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Title: TWO ZOOGEOGRAPHIC STUDIES OF DEEP SEA BENTHIC

GAMMARID AMPHIPODS

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Dr. Andrew G. Carey

Two separate studies on the distribution of gammarid amphipods

in the bathyal and abyssal benthic environments demonstrated that

different assemblages could be found at a single depth over distances on

the order of 100 kilometers. These studies evaluated changes in the

species composition and relative abundance of the amphipod assemb-

lage utilizing samples collected with an epibenthic sled.

The amphipod faunas of the San Diego Trough and Tanner Basin

were compared utilizing 18 epibenthic sled hauls. These two bathyal

basins of the Continental Borderland off Southern California are very

similar in their environments and both have a bottom depth close to

1250 meters. The amphipod fauna from each basin was characterized

by comparing the percentage each species comprised of the total

amphipod fauna, the frequency of occurrence of each species, and the

rank order of abundance of species. The large differences observed

in the structure of the amphipod assemblage between the two basins

can probably be attributed to different sources of food in the two basins.

Nineteen sled hauls were collected at two stations on Cascadia Abyssal Plain located off the Oregon coast at 2800 meters depth. The two stations were representative of the nearshore and offshore portions of this abyssal plain. The amphipod assemblages were found to be very different at these two stations, despite their similar depths and physical environments. Geological evidence indicated that the sources of food to the sea floor at these two stations were likely to be very different. It was this difference in food input that seemed most likely to be the cause of the faunal difference.

These studies of "mesoscale" zoogeography have added a new element of complexity to our understanding of factors controlling animal distributions in the deep sea benthos, because they have demonstrated that different assemblages can be found at the same depth in the same geographic region. The results suggest that the quality and quantity of food supplied to the deep sea floor may play a major role in controlling the composition of the fauna.

Two Zoogeographic Studies of Deep Sea
Benthic Gammarid Amphipods

by

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APPROVED:

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Associate Professor of Oceanography

Redacted for privacy

Acting Dean of School of Oceanography

Redacted for privacy

Dean of Graduate School

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Typed by Susie Kozlik for John Joseph Dickinson

mud. Without the help of Gene Ruff, I never could have completed my work at sea. He always found time between bridge games to help Mr. Bear retrieve his fool sled.

For all their help and encouragement through all these years, I would like to express my deepest appreciation to my parents.

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TWO ZOOGEOGRAPHIC STUDIES OF DEEP SEA
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GENERAL INTRODUCTION

The study of animal distributions in the deep sea benthos is still very much in the descriptive phase, but several general patterns have begun to emerge. A decrease in faunal density is correlated with increasing depth and increasing distance from the major land masses (Murray, 1895; Ekman, 1953; Marshall, 1954; Vinogradova, 1962; Carey, 1965; Sanders, Hessler, and Hampson, 1965). Since many factors change simultaneously with increasing depth and distance from land, it is difficult to isolate the contribution of a single environmental parameter to this decrease in faunal density. However, most deep sea ecologists agree that this decrease in animal numbers is directly related to a decrease in the amount of available food as the benthic boundary gets farther from coastal and surface influences (Zenkevitch and Birstein, 1956; Menzies, 1962; Carey, 1965; Sanders, Hessler and Hampson, 1965).

Early workers in abyssal ecology such as Murray (1895), Ekman (1953), Zenkevitch and Birstein (1956), and Bruun (1957) suggested that the decrease in faunal density in the abyssal benthos was accompanied by a decrease in faunal diversity. More recent work by Hessler and Sanders (1965), Sanders (1968), and Hessler (1972) has shown that the infauna and macro-epifauna of the deep sea has a

high "within habitat" species diversity. These workers have demon-
strated that the silt-clay sediments of the deep sea benthos are
characterized by communities of high species diversity when com-
pared to shallow water communities living on similar sediment types.
Several hypotheses have been formulated to explain this high diversity
in the deep sea benthos. Sanders (1968, 1969) and Grassle and
Sanders (1973) have suggested that the long-term environmental
stability of the deep sea has led to the evolution of a biologically
accommodated community in which biological stress between species
has been minimized. This stable community would be characterized
by high equitability and a large number of species. This mechanism
suggests that competition for a limited food supply would lead to a
high degree of feeding specialization in the deep sea community.
Dayton and Hessler (1972) have found little evidence for feeding
specialization in the abyssal benthos. They formulated a new hypothe-
sis in which a high species diversity is maintained by an indiscrimin-
ate cropping pressure which keeps the populations of potential
competitors at levels below which exclusion would take place. Recent
studies of the feeding habits of deep sea rattail fishes by Pearcy and
Ambler (1974), and Haedrich and Henderson (1974) are consistent
with the Dayton-Hessler concept of generalized predators in the deep
sea. However, a great deal more research on the structure of abyssal
food webs is needed to fully evaluate the two hypotheses which have

been proposed to explain the high species diversity in the deep sea benthos. In addition, studies on microdistribution such as Jumars' work (1975) on polychaetes are needed to assess the importance of environmental heterogeneity and biological patchiness in contributing to the high species diversity of the deep sea benthos.

The study of zoogeography of abyssal faunas is still in the earliest stages due to the paucity of deep sea samples. It was suggested by pioneer workers such as Agassiz (1888) and Bruun (1957) that abyssal species would be world wide in distribution. The work of Ekman (1953), Vinogradova (1956, 1969), Barnard (1962), and Menzies, George and Rowe (1973) summarize rather clear evidence that most deep sea benthic organisms are restricted to a single ocean or more commonly to a single ocean basin. Some abyssal species have cosmopolitan distributions, but these organisms seem to be the exception rather than the rule. The restricted distributions of most deep sea organisms are probably the result of both limited dispersal and narrow ecological tolerances. Menzies, George and Rowe (1973) summarize evidence which indicates that the majority of deep sea benthic organisms lack a pelagic larval stage. The restricted depth distributions of most abyssal animals have been used to infer that these organisms have narrow physiological tolerances. The narrow bathymetric distributions of deep sea benthic organisms certainly must play an important role in limiting their geographic distributions.

Most of the intensive sampling of the deep sea benthos has taken place on the continental borders in nearshore bathyal and abyssal depths. Studies here have demonstrated that the fauna is zoned with depth on the continental slopes and rises (see Carey, 1965; Sanders and Hessler, 1969; Rowe and Menzies, 1969; Zenkevitch, 1969; Barnard, 1971; and Menzies, George and Rowe, 1973). Since a number of environmental factors change with increasing depth down the continental slope, it is difficult to attribute this vertical zonation to any single factor. Some of the more important factors are thought to be: 1) temperature (Bruun, 1957); 2) sediment type (Carey, 1965); 3) hydrostatic pressure (Oppenheimer and Zobell, 1952); 4) bottom currents (Rowe and Menzies, 1969); and 5) quantity and quality of food (Sanders and Hessler, 1969). It should also be kept in mind that biological interactions such as predation and competition may also be important in regulating the distribution of animals (see Connell, 1961; Paine, 1966; Dayton and Hessler, 1972). It is not possible with our present knowledge to evaluate the relative importance of each of the above factors in controlling the distribution of animals with depth.

No studies of the deep sea benthos have attempted to assess the variability of the fauna within a single depth range at increasing distances from a continental boundary. The advantage of such studies would be that many environmental parameters are relatively constant with depth such as temperature, salinity, oxygen concentration, and

hydrostatic pressure. However, some parameters such as food input and sediment type change with increasing distance from continental sources even without increasing depth. Therefore, studies of faunal variability over a single depth range with increasing distance from land would enable us to evaluate more simply which factors may be most important in controlling the structure of deep sea benthic communities. Such studies also will be important in that they will describe the variability of fauna on the scale of 100 to 200 kilometers. Very few such studies of "mesoscale zoogeography" have been attempted in the deep sea benthos (Barnard 1962, 1966). These studies of Barnard were inconclusive because they were based on such small samples.

This thesis describes two studies which attempted to evaluate the changes in species composition and relative abundance observed at the same depth with increasing distance from continental sources of food and sediment. Both of these studies utilized samples collected with an epibenthic sled. The first study to be discussed was accomplished at bathyal depths on the Continental Borderland off Southern California. The second study was undertaken at abyssal depths on the Cascadia Abyssal Plain off Oregon. Both of these studies deal exclusively with species of the order Amphipoda belonging to the suborder Gammaridea of the class Crustacea. It was hoped

that by studying these different areas located at different depths that

zoogeographic patterns of a more general nature could be described.

AMPHIPOD BIOLOGY

At bathyal and upper abyssal depths, one of the most diverse groups of benthic organisms is the gammarid Amphipoda (Crustacea). The work of Barnard (1961, 1962, 1964, 1967) and Hessler and Sanders (1967) has demonstrated that as many as 50 or 60 species may be collected in a single deep water haul. Amphipods like all peracarid crustaceans carry their developing eggs in a thoracic brood pouch until the embryos reach a juvenile stage. The juvenile stage which leaves the brood pouch is essentially a miniature adult. This type of reproductive behavior along with the poor swimming capabilities of most benthic amphipods restricts their dispersal. Barnard (1962) has shown that the majority of deep water amphipods are stenobathic and have restricted geographic distributions.

Gammarid amphipods are principally deposit feeders and can feed selectively on discrete particles of organic detritus (see Barnard, 1962). This fact would suggest that they may be more sensitive to change in the quality of food input to the sea floor than groups such as deep sea holothuroids which ingest sediment directly.

The large number of species, the specialized feeding habits, and the generally restricted distributions of gammarid amphipods make them an ideal group for study of change in species composition and relative abundance at a single depth in the deep sea benthos.

The studies of bathyal and abyssal zoogeography reported here are based entirely on collections of gammarid amphipods.

The identification of deep water amphipods has been made possible by the taxonomic work of Barnard (1958, 1960a, 1960b, 1961, 1962, 1964a, 1964b, 1966, 1967, 1969, 1971, 1972, 1973), Gurjanova (1951, 1962), Hurley (1963), and Mills (1972). The studies reported here will form the basis for a significant increase in our knowledge of gammarid amphipod systematics and zoogeography in the bathyal and abyssal benthos of the Northeast Pacific Ocean. These systematic results will be published later in a series of papers based on the collections described in this thesis.

A FAUNAL COMPARISON OF TWO BATHYAL BASINS OFF SOUTHERN CALIFORNIA

Introduction

The Continental Borderland off Southern California has rather unusual submarine topography that is well described by Emery (1960). It is characterized by a series of parallel basins which are located at different distances from the coast and which are separated by a series of banks and ridges (Figure 1). This group of basins provides an interesting area in which to study zoogeography since they have different depths and are located at different distances from the continent. The two basins chosen for this study had smiliar depths, but were located at different distances from the coast. This situation fits very well the proposed study of faunal variability within a single depth at increasing distance from the continental sources of food and sediment.

The two basins chosen were the San Diego Trough and the Tanner Basin. San Diego Trough lies about 40 kilometers off the coast of Southern California with its center at about the latitude of San Diego. The Trough is a long narrow basin with a longitudinal axis of about 130 kilometers and a width of about 15 kilometers. The long axis of the Trough closely parallels the coastline. The floor of the basin is relatively featureless with depths varying between 1200 and 1350
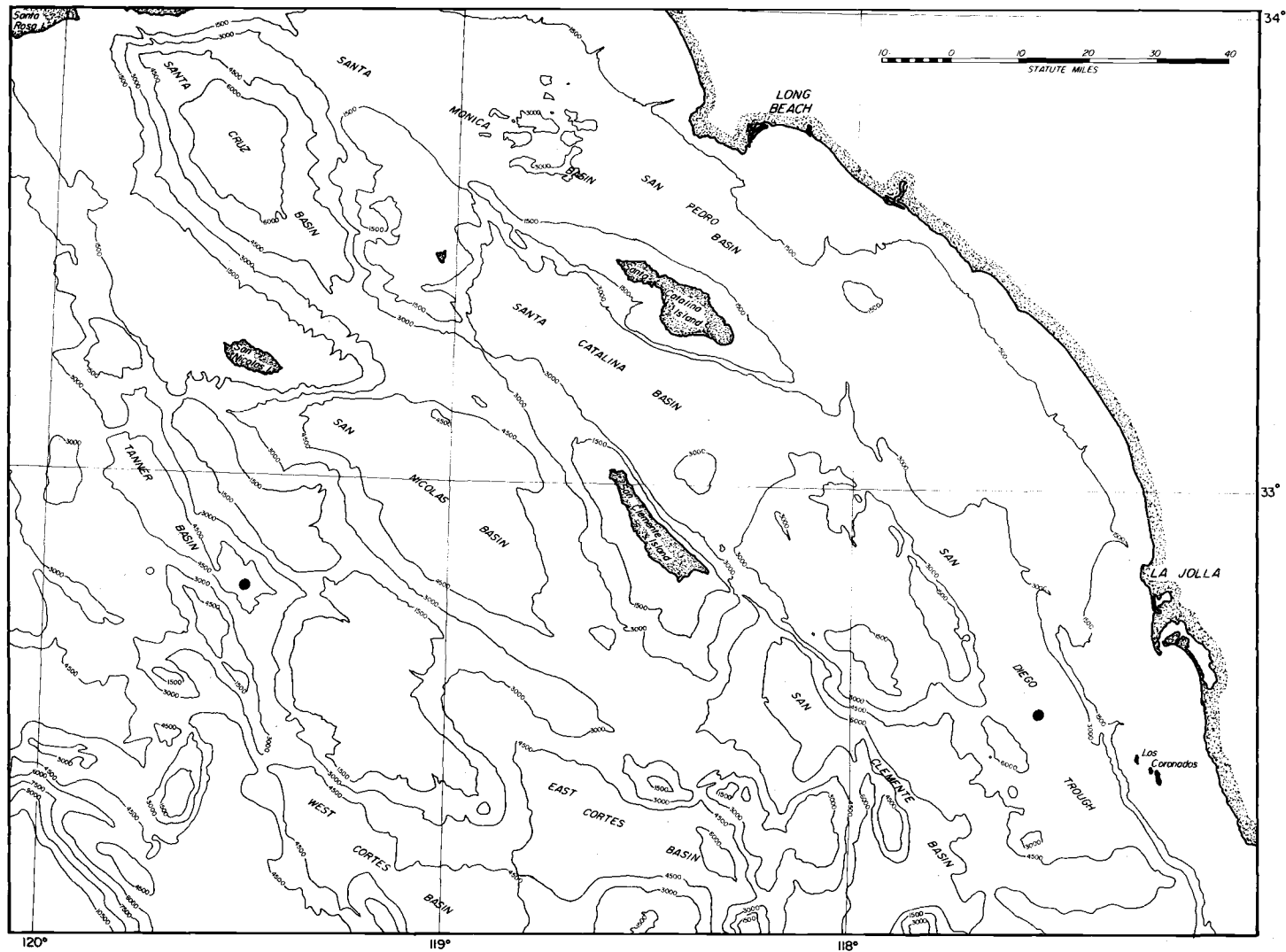
Figure 1.   Location map for the California Continental Borderland (after Emery 1960).   Station locations are marked by the dots.

meters. The area of the basin is approximately 1700 square kilometers. The Trough has a single sill to the west at a depth of 1350 meters.

Tanner Basin is located at the outer edge of the Continental Borderland about 200 kilometers from the coast of Southern California. The center of the basin lies slightly to the north of the latitude of San Diego. Tanner Basin has a length of about 65 kilometers, and it is approximately 15 kilometers wide. Its longitudinal axis is also roughly parallel to the California coastline. The floor of the basin lies at a depth between 1250 and 1400 meters. The area of the basin is approximately 520 square kilometers. This basin also has a single sill to the west located at about 1200 meters depth.

The sedimentary geology of the Continental Borderland has been well studied by Emery (1960), Shephard and Einsele (1962), Gorsline, Drake and Barnes (1968), and Moore (1970). Few studies of the benthic ecology of the borderland have been undertaken until recently. Hartman and Barnard (1958) conducted a faunal survey of the basins of the borderland, but their samples were too few to evaluate faunal differences between the basins. Barham, Ayer and Boyce (1967) conducted a camera study of the San Diego Trough, but it was restricted to macro-invertebrates. The first extensive biological sampling of the deeper basins of the borderland was undertaken by graduate students of Dr. Robert Hessler of the Scripps

Institution of Oceanography. Jumars (1975) studied the microdis-
tribution of polychaetes in the San Diego Trough. Rokop's (1974)
study of reproductive periodicity involved extensive sampling of the
San Diego Trough and Tanner Basin. Samples collected by Rokop
were used by the author to compare the amphipod faunas of these two
bathyal basins.

Methods

The samples used in this study of bathyal zoogeography were
collected with a W. H. O. I. Epibenthic Sled (Hessler and Sanders,
1967). The sled was designed to sample the upper few centimeters of
sediment and the water immediately overlying it. The net used in
this sampler had a mesh size of approximately 1.0 mm. The
samples obtained with such a device yield qualitative collections of
the major small epifaunal groups including the gammarid amphipods.
Replicate sled hauls were made in both basins on each of five cruises.
A total of eighteen sled hauls were used in the faunal analysis in-
cluding ten samples from the San Diego Trough and eight from the
Tanner Basin. Two samples from the Tanner basin had to be omitted
from the study because of gear malfunction precipitated by poor
weather conditions. Appendix I lists the date, location and depth of
each sample. The samples were washed through a 1.0 mm aperture
sieve on board ship in the manner described by Sanders, Hessler

and Hampson (1965). The samples from the San Diego Trough were sorted in the lab by Rokop using a combination of dissecting microscope and illuminated magnifier lens. The samples from the Tanner Basin were sorted by the author using similar techniques. All amphipods from each sample were sorted to family, and subsequently identified to species.

Results

A list of the amphipod species identified from each of the eighteen samples may be found in Appendix II. A comparison of the amphipod faunas of the two basins with regard to differences in species composition and relative abundance will be made treating separately each family of gammarids. The data for each family will be listed in a table including the total number of each species collected in each basin, the percentage each species comprises of the total amphipod fauna for each basin, and the number of samples in which each species was found. A summary table of the most abundant species in each basin will be used to compare the rank order of abundance of species.

Members of the gammarid family Phoxocephalidae are widely distributed at bathyal and abyssal depths and are often the numerically dominant family in a deep sea collection (Barnard 1960, 1967, 1971).

The Phoxocephalids comprised about 40% of the amphipods collected from both the San Diego Trough and the Tanner Basin (Table 1). The dominant species in each basin was Harpiniopsis excavata, but it composed a distinctly larger percentage of the fauna in the Tanner Basin. Harpiniopsis petulans was found in every sample from the San Diego Trough where it comprised 8.5% of the total amphipod fauna by number. In contrast, H. petulans was never collected from the Tanner Basin. Paraphoxus oculatus was relatively abundant in the Tanner Basin being collected in all eight sled hauls and comprising almost 10% of the amphipod fauna, but it was a rare species in the San Diego Trough being represented by only two individuals in a single haul. Harpiniopsis profundis, Harpiniopsis naiadis, and Harpiniopsis fulgens were all common in the San Diego Trough, but all three were rare in the Tanner Basin. Harpiniopsis emeryi had about the same relative abundance in each basin. The Phoxocephalids of these two bathyal basins clearly differ in their faunal composition and relative abundance.

The family Oedicerotidae is one of the more diverse families of gammarid amphipods found in deeper water (Barnard 1961, 1967). Fifteen species of oedicerotids were collected from the two basins. They comprised 20% of the fauna in the San Diego Trough and 12% of the fauna in the Tanner Basin (Table 2). Oediceroides trepedora and Monoculodes latissimanus were the dominent oedicerotids in the

Table 1. A comparison of the Phoxocephalidae collected from the San Diego Trough and the Tanner Basin. N = total number of this species collected in each basin. % = percent this species comprises of the total amphipod fauna in each basin. F = frequency of occurrence of the species in the samples from each basin.

Species	San Diego Trough			Tanner Basin		
	N	%	F	N	%	F
Harpiniopsis excavata	206	20.2	10/10	124	29.6	8/8
Harpiniopsis petulans	86	8.5	10/10	--	--	--
Harpiniopsis profundis	39	3.8	10/10	2	.5	2/8
Harpiniopsis naiadis	18	1.8	7/10	1	.2	1/8
Harpiniopsis emeryi	16	1.6	6/10	10	2.3	4/8
Harpiniopsis fulgens	13	1.3	8/10	--	--	--
Harpiniopsis galerus	4	.4	3/10	--	--	--
Leptophoxus falcatus icelus	2	.2	1/10	2	.5	1/8
Paraphoxus oculatus	2	.2	1/10	41	9.8	8/8
Metaphoxus sp. A	4	.4	3/10	--	--	--
Phoxocephalus kergueleni	4	.4	3/10	--	--	--
TOTALS:	391	38.5		181	43.1	

Table 2. A comparison of the Oedicerotidae collected from the San Diego Trough and the Tanner Basin. N = total number of this species collected in each basin. % = percent this species comprises of the total amphipod fauna in each basin. F = frequency of occurrence of this species in the samples from each basin.

Species	San Diego Trough			Tanner Basin		
	N	%	F	N	%	F
Oediceroides trepedora	43	4.2	9/10	3	.7	1/8
Monoculodes latissimanus	44	4.3	8/10	--	--	--
Monoculodes necopinus	31	3.1	7/10	4	1.0	1/8
Monoculodes diversisexus	1	.1	1/10	--	--	--
Monoculodes sp. Y	1	.1	1/10	--	--	--
Monoculodes sp. B	1	.1	1/10	--	--	--
Monoculodes sp. Z	1	.1	1/10	--	--	--
Finoculodes omnifera	--	--	--	1	.2	1/8
Bathymedon couilhani	34	3.3	9/10	2	.5	2/8
Bathymedon kassites	23	2.3	6/10	16	3.8	6/8
Bathymedon flebilis	3	.3	3/10	--	--	--
Bathymedon sp. A	2	.2	1/10	--	--	--
Bathymedon caino	1	.1	1/10	2	.5	1/8
Bathymedon sp. Z	1	.1	1/10	--	--	--
Aceroides edax	22	2.2	8/10	23	5.5	6/8
TOTALS:	210	20.5		61	12.2	

San Diego Trough. M. latissimanus was absent from Tanner Basin,
and O. trepedora was very rare there. Monoculodes necopinus
and Bathymedon covilhani were both common species in the San Diego
Trough each comprising about 3% of the fauna. Both of these species
were rare in Tanner Basin, having both low relative abundance and
low frequency of occurrence. Aceroides edax was found commonly
in both basins, but its relative abundance was much higher in the
Tanner Basin. Bathymedon kassites was about equally abundant in
both basins. The oedicerotid fauna of the two basins is also clearly
different.

The gammarid family Ampeliscidae comprised 15% of the
amphipod fauna in the San Diego Trough and 22% of the amphipod
fauna in the Tanner Basin (Table 3). Ampelisca amblyopsoides,
Ampelisca sp. A., and Byblis bathyalis all had much greater rela-
tive abundances in the Tanner Basin than in the San Diego Trough.
Conversely, Haploops lodo and Byblis crassicornis were much more
important components of the fauna in the San Diego Trough than in
the Tanner Basin. Ampelisca eoa was relatively abundant in both
basins, but it was more dominant in the San Diego Trough where it
made up a larger percentage of the fauna. Byblis tannerensis was a
common species in both basins, and had about the same relative
abundance in each. The ampeliscid data agree with the phoxocephalid

Table 3. A comparison of the Ampeliscidae collected from the San Diego Trough and the Tanner Basin. N = total number of this species collected in each basin. % = percent this species comprises of the total amphipod fauna in each basin. F = frequency of occurrence of this species in the samples from each basin.

Species	San Diego Trough			Tanner Basin		
	N	%	F	N	%	F
Ampelisca amblyopsoides	8	.8	5/10	17	4.1	5/8
Ampelisca eoa	60	5.9	9/10	16	3.8	6/8
Ampelisca coeca	1	.1	1/10	--	--	--
Ampelisca furcigera	--	--	--	1	.2	1/8
Ampelisca pugetica mora	--	--	-	1	.2	1/8
Ampelisca sp. A	--	--	--	19	4.5	6/8
Ampelisca sp. B	--	--	--	1	.2	1/8
Byblis crassicornis	14	1.4	5/10	1	.2	1/8
Byblis tannerensis	31	3.1	9/10	13	3.1	5/8
Byblis bathyalis	1	.1	1/10	10	2.4	3/8
Byblis teres	7	.7	3/10	4	1.0	2/8
Byblis sp. A	6	.6	5/10	--	--	--
Byblis sp. B	--	--	--	8	1.9	2/8
Haploops lodo	22	2.2	9/10	--	--	--
TOTALS:	150	14.9		97	21.6	

and oedicerotid data in showing clear differences in faunal composition between the two basins.

The superfamily Corophoidea includes the gammarid families: Corophiidae, Ischyroceridae and Podoceridae (Barnard 1973). These families are represented by few species in bathyal and abyssal waters, but these species can be important numerically (Barnard 1961, 1964, 1967, and 1971). The Corophoidea comprised 9% of the amphipod fauna in the San Diego Trough, and 6% of the amphipod fauna in the Tanner Basin (Table 4). Pseudoericthonius sp. A. comprised almost 7% of the fauna in the San Diego Trough, and it was present in 7 of 10 sled hauls from that basin. This species was not collected from the Tanner Basin. Bonnierella linearis was present in 7 of 10 samples from the San Diego Trough, but it only comprised 1.4% of the amphipod fauna numerically. In Tanner Basin, B. linearis was found in only one haul, but it was so abundant that it comprised over 5% of the total fauna. Corophid sp. A. was a rare species in both basins. The species composition of the Corophoidea also appeared to be different in these two basins.

The gammarid family Lysianasidae is widely distributed in the deep sea benthos. The Lysianasidae is also one of the most difficult groups systematically (Barnard 1961, 1964, 1969). The Lysianasidae comprised 7% of the amphipod fauna in the San Diego Trough, and 10% of the fauna in the Tanner Basin (Table 5).

Table 4. A comparison of the Corophoidea collected from the San
Diego Trough and the Tanner Basin. N = total number of
this species collected in each basin. % = percent this
species comprises of the total amphipod fauna in each
basin. F = frequency of occurrence of this species in the
samples from each basin.

Species	San Diego Trough			Tanner Basin		
	N	%	F	N	%	F
Pseudoericthonius sp. A	68	6.7	7/10	--	--	--
Bonnierella linearis	14	1.4	7/10	22	5.3	1/8
Corophid sp. A	11	1.1	6/10	3	.7	1/8
TOTALS:	93	9.2		25	6.0	

Table 5. A comparison of the Lysianasidae collected from the San Diego Trough and the Tanner Basin. N = total number of this species collected in each basin. % = percent this species comprises of the total amphipod fauna in each basin. F = frequency of occurrence of this species in the samples from each basin.

Species	San Diego Trough			Tanner Basin		
	N	%	F	N	%	F
Prachynella lodo	11	1.1	4/10	6	1.4	5/8
Schisturella grabensis	17	1.7	8/10	15	3.6	7/8
Schisturella robusta	6	.6	5/10	--	--	--
Hirondella fidenter	17	1.7	6/10	--	--	--
Uristes perspinus	1	.1	1/10	--	--	--
Lysianasid sp. 1	10	1.0	6/10	--	--	--
Valletiopsis dentatus	1	.1	1/10	--	--	--
Orchomene tabasco	5	.5	2/10	1	.2	1/8
Lepidepecreum sp. A	1	.1	1/10	--	--	--
Anonyx sp. A	--	--	--	5	1.2	3/8
Anonyx sp. B	--	--	--	2	.5	2/8
Lysianasid sp. 2	--	--	--	1	.2	1/8
Hippomedon granulosus	--	--	--	13	3.1	4/8
Tryphosites sp. A	--	--	--	1	.2	1/8
TOTALS:	69	6.9		44	10.4	

Hirondella fidenter and Lysianasid sp. A. were common in the San Diego Trough, but absent in the Tanner Basin collections. Hippomedon granulosus was common in the Tanner Basin, but it was never collected in the San Diego Trough. Schisturella grabensis was found in both basins, but had a higher relative abundance in the Tanner Basin. Prachynella lodo had about the same relative abundance in each basin. The Lysianasidae data again support the idea that these two bathyal basins have different faunas.

The gammarid family Synopidae comprised about 4% of the amphipod fauna in each basin, but it was represented by six species in the San Diego Trough, and only two species in the Tanner Basin (Table 6). Syrrhoe sp. A was present in both basins, but it had a much higher relative abundance in Tanner Basin. Pseudotiron longicaudata was present in half the samples from the San Diego Trough, but it was never collected in the Tanner Basin. The Synopid data are further evidence to support the idea that the gammarid amphipod faunas of these two bathyal basins are different.

The gammarid family Eusiridae forms a much smaller component of the amphipod fauna in the Tanner Basin than in the San Diego Trough (Table 7). Rhachotropis cervus was common in the San Diego Trough, but it was a rare species in the Tanner Basin. Rhachotropis sp. A. was present in more than half the samples from the San Diego Trough, but it was never collected from the Tanner

Table 6. A comparison of the Synopidae collected from the San Diego Trough and the Tanner Basin. N = total number of this species collected in each basin. % = percent this species comprises of the total amphipod fauna in each basin. F = frequency of occurrence of this species in the samples from each basin.

Species	San Diego Trough			Tanner Basin		
	N	%	F	N	%	F
Pseudotiron longicaudata	12	1.2	5/10	--	--	--
Syrrhoe sp. A	11	1.1	7/10	16	3.7	4/8
Syrrhoe sp. B	3	.3	3/10	--	--	--
Syrrhoites cohasseta	5	.5	3/10	--	--	--
Syrhoites sp. A	6	.6	5/10	3	.7	2/8
Bruzelia sp. A	1	.1	1/10	--	--	--
TOTALS:	38	3.8		19	4.4	

Table 7. A comparison of the Eusiridae collected from the San Diego Trough and the Tanner Basin. N = total number of this species collected in each basin. % = percent this species comprises of the total amphipod fauna in each basin. F = frequency of occurrence of this species in the samples from each basin.

Species	San Diego Trough			Tanner Basin		
	N	%	F	N	%	F
Rhachotropis cervus	30	3.0	8/10	2	.5	2/8
Rhachotropis sp. 1	9	.9	6/10	--	--	--
Rhachotropis sp. 2	1	.1	1/10	--	--	--
Rhachotropis clemens	1	.1	1/10	--	--	--
Rhachotropis sp. 3	1	.1	1/10	--	--	--
Eusirus sp. 1	4	.4	3/10	--	--	--
Rhachotropis sp. 4	--	--	--	1	.2	1/8
TOTALS:	46	4.6		3	.7	

Basin. The Eusirid data are consistent with the idea that these two

bathyal basins have different amphipod faunas.

A miscellaneous collection of species for other families in-

cluded representatives of the families: Astyridae, Dexaminidae,

Liljeborgiidae, Stenothidae, and Parampithoidae (Table 8). This

group of families comprised only about 2% of the fauna in both basins,

and all the species represented were so rare that differences in their

relative abundance between the two basins were not discernible.

The rank order of abundance for the first fifteen species from

each basin is compared in Table 9. Each species was ranked accord-

ing to its percentage of the total amphipod fauna in each basin. Only

five species are ranked in the first fifteen of both basins. Harpiniopsis

excavata which is a cosmopolitan species in the deep sea ranks first

in both basins. Ampelisca eoa and Byblis tannerensis have similar

ranks in both basins. Bathymedon kassites is ranked 8th in the Tan-

ner Basin and 13th in the San Dieto Trough. Aceroides edax is

ranked third in the Tanner Basin, and 14th in the San Diego Trough.

The differences in the ranking of these latter two species would seem

to represent significant differences in the dominance of these species

in the two basins. The remaining twenty species differ drastically

in their rank order of abundance in the two basins. Four of the

dominant species in the San Diego Trough were never collected in the

Tanner Basin, and three species dominant in the Tanner Basin never

Table 8. A comparison of a group of miscellaneous families collected from the San Diego Trough and Tanner Basin. N = total number of this species collected in each basin. % = percent this species comprises of the total amphipod fauna in each basin. F = frequency of occurrence of this species in the samples from each basin.

Species	San Diego Trough			Tanner Basin		
	N	%	6/10	N	%	F
Leucothoe sp. A	9	.9	6/10	--	--	--
Lepechinella bierii	4	.4	4/10	7	1.7	3/8
Astrya sp. 1	3	.3	1/10	--	--	--
Liljeborgia cota	1	.1	1/10	1	.2	1/8
Proboloides tunda	1	.1	1/10	--	--	--
Metopa samsiluna	1	.1	1/10	--	--	--
Epimeria pacifica	--	--	--	2	.4	2/8
TOTALS:	16	1.9		10	2.3	

Table 9. A comparison of the rank order of abundance of the fifteen most abundant species collected in the San Diego Trough and the Tanner Basin.

1.	Harpiniopsis excavata	1. Harpiniopsis excavata
2.	Harpiniopsis petulans	2. Paraphoxus oculatus
3.	Pseudoericthonius sp. A	3. Aceroides edax
4.	Ampelisca eoa	4. Bonnierella linearis
5.	Monoculodes latissimanus	5. Ampelisca sp. A
6.	Oediceroides trepedora	6. Ampelisca amblyopsoides
7.	Harpiniopsis profundis	7. Ampelisca eoa
8.	Bathymedon couilhani	8. Bathymedon kassites
9.	Byblis tannerensis	9. Schisturella grabensis
10.	Monoculodes necopinus	10. Syrrhoe sp. A
11.	Rhachotropis cervus	11. Hippomedon granulosus
12.	Haploops lodo	12. Byblis tannerensis
13.	Bathymedon kassites	13. Harpiniopsis emeryi
14.	Aceroides edax	14. Byblis bathyalis
15.	Harpiniopsis naiadis	15. Byblis sp. 2

appeared in the samples from the San Diego Trough. The majority

of the other species are abundant in one basin and very rare in the

other. All the evidence indicates that these two bathyal basins have

very different amphipod assemblages despite their proximity and

similar depth.

Discussion

The results of this faunal comparison clearly demonstrate that

these two bathyal basins of the Southern California Continental

Borderland have very different amphipod assemblages living in them

(Table 1-9). Since these basins are located at the same depth and in

relative proximity, the observed faunal difference seems most likely

to be related to some other environmental difference. A comparison

of the environmental characteristics of the basins was compiled from

the literature by Rokop (personal communication) (see Table 10).

The basins are similar in their physical parameters such as temper-

ature, salinity and dissolved oxygen values. There are differences

in geologic indices such as $CaCO_3$ and organic carbon content of the

surface sediments in the two basins. These two values reflect a

difference in the sedimentary geology of these two basins which is

undoubtedly paralleled by a difference in the type of food reaching the

floor of the basins. The sedimentation processes in the San Diego

Trough are dominated by turbidity flows which come down the La

Table 10. A comparison of physical and geological parameters measured in the San Diego Trough and the Tanner Basin. These values were summarized from the literature by F. Rokop (personal communication).

Parameter	San Diego Trough	Tanner Basin
Depth	1200 - 1300 M.	1200 - 1300 M.
Temperature	3.0° C	3.8° C
Salinity	34.6 o/oo	34.6 o/oo
Dissolved Oxygen	.7 ml/l	.6 ml/l
Sediment Mean Diameter	8μ	8μ
Organic Carbon	1-3 %	5-6 %
$CaCO_3$	3-8 %	40 %

Jolla and Coronado Submarine Canyons (Emery, 1960; Shepherd, 1969). The actual station location is far enough from the major turbidite activity so that recent faunal extinctions are unlikely. These turbidity flows transport sediments rich in organic matter from the continental shelf to the floor of the Trough, and probably serve as a major source of food input to this basin. The lower percentage of $CaCO_3$ in the Trough is a reflection that sedimentation processes are dominated by bottom transport of shallow water sediments rather than fallout of pelagic biogenic material.

The Tanner Basin is located far enough from the coast so that it is not affected by turbidity flows, and it depends upon fallout from the pelagic food web for its major food input (Emery, 1960; Gorsline, 1968). The high percent of $CaCO_3$ in the sediments reflects the dominance of pelagic biogenic sedimentation processes in this basin. The difference in the organic carbon values of the two basins may reflect a higher input of organics into the Tanner Basin, or more likely the lower value in the San Diego Trough is due to masking of organics by higher sedimentation rates. It is not possible to evaluate differences in the quantity of food reaching the floor of the two basins, but the differences in turbidity activity of the basins would certainly result in different kinds of organic detrital particles being available in the two basins. It seems likely that these inferred differences in

food quality and sedimentary regime are responsible for the differ-

ences observed in the faunas of the two basins.

THE ZOOGEOGRAPHY OF THE GAMMARID AMPHIPODS
LIVING ON CASCADIA ABYSSAL PLAIN

Introduction

The northeastern Pacific Ocean has an extensive system of abyssal plains which have been described by Heezen and Laughton (1963). Cascadia Abyssal Plain lies adjacent to the states of Washington and Oregon, and occupies an area of 170,000 square kilometers. The physiography and distribution of sediments on the Cascadia Abyssal Plain have been described by McManus (1964) and Griggs and Kulm (1970a, 1970b). The plain is rather flat from east to west, but it does tilt from 2100 m at its northern-most extension to 2930 m at its southern-most boundary. The topographic highs of the East Pacific Rise enclose Cascadia Plain to such an extent that it can be considered a self-contained basin (Figure 2).

The surface sediments of Cascadia Abyssal Plain are hemipelagic clays typical of nearshore abyssal environments. Turbidite deposits underlie these hemipelagic clays, but recent turbidity current activity on the plain has been confined to the Cascadia Deep Sea Channel (Griggs and Kulm, 1970b). The discharge of the Columbia River is a major source of sediment to the eastern portions of the plain (Griggs, Carey and Kulm 1969). Cascadia Deep Sea Channel divides the plain into eastern and western portions because it acts
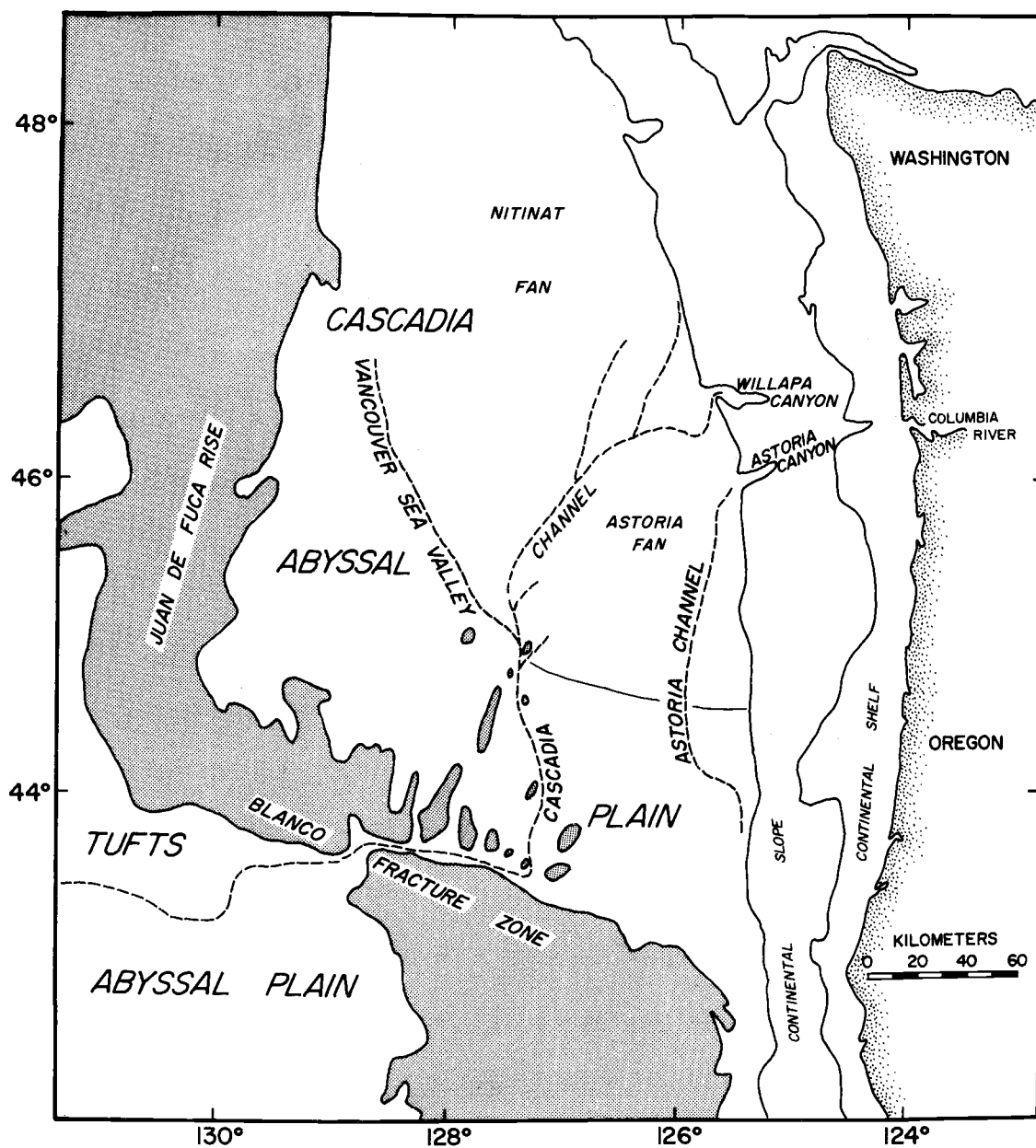
Figure 2. Location map for Cascadia Abyssal Plain (after Griggs and Kulm, 1970a).

as a barrier to the westward movement of terrestrial materials along the bottom.

The abyssal plain is an ideal area to study faunal variability at a single depth with increasing distance from continental sources of food and sediment. The infaunal populations of the plain were studied by Griggs, Carey and Kulm (1969), and they found decreasing numbers of infaunal animals at a series of stations extending east to west across Cascadia Plain. The goal of the present study was to determine if there were changes in the composition of the amphipod fauna corresponding to this decrease in infaunal density across the plain.

Methods

The samples used in this study of abyssal zoogeography were collected with a modified W. H. O. I. Epibenthic Sled (Hessler and Sanders, 1967). The net used in this sampler had a mesh size of approximately 1.0 mm. The sled was equipped with a timer package which activated a closing device to prevent winnowing of the sample during retrieval.

The use of the epibenthic sled in sampling Cascadia Abyssal Plain involved some problems in finding the proper setting of the cutting blade which determines the depth of sediment sampled. If the sled digs too deeply into the sediment only a few animals will be

collected in each haul, but if the cutting blade is set too shallow, no
sample is obtained at all. This problem was overcome by a trial
and error methodology, and rich deep-water samples were obtained.

Nineteen successful hauls were obtained on two separate cruises
aboard the R/V Yaquina. Station data for each haul used in the analy-
sis are listed in Appendix III.

The samples were collected at two stations on the plain (Figure
3). The station locations were chosen to represent the nearshore
and offshore portions of the plain. Eleven sled hauls were taken at
the eastern station (CP-1-E) and eight sled hauls were taken from
the western station (CP-3-E). The eastern station was located near
the base of the continental slope, and the western station was located
15 kilometers east of Cascadia Channel.

The samples were all washed through a 0.42 mm aperture sieve
on board ship using flotation techniques similar to those described
in Sanders, Hessler and Hampson (1965). The samples were fixed
in buffered 10% formalin and transferred to 70% isopropyl alcohol
upon return to the laboratory. All the amphipods were picked from
the samples using a dissecting microscope. The animals were first
sorted to family, and then identified to species. The entire amphipod
collection was carefully preserved in 70% ethanol to facilitate further
systematic work including the description of new species.
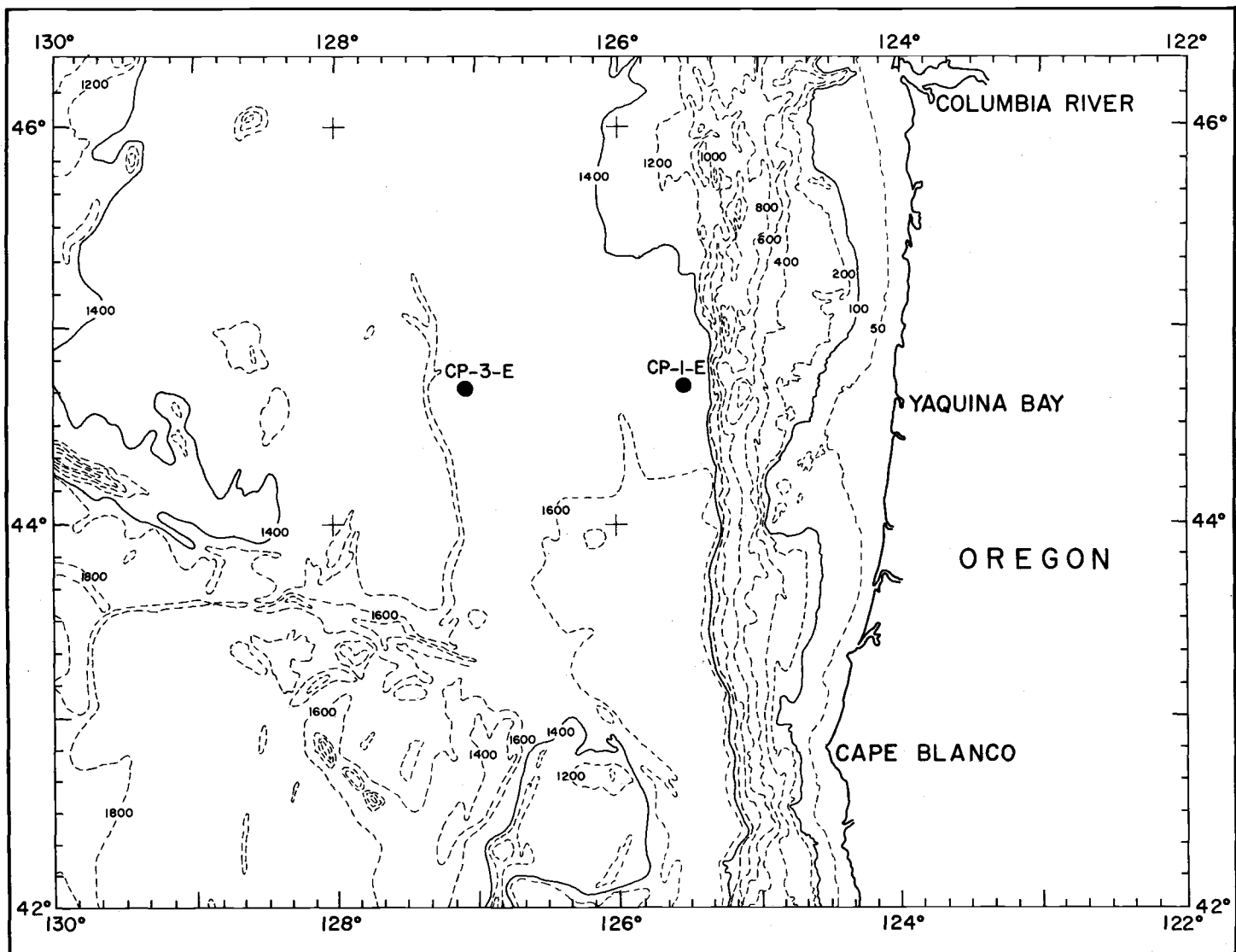
Figure 3. Station locations on Cascadia Abyssal Plain (contours in fms).

Results

A list of the amphipods identified from each of the nineteen sled hauls may be found in Appendix IV. The fauna of the two stations will be compared by examining the differences in species composition and relative abundance found in each family of gammarids. The rank order of abundance of the ten most abundant species from each station will be compared.

The gammarid family Phoxocephalidae was the numerically dominant family at the base of the slope (CP-1-E) comprising 29% of the fauna (Table 11). The phoxocephalids were a much less important group at the western station (CP-3-E) comprising only 12% of the fauna. Harpiniopsis triplex comprised 9% of the fauna at CP-1-E, and it was present in every sample at this station. This species was never collected at CP-3-E). Harpiniopsis naiadis, Harpiniopsis fulgens, and Harpiniopsis Sp. 1 were all common at CP-1-E each comprising over 3% of the amphipod fauna and occurring in over half the samples. All three of these species were rare or absent at the offshore station (CP-3-E). Harpiniopsis excavata was a dominant species at both stations comprising about 9% of the fauna. The phoxocephalids clearly differed both in composition and relative abundance between the two stations on the abyssal plain.

Table 11. A comparison of the Phoxocephalidae collected from the
Eastern (CP-1-E) and Western (CP-3-E) Stations on the
Cascadia Abyssal Plain. N = total numbers of this species
collected at each station. % = percent this species
comprises of the total amphipod fauna at each station.
F = frequency of occurrence of this species in the samples
from each station.

Species	N	CP-1-E %	F	N	CP-3-E %	F
Harpiniopsis triplex	59	9.2	11/11	--	--	--
Harpiniopsis excavata	51	8.0	10/11	57	9.7	8/8
Harpiniopsis naiadis	22	3.4	6/11	--	--	--
Harpiniopsis fulgens	23	3.6	8/11	4	.7	2/8
Harpiniopsis sp. 1	22	3.4	10/11	1	.2	1/8
Harpiniopsis emeryi	5	.8	3/11	--	--	--
Harpiniopsis percellaris	3	.5	3/11	9	1.5	6/8
Paraphoxus oculatus	2	.3	2/11	--	--	--
TOTALS:	187	29.2		71	12.1	

The family Oedicerotidae was represented by 21 species at these two stations on Cascadia Plain (Table 12). The oedicerotids comprised 23% of the amphipod fauna at CP-1-E, and 19% of the amphipod fauna at CP-3-E. Bathymedon sp. A was relatively more abundant at CP-1-E and had a much higher frequency of occurrence at this station. Bathymedon sp. 2 was found in greater abundance at CP-3-E. Monoculodes latissimanus was a common species at CP-3-E. Oediceroides sp. Y had a much higher frequency of occurrence at CP-3-E. The other oedicerotids either had about equal relative abundances or were so rare that differences could not be detected between the two stations. The oedicerotid fauna supports the idea that the amphipod assemblages from these two stations on the plain are different.

The superfamily Corophoidea was a much more important component of the fauna at CP-3-E, where it comprised 22% of the amphipod fauna, than at CP-1-E, where it comprises less than 5% of the fauna (Table 13). Bonnierella linearis was abundant at both stations, but clearly had a greater relative abundance and frequency of occurrence at CP-3-E. Gammaropsis sp. A and Photis kurilica were both common species at CP-3-E, but they were never collected at CP-1-E. The Corophoidea data strongly suggest that the amphipod assemblages at these two stations differ.

Table 12. A comparison of the Oedicerotidae collected from the
Eastern (CP-1-E) and Western (CP-3-E) Stations on the
Cascadia Abyssal Plain. N = total number of this species
collected at each station. % = percent this species
comprises of the total amphipod fauna at each station.
F = frequency of occurrence of this species in the samples
from each station.

Species	CP-1-E			CP-3-E		
	N	%	F	N	%	F
Bathymedon sp. A	40	6.3	10/11	12	2.0	3/8
Bathymedon sp. 1	10	1.6	5/11	7	1.2	3/8
Bathymedon sp. 2	7	1.1	6/11	24	4.1	5/8
Bathymedon sp. 3	1	.2	1/11	--	--	--
Bathymedon sp. 4	4	.6	1/11	--	--	--
Bathymedon sp. 5	1	.2	1/11	1	.2	1/8
Bathymedon sp. 6	1	.2	1/11	--	--	--
Bathymedon sp. 7	2	.3	2/11	--	--	--
Bathymedon sp. 8	1	.2	1/11	--	--	--
Bathymedon nepos	--	--	--	1	.2	1/8
Bathymedon caino	1	.2	1/11	--	--	--
Monoculodes recandesco	20	3.1	5/11	20	3.4	5/8
Monoculodes necopinus	16	2.5	6/11	9	1.5	3/8
Monoculodes latissimanus	14	2.2	5/11	--	--	--
Monoculodes diversisexus	1	.2	1/11	--	--	--
Monoculodes sp. Y	8	1.2	3/11	11	1.9	4/8
Monoculodes sp. X	5	.8	3/11	1	.2	1/8
Monoculodes sp. Z	1	.2	1/11	4	.7	2/8
Oediceroides abyssorum	1	.2	1/11	--	--	--
Oediceroides trepedora	10	1.6	2/11	9	1.5	2/8
Oediceroides sp. Y	3	.5	3/11	10	1.7	6/8
TOTALS:	147	23.4		109	18.6	

Table 13. A comparison of the Corophoidea collected from the
Eastern (CP-1-E) and Western (CP-3-E) Stations on the
Cascadia Abyssal Plain. N = total number of this species
collected at each station. % = percent this species
comprises of the total amphipod fauna at each station.
F = frequency of occurrence of this species in the samples
from each station.

Species	CP-1-E			CP-3-E		
	N	%	F	N	%	F
Bonnierella linearis	30	4.7	7/11	60	10.2	8/8
Corophid sp. A	1	.2	1/11	--	--	--
Gammaropsis sp. A	--	--	--	42	7.1	6/8
Photis kurilica	--	--	--	27	4.6	5/8
Dulichia abyssi	--	--	--	2	.3	2/8
TOTALS:	31	4.9		131	22.3	

The gammarid family Ampeliscidae comprises 4.3% of the total amphipod fauna by number at CP-1-E, and 3.6% of the amphipod fauna at CP-3-E (Table 14). Byblis crassicornis was a common species at CP-1-E comprising 2.4% of the amphipod fauna and present in about three quarters of the samples, but it was a rare species at CP-3-E. The ampeliscid species data further support the idea that the two portions of the plain are inhabited by different amphipod assemblages.

The gammarid family Pardaliscidae has undergone an extensive radiation in the deep sea. The pardaliscids are badly in need of taxonomic revision on the basis of recent collections (Barnard 1971). The pardaliscids comprised 18% of the amphipod fauna at CP-1-E, and 15% of the amphipod fauna at CP-3-E (Table 15). Halice sp. A was a dominant species at CP-1-E comprising 12% of the amphipod fauna, but it was never collected at CP-3-E. Halice sp. Z was relatively abundant at CP-3-E comprising 9% of the amphipod fauna, but this species was absent from CP-1-E. Pardaliscella sp. A was a common species at CP-3-E, but it was not found in the samples from CP-1-E. Pardaliscoides sp. A and Pardaliscopsis tikal both seemed to be relatively more abundant at CP-1-E than at CP-3-E, but the small differences between the stations prevents making such statements with certainty. The other pardaliscids were too rare to delineate differences in their relative abundances between stations.

Table 14. A comparison of the Ampeliscidae collected from the
Eastern (CP-1-E) and Western (CP-3-E) Stations on the
Cascadia Abyssal Plain.   N = number of this species
collected at each station.   % = percent this species
comprises of the total amphipod fauna at each station.
F = frequency of occurrence of this species in the samples
from each station.

Species	CP-1-E			CP-3-E		
	N	%	F	N	%	F
Byblis crassicornis	15	2.4	7/11	2	0.3	1/8
Haploops lodo	6	.9	5/11	--	--	--
Ampelisca coeca	5	.8	5/11	6	1.0	4/8
Ampelisca eoa	1	.2	1/11	--	--	--
Ampelisca sp. A	1	.2	1/11	--	--	--
Ampelisca plumosa	--	--	--	13	2.2	6/8
TOTALS:	28	4.5		21	3.5	

Table 15. A comparison of the Pardaliscidae collected from the Eastern (CP-1-E) and Western (CP-3-E) Stations on the Cascadia Abyssal Plain. N = number of this species collected at each station. % = percent this species comprises of the total amphipod fauna at each station. F = frequency of occurrence of this species in the samples from each station.

Species	CP-1-E			CP-3-E		
	N	%	F	N	%	F
Halice sp. A	78	12.2	10/11	--	--	--
Pardaliscoides sp. A	16	2.5	6/11	9	1.5	5/8
Pardaliscopsis tikal	16	2.5	6/11	5	.9	3/8
Pardaliscopsis copal	3	.5	3/11	--	--	--
Pardaliscoides sp. B	1	.2	1/11	1	.2	1/8
Halice sp. Z	--	--	--	54	9.2	7/8
Pardaliscella sp. A	--	--	--	15	2.5	5/8
Halice sp. Y	--	--	--	1	.2	1/8
Pardalisca sp. A	--	--	--	2	.3	2/8
Halice sp. X	--	--	--	1	.2	1/8
Halice sp. W	--	--	--	1	.2	1/8
Halice sp. B	1	.2	1/11	--	--	--
Pardaliscid sp. A	--	--	--	2	.3	1/8
TOTALS:	115	18.1		91	15.0	

The pardaliscids do offer further evidence that the amphipod faunas at these two stations on the plain are different.

The Lysianasidae are a very diverse family of gammarids including over one hundred genera (Barnard 1969). The lysianasids comprised 7.5% by number of the total amphipod fauna at CP-1-E, and 16% of the amphipod fauna at CP-3-E (Table 16). _Tryphosella_ sp. A was the most abundant lysianasid at both stations, but it comprised 9.1% of the fauna at CP-3-E and only 2.8% of the fauna at CP-1-E. _Hippomedon tracatrix_ and _Orchomene tabasco_ were common at CP-1-E, but rare or absent at CP-3-E. _Hippomedon strages_ was collected in half the samples from CP-3-E, but it was never taken at CP-1-E. The majority of the lysianasids were so rare that differences in their relative abundance are undetectable. The lysianasid data further support the concept that different amphipod assemblages live on the eastern and western portions of Cascadia Abyssal Plain.

The gammarid families Synopidae and Eusiridae are repre-sented by sixteen species on Cascadia Abyssal Plain (Table 17 and 18). The majority of the species in these two families were so rare that differences in their relative abundance between the two stations cannot be detected. However, _Syrrhoe oluta_ and _Syrrhoites_ sp. A were both common at CP-1-E and rare at CP-3-E. These two families contribute little evidence to the faunal comparison, since

Table 16. A comparison of the Lysianasidae collected from the Eastern (CP-1-E) and Western (CP-3-E) Stations on the Cascadia Abyssal Plain. N = number of this species collected at each station. % = percent this species comprises of the total amphipod fauna at each station. F = frequency of occurrence of this species in the samples from each station.

Species	CP-1-E			CP-3-E		
	N	%	F	N	%	F
Tryphosella sp. A	18	2.8	7/11	54	9.1	5/8
Hippomedon tracatrix	8	1.2	3/11	1	.2	1/8
Orchomene tabasco	9	1.6	5/11	--	--	--
Lepidepecreum sp. A	4	.6	2/11	1	.2	1/8
Uristes perspinus	4	.6	2/11	10	1.7	4/8
Paracentromedon sp. A	3	.5	3/11	2	.3	1/8
Koroga megalops	1	.2	1/11	1	.2	1/8
Hippomedon strages	--	--	--	6	1.0	4/8
Acidostoma obesum	--	--	--	5	.8	2/8
Hippomedon sp. B	--	--	--	1	.2	1/8
Hippomedon sp. A	--	--	--	2	.3	1/8
Waldeckia (?) sp. A	--	--	--	1	.2	1/8
TOTALS:	47	7.5		84	14.2	

Table 17. A comparison of the Synopidae collected from the Eastern (CP-1-E) and Western (CP-3-E) Stations on the Cascadia Abyssal Plain. N = number of this species collected at each station. % = percent this species comprises of the total amphipod fauna at each station. F = frequency of occurrence of this species in the samples from each station.

Species	CP-1-E			CP-3-E		
	N	%	F	N	%	F
Syrrhoe oluta	13	2.0	5/11	2	.3	1/8
Syrrhoe sp. A	--	--	--	2	.3	1/8
Syrrhoe sp. B	1	.2	1/11	--	--	--
Syrrhoites sp. A	15	2.4	4/11	4	.7	2/8
Syrrhoites sp. B	1	.2	1/11	--	--	--
Syrrhoites sp. C	1	.2	1/11	--	--	--
Pseudotiron sp. A	1	.2	1/11	3	.5	2/8
Bruzelia inlex	5	.8	3/11	3	.5	1/8
Bruzelia sp. A	1	.2	1/11	--	--	--
Syn - * - 1	--	--	--	2	.3	1/8
TOTALS:	38	6.2		16	2.6	

47

Table 18. A comparison of the Eusiridae collected from the Eastern
(CP-1-E) and Western (CP-3-E) Stations on the Cascadia
Abyssal Plain. N = number of this species collected at
each station. % = percent this species comprises of the
total amphipod fauna at each station. F = frequency of
occurrence of this species in the samples from each
station.

| Species | CP-1-E | | | CP-3-E | | |
	N	%	F	N	%	F
Rhachotropis ludificor	1	.2	1/11	2	.3	2/8
Rhachotropis sp. B	1	.2	1/11	1	.2	1/8
Rhachotropis sp. C	--	--	--	1	.2	1/8
Rhachotropis multisimis	1	.2	1/11	--	--	--
Rhachotropis sp. A	1	.2	1/11	--	--	--
TOTALS:	4	.8		4	.7	

most of the species were so rare.

The samples from Cascadia Plain included representatives of the gammarid families: Liljeborgiidae, Stenothidae, Parampithoidae, Dexaminidae, and Haustoridae (Table 19). Liljeborgia cota was rather abundant at CP-1-E, comprising over 4% of the total amphipod fauna by number, but it was a rare species at CP-3-E comprising 0.3% of the amphipod fauna. Urothoe rotundifrons was a relatively abundant species at CP-3-E comprising nearly 6% of the total amphipod fauna, but this species was never collected at CP-1-E. Proboloides tunda was a common species at CP-3-E, but it was rare at CP-1-E being represented by a single specimen. The data for this group of families supports the idea that different amphipod assemblages are found living at these two stations on the Cascadia Plain.

The rank order of abundance for the first ten species from each station on the plain is compared in Table 20. Each species was ranked according to its percentage of the total amphipod fauna at each station. Only three species are ranked in the first ten at both stations. Harpiniopsis excavata and Monoculodes recandesco are ranked similiarily at both stations. Bonnierella linearis is ranked first at CP-3-E and fifth at CP-1-E. This is a significant change in rank for this species at the two stations. The remaining fourteen species differ drastically in their rank order of abundance between

Table 19. A comparison of a group of miscellaneous families collected from the Eastern (CP-1-E) and Western (CP-3-E) Stations on the Cascadia Abyssal Plain. N = total numbers of this species collected at each station. % = percent this species comprises of the total amphipod fauna at each station. F = frequency of occurrence of this species in the samples from each station.

Species	CP-1-E			CP-3-E		
	N	%	F	N	%	F
Liljeborgia cota	29	4.5	9/11	2	.3	2/8
Proboloides tunda	1	.2	1/11	12	2.2	5/8
Leucothoe uschakoui	2	.3	2/11	1	.2	1/8
Epimeria sp. 1	--	--	--	1	.2	1/8
Epimeria sp. Z	1	.2	1/11	--	--	--
Lepechinella echinata	2	.3	1/11	1	.2	1/8
Lepechinella sp. A	4	.6	2/11	--	--	--
Lepechinella sp. B	--	--	--	3	.5	3/8
Lepechinella turpis	--	--	--	1	.2	1/8
Phipsiella minima	--	--	--	4	.7	2/8
Amathillopsis pacifica	--	--	--	2	.3	1/8
Urothoe rotundifrons	--	--	--	34	5.3	5/8
TOTALS:	39	6.1		61	10.1	

Table 20. A comparison of the rank order of abundance for the first
ten species at each station on Cascadia Abyssal Plain.

CP-1-E	CP-3-E
1. Halice sp. A	1. Bonnierella linearis
2. Harpiniopsis triplex	2. Harpiniopsis excavata
3. Harpiniopsis excavata	3. Halice sp. Z
4. Bathymedon sp. A	4. Tryphosella sp. A
5. Bonnierella linearis	5. Gammaropsis sp. A
6. Liljeborgia cota	6. Urothoe rotundifrons
7. Harpiniopsis fulgens	7. Photis kurilica
8. Harpiniopsis naiadis	8. Bathymedon sp. 2
9. Harpiniopsis sp. 1	9. Monoculodes recandesco
10. Monoculodes recandesco	10. Pardaliscella sp. A

the two stations (Table 20). Species that are among the dominants
at one station are rare or absent at the other station. All the evi-
dence from this data set indicates that very different amphipod
assemblages are found on the nearshore and offshore portions of
Cascadia Abyssal Plain.

Discussion

The results of this zoogeographic study on Cascadia Abyssal
Plain clearly suggest that different benthic assemblages may be
found at the same depth within a single deep sea basin (Tables 11-
20). This large change in community structure over a distance of
100 kilometers is probably caused by some environmental change.
The observed differences between the two stations in temperature,
salinity, and dissolved oxygen are so small as to indicate that they
are probably not a major influence in altering the faunal composition
(Table 21). The particle size fractions and sedimentation rates are
different enough to suggest differences between the two stations in
sedimentation processes which could result in the observed faunal
differences. The station at the base of the slope has a much higher
sand fraction content and a much lower clay fraction content than
the western station. These differences in particle size distribution
reflect rather large differences in the sedimentary regime of these
two areas on the abyssal plain.

Table 21. A comparison of biological, physical, and geological
parameters from the two stations on Cascadia Abyssal
Plain.

Parameter	CP-1-E	CP-3-E
Infaunal Density[a]	$1170/m^2$	$330/m^2$
Infaunal Biomass[a]	$5.57 \ g/m^2$	$1.82 \ g/m^2$
Temperature[b]	$1.73^{\circ}C$	$1.72^{\circ}C$
Salinity[b]	34.64 o/oo	34.65 o/oo
Oxygen[b]	1.97 ml/l	2.11 ml/l
% Silt[b]	49%	28%
% Clay[b]	42%	71%
% Sand[b]	9%	1%
Organic Carbon[a]	1.7%	1.7%
Sedimentation Rate[c]	10cm/1000 yr.	3cm/1000 yr.

[a] Griggs, Carey and Kulm (1969)

[b] Carey (unpublished data)

[c] Duncan (1968)

The presence of sand at the base of the slope is indicative that this area receives continental shelf and slope sediments via bottom layer transport down the slope (Kulm et al., 1975). This bottom turbid layer is probably responsible for the transport of significant amounts of organic material from the continental shelf and upper slope to the base of the slope. The larger percentage of clay particles at the western station on the plain is an indication that this area is sufficiently far from the coast to be influenced by only the fine grain terrestrial sediments discharged by the rivers.

The average organic carbon content of surface sediments is indistinguishable at the two stations on the plain (Table 21). It is interesting that the sediments at the base of the slope do not reflect the increased input of organics in this area via turbid layer transport along the bottom and the settlement of river discharge (Table 22). However, Duncan (1968) has shown that sedimentation rates are higher at the base of the slope (Table 21). The increased sedimentation at the base of the slope results in faster burial and dilution of surface sediments. Therefore, it is possible to have similar standing stocks of organic carbon in the surface sediments despite the inferred increase in organic input at the slope base.

Griggs, Carey and Kulm (1969) compared infaunal densities at these same two stations on Cascadia Abyssal Plain, and they found densities four times as high at the slope base station. They suggest these larger populations at the base of the slope are attributable to

greater food input in this area. This interpretation seems reasonable since it agrees with the majority of the geological evidence. It also seems reasonable that the differences in the amphipod assemblage documented by this zoogeographic study of the plain are also attributable to differences in food input to the benthos.

Table 22. Food sources to the detrital food web living on the sea floor at the two stations on Cascadia Abyssal Plain.

CP-1-E	CP-3-E
1) Transport of organics from the outer Continental Shelf and the upper Continental Slope via bottom turbid layer transport Kulm et al. (1975)	1) Fallout of detrial particles from the Pelagic Food Web.
2) Settlement of detrital particles from the Columbia River Plume. Griggs et al. (1969)	
3) Fallout of detrital particles from the Pelagic Food web.	

GENERAL DISCUSSION

Amphipod Species Diversity

These faunal studies offer further evidence for the high species diversity of deep sea benthic faunas (Table 23). The amphipod assemblages of both areas were species rich when compared to a similar shallow water habitat. The number of single occurrences of species in the deep water data sets was indicative that the amphipod diversities of these faunas were not fully characterized by the available samples (Appendices II and IV). The amphipod diversity of the Oregon Shelf Break seemed much closer to complete characterization (Appendix VI). The large number of species found in genera like Bathymedon and Harpiniopsis suggests that certain gammarid amphipod groups might have undergone extensive radiations in deep water since these genera are sparsely represented in shallow water benthos.

Zoogeography

The large number of new species collected during these studies illustrates the problems of deep sea benthic ecologists trying to describe and analyze the distribution patterns of organisms in the deep ocean basins. The sampling of the deep sea benthos has been completely inadequate to deal with the high diversity and restricted

Table 23. A comparison of the number of amphipod species found in the California Bathyal and Oregon Abyssal faunas with a station at the edge of the Oregon Continental Shelf. All stations were characterized by samples taken with an epibenthic sled. Z = depth in meters. N = number of specimens. S = number of species.

Area	Z	N	S
Oregon Shelf Break	200 m.	704	28
San Diego Trough	1250 m.	1032	64
Tanner Basin	1300 m.	449	40
Cascadia Abyssal Plain (CP-1-E)	2810 m.	633	66
Cascadia Abyssal Plain (CP-3-E)	2830 m.	588	62

distributions of the fauna.   A few deep sea amphipods have cosmo-
politian distributions i. e. <u>Harpiniopsis excavata</u> and <u>Ampelisca eoa</u>.
Most of the species in the present collections were either undescribed
or known from a single collection from the Northeast Pacific Ocean.
A few species like <u>Urothoe rotundifrons</u> and <u>Lepechinella echinata</u>
were known only from single collections in distant areas (Atlantic
Ocean).   It would be desirable to check the identification of these
specimens against the holotypes to insure that the forms in the pres-
ent collection are not sibling species.   However, it is possible that
these two species are rare cosmopolitians.   All the new species will
remain in the O. S. U. Benthic Reference Collection in hope that the
author will eventually find support to continue the systematic work.

Feeding Habits of Amphipods

Very little is known about the feeding habits of deep sea gam-
marid amphipods.   The majority of these animals are thought to
be selective deposit feeders (Barnard, 1962).   The difference in
family composition on Cascadia Abyssal Plain suggest there may be
a shift in feeding types between the two stations on the plain.   The
samples from the slope base are dominated by phoxocephalids
whereas the samples from the western station are dominated by
corophoids and a haustorid (see Table 20).   The corophoids and
haustorids are thought to be tube dwellers.   The phoxocephalids are

more mobile burrowers (Barnard, 1969). The behavior of these

amphipod groups is known only from shallow water representatives,

but it is possible that these differences in family dominance reflect

differences in feeding behavior adaptive to the different areas.

Cluster Analysis

In discussing the results of the two faunal comparisons, no

attempt was made to directly compare the variability of the fauna

within a station to the variability between stations. The reason for

this omission was the fact that the qualitative data of these studies

does not lend itself to a standard statistical analysis of between and

within station variability. However, it was decided to attempt to

verify the conclusions of the species by species comparisons through

the use of a cluster analysis. If samples from the same station are

more similar to each other than to samples from the other station,

then they should group together in a cluster analysis. The *MINT

program developed by F. J. Rohlf, and modified for use on the O.S.U.

computer center CDC3300 was utilized to run a separate analysis for

each study.

The similarity measure used to characterize the samples was

the Euclidean Distance as defined by Sokal and Sneath (1973) (see

Appendix V). This measure was well suited to the relative abundance

data generated in these faunal studies. A matrix comparing the

similarity or distance of each sample to each other sample was computed by the program. This similarity matrix was used to group the samples. The ten most abundant species from each station were used to compute the similarity indices (see Tables 9 and 20). The samples were grouped using the method of complete linkage or furthest neighbor clustering. This clustering technique specifies that a sample which is a candidate for admission to an existing cluster has a similarity to an existing cluster equal to its similarity to the farthest member within the cluster (see Sneath and Sokal, 1973, p. 222).

The method identified one large cluster and a number of small clusters at the similarity level chosen for the analysis of the California Basins (Figure 4). The large cluster was comprised of all the samples from the San Diego Trough, and the smaller clusters include all of the Tanner Basin samples. The smaller size of the Tanner Basin samples probably accounts for their greater heterogeneity (Appendix II). The cluster analysis confirms the consistent differences in the faunas of these two basins.

The program found the samples from Cascadia Abyssal Plain to be in two clusters at the similarity level chosen for this analysis (Figure 5). One cluster is composed of all the samples from CP-1-E, and the other cluster is composed of all the samples from CP-3-E. The grouping of samples within these clusters seems to

```
                ***************************************************************************
      1 (R-10)*************
                            *
      2 (R-11)***********************
                                      *
     10 (R-47)**********************************
                                                *
      9 (R-46)*****************************************************************************
                                                                                          *
      3 (R-16)*******************************                                              *
                                           *                                              *
      6 (R-36)*********************************************                                *
                                                        *                                 *
      4 (R-17)************************************                                         *
                                            *                     *                       *
      7 (R-42)**************************************                                       *
                                                *                                         *
      5 (R-30)*********************************************                                *
                                                 *                  *                      * SDT
      8 (R-43)***************************************************************************
      
     11 (R-7)  ***************************************************
                                                            *                              TB
     12 (R-8)  *************************************************************************
                                                                                          TB
     13 (R-22)***********************************************************************
     14 (R-31)*********************************************
                                                         *                                TB
     15 (R-32)*****************************************************************************
     16 (R-40)***********************************************************
                                                                      *
     17 (R-52)*****************************************
                                                     *                                    TB
     18 (R-53)****************************************************************************
  *** NORMAL TERMINATION
```
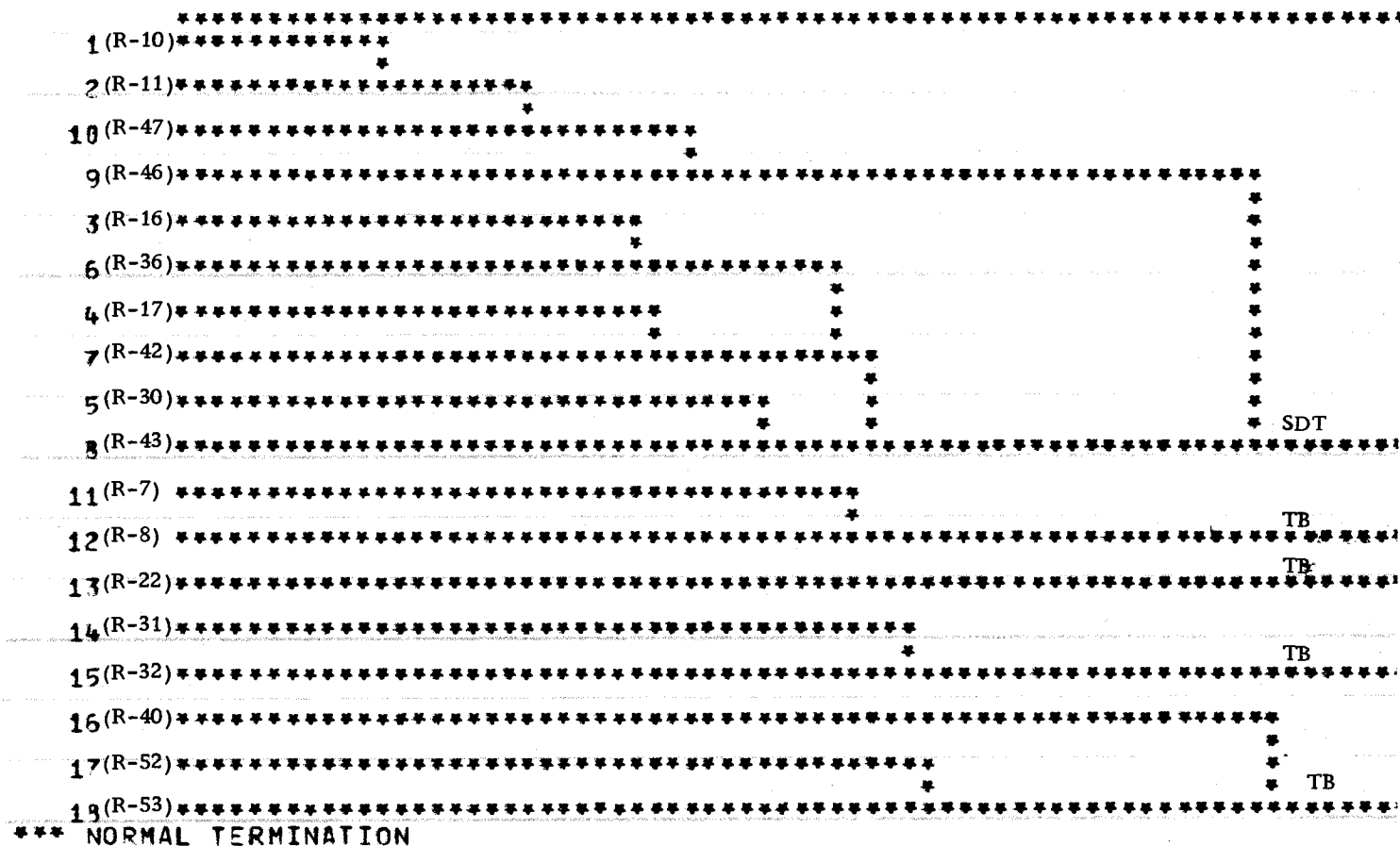
Figure 4. A dendrogram showing the similarity of samples from
           the San Diego Trough (SDT) and Tanner Basin (TB).
           Numbers 1-10 are samples from the San Diego Trough.
           Numbers 11-18 are samples from the Tanner Basin. The
           sample codes used in Appendix II are listed beside each
           number in parentheses. The Similarity Scale runs from
           0-64 Euclidean Distance Units.

Figure 5. A dendrogram showing the similarity of samples from
Cascadia Abyssal Plain. Numbers 1-11 are samples
from CP-1-E. Numbers 12-19 are samples from
CP-3-E. The sample codes used in Appendix IV are
listed beside each number in parentheses. Similarity
Scale runs from 0-108 Euclidean Distance Units.

reflect differences in sample size. Large samples group with other

large samples, and small samples group with other small samples

(Appendix IV and Figure 5). The cluster analysis again confirms the

clear differences in the faunas of the two stations on Cascadia Abyssal

Plain.

Sampling Problem

One of the weaknesses of the work described in this thesis is

that single stations were used to characterize the fauna of a large

area. It would have been desirable to have sampled other stations

to test the generality of the faunal characterizations. However, this

was not possible with the ship time available. There is considerable

evidence that abyssal and bathyal faunas are relatively constant over

large distances at the same depth and the same distance from land

(Rowe and Menzies, 1969, Sanders and Hessler, 1969).

Migration Barriers

The results of the two studies of deep sea benthic zoogeography

reported in this thesis have been taken to imply that faunal changes

at the same depth are caused by changes in the environment. This

approach assumed that the absence of a particular species was not

caused by some migrational barrier. The assumption of no migratory

barriers is an important tenent in the argument developed to explain

the observed faunal changes. However, it does seem realistic in the

studies discussed. Cascadia Abyssal Plain is flat and featureless

with no topographic boundaries between the two areas studied. The

Continental Borderland off Southern California is more complex in

its physiography, but the two basins studied are connected by a

series of topographic lows. It seems unlikely that any barrier has

prevented the movement of species between the two basins. The

presence of many of the same species in both basins also suggests

that the observed change in amphipod assemblages is not due to

migrational barriers.

"Mesoscale" Zoogeography

The research described in this thesis is unique in that it

examines faunal variability at a single depth on the 100 to 200 kilo-

meter scale in the deep sea benthos. The major effort in deep sea

benthic zoogeography has concentrated on describing distribution

patterns of organisms with depth and faunal differences between

major ocean basins (Murray, 1895, Ekman, 1953, Madsen, 1961,

Clarke, 1962, Zenkevitch, 1970, Menzies, George and Rowe, 1973).

Studies conducted by Sanders and Hessler (1969) and Rowe and

Menzies (1969) have emphasized the similarity of the fauna at a single

depth, even over distances on the order of 1000 kilometers. These

studies were conducted along isobaths of the continental slope and

abyssal rise which were equidistant from continental sources of food and sediment. Therefore, the similarity of the fauna is not surprising since the environmental conditions would be very similar in such areas. The results described herein do not contradict this earlier work, but they do illustrate that the fauna at a single depth can change drastically over distances of 100 kilometers if there is a sharp environmental gradient.

Generality of Results

The results of zoogeographic studies are certainly dependent on the animal group selected to be examined. The results of these studies might have differed considerably if pelecypods or echinoderms had been studied instead of gammarid amphipods. These groups have better dispersal mechanisms, and they are represented by fewer more widely distributed species in the deep sea. However, the gammarid amphipods are probably representative in their distribution patterns of all peracarid crustaceans found in deep water. The peracarids form an important component of the deep water benthic faunas. The results of this research are, therefore, of general interest.

Future Research

This study of mesoscale zoogeography has added a new element of complexity to our understanding of the factors controlling animal distributions in the deep sea benthos because it has demonstrated that different assemblages can be found at the same depth and in the same region. Future research into this problem should be aimed at verifying these results for other areas and other animal groups. The results of this work strongly suggest the need for research on methods to quantitatively measure energy input to the deep sea floor.

CONCLUSIONS

1) A comparison of the gammarid amphipod fauna of the San Diego Trough and the Tanner Basin demonstrated clear differences in both species composition and relative abundance of the dominant species.

2) A comparison of the gammarid amphipod fauna of the eastern and western stations on Cascadia Abyssal Plain also showed clear differences in both species composition and relative abundance of the dominant species.

3) Both of these studies support the concept that significant faunal change may occur at a single depth in the deep sea benthos over distances on the order of 100 kilometers.

4) The quantity and quality of organic detritus reaching the deep sea floor may play a major role in controlling the structure of the benthic community.

5) The study on Cascadia Abyssal Plain demonstrated that the decrease in animal numbers with increasing distance from terrestrial sources of food and sediment is accompanied by a change in faunal composition.

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APPENDICES

APPENDIX I

A list of the station data for the samples collected in the San Diego Trough and Tanner Basin which were utilized in the faunal comparison.

San Diego Trough Samples

Sample	Date	Depth	Latitude	Longitude
R-10	28-X-70	1244m	$32^{\circ}27.0'$N	$117^{\circ}29.0'$W
R-11	29-X-70	1238m	$32^{\circ}27.5'$N	$117^{\circ}29.0'$W
R-16	18-I-71	1200m	$32^{\circ}26.8'$N	$117^{\circ}28.8'$W
R-17	18-I-71	1215m	$32^{\circ}26.6'$N	$117^{\circ}28.9'$W
R-30	17-IV-71	1244m	$32^{\circ}26.2'$N	$117^{\circ}30.2'$W
R-36	20-IV-71	1235m	$32^{\circ}27.0'$N	$117^{\circ}29.0'$W
R-42	14-VII-71	1238m	$32^{\circ}26.2'$N	$117^{\circ}29.8'$W
R-43	14-VII-71	1225m	$32^{\circ}26.0'$N	$117^{\circ}29.5'$W
R-46	22-X-71	1230m	$32^{\circ}26.0'$N	$117^{\circ}29.5'$W
R-47	22-X-71	1229m	$32^{\circ}26.0'$N	$117^{\circ}29.6'$W

Tanner Basin Samples

Sample	Date	Depth	Latitude	Longitude
R-7	28-X-70	1324m	$32^{\circ}45.0'$N	$119^{\circ}26.5'$W
R-8	28-X-70	1302m	$32^{\circ}44.5'$N	$119^{\circ}26.6'$W
R-22	20-I-71	1335m	$32^{\circ}45.0'$N	$119^{\circ}26.2'$W
R-31	19-IV-71	1317m	$32^{\circ}45.0'$N	$119^{\circ}26.0'$W
R-32	19-IV-71	1326m	$32^{\circ}45.0'$N	$119^{\circ}26.0'$W
R-40	12-VII-71	1307m	$32^{\circ}44.5'$N	$119^{\circ}30.0'$W
R-52	24-X-71	1353m	$32^{\circ}45.5'$N	$119^{\circ}29.0'$W
R-53	24-X-71	1298m	$32^{\circ}45.0'$N	$119^{\circ}27.0'$W

APPENDIX II

A list of species and counts from the collections utilized in the faunal comparison of the San Diego Trough and the Tanner Basin. N = number of specimens. S = number of species.

I.   San Diego Trough

R - 10   (SDT)

Harpiniopsis excavata	43
Harpiniopsis profundis	6
Harpiniopsis fulgens	4
Harpiniopsis petulans	19
Harpiniopsis galerus	2
Harpiniopsis naiadis	1
Paraphoxus oculatus	2
Phoxocephalus kergueleni	1
Haploops lodo	5
Byblis tannerensis	6
Byblis bathyalis	1
Byblis crassicornis	2
Ampelisca eoa	10
Ampelisca amblyopsoides	1
Oediceroides trepedora	19
Monoculodes necopinus	15
Monoculodes latissimanus	17
Monoculodes diversisexus	1
Bathymedon flebilis	2
Bathymedon covilhani	7
Bathymedon kassites	9
Bathymedon sp. A	2
Aceroides edax	4

(continued)

(continued)

Prachynella lodo	7
Schisturella grabensis	8
Hirondella fidenter	10
Schisturella robusta	1
Uristes perspinus	1
Lysianasid sp. A	4
Pseudoericthonius sp. A	21
Bonnierella linearis	2
Corophid sp. A	5
Leucothoe sp. A	3
Lepechinella bierii	1
Pseudotiron longicaudatus	6
Syrrhoe sp. A	3
Syrrhoites sp. A	2
Syrrhoites cohasseta	2
Rhachotropis sp. A	1
Rhactotropis cervus	7
Eusirus sp. A	1
Proboloides tunda	1
Astrya sp. A	3
Velletiopsis dentatus	1
Gammarid sp. Z	1

S = 45   N = 269

R - 11   (SDT)

Harpiniopsis excavata	16
Harpiniopsis petulans	7
Harpiniopsis profundis	3
Harpiniopsis emeryi	2
Harpiniopsis fulgens	1
Leptophoxus falcatus icelus	1
Oediceroides trepedora	6
Monoculodes necopinus	3
Monoculodes latissimanus	4
Monoculodes sp. Y	1
Bathymedon flebilis	1
Bathymedon kassites	6
Bathymedon cov.ilhani	4
Bathymedon sp. Z	1
Aceroides edax	3
Haploops lodo	1
Byblis tannerensis	1
Byblis crassicornis	2
Byblis sp. 1	1
Ampelisca amblyopsoides	1
Ampelisca eoa	4
Orchomene tabasco	4
Schisturella robusta	1
Schisturella grabensis	1
Hirondella fidenter	1
Lysianasid sp. 1	1
Pseudoericthonius sp. A	8
Bonnierella linearis	1
Leucothoe sp. A	1
Syrrhoe sp. A	1
Syrrhoe sp. B	1
Liljeborgia cota	1
Rhachotropis cervus	3
Rhachotropis sp. 1	2

S = 34   N = 95

R - 16   (SDT)

Harpiniopsis excavata	27
Harpiniopsis profundis	9
Harpiniopsis naiadis	3
Harpiniopsis petulans	12
Harpiniopsis fulgens	1
Harpiniopsis galerus	1
Harpiniopsis emeryi	1
Leptophoxus falcatus icelus	1
Oediceroides trepedora	5
Monoculodes necopinus	1
Monoculodes latissimanus	5
Monoculodes sp. B	1
Bathymedon covilhani	5
Bathymedon caino	1
Aceroides edax	3
Byblis tannerensis	6
Ampelisca eoa	11
Ampelisca amblyopsoides	1
Haploops lodo	5
Hiondella fidenter	3
Schisterella grabensis	2
Pseudoericthonius sp. A	9
Metopa samsiluna	1
Lepechinella bierii	1
Pseudotiron longicaudata	2
Syrrhoe sp. A	2
Bruzelia sp. A	1
Rhachotropis cervus	1
Rhachotropis sp. 1	2
Rhachotropis clemens	1
Rhachotropis 2	1
Eusirus sp. 1	2

S = 32   N = 127

R - 17   (SDT)

Harpiniopsis excavata	14
Harpiniopsis fulgens	1
Harpiniopsis profundis	5
Harpiniopsis petulans	6
Harpiniopsis naiadis	1
Oediceroides trepedora	1
Monoculodes latissimanus	2
Bathymedon covilhani	1
Aceroides edax	1
Bonnierella linearis	2
Corophid sp. A	1
Leucothoe sp. A	2
Byblis tannerensis	2
Byblis teres	1
Haploops lodo	2
Ampelisca eoa	3
Ampelisca amblyopsoides	2
Syrrhoites sp. A	1
Rhachotropis cervus	3

S = 20   N = 51

R - 30   (SDT)

Harpiniopsis excavata	21
Harpiniopsis petulans	7
Harpiniopsis naiadis	2
Harpiniopsis profundis	1
Phoxocephalus kergueleni	2
Metaphoxus sp.	1
Oediceroides trepedora	1
Monoculodes sp. Z	1
Bathymedon covilhani	3
Pseudoericthonius sp. A	6
Syrrhoe sp. A	
Syrrhoites sp. A	
Schisturella grabensis	2
Lysianasid sp. 1	1
Byblis tannerensis	2
Ampelisca coeca	1
Ampelisca eoa	5
Haploops lodo	2

S = 18   N =   59

R = 36   (SDT)

Harpiniopsis excavata	26
Harpiniopsis emeryi	5
Harpiniopsis naiadis	3
Harpiniopsis petulans	8
Harpiniopsis fulgens	1
Harpiniopsis profundis	1
Ampelisca eoa	9
Byblis tannerensis	8
Byblis sp. 1	2
Byblis crassicornis	2
Haploops lodo	1
Oediceroides trepedora	4
Monoculodes latissimanus	6
Monoculodes necopinus	1
Bathymedon covilhani	2
Bathymedon kassites	3
Bathymedon sp. Z	1
Bonnierella linearis	1
Corophid sp. A	1
Pseudoericthonius sp. A	5
Syrrhoites sp. A	1
Rhachotropis cervus	2
Rhachotropis sp. 1	1
Eusirus sp. 1	1
Lysianasid sp. 1	1
Schisturella robusta	1
Schisturella grabensis	1
Hirondella fidenter	1

S = 28   N = 99

R - 42   (SDT)

Harpiniopsis excavata	15
Harpiniopsis profundis	5
Harpiniopsis petulans	3
Harpiniopsis fulgens	1
Byblis tannerensis	1
Byblis crassicornis	2
Byblis sp. 1	1
Ampelisca eoa	6
Ampelisca amblyopsoides	2
Haploops lodo	5
Bonnierella linearis	3
Pseudoericthonius sp. A	1
Corophid sp. A	1
Leucothoe sp. A	1
Lepechinella bierii	1
Bathymedon covilhani	2
Monoculodes latissimanus	1
Monoculodes necopinus	1
Aceroides edax	3
Pseudotiron longicaudata	1
Schisturella robusta cedrosiana	2
Prachynella lodo	1

S = 22   N =   59

R - 43   (SDT)

Harpiniopsis excavata	15
Harpiniopsis profundis	2
Harpiniopsis emeryi	4
Harpiniopsis petulans	1
Harpiniopsis fulgens	1
Byblis tannerensis	3
Byblis crassicornis	4
Byblis sp. 1	1
Ampelisca eoa	2
Haploops lodo	2
Oediceroides trepedora	2
Bathymedon kassites	1
Aceroides edax	1
Syrrhoites sp. A	1
Syrrhoe sp. A	1
Syrrhoites cohasseta	1
Rhachotropis cervus	6
Rhachotropis sp. 1	1
Schisturella grabensis	1
Prachynella lodo	1

S = 20   N =   51

R - 46   (SDT)

Harpiniopsis excavata	11
Harpiniopsis petulans	14
Harpiniopsis emeryi	2
Harpiniopsis naiadis	3
Harpiniopsis profundis	3
Harpiniopsis galerus	1
Phoxocephalus kergueleni	1
Oediceroides trepedora	4
Monoculodes necopinus	4
Monoculodes latissimanus	4
Aceroides edax	4
Bathymedon flebilis	1
Bathymedon covilhani	2
Bathymedon kassites	2
Corophid sp. A	2
Bonnierella linearis	2
Lepechinella bierii	1
Leucothoe sp. A	1
Byblis teres	4
Ampelisca eoa	4
Schisturella grabensis	1
Lysianasid no. 1	1
Hirondella fidenter	1
Orchomene tabasco	1
Syrrhoe sp. A	1
Syrrhoe sp. B	1
Pseudotiron longicaudata	1
Syrrhoites sp. A	1
Rhachotropis cervus	6
Rhachotropis sp. 1	1
Rhachotropis sp. 3	1

S = 31   N = 86

R - 47   (SDT)

Harpiniopsis excavata	18
Harpiniopsis naiadis	5
Harpiniopsis petulans	9
Harpiniopsis emeryi	2
Harpiniopsis profundis	4
Harpiniopsis fulgens	3
Oediceroides trepedora	2
Monoculodes latissimanus	5
Monoculodes necopinus	6
Bathymedon covilhani	7
Bathymedon kassites	2
Bathymedon vulpeculus	1
Bathymedon flebilis	1
Aceroides edax	3
Byblis tannerensis	4
Byblis crassicornis	1
Byblis teres	2
Byblis sp. 1	1
Ampelisca amblyopsoides	1
Ampelisca eoa	8
Haploops lodo	1
Pseudoericthonius sp. A	18
Bonnierella linearis	3
Corophid sp. A	1
Leucothoe sp. A	1
Rhachotropis cervus	2
Rhachotropis sp. 1	1
Schisturella robusta c.	1
Schisturella grabensis	1
Hirondella fidenter	1

(continued)

(continued)

Lysianasid sp.	2
Prachynella lodo	2
Lepidepecreum sp. 1	1
Syrrhoe sp. A	2
Pseudotiron longicaudata	2
Syrrhoites cohasseta	2
Syrrhoe sp. B	1

S = 37   N = 124

II. Tanner Basin

R - 7   (TB)

Harpiniopsis excavata	15
Harpiniopsis profundis	1
Harpiniopsis naiadis	1
Harpiniopsis emeryi	5
Paraphoxus oculatus	8
Ampelisca eoa	4
Ampelisca amblyopsoides	6
Byblis sp. 2	5
Liljeborgia cota	1
Epimeria pacifica	1
Lepechinella bierii	5
Oediceroides trepedora	3
Aceroides edax	6
Monoculodes necopinus	4
Bathymedon caino	2
Bathymedon kassites	4
Bathymedon couilhani	1
Syrrhoe sp. A	9
Syrrhoites sp. A	2
Rhachotropis cervus	1
Rhachotropis sp. 3	1
Schisturella grabensis	7
Anonyx sp. 1	3
Lysianasid sp. 2	1
Orchomene tabasco	1
Hippomedon granulosus	6
Prachynella lodo	1
Tryphosites sp. A	1

S = 28   N =   105

R - 8   (TB)

Harpiniopsis excavata	16
Harpiniopsis emeryi	1
Harpiniopsis profundis	1
Harpiniopsis fulgens	1
Paraphoxus oculatus	10
Byblis tannerensis	5
Byblis sp. 2	3
Byblis teres	3
Ampelisca eoa	5
Ampelisca sp. A	1
Ampelisca amblyopsoides	5
Lepechinella bierii	1
Finoculodes omnifera	1
Bathymedon kassites	5
Aceroides edax	2
Syrrhoe sp. A	3
Prachynella lodo	2
Hippomedon granulosus	4
Schisturella grabensis	1

S = 19   N = 70

R - 22   (TB)

Harpiniopsis excavata	10
Harpiniopsis emeryi	1
Paraphoxus oculatus	7
Leptophoxus falcatus icelus	2
Ampelisca eoa	3
Ampelisca sp. A	8
Ampelisca amblyopsoides	1
Ampelisca furcigera	1
Ampelisca pugetica mora	1
Byblis bathyalis	5
Byblis tannerensis	1
Byblis crassicornis	1
Bonnierella linearis	22
Corophid sp. A	3
Lepechinella bierii	1
Aceroides edax	10
Bathymedon kassites	3
Rhachotropis cervus	1
Anonyx sp. 1	1
Anonyx sp. 2	1
Schisturella grabensis	2
Syrrhoe sp. A	3

S = 22   N =   88

R - 31   (TB)

Harpiniopsis excavata	14
Paraphoxus oculatus	1
Ampelisca sp. A	2
Ampelisca amblyopsoides	2
Ampelisca eoa	1
Ampelisca sp. B	1
Byblis tannerensis	3
Byblis bathyalis	1
Epimeria pacifica	1
Aceroides edax	2
Hippomedon granulosus	1
Schisturella grabensis	1
Anonyx sp. 1	1
Anonyx sp. 2	1
S = 14	N = 32

R - 32   (TB)

Harpiniopsis excavata	26
Harpiniopsis emeryi	3
Paraphoxus oculatus	4
Byblis tannerensis	2
Byblis bathyalis	4
Ampelisca amblyopsoides	4
Ampelisca sp. A	1
Byblis teres	1
Bathymedon kassites	4
Bathymedon couilhani	1
Aceroides edax	1
Syrrhoe sp. A	1
Schisturella grabensis	1
Prachynella lodo	1

S = 14   N =   54

R - 40   (TB)

Harpiniopsis excavata	21
Paraphoxus oculatus	5
Ampelisca eoa	1
Ampelisca amblyopsoides	1
Byblis tannerensis	2
Prachynella lodo	1
Schisturella grabensis	1
Aceroides edax	2

S = 8   N =   34

R - 52   (TB)

Harpiniopsis excavata	11
Paraphoxus oculatus	2
Ampelisca eoa	2
Ampelisca sp. A	3
Bathymedon kassites	1
Prachynella lodo	1
Hippomedon granulosus	2
Schisturella grabensis	2

$S = 8$ $N = 24$

R - 53   (TB)

Ampelisca sp. A	4
Harpiniopsis excavata	11
Paraphoxus oculatus	4
Bathymedon kassites	1
Syrrhoites sp. A	1
S = 5	N = 21

APPENDIX III

A list of the station data for the samples collected from Cascadia
Abyssal Plain which were utilized in the faunal comparison.

Slope Base Station (CP-1-E)

Sample	Date	Depth	Latitude	Longitude
EBS-01	20-VI-73	2803m	$44^\circ41.0'$N	$125^\circ35.6'$W
EBS-02	21-VI-73	2808m	$44^\circ38.0'$N	$125^\circ35.8'$W
EBS-03	21-VI-73	2810m	$44^\circ35.0'$N	$125^\circ35.2'$W
EBS-45	27-VI-75	2809m	$44^\circ41.5'$N	$125^\circ34.7'$W
EBS-46	28-VI-75	2762m	$44^\circ47.3'$N	$125^\circ32.1'$W
EBS-47	28-VI-75	2787m	$44^\circ42.4'$N	$125^\circ35.8'$W
EBS-48	28-VI-75	2811m	$44^\circ38.2'$N	$125^\circ33.7'$W
EBS-49	29-VI-75	2800m	$44^\circ41.6'$N	$125^\circ36.4'$W
EBS-50	29-VI-75	2816m	$44^\circ36.7'$N	$125^\circ35.5'$W
EBS-51	29-VI-75	2809m	$44^\circ41.0'$N	$125^\circ36.4'$W
EBS-52	30-VI-75	2800m	$44^\circ41.2'$N	$125^\circ36.8'$W

Western Station (CP-3-E)

Sample	Date	Depth	Latitude	Longitude
EBS-54	1-VII-75	2828m	$44^\circ40.0'$N	$127^\circ29.9'$W
EBS-55	1-VII-75	2824m	$44^\circ41.1'$N	$127^\circ31.5'$W
EBS-56	1-VII-75	2815m	$44^\circ43.0'$N	$127^\circ32.0'$W
EBS-57	2-VII-75	2820m	$44^\circ40.8'$N	$127^\circ29.8'$W
EBS-58	2-VII-75	2820m	$44^\circ41.0'$N	$127^\circ27.5'$W
EBS-59	2-VII-75	2820m	$44^\circ41.2'$N	$127^\circ28.0'$W
EBS-60	3-VII-75	2813m	$44^\circ41.6'$N	$127^\circ29.3'$W
EBS-61	3-VII-75	2820m	$44^\circ40.0'$N	$127^\circ28.8'$W

APPENDIX IV

A list of species and counts from each epibenthic sled haul taken on Cascadia Abyssal Plain. N = number of specimens. S = number of species.

I. Base of the Continental Slope (CP-1-E)

EBS - 1   (CP - 1 - E)

Harpiniopsis excavata	5
Harpiniopsis triplex	2
Harpiniopsis sp. 1	1
Harpiniopsis fulgens	6
Byblis crassicornis	1
Monoculodes sp. 1	2
Monoculodes recandesco	2
Monoculodes necopinus	3
Monoculodes latissimanus	3
Bathymedon sp. A	7
Bathymedon sp. 2	1
Oediceroides sp. Y	1
Halice sp. A	9
Pardaliscoides tikal	3
Tryphosella sp. A	2
Orchomene tabasco	2
Uristes perspinus	1
Syrrhoe oluta	3
Syrrhoites sp. A	3
Bruzelia inlex	1
Rhachotropis multisimis	1

S = 21   N =   59

EBS - 2   (CP-1-E)

Harpiniopsis excavata	8
Harpiniopsis fulgens	4
Harpiniopsis emeryi	2
Harpiniopsis triplex	4
Harpiniopsis sp. 1	5
Paraphoxus oculatus	1
Byblis crassicornis	5
Haploops lodo	1
Monoculodes sp. 1	1
Monoculodes recandesco	1
Monoculodes necopinus	2
Monoculodes latissimanus	1
Bathymedon sp. A	6
Bathymedon sp. 1	1
Bathymedon sp. 2	1
Bathymedon sp. 3	1
Monoculodes sp. Y	1
Oediceroides trepedora	1
Halice sp. A	16
Pardaliscoides sp. A	4
Pardaliscoides tikal	4
Liljeborgia cota	4
Lepechinella sp. A	1
Bonnierella linearis	4
Orchomene tabasco	2
Tryphosella sp. A	1
Uristes perspinus	3
Syrrhoe oluta	2
Syrrhoites sp. A	4
Rhachotropis lucidifor	1

S = 30   N =   92

EBS - 3   (CP-1-E)

Harpiniopsis excavata	9
Harpiniopsis fulgens	4
Harpiniopsis triplex	13
Harpiniopsis percellaris	1
Harpiniopsis sp. 1	6
Byblis crassicornis	4
Haploops lodo	1
Monoculodes recandesco	6
Monoculodes necopinus	2
Bathymedon sp. A	3
Bathymedon sp. 1	1
Bathymedon sp. 2	1
Bathymedon sp. 4	4
Bathymedon sp. 5	1
Monoculodes sp. Y	1
Oediceroides sp. Y	1
Halice sp. A	6
Pardaliscoides tikal	3
Liljeborgia cota	2
Hippomedon tracatrix	4
Orchomene tabasco	2
Tryphosella sp. A	1
Koroga megalops	1
Syrrhoe oluta	1
Syrrhoites sp. A	2
Bruzelia inlex	2

S = 26   N =   81

EBS - 45   (CP-1-E)

Harpiniopsis excavata	1
Harpiniopsis triplex	9
Harpiniopsis fulgens	3
Harpiniopsis naiadis	1
Monoculodes diversisexus	1
Haploops lodo	1
Ampelisca eoa	1
Ampelisca coeca	1
Liljeborgia cota	3
Tryphosella sp. A	1
Halice sp. A	3
Corophid sp. A	1
Bonnierella linearis	3

S = 13   N =   29

EBS - 46   (CP-1-E)

Liljeborgia cota	2
Bathymedon sp. A	1
Monoculodes necopinus	1
Harpiniopsis excavata	2
Harpiniopsis triplex	6
Harpiniopsis percellaris	1
Harpiniopsis fulgens	1
Hippomedon tracatrix	1
Lepidepecreum sp. A	1
Paracentromedon sp. A	1
Proboloides tunda	1
Syrrhoe oluta	2

S = 12   N =   20

EBS - 47   (CP-1-E)

Harpiniopsis triplex	4
Harpiniopsis fulgens	1
Harpiniopsis excavata	3
Harpiniopsis naiadis	1
Harpiniopsis emeryi	2
Paraphoxus oculatus	1
Pardaliscoides sp. A	5
Pardaliscopsis tikal	2
Halice sp. A	8
Bonnierella linearis	2
Bathymedon sp. 1	1
Bathymedon sp. Z	1
Monoculodes latissimanus	3
Bathymedon sp. 2	2
Monoculodes recandesco	3
Monoculodes necopinus	2
Bathymedon sp. A	5
Syrrhoites sp. C	1
Leucothoe uschakoui	1
Ampelisca coeca	1
Byblis crassicornis	1
Liljeborgia cota	4

S = 22   N =   54

EBS - 48   (CP-1-E)

Byblis crassicornis	1
Bathymedon sp. 2	1
Bathymedon sp. A	1
Harpiniopsis triplex	8
Harpiniopsis naiadis	3
Harpiniopsis percellaris	1
Harpiniopsis fulgens	1
Harpiniopsis sp. 1	4
Paracentromedon sp. A	1
Bonnierella linearis	4
Halice sp. A	4
Pardaliscoides sp. A	1

S = 12   N =   30

EBS - 49   (CP-1-E)

Harpiniopsis excavata	1
Harpiniopsis triplex	2
Harpiniopsis naiadis	6
Harpiniopsis emeryi	1
Pardaliscopsis copal	1
Halice sp. A	10
Lepidepecreum sp. A	3
Orchomene tabasco	2
Tryphosella sp. A	7
Bonnierella linearis	4
Bathymedon sp. A	4
Bathymedon caino	1
Bathymedon sp. Z	1
Bathymedon sp. 6	1
Bathymedon sp. 1	6
Monoculodes recandesco	8
Monoculodes latissimanus	6
Monoculodes necopinus	6
Monoculodes sp. Y	5
Oediceroides trepedora	9
Oediceroides abyssorum	1
Monoculodes sp. X	2
Monoculodes sp. Z	1
Liljeborgia cota	5
Byblis crassicornis	1
Haploops lodo	2
Ampelisca coeca	1
Leucothoe uschakoui	1
Rhachotropis sp. A	1
Syrrhoe oluta	5
Pseudotiron sp. A	1
Syrrhoites sp. B	1
Syrrhoites sp. A	6
Bruzelia sp. A	1
Bruzelia inlex	3
Epimeria sp. Z	1
Lepechinella echinata	2
Lepechinella sp. A	3

S = 38   N =   121

EBS - 50   (CP-1-E)

Harpiniopsis excavata	13
Harpiniopsis triplex	8
Harpiniopsis naiadis	5
Harpiniopsis sp. 1	4
Harpiniopsis fulgens	2
Pardaliscoides sp. A	3
Pardaliscopsis tikal	2
Pardaliscopsis copal	1
Halice sp. A	11
Halice sp. B	1
Hippomedon tracatrix	3
Tryphosella sp. A	3
Orchomene tabasco	1
Bonnierella linearis	9
Monoculodes sp. Y	1
Bathymedon sp. 1	1
Bathymedon sp. 2	1
Bathymedon sp. A	9
Monculodes latissimanus	1
Oediceroides sp. Y	1
Liljeborgia cota	3
Ampelisca coeca	1
Byblis crassicornis	1

$S = 23$ $N = 85$

EBS - 51   (CP-1-E)

Harpiniopsis excavata	8
Harpiniopsis triplex	2
Harpiniopsis naiadis	3
Harpiniopsis fulgens	1
Harpiniopsis sp. 1	1
Pardaliscopsis copal	1
Pardaliscoides sp. A	1
Pardaliscopsis tikal	2
Halice sp. A	11
Tryphosella sp. A	1
Paracentromedon sp. A	1
Bonnierella linearis	4
Liljeborgia cota	3
Ampelisca coeca	1
Haploops lodo	1
Byblis crassicornis	1
Ampelisca sp. A	1
Rhachotropis sp. B	1
Syrrhoe sp. B	1
Bathymedon sp. A	3

S = 20   N =   48

EBS - 52   (CP-1-E)

Bathymedon sp. W	1
Bathymedon sp. A	1
Liljeborgia cota	3
Harpiniopsis triplex	1
Harpiniopsis excavata	1
Harpiniopsis naiadis	3
Harpiniopsis sp. 1	1
Pardaliscoides sp. A	2
Pardaliscoides sp. B	1

S = 9   N = 14

EBS - 52   (CP-1-E)

Bathymedon sp. W	1
Bathymedon sp. A	1
Liljeborgia cota	3
Harpiniopsis triplex	1
Harpiniopsis excavata	1
Harpiniopsis naiadis	3
Harpiniopsis sp. 1	1
Pardaliscoides sp. A	2
Pardaliscoides sp. B	1

S = 9   N =   14

II. Western Portion of Cascadia Abyssal Plain (CP-3-E)

<u>EBS - 54</u>   (CP-3-E)

<u>Harpiniopsis excavata</u>	2
<u>Waldekia</u> sp. A	1
<u>Koroga megalops</u>	1
<u>Bonierella linearis</u>	3
<u>Pseudotiron</u> sp. A	2
<u>Monoculodes recandesco</u>	1
S = 6	N = 10

EBS - 55   (CP-3-E)

Bathymedon sp. 2	3
Monoculodes sp. Y	1
Oediceroides sp. Y	1
Monoculodes recandesco	1
Ampelisca plumosa	1
Ampelisca coeca	1
Urothoe rotundifrons	2
Harpiniopsis excavata	8
Harpiniopsis percellaris	1
Harpiniopsis fulgens	1
Pardaliscopsis tikal	1
Halice sp. Z	12
Pardaliscoides sp. A	1
Tryphosella sp. A	18
Acidostoma obesom	1
Photis kurilica	19
Gammaropsis sp. A	13
Bonnierella linearis	7

S = 18   N =   92

EBS - 56   (CP-3-E)

Bathymedon sp. 2	7
Bathymedon sp. 1	4
Bathymedon nepos	1
Bathymedon sp. A	2
Oediceroides sp. Y	3
Oediceroides trepedora	4
Monoculodes sp. Y	2
Monoculodes recandesco	8
Monoculodes sp. Z	3
Phipsiella minima	2
Leucothoe uschakoui	1
Syrrhoe oluta	2
Syrhoites sp. A	3
Amathillopsis pacifica	2
Lepechinella sp. B	1
Urothoe rotundifrons	21
Harpiniopsis excavata	14
Harpiniopsis fulgens	3
Harpiniopsis percellaris	1
Hippomedon sp. B	1
Tryphosella sp. A	17
Uristes perspinus	5
Hippomedon tracatrix	1
Hippomedon strages	1
Gammaropsis sp. A	5
Photis kurilica	2
Bonnierella linearis	13
Pardaliscoides sp. A	1
Pardaliscopsis tikal	1
Pardaliscella sp. A	4
Halice sp. Z	4
Halice sp. Y	1
Proboloides tunda	1

S = 33   N =   141

EBS - 57   (CP-3-E)

Harpiniopsis excavata	7
Harpiniopsis percellaris	1
Pardaliscella sp. A	4
Halice sp. Z	18
Proboloides tunda	1
Hippomedon strages	2
Tryphosella sp. A	1
Bonnierella linearis	7
Gammaropsis sp. A	5
Ampelisca coeca	3
Ampelisca plumosa	1
Monoculodes necopinus	1
Bathymedon sp. 2	1
Bathymedon sp. 1	1
Monoculodes recandesco	1

S = 15   N =   54

EBS - 58   (CP-3-E)

Bathymedon sp. 2	12
Bathymedon sp. 1	2
Bathymedon sp. A	9
Bathymedon sp. 5	1
Monoculodes recandesco	9
Monoculodes sp. Y	7
Monoculodes necopinus	7
Oediceroides sp. Y	2
Oediceroides trepedora	5
Monoculodes sp. Z	1
Liljeborgia cota	1
Phipsiella minima	2
Ampelisca coeca	1
Byblis crassicornis	2
Ampelisca plumosa	6
Rhachotropis sp. B	1
Rhachotropis lucidifor	1
Rhachotropis sp. C	1
Syn * - 1	2
Bruzelia inlex	3
Syrrhoites sp. A	1
Syrrhoe sp. A	2
Pseudotiron sp. A	1
Lepechinella echinata	1
Lepechinella sp. B	1
Lepechinella turpis	1
Urothoe rotundifrons	8
Harpiniopsis excavata	12
Harpiniopsis sp. 1	1
Pardaliscopsis tikal	3
Pardaliscoides sp. A	3
Pardaliscoides sp. B	1
Halice sp. X	1
Halice sp. Z	10
Halice sp. W	1

(continued)

EBS - 58 (con't)

Pardaliscid sp. G	2
Pardallscella sp. A	5
Pardalisca sp. A	1
Proboloides tunda	3
Acidostoma obesum	4
Tryphosella sp. A	15
Uristes perspinus	3
Paracentromedon sp. A	2
Gammaropsis sp. A	14
Photis kurilica	4
Bonnierella linearis	16
Dulichia abyssi	1

S = 47   N = 192

EBS - 59   (CP-3-E)

Harpiniopsis excavata	7
Harpiniopsis percellaris	2
Halice sp. Z	2
Bonnierella linearis	2
Gammaropsis sp. A	2
Liljeborgia cota	1
Ampelisca plumosa	1
Oediceroides sp. Y	1

S = 8   N =   18

EBS - 60   (CP-3-E)

Bathymedon sp. 2	1
Bathymedon sp. A	1
Oediceroides sp. Y	1
Monoculodes sp. X	1
Ampelisca plumosa	2
Rhachotropis ludificor	1
Lepechinella sp. B	1
Urothoe rotundifrons	2
Harpiniopsis excavata	2
Harpiniopsis percellaris	1
Pardalisca sp. A	1
Halice sp. Z	6
Pardaliscoides sp. A	3
Pardaliscella sp. A	1
Proboloides tunda	8
Hippomedon sp. A	2
Tryphosella sp. A	3
Hippomedon strages	2
Lepidepecreum sp. A	1
Uristes perspinus	1
Photis kurilica	1
Gammaropsis A	2
Bonnierella linearis	8

S = 23   N =   52

EBS - 61   (CP-3-E)

Harpiniopsis excavata	5
Harpiniopsis percellaris	3
Pardaliscella sp. A	1
Halice sp. Z	2
Pardaliscoides sp. A	1
Proboloides tunda	1
Hippomedon strages	1
Uristes perspinus	1
Gammaropsis sp. A	1
Dulichia abyssi	1
Bonnierella linearis	4
Photis kurilica	1
Ampelisca coeca	1
Ampelisca plumosa	2
Epimeria no. 1	1
Urothoe rotundifrons	1
Monoculodes necopinus	1
Oediceroides sp. Y	2
Monoculodes sp. Y	1

S = 19   N =   31

APPENDIX V

The Euclidean Distance Measure as defined by Sokal and Sneath (1973).

$$
d_{jk} = \left(\frac{\sum\limits_{i=1}^{n} (x_{ij} - x_{ik})^2}{n} \right)^{1/2}
$$

where: d_{jk} = distance between sample $\underline{j}$ and $\underline{k}$

x_{ij} = percentage of species $\underline{i}$ in sample $\underline{j}$

x_{ik} = percentage of species $\underline{i}$ in sample $\underline{k}$

n = number of species

APPENDIX VI

The amphipod species data for a station at the edge of the Oregon
Continental Shelf (200 m.). The sample was collected with an epi-
benthic sled. N = number of specimens. S = number of species.

Species

Species	
Ampelisca macrocephala	24
Ampelisca agassizi	23
Ampelisca hancocki	1
Ampelisca pugetica	4
Byblis veleronis	5
Syrrhoe longifrons	13
Bruzelia tuberculata	3
Rhachotropis clemens	22
Rhachotropis inflata	2
Nicippe tumida	7
Melphidippa spinosa	1
Eriopsa elongata	17
Heterophoxus oculatus	111
Harpiniopsis fulgens	49
Metaphoxus frequens	7
Stenothid sp. A	25
Photis sp. A	106
Microjassa litotes	6
Monoculodes emarginatus	22
Bathymedon covilhani	8
Bathymedon pumilus	20
Westwoodilla caecula	41
Synchelidium shoemakeri	40
Pleusymtes coquilla	22
Orchomene pacifica	67
Pachynus barnardi	20
Opisa tridentata	6
Lepidepecreum garthi	2

S = 28   N = 704