
Oikopleura sp.					+					+							+				15	ENO	P
Pelecypod, larvae	+	+	+		+		+	+	+		+	+	+	+			+	+	++	+	75	EN	P
Polychaete, larvae	+				+	+	+	+	+	+			+	+	+		+	+	+	+	70	ENO	P
Polychaete, adult		+											+		+						15	ENO	EB

KEY:

STATIONS
- CH = Crab Harbor
- KP = Kincheloe Point
- GF = Garibaldi Flat
- HP = Hobsonville Point

RELATIVE IMPORTANCE
- + = Present
- ++ = Abundant
- +++ = 90% or more of sample

GEOGRAPHIC ORIGIN OF POPULATION
- E = Estuary
- N = Neritic
- O = Oceanic

HABITAT
- P = Planktonic
- EB = Epibenthic

Appendix B

Analysis of the Stomach Contents of Four Species of Fish Collected at Tillamook Bay, Oregon, from November 1975 to April 1976

Margaret Toner June 1976

INTRODUCTION

The purpose of this study was 1) to identify the food organisms and preferred foods for four fish species in Tillamook Bay, Oregon, 2) to identify food organisms consumed from different areas in the bay, and 3) to determine differences in food habits over the 6 month period from November 1975 to April 1976. The four species collected for this study were surf smelt *(Hypomesus pretiosus)*, chinook salmon *(Oncorhynchus tshawytscha)*, English sole *(Parophrys vetulus)*, and starry flounder *(Platichthys stellatus)*.

METHODS

The specimens used in this study were collected by seine and trawl at 20 stations, seven of which were near the mouth of the estuary or lower bay. Three stations were in the mid bay and the remaining 10 stations were in the upper bay. Fish were collected on 28 sampling dates: November 6, 13, 20, and 24; December 10, 11, 15, 19, and 22; January 12, 14, 21, 23, and 26; February 10, 12, 19, 20, and 25; March 3, 5, 12, 14, and 29; and April 8, 12, 13, and 19.

In the laboratory, the fork length of each fish was measured and the wet weight of the fish was determined to the nearest tenth of a gram. The stomach was removed to the junction of the pyloric caeca, the contents were weighed to the nearest milligram and transferred to a watch glass. The organisms were examined under a binocular microscope, identified, and counted. Initially, an attempt was made to estimate stomach fullness by comparing the wet weights of the stomach contents for each species. This modification of Reimers' (1964) method was less accurate than approximating the stomach fullness visually because of the large variation in the wet weights.

Table 1 shows the number of food organisms found per stomach for each fish. Of all the surf smelt examined, 12.5% had empty stomachs.

In November and December samples were from the lower bay. In November most of the biomass of the stomach contents consisted of small planktonic organisms, particularly small calanoid copepods and larvaceans of the genus *Oikopleura*. In December, most of the biomass of the contents consisted of epibenthic organisms, such as gammarid amphipods in the genus *Anisogammarus*, corophid amphipods in the genus *Corophium*, and harpacticoid copepods. It was difficult to compare the results of the analysis in January to the other sampling dates, because seven of the 10 specimens were juveniles that were much smaller than the fish collected in November and December. The adult specimens collected in January consumed mainly *Anisogammarus* sp. and harpacticoid copepods. One specimen contained a larval fish *(Leptocottus armatus)*. The juvenile fish from the upper bay consumed mainly harpacticoid copecods and cumaceans, while those from the lower bay consumed only small planktonic organisms, which consisted primarily of small calanoid copepods.

In February juveniles in the lower bay consumed mainly small calanoid copepods. Only three specimens were collected from the mid bay. Of these, one was empty, another was a juvenile containing cumaceans and small calanoid copepods, and the third was an adult containing *Corophium salmonis*, cumaceans and small calanoid copepods.

In March samples were collected from the lower bay only. Adults contained a large number of *Upogebia* larvae and a small number of small calanoid copepods. One of the juveniles collected was empty, two contained mainly *Upogebia* larvae, and one contained mainly harpacticoids.

The April samples contained adult surf smelt from the lower bay which consumed mainly *Upogebia* larvae and small calanoid copepods. The number of *Upogebia* larvae consumed in April was much lower than that of March. The contents of juveniles from the upper bay were almost exclusively harpacticoid copepods.

Chinook Salmon

Table 2 shows the number of food organisms found per stomach for each chinook salmon. Of the stomachs examined, 8.7% were empty. Specimens were not collected in December and April, but those collected in the other four months were all juveniles.

In November fish collected in the upper bay contained mainly the corophid amphipod *Corophium spinicorne*, the isopod *Gnorimosphaeroma oregonensis*, and insects. One specimen contained three mysids of the genus *Neomysis*.

The January samples were from the upper bay only. The main contents were insects, while one specimen contained *Corophium salmonis*, *C. spinicorne*, and *Anisogammarus* sp.

In February one specimen from the mid bay had *Upogebia* larvae in its stomach. The other samples were from the upper bay and contained mainly insects.

In March only one specimen was collected, which was from the lower bay. Its contents were a large number of *Upogebia* larvae, which were also a large part of the stomach contents of surf smelt from the lower bay at this time.

English Sole

Table 3 shows the number of food organisms found per stomach for each English sole. Ten percent of the stomachs were empty. No samples were collected in December.

Pelecypod siphons were the main constituents of the stomach contents for all of the months in which samples were collected. In November juvenile bivalves and polychaete worms were also main food items for adult English sole in the mid-bay region.

In January specimens from the lower bay region also contained polychaete worms. Only one specimen with a full stomach was collected in February, which was from the lower bay region and contained only pelecypod siphons.

In March and April juvenile English sole were collected from the lower bay. In March these contained harpacticoids in addition to the pelecypod siphons, while in April, these contained mainly tanaids.

Starry Flounder

Table 4 shows the number of food organisms found per stomach for each starry flounder. Of the stomachs examined, 36.2 were empty, with the highest monthly percentage of empty stomachs occurring in April (80%). Only adult fish were collected.

The main food organisms consumed by starry flounder were amphipods. In November *Anisogammarus* sp. and *C. spinicorne* were the main food items for fish from the upper bay. In the lower bay one specimen contained mainly *Paraphoxus* sp., a gammarid amphipod, and tanaids. In the mid-bay region, *Anisogammarus* sp. composed most of the contents.

In December two specimens from the upper bay were empty, two were approximately 10% full, while one was approximately 50% full and contained primarily nereid worms. In the mid bay many *Anisogammarus* sp. were the main part of the stomach contents, as was observed in the mid and upper bay in November.

In the upper bay in January, *Anisogammarus* sp was the main food item, while one specimen contained the shrimp *Crangon franciscorum*. The one specimen from the mid bay contained a polychaete worm and the isopod *G. oregonensis*. *Paraphoxus* sp. were the main items in samples from the lower bay, as had been the case in November.

In February *Anisogammarus* sp. and *C. spinicorne* were the main items found in stomachs from fish collected in the upper bay. Samples from other regions were not collected.

In March *Anisogammarus* sp. and some *C. spinicorne* were the most commonly found food items in the upper bay. One specimen from the mid bay contained the polychaete worm of the genus *Glycinde*. In the lower bay gammarid amphipods and pelecypod siphons were the main constituents of the diet. One specimen from this region contained only a large decapod appendage.

In April only one fish had a full stomach from the mid bay. Its contents were amphipods only, with *Anisogammarus* sp. and *C. spinicorne* as the main items. In the upper bay, the main food items were the amphipods *C. salmonis*, *Anisogammarus* sp. and *C. spinicorne*.

DISCUSSION AND CONCLUSIONS

Crustaceans are the dominant food organisms consumed by all of the fish in this study, with the exception of the English sole. The main food items for the English sole, as previously stated, were pelecypod siphons.

The food habits of the surf smelt appear to be influenced by the availability of food particles in the region of the bay which they occupy. There doesn't seem to be a great difference between the food habits of adults and juveniles based on the small numbers available for comparison for the sampling dates and locations.

Chinook salmon stomachs contained insects either as the main or one of the main food items throughout the 4 month period from November 1975 to February 1976. The amphipods, *Anisogammarus* sp., *C. salmonis*, and *C. spinicorne*, and the isopod, *G. oregonensis*, were also important food items during this time period. In March the last specimen collected contained 190 *Upogebia* larvae and one insect. *Upogebia* larvae also composed most of the stomach contents of surf smelt collected at this time in the lower bay.

The food habits for adult and juvenile English sole didn't vary greatly. Pelecypod siphons were the main food items throughout the sampling period for both groups. The juveniles consumed harpacticoids which were absent from the adult diet.

The food habits for starry flounder from the upper and mid-bay regions appear to be similar during the 6 month sampling period. The amphipods, *Anisogammarus* sp. and *C. spinicorne* were the main food items for these fish. In the lower bay region, the amphipod, *Paraphoxus* sp., was a common food item. The other important food items for these fish are epibenthic organisms, such as polychaete worms and isopods.

In summary the four species of fish analyzed consume epibenthic organisms primarily. The most common food organisms for all of the fish, with the exception of the English sole, are epibethic crustaceans.

Further detailed analyses of the stomach contents of the four species studied were restricted by quality and quantity considerations. Stomach contents that were too digested to identify to species, such as pelecypod siphons, were identified to group only. The degree to which the stomach contents from different regions of the bay could be compared was limited either by inadequate sample size or by lack of samples from all three regions for a particular sampling period.

LITERATURE CITED

Reimers, P. E. 1964. A modified method of analyzing stomach contents with notes on the food habits of coho salmon in the coastal waters of Oregon and southern Washington. Fish Comm. Oreg., Res. Briefs 10:46-56.

Table 1. The number of food organisms per stomach for 55 surf smelt collected in November 1975 to April 1976.

Collection site	Lower Bay					Lower Bay	
Date	11/20					12/19	
Type of net used	Beach Seine					Trawl	
Life stage[1]	A	A	A	A	A	A	A
Stomach fullness (%)	100	100	100	75	75	100	50
Fork length (mm)	96.5	98.0	106.0	106.5	106.5	101.0	108.8
Wet weight of contents (g)	.081	.013	.083	.038	.025	.233	.040
Wet weight of fish (g)	6.0	6.2	8.6	7.2	8.5	7.7	8.7
Food Organisms							
Epibenthic Organisms							
Amphipod, corophid							
Corophium salmonis	1					3	
Corophium spinicorne		1			1	43	6
Corophium sp.	1	3	2		1		
Amphipod, gammarid	1	3	3				1
Anisogammarus sp.			1			15	
Copepod, harpacticoid	1	19	9	3	2		
Family Ectinomidae							
Cumacean							
Cumella vulgaris	1	2	1				
Isopod	1						
Mysid larva			1				
Polychaete adult			4	2			
Eteone sp.						3	
Large Planktonic Organisms							
Copepod, calanoid (over 2mm long)							
Calanus sp.		1	2	1	1	16	9
Decapod larva							
Crab zoea			1		1		
Upogebia sp.	3						1
Euphausid furcilia			1				1
Euphausid adult							
Euphausia pacifica			1				
Fish larva							
Leptocottus armatus		1	2				
Parophrys vetulus			1				
Small planktonic organisms							
Barnacle cypris	10	6			9		
Barnacle nauplius	20	15	8	9	13		
Chaetognath		1					
Copepod, calanoid (under 2mm long)	286	434	298	160	293	6	58
Gastropod larva	1	6	4	1	2		
Larvacean							
Oikopleura sp.	161	247	183	40	55	2	8
Pelecypod larva	2	2			2		
Polychaete larva	8	26	2	6	9		5

Table 1 (cont'd)

Collection site	Lower Bay	Upper Bay					
Date	12/22	1/12					
Type of net used		75' Seine					
Life stage	A	J	J	J	A	A	A
Stomach fullness (%)	100	25	10	10	75	75	75
Fork length (mm)	94.8	57.9	58.0	61.9	93.2	97.2	110.0
Wet weight of contents (g)	.041	.006	--	--	.021	.020	.021
Wet weight of fish (g)	5.9	1.1	1.2	1.3	6.5	7.0	10.5
Food Organisms							
Epibenthic Organisms							
Amphipod, corophid							
Corophium salmonis	6					37	
Corophium spinicorne	1						
Corophium sp.	1						
Amphipod, gammarid							
Anisogammarus sp.	35				4	1	
Copepod, harpacticoid		51	3	6	18	5	
Family Ectinomidae							
Cumacean							
Cumella vulgaris		1	2	1			
Isopod							
Mysid larva					2		
Polychaete adult							
Eteone sp.							
Large Planktonic Organisms							
Copepod, calanoid (over 2mm long)							
Calanus sp.	2	1			1		
Decapod larva							
Crab zoea							
Upogebia sp.							
Euphausid furcilia							
Euphausid adult							
Euphausia pacifica							
Fish larva							
Leptocottus armatus							1
Parophrys vetulus							
Small Planktonic Organisms							
Barnacle cypris							
Barnacle nauplius							
Chaetognath							
Copepod, calanoid (under 2mm long)	13				4		
Gastropod larva							
Larvacean							
Oikopleura sp.	1						
Pelecypod larva			1		1		
Polychaete larva							

Table 1 (cont'd)

Collection site	Lower Bay				
Date	1/26				
Type of net used	150' Seine				
Life stage	J	J	J	J	J
Stomach fullness (%)	10	10	10	0	10
Fork length (mm)	46.0	46.2	49.0	51.0	57.7
Wet weight of contents (g)	--	--	--	00	--
Wet weight of fish (g)	.4	.4	.3	.5	1.0
Food Organisms					
Epibenthic Organisms					
Amphipod, corophid					
Corophium salmonis					
Corophium spinicorne					
Corophium sp.					
Amphipod, gammarid					
Anisogammarus sp.					
Copepod, harpacticoid					
Family Ectinomidae					
Cumacean					
Cumella vulgaris					
Isopod					
Mysid larva					
Polychaete adult					
Eteone sp.					
Large Planktonic Organisms					
Copepod, calanoid (over 2mm long)					
Calanus sp.					
Decapod larva					
Crab zoea					
Upogebia sp.					
Euphausid furcilia					
Euphausid adult					
Euphausia pacifica					
Fish larva					
Leptocottus armatus					
Parophrys vetulus					
Small Planktonic Organisms					
Barnacle cypris					
Barnacle nauplius					
Chaetognath					
Copepod, calanoid (under 2mm long)	1	2	1		17
Gastropod larva					
Larvacean					
Oikopleura sp.					
Pelecypod larva					1
Polychaete larva	1				7

Table 1 (cont'd)

Collection site	Mid Bay		
Date	2/20		
Type of net used	Seine		
Life stage	J	J	A
Stomach fullness (%)	25	0	50
Fork Length (mm)	57.8	62.0	91.0
Wet weight of contents (g)	--	0	.010
Wet weight of fish (g)	1.0	1.4	5.6
Food Organisms			
Epibenthic Organisms			
Amphipod, corophid			
Corophium salmonis			1
Corophium spinicorne			
Corophium sp.			
Amphipod, gammarid			
Anisogammarus sp.			
Copepod, harpacticoid			1
Family Ectinomidae			
Cumacean			
Cumella vulgaris	2		3
Isopod			
Mysid larva			
Polychaete adult			
Eteone sp.			
Large Planktonic Organisms			
Copepod, calanoid (over 2mm long)			
Calanus sp.			
Decapod larva			
Crab zoea			
Upogebia sp.			
Euphausid furcilia			
Euphausid adult			
Euphausia pacifica			
Fish larva			
Leptocottus armatus			
Parophrys vetulus			
Small Planktonic Organisms			
Barnacle cypris			
Barnacle nauplius			
Chaetognath			
Copepod, calanoid (under 2mm long)	3		2
Gastropod larva			
Larvacean			
Oikopleura sp.			
Pelecypod larva			
Polychaete larva			

Table 1 (cont'd)

Collection site	Upper Bay						
Date							
Type of net used	75' Seine						
Life stage	J	J	J	J	J	J	J
Stomach fullness (%)	100	100	0	75	50	75	50
Fork length (mm)	51.4	53.2	54.0	54.3	54.8	56.0	57.0
Wet weight of contents (g)	--	--	0	--	--	--	--
Wet weight of fish (g)	.8		1.0	.9	.9	1.1	1.2
Food Organisms							
Epibenthic Organisms							
Amphipod, corophid							
Corophium salmonis							
Corophium spinicorne							
Corophium sp.							
Amphipod, gammarid							
Anisogammarus sp.							
Copepod, harpacticoid		1					
Family Ectinomidae				9			2
Cumacean							
Cumella vulgaris							
Isopod							
Mysid larva							
Polychaete adult							
Eteone sp.							
Large Planktonic Organisms							
Copepod, calanoid (over 2mm long)							
Calanus sp.							
Decapod larva							
Crab zoea	2	1		1			1
Upogebia	1						
Euphausid furcilia							
Euphausid adult							
Euphausia pacifica							
Fish larva							
Leptocottus armatus							
Parophrys vetulus							
Small Planktonic Organisms							
Barnacle cypris							
Barnacle nauplius							
Chaetognath							
Copepod, calanoid (under 2mm long)	53	91		50	63	54	61
Gastropod larva							
Larvacean							
Oikopleura sp.							
Pelecypod larva	1			2		4	
Polychaete larva						2	

Table 1 (cont'd)

Collection site	Lower Bay			
Date	3/5			
Type of net used	Seine			
Life stage	J	J	J	J
Stomach fullness (%)	100	25	0	50
Fork length (mm)	51.0	52.0	52.8	59.5
Wet weight of contents (g)	--	--	0	--
Wet weight of fish (g)	.8	.8	.8	1.3
Food Organisms				
Epibenthic Organisms				
Amphipod, corophid				
Corophium salmonis				
Corophium spinicorne				
Corophium sp.				
Amphipod, gammarid				
Anisogammarus sp.				
Copepod, harpacticoid		9		2
Family Ectinomidae				
Cumacean				
Cumella vulgaris				
Isopod				
Mysid larva				
Polychaete adult				
Eteone sp.				
Large Planktonic Organisms				
Copepod, calanoid (over 2mm long)				
Calanus sp.				
Decapod larva				
Crab zoea				
Upogebia sp.	21			18
Euphausid furcilia				
Euphausid adult				
Euphausia pacifica				
Fish larva				
Leptocottus armatus				
Parophrys vetulus				
Small Planktonic Organisms				
Barnacle cypris				
Barnacle nauplius				
Chaetognath				
Copepod, calanoid (under 2mm long)				5
Gastropod larva				
Larvacean				
Oikopleura sp.				
Pelecypod larva				
Polychaete larva				

Table 1 (cont'd)

Collection site	Lower Bay						
Date	3/12						
Type of net used	150' Seine						
Life stage	A	A	A	A	A	A	A
Stomach fullness (%)	75	75	100	75	100	100	100
Fork length (mm)	92.0	92.2	94.0	94.8	104.0	104.7	111.0
Wet weight of contents (g)	.061	.161	.214	.202	.310	.292	.269
Wet weight of fish (g)	4.8	5.2	5.8	6.2	7.8	6.7	9.4
Food Organisms							
Epibenthic Organisms							
Amphipod, corophid							
Corophium salmonis							
Corophium spinicorne							
Corophium sp.							
Amphipod, gammarid							1
Anisogammarus sp.			3				
Copepod, harpacticoid							
Family Ectinomidae							
Cumacean							
Cumella vulgaris							
Isopod							
Mysid larva							
Polychaete adult							
Eteone sp.							
Large Planktonic Organisms							
Copepod, calanoid (over 2mm long)							
Calanus sp.							
Decapod larva							
Crab zoea							
Upogebia sp.	93	207	431	361	532	466	628
Euphausid furcilia							
Euphausid adult							
Euphausia pacifica							
Fish larva							
Leptocottus armatus							
Parophrys vetulus							
Small Planktonic Organisms							
Barnacle cypris							
Barnacle nauplius							
Chaetognath							
Copepod, calanoid (under 2mm long)	2	17	1	2	2	4	1
Gastropod larva							
Larvacean							
Oikopleura sp.							
Pelecypod larva							
Polychaete larva	1	1		1			

Table 1 (cont'd)

Collection site	Lower Bay					
Date	4/8					
Type of net used	Seine					
Life stage	A	A	A	A	A	A
Stomach fullness (%)	75	50	75	50	75	50
Fork length (mm)	61.9	63.3	67.2	68.2	71.0	72.1
Wet weight of contents (g)	--	--	--	--	--	--
Wet weight of fish (g)	1.6	1.8	1.8	2.0	2.2	2.5
Food Organisms						
Epibenthic Organisms						
Amphipod, corophid						
Corophium salmonis						
Corophium spinicorne						
Corophium sp.						
Amphipod, gammarid	1					
Anisogammarus sp.						
Copepod, harpacticoid						1
Family Ectinomidae						
Cumacean						
Cumella vulgaris						
Isopod						
Mysid larva						
Polychaete adult						
Eteone sp.						
Large Planktonic Organisms						
Copepod, calanoid (over 2mm long)						
Calanus sp.						
Decapod larva						
Crab zoea						1
Upogebia sp.	9	1	1	3	8	11
Euphausid furcilia						
Euphausid adult						
Euphausia pacifica						
Fish larva						
Leptocottus armatus						
Parophrys vetulus						
Small Planktonic Organisms						
Barnacle cypris	2					
Barnacle nauplius						
Chaetognath						
Copepod, calanoid (under 2mm long)	47	16	14	5	6	12
Gastropod larva						
Larvacean						
Oikopleura sp.						
Pelecypod larva						
Polychaete larva						

Table 1 (cont'd)

Collection site	Upper Bay					
Date	4/19					
Type of net used	75' Seine					
Life stage	J	J	J	J	J	J
Stomach fullness (%)	100	50	75	100	75	75
Fork length (mm)	51.5	52.8	57.9	58.2	58.8	59.7
Wet weight of contents (g)	--	--	--	--	--	--
Wet weight of fish (g)	.9	1.0	1.3	1.3	1.3	1.4
Food Organisms						
Epibenthic Organisms						
Amphipod, corophid						
Corophium salmonis						
Corophium spinicorne			1			
Corophium sp.						
Amphipod, gammarid			1			
Anisogammarus sp.						1
Copepod, harpacticoid	230	100	129	65	182	138
Family Ectinomidae	7		27	4	77	45
Cumacean						
Cumella vulgaris						
Isopod						
Mysid larva						
Polychaete adult						
Eteone sp.						
Large Planktonic Organisms						
Copepod, calanoid (over 2mm long)						
Calanus sp.						
Decapod larva						
Crab zoea						
Upogebia sp.						
Euphausid furcilia						
Euphausid adult						
Euphausia pacifica						
Fish larva						
Leptocottus armatus				12		
Parophrys vetulus						
Small Planktonic Organisms						
Barnacle cypris						
Barnacle nauplius						
Chaetognath						
Copepod, calanoid (under 2mm long)						
Gastropod larva						
Larvacean						
Oikopleura sp.						
Pelecypod larva						
Polychaete larva						

[1] *A = Adult and J = Juvenile.*

Table 2. The number of food organisms per stomach for 23 chinook salmon collected in November 1975 to April 1976.

Collection site	Upper Bay			Upper Bay		Lower Bay			
Date	11/6			11/13		11/20			
Type of net used	Seine			75' Seine		Beach Seine			
Life stage[1]	J	J	J	J	J	J	J	J	J
Stomach fullness (%)	100	50	25	50	100	25	50	100	25
Fork length (mm)	108.0	125.0	149.0	104.0	112.6	102.2	109.2	110.2	111.8
Wet weight of contents (g)	.267	.161	.096	.287	.583	.072	.279	.582	.127
Wet weight of fish (g)	16.3	24.4	44.2	11.5	14.6	11.1	12.7	14.9	13.6
Food Organisms									
Amphipod, corophid									
Corophium spinicorne	33	7	10	89	140	2	1		
Amphipod, gammarid	1			1		1			
Anisogammarus sp.	5		1	1	12		8		2
Isopod									
Gnorimosphaeroma oregonensis		8		1		2			6
Mysid adult									
Suborder Mysida									1
Neomysis sp.								3	
Large Planktonic Organisms									
Copepod, calanoid (over 2mm long)									
Eucalanus sp.						1			
Decapod larva									
Upogebia sp.									
Euphausid adult									
Euphausia pacifica							1		
Fish larva								2	
Small Planktonic Organisms									
Barnacle cypris						1			
Miscellaneous									
Arachnid	1								1
Insect adult		1	5	1	1	2		1	1
Insect larva	3	1							
Wood fragment				1					

Table 2 (cont'd)

Collection site	Upper Bay					Mid Bay
Date	1/12					2/19
Type of net used	75' Seine					Trawl
Life stage	J	J	J	J	J	J
Stomach fullness (%)	0	100	25	50	0	100
Fork length (mm)	35.8	36.0	38.0	38.2	38.7	38.0
Wet weight of contents (g)	0	--	--	--	0	--
Wet weight of fish (g)	.2	.2	.2	.3	.3	.3
Food Organisms						
Amphipod, corophid		5				
Corophium spinicorne		2				
Amphipod, gammarid						
Anisogammarus sp.		1				
Isopod						
Gnorimosphaeroma oregonensis						
Mysid adult						
Suborder Mysida						
Neomysis sp.						
Large Planktonic Organisms						
Copepod, calanoid (over 2mm long)						
Eucalanus sp.						
Decapod larva						
Upogebia sp.						4
Euphausid adult						
Euphausia pacifica						
Fish larva						
Small Planktonic Organisms						
Barnacle cypris						
Miscellaneous						
Arachnid						
Insect adult		1		2		1
Insect larva						
Wood fragment						1

Table 2 (cont'd)

Collection site	Upper Bay							Lower Bay
Date	2/25							3/5
Type of net used	75' Seine							Seine
Life stage	J	J	J	J	J	J	J	J
Stomach fullness (%)	100	100	75	75	50	100	100	100
Fork length (mm)	35.8	38.2	38.8	40.5	41.0	46.3	47.1	48.5
Wet weight of contents (g)	--	--	--	--	--	--	--	.100
Wet weight of fish (g)	.3	.4	.5	.6	.7	1.1	1.1	1.2
Food Organisms								
Amphipod, corophid							1	
Corophium spinicorne			1					
Amphipod, gammarid								
Anisogammarus sp.								
Isopod								
Gnorimosphaeroma oregonensis								
Mysid adult								
Suborder Mysida								
Neomysis sp.								
Large Plankton Organisms								
Copepod, calanoid (over 2mm long)								
Eucalanus sp.								
Decapod larva								
Upogebia sp.								190
Euphausid adult								
Euphausia pacifica								
Fish larva								
Small Planktonic Organisms								
Barnacle cypris								
Miscellaneous								
Arachnid								
Insect adult	2	5	1	1	1	3	6	1
Insect larva		2						
Wood fragment								

[1] *A = Adult and J = Juvenile.*

Table 2 (cont'd)

Collection site	L.Bay	Mid Bay	Lower Bay			
Date	2/10	2/19	3/5			
Type of net used	Trawl	Trawl	Seine			
Life stage	A	A	J	J	J	J
Stomach fullness (%)	50	0	25	100	100	100
Fork length (mm)	111.0	115.8	22.8	32.8	33.0	33.5
Wet weight of contents (g)	.050	0	--	--	--	--
Wet weight of fish (g)	9.8	11.0	.1	.2	.3	.3
Food Organisms						
Epibenthic Organisms						
Amphipod, gammarid						1
Anisogammarus sp.						
Paraphoxus sp.						
Copepod, harpacticoid			11	45	2	
Cumacean						
Cumella vulgaris						
Mysid larva						
Polychaete adult						
Eteone sp.						
Glycinde sp.						
Pelecypod juvenile						
Siphons				4	2	5
Tanaids					4	
Miscellaneous						
Nematode						

Table 3. The number of food organisms per stomach for 20 English sole collected in November 1975 to April 1976.

Collection site	Mid Bay					L. Bay	Lower Bay	
Date	11/14					1/14	1/23	
Type of net used[1]	Trawl					Trawl	Trawl	
Life stage	A	A	A	A	A	A	A	A
Stomach fullness (%)	25	25	50	25	75	0	100	100
Fork length (mm)	82.5	86.8	93.0	97.5	116.6	77.9	82.7	87.2
Wet weight of contents (g)	.014	--	.031	.011	.128	0	--	--
Wet weight of fish (g)	3.7	4.8	6.2	6.8	11.9	3.1	3.7	4.6
Food Organisms								
Epibenthic Organisms								
Amphipod, gammarid		1						
Anisogammarus sp.					1			
Paraphoxus sp.								
Copepod, harpacticoid								
Cumacean								
Cumella vulgaris							1	
Mysid larva								
Polychaete adult	1	1	2				1	1
Eteone sp.					3			
Glycinde sp.				4				
Pelecypod juvenile	2	2	1	1	4			
Siphons	9	4	13	13	7		2	2
Tanaids								
Miscellaneous								
Nematode								

Table 3 (cont'd)

Collection site	Lower Bay					
Date	4/8					
Type of net used	Seine					
Life stage	J	J	J	J	J	J
Stomach fullness (%)	100	100	75	100	100	100
Fork length (mm)	47.1	48.5	48.8	48.8	49.3	51.1
Wet weight of contents (g)	--	--	--	--	--	--
Wet weight of fish (g)	.8	.9	.9	.9	.9	1.2
Food Organisms						
Epibenthic Organisms						
Amphipod, gammarid						
Anisogammarus sp.				1		
Paraphoxus sp.	1	2		2		
Copepod, harpacticoid					27	6
Cumacean	1					
Cumella vulgaris						
Mysid larva						
Polychaete adult						
Eteone sp.						
Glycinde sp.						
Pelecypod juvenile					2	
Siphons	12	9		13	11	17
Tanaids						
Miscellaneous						
Nematode					7	

[1] *A = Adult and J = Juvenile.*

Table 4. The number of food organisms per stomach for 57 starry flounder collected in November 1975 to April 1976.

Collection site	Upper Bay	Upper Bay		Lower Bay	Lower Bay	Lower Bay
Date	11/6	11/13		11/14	11/20	11/24
Type of net[1] used	Seine	Beach Seine		Trawl	Beach Seine	Beach Seine
Life stage	A	A	A	A	A	A
Stomach fullness (%)	50	25	100	25	10	25
Fork length (mm)	159.5	175.3	180.0	116.0	133.0	109.0
Wet weight of contents[2] (g)	.204	.037	1.521	.198	--	.073
Wet weight of fish (g)[2]						14.0
Food Organisms						
Epibenthic Organisms						
Amphipod, corophid	1	2				
Corophium salmonis						
Corophium spinicorne	19		1	14		
Amphipod, gammarid	6				2	
Anisogammarus sp.		4	55	2		29
Paraphoxus sp.						29
Cumacean						2
Isopod						
Gnorimosphaeroma oregonensis			8			
Mysid adult						
Suborder Mysida						
Nematode	1					1
Pelecypod juvenile	2					
Siphon	3		3			
Polychaete adult			5	1		
Eteone sp.			7			
Glycinde sp.			1			
Shrimp						
Crangon franciscorum						
Tanaids	1					60
Miscellaneous						
Algae						
Insect adult						
Insect larva						
Decapod appendage						
Plant material						

Table 4 (cont'd)

Collection site	Mid Bay	Mid Bay		Lower Bay
Date	11/24	12/10		12/10
Type of net used	Beach Seine	Beach Seine		Beach Seine
Life stage	A	A	A	A
Stomach fullness (%)	75	100	50	0
Fork length (mm)	193.0	157.0	180.8	182.9
Wet weight of contents (g)	.858	2.217	.670	0
Wet weight of fish (g)	87.5	37.1		67.8
Food Organisms				
Epibenthic Organisms				
Amphipod, corophid		1		
Corophium salmonis		2		
Corophium spinicorne	3	4		
Amphipod, gammarid	2	7	2	
Anisogammarus sp.	72	108	24	
Paraphoxus sp.		5	3	
Cumacean				
Isopod				
Gnorimosphaeroma oregonensis	1			
Mysid adult				
Suborder Mysida	1			
Nematode				
Pelecypod juvenile		2		
Siphon		10	10	
Polychaete adult		3		
Eteone sp				
Glycinde				
Shrimp				
Crangon franciscorum		1	1	
Tanaids		42		
Miscellaneous				
Algae	x			
Insect adult				
Insect larva				
Decapod appendage				
Plant material				

Table 4 (cont'd)

Collection site	Upper Bay				Upper Bay
Date	12/11				12/15
Type of net used	75' Seine				Trawl
Life stage	A	A	A	A	A
Stomach fullness (%)	10	0	0	10	50
Fork length (mm)	60.8	66.0	69.0	--	84.5
Wet weight of contents (g)	--	0	0	--	--
Wet weight of fish (g)	1.8	2.6	2.7		5.9
Food Organisms					
Epibenthic Organisms					
Amphipod, corophid					1
Corophium salmonis					
Corophium spinicorne					1
Amphipod, gammarid					
Anisogammarus sp.					3
Paraphoxus sp.					
Cumacean					
Isopod					
Gnorimosphaeroma oregonensis					5
Mysid adult					
Suborder Mysida					
Nematode					
Pelecypod juvenile					
Siphon					
Polychaete adult					
Eteone sp.	1				
Glycinde sp.					
Shrimp					
Crangon franciscorum					
Tanaids					
Miscellaneous					
Algae					
Insect adult				1	
Insect larva				2	
Decapod appendage					
Plant material					

Table 4 (cont'd)

Collection site	Mid Bay		Upper Bay		Mid Bay	Upper Bay
Date	12/15		1/19		1/19	1/19
Type of net used	Trawl		Trawl		Trawl	Trawl
Life stage	A	A	A	A	A	A
Stomach fullness (%)	0	10	100	25	100	0
Fork length (mm)	83.9	102.2	77.8	101.2	123.8	160.8
Wet weight of contents (g)	0	.008	.105	.021	.424	0
Wet weight of fish (g)			4.6	10.9	19.8	39.6
Food Organisms						
Epibenthic Organisms						
Amphipod, corophid		1				
Corophium salmonis						
Corophium spinicorne			1	27		
Amphipod, gammarid						
Anisogammarus sp.		1	16			
Paraphoxus sp.						
Cumacean						
Isopod						
Gnorimosphaeroma oregonensis					1	
Mysid adult						
Suborder Mysida						
Nematode						
Pelecypod juvenile						
Siphon						
Polychaete adult		13			1	
Eteone sp.						
Glycinde sp.						
Shrimp						
Crangon franciscorum						
Tanaids						
Miscellaneous						
Algae						
Insect adult						
Insect larva						
Decapod appendage						
Plant material						

Table 4 (cont'd)

Collection site	Upper Bay		Upper Bay	Lower Bay	Lower Bay	Mid Bay
Date	1/20		1/21	1/22	1/26	2/11
Type of net used	Trawl		Seine	Seine	Seine	Trawl
Life stage	A	A	A	A	A	A
Stomach fullness (%)	100	50	100	0	100	0
Fork length (mm)	107.0	112.1	161.2	197.0	82.0	127.4
Wet weight of contents (g)	.247	.077	.773	0	.037	0
Wet weight of fish (g)	13.5	13.4	--	88.4	3.9	20.0
Food Organisms						
Epibenthic Organisms						
Amphipod, corophid						
Corophium salmonis	6					
Corophium spinicorne	1		1			
Amphipod, gammarid						
Anisogammarus sp.	36	4	12			
Paraphoxus sp.					37	
Cumacean						
Isopod						
Gnorimosphaeroma oregonensis						
Mysid adult						
Suborder Mysida						
Nematode						
Pelecypod juvenile						
Siphon			6		4	
Polychaete adult						
Eteone sp.	1		2			
Glycinde sp.						
Shrimp						
Crangon franciscorum			1			
Tanaids						
Miscellaneous						
Algae						
Insect adult						
Insect larva						
Decapod appendage						
Plant material		x				

Table 4 (cont'd)

Collection site	Upper Bay						
Date	2/12						
Type of net used	Trawl						
Life stage	A	A	A	A	A	A	A
Stomach fullness (%)	0	0				0	25
Fork length (mm)	69.0	69.2	71.8	74.0	74.2	88.5	97.2
Wet weight of contents (g)	0	0	.051	.023	.071	0	.036
Wet weight of fish (g)	2.9	2.9	3.4	3.1	3.6	7.1	11.1
Food Organisms							
Epibenthic Organisms							
Amphipod, corophid							
Corophium salmonis							
Corophium spinicorne			3	1	2		
Amphipod, gammarid							
Anisogammarus			8	3	3		6
Paraphoxus							
Cumacean							
Isopod							
Gnorimosphaeroma oregonensis				1	2		
Mysid adult							
Suborder Mysida							
Nematode							
Pelecypod juvenile							
Siphon							
Polychaete adult					2		
Eteone sp.							
Glycinde sp.							
Shrimp							
Crangon franciscorum							
Tanaids							
Miscellaneous							
Algae							
Insect adult				1	1		
Insect larva							
Decapod appendage							
Plant material							

Table 4 (cont'd)

Collection site	Upper Bay		Mid Bay	Lower Bay		
Date	2/25		3/3	3/5		
Type of net used	75' Seine			Seine		
Life stage	A	A	A	A	A	A
Stomach fullness (%)	0	25	10	100	10	100
Fork length (mm)	69.4	75.3	216.2	191.0	221.1	309.6
Wet weight of contents (g)	0	.005	.034	.852	.012	.572
Wet weight of fish (g)	3.4	4.7	129.8	106.1	149.0	--
Food Organisms						
Epibenthic Organisms						
Amphipod, corophid						
Corophium salmonis						
Corophium spinicorne						
Amphipod, gammarid		1		1		
Anisogammarus sp.						
Paraphoxus sp.						
Cumacean						
Isopod						
Gnorimosphaeroma oregonensis						
Mysid adult						
Suborder Mysida						
Nematode						
Pelecypod juvenile						
Siphon				73	1	
Polychaete adult						
Eteone sp.						
Glycinde sp.			1			
Shrimp						
Crangon franciscorum						
Tanaids						
Miscellaneous						
Algae						
Insect adult						
Insect larva						
Decapod appendage						1
Plant material						

Table 4 (cont'd)

Collection site	Lower Bay	Upper Bay	Upper Bay				
Date	3/14	3/16	3/29				
Type of net used		Trawl	Trawl				
Life stage	A	A	A	A	A	A	A
Stomach fullness (%)	10	100	50	100	25	0	0
Fork length (mm)	195.6	211.0	76.2	85.2	89.0	94.5	100.9
Wet weight of contents (g)	.031	.686	.016	.024	--	0	0
Wet weight of fish (g)	84.1	116.9	4.3	7.4	6.8	7.4	--
Food Organisms							
Epibenthic Organisms							
Amphipod, corophid							
Corophium salmonis			1				
Corophium spinicorne			1		3		
Amphipod, gammarid	1						
Anisogammarus sp.		22	1	2			
Paraphoxus sp.							
Cumacean							
Isopod							
Gnorimosphaeroma oregonensis							
Mysid adult							
Suborder Mysida							
Nematode							
Pelecypod juvenile	1	1					
Siphon							
Polychaete adult							
Eteone sp.							
Glycinde sp.							
Shrimp							
Crangon franciscorum							
Tanaids							
Miscellaneous							
Algae							
Insect adult							
Insect larva			1				
Decapod appendage							
Plant material		x					

Table 4 (cont'd)

Collection site	Mid Bay			Lower Bay
Date	4/8			4/12
Type of net used	Seine			Trawl
Life stage	A	A	A	A
Stomach fullness (%)	0	100	0	0
Fork length (mm)	99.8	123.8	133.0	106.8
Wet weight of contents (g)	0	.230	0	0
Wet weight of fish (g)	10.3	21.3	33.1	14.7
Food Organisms				
Epibenthic Organisms				
Amphipod, corophid		3		
Corophium salmonis sp.		22		
Corophium spinicorne sp.		1		
Amphipod, gammarid				
Anisogammarus sp.		11		
Paraphoxus sp.		1		
Cumacean				
Isopod				
Gnorimosphaeroma oregonensis				
Mysid adult				
Suborder Mysida				
Nematode				
Pelecypod adult				
Siphon				
Polychaete adult				
Eteone sp.				
Glycinde sp.				
Shrimp				
Crangon franciscorum				
Tanaids				
Miscellaneous				
Algae				
Insect adult				
Insect larva				
Decapod appendage				
Plant material				

Table 4 (cont'd)

Collection site	Upper Bay					
Date	4/13					
Type of net used						
Life stage	A	A	A	A	A	A
Stomach fullness (%)	0	0	0	0	10	0
Fork length (mm)	86.0	90.5	92.3	106.9	116.5	169.0
Wet weight of contents (g)	0	0	0	0	.033	0
Wet weight of fish (g)	5.9	7.2	6.8	13.7	50.3	50.3
Food Organisms						
Epibenthic Organisms						
Amphipod, corophid						
Corophium salmonis					10	
Corophium spinicorne					1	
Amphipod, gammarid						
Anisogammarus sp.					1	
Paraphoxus sp.						
Cumacean						
Isopod						
Gnorimosphaeroma oregonensis						
Mysid adult						
Suborder Mysida						
Nematode						
Pelecypod adult						
Siphon						
Polychaete adult						
Eteone sp.						
Glycinde sp.						
Shrimp						
Crangon franciscorum						
Tanaids						
Miscellaneous						
Algae						
Insect adult						
Insect larva						
Decapod appendage						
Plant material						

[1] *A = Adult and J = Juvenile.*
[2] *Cut fish were not weighed.*

OREGON

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