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ANALYSIS OF BENTHIC EPIFAUNAL COMMUNITY STRUCTURE ON THE GORDA RIDGE

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NOTICE

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TABLE OF CONTENTS

List of Figures.... ii

List of Tables.... ii

Abstract.... 1

I. Introduction.... 1
A. Scientific Background.... 1
1. Geology.... 1
2. Benthic Ecology.... 3
B. Objectives.... 6

II. Materials and Methods.... 8
A. Photography and Video Recording.... 8
1. Photographs from Submersible Dives.... 8
2. Towed Camera Sleds.... 8
B. Animal Collections.... 8
1. Collection of Invertebrate Specimens.... 8
2. *In situ* Fish Trapping.... 11
C. Photographic and Video Analysis.... 11
D. Animal Identifications.... 11
E. Data Analysis.... 14

III. Results.... 14
A. Invertebrate Epifauna.... 14
1. Species List.... 14
2. Trends Related to Substrate Type.... 18
3. Ecological Zones.... 18
B. Fish.... 26

IV. Discussion.... 26
A. Relative Abundance of Fauna.... 26
B. Origin of Fauna.... 27
C. Critique of Data.... 27
D. Significance of the research.... 29

V. Research Needs.... 29

VI. Conclusions.... 30

VII. Cited References.... 32

VIII. Acknowledgements.... 31

IX. Appendices.... 34
A. Biological Specimens Collected During the 1986 Cruises.... 35
B. List of Available Bottom Photographs - Summary.... 37
C. List of Available Bottom Videotapes - Summary.... 40
D. Summary of total mean abundances of mega-epifauna.... 42
E. Summary of percent composition by major taxa.... 45
F. Abstracts of Papers Presented at the Gorda Ridge Symposium.... 48

LIST OF FIGURES

Figure 1. Geological zones of Gorda Ridge.................................... 2

Figure 2. Percent taxonomic composition down-axis............................ 4

Figure 3. Megafaunal abundance off-axis...................................... 7

Figure 4. Station/trackline locations, NESCA - L2 86 NC...................... 9

Figure 5. Station/trackline locations, SESCA - L2 86 NC...................... 10

Figure 6. Ecological zones, Gorda Ridge axial valley......................... 25

Figure 7. Benthic epifauna, zoogeographical relationships.................... 28

LIST OF TABLES

1. Abundance of visible epifauna.. 5

2. Collaborating Taxonomists.. 12

3. Summary - Gorda Ridge Benthic Epifauna..................................... 15

4. Percent taxonomic composition vs. substrate;
   Northern Gorda, "far" altitude... 19

5. Percent taxonomic composition vs. substrate;
   Escanaba, "far" altitude... 20

6. Percent taxonomic composition vs. substrate;
   Northern Gorda, "very far" altitude.. 21

7. Percent taxonomic composition vs. substrate;
   Escanaba, "very far" altitude.. 22

8. Numerical abundance of animals per frame vs. sediment
   Northern Gorda Ridge (I)... 23

9. Numerical abundance of animals per frame vs. sediment
   Escanaba Trough (III).. 24

ABSTRACT

Based primarily on bottom photographs and videotapes taken by the USGS, NOAA, and the U.S. Navy (1984-86), we have described the taxonomic composition and patterns of distribution and abundance of the benthic epifauna in the Gorda Ridge axial valley.

Filter-feeding taxa occur in all rocky environments. Crinoids appear dominant at the northernmost stations and ascidians are dominant in mid-valley. Assemblages of invertebrates and fishes associated with rock and sediment differ in composition and abundance. Deposit-detritus feeding organisms are interspersed with stalked suspension feeders in the sediment-filled southern Escanaba Trough. Many species associated with sediments in the axial valley are also found on the surrounding abyssal plains. Biomass is unevenly distributed.

The valley fauna is abundant and diverse, undoubtedly supported by the downward flux of organics, including run-off from the Columbia River. In addition, polymetallic sulfide deposits and scattered hydrothermal venting may provide energy sources for sulfur-based food webs.

INTRODUCTION

A. Scientific Background

(1) Geology

The 300 km-long Gorda Ridge is part of the East Pacific rise off northern California and southern Oregon (Fig. 1). It is a slow to medium rate sea floor spreading center entirely within the U.S. Exclusive Economic Zone (EEZ) (Baker et al., 1987). The ridge axis is fairly wide, ranging from 3 to 10 km between inward-facing fault scarps at the crest. The axial valley floor is unusually deep (3200-3800m) (Clague et al., 1984). Gorda Ridge is comprised of three distinct geological zones -- (1) a northern area extending 120 km south of the Blanco Fracture Zone, (2) a central region extending from the Gorda Fault Zone at 42° N to the ridge-ridge transform fault junction at 41° 35'N, and (3) the sediment-filled Escanaba Trough, comprising two thirds of the ridge crest south of 41° 35'N (Baker et al., 1987). (Fig. 1). The entire ridge is considered to be a slow spreading center.

The northern ridge is classified as a "slow" spreading center although the spreading rate has been 5.5 cm or greater/yr since 4.5 My B.P. (Baker et al., 1987). It has a deep axial valley with a vertical relief of 600 to 1400 m characteristic of slow-spreading ridge systems. The valley floor lies at a depth of 3000 to 3700 m.

The central portion of the axial valley, lying between the two transform fault zones, begins at 42° N where the President Jackson Seamount Chain intersects the ridge (Baker et al., 1987). Spreading rate in this zone and is estimated to be 1.5 cm/yr. The axial valley south of this intersection widens and deepens to become Escanaba Trough.

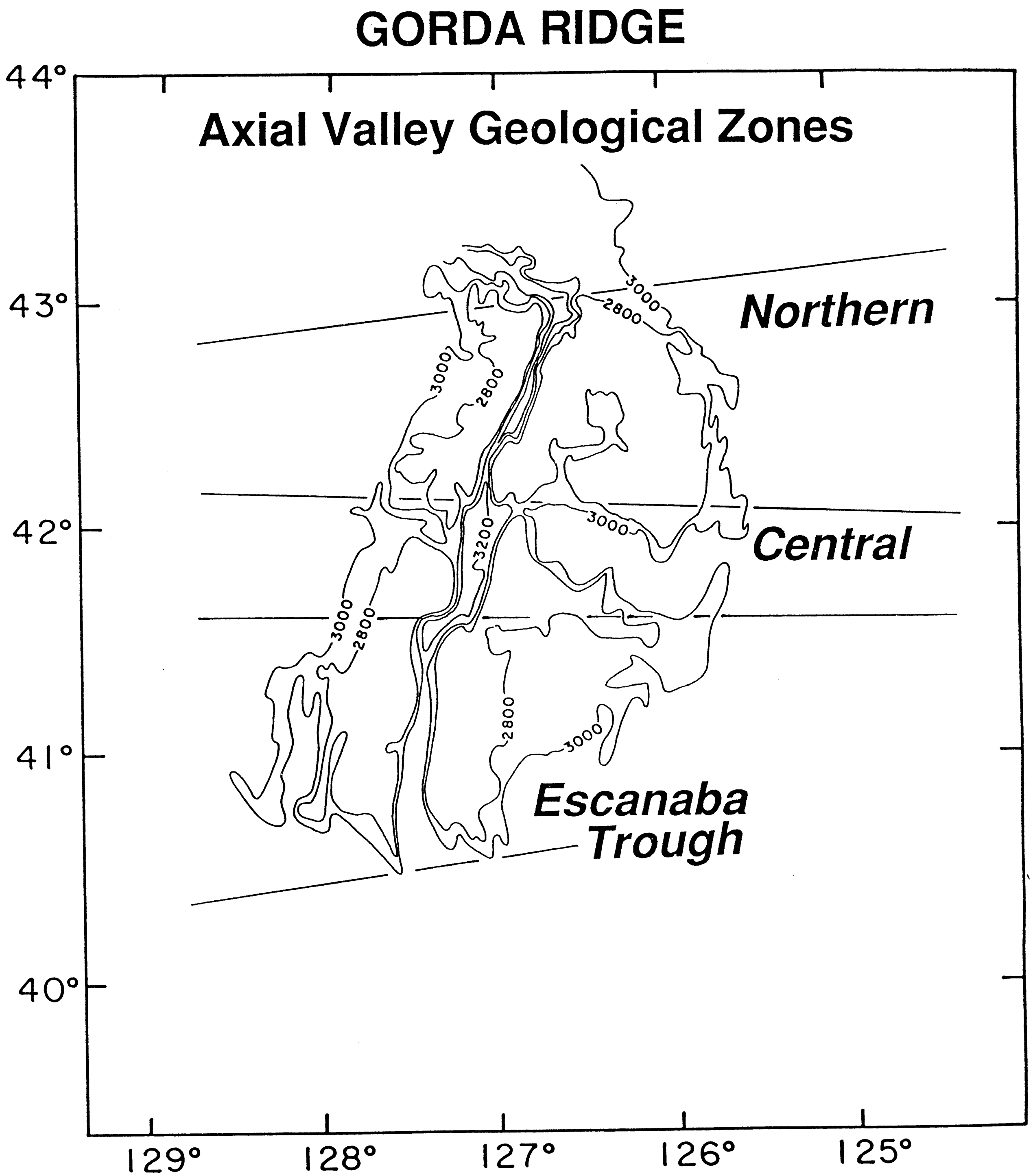

Figure 1. Geological features of the Gorda Ridge axial valley. Note that transverse faults cut the valley into three segments with differing characteristics.

The southernmost section of the ridge, Escanaba Trough is heavily sedimented by turbidites that have flowed down the continental slope, through the Gorda Basin and into the axial valley through the gap formed by the Mendocino escarpment to the south and the ridge to the north (Moore, 1970). Morton et al. (1987a, 1987b) report that two large volcanic edifices intruding through the sedimentary cover have hydrothermal sulfides associated with them. Escanaba Trough is on a slow spreading center, widening at a rate of 2.3 cm per year.

(2) Benthic Ecology

Previous research based on photographs and samples taken during the 1984 DSRV Alvin dives and the 1985 R/V S.P. Lee cruises demonstrated an extensive, visible benthic mega-fauna in the Gorda Ridge axial valley (Carey et al., 1986; Carey et al., 1987) composed primarily of suspension and deposit feeders. Although detritus feeders are generally associated with sedimentary substrates, they may be prevalent also on basalts with little sediment cover. Conversely, stalked suspension feeders are also found on sediments, though they are dominant on rocky surfaces. Suspension feeders tend to aggregate more than detrital feeders. The majority of the faunal distribution patterns tend toward patchiness and do not fit a Poisson distribution.

Distribution

Taxonomic composition of the rocky epifauna appears to change from the sponge and crinoid assemblage of the Northern (I) section to a mixed assemblage in the narrowgate area (Alvin dive no. 1406) to the ascidian-dominated southern Central (II) segment of the valley (Fig. 2). Stalked suspension feeders such as deep-sea ascidians, crinoids, glass sponges, and gorgonian soft corals are patchy in distribution, though the individual assemblages can have high population densities.

Many deposit-detritus feeding animals are present in the sediment-laden Escanaba Trough. A number of these, including holothuroids (sea cucumbers), ophiuroids (brittle starfish), asteroids (starfish), and galatheid crabs (squat lobster), are also dominant on the surrounding abyssal plains to the north (Carey, 1987). Stalked suspension feeders, e.g. hexactinellid glass sponges, pennatulid sea pens, and sea anemones, are generally interspersed amongst the surface deposit/detritus feeders.

Abundance

The axial valley fauna is abundant just south of the fault zone at 41° 35'N along the southern ridge that forms the northern boundary to Escanaba Trough (Carey et al., 1986 and Table 1). Note that the numbers of animals per photograph are higher on Alvin dive No. 1405 in this region, particularly on the hard (rocky) and mixed substrates, than at the other dive sites.

Feeding type

Large-epifaunal invertebrates on the ridge are primarily suspension and deposit/detritus feeders. Stalked suspension feeders, e.g. glass sponges, gorgonian corals, sea pens, soft corals, sea anemones, and crinoids, are dominant in both rocky and sedimentary substrates. Non-stalked suspension feeders, e.g. sponges

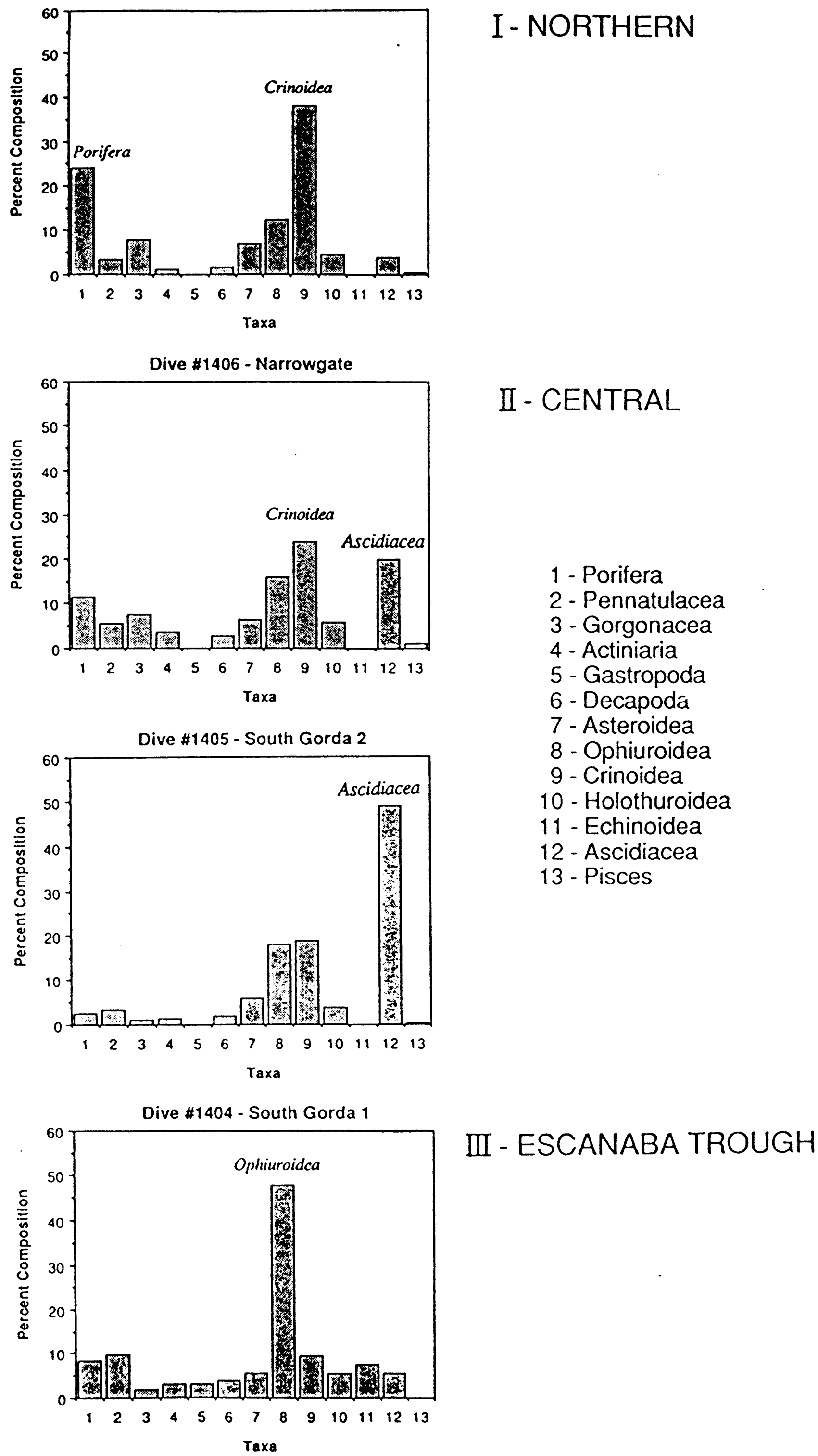

Figure 2. Percent taxonomic composition of mega-epifauna down the valley axis. Note the change in dominant fauna from the northern to the southern valley.

Table 1. Abundance of visible epifauna on the Gorda Ridge; results of analyses of 1984 DSRV *Alvin* photographs.

Substrate:	Soft	Hard	Mixed	Total
(1) Southern Gorda Ridge (Dive 1404)				
Number of frames analyzed	(16)	(1)	(8)	(25)
Mean number animals ($\bar{x}$/frame)	8.4	11.0	6.9	9.3
Range ($\bar{x}$/frame)	1-19	-	-	2-21
(2) Southern Gorda Ridge (Dive 1405)				
Number of frames analyzed	(245)	(10)	(26)	(286)
Mean number animals ($\bar{x}$/frame)	6.5	38.5	22.4	9.0
Range ($\bar{x}$/frame)	0-25	6-63	5-72	0-72
(3) Narrowgate (Dive 1406)				
Number of frames analyzed	(0)	(30)	(45)	(75)
Mean number animals ($\bar{x}$/frame)	-	10.9	8.5	9.5
Range ($\bar{x}$/frame)	-	2-19	2-20	2-20
(4) North Gorda Ridge (Dive 1407)				
Number of frames analyzed	(0)	(63)	(23)	(87)
Mean number animals ($\bar{x}$/frame)	-	8.1	8.6	8.2
Range ($\bar{x}$/frame)	-	1-22	3-17	1-22

(Demospongiae), comatulids (non-stalked crinoids), a long-armed asteroid, (Freyella cf insignis), deep-sea ascidians (Culeolus sluiteri and Bathypera ovoida), and an anemone-like tube-builder (Ceriantharia). The slender-stalked deep-sea tunicates are morphologically specialized for capturing and concentrating particles from the water (Monniot and Monniot, 1978).

Epibenthic deposit/detritus feeding animals include the common deep-sea holothurians (Paelopatides confundens and Abyssocucumus abyssorum), the galatheid crab (Munidopsis latirostris), and ophiuroids (Ophiomusium multispinum and Ophiocten hastatum ?).

Trends off-axis

Photograph-video tracklines were made on the eastern wall of the northern Gorda Ridge axial valley at a number of depths by the R/V S.P. Lee in 1985. Depth and location affect epifaunal taxonomic composition (Figure 3); five species of echinoderms, three holothuroids and two starfishes, differ in distribution and abundance at these stations.

OBJECTIVES

(1) To determine the taxonomic composition of the Gorda Ridge mega-epifauna.

(2) To define patterns of distribution and abundance of the fauna down the axial valley and on the valley walls.

(3) To determine the basic foodweb structure of the epifauna communities within the axial valley.

(4) To correlate the ecology of the benthos with geological structure and processes of the Gorda Ridge.

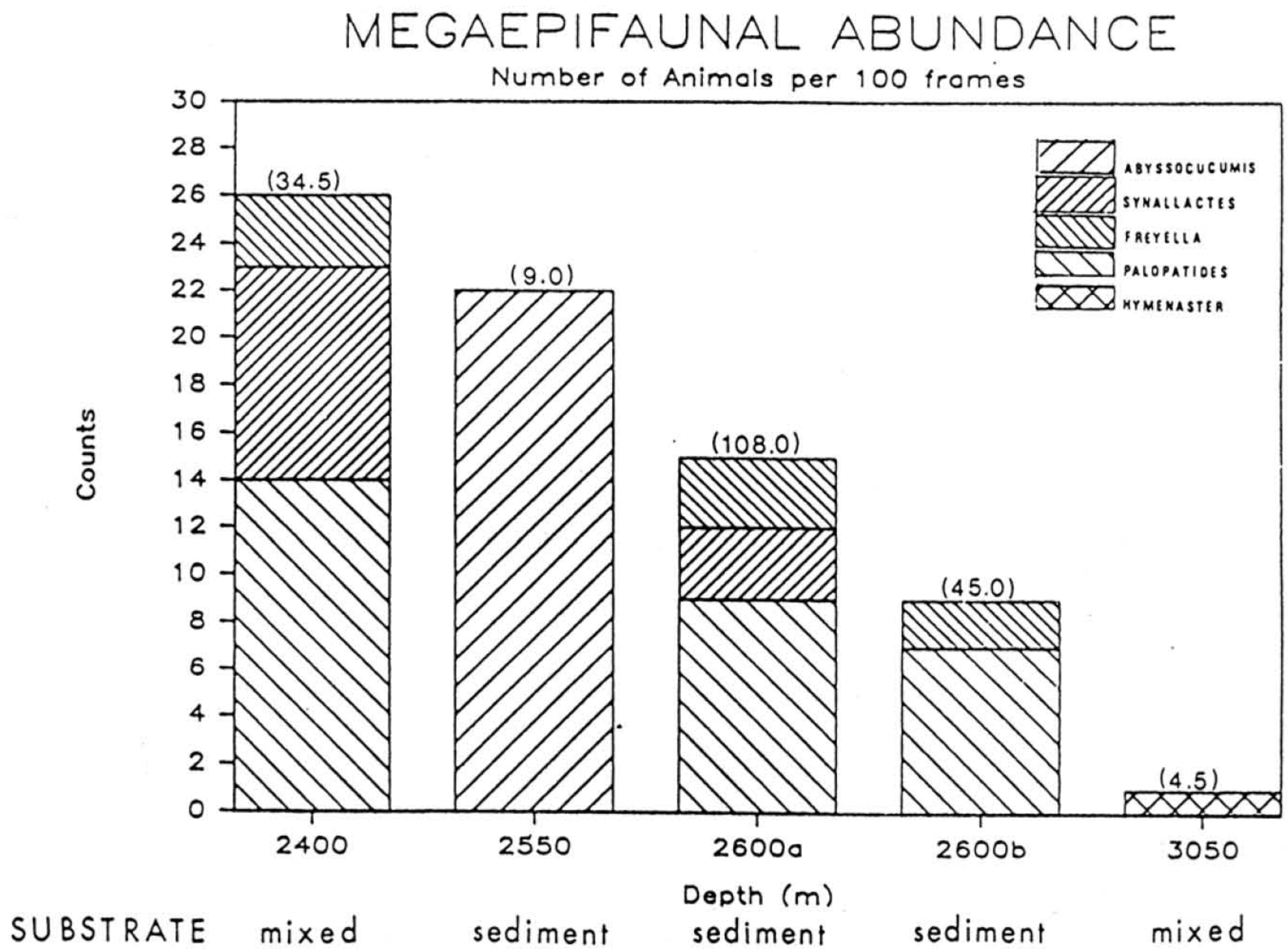

Figure 3. Abundance of mega-epifauna (counts per 100 photographs) of 5 echinoderm species on the east wall of the northern valley. Abyssocucumis, Synallactes, and Paelopatides are Holothurodia (sea cucumbers); Freyella and Hymenaster are Asteroidea (sea starfish).

MATERIALS AND METHODS

A. Photography and video recording.

(1) Photographs from submersible dives.

a. DSRV Alvin

A series of photographs was taken on each of 4 NOAA reconnaissance dives from the southern to northern Gorda Ridge rift valley (Figure 2) by DSRV ALVIN during late summer, 1984. Photographs were made with a BENTHOS survey camera system mounted at an oblique angle and using Ektachrome film (200 ASA).

b. DSV Sea Cliff

During the 1986 dives on Gorda Ridge photographs were taken with a BENTHOS 35 mm camera mounted obliquely on the bow of the submersible. In addition photos were taken with interior hand-held 35 mm cameras, and videotapes with a hand-held automatic videocamera.

(2) Towed camera sleds

Bottom photographs were taken in 1985 and 1986 by the U.S. Geological Survey vessel R/V S.P. LEE and by NOAA's Meteorological and Oceanographic Laboratory, Miami, Florida with instrumented towed camera vehicles (Chezar and Lee, 1985). The USGS (Branch of Marine Geology, Menlo Park, CA) still camera photographic system (Farre et al., 1983) consists of a 35 mm camera and 5 strobe flash units and has a maximum capacity of 400 ft. of film. Date and time (to the nearest minute) are superimposed on each frame of the film in synchronization with the videotape. Water temperature and altitude above the sea floor data are acoustically telemetered to the ship via a 12 kHz pinger and recorded aboard ship with a precision graphic recorder. The altitude data are unavailable, because of equipment malfunction on the Gorda Ridge cruises.

Camera/video tracklines made during the 1986 USGS cruise have been plotted by the Geological Survey with approximate positions on detailed topographic charts of the NESCA and SESCA dome sites in Escanaba Trough in Figures 4 and 5 (W. Normark, 1987). Accurate plots with time courses provide correlation analysis of ecological patterns with detailed topography and substrate type.

B. Animal collections

(1) Collection of invertebrate specimens

Animals obtained by the USGS were by-products of rock dredge tows in the ridge axial valley and during geological collecting with DSV Sea Cliff. Specimens were picked from the samples on board ship and were preserved in 10% formalin buffered with sodium borate. In the laboratory they were sorted, identified as far as possible and placed in 70% ethanol. Earlier rock dredge collections from 1980-83 USGS cruises to the ridge were worked up by Drs. John Pogeta, Jr. and David L. Pawson of the U.S. Natural History Museum, Smithsonian Institution (Clague et al., 1984).

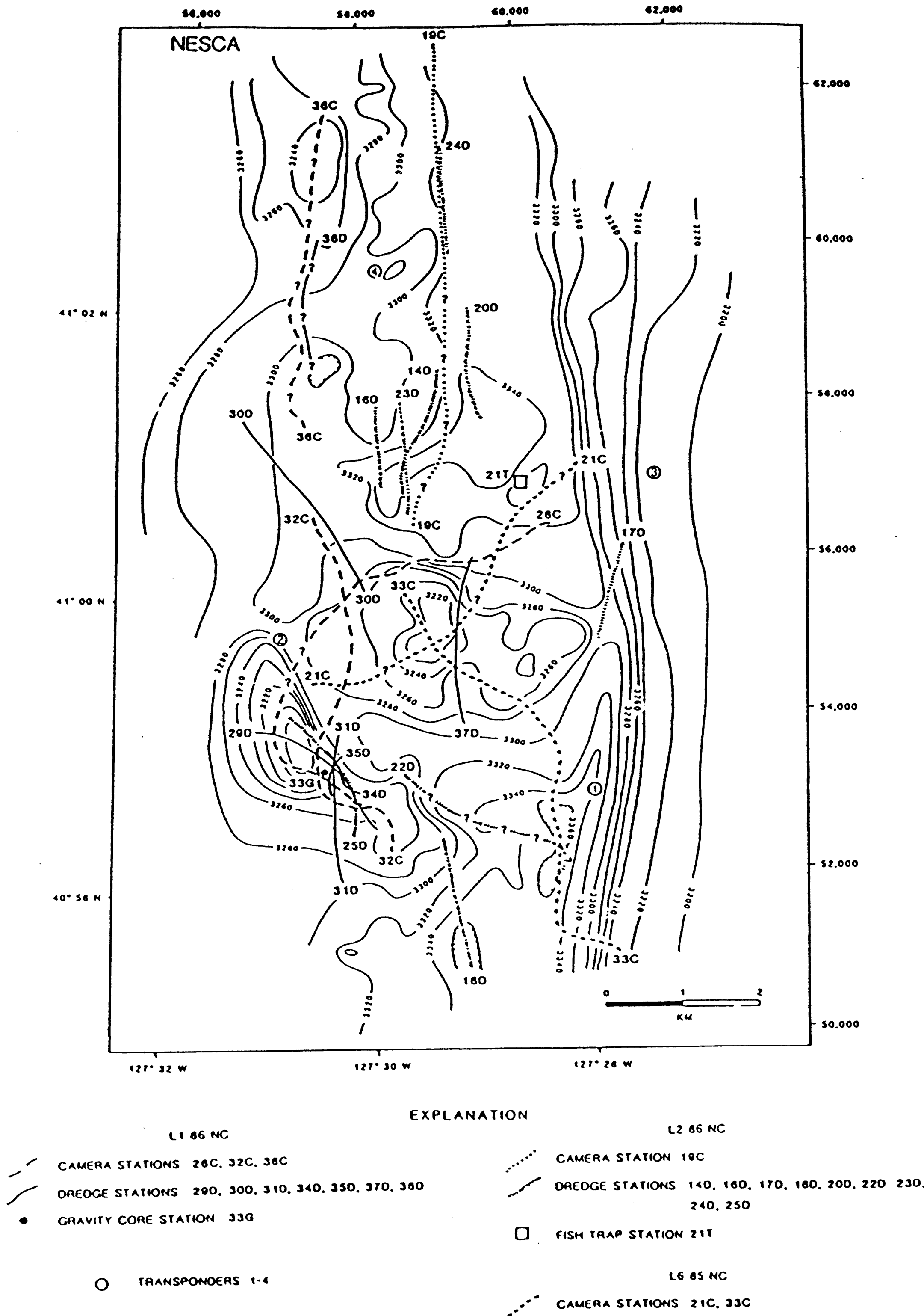

Figure 4. Tracklines and locations of USGS camera tows, rock dredge hauls, and gravity core samples and OSU fish trap station at NESCA on R/V S.P. Lee cruise L1-86-NC and L2-86-NC. (Courtesy of USGS)

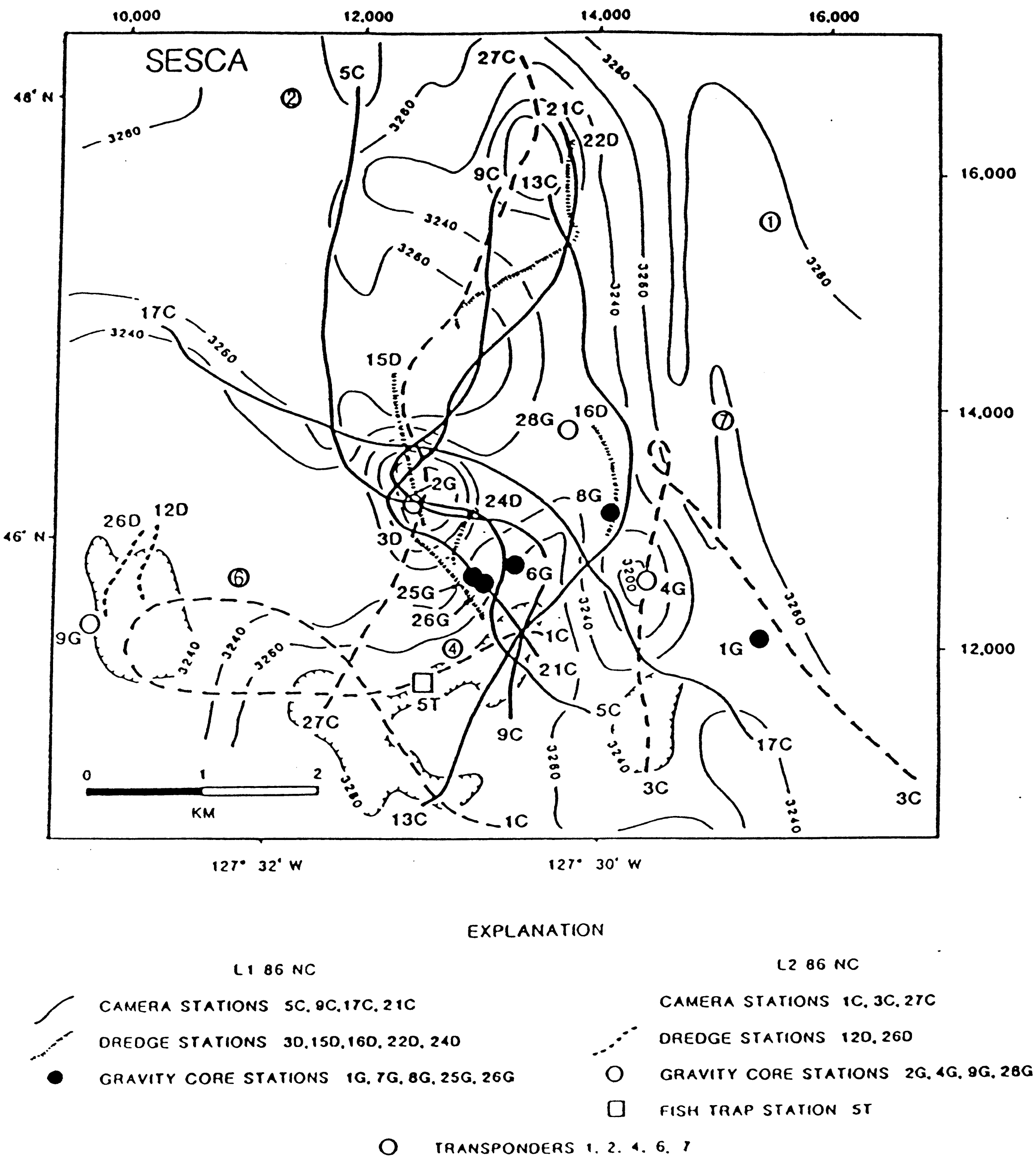

Figure 5. Tracklines and locations of USGS camera tows, rock dredge hauls, and gravity core samples at SESCA on R/V/ S.P. Lee cruise L1-86-NC and L2-86-NC. (Courtesy of USGS)

(2) In situ fish trapping

Two collections of fish were made with baited traps at stations NESCA and SESCA in Escanaba Trough during the 1986 R/V S.P. Lee cruise (L2-86-NC) (Figs. 4 and 5). The traps were constructed of 3.8 cm vinyl-covered metal mesh and were cubes 1.2 m on a side. They were baited with squid, herring, and anchovy and were deployed as free-fall vehicles for 24 hrs. Each deployment consisted of an anchor chain link ballast weight, the trap, timer-release unit, glass floats, and a locating flag mounted on a mooring wire.

C. Photographic and video analysis.

Photographs were examined using a Variscan aerial photogrammetric analysis device (Mark II, Westwood Division, Houston Fearless Corp.) allowing automated projection at 4 magnifications (3x, 6x, 12.4x, and 31.2x). Photographs utilized in the faunal analyses were chosen with the criteria of adequate lighting and non-overlap in fields of view.

Animals photographed were identified to major taxon and counted per frame. Initially, several distinctive organisms were identified tentatively to species. Subsequently, taxonomic specialists provided further identifications to species (Table 2). A small percentage of these can be identified in the photographs to species with some confidence, though the majority of the fauna is identified and counted at higher taxonomic levels during analysis of each usable frame.

For the purposes of this report, altitude estimates to the nearest meter have been read directly from the camera system pinger traces on precision depth recorder (PDR) charts. PDR plots are available for some camera tracklines. We have compared these altitude data with scale and altitude estimated from the sizes of known epibenthic organisms observed in the photographs. Average size of organisms, e.g. asteroid, ophiuroid, echinoid, and holothuroid species, collected from Cascadia Abyssal Plain at similar depths and from other abyssal environments for previous research projects provided an estimate of scale and altitude for each photograph (Carey, 1985). These rough estimates enabled us to group photographs in three altitude ranges - close (0 to 2 m), far (>2 to 5 m), and very far (>5 m).

Animal counts per frame were then summarized for each taxon, and faunal abundances were compared between the different environmental regions of the axial valley. With the aid of a grid mounted on the Variscan screen, numbers of individuals per grid cell of each major taxon were counted and substrate and evidence of bioturbation were noted. Number, means and ranges per taxon were calculated for each substrate type. Because turbidity sometimes obscured portions of the photographs, the number of usable grid cells in each frame was noted.

Taxonomic composition and abundance data were lumped from similar altitude ranges and compared within and between camera tracklines. Relative comparisons of community taxonomic structure (percent composition) between locations and substrate types were made.

D. Animal identifications

After the above analyses, slides and prints of taxa photographed were sent to 16 systematic specialists for further identification and comments (Table 2). Identi-

Table 2. Summary of collaborating taxonomists for identification of the faunal groups observed, collected, and identified from the Gorda Ridge axial valley.

Porifera	(01)	Dr. Henry Reiswig McGill University
	(02)	Dr. William Austin British Columbia
Anthozoa	(03)	Dr. Frederick Bayer Smithsonian Institution
	(04)	Dr. Daphne Fautin California Academy of Sciences
Polychaeta	(05)	Dr. Gary L. Taghon Oregon State University
Arthropoda	(06)	Dr. William A. Newman ScrippsInstitutionof Ocean.
	(07)	Dr. Austin B. Williams National MarineFishery Service
Mollusca	(08)	Dr. Frank Bernard Pacific Biological Station
	(09)	Dr. William G. Pearcy Oregon State University
Echinodermata	(10)	Ms. Maureen Downey Smithsonian Institution
	(11)	Mr. Michael A. Kyte Ardea Associates
	(12)	Dr. David L. Pawson Smithsonian Institution
	(13)	Dr. David L. Meyer University of Cincinnati
	(14)	Dr. Michel Roux Universite Claude-Bernard, France

Table 2. Summary of collaborating taxonomists (cont'd)

Urochordata	(15)	Dr. Claude Monniot Ms. Francoise Monniot Museum National d'Histoire Naturelle, France
Pisces	(16)	Dr. David L. Stein Oregon State University

fications were used to construct a preliminary photographic key to Gorda Ridge mega-epifauna. Photographs of additional taxa observed in photographs have been sent to appropriate specialists for identification. Data and photos will remain catalogued in the Benthic Ecology Laboratory, College of Oceanography, Oregon State University.

E. Data analysis

For preliminary analyses, each photograph was treated either as a similarly sized quadrat (1984 DSRV Alvin photographs) or roughly classified in broad altitude zones (1985 S.P. Lee photographs). Per-photograph counts of organisms were used to estimate faunal abundance and for statistical treatment.

Of necessity, the 1985 DSRV Alvin photographs from different altitudes were lumped to provide more data for analysis. Lower taxa were combined into 10 higher taxonomic categories to provide sufficient sample size for statistical treatment (anthozoans, asteroids, crinoids, gorgonians, holothurians, ophiuroids, pennatulids, poriferans, tunicates, and echinoids). Data were grouped into categories depending on location (dive number) and substrate type: soft substrate (present in photographs from dives 1404 and 1405), mixed substrates (present on dives 1404, 1405, 1406, and 1407), and hard substrate (present on dive 1407).

Data taken from towed camera tracklines have been grouped by rough altitude intervals and by percentage rock and sediment cover.

We have used variance-to-mean ratios of per-photograph counts to determine spatial dispersion of ten or more taxa; a discussion of these techniques is found in Carey et al., 1986.

RESULTS

A. Invertebrate Epifauna

(1) Species list.

The list of epifaunal taxa include a diverse group of organisms, including two species new to science, i.e. the crinoid, *Thalassocrinus* sp. and the ascidian, *Ascidia* sp. (Table 3). Positive species identifications are derived from actual specimens collected by rock dredge or from the submersible DSV Sea Cliff. Identifications from photographs and videotapes are generally tentative and are denoted by a question mark, excepting the verified specimens. In many cases animals observed and studied in the bottom photographs can only be identified to family or a higher taxon.

Some species occurring in the Gorda Ridge axial valley also occur on abyssal plains surrounding the ridge . These include holothurians (*Paelopatides confundens* and *Abyssocucumus abyssorum*), ophiuroids (*Ophiomusium multispinum*), an echinoid (*Urechinus loveni*). an asteroid (*Hymenaster perissonotus*), and a galatheid crab (*Munidopsis latirostris*), and fishes (*Coryphaenoides armatus*, *C. ?filifer*, *Antimora microlepis*, *Spectrunculus grandis*, and *Paraliparis ?rosaceus* (McCauley and Carey,

Table 3. Summary of benthic taxa observed, collected, and identified from the Gorda Ridge axial valley. (* = new species)

Taxonomic Composition

- PORIFERA
  - Hexactinellida
    - Amphidiscophora
      - Amphidiscosida
        - Hyalonematidae
          - *Hyalonema* sp.
          - *Hyalonema cf. apertum* Schultz 1887
    - Lyssascinosa
      - Euplectidae
        - *Leroyella* sp.?
      - Rossellidae
        - *Aulochone lilium* Schulze 1887 ?
        - *?Staurocalyptus fasciculatus* Schulze 1899
  - Demospongiae
    - Poecilosclerida
      - Cladorhizidae
    - Hadromerida
      - Suberitidae
        - *Suberites* sp.?

- CNIDARIA
  - Hydrozoa
    - Siphonophora
      - Rhodaliidae
  - Anthozoa
    - Alcyonaria
      - Pennatulacea
        - Virgularidae
      - Gorgonacea
        - *Keratoisis* sp. or *Lepidsis* sp.
        - Primnoidae
          - *Calyptrophora* sp.?
          - *Calyptrophora* sp.?
        - Isididae?
    - Zooantharia
      - Zoanthidea
        - *Epizoanthus/Isozoanthus* sp.
      - Antipatharia
        - *Antipathes* sp.
        - *Bathypathes* sp.
      - Actiniaria
        - Mesomyaria ?
          - Actinostolidae
            - *Actinostola ?spetsbergensis*
            - *Actinoscyphia*
      - Ceriantharia
        - *Actinoscyphia* ? sp.

Table 3. Summary of benthic taxa (cont'd)

MOLLUSCA
  Cephalopoda
    Octopoda
        Octopus sp. ?
      Cirromorpha
  Bivalvia
    Heterodonta
      Veneroida
        Malletia (Malletia) truncata Dall, 1908

ANNELIDA
    Polychaeta
        Sabellidae
            Fabrisabella sp.

ARTHROPODA
    Malacostraca
        Eucarida
         Decapoda
            Galatheidae
                Munidopsis sp.
                Munidopsis latirostris (Henderson)
          Caridea
            Pasiphaeidae
                Parapaisphae sulcatifrons
            Oplophoridae
                Hymenhodora frontalis Rathbun
        Peracarida
         Mysidacea
            Petalophthalmidae
                Pelalophthalomus armiger Wilemoes-Suhm
         Amphipoda
            Hyperiidae
                Phronima sedentaria (Forskal)

ECHINODERMATA
    Asteroidea
      Platyasterida
                Luidia sp. ?
      Spinulosida
                Echinaster sp. ?
      Euclasterida
            Brisingidae
                Freyella cf *insignis* Ludwig
            Pterasteridae
                Hymenaster perissonotus Fisher
            Asteriidae

    Ophiuroidea
                Ophiocten hastatum ?

Table 3. Summary of benthic taxa (cont'd).

Ophiuridae
- *Ophiomusium multispinum* ?
- *Ophiocantha* sp. a
- *Ophiocantha* sp. b
- *Ophiocantha* sp. c
- *Ophiurida*

Crinoidea
- Articulata
  - Comatulida
  - Millericrinida
    - *Rhizocrinus* sp.
    - Bathycrinidae
      - *Bathycrinus* sp. A
      - *Bathycrinus* sp. B
  - Cyrtocrinida
  - Hyocrinida
    - *Ptilocrinus pinnatus* Clark 1907?
    - *Thalassocrinus* n sp. *

Holothuroidea
- *Paelopatides confundens Theel*
- *Abyssocucumis abyssorum*
- *Synallactes* sp. a?
- *Synallactes* sp. b?

Echinoidea
- Holasteroida
  - Urechinidae
    - *Urechinus loveni* ?

CHORDATA
- Urochordata
  - Ascidiacea
    - Molgulidae?
      - *Culeolus sluiteri* Ritter, 1913
      - *Culeolus pyramidalis* Ritter, 1907
      - *Culeolus* sp.
      - *Bathypera ovoida* (Ritter, 1907)
      - *Ascidia* n sp. *
- Vertebrata
  - Pisces
    - Macrouridae
      - *Coryphaenoides armatus*
      - *Coryphaenoides filifer*?
      - *Coryphaenoides leptolepis*
    - Moridae
      - *Antimora microlepis*
    - Ophidiidae
      - *Spectrunculus grandis*
    - Zoarcidae
    - Liparididae
      - *Paraliparis* ?*rosaceus*
    - Bathysauridae
      - *Bathysaurus mollis*

1967; Carney and Carey, 1976; Ambler, 1980; Carney and Carey, 1980; Pearcy, Stein and Carney, 1982; Carey and Kyte, in prep.).

In addition, animals and fragments of animals retrieved from the axial valley with a rock dredge during 1986 R/V S.P. Lee cruises have been sorted and sent to appropriate specialists (Table 2). Even fragmentary specimens can provide enough information to positively identify to species some of the taxa photographed.

(2) Trends related to substrate type

Substrate types and their relative proportions influence the diversity, composition, and abundance of benthic fauna. Relative abundances (percent composition) of major taxa were compared for varying amounts of rock cover from 0 to 81-100 % in the Northern Valley segment and the Escanaba Trough (Tables 4 through 7). In the northern valley at "Far" altitude ophiuroids are more prevalent in habitats with less than 61 % rock coverage, where they comprise slightly more than 80 % of the mega-epifauna. Holothuroids (sea cucumbers) are sediment surface deposit-detritus feeders; they are more abundant in the 100 % sedimentary environment than in rockier habitats. The opposite is apparent for alcyonarians, a subclass of Anthozoa that includes soft corals, the gorgonians, and sea pens; their numbers increase as hard substrate increases. In environments with all sediment or all rock no one taxonomic group is dominant.

Similar comparisons made using photographs from higher altitudes show similar trends (Table 6 and 7). These data are biased toward large epifauna because the photographs do not show ophiuroids and other small-sized epifauna.

In the sediment-filled Escanaba Trough faunal composition also depends on the degree of rock cover, but the trends are not as clear-cut. Except for 100% sediment or 81-100% rock environments the species diversity was fairly even (Table 5).

The numerical abundance of the fauna is highest on mixed substrates of sediment and rock. On the floor of the northern Gorda Ridge, the mean abundance of all taxa taxa is highest at 1 % to 40 % rock cover (Table 8). Note that the same trends are evident at both "far" and "very far" altitudes, but that the numerical densities decrease at the higher altitudes. The smaller epifauna can not be observed in the photographs further above the substrate. In Escanaba Trough (III) the mean numerical abundance of all taxa is similar for all ranges of rock cover (Table 9).

(3) Ecological zones

Based on the geology and patterns of invertebrate distribution and abundance, the Gorda Ridge axial valley can be divided into three ecological zones - (1) the Northern, (2) the Central, and (3) the Southern, or Escanaba Trough (Fig. 6). Data from DSRV Alvin dives at stations down the valley axis show a characteristic fauna represents each zone (Fig. 2). In the northern steep valley there are stalked, hard substrate fauna, such as poriferans, alcyonarians, and crinoids. In the deep central valley crinoids and ascidians are dominant, while in the sediment-filled Escanaba Trough the abundant taxa include alcyonarians, ophiuroids, and holothuroids.

Table 4. Percent taxonomic composition of the visible benthic epifauna versus substrate at the "far altitude range - Northern Gorda axial valley (I).

PERCENT TAXONOMIC COMPOSITION VS. SUBSTRATE

I - NORTHERN GORDA ("Far" altitude)

Percent Rock Cover	Porifera	Alcyonaria	Zoantharia	Arthropoda	Asteroidea	Ophiuroidea	Crinoidea	Holothuroidea	Ascidiacea	Pisces	No. Frames
0	0.0	0.0	0.0	0.0	0.0	83.3	0.0	16.7	0.0	0.0	1
1-20	1.7	6.5	0.2	0.2	0.8	84.4	3.1	0.6	0.2	0.2	38
21-40	6.0	4.7	0.0	0.0	0.9	82.6	2.1	0.4	0.0	0.9	17
41-60	2.7	5.4	0.0	0.0	2.7	81.1	2.7	0.0	0.0	2.7	4
61-80	0.0	33.3	0.0	0.0	16.7	33.3	16.7	0.0	0.0	0.0	6
81-100	3.2	54.9	0.0	3.2	0.0	9.7	25.8	3.2	0.0	0.0	6

Table 5. Percent taxonomic composition of the visible benthic epifauna versus substrate at the "far" altitude range - Escanaba Trough (III).

PERCENT TAXONOMIC COMPOSITION VS. SUBSTRATE

III - ESCANABA TROUGH ("Far" altitude)

Percent Rock Cover	Porifera	Alcyonaria	Zoantharia	Arthropoda	Asteroidea	Ophiuroidea	Crinoidea	Holothuroidea	Ascidiacea	Pisces	No. Frames
0	0.0	15.4	15.4	0.0	15.4	7.7	0.0	46.1	0.0	0.0	12
1-20	0.0	25.0	0.0	0.0	25.0	50.0	0.0	0.0	0.0	0.0	3
21-40	0.0	46.7	6.7	0.0	6.7	36.7	0.0	0.0	3.3	0.0	7
41-60	0.0	15.6	0.0	1.6	10.9	64.1	1.6	3.1	3.1	0.0	15
61-80	0.0	14.3	0.0	0.0	7.1	78.6	0.0	0.0	0.0	0.0	3
81-100	0.0	22.2	3.7	0.0	25.9	33.3	0.0	7.4	7.4	0.0	7

Table 6. Percent taxonomic composition of the visible benthic epifauna versus substrate at the "very far" altitude range - Northern Gorda axial valley (I).

PERCENT TAXONOMIC COMPOSITION VS. SUBSTRATE

I - NORTHERN GORDA ("Very far" altitude)

Percent Rock Cover	Porifera	Alcyonaria	Zoantharia	Arthropoda	Asteroidea	Ophiuroidea	Crinoidea	Holothuroidea	Ascidiacea	Pisces	No. Frames
0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	1
1-20	8.3	10.7	0.0	0.0	2.1	67.6	8.3	1.5	0.6	0.6	44
21-40	7.8	7.0	0.0	0.0	4.5	64.6	10.7	0.0	3.3	1.2	39
41-60	5.5	19.4	1.4	0.0	5.5	50.0	16.7	0.0	2.8	0.0	18
61-80	2.4	42.9	0.0	1.2	1.2	31.0	21.4	0.0	0.0	0.0	17
81-100	4.5	28.3	0.7	0.0	6.3	18.6	37.2	1.1	1.9	0.7	73

Table 7. Percent taxonomic composition of the visible benthic epifauna versus substrate at the "very far" altitude range - Escanaba Trough (III).

PERCENT TAXONOMIC COMPOSITION VS. SUBSTRATE

III - Escanaba Trough ("Very far" altitude)

Percent Rock Cover	Porifera	Alcyonaria	Zoantharia	Arthropoda	Asteroidea	Ophiuroidea	Crinoidea	Holothuroidea	Ascidiacea	Pisces	No. Frames
0	0.0	16.7	8.2	0.0	29.2	0.0	0.0	41.7	0.0	4.2	20
1-20	0.0	24.2	3.2	0.0	25.8	19.4	1.6	21.0	3.2	1.6	22
21-40	1.1	22.8	7.2	0.0	17.2	34.4	1.7	8.9	5.6	1.1	47
41-60	7.7	30.8	1.5	0.0	13.9	35.4	0.0	6.2	4.6	0.0	25
61-80	2.9	26.1	0.0	1.5	36.2	24.6	4.4	4.4	2.9	0.0	16
81-100	2.2	35.6	0.0	6.7	31.1	20.0	2.2	2.2	0.0	0.0	16

Table 8. Mean numerical abundance of visible benthic epifauna (per photographic frame) versus substrate in the axial valley of northern Gorda Ridge (I) at "far" and "very far" altitudes.

NUMERICAL ABUNDANCE OF ANIMALS PER FRAME VS. SUBSTRATE

I - Northern Gorda Ridge

Percent Rock Cover	"FAR" ALTITUDE Mean Number per Frame (± sd)		"FAR" ALTITUDE Frames	"VERY FAR" ALTITUDE Mean Number per Frame (± sd)		"VERY FAR" ALTITUDE Frames
0	6.0	--	1	4.0	--	1
1-20	12.7	±6.7	38	7.6	±5.2	44
21-40	14.1	±8.6	16	7.3	±5.7	37
41-60	8.7	±7.0	6	4.0	±2.5	18
61-80	3.0	--	2	5.2	±3.2	18
81-100	4.3	±9.5	7	4.1	±2.6	72

Table 9. Mean numerical abundance of visible benthic epifauna (per photogaphic frame) versus substrate in the Escanaba Trough (III) at "far" and "very far" altitudes.

NUMERICAL ABUNDANCE OF ANIMALS PER FRAME VS. SUBSTRATE

III - Escanaba Trough

Percent Rock Cover	"FAR" ALTITUDE Mean Number per Frame (± sd)	"FAR" ALTITUDE Frames	"VERY FAR" ALTITUDE Mean Number per Frame (± sd)	"VERY FAR" ALTITUDE Frames
0	1.3 ±0.6	12	1.0 ±8.6	20
1-20	5.0 ±3.6	3	2.4 ±1.7	22
21-40	5.3 ±4.0	6	3.5 ±2.2	47
41-60	4.5 ±2.0	15	2.9 ±2.3	25
61-80	5.7 ±4.6	3	4.2 ±3.9	16
81-100	3.0 ±2.0	7	2.6 ±2.4	16

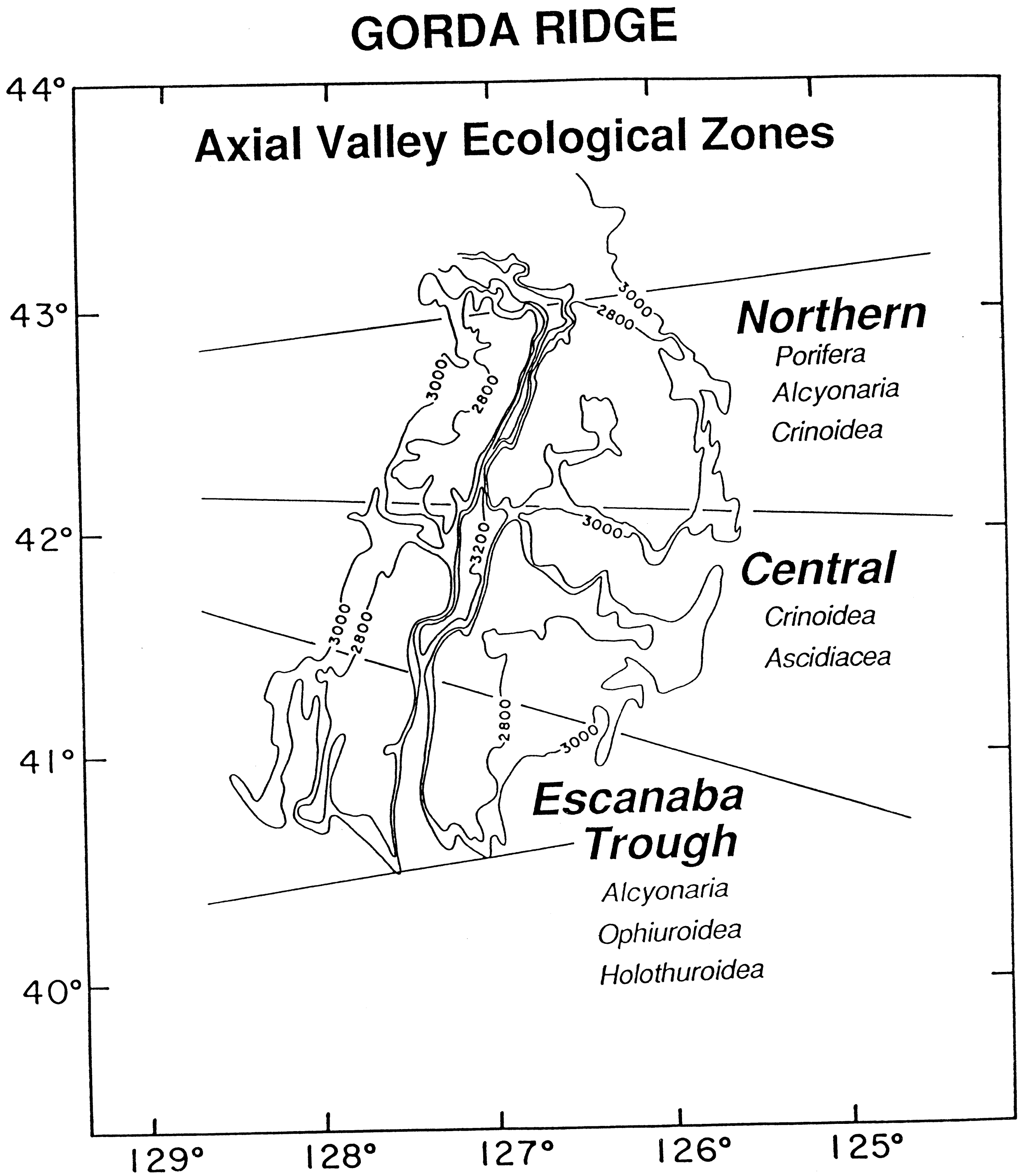

Figure 6. Gorda Ridge axial valley benthic ecological zones based on geological characteristics and indicator animals.

The visible benthic epifauna are more abundant on the axial valley floor of the northern Gorda Ridge (I) than in the Escanaba Trough (III) (Tables 8 and 9). There appear to be different standing stocks of fauna in the two environments, perhaps related to levels of food supply.

B. Fishes

At least nine different fish species from six different families were tentatively identified from fish trap collections, video tapes and photographs from Gorda Ridge. These include representatives of the families Macrouridae (Coryphaenoides armatus, C. ?filifer, C. leptolepis), Moridae (Antimora microlepis), Zoarcidae (unidentifiable species), Ophidiidae (Spectrunculus grandis, unidentified species), Liparididae (Paraliparis ?rosaceus), and Bathysauridae (Bathysaurus mollis).

Many individuals, particularly macrourids, could only be identified to family, because of low quality photography. Others could only be identified as fishes.

The first fish trap, deployed at Station SESCA, collected 12 C. armatus (4 males, 8 females), 1 S. grandis (male), and 1 zoarcid (unsexed). The second trap at Station NESCA caught 12 C. armatus (8 males, 4 females). These trap catches appear very good, although we have no other fish trap data from anywhere off Washington, Oregon, or northern California for comparison. However, trawl catches of similar numbers and biomass at the same depth would be considered large (Pearcy, Stein, and Carney, 1982; Stein, 1985).

Abundances of these taxa varied greatly between camera tracks and within camera tracks. Overall rank order of abundance of fishes observed in still photos was: (1) macrourids, (2) ophidiids, (3) zoarcids, (4) liparidids, (5) bathysaurids, and (6) morids.

DISCUSSION

A. Relative Abundance of the Fauna

Animals in the Gorda Ridge axial valley appear to be more numerous than oceanic deep-sea populations at the same depth on either sedimentary or rocky environments (VanAndel, pers. comm.; Hammond, pers. commun.; Carney and Carey, 1980; Haedrich et al.,1980; Pearcy et al., 1982). We hypothesize that this may be true because there is a larger input of food materials to the axial valley floor than at equivalent depths on the oceanic abyssal plains. Four sources of particulate organic material (POM) associated with the valley are possible: (1) from continental run-off via the Columbia River plume during its southwestern summer extension (Barnes et al., 1972; A.G. Carey, Jr., pers. observa., 1985), (2) from the entrainment of particles and the acceleration of currents by the valley walls, (3) from the downward flux of materials from biological activity in the euphotic zone and water column, and (4) from bacterial chemosynthetic primary production associated with active hydrothermal vents (Baker et al., 1987).

B. Origin of the Fauna

Results from previous studies of the mega-epifauna from Cascadia Plain, Tufts Abyssal Plain, and the Oregon continental margin (Carney and Carey, 1976; Carney and Carey, 1982; Ambler, 1980; Pearcy et al., 1982; Carey and Kyte, in prep.), suggest that much of the sediment-related fauna in Escanaba Trough is derived from the surrounding environment to the east and north (Figure 7). The holothuroids Paelopatides confundens and Abyssocucumus abyssorum are found in both the Cascadia Basin to depths of 3000 m and in Escanaba Trough at 3200 m (Carney and Carey, 1976; Carney and Carey, 1982). Enough other species are shared in common between the two environments to suggest that the fauna reached the southern Gorda Ridge axial valley through the narrow gap between the Mendocino Escarpment and the southern tip of the ridge. Though the plains fauna probably reached the axial valley from the populated areas on the south and east of the ridge, colonization by larvae could have occurred from populations living from all adjacent areas of approximately the same depth.

C. Critique of the Data

Data derived from bottom photography and videotaping suffer from problems associated with the difficulty of positive identifications of fauna in in situ photographs and from the lack of necessary detail of altitude/scale data for each photograph (See Carey et al., 1986). Many identifications are at fairly high taxonomic levels which significantly decreases their usefulness for analysis of species distributional patterns and comparative abundances of species.

Analysis of unfamiliar benthic fauna in bottom photographs results in a fairly long learning curve. Backscatter from suspended particulate material and frequent high altitudes cause indistinct images of organisms, leading to interpretation and uncertainty of taxonomic identification. Familiarity with the relatively unknown rocky substrate deep-sea fauna from non-hydrothermal vent environments has been acquired over time from close-up photographs and collected specimens. Our data, therefore, has tended to become more detailed and accurate throughout the course of our Gorda Ridge research.

The lack of usable altitude data (necessary to the nearest 0.1 m) does not allow computation of abundances per unit area for close comparisons within and between axial valley habitats and other abyssal environments. At best the altitude can be estimated to the nearest meter (Normark, pers. comm.). Note in Table 8 that the mean number of visible epibenthic animals decreases at the estimated higher altitudes because of the inability to distinguish the smaller organisms, e.g. ophiuroids. The general trends of abundance in relation to the substrate appear to be real, but the absolute numerical density data are not directly comparable.

The requirements for bottom photography differ for the fields of biology and geology. Geologists require higher altitudes, generally above 2 to 3 meters,for surveying rock forms and sedimentary structures, while biologists need closer views for identification and quantitative counts of individual taxa. Most of the photographs utililized for these biological studies are taken from high altitudes because of the primary objectives of the geological surveys and because of the very rugged topography of much of the axial valley.

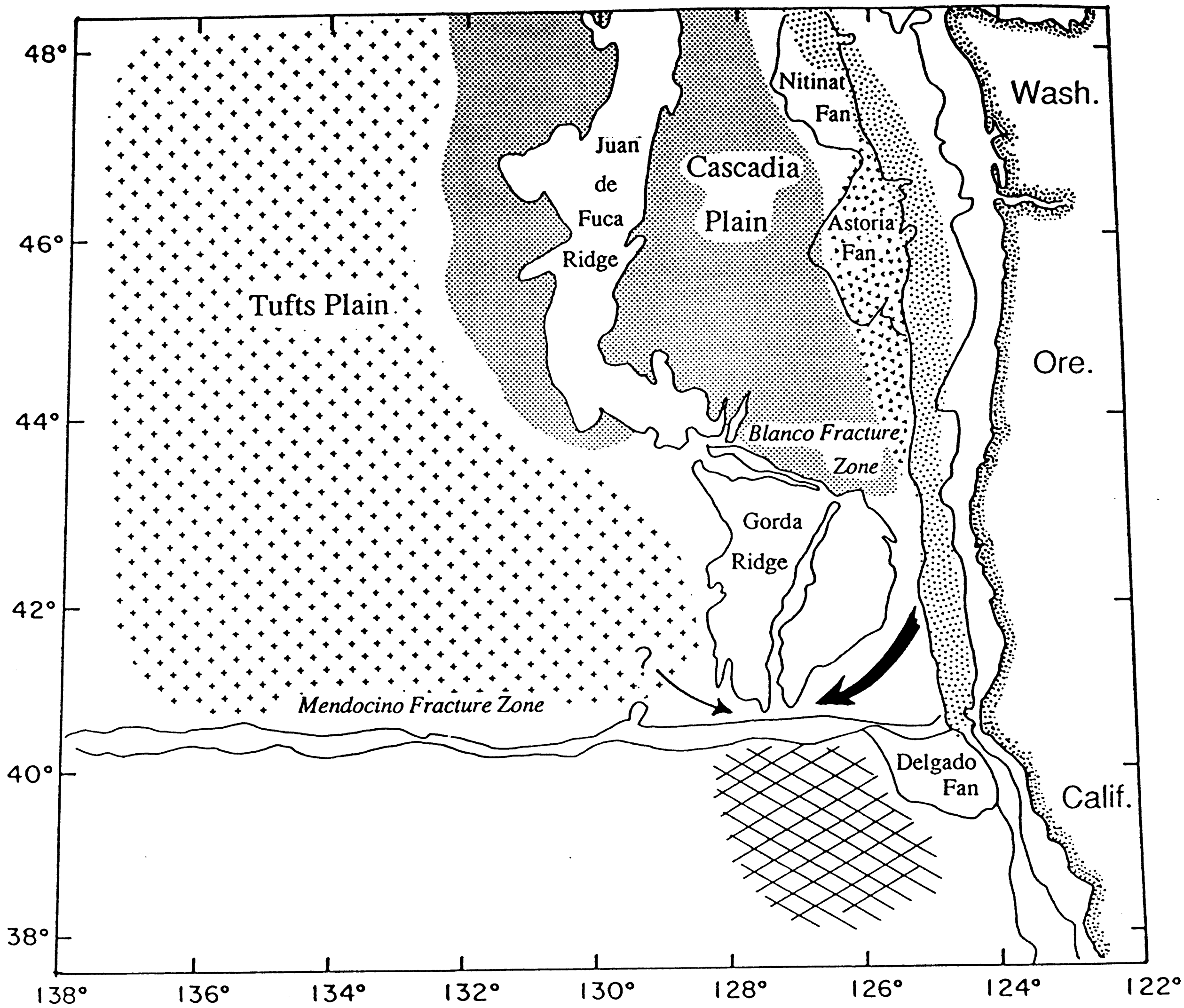

Figure 7. Zoogeographical relationships of benthic fauna on abyssal plains and the continental margin adjacent to the Gorda Ridge with suggested routes of migration into the valley of shared species.

We have utilized the expertise of taxonomic specialists to whom we sent copies of representative photographs of many species for identification. We also encouraged the collection of specimens by rock dredge and submersible manipulator whenever possible; specimens were sent to the appropriate taxonomists for positive identifications with good success.

Gaps in the geographic and depth coverage in our photo/video analyses in Escanaba Trough create an additional problem. We will supplement the present data as much as possible before presentation of a paper to the Fifth Deep-Sea Biology Symposium to be held in Brest, France.

Depth, geological, and navigational data have been received recently from the USGS for the 1986 Escanaba Trough stations occupied during the cruises L1-86-NC and L2-86-NC. Comparisons of taxonomic composition and relative abundance can now be made within and between stations. Correlations of distribution and relative abundance of taxa will be made with small-scale topography and geological features.

D. Significance of the Research

In spite of the shortcomings of the data for the above reasons, the data set is the first of its kind from the Gorda Ridge and one of the few from undisturbed oceanic ridge environments. The taxonomic list and the distributional patterns of species and higher taxa form the backbone of this final research report. These data will provide future researchers with a strong background for more detailed studies of the causes of the abundance patterns and to other process-oriented scientific questions.

We have presented two papers, one on the axial valley mega-epifauna and the other on the mega-epifauna of the surrounding plains, at the Gorda Ridge Symposium held in Portland, Oregon in May 1987. Manuscripts will be written for publication in the syposium volume; a second, expanded paper will be published in <u>Oceanologica Acta</u>

RESEARCH NEEDS

To provide more reliable quantitative information of taxonomic composition, distribution and abundance of the axial valley fauna requires additional research. The following specific needs must be satisfied:

(1) Additional specimens should be collected for positive identifications to complete a description of the epibenthic community structure in the different regions of the valley and from both rock and sediments.

(2) Further photographs and videotapes should be obtained to help complete our knowledge of distributional patterns.

(3) Better control of photographic transects including the acquisition of accurate altitude data (to the nearest 0.1 m) and lower flight path altitudes should

be obtained to provide scale for abundance computations and better photography of animals for more accurate counts and identifications.

(4) Controlled photographic-video transects should be undertaken across active hydrothermal vent fields and adjacent environments to determine the structure of any vent communities. Such surveys would also allow study of the effects of vents and associated biota on the surrounding epibenthic communities.

(5) Additional environmental data on bottom current speed direction and particle concentration, composition, and fallout should also be obtained to further define the effects of the axial valley environment and the active vent fields on the surrounding benthic fauna.

(6) Foodweb analyses by gastrointestinal tract content analysis, direct observation with submersibles, and analysis for hydrothermal vent isotopic indicators should be undertaken to more clearly understand the ecology of non-vent fauna.

CONCLUSIONS

(1) An extensive visible epibenthic fauna exists in the central axial valley of the Gorda Ridge.

(2) The invertebrate fauna appears to be comprised mainly of filter and detritus feeders with a shift in predominant feeding strategies along the axis.

(3) The taxonomic composition, even within feeding type, changes down the valley axis.

(3) Off-axis, the fauna tends to vary with depth and sediment type.

(4) Many species of soft-bottom fauna in the valley are common to the fauna on the surrounding abyssal plains.

(5) We hypothesize that the concentration of suspended particulate organic material is enhanced in the valley benthic boundary layer by topographic entrainment of currents, transportation of continental run-off by the Columbia River plume in the summer, and by the primary chemosynthetic production associated with active hydrothermal vent fields.

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CITED REFERENCES

Ambler, J. W. 1980. Species of Munidopsis (Crustacea, Galatheidae) occurring off Oregon and in adjacent waters. Fish. Bull. 78: 13-34.

Baker, E.T., G.J. Massoth, R.W. Collier, J.H. Trefry, D.Kadko, T.A. Nelsen, R.A. Rona, and J.E. Lupton. 1987. Evidence for high-temperature hydrothermal venting on the Gorda Ridge, Northeast Pacific Ocean. Deep-Sea Res. 34: 1461-1476.

Barnes, C.A., A.C. Duxbury, and A.A. Morse. 1972. Circulation and selected properties of the Columbia River effluent at sea. In: A.T. and D.L. Alverson (eds.) The Columbia River Estuary and Adjacent Ocean Waters. Univ. Washington Press, Seattle.

Carey, A.G., Jr. 1985. Benthic invertebrate organisms as vectors for dispersal of radioactive elements into the marine ecosystem: an ecological investigation at disposal site W-N. Final Research Report submitted to: Sandia National Laboratories, Albuquerque, NM.

Carey, A.G., Jr. 1987. Ecology of non-vent benthos - NE Pacific/Gorda Ridge. Paper presented at the 1987 Gorda Ridge Symposium, Portland, Oregon.

Carey, A.G., Jr., D.L. Stein, and G.L. Taghon 1986. Analysis of epifauna and infaunal community structure at the Gorda Ridge. Open-file Report 0-86-11, Oregon Dept. Geology and Mineral Industr. and the Gorda Ridge Technical Task Force, Portland, Oregon.

Carey, A.G., Jr., D.L. Stein, G.L. Taghon, and P. Rona. 1987. Patterns of distribution and abundance of mega-epifauna in the Gorda Ridge axial valley. Paper presented at the 1987 Gorda Ridge Symposium, Portland, Oregon

Carey, A.G., Jr. and M.A. Kyte (in prep.) Distributional ecology of Ophiuroidea on the Oregon continental slope and adjacent abyssal plains.

Carney, R.S. and A.G. Carey, Jr. 1976. Distribution of holothuroids on the northeastern Pacific (Oregon, U.S.A.) continental slope, shelf, abyssal plain. Thallasia Yugoslavica 12: 67-74.

Carney, R.S. and A.G. Carey, Jr. 1982. Distribution and diversity of holothuroids on Cascadia Basin and Tufts Abyssal Plain. Deep-Sea Res.29: 597-607.

Chezar, H. and J. Lee. 1985. A new look at deep-sea video. Deep-Sea Res. 32: 1429-1436.

Clague, D.A., W. Riesen, P. Quinterno, M. Holmes, J. Morton, R. Bouse, L. Morgenson, and A. Davis. 1984. Preliminary geological, geophysical, and biological data from Gorda Ridge. U.S. Geological Survey Open-File Report 84-364.

Haedrich, R., G. Rowe, and P. Polloni. 1980. The megabenthic fauna in the deep-sea south of New England. J. Mar. Res. 57: 165-179

McCauley, J.W. and A.G. Carey, Jr. 1967. Echinoidea of Oregon. J. Fish. Res. Bd. Canada 24: 1385-1401

Monniot, C. and F. Monniot. 1978. Recent work on the deep-sea tunicates. Oceanogr. Mar. Biol. Ann. Rev. 16: 181-228.

Moore, G.W. 1970. Sea-floor spreading at the junction between Gorda Rise and Mendocino Ridge. Geol. Soc. America Bull. 81: 2817-2824.

Morton, J.L., M.L. Holmes, and R.A. Koski. 1987. Volcanism and massive sulfide formation at a sedimented spreading center, Escanaba Trough, Gorda Ridge, Northeast Pacific Ocean. Geophys. Res. Letters 14: 769-772.

Morton, J.L., W.R. Normark, S.L. Ross, R.A. Koski, M.L. Holmes, W.C. Shanks III, R.A. Zierenberg, M. Lyle, and L.M. Benninger. 1987. Preliminary report, cruises L1-86-NC and L2-86-NC, Escanaba Trough, Gorda Ridge. Open-File Report 87-375-A, U.S. Geological Survey, Menlo Park, CA.

Pearcy, W.G., D.L. Stein, and R.S. Carney. 1982. The deep-sea benthic fish fauna on the northeastern Pacific Ocean of Cascadia and Tufts Abyssal Plains and adjoining continental slopes. Biol. Oceanogr. 1: 375-428

APPENDICES

A. Biological specimens collected during 1986 cruises

B. List of available bottom photographs - Summary

C. List of available bottom videotapes - Summary

D. Summary of mean total abundances of mega-epifauna per photograph frame.

E. Summary of percent composition of mega-epifauna by major taxa

F. Abstracts of papers presented at the Gorda Ridge Symposium

   (1) A.G. Carey, Jr., D.L. Stein, G.L. Taghon, and P. Rona. Patterns of distribution and abundance of mega-epifauna in the Gorda Ridge axial valley.

   (2) A.G. Carey, Jr. Ecology of nonvent benthos -Pacific/Gorda Ridge.

Appendix A. Summary list of biological specimens collected during 1986 cruises to the Gorda Ridge. (R/V S.P. Lee Cruise L3-86-NC; M/V. Transquest and DSV Sea Cliff) Received from the USGS in 3 batches.

(1) DIVE SAMPLES

	Accession No.	
Dive #658	#1	Porifera (fragments) - R2(1)
	#2	Cnidaria: Anthozoa a (6)
	#3	Cnidaria: Anthozoa b (fragments)
	#4	Bryozoa (fragments)
	#5	Nematoda (1)
	#6	Meiofauna ? (1)
	#7	Urochordata: Ascidiacea a (10) - R2 (D558?)
	#8	Urochordata: Ascidiacea b (2) (D558?)
	#9	Porifera (fragments) - R2(1)
Dive #659	#1	Cnidaria: Anthozoa a (1)
	#2	Cnidaria: Anthozoa b (34)
	#3	Bryozoa (2 fragments)
	#4	Nematoda (3)
	#5	Annelida: Polychaeta a (1)
	#6	Annelida: Polychaeta b (3)
	#7	Mollusca: Gastropoda (31)
	#8	Echinodermata: Ophiuroidea (1)
	#9	Urochordata: Ascidiacea (2)
	#10	Echinodermata: Ophiuroidea (1)
	Push Cores (2) - I and II	
Dive #662	#1	Porifera (1)
	#2	Urochordata: Ascidiacea (4)
	#3	Echinodermata: Asteroidea: Brissingidae

(2) ROCK DREDGE SAMPLES

L1-86-NC-15D	#1	Annelida: Polychaeta
	#2	Urochordata: Ascidiacea (2)
	#3	Cnidaria: Actiniaria
L1-86-NC-16D	#1	Porifera
L1-86-NC-22D	#1	Echinodermata: Ophiuroidea
	#2	Cnidaria: Gorgonacea
	#3	Annelida: Polychaeta
	#4	Arthropoda: Crustacea
	#5	Arthropoda: Crustacea

Appendix A. Summary list of biological specimens (1986) - (cont'd)

L1-86-NC-29D	#1	Arthropoda: Crustacea (Galatheidae)
	#2	Arthropoda: Crustacea
	#3	Pogonophora
	#4	Annelida: Polychaeta (?)
	#5	Echinodermata: Asteroidea
	#6	Echinodermata: Ophiuroidea
	#7	Urochordata: Ascidiacea (1)
	#8	Annelida: Polychaeta
	#9	Annelida: Polychaeta
	#10	Annelida: Polychaeta
L1-86-NC-30D	#1	Echinodermata: Holothuroidea
	#3	Echinodermata:Holothuroidea
	#2	Annelida: Polychaeta
	#4	Annelida: Polychaeta
	#5	Annelida: Polychaeta
	#6	Mollusca: Bivalvia
	#7	Cnidaria: Actiniaria
	#8	Mollusca: Cephalopoda
	#9	Arthropoda: Crustacea
	#10	Arthropoda: Crustacea
	#11	Echinodermata: Ophiuroidea (2)
L3-86-NC-03D	#1	Urochordata: Ascidiacea (3)
	#2	Chordata: Pisces: Lampanyctus regalis ?
L3-86-NC-10D	#1	Echinodermata: Ophiuroidea
L3-86-NC-11D	#1	Porifera: Hexactinellida (5)
	#2	Porifera: Hexactinellida + Demospongiae (3)
	#3	Porifera: Hexactinellida (1)
	#4	Cnidaria: Anthozoa (1)
	#5	Arthropoda: Amphipoda ? (fragments)
	#6	Echinodermata: Asteroidea (fragments - 2)
	#7	Echinodermata: Asteroidea (5 arm tips)
	#8	Chordata: Pisces: Lampanyctus regalis ?
	#9	Echinodermata: Crinoidea

NB - Selected specimens have been sent to the cooperating taxonomists; initially, only the macrofauna that can be observed in photographs or from the submersible have been identified.

Appendix B. Summary of bottom photographs taken in the Gorda Ridge axial valley.

A. NOAA, Marine Geology, Hatfield Marine Science Center, Newport, Oregon - Steven Hammond

(1) DSRV Alvin, 1984 Dives (films at HMSC)

Biology analyzed by M.A. Boudrias, G. Braun, and H.R.Jones and summarized by A.G. Carey, Jr. with statistics by G.L. Taghon (See Final Report for DOGAMI Contract # 63-630-8502, July 1986).

(a) Dive #1404
Southern Gorda Rift
41° 26"N, 127° 27'W

(b) Dive #1405
Southern Gorda Rift ("Split Volcanoes")
41° 31.5'N, 127° 26.4'W

(c) Dive #1406
Narrowgate, Gorda Rift
41° 42'N, 127° 14'W

(d) Dive #1407
North Gorda Rift
42° 46'N, 126° 46'W

B. U.S. Geological Survey, Branch of Marine Geology, Menlo Park, CA - towed camera/video fish
(Duplicate films at OSU in Benthos Laboratory)

Biology analyzed by A.G. Carey, E.M. Carey, and D.L. Stein.

1. R/V S.P. Lee, Cruise # L5-85-NC

(1) Camera Station 05C (Koski)
(2) Camera Station 01C (Koski)
(3) Camera Station 16C (Koski)
(4) Camera Station 09C (Koski)
(5) Camera Station 12C (Koski)
(6) Camera Station 15C (Koski)
(7) Camera Station 37C, Ship station #01 (Clague)

2. R/V S.P. Lee, Cruise # L6-85-NC

(1) Camera Station 01C, Ship station #21
(2) Camera Station 21C, Ship Station #01 (Morton)
(3) Camera Station 33C, Ship station #02 (Morton)

C. NOAA, Meteorological and Oceanographic Laboratory, Miami, Florida - Peter Rona

(1) 1985, Tow #2, Station GR-9
Reel # 1,2 (also selected black and white prints)

(2) 1985, Tow #3, Station GR-5
Reel # 1,2,3 (also selected black and white prints)

(3) 1986, Tow #4, Station GR-14
Reel # 1,2,3,4

D. USGS, Branch of Marine Geology, Menlo Park, California - William Normark

(01) 1986, SESCA, L1-86-NC
Station 2, CS #1, 07/03/86
Reel #1,2

(02) 1986, SESCA, L1-86-NC
Station 5, CS #2, 07/04/86
Reel #1,2

(03) 1986, SESCA, L1-86-NC
Station 13, CS #4, 07/07/86
Reel #1,2,3

(04) 1986, SESCA, L1-86-NC
Station 17, CS #5, 07/08/86
Reel #1,2

(05) 1986, SESCA, L1-86-NC
Station 21, CS #6, 07/09/86
Reel #1,2

Gorda Ridge Bottom Photograph Summary - cont'd

(06) 1986, NESCA, L1-86-NC
Station 28, CS #7
Reel A, B

(07) 1986, NESCA, L1-86-NC
Station 32, CS #8
Reel A,B

(08) 1986, SESCA, L2-86-NC
Station 3C, CS #2, 07/19/86
Reel #1,2

(09) 1986, NESCA
L2-86-NC, Station 19, Camera Station #3
Reel A,B

(10) 1986, SESCA, L2-86-NC
Station 27C, CS #4, 07/27/86
Reel #1,2

E. DSV-4 Sea Cliff, U.S. Navy (Interior cameras)

(1)	Dive #656	Normark, Holmes
(2)	Dive #657	Lyle, Carey
(3)	Dive #658*	Zierenberg, Holmes
(4)	Dive #659*	Zierenberg, Wiltshire
(5)	Dive #660*	Wiltshire, SUBDEVGRP pilot
(6)	Dive #661*	Holmes. SUBDEVGRP pilot
(7)	Dive #662*	Zierenberg, Holmes
(8)	Dive #883*	Zierenberg, Wiltshire

* malfunction of flash synchronization for port camera

E. DSV-4 Sea Cliff, U.S. Navy (exterior camera)
(NOT AVAILABLE AT OSU)

(1) Dive # 656
(2) Dive # 657
(3) Dive # 658
(4) Dive # 559
(5) Dive # 660
(6) Dive # 661
(7) Dive # 662
(8) Dive # 663

Appendix C. Summary of bottom videotapes taken in the Gorda Ridge axial valley.

A. U.S.G.S., Branch of Marine Geology, Menlo Park, California - towed camera/video fish
(Duplicate videotapes at OSU Benthos Laboratory)

Tapes viewed by D. Stein and A.G. Carey, Jr.

1. R/V S.P. Lee Cruise L5-85-NC

(1) Camera station #01, Ship station #01C
16 August 1985, Koski
Tape #1,2,3

(2) Camera station #02, Ship station #05C
18 August 1985, Koski
Tape #1,2,3

(3) Camera station #03, Ship station #09C
19 August 1985, Koski
Tape #1,2,3

(4) Camera station #04, Ship station #12C
20 August 1985, Koski
Tape #1,2,3

(5) Camera station #05, Ship station #15C
21 August 1985, Koski
Tape #1,2,3

(6) Camera station #06, Ship station #37C
28 August 1985, Clague
Tape #1,2,3

(7) Camera Station #07, Ship station #41C
29 August 1985, Clague
Tape #1,2,3

(8) Camera station #08, Ship station #46C
30 August 1985, Clague
Tape #1,2,3

2. R/V S.P. Lee Cruise L6-85-NC

(1) Camera station #01, Ship station #33
17 September 1985, Morton.Holmes

Appendix C. (cont'd)

C. U.S. Geological Survey - towed camera/video fish
(Duplicate videotapes at OSU Benthos Laboratory)

Tapes viewed by D. Stein and A.G. Carey, Jr.

1. R/V S.P. Lee Cruise L1-86-NC

   (1) Camera station #02, Ship station #05
   Tape #1,2,3

   (2) Camera station #03, Ship station #09
   Tape #1,2,3

   (3) Camera station #04, Ship station #13
   Tape #1,2,3

   (4) Camera station #05, Ship station #17
   Tape #1,2,3

   (5) Camera station #06, Ship station #21
   Tape #1

   (6) Camera station #07, Ship station #28
   Tape #1,2,3

   (7) Camera station #08, Ship station #32
   Tape #1,2,3

2. R/V S.P. Lee Cruise L2-86-NC

   (1) Camera station #01, Ship station #01
   Tape #1,2,3

   (2) Camera station #02, Ship station #03C
   Tape #1,2,3

   (3) Camera station #04, Ship station #27C
   Tape #1,2,3

   (4) Camera station #03, Ship station #19
   Tape #1,2,3

3. DSV-4 Sea Cliff/ R/V/ Transquest
Interior video-camera (handheld)
-- August - September, 1986

   (1) Dives #656-#663
   Tapes #1,2,3,4

Appendix D

TABLE 1. Faunal Abundance at USGS Camera Stations (Cruise L5-85-NC)

Station	No. of Frames	Altitude (est.)	Substrate	Total No. Animals	Average No. Animals per Frame
01C	72	Close	Sediment	800	11.1
	6	Far	Sediment	37	6.2
05C	43	Close	Sediment	187	4.4
	37	Far	60% rock	183	5.0
09C	2	Very Far	10-30% rock	6	3.0
12C	3	Close	Sediment	18	6.0
	22	Far	Mixed	101	4.6
	33	Very Far	Mixed	78	2.4
15C	6	Close	60% rock	49	8.2
	15	Far	Sediment	97	6.5
	5	Very Far	Sediment	9	1.8
16C	21	Close	Sediment	258	12.3
	14	Far	Mixed	122	8.7

Appendix D

Table 2. Faunal Abundance at Station GR-14 (NOAA Cruise 1986, Camera Tow #4)
Depth 3000-3100m

No. of Frames	Altitude (est.)	Substrate	Total No. Animals	Average No. Animals per Frame
0	Close	Sediment	0	0.0
1	Far	Sediment	6	6.0
1	Very Far	Sediment	4	4.0
1	Close	1-20% rock	3	3.0
38	Far	"	494	13.0
44	Very Far	"	336	7.6
0	Close	21-40% rock	0	0.0
17	Far	"	235	13.8
39	Very Far	"	243	6.2
0	Close	41-60% rock	0	0.0
4	Far	"	37	9.3
18	Very Far	"	74	4.1
1	Close	61-80% rock	4	4.0
2	Far	"	6	3.0
17	Very Far	"	84	4.9
2	Close	81-100% rock	7	3.5
6	Far	"	31	5.2
73	Very Far	"	269	3.7

Appendix D

Table 3. Faunal Abundance at USGS Camera Station #1 (L6-85-NC)

No. of Frames	Altitude (est.)	Substrate	Total No. Animals	Average No. Animals per Frame
1	Close	Soft sediment	2	2
12	Far	"	13	1.1
20	Very Far	"	25	1.3
1	Close	1-20% rock	0	0
3	Far	"	4	1.3
22	Very Far	"	62	2.8
0	Close	21-40% rock	0	0
7	Far	"	30	4.3
47	Very Far	"	180	3.8
0	Close	41-60% rock	0	0
15	Far	"	64	4.3
25	Very Far	"	65	2.6
0	Close	61-80% rock	0	0
3	Far	"	14	4.7
16	Very Far	"	69	4.3
2	Close	81-100% rock	4	2
7	Far	"	27	3.9
16	Very Far	"	45	2.8

Appendix E

TABLE 1. PERCENT TAXONOMIC COMPOSITION vs. SUBSTRATE, Axial Valley, Gorda Ridge USGS Cruise L6-85-NC, Morton, Ship Station 21, Camera Station #1

Altitude (est.)	Substrate (% rock cover)	Porifera	Alcyon-aria	Zoantharia	Arthro-poda	Aster-oidea	Ophiur-oidea	Crin-oidea	Holothur-oidea	Echin-oidea	Urochor-data	Pisces	No. of Frames	Total No. of Animals
Close	0%			50.00		50.00							1	2
	1-20%												1	0
	21-40%												0	0
	41-60%												0	0
	61-80%												0	0
	81-100%		25.00	25.00		25.00	25.00						2	4
Far	0%		15.39	15.39		15.39	7.69		46.15				12	13
	1-20%		25.00			25.00	50.00						3	4
	21-40%		46.65	6.66		6.66	36.60				3.33		7	30
	41-60%		15.63		1.56	10.94	64.06	1.56	3.13		3.13		15	64
	61-80%		14.28			7.14	78.57						3	14
	81-100%		22.22	3.70		25.92	33.33		7.40		7.41		7	27
Very Far	0%		16.00	8.00		28.00			40.00	4.00	4.00		20	25
	1-20%		24.19	3.23		25.81	19.36	1.61	20.97		3.22	1.61	22	62
	21-40%	1.11	22.78	7.22		17.22	34.44	1.67	8.89		5.56	1.12	47	180
	41-60%	7.69	30.78	1.54		13.85	35.39		6.16		4.62		25	65
	61-80%	2.89	26.08		1.45	36.24	24.64	4.35	1.45		2.89		16	69
	81-100%	2.22	35.55		6.66	31.10	20.00	2.22	2.22				16	45

Appendix E

TABLE 2. PERCENT TAXONOMIC COMPOSITION vs. SUBSTRATE, Axial Valley, Gorda Ridge USGS Cruise, L5-85-NC

Cam. Sta.	Altitude (est.)	Substrate (% rock cover)	Porifera	Alcyonaria	Zoantharia	Arthropoda	Asteroidea	Ophiuroidea	Crinoidea	Holothuroidea	Echinoidea	Urochordata	Pisces	No.of Frames	Total No. of Animals
09C	Very Far	10-30%					33.3		56.7					2	6
05C	Close	Sediment			0.54		0.54	97.3		1.60				43	187
	Far	0-60% Rock					3.28	91.26		3.83	1.09		0.55	37	183
01C	Close	Sediment					0.50	97.75		1.63			0.13	72	800
	Far	Sediment						91.89		5.41			2.70	6	37
16C	Close	Sediment					0.39	96.51		3.10				21	258
	Far	Mixed					2.46	95.90		1.64				14	122
12C	Close	Sediment					5.55	94.44						3	18
	Far	Mixed	1.04	1.04	2.08		1.04	75.00	12.50	6.25			1.04	22	96
	Very Far	Mixed	11.54	17.95	1.28	1.28	2.56	33.33	30.77	1.28				33	78
15C	Close	0-10% rock					2.04	93.87		2.04			2.04	6	49
	Far	Sediment					2.06	91.75		6.19				15	97
	Very Far	Sediment		11.11				33.33		55.54				5	9

Appendix E

TABLE 3. PERCENT TAXONOMIC COMPOSITION vs. SUBSTRATE
Northern Gorda Ridge, Axial Valley, NOAA, Site GR14, Tow #4
Depth 3000-3100 meters, July - August 1986, Peter Rona (not all reels have been analyzed)

Altitude (est.)	Substrate (% rock cover)	Porifera	Alcyonaria	Zoantharia	Arthropoda	Asteroidea	Ophiuroidea	Crinoidea	Holothuroidea	Echinoidea	Urochordata	Pisces	No. of Frames	Total No. of Animals
Close	0%												0	0
	1-20%		33.33				33.33	33.33					1	3
	21-40%												0	0
	41-60%												0	0
	61-80%		50.00				25.00	25.00					1	4
	81-100%	14.29	42.86			14.29		28.57					2	7
Far	0%						83.33		16.66				1	6
	1-20%	1.64	6.62	0.21	0.21	0.84	86.34	3.11	0.63		0.21	0.21	38	483
	21-40%	5.96	7.23			0.86	82.55	2.13	0.43			0.86	17	235
	41-60%	2.78	5.55			2.78	83.33	2.78				2.78	4	36
	61-80%	33.34				16.67	33.33	16.67					2	6
	81-100%	3.23	54.84		3.23		9.68	25.81	3.23				6	31
Very Far	0%						100.00						1	4
	1-20%	8.33	10.71			2.08	67.56	8.34	1.49		0.60	0.60	44	336
	21-40%	7.89	7.05			4.57	65.15	10.79			3.33	1.26	39	241
	41-60%	5.56	18.06	1.39		5.56	50.00	16.67			2.78		18	72
	61-80%	2.38	42.86		1.19	1.19	30.95	21.42					17	84
	81-100%	4.49	28.47	0.75		6.38	18.73	37.46	1.14		1.87	0.76	73	267

Appendix F. (1) Abstract of paper presented at the Gorda Ridge Symposium held by the Gorda Ridge Technical Task Force and the Oregon Department of Geology and Mineral Industries at the Hilton Hotel, Portland, Oregon, May 11-13, 1987.

CAREY, ANDREW G., JR., DAVID L. STEIN, GARY L. TAGHON. College of Oceanography, Oregon State University, Corvallis, OR 97331, USA, and RONA, PETER A., NOAA Atlantic Oceanographic and Meteorological Laboratory, Miami, FL 33149, USA.
PATTERNS OF DISTRIBUTION AND ABUNDANCE OF MEGA-EPIFAUNA IN THE GORDA RIDGE AXIAL VALLEY.

Based primarily on bottom photographs and videotapes taken by the USGS, NOAA, and the U.S. Navy (1984-86), we have described the taxonomic composition and patterns of distribution and abundance of the benthic epifauna.

Filter-feeding taxa, including endemics, are present in all rocky environments. Crinoids appear to be prevalent at the northernmost stations and ascidians, near the valley midsection. Fish assemblages associated with rock and sediment substrates differ in composition and abundance. Deposit-detritus feeding organisms are interspersed with stalked suspension feeders in the sediment-filled southern Escanaba Trough. Many species associated with sediments are similar to those found on the surrounding abyssal plains. The biomass is unevenly distributed.
la:

The valley fauna is abundant and diverse, undoubtedly supported by the downward flux of organics, including run-off from the Columbia River. In addition, polymetallic sulfide deposits and scattered hydrothermal venting may provide energy sources for sulfur-based food webs.

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Appendix F. (2) Abstract of a paper presented at the Gorda Ridge Symposium held by the Gorda Ridge Technical Task Force and the Oregon Department of Geology and Mineral Industries at the Hilton Hotel, Portland, Oregon, May 11-13, 1987.

CAREY, ANDREW G., JR. College of Oceanography, Oregon State University, Corvallis, OR 97331, USA. VENT AND NONVENT BENTHIC ECOLOGY.

The benthic ecology of deep-sea hydrothermal vent and nonvent environments are described and contrasted. The vent communities are productive and distinctive with characteristic species. Studies on Pacific and Atlantic spreading ridges provide evidence that the vent communities within, and between, ocean basins differ in taxonomic composition. There are similar large organisms, however, and chemosynthetic bacterial production processes are comparable. Food web structures can differ with varying degrees of detritivory and suspension feeding. The rocky nonvent faunas are widespread within a ridge system and are primarily suspension feeders, while the sediment epifauna within axial valleys have strong similarities to benthos from the surrounding abyssal plains and feed on surface sediments and detritus. Abyssal sediment fauna form taxonomically diverse communities; they are generally deposit feeders, small in size, and zoogeographically widespread.

The vent communities exist as productive assemblages in the food-limited deep-sea. They have evolved in response to bacterial chemosynthesis based on large amounts of reduced compounds in the hydrothermal fluids.