PARTICLE SIZE DISTRIBUTION OF SUSPENDED SOLIDS IN THE CHESAPEAKE BAY ENTRANCE AND ADJACENT SHELF WATERS

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INTRODUCTION

Characteristics of suspended solids, including total suspended matter (TSM), total suspended inorganics (TSI), total suspended organics (TSO), particle size distribution (PSD), and the presence of the 10 most prominent particle types were determined in cooperation with a NOAA/NASA program entitled Superflux. Superflux cruises were made in March, June and October, 1980.

The data set described below was determined from samples taken in October during a portion of Superflux III known as the racetrack mission. The R/V Langley (NASA), R/V Linwood Holton (ODU), R/V John Smith (VIMS), and NOAA Ship Kelez simultaneously collected samples along four transects (fig. 1). Samples were collected within a 2-hour period that coincided with the maximum ebb penetration of Chesapeake Bay outwelling (table 1). The objective of this portion of the study was to determine the particle size characteristics and contents of the Chesapeake Bay outwelling and adjacent shelf waters.

METHODS

Sixty-one samples were collected at sixteen stations during the October 15 racetrack mission. Samples were taken at the surface, -3 m, -8 m, and 1 m above the bottom to obtain maximum vertical representation of the water column. Equipment limitations did not permit sampling of the 1 m above bottom samples at stations 800, 801, and 801A. Five-hundred-milliliter samples were taken from 8 liter Niskin bottles and refrigerated to inhibit growth fluctuations of organisms in the sample. Particle size analysis was done within 24 hours of collection using a Model TA-II Coulter Counter. Instrument calibration was performed prior to analysis using an azide-free ISOTON II electrolyte solution and following standard procedures.

Each sample was analyzed for 150 s using a 400-μm aperture tube that provided a size range of 5 to 200 μm. Each analysis produced a size-distribution histogram, a total count of particles and a percent volume of the total population for each of 16 different size classes. Primary and secondary size modes of the total size frequency distribution were used to determine the areal and vertical continuity of size modes in waters in and adjacent to the entrance to Chesapeake Bay (table 2).

OBSERVATIONS AND RESULTS

Discussion

Total counts ranged from 30,000 to 500,000 particles per 150-s time interval. The three predominant size modes that reoccurred in samples were 8 to 10 μm, 20 to 25 μm and 64 to 80 μm. The two smaller size ranges apparently corresponded to inorganic particles, such as clay and silt, and to flocs of these particles. The largest size mode apparently had an offshore source that consisted of a variety of large diatom species, many of which were centric diatoms. Invariably, samples with larger total counts corresponded to those populations with smaller dominant size modes, whereas the samples with lower counts corresponded to the larger modes.

Sheldon and Parsons (ref. 1) discussed the relationship between particle diameter and concentration of suspended matter in an estuary and in coastal water for temperate latitudes. Particle size distribution for estuarine silt consisted largely of flocculated masses of very small inorganic particles, the principal constituent being quartz (fig. 2). Peak concentrations were in the 10 μm size range. Sheldon and Parsons also illustrated that the size distribution of particles in quiescent coastal waters had larger particles but the concentration of material in suspension was lower (fig. 3). The particle distribution showed modes at 20 μm, 50 μm, and 100 μm with the latter corresponding to the highest concentration. The dominant size class throughout the Superflux III study area was the 20 to 25 μm diameter range. The 20 to 25 μm size mode apparently had a polygenetic origin. When it was associated with the 8 to 10 μm mode, the population was apparently composed of inorganic material forming larger aggregates. In the presence of larger size modes, the 20 to 25 μm mode was probably produced by a variety of diatom species that fall in this range. Areal patterns of the primary and secondary size classes illustrated distinct areas characterized by specific modes (figs. 4 to 7).

Areal Patterns

Surface water.- The extent of the 8 to 10 μm size range at the water surface indicates a potential source associated with both Chesapeake and Thimble Shoal Channels (fig. 4). Since the 8 to 10 μm range is considered mostly inorganic, the distribution of this size range may illustrate a tidally driven turbidity plume. Another trend was that associated with station 800, where the only mode present was the 8 to 10 μm class. This anomaly may be related to turbidity associated with James River runoff or resuspension caused by high speed currents in the area. Samples from the outer part of the sample grid apparently had particles more characteristic of shelf waters. The 64 to 80 μm size mode was the predominant size class for the waters.

Intermediate water (-3 m).- The pattern of size mode distribution at intermediate depths was similar to the pattern illustrated for surface water (fig. 5). The extent of water containing the 8 to 10 μm size mode was smaller and closer to the coast than the respective distribution for surface water. The apparent influence of Chesapeake Channel water was still evident. The

20 to 25 μm class in the northern portion of the Bay mouth was influenced by the turbid runoff of the North Channel and possibly by resuspension of particles over shoals at the distal end of the channel. The 64 to 80 μm size mode that was characteristic of shelf water had a similar distribution as described above for surface water; however, it was closer to shore at intermediate depths.

Deep water (-8 m).- At 8 m the distribution of the 8 to 10 μm size mode was confined to the Chesapeake Channel area (fig. 6). The source for this material may have been from resuspension in the upper Bay or from resuspension in the immediate area. Samples containing 64 to 80 μm size particles were much closer to the Bay entrance. If this larger size class of particles was associated with shelf water, then it appears that a near-surface plume (containing the 8 to 10 μm size class) had partially overridden the deeper shelf water. The 20 to 25 μm size mode was present in most samples everywhere.

Near-bottom water (1 m above the seabed).- Near-bottom water characterized by the 64 to 80 μm class extended toward the axis of the Bay mouth (fig. 7). While particle size data in the Bay entrance were not collected, it is believed that shelf water with 64 to 80 μm particles migrated up the axis of Chesapeake Channel. The 8 to 10 μm size mode was absent as a primary or secondary mode in the samples collected and the 20 to 25 μm size mode was present in most samples.

Cross-sectional plots of size frequency data were made for each of the four transects to illustrate vertical changes (fig. 8). Profile A shows a "tongue" of mostly inorganic, fine-grained material that corresponded to the axis of Chesapeake Channel. The water mass with these fine-grained characteristics was traceable down the coast for about 22 km. South of profile C, the 8 to 10 μm size mode was a minor percent of the sample population. Beyond profile C, the particle size characteristics of shelf waters dominated the water column.

CONCLUSIONS

The distribution of primary and secondary particle size modes indicated the presence of a surface or near-surface plume, possibly associated with three sources: (1) runoff, (2) resuspension of material within the Bay, and/or (3) resuspension of material in the area of shoals at the Bay mouth. Additional supportive evidence for this conclusion was illustrated with Ocean Color Scanner (OCS) data (ref. 2). The OCS data showed an obvious increase in water turbidity associated with Chesapeake Channel and in water adjacent to Cape Henry, Virginia. This corresponded with the particle size data presented above. Initially, it was speculated that turbid water "outwelling" from the Bay had an upper Bay source; however, OCS data showed that the upper Bay was not a plausible source. The most likely source was resuspension due to wave and current action. This explanation would have been expected due to drought conditions that had existed for several months prior to the survey.

REFERENCES

1. Sheldon, R. W.; and Parsons, T. R.: A Practical Manual on the Use of the Coulter Counter in Marine Research. Fisheries Research Board of Canada, Pacific Oceanographic Group, 65 pp, 1967.

2. Ohlhorst, C.: Preliminary Analysis of Ocean Color Scanner Data From Superflux III. Chesapeake Bay Plume Study - Superflux 1980, NASA CP-2188, 1981 (Paper no. 12 of this compilation).

TABLE 1.- SAMPLE STATION DATA, OCTOBER 15, 1980

Vessel name	Station no.	Time	Latitude	Longitude	Depth (m)
R/V Langley	800	1018	36° 57.30' N	76° 02.90' W	--
	801	1058	36° 59.20' N	76° 00.60' W	--
	801A	1140	37° 02.10' N	75° 56.80' W	--
R/V Holton	69	1020	36° 55.00' N	75° 58.00' W	11
	802	1105	36° 55.00' N	75° 55.30' W	13
	803	1133	36° 58.00' N	75° 51.50' W	11
	804	1225	37° 01.02' N	75° 44.20' W	15
R/V John Smith	805	1017	36° 52.00' N	75° 56.00' W	11
	70	1047	36° 52.40' N	75° 53.50' W	15
	806	1127	36° 53.20' N	75° 48.60' W	15
	807	1148	36° 54.38' N	75° 41.07' W	21
NOAA Ship Kelez	808	1010	36° 45.50' N	75° 54.70' W	10
	809	1050	36° 46.40' N	75° 49.00' W	17
	821	1125	36° 47.42' N	75° 42.52' W	19
	810	1148	36° 47.67' N	75° 41.12' W	19
	811	1244	36° 48.73' N	75° 32.26' W	25

TABLE 2.- PRIMARY AND SECONDARY SIZE MODES

Station	Depth (m)	Primary mode (μm)	Secondary mode (μm)
800	Surface	8-10	--
	3	20-25	--
	8	20-25	--
801	Surface	20-25	8-10
	3	8-10	20-25
	8	20-25	8-10
801A	Surface	20-25	--
	3	8-10	--
	8	20-25	--
69	Surface	20-25	8-10
	3	20-25	8-10
	8	20-25	--
	Bottom	20-25	--
802	Surface	20-25	8-10
	3	20-25	8-10
	8	20-25	--
	Bottom	20-25	50-64
803	Surface	20-25	64-80
	3	20-25	--
	8	20-25	--
	Bottom	20-25	--
804	Surface	20-25	--
	3	20-25	80-100
	8	20-25	64-80
	Bottom	20-25	--

TABLE 2.- CONTINUED

Station	Depth (m)	Primary mode (μm)	Secondary mode (μm)
805	Surface	20-25	8-10
	3	20-25	8-10
	8	16-20	64-80
	Bottom	20-25	--
70	Surface	20-25	8-10
	3	20-25	8-10
	8	16-20	64-80
	Bottom	20-25	--
806	Surface	8-10	20-25
	3	20-25	64-80
	8	16-25	--
	Bottom	20-25	80-100
807	Surface	20-25	64-80
	3	16-25	--
	8	16-25	64-80
	Bottom	20-25	--
808	Surface	20-25	64-80
	3	20-25	64-80
	8	20-25	--
	Bottom	16-25	--
809	Surface	20-25	64-80
	3	20-25	--
	8	80-100	20-25
	Bottom	50-64	20-25

TABLE 2.- CONCLUDED

Station	Depth (m)	Primary mode (μm)	Secondary mode (μm)
821	Surface	80-100	--
	3	25-32	64-80
	8	80-100	--
	Bottom	64-100	--
810	Surface	80-100	20-25
	3	80-100	--
	8	64-80	--
	Bottom	64-80	25-32
811	Surface	80-100	20-25
	3	64-80	16-20
	8	80-100	20-25
	Bottom	20-25	80-100

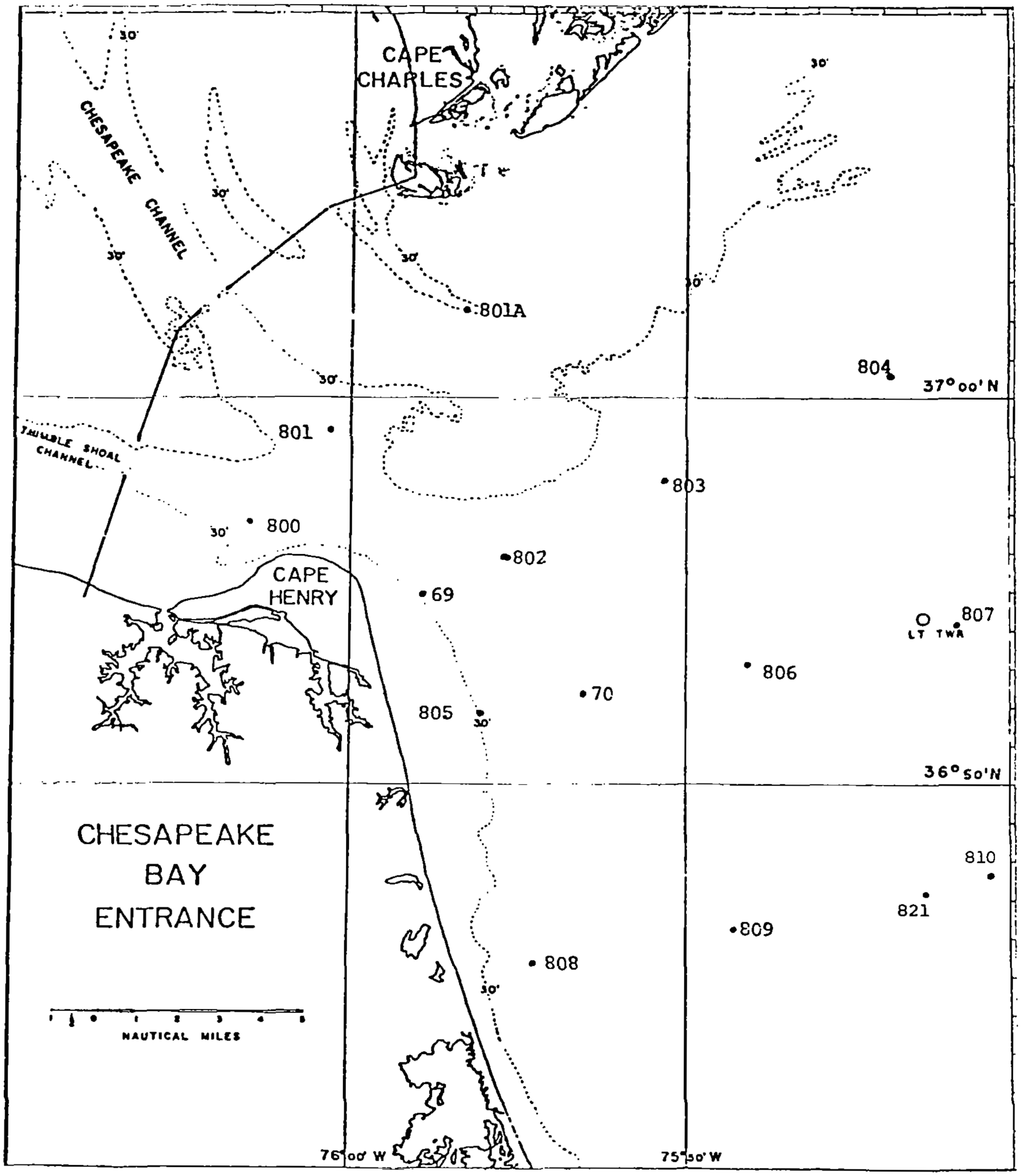

Figure 1.- Map showing station locations.

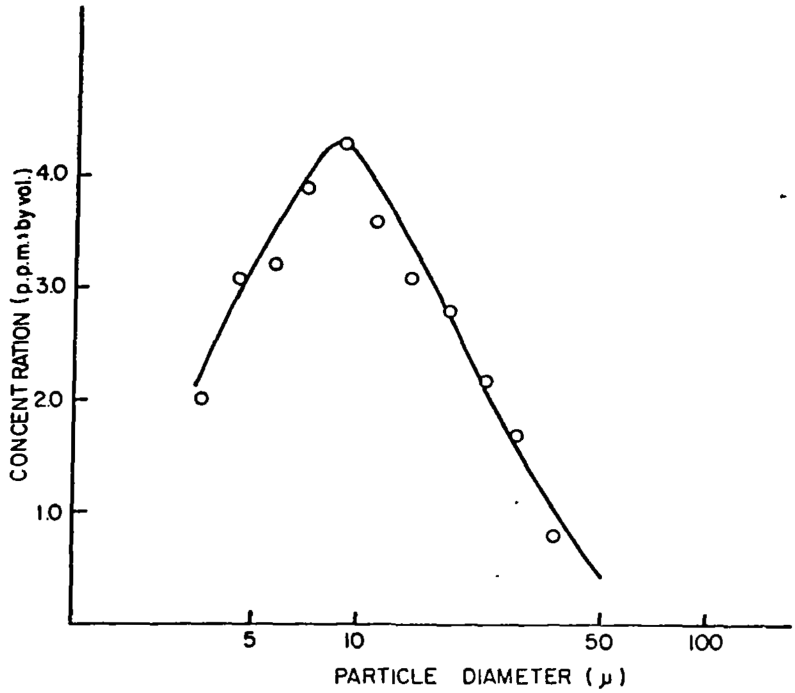

Figure 2.- Particle size distribution for estuarine silt. The material consisted largely of flocculated masses of very small inorganic particles, the principal constituent being quartz (from ref. 1).

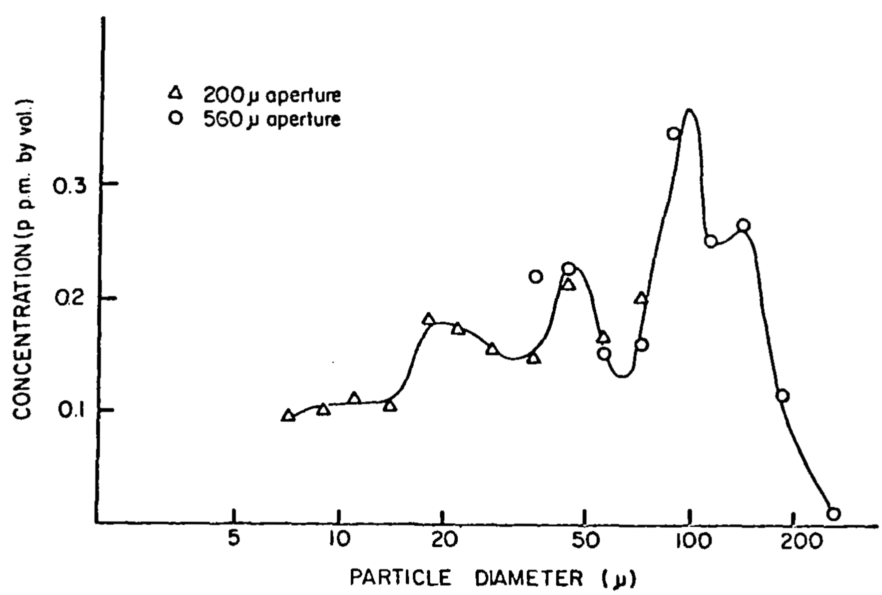

Figure 3.- Particle size distribution for coastal waters where a predominance of organisms is evident (from ref. 1).

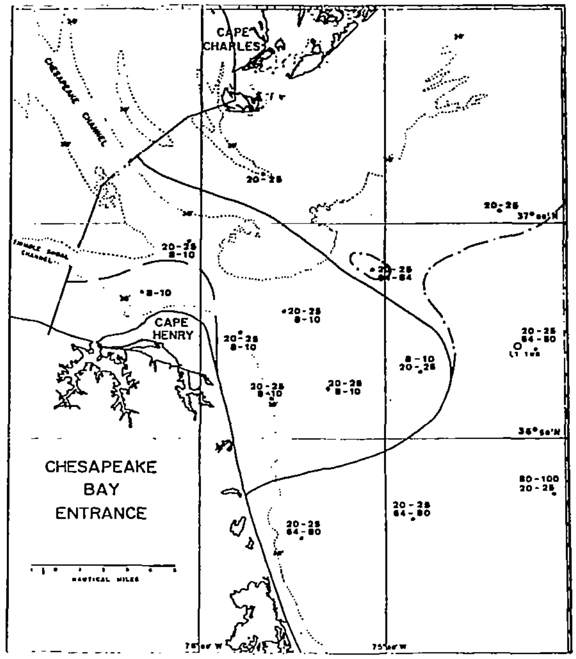

Figure 4.- Surface distribution of primary and secondary size modes. The numbers assocaited with each station represent the primary and secondary size modes for the sample population based on the percent volume of the sample population.

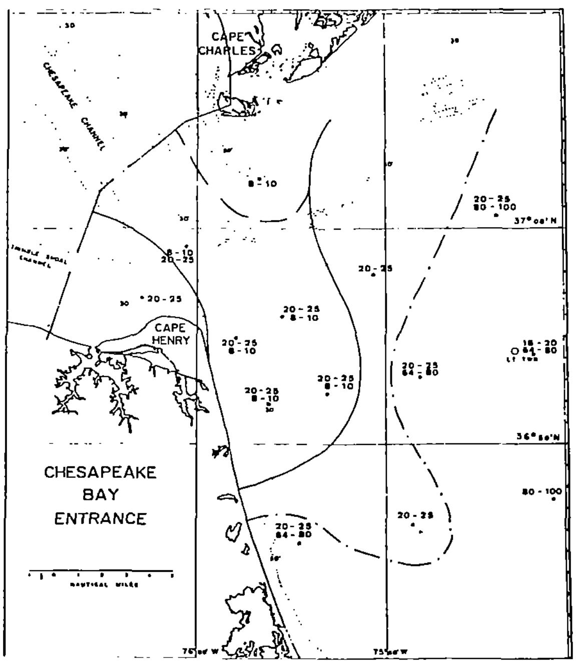

Figure 5.- Distribution of primary and secondary size modes at a depth of 3 m.

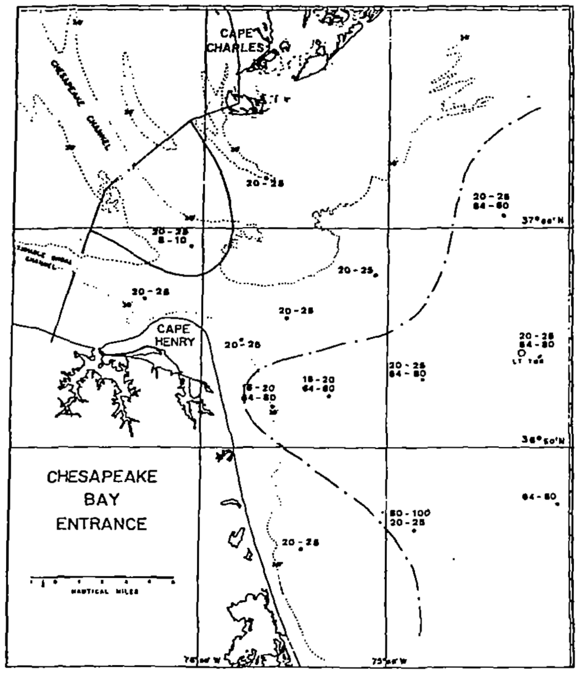

Figure 6.- Distribution of primary and secondary size modes at a depth of 8 m.

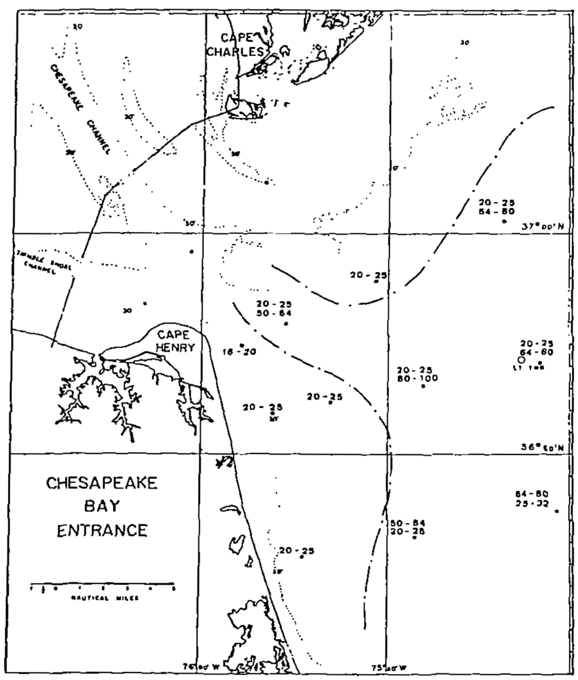

Figure 7.- Near-bottom distribution of primary and secondary size modes.

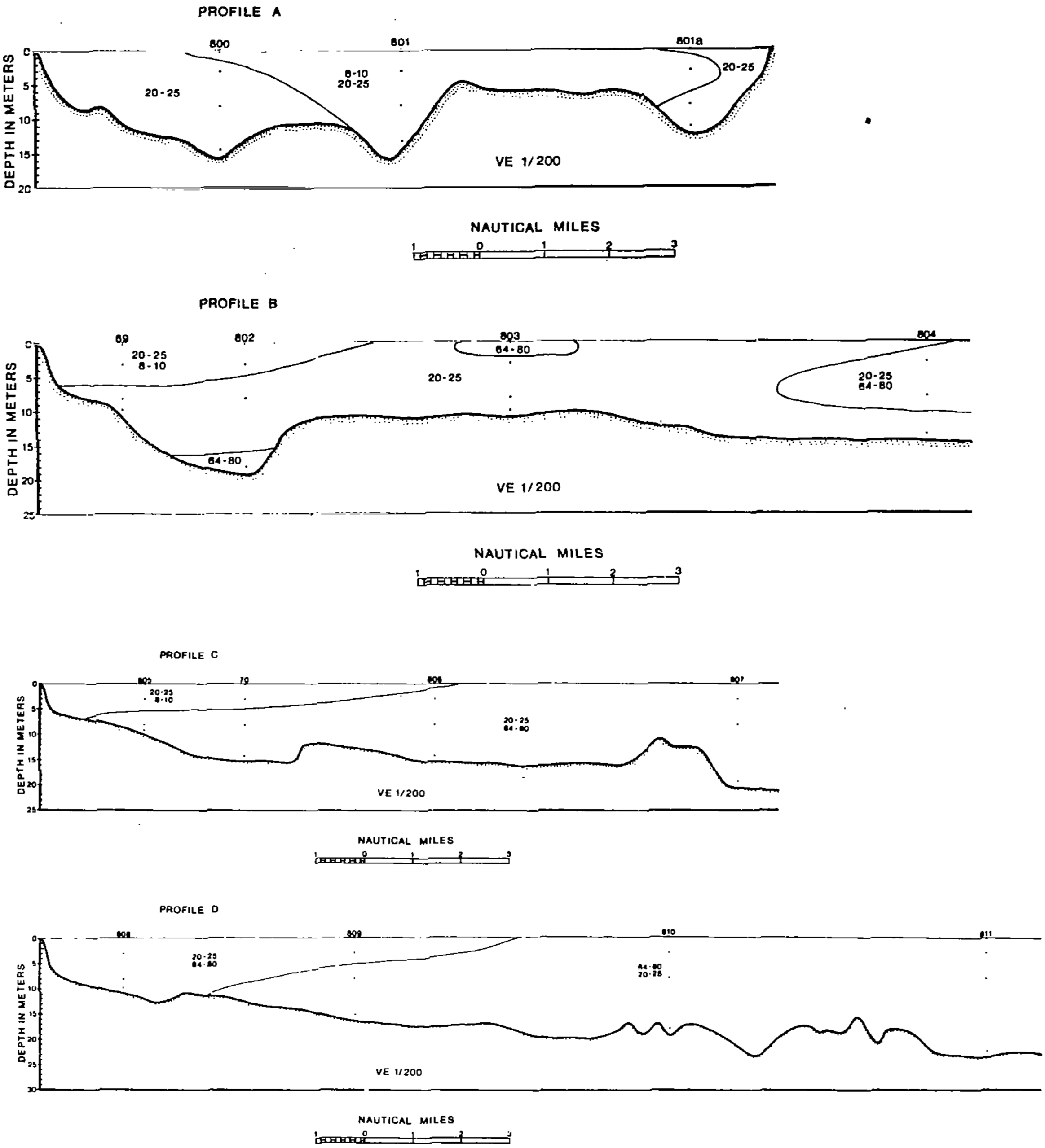

Figure 8.- Profiles of transects A, B, C, and D illustrating the distribution of primary and secondary size modes