University of Puerto Rico
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Sediment dynamics and their temporal variability in the Mayagüez Bay

Undergraduate Research by:

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ABSTRACT

The Mayagüez Bay is located in the west part of Puerto Rico between latitude N 18° 10’, 18° 16’ and longitude W 67° 10’, 67° 14’. This area is highly influenced by several rivers systems, as Rio Grande de Añasco (nutrients from agriculture and sewage), and by anthropogenic activities, like the sewer outfall (nutrients from sewage) and the tuna factory. The long-term goal of this project is to relate the amount and composition of sediments and nutrient inputs to environmental impacts in the Mayagüez Bay. This study researched how the sediment influx and its composition may affect coral growth and the influence of river discharge on the phytoplankton dynamics in coastal waters of western Puerto Rico. Four study sites along the bay were selected based on geographical location with respect to sediments and nutrients sources, coral cover present at each site, and different sedimentological environments. The Manchas Norte, Manchas Interiores 8, Algarrobo, and Escollo Negro were the sites selected for sediment trap analyses. The equivalent stations of these study sites selected for the suspended particulate matter (SPM) measurements are: Station #1, Station #5, Station #9 and Station #4, respectively. Laboratory analyses were done to determine composition (%), grain size and mineral-nutrients presence. The data obtained helped determined if there are seasonal variations in sediment inputs and composition and related to specific events identified in the river discharge data.

INTRODUCTION

The Mayagüez Bay is located in the west part of Puerto Rico between latitude N 18° 10', 18° 16' and longitude W 67° 10', 67° 14'. This area is highly influenced by several rivers systems, as Rio Grande de Añasco (nutrients from agriculture and sewage), and by anthropogenic activities, like the sewer outfall (nutrients from sewage) and the tuna factory (Morelock et al., 2002). Since the sediment influx into the bay comes from different sources, the composition of these sediments is expected to vary. The diversity of the sediments discharge in the area can provide a better understanding about the impacts in the marine life as well as the sedimentation processes. (Rivera, Undergraduate Research Project 2002) The long-term goal of this project is to study the sedimentation rate and composition as well as and nutrient in relation to the environmental impacts in the Mayagüez Bay.

This undergraduate research will incorporate data from two long-term projects that are studying different processes in the Mayagüez Bay with the objective of understanding the impact of such processes in the marine ecosystem. The first study is multidisciplinary project and it is scheduled to last 2 years. This study investigates how the sediment influx and composition may affect coral growth, since little quantitative information is available to evaluate long-term effects of terrigenous sediment and nutrient influx on the reef system and the coral community (Morelock et al., 2002). The second study evaluates the influence of river discharge on the phytoplankton dynamics in coastal waters of western Puerto Rico. The study attempts to characterize the spatial and temporal variations of phytoplankton chlorophyll *a* (Chl-a), suspended particulate matter (SPM) and light penetration in Mayagüez Bay. (Gilbes et al., 1996)

Four study sites along the Mayagüez Bay were selected (Figure 1 and 2) based on geographical location with respect to sediments and nutrients sources, coral cover present at each site, and different sedimentological environments present in each area. (Rivera, Undergraduate Research Project 2002) The sediment traps were placed at: Manchas Norte, Manchas Interiores 8, Algarrobo, and Escollo Negro (Figure 1, Table 1). The equivalent stations of these study sites selected for the SPM measurements are: Station #1, Station #5, Station #9 and Station #4, respectively. (Figure 1, Table 1) These stations are in close proximity to the sediment trap locations. Three of the study sites are exposed to high sediment-nutrient-organic input conditions: Manchas Norte/Station #1 located close to the discharge area of Río Grande de Añasco, Manchas Interiores 8/Station #5 close to the sewer outlet, and Algarrobo/Station #9 located close to the tuna plant. The fourth site, Escollo Negro/Station #4, are used as the control site because, based on coral cover and community structure and water clarity, it was proved to be located in a healthy reef environment implicated that is an area of lesser terrigenous input and away from the sediments – nutrients – organic sources.

Table 1- Coordinates for the study sites in the Mayagüez Bay. (Morelock, 2002)

Study Site	**Latitude**	**Longitude**	**Water Depth (m)**
Manchas Norte	18° 16’ 36”	67° 12’ 36”	9
Manchas Interiores 8	18° 14’ 02”	67° 11’ 29”	8
Algarrobo	18° 13’ 27”	67° 10’ 42”	5
Escollo Negro	18° 10’ 31”	67° 14’ 44”	10
Station # 1	18° 16’ 00”	67° 12’ 00”	-
Station # 4	18° 16’ 00”	67° 15’ 20”	-
Station # 5	18° 14’ 40”	67° 11’ 40”	-
Station # 9	18° 13’ 14”	67° 10’ 14”	-

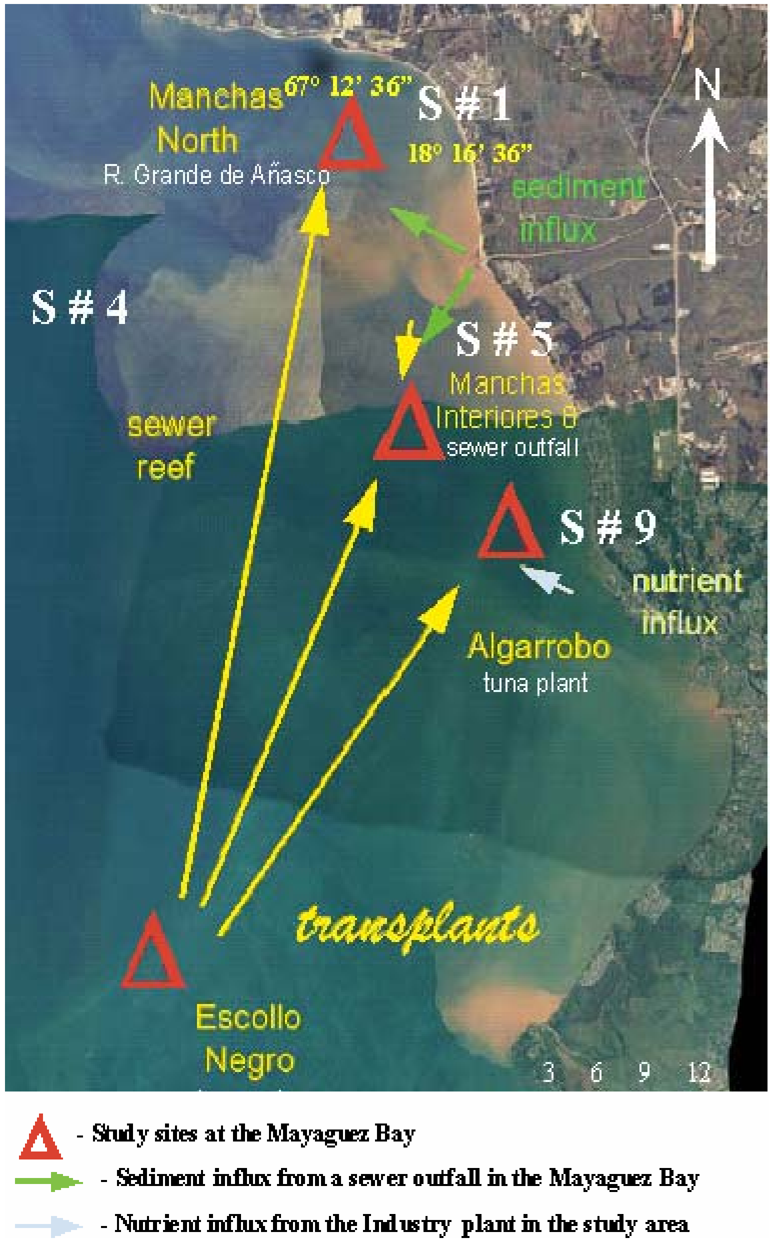


Figure 1 – Map location of the field site. (http://rmocfis.upr.clu.edu/~morelock/)

PREVIOUS WORK

Several studies have investigated the impact of sediments and nutrients in coastal and marine environments. Some of these have tested the techniques and procedures used in this project. One of these studies was the "Characterization of sediment influx and hard coral cover analysis of Boquerón and La Parguera, Puerto Rico" (Morelock, 1998). This study tried to establish possible correlations between coral cover and sediment inputs. Acevedo (1989) studied the "Modification of coral reef zonation by terrigenous sediment stress". Previous works have provided a better understanding in the sediment-nutrients impact over coral reefs cover, and have developed of tools for multidisciplinary studies. However much still need to be done to characterize and specifically to quantify the impacts of terrigenous sediments over corals reefs.

In the area of phytoplankton dynamics and the impact of nutrients and fine-sediments on this marine organism, monthly cruises between Añasco Bay and Punta Guanajibo, from March 1990 to February 1991, have been done. These established that seasonal rainfall and river discharges affected monthly variations in Chl-a and SPM in the inner regions of the Mayagüez Bay. In addition, it was stated that SPM concentrations in the inshore stations were significantly higher than those at the middle and offshore stations (Gilbes et al., 1996). This study provided a detailed quantification of nutrient concentration at Mayagüez Bay that helps to better understand the dynamics in this region.

A most recent study suggested that large spatial and temporal variability of the bio-optical properties in Mayagüez Bay are generated by changes in rivers discharge and anthropogenic activities. (Gilbes et al., 2002) This study provides an important step to better understand the use of remote sensing for land – sea interaction.

RESEARCH OBJECTIVES

The main objective of this research is to determine the spatial and temporal variations, at four sites along the Mayagüez Bay, in terms of sediment input and sediment composition. This objective can be subdivided in several sub-objectives:

1. Measure sediment influx at 4 different sites exposed to different sedimentation regimes during a span of semester.
2. Measure the composition of the sediments that are reaching the Mayagüez Bay at 4 different sites during different environmental regimes and add this data to a broader time interval (2 years) to determine if there are seasonal variations in sediment input and composition related to specific events (Figure 2).
3. Determine differences in sediment influx and sediment composition between four different sites along the bay.
4. Identify specific events in the Rio Grande de Añasco discharge data from the last two years.
5. Compare Rio Grande de Añasco discharge data with data from the sediments deposited in the sediment traps and the SPM of the last two years.
6. Learning the use of high precision GPS measurements to obtain the exact location of the submarine and boat sampling sites along the study area.

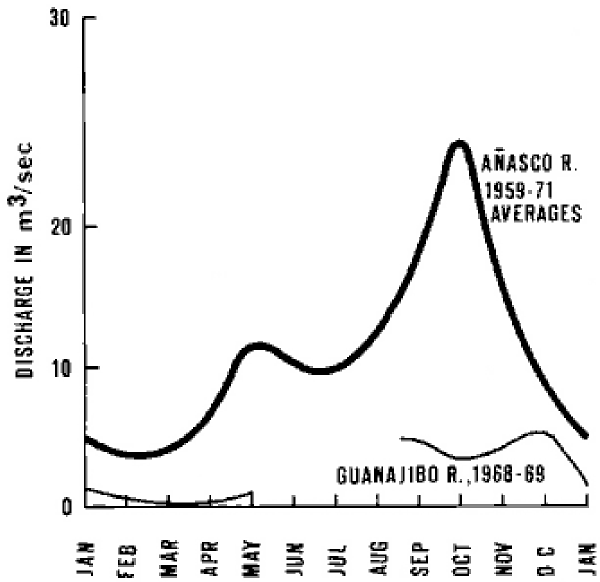


Figure 2 – Temporal variation of the river discharge. (http://rmocfis.upr.clu.edu/~morelock/)

METHODOLOGY

Field Sampling:

Sediment traps – All four sites were sampled using sediment traps that will be placed on the coral reef along the study area by a diver. These traps are wide mouth bottles of approximately 8 cm diameter and 20 cm height. The bottles are strapped to an iron bar fixed vertically into the reef and placed 50 cm above the reef surface. (Figure 3) The traps are placed in locations that will be revisited bimonthly. The study was designed to collect data for two years but for this project the data will be collected for only one semester. Scuba Diving will be required to collect the samples. I am a license diver so I will be able to participate actively in the sample collection process (Rivera, Undergraduate Research Project 2002).

Suspended Particulate Matter (SPM) – Seasonal cruises will be made to obtain samples at twelve stations. At each station, samples will be taken from two different depths: surface and middle depth (Gilbes et al., 2000). For the analysis of SPM, a peristaltic pump fitted with plastic hose collects duplicate samples (21) of seawater at each depth mentioned above.

Laboratory Analyses:

Sediment traps - After collection, sediments were leaved in the laboratory to settle for several days until the water on top of the sediments is clear, and then the liquid is decanted. The samples were then transferred from the original containers to beakers. The samples were dried at normal surface temperature, or in the oven not exceeding 60° F to prevent the agglutination of clays. After the samples are dried and weighed, the laboratory analyses will be started to determine composition (%), grain size, and mineral-nutrients presence.

SPM – The method of filtration, using Millipore HA 0.45 μm cellulose acetate membranes (Gilbes et al., 1996), were used to measure de SPM of each station. The samples were placed in a filter previously dried and weighed. Samples were heated at 70° - 80° F during 6 – 8 hours to reduce water content before weighing. The remaining sample were weighed again and subtracted from the original weight to determine the amount of suspended sediment collected.

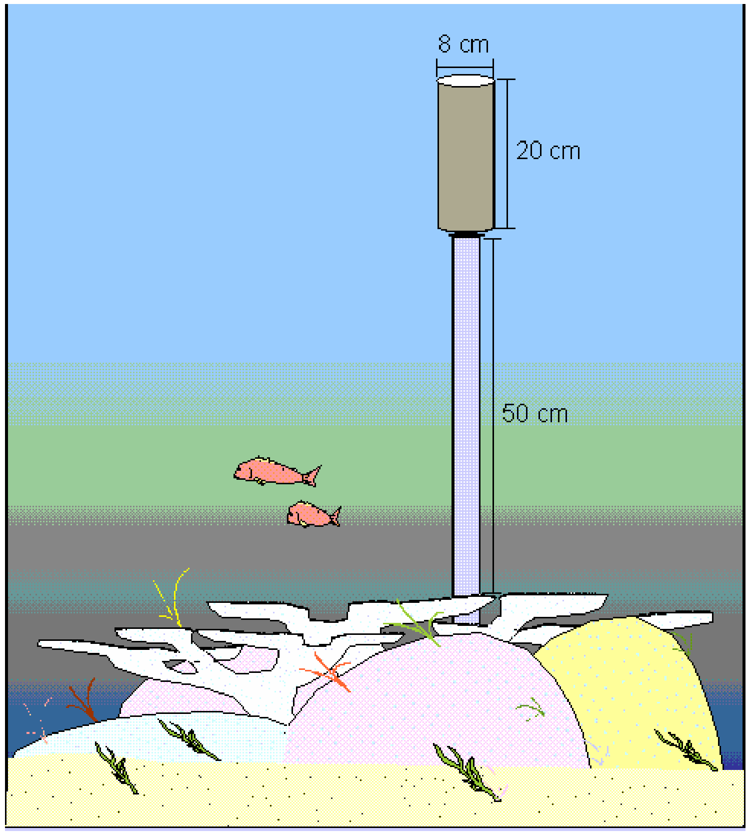


Figure 3 – Sediment trap for field sampling

Sediment Influx

For the determination of bimonthly average sediment the sample have to be dried and weighed. Bimonthly measurements of the most active seasons of the year in terms of sediment influx were done and compared with Rio Grande de Añasco water discharge data obtained during the last two years from the US Geological Survey. The bimonthly results were added to obtain the total seasonal weight for further comparison.

Sediment Composition

After the samples are dried and weighed three representative amounts of the total sample were selected and placed in separate beakers as follows:

1) 1.5 – 1.7 grams of sample is needed for sedigraph analyses.

- *Sedigraph Particle-Size Analysis*: is used for the determination of particle size fractionation of the sediments of less than 3 Φ size. The procedure for the use of the Sedigraph 5100 will follow the Micromeritics (1997) procedure. The data obtained from this method will be represented using cumulative sedimentary curves.

2) Approximately 1.0 gram of sample was used for XRD analysis.

- *X-Ray Diffractometer (XRD)* - a Siemens D5000 X-ray Diffractometer were used for the determination of the mineralogical composition of the sediment collected from the study area. The sample were completely pulverized and then poured in the XRD sample holder. The samples were analyzed in the XRD machine, and with the help of a computer identification program, the minerals present were identified. The sources and possible effects of the minerals and components identified during these previous XRD measurements (Fong, Undergraduate Research Project 2002) were determined.

3) 1.5 – 2.0 grams were used for the sediment composition analysis.

- The sample was placed in a beaker (dried and weighed). Clorox (Cl) was added to dissolve the organic present in the sample because it contains Sodium Hypochlorite at 5.25 %, which decomposes organic matter in a relatively short interval of time (Morelock, *et. al.,* 1998). The remaining sample was dried and weighed again and subtracted from the original weight to determine the amount of organic matter present in the sample.

- HCL was added to the remaining sample until all carbonate material stop fizzing, this will cause the HCL to react with the carbonate material dissolving it. The remaining sample is dried and weighed once again, and the weight is subtracted to determine the amount of carbonate present in the sample.
- The remaining residue in the beaker was weighted and compared to the original weight to determine the amount of terrigenous sediments in the sample.

Data Analyses

A comparison of the sediment influx and sediment composition between the four sites along the bay was done to discern between new sediment inputs and sediment redistribution. The data obtained during the last two years, including the data that were processed this semester (sediment traps and SPM), will help us to quantify seasonal differences produced by variations in sediment inputs and composition and relate them to specific events showed by river discharge data.

RESULTS – On Sediments from sediment traps

XRD Analyses

The results showed in this section were based on the XRD analysis. The XRD results tables show the presence of certain minerals that were identified during the analysis.

Table 2 – Minerals identified in each station – December 2002

Station – December 2002	Minerals Identified
Algarrobo	Kaolinite-montmorillonite – Na0.3 Al_4 Si_6 $O_{15}(OH)_6 \cdot 4 H_2O$ Quartz – SiO_2 Carbonatehydroxylapatite – $Ca_{10}(PO_4)_3(CO_3)_3(OH)_2$ Illite – K0.7$Al_2(Si, Al)_4O_{10}(OH)_2$ Calcite - $CaCO_3$
Escollo Negro	Aragonite - $CaCO_3$ Kaolinite-montmorillonite – Na0.3 Al_4 Si_6 $O_{15}(OH)_6 \cdot 4 H_2O$ Carbonatehydroxylapatite – $Ca_{10}(PO_4)_3(CO_3)_3(OH)_2$ Calcite, magnesian - (Ca, Mg) CO_3
Manchas Interiores 8	Calcite - $CaCO_3$ Illite – K0.7$Al_2(Si, Al)_4O_{10}(OH)_2$ Kaolinite-montmorillonite – Na0.3 Al_4 Si_6 $O_{15}(OH)_6 \cdot 4 H_2O$ Carbonatehydroxylapatite – $Ca_{10}(PO_4)_3(CO_3)_3(OH)_2$ Quartz – SiO_2
Manchas Norte	Kaolinite-montmorillonite – Na0.3 Al_4 Si_6 $O_{15}(OH)_6 \cdot 4 H_2O$ Calcite, magnesian - (Ca, Mg) CO_3 Quartz – SiO_2 Carbonatehydroxylapatite – $Ca_{10}(PO_4)_3(CO_3)_3(OH)_2$ Illite – K0.7$Al_2(Si, Al)_4O_{10}(OH)_2$

Table 3 – Minerals identified in each station – March 2003

Station – March 2003	Minerals Identified
Algarrobo	Kaolinite - $Al_2Si_2O_5$ $(OH)_4$ Quartz – SiO_2 Calcite, magnesian - (Ca, Mg) CO_3

	Halite – NaCl Albite, calcian, ordered – (Na, Ca) (Si, Al)$_4$O$_8$ Alunogen – $Al_2(SO_4)_3.16H_2O$ Aragonite - $CaCO_3$
Escollo Negro	Aragonite - $CaCO_3$ Calcite, magnesian - (Ca, Mg) CO_3
Manchas Interiores 8	Aragonite - $CaCO_3$ Halite – NaCl Kaolinite - $Al_2Si_2O_5(OH)_4$ Calcite, magnesian - (Ca, Mg) CO_3 Quartz – SiO_2
Manchas Norte	Kaolinite - $Al_2Si_2O_5(OH)_4$ Quartz – SiO_2 Albite, calcian, ordered – (Na, Ca) (Si, Al)$_4$ O$_8$ Halite – NaCl

Composition Analysis

The results showed in this section present the data collected for the composition analysis by station (Table 4 to Table 7).

Table 4 – Percentages (%) in Algarrobo

Components	December 2002	March 2003
Carbonates	20 %	24 %
Organic Matter	13 %	14 %
Terrigenous	67 %	62 %

Table 5 – Percentages (%) in Manchas Norte

Components	December 2002	March 2003
Carbonates	19 %	16 %
Organic Matter	15 %	16 %

Terrigenous	66 %	68 %

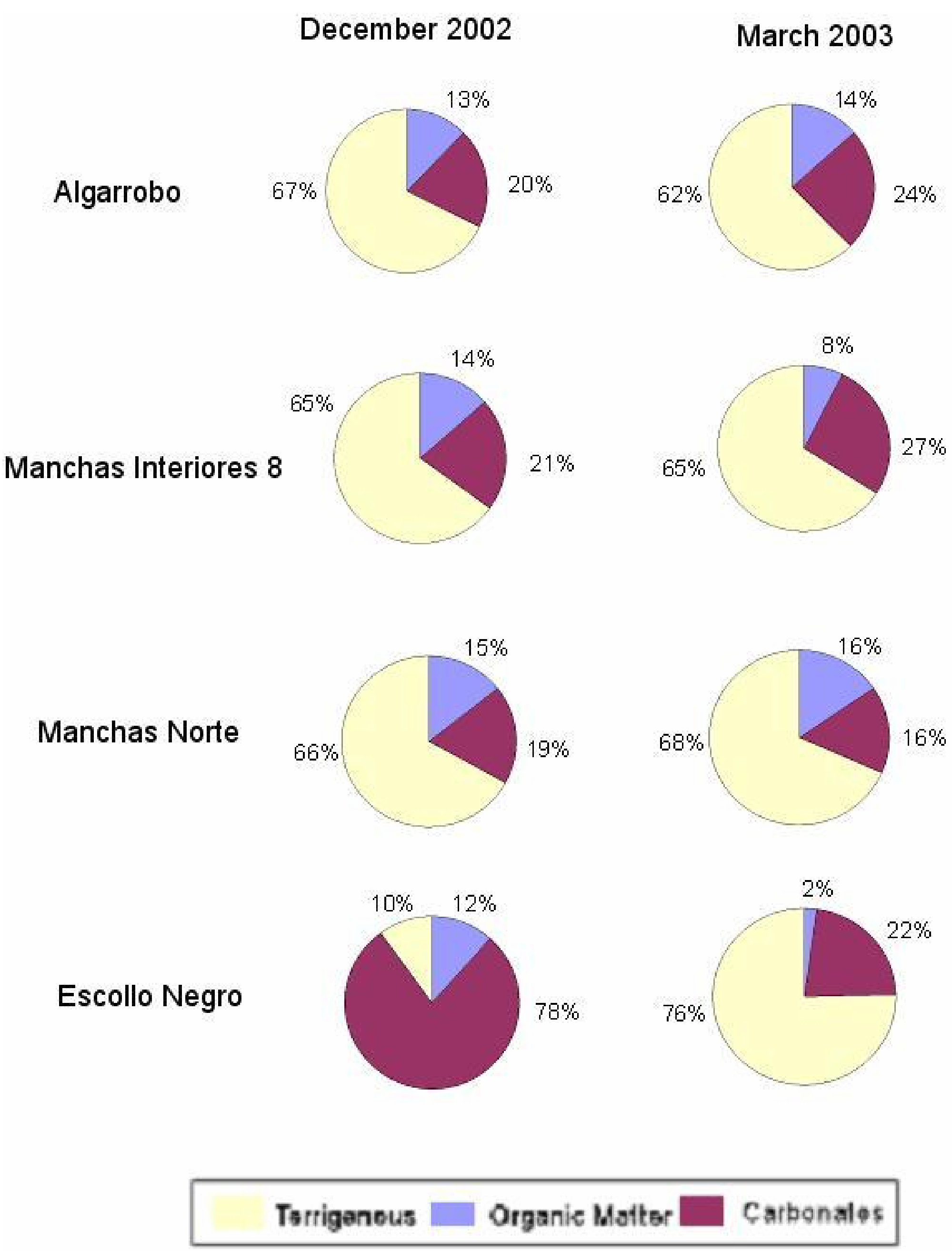
Table 6 – Percentages (%) in Manchas Interiores 8

Components	**December 2002**	**March 2003**
Carbonates	21 %	27 %
Organic Matter	14 %	8%
Terrigenous	65 %	65 %

Table 7 – Percentages (%) in Escollo Negro

Components	**December 2002**	**March 2003**
Carbonates	78 %	22 %
Organic Matter	12 %	2 %
Terrigenous	10 %	76 %

Figure 4 - Graphs comparing composition at each station per period of time.



Grain size distribution on sediments

The grain size distribution of the sediments was determined by wet sieving (-1Φ to 4 Φ) and Sedigraph (>4 Φ) analyses.

Figure 5 – Sediment distribution in Manchas Norte - June 2001

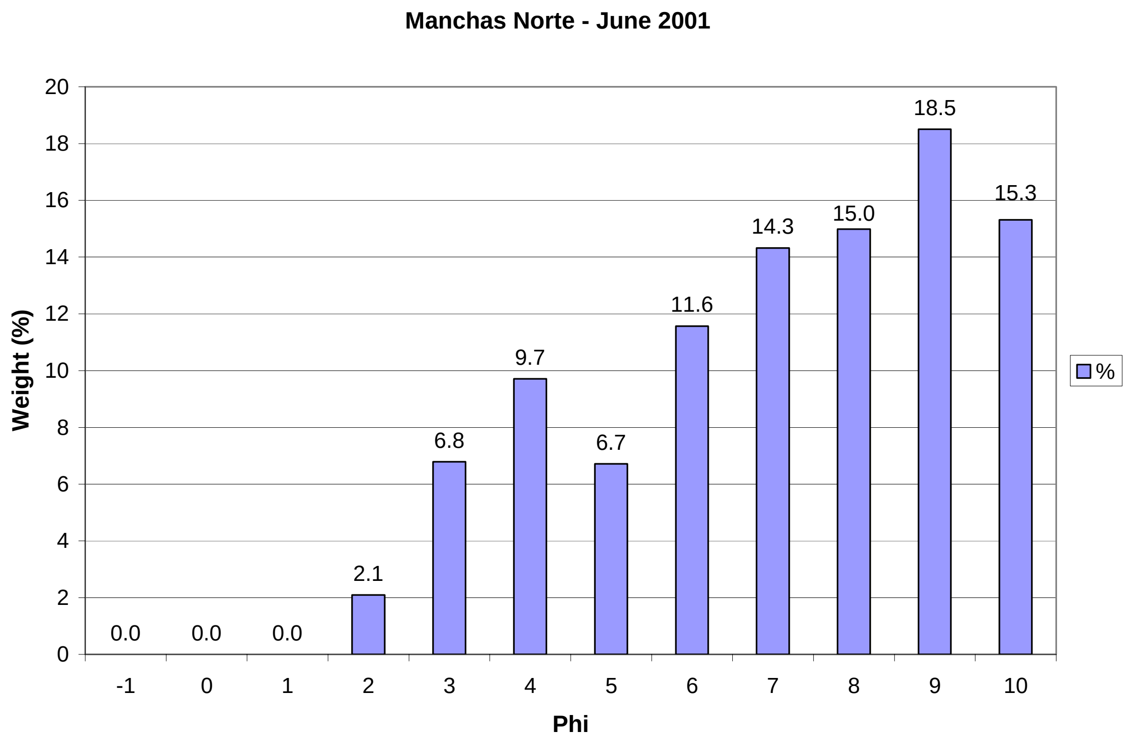


Figure 6 – Cumulative curve in Manchas Norte - June 2001

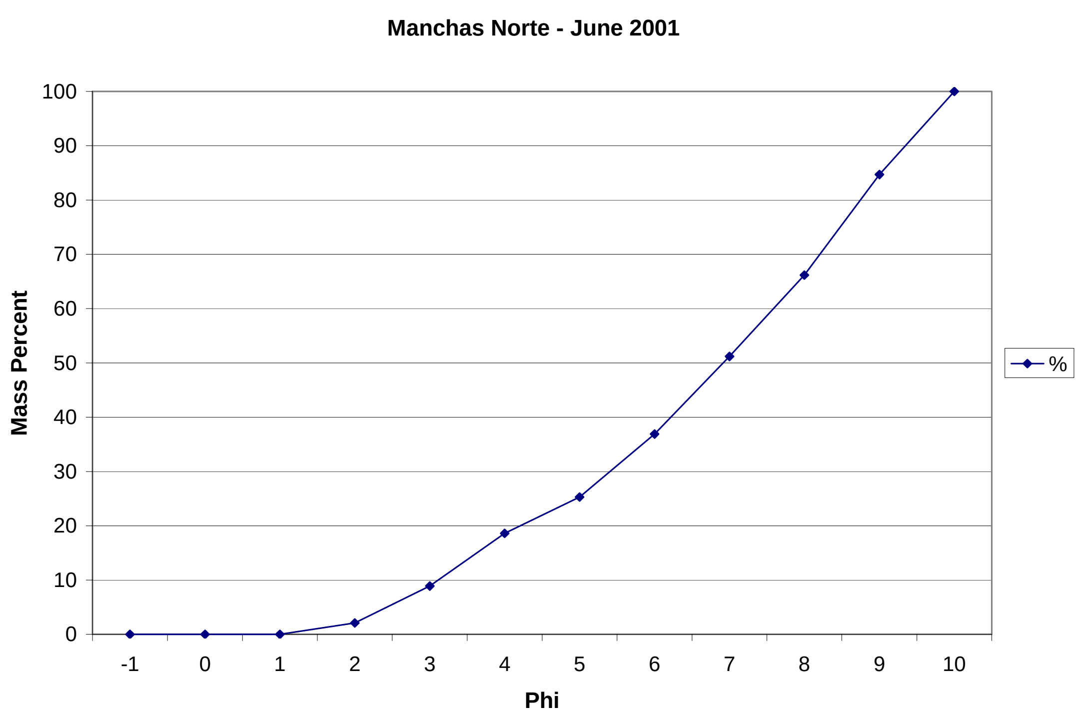


Figure 7 – Sediment distribution in Manchas Norte - September 2001

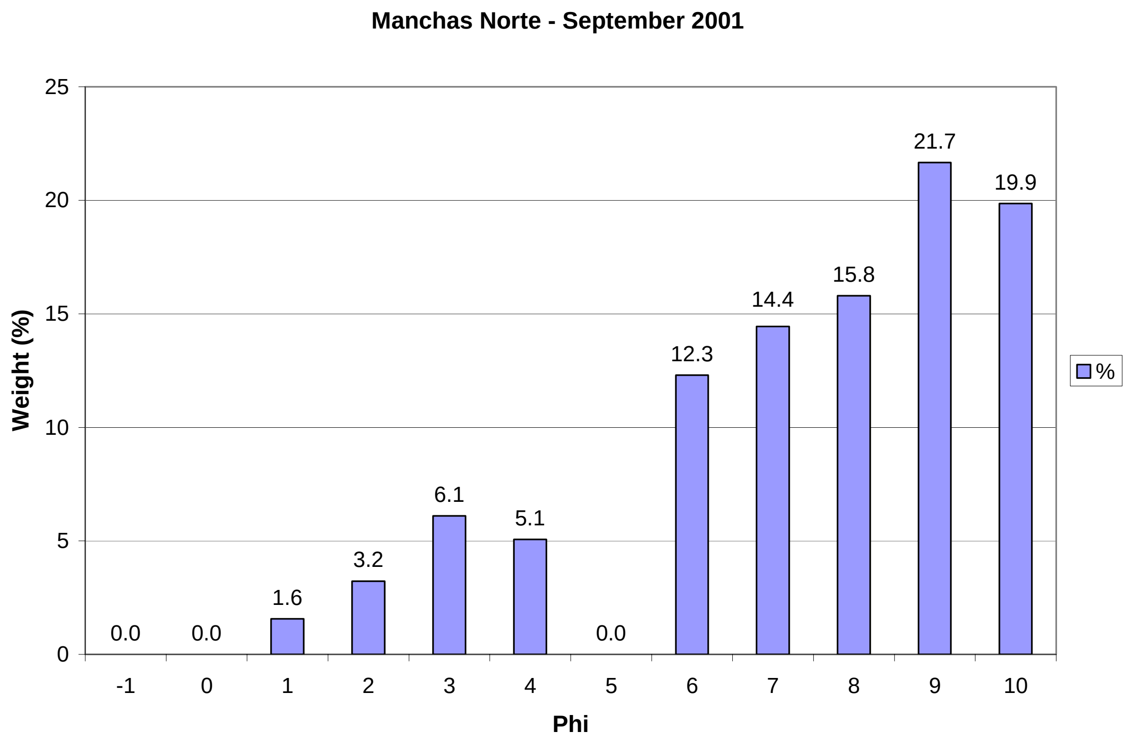


Figure 8 – Cumulative in Manchas Norte - September 2001

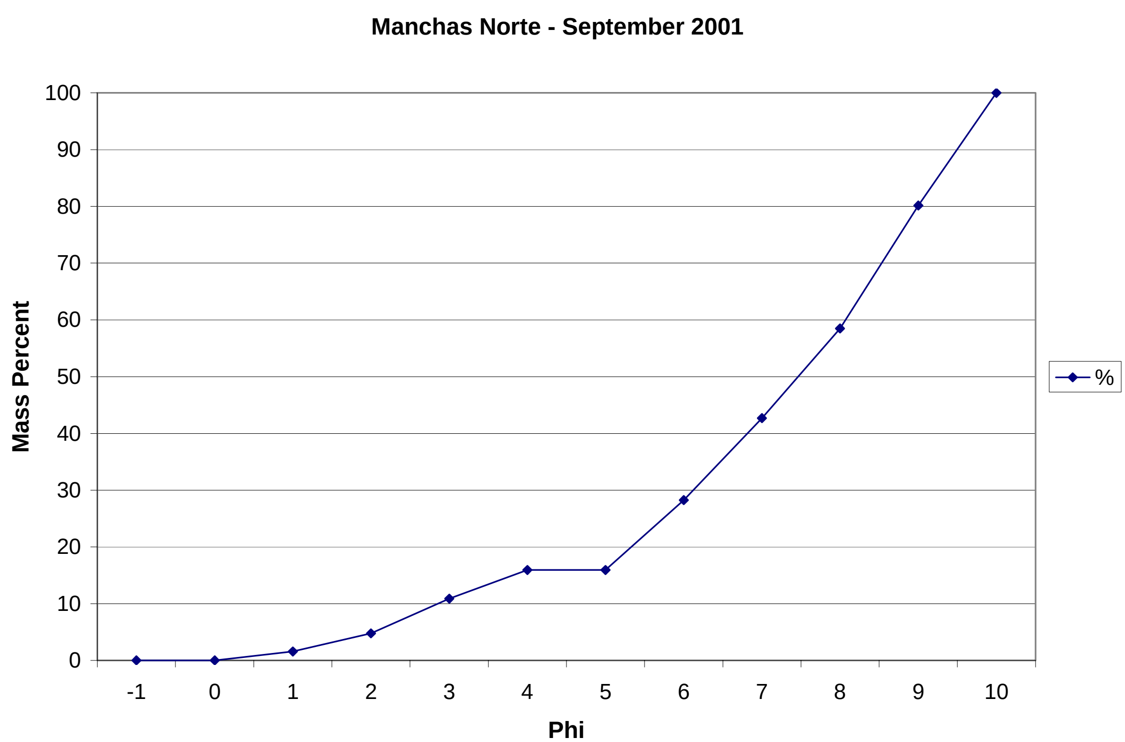


Figure 9 – Sediment distribution in Manchas Norte - December 2001

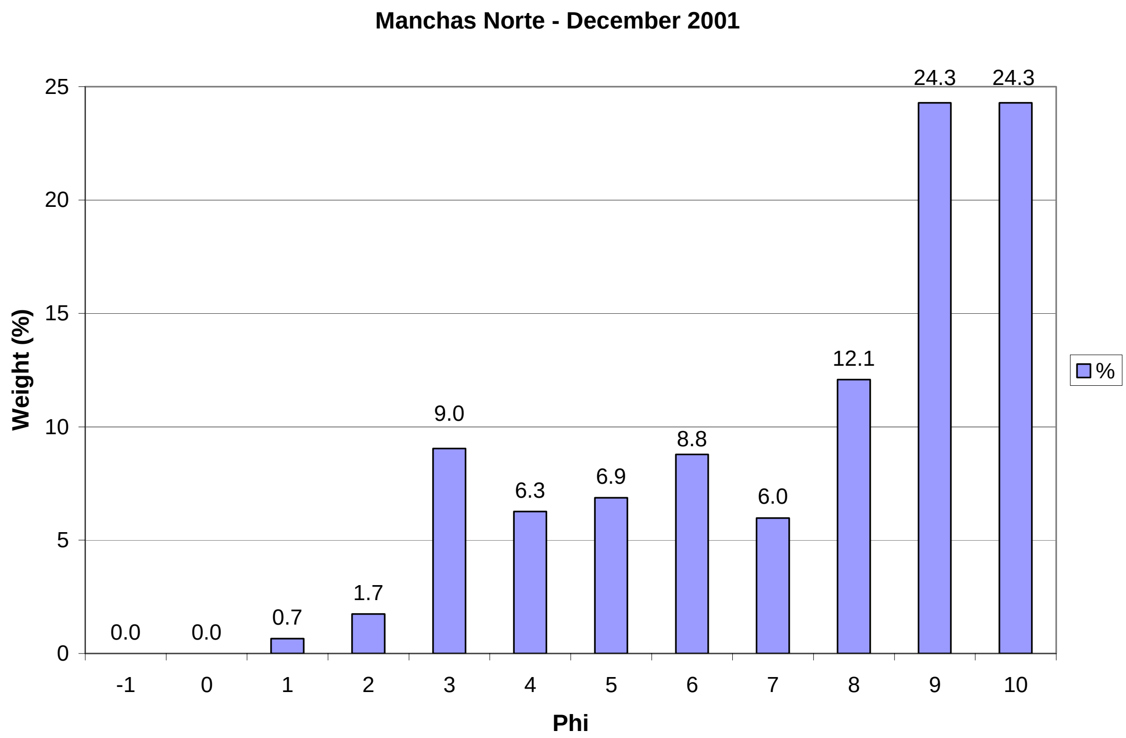


Figure 10 – Cumulative in Manchas Norte - December 2001

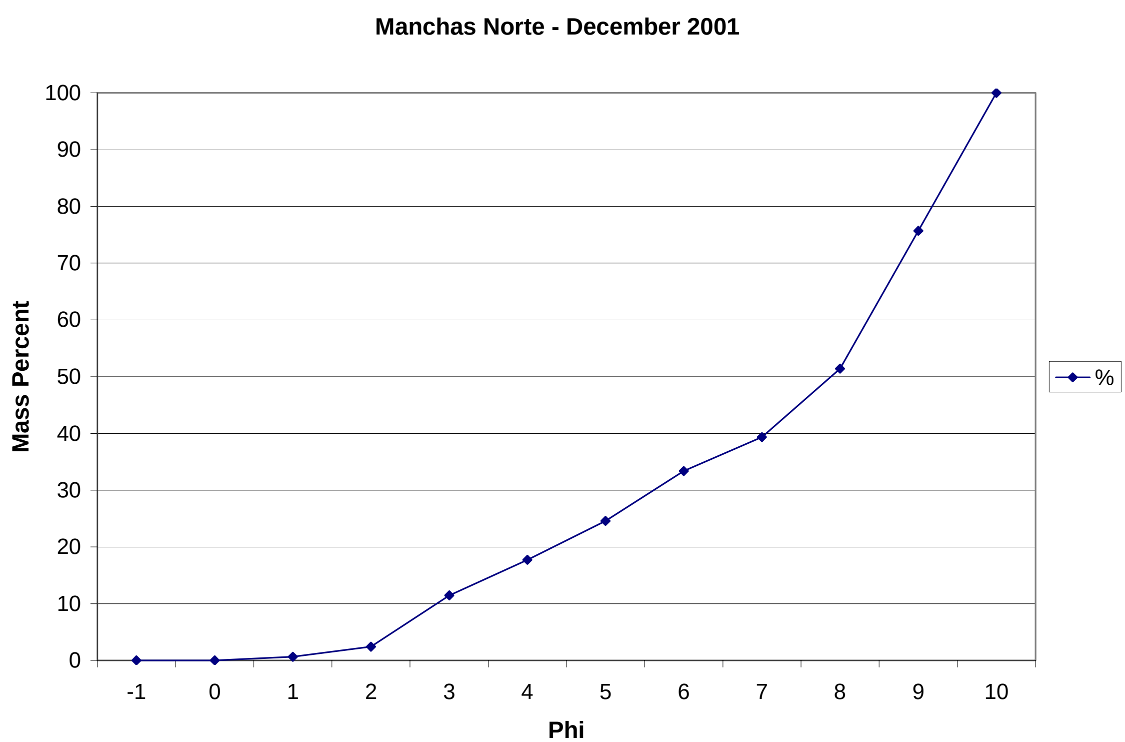


Figure 11 – Sediment distribution in Manchas Norte – March 2002

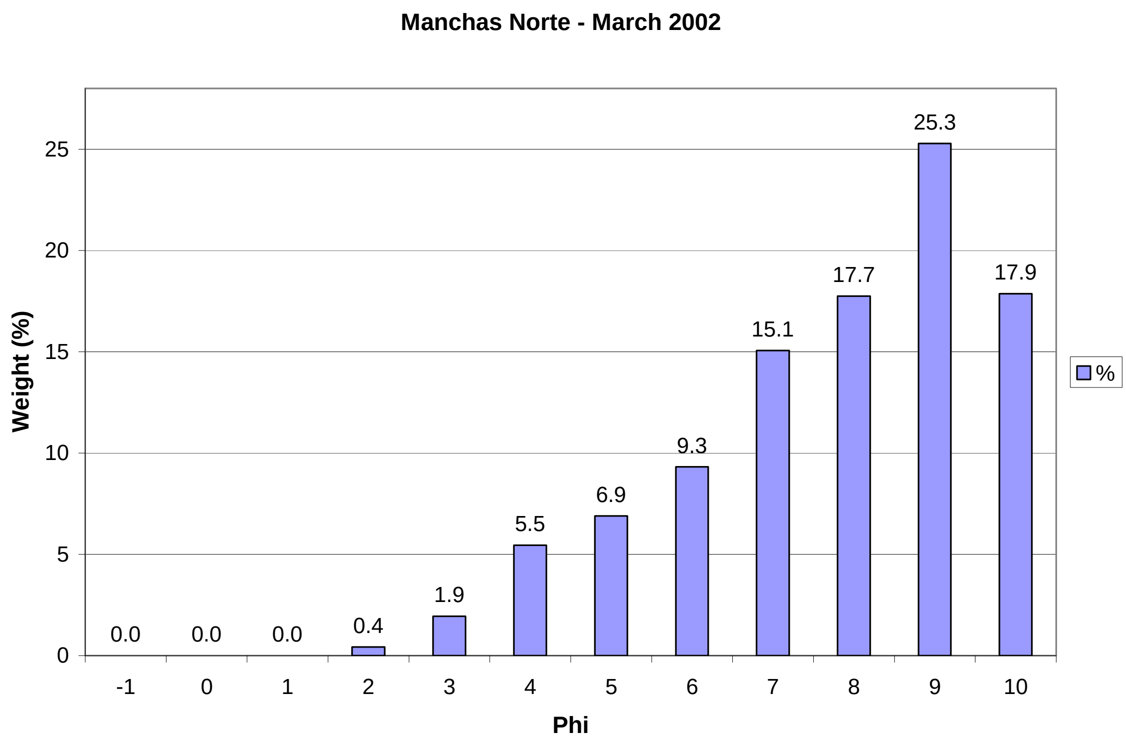


Figure 12 – Cumulative in Manchas Norte - March 2002

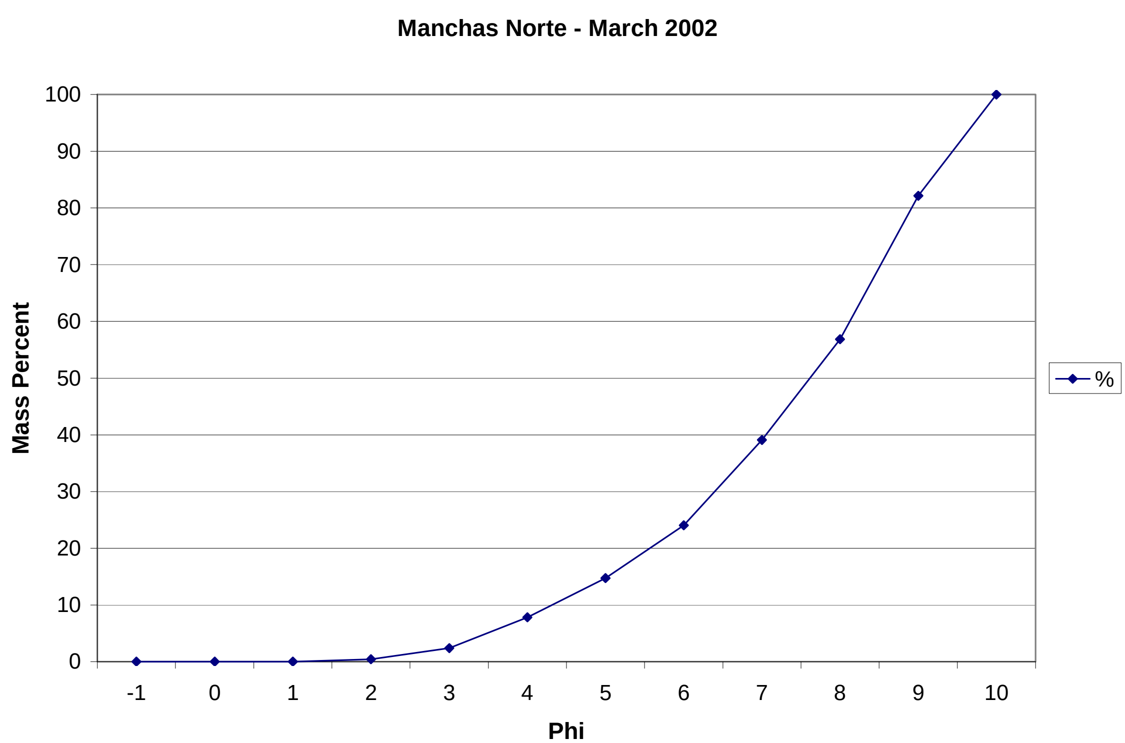


Figure 13 – Sediment distribution in Manchas Norte – July 2002

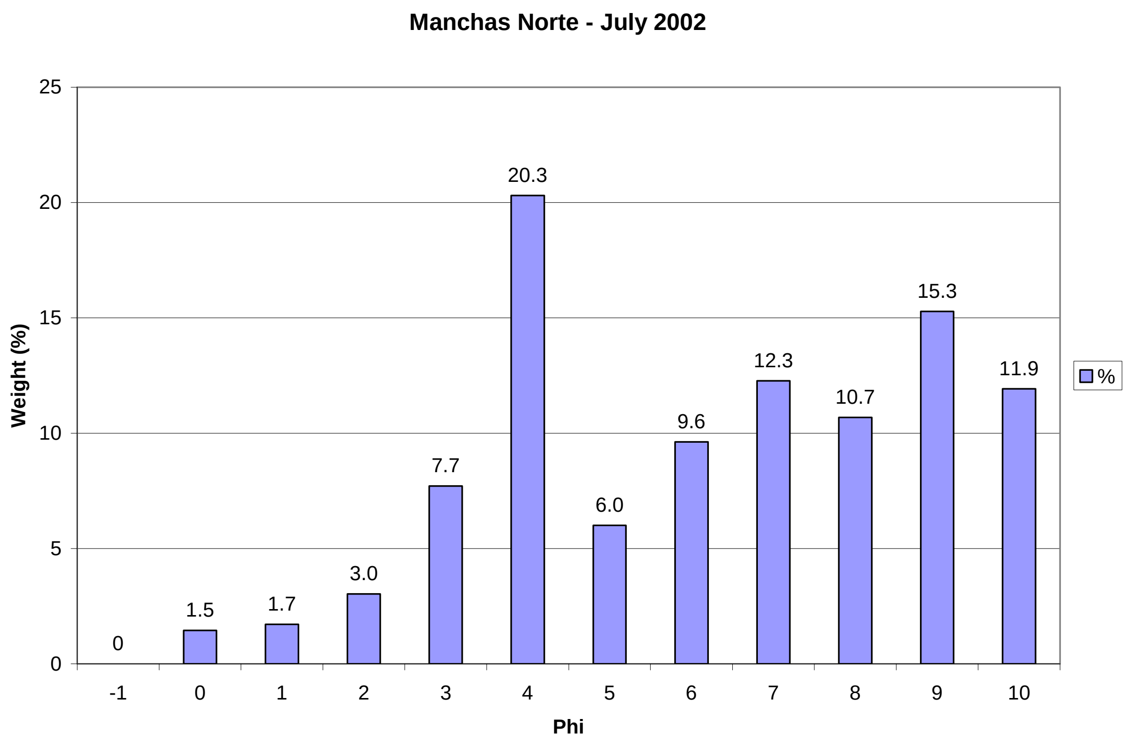


Figure 14 – Cumulative in Manchas Norte - July 2002

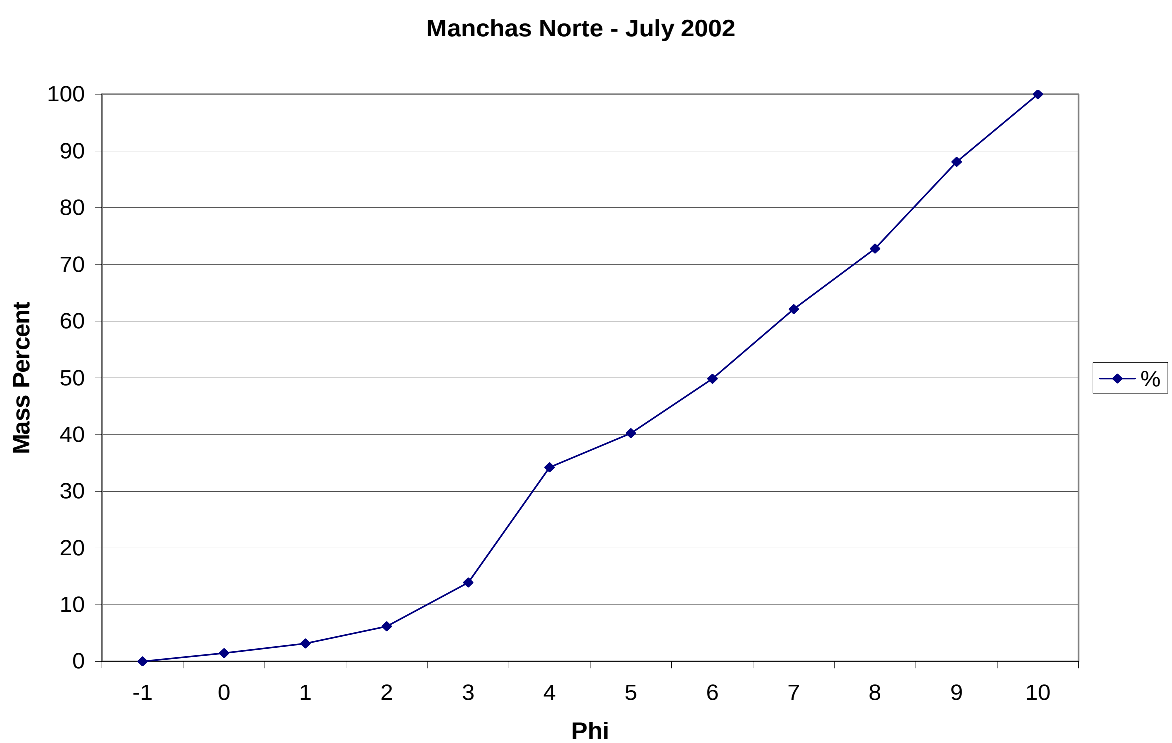


Figure 15 – Sediment distribution in Manchas Norte – October 2002

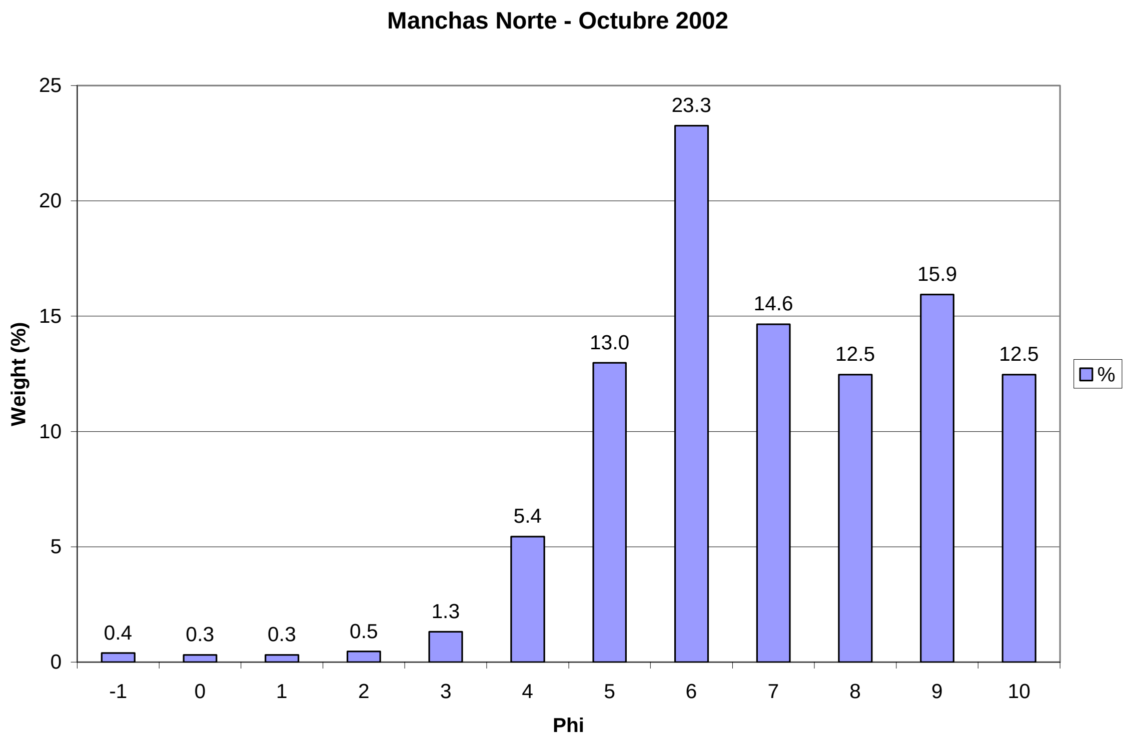


Figure 16 – Cumulative in Manchas Norte - October 2002

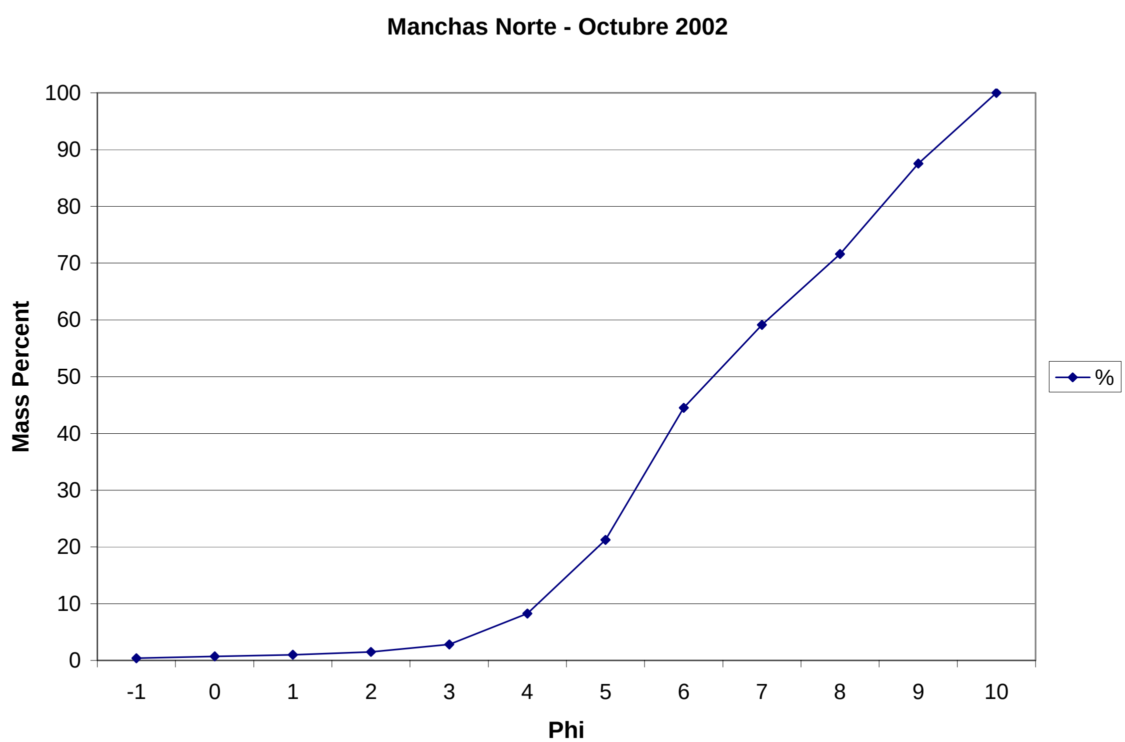


Figure 17 – Sediment distribution in Manchas Norte – December 2002

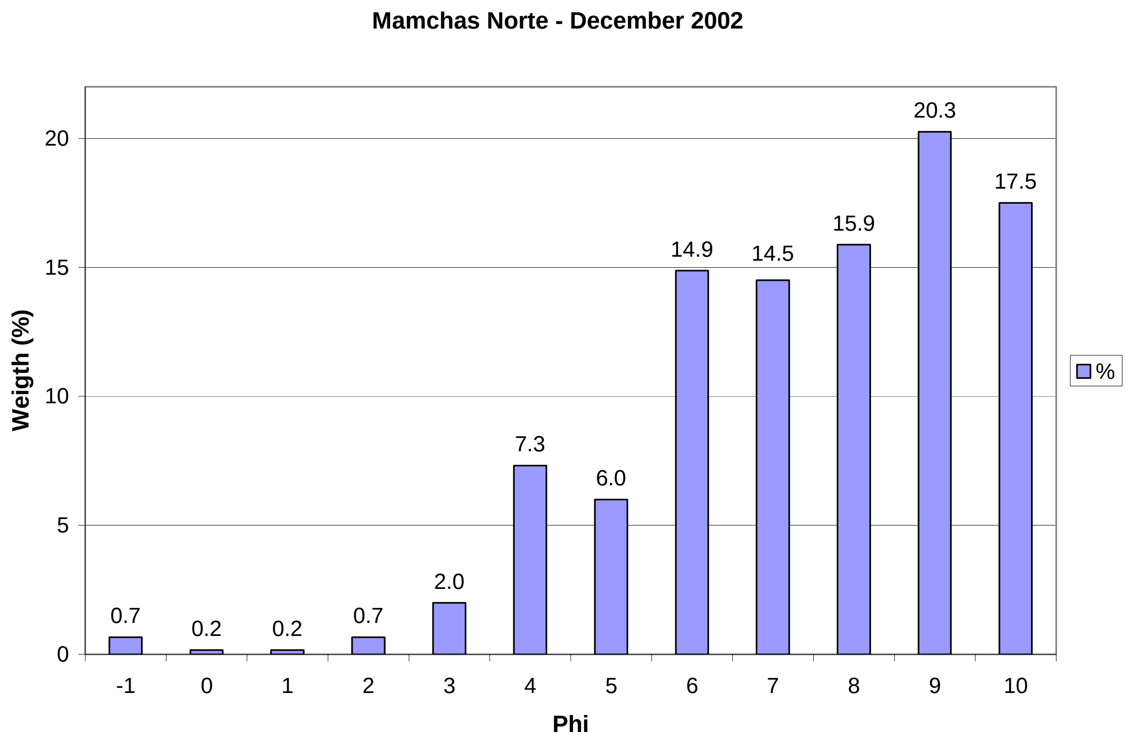


Figure 18 – Cumulative in Manchas Norte - December 2002

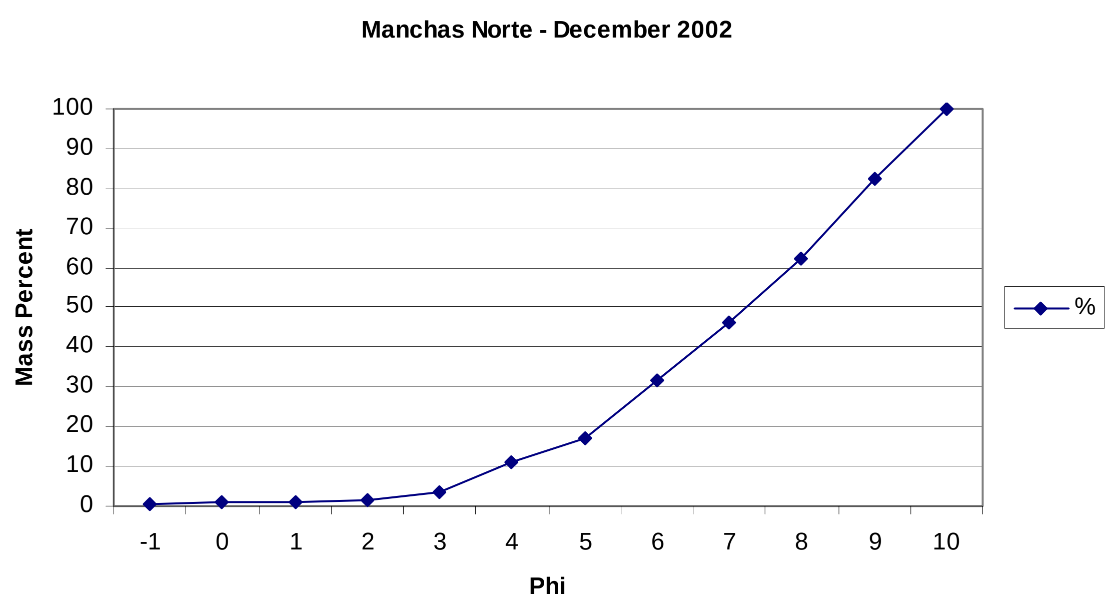


Figure 19 – Sediment distribution in Manchas Norte – March 2003

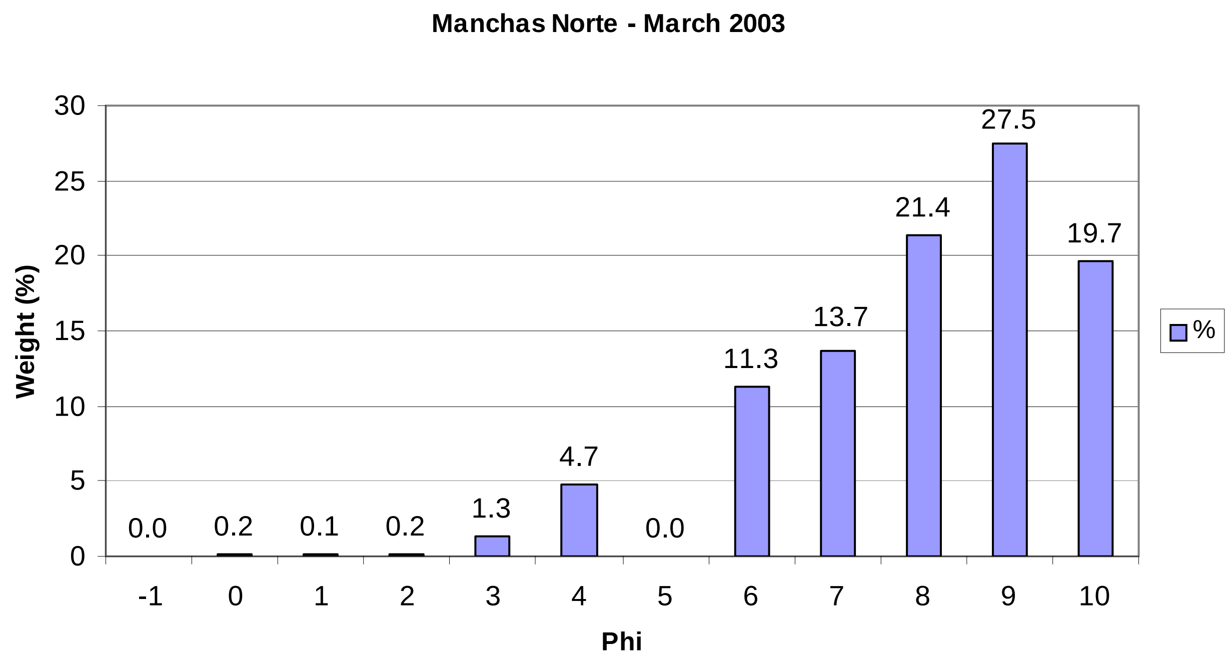


Figure 20 – Cumulative in Manchas Norte - March 2003

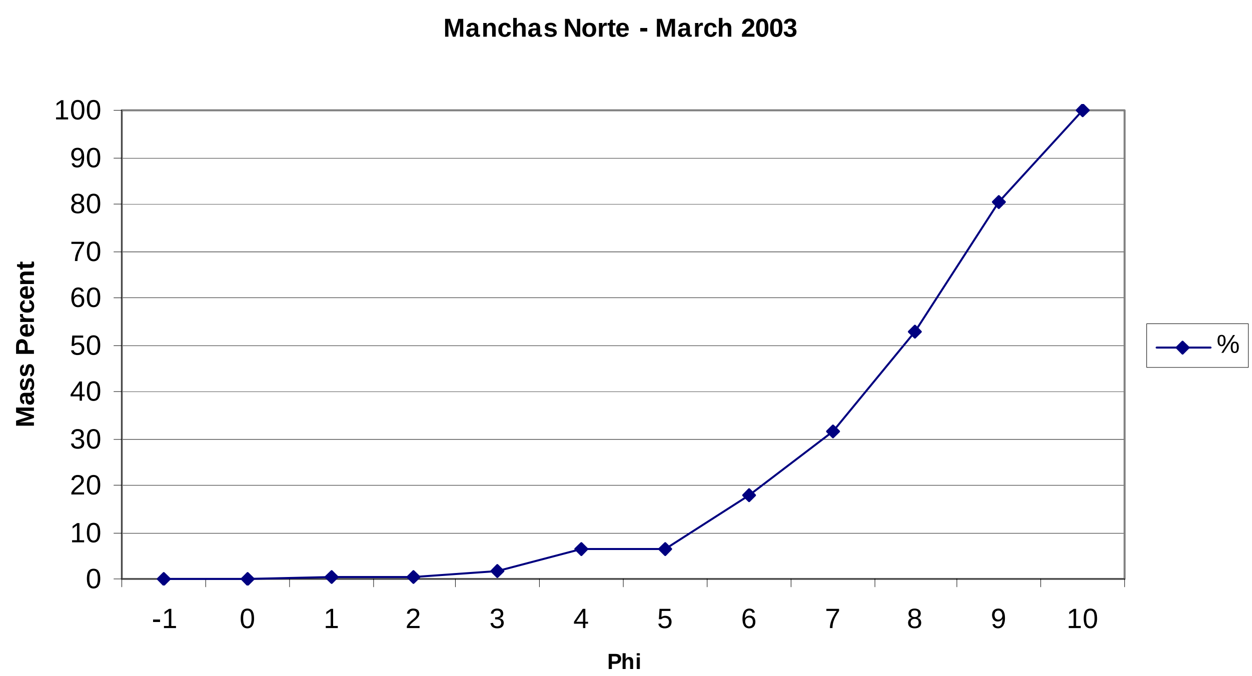


Figure 21 – Sediment distribution in Manchas Interiores 8 - September 2001

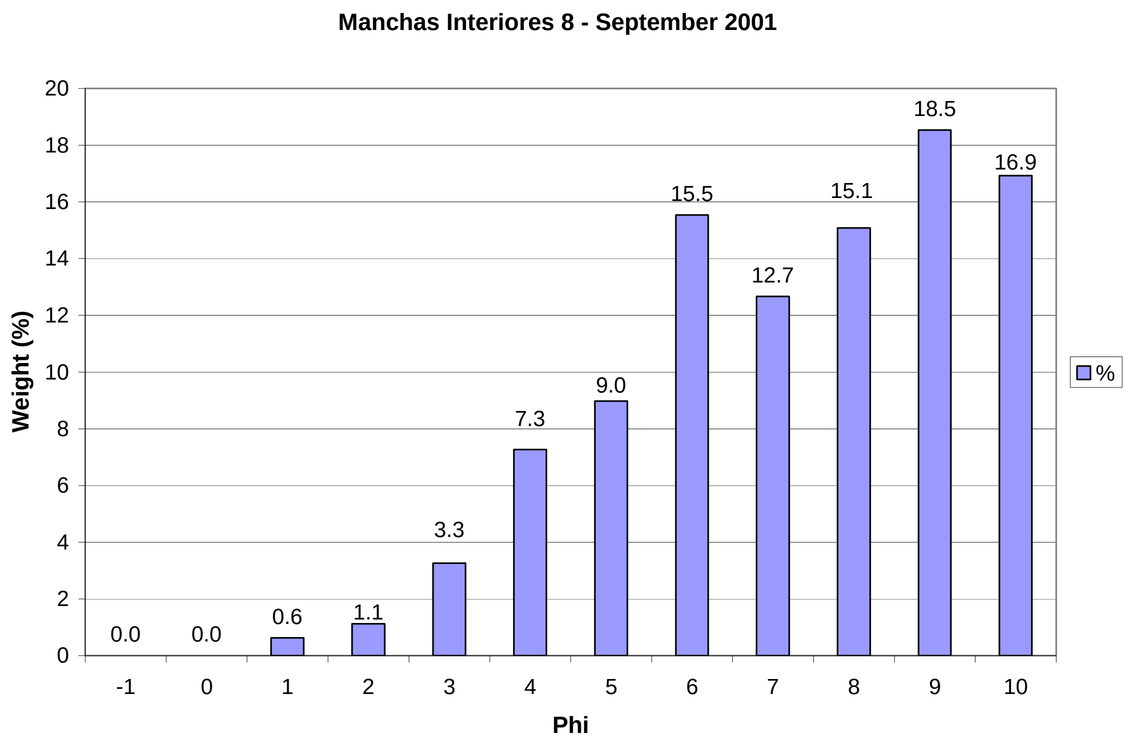


Figure 22 – Cumulative in Manchas Interiores 8 - September 2001

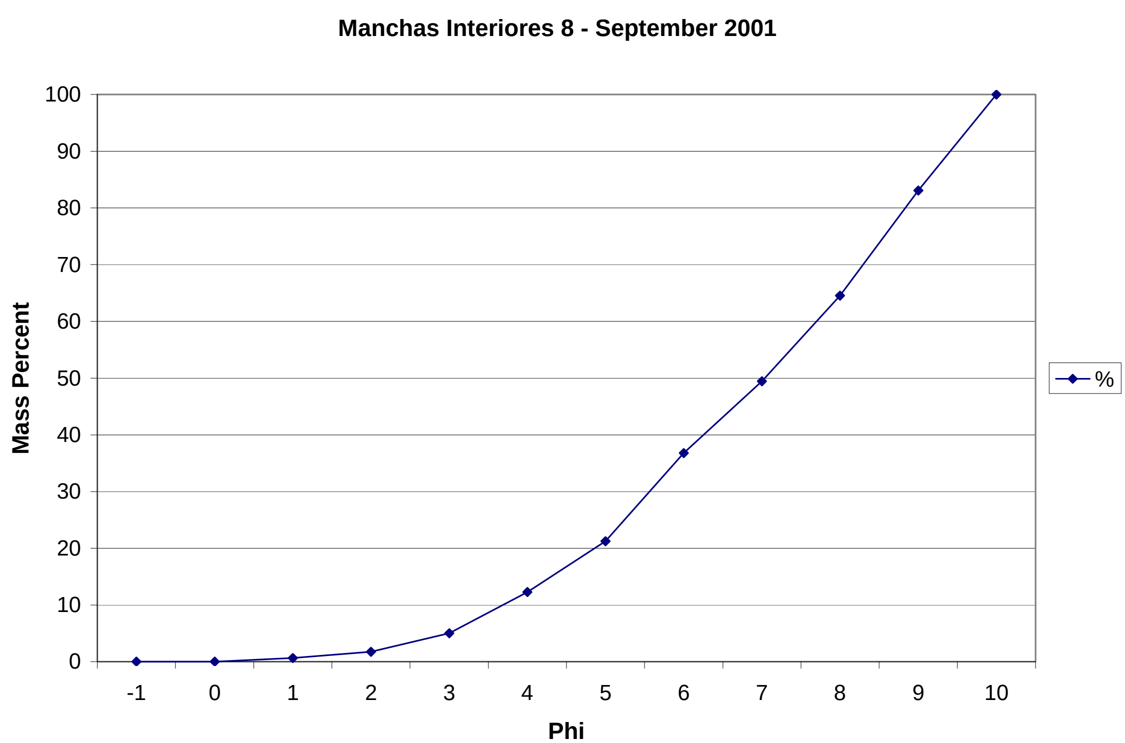


Figure 23 – Sediment distribution in Manchas Interiores 8 - December 2001

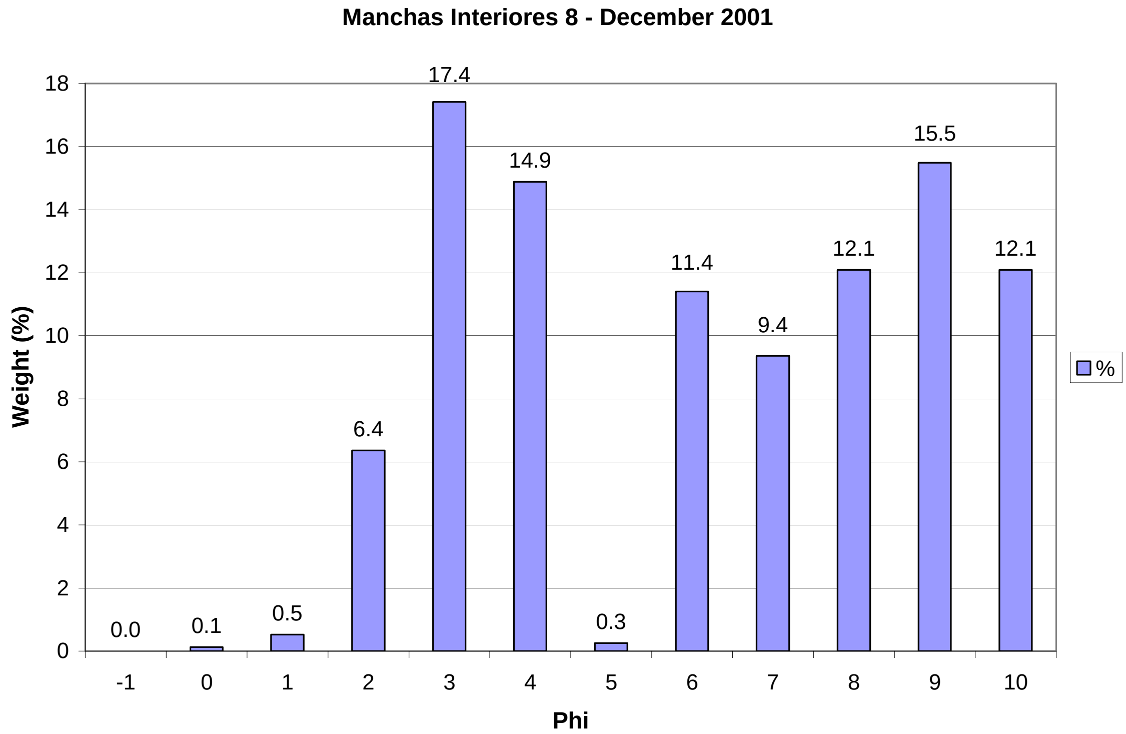


Figure 24 – Cumulative in Manchas Interiores 8 – December 2001

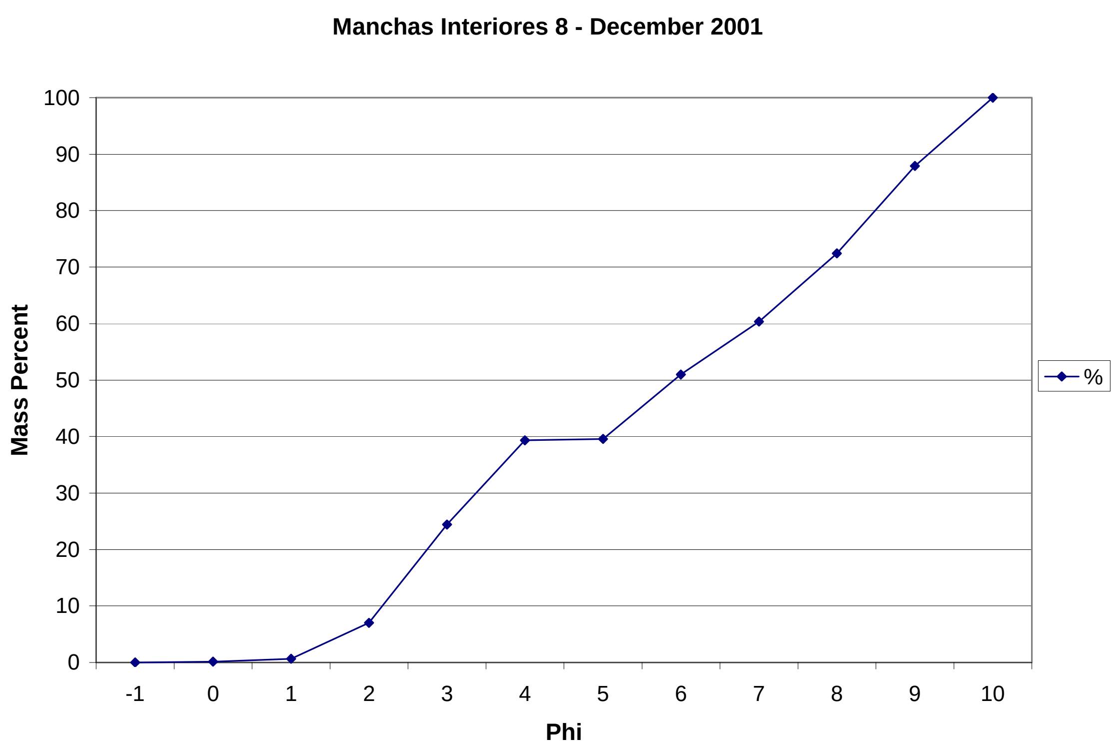


Figure 25 – Sediment distribution in Manchas Interiores 8 - March 2002

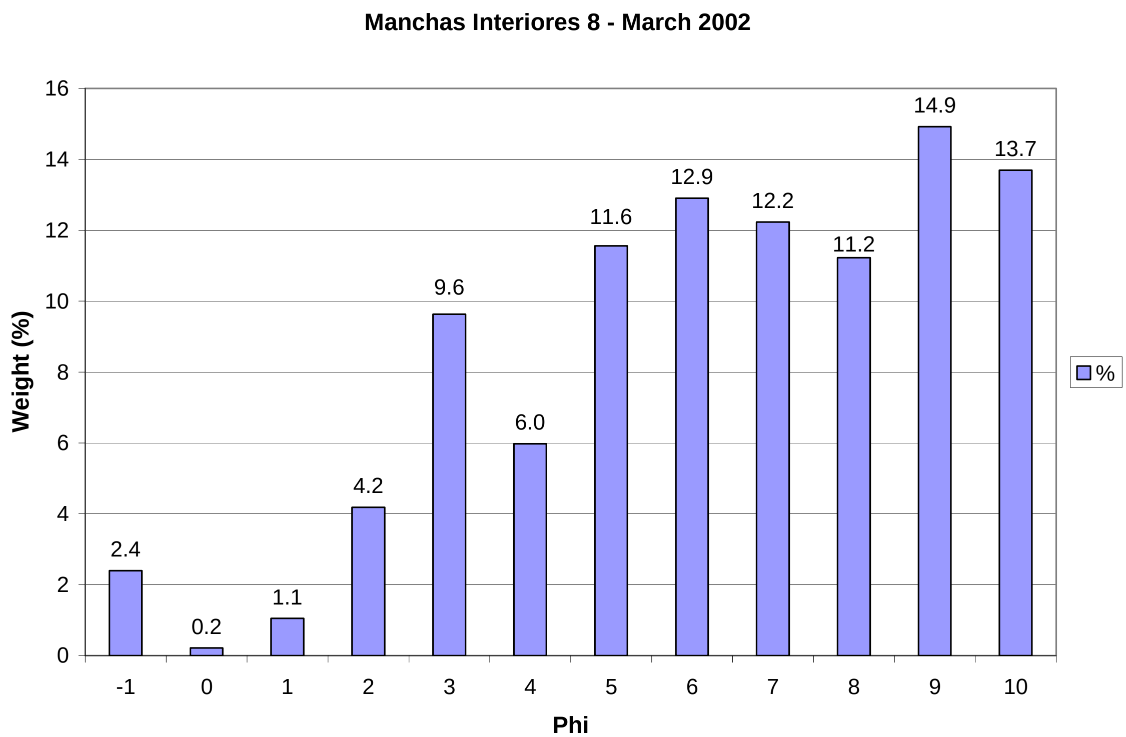


Figure 26 – Cumulative in Manchas Interiores 8 – March 2002

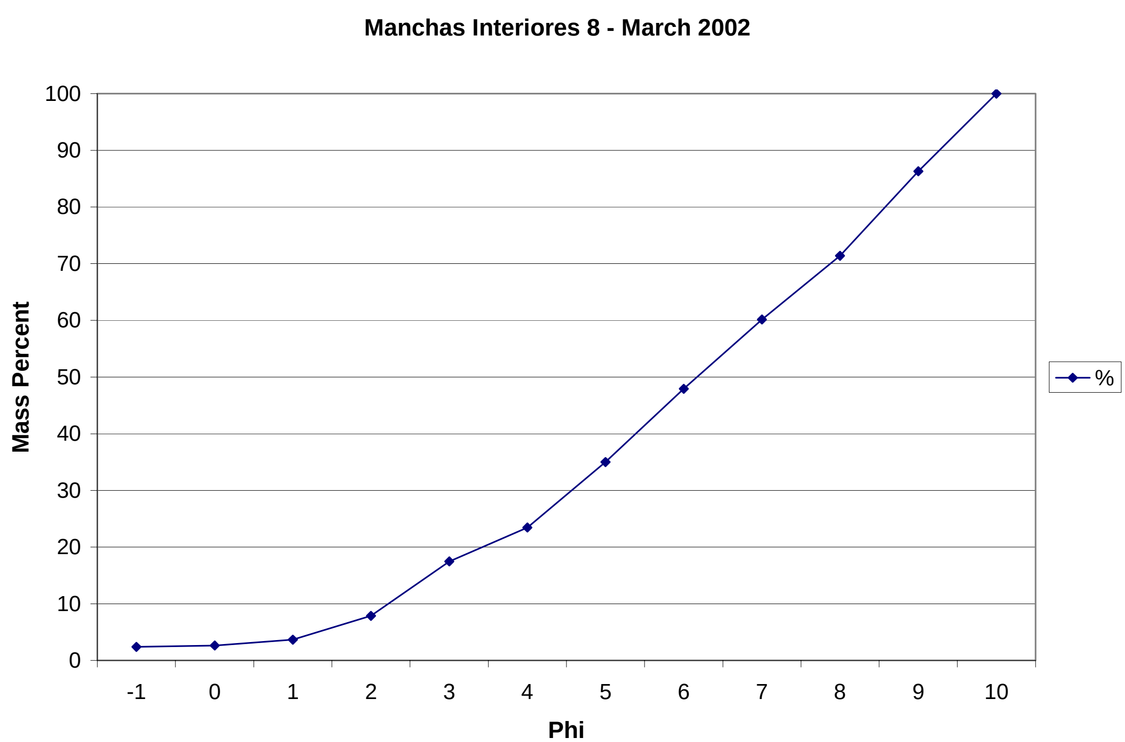


Figure 27 – Sediment distribution in Manchas Interiores 8 - July 2002

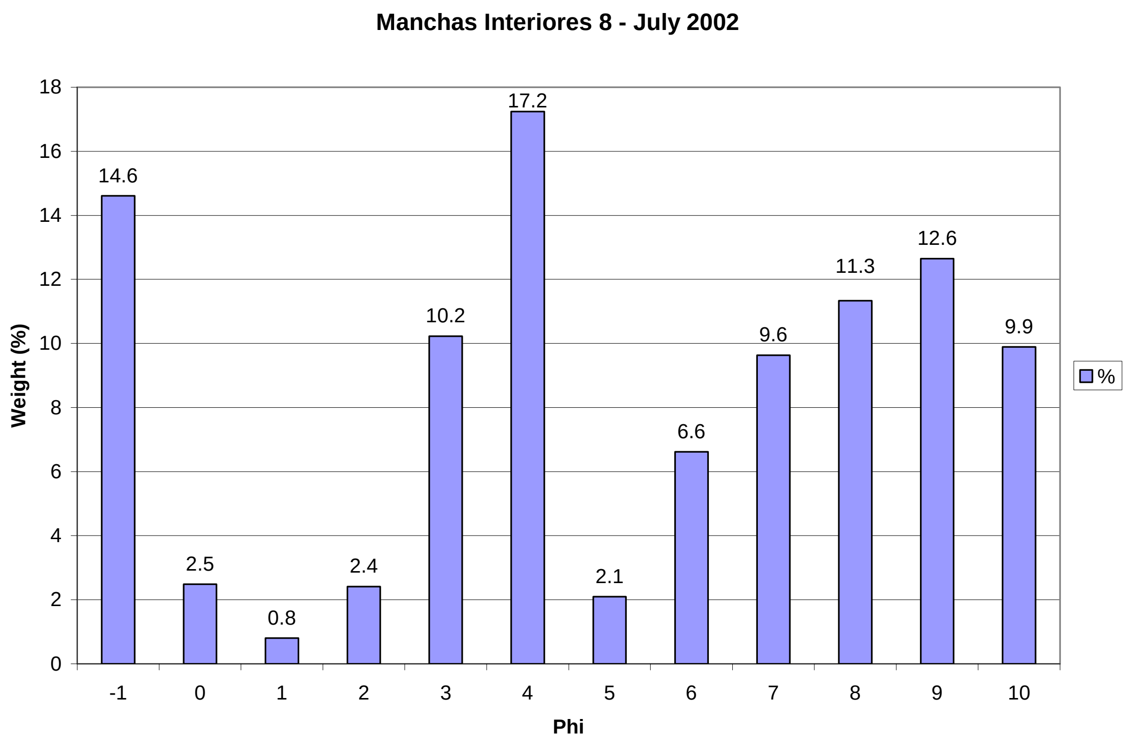


Figure 28 – Cumulative in Manchas Interiores 8 – July 2002

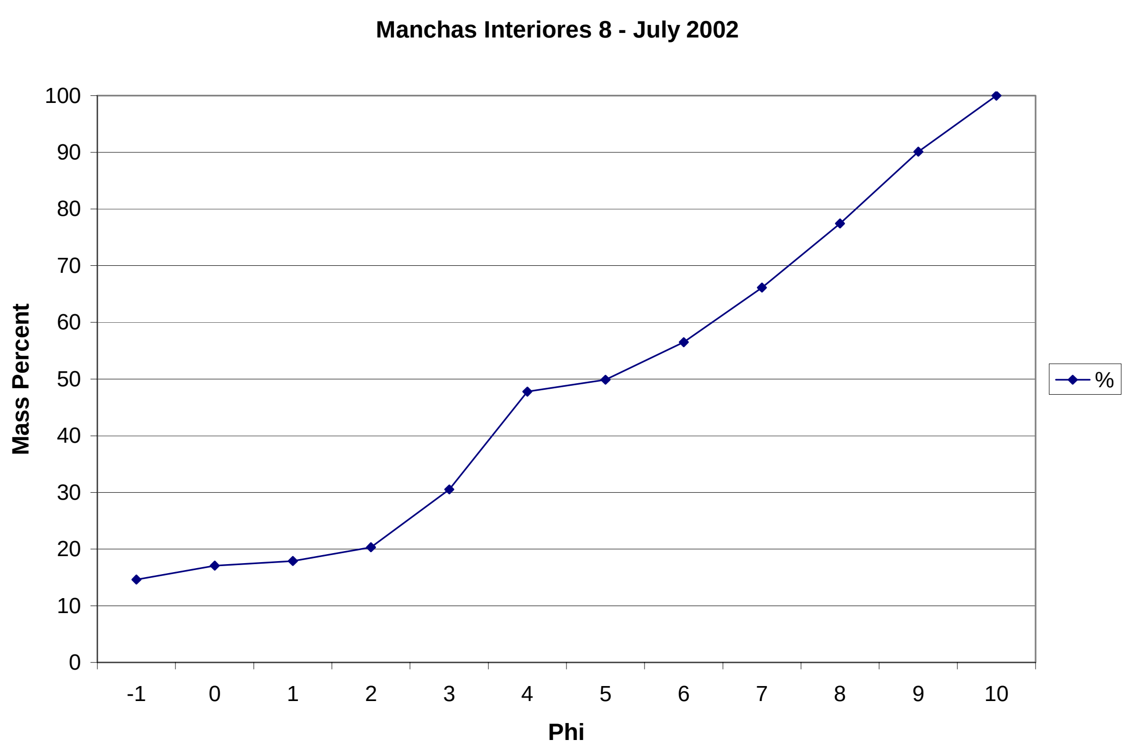


Figure 29 – Sediment distribution in Manchas Interiores 8 - October 2002

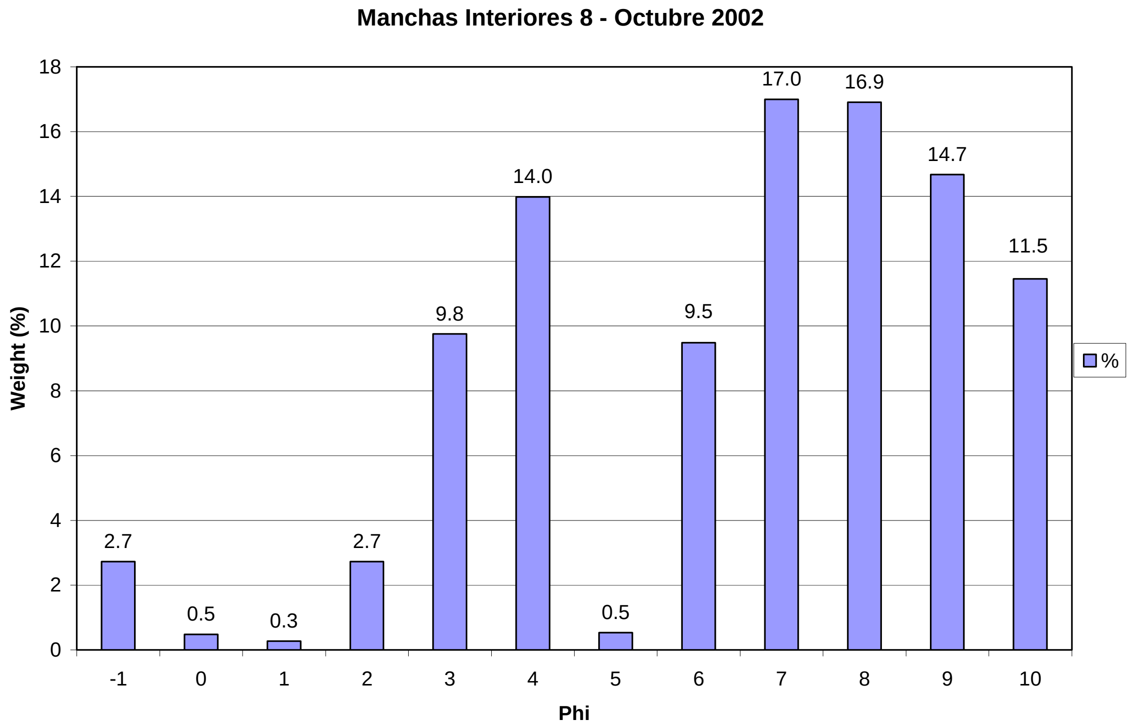


Figure 30 – Cumulative in Manchas Interiores 8 – October 2002

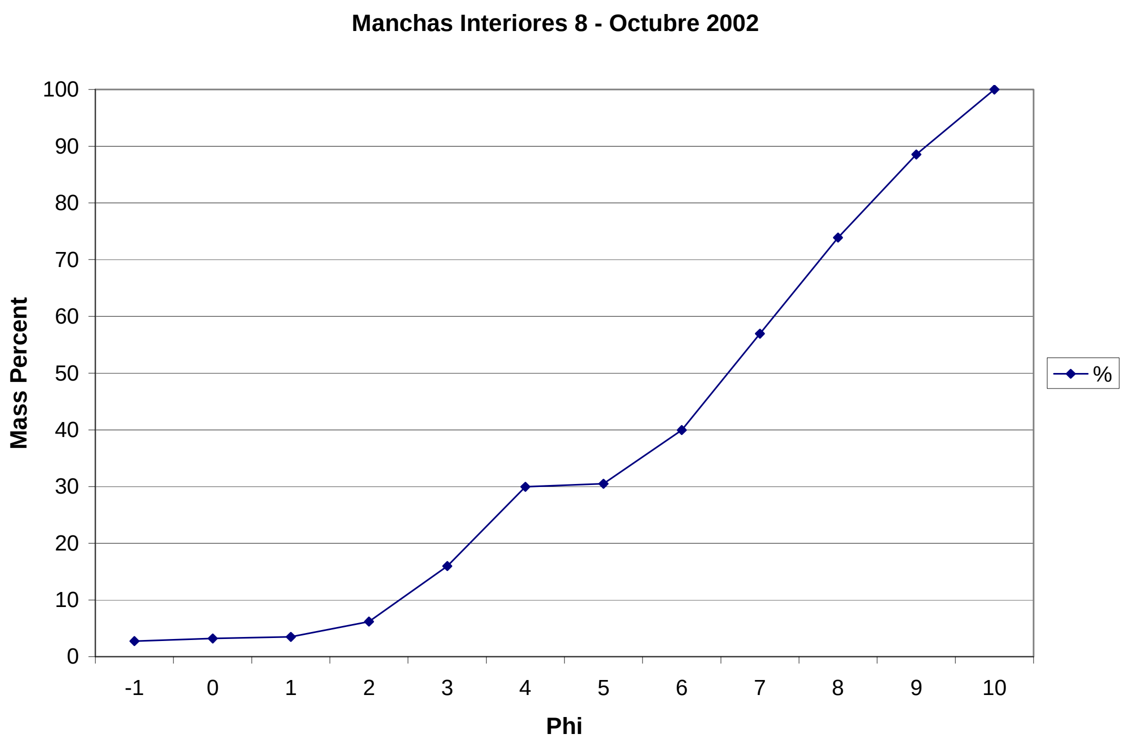


Figure 31 – Sediment distribution in Manchas Interiores 8 - December 2002.

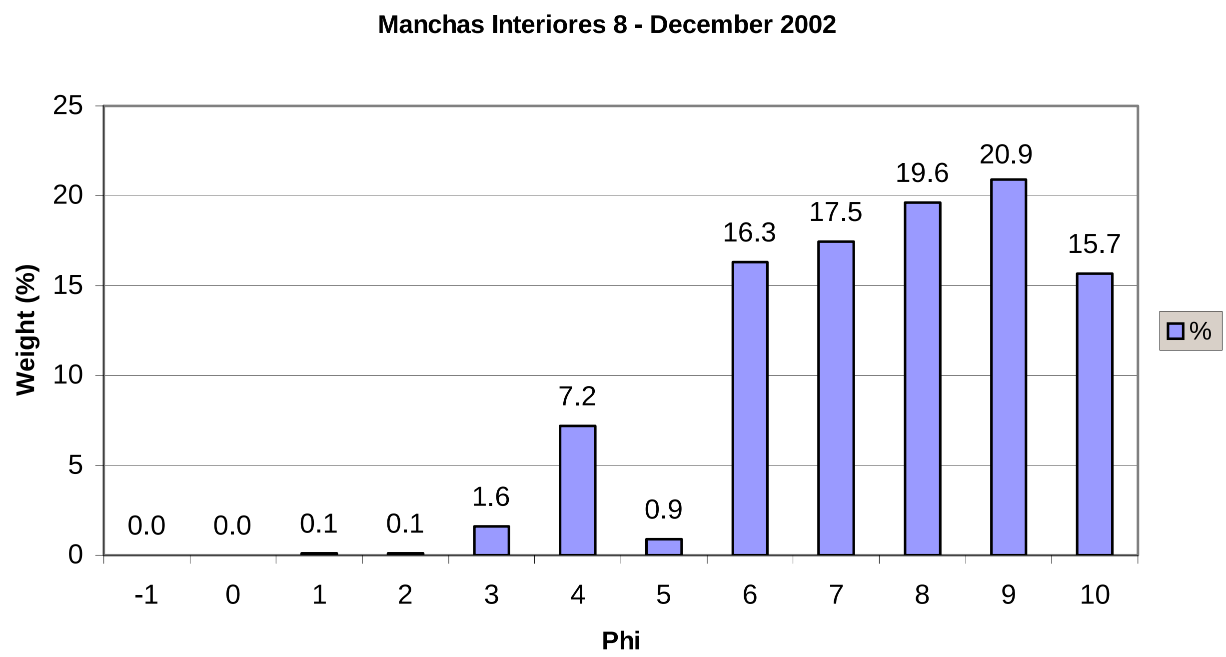


Figure 32 – Cumulative in Manchas Interiores 8 - December 2002

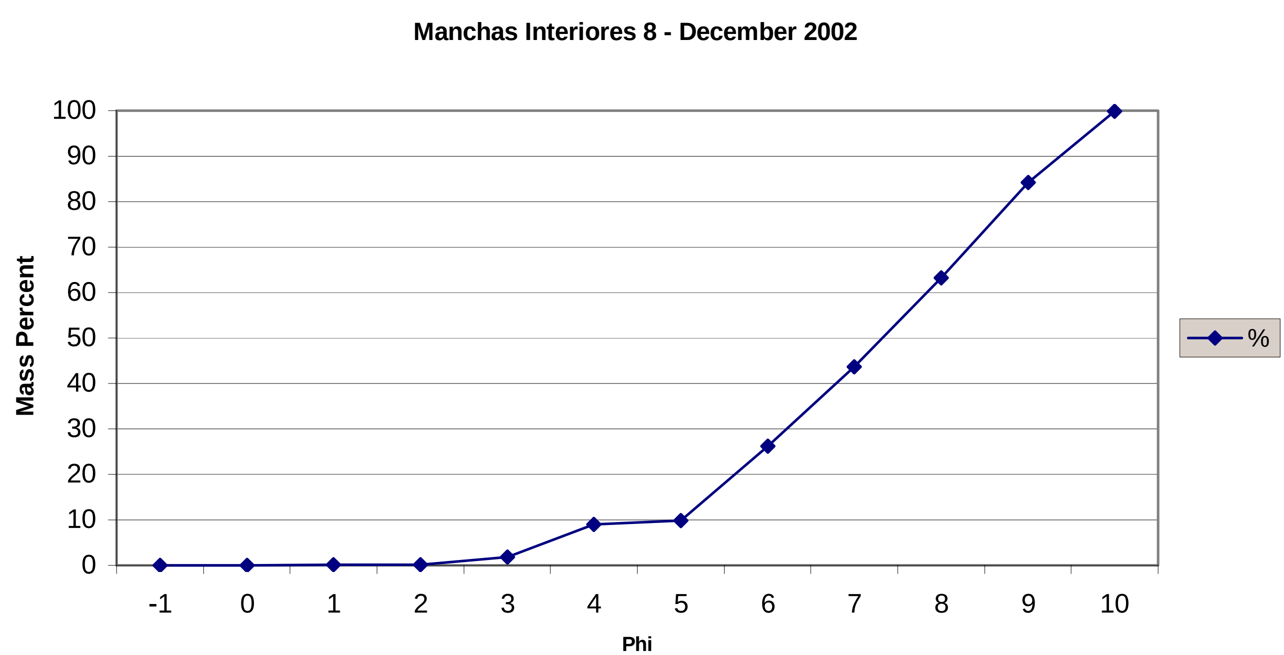


Figure 33 – Sediment distribution in Manchas Interiores 8 – March 2003

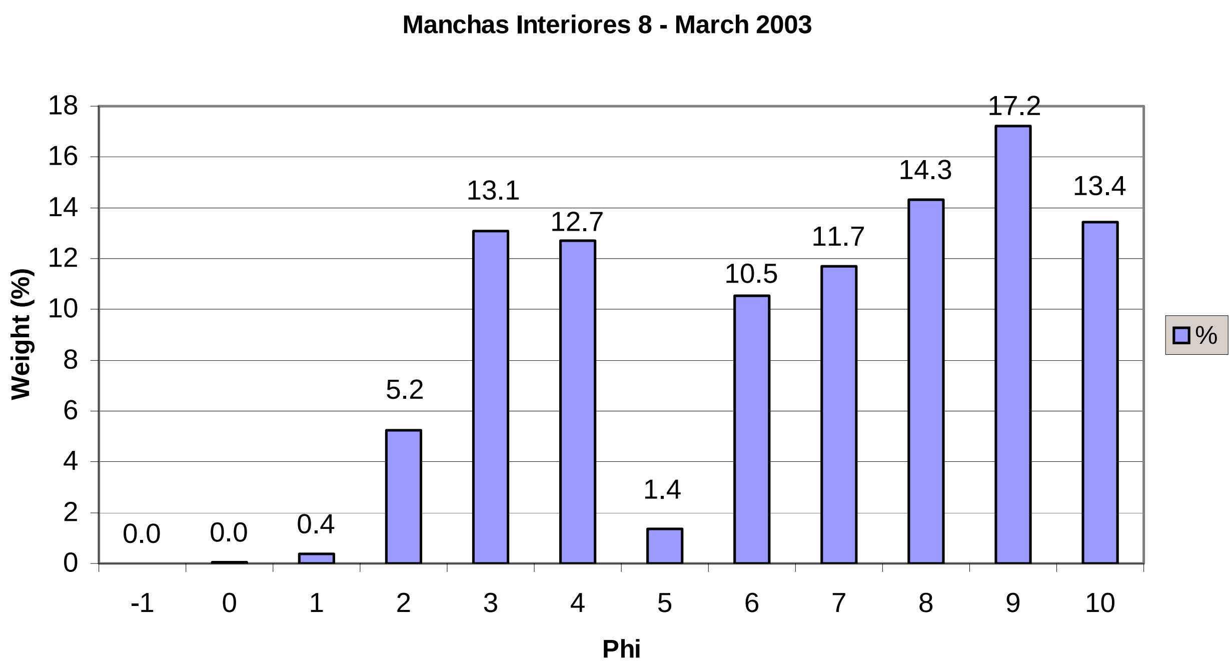


Figure 34 – Cumulative curve in Manchas Interiores 8 – March 2003

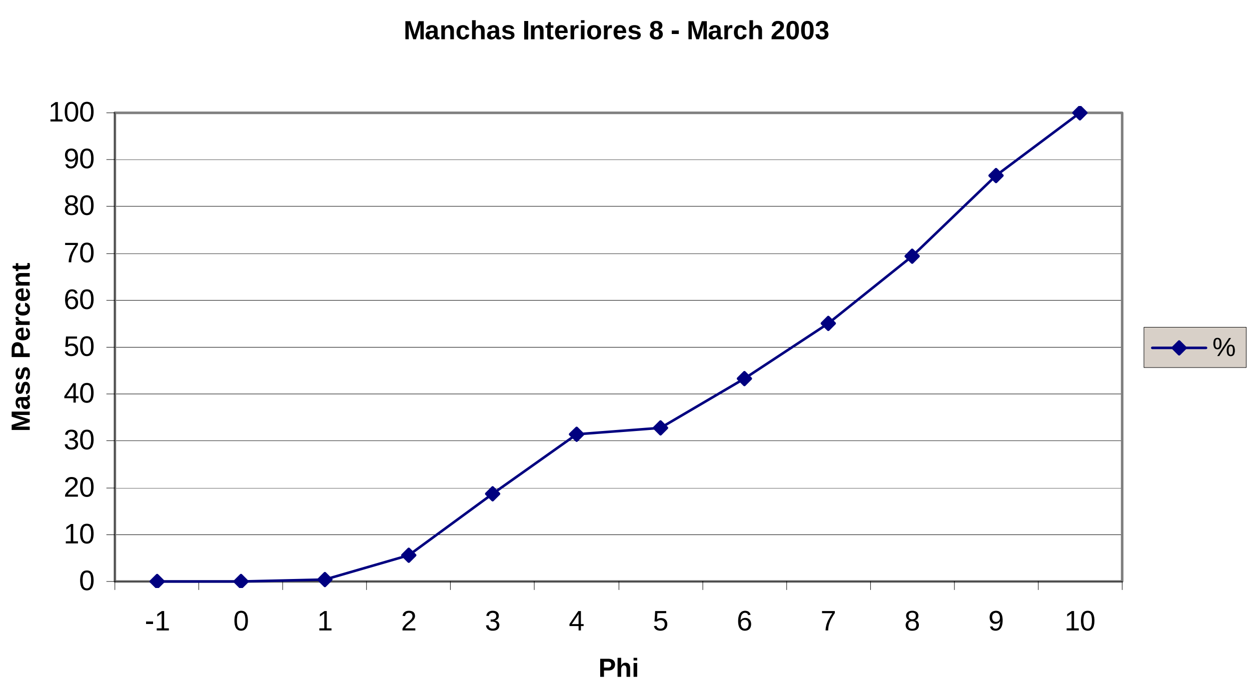


Figure 35 – Sediment distribution in Escollo Negro – June 2001

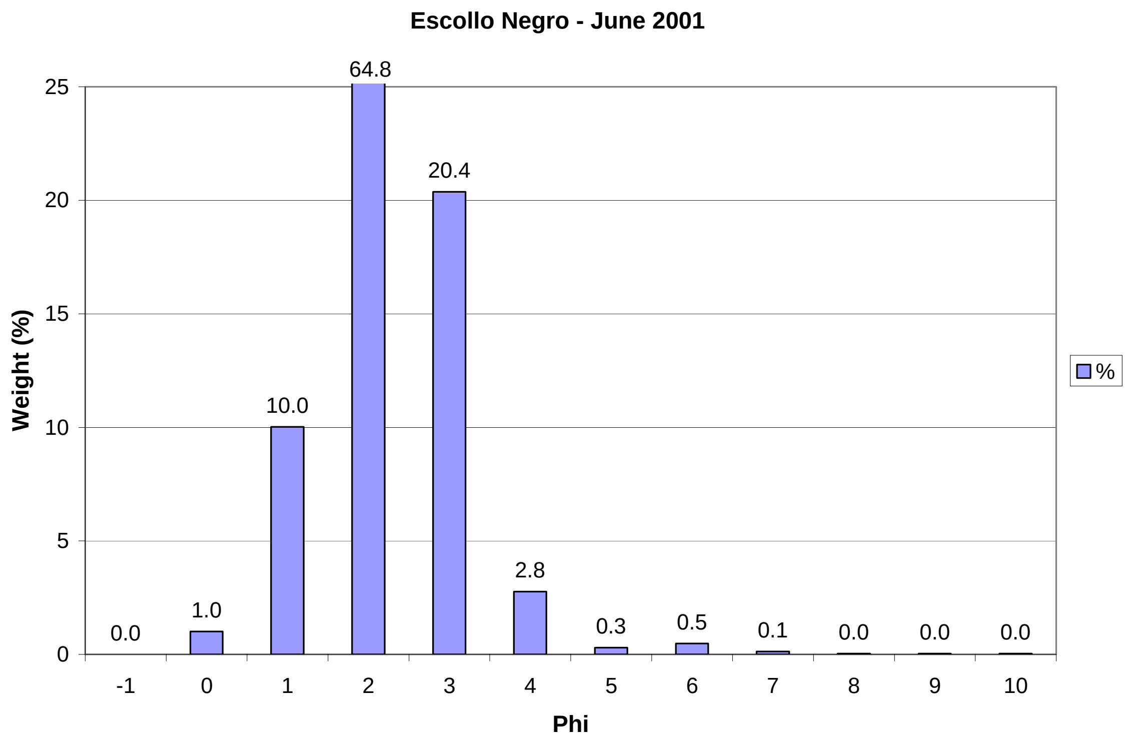


Figure 36 – Cumulative Curve in Escollo Negro – June 2001

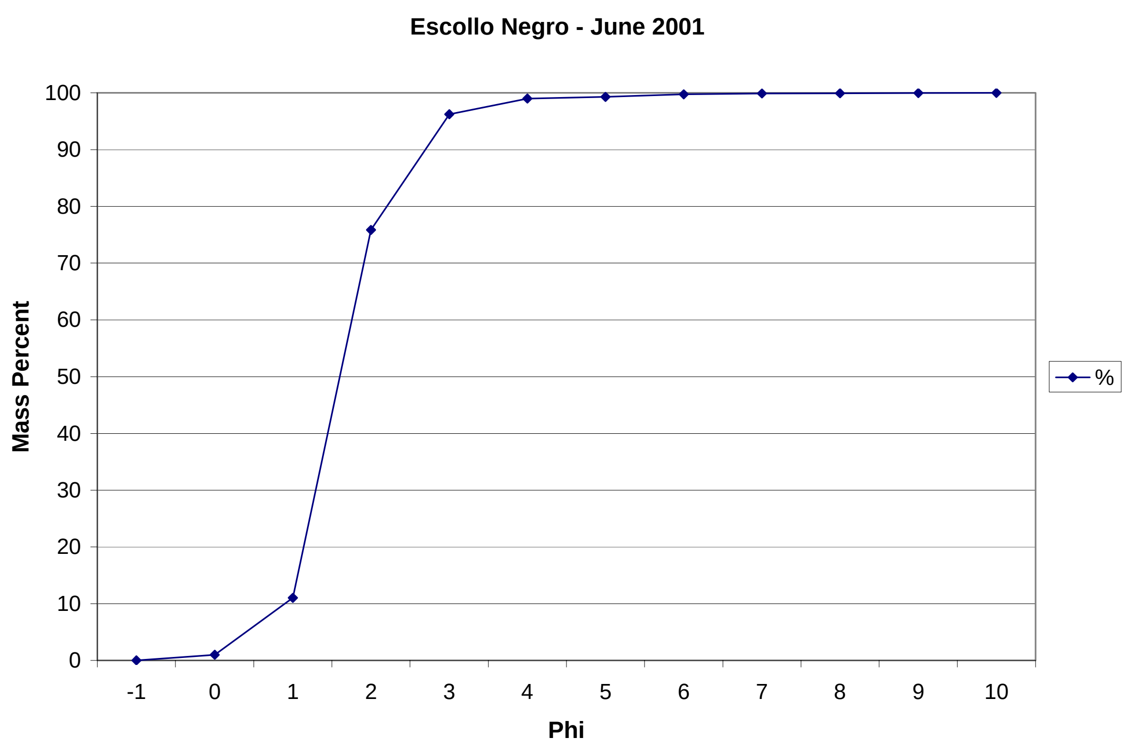


Figure 37 – Sediment distribution in Escollo Negro – December 2001

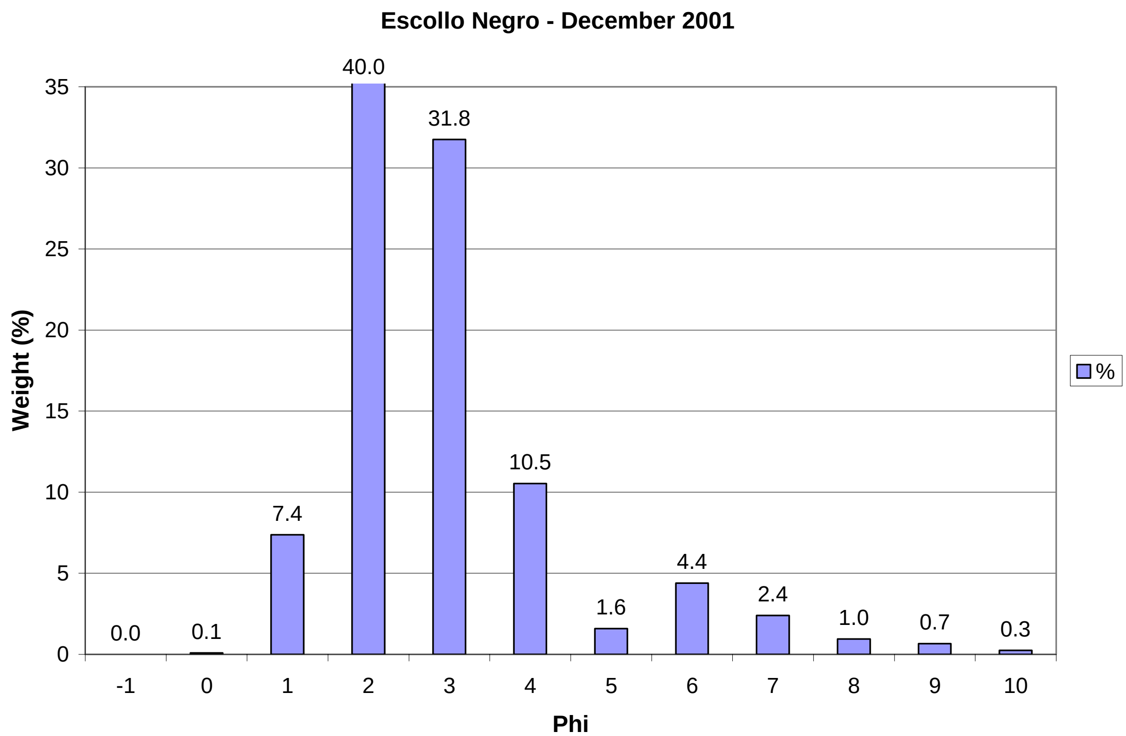


Figure 38 – Cumulative Curve in Escollo Negro – December 2001

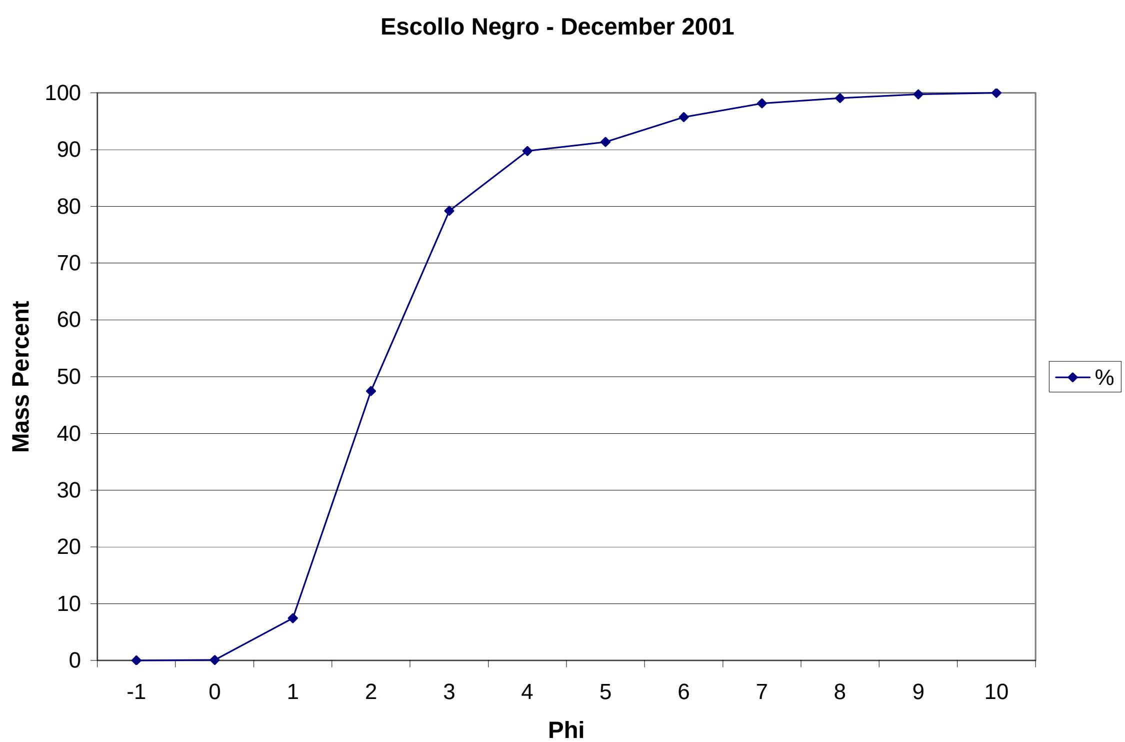


Figure 39 – Sediment distribution in Escollo Negro – March 2002

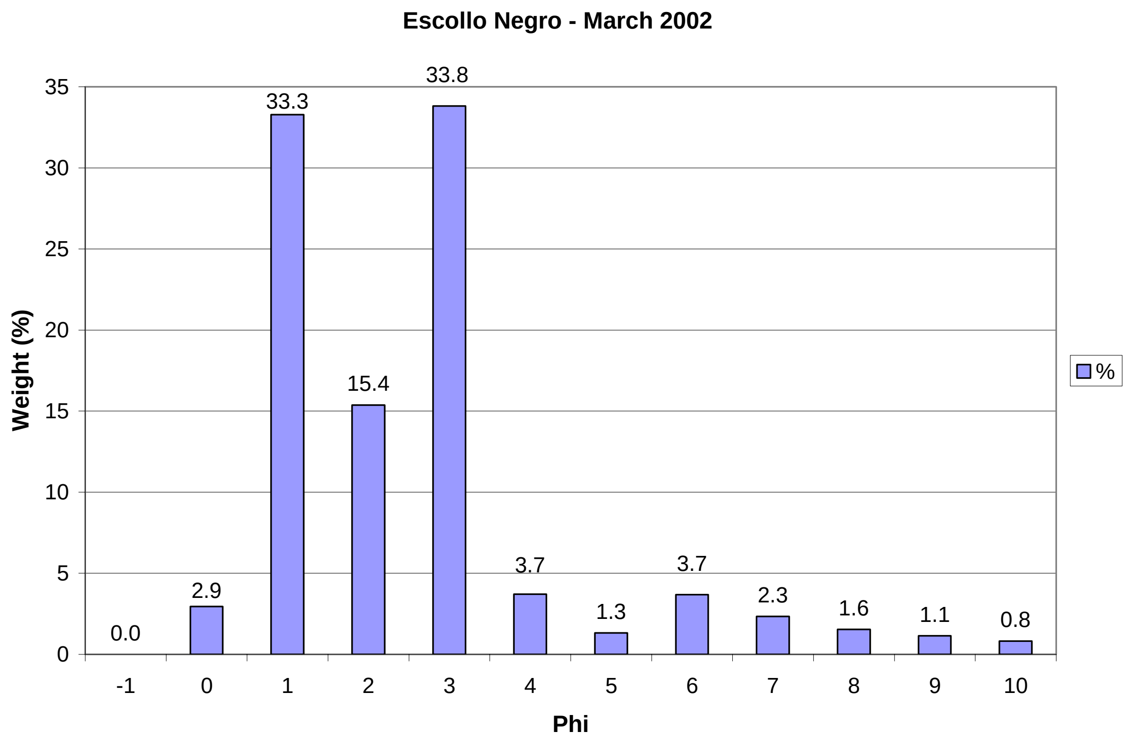


Figure 40 – Cumulative Curve in Escollo Negro – March 2002

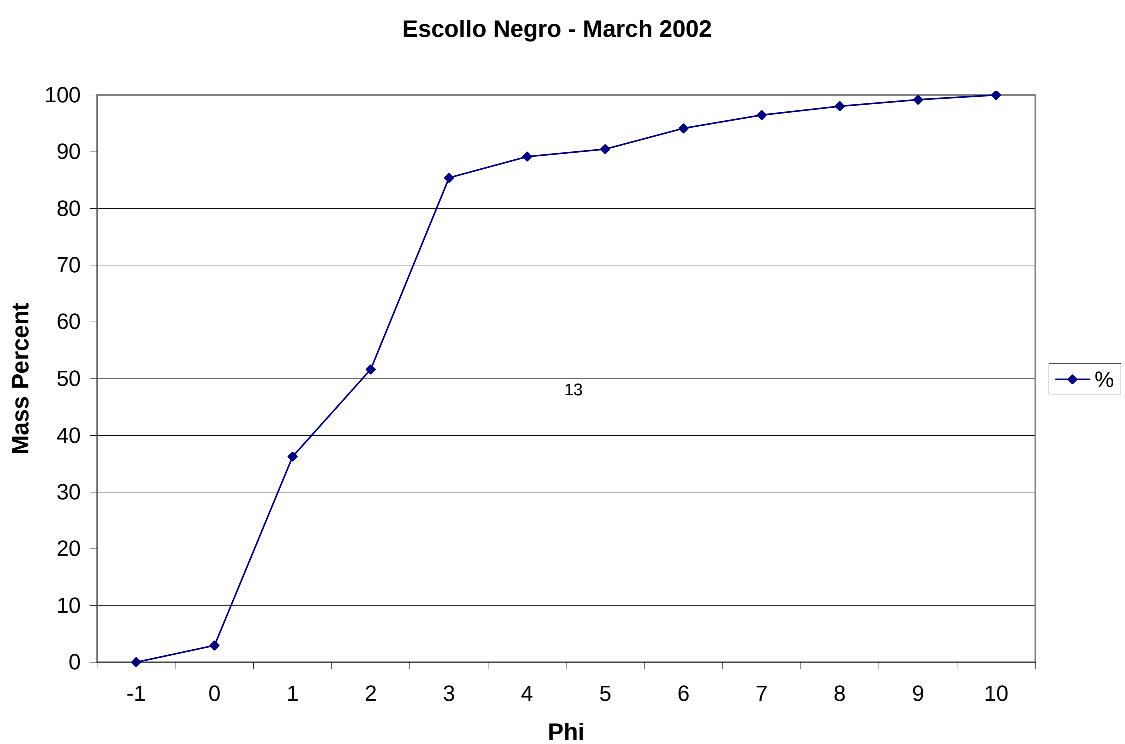


Figure 41 – Sediment distribution in Escollo Negro – July 2002

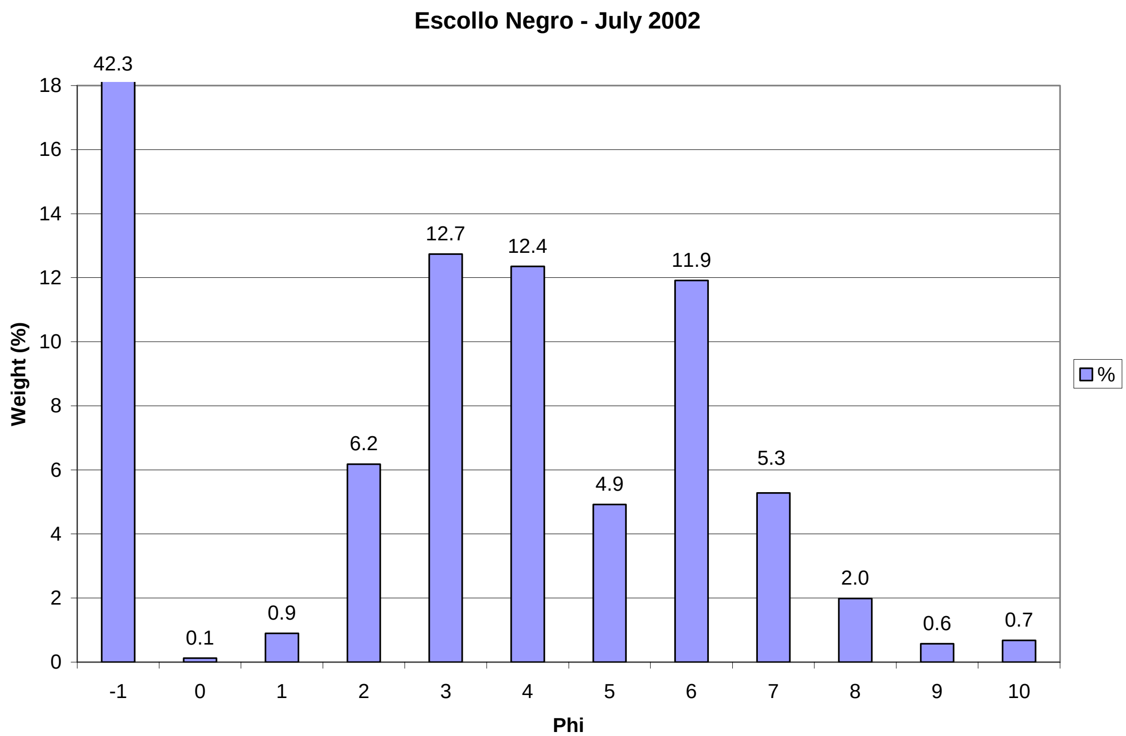


Figure 42 – Cumulative Curve in Escollo Negro – July 2002

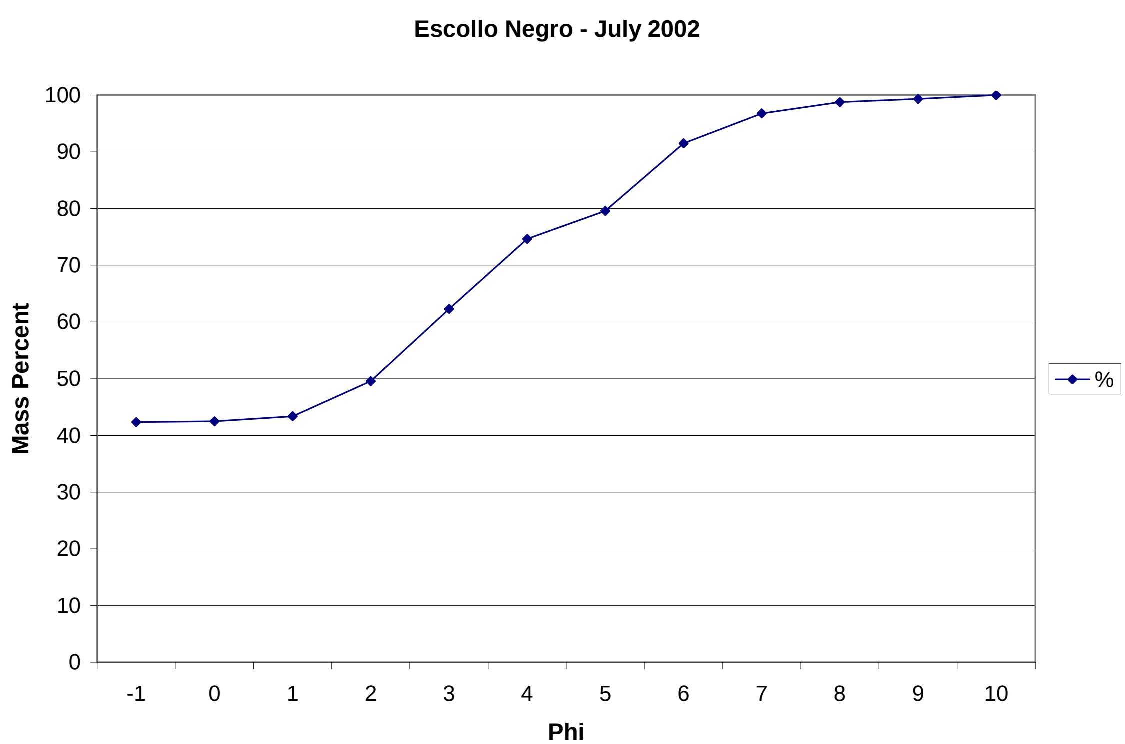


Figure 43 – Sediment distribution in Escollo Negro – October 2002

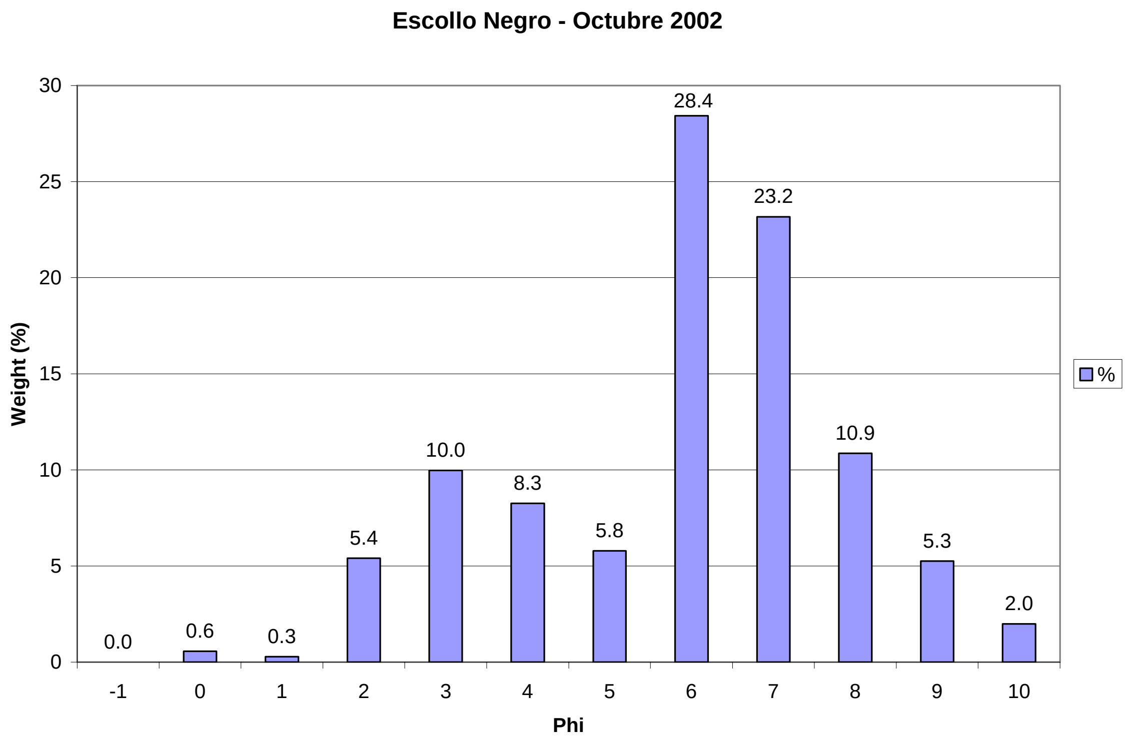


Figure 44 – Cumulative Curve in Escollo Negro – October 2002

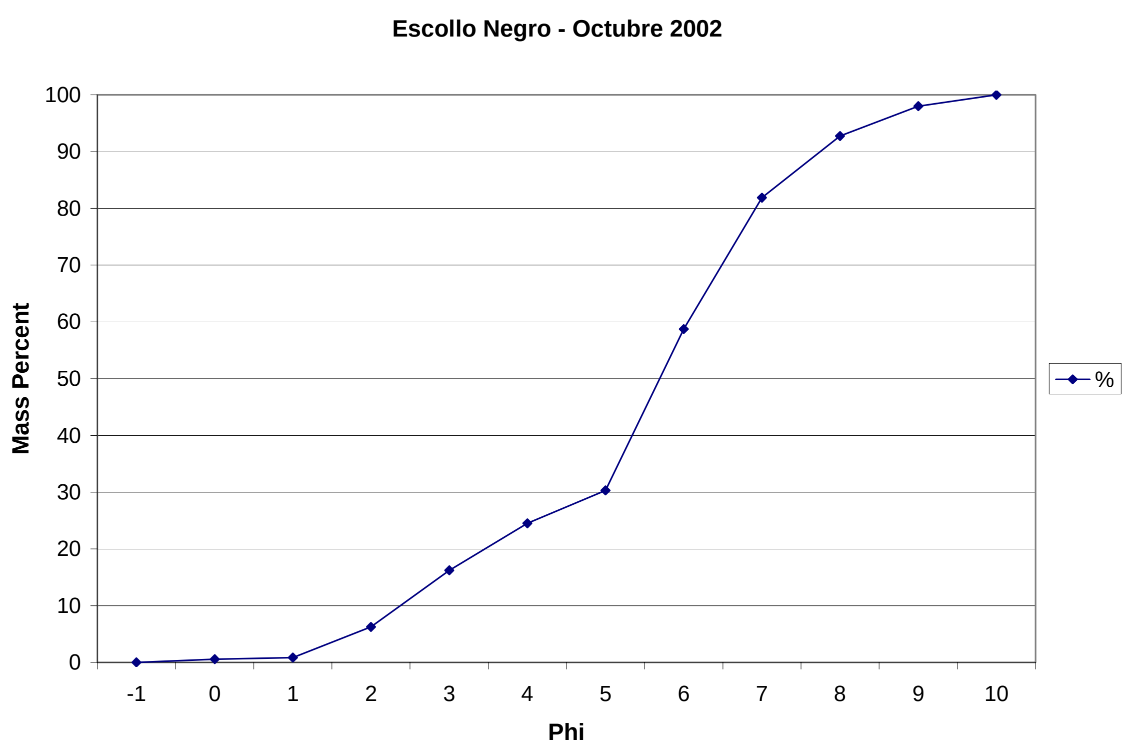


Figure 45 – Sediment distribution in Escollo Negro – December 2002

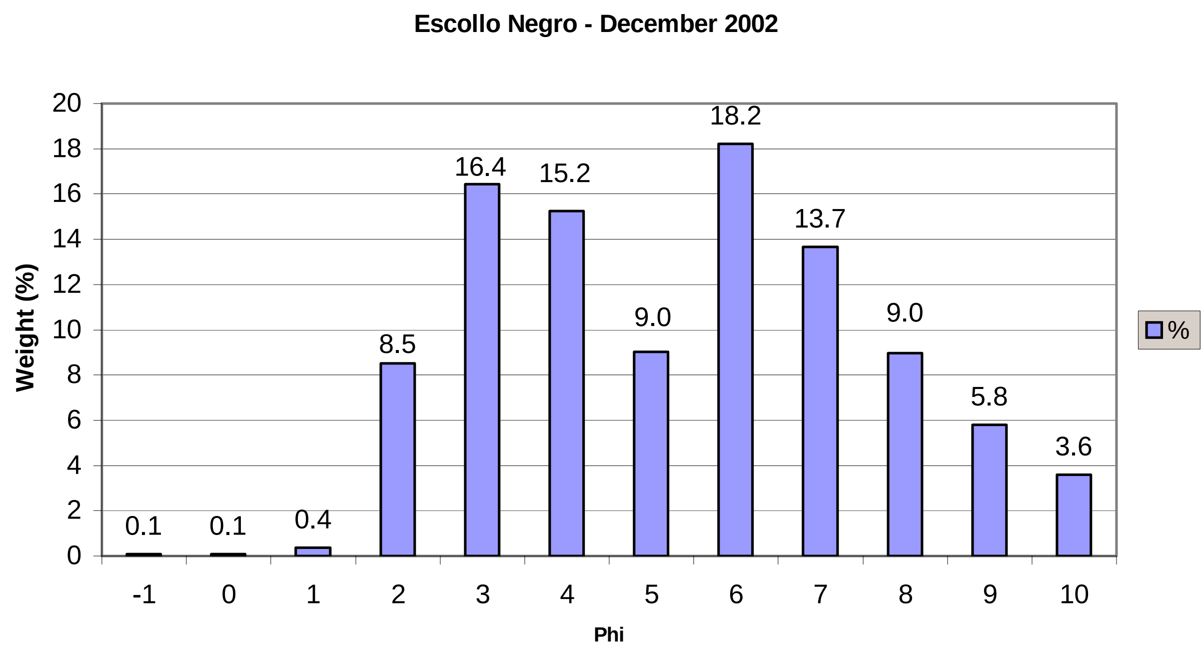


Figure 46 – Cumulative Curve in Escollo Negro – December 2002

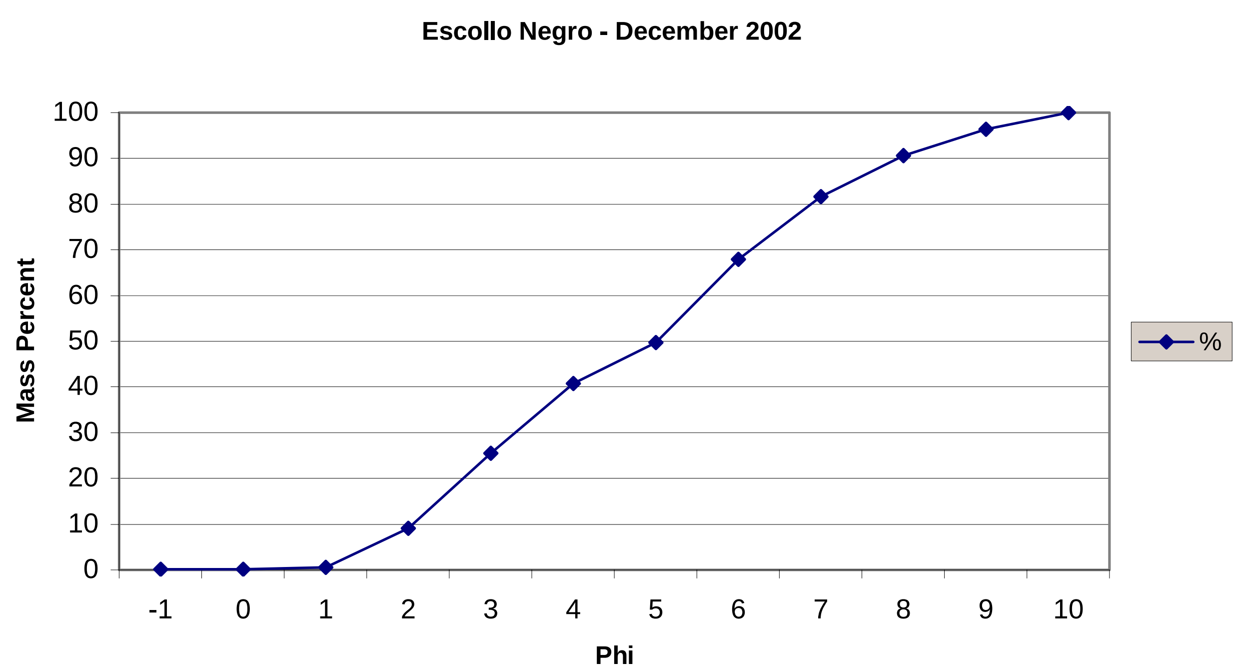


Figure 47 - Sediment distribution in Escollo Negro – March 2003

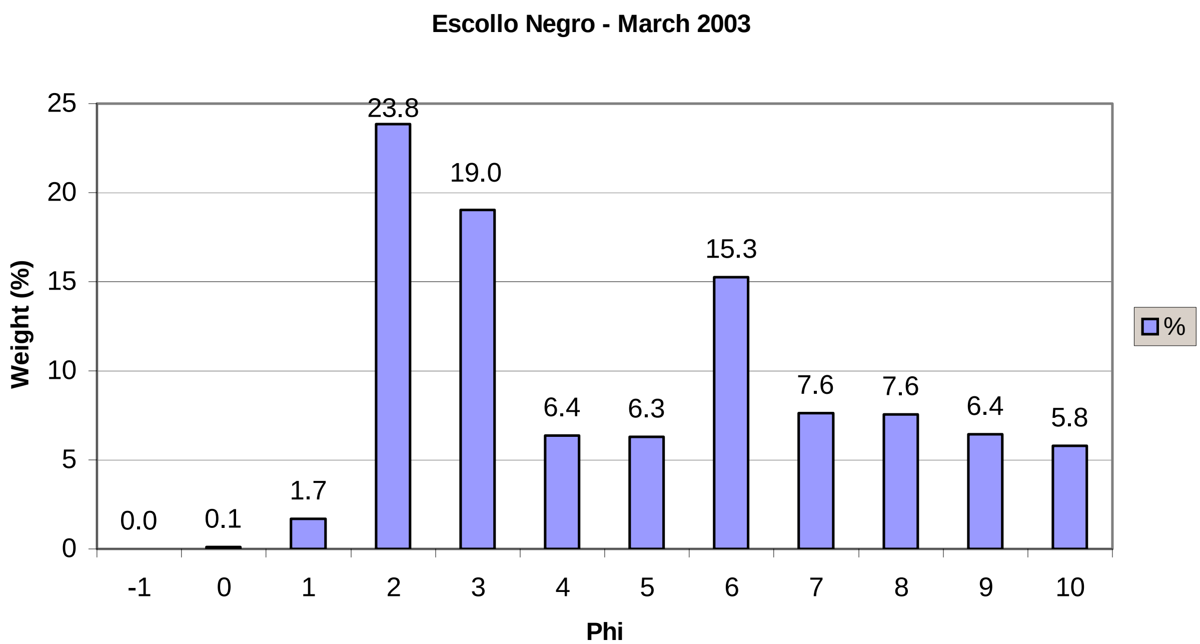


Figure 48 – Cumulative Curve in Escollo Negro – March 2003

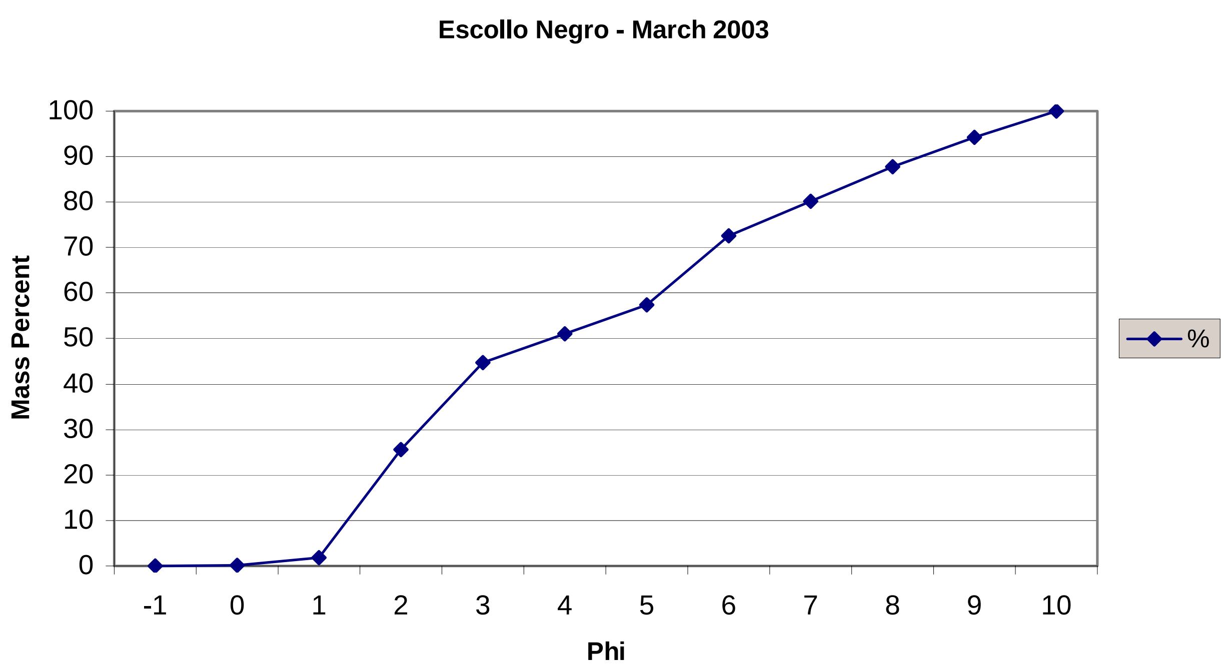


Figure 49 - Sediment distribution in Algarrobo – September 2001

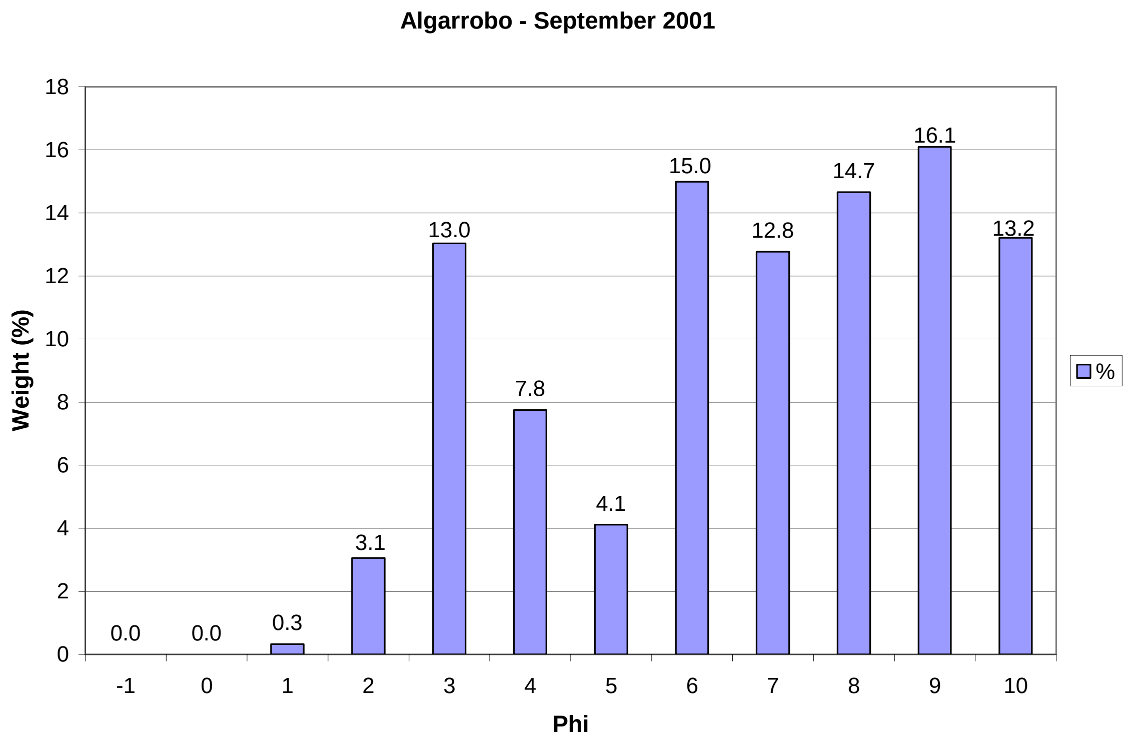


Figure 50 – Cumulative Curve in Algarrobo – September 2001

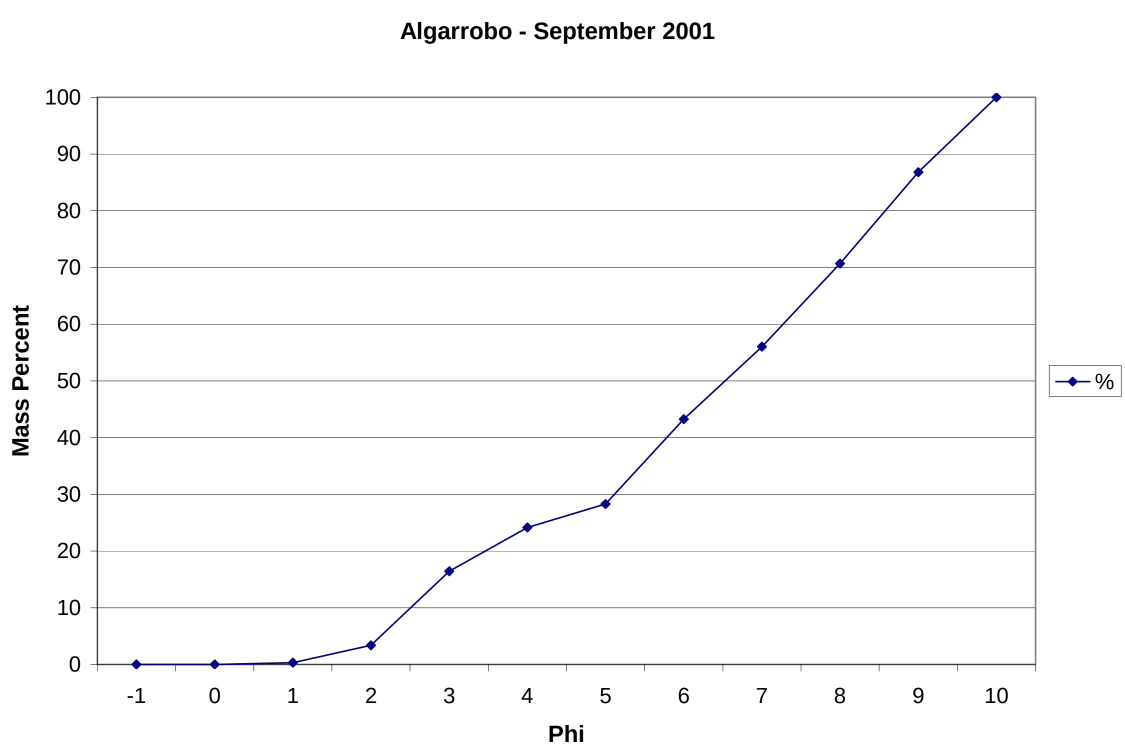


Figure 51 - Sediment distribution in Algarrobo – December 2001

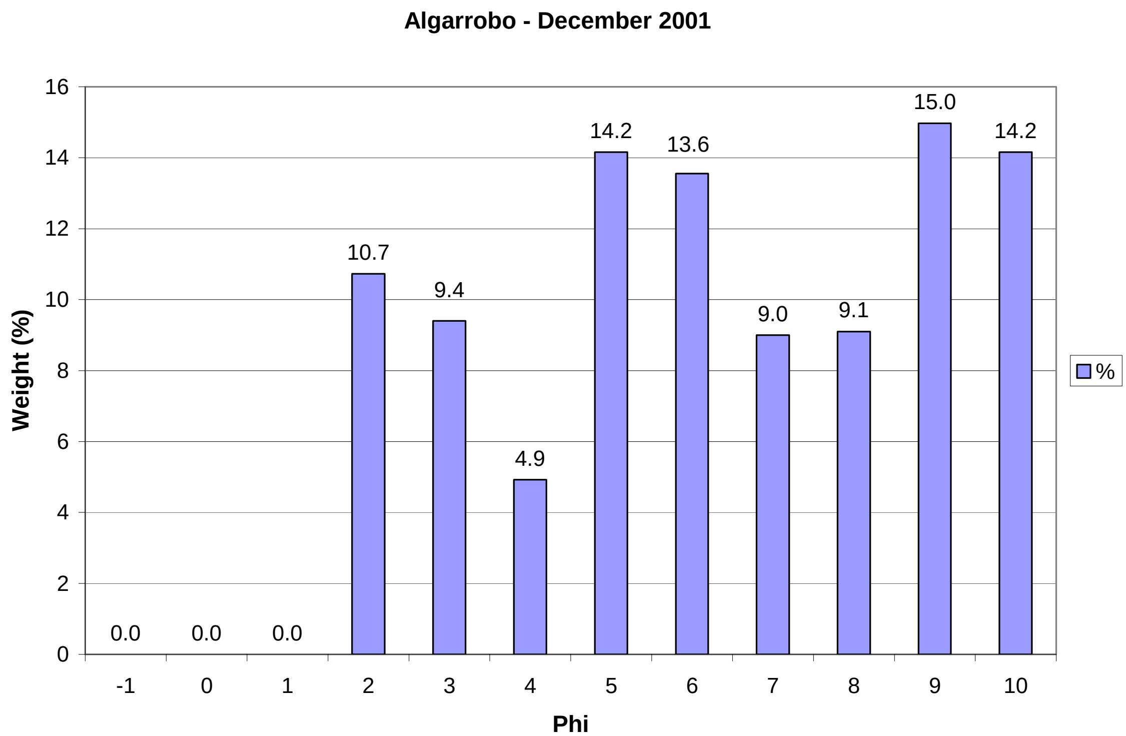


Figure 52 – Cumulative Curve in Algarrobo – December 2001

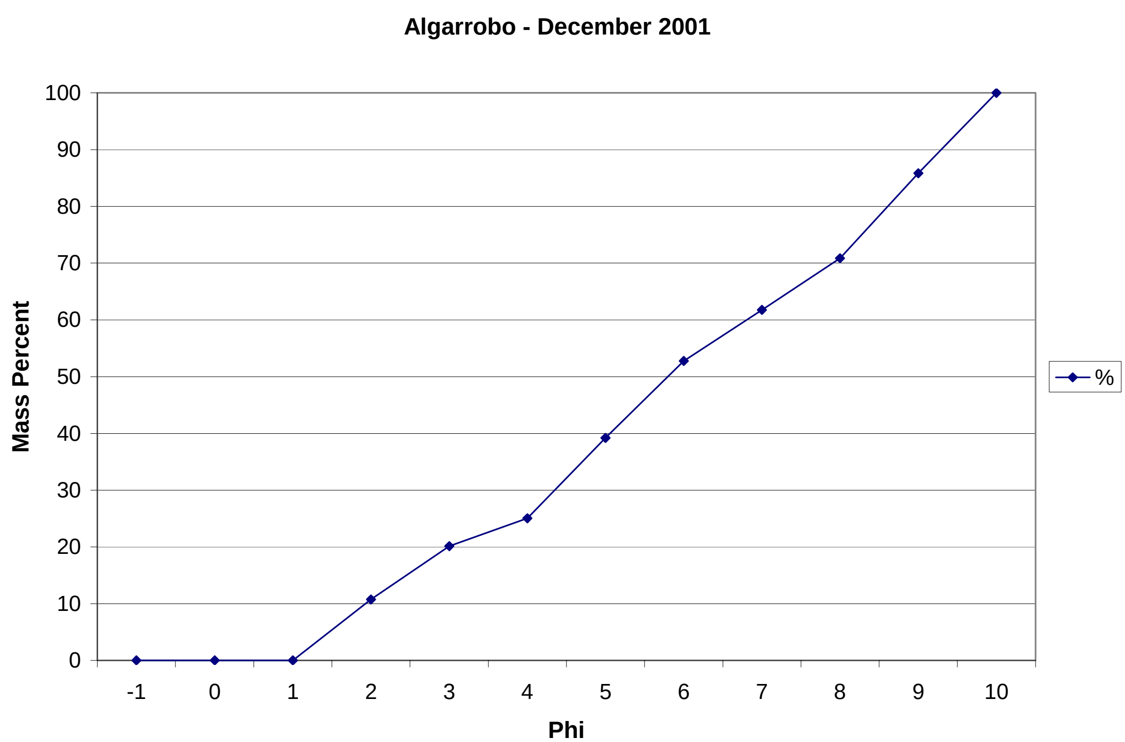


Figure 53 - Sediment distribution in Algarrobo – March 2002

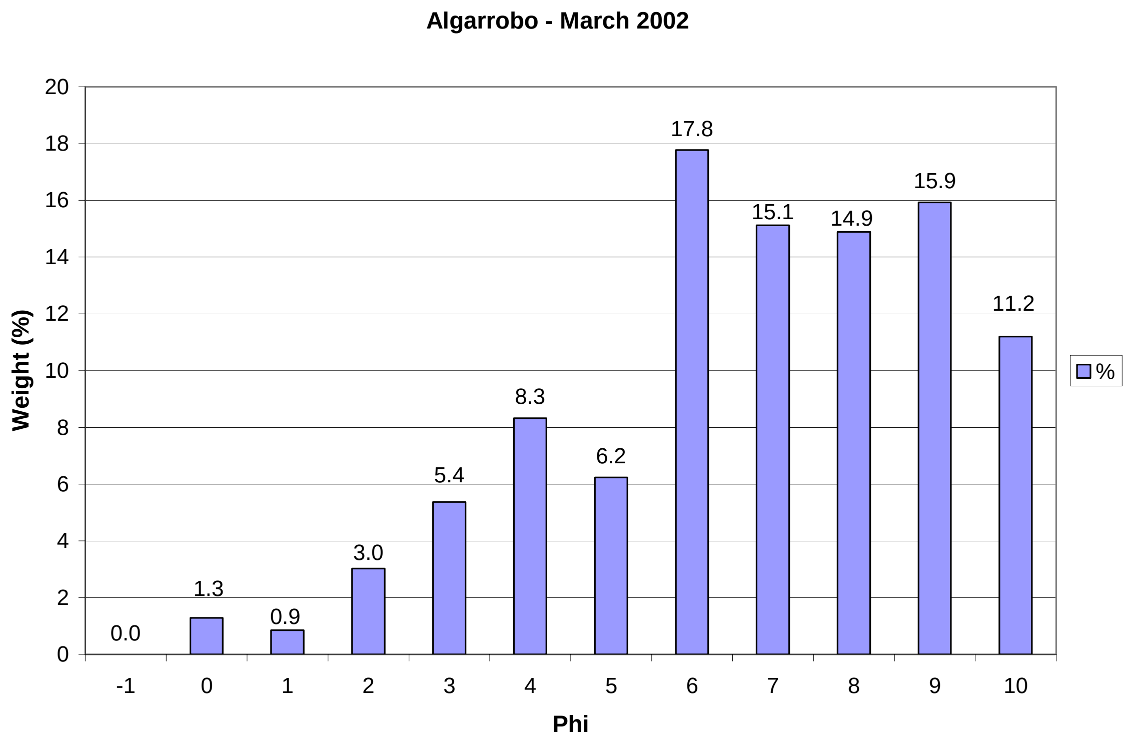


Figure 54 – Cumulative Curve in Algarrobo – March 2002

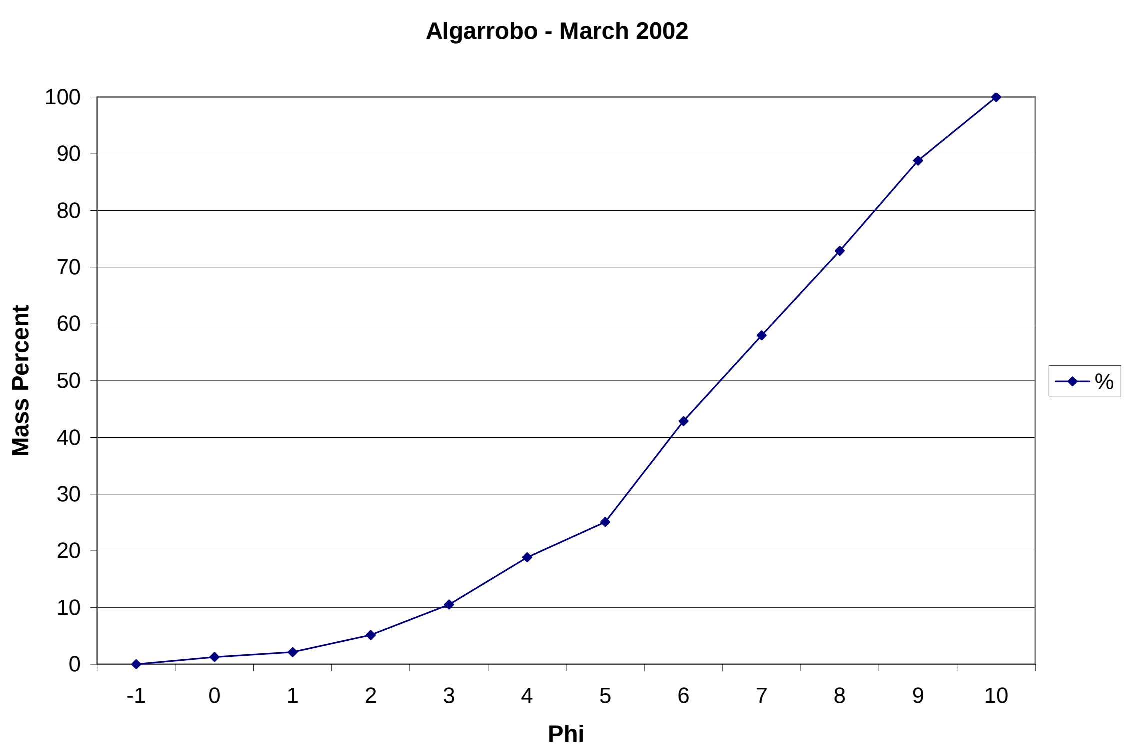


Figure 55 - Sediment distribution in Algarrobo – October 2002

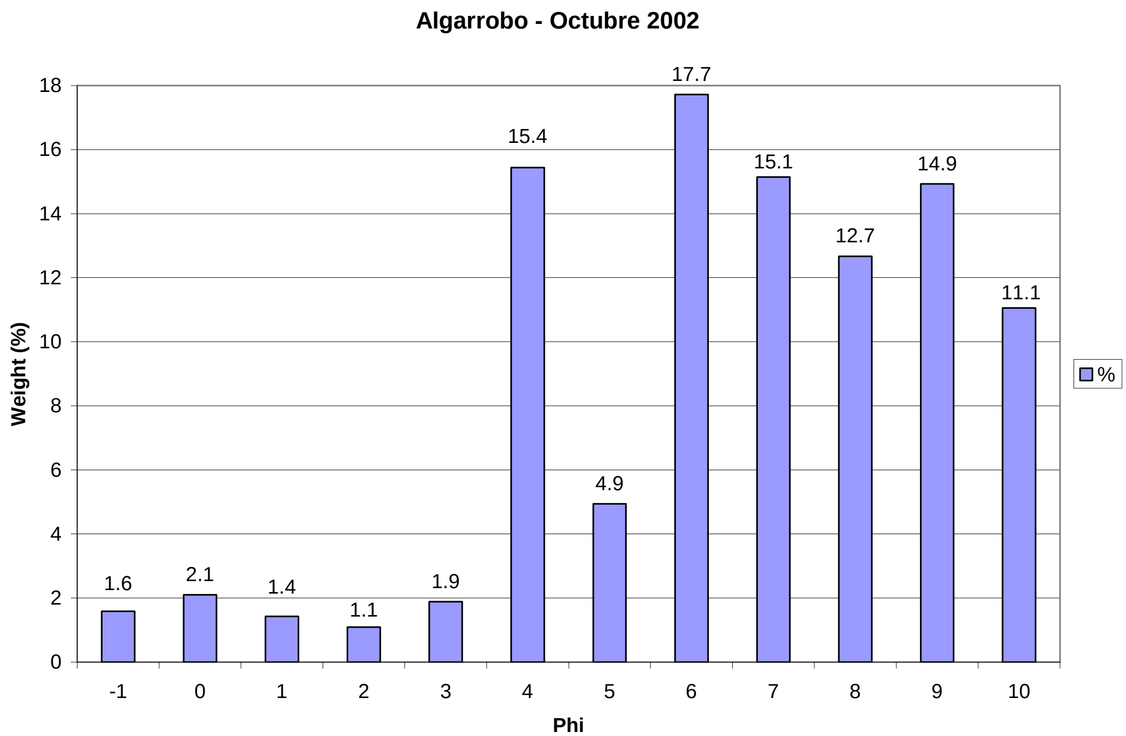


Figure 56 – Cumulative Curve in Algarrobo – October 2002

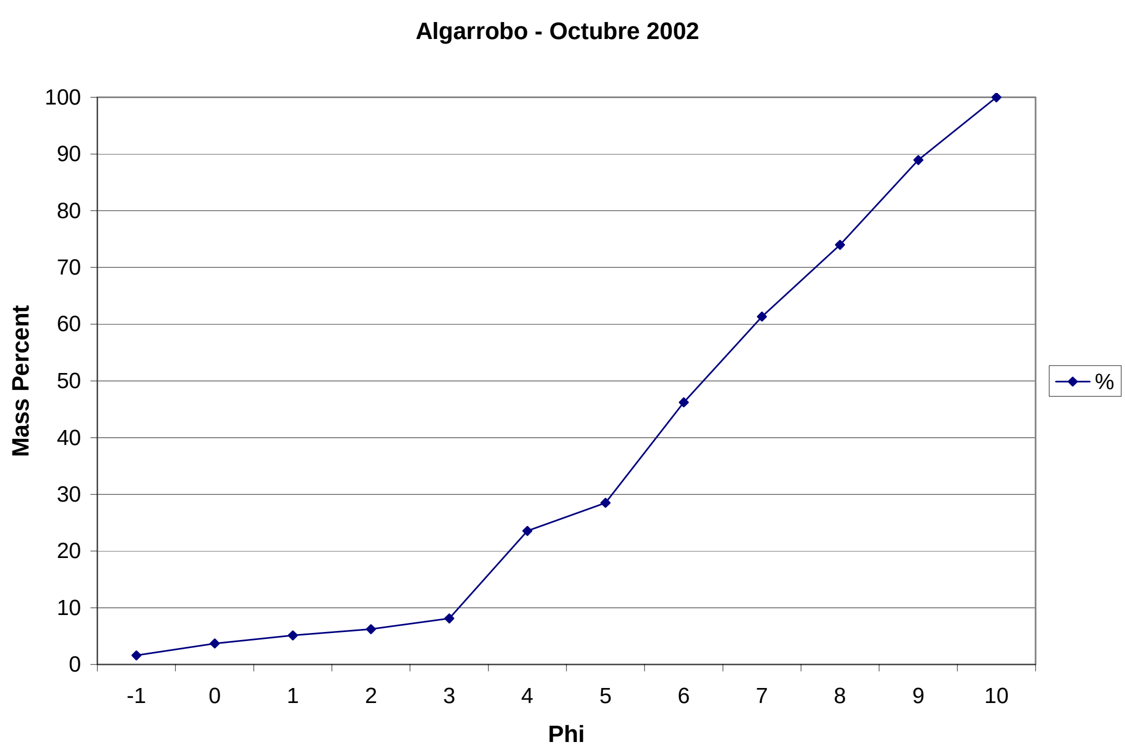


Figure 57 – Sediment Distribution in Algarrobo – December 2002

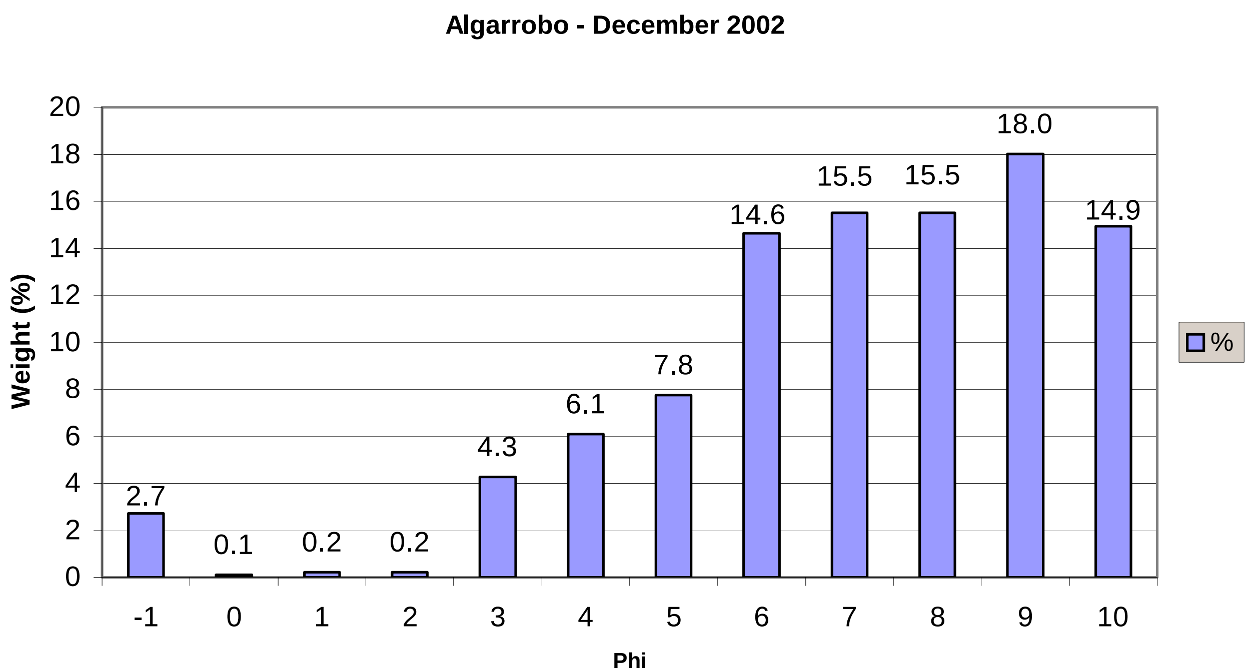


Figure 58 – Cumulative Curve in Algarrobo – December 2002

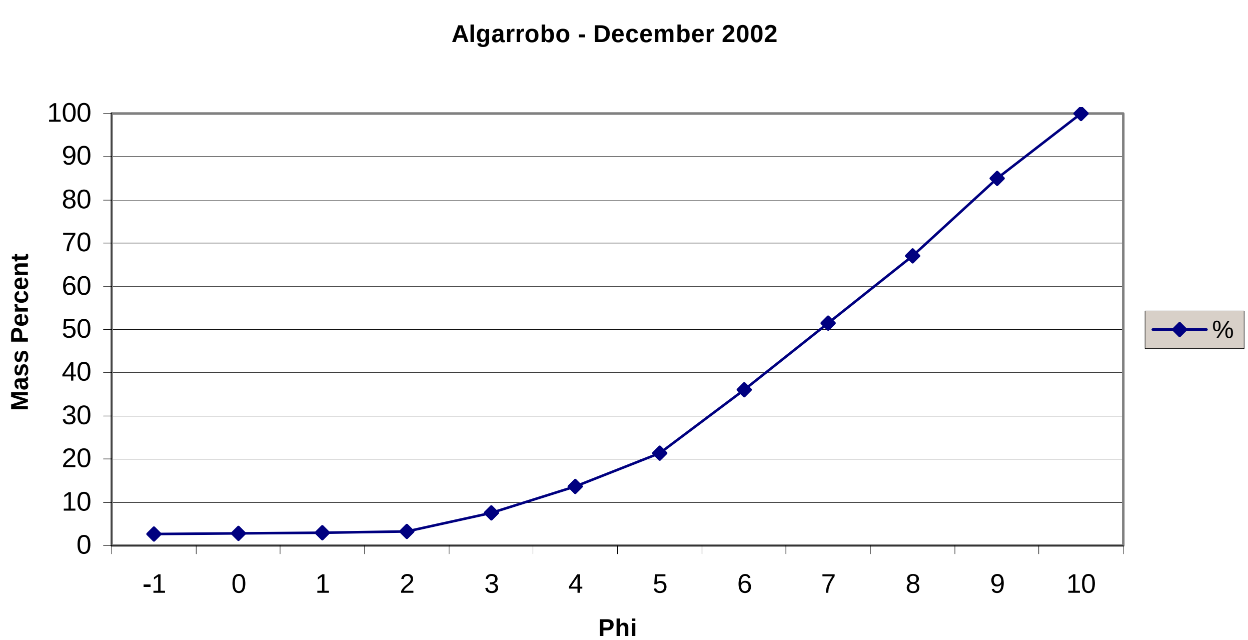


Figure 59 – Sediment Distribution in Algarrobo – March 2003

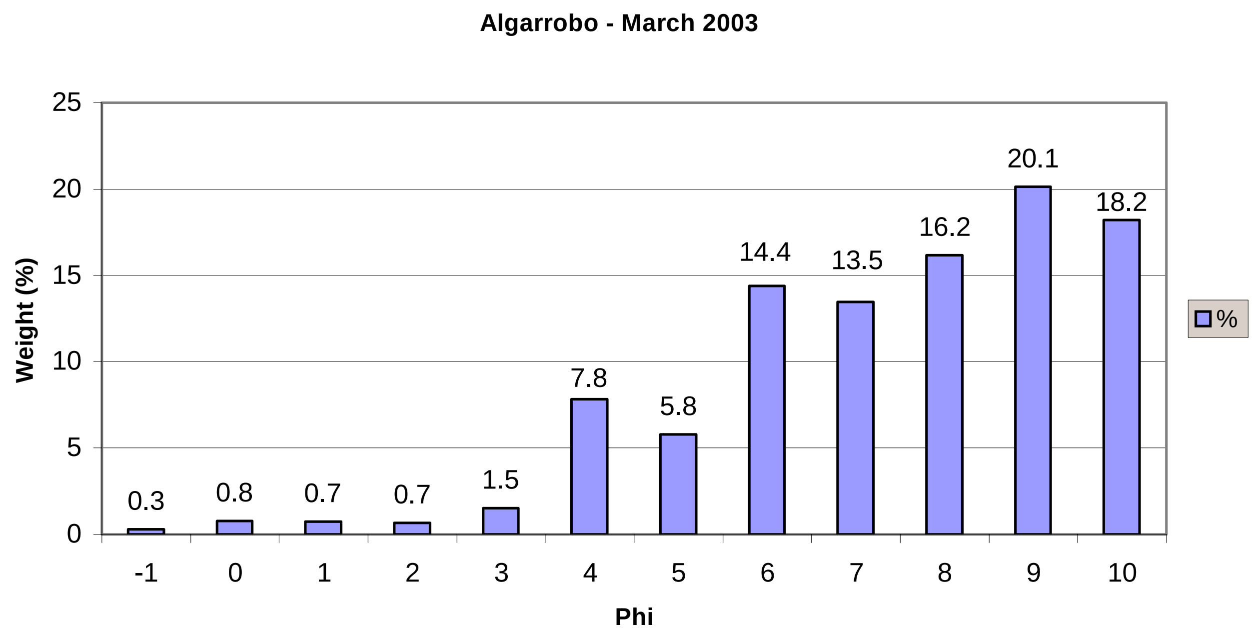


Figure 60 – Cumulative Curve in Algarrobo – March 2003

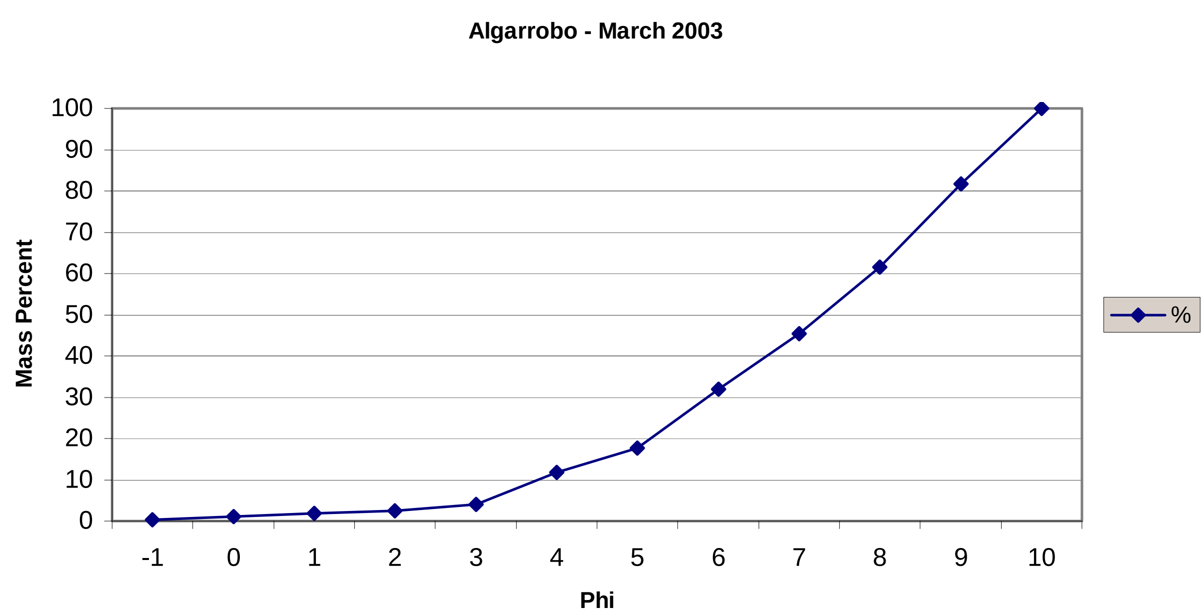
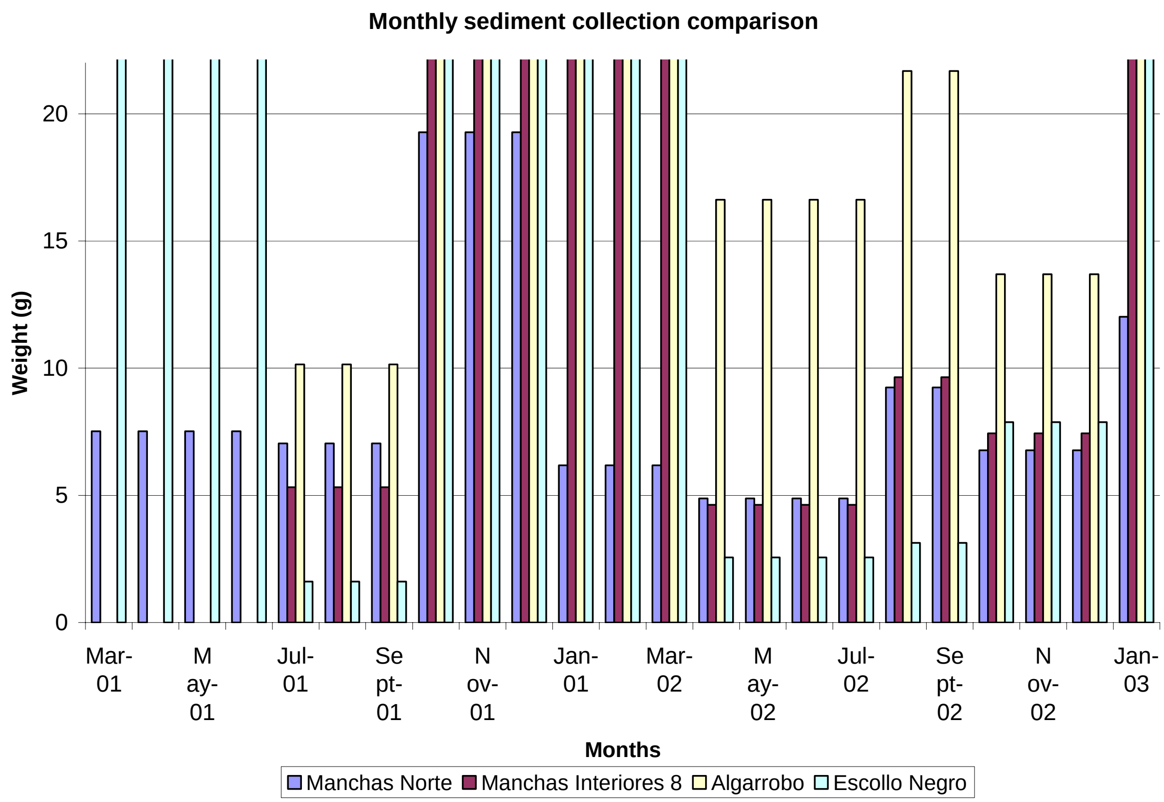


Figure 61 – Comparison of sediment collected during the last two years



RESULTS - On Suspended Particle Matter (SPM)

Figure 62 – Suspended Sediment Concentration in Station #1 at Surface

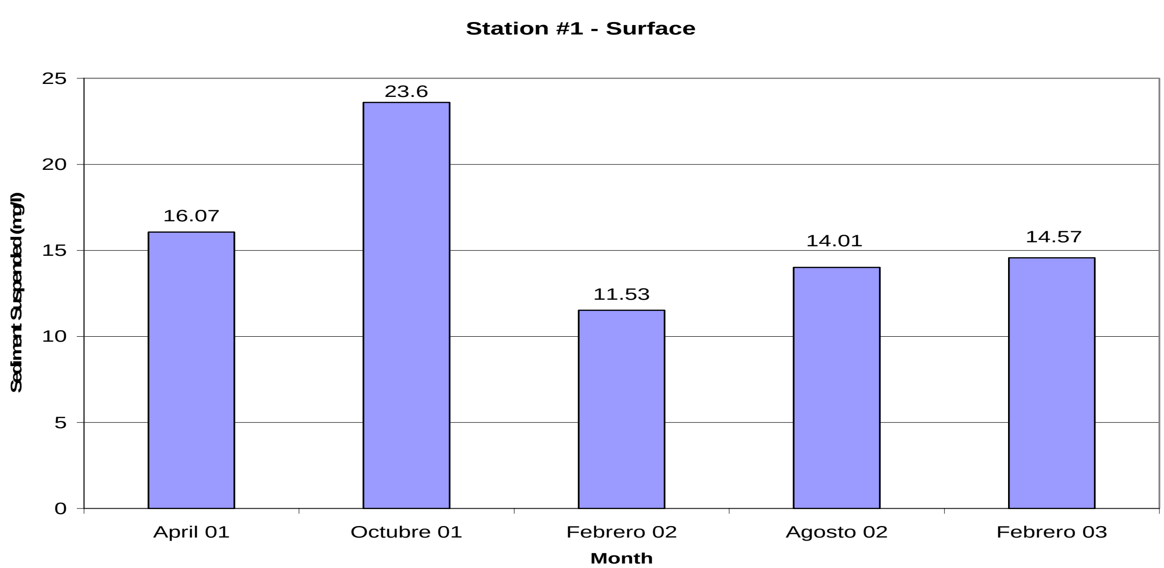


Figure 63 – Suspended Sediment Concentration in Station #1 at Depth

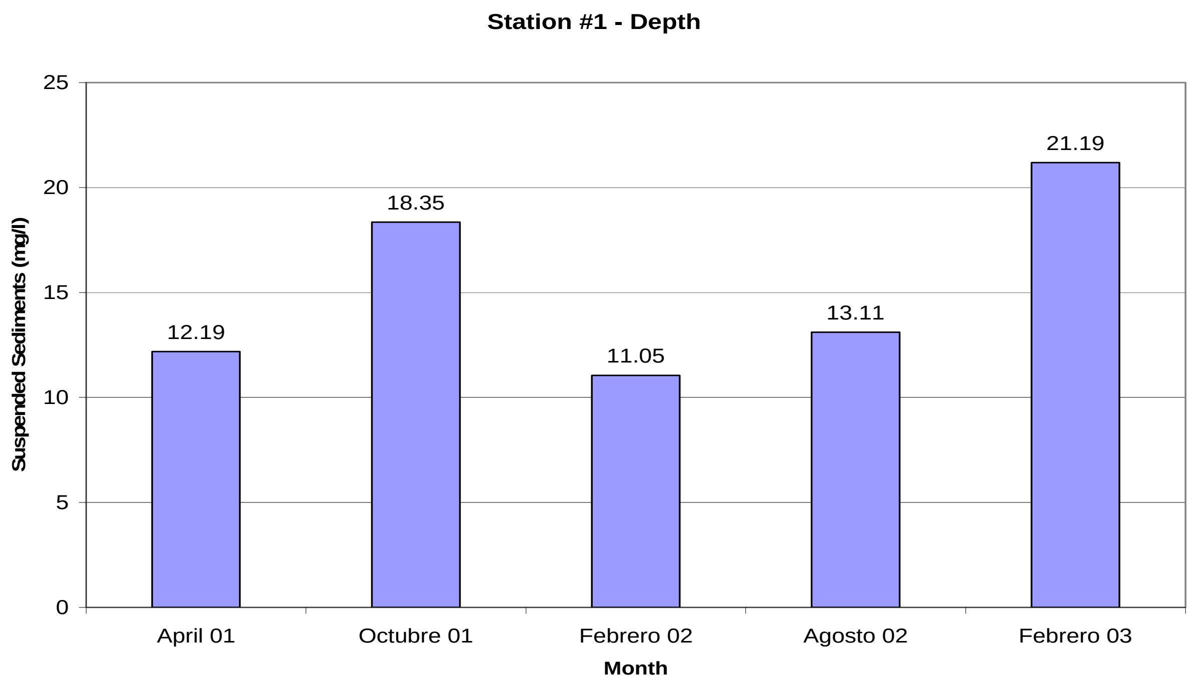


Figure 64 – Suspended Sediment Concentration in Station # 4 at Surface

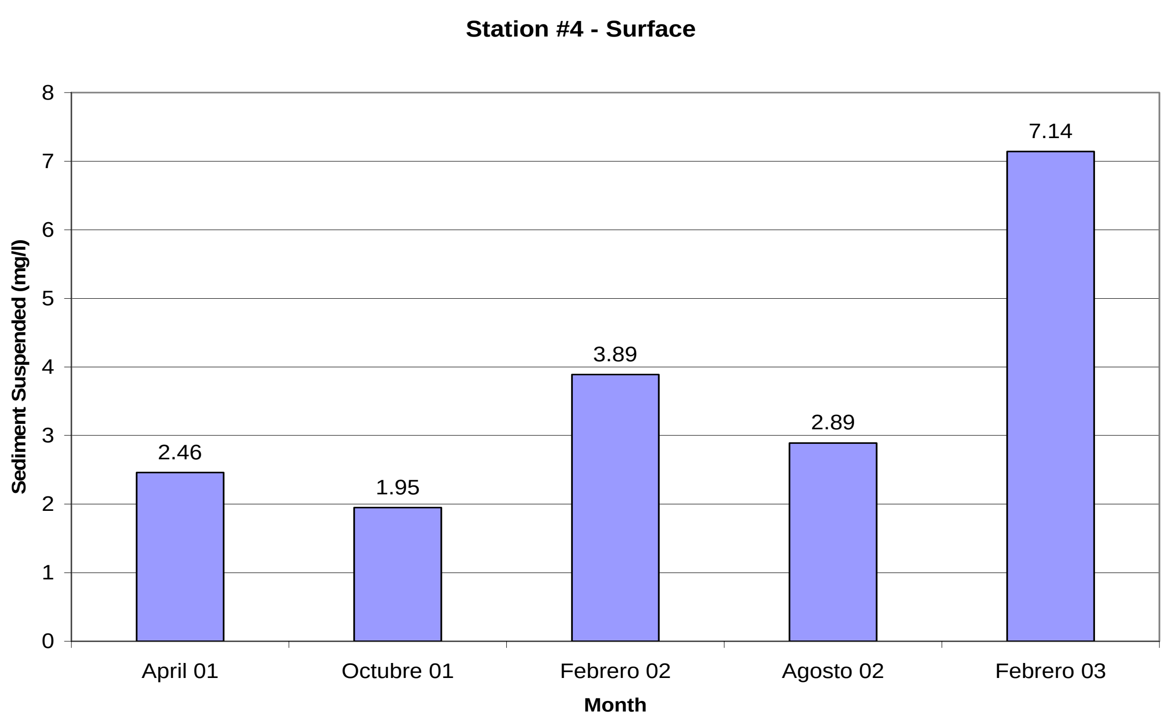


Figure 65 – Suspended Sediment Concentration in Station # 4 at Depth

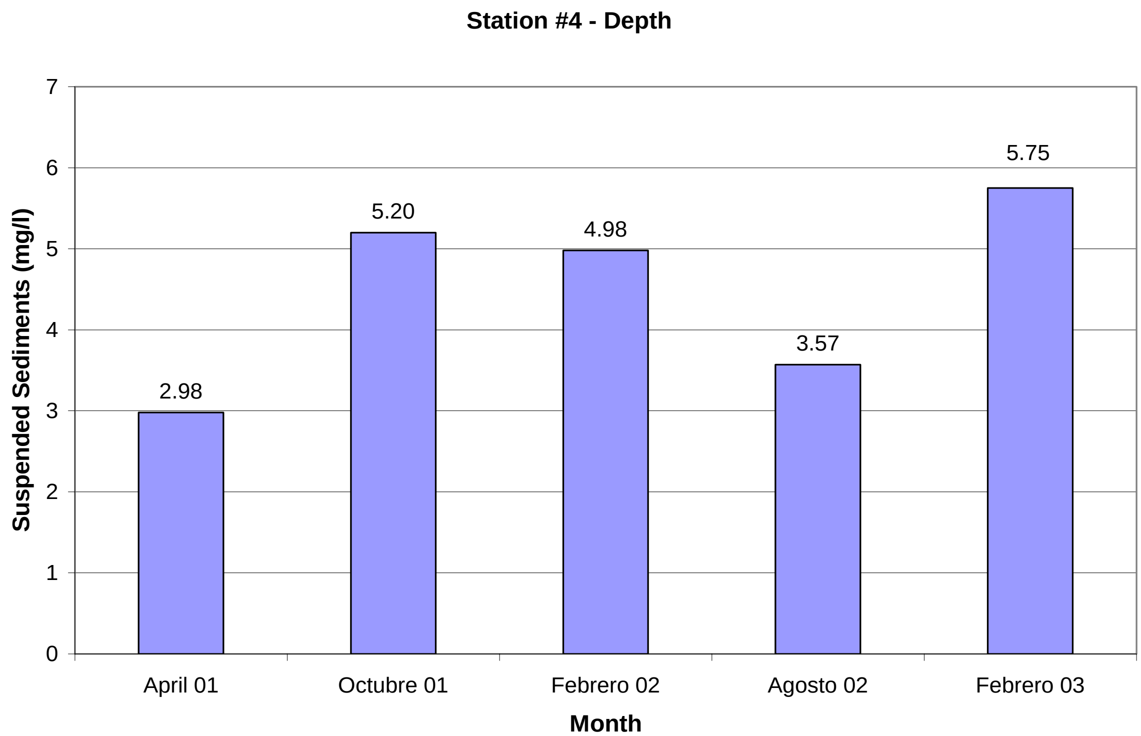


Figure 66 – Suspended Sediment Concentration in Station # 5 at Surface

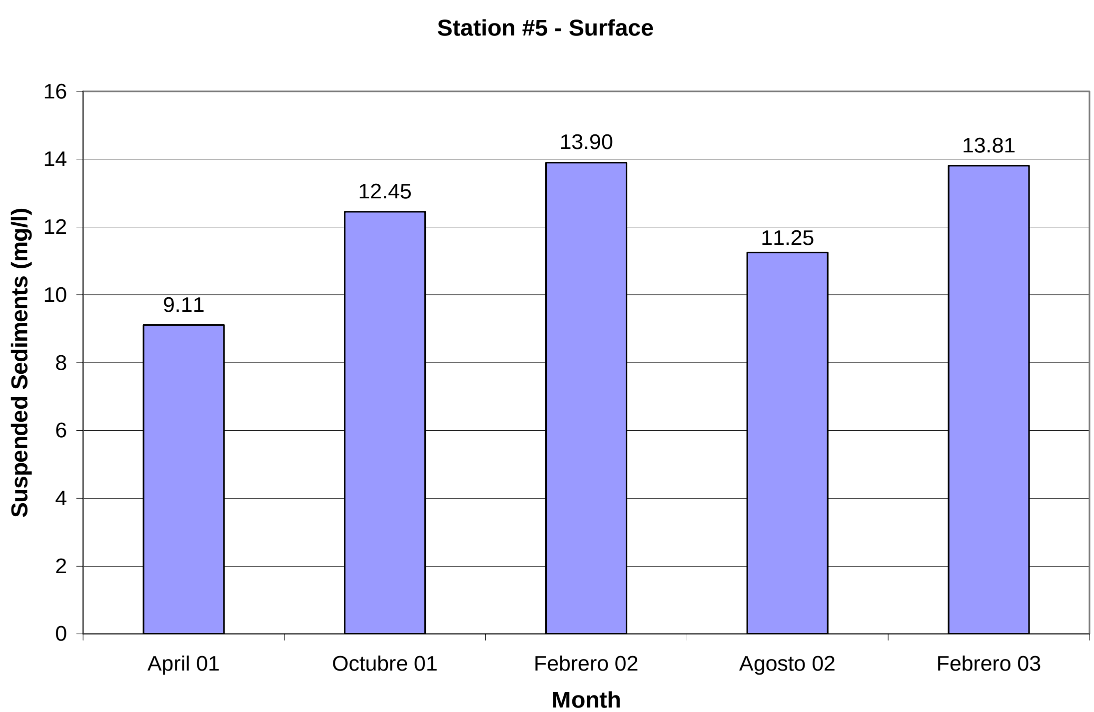


Figure 67 – Suspended Sediment Concentration in Station # 5 at Depth

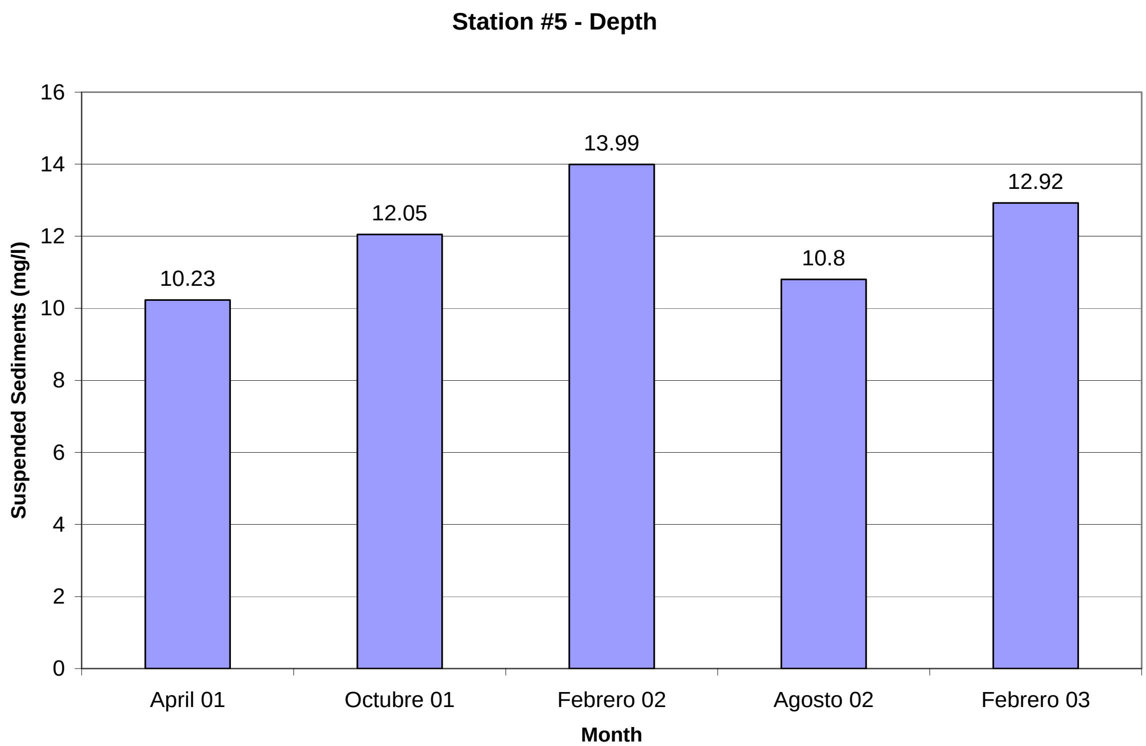


Figure 68 – Suspended Sediment Concentration in Station # 9 at Surface

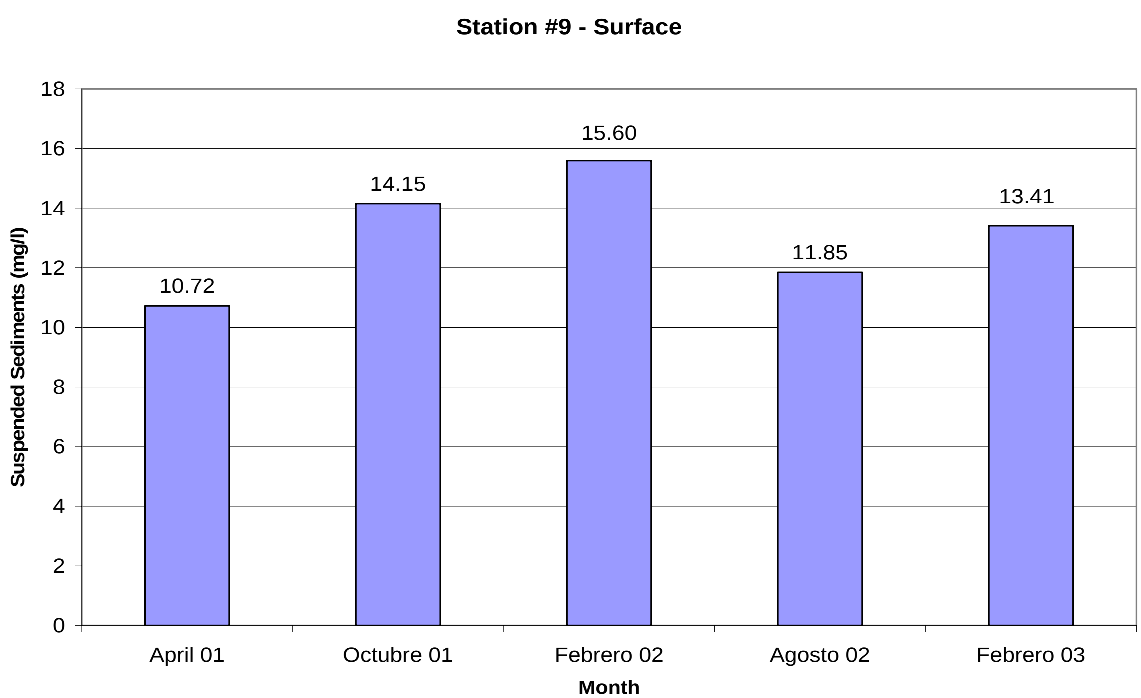
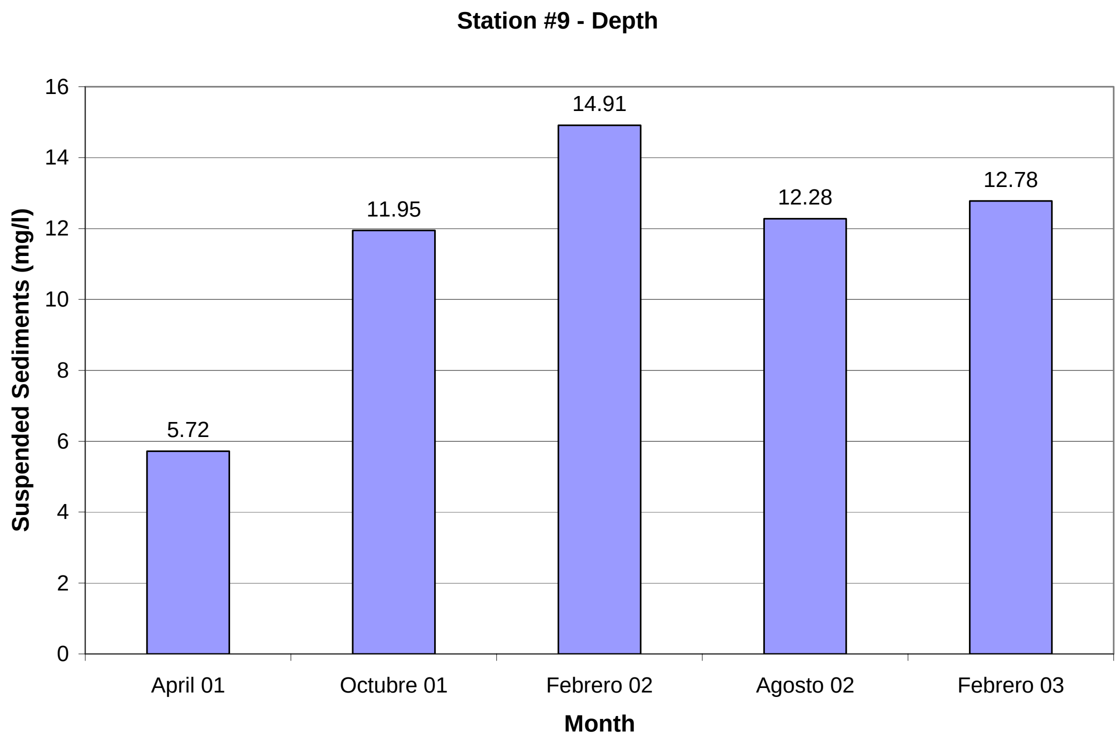


Figure 69 – Suspended Sediment Concentration in Station # 9 at Depth



RESULTS - Rio Grande de Añasco Discharge Data

Figure 70 – Discharge Data from February 2001 to June 2001

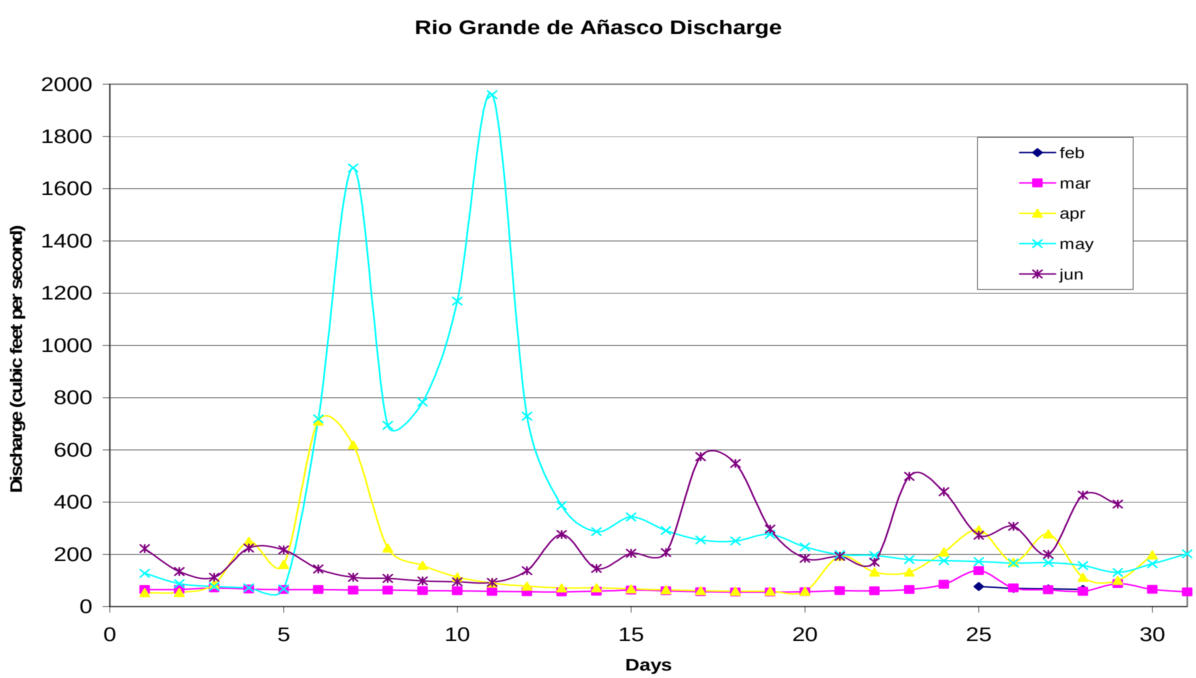
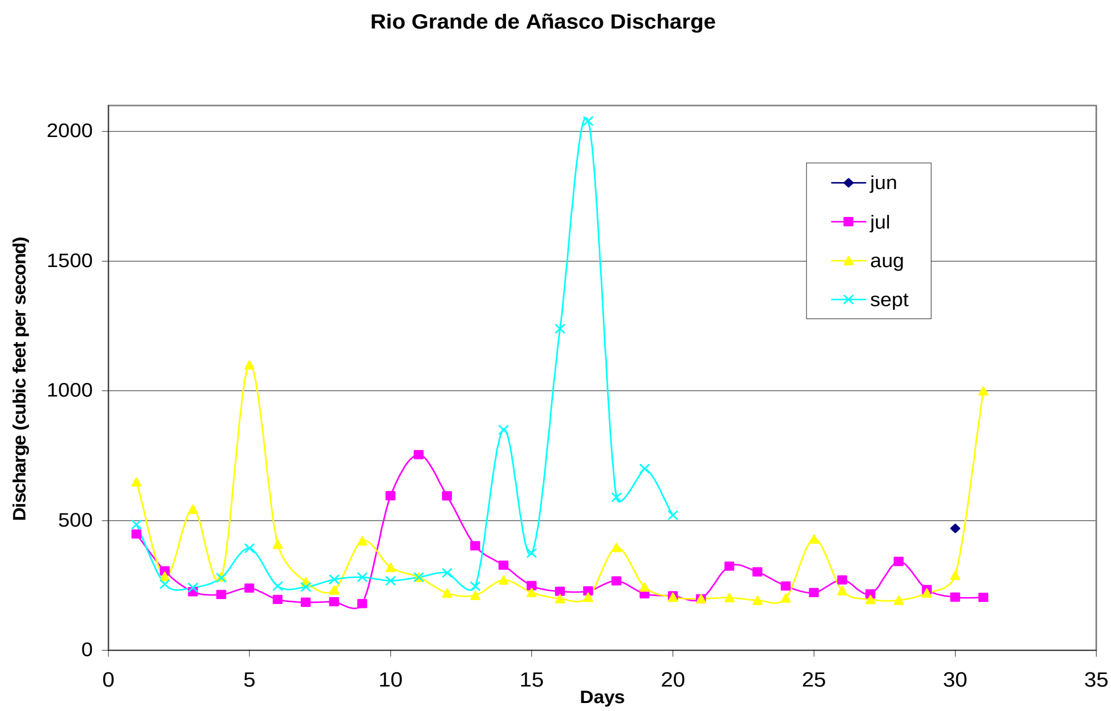


Figure 71 – Discharge Data from July 2001 to September 2001



DISCUSSION

Two sediment sources need to be considerate for the analyses of sediments collected. The first source is the new sediment deposited in the trap by a river or reef inputs. The second source is the sediment already present that is collected by re-deposition (re-distributed material that has been re-suspended after it was deposited) (Rivera, Undergraduate Research Project 2002).

These sediments can be re-suspended during winter storms that occur seasonally in the bay. During these events the majority of sediments will be terrigenous in composition because these are the majority of sediments that settle during the fluvial inputs. On the other hand, during the time of the season with no storms the predominant sediment composition will be composed of carbonates produced by the reefs (Fong, Undergraduate Research Project 2002).

XRD Analyses

In this analyses certain minerals were identified at each station, some of them are common in all samples. Comparison of this study with data collected through this last two years showed that some minerals are present in both analyses, as Halite and Calcite, but other minerals, chemicals or pesticides were note.

Similar minerals (Calcite, Halite, Kaolinite, Quartz) were identified in the different stations during December 2002 and March 2003 (Table 2 and 3), suggesting that a representative sample of the components present have been reached. Two new mineral has been only identified in every station for December 2002 samples (Table 2). One was Carbonatehydroxylapatite that is member of the Apatite Group, and the other was Illite that is part of the clay mineral group.

Composition Analysis

During previous analyses, high concentrations of terrigenous sediments, low concentrations of carbonate sediments and small amounts of organic matter were found in the Manchas Norte station. Such results are similar to the ones I obtained in this study showing again high terrigenous compositions in MN (Table 5 and Figure 4) due probably to its proximity to Río Añasco, which produced a high terrigenous input in the area.

In Manchas Interiores 8, Fong and Rivera (Undergraduate Research Projects) found high concentrations of terrigenous sediments and low concentration of carbonates. Again, the results are similar to the ones acquired during this study (Table 6). Although this station is close the sewer outlet located in the Mayagüez Bay, the low concentration of organic matter in this station is caused by the effective removal of solid organic matter from the sewage before disposal.

The Algarrobo station had a high concentration of terrigenous material (Table 4). The presence of organic matter in this station is probably the cause of its proximity to an industry nearby, the tuna plant, which is known to have disposed organic matter (from the tuna production and the cleaning of the boat tanks) in this bay. In this station $CaCO_3$ has been reported to be high in the sediments traps since July 2002. Epifauna with $CaCO_3$ skeletons was observed around the mouth of the sediment trap, but in a lower amount compared with the last year. The presence of carbonate sediments probably represents the input by organisms with $CaCO_3$ skeletons ("epifauna") on the mouth of the sediment trap and not actual collection of carbonates sediments.

At Escollo Negro, Fong found an alternating abundance of carbonate vs. terrigenous at different sampling periods. This relation is also reflected in the data analyzed during this study. Previous studies stated that this station is composed of terrigenous and carbonate materials with low concentration of organic matter. The data from this study also reflects low quantities of organic matter (Table 7), probably because this station is located farther from the influence of the nutrients, sediments and contaminants near the coast. The carbonates material sediments found at this site are probably generated from the coral reefs in the area.

<u>Grain Size Distribution</u>

Where the samples show a percentage in the $\leq$ -1 ø, it was caused by the presence of entire shells and not sediments from this size. Some factors that influenced the sorting of the sediments are the energy of the area, the re-distribution of grains caused by the wave motion during storm events, and the process of sediment carried by the river (Rivera, Undergraduate Research Project 2002).

A complete distribution of grain size from the samples collected since the beginning of the long-term project was made during this semester. Table 8 shows how the sorting was identified at every station, covering the two-year period of research.

All the stations show higher quantities of grain size sediments in the range of ≥ 4ø (Figures 5-60). Manchas Norte shows the best well sorted distribution, meanwhile Algarrobo has the less well-sorted distribution.

Table 8 – Sorting by stations.

June 2001	
Manchas Norte	Medium sorted
Manchas Interiores 8	--
Escollo Negro	Well sorted
Algarrobo	--

July 2002	
Manchas Norte	Poorly sorted
Manchas Interiores 8	Poorly sorted
Escollo Negro	Medium sorted
Algarrobo	--

September 2001	
Manchas Norte	Medium sorted
Manchas Interiores 8	Medium sorted
Escollo Negro	--
Algarrobo	Poorly sorted

October 2002	
Manchas Norte	Well sorted
Manchas Interiores 8	Poorly sorted
Escollo Negro	Poorly sorted
Algarrobo	Poorly sorted

December 2001	
Manchas Norte	Medium sorted
Manchas Interiores 8	Poorly sorted
Escollo Negro	Well sorted
Algarrobo	Poorly sorted

December 2002	
Manchas Norte	Well sorted
Manchas Interiores 8	Well sorted
Escollo Negro	Poorly sorted
Algarrobo	Poorly sorted

March 2002	
Manchas Norte	Well sorted
Manchas Interiores 8	Poorly sorted
Escollo Negro	Well sorted
Algarrobo	Poorly sorted

March 2003	
Manchas Norte	Well sorted
Manchas Interiores 8	Poorly sorted
Escollo Negro	Poorly sorted
Algarrobo	Medium sorted

Monthly and yearly average amount of sediments collection:

Table 9 shows a comparison between the total sediment weight collected during December 2002 and March 2003. It shows a higher amount of sediment collected during March, suggesting a notable increased in the sediment input and re-distribution and reaching our expectations of higher sediment collector during the active discharge months (Figure 2). Escollo Negro reflected the greater increment between December 2002 and March 2003, while Manchas Norte reflected the lowest increment for the same period of time.

Table 9 - Total weight of sediments recollected at each station by period of time.

Stations	**December 2002**	**March 2003**
Algarrobo	41.06 g	171.49 g
Escollo Negro	23.64 g	447.70 g
Manchas Interiores 8	22.31 g	120.93 g
Manchas Norte	20.36 g	36.07 g
Total	107.37 g	776.19 g

Figure 61 presents a comparison between the sediment collected by each station along the two-year period to determine seasonal variations as a factor of sediment deposition. This figure shows a decrease in the sediment input during the May-August period. The Escollo Negro station has the most remarkable change in seasonal sediment input , while Manchas Norte shows a lower, but significant, change.

Suspended Sediments

Surface and depth measurements from the water column were made to quantify the sediment concentrations present at each station (Figures 62-69). Table 10 describes the concentration of the suspended sediments at both water levels (surface and depth) by station.

Stations #1 and #9 present higher concentrations at surface; Station #4 presents it at depth, while Station #5 has an equal behavior between both water levels. A pattern can be identified with these results: the farther the station is located from the coast line, the deeper is the suspended sediment.

Table 10 – Sediments concentrations by station

Station 1	
April 2001	Higher at surface
October 2001	Higher at surface
February 2002	No significant difference
August 2002	Higher at surface
February 2003	Higher at depth

Station 5	
April 2001	Higher at depth
October 2001	No significant difference
February 2002	No significant difference
August 2002	Higher at surface
February 2003	Higher at surface

Station 4	
April 2001	No significant difference
October 2001	Higher at depth
February 2002	Higher at depth
August 2002	Higher at depth
February 2003	Higher at surface

Station 9	
April 2001	Higher at surface
October 2001	Higher at surface
February 2002	Higher at surface
August 2002	Higher at depth
February 2003	Higher at surface

Rio Grande de Añasco Discharge Data

Two periods of the river discharge were analyzed to quantify the amount of sediment input reaching the bay during the study. These periods were from February 2001 to June 2001 (Figure 70) and from July 2001 to September 2001 (Figure 71).

Several significant events, represented as peaks, were identified. Those events are assumed to be the controlling factor in the redistribution of sediments in the area.

In the first period (February 2001-June 2001) the most active month was May with an important event registered during days 6-12. The following active month was June with two different events identified during days 17-18 and 23-24. April is the next month with just one event occurred during days 6-7. March appeared as the less active month, not showing any significant event.

The most active month for both periods was September and it was registered during the second period that consists from July 2001 until September 2001. This month had the biggest discharge starting day 15 until the end of the month. August was the following active month with three events registered on days 4, 6 and 31. The less active month was July with only one event during days 11-13.

Comparing the Rio Grande de Añasco discharge data from both periods, the difference in the discharge is notable due to seasonal variation. The July-September 2001 period presents higher discharge values in relation with the February-June 2001 period. However, a relationship between the river discharge and the sediment deposition (Figure 61) can not be established with the data available. Is necessary to obtain the river discharge data for the two-year period in order to have a better understanding of this relationship, if exists.

CONCLUSIONS

- XRD analyses updated the project database with respect to the mineralogy present on each station.

- Grain size distribution and composition is influenced by new inputs of sediments (i.e. rivers and reefs) and by the redistribution of already deposited sediments.
- Sediment composition is controlled by the location of the stations in relation with the sediment input sources.
- Concentration of suspended sediments is controlled by the location of the stations with respect to the coast line.

FUTURE WORKS

- Use satellite images and/or aerial photos of the area to study the extent of the migration of the sediment cloud and compare its relation to sediment textures and relate it to the water quality and influences in marine life.
- Complete the Rio Grande de Añasco discharge data for the period of October 2002 until March 2003 to relate specific events to seasonal variations in sediment input.

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