19. ICHTHYOLITHS, DEEP SEA DRILLING PROJECT LEGS 51 THROUGH 53

Robert J. Kozarek, Phillips Petroleum Company, Englewood, Colorado
and
William N. Orr, University of Oregon, Eugene, Oregon

INTRODUCTION

A fundamental problem with microfaunas from Legs 51-53 was the poor preservation of calcareous fossils. The resistance of fish remains, composed of calcium phosphate, to solution makes them a natural group to turn to for biostratigraphy in sediments accumulating below the calcium carbonate composition depth (CCD). The paucity of ichthyoliths in the sediments precludes their emergence as a major microfossil group along the lines of foraminifers or radiolarians. For comparison we have developed range charts (Tables 1 and 2) of osteichthyian and elasmobrachian types from the work of various authors (Riedel, Kennedy, and Doyle, as well as other investigators. On our own range charts for Holes 417A,B,C,D, and 418A,B (Tables 3 and 4) we have included also data from a Pacific site (Site 164) for comparison.

METHOD OF STUDY

Leg 51 samples were already taken and mounted, but the majority of samples needed mechanical and chemical treatment before use.

The samples used in this study were of 20 and 40 cm^3 size. The larger ones are more desirable for ichthyolith studies owing to low specimen frequency. In order to disaggregate the sample, it was boiled in a 10 per cent solution of water and hydrogen peroxide, 30 per cent stabilized. The disaggregated sample was then wet-sieved through a 100-μm sieve. Any large chert chips and other undesirable components were removed by hand from the sieve at this point. The remaining coarse fraction was washed into large evaporating dishes, allowed to settle for at least 1 hour, and then decanted. Finally, the sample was oven-dried at 40°C for 24 hours or more.

The dried residues were concentrated by means of a Franz Isodynamic Separator. Except for radiolarian oozes, two-thirds or more of the residue was eliminated in this manner. With oozes, the separator eliminated from one-fourth to one-half of the residue from the sample. Because most of the samples were of uniform lithology, the same setting was used for all samples. Settings of 15° forward tilt, 15° lateral tilt, electromagnet adjusted to 1.0 ampere (high range), and vibrator set at 10, were found to maximize separation and minimize loss of ichthyoliths. All samples were examined under the microscope to check for microfossils that had been separated into the magnetic fraction. The attrition of microfossils at this juncture was found to be negligible, and occurred only when the microfossil adhered to a clay chip.

Ichthyoliths were taken from the residue, dry-mounted on Curtin micropaleontological slides, and studied under reflected light.

ABUNDANCE, PRESERVATION, AND REWORKING

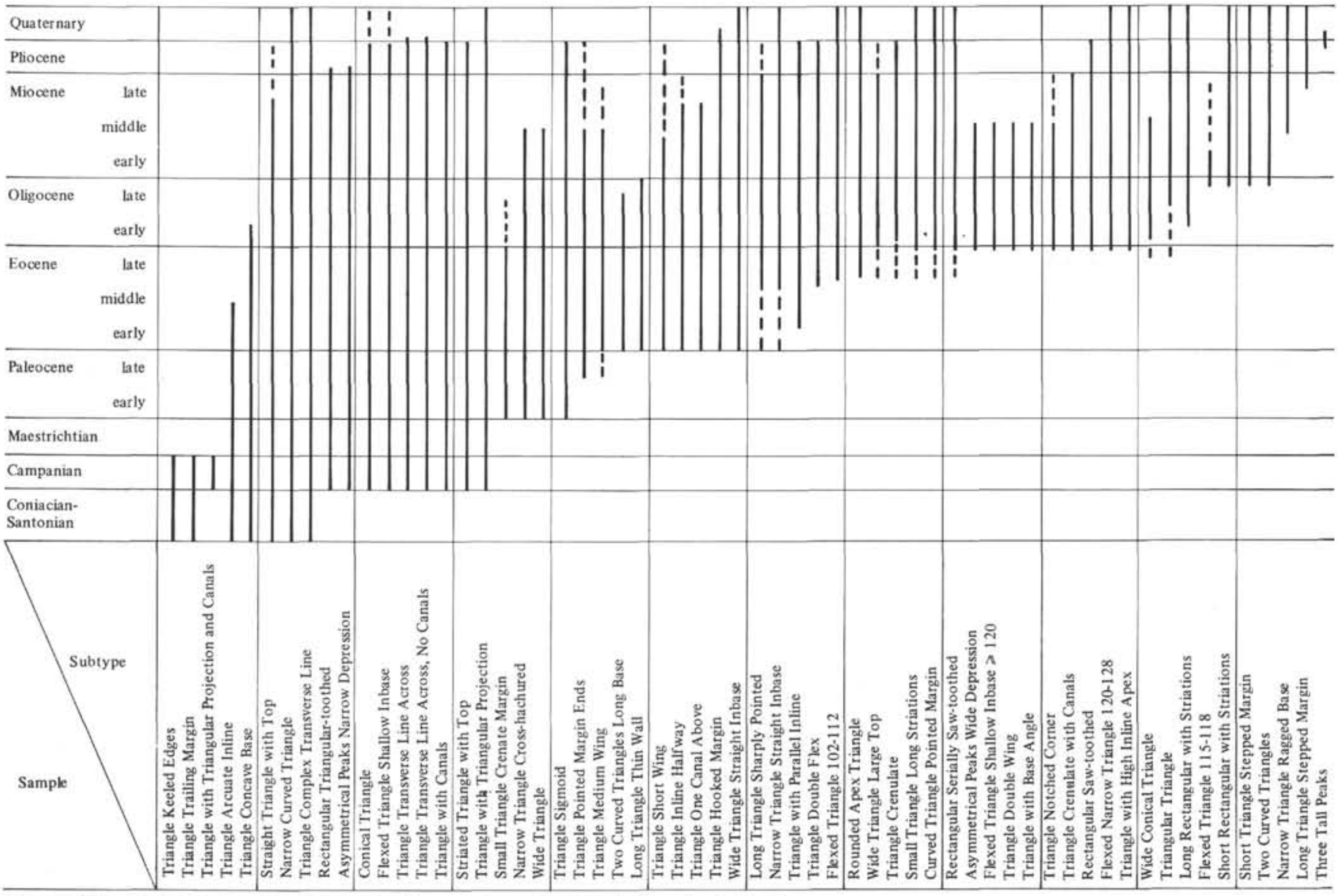
Abundance

Ichthyoliths do not occur in the large numbers characteristics of other microfossils that comprise many deep-sea deposits. The number of ichthyoliths per cubic centimeter of sediment is recorded in Table 4 and varies from a scant 0.02 to nearly 17, with an average of 1.54. Edgerton et al. (in press) have calculated the number of tooth-shaped ichthyoliths per gram of dried sample as ranging from 0.81 to 46.61.

Preservation

Because of their phosphatic composition, ichthyoliths are well preserved even below the CCD. The only major problem in this respect is breakage. This applies to the *a9/b5* subtypes, viz. *Triangle with triangular projection, Narrow curved triangle, Narrow triangle cross-hachured, Triangle transverse line across,* and *Triangle transverse line across no canals.* Breakage normally occurs at or near the transverse line. Even if broken, these subtypes are usually easily recognized. On the other hand, a special problem involves *Triangle transverse line across no canals.* This subtype, if broken near the transverse line, closely resembles either *Narrow triangle straight inbase* or *Triangle pointed margin ends.* The question as to the proper placement of these three subtypes remains unanswered. It is rare that samples contain severely pitted and corroded specimens that are unidentifiable because of their preservation. Techniques established by Doyle et al. (1974) for studying ichthyoliths call for examination in transmitted light in a Canada balsam mount. The Doyle technique precludes the effective study of elasmobranchian hard parts (teeth and dermal denticles) because in order to place them within a Linnaean classification, it is necessary to view specimens in three dimensions — a process only possible when using reflected light. Features on sharks' dermal denticles, including the acuteness of keels, the shape of the area between keels, length and width of pedicel, and the angle that the blade rises from the base, are of

TABLE 1
Ranges of Osteichthyian Ichthyolith Subtypes



Note: Doubtful-age assignments are shown by dashed lines (summarized from Riedel, Doyle, Kennedy and others).

interest taxonomically (White, 1937; Bigelow and Schroeder, 1948; Applegate, 1967). The height of the crown on skates and rays' teeth also has taxonomic significance (Bigelow and Schroeder, 1953). These features are not distinguishable or measurable when the specimens are viewed with transmitted light. The bulk of the ichthyolith material consists of the teeth of bony fish, and these may be adequately studied using reflected light. In our opinion, all material should be prepared for study under reflected light because of the considerable biostratigraphic and paleoecologic importance of elasmobranchian hard parts, even though the latter may be in the minority.

Selected ichthyoliths were examined and photographed with an AMR 1000 scanning electron microscope. Specimens were mounted on aluminum stubs with double-sided Scotch tape, coated with a thin layer of gold-palladium alloy, and photographed with Polaroid Type 665 positive/negative film. Other specimens were photographed in transmitted light, in an oil with a refractive index of 1.46, using Polaroid Type 55 positive/negative film. We have illustrated specimens from a large suite of Pacific sites in addition to Sites 417 and 418 in the Atlantic where the former were better preserved.

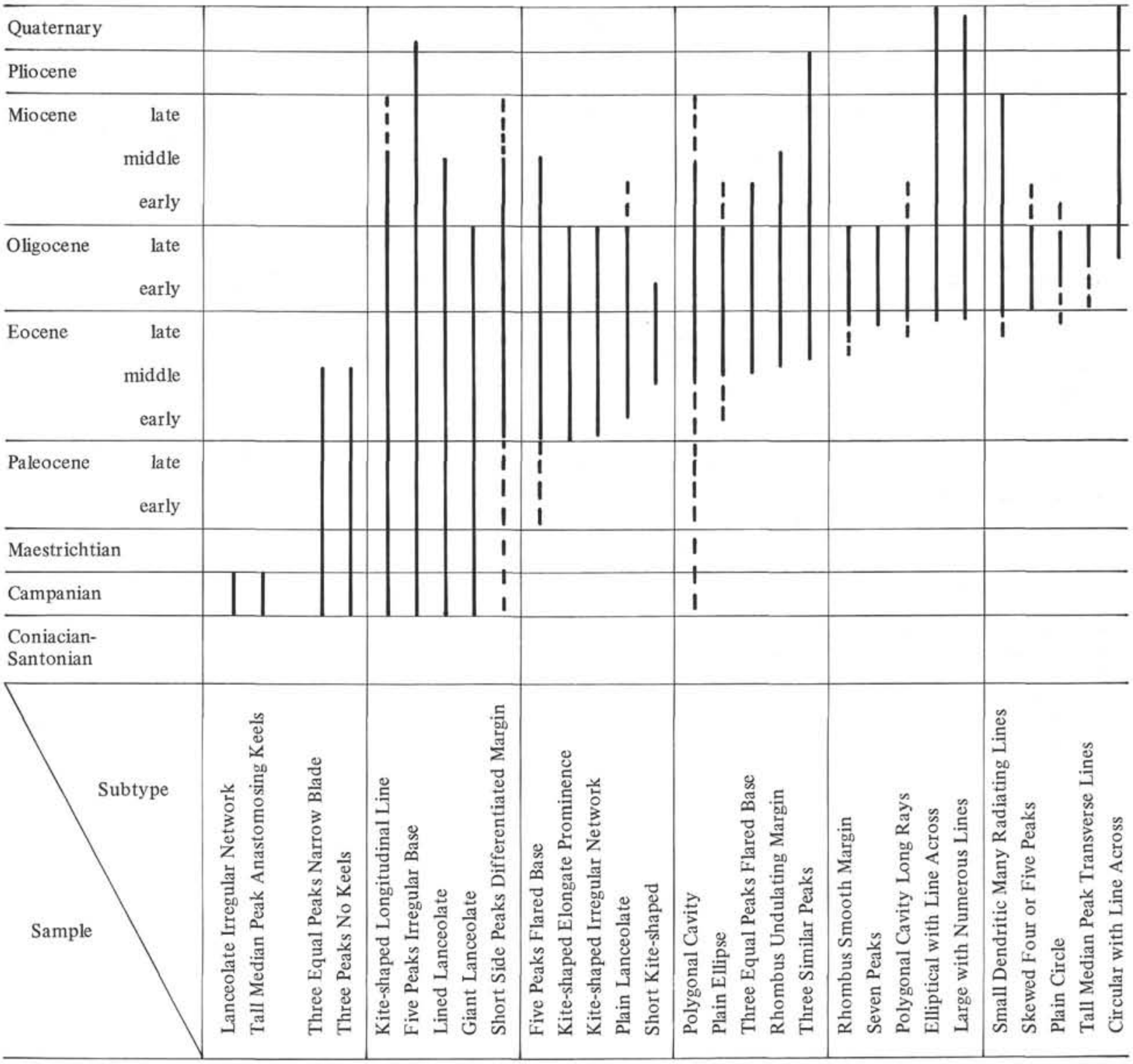
Reworking

Doyle et al. (in press) suggest that ichthyoliths may be reworked but not to the extent noted in radiolarians. For example, they note an area in the North Pacific with Eocene radiolarians but no Eocene ichthyoliths, mixed with an assemblage of Pliocene ichthyoliths. It appears that the Eocene radiolarians are reworked but the Pliocene ichthyoliths are *in situ.* In the same vicinity, ichthyoliths occur in other Eocene deposits, prompting Doyle and her coworkers to postulate that the heavier ichthyoliths form lag deposits while lighter, more easily transported components are removed and deposited elsewhere. This may be a contributing factor to the high concentration of ichthyoliths found in some samples.

Turbidites and submarine slumping appear to be the cause of some ichthyolith reworking, such as in Hole 417A.

Some ichthyolith subtypes appear to be more prone to reworking than others, and these include: *Triangle*

TABLE 2
Ranges of Elasmobranchian Ichthyolith Subtypes



Note: Doubtful-age assignments are shown by dashed lines (summarized from Riedel, Doyle, Kennedy and others).

pointed margin ends; Triangle short wing; Small triangle crenate margin, and *Triangle with canals.*

SITE 417

Hole 417A

Well-preserved, but sparse, ichthyoliths were recovered from all cores at this hole, except Cores 3, 4, 7, 13, 14, and 17.

Core 1 is Quaternary in agreement with data from other microfossil groups. Section 2-2 is assigned to the middle Miocene on the basis of the overlapping range zones of *Long triangle stepped margin* and *Wide conical triangle.* Ichthyoliths from Section 2-3 to Core 5 are assigned to the interval from late Oligocene to middle Miocene.

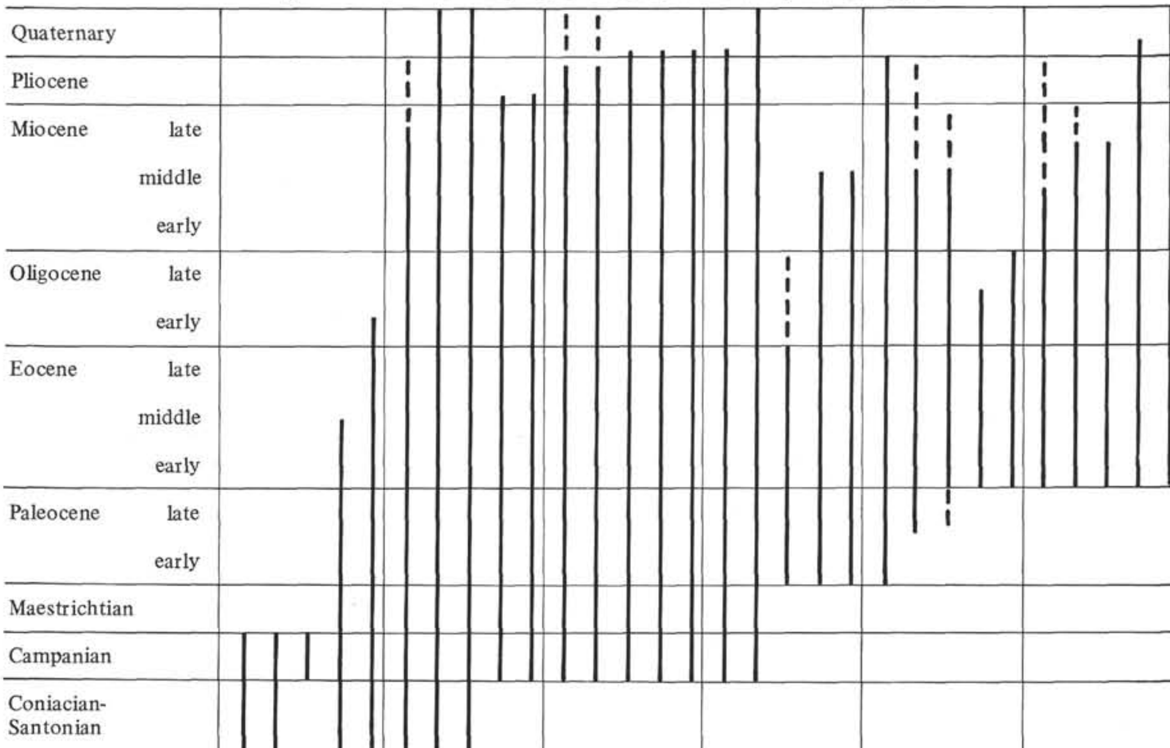
Section 6-1 bears both *Short triangle stepped margin* and *Polygonal cavity long rays,* and is assigned to the late Oligocene. Section 8-1 marks the highest stratigraphic occurrence of *Two curved triangles long base,* and is assigned to the early Oligocene.

The initial appearance of the subtype *Plain ellipse, Skewed four or five peaks,* and *Three equal peaks flared base* in the interval from Section 8-4 to Section 9-3 indicates a late Eocene to early Oligocene age for this interval.

Section 9-4 to Section 10-1 is assigned to the late Eocene by the initial appearance of *Small dendritic many radiating lines* and *Large with numerous lines.*

Section 10-2 to Core 15 is assigned to the middle Eocene to late Eocene interval on the basis of the highest local stratigraphic occurrence of *Rounded apex tri-*

TABLE 3
Ranges and Distribution in Samples of Osteichthian Ichthyolith Subtypes



Sample (Interval in cm) \ Subtype	Triangle Keeled Edges	Triangle Trailing Margin	Triangle with Triangular Projection and Canals	Triangle Arcuate Inline	Triangle Concave Base	Straight Triangle with Top	Narrow Curved Triangle	Triangle Complex Transverse Line	Rectangular Triangular-toothed	Asymmetrical Peaks Narrow Depression	Conical Triangle	Flexed Triangle Shallow Inbase	Triangle Transverse Line Across	Triangle Transverse Line Across, No Canals	Triangle with Canals	Striated Triangle with Top	Triangle with Triangular Projection	Small Triangle Crenate Margin	Narrow Triangle Cross-hachured	Wide Triangle	Triangle Sigmoid	Triangle Pointed Margin Ends	Triangle Medium Wing	Two Curved Triangles Long Base	Long Triangle Thin Wall	Triangle Short Wing	Triangle Inline Halfway	Triangle One Canal Above	Triangle Hooked Margin	Wide Triangle Straight Inbase
164-7-1, 97-101	13	3	5	10		4	12	4	1	2	1		5	1	38	2	12													
164-7-4, 96-100	4	2		5		3	13	3	1	1					12	2	2													
164-11-2, 36-40	1			3		2	2																							
164-12, CC	1			1																										
417A-1-1, 148-150							12	4			1	1		2							1									1
417A-1-2, 5-7							6				2				1															
417A-1-4, 16-18							2		1		2			1																
417A-2-2, 44-46							7				1	1			1															
417A-2-3, 142-144							1				2																			
417A-2, CC							1	2						1																
417A-5-1, 58-60						1	9	1			1										1									
417A-6-1, 43-45							20	2			4						3			1										
417A-6-4, 96-98							5	1			2	1		1		1				2		1								
417A-8-1, 140-142							6	1			2				1	1	1							1						

TABLE 3 – *Continued*

Long Triangle Sharply Pointed	Narrow Triangle Straight Inbase	Triangle with Parallel Inline	Triangle Double Flex	Flexed Triangle 102-112	Rounded Apex Triangle	Wide Triangle Large Top	Triangle Crenulate	Small Triangle Long Striations	Curved Triangle Pointed Margin	Rectangular Serially Saw-toothed	Asymmetrical Peak Wide Depression	Flexed Triangle Shallow Inbase ⩾ 120	Triangle Double Wing	Triangle with Base Angle	Triangle Notched Corner	Triangle Crenulate with Canals	Rectangular Saw-toothed	Flexed Narrow Triangle 120-128	Triangle with High Inline Apex	Wide Conical Triangle	Triangular Triangle	Long Rectangular with Striations	Flexed Triangle 115-118	Short Rectangular with Striations	Short Triangle Stepped Margin	Two Curved Triangles	Narrow Triangle Ragged Base	Long Triangle Stepped Margin	Three Tall Peaks	Total Number of Osteichthyian Ichthyoliths	Number of Ichthyoliths/cm^3 of Sediment
																														153	5.40
																														86	2.48
																														17	.45
																														3	.10
	9			3				2	1	1									6		2							1		52	2.85
	6							1		2									2						1					23	1.30
	1	1		1				1																						11	.65
	2							2											3	1								1		19	1.00
	3							1											3											12	.65
	3			2				1	1								1													12	.70
	2	3		1		1								1			1		3											25	1.30
	3			1		3		1		1									7	1					1					49	2.50
	8			2			1	1		2		1		1					2											33	1.90
	2					1	1		1																					22	1.15

TABLE 3 – *Continued*

Sample (Interval in cm) / Subtype	Triangle Keeled Edges	Triangle Trailing Margin	Triangle with Triangular Projection and Canals	Triangle Arcuate Inline	Triangle Concave Base	Straight Triangle with Top	Narrow Curved Triangle	Triangle Complex Transverse Line	Rectangular Triangular-toothed	Asymmetrical Peaks Narrow Depression	Conical Triangle	Flexed Triangle Shallow Inbase	Triangle Transverse Line Across	Triangle Transverse Line Across, No Canals	Triangle with Canals	Striated Triangle with Top	Triangle with Triangular Projection	Small Triangle Crenate Margin	Narrow Triangle Cross-hachured	Wide Triangle	Triangle Sigmoid	Triangle Pointed Margin Ends	Triangle Medium Wing	Two Curved Triangles Long Base	Long Triangle Thin Wall	Triangle Short Wing	Triangle Inline Halfway	Triangle One Canal Above	Triangle Hooked Margin	Wide Triangle Straight Inbase
417A-8-2, 140-142							1	2								2						1								
417A-8-4, 64-66							6	1			1				1		3													
417A-8-5, 55-57							6				3				2		3													
417A-9-2, 139-141					1		5	1			1						6									1				
417A-9-3, 123-125							9	2			2						2					1								
417A-9-4, 38-40							9	2			2					1	2									1				
417A-10-1, 140-142						2	6	2								2	2					1				1				
417A-10-2, 64-66												1				1						2	1			2				
417A-11-1, 130-132							6	1			1			1			1					1								
417A-11-6, 8-10																														
417A-12-2, 130-132							5										6					2				1				
417A-12-4, 26-28							6		1		3	1			2		1			1		3								
417A-15-1, 15-19						2	4				1				1		1					2								1
417A-15-2, 40-42							3					1										1								1
417A-16-3, 73-75							3				2			1	1		2		1			1								1
417A-16-5, 103-105						1																2				1				
417A-18-1, 68-70																														
417A-19-1, 61-63								1																						
417A-19-2, 96-98																														2
417A-20-2, 128-130							1							1																
417B-1-1, 10-12							2	1			1				1		4									1				
417B-1-2, 10-12							5	2			3			1			1					1								2
417B-1-3, 10-12							4	2			2				1		3						1							1
417B-1-4, 10-12							8	2			2	1					1													
417B-1, CC						3	7	1			3				2		2													
417D-1, CC								2			4															1				
417D-2-1, 15-17							2	2			1						1												1	1
417D-2-2, 10-12							3		1																					1
417D-2, CC						1	8				1				1	1	6					2							1	
417D-5, CC							1				1				1							1							2	
417D-6, CC						1									2															2
417D-7-1, 13-15																					1									
417D-7-2, 13-15																														
417D-7, CC							2																							1
417D-10-2, 10-12							1															1								
417D-10, CC																					1									
417D-13-2, 17-19																														
417D-14-1, 10-12																														
417D-14-4, 10-12																														
417D-17-2, 104-106							2																							
417D-17, CC							2								1											1				
417D-19-2, 1-3																														
417D-19, CC																														
417D-20-2, 98-100																														

TABLE 3 – *Continued*

Long Triangle Sharply Pointed	Narrow Triangle Straight Inbase	Triangle with Parallel Inline	Triangle Double Flex	Flexed Triangle 102-112	Rounded Apex Triangle	Wide Triangle Large Top	Triangle Crenulate	Small Triangle Long Striations	Curved Triangle Pointed Margin	Rectangular Serially Saw-toothed	Asymmetrical Peak Wide Depression	Flexed Triangle Shallow Inbase ⩾ 120	Triangle Double Wing	Triangle with Base Angle	Triangle Notched Corner	Triangle Crenulate with Canals	Rectangular Saw-toothed	Flexed Narrow Triangle 120-128	Triangle with High Inline Apex	Wide Conical Triangle	Triangular Triangle	Long Rectangular with Striations	Flexed Triangle 115-118	Short Rectangular with Striations	Short Triangle Stepped Margin	Two Curved Triangles	Narrow Triangle Ragged Base	Long Triangle Stepped Margin	Three Tall Peaks	Total Number of Osteichthyian Ichthyoliths	Number of Ichthyoliths/cm^3 of Sediment
	1						1																							8	.70
							1		1										2											18	1.35
	2						1		1																					20	1.30
	1																													16	.90
	1										1								1											22	1.40
			1																											21	1.15
	3				1	1																								22	1.15
																														17	1.15
									1																					12	.65
																														0	.05
	1								1									1												19	.95
	1				1			2																						24	1.50
						1																								15	.75
	1					1																								11	.55
	2																													19	1.05
	1																													6	.30
																														6	.30
																														3	.15
																														4	.20
																														6	.30
								1										1	4											18	1.90
	6				3	1		1																						26	1.35
	1				1														2											21	1.10
																														16	.80
	3				4	1		4		1								1			1	1						2		38	1.95
2	2			1	3		1												1											21	1.10
	1			2	1																									13	.65
	1				1				1		1								1											13	.65
2	2				1	1													1											33	1.65
	3																													12	.95
																														6	.30
																														3	.15
																														3	.15
						1																								4	.20
																														1	.05
																														1	.05
																														0	.10
																														0	.05
																														1	.05
																														2	.15
						2																								9	.45
																														0	.05
																														0	.05
									1																					1	.05

TABLE 3 – *Continued*

Sample (Interval in cm) \ Subtype	Triangle Keeled Edges	Triangle Trailing Margin	Triangle with Triangular Projection and Canals	Triangle Arcuate Inline	Triangle Concave Base	Straight Triangle with Top	Narrow Curved Triangle	Triangle Complex Transverse Line	Rectangular Triangular-toothed	Asymmetrical Peaks Narrow Depression	Conical Triangle	Flexed Triangle Shallow Inbase	Triangle Transverse Line Across	Triangle Transverse Line Across, No Canals	Triangle with Canals	Striated Triangle with Top	Triangle with Triangular Projection	Small Triangle Crenate Margin	Narrow Triangle Cross-hachured	Wide Triangle	Triangle Sigmoid	Triangle Pointed Margin Ends	Triangle Medium Wing	Two Curved Triangles Long Base	Long Triangle Thin Wall	Triangle Short Wing	Triangle Inline Halfway	Triangle One Canal Above	Triangle Hooked Margin	Wide Triangle Straight Inbase
418-1-1, 40-42							2																							
418-1-2, 40-42							3	1							1															
418-1-3, 40-42							2				2					1														
418-1-4, 44-46							2																							
418-1-6, 79-81																	1													
418-1, CC							2										1													
418A-1-2, 58-60							2																							
418A-1-3, 50-52						1	3																			1				
418A-2-2, 30-32							1																			1				
418A-2, CC												1					1													
418A-3-1, 50-52							2															1				3				
418A-3-2, 40-42							1									2										1				
418A-3-3, 30-32												1				1	3					1	1			1				
418A-3-4, 50-52							1									1	1					2								
418A-3-5, 50-52																2	1													
418A-3-6, 13-15					1		2				1					2														1
418A-3-6, 50-52																						1								
418A-3, CC					1		2									4										3				
418A-4-1, 50-52						2	5				1					3	1					5								
418A-4-2, 50-52							4				1					1	3													1
418A-4-3, 50-52						1	4										1					1								1
418A-4-4, 50-52							2															1								1
418A-4-5, 40-42						2	5	1								2	1			1		3								
418A-5-1, 50-52					1		4				1		1				2									1				1
418A-5-2, 99-101						2	5				1				3		3			1		4				1				1
418A-5-3, 50-52					1	2	5	1			4	1		1		1	1			2		5				1				2
418A-5-4, 50-52							4							1		2						5								2
418A-5-5, 34-36						1	9				1					1	1					9	1			1			1	
418A-5-6, 2-4						2	2	1			2			1	1	2	1					5				1				
418A-5, CC					1	2	3	1			1			2			1					5				2				1
418A-6-3, 50-52											1					1	2					2								
418A-6-5, 19-21							2															1								
418A-7-1, 50-52						2	2							1								7								
418A-7-2, 50-52																						1								
418A-12-2, 28-30																														
418B-2-1, 93-95							1				1								1											
418B-3-1, 121-123																			1											
418B-3-4, 126-128						1	2							1	1															
418B-4-1, 100-102						1	1							1																
418B-5-3, 60-62							2																							
418B-6-2, 67-69							3				1																			
418B-7-3, 85-87							2	1								1				1										
418B-8-2, 105-107							4	1			4	1	1								1	2								1
418B-12-1, 40-42											1																			
418B-16-1, 80-82							15				4	1			3	3										2				3

TABLE 3 – *Continued*

Long Triangle Sharply Pointed	Narrow Triangle Straight Inbase	Triangle with Parallel Inline	Triangle Double Flex	Flexed Triangle 102-112	Rounded Apex Triangle	Wide Triangle Large Top	Triangle Crenulate	Small Triangle Long Striations	Curved Triangle Pointed Margin	Rectangular Serially Saw-toothed	Asymmetrical Peak Wide Depression	Flexed Triangle Shallow Inbase ⩾ 120	Triangle Double Wing	Triangle with Base Angle	Triangle Notched Corner	Triangle Crenulate with Canals	Rectangular Saw-toothed	Flexed Narrow Triangle 120-128	Triangle with High Inline Apex	Wide Conical Triangle	Triangular Triangle	Long Rectangular with Striations	Flexed Triangle 115-118	Short Rectangular with Striations	Short Triangle Stepped Margin	Two Curved Triangles	Narrow Triangle Ragged Base	Long Triangle Stepped Margin	Three Tall Peaks	Total Number of Osteichthyian Ichthyoliths	Number of Ichthyoliths/cm^3 of Sediment
	1			1			1	1																					1	6	.40
	1																		1									1		12	.65
1								3	1									1	2											14	.70
	2						1																							5	.25
	3			1																								1		6	.40
	2								1					2																9	.50
																														4	.25
																														6	.30
						1																								3	.25
							1									2														5	.25
	3								1							4			2											17	.85
2	1																		3											12	.60
	1																													8	.45
																														5	.25
			1																1											5	.30
			1																1	1	1									1	.05
																														13	.80
	2																				2									17	.90
2	1																													23	1.30
1	1			1		2													1											20	1.10
	1																													15	.75
						1																								6	.35
	2					1																								22	1.30
2	2					1											2													22	1.35
	5				1	2	1																							30	1.55
1	4	1			1	1																								40	2.20
	2																													17	.85
1	5				1	1																								37	2.00
1	1			1		1																								22	1.25
						1																								21	1.05
	1																													7	.40
																														4	.20
						1																								13	.95
																														1	.05
																														1	.10
	1			1			1	1											1											8	.40
	2						1			1																				9	.35
				1															2											5	.60
	2							2													1									7	.45
	3					1		2											1			1								11	.55
																			1											6	.40
	1									1									2											10	.55
	1							2										3	4						1					28	1.50
							1												2											5	.25
	4		2		1			3	1								1	1	6											53	2.95

TABLE 3 – *Continued*

Sample (Interval in cm) \ Subtype	Triangle Keeled Edges	Triangle Trailing Margin	Triangle with Triangular Projection and Canals	Triangle Arcuate Inline	Triangle Concave Base	Straight Triangle with Top	Narrow Curved Triangle	Triangle Complex Transverse Line	Rectangular Triangular-toothed	Asymmetrical Peaks Narrow Depression	Conical Triangle	Flexed Triangle Shallow Inbase	Triangle Transverse Line Across	Triangle Transverse Line Across, No Canals	Triangle with Canals	Striated Triangle with Top	Triangle with Triangular Projection	Small Triangle Crenate Margin	Narrow Triangle Cross-hachured	Wide Triangle	Triangle Sigmoid	Triangle Pointed Margin Ends	Triangle Medium Wing	Two Curved Triangles Long Base	Long Triangle Thin Wall	Triangle Short Wing	Triangle Inline Halfway	Triangle One Canal Above	Triangle Hooked Margin	Wide Triangle Straight Inbase
418B-17-1, 23-25							8				5	3			1	1	1					3				1				
418B-18-1, 96-98							7				3		1		1	3	2				2	1				3				1
418B-20-1, 96-98					1						1																			
418B-20-4, 24-26					1		1				1															1				
418B-21-2, 11-13				1				1																						
418B-21-4, 17-19				1																										
418B-26-1, 90-92															1															

Note: On the far right there is a column which shows the total number of osteichthyian ichthyoliths in each sample and one which shows the number of ichthyoliths per cubic centimeter of sediment in each sample. A number followed by a question mark indicates that all specimens found are broken so as to render identification doubtful.

angle, Flexed narrow triangle 120-128, Curved triangle pointed margin, and *Skewed four or five peaks.*

Assignment of ages to Cores 16 through 20 is not possible because of the lack of a stratigraphic synthesis of lower Paleogene ichthyoliths.

Hole 417B

Recovery from this hole consisted of only core in which well-preserved ichthyoliths are present in moderate quantities.

Sections 1-2, 1-3, and 1-4 bear ichthyoliths that are suggestive of the interval from middle Miocene to late Miocene. These ichthyoliths include the subtypes *Triangle pointed margin ends, Triangle medium wing,* and *Polygonal cavity*. The core catcher of Core 1 bears a middle Miocene ichthyolith fauna characterized by the mutual occurrence of *Long triangle stepped margin* and *Short side peaks differentiated margin.*

The ichthyolith-based age assignment of Miocene for this interval is in disagreement with the age of Quaternary indicated by calcareous microfossil groups. Because this hole is presently well below the CCD, we propose that sometime in the Quaternary turbidity currents deposited the top stratum containing calcareous microfossils. At the same time the turbidite(s) eroded down to the stratum that contained the Miocene ichthyolith fauna, stripping away the younger sediments and creating an admixture of old ichthyoliths and young calcareous microfossils.

Hole 417D

The very sparse faunas of ichthyoliths recorded throughout this hole preclude precise correlations based on this microfossil group. The paucity of ichthyoliths recovered from this hole could be attributed either to insufficient sample volume processed or to rapid depositional history diluting the ichthyolith assemblage.

The occurrences of *Triangle pointed margin ends* and *Triangle short wing* in Section 1-2 and Sample 1, CC suggest a middle Miocene age for the interval, but the occurrence in these samples also of the Pliocene form *Triangle hooked margin* indicates that the forms may be reworked.

In Section 2-2, the presence of *Asymmetrical peak wide depression* would preclude this horizon being younger than middle Miocene. Similarly, the occurrence of *Kite-shaped elongate prominence* and *Plain lanceolate* in Core 5 indicates that this level cannot be younger than late Oligocene.

SITE 418

Hole 418

In Core 1 at this hole ichthyoliths are well preserved but scarce. Regardless of this, the subtypes present are reliable Neogene guide fossils. Section 1-1 is marked by the presence of *Three tall peaks,* indicating either a late Pliocene or Quaternary age. Sections 1-2 and 1-6 bear *Long triangle stepped margin,* suggesting an age no

TABLE 3 – *Continued*

Long Triangle Sharply Pointed	Narrow Triangle Straight Inbase	Triangle with Parallel Inline	Triangle Double Flex	Flexed Triangle 102-112	Rounded Apex Triangle	Wide Triangle Large Top	Triangle Crenulate	Small Triangle Long Striations	Curved Triangle Pointed Margin	Rectangular Serially Saw-toothed	Asymmetrical Peak Wide Depression	Flexed Triangle Shallow Inbase ≥ 120	Triangle Double Wing	Triangle with Base Angle	Triangle Notched Corner	Triangle Crenulate with Canals	Rectangular Saw-toothed	Flexed Narrow Triangle 120-128	Triangle with High Inline Apex	Wide Conical Triangle	Triangular Triangle	Long Rectangular with Striations	Flexed Triangle 115-118	Short Rectangular with Striations	Short Triangle Stepped Margin	Two Curved Triangles	Narrow Triangle Ragged Base	Long Triangle Stepped Margin	Three Tall Peaks	Total Number of Osteichthyian Ichthyoliths	Number of Ichthyoliths/cm^3 of Sediment
	10			1		1											1		2											40	2.50
	3							1						1	2		5		1											41	2.35
								1																						3	.35
																														4	.40
																														7	.60
																														5	.85
																														1	.05

older than late Miocene. Sample 1, CC is marked by the highest local stratigraphic occurrence of *Three equal peaks flared base,* indicating that this horizon can be no younger than late Miocene.

Hole 418A

Well-preserved ichthyoliths in moderate quantities are present in Cores 1 through 7 and Core 12.

Core 1, Section 2-2, and Core 2, CC contain no diagnostic *in situ* ichthyoliths. *Triangle short wing* is represented by a single specimen in Section 1-3 and Section 2-2, but this may be caused by reworking.

Section 3-1 bears *Short triangle stepped margin* as well as abundant specimens of *Triangle short wing,* and is assigned the late Oligocene to middle Miocene interval.

The presence of *Polygonal cavity* in Section 3-3 indicates an age no younger than middle Miocene.

Section 3-6 through Section 4-1 is assigned to the early Oligocene by the occurrence together of *Triangle concave base, Polygonal cavity long rays* and *Rhombus undulating margin.*

Section 4-4 to Core 5 is assigned to the late Eocene by the occurrence in this interval of *Skewed four or five peaks.*

Section 5-3 to Section 5-6 is assigned to the middle Eocene by the occurrence together of *Polygonal cavity, Three similar peaks, Rounded apex triangle, Polygonal cavity long rays, Flexed triangle 102-112,* and *Plain lanceolate.*

Section 7-2 is marked by the lowest local stratigraphic occurrence of *Triangle pointed margin ends,* which would indicate an age of early Eocene for the horizon.

Hole 418B

Ichthyoliths were recovered in this hole from Cores 2 through 8, 12, 16, 17, 18, 20 and 21, 22, 24, and 26. Their preservation was good and frequency ranged from sparse to moderate.

Cores 2 and 3 appear to be no younger than middle Miocene because of the presence of *Narrow triangle cross-hachured.*

Cores 4 through 8 are assigned to the interval from late Oligocene to early Miocene because of the presence of *Seven peaks.* Section 5-2 is assigned to the early Miocene by the occurrence of *Skewed four or five peaks.* Section 8-2 is marked by the lowest local stratigraphic occurrence of *Short triangle stepped margin,* suggesting a late Oligocene age.

The lack of diagnostic subtypes in Cores 12 through 18 prevents the assignment of a date more exact than late Eocene to Oligocene.

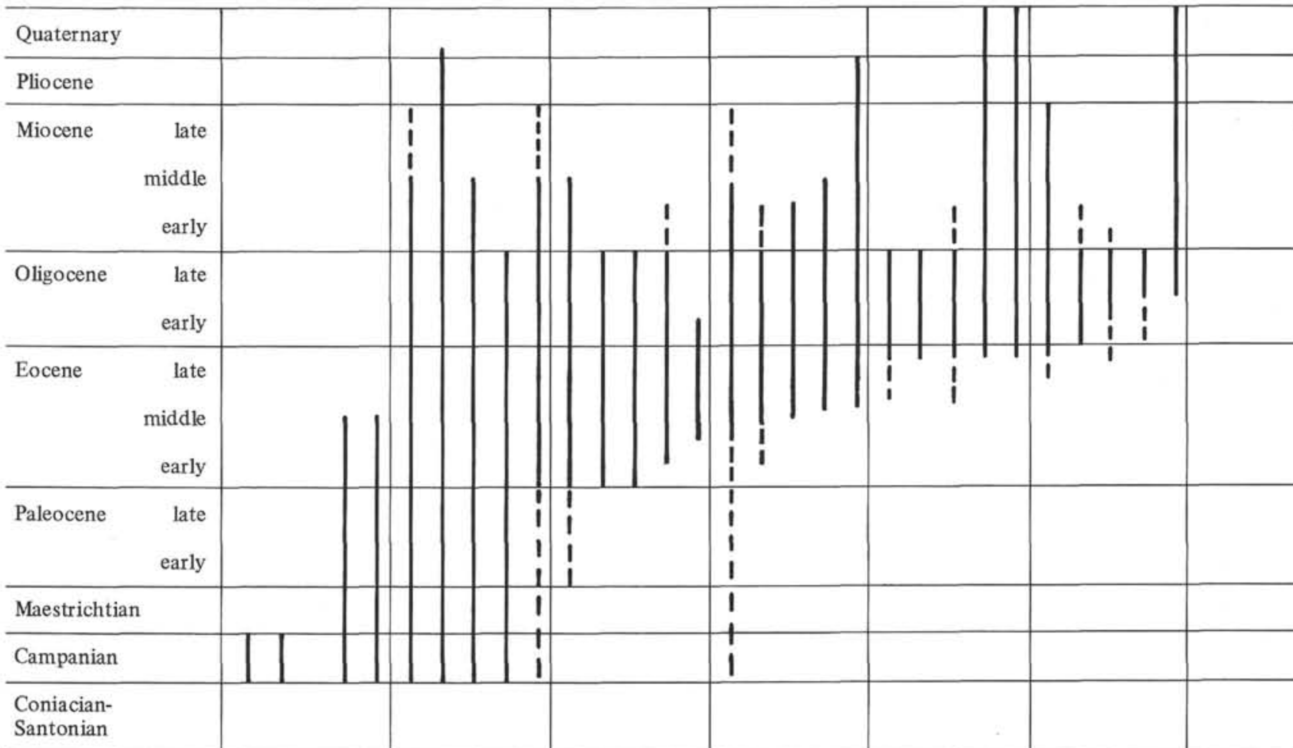
The lowest local stratigraphic occurrence of *Polygonal cavity long rays* in Section 20-4 would indicate a late Eocene age for this horizon. Cores 21, 22, 24, and 26 did not yield any diagnostic ichthyolith subtypes.

SEDIMENTATION

Hole 417A

Of the 417 meters of sediment penetrated at this hole, 249.5 meters were recovered. Six units are distinguishable at this site: (1) 9 meters of Quaternary brown clay with reworked nannofossils and foraminifers; (2) 96 meters of brown clay with sparse rhyolitic ash; (3) 26 meters of zeolitic clay; (4) 38 meters of middle Eocene

TABLE 4
Ranges and Distribution in Samples of Elasmobranchian, Ichthyolith Subtypes



Sample (Interval in cm) \ Subtype	Lanceolate Irregular Network	Tall Median Peak Anastomosing Keels		Three Equal Peaks Narrow Blade	Three Peaks No Keels	Kite-shaped Longitudinal Line	Five Peaks Irregular Base	Lined Lanceolate	Giant Lanceolate	Short Side Peaks Differentiated Margin	Five Peaks Flared Base	Kite-shaped Elongate Prominence	Kite-shaped Irregular Network	Plain Lanceolate	Short Kite-shaped	Polygonal Cavity	Plain Ellipse	Three Equal Peaks Flared Base	Rhombus Undulating Margin	Three Similar Peaks	Rhombus Smooth Margin	Seven Peaks	Polygonal Cavity Long Rays	Elliptical with Line Across	Large with Numerous Lines	Small Dendritic Many Radiating Lines	Skewed Four or Five Peaks	Plain Circle	Tall Median Peak Transverse Lines	Circular with Line Across	Total Number of Elasmobranchian Ichthyoliths
164-7-1, 97-101	10	15	5	7	3	4	3	5		2																					63
164-7-4, 96-100	2	1		6	4																										13
164-11-2, 36-40								1																							1
164-12, CC								1																							1
417A-1-1, 148-150								2		1																					5
417A-1-2, 5-7								1																	2						3
417A-1-4, 16-18																															1
417A-2-2, 44-46								1																							1
417A-2-3, 142-144																										1					1
417A-2, CC																									1					1	2
417A-5-1, 58-60																															1
417A-6-1, 43-45																							1								1
417A-6-4, 96-98							1				1			1										1							5
417A-8-1, 140-142																	1						1								2
417A-8-2, 140-142							1			1						2							1								5
417A-8-4, 64-66										1						5	1														9
417A-8-5, 55-57							1	1									1	1										1			7
417A-9-2, 139-141							2																								2
417A-9-3, 123-125																4		1										1			6

TABLE 4 – *Continued*

Sample (Interval in cm) \ Subtype	Lanceolate Irregular Network	Tall Median Peak Anastomosing Keels	Three Equal Peaks Narrow Blade	Three Peaks No Keels	Kite-shaped Longitudinal Line	Five Peaks Irregular Base	Lined Lanceolate	Giant Lanceolate	Short Side Peaks Differentiated Margin	Five Peaks Flared Base	Kite-shaped Elongate Prominence	Kite-shaped Irregular Network	Plain Lanceolate	Short Kite-shaped	Polygonal Cavity	Plain Ellipse	Three Equal Peaks Flared Base	Rhombus Undulating Margin	Three Similar Peaks	Rhombus Smooth Margin	Seven Peaks	Polygonal Cavity Long Rays	Elliptical with Line Across	Large with Numerous Lines	Small Dendritic Many Radiating Lines	Skewed Four or Five Peaks	Plain Circle	Tall Median Peak Transverse Lines	Circular with Line Across	Total Number of Elasmobranchian Ichthyoliths
417A-9-4, 38-40													1		1										1					3
417A-10-1, 140-142																								1	1					2
417A-10-2, 64-66					1	2													1			2								8
417A-11-1, 130-132							1																							3
417A-11-6, 8-10						1																								1
417A-12-2, 130-132																														0
417A-12-4, 26-28							1			1					2					1		1								6
417A-15-1, 15-19																														0
417A-15-2, 40-42																														0
417A-16-3, 73-75					1		2																							3
417A-16-5, 103-105																														0
417A-18-1, 68-70																														0
417A-19-1, 61-63																														0
417A-19-2, 96-98																														0
417A-20-2, 128-130																														0
417B-1-1, 10-12																														0
417B-1-2, 10-12															1															1
417B-1-3, 10-12							1																							1
417B-1-4, 10-12																														0
417B-1, CC							1																							1
417D-1, CC										1																				1
417D-2-1, 15-17																														0
417D-2-2, 10-12																														0
417D-2, CC																														0
417D-5, CC						2	3															1								7
417D-6, CC																														0
417D-7-1, 13-15																														0
417D-7-2, 13-15																														0
417D-7, CC																														0
417D-10-2, 10-12																														0
417D-10, CC																														0
417D-13-2, 17-19						1																								2
417D-14-1, 10-12																					1									1
417D-14-4, 10-12																														1
417D-17-2, 104-106										1																				1
417D-17, CC																														0
417D-19-2, 1-3																														1
417D-19, CC																			1											1
417D-20-2, 98-100																														0
418-1-1, 40-42																														2
418-1-2, 40-42						1																								2
418-1-3, 40-42																														0
418-1-4, 44-46																														0
418-1-6, 79-81										1																				2
418-1, CC										1																				1
418A-1-2, 58-60						1																								2
418A-1-3, 50-52																														0
418A-2-2, 30-32						2																								2

TABLE 4 – *Continued*

Sample (Interval in cm) \ Subtype	Lanceolate Irregular Network	Tall Median Peak Anastomosing Keels	Three Equal Peaks Narrow Blade	Three Peaks No Keels	Kite-shaped Longitudinal Line	Five Peaks Irregular Base	Lined Lanceolate	Giant Lanceolate	Short Side Peaks Differentiated Margin	Five Peaks Flared Base	Kite-shaped Elongate Prominence	Kite-shaped Irregular Network	Plain Lanceolate	Short Kite-shaped	Polygonal Cavity	Plain Ellipse	Three Equal Peaks Flared Base	Rhombus Undulating Margin	Three Similar Peaks	Rhombus Smooth Margin	Seven Peaks	Polygonal Cavity Long Rays	Elliptical with Line Across	Large with Numerous Lines	Small Dendritic Many Radiating Lines	Skewed Four or Five Peaks	Plain Circle	Tall Median Peak Transverse Lines	Circular with Line Across	Total Number of Elasmobranchian Ichthyoliths
418A-2, CC																														0
418A-3-1, 50-52																														0
418A-3-2, 40-42																														0
418A-3-3, 30-32						2									1										1					4
418A-3-4, 50-52																														0
418A-3-5, 50-52						1																								1
418A-3-6, 13-15															2	1						1								4
418A-3-6, 50-52																														0
418A-3, CC															1															2
418A-4-1, 50-52						1	2											1												4
418A-4-2, 50-52										1		1																		2
418A-4-3, 50-52																														0
418A-4-4, 50-52												1																		1
418A-4-5, 40-42						1				1																				3
418A-5-1, 50-52															2			1												5
418A-5-2, 99-101															1															1
418A-5-3, 50-52						1									1				1			1								4
418A-5-4, 50-52																														0
418A-5-5, 34-36					1										1							1								3
418A-5-6, 2-4											1				1															4
418A-5, CC																														0
418A-6-3, 50-52																		1												1
418A-6-5, 19-21																														0
418A-7-1, 50-52					1	1					1		2			1					1									7
418A-7-2, 50-52																														0
418A-12-2, 28-30																														1
418B-2-1, 93-95																														0
418B-3-1, 121-123																1														2
418B-3-4, 126-128						1	1														2									3
418B-4-1, 100-102																														2
418B-5-3, 60-62																														0
418B-6-2, 67-69															1															2
418B-7-3, 85-87																													1	1
418B-8-2, 105-107										1											1									2
418B-12-1, 40-42																														0
418B-16-1, 80-82						2				1		1			2															6
418B-17-1, 23-25					2				1						4						2									10
418B-18-1, 96-98							1						1		3															5
418B-20-1, 96-98				1																										4
418B-20-4, 24-26			1									2			1															4
418B-21-2, 11-13					1				1				1		1															4
418B-21-4, 17-19							1		1						1			1												9
418B-26-1, 90-92																														0

Note: Doubtful age assignments are shown by dashed lines. Column on the far right shows the total number of elasmobranchian ichthyoliths in each sample. A number followed by a question mark indicates that all specimens found are broken so as to render identification doubtful.

radiolarian-zeolitic clay and ooze; (5) 37 meters of Upper Cretaceous zeolitic clay; and (6) 11 meters of Upper Cretaceous clay and basalt rubble.

Sedimentation has been continuous throughout the interval between middle Eocene and middle Miocene, which is represented by most of the section from Unit 4 to Unit 1. The sedimentation rate for this interval is 3.3 mm/1000 years. This rate is considerably higher than that calculated for the North Pacific and is probably due to the greater influx of terrigenously derived detrital material in the western North Atlantic.

The absence of ichthyoliths younger than middle Miocene may be due to the paucity of diagnostic upper Neogene subtypes. It is also possible — and this seems more likely on account of the reworked nature of Unit 1 — that the sediment containing these ichthyoliths was rapidly eroded by a turbidity current. A hiatus exists between Units 4 and 5 (i.e., between the middle Eocene and Late Cretaceous), but ichthyolith study has not resolved the uncertainty of the duration of this hiatus.

Hole 417B

Sediments at this hole were recovered from one 9-meter core. They consist of dark yellow-brown to yellow-brown zeolitic clays with thin beds of nannoplankton and foraminiferal ooze. Chert chips are common in the basal portion of this section.

Ichthyoliths from this core suggest an age of late Miocene for the top of the section, which is in disagreement with the age of Quaternary as derived from other microfossil groups. That this site is presently below the CCD and yet contains calcareous microfossils suggests that the upper portion of this unit is not *in situ,* but instead was deposited by a turbidity current that stripped away the brown clay section down to the horizon which bears Miocene ichthyoliths. The depositional rate for the 9-meter interval, which represents the time between middle Miocene and late Miocene, is 1.6 mm/1000 years. Because this rate is lower, by a factor of 2, than that for other western North Atlantic sample sites, we postulate that the turbidite affecting this site was more erosive than depositional in nature, and that, indeed there was previously a thicker section of brown clays deposited at rates similar to those of nearby sites.

Hole 417D

There is a thick sequence of brown clays and zeolitic brown clays at this hole, but the age relationships are not established well enough to compute sedimentation rates.

Hole 418

Only 6 meters of brown clay was recovered from this hole. This was deposited during the interval from the late Miocene to the late Pliocene at a rate of 3.0 mm/1000 years.

Hole 418A

Of the 383.5 meters of sediment penetrated at this hole, only 212 meters was recovered. Analogous to Hole 417A, Hole 418A is composed of five distinct lithologic units as follows: (1) brown pelagic clay from 0 to 6 meters; (2) gray-orange to olive-brown pelagic clay from 6 to 151 meters; (3) dark gray-brown or dark red-brown pelagic clay, with or without zeolites and radiolarians from 151 to 234 meters; (4) black, dark gray, green-gray, olive-gray, and blue-green clays with nannofossils with 234 to 292 meters; and (5) green, brown, pink, and olive-gray nannofossil clays from 292 to 324 meters.

Continuous sedimentation has been ongoing at Hole 418A from before the early Eocene until a time later than the middle Miocene. The rate of sediment accumulation for the interval from 19 meters to 66 meters below the sea bed is 0.94 mm/1000 years, and represents the interval from the early Eocene to the middle Miocene.

Hole 418B

The pattern of sedimentation at this hole is essentially the same as that of Hole 418A, except that the amount of sediment accumulated in the Tertiary was greater, and it accumulated at an accelerated rate.

From the late Eocene to the middle Miocene, 144 meters of clay was deposited at a rate of 5.5 mm/1000 years. The lowest depositional rates occurred in the interval from late Oligocene to middle Miocene, when 55.5 meters of clay was deposited at a rate of 2.9 mm/1000 years. The highest rates of accumulation occurred from late Eocene to late Oligocene, where 88.5 meters of clay was deposited at a rate of 12.6 mm/1000 years.

SUMMARY

Average sedimentation rates are higher, by a factor of nearly 3, in the western North Atlantic (3.0 mm/1000 years) than in the North Pacific (1.0 mm/1000 years). In addition, sedimentation rates are apparently higher in the interval from middle Eocene to middle Miocene, and the sections representing this period are more complete. However, this may be an effect of incomplete biostratigraphic synthesis of Neogene ichthyoliths.

SYSTEMATIC PALEONTOLOGY

The systematic study of ichthyoliths is inherently beset with problems. The overwhelming majority of ichthyoliths are undoubtedly the teeth of osteichthyian fishes. To compare this material with the teeth of modern fishes, and thereby place the ichthyoliths into a Linnaean classification is, at the present, not possible. This is because of the lack of detailed descriptions of modern osteichthyian fishes' teeth, and the varying shapes and sizes of the teeth within a single fish's jaw.

The hard parts of elasmobranchian fishes, which include the teeth and dermal denticles of sharks, sawfishes, skates, and rays, on the other hand, are taxonomically important (White, 1937; Applegate, 1967). This is probably because they are usually the only materials the paleontologist and the ichthyologist have to work with, so that the descriptions and illustrations are more detailed and accurate. Other contributing factors are that sharks' teeth, although varying within the jaw, vary in a more orderly and predictable manner. In most sharks, moreover, the majority of their dermal denticles are identical.

The strategy adopted in this chapter is to list the elasmobranchian hard parts within a Linnaean classification system and to describe them in this manner. The classification scheme we used is that of Bigelow and Schroeder (1948, 1953) as pertaining to modern elasmobranchs, which, in nearly all instances, is adequate for the task. In order to describe the osteichthyian teeth, it is necessary to employ the alphanumeric descriptive system of Doyle et al. (1974) as modified herein, and in Dunsworth et al. (1975), Ramsey et al. (1976), and Doyle et al. (1978).

CHANGES TO THE DESCRIPTIVE SYSTEM

To facilitate the description of previously undescribed forms and make allowances for the specimens being viewed in reflected light, the following additions are made to the descriptive system established by Doyle et al. (1974).

1) In Type *a2/b2*, to character "i" add the state
   i.4 anastomosing or irregular network

2) In Type *a3,4/b1*, to character "c" add the state
   c.5 cruciform

3) In Type *a3,4/b1*, to character "d" add the state
   d.5 central polygonal network of lines

4) In Type *a9/b1*, to character "q" add the state
   q.5 triangular

5) In type *a9/b5*, to character "v" add the states
   v.5 triangular
   v.6 rectangular

TAXA

Subtype *a2/b2/c5/d1,2/e1/f1/g1,2/h1,3/i1/j1/k1,2*
Kozarek and Orr, new subtype

Five peaks irregular base

(Plate 4, Figure 8)

Description: Elliptical to ovoid in outline with five peaks, the median less than twice the length of the laterals, five corresponding strong keels which are parallel, depressions between peaks generally U-shaped but occasionally V-shaped, length-to-width ratio of blade varying between 1.0 and 1.4, blade not skewed; anterior end of blade either rounded or undulatory.

Range: Campanian to Quaternary.

Subtype *a2/b2/c7/d1/e1/f1/g2/h1/i1/j1/k2*
Kozarek and Orr, new subtype

Seven peaks

(Plate 1, Figure 5 [in part])

Description: Blade approximately elliptical in outline with seven peaks, the median less than twice the length of the laterals, seven matching strong keels which are parallel, depressions between peaks V-shaped, length-to-width ratio of blade about 1.0, blade not skewed; anterior portion of blade rounded.

Range: Late Eocene to late Oligocene or early Miocene.

Subtype *a2/b2/c3/d1/e1/f1/g2/h1/i0/j1/k2*
Kozarek and Orr, new subtype

Three peaks no keels

(Plate 4, Figure 7)

Description: Elliptical to ovoid in outline with three peaks, the median less than twice the length of the laterals, no matching keels, depressions between cusps V-shaped, length-to-width ratio about 1.0, blade not skewed; anterior portion of blade rounded.

Remarks: This form keys out very similarly to *Three tall peaks*, but it is distinct from the latter in that the cusps are not as long; they are pointed, and the depressions between them are V-shaped and not U-shaped.

Range: Campanian to middle Eocene.

Subtype *a2/b2/c3/d1/e1/f1/g2/h2/i1/j1/k2*
Kozarek and Orr, new subtype

Three equal peaks narrow blade

(Plate 4, Figure 6)

Description: Elliptical in outline with three peaks of nearly the same length, three matching keels, the median raised higher than the laterals, depressions between cusps V-shaped, length-to-width ratio of blade approximately 3.0, blade not skewed; anterior portion of blade V-shaped; angular.

Range: Campanian to middle Eocene.

Subtype *a2/b2/c3/d1/e1,2/f3/g1/h4/i0/j2/k2*
Kozarek and Orr, new subtype

Tall median peak anastomosing keels

(Plate 4, Figure 3)

Description: Elliptical or lanceolate in outline with three peaks, the median more than three times the length of the laterals, keels anastomosing or irregular, depressions between cusps broadly U-shaped, length-to-width ratio approximately 1.3; anterior portion of blade rounded.

Remarks: It is likely that *Tall median peak anastomosing keels* and *Lanceolate irregular network* belonged to the same species of shark but are located on different parts of the body.

Range: Campanian.

Subtype *a3/b1/c4, /d5/e1/f1/g1+2* Kozarek and Orr, new subtype

Polygonal cavity

(Plate 2, Figure 4)

Description: Quadrilateral or rhombohedral in outline with concave margins and rounded or square corners; central portion of blade depressed in the shape of a tetragon, pentagon, or hexagon and rimmed with ridges of the same shape (i.e., a cavity); no differentiated margin.

Range: Middle Eocene or older to middle Miocene.

Subtype *a3/b1/c5/d5/e1/f1/g1+2* Kozarek and Orr, new subtype

Polygonal cavity long rays

(Plate 2, Figure 5)

Description: Cruciform in outline, margins concave, corners square; central portion of the blade depressed in the form of a tetragon and rimmed with ridges that have the same shape (i.e., cavity); no differentiated margin.

Range: Late Eocene to late Oligocene or early Miocene.

Subtype *a4/b1/c2/d4/e0/f2+3/g1+2* Kozarek and Orr, new subtype

Lanceolate irregular network

(Plate 4, Figure 4)

Description: Lanceolate, smaller than 650 μm, with an irregular or anastomosing network of ridges, length-to-width ratio approximately 1.0; narrow differentiated area present around a smooth and continuous margin.

Remarks: It is likely that *Lanceolate irregular network* and *Tall median peak anastomosing keels* are both from the same species of shark but from different genera.

Range: Campanian.

Subtype *a4/b2/c1/d2,3/e0/f2+3/g1+2*
Kozarek and Orr, new subtype

Lined lanceolate

(Plate 4, Figure 5)

Description: Lanceolate, smaller than 650 mm, with one, three, five, or seven parallel or subparallel longitudinal ridges, length-to-width ratio varying from 2.0 in most forms to about 1.0 in many forms with three to seven longitudinal ridges; with or without narrow differentiated edge, margins smooth and continuous.

Remarks: Cretaceous forms invariably have seven ridges while younger forms have one to five ridges.

Range: Coniacian to middle Miocene.

Type ***a5,6/b1***

Description: Circular or elliptical in outline without any central pattern of ridges or lines.

Subtype ***a5/b1.*** Kozarek and Orr, new subtype

Plain circle

(Plate 4, Figure 16)

Description: Circular in outline without any central pattern or ridges or lines.

Range: Late Eocene to early Miocene.

Subtype ***a6/b1.*** Kozarek and Orr, new subtype

Plain ellipse

(Plate 4, Figure 15)

Description: Elliptical in outline without any central pattern of ridges or lines.

Range: Middle Eocene to early Miocene.

Subtype ***a7/b1,5/e1/d3/e5*** Kozarek and Orr, new subtype

Rectangular triangular-toothed

(Plate 5, Figure 14)

Description: Numerous triangular tooth-like projections, with the longest side of the triangle longitudinally oriented, some with a transverse line, arising from an elongated rectangular base.

Remarks: These forms look like parts of jawbones of osteichthyian fishes.

Range: Campanian to Pliocene.

Subtype ***a9/b1/c6/d6,7/e1/f1/g1/h5/i2,6/j2/k8/l0.2-0.5/m2.2-3.0/n2/o1/p2,3*** Kozarek and Orr, new subtype

Triangle double wing

(Plate 6, Figure 5)

Description: Moderately narrow triangle (length-to-width ratio 2.2-3.0) with both margins modified by shallow reflexed angles or curves, both usually located in the upper fifth of triangle, but occasionally one will be in the second fifth of the distance from the apex; margins either both straight or with one concave; incline extending into the upper half of the outline; circular in basal view.

Range: Late Eocene to middle Miocene.

Subtype ***a9/b1/c1/d1/e1/f1/g1/h5/i2,3/k0,8/l0.0-0.8/m1.5-2.75/n1/o1/p3/q2*** Kozarek and Orr, new subtype

Conical triangle

(Plate 6, Figure 3)

Description: Moderately narrow triangle (length-to-width ratio 1.5-2.75) with either both margins straight, or one convex and the other concave; inline rarely present and, if so, approximately parallel to outline and in its lower half; circular in basal view.

Range: Campanian to Pliocene or Quaternary.

Subtype ***a9/b1/c1/d1/e1/f1/g1/h5/i2,6/j2,3/k0/l0/m2,75/n1/o1/p2/q2*** Kozarek and Orr, new subtype

Long triangle sharply pointed

(Plate 6, Figure 4)

Description: Narrow triangle (length-to-width ratio 2.75) with either both margins straight or one convex and the other concave; inline absent; apex sharply pointed; circular in basal view.

Range: Middle Eocene to late Miocene, rarely in older samples.

Subtype ***a9/b1/c1/d1/e1/f1/g1/h5/i2,3/j2,3/k0/l0/m1.0/n1/o1/p3/q2*** Kozarek and Orr, new subtype

Wide conical triangle

(Plate 6, Figure 2)

Description: Wide triangle (length-to-width ratio 1.0) with either both the margins straight or both convex; inline absent; apex blunt; circular in basal view.

Range: Late Eocene to middle Miocene.

Subtype ***a9/b1/c1/d1/e1/f1,6/g1/h5/i2,6/j2,3/k0,8/l0.0-0.8/m2.0-3.5/n1/o1/p3/q5*** Kozarek and Orr, new subtype

Triangular triangle

(Plate 6, Figure 10)

Description: Moderately narrow to narrow triangle (length-to-width ratio 2.0-3.5) with either both margins straight or one convex and the other concave; inline rarely present and, if so, approximately parallel to the outline and restricted to its lowest quarter striations may or may not be present but, if present, extending the length of the triangle; triangular in basal view.

Range: Oligocene to Quaternary.

Subtype ***a9/b5/c1/d1/e3/f1/g1/h2/i1/j1/k3/l3/m4/n3/o4/p2/q0/r1.0/s2.0-2.5/t1/u1/v2,3*** Kozarek and Orr, new subtype?

Triangle with triangular projection and canals

(Plate 7, Figure 14)

Description: Curved triangle of moderate width (length-to-width ratio 2.0-2.5 below curved transverse line which ends at the margin), with single triangular projection modifying the margin below the transverse line; branched canals also present below the transverse line; apex neither acute nor blunt; circular or elliptical in basal view.

Range: Several specimens in the Campanian.

Subtype ***a9/b5/c1/d1/e1/f1/g1/h1/i1/j1/k2,3/l2/m2,4/n2,3/o2,6/p2/q0/r1.0-1.5/s≤1.0/t3/u1/v2*** Kozarek and Orr, new subtype

Wide triangle large top

(Plate 6, Figure 1)

Description: Wide triangle (length-to-width ratio below straight transverse line less than or equal to 1.0), with either both margins straight, or one concave and the other convex; inline absent; blunt apex; circular in basal view.

Range: Late Eocene to late Miocene.

Subtype ***a9/b5/c1/d1/e1/f1/g1/h1/i1/j1/k2/l2/m2/n2/o2/p2,3/q0.0-0.5/r0.8-1.2/s2.5-4.0/t3/u1/v2*** Kozarek and Orr, new subtype?

Straight triangle with top

(Plate 8, Figure 10)

Description: Narrow to very narrow triangle (length-to-width ratio below straight transverse line 2.5-4.0), with both margins straight; inline absent or not easily distinguished; blunt apex; circular in basal view.

Range: Coniacian to middle Miocene, rarely in younger samples.

Subtype ***a9/b5/c1/d1/e1/f1,7/g1/h1/i1,9/j3/k2/l2/m4/n3/o2/p2/q0/r1.2-2.0/s1.0-4.0/t2/u1/v2/*** Kozarek and Orr, new subtype

Striated triangle with top

(Plate 7, Figure 12)

Description: Triangle of variable width (length-to-width ratio below straight transverse line 1.0-4.0), outline not rectangular; margins straight above transverse line and curved below it; ornamented with parallel striations below the transverse; no triangular projection modifying the margin; circular in basal view.

Range: Campanian to Pliocene.

Subtype ***a9/b5/c1/d1/e1/f1/g1/h1,2/i1,4/j1/ k2,4,6/l2,4/m2,3/n2,3/o4,6/p3/q0.2-0.4/ r1.5-2.5/s0/t1/u1/v3*** Kozarek and Orr, new subtype

Triangle transverse line across no canals

(Plate 7, Figure 4)

Description: Triangle with length-to-width ratio 1.5-2.5; occasionally with lateral shadows; transverse line curved, either terminating at the margins, or somewhere between the inline and the outline; inline approximately parallel to outline, and with its apex within the upper half of the outline; canals may or may not be present below the transverse line, but are not present above it; elliptical or lensoid in basal view.

Remarks: This subtype, when whole, is unique and set apart from *Triangle transverse line across* in that it has no canals above the transverse line, and occasionally the transverse line does not terminate at the margins. This subtype, however, when broken at or very near the transverse line looks nearly identical to either *Triangle pointed margin ends* or *Narrow triangle straight inbase*.

Range: Campanian to Quaternary.

SPECIES LIST

Heptranchias (?) Rafinesque, 1810. (Plate 1, Figure 9) Bigelow and Schroeder, 1948.

Isurus (?) Rafinesque, 1810. (Plate 1, Figure 17; Plate 3, Figure 3). Bigelow and Schroeder, 1948.

Carcharadon (?) Agassiz, 1838. (Plate 1, Figure 14). Bigelow and Schroeder, 1948.

Apristurus cf. *riveri* Bigelow and Schroeder, 1944. (Plate 1, Figure 15). Bigelow and Schroeder, 1948.

Pseudotriakis sp. Brito Capello, 1867. (Plate 1, Figure 8). Bigelow and Schroeder, 1948.

Mustelus Link, 1790. (Plate 1, Figures 1, 2). Bigelow and Schroeder, 1948.

Galeocerdo (?) Müller and Henle, 1837. (Plate 1, Figure 16). Bigelow and Schroeder, 1948.
Schroeder, 1948.

Prionace cf. *glauca* (Linnaeus), 1758. (Plate 3, Figure 1). Bigelow and Schroeder, 1948.

Carcharhinus cf. *floridanus* Bigelow, Schroeder, and Springer, 1943. (Plate 1, Figure 5). Bigelow and Schroeder, 1948.

Carcharhinus cf. *longimanus* (Poey), 1861. (Plate 1, Figure 7). Bigelow and Schroeder, 1948.

Carcharhinus maculipinnis (Poey), 1865. (Plate 1, Figure 3). Bigelow and Schroeder, 1948.

Carcharhinus spp. (Plate 1, Figures 4, 6). Bigelow and Schroeder, 1948.

Sphyrna diplana Springer, 1941. (Plate 1, Figure 10). Bigelow and Schroeder, 1948.

Sphyrna zygaena (Linnaeus), 1758. (Plate 1, Figure 11; Plate 3, Figure 2). Bigelow and Schroeder, 1948.

Sphyrna spp. (Plate 1, Figures 12, 13). Bigelow and Schroeder, 1948.

Squalus (?) Linnaeus, 1758. (Plate 2, Figure 1; Plate 3, Figure 6). Orlov, 1967; Bigelow and Schroeder, 1948.

Etmopterus Rafinesque, 1810. (Plate 2, Figure 3). Bigelow and Schroeder, 1948.

Centroscymnus (?) Bocage and Brito Capello, 1864. (Plate 2, Figure 2). Bigelow and Schroeder, 1948.

Dalatias (?) Rafinesque, 1810. (Plate 2, Figures 8, 9). Bigelow and Schroeder, 1948.

Family Dalatidae. (Plate 2, Figure 10).

Isistius cf. *brasiliensis* (Quoy and Graimard), 1824. (Plate 2, Figure 4). Bigelow and Schroeder, 1948.

Somniosus cf. *microcephalus* (Bloch and Schneider), 1801. (Plate 2, Figure 11). Bigelow and Schroeder, 1948.

Echinorhinus cf. *brucus* (Bonnaterre), 1788. (Plate 3, Figure 5). Orlov, 1967; Bigelow and Schroeder, 1948.

Squatina melleri Reuss. (Plate 3, Figure 4). Orlov, 1967.

Pristis cf. *perotteti* Müller and Henle, 1841. (Plate 2, Figure 13). Bigelow and Schroeder, 1953.

Family Rajidae (?) Bonaparte, 1831. (Plate 2, Figure 12; Plate 3, Figure 7).

SUBTYPES LIST

Subtype ***a2/b2/c3/d1/e1/f1/g1/h3/i1/j1*** Doyle et al., 1974

Three similar peaks

(Plate 4, Figure 3)

Doyle et al., 1974, p. 836, pl. 1A, fig. 1, pl. 2A, fig. 1.

Subtype ***a2/b2/c3/d1/e1/f3/g1/h3/i1/j1,2*** Doyle et al., 1974

Short side peaks differentiated margin

(Plate 1, Figure 9)

Doyle et al., 1974, p. 836, pl. 2A, fig. 2-7.

Subtype ***a2/b2/c3/d1/e2/f3/g1/h1/i2/j3*** Doyle et al., 1974

Tall median peak transverse lines

(Plate 4, Figure 9)

Doyle et al., 1974, p. 844, pl. 2A, fig. 8, 9.

Subtype ***a2/b2/c3/d2,3/e1/f1/g1,2/h4/i1,2/j1*** Doyle et al., 1974

Three equal peaks flared base

(Plate 4, Figure 11)

Doyle et al., 1974, p. 844, pl. 2B, fig. 1-3.

Subtype ***a2/b2/c4,5/d1/e2/f2/g1/h2/i1/j2*** Doyle et al., 1974

Skewed four or five peaks

(Plate 4, Figure 12)

Doyle et al., 1974, p. 844, pl. 1A, fig. 4; pl. 2B, fig. 4, 5.

Subtype ***a2/b2/c5/d3/e1/f1/g1/h4/i1/j1,2*** Doyle et al., 1974

Five peaks flared base

(Plate 1, Figure 11 [in part])

Doyle et al., 1974, p. 844, pl. 2B, fig. 6-8.

Subtype ***a2/b2/c3/d1/e1/f1/g1/h0,1/i0/j1,2/k1,3*** Dunsworth et al., 1975

Three tall peaks

(Plate 4, Figure 10)

Dunsworth et al., 1975 p. 856, pl. 1, fig. 1, 2.

Subtype ***a3/b1/c3/d1,3/e1/f1,(2+3)/g1+2*** Doyle et al., 1974

Short kite-shaped

(Plate 4, Figure 14)

Doyle et al., 1974 p. 844, pl. 2B, fig. 9-11.

Subtype ***a3/b1/c3/d3,4/e4/f2/g1+8*** Doyle et al., 1974

Kite-shaped elongate prominence

(Plate 2, Figure 3 [in part])

Doyle et al., 1974 p. 844, pl. 2C, fig. 3-6.

Subtype ***a3/b1/c3/d4/e2/f2/g1+4*** Doyle et al., 1974

Kit-shaped irregular network

(Plate 4, Figure 13)

Doyle et al., 1974 p. 844, pl. 2C, fig. 7, 8.

Subtype *a3/b1/c3/d2/e2/f2+3/g1+2* Doyle et al., 1974

Kite-shaped longitudinal line

(Plate 2, Figure 8)

Doyle et al., 1974 pl. 2C, fig. 7, 8.

Subtype *a3/b1/c4/d1/30/f2+3/g5+6* Doyle et al., 1974

Rhombus smooth margin

(Plate 1, Figure 16 [in part])

Doyle et al., 1974 p. 844, pl. 2D, fig. 1, 3.

Subtype *a3/b1/c4/d1/e0/f2+3/g5+6* Doyle et al., 1974

Rhombus undulating margin

(Plate l, Figure 3 [in part])

Doyle et al., 1974 p. 844, pl. 1A, fig. 5; pl. 2D, fig. 4-6.

Subtype *a4/b1/c2/d1/30/f2+3/g1+2* Doyle et al., 1974

Giant lanceolate

(Plate 4, Figure 1)

Doyle et al., 1974 p. 844, pl. 2E, fig. 1-7.

Subtype *a4/b1/c2/d1/e0/f1,(2+3)/g1+2* Doyle et al., 1974

Plain lanceolate

(Plate 1, Figure 1 [in part])

Doyle et al., 1974 p. 844, pl. 2F, fig. 1-4.

Subtype *a5,6/b3/c1/d2* Doyle et al., 1974

Small dendritic many radiating lines

(Plate 5, Figure 10)

Doyle et al., 1974 p. 845, pl. 1B, fig. 4-7.

Subtype *a5,6/b3/c2/d1,2/e1* Doyle et al., 1974

Large with numerous lines

(Plate 5, Figure 9)

Doyle et al., 1974 p. 845, pl. 1B, fig. 10-12; pl. 2F, fig. 5, 8, 9.

Subtype *a5/b4* Doyle et al., 1974

Circular with line across

(Plate 5, Figure 11)

Doyle et al., 1974 p. 845, pl. 1C, fig. 1-15.

Subtype *a6/b4* Doyle et al., 1974

Elliptical with line across

(Plate 3, Figure 7 [in part])

Doyle et al., 1974 p. 845, pl. 1C, fig. 16-23.

Subtype *a7/b1/c1/d4/e4* Doyle et al., 1974

Two curved triangles

(Plate 5, Figure 7)

Doyle et al., 1974 p. 845, pl. 26, fig. 1.

Subtype *a7/b1/c1/d2/e2* Doyle et al., 1974

Two curved triangles long base

(Plate 5, Figure 8)

Doyle et al., 1974 p. 845, pl. 26, fig. 2, 3.

Subtype *a7/b1/c2/d3/e3* Doyle et al., 1974

Rectangular saw-toothed

(Plate 5, Figure 13)

Doyle et al., 1974 p. 845, pl. 1D, fig. 3-8; plate 2G, fig. 4-8.

Subtype *a7/b1/c2/d3/e6* Dunsworth et al., 1975

Rectangular serially saw-toothed

(Plate 5, Figure 12)

Dunsworth et al., 1975 p. 856, pl. 1, fig. 3.

Subtype *a7/b6/c1* Doyle et al., 1974

Asymmetrical peak wide depression

(Plate 8, Figure 20)

Doyle et al., 1974 p. 845, pl. 2D, fig. 9, 10; pl. 26, fig. 9.

Subtype *a7/b6/c3* Doyle et al., 1974

Asymmetrical peak narrow depression

(Plate 8, Figure 17)

Doyle et al., 1974 p. 845, pl. 1F, fig. 1, 2; pl. 2H, fig. 1-4.

Subtype *a8/b1,5/c1/d1/e102-112/f26-36* Doyle et al., 1974

Flexed triangle 102-112

(Plate 5, Figure 1)

Doyle et al., 1974 p. 845, pl. 1F, fig. 3, 4; pl. 2H, fig. 5.

Subtype *a8/b1,5/c1/d1,e115-118/f25-35* Doyle et al., 1974

Flexed triangle 115-118

(Plate 5, Figure 5)

Doyle et al., 1974 p. 845, pl. 1F, fig. 5; pl. 1H, fig. 6, 7.

Subtype *a8/b1,5/c1/d1/e120-128/f20-26* Doyle et al., 1974

Flexed narrow triangle 120-128

(Plate 5, Figure 2)

Doyle et al., 1974 p. 845, pl. 1E, fig. 6, 7; pl. 2H, fig. 8, 9.

Subtype *a8/b1,5/c1/d2/e80-140/f26-36* Doyle et al., 1974

Flexed triangle shallow inbase

(Plate 5, Figure 4)

Doyle et al., 1974 p. 846, pl. 1F, fig. 8; pl. 2H, fig. 10-13.

Subtype *a8/b1,5/c1/d2,3/e≥120/f≤25+a9 + a9/b1/c13/d1/e1/f4+(9+13+15)/g1/h2,3,4,5/i2/j2/k4,8/l0.25-0.45/m2.0-3.0/n2,3,4,6,7/02/p1/q1* Dunsworth et al., 1975

Flexed triangle shallow inbase ≥ 120

(Plate 5, Figure 3)

Dunsworth et al., 1975 p. 857, pl. 1, fig. 4, 5.

Subtype *a8/b1/c2/d2,3/e60-100/f20-35* Dunsworth et al., 1975

Triangle double flex

(Plate 5, Figure 6)

Dunsworth et al., 1975 p. 357, pl. 1, fig. 6.

Subtype *a9/b1/c1/d1/e1/f1,4/g1/h1,2/i2,6,8/j2,6,8/k2,3/l<0.2/ml.5-2.0/n3,4/o1/p1,3* Doyle et al., 1974

Triangle with high inline apex

(Plate 7, Figure 2)

Doyle et al., 1974 p. 846, pl. 1F, fig. 1-3; pl. 2I, fig. 1, 2.

Subtype *a9/b1/c1/d1/e1,2/f1/g1/h1,2/i2/j2/k2/l0.2-0.4/m1.6-2.0/n4,5/o1/p1,3* Doyle et al., 1974

Narrow triangle straight inbase

(Plate 8, Figure 13)

Doyle et al., 1974, p. 846, pl. 1F, fig. 4-6; pl. 2I, fig. 3, 4.

Subtype *a9/b1/c1/d1/e1/f1/g1/h1,2,3/i2,3/j2,3/k2,8/l0.25-0.45/m1.0-1.5/n4,5/o1/p3* Doyle et al., 1974

Wide triangle straight inbase

(Plate 7, Figure 13)

Doyle et al., 1974, p. 846, pl. 1F, fig. 7-9; pl. 2I, fig. 5-8.

Subtype *a9/b1/c1/d1/e1/f1,4/g1/h1/i2/j2/k7/l0.5-0.7/m2.5-3.5/N2/o1/p1,2* Doyle et al., 1974

Triangle with parallel inline

(Plate 8, Figure 15)

Doyle et al., 1974, p. 846, pl. 1H, fig. 4, 5; pl. 2K, fig. 9-12.

Subtype *a9/b1/c1/d1/e1/f1/g1/h2,4,5/i2,6/j2/k8/l0.2-0.3/m1.9-2.5/n6,7,8/o1,3/q1* Edgerton et al., in press

Triangle concave base

(Plate 7, Figure 10)

Edgerton et al., in press, p. 17, pl. 1, fig. 9.

Subtype *a9/b1/c1/d1/e1/f1/g1/h3,4,5/i3/k8/l0.2-0.8/m<1.0/n4-8/o1/p3* Dunsworth et al., 1975

Wide triangle

(Plate 7, Figure 15)

Dunsworth et al., 1975 p. 857, pl. 1, fig. 17, 18.

Subtype *a9/b1/c1/d1/e1/f1/g1/h3,4,5/i6/j3/k9/l0.2-0.7/m≥4.0/n1/o1/p3* Dunsworth et al., 1975

Narrow triangle ragged base

(Plate 7, Figure 6)

Dunsworth et al., 1975, p. 857, pl. 1, fig. 7, 8.

Subtype *a9/b1/c1/d1/e1/f1,3/g1/h5/i9/j9/k8/l0.75-0.95/m≥2.75/n2/o1/p2 + a9/b5/c1/d1/e1/f1/g1/h1/i1/j1/k9/l9/m1,4/n1,3/o9/p3/q0.75-0.95/r≥2.75/s0/t2/u1* Dunsworth et al., 1975

Triangle sigmoid

(Plate 6, Figure 9)

Dunsworth et al., 1975, p. 857, pl. 1, fig. 11, 12; pl. 2, fig. 14.

Subtype *a9/b1/c1/d1/e1/f4-8/g1/h5/i3/j3/k5/l0.4-017/m1.0-1.5/n6,7,9/o1/p3/q4* Ramsey et al., 1976

Triangle keeled edges

(Plate 8, Figure 16)

Ramsey et al., 1976, p. 131, pl. 3, fig. 4, 5.

Subtype *a9/b1/c1/d1/e1/f8/g5/h5/i1,6/j1,4/k5/l0.3-0.5/m1.5-2.5/n9/o1/p1/q1* Ramsey et al., 1976

Triangle arcuate inline

(Plate 8, Figure 19)

Ramsey et al., 1976, p. 132, pl. 3, fig. 3.

Subtype *a9/b1/c1/d1/e1/f1/g4/h3/i7/j2/k0/l0/m2.0-2.5/n9/o1/p1/q1* Ramsey et al., 1976

Triangle trailing margin

(Plate 8, Figure 9)

Ramsey et al., 1976, p. 131, pl. 2, fig. 1, 2.

Subtype *a9/b1/c1/d1/e1/f2/g1/h1,2,3/i6/j4/k2,4/l0.2-0.4/m1.0-2.0/n3,4,5/o2,p1* Doyle et al., 1974

Curved triangle pointed margin

(Plate 7, Figure 11)

Doyle et al., 1974, p. 846, pl. 1G, fig. 3, 4; pl. 2J, fig. 1-3.

Subtype *a9/b1/c1/d1/e1/f4/g1/h1/i2/j2/k2/l0.45-0.55/m2.5-3.5/n2/o1,5/p2* Doyle et al., 1974

Triangle inline halfway

(Plate 8, Figure 15)

Doyle et al., 1974, p. 846, pl. 1H, fig. 1-3; pl. 2K, fig. 5-8.

Subtype *a9/b1/c1/d1/e1/f6/g1/h5/i2/j2/k0,5/l0.75-1.0/m1.5-1.8/n2/o1/p1 + a9/b5/c1/d1/e1/f1/g1/h1/i8/j1/k2/l2/m2/n2/o2/p0,6/q0.75-1.0/r1.5-1.8/s0/t1/u1* Dunsworth et al., 1975

Small triangle long striations

(Plate 8, Figure 2)

Dunsworth et al., 1975, p. 857, pl. 1, fig. 13, 14.

Subtype *a9/b1/c3/d1,3/e1,2/f1,2/g1/h1,2,3/i3,6/j2,3,6/k2/l*<**0.3/m1.0-2.0/n4,5/o1/p1,3** Doyle et al., 1974

Triangle crenulate

(Plate 8, Figure 14)

Doyle et al., 1974, p. 846, pl. 1G, fig. 1, 2; pl. 2J, fig. 9, 10.

Subtype *a9/b1/c5/d1/e1/f1,4,5/g1/h1,3/i2,3/j6/k2/l<0.4/m1.5-2.0/n1/o1/p1* Doyle et al., 1974

Triangle short wing

(Plate 7, Figure 8)

Doyle et al., 1974, p. 846, pl. 1G, fig. 5; pl. 2J, fig. 4-6.

Subtype *a9/b1/c6,7/d1/e1/f1,4,5/g1/h1,3/i2,3/j6/k2/l<0.4/m1.5-2.0/n1/o1/p1* Doyle et al., 1974

Triangle medium wing

(Plate 8, Figure 12)

Doyle et al., 1974, p. 846, pl. 1G, fig. 6; pl. 2J, fig. 8-10.

Subtype *a9/b1/c9/d1,9,13/e1/f2,4/g1/h1/i2/j2/k2,3,5/l0.8-1.0/m1.8-2.5/n2/o1/p1* Doyle et al., 1974

Triangle notched corner

(Plate 7, Figure 16)

Doyle et al., 1974, p. 847, pl. 2J, fig. 12-14.

Subtype *a9/b1/c9,13/d1/e1/f4+(6,7)/g1/h4/i2/j2/k7,8/l0.2-0.6/m1.6-2.8/n2/o1,2/p1 + a9/b5/c8,12/d1/e1/f1/g1/h1/j2+4/j1/k2/l2/m2/n2/o9/p3,8/q0.2-0.6/r1.6-2.8/s0/t1/u1*
Dunsworth et al., 1975

Triangle with base angle

(Plate 7, Figure 7)

Dunsworth et al., 1975, p. 857, pl. 1, fig. 15, 16.

Subtype *a9/b1/c13/d13/e1/f4/g1/h1/i2/j2/k2/l<0.6/m2.0-3.0/n3/o3/p2* Doyle et al., 1974

Triangle pointed margin ends

(Plate 8, Figure 1)

Doyle et al., 1974, p. 847, pl. 1G, fig. 7; pl. 2K, fig. 1-4.

Subtype *a9/b1/c14/d1/e1/f2+5/g1/h2/i4/j2,3/k2/l0.1-0.4/m1.0-2.0/n1/o1/p1 + a9/b5/c13/d1/e1/f1/g1/h1/i2+7/j1/k2/l4/m3/n1/o1/p3/q<0.4/r1.0-2.0/s0/t1* Doyle et al., 1974

Triangle hooked margin

(Plate 8, Figure 5)

Doyle et al., 1974, p. 847, pl. 2H, fig. 6; pl. 2K, fig. 13-16.

Subtype ***a9/b1/c15,17/e1,2/f1/g1/h5/i2,3/k9/l0.25-0.5/m0.5-0.4/n1/o1/p1*** Dunsworth et al., 1975

Small triangle crenate margin

(Plate 8, Figure 21)

Dunsworth et al., 1975, p. 857, pl. 2, fig. 4, 5.

Subtype ***a9/b5/c1/d1/e3/f1/g1/h1/j1/k2,7/l2/m2,4/n3/o1,2/p2,3/q0/r>1.0/s>3.0/t2*** Doyle et al., 1974

Triangle with triangular projection

(Plate 6, Figure 6)

Doyle et al., 1974, p. 847, pl. 1H, fig. 16-19; pl. 2K, fig. 17-21.

Subtype ***a9/b5/c1/d1/e1/f1/g1/h1/i1,3,5/j1/k2,6/m2,4/n2,3/o3/p3,8/q0.4/r2.0/s0/t2*** Doyle et al., 1974

Short triangle stepped margin

(Plate 8, Figure 8)

Doyle et al., 1974, p. 847, pl. 1I, fig. 1-4.

Subtype ***a9/b5/c1/d1/e1/f1/g1/h1/i1,5/j1/k2,6/l3/m2,4/n2,3/o3/p3,8/q>0.4/r>2.0/s0/t2*** Doyle et al., 1974

Long triangle stepped margin

(Plate 8, Figure 7)

Doyle et al., 1974, p. 847, pl. 1I, fig. 5-6.

Subtype ***a9/b5/c1/d1/e1/f1/g1/h1/i1,3/j1/k2,6/l3/m2,3,5/n3/o2/p3,8/q0.2-0.6/r≥2.75/s0/t2*** Doyle et al., 1974

Narrow curved triangle

(Plate 6, Figure 8)

Doyle et al., 1974, p. 847, pl. 1I, fig. 8; pl. 2L, fig. 9.

Subtype ***a9/b5/c1/d1/e1/f1/g1/h1/i1,6/j3/k1/l1/m2,3,5/n2,3,5/o3,4/p2/q0/r0/s≤1.0/t2,3*** Doyle et al., 1974

Short rectangular with striations

(Plate 8, Figure 4)

Doyle et al., 1974, p. 847, pl. 1H, fig. 7-11.

Subtype ***a9/b5/c1/d1/e1/f1/g1/h1/i3/j1/k6/l3/m4/n3/o8/p2,3/q0/r0.8-2.5/s1.0-3.0/t3*** Doyle et al., 1974

Triangle complex transverse line

(Plate 8, Figure 11)

Doyle et al., 1974, p. 848, pl. 1I, fig. 9-12; pl. 2L, fig. 10-12.

Subtype ***a9/b5,c1,4/d1/e1,3/f1/g1/h1/i5/j2/k2,7/l2/m2,4/n2,3/o1,2/p2,3,6/q0/r>0.5/s>3.0/t2*** Doyle et al., 1974

Narrow triangle cross-hachured

(Plate 6, Figure 11)

Doyle et al., 1974, p. 847, pl. 2L, fig. 1-6.

Subtype ***a9/b5,c1/d1/e1/f1/g1/h1/i6/j3/l1/m2/n2/o3,4/p2/q0/r0/s>1.0/t2,3*** Doyle et al., 1974

Long rectangular with striations

(Plate 8, Figure 3)

Doyle et al., 1974, p. 848, pl. 1H, fig. 12-15.

Subtype ***a9/b5/c1/d1/e1/f1/g1,2/h2/i1,4/j1/k2/l2/m2/n2/o5,6/p3/q0.2-0.5/r1.0-1.5/s0/t1*** Doyle et al., 1974

Triangle with canals

(Plate 7, Figure 9)

Doyle et al., 1974, p. 848, pl. 1I, fig. 13-14; pl. 2L, fig. 13-15.

Subtype ***a9/b5/c1/d1/e1/f1/g1/h2/i4+(1,5)/j1/k2/l2/m2/n2/o4/p8/q0.3-0.6/r1.0-2.0/s0/t1*** Doyle et al., 1974

Triangle one canal above

(Plate 7, Figure 3)

Doyle et al., 1974, p. 848, pl. 1I, fig. 15; pl. 2M, fig. 1-5.

Subtype ***a9/b5/c1/d1/e1/f1/g2/h2/i4/j1/k2,4,6/l2,3/m1/n1/o4/p3/q0.2-0.4/r1.5-2.5/s0/t1*** Doyle et al., 1974

Triangle transverse line across

(Plate 7, Figure 5)

Doyle et al., 1974, p. 848, pl. 1J, fig. 1; pl. 2M, fig. 6-9.

Subtype ***a9/b5/c3/d1,3/e1/f1/g1,2/h2/i1/j1/k2/l2/m2/n2/o5/p3/q0.2-0.4/r1.0-1.5/s0/t1*** Doyle et al., 1974

Triangle crenulate with canals

(Plate 7, Figure 1)

Doyle et al., 1974, p. 848, pl. 1J, fig. 2, 3; pl. 2M, fig. 10, 11.

Subtype ***a9/b5/c1/d1/e1/f1/g1/h1/i1/j1/k2,6/l2,3/m2,4/n2,3/o2/p2,3,7/q0/r1.5-2.5/s≥4.0/t2/u3*** Dunsworth et al., 1975

Long triangle thin wall?

(Plate 7, Figure 17)

Dunsworth et al., 1975, p. 847, pl. 1, fig. 9, 10.

Type ***a9/b7*** Doyle et al., 1974

Rounded apex triangle

(Plate 8, Figure 6)

Doyle et al., 1974, p. 848, pl. 1J, fig. 7-10; pl. 2M, fig. 12-15.

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PLATE 1
Elasmobranchian Dermal Denticles

Figure 1	*Mustelus* sp. A. *a4/b1/c2/d1/e0/f1,(2+3)/g1+2* Doyle et al. Plain lanceolate (in part). Sample 38-5-5, 0-4 cm. Top view ×175.
Figure 2	*Mustelus* sp. B. Sample 38-3-5,5-9 cm. Top view. ×110.
Figure 3	*Carcharhinus* cf. *maculipinnis* (Poey). *a3/b1/c4/d1/e0/f2+3/g5+6* Doyle et al. Rhombus undulating margin (in part). Sample 38-3,CC. Top view. ×110.
Figure 4	*Carcharhinus* sp. Sample 38-5-3,0-4 cm. Top view. ×190.
Figure 5	*Carcharhinus* cf. *floridanus* Bigelow, Schroeder, and Springer. *a2/b2/c7/d1/e1/f1/g2/h1/i1/j1/k2*, new subtype Seven peaks (in part) Sample 38-3,CC. Top view. ×130.
Figure 6	*Carcharhinus* sp. Sample 38-5-3,0-4 cm. Top view. ×100.
Figure 7	*Carcharhinus* cf. *longimanus* (Poey). Sample 38-5,CC. Top view. ×110.
Figure 8	*Pseudotriakis* sp. Sample 38-4-5,0-4 cm. Top-lateral view. ×110.
Figure 9	*Heptranchias* (?). *a1/b2/c3/d1/e1/f3/g1/h3/i1/j1,2* Doyle et al. Short side peaks differentiated margin (in part) Sample 39-2-3,0-4 cm. Top-lateral view. ×95.
Figure 10	*Sphyrna diplana* Springer. Sample 39-2-3,0-4 cm. Top-lateral view. ×190.
Figure 11	*Sphyrna zygaena* (Linnaeus). *a2/b2/c5/d3/e1/f1/g1/h1/i1/j1,2* Doyle et al. Five peaks flared base (in part) Sample 39-1,CC. Top view. ×85.
Figure 12	*Sphyrna* sp. Sample 40-1-5,0-5 cm. Top-lateral view. ×90.
Figure 13	*Sphyrna* sp. Sample 38-3,CC. Top view. ×150.
Figure 14	*Carcharadon* (?). Sample 39-2-5,0-4 cm. Top view. ×185.
Figure 15	*Apristurus* cf. *riveri* Bigelow and Schroeder. Sample 38-5-5,0-4 cm. Top view. ×150.
Figure 16	*Galeocerdo* (?). *a3/b1/c4/d1,3/e0/f1,(2+3)/g1+2* Doyle et al. Rhombus smooth margin (in part) Sample 38-5-3,0-4 cm. Top view. ×110.
Figure 17	*Isurus* (?). Sample 418B-6-2,67-69 cm. Top view. ×90.

PLATE 1

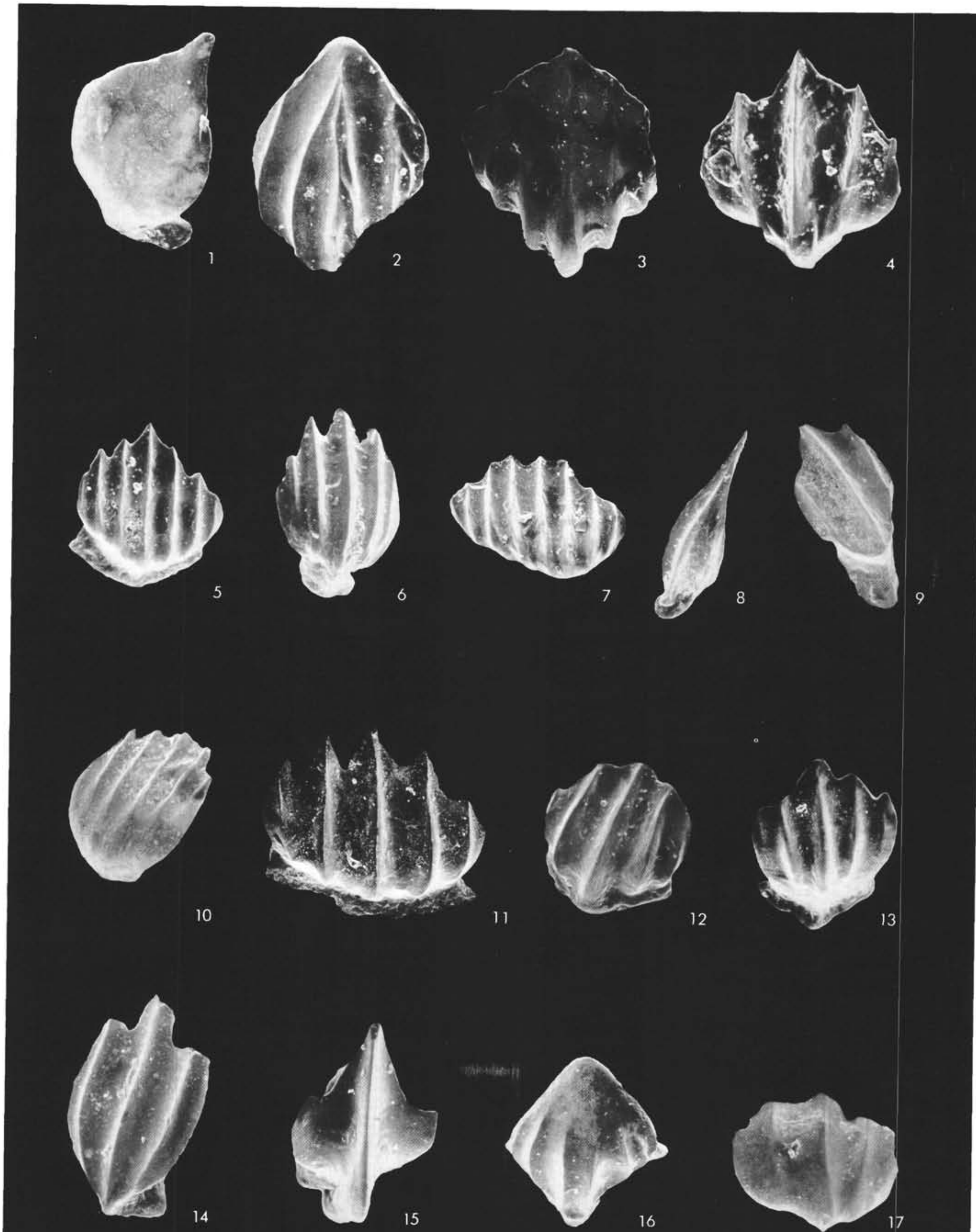

PLATE 2
Elasmobranchian Dermal Denticles

Figure 1	*Squalus* sp. Sample 164-7-4,96-100 cm. Top view. ×90.
Figure 2	*Centroscymnus* (?). Sample 40-1-5,0-5 cm. Top view. ×105.
Figure 3	*Etmopterus* sp. *a3/b1/c3/d3,4/e4/f2/g1+8* Doyle et al. Kite-shaped elongate prominence (in part) Sample 38-5-5,0-4 cm. Top-lateral view. ×105.
Figure 4	*Isistius* cf. *brasiliensis* (Quoy and Graimard). *a3/b1/c4/d5/e1/f1/g1+2*, new subtype. Polygonal cavity. Sample 40-1-3,0-4 cm. Top view. ×105.
Figure 5	*Isistius* sp.A *a3/b1/c5/d5/e1/f1/g1+2*, new subtype. Polygonal cavity long rays. Sample 40-1-3,0-4 cm. Top view. ×105.
Figure 6	*Isistius* sp. Sample 417A-1-4,16-18 cm. Top view. ×105.
Figure 7	*Isistius* sp. B. Sample 40-1-3,0-4 cm. Top view. ×90.
Figure 8	*Dalatias* sp. (?). *a3/b1/c3/d2/e2/f2+3/g1+2* Doyle et al. Kite-shaped longitudinal line (in part). Sample 37-3,CC. From trunk of body. Top view. ×100.
Figure 9	*Dalatias* sp. (?). Sample 38-4,CC. From ventral surface of snout. Top view. ×105.
Figure 10	Family Dalatidae. Sample 164-7-1,97-101 cm. Dermal denticle. Top view. ×185.
Figure 11	*Somniosus* cf. *microcephalus* (Bloch and Schneider). Sample 39-2-3,0-4 cm. Top view. ×105.
Figure 12	Family Rajidae. Sample 50.1-2,CC. Thorn. Top view. ×90.
Figure 13	*Pristis* cf. *perotteti* Muller and Henle. Sample 417A-2-3,142-144 cm. Top view. ×185.

PLATE 2

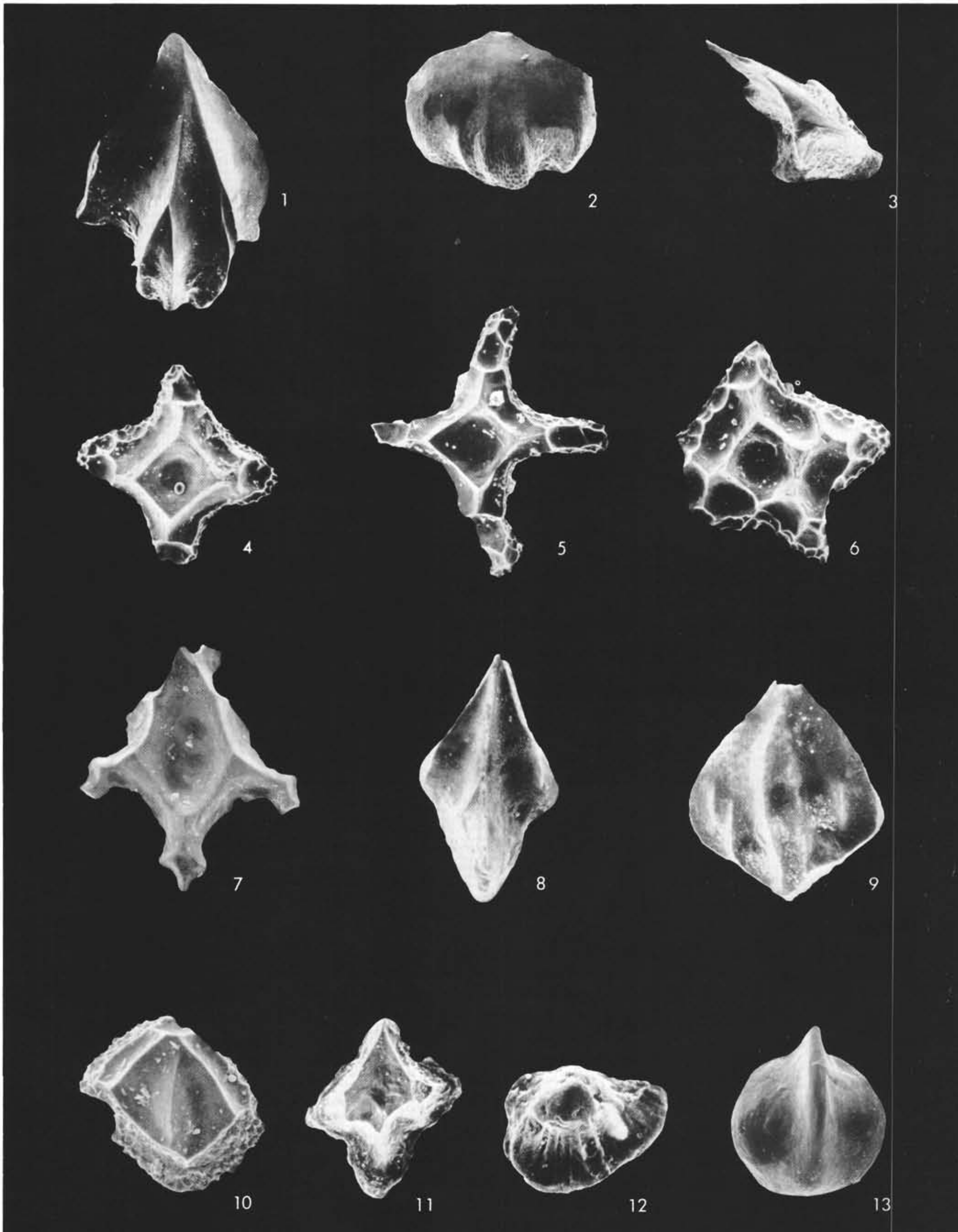

PLATE 3
Elasmobranchian Teeth

Figure 1	*Prionace* cf. *glauca* (Linnaeus). Sample 40-1-1,0-4 cm. Lateral view. ×20.
Figure 2	*Sphyrna zygaena* (Linnaeus). Sample 37-3,CC. Lateral view. ×90.
Figure 3	*Isurus* (?). Sample 38-3,CC. Lateral view. ×130.
Figure 4	*Squatina melleri* Reuss. Sample 164-7-1,97-101 cm. Lateral view. ×115.
Figure 5	*Echinorhinus* cf. *brucus* (Bonnaterre). Sample 39-2-5,0-4 cm. Lateral view. ×130.
Figure 6	*Squalus*. Sample 164-7-4,96-100 cm. Lateral view. ×130.
Figure 7	Family Rajidae. *a6/b4* Doyle et al. Elliptical with line across. Sample 39-1-1,50-54 cm. Top view. ×190.

PLATE 3

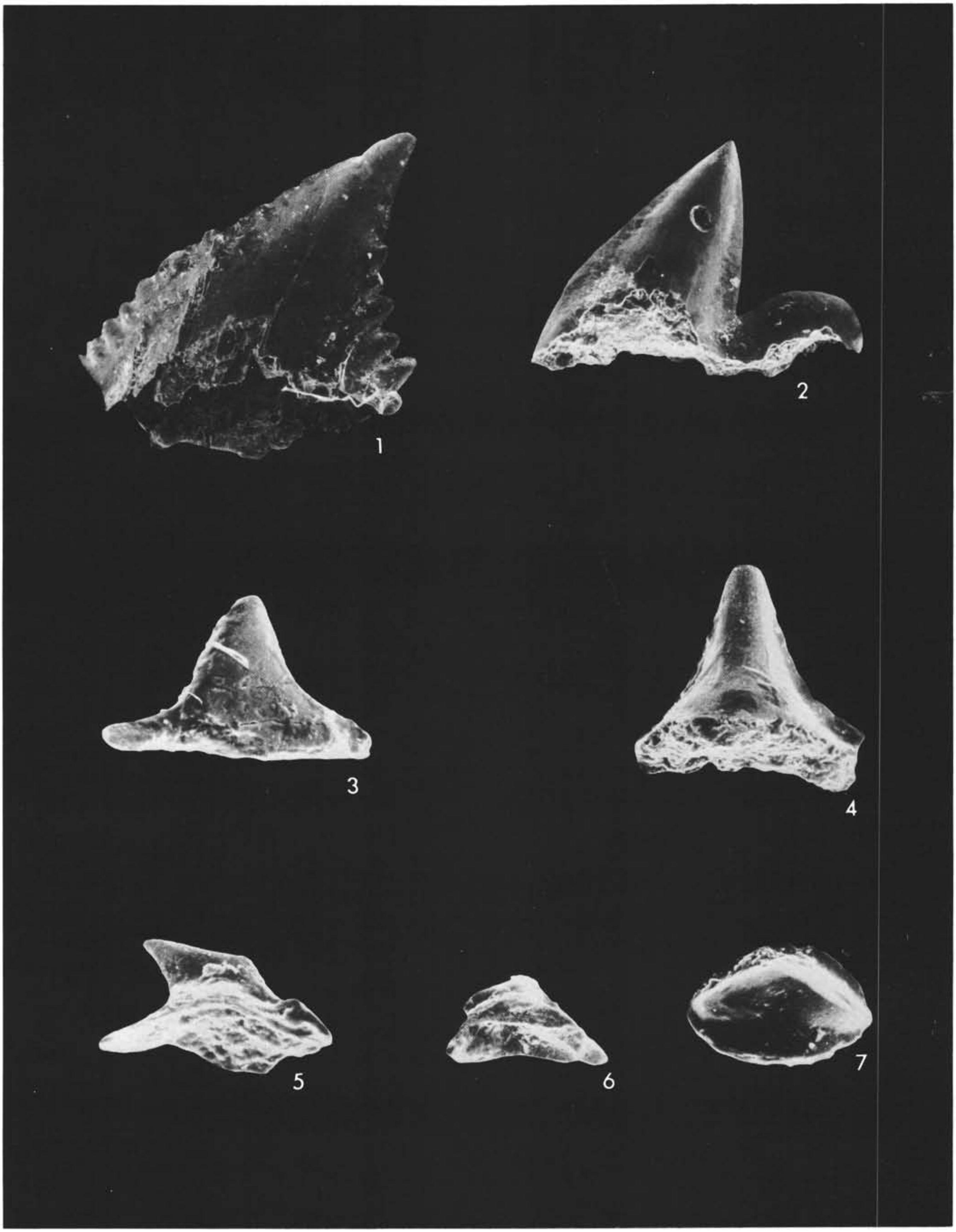

PLATE 4
Elasmobranchian Hard Parts

Figure 1 *a4/b1/c2/d1/e0/f2+3/g1+2* Doyle et al.
Giant lanceolate. Sample 40-1-5,0-5 cm. Top view. ×75.

Figure 2 *a2/b2/c3/d1/e1/f1/g1/h3/i1/j1* Doyle et al.
Three similiar peaks. Sample 38-5-5,0-4 cm. Top view. ×185.

Figure 3 *a2/b2/c3/d1/e1,2/f3/g1/h4/i0/j2/k2* new subtype
Tall median peak anastomosing keels. Sample 164-7-1,97-101 cm. Top view. ×90.

Figure 4 *a4/b1/c2/d4/e0/f2+3/g1+2*, new subtype.
Lanceolate irregular network. Sample 164-7-1,97-101 cm. Top view. ×90.

Figure 5 *a4/b2/c1/d2,3/e0/f2+3/g1+2*, new subtype.
Lined lanceolate. Sample 164-7-1,97-101 cm. Top view. ×90.

Figure 6 *a2/b2/c3/d1/e1/f1/g2/h2/i1/j1/k2*, new subtype.
Three equal peaks narrow blade. Sample 164-7-4,96-100 cm. Top view. ×185.

Figure 7 *a2/b2/c3/d1/e1/f1/g2/h1/i0/j1/k2*, new subtype.
Three peaks no keels. Sample 164-7-1,97-101 cm. Top view. ×185.

Figure 8 *a2/b2/c5/d1,2/e1/f1/g1,2/h1,3/i1/j1/k1,2,* new subtype.
Five peaks irregular base. Sample 38-5-5,0-4 cm. Top view. ×190.

Figure 9 *a2/b2/c3/d1/e2/f3/g1/h1/i2/j3* Doyle et al.
Tall median peak transverse lines. Sample 417A-1-1,148-150 cm. Top view. ×90.

Figure 10 *a2/b2/c3/d1/e1/f1/g1/h0,1/i0/j1,2/k1,3* Dunsworth et al.
Three tall peaks. Sample 418-1-1,40-42 cm. Lateral view. ×185.

Figure 11 *a2/b2/c3/d2,3/e1/f1/g1,2/h4/i1,2/j1* Doyle et al.
Three equal peaks flared base. Sample 39-2-5-,0-4 cm. Top-lateral view. ×185.

Figure 12 *a2/b2/c4,5/d1/e2/f2/g1/h2/i1/j2* Doyle et al.
Skewed four or five peaks. Sample 40-1-5,0-5 cm. Top view. ×90.

Figure 13 *a3/b1/c3/d4/e2/f2/g1+4* Doyle et al.
Kite-shaped irregular network. Sample 38-5-3,0-4 cm. Top view. ×80.

Figure 14 *a3/b1/c3/d1,3/e1/f1,(2+3)/g1+2* Doyle et al.
Short kite-shaped. Sample 40-2-1,0-4 cm. Top view. ×90.

Figure 15 *a6/b1*, new subtype.
Plain ellipse. Sample 37-3,CC. Top view. ×105.

Figure 16 *a5/b1*, new subtype.
Plain circle. Sample 417A-8-5,55-57 cm. Top view. ×185.

PLATE 4

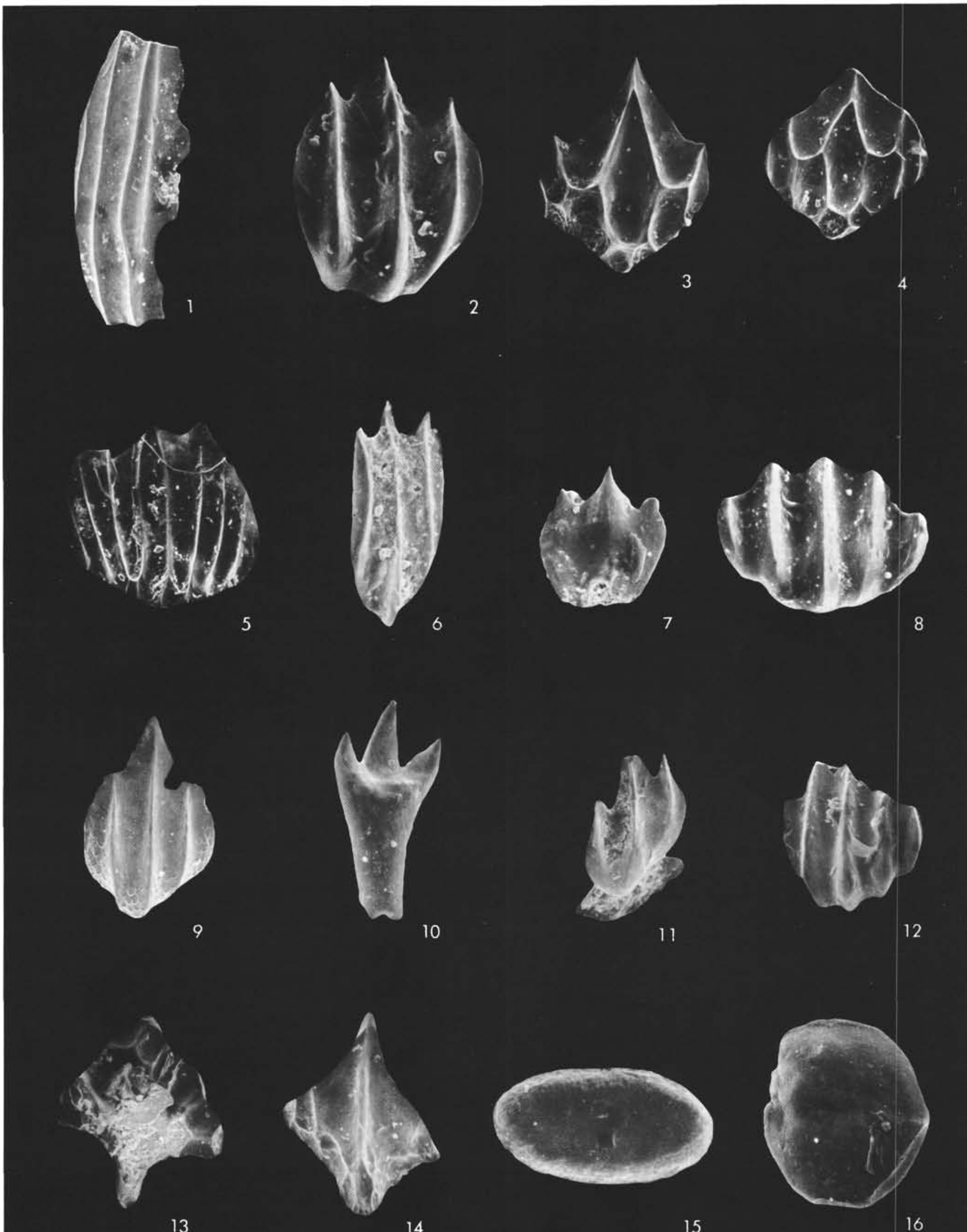

PLATE 5
Elasmobranchian and Osteichthyian Hard Parts

Figure 1 *a8/b1,5/c1/d1/e102-112/f26-36* Doyle et al.
Flexed triangle 102-112. Sample 40-1-3,0-4 cm. Lateral view. ×120.

Figure 2 *a8/b1,5/c1/d1/e120-128/f20-26* Doyle et al.
Flexed narrow triangle 120-128. Sample 40-1-3,0-4 cm. Lateral view. ×100.

Figure 3 *a8/b1,5/c1/d2/e80-140/f26-36* Doyle et al.
Flexed triangle shallow inbase. Sample 40-1-1,0-4 cm. Lateral view. ×105.

Figure 4 *a8/b1,5/c1/d2,3/e≥120/f≤25 + a9/b1/c13/d1/e1/f4+ (9 + 13 + 15)/g1/h2,3,4,5/i2/k4,8/l0.25-0.45/m2.0-3.0/ n2,3,4,6,7/o2/p1/q1*Dunsworth et al.
Flexed triangle shallow inbase ≥ 120. Sample 37-3-5,0-4 cm. Lateral view. ×70.

Figure 5 *a8/b1,5/c1/d1/e115-118/f25-35* Doyle et al.
Flexed triangle 115-118. Sample 40-1-3,0-4 cm. Lateral view. ×105.

Figure 6 *a8/b1/c2/d2,3/e60-100/f20-35* Dunsworth et al.
Triangle double flex. Sample 418A-3-5,50-52 cm. Lateral view. ×55.

Figure 7 *a7/b1/c1/d1/e2* Doyle et al.
Two curved triangles. Sample 39-1-5,6-10 cm. Lateral view. ×185.

Figure 8 *a7/b1/c1/d2/e2* Doyle et al.
Two curved triangles long base. Sample 417A-8-1,140-142 cm. Lateral view. ×110.

Figure 9 *a5,6/b3/c2/d1,2/e1* Doyle et al.
Large with numerous lines. Sample 37-3-5,0-4 cm. Top view. ×60.

Figure 10 *a5,6/b3/c1/d2/e2* Doyle et al.
Small dendritic many radiating lines. Sample 39-1,CC. Top view. ×105.

Figure 11 *a5/b4* Doyle et al.
Circular with line across. Sample 418B-21-4,17-19 cm. Top view. ×175.

Figure 12 *a7/b1/c2/d3/e6* Dunsworth et al.
Rectangular serially saw-toothed. Sample 417A-1-2,5-7 cm. Lateral view. × 75.

Figure 13 *a7/b1/c2/d3/e3* Doyle et al.
Rectangular saw-toothed. Sample 418B-18-1,96-98 cm. Lateral view. ×105.

Figure 14 *a7/b1,5/e1/d3/e5,* new subtype.
Rectangular triangular-toothed. Sample 39-2-5,0-4 cm. Lateral view. ×90.

PLATE 5

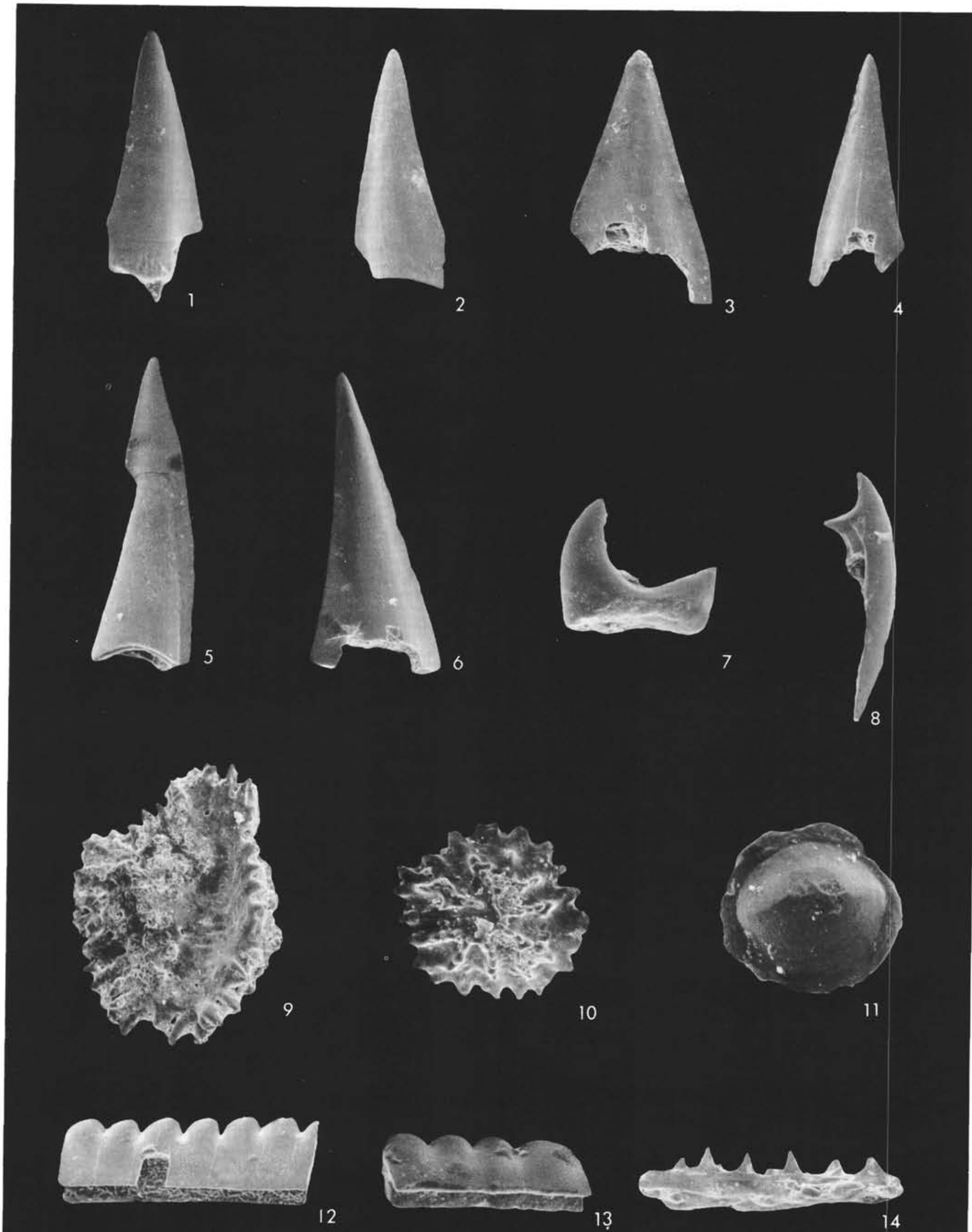

PLATE 6
Osteichthyian Hard Parts

Figure 1 — *a9/b5/c1/d1/e1/f1/g1/h1/i1/j1/k2,3/l2/m2,4/n2,3/o2,6/p2/q0/r1.0-1.5/s≤1.0/t3/u1/v2,* new subtype.
Wide triangle large top. Sample 38-5-5,0-4 cm. Lateral view. ×200.

Figure 2 — *a9/b1/c1/d1/e1/f1/g1/h5/i2,3/j2,3/k0/l0/m≤1.0/n1/o1/p3/q2,* new subtype.
Wide conical triangle. Sample 40-1-3,0-4 cm. Oblique lateral view. ×200.

Figure 3 — *a9/b1/c1/d1/e1/f1/g1/h5/i2,6/j2,3/k0,8/l0.0-0.8/m1.5-2.75/n1/o1/p3/q2,* new subtype.
Conical triangle. Sample 40-1-3,0-4 cm. Lateral view. ×200.

Figure 4 — *a9/b1/c1/d1/e1/f1/g1/h5/i2,6/j2,3/k0/l0/m>2.75/n1/o1/p2/q2,* new subtype.
Long triangle sharply pointed. Sample 40-1-3,0-4 cm. Lateral view. ×200.

Figure 5 — *a9/b1/c6/d6,7/e1/f1/g1/h5/i2,6/j2/k8/l0.2-0.5/m2.2-3.0/n2/o1/p2,3,* new subtype.
Triangle double wing. Sample 38-5-5,0-4 cm. Lateral view. ×90.

Figure 6 — *a9/b5/c1/d1/e3/f1/g1/h1/i1/j1/k2,7/l2/m2,4/n3/o1,2/p2,3/q0/r>1.0/s>3.0/t2* Doyle et al.
Triangle with triangular projection. Sample 40-1-5,0-5 cm. Lateral view. ×90.

Figure 7 — *a9/b5/c1/d1/e1/f1/g1/h1/i1,5/j1/k2,6/l3/m2,4/n2,3/o3/p3,8/q>0.4/r>2.0/s0/t2* Doyle et al.
Long triangle stepped margin. Sample 417B-1,CC. Lateral view. ×200.

Figure 8 — *a9/b5/c1/d1/e1/f1/g1/h1/i1,3/j1/k2,6/l3/m2,3,5/n3/o2/p3,8/q0.2-0.6/r≥2.75/s0/t2* Doyle et al.
Narrow curved triangle. Sample 40-1-5,0-5 cm. Lateral view. ×90.

Figure 9 — *a9/b1/c1/d1/e1/f1,3/g1/h5/i9/j9/k8/l0.75-0.95/m≥2.75/n2/o1/p2/ + a9/b5/c1/d1/e1/f1/g1/h1/i1/j1/k9/l9/m1,4/n1,3/o9/p3/q0.75-0.95/r≥2.75/s0/t2/u1* Dunsworth et al.
Triangle sigmoid. Sample 37-3-5,0-4 cm. Lateral view. ×100.

Figure 10 — *a9/b1/c1/d1/e1/f1,6/g1/h5/i2,6/j2,3/k0,8/l0.0-0.8/m2.0-3.0/n1/o1/p3/q5,* new subtype.
Triangular triangle. Sample 38-3-3,0-4 cm. Lateral view. ×100.

Figure 11 — *a9/b5/c1,4/d1/e1,3/f1/g1/h1/i5/j2/k2,7/l2/m2,4/n2,3/o1,2/p2,3,6/q0/r>0.5/s>3.0/t2* Doyle et al.
Narrow triangle cross-hachured. Sample 38-5-5,0-4 cm. Lateral view. ×90.

PLATE 6

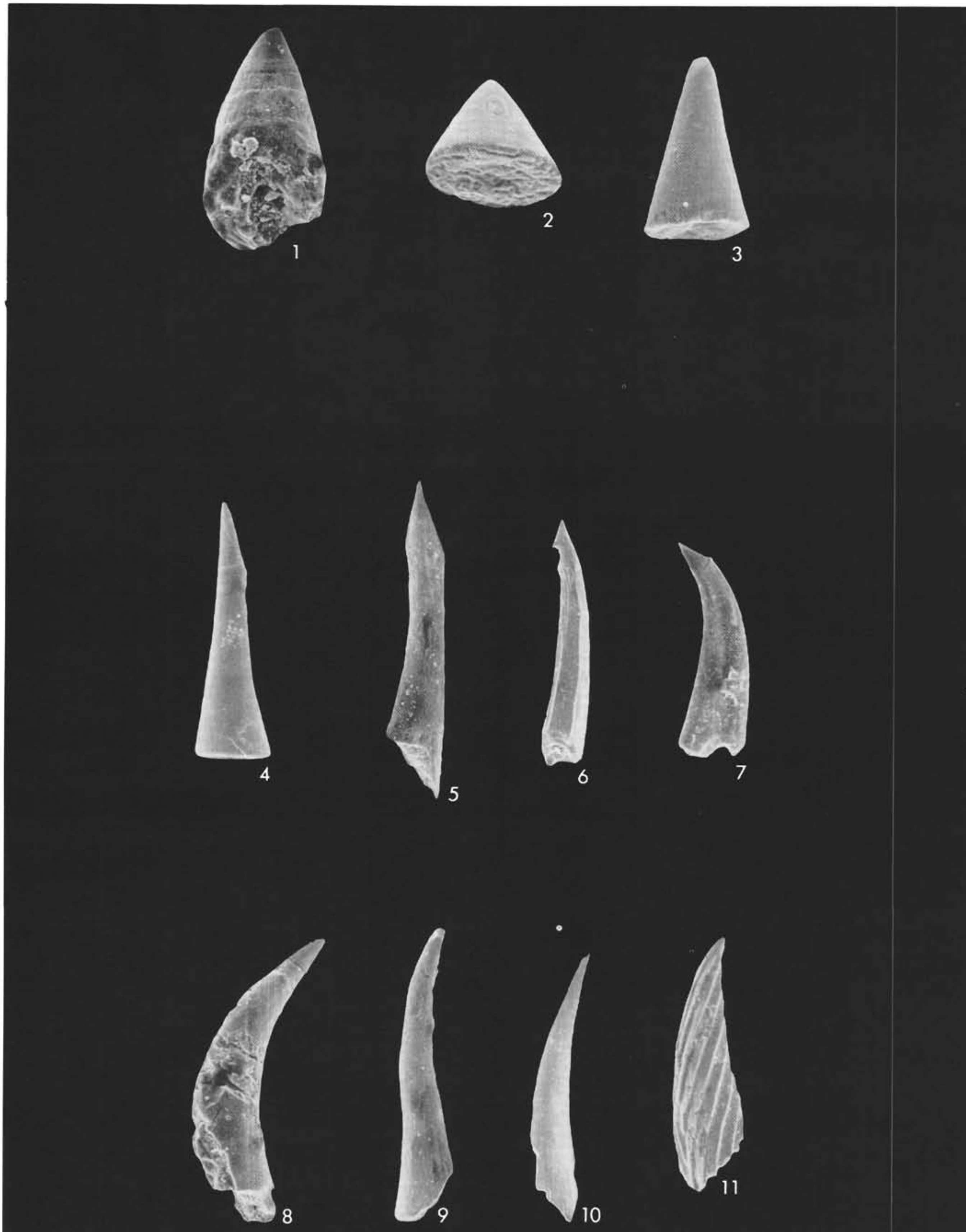

PLATE 7
Osteichthyian Hard Parts

Figure 1
a9/b5/c3/d1,3/e1/f1/g1,2/h2/i1/j1/k2/l2/m2/n2/o5/p3/q0.2-0.4/r1.0-1.5/s0/t1 Doyle et al.
Triangle crenulate with canals. Sample 418A-2,CC. Lateral view. ×135.

Figure 2
a9/b1/c1/d1/e1/f1,4/g1/h1,2/i2,6,8/k2,3/l<0.2/m1.5-2.0/n3,4/o1/p1,3 Doyle et al.
Triangle with high inline apex. Sample 40-1-1,0-4 cm. Lateral view. ×135.

Figure 3
a9/b5/c1/d1/e1/f1/g1/h2/i4+(1,5)/j1/k2/l2/m2/n2/o4/p8/q0.3-0.6/r1.0-2.0/s0/t1 Doyle et al.
Triangle one canal above. Sample 38-5-5,0-4 cm. Lateral view. ×135.

Figure 4
a9/b5/c1/d1/e1/f1/g1/h1,2/i1,4/j1/k2,4,6/l2,4/m2,3/n2,3/o4,6/p3/q0.2-0.4/r1.5-2.5/s0/u1/v3, new subtype.
Triangle transverse line across no canals. Sample 39-1,CC. Lateral view. ×135.

Figure 5
a9/b5/c1/d1/e1/f1/g2/h2/i4/j1/k2,4,6/l2,4/m1/n1/o4/p3/q0.2-0.4/r1.5-2.5/s0/t1 Doyle et al.
Triangle transverse line across. Sample 40-1-5,0-5 cm. Lateral view. ×135.

Figure 6
a9/b1/c1/d1/e1/f1/g1/h3,4,5/i6/j3/k9/l0.2-0.7/m≥4.0/n1/o1/p3 Dunsworth et al.
Narrow triangle ragged base. Sample 51-1-3,12-14 cm. Lateral view. ×135.

Figure 7
a9/b1/c9,13/d1/e1/f4+(6,7)/g1/h4/i2/j2/k7,8/l0.2-0.6/m1.6-2.8/n2/o1,2/p1 + a9/b5/c8,12/d1/e1/f1/g1/h1/i2+4/j1/k2/l2/m2/n2/o9/p3,8/q0.2-0.6/r1.6-2.8/s0/t1/u1 Dunsworth et al.
Triangle with base angle. Sample 417A-6-4,96-98 cm. Lateral view. ×75.

Figure 8
a9/b1/c5/d1/e1/f1,4,5/g1/h1,3/i2,3/j6/k2/l<0.4/m1.5-2.0/n1/o1/p1 Doyle et al.
Triangle short wing. Sample 418A-3-1,50-52 cm. Lateral view. ×135.

Figure 9
a9/b5/c1/d1/e1/f1/g1,2/h2/i1,4/j1/k2/l2/m2/n2/o5,6/p3/q0.2-0.5/r1.0-1.5/s0/t2 Doyle et al.
Triangle with canals. Sample 40-1-3,0-4 cm. Lateral view. ×135.

Figure 10
a9/b1/c1/d1/e1/f1/g1/h2,4,5/i2,6/j2/k8/l0.2-0.3/m1.9-2.5/n6,7,8/o1,3/p1,2/q1 Edgerton et al.
Triangle concave base. Sample 40-2-3,0-4 cm. Lateral view. ×135.

Figure 11
a9/b1/c1/d1/e1/f2/g1/h1,2,3/i6/j4/k2,4/l0.2-0.4/m1.0-2.0/n3,4,5/o2/p1 Doyle et al.
Curved triangle pointed margin. Sample 418-1,CC. Lateral view. ×135.

Figure 12
a9/b5/c1/d1/e1/f1,7/g1/h1/i1,9/j3/k2/l2/m4/n3/o2/p2/q0/r1.2-2.0/s1.0-4.0/t2/u1/v2, new subtype.
Striated triangle with top. Sample 39-1,CC. Lateral view. ×135.

Figure 13
a9/b1/c1/d1/e1/f1/g1/h1,2,3/i2,3/j2,3/k2,8/l0.25-0.45/m1.0-1.5/n4,5/o1/p3 Doyle et al.
Wide triangle straight inbase. Sample 40-1-3,0-4 cm. Lateral view. ×135.

Figure 14
a9/b5/c4/d1/e3/f1/g1/h2/i1/j1/k3/l3/m4/n3/o4/p2/q0/1.0/s2.0-2.5/t1/u1/v2,3, new subtype.
Triangle with triangular projection and canals. Sample 164-7-1,97-101 cm. Lateral view. ×135.

Figure 15
a9/b1/c1/d1/e1/f1/g1/h3,4,5/i3/j3/k8/l0.2-0.8/m<1.0/n4-8/o1/p3 Dunsworth et al.
Wide triangle. Sample 38-5-3,0-4 cm. Lateral view. ×135.

Figure 16
a9/b1/c9/d1,9,13/e1/f2+4/g1/h1/i2/j2/k2,3,5/l0.8-1.0/m1.8-2.5/n2/o1/p1 Doyle et al.
Triangle notched corner. Sample 38-4-3,0-4 cm. Lateral view. ×135.

Figure 17
a9/b5/c1/d1/e1/f1/g1/h1/i1/j1/k2,6/l2,3/m2,4/n2,3/o2/p2,3,7/q0/r1.4-2.5/s≥4.0/t2/u3 Dunsworth et al.
Long triangle thin wall. Sample 40-2-3,0-4 cm. Lateral view. ×135.

PLATE 7

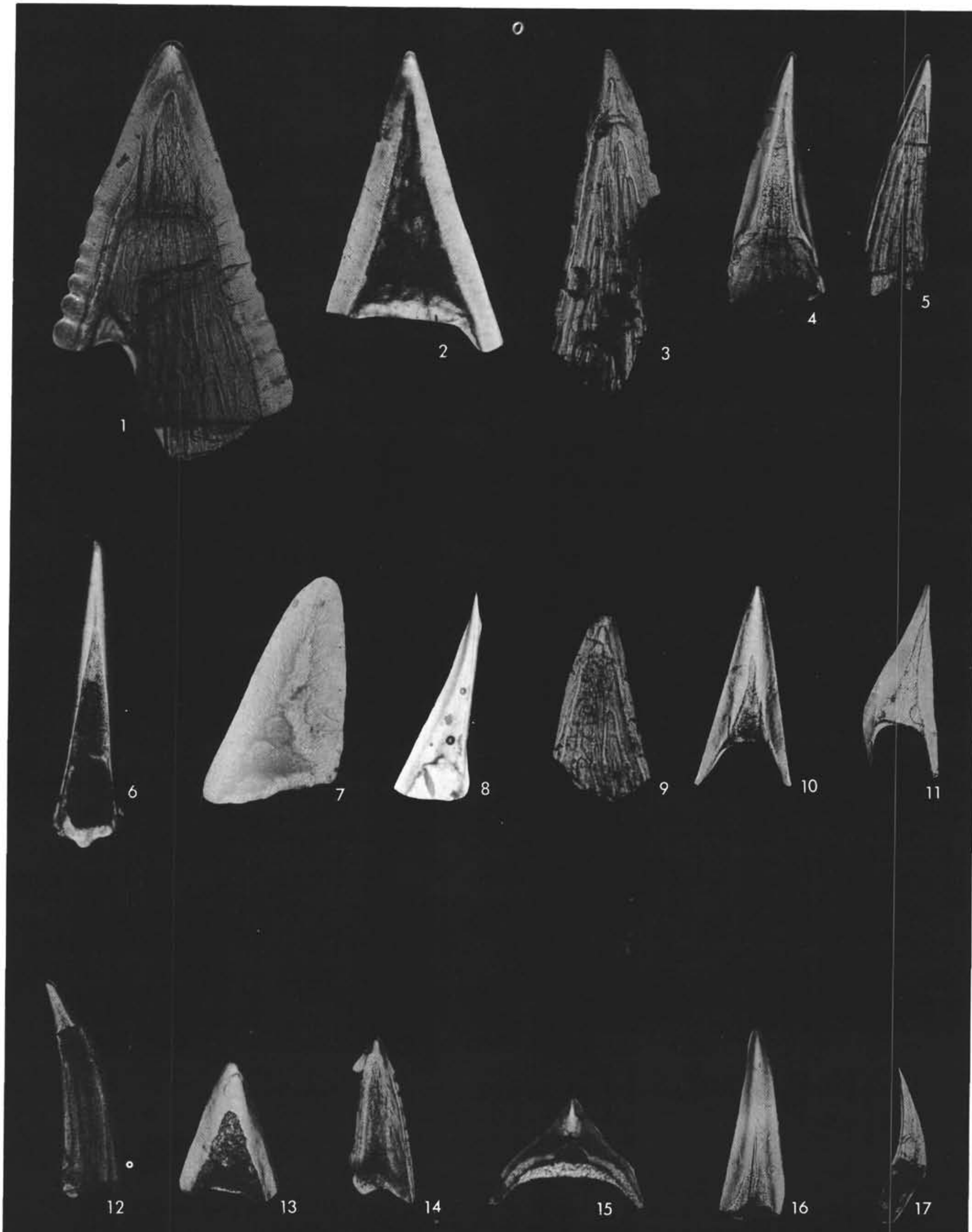

PLATE 8
Osteichthyian Hard Parts

Figure 1	*a9/b1/c13/d13/e1/f4/g1/h1/i2/ j2/k2/l<0.6/m2.0-3.0/n3/o2/p2* Doyle et al. Triangle pointed margin ends. Sample 40-2-1,0-4 cm. Lateral view. ×180.
Figure 2	*a9/b1/c1/d1/e1/f6/g1/h5/i2/j2/k0,5/l0.75-1.0m1.5-1.8/n2/o1/p1 +a9/b5/c1/d1/e1/f1/g1/i8/j1/k2/l2/m2/n2/o2/p0,6/q0.75-1.0/r1.5-1.8/s0/t1/u1* Dunsworth et al. Small triangle long striations. Sample 39-1-1, 50-54 cm. Lateral view. ×180.
Figure 3	*a9/b5/c1/d1/e1/f1/g1/h1/i6/j3/k1/l1/m2/n2/o3,4/p2/q0/r0/s>1.0/t2,3* Doyle et al. Long rectangular with striations. Sample 39-2-3,0-4 cm. Lateral view. ×180.
Figure 4	*a9/b5/c1/d1/e1/f1/g1/h1/i1,6/j3/k1/l1/m2,3,5/n2,3,5/o3,4/p2/q0/r0/s≤1.0/t2,3* Doyle et al. Short rectangular with striations. Sample 40-1-5, 0-5 cm. Lateral view. ×180.
Figure 5	*a9/b1/c14/d1/e1/f2+5/g1/h2/i4/j2,3/k2/l0.1-0.4/m1.0-2.0/n1/o1/p1 + a9/b5/c13/d1/e1/f1/g1/h1/i2+7/j1/k2/l4/m3/n1/o1/p3/q<0.4/r1.0-2.0/s0/t1* Doyle et al. Triangle hooked margin. Sample 417A-2-3, 142-144 cm. Lateral view. ×180.
Figure 6	*a9/b7* Doyle et al. Rounded apex triangle. Sample 37-1, CC. Lateral view. ×180.
Figure 7	*a9/b5/c1/d1/e1/f1/g1/h1/i1,5/j1/k2,6/l3/m2,4/n2,3/o3/p3,8/q>0.4/r>2.0/s0/t2* Doyle et al. Long triangle stepped margin. Sample 417B-1, CC. Lateral view. ×180.
Figure 8	*a9/b5/c1/d1/e1/f1/g1/h1/i1,3,5/j1/k2,6/l3/m2,4/n2,3/o3/p3,8/q>0.4/r<2.0/s0/t2* Doyle et al. Short triangle stepped margin. Sample 417A-1-2, 5-7 cm. Lateral view. ×180.
Figure 9	*a9/b1/c1/d1/e1/f1/g4/h3/i7/j2/k0/l0/m2.02.5/n9/o1/p1/q1* Ramsey et al. Triangle trailing margin. Sample 164-7-1, 97-101 cm.Lateral view. ×180.
Figure 10	*a9/b5/c1/d1/e1/f1/g1/h1/i1/j1/k2/l2/m2/n2/o2/p2,3/q0.0-0.5/r0.8-1.8/s2.5-4.0/ t3/u1/v2*, new subtype. Straight triangle with top. Sample 418B-1, CC. Lateral view. ×180.
Figure 11	*a9/b5/c1/d1/e1/f1/g1/h1/i3/ji/k6/l3/m4/n3/o8/p2,3/q0/r0.8-2.5/s1.0-3.0/t3* Doyle et al. Triangle complex transverse line. Sample 40-1-3, 0-4 cm. Lateral view. ×180.
Figure 12	*a9/b1/c6,7/d1/e1/f1,4,5/g1/h1,3/i2,3/j6/k2/l<0.4/m1.5-2.0/n1/o1/p1* Doyle et al. Triangle medium wing. Sample 38-4, CC. Lateral view. ×100.
Figure 13	*a9/b1/c1/d1/e1,2/f1/g1/h1,2/i2/j2/k2/l0.20.4/m1.6-2.0/n4,5/o1/p1,3* Doyle et al. Narrow triangle straight inbase. Sample 417A-5-1, 58-60 cm. Lateral view. ×180.
Figure 14	*a9/b1/c3/d1,3/e1,2/f1,2/g1/h1,2,3/i2,6/j2,3/k2/l0,3/m1.0-2.0/n4,5/o1/p1,3* Doyle et al. Triangle crenulate. Sample 417D-1, CC. Lateral view. ×100.
Figure 15	*a9/b1/c1/d1/e1/f1,4/g1/h1/i2/j2/k7/l0.5-0.7/m2.5-3.5/n2/o1/p1,2*, Doyle et al. Triangle with parallel inline. Sample 51-1-5, 0-4 cm. Lateral view. ×180.
Figure 16	*a9/b1/c1/d1/e1/f4+8/g1/h5/i3/j3/k5/l0.4-0.7/j1.0-1.5/n6,7/o1/p3/q4* Ramsey et al. Triangle keeled edges. Sample 164-7-4, 96-100 cm. Lateral view. ×180.
Figure 17	*a7/b6/c3* Doyle et al. Asymmetrical peaks narrow depression. Sample 37-3-5, 0-4 cm. Lateral view. ×180.
Figure 18	*a9/b1/c1/d1/e1/f4/g1/h1/i2/j2/k2/l0.45-0.55/m2.5-3.5/n2/o1,5/p2* Doyle et al. Triangle inline halfway. Sample 38-2, CC. Lateral view. ×180.
Figure 19	*a9/b1/c1/d1/e1/f8/g5/h5/i1,6/j1,4/k5/l0.30.5/m1.5-2.5/n9/o1/p1/q1* Ramsey et al. Triangle arcuate inline. Sample 164-7-4, 96-100 cm. Lateral view. ×180.
Figure 20	*a7/b6/c1* Doyle et al. Asymmetrical peak wide depression. Sample 39-2-5, 0-4 cm. Lateral view. ×180.
Figure 21	*a9/b1/c15,17/d15,17/e1,2/f1/g1/h5/i2,3/k9/l0.25-0.5/m0.5-1.4/n1/o1/p1* Dunsworth et al. Small triangle crenate margin. Sample 39-2-5, 0-4 cm. Lateral view. ×180.

PLATE 8