THE FORAMINIFERAL SEQUENCE

IN THE BASS BASIN

By

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Contents

A. INTRODUCTION

The Bass Basin is the central one of the three Bass Strait Basins. It is a discrete basin, being separated from the Gippsland Basin in the east and the Otway Basin in the west by ridges of metasediments and igneous rocks.

The following six wells have been drilled in the offshore portion of the basin; Bass 1, 2 and 3, Pelican 1 and 2, and Cormorant 1. Conventional cores, sidewall cores and rotary cuttings have been examined from these wells and foraminifera distribution charts assembled for all wells except Pelican 2. In all wells there is a continuous sequence of marine sediments from Eocene to Pliocene age. This sequence is over 5000' thick and is on top of non-marine rocks of Paleocene and Eocene age.

The marginal areas of the basin consist of the north coast of Tasmania, portion of the Victorian coast and the islands of the Flinders Island chain in the east and the King Island chain in the west. Tertiary marine rocks outcrop sporadically in these marginal areas. Many of these outcrops have been visited and material collected and examined. Further details were obtained from an unpublished thesis by Qulity (1968). Summarised information is given by Quilty (1966). The oldest marine Tertiary strata are at Fossil Bluff, Wynyard, Tasmania which contain faunas of the uppermost Oligocene and lowermost Miocene. Other outcrops on the margins are of lower Miocene age.

The marginal sequences are in no place complete and do not duplicate those of the offshore wells. Sedimentation obviously was delayed in the marginal areas and was interrupted from time to time due probably to structural movements. However, the Anglesea to Torquay (Victoria) outcrop section duplicates the Bass Basin offshore marine sequence from Eocene to mid Miocene. This duplication is not only micropaleontological but also lithological. Strictly speaking the Anglesea area is not in the Bass Basin, being north of the Mornington Peninsula to King Island high and is therefore in the Otway Basin. The Bass Basin sequence is not duplicated in the Otway Basin proper, i.e., west of Cape Otway. It can be suggested that the Mornington Peninsula to King Island high was not effective as a sill during mid Tertiary sedimentation.

B. BIOSTRATIGRAPHY

The biostratigraphic sequences of the Bass Basin can be subdivided in the broad terms of Taylor's (1966) letter scheme for the Gippsland Basin. There has been further subdivision of the Gippsland Zonules, which is not possible in the Bass Basin apart from subdivision of Zonule I. This inability to refine the Zonules suggests immediately that the Bass Basin was relatively shallow with only a "minimal layer" planktonic association present. This "minimal layer" concept is that of Taylor & Mee (1971) based on a study of the modern Gippsland planktonic biofacies. In deeper regions of the Gippsland Basin the water column is thicker and more complex so that extra planktonic associations are mixed with the "minimal layer" association in the modern sediment sample. Thus, in a Tertiary sample, the thicker the water column was above the sample site, the greater the chance of biostratigraphic subdivision. Conversely, the inability to subdivide biostratigraphically indicates the thin water column. Although only 6 locations have been drilled in the offshore Bass Basin, the scatter is such that it can be confidently assumed that in no place can further subdivision of the Bass Basin biostratigraphically be achieved.

The biostratigraphic sequences will be discussed briefly in ascending order; the scheme is summarised on Table 1 and greater details are presented in the distribution charts. Figure 1 gives the interpreted depths of the various Zonules in Bass 1, 2 and 3, Pelican 1 and Cormorant 1.

Eocene. The earliest faunas are assumed to be of mid to upper Eocene age on grounds of super-position in an unbroken sequence. The faunas are dominated by Bathysiphon spp. and Haplophragmoides spp. without any planktonic species. Towards the top of this formation Zonule K planktonic species are present. These species include Globigerina linaperta and G. ampliapertura.

Zonule K occurs within the top of the Demons Bluff Formation in Bass 3 and extends upwards through the sandy unit into the base of the marl. In the other wells it is in the sandy unit immediately on top of the Demons Bluff Formation and extends into the marl. This indicates a degree of diacronuity of the onset of open marine conditions in the basin.

Oligocene. Zonule J faunas are well developed in the base of the marl sequence in all wells apart from Pelican. This unit contains the highest appearance of Globigerina angioporoides, Globorotalia testarugosa and Chiloguembelina cubensis.

Zonule I can be subdivided in Bass 1 and 3 and Cormorant 1. The subdivision into I-2 is based on the presence of Globorotalia extans and Guembelitra stavensis, together with normal Zonule I indicators of Globigerina euapertura and Globorotalia opima opima. Unit I-2 is developed only sporadically in the Gippsland Basin where it is seldom present in the deeper water sequences. It is strange that an association can be recognized in shallow water but not in deep water; being contrary to the findings of Taylor & Mee (1971). The explanation may be that the diagnostic species were susceptible to selective CaCO3 solution where the water column was thicker.

Zonule I-1 is clearly recognized in all wells apart from Pelican where planktonic faunas are sparse and represented by few specimens.

Lower Miocene. The boundary between the Oligocene and Miocene is taken for convenience at the disappearance of Globigerina euapertura and the appearance of Globigerina woodi. The Zonule H faunas are fairly nondescript containing mainly Globigerina spp. Upwards through the unit G. woodi connecta appears. In the Gippsland Basin this appearance, together with the presence of other species, is taken as the beginning of Zonule H-1. However, the faunas in the Bass Basin are not diagnostic enough to enable this subdivision.

Zonule G contains the first appearance of Globigerinoides trilobus which leads to the Orbulina lineage. Clear recognition of Zonule F is only possible in Bass 3; the other wells do not contain the G. bisphericus association in large enough numbers to enable clear recognition of the unit.

Upper Miocene. The base of the upper Miocene corresponds with the base of Zonule E which is recognized on the presence of Orbulina-like forms. Zonule E is well developed and easily recognized in all wells. This is believed to be due to the fact that it is the point of maximum transgression throughout the basin, even though it does not appear to reach the marginal areas.

Zonule D is indicated by the first appearance of the completely globular Orbulina universa.

Zonule C is diagnozed by the replacement of Globorotalia mayeri barisaensis by G. mayeri mayeri. This unit also contains G. miotumida. The Zonule is recognized in Bass 1, 2 and 3 but cannot be clearly distinguished in Pelican or Cormorant. The other unit of the upper Miocene, Zonule B, is not clearcut in any of the wells apart from Bass 1.

Pliocene. This is represented by Zonule A in the Gippsland Basin, however, the diagnostic species Globorotalia inflata is not present in the Bass Basin and the Pliocene cannot be clearly distinguished.

The Bass Basin Zonules are similar to those originally proposed by Taylor (1966). Table 2 shows the correlation with planktonic foraminiferal zonation proposed for southern Australia and New Zealand and the worldwide zonation proposed by Blow (1969). There is close agreement between the Bass Basin and South Australian schemes by Lindsay (1967) and Ludbrook & Lindsay (1969). This is especially so with regard to the upper Eocene and Oligocene zonation of Lindsay, in that Zonules K, J and I-2 correspond exactly with his Globigerina linaperta, Chiloguembelina cubensis and Guembelitra stavensis Zones, respectively. This close agreement is possible because both the South Australian and Bass Basin biostratigraphic schemes are based on shallow water foraminiferal sequences. Correlation with the New Zealand zonation of Jenkins (1966 & 1967) is not as close as correlation between New Zealand and the Gippsland Basin. Once again this is a reflection of the depositional depth as the closely subdivided New Zealand zonation is based on deeper water sequences. For example, Zonule H

can be subdivided in Gippsland so that H-2 and H-1 correspond with the New Zealand Globigerina woodi woodi and G. woodi connecta Zones respectively.

Only a very broad correlation can be achieved with Blows (1969) worldwide scheme. This is due to the fact that Blow's scheme is based on deep water tropical sequences rather than the cool temperate regime of the Bass Basin and South Australia. There was apparent interconnection between Gippsland Basin, New Zealand and the central Pacific region during the mid Tertiary, however, the hydrological conditions in this area did not extend across the narrow divide between the Gippsland and the Bass Basins. Therefore, because of paleoclimatological, paleogeographical and structural reasons worldwide correlation of the Bass Basin becomes tenuous.

One fact that does emerge in the attempted correlations with the worldwide schemes of Blow (1.c.) and Berggren (1970) is that the base of the lower Miocene should be placed within and not at the base of Zonule H. The paucity of diagnostic species makes the placement of the lower Miocene a matter of convenience in the Bass Basin, but the presence of Globorotalia kugleri in the Gippsland Basin enables the lower Miocene/Oligocene boundary to be placed at the junction between Zonule H-1 and the underlying Zonule H-2.

Because of the absence of diagnostic faunas at the top of the Miocene, a two-fold division of this epoch is used in the Bass and Gippsland Basins rather than the more common threefold division of lower, middle and upper. The lower/upper Miocene boundary is placed at the base of Zonule E and coincides with the first appearance of the Orbulina-like forms. The failure to identify middle Miocene does not imply that it is absent, but reflects our inability in the Bass Basin to identify it precisely.

C. DEPOSITIONAL HISTORY

The main conclusions from the Biostratigraphic distribution are:

1. That the onset of an open marine transgression occurred in uppermost Eocene times. The direction of this transgression was from the west towards the east. In other words the western sill was opened before the eastern one.

2. The transgression progressed across the basin during Oligocene times but was not completely effective in the Pelican area.

3. The transgression reached a peak in the upper Miocene Zonule E throughout the offshore part of the basin, but does not appear to have reached the margins.

All wells show the same general sequence of depositional events. This history is summarised on Figure 2 for Bass 1 well. The initial marine event was in the mid to late Eocene when marine deposition was in a barred basin with anaerobic conditions or on a broad tidal flat or salt marsh. Faunas are entirely arenaceous, indicating poor conditions with either fluctuating salinities or restriction of circulation reducing the amount of oxygen in the environment. These conditions appeared throughout the Demons Bluff Formation, although calcareous benthonic species appear higher in the unit. These calcareous forms are dominated by the thick shelled cassidinids and the uvigerinids, indicating poorly oxygenated circulation. As suggested, the water was very shallow and the sediment could have, at times, been exposed.

At the beginning of the Oligocene there was a gradual overflow of oceanic currents marked by a rapid increase of planktonic foraminifera, an increase in the diversity of calcareous benthonic forms, and a decrease in the percentage of arenaceous species. This is suggestive of improved circulation throughout the water column. By analogy with the present, the depth was from 110' to 500', indicating inner to outer continental environments.

In Bass 1, during the lower Miocene, open continental shelf conditions prevailed with gradual deepening towards the top of the lower Miocene. This was interrupted by vulcanism which must have taken place on the sea floor as there

is no environmental break between the base and the top of the volcanic interval (see fig. 1). In the upper Miocene (shown as mid Miocene on fig. 2), open continental conditions continue with a gradual shallowing towards the top of the sequence.

The graphical presentation of the paleoenvironments of five of the Bass Basin wells is shown in Fig. 1 and this indicates that the environmental trend of Bass 1 is similar to that in the other wells. However, differences in detail are evident.

1. The Bass 2 sequence was deposited in relatively shallower conditions during the Oligocene and lower Miocene but deepened substantially at the beginning of the upper Miocene (Zonule E) which corresponds to the transgressive peak mentioned earlier. After Zonule E times there is a rapid decrease in water depth at a more accelerated pace than in Bass 1.

2. The curve for Bass 3 corresponds fairly closely with that for Bass 1 except that a transgressive peak was reached slightly later in the upper Miocene.

3. During the lower Miocene conditions at Cormorant 1 are generally shallower than those in the three Bass wells. The upper Miocene is represented by calcarenites rather than by marls.

4. After the initial marine transgression in Pelican 1 there is a considerable decrease in water depth with calcarenites being deposited during the Oligocene. The suggested environment is innermost continental shelf which is shallower than the environment represented in the outcrop section at Wynyard immediately to the south. The Wynyard outcrop is on or close to the southern margin of the basin yet it was deposited in deeper water during the Oligocene and lowermost Miocene than at Pelican. The only possible seaway is from the west between Pelican and Wynyard. Field examination shows little possibility of an Oligocene to lower Miocene seaway across the northwestern corner of Tasmania. Wynyard is within the fault zone. It is suggested that Pelican was a structural high during the Oligocene to lower Miocene. The deepest conditions in Pelican are represented by outer continental shelf deposits at the beginning of the upper Miocene (Zonule E). This corresponds with the transgressive peak generally within the basin. There is a rapid decrease in water depth after this peak and calcarenites are prevalent throughout the rest of the upper Miocene.

The major conclusion is that the Bass Basin was occupied by a shallow, partially silled sea during the mid Tertiary. Oceanic circulation was from the west during this period with little influence coming from the Gippsland Basin in the east. This indicates that the western sill was more reduced in effectiveness than the eastern sill or it could merely be an expression of the hydrological circumstances which appear to have been similar to those operating today. Even the benthonic faunas of the Bass Basin are more similar to those of the Otway Basin and South Australia than they are to the Gippsland Basin. The shallow nature of the basin is assumed by analogy with foraminiferal distribution on the modern Gippsland sea floor (Taylor & Mee, 1970) and samples examined from the sea floor at Bass Basin drilling sites. Marked differences in assumed water depths are evident in some of the drilled sections (see fig. 1). These differences do not appear to be due purely to proximity to the basin margins, therefore, the Bass Basin sea floor was not uniformly flat or gently sloping towards the centre of the basin as it is today. It is believed that mid Tertiary sedimentation was structurally controlled.

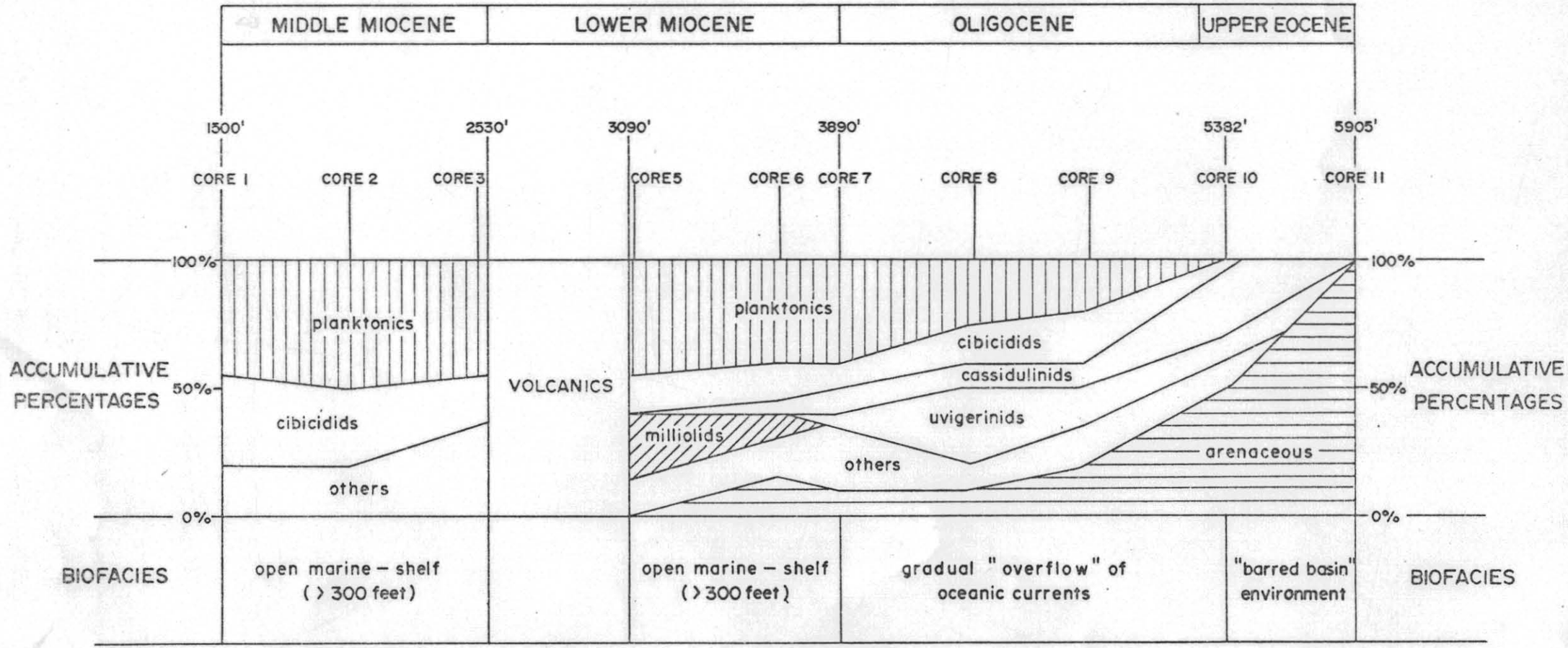

FIG. 2 – FORAMINIFERAL BIO-FACIES SEQUENCE – ESSO BASS No.1 WELL

(based on accumulative % of dominant faunal elements)

5 cm

INTERPRETATIVE

151

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009009

BASS BASIN PALEOTOPOGRAPHY

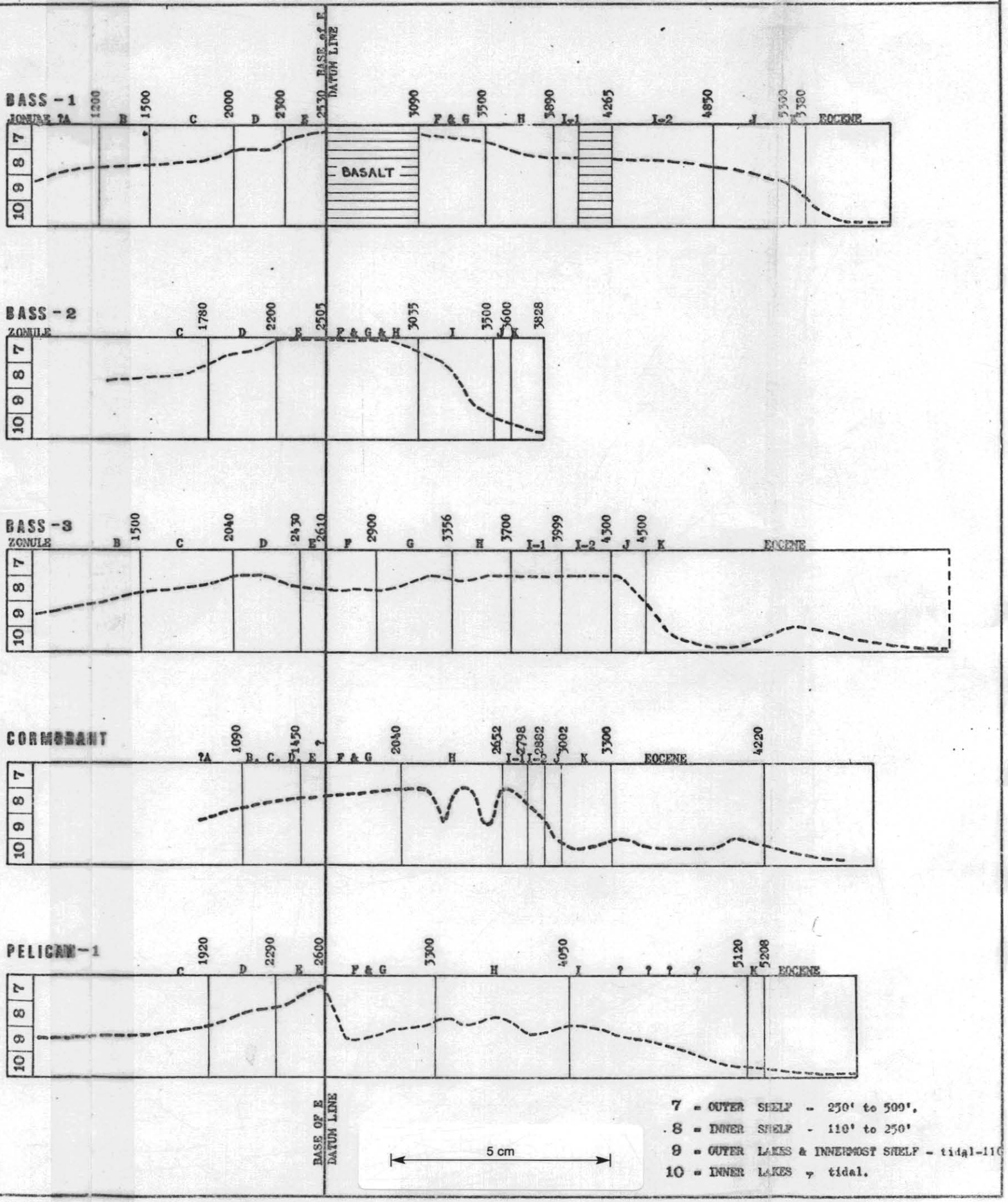
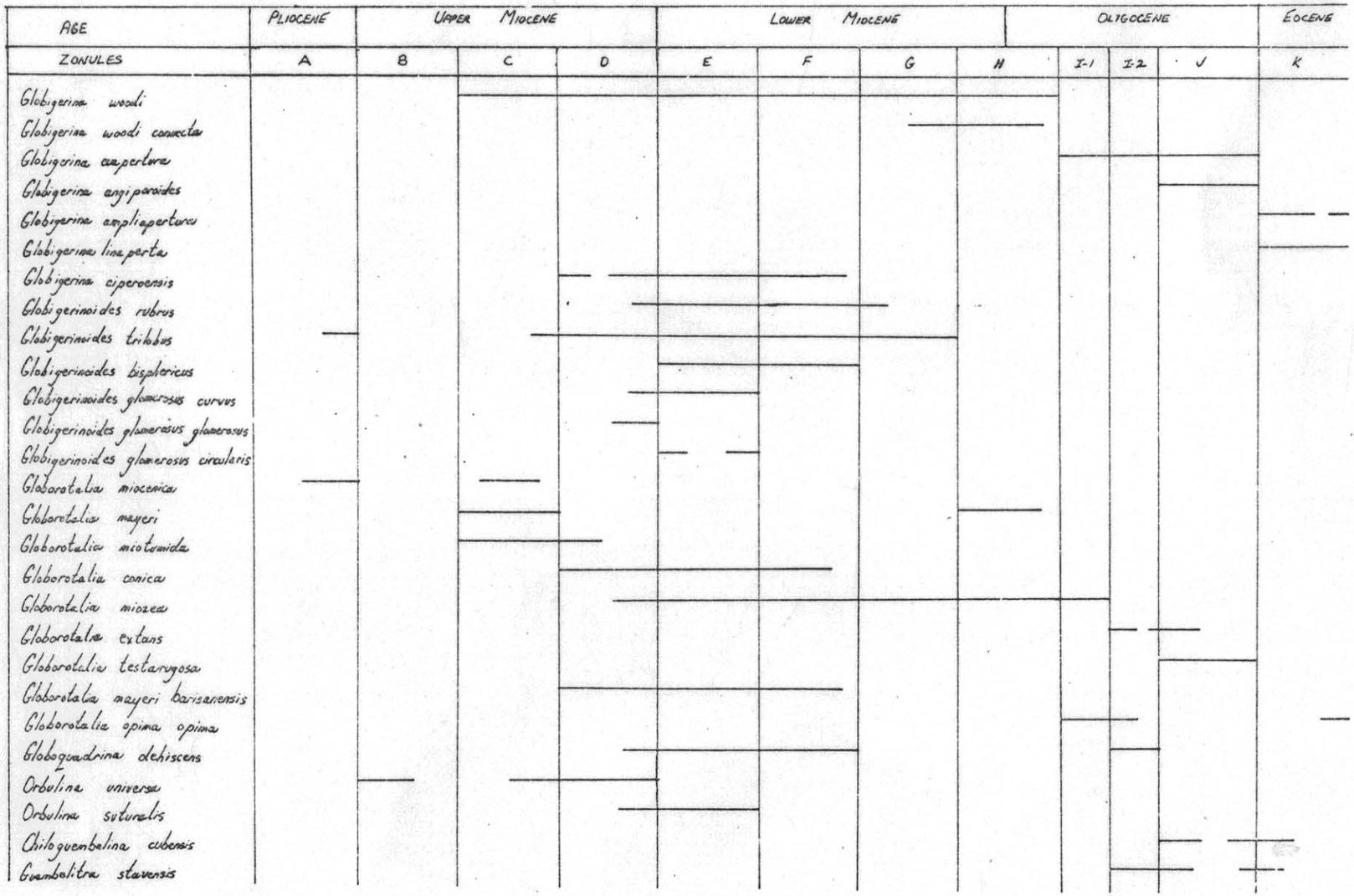


TABLE - 1 BASS BASIN - PLANKTONIC FORAMINIFERAL BIOSTRATIGRAPHY



009011

BASS - 1

Sheet - 1 - Distribution of Planktonic species & biostratigraphic zonation.

Sheets -2-5 - Distribution of calcareous & arenaceous benthonic foraminifera as well as other fauna on sheet - 5.

Sheet - 6 - Statistical data & environmental log.

ALL DEPTHS ARE FROM DATUM + 31' M.S.L.

BIOSTRATIGRAPHY

Pliocene	Zonule	A	? -1200
		B	1200-1500
upper		C	1500-2000
Miocene		D	2000-2300
		E	2300-2530
	VULCANISM		2530-3090
lower	Zonule	F	3090- ?
Miocene		G	? -3500
		H	3500-3890
		I-1	3890-4025
Oligocene	VULCANISM		4025-4265
	Zonule	I-2	4265-4850
		J	4850-5300
upper		K	5300-5380
Eocene	K or pre-K		5388-5905

BASE OF FAUNAL SEQUENCE.....5905

KEY to SYMBOLS used on sheets 1 - 6

T = side wall cores at:- 4160 & 4226 - nothing found in either

$\blacksquare^{1}$ = Conventional core-1: samples at 1500' & 1527'

$\blacksquare^{2}$ = " " core-2: " " 1998' & 2005'

$\blacksquare^{3}$ = " " core-3: " " 2496' & 2500'

$\blacksquare^{4}$ = " " core-4: 2617 - 2647' - basalt- nothing found.

$\blacksquare^{5}$ = " " core-5: sample at 3155'

$\blacksquare^{6}$ = " " core-6: " " 3665'

$\blacksquare^{7}$ = " " core-7: " " 3881'

$\blacksquare^{8}$ = " " core-8: samples at 4405 & 4410'

$\blacksquare^{9}$ = " " core-9: " " 4856 & 4860'

$\blacksquare^{10}$ = " " core-10: " " 5382, 5390 & 5395'.

$\blacksquare^{11}$ = " " core-11: " " 5880, 5890 & 5898'.

Other samples are rotary cuttings with entire content plotted

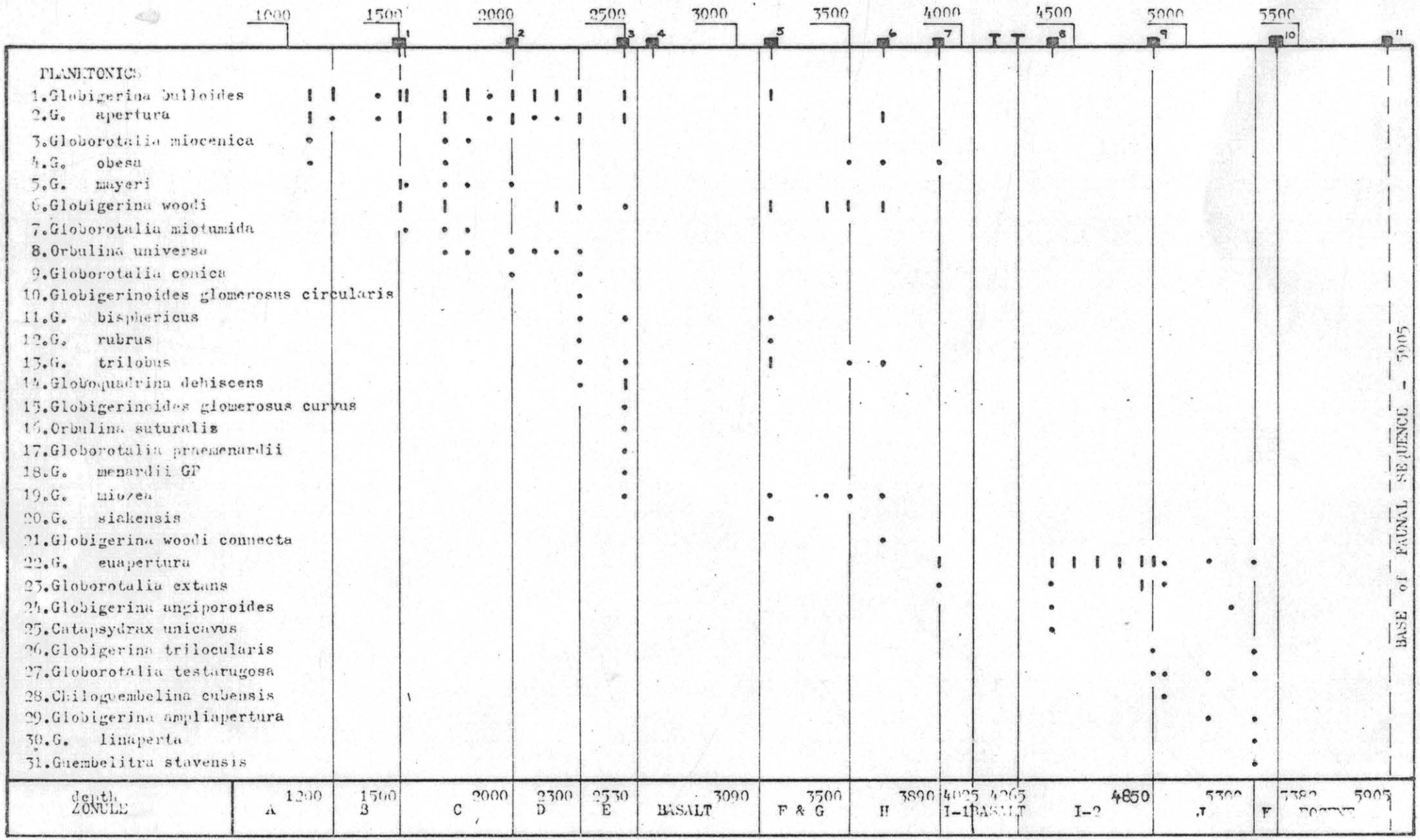
• = 1 - 20 specimens

| = > 20 specimens

009012

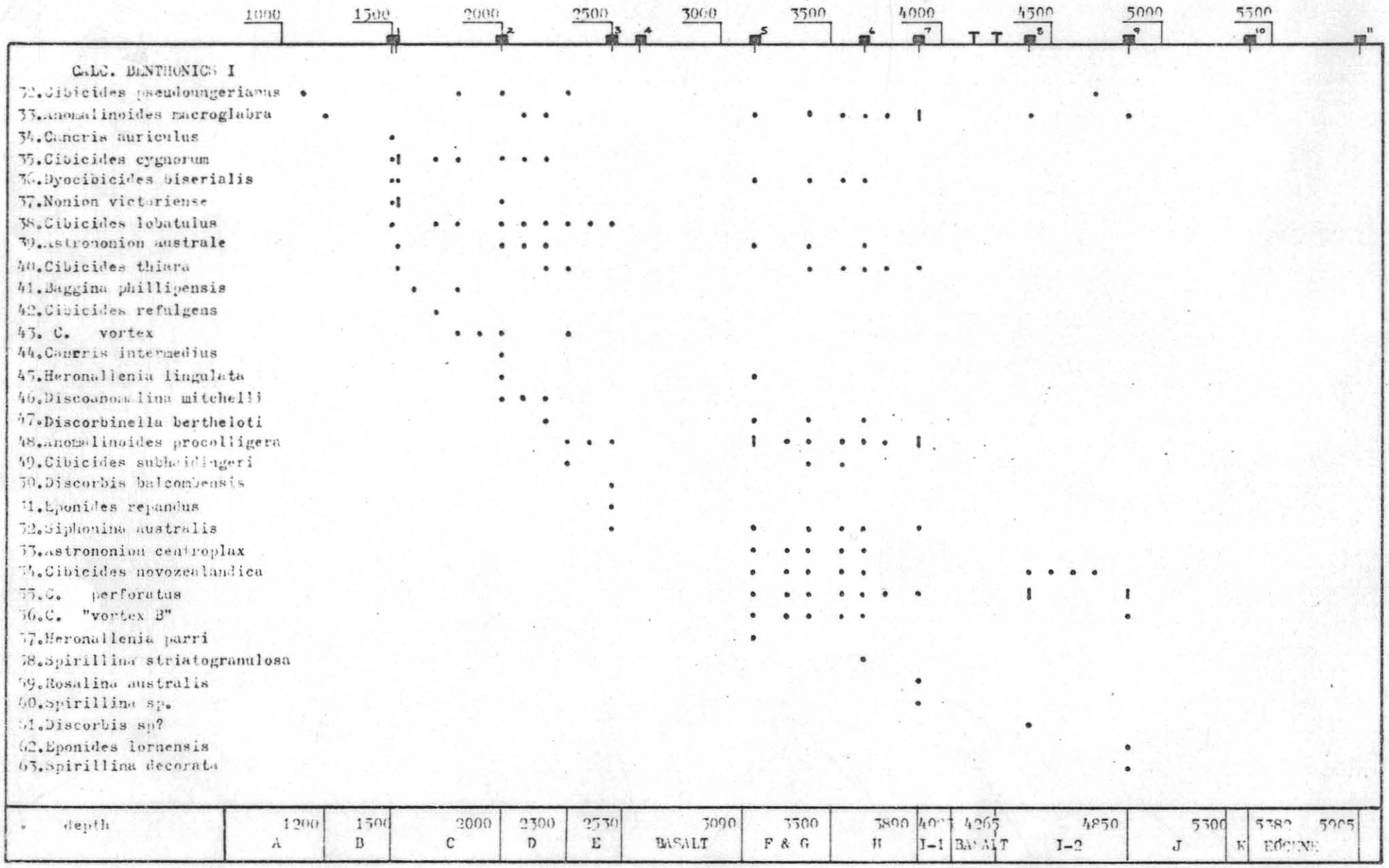
Sheet - 1
of 6 sheets.

BASS - 1



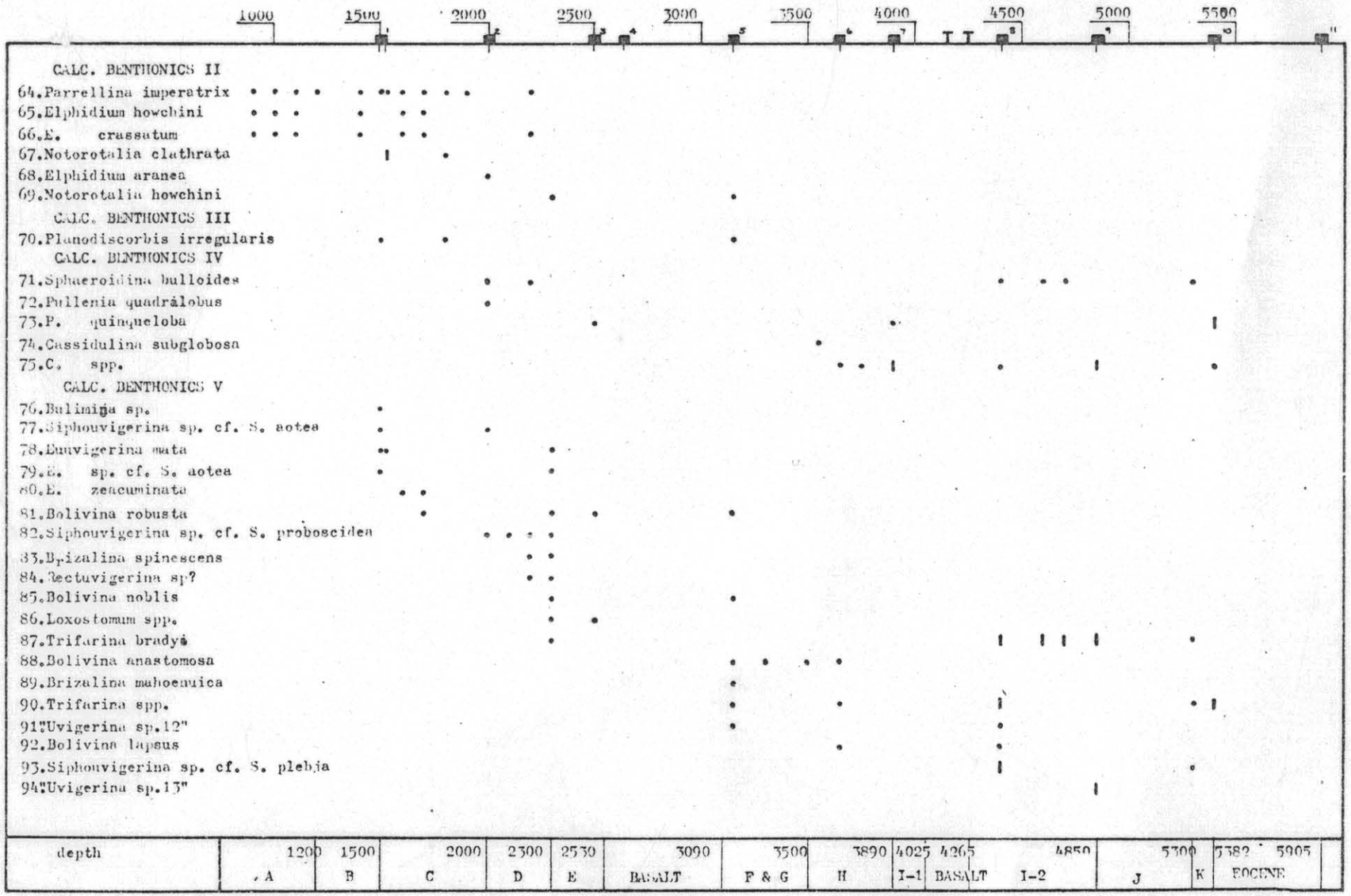
5 cm

BASS - 1


1000
1500
2000
2500
3000
3500
4000
4500
5000
5300
CALC. BENTHONICS I
72.Cibicides pseudoungerianus
33.Anomalinoides macroglabra
34.Cancris auriculus
35.Cibicides cygnorum
36.Pyocibicides biserialis
37.Nonion victoriense
38.Cibicides lobatulus
39.Astrononion australe
40.Cibicides thiara
41.Baggina phillipensis
42.Cibicides refulgens
43. C. vortex
44.Cancris intermedius
45.Heronallenia lingulata
46.Discoanomalina mitchelli
47.Discorbinella bertheloti
48.Anomalinoides procolligera
49.Cibicides subhaidingeri
50.Discorbis balcombensis
51.Eponides repandus
52.Siphonina australis
53.Astrononion centroplax
54.Cibicides novozealandica
55.C. perforatus
56.C. "vortex B"
57.Heronallenia parri
58.Spirillina striatogranulosa
59.Rosalina australis
60.Spirillina sp.
61.Discorbis sp?
62.Eponides lornensis
63.Spirillina decorata
depth
1200
A
1500
B
2000
C
2300
D
2530
E
3090
BASALT
3500
F & G
3800
H
4015
I-1
4265
BASALT
4850
I-2
5300
J
K
5382
5905
EOCENE

5 cm

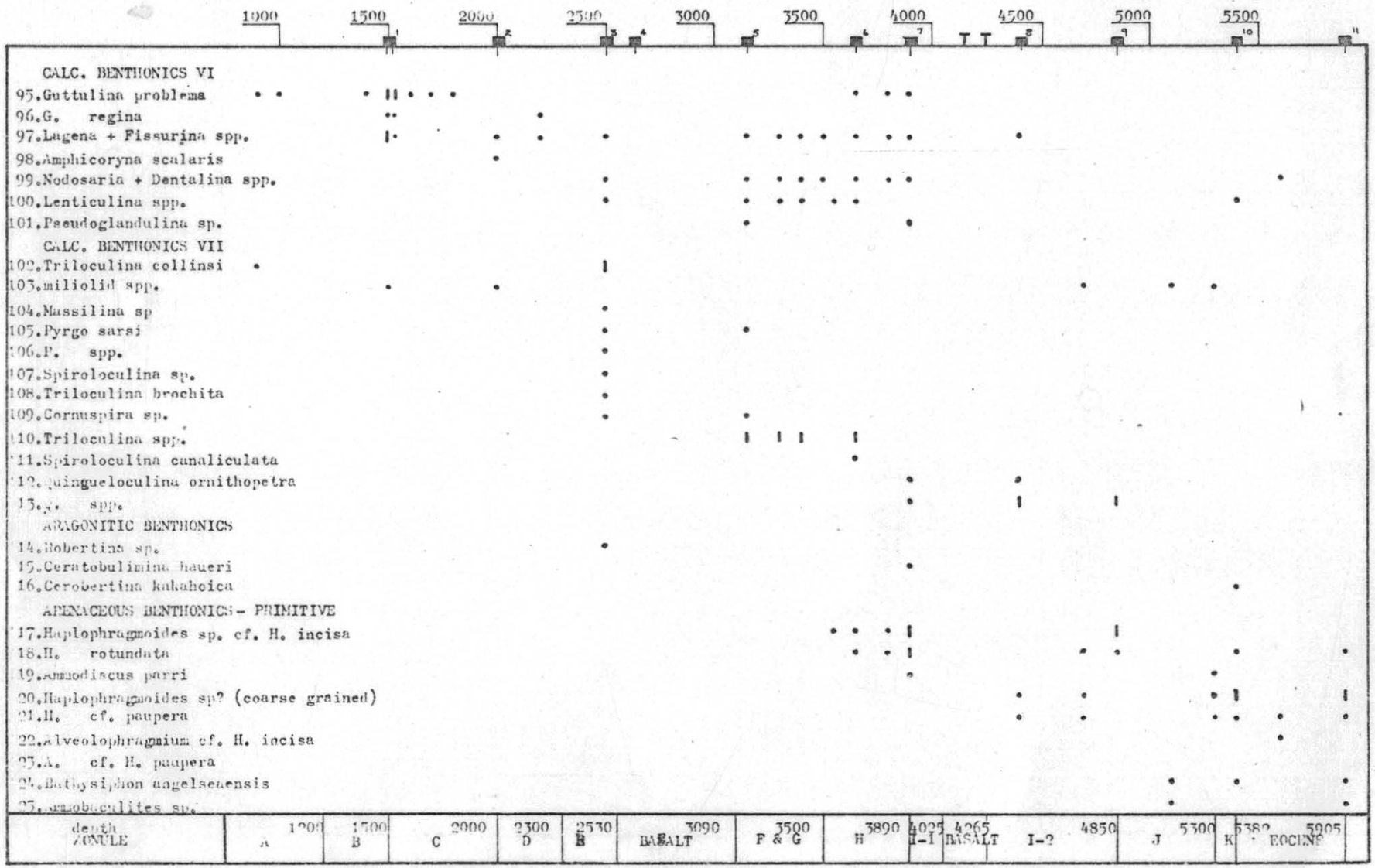
BASS - 1



depth	1200	1500	2000	2300	2530	3090	3500	3890	4025	4265	4850	5300	5382	5905
	A	B	C	D	E	BASALT	F & G	H	I-1	BASALT	I-2	J	K	EOCENE

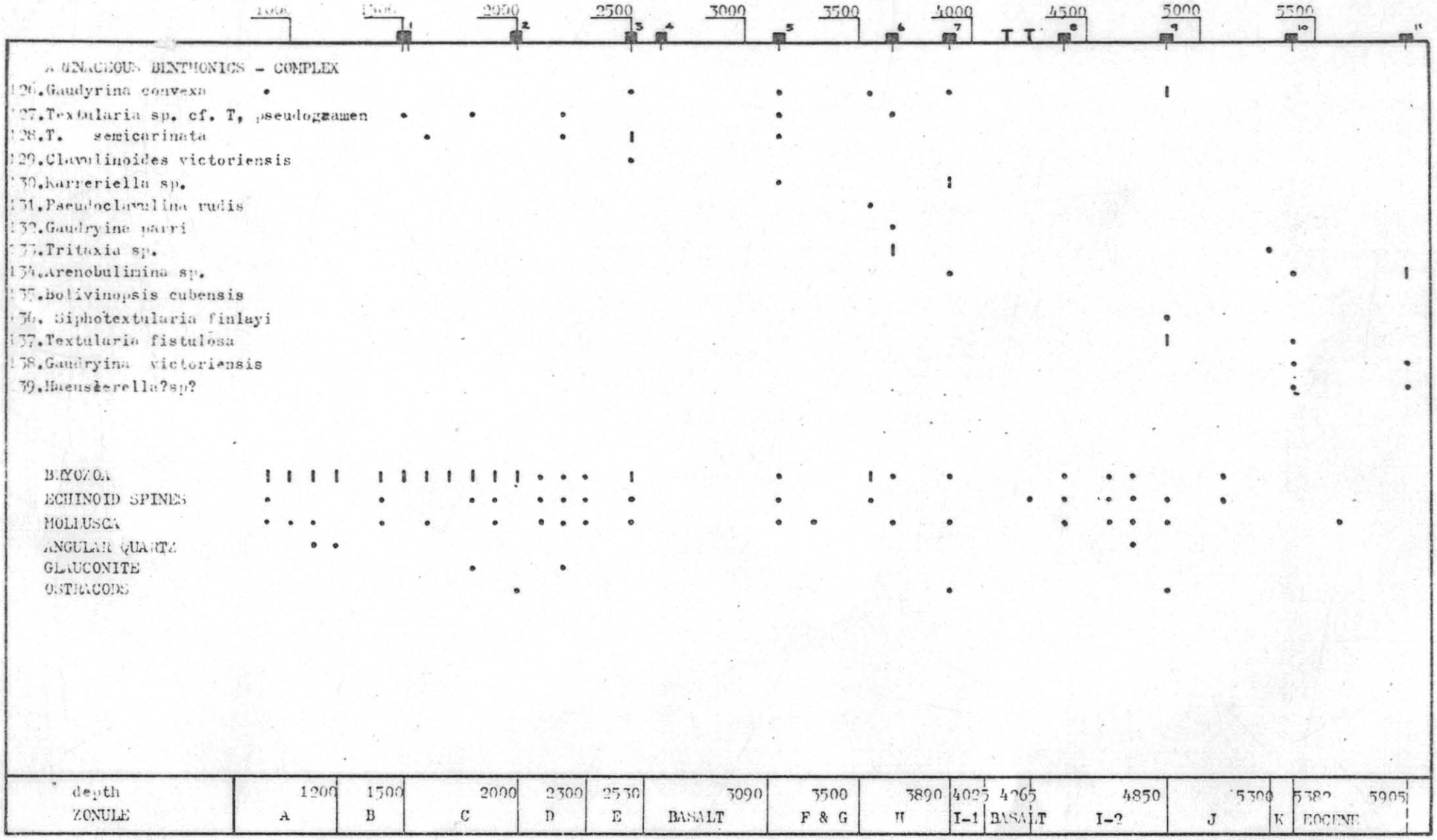
5 cm

BASS - 1


1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
1
2
3
4
5
6
7
8
9
10
11
CALC. BENTHONICS VI
95.Guttulina problema
96.G. regina
97.Lagena + Fissurina spp.
98.Amphicoryna scalaris
99.Nodosaria + Dentalina spp.
100.Lenticulina spp.
101.Pseudoglandulina sp.
CALC. BENTHONICS VII
102.Triloculina collinsi
103.miliolid spp.
104.Massilina sp
105.Pyrgo sarsi
106.P. spp.
107.Spiroloculina sp.
108.Triloculina brochita
109.Cornuspira sp.
110.Triloculina spp.
111.Spiroloculina canaliculata
112.Quinqueloculina ornithopetra
113.Q. spp.
ARAGONITIC BENTHONICS
114.Robertina sp.
115.Ceratobulimina haueri
116.Cerobertina kahahoica
ARENACEOUS BENTHONICS - PRIMITIVE
117.Haplophragmoides sp. cf. H. incisa
118.H. rotundata
119.Ammodiscus parri
120.Haplophragmoides sp? (coarse grained)
121.H. cf. paupera
122.Alveolophragmium cf. H. incisa
123.A. cf. H. paupera
124.Bathysiphon aagelseaensis
125.Rhabdammina sp.
depth
ZONULE
1200
A
1500
B
2000
C
2300
D
2530
E
3090
BASALT
3500
F & G
3890
H
4025
I-1
4265
BASALT
4850
I-2
5300
J
5382
K
5905
EOCENE

5 cm

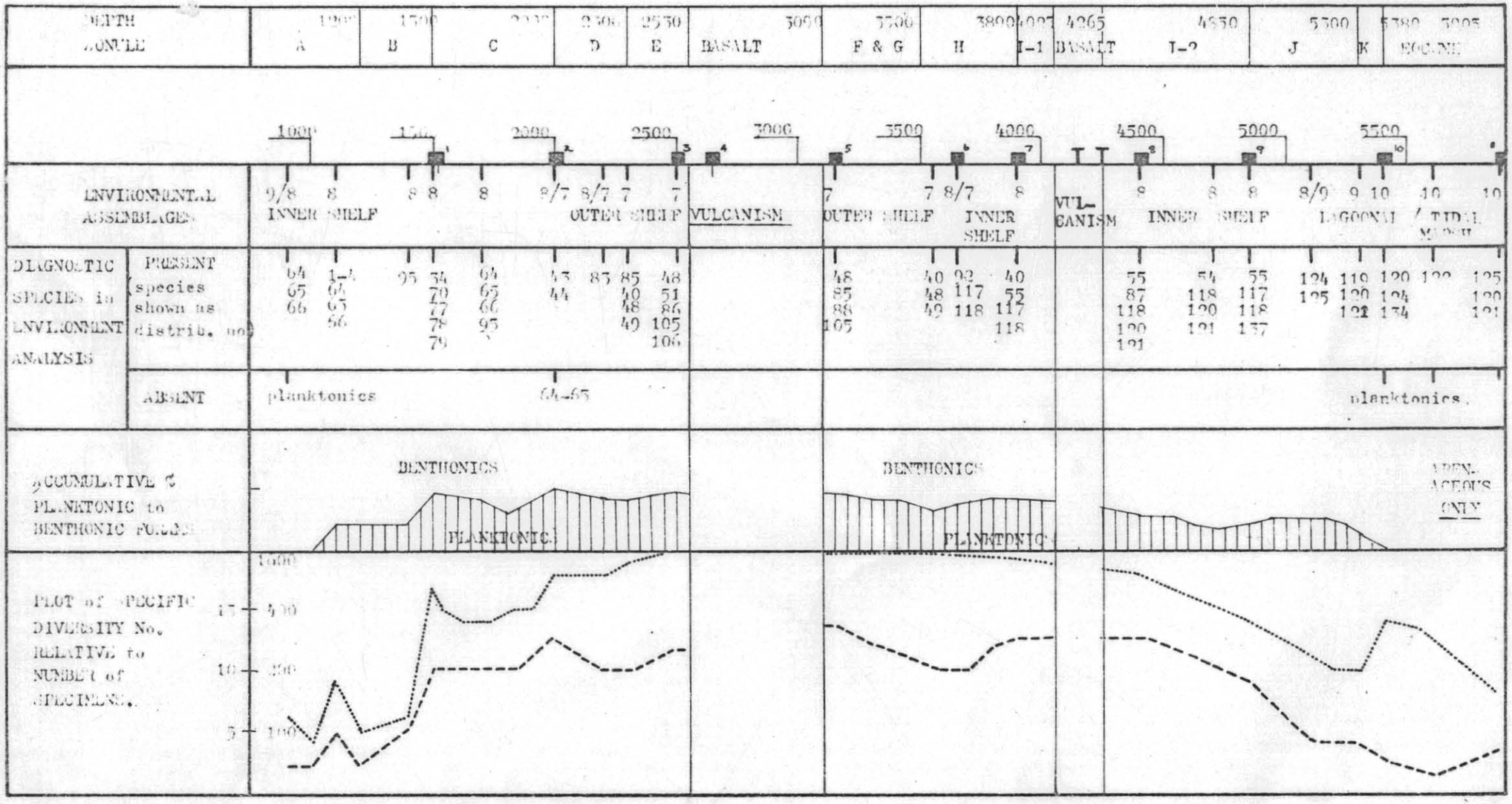
BASS - 1



depth	1200	1500	2000	2300	2530	3090	3500	3890	4025	4265	4850	5300	5382	5905
ZONULE	A	B	C	D	E	BASALT	F & G	H	I-1	BASALT	I-2	J	K	EOCENE

5 cm

BASS - 1


DEPTH
ZONULE
A
B
C
D
E
BASALT
F & G
H
I-1
BASALT
I-2
J
K
ENVIRONMENTAL ASSEMBLAGES
INNER SHELF
OUTER SHELF
VULCANISM
OUTER SHELF
INNER SHELF
VULCANISM
INNER SHELF
LAGOONAL / TIDAL MARSH
DIAGNOSTIC SPECIES in ENVIRONMENT ANALYSIS
PRESENT species shown as distrib. nos
ABSENT
planktonics
64-65
planktonics.
ACCUMULATIVE % PLANKTONIC to BENTHONIC FORAMS
BENTHONICS
PLANKTONICS
BENTHONICS
PLANKTONICS
ARENACEOUS ONLY
PLOT of SPECIFIC DIVERSITY No. RELATIVE to NUMBER of SPECIMENS.
1000
500
100
15
10
5
..... = specific diversity number
----- = no. of specimens
5 cm

B A S S - 2.

Sheet - 1 - Distribution of planktonic fauna & biostratigraphic zonation.
Sheets- 2-5 - Distribution of calcareous & arenaceous benthonic foraminifera as well as other fauna on sheet 5.
Sheet - 6 - Statistical data & environmental log. Diagnostic species are given as numbers & refer to sheets 1 - 5.

ALL DEPTHS FROM DATUM + 31' M.S.L.

BIOSTRATIGRAPHY

	Zonule A + B	Present
Upper	Zonule C	? to 1780
Miocene	Zonule D	1780 to 2220
	Zonule E	2220 to 2504
Lower	Zonule F + G	Present
Miocene	Zonule H	? to 3035
Oligocene	Zonule I	3035 to?3390
	Zonule I-2	?3390 to 3500
	Zonule J	3500 to 3600
Eocene	Zonule K &/or pre-K	3600 to 3828

BASE OF FORAMINIFERAL SEQUENCE = 3828

KEY.

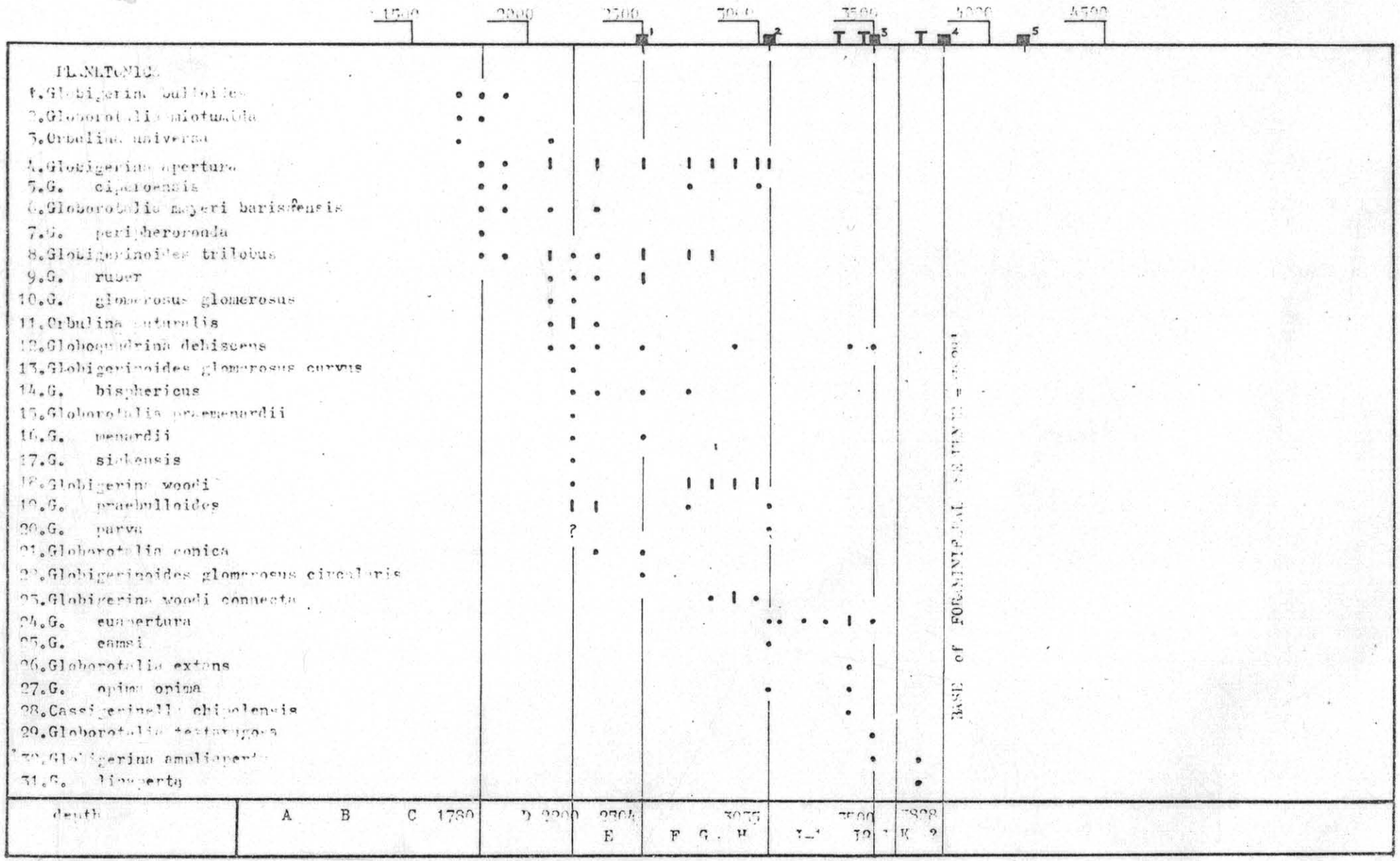
⊤ = side wall cores at 3345; 3450; 3700.
= conventional core 1 at 2504
= " " " 2 at 3050
= " " " 3 at 3519
= " " " 4 at 3803

All other samples are rotary cuttings with entire contents plotted and depths as labelled on rig.

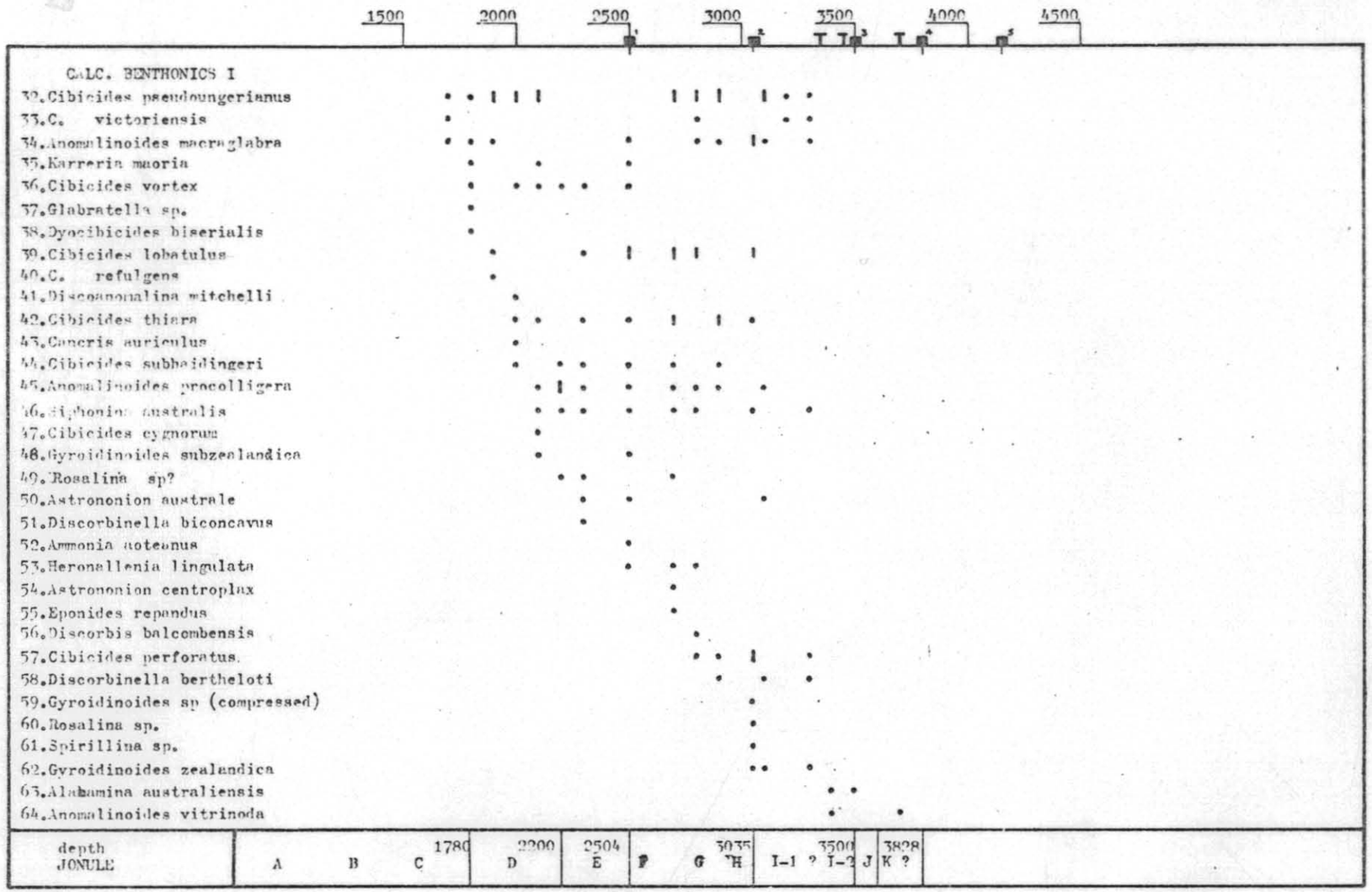
• = 1 - 20 specimens
| = over 20 specimens

BASS-2

Sheet – 1
of 6 sheets

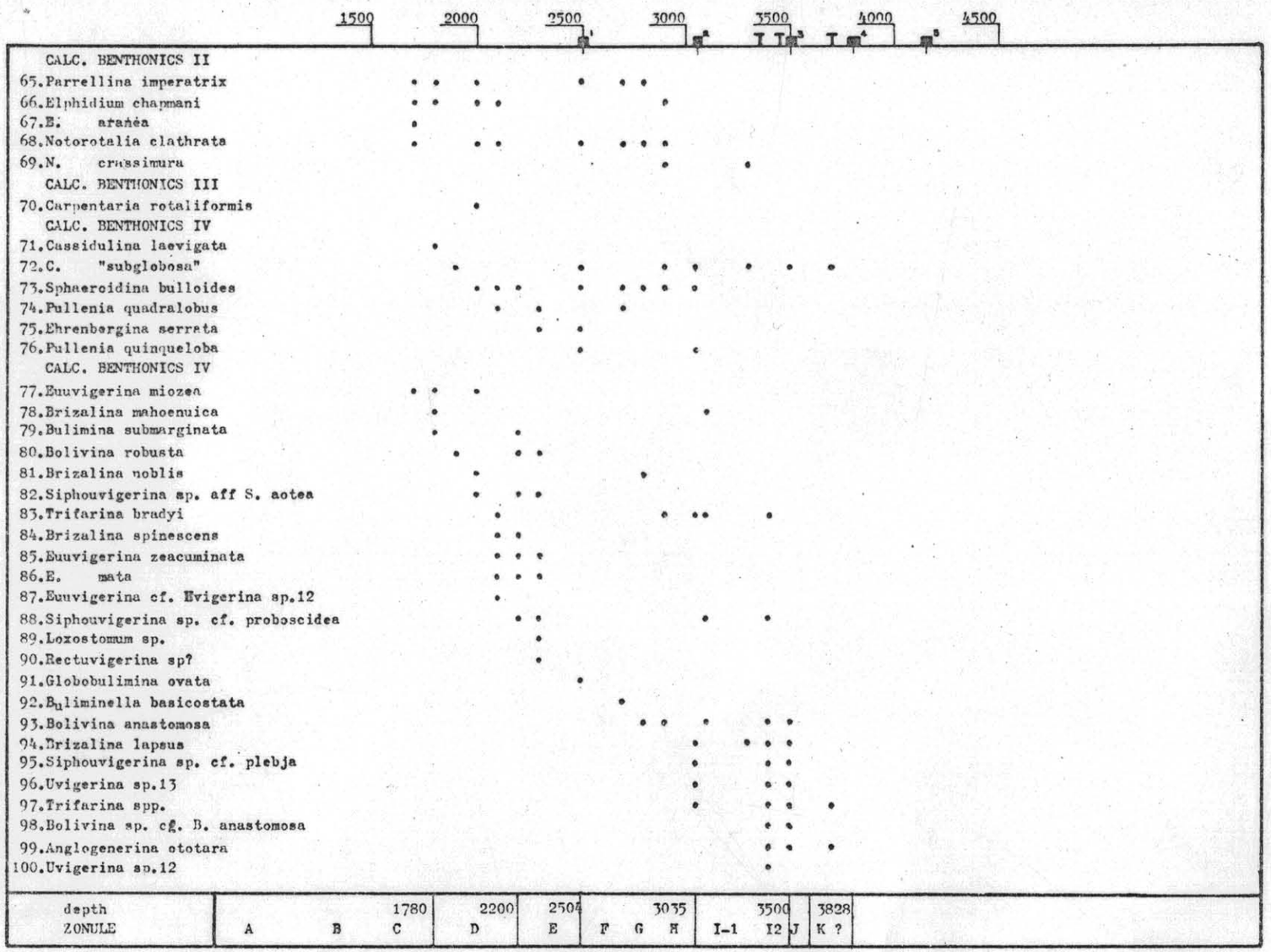


BASS - 2


1500
2000
2500
3000
3500
4000
4500
CALC. BENTHONICS I
32.Cibicides pseudoungerianus
33.C. victoriensis
34.Anomalinoides macraglabra
35.Karreria maoria
36.Cibicides vortex
37.Glabratella sp.
38.Dyocibicides biserialis
39.Cibicides lobatulus
40.C. refulgens
41.Discoanomalina mitchelli
42.Cibicides thiara
43.Cancris auriculus
44.Cibicides subbeidingeri
45.Anomalinoides procolligera
46.Siphonina australis
47.Cibicides cygnorum
48.Gyroidinoides subzealandica
49.Rosalina sp?
50.Astrononion australe
51.Discorbinella biconcavus
52.Ammonia aoteanus
53.Heronallenia lingulata
54.Astrononion centroplax
55.Eponides repandus
56.Discorbis balcombensis
57.Cibicides perforatus
58.Discorbinella bertheloti
59.Gyroidinoides sp (compressed)
60.Rosalina sp.
61.Spirillina sp.
62.Gyroidinoides zealandica
63.Alabamina australiensis
64.Anomalinoides vitrinoda
depth
JONULE
A
B
C
1780
D
2200
E
2504
F
G
H
3035
I-1 ?
I-2
3500
J
K ?
3828

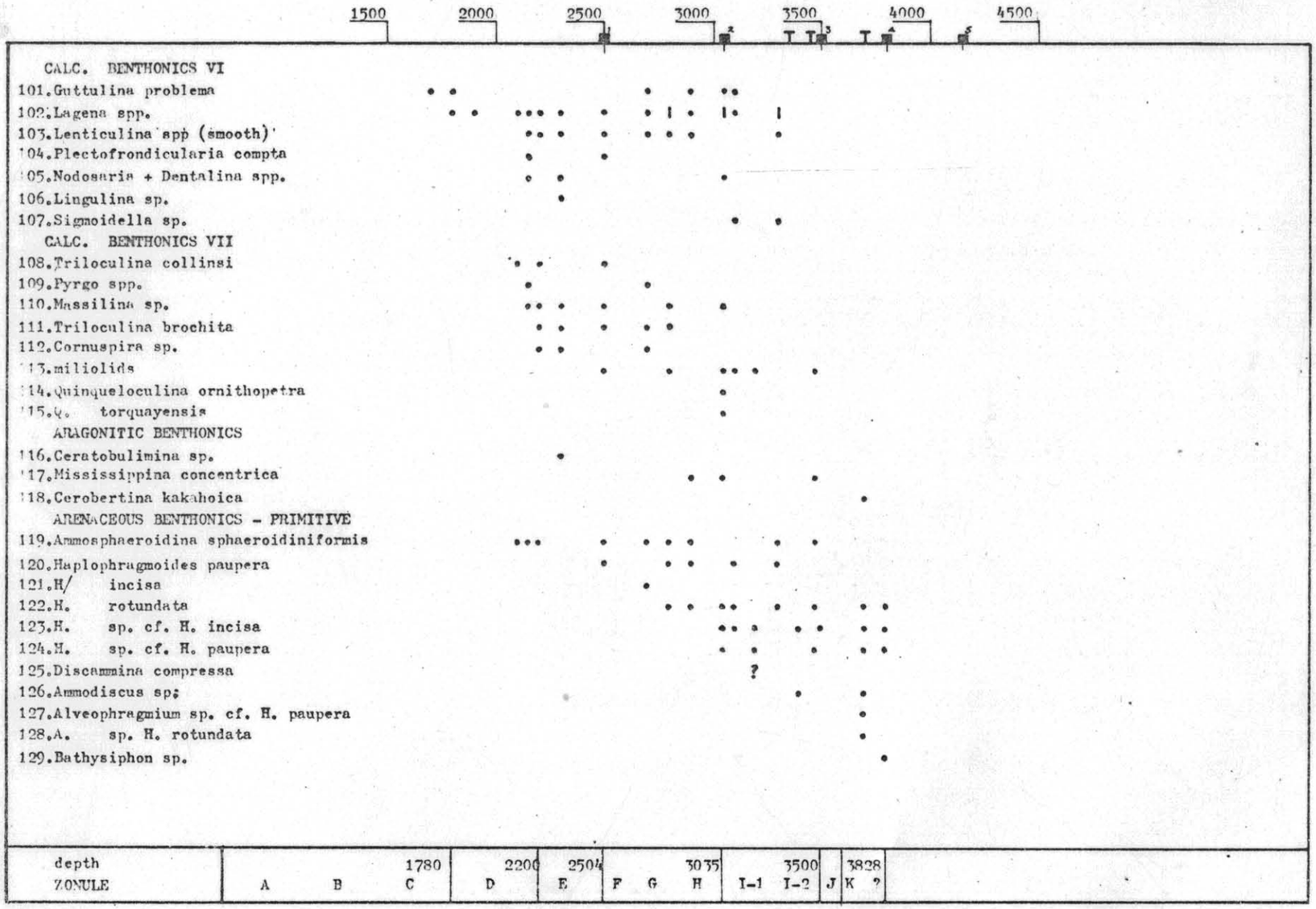
5 cm

BASS - 2


1500
2000
2500
3000
3500
4000
4500
CALC. BENTHONICS II
65.Parrellina imperatrix
66.Elphidium chapmani
67.E. aranea
68.Notorotalia clathrata
69.N. crassimura
CALC. BENTHONICS III
70.Carpentaria rotaliformis
CALC. BENTHONICS IV
71.Cassidulina laevigata
72.C. "subglobosa"
73.Sphaeroidina bulloides
74.Pullenia quadralobus
75.Ehrenbergina serrata
76.Pullenia quinqueloba
CALC. BENTHONICS IV
77.Euuvigerina miozea
78.Brizalina mahoenuica
79.Bulimina submarginata
80.Bolivina robusta
81.Brizalina noblis
82.Siphouvigerina sp. aff S. aotea
83.Trifarina bradyi
84.Brizalina spinescens
85.Euuvigerina zeacuminata
86.E. mata
87.Euuvigerina cf. Uvigerina sp.12
88.Siphouvigerina sp. cf. proboscidea
89.Loxostomum sp.
90.Rectuvigerina sp?
91.Globobulimina ovata
92.Buliminella basicostata
93.Bolivina anastomosa
94.Brizalina lapsua
95.Siphouvigerina sp. cf. plebja
96.Uvigerina sp.13
97.Trifarina spp.
98.Bolivina sp. cf. B. anastomosa
99.Anglogenerina ototara
100.Uvigerina sp.12
depth
ZONULE
1780
2200
2504
3035
3500
3828
A
B
C
D
E
F
G
H
I-1
I2
J
K ?

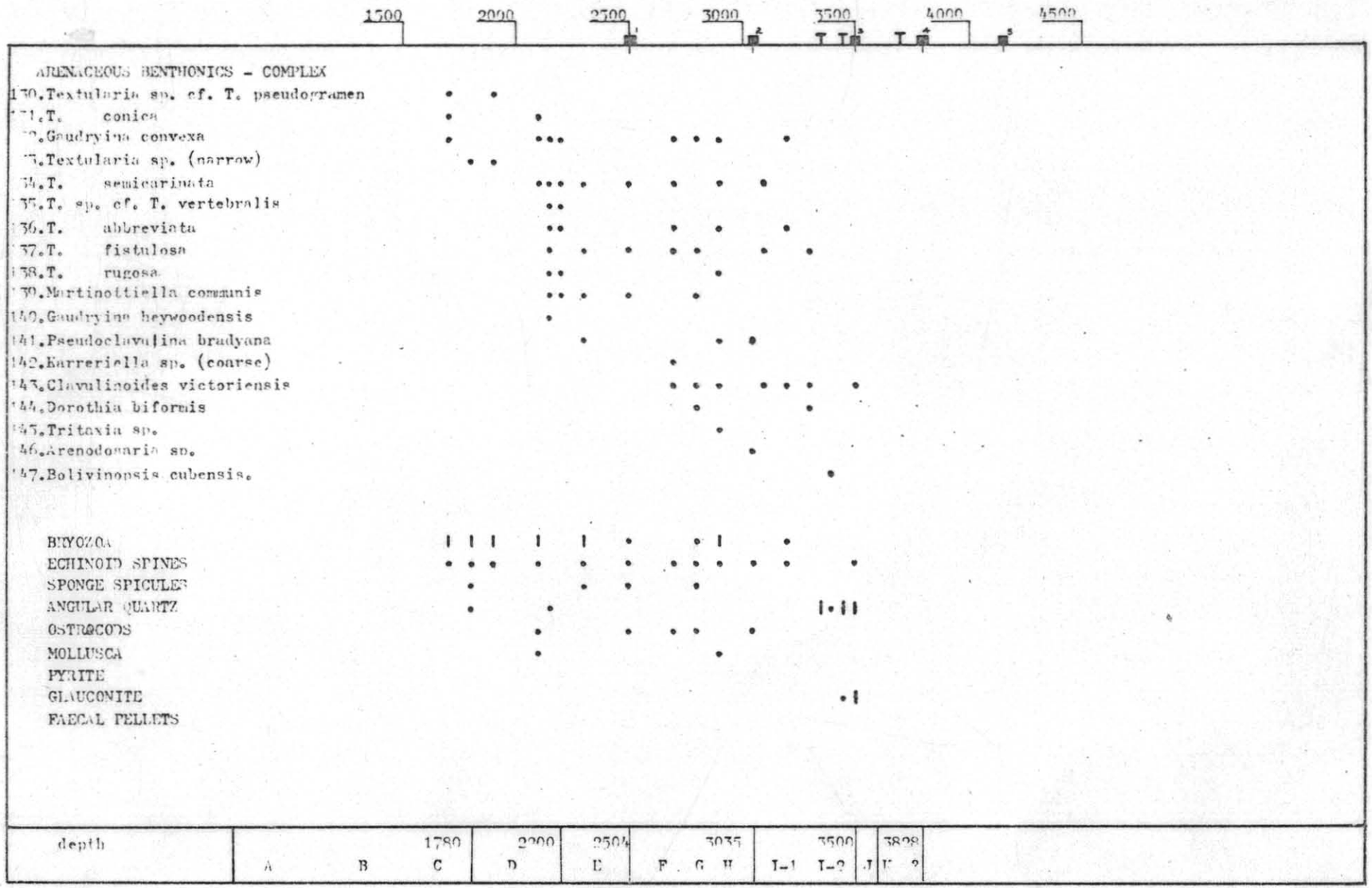
5 cm

BASS-2


1500
2000
2500
3000
3500
4000
4500
CALC. BENTHONICS VI
101.Guttulina problema
102.Lagena spp.
103.Lenticulina spp (smooth)
104.Plectofrondicularia compta
105.Nodosaria + Dentalina spp.
106.Lingulina sp.
107.Sigmoidella sp.
CALC. BENTHONICS VII
108.Triloculina collinsi
109.Pyrgo spp.
110.Massilina sp.
111.Triloculina brochita
112.Cornuspira sp.
113.miliolids
114.Quinqueloculina ornithopetra
115.Q. torquayensis
ARAGONITIC BENTHONICS
116.Ceratobulimina sp.
117.Mississippina concentrica
118.Cerobertina kakahoica
ARENACEOUS BENTHONICS - PRIMITIVE
119.Ammosphaeroidina sphaeroidiniformis
120.Haplophragmoides paupera
121.H/ incisa
122.H. rotundata
123.H. sp. cf. H. incisa
124.H. sp. cf. H. paupera
125.Discammina compressa
126.Ammodiscus sp;
127.Alveophragmium sp. cf. H. paupera
128.A. sp. H. rotundata
129.Bathysiphon sp.
depth
ZONULE
1780
2200
2504
3035
3500
3828
A
B
C
D
E
F
G
H
I-1
I-2
J
K
?

5 cm

BASS - 2


1500
2000
2500
3000
3500
4000
4500
ARENACEOUS BENTHONICS - COMPLEX
130.Textularia sp. cf. T. pseudogramen
131.T. conica
132.Gaudryina convexa
133.Textularia sp. (narrow)
134.T. semicarinata
135.T. sp. cf. T. vertebralis
136.T. abbreviata
137.T. fistulosa
138.T. rugosa
139.Martinottiella communis
140.Gaudryina heywoodensis
141.Pseudoclavulina bradyana
142.Karreriella sp. (coarse)
143.Clavulinoides victoriensis
144.Dorothia biformis
145.Tritaxia sp.
146.Arenodosaria sp.
147.Bolivinopsis cubensis.
BRYOZOA
ECHINOID SPINES
SPONGE SPICULES
ANGULAR QUARTZ
OSTRACODS
MOLLUSCA
PYRITE
GLAUCONITE
FAECAL PELLETS
depth
1780
2200
2504
3035
3500
3828
A
B
C
D
E
F
G
H
I-1
I-2
J
K
?

5 cm

BASS - 2

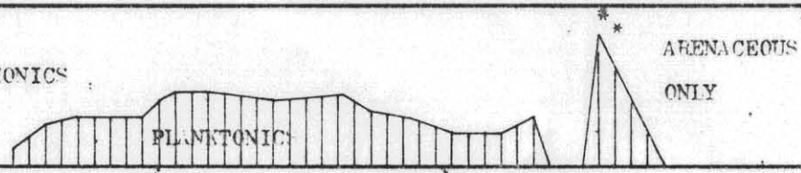
depth		1780	2200	2504	3035	3500	3828
ZONULE	A B	C	D	E	F G H	I-1 I-2	J K ?

1500 2000 2500 3000 4000 4500 5000

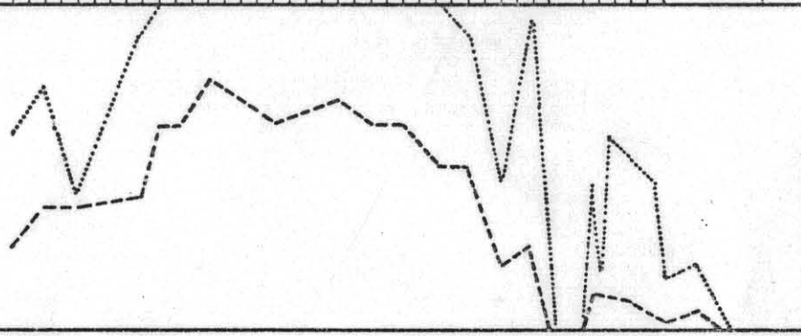
1 2 3 4 5

ENVIRONMENTAL ASSEMBLAGES		8 8/7 7 7/6 7/6 7/6 7/6 ? 7/8 ?9?9** 10 10 ? — * * = transgressive INNER SHELF - OUTER SHELF- ?SHELF/SLOPE BREAK -OUTER-INNER SHELF LAGOONAL or SALT MARSH
DIAGNOSTIC SPECIES in ENVIRONMENT ANALYSIS	PRESENT (species shown as distributions)	65 78 / 66 79 / 101 — 43 45 / 81 46 / 45 / 139 — 43 / 91 / 120 — 42 / 55 — 42 / 43 / 66 / 122 — 101 / 123 / 124 — 113 / 123 / 124 — 24 / 29 / 30 / * / * — 123 / 124 / 128 — 123 / 124
	ABSENT	91 — 42 / 45 — planks & Calc. benth I-VII

ACCUMULATIVE % PLANKTONIC to BENTHONIC FORAMINIFERA



PLOT of SPECIFIC DIVERSITY NO. RELATIVE to NUMBER of SPECIMENS



5 cm

..... = specific diversity number. ----- no. of specimens.

BASS - 3

Sheet - 1 - Distribution of planktonic fauna & biostratigraphic zonation

Sheets - 2-4 - Distribution of calcareous & arenaceous benthonic foraminifera + other fauna on sheet - 4.

SHEET 5 - STATISTICAL data & environmental log. Diagnostic species are given as species numbers & refer to sheets 1-4

ALL DEPTHS ARE FROM DATUMM of +31' M.S.L.

BIOSTRATIGRAPHY

Pliocene	- Zonule A present	
	- Zonule B present	
Upper Miocene	- Zonule C	1500 - 2040
	- Zonule D	2040 - 2430
	- Zonule E	2430 - 2610
lower Miocene	- Zonule F	2610 - 2900
	- Zonule G	2900 - 3356?
	- Zonule H	3356?- 3700
Oligocene	- ZonuleI-1	3700 - 4000
	- ZonuleI-2	4000- 4300
	- ZonuleJ-1	4300-@4516
	- ZonuleJ-2	? ?
upper Eocene	- Zonule K	4516 - 4654
	- K or pre-K	

BASE of FORAM. SEQUENCE = 5175'

KEY to symbols on distribution sheets.

T = side wall cores at:-3356; 4654; 4731; 4794; 4917 & 5085 (N.F.F.); 5175 & 5203 (N.F.F.)

$\square^1$ = conventional core - 1 ; samples at 3002 & 3026.

$\square^2$ = conventional core - 2 ; samples at 3501 & 3528.

$\square^3$ = conventional core - 3 ; samples at 3999 & 4012.

$\square^4$ = conventional core - 4 ; sampled every 2" from 4516 - 4539.

$\square^5$ = conventional core - 5 ; sampled every 2" from 5009 - 5036.

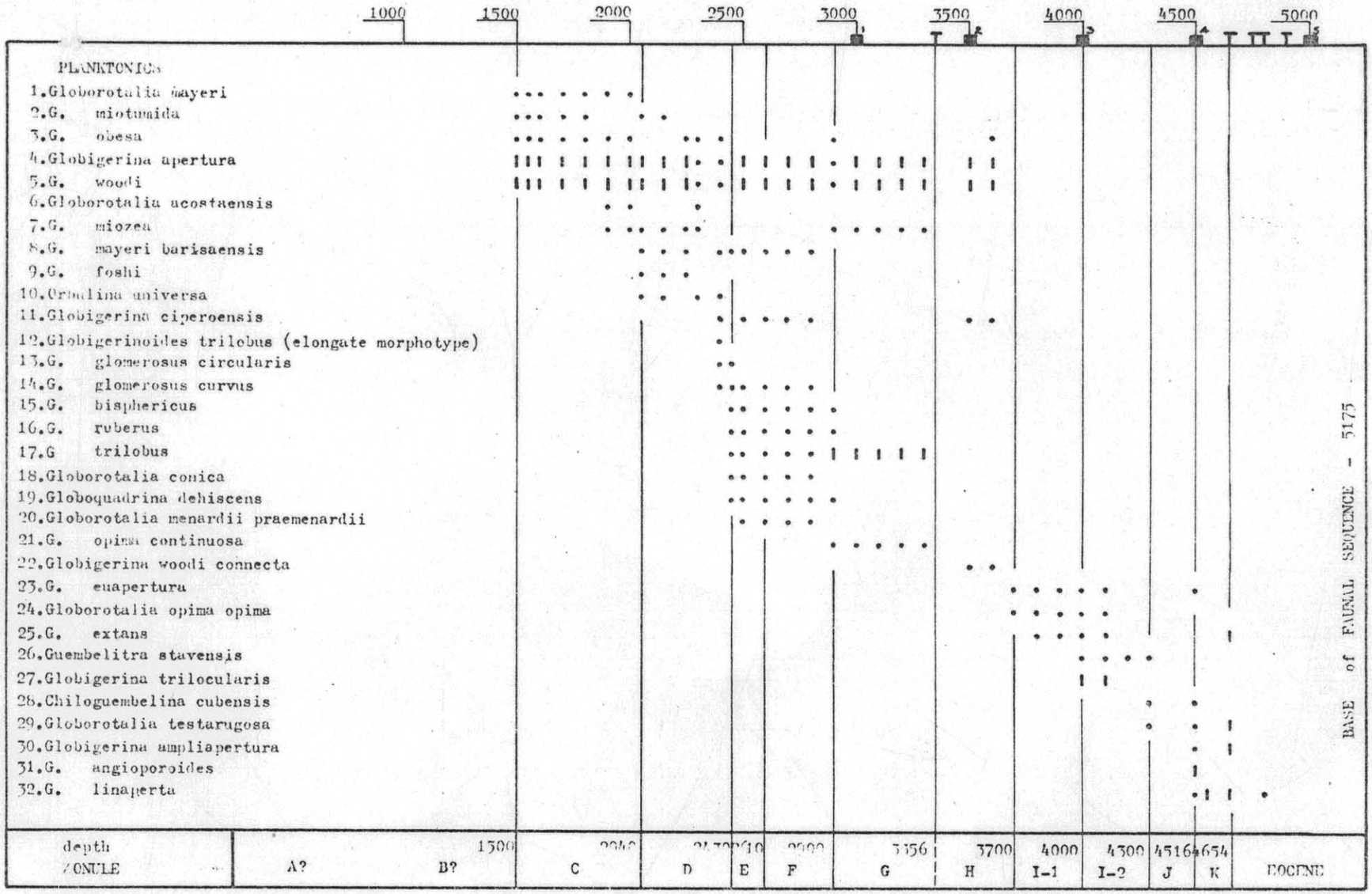
Other samples are rotary cuttings with entire content plotted.

N.F.F. = No forams. found.

• = 1 - 20 specimens

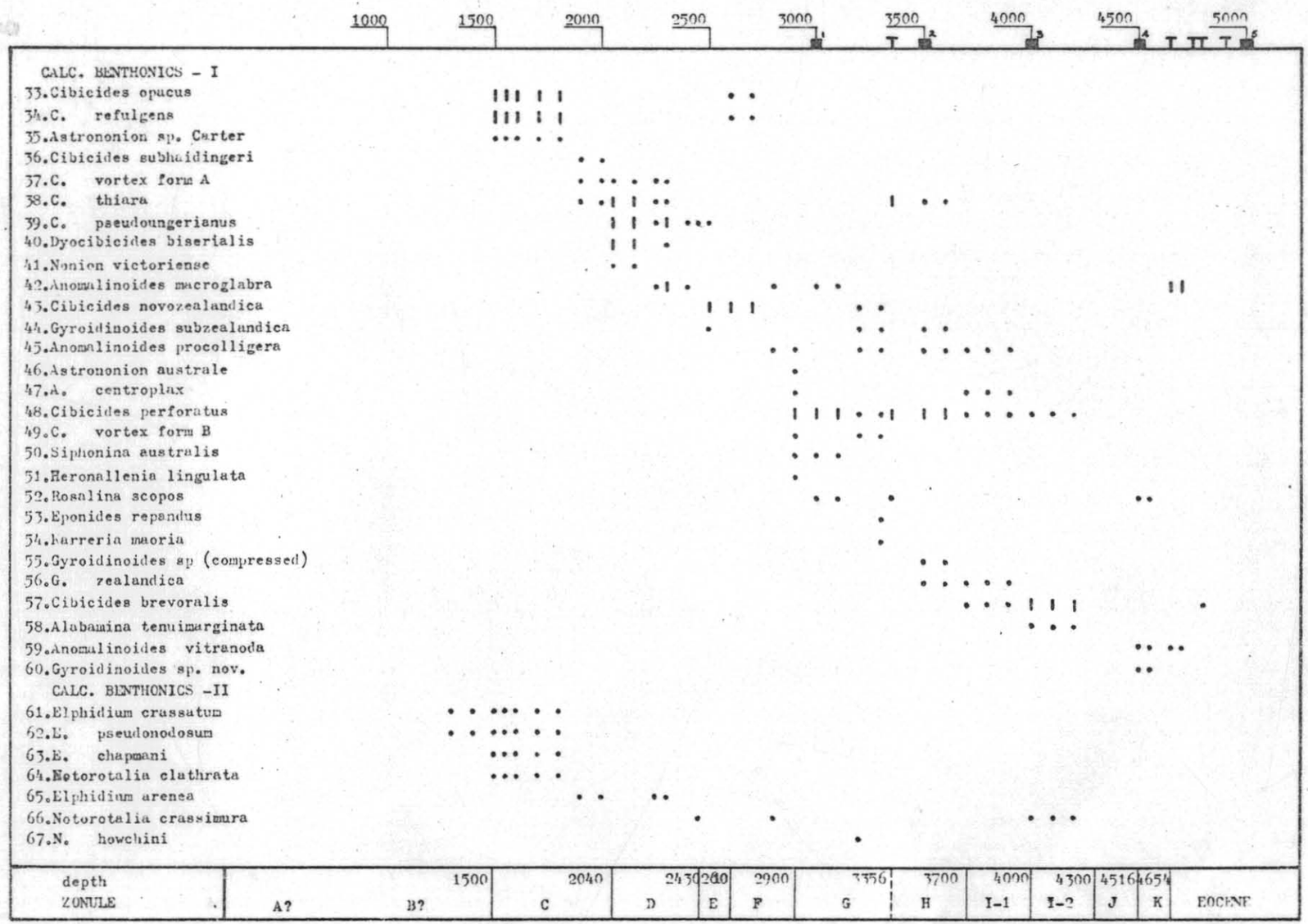
| = > 20 specimens.

BASS - 3


1000
1500
2000
2500
3000
3500
4000
4500
5000
PLANKTONICS
1.Globorotalia mayeri
2.G. miotumida
3.G. obesa
4.Globigerina apertura
5.G. woodi
6.Globorotalia acostaensis
7.G. miozea
8.G. mayeri barisaensis
9.G. foshi
10.Orbulina universa
11.Globigerina ciperoensis
12.Globigerinoides trilobus (elongate morphotype)
13.G. glomerosus circularis
14.G. glomerosus curvus
15.G. bisphericus
16.G. ruberus
17.G trilobus
18.Globorotalia conica
19.Globoquadrina dehiscens
20.Globorotalia menardii praemenardii
21.G. opima continuosa
22.Globigerina woodi connecta
23.G. euapertura
24.Globorotalia opima opima
25.G. extans
26.Guembelitra stavensis
27.Globigerina trilocularis
28.Chiloguembelina cubensis
29.Globorotalia testarugosa
30.Globigerina ampliapertura
31.G. angioporoides
32.G. linaperta
BASE of FAUNAL SEQUENCE - 5175
depth
ZONULE
1500
A?
B?
C
D
E
F
3356
G
3700
H
4000
I-1
4300
I-2
4516
4654
J
K
EOCENE

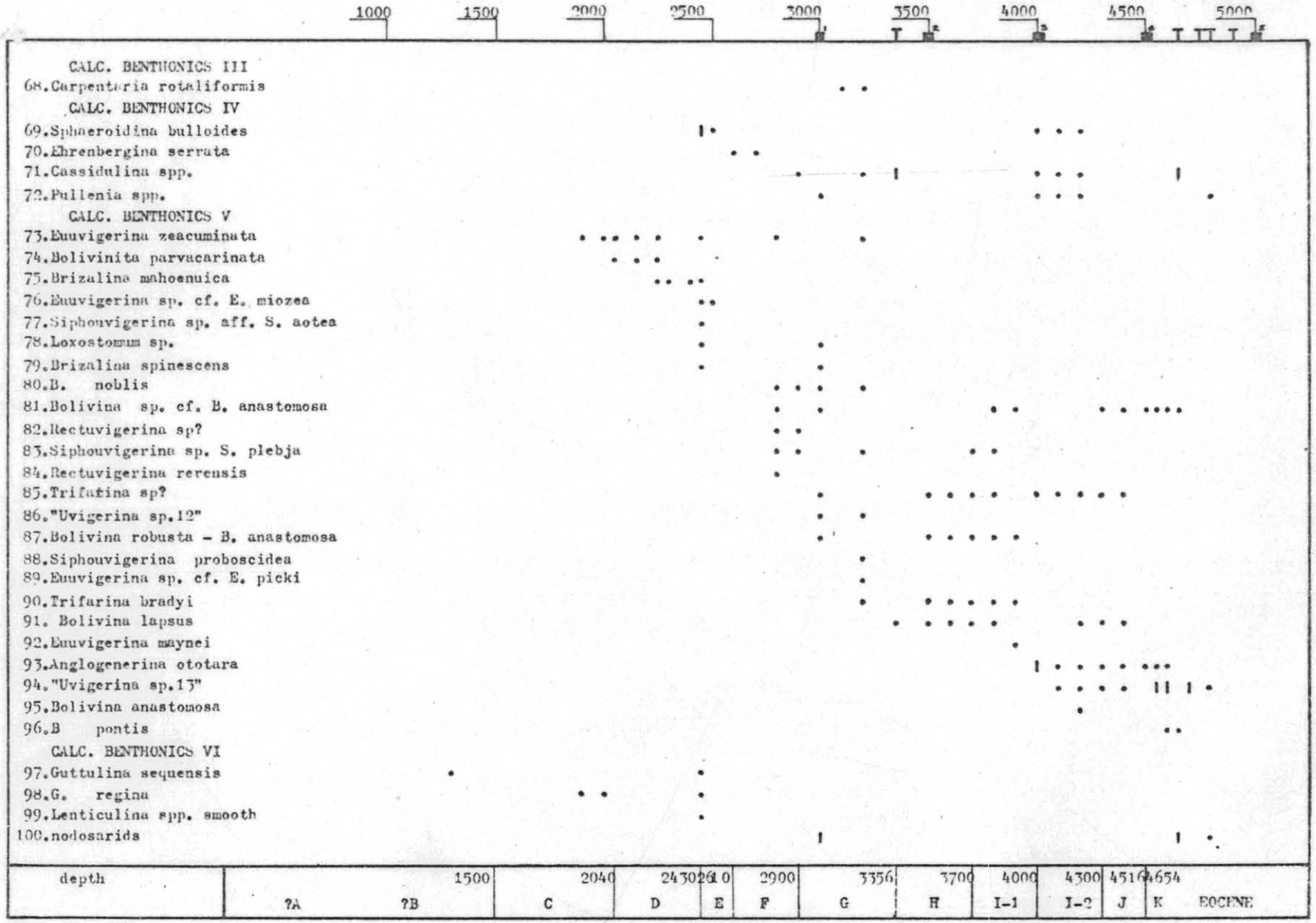
5 cm

BASS - 3


1000
1500
2000
2500
3000
3500
4000
4500
5000
CALC. BENTHONICS - I
33.Cibicides opacus
34.C. refulgens
35.Astrononion sp. Carter
36.Cibicides subhaidingeri
37.C. vortex form A
38.C. thiara
39.C. pseudoungerianus
40.Dyocibicides biserialis
41.Nonion victoriense
42.Anomalinoides macroglabra
43.Cibicides novozealandica
44.Gyroidinoides subzealandica
45.Anomalinoides procolligera
46.Astrononion australe
47.A. centroplax
48.Cibicides perforatus
49.C. vortex form B
50.Siphonina australis
51.Heronallenia lingulata
52.Rosalina scopos
53.Eponides repandus
54.Karreria maoria
55.Gyroidinoides sp (compressed)
56.G. zealandica
57.Cibicides brevoralis
58.Alabamina tenuimarginata
59.Anomalinoides vitranoda
60.Gyroidinoides sp. nov.
CALC. BENTHONICS -II
61.Elphidium crassatum
62.E. pseudonodosum
63.E. chapmani
64.Notorotalia clathrata
65.Elphidium arenea
66.Notorotalia crassimura
67.N. howchini
depth
ZONULE
1500
2040
2430
2900
3356
3700
4000
4300
4516
4654
A?
B?
C
D
E
F
G
H
I-1
I-2
J
K
EOCENE

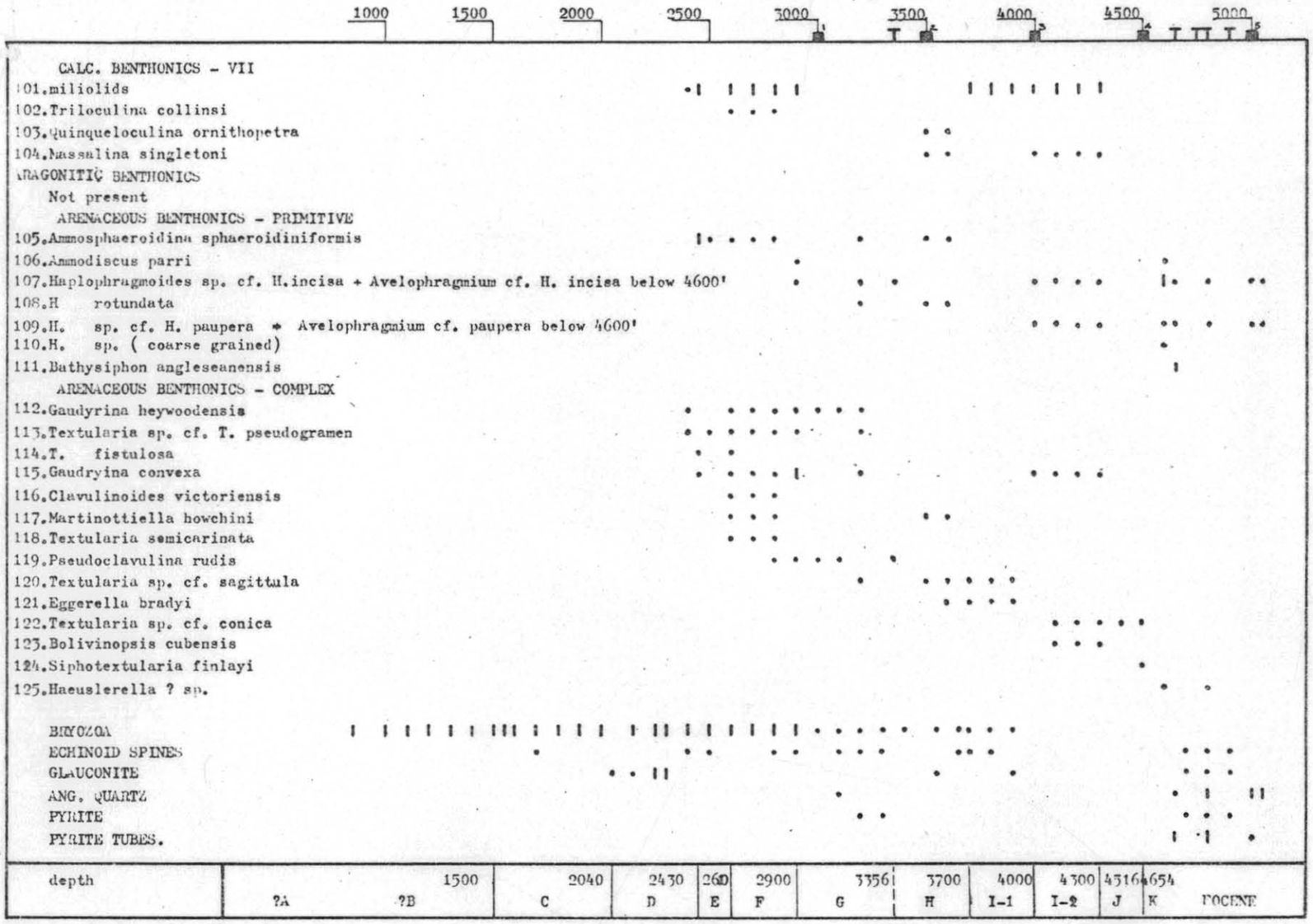
5 cm

BASS - 3


1000
1500
2000
2500
3000
3500
4000
4500
5000
CALC. BENTHONICS III
68.Carpenteria rotaliformis
CALC. BENTHONICS IV
69.Sphaeroidina bulloides
70.Ehrenbergina serrata
71.Cassidulina spp.
72.Pullenia spp.
CALC. BENTHONICS V
73.Euuvigerina zeacuminata
74.Bolivinita parvacarinata
75.Brizalina mahoenuica
76.Euuvigerina sp. cf. E. miozea
77.Siphouvigerina sp. aff. S. aotea
78.Loxostomum sp.
79.Brizalina spinescens
80.B. noblis
81.Bolivina sp. cf. B. anastomosa
82.Rectuvigerina sp?
83.Siphouvigerina sp. S. plebja
84.Rectuvigerina rerensis
85.Trifatina sp?
86."Uvigerina sp.12"
87.Bolivina robusta - B. anastomosa
88.Siphouvigerina proboscidea
89.Euuvigerina sp. cf. E. picki
90.Trifarina bradyi
91. Bolivina lapsus
92.Euuvigerina maynei
93.Anglogenerina ototara
94."Uvigerina sp.13"
95.Bolivina anastomosa
96.B pontis
CALC. BENTHONICS VI
97.Guttulina sequensis
98.G. regina
99.Lenticulina spp. smooth
100.nodosarids
depth
1500
2040
2430
2610
2900
3356
3700
4000
4300
4516
4654
?A
?B
C
D
E
F
G
H
I-1
I-2
J
K
EOCENE

5 cm

BASS-3


1000
1500
2000
2500
3000
3500
4000
4500
5000
CALC. BENTHONICS - VII
101.miliolids
102.Triloculina collinsi
103.Quinqueloculina ornithopetra
104.Massalina singletoni
ARAGONITIC BENTHONICS
Not present
ARENACEOUS BENTHONICS - PRIMITIVE
105.Ammosphaeroidina sphaeroidiniformis
106.Ammodiscus parri
107.Haplophragmoides sp. cf. H.incisa + Avelophragmium cf. H. incisa below 4600'
108.H rotundata
109.H. sp. cf. H. paupera + Avelophragmium cf. paupera below 4600'
110.H. sp. (coarse grained)
111.Bathysiphon angleseanensis
ARENACEOUS BENTHONICS - COMPLEX
112.Gaudyrina heywoodensis
113.Textularia sp. cf. T. pseudogramen
114.T. fistulosa
115.Gaudryina convexa
116.Clavulinoides victoriensis
117.Martinottiella howchini
118.Textularia semicarinata
119.Pseudoclavulina rudis
120.Textularia sp. cf. sagittula
121.Eggerella bradyi
122.Textularia sp. cf. conica
123.Bolivinopsis cubensis
124.Siphotextularia finlayi
125.Haeuslerella ? sp.
BRYOZOA
ECHINOID SPINES
GLAUCONITE
ANG. QUARTZ
PYRITE
PYRITE TUBES.
depth
1500
2040
2430
2600
2900
3356
3700
4000
4300
4316
4654
?A
?B
C
D
E
F
G
H
I-1
I-2
J
K
EOCENE

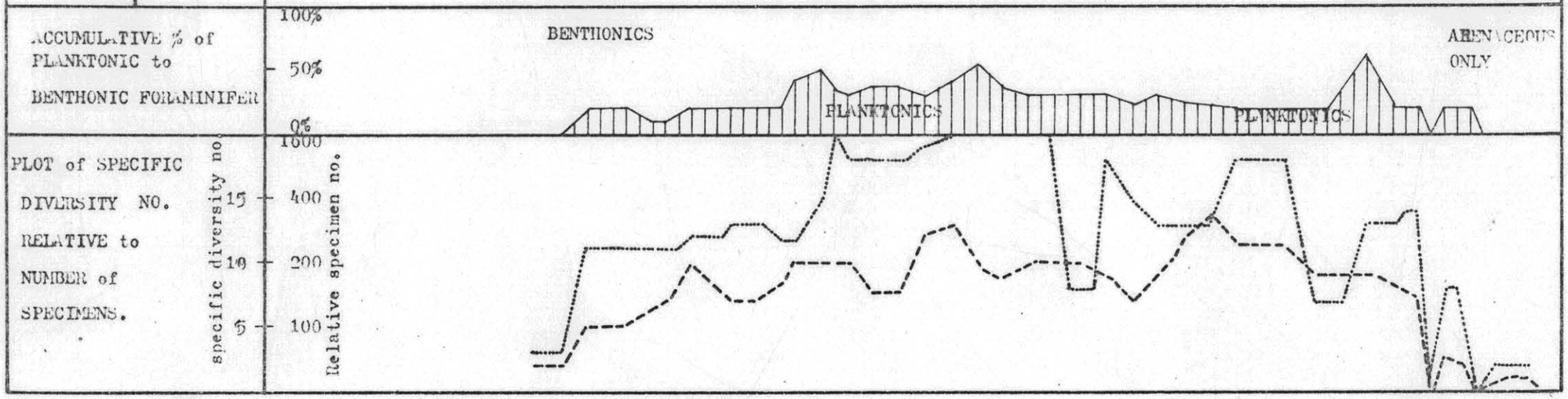
5 cm

BASS - 3

depth / ZONULE	?A	?B	C	D	E	F	G	H	I-1	I-2	J	K	EOCENE
		1500	2040	2430	2610	2900	3356	3700	4000	4300	4516	4652	

1000 1500 2000 2500 3000 3500 4000 4500 5000

ENVIRONMENTAL ASSEMBLAGE		?9 9/8 8 8 8/7 8/7 8 8 8 8 8 8/7 8 8/7 8/7 8/7 8/7 8/7 8 8/9 9/10 10 10 STRAND-SHALLOW SHELF / INNER SHELF / INNER SHELF - OUTER SHELF / INNER SHELF-LAGOONAL or TIDAL MARSH
DIAGNOSTIC SPECIES in ENVIRONMENT ANALYSIS	PRESENT species given as distribution numbers	61 1-3 36 74 75 101 112-118 46 52 68 45 52 44 57 57 81 52 106 125 107 62 33 38 37 102 47 83 45 93 91 123 107 107 109 97 34 38 113 66 88 55 93 124 109 109 112-118 89 56 abundant planktonics 110 Only arenaceous species 125
	ABSENT	planktonics 61-64 planktonics planktonics + calc.benth. I - VII



5 cm

C O R M O R A N T — 1

Sheet - 1 - distribution of planktonic fauna & biostratigraphic zonation.

Sheets- 2-4 - distribution of calcareous & arenaceous benthonic species as well as other fauna.

Sheet - 5 - statistical data & environmental log. Diagnostic species are given as numbers & refer to sheets 1 - 4.

ALL DEPTHS ARE FROM DATUM of + M.S.L.

BIOSTRATIGRAPHY

Pliocene	Zonule A	? - 1090
Middle	Zonule B	1090 - ?
	Zonule C	?
Miocene	Zonule D	? - 1450
	Zonule E	1450 - ?
Lower	Zonule F	?
Miocene	Zonule G	? - 2040
	Zonule H	2040 - 2652
Oligocene	ZONULE I	2652 - 2882
	I-1	?2652 - 2798
	I-2	2798 - 2882
	Zonule J	2882 - 3002
Upper	Zonule K	3002 - 3300
Eocene	Zonule K &/or preK	3300 - 4220

BASEof FORAM. SEQUENCE = 4220

KEY to symbols on distribution sheets.

T = side wall cores at 865; 960; 1090; 1205; 1325(N.F.F.); 1450; 1596; 1739; 1804; 1920; 2040; 2137; 2200; 2298; 2420; 2557; 2564; 2652; 2798; 2882; 3150; 3300; 3490; 3510; 3600; 3700; 3926; 4020; 4120; 4220; 4359 (N.F.F.).

1 = conventional core-1; samples at 2973; 2989; 2998 & 3092.

2 = conventional core-2; samples at 3801 & 3815.

3 = conventional core-3; samples at 4277 (N.F.F.)

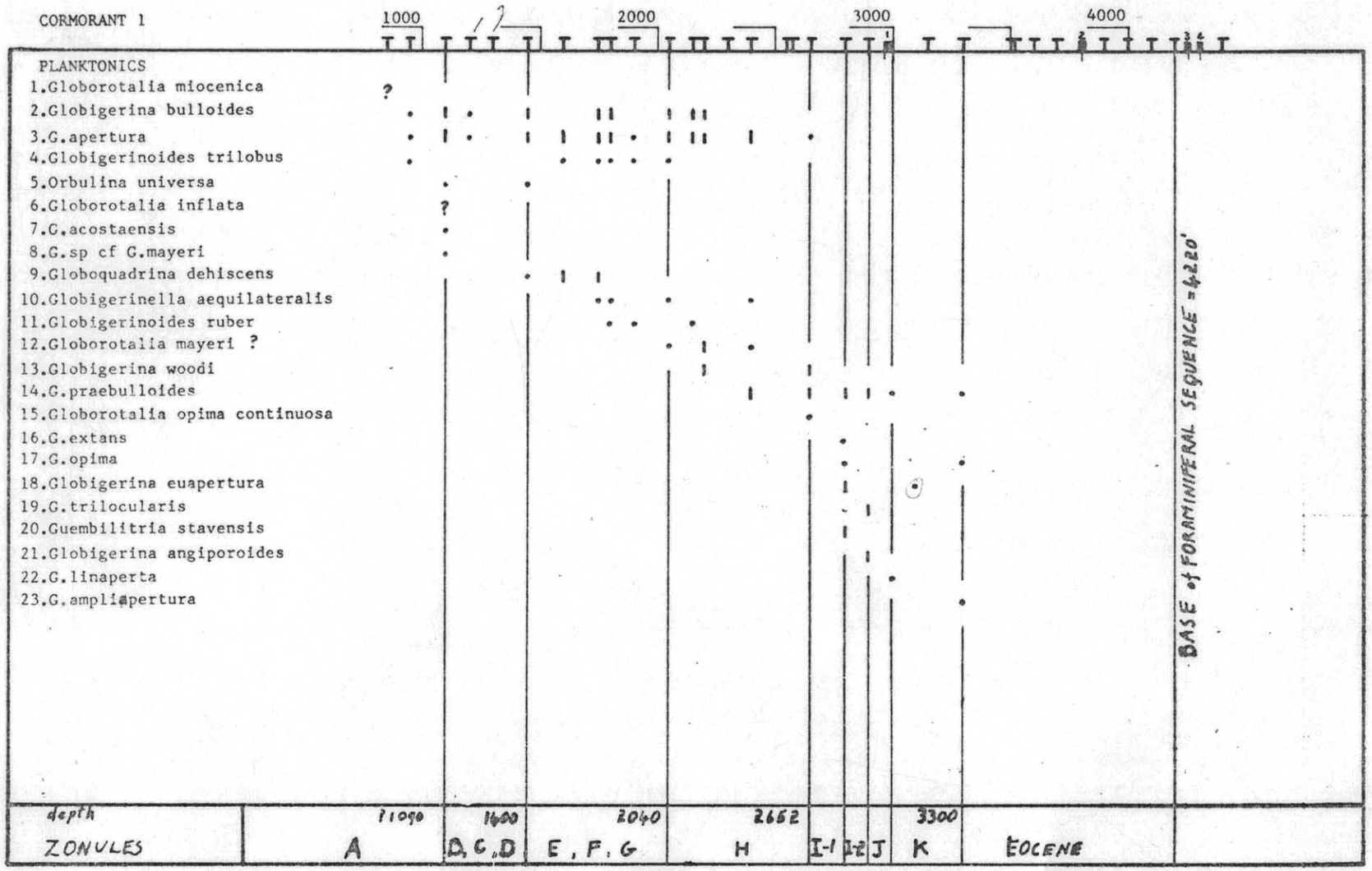
4 = conventional core-4; samples at 4291; 4299 & 4305 (all N.F.F.).

N.F.F.= No foramimifera found.

• = 1 - 20 specimens

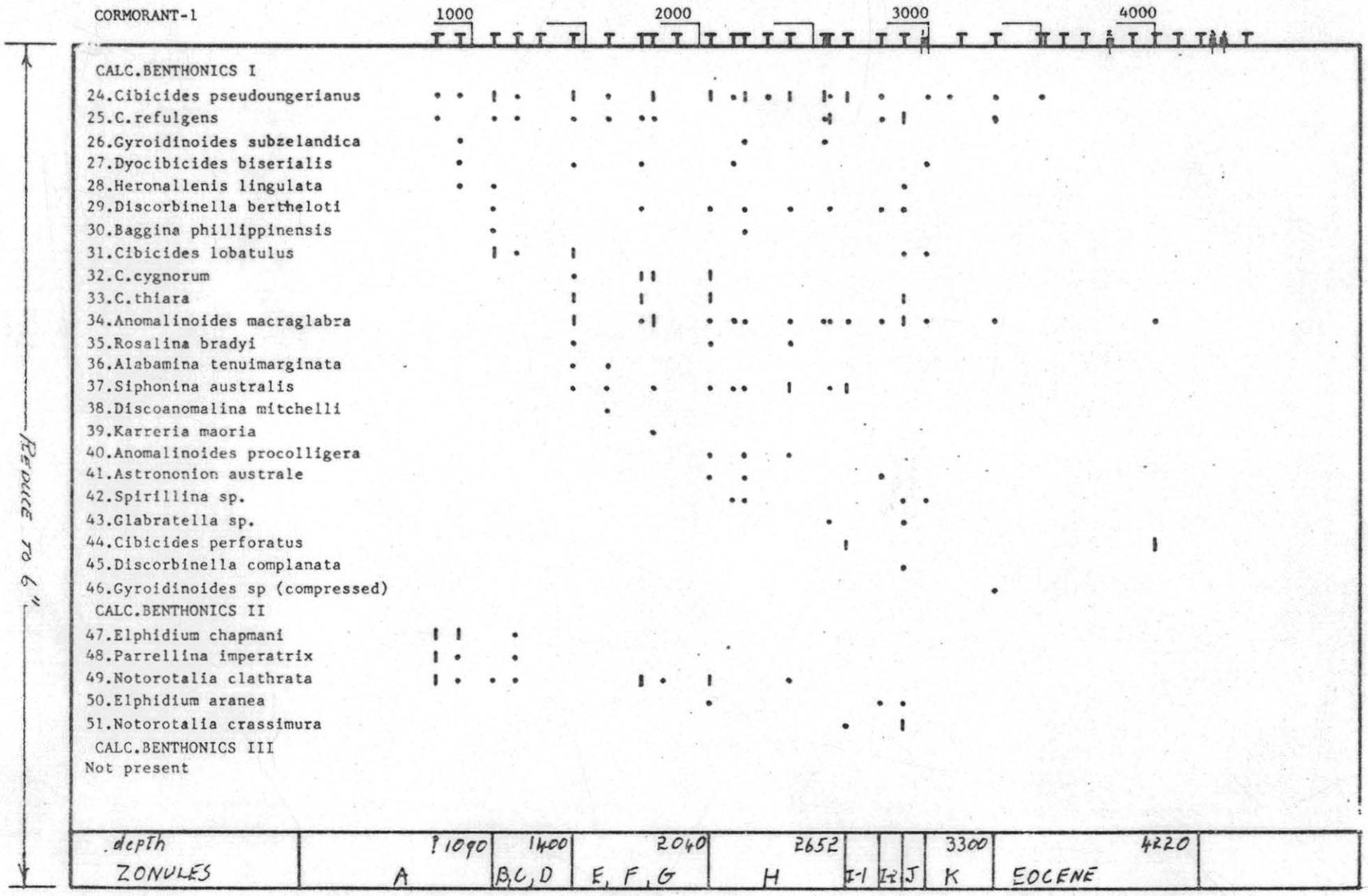
I = >20 specimens.

CORMORANT 1



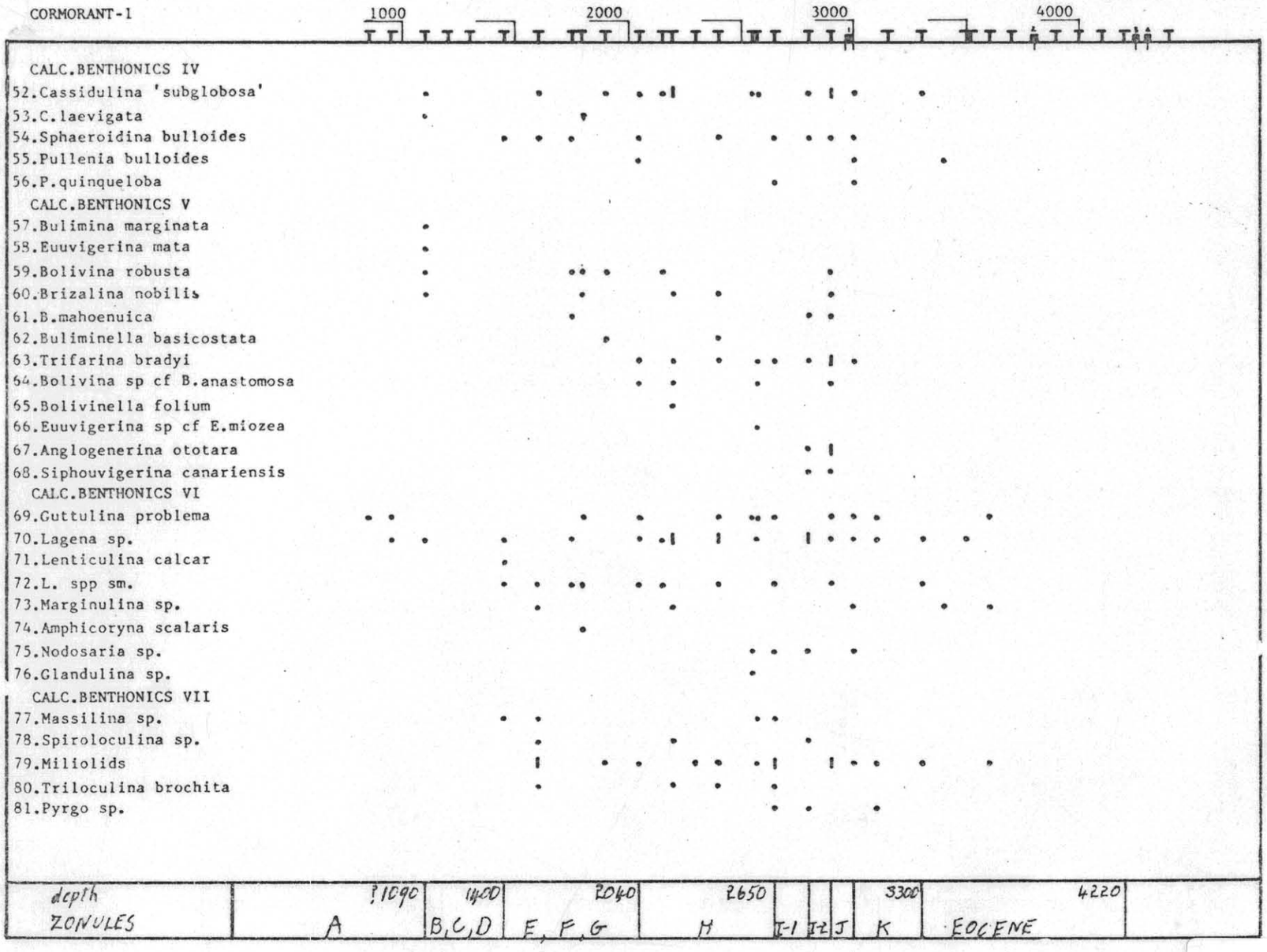
5 cm

CORMORANT-1



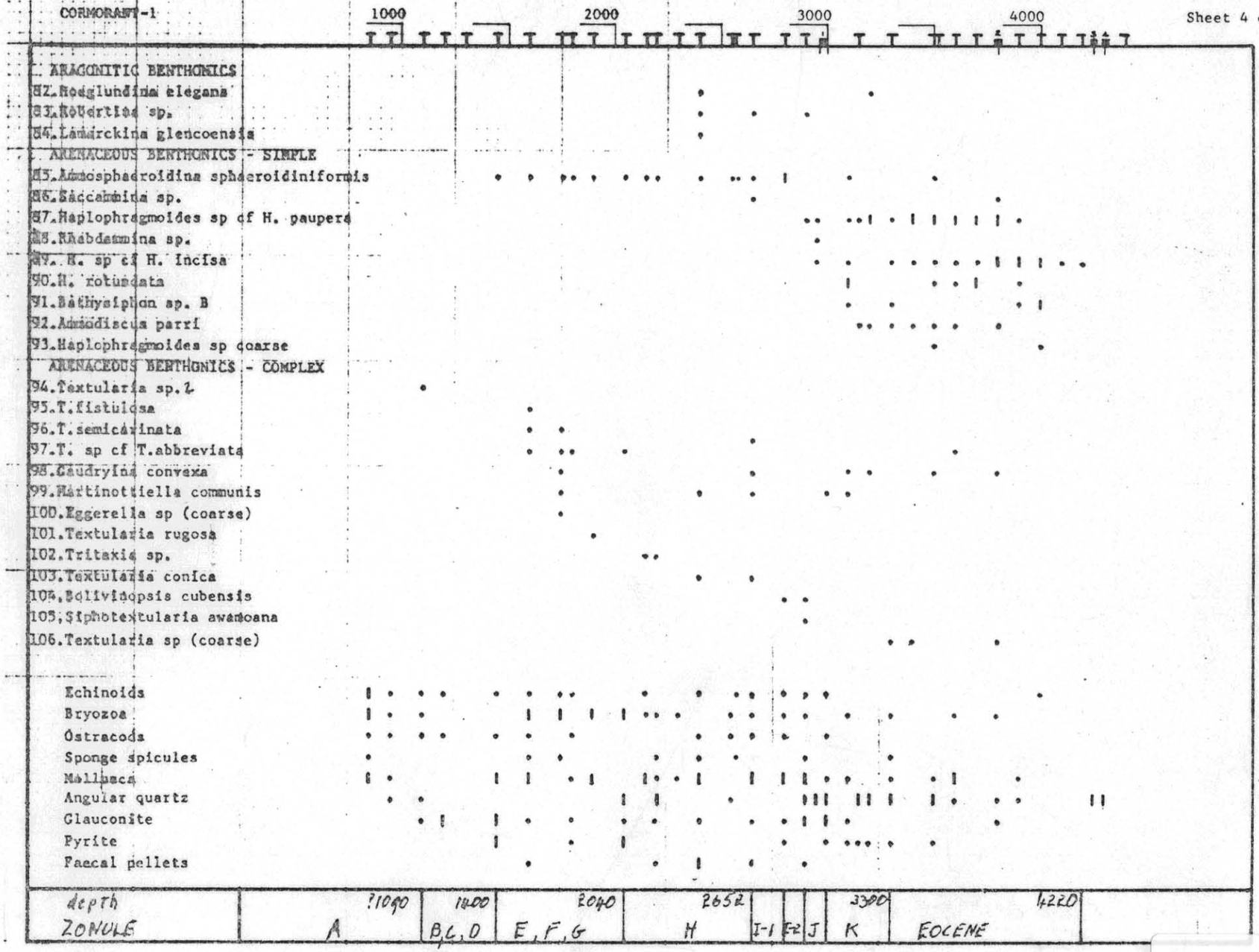
5 cm

CORMORANT-1



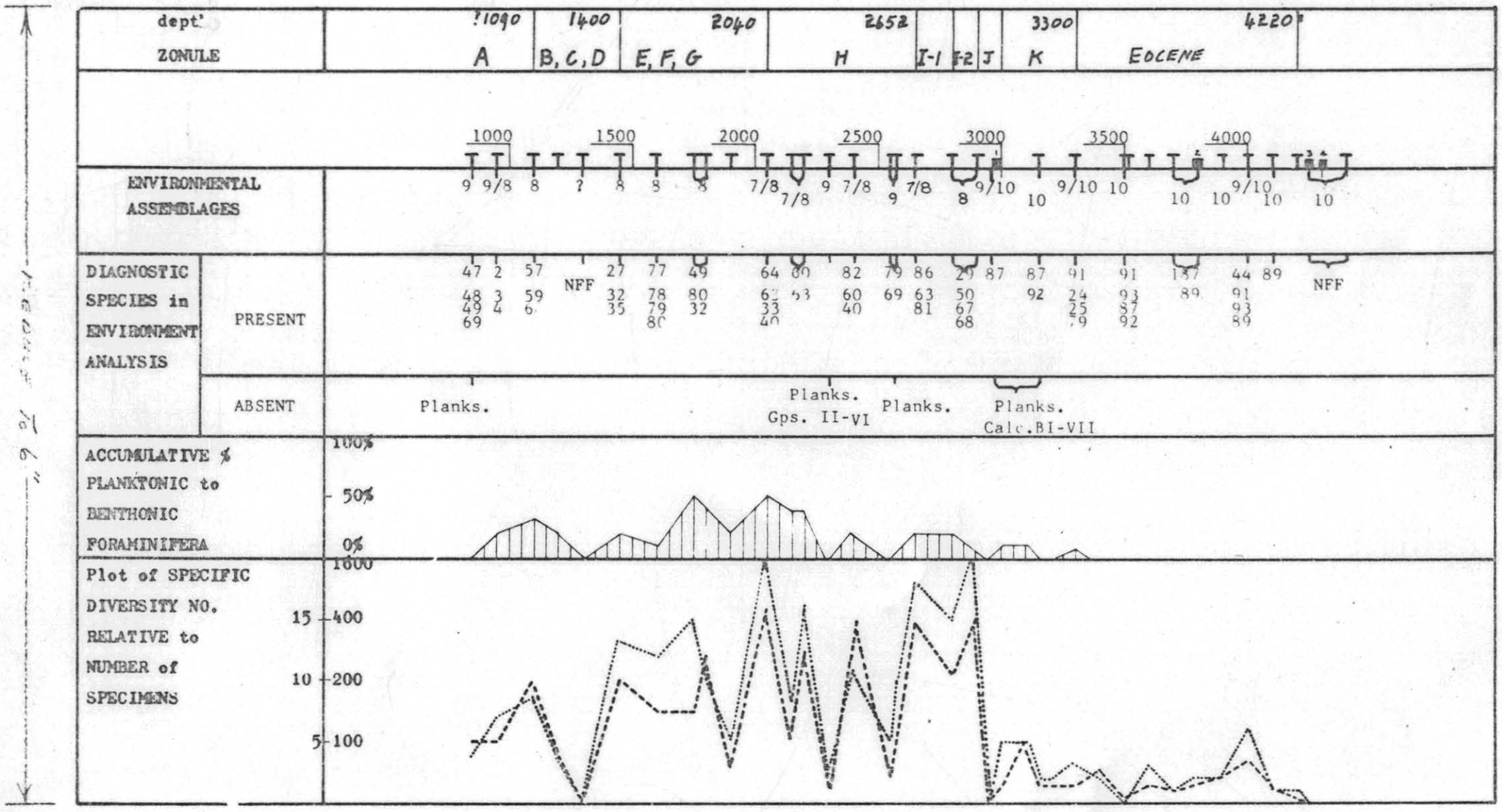
5 cm

CORMORANT-1



5 cm

CORMORANT-1


dept'
?1090
1400
2040
2652
3300
4220'
ZONULE
A
B, C, D
E, F, G
H
I-1
J
K
EOCENE
1000
1500
2000
2500
3000
3500
4000
ENVIRONMENTAL ASSEMBLAGES
DIAGNOSTIC SPECIES in ENVIRONMENT ANALYSIS
PRESENT
ABSENT
NFF
Planks.
Planks. Gps. II-VI
Planks.
Planks. Calc.BI-VII
ACCUMULATIVE % PLANKTONIC to BENTHONIC FORAMINIFERA
100%
50%
0%
Plot of SPECIFIC DIVERSITY NO. RELATIVE to NUMBER of SPECIMENS
15
10
5
1600
400
200
100
Specific diversity
Specimen numbers
5 cm

P E L I C A N - 1

Sheet - 1 - distribution of planktonic fauna & biostratigraphic zonation.

Sheets - 2-4 - distribution of calcareous & arenaceous benthonic species as well as other fauna (see sheet 4)

Sheet - 5 - Statistical data & environmental log. Diagnostic species are given as numbers & refer to sheets 1 - 4.

ALL DEPTHS ARE FROM DATUM of + 100' M.S.L.

BIOSTRATIGRAPHY

Pliocene -	Zonule A	890 - ?
	Zonule B	? present
Upper	Zonule C	? - 1920
Miocene	Zonule D	1920 - 2290
	Zonule E	2290 - 2600
Lower	Zonule F	2600 - ?
Miocene	Zonule G	? - 3300
	Zonule H	3300 - 4050
Oligocene	ZOnule I	4050 -?5006
	I-1	4050 - ?
	I-2	present
	Zonule J	only definite at 5006.
	J-1	present at 5006
	J-2	?
Upper	Zonule K	?5120 - 5204
Eocene	Zonule K	5204 - 5750
	&/or pre-K	
BASE of FORAM. SEQUENCE		- 5750

KEY to symbols on distribution sheets.

T = side wall cores at 890; 910; 1050; 1380; 1410; 1510; 1700; 1800; 1920; 2100; 2230; 2290; 2400; 2533; 3000; 3300; 3600; 4050; 4300; 4604; 4840; 4856; 4893 (N.F.F.); 5006; 5120; 5208; 5310; 5370; 5748; 5750; 5764 (N.F.F.).

= conventional core-1 samples at 5602 & 5612.

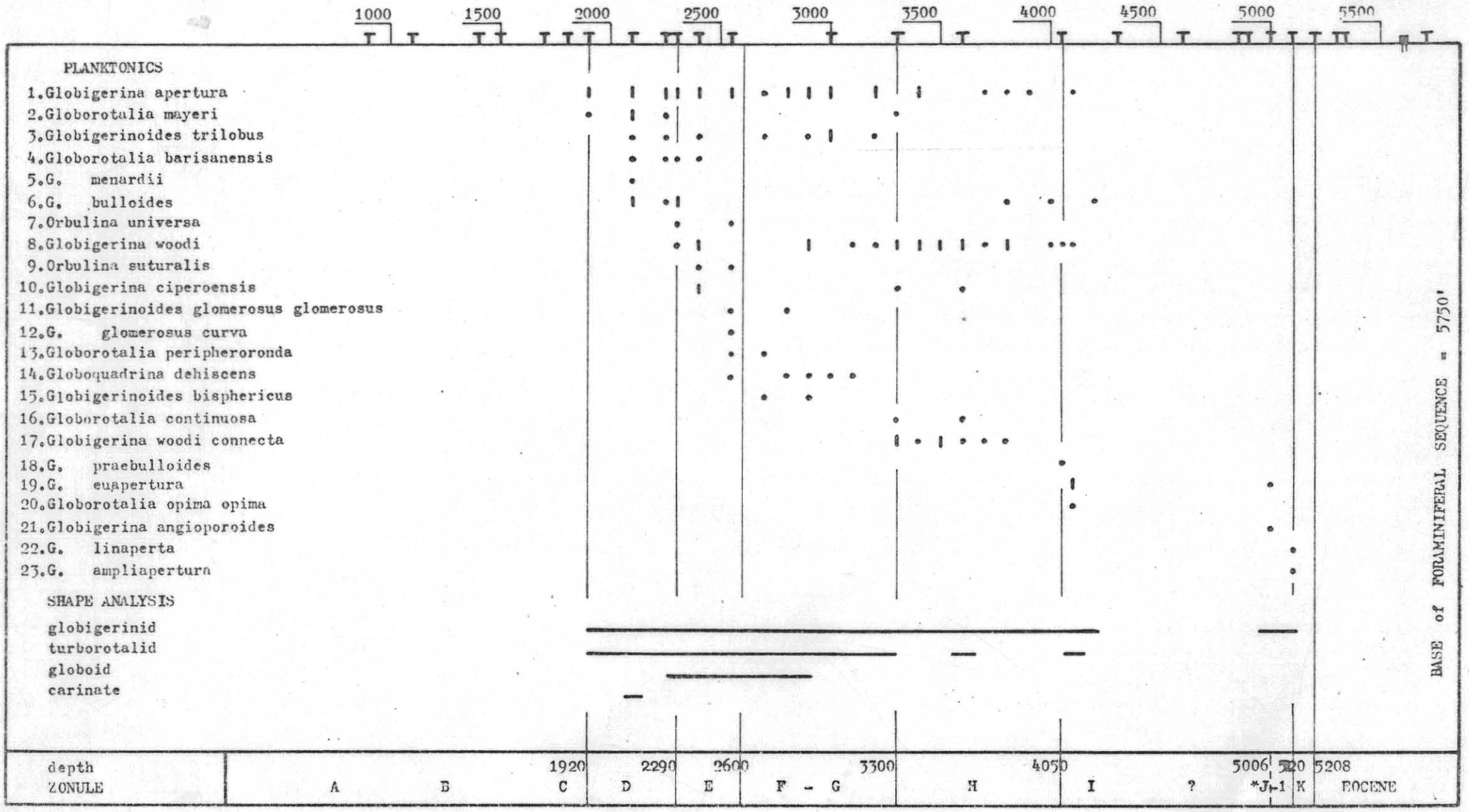
Other samples are rotary cuttings with entire content plotted.

N.F.F. No forams found.

• = 1 - 20 specimens

| = > 20 specimens

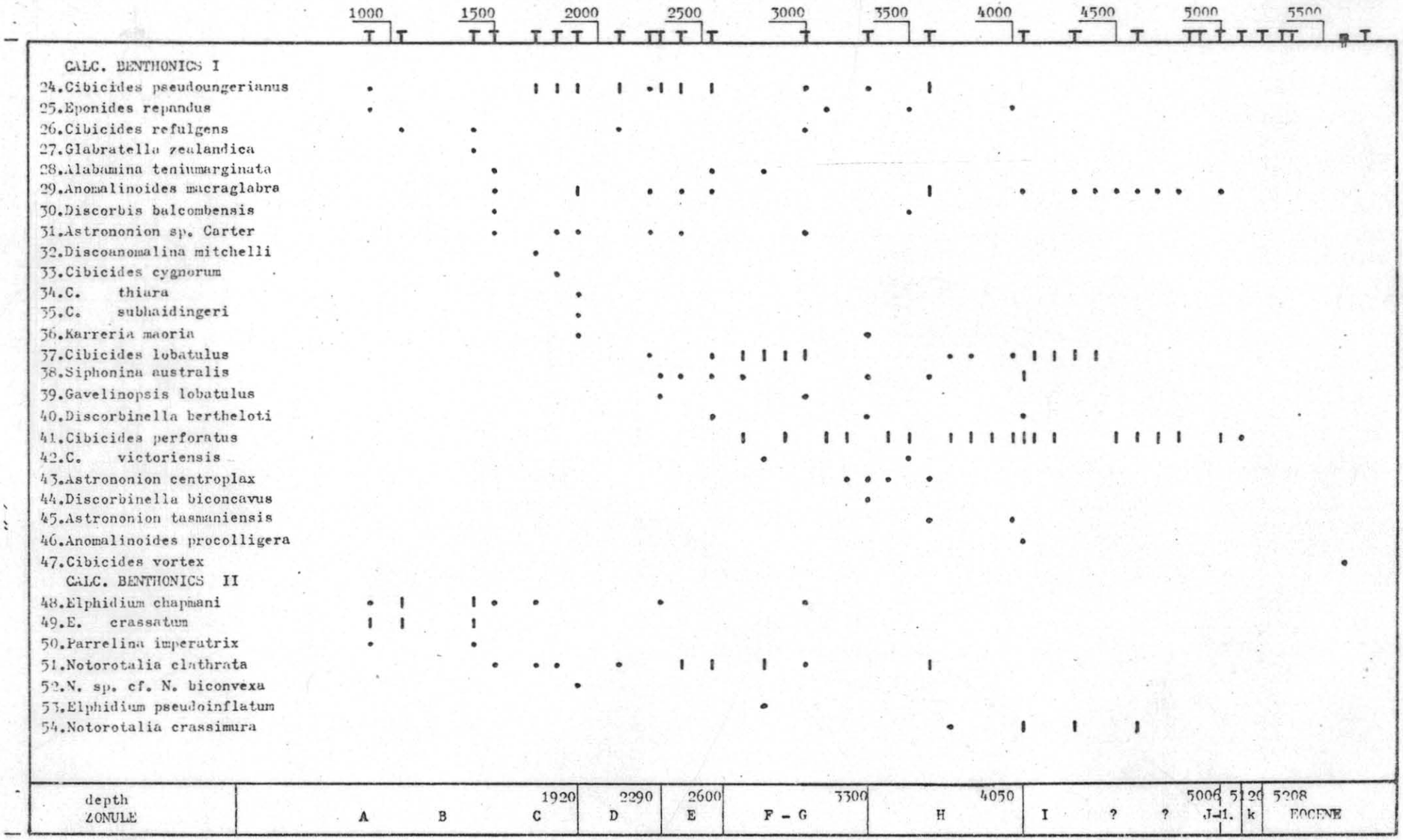
PELICAN - 1



* J-1 at 5006 only
top K at 5120

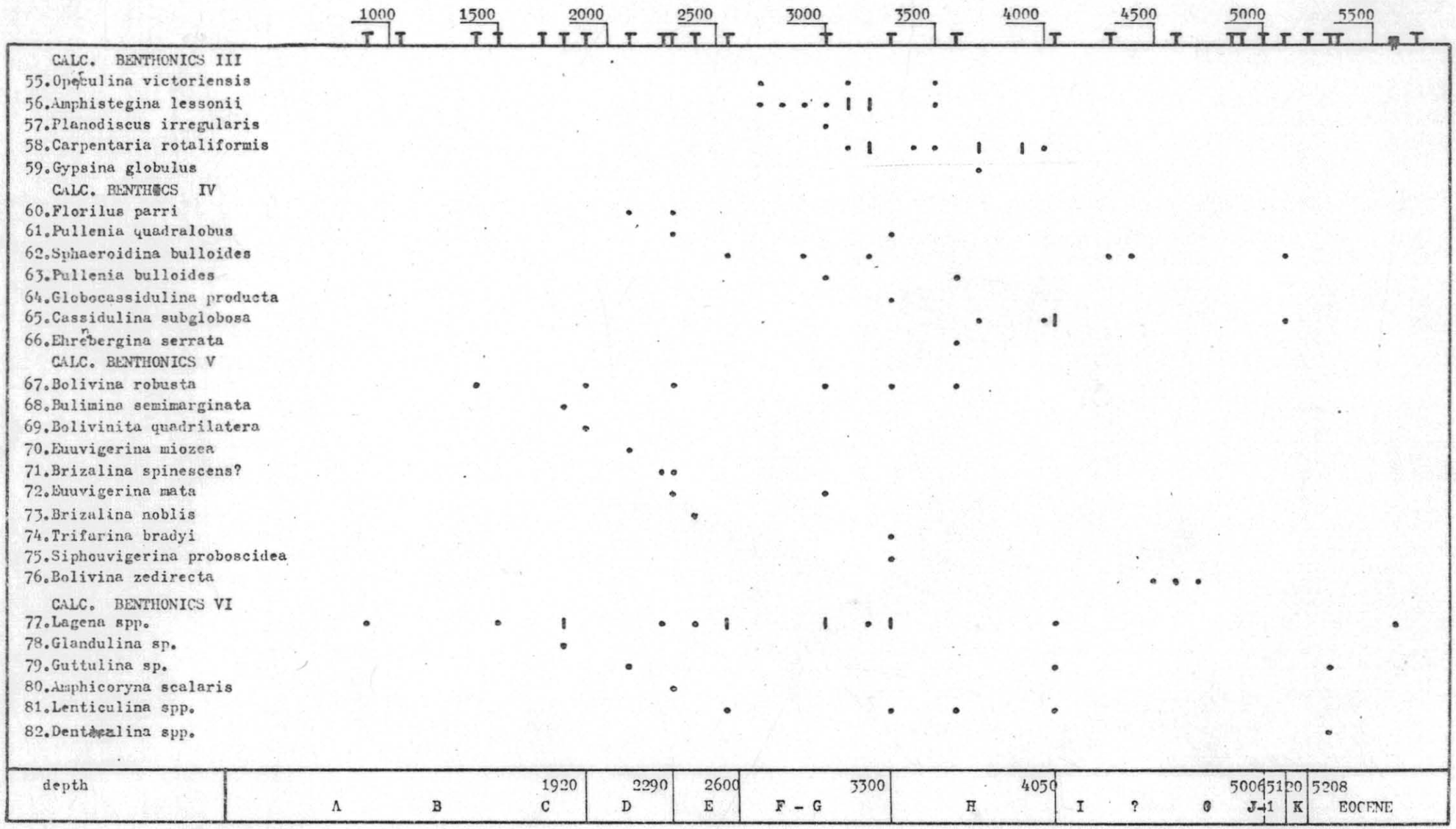
5 cm

PELICAN - 1



5 cm

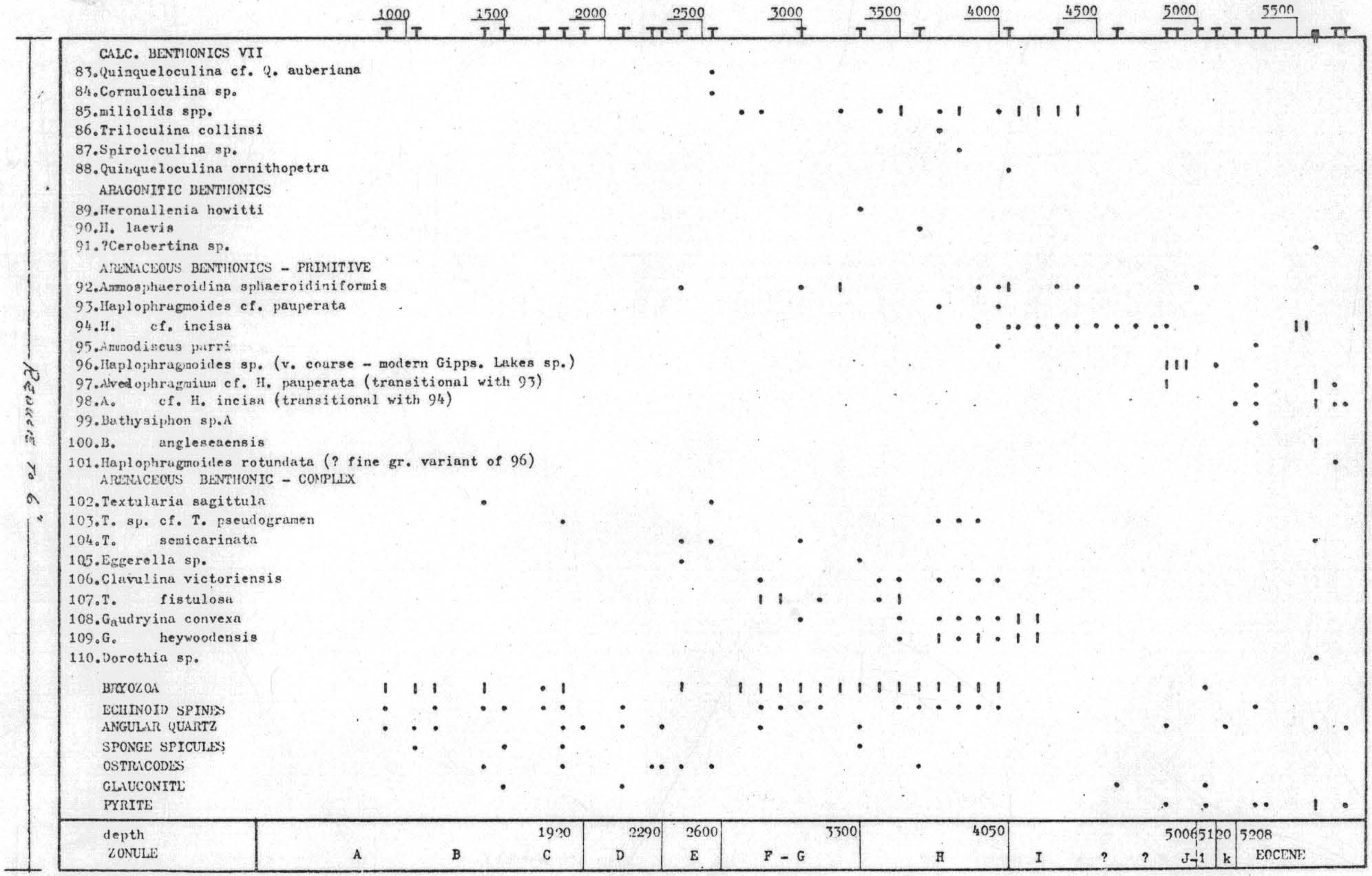
PELICAN - 1



5 cm

PELICAN-1

Sheet - 4 of 5 sheets

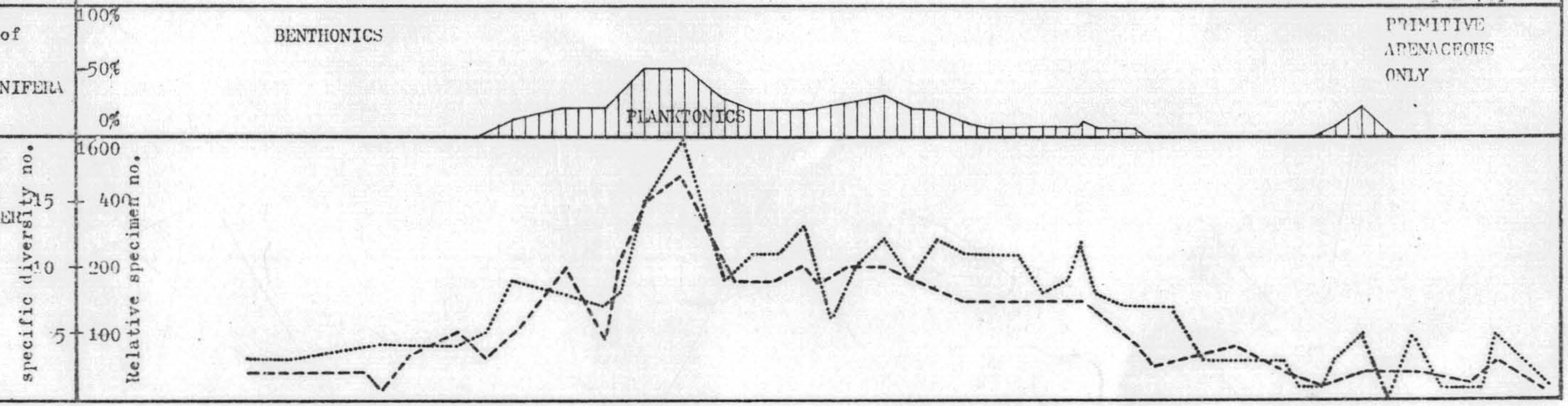


5 cm

PELICAN-1

009042

Sheet - 5
of 5 sheets

depth ZONULE	A B 1920 C 2290 D 2600 E 3300 F - G 4050 H I ? ? ‡500651 J-1 00 F 5208 EOCENE
	J-1 at 5006 only. Base of sequence= 5750. 1000 1500 2000 2500 3000 3500 4000 4500 5000 5500
ENVIRONMENTAL ASSEMBLAGE	9 9 9 9 9/8 8 8 8/7 7 9 9 8/9 8/9 8 8/9 8 9 9 9/8 9 9 10 10 10 10 10. INNER SHELF - LAGOONAL; INNER SHELF; OUTER SHELF; INNER SHELF; INNER SHELF - LAGOONAL; INNER transgressive LAGOONAL
DIAGNOSTIC SPECIES in ENVIRONMENT ANALYSIS: PRESENT (species shown as distrib. no)	48 49; 48 49; 51 30; 32 48; 67 69; 1-6; 48 67 38 1-6; 73 61; 1-14 37; 55 56; 56; 56 57 67 72; 56 58; 67 75 74; 58; 67 45; 58 59 93; 93 58; 46 38; 94 54; 54 94; 96 97 pyrite tubes; 19 21; 98 99 py. tubes fucoidal marks. planktonics; 97 98, 100
ABSENT	all planktonics; 48 & 49; planktonics calc. benths I-VII; planktonics calc. benths I - VII
ACCUMULATIVE % of PLANKTONIC to BENTHONIC FORAMINIFERA	
PLOT of SPECIFIC DIVERSITY NUMBER RELATIVE to NUMBER of SPECIMENS.	(see figure above)

.... = specific diversity number. ------- = no. of specimens.

5 cm