FEEDING ECOLOGY OF THE COMMON MURRE, *Uria aalge*, OFF THE OREGON COAST

by

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A THESIS

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Common Murres were censused and collected along the Oregon coast. Strip transects were conducted off Newport and the Columbia River in 1982, and off Coos Bay from 1979 to 1982. Density estimates were made and feeding analyses were done by examining stomach contents. 635 murres were collected. Diet included 37 species of fish, crustaceans and cephalopods. Opportunistic feeding is strongly suggested by diet diversity. The diet varied from location to location, seasonally, and from year to year off Coos Bay. Density estimates indicate similar murre densities off Coos Bay, Newport and the Columbia River in 1982. However, off Coos Bay, density was 127 murres/km^2 in 1981, but only 41 murres/km^2 in 1982. It is proposed, from feeding analyses, that differences in prey availability between 1981 and 1982 resulted in these density differences.

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INTRODUCTION

Seasonal changes in wind, surface currents and associated upwelling off the Oregon coast result in large seasonal changes in primary productivity (Bolin and Abbott, 1963, Peterson and Miller, 1976, Hobson, 1980). The spring and summer period of high productivity gives rise to a food resource large enough to support several species of seabirds and commercially valuable fish.

The Common Murre (*Uria aalge*) is the largest of the breeding populations of seabirds along the Oregon coast (Varoujean and Pitman, 1980). It has a circumpolar range (Tuck, 1961) and has been studied in both the Atlantic and Pacific oceans. In the Atlantic, Common Murres have been studied as far south as Scotland on the east coast (Swennen and Duiven, 1977) and Newfoundland on the west coast (John F. Piatt, pers. comm.). In the Pacific, studies have been carried out as far south as the Okhotsk Sea on the west coast (Ogi and Tsujita, 1977) and Monterey Bay on the east coast (Baltz and Morejohn, 1977). Off the Oregon coast, the breeding population of Common Murres has been estimated as 260,000 individuals (Varoujean and Pitman, 1980) on 20 major breeding colony sites (see Figure 1). The offshore range of Common Murres is from just outside the surf zone to about 60 km from shore.

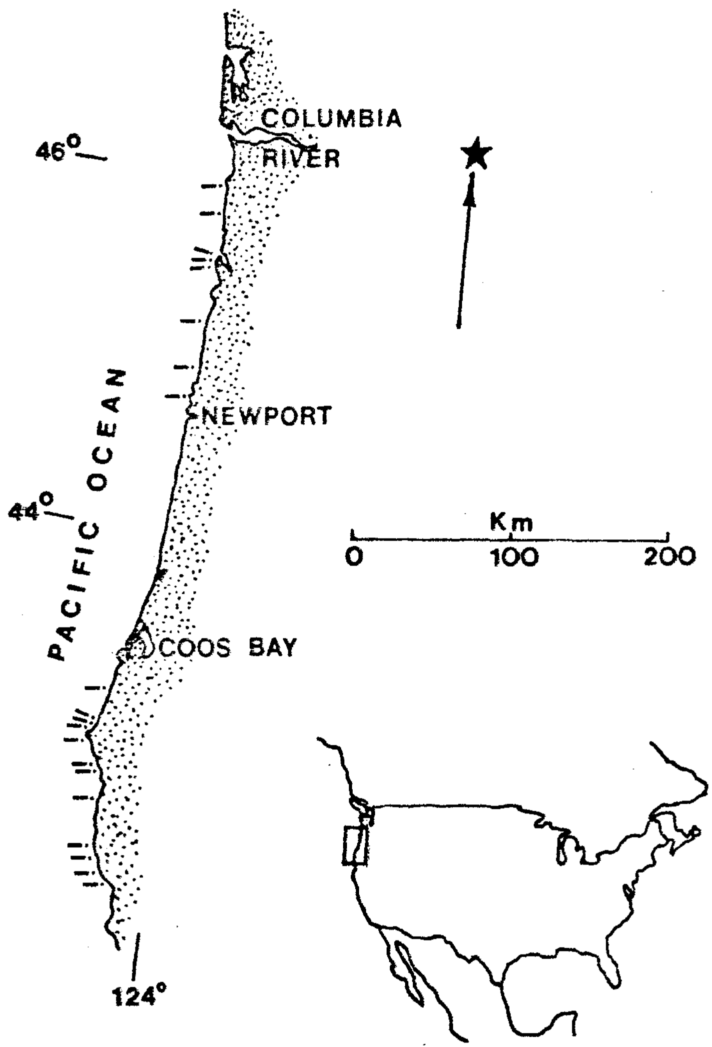

Figure 1. The Oregon Coast. The three study areas in which Common Murres were censused and collected are shown. —· = location of Common Murre colony sites.

During the breeding season, however, few Common Murres are found farther than 7 km from shore, and the average distance offshore is slightly greater during winter months (Scott, 1973).

Breeding begins with the arrival of murres at the colony site in April (Storer, 1952). Parents share the incubation and feeding of the single chick (Birkhead, 1976). The foraging distance from the colony site has not been established, but it is at least as far as 40 km, which is the distance from the nearest colony site south of Coos Bay. Furthermore, based on information about Thick-billed Murres (Gaston and Nettleship, 1981), foraging distances may be as high as 150 km, the distance from Coos Bay to Yaquina Head, the nearest colony site north of Coos Bay. Parent birds return from foraging with whole fish carried in the bill to feed the young (Pearson, 1968). Such birds have been seen in the Coos Bay study area, heading both north and south.

Chicks begin leaving the colony site in late June or early July with the male parent (Storer, 1952). The parent-chick pairs disperse from the colony site, swimming generally alongshore. The time of parent-chick association extends until late August to mid-September. Foraging during this time takes place in the immediate vicinity of the pair, since the chick is not fully "fledged" and cannot fly (personal observation). The adult forages for itself and its chick until late in the season, when the chick can begin to forage for itself.

Common murres pursue their prey by wing-propelled diving (Storer, 1952). Although Cody's study (1973) of diving capability reported the maximum dive times to be 71 seconds, murres have been recorded diving up to four minutes off the Oregon coast (personal observation) and to depths of 200 m off the Newfoundland coast (Piatt, pers. comm.).

Studies of murre feeding requirements have shown that adult murres need to consume about 25 percent of their body weight in food daily to maintain a constant weight (Sanford and Harris, 1967). The average weight of murres off the Oregon coast is about 1000 g (personal observation). This means that an adult murre should consume approximately 250 g of food per day to maintain constant body weight. This same food intake is required by chicks to maintain a positive growth rate (Varoujean, pers. comm.). Considering the entire Oregon population of Common Murres, the daily individual food requirements result in a total calculated intake of 65 metric tons of food per day. During the breeding season (from April to July), it is believed that the Oregon population of Common Murres is stable (Varoujean, 1981). Thus the total food requirements during the breeding season of the Oregon Common Murre population can be calculated to be about 7800 metric tons.

Feeding studies have shown that the size of prey items taken by murres off Scotland is from 2.2 cm to 15 cm (Swennen and Duiven, 1977). The average weight of prey items from Common Murres collected in the Okhotsk Sea was found to be 14 g, with a range of 1.3 g to 50 g (Ogi and Tsujita, 1977). This size class includes the midwater schooling fishes (the "bait fish": northern anchovy (Engraulis mordax), Pacific herring (Clupea harengus), and smelt (Osmeridae spp.)), market squid (Loligo opalescens), and juvenile rockfoshes (Sebastes spp.) and greenlings (Hexagrammidae spp.). This group of prey items is important as the primary food source for some commercially valuable species (Healy, 1980, Myers, 1979, Karpov and Cailliet, 1978, Peterson et. al., 1982). This size class may also include juveniles of commercially valuable species, such as salmon (Oncorhynchus spp.) and rockfishes (Miller and Lea, 1972). Thus murres may be feeding on the young of commercially valuable species, or competing with adults of these species for the same food resource.

Lists of prey items have been made, and trophic models constructed for Common Murre populations, but all of these studies have been based on extremely small sample sizes (Weins and Scott, 1973, Ogi and Tsujita, 1977, Baltz and Morejohn, 1977, Swennen and Duiven, 1977). In developing lists of prey items, samples in all these studies were also taken over a very short time and/or over a small study area.

The purpose of this study is to more accurately define Common Murre feeding off the Oregon coast. Various factors were emphasized in this study which were not adequately taken into account previously. First, a greater number of birds have been sampled. Second, the number of locations from which sampling was conducted was increased. And finally, the time frame during which sampling was conducted was expanded to include both the breeding and the nonbreeding seasons.

METHODS

Offshore cruises were conducted for two purposes: 1) to assess the density of Common Murres in the three study areas (see Figure 1); and 2) to develop a comprehensive list of prey items for each study area through the examination of the stomach contents of collected murres.

The Study Areas

Coos Bay

Coos Bay is approximately 160 km north of the California-Oregon border. The estuary covers approximately 10,000 acres. Tidewater extends inland about 22 km from the mouth. Fresh water yields from the estuary average 85 m^3/sec (Percy, et. al., 1974).

The offshore study area is shown in Figure 2. It includes sandy and rocky bottoms and submerged rock reefs. The depth offshore drops from about 15 meters at the mouth of the estuary to over 100 meters at a distance of 10 km west of the estuary mouth (see Figure 5).

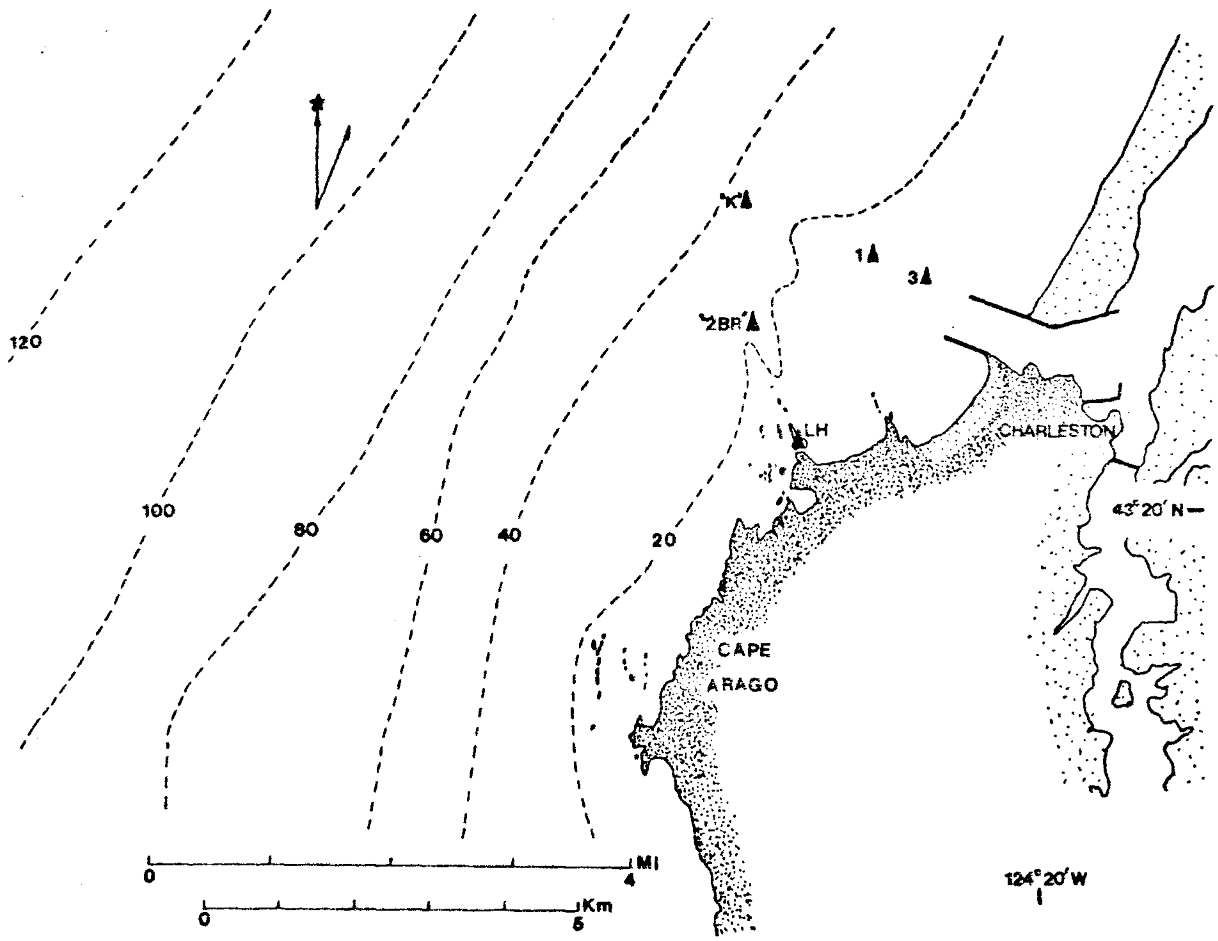

Figure 2. The Coos Bay study area. Offshore transects for each sampling day are shown in Appendices A and B. Depth contours are in meters. ▲ = location of navigation buoys.

Newport

The Newport study area includes Yaquina Bay, located near the center of the Oregon coast, about 150 km north of Coos Bay and 175 km south of the Columbia River. Yaquina Bay covers an area of approximately 4000 acres, and extends about 10 km inland from its mouth. Freshwater runoff from Yaquina Bay averages 30 m^3/sec (Percy, et. al., 1974).

The offshore study area is shown in Figure 3. It includes an area of sandy bottom and submerged rock reefs, and extends from the mouth of Yaquina Bay to Yaquina Head, about 7 km north. Depths offshore range from about 16 meters at the mouth of the estuary to about 60 meters at a distance of 10 km west of the estuary mouth (see Figure 5).

Columbia River

The Columbia River is located on the border between Oregon and Washington. It is the largest river on the Pacific coast of North America. Area in which tidal fluctuation occurs is approximately 350 km^2. Freshwater runoff is about 18,000 m^3/sec in May and 2000 m^3/sec in September (Orem, 1968, and Neal, 1972).

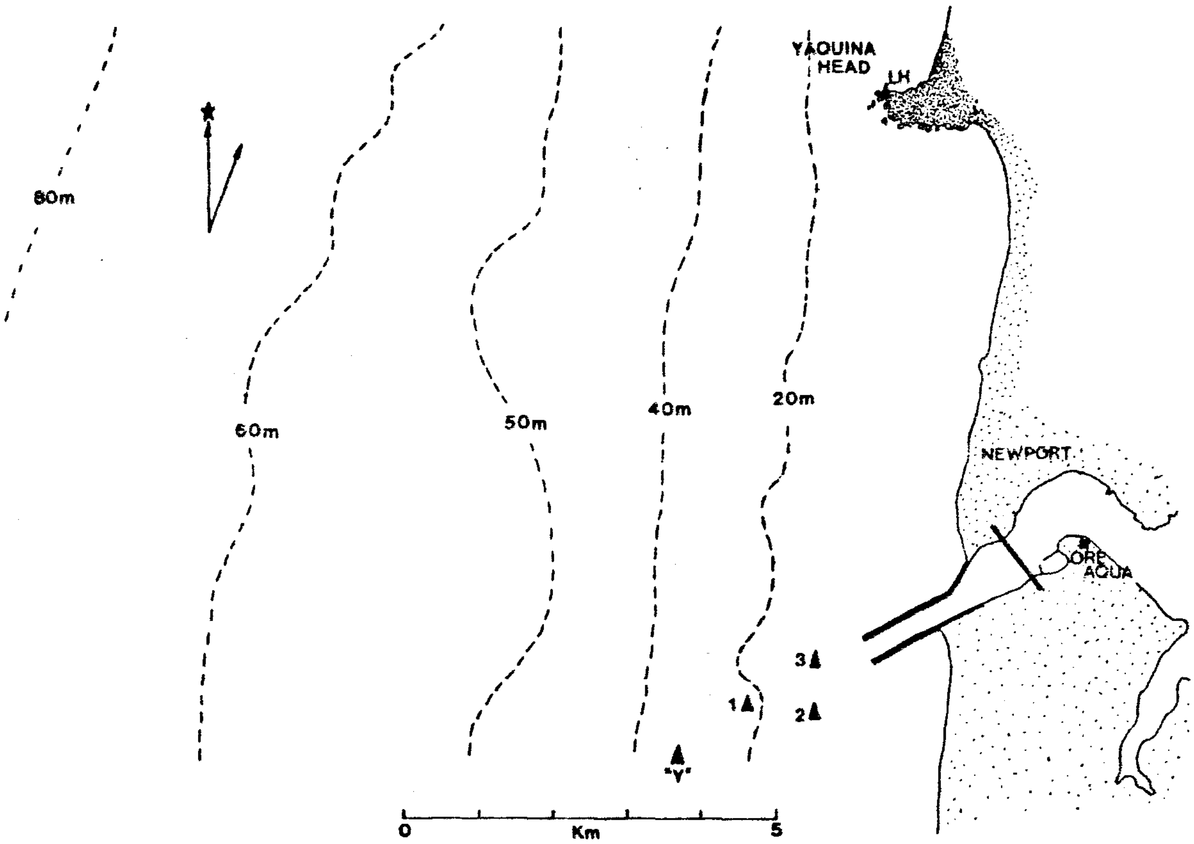

Figure 3. The Newport study area. Offshore transects for each sampling day are shown in Appendix C. Depth contours are in meters. ▲ = location of navigation buoys.

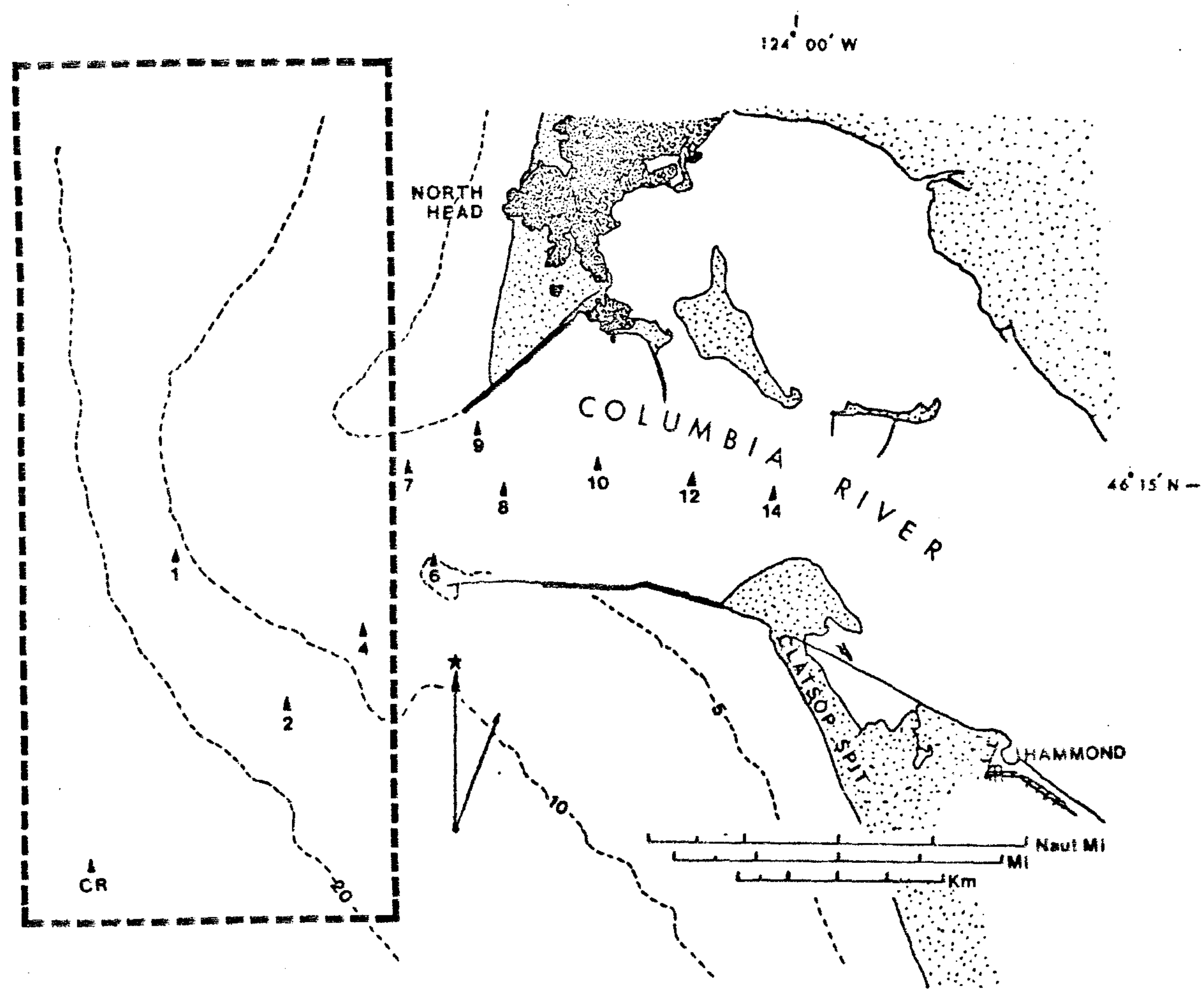

Figure 4. The Columbia River study area. Offshore transects for each sampling day are shown in Appendix D. Offshore sampling was conducted in the area approximated by the dashed-line rectangle. Depth contours are in fathoms (1 fathom = 1.8 meters). ▲ = location of navigation buoys.

The offshore study area is shown in Figure 4. It includes an area of almost exclusively sandy bottom, and extends from North Head to the Columbia River Lightship (a navigation buoy). The freshwater plume from the river extends over the entire study area. Depths offshore range from about 6 meters at the mouth of the river to just over 40 meters at a distance of 10 km west of the river mouth (see Figure 5).

Density Estimates

In each study area, predetermined strip transects were conducted, and will be discussed separately. In each of the study areas a standard census method was used. Transect width was established as 300 meters; i.e., 150 meters on each side of the vessel. Only swimming murres were used for density estimates, although flying murres were often recorded for other purposes. In rough seas, 150 meters is the maximum distance at which an observer can be confident of counting virtually all murres. Therefore, to be consistent, the transect width remained 300 meters even during conditions of calm seas, when birds could be seen at distances greater than 150 meters from either side of the vessel.

On each sampling day the total transect area com-

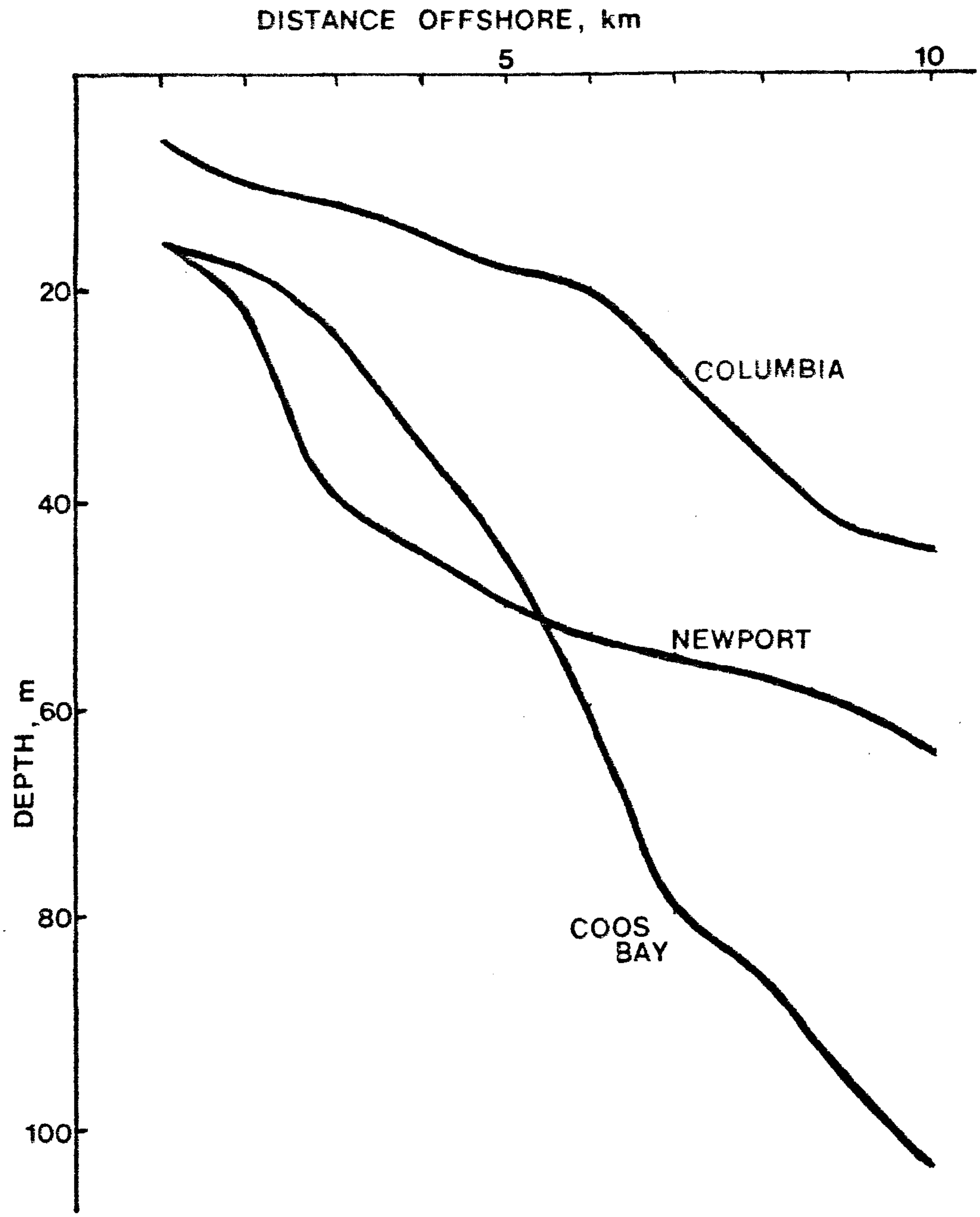

Figure 5. Graph showing the depth offshore in the three study areas. Depths shown are taken from National Ocean Survey Charts for each area, and indicate the depth due west of the tip of the south jetty at each estuary.

prised more than one transect segment. In calculating the density of murres, the total number of murres sighted was divided by the total transect area traversed during each sampling day. Additionally, murre densities along each transect segment were calculated separately, and comparisons were made of the maximum and minimum densities for that sampling day (see Appendices A-D). The actual number and configuration of the transect segments, and the vessel used, were different in each study area. The following is a description of the methods used in each study area.

Coos Bay Density Estimates

In the summers of 1979 and 1980, Common Murre censusing off Coos Bay was conducted from the 24-foot Oregon Institute of Marine Biology (OIMB) Survey Launch. Most censusing was done in the area between the navigation buoys marking the entrance of the channel and the Gregory Point Buoy, "2BR", thence extending west to about the 55-fathom line (see Figure 2). This represents a study area of approximately 15 km^2.

In 1981, two more transect segments were added, to include a region about 2 km north of the north jetty, at depths of about 18 and 30 meters. This increased the total study area to about 20 km^2. Transect lengths and positions were determined by compass headings and depth readings, as indicated by the onboard compass and fathometer. Observer height from the Survey Launch was 2 meters.

In 1982, the 14-foot OIMB Zodiak, Wovoka, was used for all but one cruise (one being conducted on the Survey Launch). Transects were increased to include an area west of Cape Arago, out to a distance of 6 to 15 km. This represents a study area of about 70 km^2. Seasonal censusing and collection were expanded to include the months of January through November. Positions were determined by taking at least two compass headings off prominently visible landmarks. Transect lengths were determined in the laboratory by the use of U.S. National Ocean Survey Chart 18521. Observer height from the Wovoka was one meter.

Newport Density Estimates

In 1982, Common Murres were censused and collected off Yaquina Bay (Newport) on the central Oregon coast (see Figure 3). Six cruises were conducted between April and September. The 14-foot OIMB Wovoka was used on all cruises. In general, the study area included the region from the navigation buoys marking the entrance to the harbor, west approximately 6 km, and north to Yaquina Head, about 7 km, where there is a breeding colony of Common Murres. This represents an area of approximately 42 km^2. Large groups of nonfeeding murres are found in the water near the colony site. Since including these birds in density estimates for the entire study area would result in elevated density estimates, murres within 500 meters of the colony site were not included in final density estimates.

Murres were also censused within Yaquina Bay, from the Oregon Aqua-Foods Inc. release site for salmon smolts to the end of the jetties. Murres were not collected in this area, due to restrictions governing the use of firearms.

Positions offshore were determined by at least two compass headings from prominently visible landmarks, and transect lengths were determined in the laboratory by use of U. S. National Ocean Survey Chart No. 18581. All cruises were conducted in the early morning, because during the season of the study, northwest winds and accompanying rough seas prevailed in the afternoon hours. Observer height from the *Wovoka* was one meter.

Columbia River Density Estimates

In May and June of 1982 six cruises were conducted off the Columbia River, on the northernmost end of the

Oregon coast. The purpose of the cruises was to determine the extent to which Common Murres forage on juvenile salmon. All cruises were conducted aboard the 40-foot U.S. National Marine Fisheries vessel _Egret_. Transects followed a similar plan (see Figure 4), beginning in the Columbia River channel, from navigation buoy No. 7 to buoy No. 14, at the end of the north jetty. Offshore, the study area extended north to North Head, west to navigation buoy No. 1, south to navigation buoy "CR", the Columbia River Lightship, and east from buoy "CR" to approximately the 10-fathom line. The total study area was approximately 125 km^2. Murres were again censused along the return route inside the channel, from navigation buoy No. 7 to No. 14. Return censusing in the channel represented a time difference of about three hours from the first transect segment (see Table H-1). The vessel's position and course was determined by on-board radar, compass and fathometer. Transects were plotted from this information, using U.S. National Ocean Survey Chart No. 1852. Observer height from the _Egret_ was 2 meters.

Due to hazardous bar conditions during the ebb tide on the Columbia River, cruises were timed so the entire transect was conducted during the flood tide.

Collection and Feeding Analysis

The methods of collection and feeding analysis remained consistent throughout the study. Common Murres were collected within 50 meters of a transect line, with a 12-guage shotgun and dip net. A conscientious effort was made to collect representative samples of the population; i.e., individuals were collected in areas of both high and low density. However, relatively fewer individuals were collected from large feeding flocks.

Immediately upon collection, an incision was made along the left side. The stomach (from lower esophagus to pylorus) was removed, labelled, bagged and placed on ice. The carcass was identically labelled and, in most cases, bagged. Record was made on the carcass label of time of collection, along with position and depth, if known at the time of collection. In all cases, position and depth information was checked in the laboratory, using navigational charts.

In the laboratory, carcasses were weighed to the nearest gram, and various anatomical features were measured, including gonads and brood patch. Determination of breeding status was based on the size and development of the brood patch and gonads. Carcasses were then frozen.

Prior to dissection, stomachs were weighed to the nearest 0.1 gram. Contents of the proventriculus were removed into a pan. Any whole or identifiable prey items were identified to species, weighed and measured. Fish otoliths (saggitae) or cephalopod beaks were removed from the whole prey item and saved. The remaining contents of the proventriculus was often a gruel consisting of flesh and bone fragments. This gruel was irrigated to wash away the lighter fragments. Remaining otoliths and/or cephalopod beaks were then carefully removed and saved for identification.

Fish otoliths and cephalopod beaks resist digestion and mechanical breakdown in the gizzard. These were carefully removed from bone fragments. Otoliths and cephalopod beaks from the proventriculus and gizzard were identified and stored in separately labelled gelatin capsules. Identification was accomplished by comparison with fish otoliths and cephalopod beaks in the OIMB reference collection, and by comparison with otolith photographs (Fitch, 1970, and Fitch, 1972) and drawings of cephalopod beaks (Huddleston and Barker, 1978). Dissected stomachs were rinsed and weighed to the nearest 0.1 gram. Weight of stomach contents was calculated. Weight of the empty stomach was added to the total body weight.

The minimum number of fish in a given stomach was taken to be the greatest number of right or left otoliths for each species. In some cases, otoliths were too badly eroded or broken to distinguish right from left. In these cases, the minimum number of fish was taken to be half of the number of otoliths. In cases where only small fragments of otoliths remained, the number of each recognizable species was taken to be one. When cephalopod beaks were present, the minimum number of individuals was taken to be the greatest number of upper or lower beak halves.

Frequency was determined by counting the number of times a particular prey taxa was found in the stomach contents, and dividing that number by the total number of murres collected in that study area. For example, 107 murres were collected off Coos Bay in 1981. 50 stomachs contained tomcod, so the frequency was 50/107, or 47%. At the same time, 72 stomachs contained market squid. Thus the frequency of market squid was 72/107, or 67% (see Appendix Table E-3).

RESULTS

Density Estimates

Off Coos Bay, six transects were conducted in 1981, and ten transects were conducted in 1982. Density estimates are presented in Tables 1 and 2. In 1981 the mean density of Common Murres was calculated to be 123 murres/km^2, while the mean density in 1982 was calculated to be 17 murres/km^2. During 1982, transects were conducted from April through November, while in 1981 transects were conducted from May through July. As Table 2 shows, murre density is low in April and November. Calculating murre density from May through July, 1982 (to compare with the same months in 1981), mean density was found to be 42 murres/km^2.

Six transects were conducted in each of the Newport and Columbia River study areas. Density estimates for these areas are presented in Tables 3 and 4. Mean density was calculated to be 41 murres/km^2 off Newport, and 51 murres/km^2 off the Columbia River.

April and May densities are shown to be low off Coos Bay and Newport. In 1982, murre density in April was 6 murres/km^2 off Coos Bay and 2 murres/km^2 off Newport. In May, density is only slightly higher. Off Coos Bay, murre density was 11 murres/km^2 in May, 1981. In 1982

Table 1. Abundance and density estimates of Common Murres off Coos Bay, 1981. Transect width = 0.3 km. For transect details, see Appendix A.

Date	Total Transect Length, km	Transect Area km^2	Number of Murres	Murres per km^2
25 May	9.5	2.9	32	11
2 June	7.4	2.2	446	201
30 June	19.0	5.7	1524	267
2 July	5.3	1.6	82	51
14 July	14.7	4.4	311	71
17 July	14.7	4.4	290	66
Totals	70.6	21.2	2685	mean 127

Table 2. Abundance and density estimates of Common Murres off Coos Bay, 1982. Transect width = 0.3 km. For transect details, see Appendix B.

Date	Total Transect Length, km	Transect Area km^2	Number of Murres	Murres per km^2
8 April	25.6	7.7	6	0.8
9 April	21.5	6.5	15	2.3
21 April	38.8	11.6	138	12
26 April	25.5	7.7	7	0.9
6 May	14.5	4.4	21	4.8
13 May	24.8	7.4	23	3.1
1 June	37.4	11.2	495	44
1 July	10.0	3.0	448	149
27 July	4.5	1.4	127	91
11 November	64	19.2	90	4.7
Totals	267	80.1	1370	mean 17

Table 3. Abundance and density estimates of Common Murres off Newport, 1982. Transect width = 0.3 km. For transect details, see Appendix C.

Date	Total Transect Length, km	Transect Area km^2	Number of Murres	Murres per km^2
29 April	36.7	11.0	25	2.3
11 May	43.2	13.0	121	9.3
18 May	7.0	2.1	15	7.1
29 June	21.8	6.5	358	55
3 August	31.2	9.4	932	99
4 Sept	21.3	6.4	585	91
Totals	161.2	48.4	2036	mean 42

Table 4. Abundance and density estimates of Common Murres off the Columbia River, 1982. Transect width = 0.3 km. For transect details, see Appendix D.

Date	Total Transect Length, km	Transect Area km^2	Number of Murres	Murres per km^2
24 May	23.0	6.9	852	123
3 June	35.5	10.7	195	18
4 June	42.0	12.6	659	52
10 June	36.0	10.8	478	44
11 June	38.5	11.6	751	65
22 June	40.5	12.2	344	28
Totals	215.5	64.8	3279	mean 51

murre density was 4 murres/km^2 off Coos Bay and 8 murres/km^2 off Newport. Although peak murre density was in late May off the Columbia River, peak murre density was in late June and early July off Coos Bay in both 1981 and 1982. Peak density off Newport was in August, but was lower than peak density estimates in the other study areas, and dropped little in September, from 99 murres/km^2 to 91 murres/km^2. Peak densities off Coos Bay and Newport correspond to the time of fledging of murre chicks (Storer, 1952). Mean murre density off Coos Bay in July and August was 66 murres/km^2 in 1981 and 55 murres/km^2 in 1982. By November, 1982, murre density off Coos Bay had dropped to levels similar to April and May estimates, 5 murres/km^2.

As shown in Appendix Tables A-D, there was little correlation between murre density and distance from shore for the three study areas. Likewise, depth offshore did not seem to have a positive correlation with murre density. In every study area, offshore density was higher than inshore density on some sampling days, and lower on others, with no general pattern.

During the Newport and Columbia River studies, murres were censused between the jetties at the beginning and again at the end of each transect (Appendix H). The time interval on each sampling day was about 3 hours. Average change in murre density between censuses was 241 murres/km^2 at Newport, and 26 murres/km^2 in the Columbia channel

Feeding Analysis

During the study, 635 murres were collected, 40 of which had empty stomachs. Remains of 5847 individual prey items, mostly otoliths, were found. Off Coos Bay, 31 species of fishes, 3 species of crustaceans, market squid and octopus (*Octopus* spp.) were identified in the stomachs of murres. Analysis of Newport murres showed 15 species of fishes, along with market squid and crab megalops (*Cancer* spp.). Prey items off the Columbia River included market squid and 13 species of fishes. Complete lists of stomach analyses are presented in Appendix E.

Of the 635 murres collected at all three sites, 503 murres were collected off Coos Bay from 1979 to 1982. Of these, 30 had empty stomachs. The others contained remains of 4977 prey items. Results are summarized in Table 5. In 1979, 41.3% of the diet (by number) was Pacific sand-lance (*Ammodytes hexapterus*). The largest dietary component by number in 1980 and 1981 was juvenile rockfishes, composing 42.5% and 24.5% of the diet, respectively. In 1982 euphausiids made up 35.5% of the diet by number, but were found in only 15 out of 120 stomachs examined.

Frequency of prey items varied from year to year. During the entire study period, 1979 to 1982, Pacific tomcod (*Microgadus proximus*) was found in 48% of the

Table 5. Summary of Common Murre prey items, Coos Bay, 1979-1982. This list includes only those prey species composing more than one percent of the diet during any year. For complete lists of prey items, see Appendix E.

Prey Species	Per Cent of Diet by Number 1979	1980	1981	1982	Total	Frequency* %
rockfish juv.	9.2	42.5	24.5	0.7	20.7	25
Pacific sandlance	41.3	11.8	11.3	4.5	15.2	19
Pacific tomcod	22.2	9.3	13.0	18.2	15.0	48
whitebait smelt	14.8	6.4	13.7	13.3	11.4	29
euphausiids	0	0	0	35.5	10.4	3
market squid	6.3	2.5	24.0	3.8	7.6	32
northern anchovy	0.4	3.6	3.1	14.4	6.1	14
speckled sanddab	0	11.1	0.7	0	3.8	2
Pacific herring	3.4	2.6	1.1	3.3	2.7	14
coho salmon	0.1	0.3	6.5	0.1	1.4	6
octopus	0.1	3.6	0	0	1.2	3
greenling juv.	0	1.6	0.5	1.1	0.9	3
shiner surfperch	0.1	0.4	0.3	1.6	0.7	4
total number of prey items	939	1661	921	1456	4977	

*Based on 503 murres collected.

For scientific names of the above prey species, refer to Table G-1.

stomachs, and the frequency of whitebait smelt (Allosmerus elongatus) was 29%.

Stomach contents were compared on a month-by-month basis each year to try to find a seasonal pattern to murre feeding (Appendix F). There were large monthly variations in the contribution of each species to the diet. Some species showed seasonal highs in dietary abundance, but there was no consistency in monthly prey abundance from year to year for any particular species.

A geographical comparison was made of the diets of murres feeding off Coos Bay, Newport, and the Columbia River (Table 6). Pacific tomcod was the most frequently consumed prey item off Coos Bay (62%) and Newport (38%). There was no other close comparison in diet between the three study areas. As dietary components, euphausiids were highest off Coos Bay (35.5% of the diet by number). Pacific herring was highest off Newport (23.4% by number, including 18.1% juveniles), while northern anchovy was highest off the Columbia River, both in frequency (74%) and in percent of the diet (46.7% by number).

Murres collected off Newport were divided into two groups to determine any difference in diet with respect to distance from the mouth of the estuary. The first group included those murres collected within 2 km of the ends of the jetties. The second group included those murres

Table 6. Summary of Common Murre prey items from murres collected off Coos Bay, Newport and the Columbia River, 1982. This list includes only those prey species composing more than one percent of the diet in any study area. For complete lists of prey species, refer to Appendix Tables E-4, E-5 and E-6.

Prey Species	Per Cent of Diet Coos Bay	Newport	Columbia
euphausiids	35.5	0	0
Pacific tomcod	18.2	13.8	29.5
northern anchovy	14.4	2.7	46.7
whitebait smelt	13.3	0.7	7.6
Pacific sandlance	4.5	1.9	0.7
market squid	3.8	14.7	0.4
Pacific herring	3.3	23.4*	1.5
shiner surfperch	1.6	2.4	0
smelt**	1.3	1.7	7.8
greenling juveniles	1.2	5.6	0
rockfish juveniles	0.7	2.2	1.5
coho salmon	0.1	9.4	2.0
crab megalops	0	18.8	0
Total number of prey items	1456	409	461

* includes 18.1% juveniles

** all smelt species other than whitebait smelt

For scientific names of the above prey species, refer to Table G-1.

collected at a distance greater than 2 km from the ends of the jetties. The results of this comparison are presented in Table 7. There was little difference in the contributions of Pacific herring and Pacific tomcod to the diets in the two areas. Crab megalops and coho salmon (Oncorhynchus kisutch)made up a larger percent of the diet within 2 km of the jetties. Market squid and juvenile rockfishes were found in larger numbers in murres collected more than 2 km from the jetties.

A comparison of stomach contents of murres collected off Newport with those collected off Coos Bay in 1982 showed little similarity in monthly composition (Tables F-4 and F-5).

Stomach contents of murres collected off Coos Bay were examined to determine the number of prey species present in the stomach of each individual (Table 8). The largest proportion of murres (34% to 38%) had two prey species in the stomach. The number of individuals that had one prey species in the stomach was similar to the number of individuals that had three prey species in the stomach. In 1979, 28% of the murres had four or more prey species in the stomach. Furthermore, in all years some murres had up to seven prey species in the stomach. Table 9 compares the contents of the proventriculus portion of the stomach for all murres collected on one

Table 7. Comparison of Common Murre prey items with respect to proximity to the mouth of Yaquina Bay (Newport), 1982. Only those species composing one percent or more of the diet are included. See Table E-5 for complete list.

	Per Cent of Diet	
Prey Species	Within 2 km of jetty	Over 2 km from jetty
Pacific herring	24	23
crab megalops	26	2.5
market squid	5.9	36
Pacific tomcod	14	14
coho salmon	13	1.6
greenling juveniles	6.3	4.1
northern anchovy	2.8	2.5
shiner surfperch	2.4	2.5
Pacific sandlance	1.7	2.5
rockfish juveniles	0	7.4
whitebait smelt	0.7	0.8
surf smelt	1.0	0
Total number of prey items	287	122

For scientific names of the above prey species, refer to Table G-1.

Table 8. Number of prey species per murre. From murres collected off Coos Bay, 1979-1982

The total number of murres examined each year appears as N, in parentheses, after the date. The number of prey species found in the stomach is expressed as frequency, percent of N.

	Number of Prey Species in Stomach						
Date	1	2	3	4	5	6	7
1979 (N=125)	23	34	22	11	2	1	0
1980 (N=151)	12	34	17	17	9	1	1
1981 (N=107)	21	35	25	10	3	2	1
1982 (N=120)	19	38	24	8	3	1	2

sampling day off Coos Bay. Identifiable remains, including otoliths, remain in the proventriculus for no more than one hour (Varoujean, unpub. data). Contents of the proventriculus varied from empty to four prey species.

Table 9. Contents of the proventriculus portion of the stomach of Common Murres collected off Coos Bay, 3 June, 1980. Listed are the actual number of prey found in the stomach of each specimen collected.

		Number of Individuals in Proventriculus						
Specimen Number	Depth f	Pacific tomcod	Pacific sandlance	market squid	juvenile rockfishes	northern anchovy	Pacific herring	octopus
DHV 025	9	empty						
026	9	empty						
027	9				6			
029	16	1		1		2		
030	16				1	4		
031	16	4		1				
032	18	empty						
033	22				1		1	
034	22				5			
035	19		2	1		1		3
036	19	empty						

Collecting began at 1445 hrs and ended at 1705 hrs.

DISCUSSION

Density Estimates

A significant difference in murre density was found off Coos Bay between 1981 and 1982. Comparing the months of May through July, murre density was calculated to be 123 murres/km^2 in 1981 and 41 murres/km^2 in 1982.

There are two possible reasons for this difference in density. First, methods were different between 1981 and 1982. Generally, 1981 transects included fewer segments, covering a smaller area than in 1982. Average transect length was 11.8 km in 1981, and 26.7 km in 1982. Since there was a spatial variation in density on every sampling day (see Appendix Tables A-D), smaller transect area could result in inaccurate density estimates if areas of high murre density were not censused. Furthermore, some 1981 transects were conducted in the afternoon and evening hours. In 1982, all transects were conducted in the early morning. It is not known how murre foraging (and therefore density) varies with the time of day, but this may have resulted in higher density estimates for the 1981 census.

Second, more murres may have actually occurred off Coos Bay in 1981 than in 1982. Differences in densities of available prey items may be an explanation for the difference in murre density. If there was less food available in 1982, murres may have travelled to other more productive feeding areas. Analysis of stomach contents supports this idea. A significant difference in the abundance of some prey items in the diet between 1981 and 1982 was found (see Table 5 and Appendix Tables E-3 and E-4). In 1981, coho salmon made up 6.5% of the diet, but only 0.1% of the diet in 1982. Release records from private salmon producers in Coos Bay (Oregon Aqua-Foods, Inc. and Anadromous, Inc.) show that 11.7 million coho salmon smolts were released in 1981, compared to 2.2 million released in 1982 (Varoujean and Matthews, 1983). The presence of an increased number of salmon smolts may have been a factor in the increased murre density found in 1981.

At the same time, however, other prey items were also found in larger numbers in murres collected in 1981. Juvenile rockfishes represented 24.5% of the diet by number in 1981, compared to 0.7% of the diet in 1982. Market squid composed 24% of the diet in 1981 and only 3.8% of the diet in 1982. It should be noted, however, that the apparent decrease in the dietary contribution of these prey species is by number, and is somewhat exaggerated due to the presence of euphausiids in the 1982 diet, composing 35.5% of the diet by number, and thus driving down the percent contribution by number of the other prey species.

Density of murres off the Columbia River, Newport and Coos Bay (May through July) was very similar, calculated to be 51, 42, and 41 murres/km^2, respectively, in spite of differences in latitude, proximity to colony sites (see Figure 1), size of estuary (Percy et. al., 1974, Orem, 1968, Neal, 1972), depth offshore (Figure 5), or diet (Table 5).

A comparison of murre density seasonally shows large changes in the number of murres utilizing an area. Prior to the breeding season, murres are not found in large numbers off the Oregon coast, but they are found in numbers much larger than the resident breeding populations in Puget Sound and off the southern British Columbia coast (Steven Speich, pers. comm.). Thus murre density would be low during early spring. May numbers would be expected to increase as murres arrive at colony sites (Storer, 1952). Since they are travelling south, one might expect to see larger numbers at the northern study areas first, Perhaps this accounts for the peak density off the Columbia River in May, whereas the peak in Coos Bay is in late June. Summer highs in density would be expected as the parents travel from the colony sites in search of food for chicks (Birkhead, 1976, Gaston and Nettleship, 1981). As the chicks leave the colony site with the male parent, numbers of murres censused would appear high, because female parents would be free from nesting responsibilities, able to spend all their time in the water foraging, and the appearance of the chick with the male parent would increase even further the number of murres in the water(Storer, 1952, Scott, 1976). As the chick becomes able to forage for itself, the male parent follows the female north, to be followed by the chick. Late in the season, murre density is again low off Oregon (as shown by November density estimates) and high in Puget Sound (Speich, pers, comm.).

An attempt was made to compare calculated murre densities above to previous studies. The only other research completed on murre density was that done by Scott (1976) off Newport. Unfortunately, murre density was reported as "adults per mile", not as murres/km^2, with no transect width given. Therefore no useful comparison can be made.

There was no correlation between spatial variation in murre density and distance offshore at any study area. This suggests that there may be a spatial variation in prey availability that changes with time, and murres change their foraging location with changing prey availability. However, little is known about distribution of many prey species (W.G. Pearcy, pers. comm.). A study correlating murre density with foraging success may show a relationship between murre density and prey availability.

In every study area there were factors which may have had an effect on the accuracy of density estimates. Such factors include environmental conditions, murre behavior, censusing methods and interpretation of data. It is unlikely that any of these factors have influenced the data of this paper. However, they are presented below.

Wind waves and swell size would at first seem to be a problem in observing murres. However, murres are large (as far as alcids go) and easily recognizable at a glance. Furthermore, the speed of the vessel was slow enough to allow a given region to be in the observer's field of view for over a minute, thus any murre which may not have been seen behind a wave for a few seconds would very likely have been seen given a full minute of observation. For example, on 22 June, 1982, off the Columbia River, the wind was out of the northwest at Beaufort 3 to 4, with a swell of 4 to 5 feet (Matthews, field notes). Murres would occasionally disappear for up to 18 seconds, but were in the observer's field of view for over a minute (at a speed of 9 knots), and thus were censused. The effect of the condition of the ocean surface is actually quite small in this study, as 22 June 1982 represents the most extreme conditions during which murres were censused.

Fog and glare from the sun are other weather conditions limiting visibility. Censusing was not conducted when fog limited visibility to less than 150 m. Surface glare was sometimes a problem during censusing, but only in a fairly narrow field of view (i.e. when the observer looks into the sun). By adjusting the observer's field of view this effect can be minimized.

Observer fatigue could have led to inaccurate results, if lengthy censusing were carried out with no breaks. However, since murres were being collected during the transects, this provided a break in the censusing routine. Furthermore, the time involved for each transect was approximately three hours. Thus, observer fatigue was low. Census totals were recorded every five minutes during transects.

Actively foraging murres may have escaped observation while diving. However, the number of murres engaged in foraging at any one time is usually a small fraction of the number of murres present (except in the uncommon dense feeding flocks), for the following reason. On many occasions, foraging murres were sought out to determine dive times. Only approximately five percent of the murres in an area were actually engaged in diving activities at any one time. Also, due to the average length of dive times, rest intervals on the surface (Scott, 1976) and the speed of the vessel, most diving murres would have been sighted upon surfacing.

Avoidance behavior at the approach of a vessel has been observed in small alcids (personal observation). Auklets or murrelets will dive or fly away at the approach of a vessel. Murres, however, do not show this avoidance response. When a vessel approaches, murres will simply swim out of the path of the vessel, or propel themselves along the surface with a few flaps of the wings, and can be counted on a census transect (personal observation).

The problem of making accurate density estimates over a large study area was addressed by conducting many strip transects, both offshore and longshore, at various depths, in regions representative of the entire study area. As murre density varied throughout the study areas (see Appendix Tables A-D), transect results were incorporated by calculating the mean murre density for the entire transect length.

Another more subtle problem is being sure that the number of murres censused is a true representation of the actual number of murres in the study area. One must be certain that the number of murres does not change drastically during the time the transect is conducted. For example, if the feeding behavior of murres is related to tidal regime or time of day, one may see a very different number of murres on the same transect lines measured at different times of the day. Perhaps during the ebb cycle of the tide, when a large volume of water is leaving the estuary, numbers of available prey items in or near the mouth of the estuary may change. If murres respond to this change in prey availability, the number of murres in the vicinity of the mouth of the estuary may change as well. For example, in the mouth of the Columbia River and during the Newport study, murres inside the jetties were counted twice- once on the way out to sea, and again on the return trip (see Appendix Tables H-1 and H-2). The average change in number of murres was 241 murres/km^2 off Newport (with a range of 0 to 805), and 26 murres/km^2 in the Columbia River (with a range of 7 to 93). Changes in density in the Columbia channel seem to be related to tidal regime. Lower densities were recorded on the outward census, with a low incoming tide. Higher densities were recorded on the inward census, near high tide. In Newport, outgoing tide corresponded to higher densities except on 3 August, 1982, when lower density corresponded to low incoming tide, and higher density was recorded near high tide. These differences in density, however, are comparable to the differences found when comparing the highest and lowest transect legs in the two study areas. Since the number of murres inside the jetties may be dependent on tidal regime, these numbers were not included in offshore density estimates.

Feeding Analysis

Upon examination of the data, the most compelling conclusion is that a strong case has been made for opportunism in murre feeding, although Scott (1976) suggested that murres may be selective, based on low diet diversity. However, by examining the results of a much larger sampling regime, it is shown that the diet of murres is in fact diverse. There are large daily and monthly differences in the diet with no clear annual pattern (Table 9 and Appendix Tables F-1 through F-5) when examined on a monthly basis. Many of the prey taxa vary in abundance seasonally, though, in a way suggestive of seasonal environmental changes (Parrish, et.al., 1981, Peterson and Miller, 1976 Hobson, 1980) and the seasonal reproductive cycle of the prey taxa. Larval young of many prey species appear in the offshore zone in late winter to early spring (J. Laroche and Richardson, 1980, 1981, Richardson, et.al., 1979, Ahlstrom and Moser, 1975, Ahlstrom, et.al., 1978, Pearcy and Myers, 1974, Peterson, et.al., 1982, Richardson, 1981, Richardson and Pearcy, 1977) and enter the inshore murre food resource in large numbers by late spring, dependent upon upwelling.

For example, market squid is a pelagic schooling cephalopod (Pearcy, pers. comm.) that spawns in the near-shore zone in late winter and early spring (Reckseik, 1978). In 1982, peak numbers of market squid in the diet of murres were found in February off Coos Bay and April/May off Newport. In 1980, peak numbers of market squid in the diet occurred off Coos Bay in April. This suggests a correlation between squid availability as described by Reckseik and the appearance of squid as a major dietary component of murres.

Furthermore, juvenile rockfishes were major components in the diet of murres collected off Coos Bay in May/June 1981 and from May through September 1980 (Appendix Tables F-2 and F-3). The gestation of rockfish is from March to May (Moser, 1967, Ahlstrom, 1978). Juveniles move into shallow water, and are found at depths of less than 20 m until they reach a length of about 100 mm (Moser, 1967, 1974, Ahlstrom, et.al., 1978). Richardson (1980) showed high abundance for larval rockfishes off Oregon during March and April. W. Laroche and Richardson (1980) showed a seasonal peak in abundance of juvenile rockfishes to occur in mid- to late summer. In the years 1979-1981, off Coos Bay,juvenile rockfishes were in greatest numbers in the diet of murres in mid- to late summer (Appendix Tables F-1 through F-3). Again this suggests that as juveniles appear as a food resource, they are readily consumed.

Speckled sanddab juveniles were collected in largest numbers off the California coast in June and July (Ahlstrom, 1975). In 1980, speckled sanddab juveniles were a major dietary component of murres in May and July.

The relative abundance of prey taxa also varied from location to location. Northern anchovy was the largest dietary component off the Columbia River, composing 46.7% of the diet by number (Table 6) and consumed by 74% of the murres examined (Appendix Table E-6). Off Coos Bay and Newport, northern anchovy made up only 14.4% and 2.7% of the diet, respectively. Northern anchovy has been shown to spawn off the Columbia River (Richardson, 1973, J. Laroche and Richardson, 1980, Richardson, 1980) in numbers large enough to be a potentially harvestable resource (Pruter, 1972). Purse seines conducted in the Columbia River plume showed northern anchovy to make up 56% of the total 1981 catch by number (Terry Durkin, pers. comm.). This is nearly the same as the 46.7% dietary contribution of northern anchovy to the diet of murres off the Columbia River, strongly suggesting that the type of prey consumed is related to prey availability.

Pacific herring made up the largest contribution to the diet of murres off Newport in August and September, 1982, and composed 23.4% of the diet for the sampling season. Off Coos Bay and the Columbia River, Pacific herring made up only 3.3% and 1.5% of the diet, respectively. It has been shown that Pacific herring spawn in Yaquina Bay (Pearcy and Myers, 1974), with spawning taking place from January through March. It is not known how long juveniles remain in the estuary, but the appearance of large numbers of otoliths from juvenile Pacific herring in murres collected in August and September would suggest that they are feeding on juveniles as they leave the estuary. Also, murre diets off Coos Bay showed a high in Pacific herring twice in 1982- once in February, the second in September.

Crab megalops were found in murres collected off Newport, and at neither Coos Bay nor the Columbia River. And at Newport, crab megalops were only found in the murre diet in the month of May. This is the time of year when crab megalops would most likely be seen in large numbers in the inshore zone (Lough, 1975 and Rowell, 1981). This prey item may not have been seen off Coos Bay due to the relatively steep bottom contour. They may not have been seen off the Columbia River , since most sampling was done in the plume offshore.

Market squid was abundant in the diet of murres collected off Newport, composing 14.7% of the diet. The contribution of market squid to the diet off Coos Bay and the Columbia River was small. Peak abundance in the diet off Newport occurred in April and May. Spawning takes place in winter (Morejohn, et.al., 1978), and juveniles become sexually mature adults in a little over three months (Spratt, 1978). This correlates well to the April/May high in dietary abundance.

The high abundance of euphausiids off Coos Bay in 1982 is difficult to explain. Euphausiids were the largest dietary component in May and June, and second highest in August by number. Although they are small and many were consumed, these are the only occurrences of euphausiids in the diet of murres in the entire study. Some sampling was done at offshore depths that were slightly greater in 1982 than in 1981, but most of the murres taken with euphausiids in the stomach were not collected at depths greater than in 1981. It may be argued that the depth offshore drops off much faster off Coos Bay than the other two study areas, which is true. Since euphausiids are pelagic, one may expect to see them at greater depths (Hebard, 1966 and Peterson and Miller, 1976). But then they should appear in the diets off Coos Bay from 1979 to 1981, and they do not.

As mentioned earlier, coho salmon made up 6.5% of the diet of murres collected off Coos Bay in 1981, but only 0.1% of the diet in 1982. At the same time, private coho salmon releases dropped from 11.7 million to 2.2 million. This could account for the different contribution of coho salmon to the diet in the two study years.

The diet of murres includes both juveniles and adults of the same species (e.g. tomcod, herring, anchovy, white-bait smelt). Otoliths of adult and juvenile fishes often were found in the same stomach. This would seem to indicate that murres make no selection as to size of prey, even when there may be a choice.

A large number of prey taxa makes up a small, "incidental" part of the diet. For example, in 1981, 19 prey taxa made up only 6.4% of the diet (Table E-3). These prey taxa included midwater schooling fishes, demersal species and crab megalops. Another more specific example occurred off Coos Bay, 3 June, 1980 (Table 9). The lack of pattern from individual to individual, and the high diversity in the diet during a short time period (contents of the proventriculus represent prey items consumed within an hour prior to collection) strongly suggests that these murres are feeding in an opportunistic fashion.

This is further evidenced by looking at the number of prey taxa found in the stomachs of murres off Coos Bay during the entire study period of 1979-1982 (Table 8). Even though murres feed for extended periods in one location (the present writer has observed murres foraging for over 90 minutes in one location), the contents of the stomach are likely to contain more than one prey taxa, and may contain up to seven prey taxa.

Finally, the diet of murres collected off Newport varied with respect to distance from the jetties (Table 7).

Crab megalops were found in much greater numbers within 2 km of the jetties. This may be related to their relative abundance in the nearshore zone as described by Lough (1975) and Rowell (1981). The larger numbers of coho salmon within 2 km of the jetties can be explained by the release of about 19 million smolts by Oregon Aqua-Foods, Inc. during the sampling season. Since all the salmon smolts must leave the estuary through the channel, density of salmon smolts would be higher in regions near the mouth of the channel. Increased market squid abundance in the diet would be expected at distances greater than 2 km from the jetties, since market squid are pelagic schoolers (Reckseik, 1978 and Pearcy, pers. comm.).

Thus a high degree of variability in the diet of murres seasonally, geographically and from individual to individual in the same study area on the same sampling day strongly suggests that Common Murres are opportunistic predators. There are some biases associated with the feeding analysis above. These are presented below.

First, by using strictly the number of individual prey items consumed to calculate percent of diet, a large percentage of the diet is represented by groups of small prey items (e.g., euphausiids, crab megalops, and juvenile rockfishes, tomcod, sanddab and herring). This bias is in part reflected in the frequency data, where it is shown that in many cases relatively few murres consumed a large number of small prey items. However, there is another problem. For many prey species, no distinction was made between juveniles and adults on the basis of otoliths. For example, larval tomcod (as described by Matarese, et.al., 1981) weighing only 1.5 g have recognizable otoliths, but they are counted only as tomcod in the diet. Other tomcod may weigh up to 50 g. When feeding on groups of small tomcod, the number of tomcod recorded in the diet is artificially increased. The same is true for herring and sanddab. A more accurate way to assess the contribution of various prey items to the diet would be to measure the total weight of each prey taxa. Unfortunately, recognizable whole prey items made up only a small part of the stomach contents. The pH of the digestive fluids in murres is about 2 (Varoujean, pers. comm.), and within only a short time after consumption, only otoliths remain in the proventriculus.

Second, seasonal restrictions on collecting favor the appearance of juveniles in the diet. The bulk of the collecting was carried out during the spring and summer months. This corresponds to the time when many of the juveniles of prey taxa are present in large numbers, as discussed above. This further increases the contribution of juvenile prey items to the diet.

Third, the high acidity of the digestive juices would more quickly erode very small prey items such as euphausiids and larval fishes. Thus the actual contribution of these types of prey to the diet may be higher than recorded.

Fourth, as is shown on Table 5, some of the most frequently consumed prey items off Coos Bay from 1979 to 1982 were pelagic schoolers (Pearcy, pers. comm.). If a murre forages in a school of fish, the effort per capture would be smaller than for nonschooling fishes, and it would be expected that these prey would appear with a higher frequency.

Another bias is related to the time of collection. Due to restrictions imposed by daylight and tidal regime, collection can take place only at certain times of the day. Murres may be feeding at times when collecting is not done. Of the stomachs examined from murres collected off Coos Bay, 42% had no recognizable prey items in the proventriculus portion of the stomach. In murres collected off the Columbia River, the value was 56%. These murres had not been feeding for two to four hours prior to collection, based on results from feeding studies carried out on captive murres (Varoujean, unpublished data).

Finally, a bias exists when analyzing the frequency data. Off Coos Bay, many parent-chick pairs were collected.

It was found that the parent male feeds the chick much the same as itself, with respect to quantity and prey species (Matthews, unpublished data). In analyzing the diet, no distinction was made between lone foraging adults and parent-chick pairs. Thus the frequency of many prey species may have been artificially increased.

A comparison was made between the results of this feeding study and earlier studies. None of the earlier studies identified all pery taxa to species. Baltz and Morejohn (1977) found 9 prey taxa in the stomachs they examined from Monterey Bay. Scott (1976) reported 5 prey taxa off Newport, including a large contribution by "Scorpaenidae (except Sebastes)", which is unclear in the light of the present study. Ogi and Tsujita's results from the Okhotsk Sea (1977) were reported as weight, and grouped as "fish, euphausiids, digested matter, squid". A comparison here would be difficult to make, since the present study has examined only precent of diet by number. Table 10 compares the present study with Baltz and Morejohn's, and Scott's. Low numbers of prey taxa reported in the other studies are understandable in light of the very small sample sizes and breif sampling season. The lack of similarity in the reported diets are likely, for the same reasons.

Table 10. Comparison of feeding analyses conducted by Baltz and Morejohn (1977), Scott (1973) and Matthews, Coos Bay, 1979-1982.

Prey Species	Baltz and Morejohn	Scott	Matthews
	Per Cent of Diet		
northern anchovy	32.5	17	6.1
Pacific tomcod	3.6	-	15.0
rockfish juveniles	30.1	52	20.7
Pacific herring	3.6	0	2.7
market squid	19.3	0	7.6
butterfish*	3.6	0	0
smelt spp.	0	1.6	11.4
unidentified fish	2.4	9	1
Scorpaenidae (except *Sebastes*)	0	43	0

This list includes only those species composing more than 1.5% of the diet as reported by either Baltz and Morejohn or Scott.

**Peprilus simmillimus*

For scientific names of the above prey items, refer to Table G-1.

APPENDIX A

COOS BAY TRANSECTS, 1981

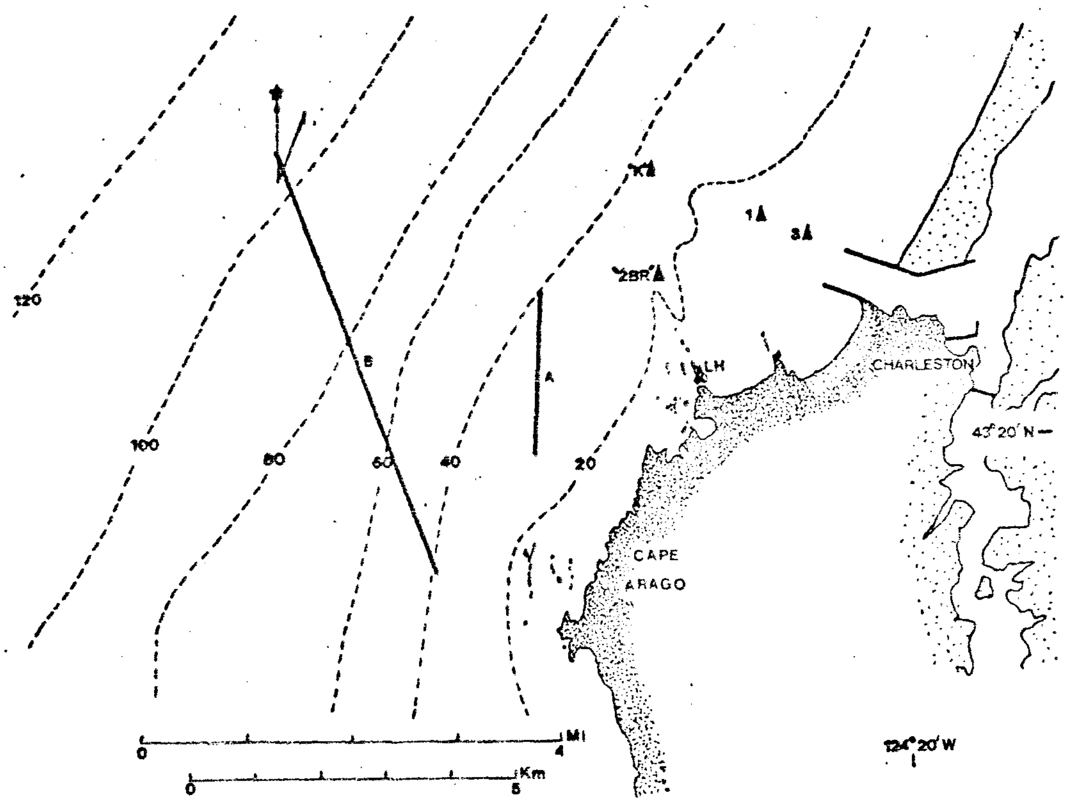

Figure A-1. 25 May, 1981 transect, Coos Bay. Sampling began at 1520 hrs and ended at 1645 hrs. Depth contours are in meters.

Table A-1. 25 May, 1981 census results.

TRANSECT SEGMENT	TRANSECT LENGTH KM	TRANSECT AREA KM^2	NUMBER OF MURRES	MURRES PER KM^2
A	2.5	.75	19	25
B	7.0	2.1	13	6

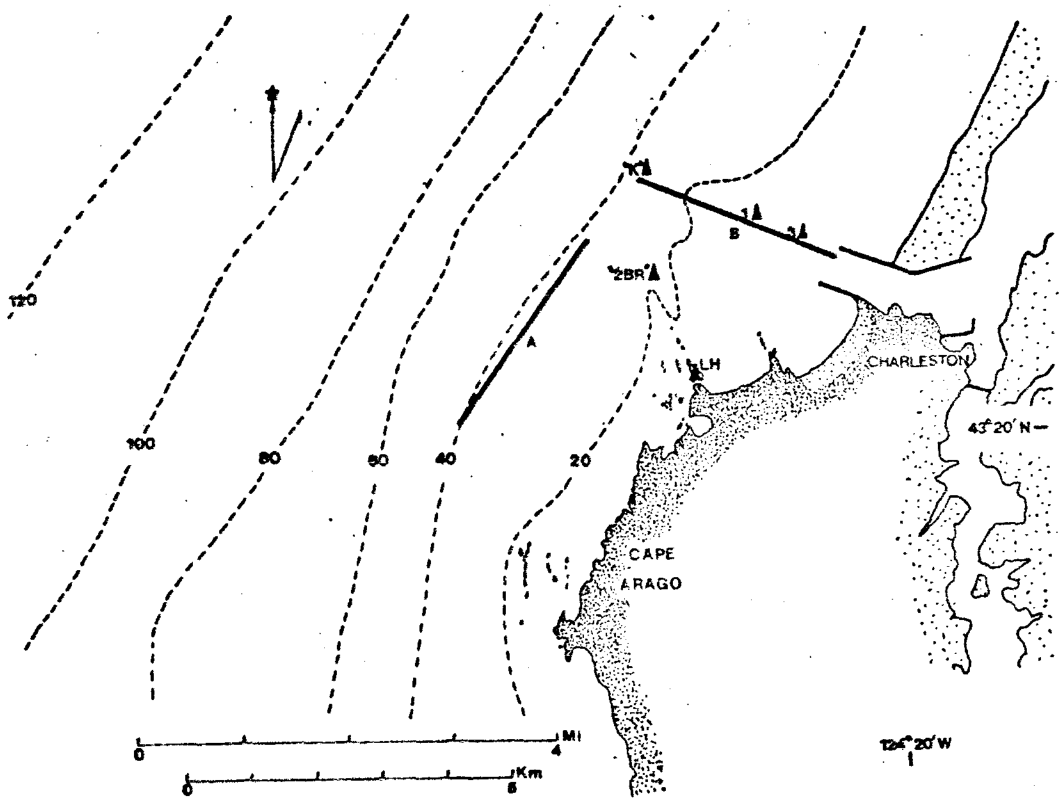

Figure A-2. 2 June, 1981 transect, Coos Bay. Sampling began at 1800 hrs and ended at 2020 hrs. Depth contours are in meters.

Table A-2. 2 June, 1981 census results.

TRANSECT SEGMENT	TRANSECT LENGTH KM	TRANSECT AREA KM^2	NUMBER OF MURRES	MURRES PER KM^2
A	3.6	1.08	299	277
B	3.8	1.14	147	129

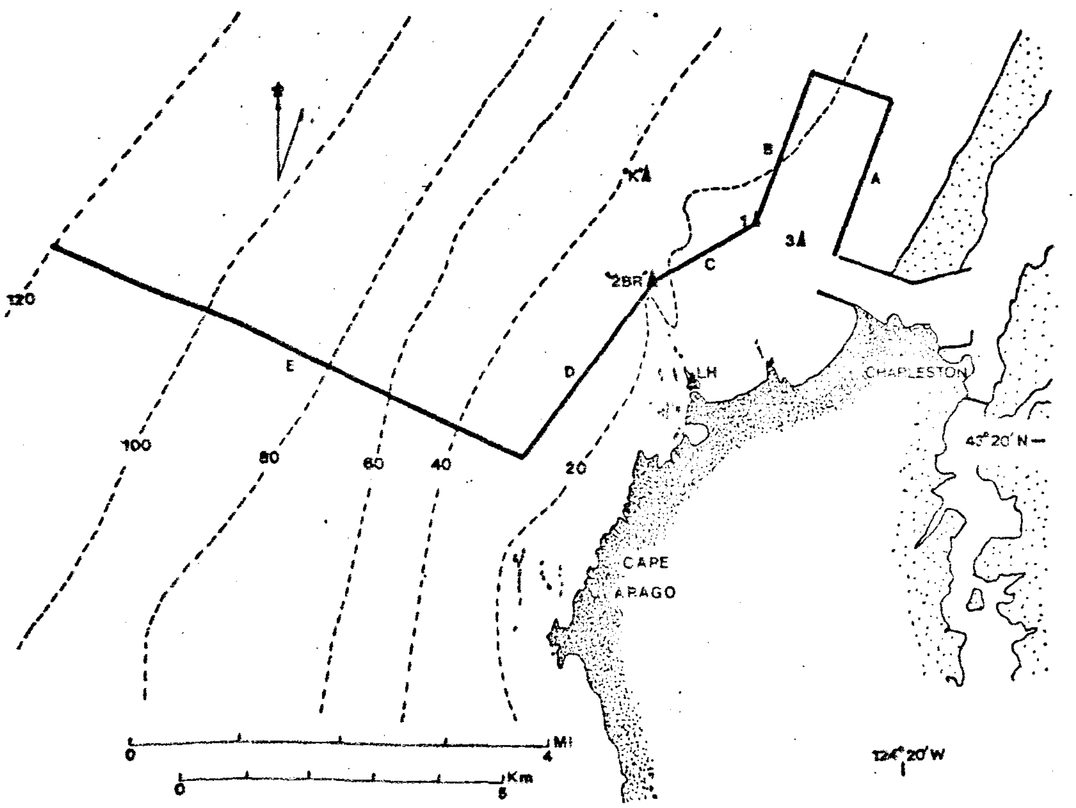

Figure A-3. 30 June, 1981 transect, Coos Bay. Sampling began at 1020 hrs and ended at 1155 hrs. Depth contours are in meters.

Table A-3. 30 June, 1981 census results.

TRANSECT SEGMENT	TRANSECT LENGTH KM	TRANSECT AREA KM^2	NUMBER OF MURRES	MURRES PER KM^2
A	2.5	.75	1138	1517
B	2.5	.75	178	237
C	2.2	.66	87	132
D	4.0	1.20	62	26
E	7.8	2.34	59	25

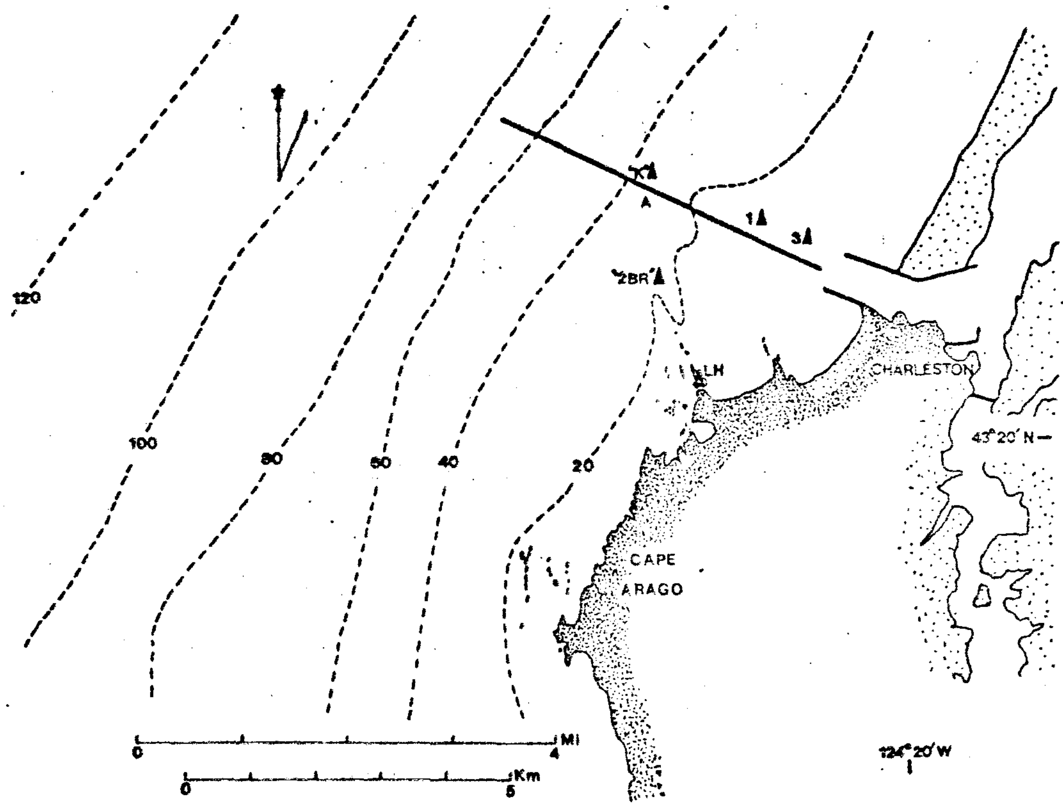

Figure A-4. 2 July, 1981 transect, Coos Bay. Depth contours are in meters.

Table A-4. 2 July, 1981 census results.

TRANSECT SEGMENT	TRANSECT LENGTH KM	TRANSECT AREA KM^2	NUMBER OF MURRES	MURRES PER KM^2
A	5.3	1.6	82	51

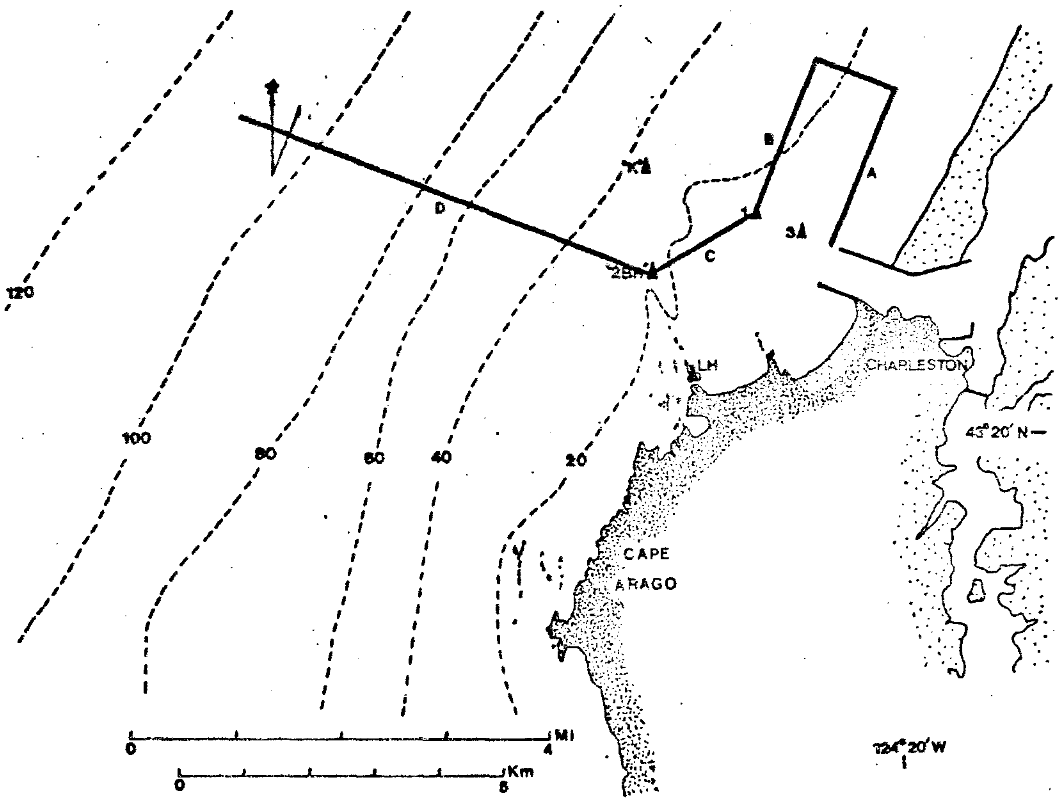

Figure A-5. 14 July, 1981 transect, Coos Bay. Sampling began at 0705 hrs and ended at 0900 hrs. Depth contours are in meters.

Table A-5. 14 July, 1981 census results.

TRANSECT SEGMENT	TRANSECT LENGTH KM	TRANSECT AREA KM^2	NUMBER OF MURRES	MURRES PER KM^2
A	2.5	.75	61	81
B	2.5	.75	40	53
C	2.2	.66	74	112
D	7.5	2.25	136	60

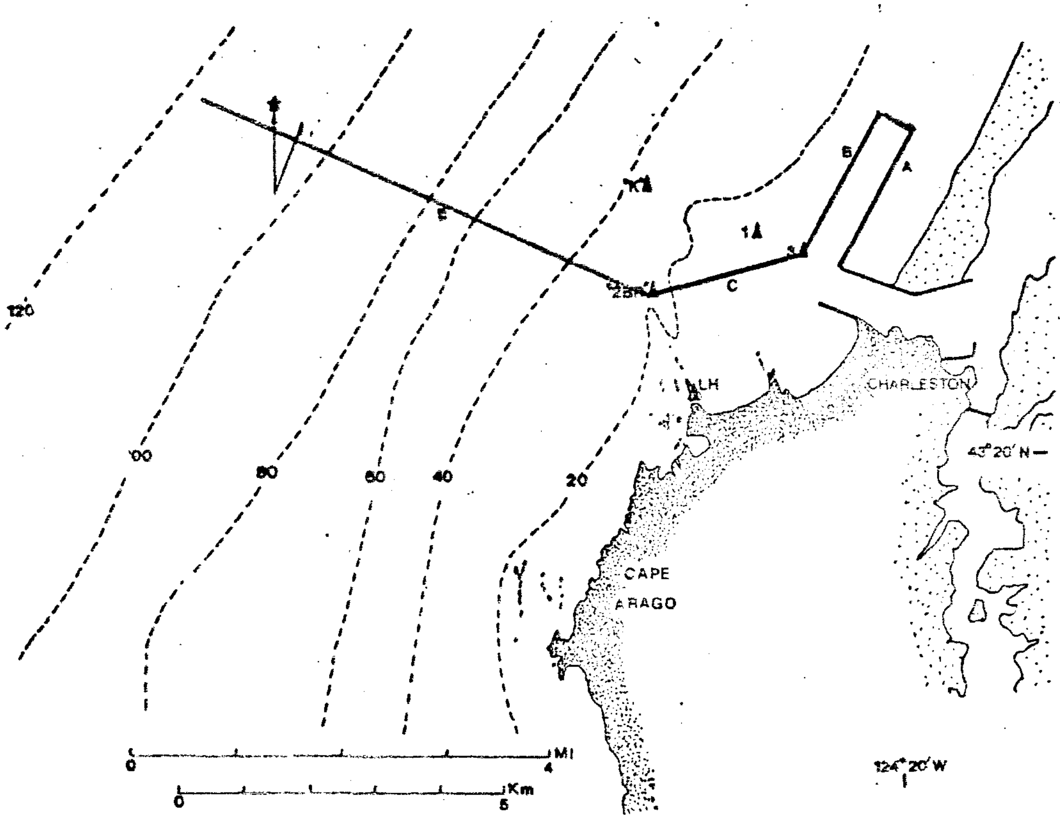

Figure A-6. 17 July, 1981 transect, Coos Bay. Sampling began at 0825 hrs and ended at 1055 hrs. Depth contours are in meters.

Table A-6. 17 July, 1981 census results.

TRANSECT SEGMENT	TRANSECT LENGTH KM	TRANSECT AREA KM^2	NUMBER OF MURRES	MURRES PER KM^2
A	2.5	.75	63	84
B	2.5	.75	39	52
C	2.2	.66	77	117
D	7.5	2.25	111	49

APPENDIX B

COOS BAY TRANSECTS, 1982

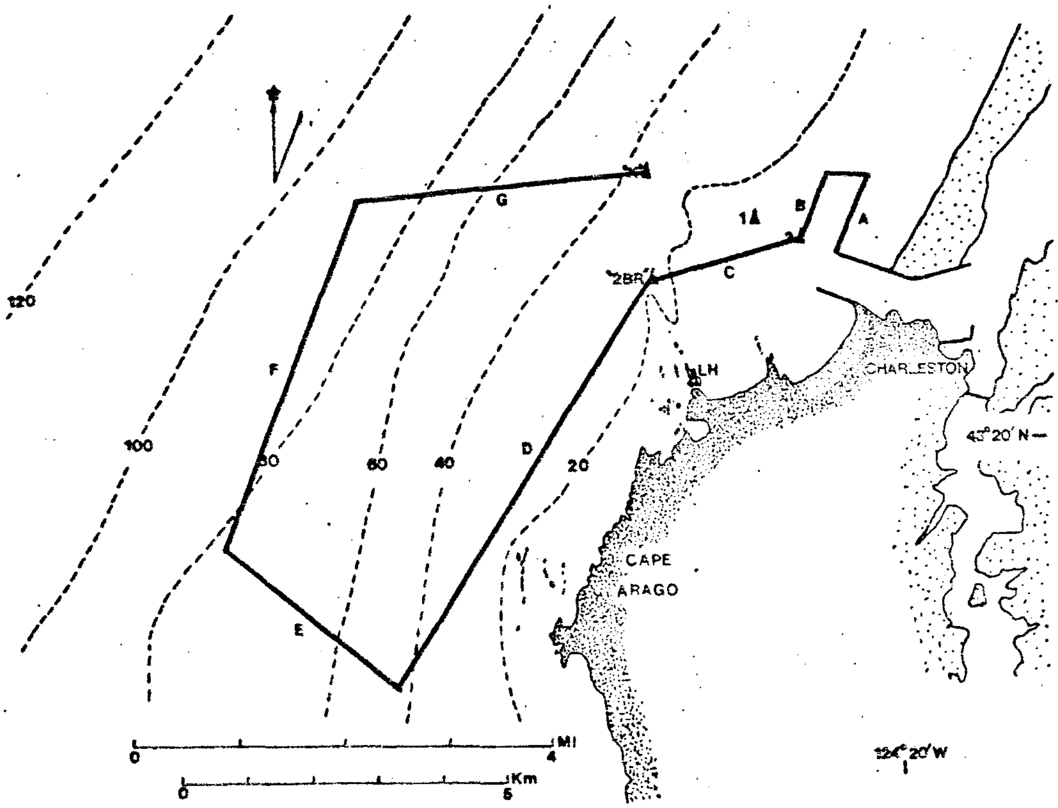

Figure B-1. 8 April, 1982 transect, Coos Bay. Sampling began at 0830 hrs and ended at 1100 hrs. Depth contours are in meters.

Table B-1. 8 April. 1982 census results.

TRANSECT SEGMENT	TRANSECT LENGTH KM	TRANSECT AREA KM^2	NUMBER OF MURRES	MURRES PER KM^2
A	1.3	.39	0	0
B	1.4	.42	0	0
C	2.5	.75	0	0
D	7.7	2.3	0	0
E	3.4	1.0	3	3
F	6.0	1.8	0	0
G	4.3	1.3	3	2.3

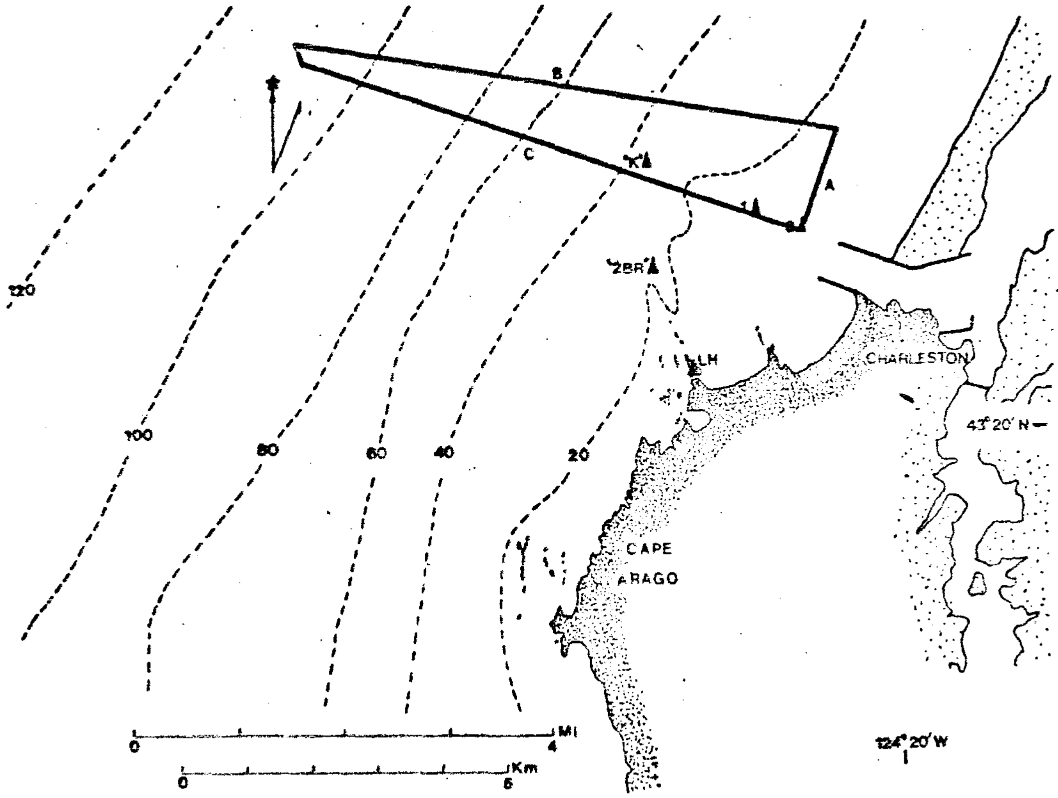

Figure B-2. 9 April, 1982 transect, Coos Bay. Sampling began at 1000 hrs and ended at 1230 hrs. Depth contours are in meters.

Table B-2. 9 April, 1982 census results.

TRANSECT SEGMENT	TRANSECT LENGTH KM	TRANSECT AREA KM^2	NUMBER OF MURRES	MURRES PER KM^2
A	2.4	.72	0	0
B	9.9	3.0	3	1.0
C	9.2	2.8	12	4.3

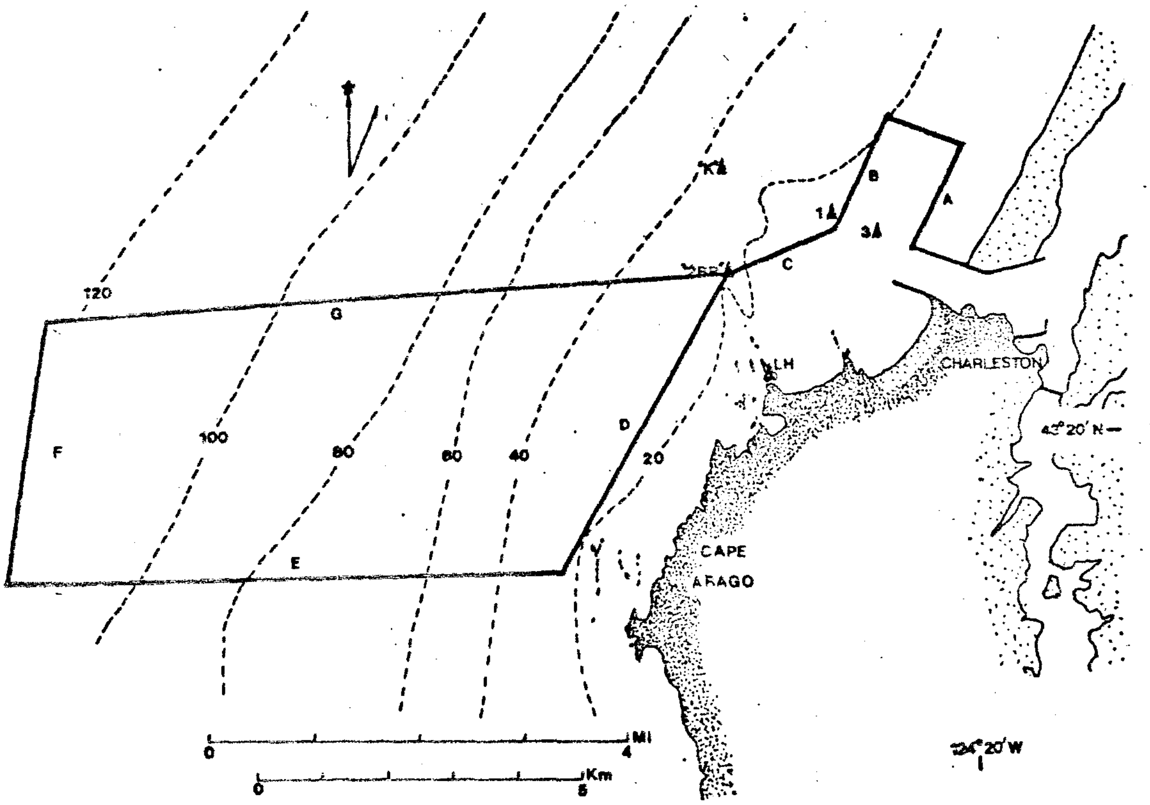

Figure B-3. 21 April, 1982 transect, Coos Bay. Sampling began at 0900 hrs and ended at 1300 hrs. Depth contours are in meters.

Table B-3. 21 April, 1982 census results.

TRANSECT SEGMENT	TRANSECT LENGTH KM	TRANSECT AREA KM^2	NUMBER OF MURRES	MURRES PER KM^2
A	2.8	.84	0	0
B	2.7	.81	0	0
C	2.5	.75	0	0
D	5.8	1.7	7	4.1
E	10.2	3.1	18	5.8
F	4.6	1.4	22	15.7
G	11.6	3.5	91	26

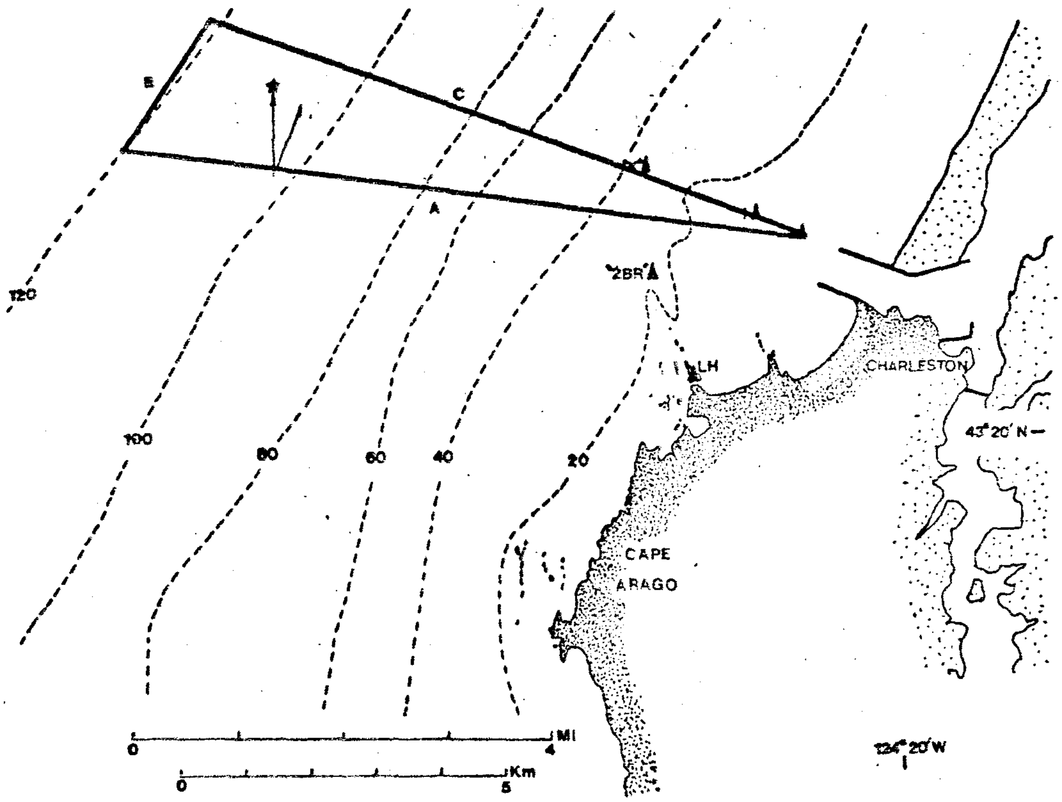

Figure B-4. 26 April, 1982 transect, Coos Bay. Sampling began at 0900 hrs and ended at 1130 hrs. Depth contours are in meters.

Table B-4. 26 April, 1982 census results.

TRANSECT SEGMENT	TRANSECT LENGTH KM	TRANSECT AREA KM^2	NUMBER OF MURRES	MURRES PER KM^2
A	11.1	3.3	0	0
B	3.9	1.2	3	2.5
C	10.2	3.1	4	1.3

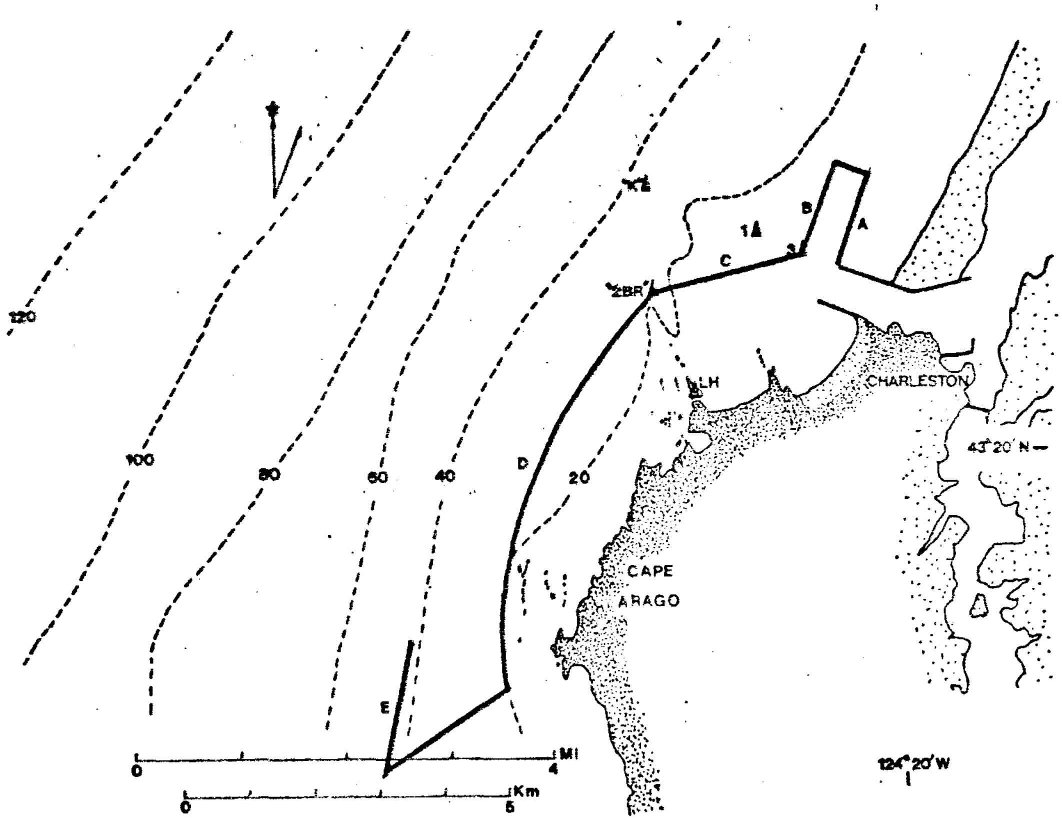

Figure B-5. 6 May, 1982 transect, Coos Bay. Sampling began at 0800 hrs and ended at 1035 hrs. Depth contours are in meters.

Table B-5. 6 May, 1982 census results.

TRANSECT SEGMENT	TRANSECT LENGTH KM	TRANSECT AREA KM^2	NUMBER OF MURRES	MURRES PER KM^2
A	1.4	.42	5	11.9
B	1.4	.42	0	0
C	2.5	.75	5	6.7
D	7.0	2.1	8	3.8
E	2.2	.66	3	4.5

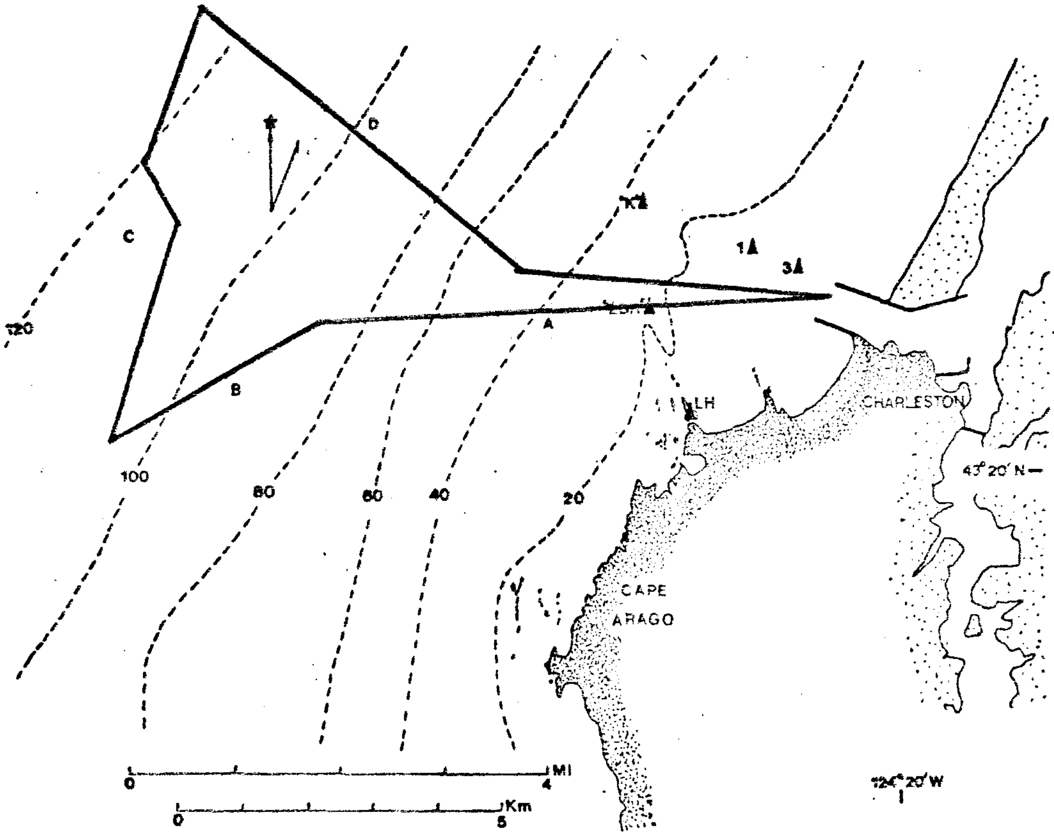

Figure B-6. 13 May, 1982 transect, Coos Bay. Sampling began at 0850 hrs and ended at 1215 hrs. Depth contours are in meters.

Table B-6. 13 May, 1982 census results.

TRANSECT SEGMENT	TRANSECT LENGTH KM	TRANSECT AREA KM^2	NUMBER OF MURRES	MURRES PER KM^2
A	8.0	2.4	7	2.9
B	3.8	1.1	3	2.7
C	9.0	2.7	8	3.0
D	6.5	2.0	5	2.5

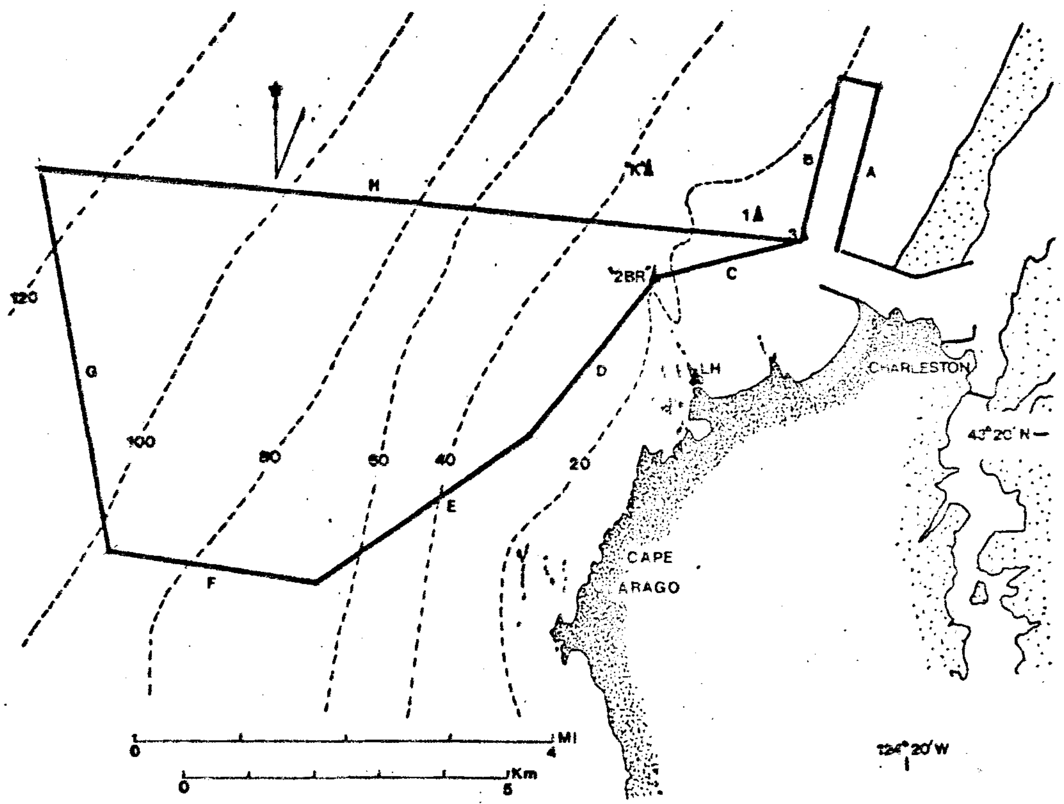

Figure B-7. 1 June, 1982 transect, Coos Bay. Sampling began at 0850 hrs and ended at 1235 hrs. Septh contours are in meters.

Table B-7. 1 June, 1982 census results.

TRANSECT SEGMENT	TRANSECT LENGTH KM	TRANSECT AREA KM^2	NUMBER OF MURRES	MURRES PER KM^2
A	3.0	.90	18	20
B	3.0	.90	72	80
C	2.5	.75	6	8
D	3.5	1.1	38	35
E	4.2	1.3	27	21
F	3.2	.96	123	128
G	6.0	1.8	93	52
H	12.0	3.6	108	30

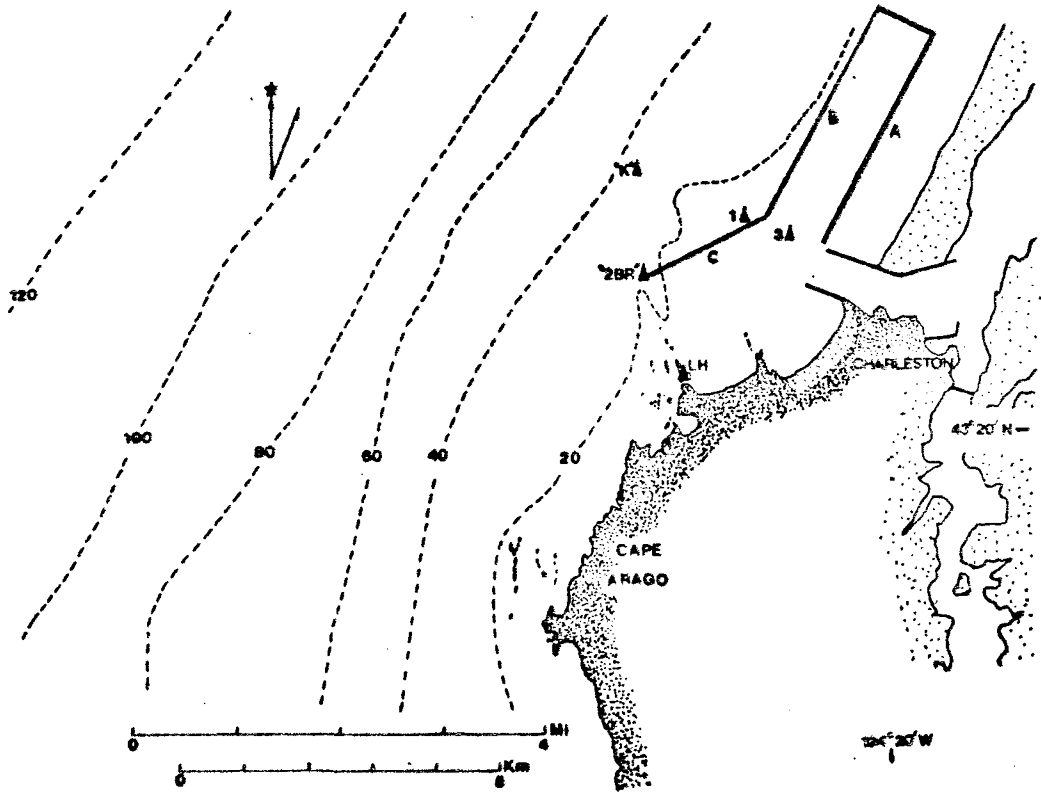

Figure B-8. 1 July, 1982 transect, Coos Bay. Sampling began at 0835 hrs and ended at 0950 hrs. Depth contours are in meters.

Table B-8. 1 July, 1982 census results.

TRANSECT SEGMENT	TRANSECT LENGTH	TRANSECT AREA	NUMBER OF	MURRES PER KM^2
A	3.8	1.1	11	10
B	3.7	1.1	425	386
C	2.5	.75	12	16

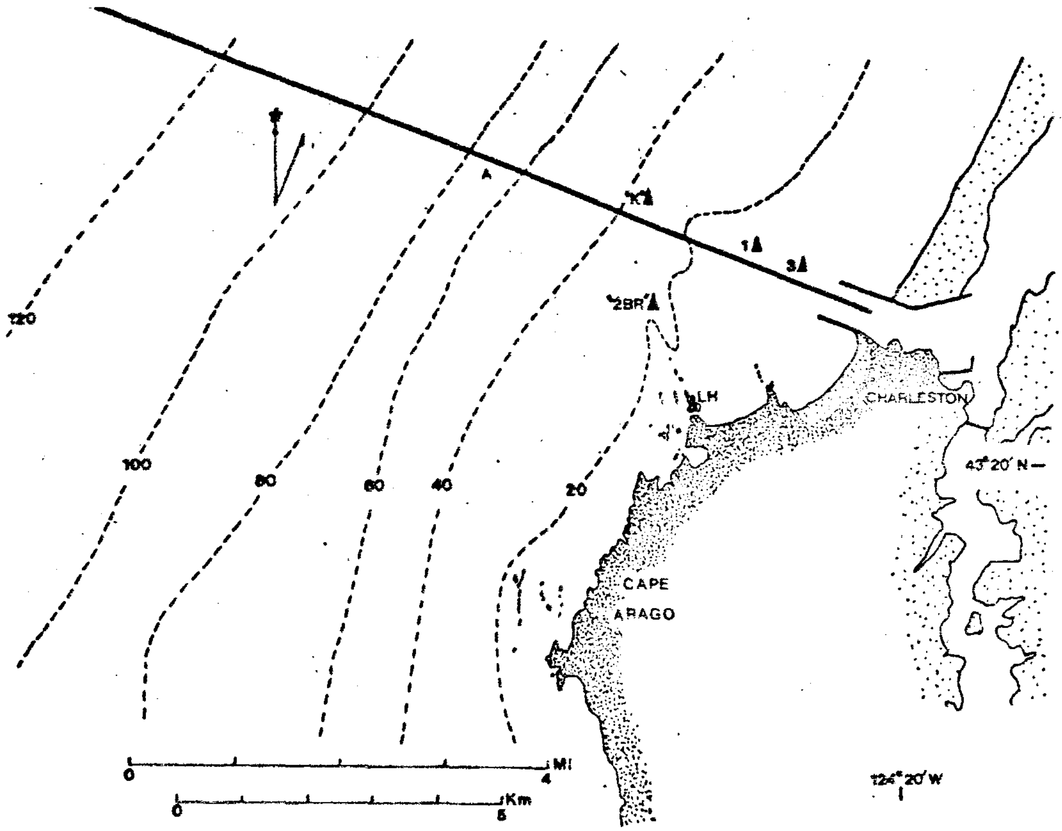

Figure B-9. 27 July, 1982 transect, Coos Bay. Sampling began at 0800 hrs and ended at 1410 hrs. Depth contours are in meters.

Table B-9. 27 July, 1982 census results.

TRANSECT SEGMENT	TRANSECT LENGTH KM	TRANSECT AREA KM^2	NUMBER OF MURRES	MURRES PER KM^2
A	4.5	1.4	127	90.7

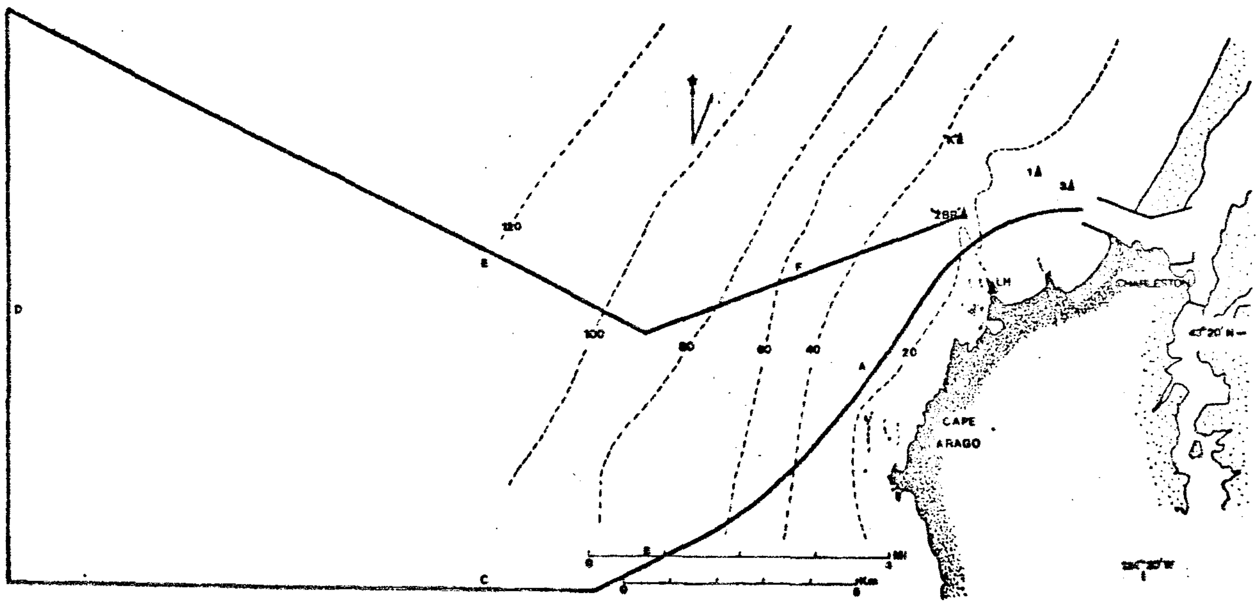

Figure B-10. 11 November, 1982 transect, Coos Bay. Sampling began at 0925 hrs and ended at 1230 hrs. Depth contours are in meters.

Table B-10. 11 November, 1982 census results.

TRANSECT SEGMENT	TRANSECT LENGTH KM	TRANSECT AREA KM^2	NUMBER OF MURRES	MURRES PER KM^2
A	12.4	3.7	4	1.1
B	2.8	.84	8	9.5
C	13.6	4.1	30	7.3
D	13.2	4.0	0	0
E	16.6	5.0	10	2
F	8.1	2.4	38	15.8

APPENDIX C

NEWPORT TRANSECTS, 1982

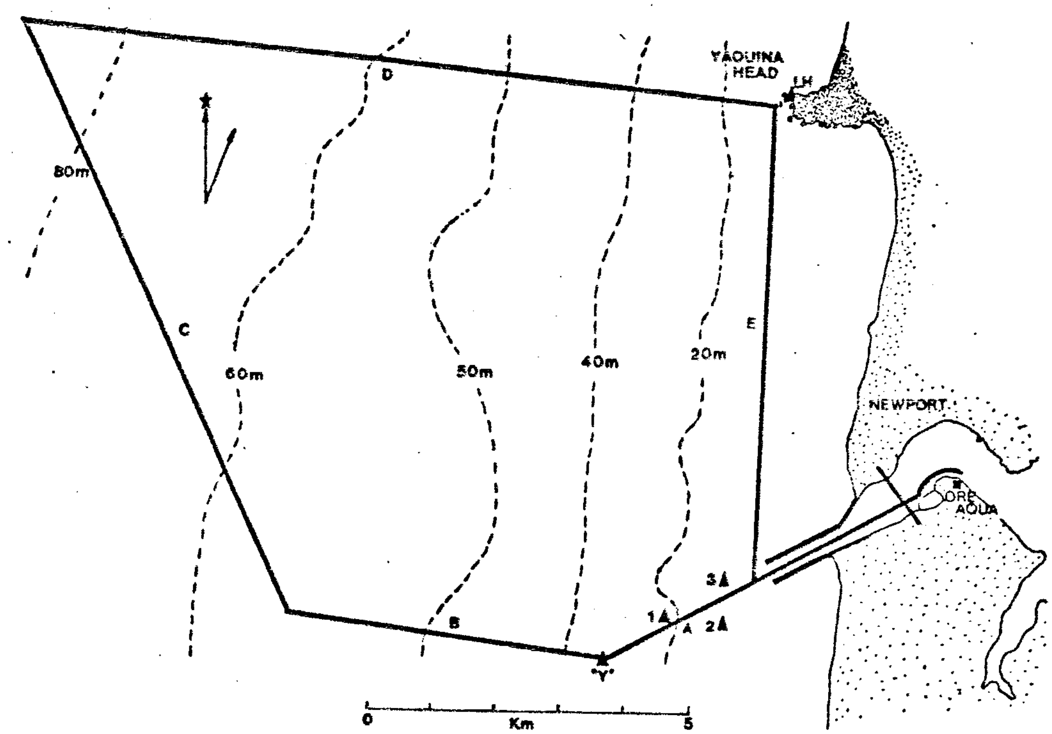

Figure C-1. 29 April, 1982 transect, Newport. Sampling began at 0800 hrs and ended at 1130 hrs.

Table C-1. 29 April, 1982 census results.

TRANSECT SEGMENT	TRANSECT LENGTH KM	TRANSECT AREA KM^2	NUMBER OF MURRES	MURRES PER KM^2
A	3.0	.90	1	1.1
B	4.9	1.5	14	9.3
C	10.0	3.0	7	2.3
D	11.5	3.5	3	.90
E	7.3	2.2	0	0

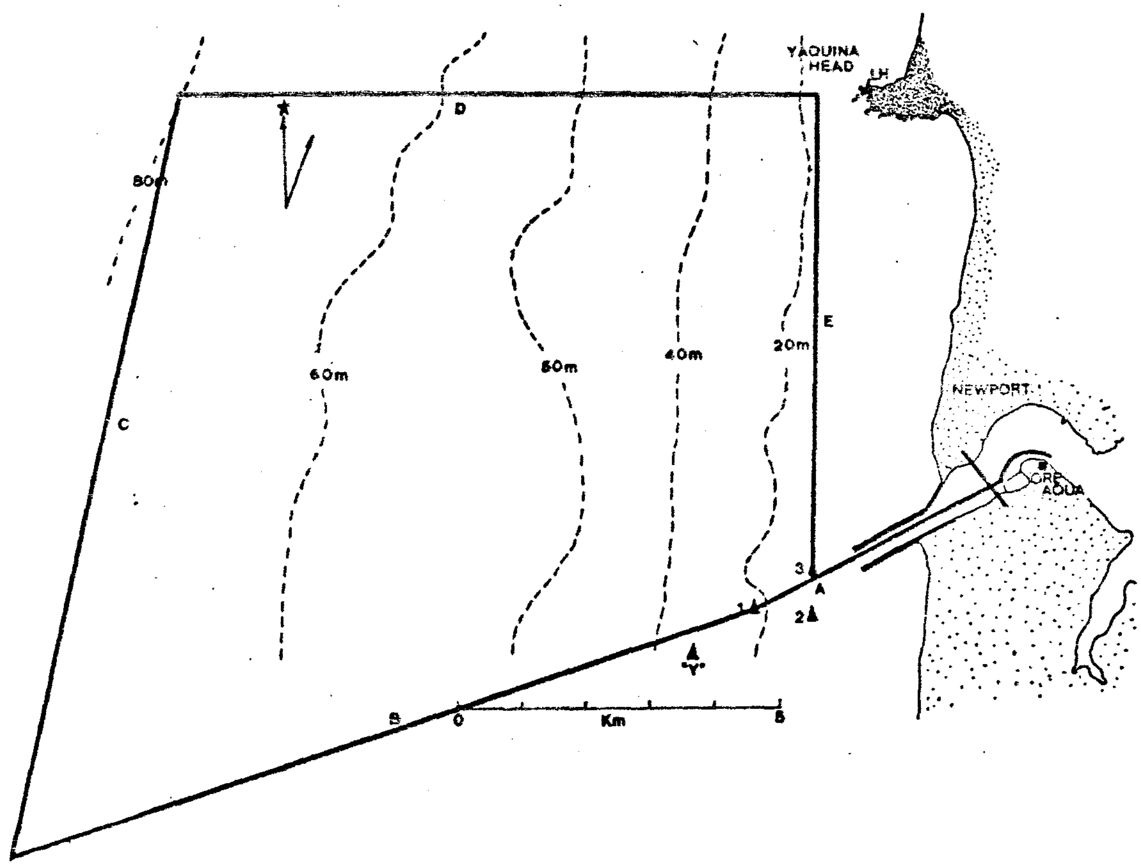

Figure C-2. 11 May, 1982 transect, Newport. Sampling began at 0730 hrs and ended at 1100 hrs.

Table C-2. 11 May, 1982 census results.

TRANSECT SEGMENT	TRANSECT LENGTH KM	TRANSECT AREA KM^2	NUMBER OF MURRES	MURRES PER KM^2
A	3.0	.9	92	102
B	10.9	3.3	25	7.6
C	12.1	3.6	1	0.3
D	9.8	2.9	0	0
E	7.4	2.2	3	1.4

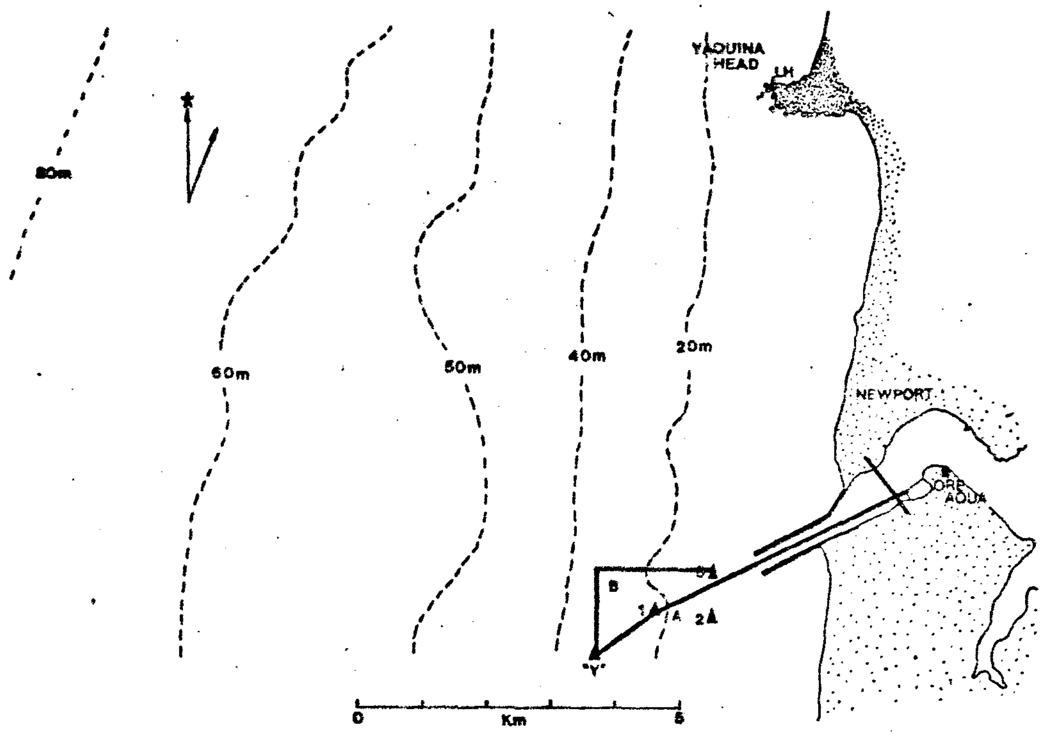

Figure C-3. 18 May, 1982 transect, Newport. Sampling began at 0730 hrs and ended at 0905 hrs.

Table C-3. 18 May, 1982 census results.

TRANSECT SEGMENT	TRANSECT LENGTH KM	TRANSECT AREA KM^2	NUMBER OF MURRES	MURRES PER KM^2
A	3.0	.9	5	5.6
B	4.0	1.2	10	8.3

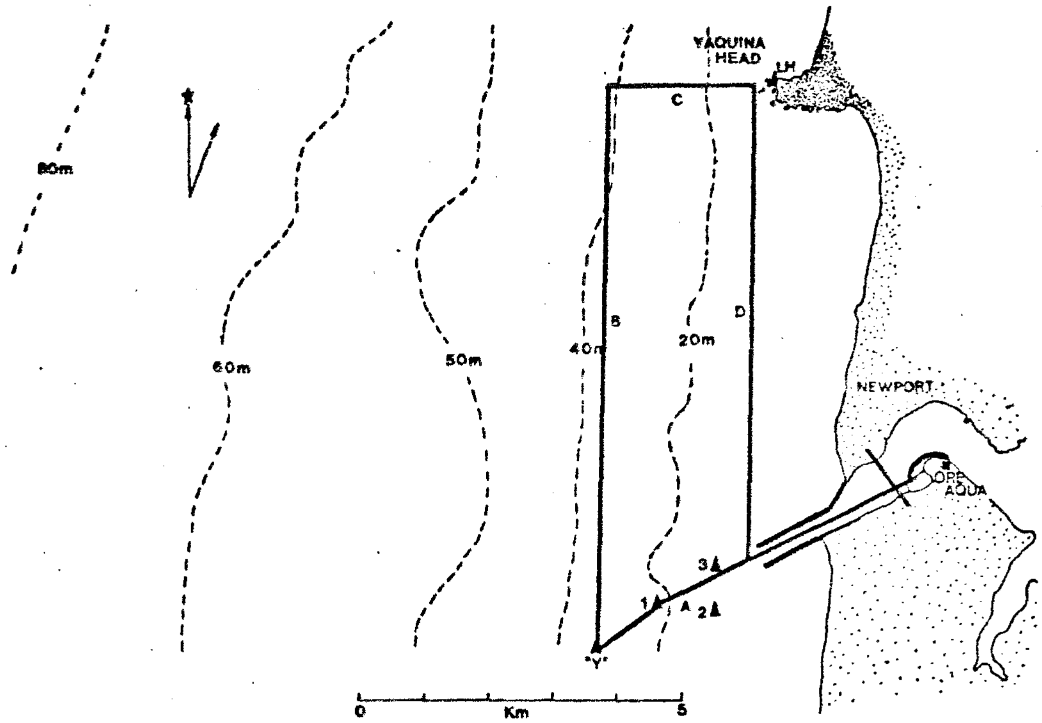

Figure C-4. 29 June, 1982 transect, Newport. Sampling began at 0805 hrs and ended at 1055 hrs.

Table C-4. 29 June, 1982 census results.

TRANSECT SEGMENT	TRANSECT LENGTH KM	TRANSECT AREA KM^2	NUMBER OF MURRES	MURRES PER KM^2
A	3.0	.9	75	83
B	8.9	2.7	160	59
C	2.3	.7	71	101
D	7.6	2.3	52	23

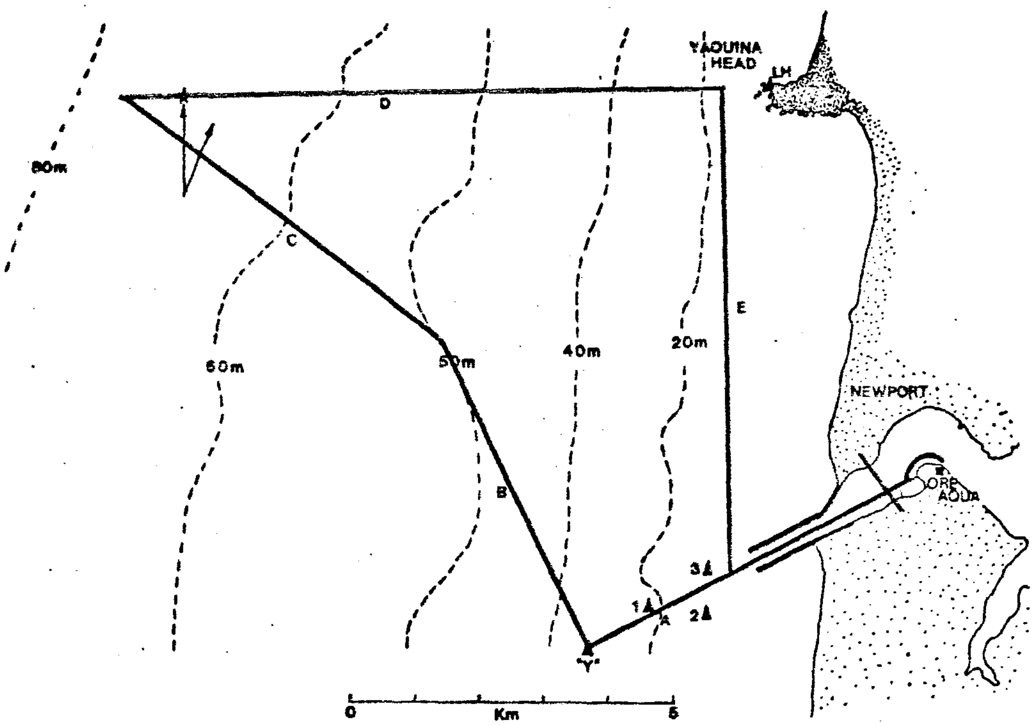

Figure C-5. 3 August, 1982 transect, Newport. Sampling began at 0720 hrs and ended at 1055 hrs.

Table C-5. 3 August, 1982 census results.

TRANSECT SEGMENT	TRANSECT LENGTH KM	TRANSECT AREA KM^2	NUMBER OF MURRES	MURRES PER KM^2
A	3.0	.9	460	511
B	5.2	1.6	115	72
C	6.3	1.9	0	0
D	9.2	2.8	177	63
E	7.5	2.3	180	78

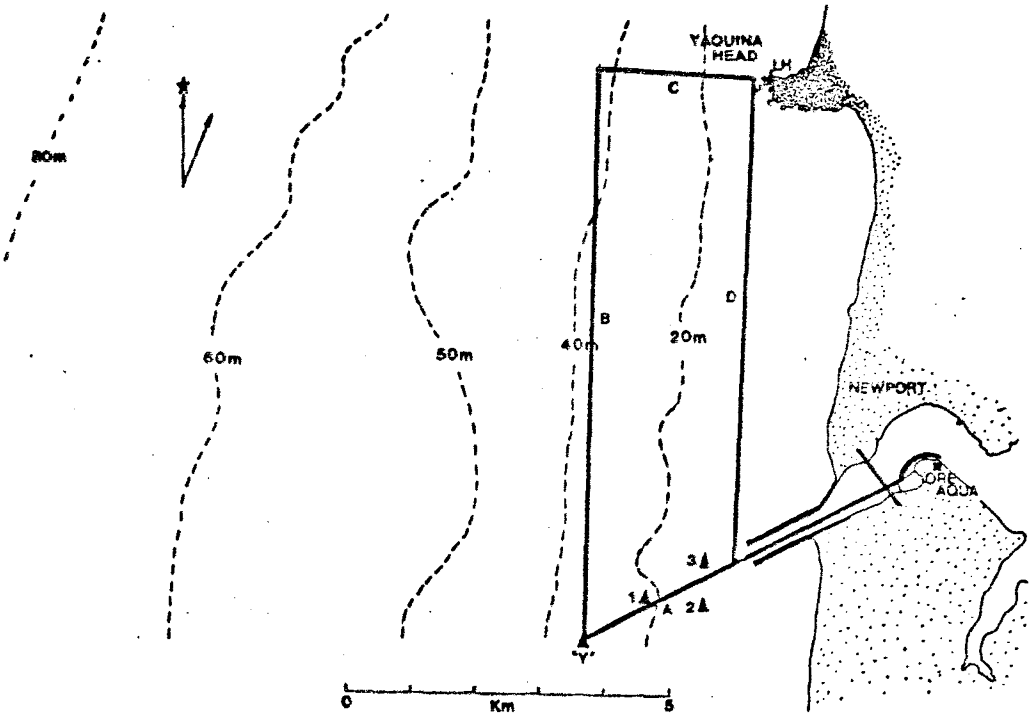

Figure C-6. 4 September, 1982 transect, Newport. Sampling began at 0840 hrs and ended at 1210 hrs.

Table C-6. 4 September, 1982 census results.

TRANSECT SEGMENT	TRANSECT LENGTH KM	TRANSECT AREA KM^2	NUMBER OF MURRES	MURRES PER KM^2
A	3.0	.9	40	44
B	8.7	2.6	327	126
C	2.3	.7	71	101
D	7.3	2.2	147	67

APPENDIX D

COLUMBIA RIVER TRANSECTS, 1982

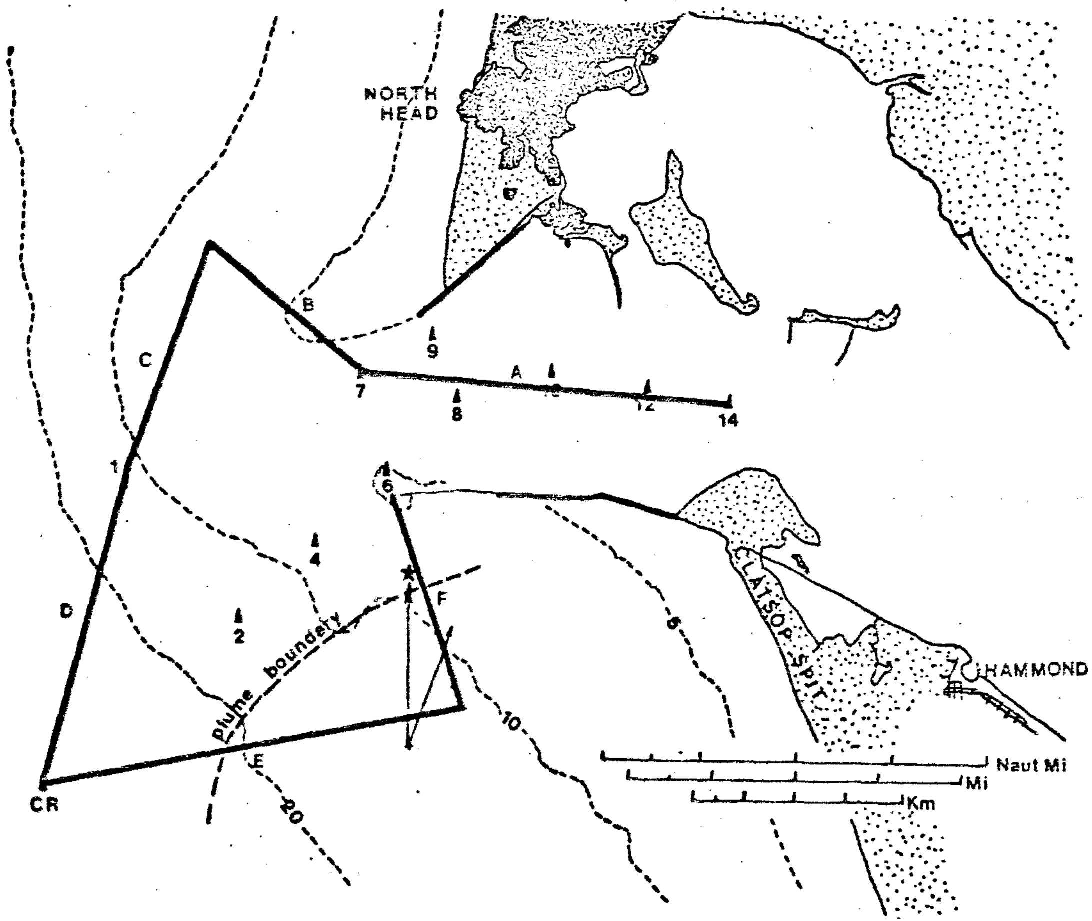

Figure D-1. 24 May, 1982 transect, Columbia River. Sampling began at 1105 hrs and ended at 1445 hrs. Depth contours are in fathoms (1 fathom = 1.8 meters).

Table D-1. 24 May 1982 census results.

TRANSECT SEGMENT	TRANSECT LENGTH KM	TRANSECT AREA KM^2	NUMBER OF MURRES	MURRES PER KM^2
A	7.0	2.1	23	11
B	3.8	1.1	60	53
C	4.4	1.3	36	27
D	6.4	1.9	60	31
E	8.3	2.5	633	254
F	4.4	1.3	63	48

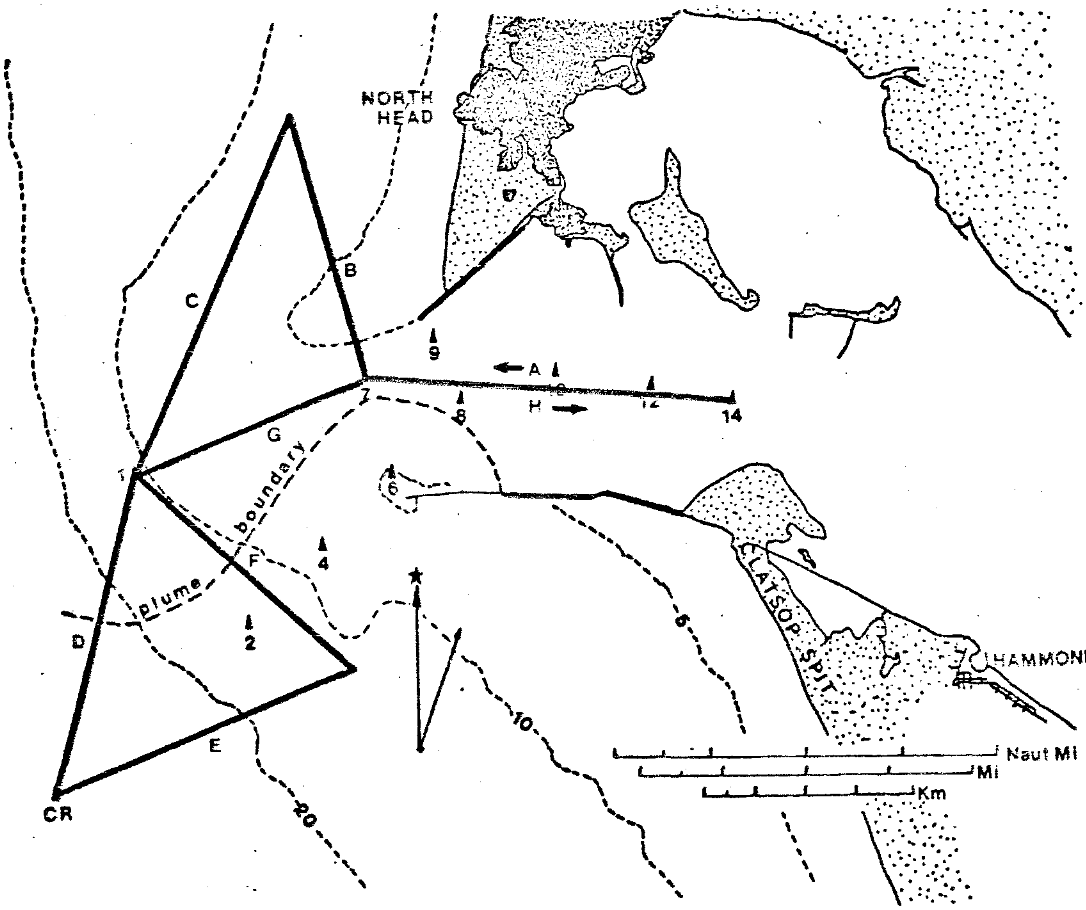

Figure D-2. 3 June, 1982 transect, Columbia River. Sampling began at 0655 hrs and ended at 1010 hrs. Depth contours are in fathoms (1 fathom = 1.8 meters).

Table D-2. 3 June, 1982 census results.

TRANSECT SEGMENT	TRANSECT LENGTH KM	TRANSECT AREA KM^2	NUMBER OF MURRES	MURRES PER KM^2
A	7.0	2.1	19	9
B	5.2	1.6	23	15
C	7.4	2.2	81	37
D	6.4	1.9	34	18
E	6.3	1.9	23	12
F	5.6	1.7	23	14
G	4.8	1.4	11	8

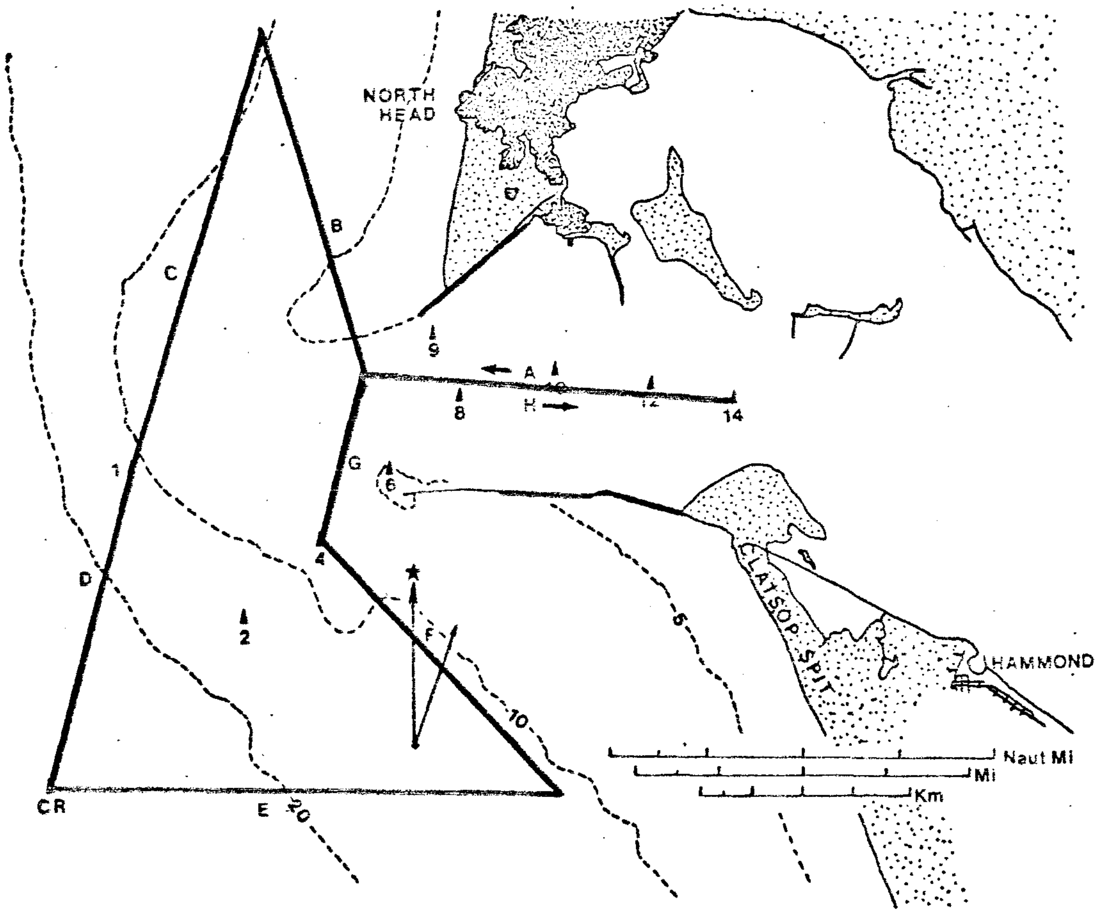

Figure D-3. 4 June, 1982 transect, Columbia River. Sampling began at 0735 hrs and ended at 1025 hrs. Depth contours are in fathoms (1 fathom = 1.8 meters).

Table D-3. 4 June, 1982 census results.

TRANSECT SEGMENT	TRANSECT LENGTH KM	TRANSECT AREA KM^2	NUMBER OF MURRES	MURRES PER KM^2
A	7.0	2.1	16	8
B	6.8	2.0	91	45
C	8.7	2.6	136	52
D	6.4	1.9	37	19
E	10.0	3.0	265	88
F	6.7	2.0	17	9
G	3.4	1.0	113	111
H	7.0	2.1	213	101

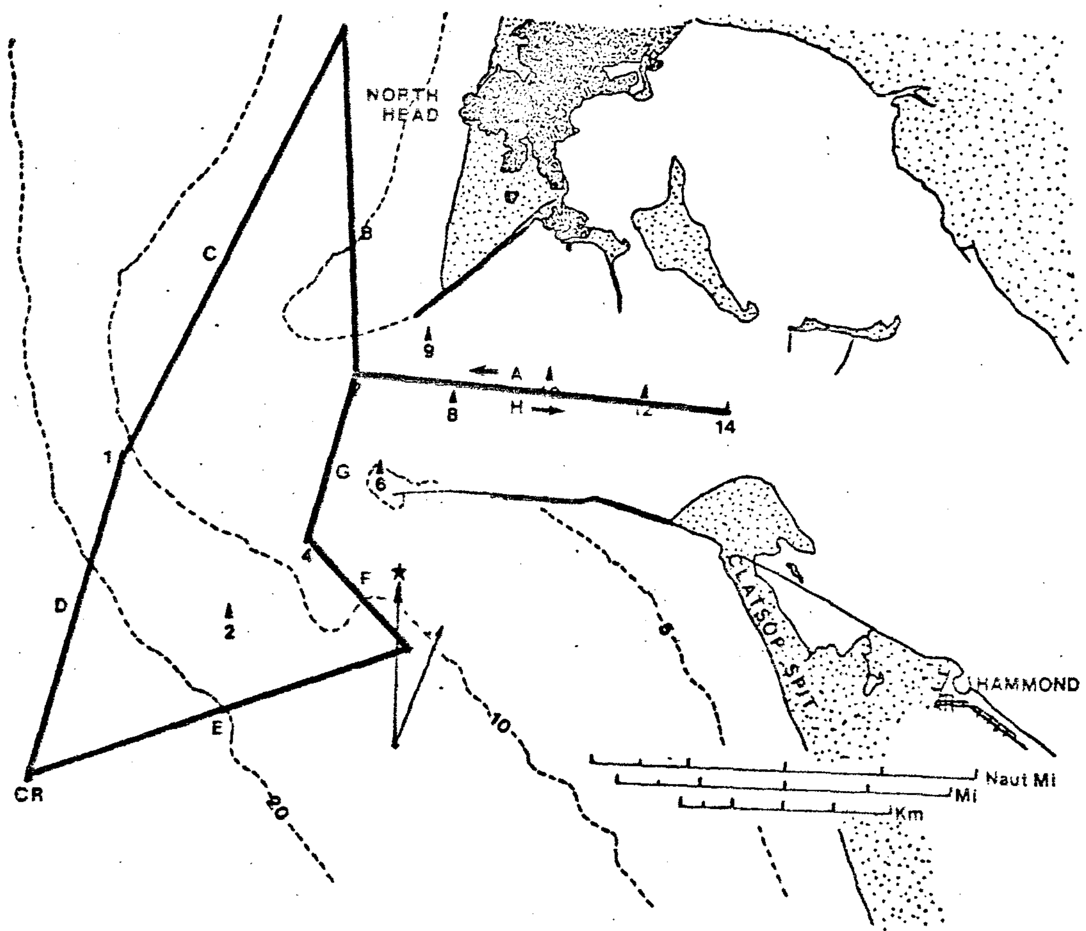

Figure D-4. 10 June, 1982 transect, Columbia River. Sampling began at 1140 hrs and ended at 1452 hrs. Depth contours are in fathoms (1 fathom = 1.8 meters).

Table D-4. 10 June 1982 census results.

TRANSECT SEGMENT	TRANSECT LENGTH KM	TRANSECT AREA KM^2	NUMBER OF MURRES	MURRES PER KM^2
A	7.0	2.1	3	1
B	6.5	2.0	10	5
C	9.2	2.8	13	5
D	6.4	1.9	28	15
E	7.8	2.3	60	26
F	2.8	.8	64	76
G	3.4	1.0	303	297
H	7.0	2.1	17	8

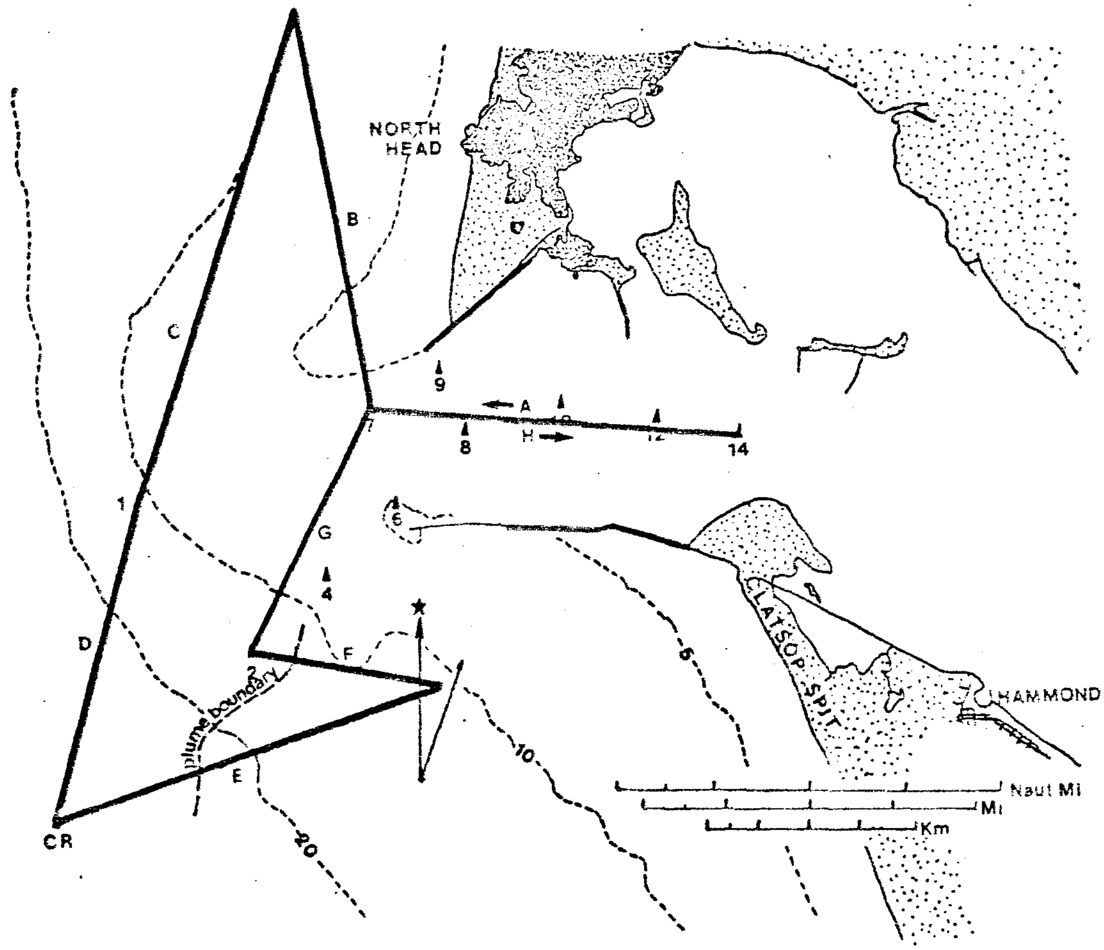

Figure D-5. 11 June, 1982 transect, Columbia River. Sampling began as 1145 hrs and ended at 1441 hrs. Depth contours are in fathoms (1 fathom = 1.8 meters).

Table D-5. 11 June, 1982 census results.

TRANSECT SEGMENT	TRANSECT LENGTH KM	TRANSECT AREA KM^2	NUMBER OF MURRES	MURRES PER KM^2
A	7.0	2.1	71	34
B	7.6	2.3	211	93
C	9.9	3.0	133	45
D	6.4	1.9	79	41
E	7.8	2.3	259	111
F	3.6	1.1	12	11
G	5.2	1.6	57	37
H	7.0	2.1	135	64

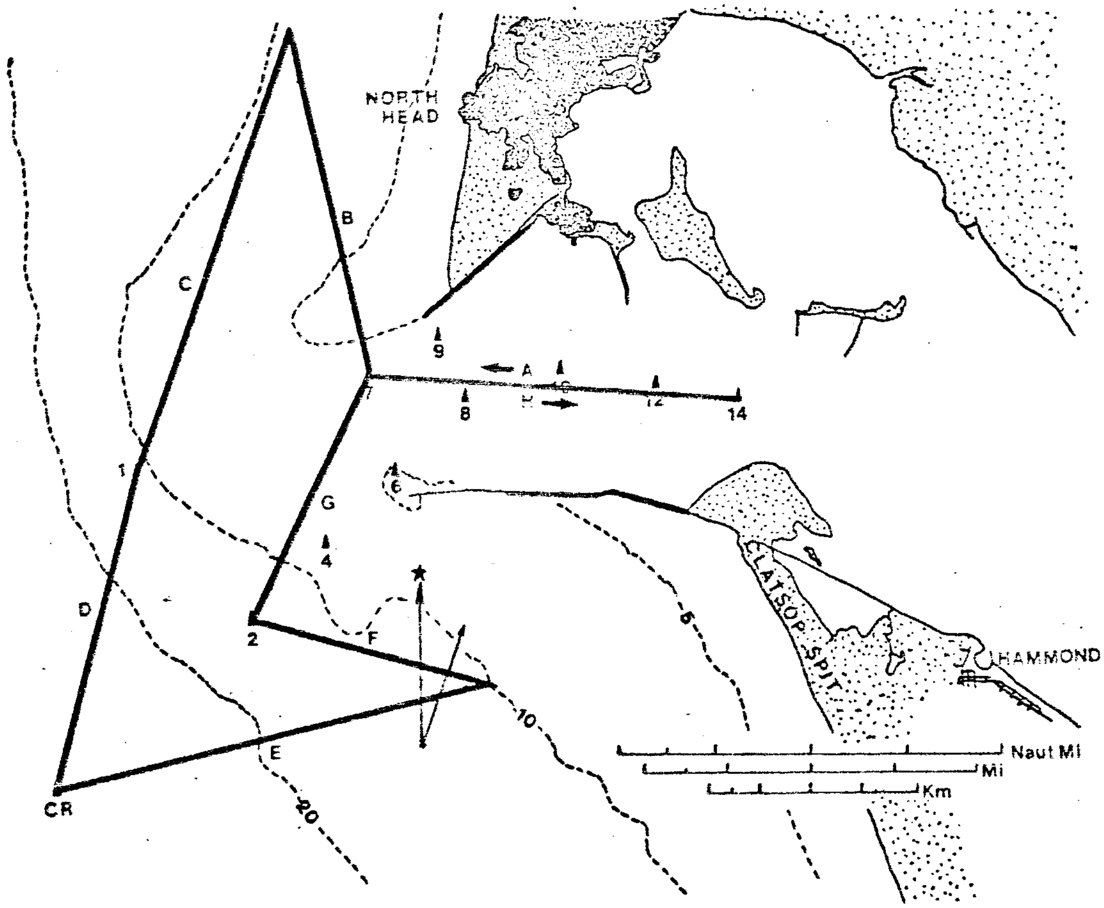

Figure D-6. 22 June, 1982 transect, Columbia River. Sampling began at 0923 hrs and ended at 1350 hrs. Depth contours are in fathoms (1 fathom = 1.8 meters).

Table D-6. 22 June, 1982 census results.

TRANSECT SEGMENT	TRANSECT LENGTH KM	TRANSECT AREA KM^2	NUMBER OF MURRES	MURRES PER KM^2
A	7.0	2.1	1	1
B	6.7	2.0	12	6
C	8.9	2.7	14	5
D	6.4	1.9	0	0
E	8.6	2.6	53	21
F	4.8	1.4	245	170
G	5.2	1.6	20	13
H	7.0	2.1	15	7

APPENDIX E

PREY ITEMS OF COMMON MURRES

Table E-1. Prey items of Common Murres collected off Coos Bay, 1979. Presented are the incidence of each prey species (both total number of individuals and percentage of diet) and the frequency of occurrence of each prey species (both as number and percent).

Number of murres collected = 125, including 10 empty stomachs.

Prey Species	Incidence		Frequency	
	no.	%	no.	%
Pacific sandlance	388	41.3	34	27
Pacific tomcod	208	22.2	57	46
whitebait smelt	139	14.8	49	39
rockfish juveniles	86	9.2	33	26
market squid	59	6.3	32	26
Pacific herring	32	3.4	23	18
unidentified fish	14	1.5	13	10
flatfish species	4	0.4	3	2
coho salmon	1	0.1	1	0.8
octopus	1	0.1	1	0.8
shiner surf perch	1	0.1	1	0.8
unidentified smelt	1	0.1	1	0.8
crab megalops	1	0.1	1	0.8
Total	939			

For scientific names of the above prey species, refer to Table G-1.

Table E-2. Prey items of Common Murres collected off Coos Bay, 1980. Presented are the incidence of each prey species (both total number of individuals and percentage of diet) and the frequency of occurrence of each prey species (both as number and percent).

Number of murres collected = 151, including 7 empty stomachs.

Prey Species	Incidence no.	Incidence %	Frequency no.	Frequency %
rockfish juveniles	706	42.5	73	48
Pacific sandlance	196	11.8	30	20
Speckeled sanddab	185	11.1	7	5
Pacific tomcod	155	9.3	74	49
whitebait smelt	107	6.4	35	23
octopus	60	3.6	15	10
northern anchovy	59	3.6	25	17
Pacific herring	43	2.6	24	16
market squid	42	2.5	25	17
greenling juveniles	26	1.6	8	5
unidentified fish	23	1.4	18	12
shiner surfperch	7	0.4	4	3
lingcod	7	0.4	3	2
crab megalops	7	0.4	2	1
coho salmon	5	0.3	5	3
longfin smelt	5	0.3	3	2
unidentified surfperch	5	0.3	5	3
night smelt	4	0.2	3	2
surf smelt	4	0.2	4	3
topsmelt	3	0.2	3	2
unidentified sculpin	3	0.2	3	2
unidentified flatfish	2	0.1	2	1
staghorn sculpin	1		1	
eulachon	1		1	
chinook salmon	1		1	
striped surfperch	1		1	
Dover sole	1		1	
unidentified smelt	1		1	
Total	1661			

For scientific names of the above prey species, refer to Table G-1.

Table E-3. Prey items of Common Murres collected off Coos Bay, 1981. Presented are the incidence of each prey species (both total number of individuals and percentage of diet) and the frequency of occurrence of each prey species (both as number and percent).

Number of murres collected = 107, including 6 empty stomachs.

Prey Species	Incidence		Frequency	
	no.	%	no.	%
rockfish juveniles	226	24.5	17	16
market squid	221	24.0	72	67
whitebait smelt	126	13.7	25	23
Pacific tomcod	120	13.0	50	47
Pacific sandlance	104	11.3	13	12
coho salmon	60	6.5	21	20
northern anchovy	29	3.1	17	16
Pacific herring	10	1.1	8	7
speckeled sanddab	6	0.7	2	2
greenling juveniles	5	0.5	3	3
shiner surfperch	3	0.3	3	3
unidentified flatfish	3	0.3	3	3
unidentified fish	3	0.3	3	3
night smelt	2	0.2	2	2
unidentified sculpin	2	0.2	2	2
topsmelt	1	0.1	1	1
shrimp	1	0.1	1	1
Total	921			

For scientific names of the above prey species, refer to Table G-1.

Table E-4. Prey items of Common Murres collected off Coos Bay, 1982. Presented are the incidence of each prey species (both total number of individuals and percentage of diet) and the frequency of occurrence of each prey species (both as number and percent).

Number of murres collected = 120, including 7 empty stomachs.

Prey Species	Incidence		Frequency	
	no.	%	no.	%
euphausids	517	35.5	15	13
Pacific tomcod	265	18.2	62	52
northern anchovy	210	14.4	27	23
whitebait smelt	194	13.3	39	33
Pacific sandlance	66	4.5	19	16
market squid	56	3.8	34	28
Pacific herring	48	3.3	17	14
shiner surfperch	24	1.6	13	11
unidentified fish	17	1.2	10	8
rockfish juveniles	10	0.7	5	4
unidentified smelt	9	0.6	4	3
surf smelt	7	0.5	4	3
night smelt	4	0.3	4	3
coho salmon	2	0.1	2	2
slender sole	2	0.1	2	2
topsmelt	2	0.1	2	2
longfin smelt	2	0.1	2	2
unidentified surfperch	2	0.1	2	2
kelp greenling	1	0.1	1	1
eulachon	1	0.1	1	1
English sole	1	0.1	1	1
unidentified flatfish	1	0.1	1	1
Total	1456			

For scientific names of the above prey species, refer to Table G-1.

Table E-5. Prey items of Common Murres collected off Newport, 1982. Presented are the incidence of each prey species (both total number of individuals and percentage of diet) and the frequency of occurrence of each prey species (both as number and percent).

Number of murres collected = 55, including 5 empty stomachs.

Prey Species	Incidence no.	Incidence %	Frequency no.	Frequency %
Pacific herring*	97	23.7	11	20
crab megalops	78	19.1	2	4
market squid	61	14.9	15	27
Pacific tomcod	57	13.9	21	38
coho salmon	39	9.5	18	33
greenling juveniles	23	5.6	3	5
northern anchovy	11	2.6	6	11
shiner surfperch	10	2.4	6	11
rockfish juveniles	9	2.2	2	4
Pacific sandlance	8	2.0	3	5
whitebait smelt	3	0.7	3	5
surf smelt	3	0.7	2	4
unidentified fish	3	0.7	3	5
unidentified smelt	2	0.5	2	4
unidentified surfperch	1	0.2	1	2
Dover sole	1	0.2	1	2
speckeled sanddab	1	0.2	1	2
lingcod	1	0.2	1	2
Total	409			

*includes 75 juveniles

For scientific names of the above prey species, refer to Table G-1.

Table E-6. Prey items of Common Murres collected in and offshore of the Columbia River estuary, 1982. Presented are the incidence of each prey species (both total number of individuals and percentage of diet) and the frequency of occurrence of each prey species (both as number and percent).

Number of murres collected = 77, including 5 empty stomachs.

Prey Species	Incidence		Frequency	
	no.	%	no.	%
northern anchovy	215	46.7	57	74
Pacific tomcod	136	29.5	34	44
whitebait smelt	35	7.6	19	25
longfin smelt	17	3.7	3	4
night smelt	11	2.4	7	9
coho salmon	9	2.0	8	10
eulachon	8	1.7	2	3
Pacific herring	7	1.5	7	9
rockfish juveniles	7	1.5	5	7
unidentified fish	7	1.5	6	8
Pacific sandlance	3	0.7	2	3
chinook salmon	2	0.4	2	3
market squid	2	0.4	2	3
Pacific lamprey	1	0.2	1	1
topsmelt	1	0.2	1	1
Total	461			

For scientific names of the above prey species, refer to Table G-1.

APPENDIX F

MONTHLY DIETARY ANALYSES

Table F-1. Monthly dietary analysis of Common Murres collected off Coos Bay, 1979. Presented are the dietary contributions of each prey species, as a percentage of the total diet for each month listed. This list includes only those prey items composing one percent or more of the total diet in at least one month. Totals at the bottom include all prey items (used in calculating percent of diet).

	Per Cent of Diet			
Prey Species	May	Jul	Aug	Sep
Pacific tomcod	1	43	24	18
northern anchovy	1	0	0	0
whitebait smelt	1	34	19	5
Pacific sandlance	85	1	37	26
market squid	4	3	4	19
Pacific herring	0	3	8	5
rockfish juveniles	2	13	4	24
coho salmon	0	0	1	0
flatfish	0	0	1	0
octopus	0	0	1	0
Number of prey items	325	275	186	153

For scientific names of the above prey items, refer to Table G-1.

Table F-2. Monthly dietary analysis of Common Murres collected off Coos Bay, 1980. Presented are the dietery contributions of each prey species, as a percentage of the total diet for each month listed. This list includes only those prey items composing one percent or more of the total diet in at least one month. Totals at the bottom include all prey items (used in calculating percent of diet).

	Per Cent of Diet					
Prey Species	Apr	May	Jun	Jul	Aug	Sep
Pacific tomcod	0	1	8	13	8	24
northern anchovy	52	0	13	4	0	0
whitebait smelt	4	0	2	3	23	7
Pacific sandlance	17	14	24	2	2	11
market squid	13	1	2	2	7	0
Pacific herring	4	0	5	2	2	26
surfperches	0	2	0	0	0	7
greenling juveniles	0	0	1	3	1	0
rockfish juveniles	9	0	39	65	38	24
coho salmon	0	1	0	0	0	0
flatfishes	0	52	0	1	0	0
octopus	0	1	2	1	14	0
Number of prey items	23	335	128	811	312	46

For scientific names of the above prey items, refer to Table G-1.

Table F-3. Monthly dietary analysis of Common Murres collected off Coos Bay, 1981. Presented are the dietary contributions of each prey species, as a percentage of the total diet for each month listed. This list includes only those prey items composing one percent or more of the total diet in at least one month. Totals at the bottom include all prey items (used in calculating percent of diet).

Prey Species	Per Cent of Diet				
	Apr	May	Jun	Jul	Aug
Pacific tomcod	2	29	10	9	18
northern anchovy	10	1	3	2	0
whitebait smelt	5	0	0	57	8
Pacific sandlance	66	1	0	0	0
market squid	3	38	18	23	65
Pacific herring	1	1	0	3	2
surfperches	1	1	0	0	0
greenling juveniles	0	1	1	0	0
rockfish juveniles	0	21	57	2	3
coho salmon	10	7	8	3	0
flatfishes	1	0	2	1	2
Number of prey items	154	195	314	197	60

For scientific names of the above prey items, refer to Table G-1.

Table F-4. Monthly dietary analysis of Common Murres collected off Coos Bay, 1982. Presented are the dietary contributions of each prey species, as a percentage of the total diet for each month listed. This list includes only those prey items composing one percent or more of the the total diet in at least one month. Totals at the bottom include all prey items (used in calculating percent of diet).

	Per Cent of Diet								
Prey Species	Jan	Feb	Apr	May	Jun	Jul	Aug	Sep	Nov
euphausids	0	0	0	43	91	0	16	0	0
Pacific tomcod	24	31	6	17	3	45	54	13	0
northern anchovy	0	0	30	1	0	4	5	0	97
whitebait smelt	70	6	10	1	3	33	9	15	0
Pacific sandlance	0	19	27	15	0	1	6	0	0
market squid	2	18	6	5	1	1	4	15	0
Pacific herring	0	22	0	0	2	1	1	48	3
surfperches	1	3	13	4	0	1	0	0	0
greenling juveniles	0	0	0	9	1	1	0	0	0
rockfish juveniles	0	0	0	4	1	0	0	0	0
coho salmon	0	0	0	0	0	0	1	0	0
flatfishes	0	1	0	0	0	1	1	2	0
Number of prey items	138	68	125	134	471	124	193	52	160

For scientific names of the above prey items, refer to Table G-1.

Table F-5. Monthly dietary analysis of Common Murres collected off Newport, 1982. Presented are the dietary contributions of each prey species, as a percentage of the total diet for each month listed. This list includes only those prey items composing one percent or more of the total diet in at least one month. Totals at the bottom include all prey items (used in calculating percent of diet).

	Per Cent of Diet				
Prey Species	Apr	May	Jun	Aug	Sep
Pacific tomcod	38	5	17	18	12
northern anchovy	3	6	0	0	0
whitebait smelt	0	1	0	1	0
Pacific sandlance	0	0	6	2	5
market squid	14	32	2	0	2
Pacific herring	0	1	0	62	58
rockfish juveniles	0	1	6	0	0
greenling juveniles	0	0	33	1	0
shiner surfperch	14	2	0	0	0
coho salmon	0	4	28	12	10
smelt*	3	1	4	1	2
flatfishes	0	0	0	1	0
crab megalops	0	47	0	0	0
Number of prey items	35	167	54	100	55

*excluding whitebait smelt

For scientific names of the above prey items, refer to Table G-1.

APPENDIX G

SCIENTIFIC NAMES OF PREY ITEMS

Table G-1. Scientific names of prey items of Common Murres collected off the Oregon coast.

Fish	
Pacific lamprey	*Lampetra tridentata*
Pacific herring	*Clupea harengus*
northern anchovy	*Engraulis mordax*
chinook salmon	*Oncoryhnchus tshawytscha*
coho salmon	*Oncoryhnchus kisutch*
surf smelt	*Hypomesus pretiosus*
eulachon	*Thaleichthys pacificus*
whitebait smelt	*Allosmerus elongatus*
night smelt	*Spirinchus starksi*
longfin smelt	*Spirinchus thaleichthys*
Pacific tomcod	*Microgadus proximus*topsmelt
topsmelt	*Atherinops affinis*
rockfish juveniles	*Sebastes* spp.
greenling juveniles	*Hexagrammidae* spp.
lingcod	*Ophiodon elongatus*
sculpin (unidentified)	*Cottidae* spp.
staghorn sculpin	*Leptocottus armatus*
shiner surfperch	*Cymatogaster aggregata*
surfperch (unidentified)	*Embiotocidae* spp.
English sole	*Parophrys isolepis*
speckeled sanddab	*Citharichthys stigmaeus*
Dover sole	*Microstomus pacificus*
Pacific sandlance	*Ammodytes hexapterus*
Cephalopods	
market squid	*Loligo opalescens*
octopus	*Octopus bimaculatus*
Crustaceans	
crab megalops	*Cancer* spp.
euphausiid	*Euphausiidae* spp.
shrimp	*Pandalus jordani*

APPENDIX H

DENSITY OF COMMON MURRES WITHIN THE CHANNEL, NEWPORT AND COLUMBIA RIVER

Table H-1. Density of Common Murres along the Columbia River channel, 1982. Census was conducted between navigation buoys No. 7 and No. 14. In all cases, transects were the same; length = 7.0 km, width = 0.3 km, area = 2.1 km^2.

Date	Time	Number of Murres	Murres per km^2
24 May	1105-1118	23	11
3 June	0655-0707	19	9
4 June	0735-0755	16	8
	1005-1025	213	101
10 June	1140-1200	3	1
	1440-1452	17	8
11 June	1145-1200	71	34
	1425-1441	135	64
22 June	0923-0937	1	0.5
	1335-1350	15	7

Table H-2. Density of Common Murres inside the Yaquina Bay jetties, Newport, 1982. Census was conducted between the Yaquina Bay bridge and navigation buoy No. 3. In all cases, transects were the same: length = 2.3 km, width = 0.3 km, area = 0.7 km^2.

Date	Time	Number of Murres	Murres per km^2
29 April	0810	0	0
11 May	0740	9	13
	1100	3	4
18 May	0730	4	6
	0905	6	9
29 June	0805	200	289
	1045	626	907
3 August	0730	1175	1678
	1025	1714	2484
4 September	0840	6	9

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