Biostratigraphy Beneath Central San Francisco Bay Along the San Francisco-Oakland Bay Bridge Transect

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CONTENTS

Abstract

To define the late Pleistocene and Holocene biostratigraphy of the sedimentary deposits beneath San Francisco Bay near the San Francisco-Oakland Bay Bridge and to assess possible fault offsets near Yerba Buena Island, we examined cores taken by the California Department of Transportation for seismic retrofitting of the bridge. We used foraminifers, diatoms, and other microorganisms to identify intervals of Pleistocene and Holocene estuarine and alluvial deposition, and examined the estuarine intervals in greater detail to characterize the bay at the time when the sediment was deposited. Although foraminifers generally were poorly preserved, sufficient microfossils were observed in the estuarine deposits to define three biofacies: biofacies A, dominated by *Trochammina inflata* and shallow-water diatoms; biofacies B, with *Ammonia beccarii* and *Elphidium excavatum* and subtidal diatoms; and biofacies C, with *Elphidiella hannai* and the diatom *Isthmia nervosa*. These biofacies indicate progressively deeper or colder estuarine conditions, from intertidal mudflat and marsh to deep subtidal. This biostratigraphy, which correlates with that reported at other transects in the south bay, reflects the late Pleistocene transgressive episode that has been correlated with the latest interglacial (Substage 5e, ~125–120 ka).

The use of microfossils in this study permits a more detailed late Pleistocene stratigraphy at the San Francisco-Oakland Bay Bridge transect than was previously available on the basis of engineering data alone. Holocene samples were too discontinuous to permit definition of a detailed stratigraphy and resolution of the question of faults beneath the bay. More closely spaced, better preserved samples are needed to address these issues.

Introduction

The objectives of this study were (1) to define the late Pleistocene and Holocene biostratigraphy of the sedimentary deposits beneath San Francisco Bay along the eastern and western spans of the San Francisco-Oakland Bay Bridge (figs. 1, 2), and (2) to compare the biostratigraphy in adjacent boreholes to assess possible fault offsets near Yerba Buena Island.

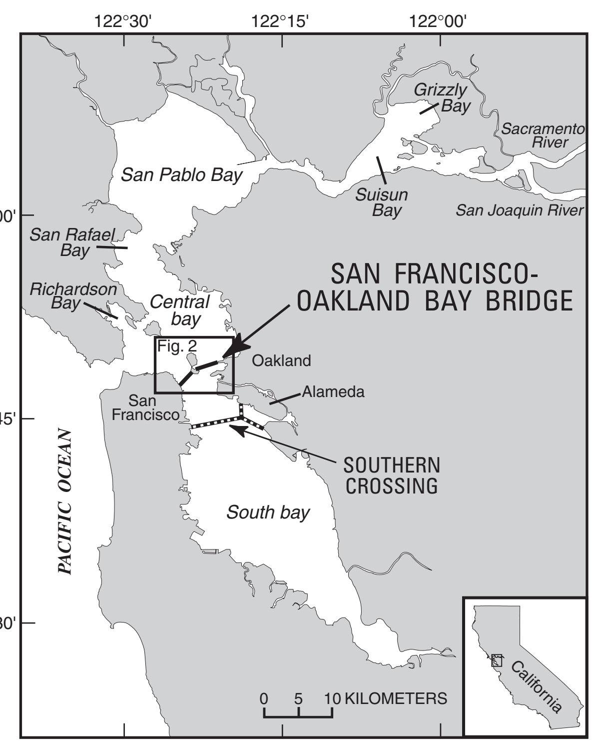

Figure 1.—San Francisco Bay, showing locations of the San Francisco-Oakland Bay Bridge and the Southern Crossing, a proposed bridge between San Francisco and Alameda that was to be constructed just south of the existing San Francisco-Oakland Bay Bridge.

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We used core samples from 12 boreholes drilled to bedrock by the California Department of Transportation (Caltrans) for seismic retrofitting of the bridge. We identified intervals of estuarine and alluvial deposition on the basis of foraminifers and other microfossils in the sediment and examined the estuarine intervals in greater detail to characterize San Francisco Bay at the time when the sediment was deposited.

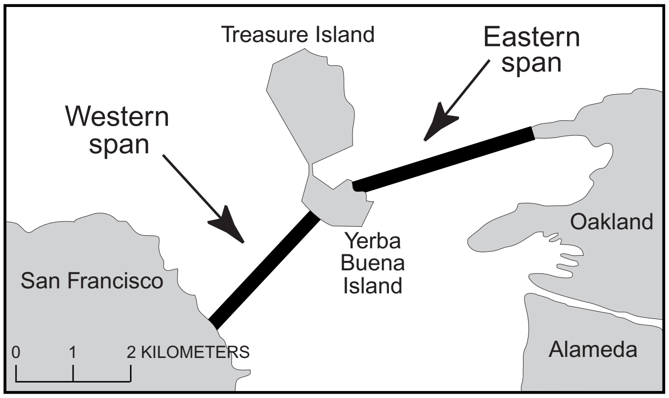

Figure 2.—San Francisco-Oakland Bay Bridge, showing locations of eastern and western spans.

In earlier studies of central San Francisco Bay (fig. 1), Trask and Rolston (1951) identified four sedimentary units along the San Francisco-Oakland Bay Bridge transect: (1) a Pleistocene unit of alluvial and estuarine deposits (Alameda formation), (2) late Pleistocene estuarine deposits (San Antonio formation), (3) alluvial and eolian deposits (Posey Sand and Merritt formation), and (4) Holocene estuarine deposits (bay mud). Wagner (1978) studied foraminifers in cores from the bridge and found that a stronger open-ocean influence existed in the past. Sloan (1992) examined late Pleistocene estuarine deposits at the proposed (but never built) Southern Crossing transect (fig. 1); she informally named them the "Yerba Buena mud member of the San Antonio formation," to distinguish them from alluvial components of the San Antonio formation.

Methods

To define the stratigraphy beneath San Francisco Bay for this study, we used foraminifers, diatoms, and other microorganisms that previously had proved valuable in defining the biostratigraphy of southern San Francisco Bay (Sloan, 1992). We defined stratigraphic units on the basis of lithology and microfossils, primarily benthic foraminifers and diatoms. Where microfossils were absent, we relied on engineering data to locate the contacts in cores from boreholes east of Yerba Buena Island (fig. 3*A*). No engineering data were available on cores from boreholes west of Yerba Buena Island (fig. 3*B*).

We examined 210 samples of 50 to 300 g each from eight boreholes east of Yerba Buena Island (fig. 3*A*) and 42 samples from four boreholes west of Yerba Buena Island (fig. 3*B*), using standard paleontologic techniques to recover microfossils. Foraminifers were poorly preserved in most samples, partly because the cores had been stored without refrigeration for more than a year before we acquired them. Gypsum, which was present in many samples (tables 1, 2), is likely to have formed through the dissolution of foraminifers. Therefore, we considered its presence as evidence of an estuarine depositional environment. In the western cores, foraminifers were better preserved in samples near the top of the core than in the lower part.

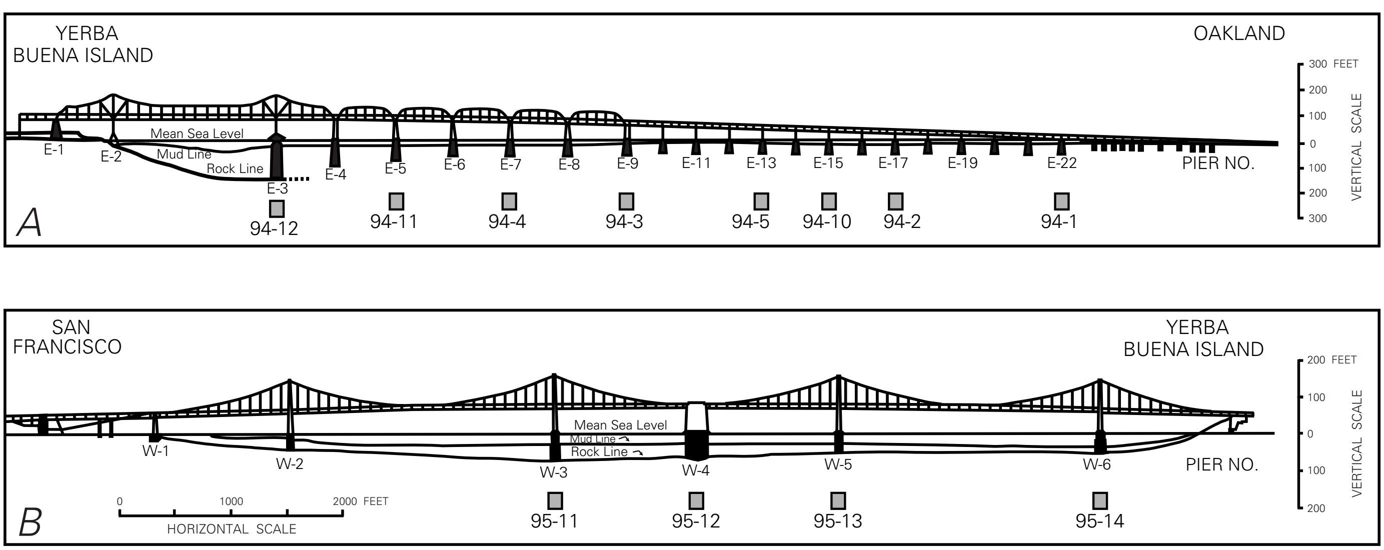

Figure 3.—Schematic diagrams showing approximate placement of boreholes (squares) along the San Francisco-Oakland Bay Bridge (after Trask and Rolston, 1951, and Buell and others, 1997). *A*, Eastern span between Oakland and Yerba Buena Island. *B*, Western span between Yerba Buena Island and San Francisco.

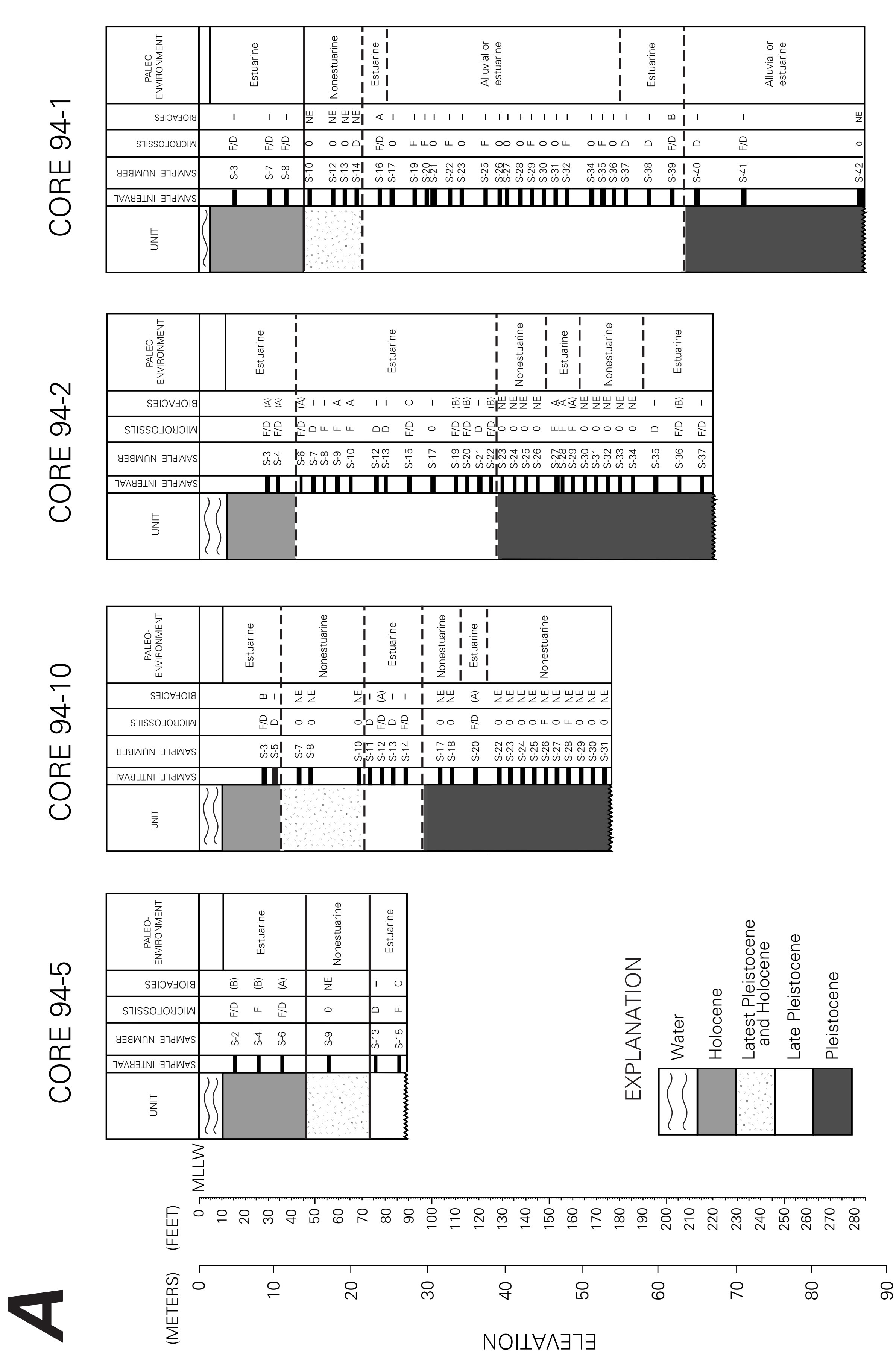

Figure 4.—Stratigraphic sedimentary sections in boreholes beneath the eastern span of the San Francisco-Oakland Bay Bridge. Contacts are based primarily on micropaleontologic data. Where microfossils are absent, engineering data were used. *A*, Cores 94–5, 94–10, 94–2, and 94–1. *B*, Cores 94–12, 94–11, 94–4, and 94–3. Only uppermost part of Pleistocene unit is shown.

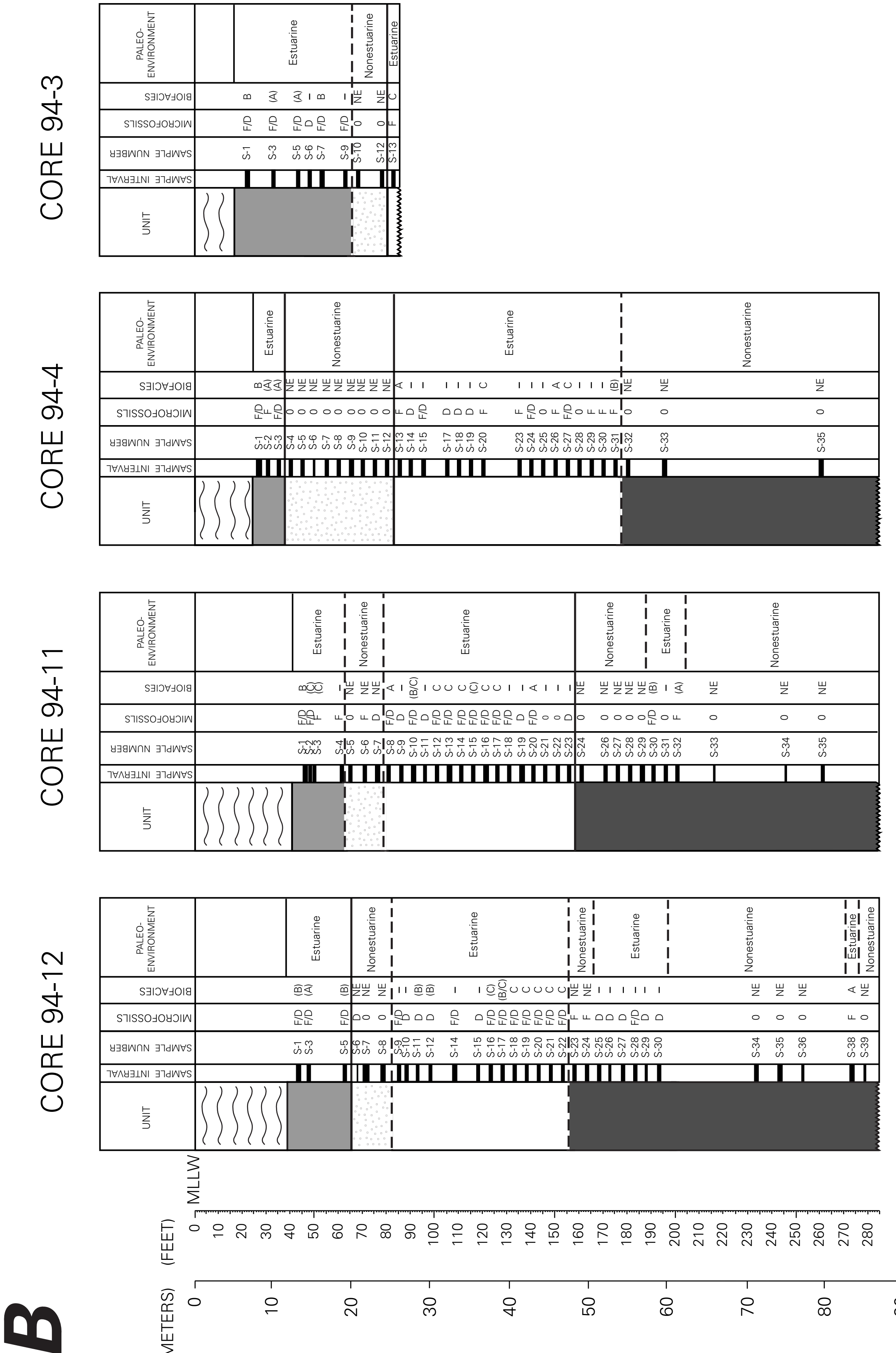

Figure 4.—Continued.

In the eastern cores, only 24 of 210 samples (11 percent) contained more than 300 foraminifers; a total of 37 samples (18 percent) contained more than 100 foraminifers, and an additional 6 samples contained from 50 to 100 foraminifers (3 percent with >50 foraminifers; table 1). In two cores, foraminifers were very rare: In core 94–1 (fig. 4*A*) only two samples (S–16, S–39) contained sufficient foraminifers for reliable analysis; and in core 94–10 (fig. 4*A*), foraminifers were common only in sample S–3. Preservation was best in cores 94–11 and 94–12 (fig. 4*B*).

In the western cores, 7 of 42 samples (17 percent) contained more than 300 specimens, all in core 95–14 (fig. 5); a total of 18 samples (43 percent) contained more than 100 foraminifers, and an additional 5 samples contained from 50 to 100 specimens (12 percent with >50 foraminifers; table 2). In many of these samples, the foraminifers are well preserved; however, the samples were spaced too far apart to permit stratigraphic interpretation of the cores. Therefore, in the interest of completeness, we report microfossil occurrences in table 2 without biostratigraphic interpretation.

In many samples containing no or few foraminifers, sufficient diatoms were preserved to permit environmental interpretations. Several samples contained a few foraminifers but no other organic evidence of estuarine deposition. Where the mineral content of the residues appeared to be nonestuarine, we considered the foraminifers to be displaced and interpreted the depositional environment as nonestuarine.

Results

Lithology and microfossils indicate that the stratigraphy at the Bay Bridge is much like that described in earlier studies (Trask and Rolston, 1951; Wagner, 1978; Sloan, 1992). We identified four sedimentary units (fig. 4): (1) at least 120 ft of Pleistocene alluvial and estuarine deposits, (2) about 15 to 95 ft of late Pleistocene estuarine deposits, (3) 5 to 45 ft of alluvial and eolian deposits, and (4) 20 to 40 ft of Holocene estuarine deposits. We report here on the biostratigraphy of the two youngest estuarine units. In the earlier Pleistocene deposits, estuarine and alluvial depositional environments were discriminated where sufficient microfossil data were available; however, in many cores, sampling intervals were too widely spaced and microfossils too poorly preserved to permit more detailed stratigraphic analysis.

The dominant species of foraminifers in both the late Pleistocene and Holocene estuarine units are *Ammonia beccarii* (Linné), *Elphidiella hannai* (Cushman and Grant), *Elphidium excavatum* (Terquem), and *Trochammina inflata* (Montagu) (tables 1, 2). They indicate deposition under intertidal and shallow to deep subtidal estuarine conditions (0–~20 m water depth; salinity, ~10–~31 practical salinity units; Arnal and others, 1980; Sloan, 1992; McGann and Sloan, 1999; San Francisco Estuary Institute, 1999; see the U.S. Geological Survey's Water Resources Division San Francisco Bay water-quality Web site at URL http//: sfbay.wr.usgs.gov/access/wqdata/index.html). *Trochammina hadai,* a species recently introduced into San Francisco Bay (McGann and others, 2000), is present in low numbers in three Holocene samples (core 94–11, samples S–2, S–4; core 94–12, sample S–3T); its presence in subsurface samples is likely due either to bioturbation or to contamination during coring.

The dominant sand-size diatoms in the estuarine units include *Actinoptychus, Arachnodiscus, Biddulphia, Campylodiscus, Cymbella, Isthmia, Gyrosigma*, and *Thalassiosira.* These brackish to marine genera are all common in the surface sediment of San Francisco Bay today (Mahood and others, 1986; Laws, 1988).

On the basis of the occurrence of these foraminifers and diatoms, we define three biofacies in the late Pleistocene and Holocene estuarine deposits: biofacies A, dominated by *Trochammina inflata* and diatoms, including *Campylodiscus, Biddulphia, Cymbella, Gyrosigma, Melosira, Nitzschia*, *Pinnularia*, or *Thallasiosira*; biofacies B, dominated by *Ammonia beccarii* and *Elphidium excavatum*, including also the diatoms *Actinoptychus* and *Arachnodiscus*; and biofacies C, containing abundant *Elphidiella hannai* and the diatom *Isthmia nervosa*. These three biofacies indicate progressively deeper or colder estuarine conditions, from intertidal mudflat and marsh (biofacies A, ~0–7-ft depth; maximum salinity, ~10 practical salinity units), through shallow subtidal (biofacies B, ~7–49-ft depth; salinity, ~10–30 practical salinity units), to deep subtidal (biofacies C, 39–72-ft depth; salinity, ~15–32 practical salinity units).

Eastern Transect

In the late Pleistocene estuarine deposits, biofacies C is most common, occurring in 17 samples (figs. 4*A*, 4*B*; table 1). Biofacies A and B are present in 14 and 9 samples, respectively, and 2 samples have a biofacies transitional between biofacies B and C. In most cores, the top and bottom samples contain biofacies A or B, or too few data are available for reliable interpretation. Biofacies C occurs near the middle of the unit.

In contrast, in the Holocene estuarine deposits, biofacies A and B are most common, occurring in 8 and 9 samples, respectively (figs. 4*A*, 4*B*; table 1). Biofacies C is present in only 2 samples. Biofacies A occurs near the base of the unit, except in cores 94–3 and 94–12, where biofacies B is present in the lowermost samples, and in cores 94–10 and 94–11, where biofacies A is absent. Biofacies B occurs in the uppermost samples from all cores except 94–2, in which it is absent.

Western Transect

In the undifferentiated late Pleistocene and Holocene estuarine deposits, no samples contain biofacies A; however, a biofacies transitional between biofacies A and B is present in 1 sample from core 95–13 (S–5–3; fig. 5; table 2). Biofa-

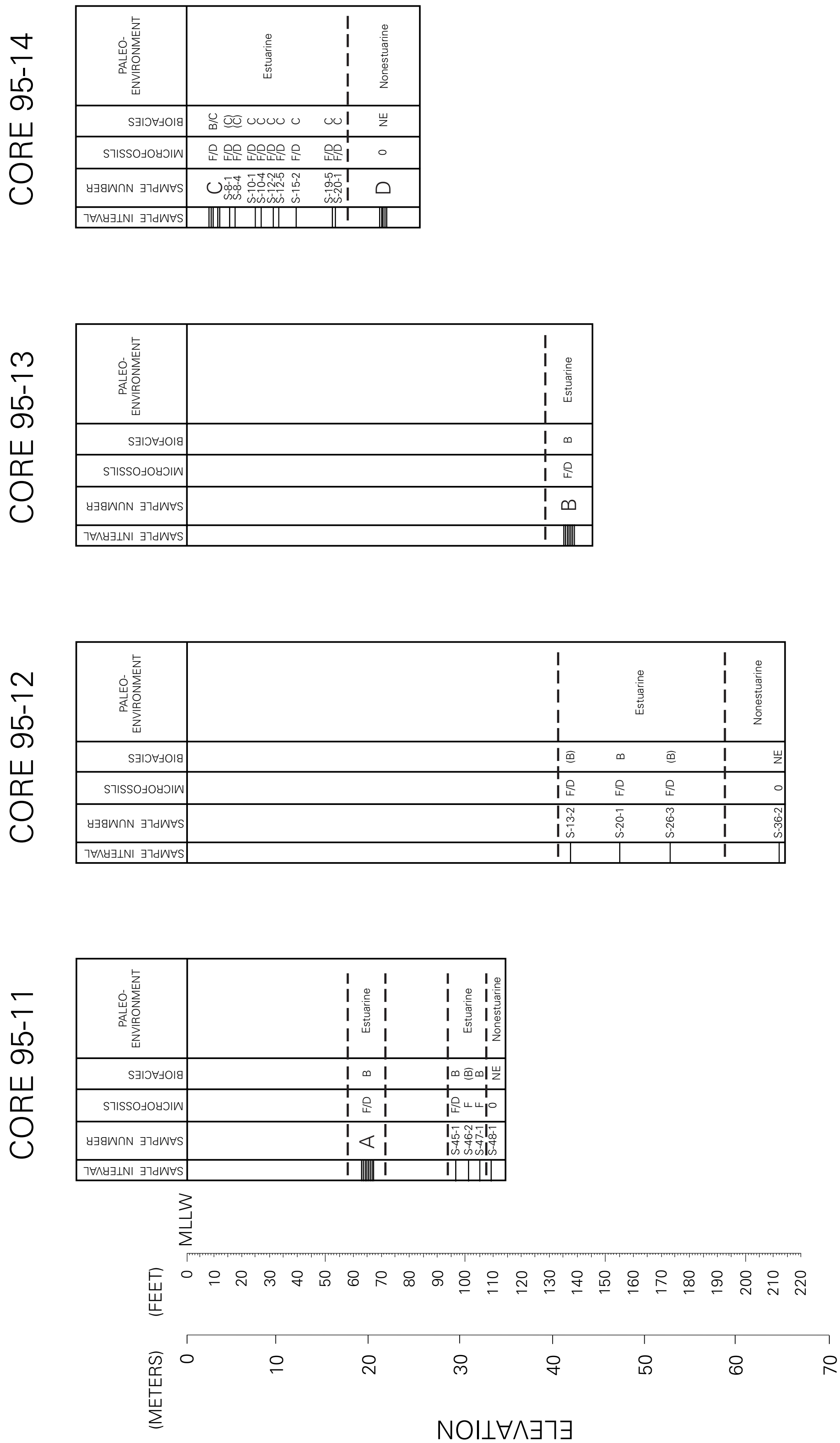

Figure 5.—Sample locations and paleoenvironmental interpretation of sedimentary deposits in boreholes beneath the western span of the San Francisco-Oakland Bay Bridge. Contacts are based on micropaleontologic data. Sample A, S–26–1 to S–26–8; B, S–5–1 to S–5–7; C, S–7–1 to S–7–5; D, S–26–1 to S–26–5.

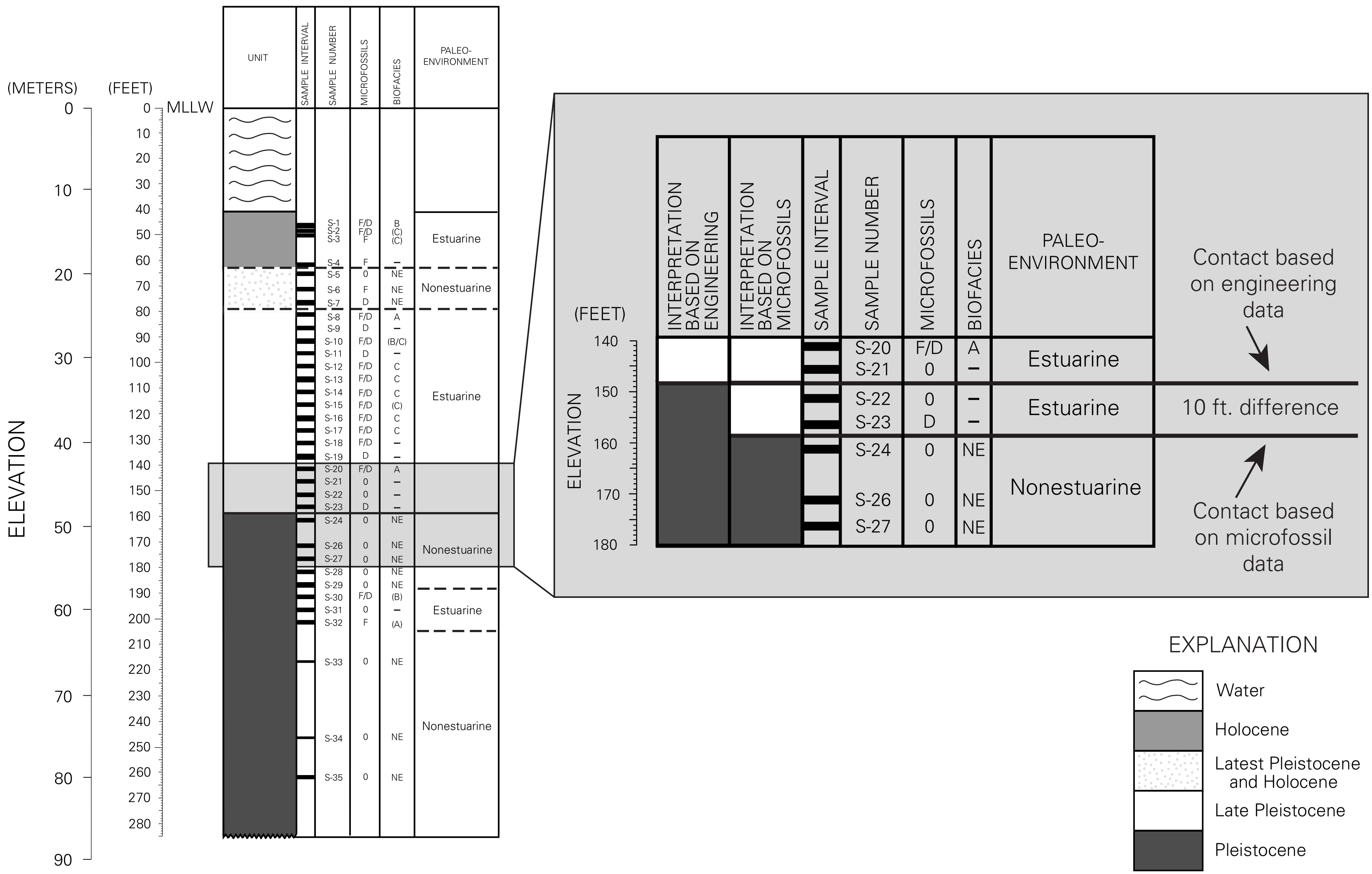

Figure 6.—Expanded view of stratigraphic sedimentary section in core 94–11, showing difference between contacts based on micropaleontologic and engineering data.

cies B is the only one present in cores 95–11 and 95–12. Biofacies C is present in 10 of the 14 estuarine samples from core 95–14, and the other 4 samples have a biofacies transitional between biofacies B and C. Little vertical change was noted in any of these four cores.

Discussion

On the basis of the stratigraphic position of the sedimentary units and the biofacies present in the deposits, the stratigraphy at the San Francisco-Oakland Bay Bridge transect can be correlated with the stratigraphies at the Southern Crossing transect ~6 km to the south studied by Sloan (1992) and at the San Mateo Bridge transect (Atwater and others, 1977), ~26 km south of the bridge. The late Pleistocene estuarine unit at the San Francisco-Oakland Bay Bridge transect is correlative with Sloan's informally named Yerba Buena mud of Sangamon age (Substage 5e, ~125–120 ka). The Holocene estuarine deposits are present at all three transects.

The biofacies present in the eastern Caltrans cores reflect the same late Pleistocene transgressive episode as that seen at the Southern Crossing (Sloan, 1992) and San Mateo Bridge (Atwater and others, 1977) transects. The intertidal-mudflat and marsh deposits at the base (with biofacies A) are succeeded by shallow subtidal (with biofacies B) and then deep subtidal (with biofacies C) deposits. A subsequent drop in sea level or a tectonic event that created a shallower bay is indicated by the presence of biofacies B or A near the top of the late Pleistocene deposits.

In the Holocene unit east of Yerba Buena Island, the transgressive pattern is less clear, partly because of poor sample coverage. Although biofacies A is present in the lowermost samples from several cores from boreholes east of Yerba Buena Island, in cores 94–3 and 94–12 (fig. 4*B*) biofacies A is present in the middle of the unit rather than at the base or top, as in the late Pleistocene unit. This sequence may reflect a shallowing episode or may be an artifact of the spacing of samples or the poor preservation of foraminifers.

The use of microfossils in this study permits a more detailed late Pleistocene stratigraphy at the San Francisco-Oakland Bay Bridge transect than was previously available. Most earlier studies relied on engineering properties alone (Hoover-Young Bridge Commission, 1930; Trask and Rolston, 1951). By using foraminifers and diatoms as indicators of estuarine environments, we can locate contacts between the estuarine and alluvial units with greater precision than was previously possible. For example, in core 94–12 (fig. 4*B*), the micropaleontologic data support a contact between the late Pleistocene and Pleistocene units as defined by Caltrans on the basis of engineering data (Reid Buell, oral commun., 1997). In contrast, in core 94–11, the engineering data suggest that the base of the Yerba Buena mud is lower than set by Caltrans, who located it at ~145 ft, below sample 21 (fig. 6). However, the presence of the marine and estuarine diatom *Campylodiscus* in sample 23 indicates that this sample is not alluvial, and that therefore the contact should be placed another 10 ft lower. Where no microfossil evidence is available, engineering data can provide the necessary control, as in contacts between the latest Pleistocene and Holocene alluvial units and the latest Pleistocene estuarine unit in core 94–5.

Because microfossils were poorly preserved and the cores were discontinuous, samples containing preserved foraminifers were not closely enough spaced to permit us to resolve the question of faults beneath the bay.

Conclusions

Microfossil and engineering data are both essential to developing a detailed subsurface stratigraphic framework for San Francisco Bay. Microfossils are important in defining the environmental conditions in past estuaries. Both types of information are needed by engineers as they site bridges in the Nation's estuaries or undertake seismic retrofitting of bridges in regions susceptible to earthquake activity, such as San Francisco Bay. If more closely spaced and better preserved samples are available when the sedimentary deposits beneath San Francisco Bay are sampled in the future, the Holocene stratigraphy of the central bay can be further refined.

Acknowledgments

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TABLES 1, 2

Table 1.—Microfossil occurrences in boreholes along the eastern span of the San Francisco-Oakland Bay Bridge

[All values in absolute abundances; P, present. LS, Lexan sample; NE, nonestuarine biofacies. Biofacies in parentheses, samples containing less than 100 foraminifers but enough microfossils to indicate biofacies; dashes, insufficient data to determine estuarine biofacies]

Core	94-1																																	
Sample	S-3	S-7	S-8	S-10	S-12	S-13	S-14	S-16	S-17	S-19	S-20	LS-21A	LS-21B	S-22	S-23	S-25	S-26	S-27	S-28	S-29	S-30	S-31	S-32	S-34	S-35	LS-35	S-36	S-37	S-38	S-39	S-40	LS-40	LS-41	S-42
Elevation (ft)	15-16.5	30-31.5	37.5-39	47-48.5	57-58.5	62-63.5	67.5-69	77-78.5	82-84	92-93.5	97-98.5	99.5-101	99.5-101	107-108.5	112-113.5	122.5-124	128.5-130	131.5-133	137-138.5	142-143.5	147-148.5	152-153.5	157-158.5	167.5-169.5	172-174	172-174	177-178.5	182-183.5	192-193.5	202-203.5	212.5-214	213-214	232.5-234.5	282-285
Biofacies	–	–	–	NE	NE	NE	NE	A	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	B	–	–	–	NE
FORAMINIFERS																																		
Ammonia beccarii																							1							3				
Buccella frigida																																		
B. tenerrima																																		
Buliminella elegantissima																																		
Cibicides lobatulus																																		
C. spp.																																		
Elphidiella hannai										5						1				1										3				
Elphidium excavatum														1											1					129				
E. gunteri																																		
E. magellanicum																																		
E. spp.																																		
Glabratella spp.																																		
Hopkinsina pacifica																																		
Lagena acuticosta																																		
Miliammina fusca																																		
Nonionella basispinata																																		
N. stella																																		
Oolina melo																																		
Quinqueloculina sp.																																		
Rosalina globularis																																		
Rotorbinella campanulata																																		
Spirillina vivapara																																		
Trochammina charlottensis																																		
T. hadai																																		
T. inflata	2	2	6					5			1																							
T. kelletae																																		
T. macrescens								441			1																						7	
T. spp.																																		
Other											1																							
Total foraminiferal count	2	2	6	0	0	0	0	446	0	5	3	0	0	1	0	1	0	0	0	1	0	0	1	0	1	0	0	0	0	135	0	0	7	0
DIATOMS																																		
Actinoptychus splendons																												P	P					
Arachnodiscus ehrenbergi	P						P	P																										
Biddulphia aurita		P	P																												P			
Campylodiscus spp.		P	P					P																				P	P	P	P	P	P	
Coscinodiscus spp.																												P		P				
Cymbella sp.								P																							P			
Isthmia nervosa	P	P																													P			
Gyrosigma balticum		P																																
Melosira spp.																																		
Nitschia spp.		P																																
Pinnularia sp.																																		
Thalassiosira spp.								P																				P						
MISCELLANEOUS																																		
Radiolarians																																		
Ostracods							P																											
Macroinvertebrates	P						P			P		P	P												P			P		P	P			
Fish	P									P																		P		P				
Plant material	P	P	P	P			P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P		P	P	P	P	P	P	P	P	P	P
Seeds	P												P				P									P				P	P	P	P	
Gypsum	P	P	P																												P			

Table 1.—Continued.

Core	94-2																															
Sample	S-3	S-4	S-6	S-7	S-8	S-9-1	S-9-2	S-10	S-12	S-13	LS-15	S-17	S-19	S-20	S-21	S-22	S-23	S-24	S-25	S-26	S-27	LS-27	S-28	S-29	S-30	S-31	S-32	S-33	S-34	S-35	S-36	S-37
Elevation (ft)	28.2-30.2	33-34.5	43.2-44.7	48.5-50	53.2-54.7	58.2-60.2	58.2-60.2	64-65.5	74-76	79-80.5	89-91	99-101	109-110.5	114-115.5	119-121	124-125.5	129-130.5	134-135.5	139-140.5	144-145.5	152-154	152-154	154.5-156	159-160.5	164-165.5	169-170.5	174-175.5	179-180.5	184.5-186	194.5-196	204.5-206	214-219
Biofacies	(A)	(A)	(A)	-	-	A	A	A	-	-	C	-	(B)	(B)	-	(B)	NE	NE	NE	NE	A	A	A	(A)	NE	NE	NE	NE	NE	-	(B)	-
FORAMINIFERS																																
Ammonia beccarii														8		8															5	
Buccella frigida																																
B. tenerrima																																
Buliminella elegantissima																																
Cibicides lobatulus																																
C. spp.																																
Elphidiella hannai											101																				2	
Elphidium excavatum						1							15	44		16															22	
E. gunteri													1	11		4																
E. magellanicum																																
E. spp.																																
Glabratella spp.																																
Hopkinsina pacifica																																
Lagena acuticosta																																
Millammina fusca																																
Nonionella basispinata																																
N. stella																																
Oolina melo																																
Quinqueloculina sp.																																
Rosalina globularis																																
Rotorbinella campanulata																																
Spirillina vivapara																																
Trochammina charlottensis																																
T. hadai																																
T. inflata	2	3			1	335	219	440					3								221	335	358	4								1
T. kelletae																																
T. macrescens							6	56																3								
T. spp.																					3											
Other			11																													
Total foraminiferal count	2	3	11	0	1	336	225	496	0	0	101	0	19	63	0	28	0	0	0	0	224	335	358	7	0	0	0	0	0	0	29	1
DIATOMS																																
Actinoptychus splendons		P																														
Arachnodiscus ehrenbergi		P												P																P		
Biddulphia aurita	P	P																														
Campylodiscus spp.		P								P	P		P		P	P														P	P	P
Coscinodiscus spp.																															P	
Cymbella sp.																																
Isthmia nervosa		P																														
Gyrosigma balticum	P	P	P	P					P	P																						
Melosira spp.	P								P	P																						
Nitschia spp.		P	P							P																						
Pinnularia sp.																																
Thalassiosira spp.																																
MISCELLANEOUS																																
Radiolarians							P				P																					
Ostracods																															P	
Macroinvertebrates		P	P				P						P	P		P	P		P												P	
Fish											P										P		P					P				
Plant material	P	P	P	P	P	P	P		P	P	P	P	P	P	P	P		P		P	P	P	P	P	P		P	P	P	P	P	P
Seeds	P				P		P				P							P						P						P	P	P
Gypsum		P	P	P																			P	P						P	P	

Table 1.—Continued.

Core	94-3								
Sample	S-1	S-3	S-5	S-6	S-7	S-9	S-10	S-12	S-13
Elevation (ft)	22-24	33-34.5	43-44.5	48-49.5	53-55	63-64.5	68-69.5	78-79.5	83-84.5
Biofacies	B	(A)	(A)	-	B	-	NE	NE	C
FORAMINIFERS									
Ammonia beccarii	7				6				
Buccella frigida									2
B. tenerrima									
Buliminella elegantissima									
Cibicides lobatulus									
C. spp.									
Elphidiella hannai									352
Elphidium excavatum	290				126				26
E. gunteri	12				8				
E. magellanicum									2
E. spp.									
Glabratella spp.									
Hopkinsina pacifica									
Lagena acuticosta									
Miliammina fusca									
Nonionella basispinata									
N. stella									1
Oolina melo									
Quinqueloculina sp.									
Rosalina globularis									
Rotorbinella campanulata									
Spirillina vivapara									
Trochammina charlottensis									
T. hadai									
T. inflata		13	2		6				
T. kelletae									
T. macrescens						2			
T. spp.									
Other									
Total foraminiferal count	309	13	2	0	146	2	0	0	383
DIATOMS									
Actinoptychus splendons									
Arachnodiscus ehrenbergi					P				
Biddulphia aurita		P	P		P	P			
Campylodiscus spp.	P	P	P	P	P				
Coscinodiscus spp.		P							
Cymbella sp.									
Isthmia nervosa		P	P		P				
Gyrosigma balticum									
Melosira spp.	P								
Nitschia spp.									
Pinnularia sp.									
Thalassiosira spp.									
MISCELLANEOUS									
Radiolarians	P							P	
Ostracods	P				P				
Macroinvertebrates	P	P		P	P				P
Fish				P	P				
Plant material	P	P	P	P	P	P		P	P
Seeds		P			P				
Gypsum	P				P	P			

Core	94-4													
Sample	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	S-11	S-12	S-13	S-14
Elevation (ft)	25.5-27.5	29.9-31.4	34.5-36	39.5-41	43-44.5	48-49.5	54.5-56	59.5-61	64.5-66	69.5-71	74.5-76	79.5-81	84.5-86	89.5-91
Biofacies	B	(A)	(A)	NE	NE	NE	NE	NE	NE	NE	NE	NE	A	-
FORAMINIFERS														
Ammonia beccarii	14													
Buccella frigida	1													
B. tenerrima														
Buliminella elegantissima														
Cibicides lobatulus														
C. spp.														
Elphidiella hannai	51													
Elphidium excavatum	11													
E. gunteri														
E. magellanicum														
E. spp.														
Glabratella spp.														
Hopkinsina pacifica														
Lagena acuticosta														
Miliammina fusca														
Nonionella basispinata														
N. stella														
Oolina melo														
Quinqueloculina sp.														
Rosalina globularis														
Rotorbinella campanulata														
Spirillina vivapara														
Trochammina charlottensis														
T. hadai	242													
T. inflata	10	15	8											
T. kelletae														
T. macrescens													108	
T. spp.														
Other	1													
Total foraminiferal count	330	15	8	0	0	0	0	0	0	0	0	0	108	0
DIATOMS														
Actinoptychus splendons														
Arachnodiscus ehrenbergi	P													P
Biddulphia aurita			P											
Campylodiscus spp.														
Coscinodiscus spp.	P													
Cymbella sp.														
Isthmia nervosa	P		P											P
Gyrosigma balticum	P													
Melosira spp.														
Nitschia spp.														
Pinnularia sp.														
Thalassiosira spp.	P													
MISCELLANEOUS														
Radiolarians	P													
Ostracods	P										P			
Macroinvertebrates	P		P											
Fish	P		P											
Plant material	P	P	P	P					P			P	P	
Seeds		P	P						P				P	
Gypsum														

Core	94-4																
Sample	LS-15	S-17	S-18	S-19	S-20	S-23	S-24	S-25	S-26	LS-27	S-28	S-29	S-30	S-31	S-32	S-33	S-35
Elevation (ft)	94.5-95.5	104.5-106	109.5-111	114.5-116	119.5-121	134.5-136	139.5-141	144.5-146	149.5-151	154-155	159.5-161	164.5-166	169.5-171	174.5-176	179.5-181	194.5-196.5	259.5-261
Biofacies	-	-	-	-	C	-	-	-	A	C	-	-	-	(B)	NE	NE	NE
FORAMINIFERS																	
Ammonia beccarii					2									24			
Buccella frigida													1				
B. tenerrima																	
Buliminella elegantissima																	
Cibicides lobatulus					2												
C. spp.																	
Elphidiella hannai	2				83	3	4			172			1				
Elphidium excavatum					17		2			3		1		1			
E. gunteri					2												
E. magellanicum																	
E. spp.																	
Glabratella spp.																	
Hopkinsina pacifica					1												
Lagena acuticosta																	
Miliammina fusca																	
Nonionella basispinata																	
N. stella																	
Oolina melo																	
Quinqueloculina sp.																	
Rosalina globularis																	
Rotorbinella campanulata					4												
Spirillina vivapara																	
Trochammina charlottensis																	
T. hadai																	
T. inflata						1			254					4			
T. kelletae																	
T. macrescens									47								
T. spp.																	
Other																	
Total foraminiferal count	2	0	0	0	111	4	6	0	301	175	0	1	2	29	0	0	0
DIATOMS																	
Actinoptychus splendons																	
Arachnodiscus ehrenbergi																	
Biddulphia aurita																	
Campylodiscus spp.																	
Coscinodiscus spp.	P	P					P										
Cymbella sp.																	
Isthmia nervosa	P	P	P	P						P							
Gyrosigma balticum																	
Melosira spp.	P																
Nitschia spp.																	
Pinnularia sp.																	
Thalassiosira spp.	P																
MISCELLANEOUS																	
Radiolarians					P		P										
Ostracods					P					P							
Macroinvertebrates			P		P	P	P	P		P	P	P					
Fish				P	P	P			P	P	P	P	P	P			
Plant material		P	P	P	P	P	P	P	P	P			P	P	P		P
Seeds				P	P	P			P				P	P			P
Gypsum														P			P

Table 1.—Continued.

Core	94-5						94-10																					
Sample	S-2	S-4	S-6	S-9	S-13	S-15	S-3	S-5	S-7	S-8	S-10	S-11	S-12	S-13	S-14	S-17	S-18	S-20	S-22	S-23	S-24	S-25	S-26	LS-27	S-28	S-29	S-30	S-31
Elevation (ft)	15-16.5	25-26.5	35-36.5	55-57.5	75-76.5	85-86.5	27-29	32-33.5	42-43.5	47-48.5	68-69.5	73-74.5	78-79.5	82.5-84	87.5-89	102.5-104	107.5-109	118-119.5	128-129.5	132.5-134	138-139.5	142.5-144	147.5-149	152.5-153.5	157.5-159	162.5-164	167.5-169	172.5-174
Biofacies	(B)	(B)	(A)	NE	-	C	B	-	NE	NE	NE	-	(A)	-	-	NE	NE	(A)	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
FORAMINIFERS																												
Ammonia beccarii		1					12																		3			
Buccella frigida						10																						
B. tenerrima																												
Buliminella elegantissima																												
Cibicides lobatulus																												
C. spp.																												
Elphidiella hannai						214	1								1													
Elphidium excavatum	42	6				72	306																1					
E. gunteri							11																					
E. magellanicum																												
E. spp.																												
Glabratella spp.																												
Hopkinsina pacifica																												
Lagena acuticosta																												
Miliammina fusca																												
Nonionella basispinata																												
N. stella																												
Oolina melo																												
Quinqueloculina sp.																												
Rosalina globularis																												
Rotorbinella campanulata																												
Spirillina vivapara																												
Trochammina charlottensis																												
T. hadai																												
T. inflata	9	2	1										3					8										
T. kelletae																												
T. macrescens															3													
T. spp.																												
Other	1														1													
Total foraminiferal count	52	9	1	0	0	296	330	0	0	0	0	0	3	0	5	0	0	8	0	0	0	0	1	0	3	0	0	0
DIATOMS																												
Actinoptychus splendens					P		P																					
Arachnodiscus ehrenbergi	P																											
Biddulphia aurita			P					P				P	P	P	P													
Campylodiscus spp.	P		P		P			P				P	P	P	P			P										
Coscinodiscus spp.							P						P															
Cymbella sp.					P									P	P													
Isthmia nervosa	P		P										P															
Gyrosigma balticum			P					P				P	P	P	P													
Melosira spp.																		P										
Nitschia spp.			P		P			P					P	P														
Pinnularia sp.					P																							
Thalassiosira spp.															P													
MISCELLANEOUS																												
Radiolarians	P																											
Ostracods							P				P				P													
Macroinvertebrates	P	P	P	P		P	P	P			P												P					
Fish			P			P	P				P	P		P	P			P										
Plant material	P	P	P	P	P	P	P	P		P	P	P	P	P	P			P	P	P		P					P	P
Seeds		P			P			P				P	P		P			P		P								
Gypsum	P		P		P			P				P	P	P				P						P				

Table 1.—Continued.

Core	94-11																
Sample	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	S-11	S-12	S-13	S-14	S-15	S-16	S-17
Elevation (ft)	45-47	47.5-49	49-50.5	60.5-62	64-65.5	70-71.5	75.5-77.5	80-81.5	85-86.5	90-92	95-96.5	101.5-102	105-107	110.5-112	115.5-117	120.5-122.5	125.5-127
Biofacies	B	(C)	(C)	-	NE	NE	NE	A	-	(B/C)	-	C	C	C	(C)	C	C
FORAMINIFERS																	
Ammonia beccarii	151	8	1	1													1
Buccella frigida												4	3	10	1		11
B. tenerrima													5	9		5	
Buliminella elegantissima																	
Cibicides lobatulus													1	2	1	4	6
C. spp.																	
Elphidiella hannai	97	69	7	1						2		441	329	547	27	292	543
Elphidium excavatum	85	3				1						36	19	94	9	16	39
E. gunteri	3															2	2
E. magellanicum												1		3			3
E spp.	1																2
Glabratella spp.																	
Hopkinsina pacifica																	
Lagena acuticosta														1			
Miliammina fusca																	
Nonionella basispinata														1			2
N. stella												1	1	3		1	
Oolina melo															1		
Quinqueloculina sp.												1					
Rosalina globularis																	4
Rotorbinella campanulata																3	6
Spirillina vivapara																	
Trochammina charlottensis																	
T. hadai		3		1													
T. inflata	39	4															
T. kelletae																	
T. macrescens	4							153								1	
T. spp.	2																
Other																	
Total foraminiferal count	362	87	8	3	0	1	0	153	0	2	0	484	358	670	39	324	619
DIATOMS																	
Actinoptychus splendons									P		P						
Arachnodiscus ehrenbergi	P	P					P	P	P	P	P	P	P	P	P		
Biddulphia aurita																	
Campylodiscus spp.								P						P			P
Coscinodiscus spp.	P	P									P		P	P	P		P
Cymbella sp.	P	P															
Isthmia nervosa								P	P	P	P	P	P		P	P	
Gyrosigma balticum								P									
Melosira spp.																	
Nitschia spp.																	
Pinnularia sp.																	
Thalassiosira spp.																	
MISCELLANEOUS																	
Radiolarians							P						P	P	P	P	P
Ostracods	P											P		P		P	P
Macroinvertebrates	P	P	P	P	P					P		P	P	P	P	P	P
Fish	P	P						P		P		P	P	P	P	P	P
Plant material	P	P		P			P	P	P	P	P	P	P	P	P	P	P
Seeds		P					P	P			P	P		P	P	P	P
Gypsum		P						P			P	P		P	P		P

Core	94-11																
Sample	S-18	S-19	S-20	S-21	S-22	S-23	S-24	S-26	S-27	S-28	S-29	S-30	S-31	S-32	S-33	S-34	S-35
Elevation (ft)	130.5-132	135.5-137.5	140.5-142	145-146.5	150.5-152	155.5-157	160.5-162	170.5-172	175.5-177	180.5-182	185.5-187.5	190.5-192	195.5-197	200-201.5	215.5-217	245.5-246	260.5-262
Biofacies	-	-	A	-	-	-	NE	NE	NE	NE	NE	(B)	-	(A)	NE	NE	NE
FORAMINIFERS																	
Ammonia beccarii												27					
Buccella frigida																	
B. tenerrima																	
Buliminella elegantissima																	
Cibicides lobatulus																	
C. spp.																	
Elphidiella hannai																	
Elphidium excavatum												3					
E. gunteri												1					
E. magellanicum																	
E spp.																	
Glabratella spp.																	
Hopkinsina pacifica																	
Lagena acuticosta																	
Miliammina fusca																	
Nonionella basispinata																	
N. stella																	
Oolina melo																	
Quinqueloculina sp.																	
Rosalina globularis																	
Rotorbinella campanulata																	
Spirillina vivapara																	
Trochammina charlottensis																	
T. hadai																	
T. inflata			134														
T. kelletae																	
T. macrescens	1		169											11			
T. spp.																	
Other																	
Total foraminiferal count	1	0	303	0	0	0	0	0	0	0	0	31	0	11	0	0	0
DIATOMS																	
Actinoptychus splendons																	
Arachnodiscus ehrenbergi												P					
Biddulphia aurita																	
Campylodiscus spp.			P			P											
Coscinodiscus spp.		P															
Cymbella sp.																	
Isthmia nervosa	P	P															
Gyrosigma balticum																	
Melosira spp.																	
Nitschia spp.																	
Pinnularia sp.																	
Thalassiosira spp.																	
MISCELLANEOUS																	
Radiolarians								P			P						
Ostracods																	
Macroinvertebrates									P			P				P	
Fish		P					P										
Plant material	P	P	P	P		P	P	P	P	P	P	P	P	P			P
Seeds	P	P	P			P	P	P	P			P	P	P			
Gypsum	P		P						P				P				

Table 1.—Continued.

Core	94-12																																								
Sample	S-1B	S-3T	S-3B	S-5T	S-5B	S-6	S-7	S-8	S-9T	S-10T	S-10	S-11	S-12T	S-14A	S-15T	S-16T	S-17	LS-17	S-18	S-19T	S-19	S-20	LS-20	S-21T	S-21	S-22T	S-22	S-23	S-24	S-25	LS-26	S-27	S-28	LS-29	S-30	S-34	LS-34	S-35	LS-35	LS-36	S-38	LS-39
Elevation (ft)	42.5-44.5	47-48.5	47-48.5	62-63.5	62-63.5	67.5-68	71-72.5	77.5-79.5	84.5-86	87.5-89	87.5-89	92.5-93.5	97.5-99	107.5-109.5	117.5-119	122.5-124	127.5-129	127.5-128.5	132.5-134	137.5-139	137.5-139	142.5-143.5	142.5-143.5	147.5-149	147.5-149	152.5-154	152.5-154	157.5-159	162.5-164	167.5-169	172.5-173.5	177.5-179	182.5-184	187.5-188.5	192.5-194	232.5-234.5	232.5-233.5	242.5-244.5	242.5-244.5	252.5-253.5	272.5-274.5	278.5-279.5
Biofacies	(B)	(A)	(A)	(B)	-	NE	NE	NE	-	-	-	(B)	(B)	-	-	(C)	(B/C)	(C)	C	C	C	C	C	C	C	C	C	NE	NE	-	-	-	-	-	-	NE	NE	NE	NE	NE	A	NE
FORAMINIFERS																																										
Ammonia beccarii	21	3		1																								1		1																
Buccella frigida																2	2		11	28	16	9	9	4	13	3	14																
B. tenerrima																			3	7	7	6	7	2	9	1	3																
Buliminella elegantissima																		5																												
Cibicides lobatulus																				4			1	6	3	2	2																
C. spp.																						1			13	1																	
Elphidiella hannai	16	2	1	6												15	21	5	333	537	337	300	132	43	177	92	257		2													
Elphidium excavatum	17			11												5	37		67	137	100	64	29	38	63	16	100																
E. gunteri				1																			1		1		2																
E. magellanicum																6	24		6	7	14		6	1	9	2																	
E. spp.																				4	1	10	1		3																		
Glabratella spp.																				3		2																					
Hopkinsina pacifica																																										
Lagena acuticosta																						1																					
Miliammina fusca |1|																																									
Nonionella basispinata																			1	2					3																		
N. stella																	1		3	4	2		3	4	6	1	3																
Oolina melo																																										
Quinqueloculina sp.																									2		2																
Rosalina globularis																				7		2	1	2	3	1	7																
Rotorbinella campanulata																								3	10		2																
Spirillina vivapara																								1																				
Trochammina charlottensis			1																																								
T. hadai		3																																									
T. inflata	11	4	41	3	8																																					
T. kelletae	2		3																																								
T. macrescens	3		5						3																																358	
T. spp.																																										
Other		2			1									1			2		1			2								1						4										
Total foraminiferal count	71	14	51	22	9	0	0	0	3	0	0	0	0	1	0	28	92	5	425	740	477	397	190	104	316	119	393	1	2	0	0	0	4	0	0	0	0	0	0	0	358	0
DIATOMS																																										
Actinoptychus splendons			P									P																															
Arachnodiscus ehrenbergi	P		P									P	P				P		P					P					P			P	P	P		P								
Biddulphia aurita	P														P																											
Campylodiscus spp.			P	P	P				P			P																													
Coscinodiscus spp.	P		P										P		P	P		P		P	P	P	P	P	P	P	P	P			P	P	P	P	P	P							
Cymbella sp.			P	P																											P											
Isthmia nervosa	P	P	P	P		P	P			P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P			P	P	P	P	P	P							
Gyrosigma balticum					P																																					
Melosira spp.	P				P																																					
Nitschia spp.																																										
Pinnularia sp.																																										
Thalassiosira spp.				P	P						P								P																								
MISCELLANEOUS																																										
Radiolarians			P								P									P			P	P					P						P	P											
Ostracods	P											P						P	P	P	P	P	P	P	P	P	P	P		P				P									
Macroinvertebrates	P	P	P	P		P	P										P	P	P	P	P	P	P	P	P	P					P								P				
Fish			P																P	P		P	P					P				P	P	P	P	P								
Plant material	P	P	P		P		P	P	P	P	P	P	P	P	P	P		P	P	P		P	P	P	P	P	P			P	P	P	P	P	P	P		P			P	P
Seeds	P		P				P	P					P			P		P	P	P	P													P	P									
Gypsum		P	P	P						P						P				P	P																						

Table 2.—Microfossil occurrences in boreholes along the western span of the San Francisco-Oakland Bay Bridge.

[All values in absolute abundances; P, present. NE, nonestuarine biofacies. Biofacies in parentheses, samples containing less than 100 foraminifers but enough microfossils to indicate biofacies; dashes, insufficient data to determine estuarine biofacies]

Core	95-11											
Sample	S-26-1	S-26-2	S-26-3	S-26-4	S-26-5	S-26-6	S-26-7	S-26-8	S-45-1	S-46-2	S-47-1	S-48-1
Elevation (ft)	62.8-63.0	63.5-63.7	64.2-64.4	64.8-65.0	65.5-65.7	66.1-66.3	66.8-67.0	67.3-67.5	96.5-96.7	101.1-101.3	104.9-105.1	109.1-109.3
Biofacies	B	(B)	(B)	(B)	(B)	-	-	(B)	B	(B)	B	NE
FORAMINIFERS												
Ammonia beccarii									37	6	6	
Buccella frigida												
B. tenerrima	2		5	1	2				1			
Buliminella elegantissima												
Cibicides lobatulus												
C. spp.												
Elphidiella hannai	2		4	1	4				28	5	1	
Elphidium excavatum	99	36	38	21	49			9	209	74	95	
E. gunteri	2	1	1		5			1			2	
E. magellanicum			1	2	1							
E. spp.				1								
Glabratella spp.												
Hopkinsina pacifica												
Lagena acuticosta												
Miliammina fusca												
Nonionella basispinata												
N. stella			1	1								
Oolina melo												
Quinqueloculina sp.												
Rosalina globularis			1									
Rotorbinella campanulata												
Spirillina vivapara												
Trochammina charlottensis												
T. hadai												
T. inflata												
T. kelletae												
T. macrescens												
T. spp.					1							
Other												
Total foraminiferal count	105	37	51	27	62	0	0	10	275	85	104	0
DIATOMS												
Actinoptychus splendons												
Arachnodiscus ehrenbergi									P			
Biddulphia aurita												
Campylodiscus spp.												
Coscinodiscus spp.												
Cymbella sp.												
Isthmia nervosa	P				P	P						
Gyrosigma balticum												
Melosira spp.												
Nitschia spp.												
Pinnularia sp.												
Thalassiosira spp.									P			
MISCELLANEOUS												
Radiolarians			P									
Ostracods			P		P	P	P	P	P	P	P	
Macroinvertebrates									P	P	P	P
Fish				P	P	P	P	P	P		P	
Plant material	P	P	P	P	P	P	P	P			P	
Seeds				P	P	P	P	P				
Gypsum						P	P		P		P	P

Core	95-12			
Sample	S-13-2	S-20-1	S-26-3	S-36-2
Elevation (ft)	110.9-111.1	128.3-128.5	146.5-146.7	185.2-185.4
Biofacies	(B)	B	(B)	NE
FORAMINIFERS				
Ammonia beccarii		3		
Buccella frigida				
B. tenerrima				
Buliminella elegantissima				
Cibicides lobatulus				
C. spp.				
Elphidiella hannai	1		1	
Elphidium excavatum	12	82	10	
E. gunteri		1		
E. magellanicum		1		
E. spp.				
Glabratella spp.				
Hopkinsina pacifica				
Lagena acuticosta				
Miliammina fusca				
Nonionella basispinata				
N. stella				
Oolina melo				
Quinqueloculina sp.	1			
Rosalina globularis				
Rotorbinella campanulata				
Spirillina vivapara				
Trochammina charlottensis				
T. hadai				
T. inflata				
T. kelletae				
T. macrescens	1	12		
T. spp.				
Other		8		
Total foraminiferal count	15	107	11	0
DIATOMS				
Actinoptychus splendons				
Arachnodiscus ehrenbergi		P	P	
Biddulphia aurita				
Campylodiscus spp.	P	P		
Coscinodiscus spp.		P		
Cymbella sp.				
Isthmia nervosa	P	P		
Gyrosigma balticum				
Melosira spp.				
Nitschia spp.				
Pinnularia sp.				
Thalassiosira spp.	P			
MISCELLANEOUS				
Radiolarians				
Ostracods	P	P	P	
Macroinvertebrates	P	P	P	
Fish		P		
Plant material	P	P	P	P
Seeds	P	P		
Gypsum	P	P		

Core	95-13						
Sample	S-5-1	S-5-2	S-5-3	S-5-4	S-5-5	S-5-6	S-5-7
Elevation (ft)	90.8-91.0	91.4-91.6	92.1-92.3	92.7-92.9	93.4-93.6	94.0-94.2	94.4-94.6
Biofacies	B	B	(A/B)	B	B	B	(B)
FORAMINIFERS							
Ammonia beccarii	3	6		10	6	6	2
Buccella frigida							
B. tenerrima						2	1
Buliminella elegantissima							
Cibicides lobatulus							
C. spp.							
Elphidiella hannai			1	3	3	4	1
Elphidium excavatum	101	135	33	178	143	118	75
E. gunteri		2		4	3		1
E. magellanicum				1			
E. spp.	2						
Glabratella spp.							
Hopkinsina pacifica							
Lagena acuticosta							
Miliammina fusca							
Nonionella basispinata							
N. stella						1	
Oolina melo							
Quinqueloculina sp.							
Rosalina globularis							
Rotorbinella campanulata							
Spirillina vivapara							
Trochammina charlottensis							
T. hadai							
T. inflata	25	31	37	19	30	31	10
T. kelletae							
T. macrescens							
T. spp.							
Other	3						
Total foraminiferal count	134	174	71	215	185	162	90
DIATOMS							
Actinoptychus splendons							
Arachnodiscus ehrenbergi	P					P	
Biddulphia aurita							
Campylodiscus spp.	P						
Coscinodiscus spp.	P				P		P
Cymbella sp.							
Isthmia nervosa	P	P		P	P		P
Gyrosigma balticum							
Melosira spp.							
Nitschia spp.							
Pinnularia sp.							
Thalassiosira spp.	P						
MISCELLANEOUS							
Radiolarians		P		P		P	
Ostracods	P	P	P	P	P	P	P
Macroinvertebrates		P		P	P	P	P
Fish	P	P				P	
Plant material	P	P	P	P	P	P	P
Seeds		P	P	P	P		P
Gypsum			P				

Core	95-14																		
Sample	S-7-1	S-7-2	S-7-3	S-7-4	S-7-5	S-8-1	S-8-4	S-10-1	S-10-4	S-12-2	S-12-5	S-15-2	S-19-5	S-20-1	S-26-1	S-26-2	S-26-3	S-26-4	S-26-5
Elevation (ft)	8.2-8.4	9.0-9.2	9.6-9.8	11.5-11.7	12.1-12.3	15.5-15.7	17.5-17.7	25.0-25.2	26.9-27.1	31.2-31.4	33.2-33.4	39.6-39.8	52.4-52.6	53.5-53.7	69.4-69.6	70.0-70.2	70.7-70.9	71.4-71.6	72.0-72.2
Biofacies	(B/C)	(B/C)	B/C	B/C	(C)	(C)	(C)	C	C	C	C	C	C	C	NE	NE	NE	NE	NE
FORAMINIFERS																			
Ammonia beccarii	1					1								1					
Buccella frigida	2		5	18				1	10	14	5	3	1	5					
B. tenerrima			1	7				11	6	3	2	4	2						
Buliminella elegantissima				1															
Cibicides lobatulus										2	1			4					
C. spp.																			
Elphidiella hannai	17	5	42	204	23	19	14	216	389	371	324	383	235	336					
Elphidium excavatum	16	3	59	274	8	8		119	142	54	35	45	15	21					
E. gunteri			1											1					
E. magellanicum				15							1			2					
E. spp.																			
Glabratella spp.												1	1						
Hopkinsina pacifica																			
Lagena acuticosta			1																
Miliammina fusca																			
Nonionella basispinata				1				1	2	3				3					
N. stella												2							
Oolina melo				2															
Quinqueloculina sp.																			
Rosalina globularis											1	1		13					
Rotorbinella campanulata														2					
Spirillina vivapara																			
Trochammina charlottensis																			
T. hadai																			
T. inflata											1								
T. kelletae																			
T. macrescens																			
T. spp.				1															
Other													2	1					
Total foraminiferal count	36	8	109	523	31	28	14	348	549	447	370	439	256	389	0	0	0	0	0
DIATOMS																			
Actinoptychus splendons																			
Arachnodiscus ehrenbergi		P	P	P	P	P	P	P	P	P									
Biddulphia aurita						P													
Campylodiscus spp.																			
Coscinodiscus spp.	P		P	P	P	P	P	P	P	P		P							
Cymbella sp.																			
Isthmia nervosa	P	P	P	P	P	P	P	P	P	P	P	P	P						
Gyrosigma balticum																			
Melosira spp.				P			P												
Nitschia spp.																			
Pinnularia sp.																			
Thalassiosira spp.		P						P											
MISCELLANEOUS																			
Radiolarians	P	P	P		P	P	P	P	P	P									
Ostracods	P			P								P		P					
Macroinvertebrates	P	P			P	P	P		P		P	P	P						
Fish		P	P	P	P	P	P	P			P	P							
Plant material	P	P	P	P	P	P	P	P	P		P	P		P					
Seeds	P	P	P	P	P	P	P	P	P	P									
Gypsum			P								P								