UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

PARTICLE SIZE OF SEDIMENTS COLLECTED FROM THE BED OF THE AMAZON RIVER AND ITS TRIBUTARIES IN MAY AND JUNE 1977

Open-File Report 79-329

557
U58o
#79-329

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

PARTICLE SIZE OF SEDIMENTS COLLECTED FROM THE BED OF THE AMAZON RIVER AND ITS TRIBUTARIES IN MAY AND JUNE 1977

By Carl F. Nordin, Jr., Robert H. Meade, William F. Curtis,
Nivaldo J. Bósio, and Bruce M. Delaney

Open-File Report 79-329

Denver, Colorado

1979

UNITED STATES DEPARTMENT OF THE INTERIOR

CECIL D. ANDRUS, Secretary

GEOLOGICAL SURVEY

H. William Menard, Director

For additional information write to

U.S. Geological Survey
Water Resources Division
Mail Stop 413, Box 25046
Denver Federal Center
Denver, Colorado 80225

Contents

Illustrations

Tables

PARTICLE SIZE OF SEDIMENTS COLLECTED FROM THE BED OF THE AMAZON RIVER AND ITS TRIBUTARIES IN MAY AND JUNE 1977

By Carl F. Nordin, Robert H. Meade, William F. Curtis, Nivaldo J. Bósio, and Bruce M. Delaney

Abstract

One-hundred-eight samples of bed material were collected from the Amazon River and its major tributaries between Belém, Brazil, and Iquitos, Peru. Samples were taken with a standard BM-54 sampler or with pipe dredges. Most of the samples have median diameters in the size range of fine to medium sand and contain small percentages of fine gravel. Complete size distributions are tabulated.

Introduction

Samples from the bed of the Amazon River and the lower reaches of some of the larger tributaries were collected between May 18 and June 5, 1977, during a cruise of Research Vessel Alpha Helix between Belém, near the mouth of the river in Brazil, and Iquitos, some 4,000 km up the river in Peru (fig. 1). This report (1) describes shipboard procedures for collecting and preserving bed samples and laboratory procedures for determining particle sizes, and (2) lists the particle-size data. Similar information for samples collected in 1976 is given by Nordin and others (1977). Interpretive reports of these data will be published later.

FIG. 1 (near here)

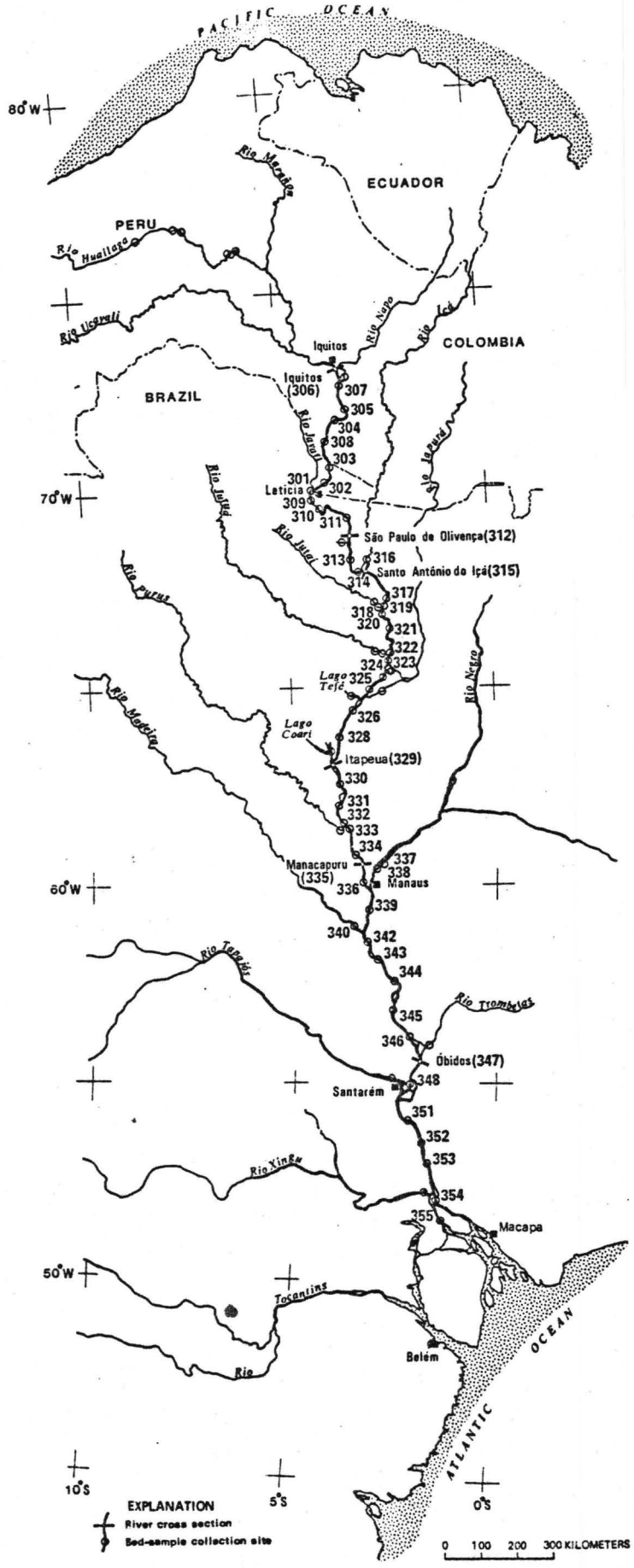

Figure 1.--Location map for bed-sample sites.

Acknowledgments

The research vessel "Alpha Helix" is operated for the U.S. National Science Foundation by Scripps Institution of Oceanography, University of California, San Diego, Calif. The research of the geochemistry and sediment of the Amazon was initiated and organized by John M. Edmond, Department of Earth and Planetary Sciences, Massachusetts Institute of Technology, Cambridge, Mass., who was Chief Scientist on the cruise. The study was an international cooperative effort involving scientists from Woods Hole Oceanographic Institution, Massachusetts Institute of Technology, and the U.S. Geological Survey, of the United States; University of Edinburgh, Scotland; University of Pisa, Italy; State University of São Paulo at Rio Claro, Brazil; the Columbian Navy; the Brazilian Navy; Companhia de Pesquisa de Recursos Minerais (CPRM), Belém, Brazil; and the consulting firm Hidrologia S.A., Rio de Janeiro, Brazil. The Brazilian agencies Centrais Eletricas Brasileiras, S.A. (Eletrobrás), and Divisão de Concessao de Recursos Hidricos of the Departamento Nacional de Águas e Energia Eletrica (DNAEE) were involved in planning these studies, and supported a part of the Brazilian participation.

The U.S. Geological Survey participation is a contribution to the International Hydrologic Program of the United Nations Educational, Scientific, and Cultural Organization (UNESCO) under the guidance of the U.S. National Committee on Scientific Hydrology, Joseph S. Cragwall, Jr., Chief Hydrologist, U.S. Geological Survey, Chairman.

Sampling locations

In 1977, we sailed downriver from Iquitos at approximately the same speed as the floodwave, so mainstream samples were collected at or near peak stage. Samples were taken from the bed of the rivers at locations shown in figure 1. Cruise station numbers were given to most of the sampling localities; they were also used by other investigators on the cruise. Some of the stations in the tributaries are not numbered. Other unnumbered samples were taken at rivergaging sections, named below, where streamflows are regularly measured by Companhia de Pesquisa de Recursos Minerais (CPRM) and by Hidrologia, S.A. for the Divisão de Concessão de Recursos Hidricos of the Departamento Nacional de Águas e Energia Eletrica (DNAEE) and for Centrais Elétricas Brasileiras, S.A. (Eletrobrás). These measuring sections are:

Section	Location	Longitude (W) at middle of section
São Paulo de Olivenca	6 km below town	69°00' (Chart P 4 112 B)
Santo Antônio do Icá	9 km below town	68°00' (Chart P 4 112 A)
Itapeua	12 km below town of Coari	63°03' (Chart P 4 108 B)
Manacapuru	6 km below town	60°34' (Chart P 4 107 A)
Óbidos	2 km below town	55°30.5' (Chart P 4 104 A

In addition, samples were collected at a section in Peru some 25 km below Iquitos.

Iquitos	25 km below city	73°14.5 (Chart P 4 116 A)

When reporting locations on the Amazon in degrees and minutes of latitude and longitude, one must also refer to the map or chart from which the coordinates were taken. Different series of maps and charts (and even charts in the same series) often disagree on latitudes and longitudes of specific localities such as towns.

The charts referred to in the series P 4 101 A, and so forth, are the 1- to 100,000-scale piloting charts of the river published by the Hydrography and Navigation Office (Diretoria de Hidrografia e Navegacão) of the Brazilian Navy under the name of Cartas de Practicagem da Flotilha do Amazonas--Marinha do Brasil. These charts cover the river from Macapá (near the mouth) to Iquitos, which is the part of the river that is generally navigated by ocean-going ships. Distances below Iquitos were measured along the thalweg of the river on these charts. Our measurements showed the center of the town of Iquitos to be 3,522 km upriver of Macapá, which is about 140 km above the mouth of the Canal do Norte distributary of the Amazon.

The maps referred to in the series SA 18, SB 19, and so forth, are parts of the world 1- to 1,000,000-scale map (1301 series), which are available from the U.S. Defense Mapping Agency. Other maps at this scale that were used to locate samples above Iquitos in Peru are in the Operational Navigation Chart (ONC) series.

When we refer in this report to samples from the main stem of the Amazon River system, we follow the Brazilian usage. That is, the river is called Amazonas from the mouth to the confluence with Rio Negro, Solimões from the Negro confluence to the western border of Brazil, and Marañon in Colombia and Peru.

Sampling equipment

Two pieces of equipment were used to sample the river bed: a standard BM-54 bed-material sampler and several different sizes of pipe dredges.

BM-54

Some of the samples were collected with a standard BM-54 bed-material sampler (U.S. Inter-Agency Report no. 14, 1963, p. 97). This sampler is designed to collect about 500 mL of material off the top 5 cm of the river bed and to bring it to the surface in a closed semicylindrical cavity. The BM-54 did not work properly at great depths and high velocities, so most of our samples were collected with pipe dredges.

Pipe dredge

Most of the bed samples were taken with a steel pipe dredge, about 30 cm in diameter and 90 cm long, closed at one end. The open end was beveled to a cutting edge and secured to the winch cable by a loop of chain. The dredge was lowered to the bottom, and an amount of wire equal to about twice the depth of the water was played out. The ship was allowed to drift with the river current, dragging the dredge along the bottom. This procedure never failed to collect a sample. The dredge was usually recovered more than half full. Smaller pipe dredges, about 12 cm in diameter and 50 cm long, were used in the shallower flows and for sampling the tributaries.

Most of the samples recovered with the pipe dredge were of uniform grain size. Each time the dredge was recovered, the topmost 20 cm or so of material was discarded, to allow for the possibility that the sediment at the exposed surface of the sample might have been washed on the way up from the river bottom. About 500 mL of sediment from the dredge was preserved for grain-size analysis. The remaining material was washed out of the pipe dredge and checked visually to make sure the grain-size distribution was uniform throughout. Some of the occasional pebbles, if there were any, were saved for petrographic analysis.

In a few samples taken with the pipe dredge, the recovered material was nonuniform in grain size. In the sample from station 311, sand of two size populations, which seemed to have been distinct from each other on the river bottom, were collected in the dredge. We were able to analyze the two size populations separately. At station 352, the dredge recovered sand along with pieces of the clay "bedrock" that lay just beneath the sand.

Shipboard processing of samples

All samples for size analyses were placed in plastic bags aboard ship. Most of the excess water was poured out of the bags; we were careful not to elutriate micas and small mineral grains in the process. Clayey samples were not dried further but were double-wrapped in plastic bags to remain damp during shipment. Sand samples were dried further aboard ship, either in the sun on deck or under an infrared lamp in the ship's laboratory. They were then double-wrapped for shipment to the laboratory.

Laboratory procedures

Sands

Particle sizes of the sands were determined in the U.S. Geological Survey sediment laboratory in Denver. The sand samples were dumped and washed from their plastic bags into evaporating dishes and dried overnight in an oven at 110°C. Each sample was then poured over a splitter and divided into four more-or-less equal fractions. Two of the fractions were bottled separately for reference samples. A third sample was bottled and set aside for petrographic analysis. The fourth fraction was split further, if necessary, to 50 to 100 grams for particle-size analysis. In some instances where the sediment contained an appreciable proportion of material coarser than 2 mm, the entire sample was screened through sieves with openings of 2 mm and larger before being split.

All samples were sieved through a standard set of 20-cm (8-inch) sieves. Each sample was shaken mechanically on a Ro-tap machine for 15 minutes, and the weight of the material retained on each sieve and on the pan was recorded to the nearest 0.01 gram.

Finer materials

Twenty-one of the samples contained mostly clay and silt-size particles. These samples were analyzed by pipet and visual accumulation tube or by pipet and wet sieving (Guy, 1969) at the U.S. Geological Survey's laboratory in Albuquerque, N. Mex.

Results

Table 1 identifies the samples, gives the locations in downstream order where the samples were taken, and the equipment used to obtain them. Sampling locations correspond to those shown on figure 1. Tables 2 and 3 list the particle-size distribution.

References

Guy, H. P., 1969, Laboratory theory and methods for sediment analysis: U.S. Geol. Survey Techniques Water-Resources Inv., book 5, chap. C1, 58 p.

Nordin, C. F., Jr., Meade, R. H., Mahoney, H. A., and Delaney, B. M., 1977, Particle size of sediments collected from the bed of the Amazon River and its tributaries in June and July 1976: U.S. Geological Survey Open-File Rept. 77-400, 18 p.

U.S. Interagency Committee on Water Resources, 1963, Determination of fluvial sediment discharge: Washington, U.S. Govt. Printing Office, Rept. no. 14, 151 p.

Table 1.--Sample locations

Cruise station, Measuring section, or sampling site	Thalweg distance below Iquitos (km)	Distance from left bank (m)	Water depth (m)	Date of sampling (1977)	Latitude (S)	Longitude (W)	Chart or map	Sampling equipment	Table containing size analysis	Remarks
Rio Huallaga at Tocache	-------	0	0	May 8	8°11'	76°31'	ONC N-25	Hand	3	Either bank material or river mud. Collected by R. F. Stallard.
Rio Huallaga at Balsayacu	-------	0	0	May 9	7°22'	76°40'	ONC M-25	Hand	2	Sand from near left bank (riverbed mostly cobbles). Collected by R. F. Stallard.
Rio Sapo at road bridge	-------	--------	0	May 11	7°05'	76°39'	ONC M-25	Hand	3	Sandy clay, recently deposited. Collected by R. F. Stallard.
Tributary of Rio Huallaga just above Yurimaguas	-------	--------	0	May 12	5°55'	76°06'	ONC M-25	Hand	3	Mud, from inside of meander bend. Collected by R. F. Stallard.
Rio Huallaga at Yurimaguas----------	-------	--------	0	May 12	5°53'	76°06'	ONC M-25	Hand	2	Sand, from downstream end of recently emerged island. Collected by R. F. Stallard.
Rio Paranapura near Yurimaguas--------	-------	--------	0	May 12	5°52'	76°07'	ONC M-25	Hand	3	Mud, from inside of meander bend. Collected by R. F. Stallard.
Iquitos (306)----------	25	160	20	May 20	3°46.9'	73°14.6'	P4116A	BM-54	2	Marañon on line of section (about 1,080 m wide from bank to bank); straight reach.
Iquitos (306)----------	25	400	28	May 20	3°46.9'	73°14.5'	P4116A	BM-54	2	
Iquitos (306)----------	25	600	26	May 20	3°47.0'	73°14.5'	P4116A	BM-54	2	
Iquitos (306)----------	25	830	23	May 20	3°47.1'	73°14.3'	P4116A	BM-54	2	
Iquitos (306)----------	25	990	24	May 20	3°47.2'	73°14.2'	P4116A	BM-54	2	
Rio Napo----------	-------	--------	22-23	May 20	3°16'	72°39'	SA-18	Pipedredge	2	Rio Napo, about 10 km above Corococha and about 20 km above mouth.
307----------	92	310	37	May 20	3°37.7'	72°44.0'	P4115B	BM-54	2	Marañon on line of section (about 1,200 m wide from bank to bank), 3 km below mouth of Rio Napo; crest of broad bend (left bank is outside of bend).
307----------	92	730	26	May 20	3°38.0'	72°44.0'	P4115B	BM-54	2	
307----------	92	950	11	May 20	3°38.1'	72°44.0'	P4115B	BM-54	2	

Table 1.--Sample locations--Continued

Cruise station, Measuring section, or sampling site	Thalweg distance below Iquitos (km)	Distance from left bank (m)	Water depth (m)	Date of sampling (1977)	Latitude (S)	Longitude (W)	Chart or map	Sampling equipment	Table containing size analysis	Remarks
305	171	1,350	29	May 19	3°33.8'	72°06.4'	P4115A	BM-54	2	Marañon below Isla Apayuca; straight reach.
304	248	500	37	May 19	3°51.1'	71°46.2'	P4115A	Pipedredge	2	Marañon at crossing just below San Francisco; dunes 4-5 m high.
308	322	1,100	37	May 21	4°02.7'	71°16.3'	P4114B	Pipedredge	2	Marañon just below crossing below Ilha Poca Playa; dunes.
303	411	700	30	May 18	3°54.6'	70°34.5'	P4114A	Pipedredge	2	Marañon at crossing by Reten del Sancudo.
302	465	190	21	May 18	3°59.2'	70°12.9'	P4114A	Pipedredge	2	Marañon at crossing above Isla St. Helena no. 3; close to left bank
301	507	100	21	May 16	4°12.2'	67°57.0'	P4114A	BM-54	2	Leticia Harbor; out of main channel.
309A	518	900	20-23	May 21	4°28.0'	70°03.2'	P4113B	BM-54	2	Solimões at crossing below Tabatinga; dunes 1-3 m high.
309B	518	900	20-23	May 21	4°28.0'	70°03.2'	P4113B	Pipedredge	2	
310	593	600	25	May 21	4°19.4'	69°30.5'	P4113B	Pipedredge	2	Solimões at crossing below Punta do Ourique; small dunes.
311	691	800	28-32	May 21	3°46.2'	69°27.0'	P4113A	Pipedredge	2	Solimões at crossing above Ilha de Santa Rita; dunes 3-4 m high.
										Two sizes of material in dredge (sampled and analyzed separately)
São Paulo de Olivença (312)	757	70	25	May 22	3°34.4'	69°00.0'	P4112B	BM-54	2	Sand — Solimões at measuring section (about 1,400 m wide from bank to bank); straight reach.
São Paulo de Olivença (312)	757	510	30	May 22	3°34.6'	69°00.0'	P4112B	Pipedredge	2	Sand
São Paulo de Olivença (312)	757	770	27	May 22	3°34.7'	69°00.0'	P4112B	Pipedredge	2	Sand
São Paulo de Olivença (312)	757	1,140	16	May 22	3°34.9'	69°00.0'	P4112B	BM-54	2	Sand
São Paulo de Olivença (312)	757	1,350	16	May 22	3°35.0'	69°00.0'	P4112B	BM-54	3	Mud (bank material ?)
Rio Jandiatuba	-----	-----	14	May 22	3°40'	68°55'	P4112B	Pipedredge	2	Rio Jandiatuba, about 10 km above mouth.
313	825	800	18-22	May 22	3°27.6'	68°26.5'	P4112B	Pipedredge	2	Solimões at small crossing where thalweg deflects around Isla Amatachiro; dunes 5-6 m high.
314	895	500	22	May 22	3°15.2'	68°01.4'	P4112A	Pipedredge	2	Solimões just above mouth of Rio Içá; straight reach.

Table 1.--Sample location--Continued

Cruise station, Measuring section, or sampling site	Thalweg distance below Iquitos (km)	Distance from left bank (m)	Water depth (m)	Date of sampling (1977)	Latitude (S)	Longitude (W)	Chart or map	Sampling equipment	Table containing size analysis	Remarks
Rio Içá (316A)----------	--------	--------	21	May 23	3°00'	68°12'	SA-19	BM-54	2	Coarser sand } Rio Içá, just above Enseada Buissú, about 40 km
Rio Içá (316B)----------	--------	--------	23	May 23	3°00'	68°12'	SA-19	BM-54	2	Finer sand } above mouth.
Santo Antônio do Içá (315)	909	150	27	May 23	3°07.7'	68°00.4'	P4112A	BM-54	2	}
Santo Antônio do Içá (315)	909	490	28	May 23	3°07.7'	68°00.3'	P4112A	BM-54	2	
Santo Antônio do Içá (315)	909	940	21	May 23	3°07.8'	68°00.2'	P4112A	BM-54	2	Solimões at measuring section (about 2,100 m wide from bank to bank); straight reach.
Santo Antônio do Içá (315)	909	1,360	21	May 23	3°07.9'	68°00.0'	P4112A	BM-54	2	
Santo Antônio do Içá (315)	909	1,700	24	May 23	3°08.0'	67°59.9'	P4112A	BM-54	2	}
317----------	1,010	1,000	32	May 23	2°40.2'	67°23.2'	P4111B	Pipedredge	2	Solimões at crossing by Ilha Urutuba.
319----------	1,084	1,400	27	May 24	2°48.2'	66°54.7	P4111A	Pipedredge	2	Solimões at crest of bend, 3 km above mouth of Rio Jutaí.
Rio Jutaí----------	------	-1,000	14	May 24	2°49'	67°07'	SA-19	Pipedredge	2	Rio Jutaí, about 30 km above mouth; river about 2 km wide.
Rio Jutaí (318)---------	------	-----	27	May 24	2°49.5'	66°44.2'	P4111A	BM-54	2	Sand } Rio Jutaí about 1.5 km above mouth.
Rio Jutaí (318)---------	------	-----	27	May 24	2°49.5'	66°44.2'	P4111A	BM-54	3	Clay }
320----------	1,091	1,300	29	May 24	2°48.2'	66°51.1'	P4111A	Pipedredge	2	Solimões at crest of bend, 4 km below mouth of Rio Jutaí.
321----------	1,168	500	30	May 24	2°29.7'	66°28.4'	P4111A	Pipedredge	2	Solimões at crossing by Ilha Aracatuba.
322----------	1,280	1,100	25	May 24	2°30.5'	65°47.3'	P4110B	Pipedredge	2	Solimões at small crossing where thalweg deflects around Ilha Paciência; 3 km above mouth of Rio Juruá.
Rio Juruá----------	------	300	24	May 24	2°43'	65°49'	SA-20	Pipedredge	2	Rio Juruá near Paraiba, about 20 km above mouth; river 600-700 m wide.
Tributary of Rio Juruá	------	-----	---	May 24	2°31.1'	66°49.0'	P4110B	Pipedredge	3	Last left-side tributary before Rio Juruá joins Solimões.
323----------	1,294	900	40	May 24	2°34.0'	65°40.6'	P4110B	Pipedredge	2	Sample may have been washed somewhat during recovery. Solimões at small crossing where thalweg deflects around Ilha Paçiência; 11 km below mouth of Rio Juruá.

Table 1.--Sample location--Continued

Cruise station, Measuring section, or sampling site	Thalweg distance below Iquitos (km)	Distance from left bank (m)	Water depth (m)	Date of sampling (1977)	Latitude (S)	Longitude (W)	Chart or map	Sampling equipment	Table containing size analysis	Remarks
324----------	1,371	1,500	30	May 24	2°33.0'	65°22.0'	P4110B	Pipedredge	2	Solimões at crossing below Ilha do Ferro.
325----------	1,472	500	25	May 25	3°05.1'	64°56.1'	P4110A	Pipedredge	2	Solimões at crossing by Pedras Canarias.
Rio Japurá----------	-----	-----	21	May 25	2°58.8'	64°47.3	P4110A	Pipedredge	2	Rio Japurá, about 40 km above mouth.
Lago Tefé----------	-----	-----	11	May 25	3°30'	64°46'	SA-20	Pipedredge	3	Lago Tefé, about 25 km above town of Tefé.
326----------	1,546	1,500	28	May 25	3°26.9'	64°27.4'	P4109B	Pipedredge	2	Solimões at crossing by Porto São Francisco.
328----------	1,692	1,000	34-38	May 25	3°54.5'	63°23.2'	P4109A	Pipedredge	2	Solimões at crossing by Ilha do Surubim; dunes 2-3 m high.
Lago Coari----------	-----	-----	-----	May 26	4°01.5'	63°17'	P4109A	Pipedredge	3	Lago Coari, about 10 km above town of Coari.
Itapeua (329)----------	1,745	500	60	May 26	4°03.3'	63°02.5'	P4108B	Pipedredge	2	Solimões, midriver at Itapeua measuring section.
330----------	1,819	3,300	27	May 26	3°51.6'	62°27.8'	P4108B	Pipedredge	2	Solimões at crossing at Enseada do Tapira; small dunes.
331----------	1,895	900	32	May 26	3°55.3'	61°57.0'	P4108A	Pipedredge	2	Solimões by Ilha Jamacana; straight reach; small dunes.
332----------	1,964	1,100	36-40	May 26	3°41.0'	61°29.4	P4107B	Pipedredge	2	Solimões, 4 km above mouth of Rio Purus; straight reach; dunes.
Rio Purus----------	-----	-----	-----	May 26	3°49'	61°24'	P4107B	Pipedredge	3	Rio Purus, 15-20 km above mouth.
333----------	1,972	1,200	42	May 26	3°38.7'	61°26.9'	P4107B	Pipedredge	2	Solimões, 6 km below mouth of Rio Purus; straight reach; small dunes.
334----------	2,048	1,400	40	May 26	3°31.7'	60°47.9'	P4107B	Pipedredge	2	Solimões at crossing below Ilha Mundurucus.
Manacapuru (335)--------	2,086	190	27	May 27	3°18.8'	60°34.0'	P4107A	BM-54	3	Mud (bank material ?).
Manacapuru (335)--------	2,086	190	27	May 27	3°18.8'	60°34.0'	P4107A	BM-54	2	Sand.
Manacapuru (335)--------	2,086	890	25	May 27	3°19.2'	60°34.0'	P4107A	BM-54	2	Sand
Manacapuru (335)--------	2,086	2,000	32	May 27	3°19.9'	60°34.0'	P4107A	Pipedredge	2	Sand
Manacapuru (335)--------	2,086	2,520	34	May 27	3°20.1'	60°34.0'	P4107A	BM-54	2	Sand
Manacapuru (335)--------	2,086	2,970	23	May 27	3°20.3'	60°34.0'	P4107A	BM-54	2	Sand

Solimões at measuring section (about 3,100 m wide from bank to bank) on straight reach.

Table 1.--Sample locations--Continued

Cruise station, Measuring section, or sampling site	Thalweg distance below Iquitos (km)	Distance from left bank (m)	Water depth (m)	Date of sampling (1977)	Latitude (S)	Longitude (W)	Chart or map	Sampling equipment	Table containing size analysis	Remarks
336----------	2,149	3,700	32-37	May 28	3°18.0'	60°01.2'	P4106B	Pipedredge	2	Solimões just above Ilha dos Mouras; straight reach; dunes 3-4 m high; about 27 km above confluence with Rio Negro.
Rio Negro (337)---------	-----	1,000	25	May 28	2°58'	60°27'	SA-20	BM-54	2	Rio Negro about 55 km above Manaus, 1.7 km north of northwest tip of Ilha Anavilhana.
Rio Negro (338)---------	-----	1,600	29	May 28	3°02.7'	60°22.5'	P4106B	BM-54	3	Rio Negro on line of section (about 7 km wide from bank to bank), about 40 km above Manaus and about 7 km above narrowest point (1.8 km wide) in this part of river.
Rio Negro (338)---------	-----	3,700	17	May 28	3°03.8'	60°22.5'	(extrapolated)	BM-54	3	
Rio Negro (338)---------	-----	5,600	25	May 28	3°04.8'	60°22.5'		BM-54	3	
339----------	2,253	1,600	45-47	June 1	3°12.7'	59°18.0'	P4106B	Pipedredge	2	Amazonas by Costa do Varre-Vento; straight reach; dunes 1-2 m high; about 80 km below confluence with Rio Negro and about 70 km above confluence with Rio Madeira.
Rio Madeira (340)-------	-----	375	20	June 1	3°39'	59°03'	SA-21	BM-54	2	Rio Madeira on line of section (~1,500 m wide from bank to bank), about 50 km above confluence with Amazonas and about 6 km below Ilha Rosarinho.
Rio Madeira (340)-------	-----	750	22	June 1	3°39'	59°03'	SA-21	BM-54	2	
Rio Madeira (340)-------	-----	1,125	21	June 1	3°39'	59°03'	SA-21	BM-54	2	
342----------	2,359	1,400	42-45	June 1	3°11.4'	58°32.1'	P4106A	Pipedredge	2	Amazonas at crossing above Itacoatiara; dunes 2-3 m high.
343----------	2,424	900	54-60	June 1	3°00.0'	58°09.7'	P4105B	Pipedredge	2	Amazonas at crossing below Ilha do Risco; dunes 4-5 m high.
344----------	2,524	1,600	30-32	June 1	2°26.9'	57°34.3'	P415A	Pipedredge	2	Amazonas by Albano; midway between crossing and meander crest; dunes 1-2 m high.
345----------	2,625	1,400	38-42	June 2	2°34.9'	56°52.5'	P4105A	Pipedredge	2	Amazonas at crossing above Parintins; dunes 3-4 m high.
346----------	2,714	2,100	29-31	June 2	2°13.6'	56°16.5'	P4104B	Pipedredge	2	Amazonas at crossing below Ilhas do Caldeirão; dunes 1-2 m high.
Rio Trombetas----------	-----	-----	15	June 3	1°42'	55°53'	SA-21	Pipedredge	3	Rio Trombetas, about 35 km above mouth.

Table 1.--Sample locations--Continued

Cruise station, Measuring section, or sampling site	Thalweg distance below Iquitos (km)	Distance from left bank (m)	Water depth (m)	Date of sampling (1977)	Latitude (S)	Longitude (W)	Chart or map	Sampling equipment	Table containing size analysis	
Óbidos (347)----------	2,827	80	25	June 2	1°55.7'	55°30.1'	P4104A	Pipedredge	3	Mud (bank material ?)
Óbidos (347)----------	2,827	500	60-64	June 2	1°55.9'	55°30.2'	P4104A	Pipedredge	2	Dunes 4-6 m high
Óbidos (347)----------	2,827	900	58-64	June 2	1°56.1'	55°30.4'	P4104A	Pipedredge	2	Dunes 2-3 m high
Óbidos (347)----------	2,827	1,200	52-64	June 2	1°56.2'	55°30.5'	P4104A	Pipedredge	2	Dunes 4-6 m high
Óbidos (347)----------	2,827	1,600	56-62	June 2	1°56.4'	55°30.6'	P4104A	Pipedredge	2	Dunes about 2 m high
Óbidos (347)----------	2,827	1,900	50	June 2	1°56.5'	55°30.7'	P4104A	Pipedredge	3	Clay, stiff, laminated
Óbidos (347)----------	2,827	2,250	35	June 2	1°56.6'	55°30.8'	P4104A	Pipedredge	3	Mud (bank material ?)
										} Amazonas at measuring section (about 2,340 m wide from bank to bank; on crest of meander (left bank is on outside of bend).
348----------	2,903	1,100	40-42	June 3	2°10.0'	54°54.0'	P4103B	Pipedredge	2	Amazonas by Ilha do Marimarituba between crossing and meander crest; dunes 1-2 m high.
349----------	2,935	1,300	37-38	June 3	2°20.0'	54°43.9'	P4103B	Pipedredge	2	Amazonas at crossing by Punta Piracauera, about 8 km above mouth of Rio Tapajós; small dunes.
Rio Tapajós----------	-----	-----	-----	June 4	2°34'	54°59'	SA-21	Pipedredge	3	Rio Tapajós, midriver by Santa Maria, about 40 km above mouth (Santarém).
351----------	3,046	2,400	32-37	June 4	2°07.0'	54°02.9'	P4103A	Pipedredge	2	Amazonas at crossing by Costa do Cataú; dunes 4-5 m high.
352----------	3,117	4,900	30	June 4	1°51.6'	53°31.8'	P4103A	Pipedredge	2	Sand } Amazonas above Ilha do Prainha at small crossing where thalweg deflects around island; flat bottom; sand sample contaminated by a few small clay lumps (broken up during size analysis).
352----------	3,117	4,900	30	June 4	1°51.6'	53°31.8'	P4103A	Pipedredge	3	Clay }
353----------	3,194	2,500	43-50	June 4	1°38.8'	52°55.8'	P4102B	Pipedredge	2	Amazonas at crossing above Ilha do Jurupari; dunes 5-6 m high.

Table 1.--Sample locations--Continued

Cruise station, Measuring section, or sampling site	Thalweg distance below Iquitos (km)	Distance from left bank (m)	Water depth (m)	Date of sampling (1977)	Latitude (S)	Longitude (W)	Chart or map	Sampling equipment	Table containing size analysis	Remarks
354----------	3,300	1,100	32-34	June 5	1°25.6'	52°02.0'	P4102A	Pipedredge	2	Amazonas on line of section (3,700 m from bank to bank) at last downstream reach where river is all in one channel, by Ilha Baixa Grande; straight reach; about 21 km above mouth of Rio Xingu.
354----------	3,300	2,000	47-50	June 5	1°26.1'	52°01.9'	P4102A	Pipedredge	2	
354----------	3,300	2,900	43-45	June 5	1°26.6'	52°01.8'	P4102A	Pipedredge	2	
Rio Xingu----------	-----	-----	20	June 5	1°45'	52°15'	SA-22	Pipedredge	3	Rio Xingu, midriver by Pôrto de Moz, about 60 km above mouth.
Rio Xingu beach---------	-----	-----	0	June 5	1°44'	52°15'	SA-22	----------	2	Rio Xingu, right bank beach sand, just below Pôrto de Moz.
Canal do Vieira (355)---	-----	-----	42-44	June 5	1°07'	51°13'	SA-22	Pipedredge	2	Canal do Vieira (Amazonas distributary) at Furo do Ituguara; small dunes.

Table 2.--Particle size distribution determined by sieving

Cruise station, measuring section, or sampling site	Distance from left bank, (m)	Percent finer than indicated size, in mm														Median diameter d_{50} (mm)
		0.063	0.088	0.125	0.177	0.250	0.350	0.500	0.707	1.00	1.41	2.00	2.80	4.00	5.60	8.00	
Rio Huallaga at Balsayacu	0	13.7	50.3	82.1	94.6	97.9	99.7	100	-----	-----	-----	-----	-----	-----	-----	-----	0.090
Rio Huallaga at Balsayacu	---------	2.4	10.2	21.3	41.2	76.1	99.7	100	-----	-----	-----	-----	-----	-----	-----	-----	.20
Iquitos (306)----------	160	.4	3.1	10.7	61.7	97.1	99.8	100	-----	-----	-----	-----	-----	-----	-----	-----	.17
Iquitos (306)----------	400	.2	.3	1.3	10.0	26.9	65.3	94.7	99.8	100	-----	-----	-----	-----	-----	-----	.31
Iquitos (306)----------	600	.1	.3	.7	5.2	20.2	71.8	97.2	99.8	100	-----	-----	-----	-----	-----	-----	.30
Iquitos (306)----------	830	.7	2.4	7.8	42.4	87.7	99.8	100	-----	-----	-----	-----	-----	-----	-----	-----	.19
Iquitos (306)----------	990	.2	1.1	3.6	39.3	91.3	99.9	100	-----	-----	-----	-----	-----	-----	-----	-----	.19
Rio Napo----------	---------	.3	1.1	4.5	28.2	73.1	97.6	99.7	100	-----	-----	-----	-----	-----	-----	-----	.21
307----------	310	.1	.2	.4	1.5	6.6	28.7	61.6	89.0	97.8	99.2	99.5	99.6	99.7	99.8	100	.44
307----------	730	.4	1.9	8.7	31.1	56.9	98.1	100	-----	-----	-----	-----	-----	-----	-----	-----	.23
307----------	950	.2	.5	1.3	7.6	39.5	96.4	99.9	100	-----	-----	-----	-----	-----	-----	-----	.26
305----------	1,350	0	.4	1.4	8.7	39.1	97.6	99.8	100	-----	-----	-----	-----	-----	-----	-----	.26
304----------	500	0	.2	.5	1.0	5.6	24.7	98.7	99.9	100	-----	-----	-----	-----	-----	-----	.38
308----------	1,100	.2	.7	3.0	14.7	43.5	79.4	94.3	98.2	99.5	99.8	100	-----	-----	-----	-----	.26
303----------	700	0	.1	.9	1.4	8.0	48.8	91.8	98.7	99.5	99.6	99.7	100	-----	-----	-----	.50
302----------	190	.2	.3	.4	2.1	12.3	68.5	92.7	98.4	99.4	99.7	99.8	99.8	100	-----	-----	.32
301----------	100	23.2	61.6	87.2	97.4	99.6	100	-----	-----	-----	-----	-----	-----	----	-----	-----	.08
309A----------	900	.3	1.4	4.2	29.9	72.4	88.6	94.6	95.9	96.6	97.8	98.3	98.6	99.0	100	-----	.21
309B----------	900	.2	1.1	4.3	59.5	97.2	99.6	100	-----	-----	-----	-----	-----	-----	-----	-----	.17
310----------	600	0	.2	.9	6.3	23.1	67.4	92.5	98.1	99.3	99.5	99.8	99.8	100	-----	-----	.31
311----------	800	.1	.5	1.1	7.0	54.0	97.4	99.6	99.9	100	-----	-----	-----	-----	-----	-----	.24
311----------	800	.2	.4	1.0	6.1	44.2	82.2	91.0	96.6	97.9	98.5	98.7	98.8	99.6	100	-----	.26

Table 2.--Particle size distribution determined by sieving--Continued

Cruise station, measuring section, or sampling site	Distance from left bank, (m)	Percent finer than indicated size, 0.063	0.088	0.125	0.177	0.250	0.350	0.500	0.707	1.00	1.41	2.00	2.80	4.00	5.60	8.00	Median diameter d_{50} (mm)
São Paulo de Olivença (312)	70	0.1	0.3	1.4	13.8	68.0	99.4	100	-----	-----	-----	-----	-----	-----	-----	-----	0.23
São Paulo de Olivença (312)	510	.1	.2	.6	3.9	19.2	54.8	83.2	96.2	98.9	99.6	99.7	99.9	100	-----	-----	.30
São Paulo de Olivença (312)	770	.1	1.4	8.7	41.8	83.9	99.2	100	-----	-----	-----	-----	-----	-----	-----	-----	.19
São Paulo de Olivença (312)	1,140	0	.1	.6	10.5	63.8	98.2	100	-----	-----	-----	-----	-----	-----	-----	-----	.23
Rio Jandiatuba----------	-----	0	0	.2	1.0	13.7	88.3	99.8	100	-----	-----	-----	-----	-----	-----	-----	.29
313----------	800	0	.2	1.0	10.5	59.4	98.1	99.8	100	-----	-----	-----	-----	-----	-----	-----	.24
314----------	500	0	.2	.5	3.6	17.0	67.0	92.9	99.5	99.9	100	-----	-----	-----	-----	-----	.31
Rio Içá (316A)----------	-----	0	.2	.4	1.6	8.6	32.6	67.3	86.5	94.1	97.9	99.3	99.8	100	-----	-----	.43
Rio Içá (316B)----------	-----	.3	.6	1.4	12.9	45.3	85.7	97.2	99.7	100	-----	-----	-----	-----	-----	-----	.26
Santo Antônio do Içá (315)	150	2.8	19.7	56.0	98.3	99.8	99.9	100	-----	-----	-----	-----	-----	-----	-----	-----	.12
Santo Antônio do Içá (315)	490	.1	.3	2.4	41.6	81.7	97.9	99.8	100	-----	-----	-----	-----	-----	-----	-----	.19
Santo Antônio do Içá (315)	940	0	.1	.3	3.6	30.1	91.5	99.8	100	-----	-----	-----	-----	-----	-----	-----	.27
Santo Antônio do Içá (315)	1,360	.1	.4	1.3	13.9	72.5	99.8	100	-----	-----	-----	-----	-----	-----	-----	-----	.22
Santo Antônio do Içá (315)	1,700	.1	1.0	5.3	33.2	74.3	96.1	98.3	99.8	100	-----	-----	-----	-----	-----	-----	.20
317----------	1,000	0	.3	1.0	5.4	25.5	81.4	99.5	100	-----	-----	-----	-----	-----	-----	-----	.29
319----------	1,400	3.7	18.0	59.6	99.8	100	----	-----	-----	-----	-----	-----	-----	-----	-----	-----	.12
Rio Jutaí----------	-1,000	.1	.3	3.1	25.9	86.5	99.6	100	-----	-----	-----	-----	-----	-----	-----	-----	.20
Rio Jutaí (318)----------	-----	0	0	.2	13.9	50.8	88.6	98.3	99.8	100	-----	-----	-----	-----	-----	-----	.25
320----------	1,300	.1	.4	.6	2.5	24.6	80.0	97.1	99.7	100	-----	-----	-----	-----	-----	-----	.29
321----------	500	.1	.2	.5	3.6	18.0	57.7	84.2	95.4	98.0	98.9	100	-----	-----	-----	-----	.33
322----------	1,100	.1	.3	.8	4.3	14.0	65.1	98.8	100	-----	-----	-----	-----	-----	-----	-----	.32
Rio Juruá----------	300	0	0	.9	12.6	48.5	91.1	98.4	99.8	100	-----	-----	-----	-----	-----	-----	.25

Table 2.--Particle size distribution determined by sieving--Continued

Cruise station, measuring section, or sampling site	Distance from left bank, (m)	Percent finer than indicated size, in mm														Median diameter d_{50} (mm)
		0.063	0.088	0.125	0.177	0.250	0.350	0.500	0.707	1.00	1.41	2.00	2.80	4.00	5.60	8.00	
323----------	900	0.2	0.7	2.6	18.6	62.7	89.4	95.4	98.0	98.6	99.5	99.8	100	-----	-----	-----	0.23
324----------	1,500	.2	.4	.9	7.9	29.1	57.3	79.8	94.2	98.1	99.0	99.2	99.3	99.4	99.8	100	.32
325----------	500	0	0	.2	.6	5.4	22.4	74.5	96.1	98.3	99.1	99.5	99.6	100	-----	-----	.42
Rio Japurá----------	-----	.1	.2	1.0	2.8	7.4	31.0	70.9	92.2	97.4	98.7	99.5	99.7	100	-----	-----	.42
326----------	1,500	.1	.2	.7	6.0	24.6	76.5	91.6	98.4	99.7	100	-----	-----	-----	-----	-----	.29
328----------	1,000	1.7	10.4	44.5	96.5	98.8	99.4	100	-----	-----	-----	-----	-----	-----	-----	-----	.13
Itapeua (329)----------	500	.1	.2	.6	1.3	6.0	37.9	73.8	91.0	96.8	97.9	96.6	99.1	100	-----	-----	.56
330----------	3,300	.1	.5	1.6	10.8	46.6	96.4	99.8	100	-----	-----	-----	-----	-----	-----	-----	.25
331----------	900	.2	.5	2.1	9.9	40.8	87.5	95.0	97.2	98.3	99.3	99.8	100	-----	-----	-----	.27
332----------	1,100	.1	.3	1.2	5.2	13.3	48.2	74.7	89.3	93.7	95.0	95.5	96.0	97.9	98.3	100	.36
333----------	1,200	0	0	0	.1	2.4	22.0	54.0	81.2	93.7	98.2	98.7	99.4	99.8	100	-----	.48
334----------	1,400	3.6	20.5	47.0	87.3	94.2	98.3	99.9	100	-----	-----	-----	-----	-----	-----	-----	.13
Manacapuru (335)----------	190	2.2	3.0	5.2	33.2	92.0	99.8	100	-----	-----	-----	-----	-----	-----	-----	-----	.20
Manacapuru (335)----------	890	.1	.3	1.2	6.8	47.8	98.3	99.8	100	-----	-----	-----	-----	-----	-----	-----	.25
Manacapuru (335)----------	2,000	.3	2.0	9.0	40.1	82.4	99.5	100	-----	-----	-----	-----	-----	-----	-----	-----	.19
Manacapuru (335)----------	2,520	.1	.6	1.8	10.4	42.9	93.6	99.3	99.7	100	-----	-----	-----	-----	-----	-----	.26
Manacapuru (335)----------	2,970	.2	.6	2.1	11.2	77.2	99.8	100	-----	-----	-----	-----	-----	-----	-----	-----	.22
336----------	3,700	.1	.3	1.2	7.5	28.2	82.6	96.0	98.1	98.9	99.4	99.5	99.6	100	-----	-----	.29
Rio Negro (337)----------	1,000	0	.2	.4	4.4	19.5	47.7	66.1	78.0	85.2	89.4	94.0	98.3	99.9	100	-----	.37
Rio Negro (337)----------	1,000	0	.2	.3	2.7	16.5	47.3	68.2	82.7	91.8	97.1	99.7	100	-----	-----	-----	.37
339----------	1,600	.4	2.6	13.5	52.9	91.2	99.6	99.9	100	-----	-----	-----	-----	-----	-----	-----	.18
Rio Madeira (340)----------	375	.1	.5	1.3	6.3	40.5	97.0	99.6	99.8	100	-----	-----	-----	-----	-----	-----	.26

Table 2.--Particle size distribution determined by sieving--Continued

Cruise station, measuring section, or sampling site	Distance from left bank, (m)	Percent finer than indicated size, in mm														Median diameter d_{50} (mm)
		0.063	0.088	0.125	0.177	0.250	0.350	0.500	0.707	1.00	1.41	2.00	2.80	4.00	5.60	8.00	
Rio Madeira (340)----------	750	0.4	1.6	9.5	46.9	93.0	99.0	100	-----	-----	-----	-----	-----	-----	-----	-----	0.19
Rio Madeira (340)----------	1,125	.2	.7	3.6	37.6	89.6	99.8	100	-----	-----	-----	-----	-----	-----	-----	-----	.19
342----------	1,400	.7	1.8	5.9	15.1	36.5	96.8	99.8	100	-----	-----	-----	-----	-----	-----	-----	.27
343----------	900	.4	2.6	11.3	62.0	87.3	94.2	96.1	97.0	97.5	97.8	98.1	98.5	100	-----	-----	.17
344----------	1,600	0	.2	.8	6.4	27.3	88.4	99.4	99.8	100	-----	-----	-----	-----	-----	-----	.28
345----------	1,400	0	.1	.5	4.6	23.7	87.9	99.8	100	-----	-----	-----	-----	-----	-----	-----	.29
346----------	2,100	1.0	5.1	16.4	57.3	86.4	99.9	100	-----	-----	-----	-----	-----	-----	-----	-----	.17
Óbidos (347)----------	500	.1	.1	.3	2.1	11.9	40.6	81.6	97.2	99.0	99.7	99.8	99.9	100	-----	-----	.38
Óbidos (347)----------	900	0	.2	.6	1.2	4.2	30.2	88.8	99.1	99.8	100	-----	-----	-----	-----	-----	.39
Óbidos (347)----------	1,200	.4	6.0	28.6	73.6	95.5	99.6	100	-----	-----	-----	-----	-----	-----	-----	-----	.15
Óbidos (347)----------	1,600	1.4	11.1	50.6	97.4	99.8	100	-----	-----	-----	-----	-----	-----	-----	-----	-----	.12
348----------	1,100	0	.4	1.3	13.7	47.8	85.2	93.2	96.3	97.6	97.8	98.2	99.1	99.8	100	-----	.25
349----------	1,300	2.1	18.6	49.8	71.8	87.6	98.5	99.6	100	-----	-----	-----	-----	-----	-----	-----	.12
351----------	2,400	.1	.4	.7	3.4	20.9	74.8	92.3	96.7	98.4	99.3	99.6	99.7	99.8	100	-----	.30
352----------	4,900	2.0	3.3	5.7	17.6	80.4	99.8	100	-----	-----	-----	-----	-----	-----	-----	-----	.21
353----------	2,500	.3	1.9	11.9	80.7	98.6	99.8	100	-----	-----	-----	-----	-----	-----	-----	-----	.15
354----------	1,100	0	2.5	12.6	62.1	95.4	99.8	100	-----	-----	-----	-----	-----	-----	-----	-----	.17
354----------	2,000	4.4	25.6	66.3	96.0	97.1	97.8	99.3	99.6	100	-----	-----	-----	-----	-----	-----	.11
354----------	2,900	1.2	6.2	22.8	65.2	96.9	99.6	100	-----	-----	-----	-----	-----	-----	-----	-----	.16
Rio Xingu Beach----------	-----	0	0	0	.2	2.2	55.9	98.0	98.8	100	-----	-----	-----	-----	-----	-----	.34
Canal do Vieira (355)-----	-----	.3	5.6	24.8	87.6	99.7	100	-----	-----	-----	-----	-----	-----	-----	-----	-----	.15

Table 3.--Particle size distributions determined by pipet and visual accumulation tube or wet sieving

[Method of analysis; P, pipet; V, visual accumulation tube; W, wet sieving]

Cruise station, measuring section, or sampling site	Distance from left bank, (m)	Percent finer than indicated size, in mm										Method of analysis
		0.001	0.00195	0.0039	0.0078	0.0156	0.0312	0.0625	0.125	0.250	0.500	1.00	
Rio Huallaga at Tocache	0	1.9	3.2	4.3	5.0	8.0	18.4	46.6	84.1	97.4	100	----	VP
Rio Sapo at road bridge	--------	2.4	3.6	4.9	5.8	7.3	14.2	46.8	90.4	100	-----	----	VP
Tributary of Rio Huallaga just above Yurimaguas	--------	2.7	3.9	5.1	5.8	8.1	11.7	38.4	98.3	100	-----	----	VP
Rio Paranapura near Yurimaguas----------	--------	2.6	3.9	5.3	5.9	7.4	11.6	51.7	98.5	100	-----	----	VP
São Paulo de Olivença	1,350	16.7	21.9	29.3	33.6	48.4	74.5	92.7	94.3	96.3	98.8	100	VP
318----------	--------	26.7	33.9	40.1	43.5	54.5	69.6	85.8	98.1	100	-----	----	VP
Tributary of Rio Juruá	--------	7.9	9.7	11.5	12.0	15.2	18.5	23.8	28.2	88.7	99.6	100	VP
Lago Tefé----------	--------	15.5	22.3	26.0	29.0	38.9	58.9	94.2	99.7	100	-----	----	VP
Lago Coari----------	--------	45.4	60.8	70.9	75.6	81.6	83.8	84.4	85.9	94.2	99.8	100	VP
Rio Purus----------	--------	44.8	53.1	60.2	65.5	80.2	90.2	97.8	99.2	99.9	100	----	VP
Manacapuru (335)-------	190	12.5	18.2	22.3	25.8	39.9	68.1	96.2	99.2	100	-----	----	VP
Rio Negro (338)--------	1,600	12.6	14.3	16.5	17.5	23.1	31.4	90.2	99.6	100	-----	----	VP
Rio Negro (338)--------	3,700	4.5	5.1	5.9	6.5	7.4	10.0	72.4	99.2	99.8	99.8	100	VP
Rio Negro (338)--------	5,600	4.5	4.7	5.4	6.1	6.5	8.8	37.4	98.5	100	-----	----	VP
Rio Trombetas----------	-----	26.6	42.4	54.3	61.1	66.2	72.6	82.2	99.5	100	-----	----	VP
Óbidos (347)----------	80	5.9	9.1	11.2	12.5	19.6	30.3	52.1	83.9	100	-----	----	VP
Óbidos (347)----------	1,900	20.9	28.3	36.5	39.4	59.5	76.9	96.0	100	----	-----	----	VP
Óbidos (347)----------	2,250	9.8	15.0	18.3	25.0	43.1	64.0	94.0	100	----	-----	----	VP
Rio Tapajós----------	-----	56.1	70.3	84.3	94.4	97.8	99.8	99.9	100	----	-----	----	WP
352----------	-----	9.9	14.3	18.4	20.1	29.8	54.7	82.5	98.8	100	-----	----	VP
Rio Xingu----------	-----	5.4	7.8	9.1	10.9	16.5	28.3	77.5	100	---	-----	----	VP