WATER QUALITY OF BAIS BAY

Pascualita Sa-a and Roy A. Bustillo
Silliman University Marine Laboratory
6200 Dumaguete City

INTRODUCTION

Secondary data on Bais Bay, and information derived from consultations with the Bais Bay community made apparent the issue of the Bay's siltation and pollution problem. Information gaps regarding the Bay were identified and these included the absence of data on the sedimentation rate as well as the lack of information on the water quality and the nutrients in the sediment. The research activities on the water quality aspect of the marine component were geared toward addressing these gaps.

SPECIFIC OBJECTIVES

This aspect of the project was undertaken with the following specific objectives:

1) to measure the sedimentation rate of Bais Bay and its rivers;

2) to assess the water quality of the Bay; and

3) to determine the nutrient content, specifically the nitrate and the phosphate in the sediment.

MATERIALS AND METHODS

Site Selection

Four major rivers which empty into the Bais Bay basin were located and identified. These were Alangilanan, Panambalon, and Tamogong River which empty into North Bais Bay and Panamangan River which discharges into South Bais Bay.

Based on a preliminary ocular survey, three sampling stations were established at specific points along each river. The sites selected are indicated in Figure 1. The stations were set up at points which were approximately at the rivermouth, 100 - 200 m upstream and 100 - 200 m offshore.

In order to obtain an estimate of the river discharge, the width and depth of each river were measured along different points of the riverbed using a calibrated line. The

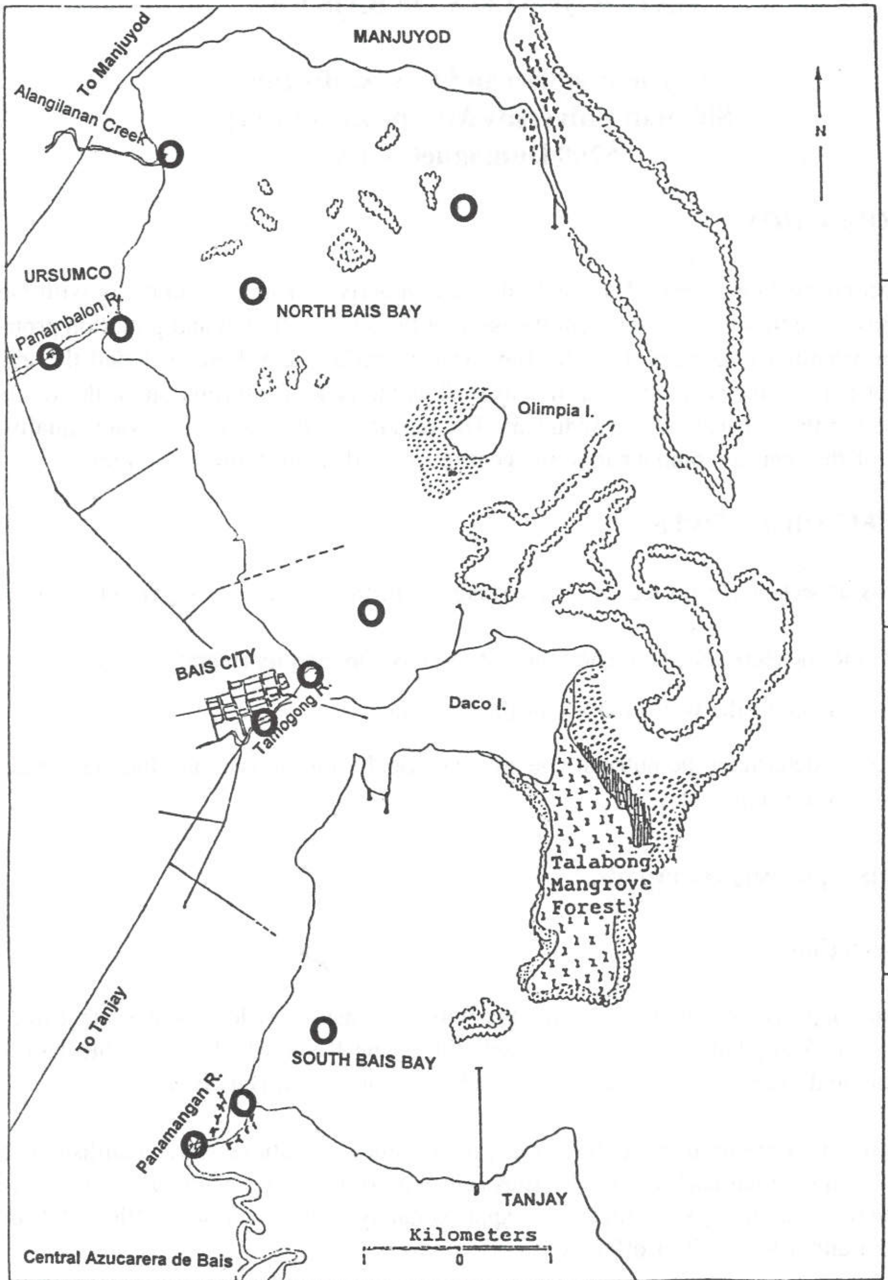

Figure 1. Map of Bais City showing study sites (O).

water velocity was calculated, based on repeated measurements of the rate of movement of paper floats which were allowed to flow along the surface of the water. River discharge was then calculated according to the formula (modified from Dunne and Leopold, 1978):

$$Q\ (m^3/min) = width\ (m) \times depth\ (m) \times velocity\ (m/min) \times c$$

where c = 0.9 for mud/silt/slate substrates
0.8 for rock/boulder/gravel substrates

Fabrication of Sediment Traps

Sediment traps (Figure 2), with a dimension of 11 x 5 cm (height/weight ratio of 2:2, as suggested in Gardner 1980), were fabricated out of whole lengths of 5-cm diameter PVC pipes which were sawed off into 11-cm sections. One end of each 11-cm PVC cylinder was sealed off with a plastic cap using epoxy adhesive. Rough edges were smoothened and each fabricated trap was checked for leakage before these were deployed in the field.

Measurement of Sedimentation Rate

To measure sedimentation rates, sediment traps were deployed in sets of three with three replicates per set at each sampling station. Rubber strips were used to secure the traps to bamboo stakes which were embedded in the substrate. The traps were positioned in such a way that the bottom of the traps were elevated about 30 cm above the substrate. Upon deployment and retrieval, care was taken to ensure that there was minimal agitation of the substrate.

Two sets of traps were deployed monthly. During sampling, a set of traps were deployed and were immediately retrieved following a 24-hour exposure in the field. Upon retrieval, the contents of the traps were poured into sampling containers for subsequent filtration in the laboratory. After the contents were poured out, the traps were returned underwater to be retrieved during the next sampling. This allowed a month-long exposure of the traps in the field.

In the laboratory, the samples were filtered using pre-weighed Whatman filter paper #1. After filtering the samples, the filter paper which contained the sediments were oven-dried to constant weight. Sedimentation rate was then calculated, based on the number of days during which the traps were exposed in the field.

Physicochemical Characteristics

A cursory check of the temperature during sampling was done using the built-in thermometer of the D.O. meter while salinity was determined using a temperature-

Figure 2. Sediment traps.

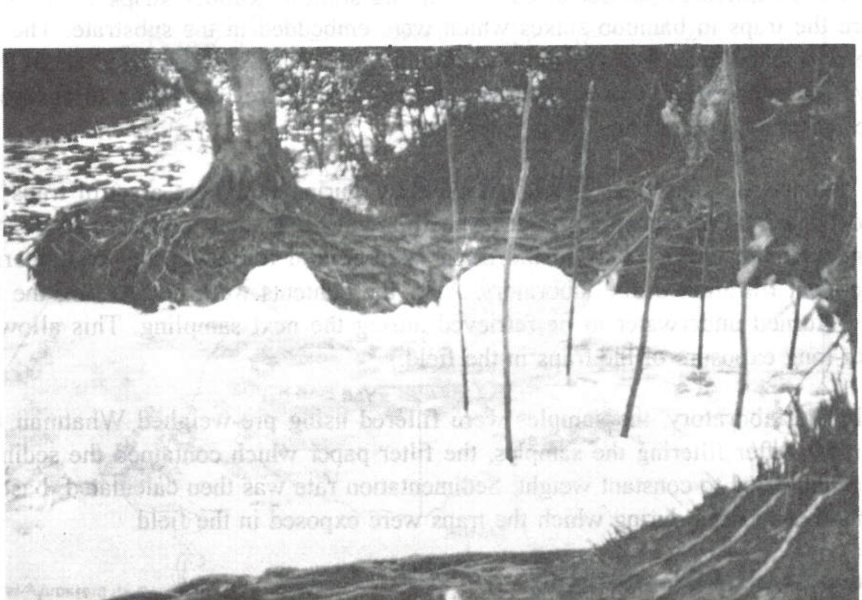

Figure 3. Mouth of Panamangan Creek.

compensated refractometer. Dissolved oxygen levels were monitored using a D.O. meter. The secchi disc was not used in measuring turbidity since the water in the sites was shallow and the readings often coincided with the maximum depth of the water at the time of sampling. Color of the water was determined visually.

Nutrient Analysis

Available nitrogen and phosphorus in the water were determined using the standard methods for analysis in Grasshoff (1983). Because of the amount of time and money involved in analyzing samples for nutrient content, only two samplings were done for this aspect of the study. Initial samples were collected in April and a second sampling was carried out in July.

Sampling Procedure

Sampling Site. Water samples were collected in north and south Bais Bay where the effluents of two sugar mills, namely: URSUMCO (United Robina Sugar Milling Co.) in the north and and CAB (Central Azucarera de Bais) in the south, are discharged. In each area, five sampling stations were established. Each station was approximately 500 meters apart from the other, three of which were oriented parallel to the shore at an approximate distance of 500 meters. A fourth station was established 500 meters away from the three parallel stations while the fifth station was situated at the mouth of the river where the effluents were discharged (Figure 3).

Sample Collection - Frequency and Preservation. Three replicate water samples were collected from each station using a Nansen bottle at the maximum depth but not quite reaching the sea floor. The samples were stored in an icebox during transport. Upon reaching the laboratory, the samples were kept frozen.

Samples for B.O.D. determination were fixed *in situ*. Titration of the samples was done in the laboratory.

Laboratory Procedure

Determination of Phosphate in Seawater - Ascorbic Acid Method (Colorimetric Method).

1) Reagents

a) Sulphuric Acid (4.5M)- Add 125 ml concentrated H_2SO_4 and dilute to 500 ml. Store in a plastic bottle.
b) Ascorbic Acid- Dissolve 5.0 g ascorbic acid in 25 ml water, then add 25 ml sulphuric acid solution (4.5M) solution. Refrigerate in an amber glass bottle.

The solution should be stable for at least a week or as long as it remains colorless. Prepare as needed.

c) Mixed reagent- Dissolve 6.25 g ($(NH_4)6Mo7024.4H_2O$) in 62.5 ml water. Dissolve 0.25 g potassium antimony tartrate to the molybdate solution. Add the molybdate solution to 175 ml dilute sulphuric acid. Add the tartrate to the molybdate and mix. Store in a glass bottle. This reagent is stable for several months.

d) In a scintillation vial or volumetric flask, add the following: 10 ml filtered sample, 0.2 ml ascorbic acid reagent, and 0.2 ml of the mixed reagent.

Measure extinction at 880 nanometers within 30 minutes after mixing. Treat the standard solutions with the sample.

Nitrate plus nitrite in seawater - Cadmium Reduction Method

1) Reagents

a) Ammonium Chloride - Dissolve 10 g NH_4Cl in water and dilute to 1000 ml, adjust the pH to 8.5 with concentrated NH_4OH.

b) Sulphanilamide reagent- Add 10 ml HCl to about 50 ml water, add 4 g sulphanilamide and dilute to 100 ml. Store in a plastic bottle.

c) N-1-naphthyl-ethylene Dihydrochloride- Dissolve 0.1 g of the amine in water and dilute to 100 ml. Refrigerate in a plastic bottle.

2) Preparation of Cadmium Column

Wash 20 g of cadmium fillings with 10% HCl and rinse copiously with distilled water. Stir the fillings with 100 ml of 2% copper sulphate solution until all the blue tartar has left the solution. Rinse with distilled water until all the colloidal copper have been removed. Pack the column under ammonium chloride solution.

3) Determination of Column Efficiency

Run both nitrate and nitrite standards at 10 ug-at/l concentration through the column and measure for nitrite. Correct extinction values and compute for efficiency of nitrate conversion. The cadmium columns should be reconditioned or regenerated if the conversion efficiency is below 85%.

Procedure:

Add to the scintillation vial or test tube the following: 10 ml filtered sample, 10 ml buffer reagent. Pour into the cd column. Collect the remainder and adjust the final volume to 10 ml. Add 0.4 ml sulphanilamide reagent (allow to react for 60 seconds). Add 0.4 ml N-1-napthylethylenediamine dihydrochloride. Measure the extinction at 540 nm within 15 minutes to one hour. Treat standards as in sample.

Dissolved Oxygen - Winkler Titration

1) Reagents

a) Fixing Reagent #1- Dissolve 14.6 g $MnSO_4$ in a little water and dilute to 100 ml.

b) Fixing Reagent #2- Dissolve 25 g NaOH in 125 ml distilled water. Dissolve 15 g KI in 112.5 ml distilled water. Combine the two solutions at room temperature after these have settled.

c) Soluble starch:- Dissolve 0.5 g of soluble starch in 350 ml boiling distilled water. Boil for 5 minutes. Dilute the solution to 1.25 liters.

d) Thiosulphate titrant- Dissolve 11.6 g $Na_2S_2O_3$ and 0.4 g Na_2CO_3 in distilled water and dilute to 4 liters.

e) Primary standard- Dilute 0.1784 g KIO_3 in distilled water and dilute to 500 ml.

f) Dilute acid (1+4) ml- Mix 20 ml concentrated H_2SO_4 with 80 ml distilled water.

Procedure

1) Standardization of the titrant: Add 1 ml of dilute acid to the B.O.D. bottle. Add 1 ml fixing reagent #2 to B.O.D. bottle filled with water, cap and mix. Allow the flock to settle halfway down the bottle. Add 1 ml fixing reagent #1, cap and mix. Empty entire flask into 125 ml erlenmeyer flask. Add 5 ml of primary standard solution. Titrate using 5 ml soluble starch. Repeat standardization three times. Run several blanks without adding the primary standard.

2) Fill the sample B.O.D. bottle by inserting a piece of tubing into the bottom of the bottle and filling from the bottom up, allowing about one bottle to overflow.

3) Inject 1 ml of each fixing reagent (in either order), cap and mix. Exclude all air bubbles before mixing.

4) Allow the flock to settle halfway down the bottle then remix and allow to settle a second time.

5) Add 1 ml dilute acid, cap and mix the bottle to dissolve the precipitated flock. Empty the entire flask into 125 ml erlenmeyer flask. Titrate up to standard end point.

Biological Oxygen Demand (B.O.D.)

1) Reagents- same as in D.O.

2) Procedure

a) Pipette 100 ml unfiltered sample and dilute to 250 ml in a 250-ml volumetric flask. Mix by inverting the flask.

b) Slowly pour the diluted sample into 2 B.O.D. bottles. Exclude all air bubbles before capping with its stopper.

c) Titrate the first bottle for initial D.O. Treat with reagents for D.O. Incubate the other bottle for 5 days at 20 ° in the dark. After five days do as in D.O. analysis.

RESULTS

Sedimentation Rate for Samples Collected After 24 Hours

Preliminary samples collected from rivermouth stations in December showed high values of 7.65, 6.67, and 5.36 g/day for Alangilanan, Panambalon, and Panamangan River. No data were collected from Tamogong River. An offshore sample collected off Alangilanan River showed a lower accumulation rate of 2.52 g/day.

Figure 4 is a graph of the sedimentation rates based on monthly samples which were deployed for 24 hours in the field. Sedimentation rates were consistently high for Panamangan River in January and March with respective values of 7.76 and 11.45 g/day. Samples which were collected from Alangilanan ranked second, with sedimentation rates of 6.15 and 3.49 g/day recorded for the same period. Except for the relatively higher sedimentation rate recorded in December, samples collected from the rivermouth of Panambalon was consistently low from February to August. Traps deployed in Tamogong were particularly high in March at 9.98 g/day whereas previous samples collected in January and March yielded 2.04 and 2.54 g/day. Samples collected in April showed lower sediment accumulation at 2.81 g/day, which increased to 4.2 g/day in May and June but decreased to 0.73 g/day in July.

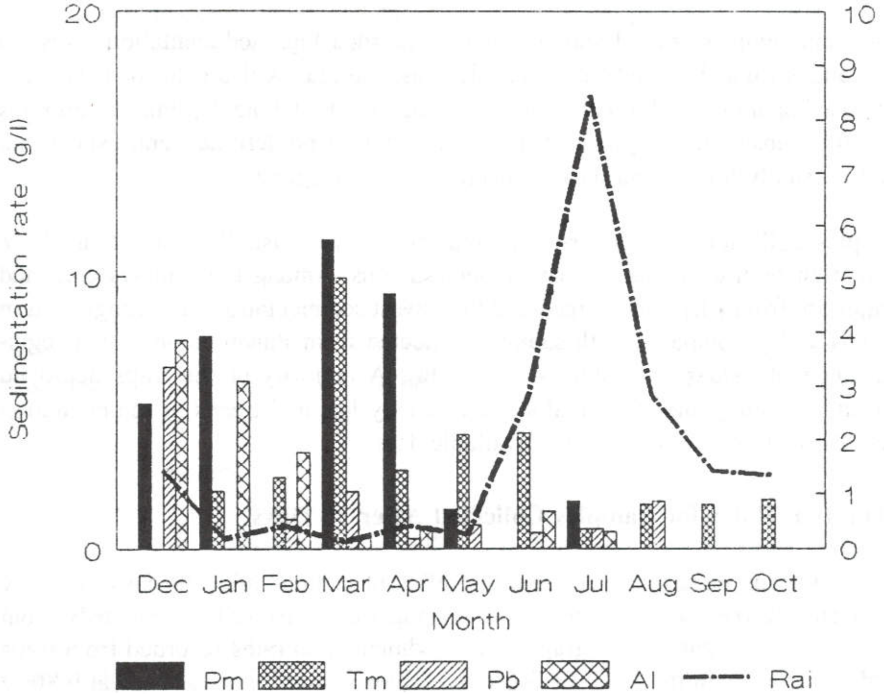

Figure 4. Sedimentation rate, 24 hrs.

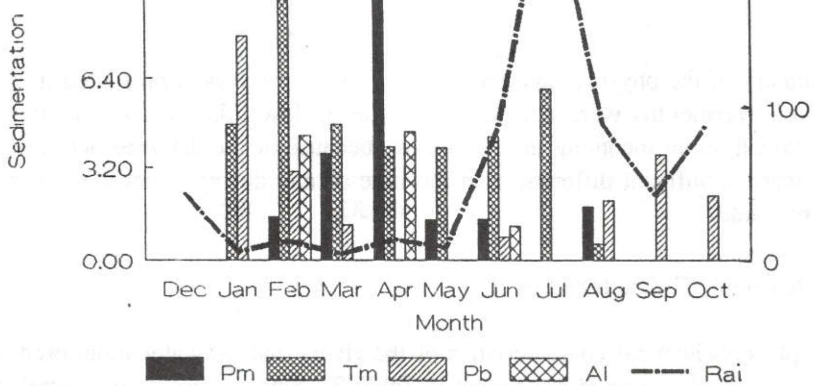

Figure 5. Sedimentation rate, 30 days.

Upstream samples from Tamogong River recorded high sedimentation rates in February and April at 4.23 and 4.62 g/day, decreased in May with a value of 1.98 g/day and increased again to 4.94 g/day in the following month of June. Sedimentation rates recorded from upstream samples in Panambalon showed no definite trend except that these were usually lower than those collected from Tamogong.

Samples collected offshore from all four rivers were usually lower than those collected from both upstream and rivermouth stations. Among the samples collected offshore, those from Alangilanan recorded the lowest sedimentation rates ranging from 0.30 - 0.67 g/day compared with samples collected from Panambalon which registered a range of values from 0.67 - 3.25 g/day. A majority of the traps deployed offshore in Tamogong and Panambalon were usually lost and trends in sedimentation rate were difficult to discern from the available data.

Sedimentation Rates for Samples Collected After 30 Days

Very few traps were retrieved from the different stations after 30 days and only samples from the rivermouth station in Tamogong were retrieved continuously from January to August. Figure 5 is a graph of the sedimentation rates recorded from traps deployed for 30 days in the field. In February, sedimentation rate was high at 9.80 g/day but leveled off to 4.74 g/day in March, comparable to the 4.73 g/day recorded in January. Sedimentation increased slightly in July to 6.02 g/day but decreased again to 0.56 g/day in August. Rivermouth samples collected from Panamangan River averaged at 1.51, 1.44, 1.41 and 1.43 g/day from February to June, excluding the samples collected in March which was slightly higher at 3.66 g/day. Samples collected at the rivermouth in Panambalon showed a high accumulation rate at 7.89 g/day in January which decreased to 3.06 and 2.22 g/day in succeeding samples. A number of the traps which were deployed for a month in the different stations in Alangilanan were not retrieved.

A summary of the physical characteristics of the four rivers is presented in Table 1. Since the rivermouths were not accessible during low tide, measurements were usually obtained on an incoming tide. However, because of the distance between rivers, there were significant differences in the time of day during which the measurements were made.

Physico-chemical Characteristics

Some physicochemical characteristics of the rivers and seawater monitored during the whole sampling period are shown in Table 2. Since sampling was conducted from mid-morning to mid-afternoon, temperature recorded during sampling fluctuated

Table 1. Physical characteristics and estimated discharge of the four rivers which empty into Bais Bay.
[width (m); depth (m); velocity (m/min); discharge (m^3/min)]

Month December

River	Width	Depth	Velocity	Discharge	*C
Panamangan	10.00	1.00	4.29	34.32	0.80
Tamogong	15.66	1.20	2.14	32.17	0.80
Panambalon	14.00	0.50	5.45	30.52	0.80
Alangilanan	11.33	0.80	3.33	24.15	0.80

Month January

River	Width	Depth	Velocity	Discharge	*C
Panamangan	10.00	1.00	4.15	33.20	0.80
Tamogong	15.66	1.20	2.20	33.07	0.80
Panambalon	14.00	0.50	5.30	29.68	0.80
Alangilanan	11.33	0.80	3.15	22.84	0.80

Month February

River	Width	Depth	Velocity	Discharge	*C
Panamangan	10.00	0.90	4.20	30.24	0.80
Tamogong	15.66	1.10	2.30	31.70	0.80
Panambalon	14.00	0.60	5.20	34.94	0.80
Alangilanan	11.33	0.50	3.20	14.05	0.80

Month March

River	Width	Depth	Velocity	Discharge	*C
Panamangan	10.00	0.70	4.00	22.40	0.80
Tamogong	15.66	1.10	2.10	29.94	0.80
Panambalon	14.00	0.50	5.10	28.56	0.80
Alangilanan	11.33	0.40	3.00	10.88	0.80

Table 1. (Continued)

Month April

River	Width	Depth	Velocity	Discharge	*C
Panamangan	10.00	0.80	4.20	26.88	0.80
Tamogong	15.66	1.20	2.10	31.57	0.80
Panambalon	14.00	0.50	4.80	26.88	0.80
Alangilanan	11.33	0.40	2.80	10.15	0.80

Month May

River	Width	Depth	Velocity	Discharge	*C
Panamangan	10.00	0.80	4.00	25.60	0.80
Tamogong	15.66	1.00	2.50	31.32	0.80
Panambalon	14.00	0.40	5.20	23.30	0.80
Alangilanan	11.33	0.30	3.50	9.52	0.80

Month June

River	Width	Depth	Velocity	Discharge	*C
Panamangan	10.00	1.00	3.20	25.60	0.80
Tamogong	15.66	1.50	2.50	46.98	0.80
Panambalon	14.00	1.10	4.80	59.14	0.80
Alangilanan	11.33	0.80	3.50	25.38	0.80

Month July

River	Width	Depth	Velocity	Discharge	*C
Panamangan	10.00	0.90	3.50	25.20	0.80
Tamogong	15.66	1.30	2.30	37.46	0.80
Panambalon	14.00	1.00	5.25	58.80	0.80
Alangilanan	11.33	0.60	3.00	16.32	0.80

Table 1. (Continued)

Month August

River	Width	Depth	Velocity	Discharge	*C
Panamangan	10.00	0.80	3.50	22.40	0.80
Tamogong	15.66	1.00	2.15	26.94	0.80
Panambalon	14.00	0.50	4.50	25.20	0.80
Alangilanan	11.33	0.30	3.00	8.16	0.80

Month September

River	Width	Depth	Velocity	Discharge	*C
Panamangan	10.00	0.90	3.20	23.04	0.80
Tamogong	15.66	1.00	2.30	28.81	0.80
Panambalon	14.00	0.70	4.50	35.28	0.80
Alangilanan	11.33	0.50	3.20	14.50	0.80

Month October

River	Width	Depth	Velocity	Discharge	*C
Panamangan	10.00	0.90	4.29	30.89	0.80
Tamogong	15.66	1.00	2.14	26.81	0.80
Panambalon	14.00	0.70	5.45	42.73	0.80
Alangilanan	11.33	0.50	3.33	15.09	0.80

somewhere between 29 - 33 °C. Salinity in the upstream and rivermouth stations approximated those which were recorded in offshore stations which ranged from 35 - 36 ppt. Similarly, average readings in dissolved oxygen levels varied little between 6.9 and 7.3 ppm.

Secchi disc readings for Tamogong, Panambalon, and Alangilanan approximated the maximum depth at the time of sampling.

The color of the water, generally green-brown in rivermouth and upstream stations, became clearer and more transparent in offshore stations.

The pH of water samples collected in April and July (Table 3) were not significantly different and these fall within the range of 8.33 - 8.46 which are well within the normal range of seawater pH.

Salinity varied little between 32 and 35 parts per thousand. Dissolved oxygen levels of the samples collected in April were slightly lower than those which were collected in July but none were below 5 mg O_2/l. Biological oxygen demand values, ranging from 0.94 - 2.22 mg O_2/l were much lower than the maximum allowable limit for coastal and marine waters set by the DENR, indicating minimal organic matter content in the samples.

Nutrients

Shown on Table 3 are the results of the nutrient analyses of water samples collected from the Bay suggesting minimal organic content in the samples. However, these determinations were from one sampling, before the onset of the milling season. Another sample taken after the milling season is still being analyzed.

DISCUSSION

Most of the traps which were deployed in the field were either stolen or washed away, so that less than fifty percent of the traps were retrieved during sampling. Consequently, with the patchy data on hand, it is difficult to compare sedimentation rates among the different sampling stations of the four rivers. Nevertheless, the values obtained for sedimentation rates provide baseline information on the amount of accumulated sediments which were collected at specific points in the Bay. Although no distinction can be made as to the source of the sediments which are deposited into the Bay, problem sites can be identified. Due to a major oversight in the sampling design, no measurements of total suspended solids was carried out in this study.

The high rates of sedimentation recorded in December, January, and March for samples collected from Panamangan River coincided with the onset of the sugar mill-

Table 2. Environmental data collected from the sampling stations of the four rivers in Bais Bay.

Station	Temp. (°C)	Salinity (o/oo)	D.O. (ppm)	Depth (m)	Color
Panamangan					
upstream	26.9-32.5	2-31	7.0-7.1	0.5-1.5	gray to brown
rivermouth	26.9-35.5	31-35	7.0-7.6	0.5-1.5	green-brown
offshore	29.7-31.5	31-35	7.1-7.5	0.5-1.5	green-brown
Tamogong					
upstream	28.4-29-0	0-25	7.0-7.7	0.2-0.5	opaque green
rivermouth	29.7-32.0	31-35	7.0-7.8	0.3-0.8	clear green
offshore	29.0-30-8	31-35	7.5-7.9	0.5-1.5	clear green
Panambalon					
upstream	29.3-31.1	2-31	7.0-7.2	0.5-1.5	green-brown
rivermouth	29.3-31-1	31-35	7.2-7.8	0.5-1.5	green-brown
offshore	32.0-32.2	31-35	7.1-7.4	0.5-1.5	green-brown
Alangilanan					
rivermouth	30.8-32.2	32-36	6.9-7.3	0.4-1.0	green-brown
offshore	29.0-29.7	32-36	7.0-7.6	0.5-1.7	green-brown

Table 3. Chemical characteristics of the waters of Bais Bay.

Station	ph	Salinity ppt	D.O. mgO_2/l	BOD_5 mgO_2/l	NO_3-N ug-at N/l	PO_4-P ug-at P/l
CAB	8.39	33.73	6.75	2.22	0.01	0.04
	8.35	32.47	8.76	0.94	0.01	0.02
URSUMCO	8.46	34.83	7.22	0.94	0.02	0.01
	8.33	32.60	8.57	1.11	0.01	0.01
Lag-it	8.41	33.80	7.76	1.17	0.02	0.01
	8.62	32.07	9.12		0.00	0.01

ing season when increased activity in the sugar mill resulted in the use of this river as a stream channel to convey the discharge from the mill into the open sea (Figure 6). In cane sugar manufacture, cane crushing water contains a substantial amount of soil and impurities, especially where harvesting is done manually, as is the case in Bais. The cane wash water also contains sugar and may appear colored. Other waste waters that cause pollution problems include those from washing floors and equipment. Effluents from sugarcane processing plants are characterized by high biological demand and high suspended solids. The solid trash remaining contains nutrients including nitrate and phosphate, and its disposal near or in estuaries may lead to eutrophication problems. The return of the mill mud and mill ash to the cane fields is highly recommended (Carpenter and Maragos 1989).

The high rates of sedimentation recorded for Alangilanan River which is the smallest among the four rivers, may be explained by the fact that terrigenous inputs from the steep slope of a nearby mountain drain heavily into this river. Traps retrieved from Tamogong after 24 hours and after 30 days in the field showed respective average sediment accumulation rates of 3.52 g/l^{-day} and 4.70 g/l^{-day} throughout the monitoring period.

Tamogong River, the largest among the four rivers, traverses several sites of human activity before it empties into the north Bais Bay basin. Changes in the vegetative cover of adjacent sugar cane fields together with urban run-off contribute towards sediment deposition in the area. Land run-off contribute significant amounts of suspended solids, BOD, nitrates, phosphates, as well as fecal coliforms and toxic metals (Viessman and Welty 1985)

IMPLICATION OF RESULTS

Effects of sedimentation include the following:

1) physical impact - moderate to severe damage to corals on the shelf; reduced light penetration in the water column; frequently dirty seawater

2) biological effects - reduced coral fauna diversity and reduced numbers and diversity of fish

3) effects on fishing - reduced catch of fish

Based on the available information, sedimentation rate is lower in offshore stations, which would indicate a settling out of the sediments in areas close to the rivermouth stations or a dispersal of the sediments to other parts of the bay.

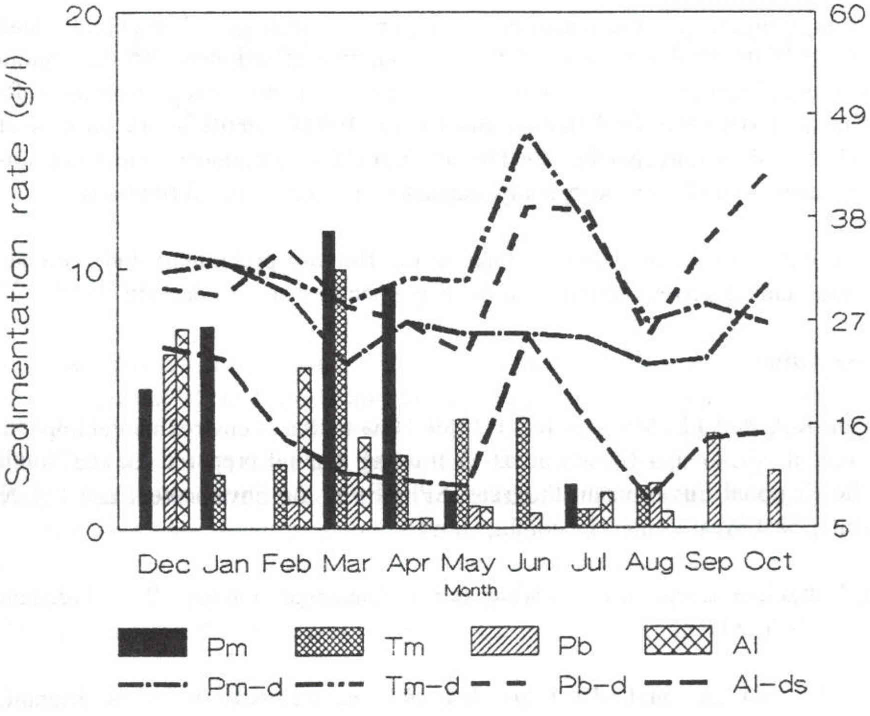

Figure 6. Sedimentation and river discharge.

The long-term effects of sediment deposition on the substrate will eventually lead to shallowing of the Bay. Furthermore, the accumulation of sediments on the bottom can have a significant effect on the bottom-dwelling organisms. A report on the soft-bottom fauna of Bais Bay by Estacion and Oñate (1991) identified 119 species of animals classified as polychaetes, crustaceans, molluscs, nematodes, and some unknown organisms which are ecologically important in energy transformations.

Present data on the sedimentation rates in the Bay are preliminary but portends potential problems if current activities in the Bay's vicinity are to continue.

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