6.2 Natural Environment

6.2.1 Air Quality

Air quality monitoring within the Subic Bay Freeport Zone was conducted in a World Bank Study conducted by Woodward-Clyde from December 1995 to October 1996. Concentrations of (total suspended particulates, (TSP), nitrogen dioxide (NO_2), sulfur dioxide (SO_2) satisfied the DENR's Ambient Air Quality Standards for Criteria Pollutants (Tables 6.2.1-1, 6.2.1-2 and 6.2.1-3). Similarly, none of the observed TSP, NO_2 and SO_2 in Pequeña Island, Redondo Peninsula, and Triboa area exceeded the DENR standards (Woodward-Clyde, 1998b, c and d) (Table 6.2.1-4). The data indicate that Subic Bay is still unpolluted with respect to its air quality.

Table 6.2.1-1 Summary of one-hour TSP concentrations (μg/Ncm)

STATION	4AM TO	12 NOON	12 NOON	TO 8 PM	8 PM TO	4 AM
	AVE.	S.D.	AVE.	S.D.	AVE.	S.D.
Leyte Wharf	25.29	26.35	36.05	29.34	37.88	40.16
Binictican Housing	38.04	28.40	39.43	22.01	37.00	31.88
Cubi Point	29.83	21.94	28.80	17.62	21.66	31.36
SRF	72.54	92.19	41.63	51.21	51.26	24.67
POL Facility	24.99	15.31	22.17	18.21	27.73	19.84
Rizal Hwy	76.66	83.23	59.52	66.99	43.94	31.46

Source: Subic Bay Environmental Baseline Study (WCPI, 1997)

DENR Ambient Air Quality Standard: 300 μg/Ncm for TSP, μg/Ncm -- micrograms per normal cubic meter

Table 6.2.1-2 Summary of One-hour NO_2 Concentrations (μg/Ncm)

STATION	4AM TO	12 NOON	12 NOON	TO 8 PM	8 PM TO	4 AM
	AVE.	S.D.	AVE.	S.D.	AVE.	S.D.
Leyte Wharf	10.25	9.64	13.29	18.27	12.98	11.63
Binictican Housing	4.17	6.97	2.71	4.64	6.36	11.99
Cubi Point	12.58	15.08	13.46	8.07	12.74	8.65
SRF	24.61	39.56	8.83	10.73	15.52	15.46
POL Facility	7.67	10.72	8.65	7.30	9.88	11.88
Rizal Hwy	20.71	26.85	13.87	7.93	16.66	14.56

Source: Subic Bay Environmental Baseline Study (WCPI, 1997),DENR Ambient Air Quality Standard: 260 μg/Ncm for NO_2

6.2.1-3 Summary of One-Hour SO_2 Concentrations (μg/Ncm)

STATION	4AM TO	12 NOON	12 NOON	TO 8 PM	8 PM TO	4 AM
	Average	Standard Deviation	Average	Standard Deviation	Average	Standard Deviation
Leyte Wharf	27.26	16.82	29.59	17.52	55.74	29.61
Binictican Housing	39.20	31.70	40.72	30.80	34.11	36.50
Cubi Point	26.52	22.73	26.44	42.04	20.43	18.23
SRF	32.65	27.04	44.66	42.23	56.62	46.29
POL Facility	34.68	21.61	59.27	51.07	53.48	50.69
Rizal Hwy	47.30	23.80	44.39	26.85	61.11	37.40

Source: Subic Bay Environmental Baseline Study (WCPI, 1997)

DENR Ambient Air Quality Standard: 340 μg/Ncm for SO_2

Table 6.2.1-4 Concentration of Total Suspended Particulates (TSP), Nitrogen Dioxide (NO_2) and Sulfur Dioxide (SO_2) in Some Coastal Areas Around Subic Bay

SAMPLING DATE	LOCATION	TSP (μg/Ncm)	NO_2 (μg/Ncm)	SO_2 (μg/Ncm)
1. March 1998	Pequeña Island	21.5 - 70.7	nd	nd
2. April 1998	Redondo Peninsula (Agusuhin)	39.9 - 76.8	4.2 - 5.3	<1.0 - 6.9
3. September 1998	Triboa Area	4.5 - 69.8	5.7 - 12.30	< 0.37
DENR Ambient Air Quality Standards		300	260	340

Source: Subic Bay Environmental Baseline Study (WCPI, 1998)

nd = No data available

6.2.2 Sea Bottom Quality

The results of the chemical analysis of the bottom sediment samples collected at 16 stations are shown in Table 6.2.2-1. The locations of the sampling stations are shown in Figure 6.2.2-1.

(1) Loss of Ignition, COD and Sulfide

The observed loss of ignition (LOI) of sediment samples in the area ranged from 2.8 to 19.72%. Higher levels were generally found off Cubi Point and in areas near the mouths of rivers. The LOI values obtained indicate high organic matter content of the bottom sediments in the area.

Table 6.2.2-1 Results of the Chemical Analysis of the Bottom Sediments Sampled at Sixteen Stations During the JICA Study (February 1998 and January 1999)

PARAMETERS	Northern Subic Bay Station No. (February 1998)										Cubi Point Station No.				Binictican Estuary Station No. (January 1999)								Screening Criteria * (mg/kg)
	S15	S17	S19	S21	S24	S25	S26	S27	S28	S30	S31		S36		S33		S34		S35		S32		
											HT	LT	HT	LT	HT	LT	HT	LT	HT	LT	HT	LT	
Loss of Ignition (%)	9.4	2.8	5.8	8.3	4.0	9.9	8.6	12.4	12.1	2.9	16.21	10.02	19.72	9.31	7.60	8.99	3.48	9.50	8.09	7.97	8.40	8.75	NA
COD (g/kg)	6.17	7.57	11.5	12.3	14.9	24	11.9	45.5	9.3	11.3	2.52	4.33	9.09	11.48	12.93	21.77	6.02	11.70	13.79	20.57	5.84	10.44	NA
Sulfide (mg/kg)	<100	<100	300	100	700	300	300	1300	100	200	2.94	3.05	ND	10.43	0.22	2.97	ND	ND	ND	ND	ND	ND	NA
As (mg/kg)	<1	<1	4	3	5	2	6	<1	<1	1	1.73	1.86	3.45	1.93	3.39	2.63	2.26	2.68	3.05	3.19	3.32	3.48	8.2
Cd (mg/kg)	<1	<1	1	<1	<1	<1	<1	<1	<1	<1	1.88	1.54	2.05	1.37	0.85	1.54	0.85	1.2	0.85	1.20	0.85	0.85	0.6
Cr (mg/kg)	4	11	32	9	24	81	18	329	27	43	199.89	230.9	105.65	224.01	99.93	140.89	142.53	179.21	108.11	81.09	140.89	78.63	81
Pb (mg/kg)	61	<1	3	<1	<1	<1	2	<1	<1	3	17.5	15.32	21.88	14.22	20.79	26.36	20.79	21.88	20.79	22.43	15.32	18.6	46.7
Hg (mg/kg)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.0001	0.0004	0.0026	<0.0001	0.001	0.0024	0.0019	0.0014	0.0023	0.0032	0.0009	<0.0001	0.15
Color	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	grayish		grayish		grayish		grayish		grayish		grayish		
Odor	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	none		none		none		none		none		none		
Texture	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	sandy		sandy		sandy		sandy		sandy		sandy		

Limit of Reporting (Detection Limit in mg/kg) : As = 1.0; Cd = 1.0; Pb = 1.0; Sulfide = 100

NA = Not available

ND = Not detected

nd = No data available

HT = High tide

LT = Low tide

COD = Chemical oxygen demand ; As = Arsenic; Cd = Cadmium ; Cr = Chromium; Pb = Lead; and Hg = Mercury

* U.S. National Oceanic and Atmospheric Administration (NOAA) sediment (taken from World Bank Ecological Baseline Study Final Report)

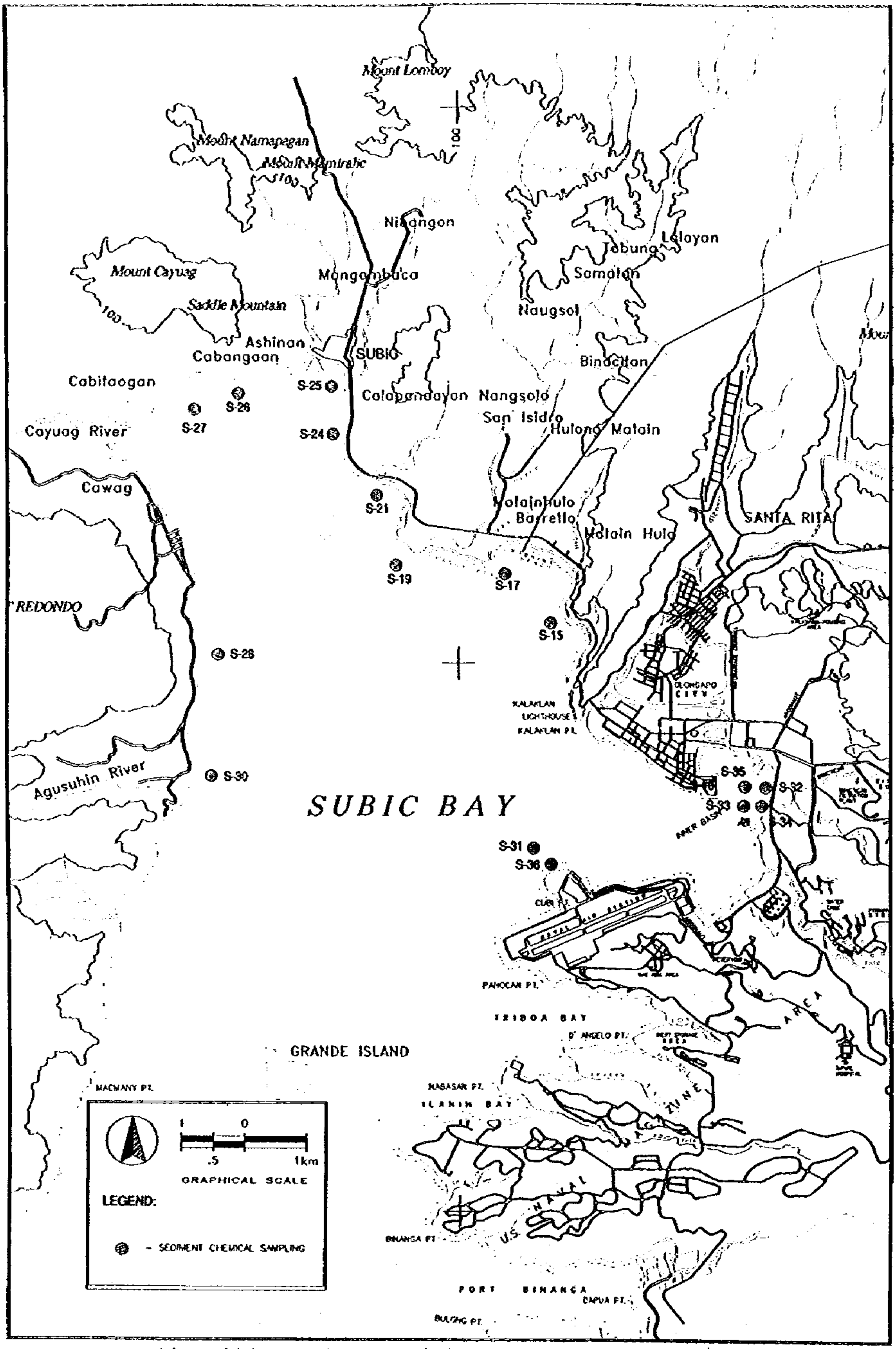


Figure 6.2.2-1 Sediment Chemical Sampling Stations in Subic Bay

Observations from the coastal and estuarine areas around Subic Bay give CODs in sediments ranging from 2.52 to 45.40 g/kg. The lowest COD value was taken from the sediment sample of Stn. S31 (off Cubi Point) while the highest was measured from the sediment sample at Stn. S27 (Cabitaogan). In general, the measured COD concentrations showed increasing values during ebb tide. This could be attributed to the seaward transport of oxidizable organic matter by the ebb currents from riverine and coastal sources.

The levels of sulfide varied from not detectable at <100 mg/kg up to a maximum of 1,300 mg/kg. However, most of the stations sampled around the northern portion of Subic Bay recorded low sulfide levels (<100 to 300 mg/kg), especially those along the recreational beaches such as in Maquina Beach, Mango Beach, Calapandayan and Redondo Peninsula. The sulfide concentrations in the offshore area fronting Cubi Point and Binictican estuary showed very low concentrations, ranging mostly from non-detectable to a maximum of 10.3 mg/kg. The observations further showed that higher sulfide concentrations occur at low tide than during high tide. This was also attributed to the transport of tidal currents.

The concentrations of the two parameters, COD and sulfide, in the surficial sediment were highest at Cabitaogan area. Its organic matter content is also high at 12.4%. The high content of organic matter in the sediment poses as a potential source of eutrophication. These organic pollutants are brought by land-based waste discharges, waste from the intensive coastal aquaculture, domestic effluents and poor hydrodynamic conditions.

(2) Heavy Metals

Some heavy metals were also detected in bottom sediments of the northern portion of Subic Bay. Mercury and cadmium were not detected in any sea bottom sediments, but arsenic, chromium and lead were found to be elevated (not detectable at <1 up to 6 mg/kg, 4 to 329 mg/kg and not detectable at <1 up to 61 mg/kg, respectively) in some stations. Highest concentrations of lead and chromium were found in areas fronting the mouths of Matain River and Nibangon River and Cayuag River.

The seabed in the offshore area fronting Cubi Point and at Binictican estuary was also contaminated by heavy metals. However, very low concentrations of mercury were detected (not detectable at <0.0001 up to 0.0032 mg/kg). The lowest concentration of <0.0001 mg/kg was noted for Stns. S31 (high tide) and S36 (low tide) at Cubi Point. Chromium and lead were also found to be elevated (78.63 to 230.90 mg/kg and 14.22 to 26.36 mg/kg, respectively). The higher concentrations of chromium were found in bottom sediments sampled from Cubi Point.

Heavy metal analysis in bottom sediments was also conducted during the World Bank Study at the Subic Bay Freeport (SBF) area between September 1995 and May 1996 (Table 6.2.2-2). The study reported no detectable levels of cadmium and silver. Barium, chromium, copper, manganese, vanadium and zinc were found in all the samples. Arsenic, mercury and nickel were found only near Riviera Pier and at two stations in the Inner Basin. The metal concentration ranges of the sediment samples reported are as follows: <1 to 1.34 mg/kg for antimony; <1 to 63.54 mg/kg for arsenic; 3.18 to 662.65 mg/kg for barium; 5.72 to 1181.25 mg/kg for copper; 1.81 to 83.00 mg/kg for chromium; <1 to 240.59 mg/kg for lead; 30.42 to 643.38 mg/kg for manganese; <0.1 to 9.6 mg/kg for mercury; <1 to 131.86 for nickel; 4.14 to 65.19 mg/kg for vanadium; and 7.05 to 1,730 mg/kg for zinc.

At present there are no Philippine or internationally accepted standards for permissible levels of heavy metals in sediments. However, the concentrations of detected heavy metals herein were generally higher than the sediment screening values for metals developed by the U.S. National Oceanic and Atmospheric Adminitration (NOAA)(Woodward-Clyde, 1997). This may indicate that, in general, certain areas close to harbors and estuaries with intense shipping activity and heavy industry are more contaminated than other areas. Even if levels of heavy metals in the water are low, the amount present in sediments may be many times higher due to their tendency to accumulate at the bottom.

Recently, the JICA Study conducted sampling of bottom sediment in 2-bore hole stations (BH-11 and BH-12) for chemical test in August 1998 in the estuaries of Binictican (Table 6.2.2-3). The sediment samples obtained at 0.55 - 1.0 m and 1.55 - 2.0 m depth intervals were contaminated by some heavy metals. High concentrations of mercury (1.70 - 7.70 mg/kg) were found. Cadmium was the next highest (2.36 - 4.08 mg/kg) followed by chromium (1.50 - 2.20 mg/kg). However, arsenic and lead were not detected.

The vertical heavy metal distribution in the sediments from the Binictican is shown in Figure 6.2.2-2. Station BH-12 sediments generally have greater heavy metal concentrations than Station BH-11 sediments. Except for chromium, the concentrations of mercury and cadmium at Station BH-11 were higher in the upper layer than in the deeper layer sediments. This may indicate that there was a recent enrichment of mercury and cadmium in the sediments of the Station BH-11. By contrast, the distribution of mercury and cadmium at Station BH-12 were higher in the deeper layer as compared with the upper sediments. Cadmium was not detected in the upper layer of this station, while the concentration of chromium was uniformly distributed between the layers.

Table 6.2.2-2 Range of Heavy Metals and Organic Compounds Detected in the Bottom Sediment of the Subic Bay Freeport

PARAMETERS	RANGE	SCREENING CRITERIA (mg/kg)
HEAVY METALS (mg/kg)		
Antimony	< 1 to 1.34	2
Arsenic	< 1 to 63.54	8.2
Barium	3.18 to 662.65	20
Copper	5.72 to 1,181.25	34
Chromium	1.81 to 8.3	81
Lead	< 1 to 240. 59	46.7
Manganese	30.42 to 643.38	460
Mercury	< 0.1 to 9.6	0.15
Nickel	< 1 to 131.86	21
Vanadium	4.14 to 65.19	NA
Zinc	7.05 to 1,730	150
ORGANIC COMPOUNDS		
Petroleum Hydrocarbons (mg/kg)		1,000 **
C6 - C9 (Gasoline)	3.26	
C10 - C 14 (kerosene /Jel Fuel)	83.08 to 103.94	
C15 - C28 (Diesel)	131.03 to 1,189.63	
C29 - C36 (Fuel Oil)	102.41 to 690.44	
Organotin (μg/kg)		0.0015 **
Tributyltin Oxide	4.3 to 39.0	
Dibutyltin	2.5 to 94.0	
Monobutyltin	7.4 to 325.0	
POLYCHLORINATED BIPHENYLS (μg/kg)	1.3	NA

Data Source : World Bank Study Final Report (Woodward - Clyde, 1997)

NA - Not Available

* - U.S. National Oceanic and Atmospheric Administration (NOAA) Sediment

** - Netherland Sediment Criteria (Limit value, screening criteria for newly deposited sediment)

Table 6.2. 2-3- Results of the Chemical Analysis of Bottom Sediments in 2-Bore Hole Stations in Binictican (August 1998)

Sample Designation	COD mg/kg	Cd mg/kg	Cr mg/kg	Hg mg/kg	Loss of Ignition %	Sulfide %	Pb %	As %	Temperature °C
BH - 11 / S-1 Sea-bed Depth 0.55 - 1.0 m	2,492.00	2.36	1.50	4.40	22.91	0.44	ND	ND	31.00
BH - 11 / S-2 Sea-bed Depth 1.55 - 2.0 m	7,960.00	ND	1.90	2.60	44.7	1.30	ND	ND	31.00
BH - 12 / S-1 Sea-bed Depth 0.55 - 1.0 m	5,881.00	ND	2.20	1.70	20.86	0.40	ND	ND	31.00
BH - 12 / S-2 Sea-bed Depth 1.55 - 2.0 m	145,702.00	4.08	2.20	7.70	49.9	4.85	ND	ND	31.00

ND = Not detected

(3) Organic Chemicals

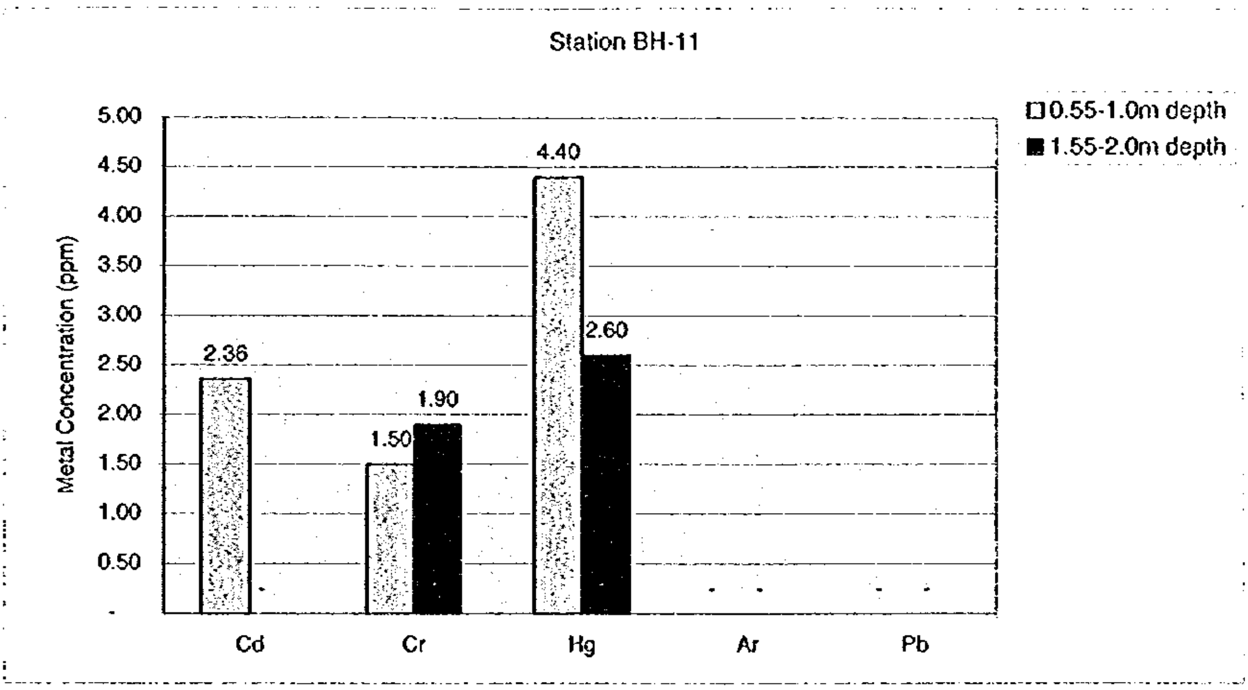
World Bank Study shows that there were only three organic compounds detected in the sediments, particularly in the port area. These were: total petroleum hydrocarbons (TPH), organotin, and polychlorinated biphenyls (PCBs). Chlorinated pesticides or herbicides were not detected in all sediment samples. A summary of the background levels of the detected substances in the sediment is also presented in Table 6.2.2-2. The results from the analysis of the detected parameters are briefly summarized as follows:

1) Petroleum Hydrocarbons

The most common petroleum hydrocarbons were the C15 to C28 and C29 to C36 fractions (diesel and fuel oils) in the concentration range of 102.41 to 1,189.63 mg/kg detected in 13 out of the 28 sites sampled. Highest concentrations were observed around the Inner Basin area. The average petroleum hydrocarbon concentration was about 662 mg/kg. At present there is no Philippine standard for the petroleum hydrocarbon in sediments, although the Netherlands Environmental Protectorate has a limit value of 1,000 mg/kg for newly deposited sediment. The detected petroleum hydrocarbon in the sediment samples were all below the Netherlands limit value except at three stations in the Inner Basin and one in the Osir Basin. The measured ranges of petroleum hydrocarbon levels in the sediments at Subic Bay may be attributed to the long history of fuel handling and shipping activities.

2) Organotin and polychlorinated biphenyls

Tributyltin oxide (TBTO), which is highly toxic to marine life has been used in antifoulant paints since the late 1960s. It was detected in the concentration range of 4.3 to 39 μg/kg. The highest concentration was found near the POL pier. TBTO was also detected in a sediment sample from a tidal canal draining the landfill, which may have originated from either the disposal of harbor sediments containing TBTO or, more likely, from sandblasting and paint wastes disposed at the landfill during the U.S. Navy times. The study also found monobutyltin (7.4 to 325 μg/kg) and dibutyltin (2.5 to 94 μg/kg) in the sediments. The highest concentration for both pollutants was detected from a sample on the eastern side of Riviera Pier. There are no Philippine standards for these compounds in sediments. There is also no quality standard set for TBTO in sediments other than to prevent levels from increasing (Langston, 1996, as quoted by Chua *et al.*, 1997). The Netherlands Environmental Protectorate indicates a limit value of 0.0015 μg/kg in newly deposited sediments, and an intervention value of 10,000 μg/kg. Comparing to this standard, the measured concentrations of TBTO in sediments were below the intervention value but generally above the limit value.



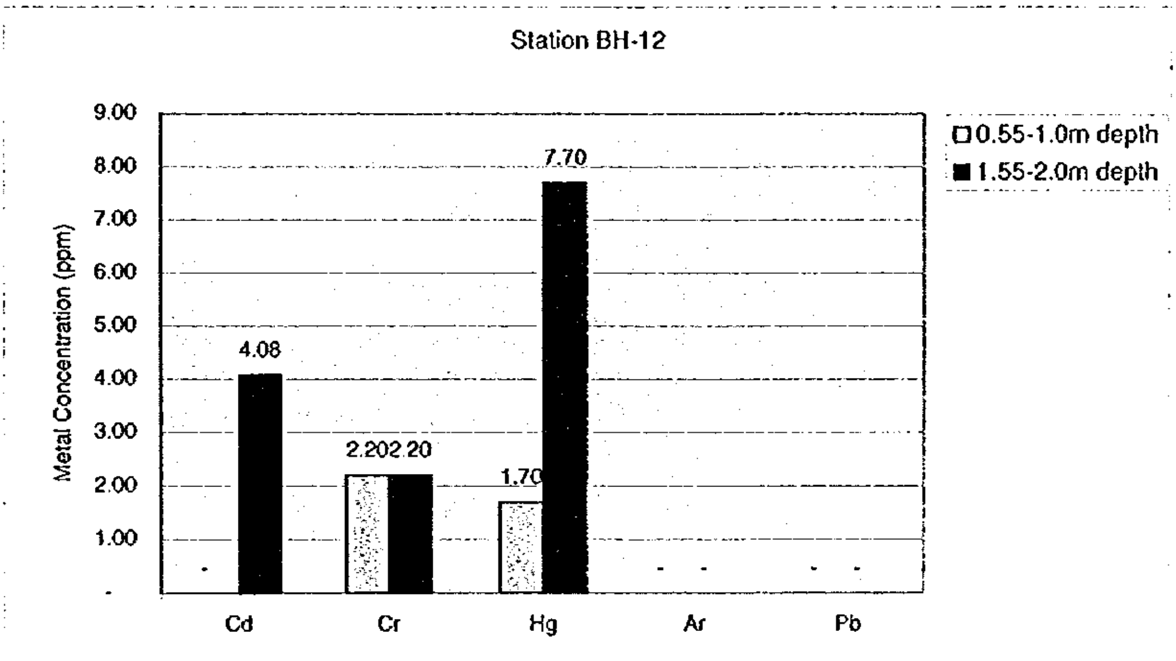


Figure 6.2.2-2 Vertical Distribution of Metals in the Sediments from the Binictican Area, Olongapo City

Polychlorinated biphenyls (PCBs) were not found in the sediments at Subic Bay. Only one sediment sample (Stn. SDM 32) had positive PCB detection but its concentration (1.3 µg/kg) is very much below the Netherlands threshold criteria of 1,000 µg/kg.

6.2.3 Water Quality

(1) Water Usage and Classification

The Subic Bay may be classified as Class SB waters which are suitable for contact recreation such as bathing, swimming, skin or scuba diving and jet skiing. Within the SBMA jurisdiction, the Binanga Bay and those areas of Subic Bay fronting Seafront Road and the Cubi Point beaches have been classified by SBMA as Class SB waters. However, other portions of Subic Bay are used for shipping/navigation, docking, industrial, recreational and fishery purposes. Based on this usage, these portions of the bay may be classified as Class SC. Olongapo Bay is classed as Class SC but is a restricted area for fishing purposes. Bay waters being used for shipping and ports also receive untreated, partially treated and fully treated wastes. Triboa Bay and Ilanin Bay are classed as Class SA for tourist zones and national marine parks and reserves.

The downstream portion of the rivers at Subic Bay, such as Binictican River, Boton River, Kalaklan River, Nibangon River and Cayuag River may be classified as Class C waters since these areas are still being used for subsistence fishing.

(2) Marine/Estuarine Water Quality

The results of the JICA water quality surveys of the marine/estuarine waters around the northern portion of Subic Bay in February 1998 (a total of four stations) and at Cubi Point and along the estuaries of the Inner Basin in January 1999 (a total of four stations) are presented in Table 6.2.3-1 and Table 6.2.3-2, respectively. The locations of the sampling stations are shown in Figure 6.2.3-1.

1) Water Temperature

The water temperatures around the northern portion of Subic Bay ranged from 27.0 to 27.5°C on the surface compared to 26.2 to 27.3°C near the bottom in February 1998. The water temperatures in the offshore area fronting Cubi Point and Inner Basin ranged from 25.9 to 26.9°C on the surface compared to 25.0 to 28.0°C near the bottom in January 1999. The annual variation of surface temperature values of Subic Bay Freeport area and its estuaries reported by the World Bank Study varied from 25 to 29°C (Woodward-Clyde, 1997). However, temperatures between 30.2 to 30.8°C were measured on the surface during one of the El Niño months, in September 1998, along Triboa Bay (Woodward-Clyde, 1998d).

Table 6.2.3-1 Seawater Quality Data for the Northern Portion of Subic Bay (February 1998)

Station No	Sample Identification	Depth (meters)	Transparency (meters)	Dissolved Oxygen (mg/L)	pH	Temperature (°C)	Salinity (ppt)	COD (mg/L)	Total N (mg/L)	Total P (mg/L)	n-hexane (mg/L)	Chlorophyll-a (mg/m³)
WS -1	LTSW-1S	2.5	2.5	5.4	8.1	27.3	31.0	494	0.2	0.02	<20	0.357 +0.083
	LTSW-1B			5.4		26.2	31.1	690	<0.1	0.03	*	0.252+0.025
	HTSW-1S	2.8	2.8	5.8		27.2	31.0	200	0.1	0.06	<20	0.350+0.084
	HTSW-1B			5.8		27.1	31.0	138	<0.1	0.03	*	0.610+0.068
WS-2	LTSW-2S	7	3.4	6	8.16	27.5	31.0	138	<0.1	0.04	<20	1.219+0.364
	LTSW-2M			5.5		27.2	31.7	154	<0.1	0.06	*	0.423+0.127
	LTSW-2B			5.1		26.8	32.0	77	<0.1	0.05	*	0.821+0.435
	HTSW-2S	7	5	6.5		26.9	32.0	154	0.1	0.05	<20	1.056+0.020
	HTSW-2M			5.5		26.8	32.0	200	<0.1	0.03	*	1.313+0.114
	HTSW-2B			5.3		26.8	32.3	77	0.8	0.5	*	0.821+0.435
WS-3	LTSW-3S	6	6	5.6	8.12	27.5	31.0	230	0.1	0.03	<20	0.207+0.040
	LTSW-3M			5.3		27.3	31.9	154	<0.1	0.05	*	0.284+0.073
	LTSW-3B			5		27.3	32.0	230	<0.1	0.05	*	0.436+0.104
	HTSW-3S	7.4	7.4	5.5		27.5	32.1	230	<0.1	0.03	<20	0.406+0.144
	HTSW-3M			5.1		27.5	32.0	154	<0.1	0.03	*	0.284+0.140
	HTSW-3B			5		27.3	32.5	92	<0.1	0.03	*	0.241+0.003
WS-4	LTSW-4S	9	9	5.7	8.2	27	31.9	276	0.1	0.05	<20	0.208**
	LTSW-4M			5.4		27	32.2	92	<0.1	0.04	*	7.637**
	LTSW-4B			5.4		26.9	33.0	108	<0.1	0.03	*	1.070+0.777
	HTSW-4S	10.4	10.4	6.5		27.5	32.8	154	0.1	0.02	<20	0.024+0.021
	HTSW-4M			6.5		27.2	32.9	77	<0.1	0.04	*	0.370+0.363
	HTSW-4B			6.2		26.9	33.0	138	<0.1	0.03	*	ND

* Not determined

** Only one trial

ND - Not detected

Legend: WS-1 = Water Sampling at Stn. 1

LTSW-1S = Low Tide, Sea Water - Stn. 1 Surface

LTSW-1M = Low Tide, Sea Water - Stn. 1 Middle

LTSW-1B = Low Tide, Sea Water - Stn. 1 Bottom

HTSW-1S = High Tide, Sea Water - Stn. 1 Surface

HTSW-1M = High Tide, Sea Water - Stn. 1 Middle

HTSW-1B = High Tide, Sea Water - Stn. 1 Bottom

Table 6.2.3-2 Seawater Quality Data for the Cubi Point and Inner Basin of Subic Bay (January 1999)

Station No.	Sample Identification	Air Temp. (°C)	Wind Direction/ Velocity	Depth (meters)	Transparency (meters)	Dissolved Oxygen (mg/L)	pH	Water Temperature (°C)	Salinity (ppt)	COD (mg/L)	Total N (mg/L)	Total P mg/L	n-hexane (mg/L)	Chlorophyll-a (mg/m^3)
WS -5	LTSW-5S	30.0	270°	7	4	10.8	8.28	26.5	31.20	2.30	4.6	0.73	nil	1.46
	LTSW-5M		strong			*	*	26.0	*	0.77	0.44	0.05	ND	12.18
	LTSW-5B					*	*	26.0	*	ND	ND	0.16	ND	1.67
	HTSW-5S	29.5	270°	9	7	11.2	8.20	26.9	31.48	ND	0.04	0.10	nil	*
	HTSW-5M		slight			*	*	27.0	*	ND	0.43	ND	ND	<0.20
	HTSW-5B					*	*	27.5	*	ND	0.5	0.23	ND	2.91
WS-6	LTSW-6S	28.0	280°	14	4	9.5	8.20	25.9	32.98	1.2	0.18	ND	nil	3.88
	LTSW-6M		moderate			*	*	26.0	*	ND	1.3	1.80	ND	1.88
	LTSW-6B					*	*	26.0	*	2.30	0.32	0.20	ND	0.60
	LTSW-8M		moderate			*	*	25.0	*	1.9	ND	ND	ND	2.65
	LTSW-8B					*	*	25.0	*	2.3	ND	0.10	ND	4.59
	HTSW-8S	26.0	250°	14	4	11.6	8.22	26.8	30.90	2.7	ND	ND	nil	4.78
	HTSW-8M		moderate			*	*	28.0	*	1.5	ND	1.50	ND	4.98
	HTSW-8B					*	*	28.0	*	3.1	ND	0.39	ND	4.24

* = Not determined

ND = Not detected

Legend: WS-5 = Water Sampling at Stn. 5

LTSW-5S = Low Tide, Sea Water - Stn. 5 Surface

LTSW-5M = Low Tide, Sea Water - Stn. 5 Middle

LTSW-5B = Low Tide, Sea Water - Stn. 5 Bottom

HTSW-5S = High Tide, Sea Water - Stn. 5 Surface

HTSW-5M = High Tide, Sea Water - Stn. 5 Middle

HTSW-5B = High Tide, Sea Water - Stn. 5 Bottom

2) Salinity

The water column in the northern portion of Subic Bay had a general pattern of high salinity values during the dry month in February 1998, where salinity varied from 31.0 to 32.8 ppt on the surface compared to 31.0 to 33.0 ppt near the bottom. The salinity off Cubi Point and in the Inner Basin, also during the dry month in January 1999, ranged from 30.9 to 35.2 ppt. The runoffs from rivers are largely responsible for lowering the surface salinity regime, while the monsoons that cause rainy and dry seasons play a key role in affecting the annual salinity variation.

3) pH Values

The pH values in the surface water samples are typical for those of the sea and ranged from 8.1 to 8.2 on the northern portion of Subic Bay, and from 8.2 to 8.3 at Cubi Point and the Inner Basin. The World Bank Study recorded pH values to vary from 7.0 to 8.5. However, in May 1996, the pH reached 8.7 and 9.0 at the center of the Inner Basin and in the estuarine water near the Olongapo City drainage channel discharge Point to Osir Basin, respectively. The DENR water quality standard for pH in Class SB waters is 6.5 to 8.5.

4) Dissolved Oxygen

Coastal waters typically need a minimum of 4.0 mg/L and do better with 5.0 mg/L (Clark, 1996). The data for dissolved oxygen (DO) obtained during the February 1998 survey along the northern portion of Subic Bay varied from 5.0 to 6.5 mg/L, consistently above the 5 mg/L criterion of DENR for Class SB waters. DO data taken from the Cubi Point and Inner Basin in January 1999 showed relatively higher values, ranging from 9.5 to 14.9 mg/L. The DO contents in the coastal and estuarine waters may show high variations from one locality to another due to the influence of land drainage, surface runoffs and freshwater runoffs from rivers. A report from different surveys in certain areas of Subic Bay such as in SBF area, east coast of Pequeña Island, Redondo Peninsula and Triboa Bay showed DO values that fall within the range of 3.7 to 12.7 mg/L (Woodward-Clyde, 1997; 1998b, c and d). DO levels below 5 mg/L were measured on very few occasions in the Inner Basin, particularly during the heavy rain, at some stations close to mouths of rivers and sewage outfalls (Woodward-Clyde, 1997).

5) Total Suspended Solids

The total suspended solids (TSS) include both inorganic (sand and clay) and organic (particulate material, bacteria and plankton) substances in the water. Water that contains an excess of TSS is described as turbid. The World Bank Study reported that the levels of TSS at the SBF area (from Kalaklan estuary, Osir Basin, Inner Basin, Cubi Point, Triboa Bay and Ilanin Bay) varied from <1 mg/L up to a maximum of 152 mg/L (Table 6.2.3-3). However, most of the stations showed levels below the DENR incremental standard of 30 mg/L increase for Class SB waters. Some areas surveyed by Woodward-Clyde (1998b, c and d), especially those in Pequeña

Island (11.0 to 19.0 mg/L), Redondo Peninsula (<1 to 20.8 mg/L) and Triboa Bay (not detectable level at <1 mg/L), were found to contain very low levels of TSS.

Table 6.2.3-3 Range of Total Suspended Solids (TSS) in Subic Bay Freeport Marine and Estuarine Surface Waters [a]

SAMPLING EVENT	SEASON	TSS RANGES (mg/L or ppm)	DENR CRITERIA
1. Sept 1995	Wet	7.5 to 152	Class SA - Not more than 30% increase
2. Dec 1995	Transition from Wet to Dry	< 1 to 28	Class SB - Not more than 30% mg/L increase
3. Feb 1996	Dry	< 1 to 20	Class SC - Not more than 30% mg/L increase
4. May 1996	Transition from Dry to Wet	< 1 to 43	Class SD - Not more than 60% mg/L increase

Data Source: WORLD BANK STUDY (Woodward Clyde, 1997)

LEGEND:

S A = Waters suitable for the propagation, survival and harvesting of shellfish for commercial purposes; for tourist zone and national marine parks and reserves.

S B = Regularly used by the public for bathing, swimming, skin diving, etc.

S C = Boating, etc., commercial/municipal fishing

S D = Industrial water supply, e.g. cooling

(a) = Kalaklan, Sea Front, Inner Basin, OSIR Basin, Cubi Point, Triboa Bay and Ilanin Bay

<1 = Not detectable, or below detection limit

6) Water Transparency

Except for Stn. WS2 (near the mouth of Nibangon River), all the rest of the stations sampled during the February 1998 survey along the northern portion of Subic Bay were transparent up to the bottom. The low transparency of the water column at Stn. WS2 may be attributed to the elevated presence of suspended (living and non-living) materials. The transparency conditions during the January 1999 survey at Cubi Point (4 to 7 m) and Inner Basin (3 to 6 m) indicates more turbid coastal water. This was probably due to high concentration of suspended sediments from Boton, Binictican-Malawaan Rivers and rich phytoplankton in the water column.

7) Chlorophyll-*a* Concentrations

Chlorophyll-*a* is an indicator of phytoplankton biomass or the living part of suspended matter. Data taken along the northern portion of Subic Bay indicates that chlorophyll-*a* concentrations were generally higher in the area fronting the mouth of Nibangon River than the rest of the locations sampled. The amount in other locations was more or less in the same order of magnitude. Higher concentration of growth-promoting nutrients (see nitrogen and phosphorous, below) may be responsible for the greater concentrations of chlorophyll-*a* at Stn. WS2. In Cubi Point and Inner Basin, a recent survey January 1999 obtained a concentration of 1.46 to 4.82 mg/m^3 of chlorophyll-*a* on the surface compared to <0.20 to 4.59 mg/m^3 near the bottom. The highest concentration of 12.18 mg/m^3 was observed during low tide (mid-depth) at Cubi Point. The high chlorophyll-*a* content in all sampling stations during this sampling period indicates high phytoplankton concentrations in the area.

8) Biochemical Oxygen Demand

One of the most important measures of water quality is biochemical oxygen demand (BOD_5) the amount of dissolved oxygen used by organisms to consume biodegradable organic materials. The BOD_5 levels obtained during the World Bank Study ranged from <2 mg/L up to a maximum of 137 mg/L (Table 6.2.3-5). However, most of the stations showed very low levels (<2 mg/L, or below the detection limit). The high levels of BOD_5 (8.9 to 137.0 mg/L) were usually found close to drainage canals, sewage outfalls and mouths of rivers draining into the bay. This is may be due to the influx of organic matter in the bay due to heavy rain. For the other areas in the bay such as in Pequeña Island, the BOD_5 values ranged from 1.1 to 1.3 mg/L (Woodward-Clyde, 1998b); Redondo Peninsula from 1.1 to 1.7 mg/L (Woodward-Clyde 1998b); and for the Triboa Bay from 1.0 to 1.2 mg/L (Woodward-Clyde, 1998c). These ranges of values measured were all below the applicable standards. DENR Class SB waters are required to maintain BOD_5 concentration up to or below 5 mg/L, and for Class SC waters up to or below 7 mg/L.

Table 6.2.3-5 Range of Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) in Subic Bay Freeport Marine and Estuarine Surface Waters

Sampling Event	Season	BOD (mg/L)	COD (mg/L)
1. Sept 1995	Wet	8.9 to 137.0	31.6 to 356.0
2. Dec 1995	Transition from Wet t o Dry	< 2	4.0 to 40.0
3. Feb 1996	Dry	< 2 to 4	170.0 to 40.0
4. May 1996	Transition from Dry to Wet	< 2 to 13	10.0 to 57.0

Data Source : World Bank Study (Woodward - Clyde , 1997)

<2 = Not detectable, or below detection limit

9) Chemical Oxygen Demand

Chemical oxygen demand (COD) measures the amount of dissolved oxygen required to oxidize organic compounds that are not biologically degradable. COD values are always higher than BOD_5 values. The COD data obtained in February 1998 around the northern portion of Subic Bay ranged from 77 to 690 mg/L. The high values of COD were found in the water column south of Pequeña Island. In the estuarine area along the Inner Basin and coastal water fronting Cubi Point, the COD levels ranged from not detectable to 4.2 mg/L. However, these values could not be directly compared to a set of limits since there are no existing COD standards (DENR Administrative Order No.34) for surface seawater or freshwater bodies. However, the samples obtained from the northern portion of Subic Bay were all above the effluent standards (DENR Administrative Order No.35) for Class SB of 60 mg/L. The World Bank Study (Woodward-Clyde, 1997) found an annual variation of 4 to 356 mg/L (see Table 6.2.3-5). In the coastal waters along the east coast of North Sumatra, the COD values ranged from 11 to 766 mg/L (Abdullah et al., 1995 as quoted by Chua et al., 1997).

10) Total Nitrogen

Nitrogen becomes available to the aquatic ecosystem in the form of nitrate ions (NO_3). The survey in February 1998 along the northern portion of Subic Bay showed that total nitrogen (total-N) levels in the water samples have values ranging from < 0.1 mg/L up to 0.8 mg/L. However, most of the stations showed very low levels (<0.1 mg/L). The highest level of total -N was found during high tide on the bottom near the mouth of Nibangon River. Among the areas sampled in January 1999 (Cubi Point and Inner Basin), total-N values ranged from not detectable to 4.6 mg/L. Almost 50% of the samples analyzed contained very low concentrations (not detectable) while the other 50% indicated detectable levels between 0.04 to 4.6 mg/L.

In such areas as Pequeña Island, Redondo Peninsula and Triboa Bay, the NO_3 content ranged from not detectable to a maximum of 1.30 mg/L (Woodward-Clyde, 1998b, c and d). Similarly, a World Bank Study (Woodward-Clyde, 1997) reported low levels of NO_3 (< 0.01 to 2.8 mg/L) along Kalaklan, Inner Basin, Osir Basin, Cubi Point, Triboa Bay and Ilanin Bay (Table 6.2.3-6). For most of the stations, NO_3 levels were highest during the rainy or wet season. At present there is no DENR standard for nitrogen in coastal and estuarine waters. Surface waters contain at least trace levels of NO_3 (<1 mg/L) but rarely more than 5 mg/L. Levels above 5 mg/L reflect unsanitary conditions because one of the major sources of NO_3 is human and animal waste. Rain water may contain NO_3 of 0.2 mg/L (Canadian Council of Ministers of the Environment, as quoted by Woodward-Clyde, 1997). In conclusion, the NO_3 concentrations measured at Subic Bay and its estuaries suggest that the presence of NO_3 in the water is not due to human activities.

Table 6.2.3-6 Range of Nitrate (NO3) in Subic Bay Freeport Marine and Estuarine Surface Waters

SAMPLING EVENT	SEASON	NO_3 (mg/L)
1. September 1995	Wet	< 0.01 to 2.8
2. December 1995	Transition from Wet to Dry	0.01 to 0.09
3. February 1996	Dry	< 0.01 to 0.04
4. May 1996	Transition from Dry to Wet	< 0.01 to 0.40

Data Source : World Bank Study (Woodward - Clyde , 1997)

11) Total Phosphorous

Phosphorous usually exists in seawater as phosphate ions (PO_4). Total phosphorous (total -P) along the northern portion of Subic Bay ranged from 0.02 to 0.50 mg/L. However, most of the sampling stations showed levels from 0.03 to 0.05 mg/L. High concentration of total-P was detected during high tide (near the bottom) fronting the mouth of Nibangon River. On the Inner Basin and Cubi Point, total-P ranged from not-detectable to 6.30 mg/L.

Readings taken at the Pequeña Island ranged from not detectable to 0.02 mg/L, those at the Redondo Peninsula ranged from not detectable to 0.77 mg/L and show at the Triboa Bay from 0.10 to 0.49 mg/L (Woodward-Clyde, 1998b, c and d). The DENR has not set a definite standard for this nutrient. However, EPA (1979) standards prescribe a maximum allowable concentration of 0.1 μg/L (0.0001 mg/L) for total -P in coastal waters. The measured PO_4 could be attributed to natural sources such as decay of organisms and rock weathering (Woodward-Clyde, 1997).

12) Oil & Grease, N-hexane and Other Parameters

The measurements for oil & grease showed a range of < 1 to 33.4 mg/L from the World Bank Study (Woodward-Clyde, 1997) covering the water bodies along Kalaklan, Inner Basin , Osir Basin, Cubi Point, Triboa Bay and Ilanin Bay (Table 6.2.3-7). Oil & grease were found to be higher during the rainy season, particularly in water samples from the POL Pier and near the mouths of Boton and Kalaklan Rivers where oil & grease concentrations were generally above the 2 mg/L standard for Class SB waters and 3 mg/L for Class SC waters. This is may be due to surface runoff from the industrial area of SBMA where activities such as cleaning and maintenance of equipment and machinery take place (Woodward-Clyde, 1997). Oil & grease were also reported in the marine waters around Pequeña Island (not detectable to 1.2 mg/L), the east coast of Redondo Peninsula (not detectable to 0.76 mg/L) and the Triboa Bay (not detectable to 2.1 mg/L) (Woodward-Clyde 1998 b, c and d). The presence of oil & grease in these locations implies that these areas are also affected by the oily wastewater discharge from harbors/marinas or piers, industrial sites and shipping lanes.

Table 6.2.3-7 Range of Oil & Grease in Subic Bay Freeport Marine and Estuarine Surface along Waters

SAMPLING EVENT	SEASON	OIL and GREASE (mg/L)
1. September 1995	Wet	< 20. TO 33.4
2. December 1995	Transition from Wet to Dry	< 1.0 TO 2.0
3. February 1996	Dry	< 1.0 TO 4.0
4. May 1996	Transition from Dry to Wet	1.0 TO 4.0

Data Source : World Bank Study (Woodward - Clyde , 1997)

The data for n-hexane were even more very limited. N- hexane was not detected in all surface seawater samples collected in February 1998 along the northern portion of Subic Bay. Similarly, the water samples taken in January 1999 from Cubi Point and Inner Basin ranged from not detectable to nil.

Data obtained by the World Bank Study indicate that the additional parameters, such as halogenated organic compounds, BTX, phenols, pesticides, and cyanide were not detected in any of the marine and estuarine water samples. The only organic compound detected is total petroleum hydrocarbon (TPH).

According to the World Bank Study (Woodward-Clyde, 1997), the petroleum hydrocarbon C6 to C9 fraction (gasoline) was not detected in all of the samples analyzed for TPH (Table 6.2.3-8). The C10 to C14 fraction (from kerosene and jet fuel) was detected only near Boton wharf (28 μg/L) during the rainy month in September 1995. Similarly, the C29 to C36 fraction (fuel oil) was only detected near the marine terminal and Boton wharf during the rainy month (35 and 26 μg/L, respectively). C15 to C28 fraction (diesel) was detected in the estuaries of Binictican River (32 to 49 μg/L), near the marine terminal (34 to 138 μg/L) and harbors (POL pier, 34 μg/L; Boton wharf, 34 to 78 μg/L). The levels of hydrocarbon determined are well above FAO's 0.0025 mg/L (2.5 μg/L) water column standard. There appear to be very limited data on petroleum hydrocarbons for other areas in the bay.

Table 6.2.3-8 Total Petroleum Hydrocarbon or TPH Content (μg/L) in Waters of Selected Sites in the Subic Bay Freeport Area

LOCATION	SEPTEMBER 1995				FEBRUARY 1996			
	C6-C9	C10 - C14	C15 - C28	C29 - C36	C6 - C9	C10 - C14	C15 - C28	C29 - C36
Waterfront, (near Asphalt Plant)	ND	ND	33	ND	ND	ND	32	ND
Sewerage Outfall, (near Bldg. 408)	ND	ND	46	ND	ND	ND	29	ND
Center of Inner Basin, (Marine Terminal)	ND	ND	138	35	ND	ND	34	ND
Mouth of Binictican River	ND	ND	32	ND	ND	ND	49	ND
Infront of POL Pier	ND	ND	nd	ND	ND	ND	34	ND
Mouth of Opoc River	ND	ND	58	ND	ND	ND	42	ND
Boton Wharf	ND	28	78	26	ND	ND	34	ND
Dungaree Beach	ND	ND	70	ND	ND	ND	35	ND

Data Source : World Bank Study (Woodward - Clyde, 1997)

ND = Not Detected

nd = No data available

C6 - C9 Fraction = Gasoline

C10 - C14 Fraction = Kerosene / Jet Fuel

C15 - C28 Fraction = Diesel

C29 - C36 Fraction = Fuel Oil

13) Heavy metals

A summary of the background levels (ranges) of these pollutants in the water column is presented in Table 6.2.3-9. World Bank Study reported very low concentrations of heavy metals (chromium, copper, lead, barium, nickel, selenium, silver, vanadium and zinc) in the coastal/estuarine waters of Kalaklan, Waterfront, Inner Basin, Osir Basin, Cubi Point, Triboa Bay and Ilanin Bay at levels below the standards for Class SB waters. No detectable levels (i.e., below the detection limit) of antimony, arsenic, cadmium and mercury were recorded. Among all the metals identified, manganese had the highest concentration. The highest manganese concentration (0.42 mg/L) was reported near the mouth of Kalaklan River. The Philippines has no criteria for manganese in Class SB waters. It is usually present in natural surface waters at a concentration of 0.2 mg/L or less (Canadian Council of Ministers of the Environment, 1995 as quoted by Woodward-Clyde, 1997). Some water samples collected by the Woodward-Clyde (1998 b and d), such as in the marine waters around Pequeña Island (0.6 mg/L in all 4 stations) and Triboa Bay (0.3 to 0.4 mg/L), were found to contain lead at levels above the Class SB standard of 0.05 mg/L.

Mercury(d)	ND	ND	ND	ND	0.002
Nickel(e)	<0.001-0.001	NA	0.003-0.008	ND	-
Selenium(f)	<0.01-0.03	NA	ND	<0.01-0.02	-
Silver(g)	<0.001-0.002	ND	0.001-0.029	ND	-
Vanadium(h)	0.02-0.03	NA	ND	NA	-
Zinc	0.014-0.087	NA	0.004-0.026	0.001-0.02	2.0*

Data Source: World Bank Study (Woodward - Cylde, 1997)

ND = Not Detected

NA = Not Analyzed

(-) = No Water Quality Standards Recommended

(*) = Based on NPCC (1978) standards

(a) ND<0.001 (b) ND<0.01 (c) ND<0.001 (d) ND <0.0005 (e) N<0.01 (f) ND<0.001 (g) ND<0.05 (h) ND<0.5

14) Coliform Bacteria

The data for coliforms for Subic Bay were very limited. The marine waters of Pequeña Island and Triboa Bay are relatively free of bacterial pollutants (Woodward-Clyde, 1998b and d). Fecal coliform *Escherichia coli*, which is mostly associated with human and animal waste, was not detected in the four sampling stations in Triboa Bay. However, survey conducted in April 1998 (Woodward-Clyde, 1998c) showed that the total coliform level reached up to 2,400 MPN/100 ml in the Redondo Peninsula (Sitio Agusuhin) area.

(3) River Water Quality

Table 6.2.3-10 shows the measurements of a number of water quality parameters from Kalaklan River (Stn.WR1), Cayuag River (Stn. WR2), Boton River (Stn.WR3) and Binictican

River (Stn. WR4) during the JICA Study in February 1998 and January 1999. The locations of the sampling stations are shown in Figure 6.2.3-1 . The World Bank Study also conducted river water quality surveys between September 1995 and May 1996 along Binictican River, Malawaan River, Boton River, Triboa River and Ilanin River. The range of the river water quality parameters obtained during this study are summarized in Table 6.2.3-11.

Table 6.2.3-10 River Water Quality and Relevant Meteorological Parameters at the Four Rivers in Subic Bay (JICA Study)

PARAMETERS	Feb-98		Jan-99		DENR Water Quality Standards (Class C Waters)
	Stn. WR1 Kalaklan River	Stn. WR2 Cayuag River	Stn. WR3 Boton River	Stn. WR4 Binictican River	
Air Temperature (°C)	nd	nd	28.0	27.50	
Wind Speed / Direction	nd	nd	calm/240°	slight/240°	
Water Depth (m)	nd	nd	1.00	3.75	
Transparency (Secchi Depth in m)	nd	nd	1.00	3.00	-
Water Temperature (°C)	nd	nd	27.00	25.90	3°C rise
PH	7.78	8.50	7.99	7.98	6.5 - 8.5
Salinity (ppt)	nd	nd	26.80	21.30	-
DO (mg/L)	3.50	7.20	8.80	8.50	5.0
BOD_5(mg/L)	14.30	7.70	1.60	2.00	5.0
COD (mg/L)	31.00	31.00	5.00	7.70	-
Total SS (mg/L)	nd	nd	10.00	20.00	not more than 30 mg/L increase
Settleable Solids (mg/L)	0.20	ND	nd	nd	-
Total-N (mg/L)	4.10	0.20	ND	ND	-
Total-P (mg/L)	0.48	0.02	ND	ND	-
Chrolophyll-a (mg/m³)	12.230*	1.386+ 0.270	4.05	4.55	-

ND = Not detected

nd = No data available

*- = No Water Quality Standards recommended * = Only one trial*

1) Water Temperature

Temperature measurements done by World Bank Study in the rivers that led to Subic Bay showed a variation of 25.0 to 31.8°C (see Table 6.2.3-11). According to the study, temperature values recorded during the wet month (September 1995) were generally lower than values recorded during the other sampling months (December 1995, February 1996 and May 1996).

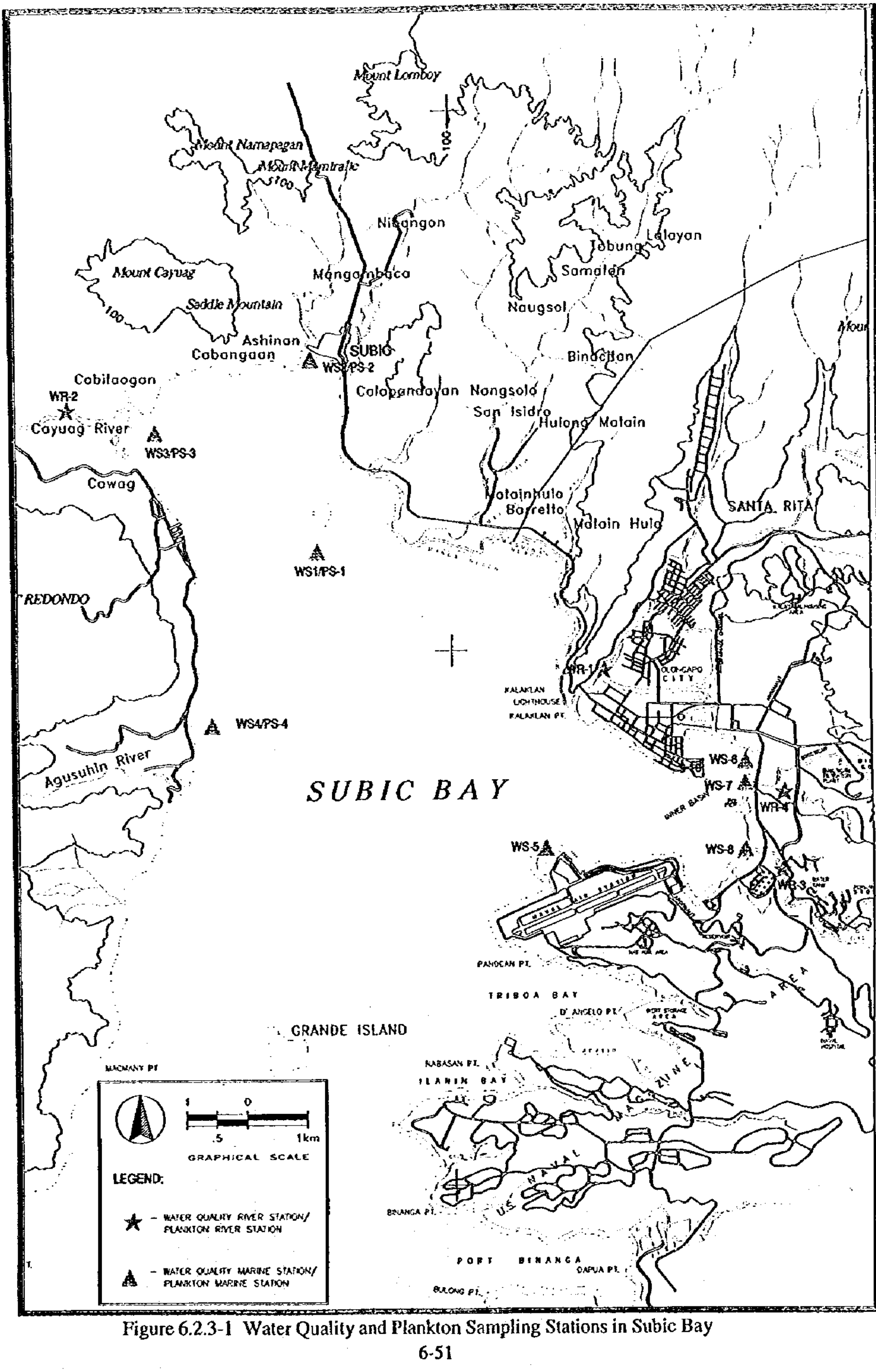


Figure 6.2.3-1 Water Quality and Plankton Sampling Stations in Subic Bay

Table 6.2.3-11 Ranges of Water Quality Parameters from Locations at the Rivers within the Subic Bay Freeport (World Bank Study)

WATER QUALITY PARAMETERS	Binictican River (near landfill area)	Binictican River (inside Aeta Village)	Binictican River (bridge along Rizal hi-way)	Malawaan River (after the horse stable)	Boton River (near coastal Petroleum Tanks)	Triboa River (upstream)	Ilanin River (upstream)	DENR Water Quality Standards (Class A Waters)
Temparature (°C)	25.7 - 31.8	25.8 - 28.8	25.4 - 29.1	26.9 - 28.0	25.1 - 26.8	25.0 - 26.9	24.3 - 26.8	3°C rise
pH (range)	6.8 - 7.6	7.5 - 8.3	7.1 - 7.8	6.3 - 7.9	6.9 - 7.7	6.6 - 7.2	6.4 - 7.6	6.5 - 8.5
DO (mg/L)	3.1 - 6.2	5.6 - 10.8	4.9 - 6.5	6.6 - 10.9	6.5 10.6	6.5 - 10.6	6.5 - 10.6	5.0
Total SS (mg/L)	6 - 46	4 - 157	3 - 54.5	<1 - 156	1 - 44.4	<1 - 283	<1 - 240	50
Total DS (mg/L)	291 - 12,100	23.4 - 205	214 - 27,600	71 - 162	104 - 218	82 - 134	63 - 102	1000
BOD (mg/L)	<2 - 59.5	<2 - 10.5	<2 - 10.8	< 2 - 54.5	<2 - 28.8	<2 - 34.0	<2 - 97.5	5.0
COD (mg/L)	29 - 114	2 - 36	14 - 44	<1 - 136	<1 - 72.6	1 - 112	<1 - 126	-
Nitrate (mg/L)	0.05 - 0.06	<0.01 - 0.04	0.05 - 2.8	<0.01 - 0.40	<0.01 - 0.70	0.06 - 1.0	0.07 - 1.2	10
Oil and Grease (mg/L)	2 - 3	<1 - 3	<1 - 4	<1 - 7.2	<1 -3	<1 - 4	<1- 21.2	1
Phenols	ND	ND	ND	ND	ND	ND	ND	0.002
TPH C6 - C9 Fraction (µg/L)	ND	nd	nd	nd	nd	nd	nd	-
TPH C10 - C14 Fraction (µg/L)	70	nd	nd	nd	nd	nd	nd	-
TPH C15- C28 Fraction (µg/L)	267	nd	nd	nd	nd	nd	nd	-
TPH C29- C36 Fraction (µg/L)	26	nd	nd	nd	nd	nd	nd	-
Antimony (mg/L)	ND	nd	nd	nd	nd	nd	nd	-
Arsenic (mg/L)	ND	ND	ND	ND	ND	ND	ND	0.05
Barium (mg/L)	0.087 - 0.289	<0.001 - 0.048	0.009 - 0.036	0.006 - 0.032	0.006 - 0.033	0.011 - 0.045	0.012- 0.042	0.70*
Cadium (mg/L)	ND	ND	ND	ND	ND	ND	ND	0.01
Chromium (mg/L)	<0.001 - 0.003	ND	<0.001 - 0.003	<0.001 - 0.002	<0.001 - 0.002	<0.001 - 0.002	<0.001 - 0.003	0.05
Copper (mg/L)	0.004 - 0.013	0.001 - 0.008	0.003 - 0.007	0.002 - 0.004	0.001 - 0.008	0.001 - 0.014	0.004 - 0.012	1.0
Lead (mg/L)	0.001 - 0.005	<0.001 - 0.002	<0.001 - 0.004	<0.001 - 0.004	<0.001 - 0.004	<0.001 - 0.006	<0.001 - 0.003	0.05
Manganese (mg/L)	0.552 - 1.390	0.002 - 0.177	0.026 - 0.073	0.053 - 0.0153	0.028 - 0.185	0.024 - 0.028	0.019 - 0.194	-
Mercury (mg/L)	ND	ND	ND	ND	ND	ND	ND	0.002
Nickel (mg/L)	<0.001 - 0.007	ND	<0.001 - 0.004	<0.001 - 0.002	<0.001 - 0.002	ND	<0.001 - 0.002	-
Selenium (mg/L)	ND	ND	ND	ND	ND	ND	ND	0.05*
Silver (mg/L)	<0.001 - 0.002	ND	ND	ND	ND	<0.001 - 0.003	<0.001 - 0.001	0.05*
Vanadium (mg/L)	ND	nd	nd	nd	nd	nd	nd	-
Zinc (mg/L)	0.012 - 0.048	0.006 - 0.034	0.002 - 0.056	0.002 - 0.021	<0.001 - 0.0032	<0.001 - 0.063	<0.006 - 0.038	5.0*

Data Source: World Bank Study (Woodward - Clyde, 1997)

ND = Not detected, or below the detection limit

nd = No data available

\- = No Water Quality Standards recommended

* = Based on NPCC (1978) Standards

2) pH Values

The levels of pH obtained during the JICA Study varied from 7.8 to 8.5, and well within the range for Class C waters (i.e., fishery water for the propagation and growth of aquatic life). The World Bank Study reported that pH varied from 6.3 to 8.3. In general, the pH values tended towards slightly acidic to slightly alkaline.

3) Dissolved Oxygen

The minimum dissolved oxygen (DO) standard for Class C waters is 5.0 mg/L. The lowest requirement for most fish in warm water temperature is about 4 mg/L. JICA Study found that DO varied from 3.5 to 8.8 mg/L. The lowest DO level was found in Kalaklan River, while the highest was found in Boton River. Along the five rivers (Binictican River, Malawaan River, Boton River, Triboa River and Ilanin River) monitored by the World Bank Study, DO levels ranged from 3.1 to 10.9 mg/L. However, most of the stations recorded DO levels above the standard. According to the study, the depressed DO level (3.1 - 4.3 mg/L) found in a creek downstream of the landfill area, can be attributed to the leachate coming from the landfill. The slightly low DO content (4.9 mg/L in May 1996) found below the bridge along Rizal Highway in Binictican River can be attributed to the surface runoffs and discharges from the surrounding areas (i.e., Subic Power Plant, Binictican Filtration Plant and Binictican Golf Course) draining to Binictican River. The level of DO can be affected by a number of factors, such as high primary productivity, high water temperature (27.4 to 32.8°C) and high salinity levels and organic loading (Chua et al., 1997).

4) Total Suspended Solids, Total Dissolved Solids and Settleable Solids

The Philippine standard for total suspended solids (TSS) in Class C waters specifies an increase of not more than 30 mg/L. Concentrations of TSS less than 25 mg/L usually have no harmful effects on fisheries. Waters containing concentrations of 25 to 80 mg/L should be capable of supporting good to moderate fisheries (UNESCO/WHO, 1978 as quoted by Clark, 1996). Where concentrations exceed 80 mg/L, good freshwater fisheries are unlikely (Clark, 1996). There was no river sampling for TSS during the JICA survey in February 1998. Data from January 1999 survey in Boton River and Binictican River clearly indicates low TSS levels (10 and 20 mg/L, respectively). However, from the monitoring surveys conducted by the World Bank Study the TSS ranged from <1 mg/L up to a maximum of 283 mg/L (see Table 6.2.3-11). Most stations during the entire survey period were generally below the standard except during the rainy month (September 1995) when all the stations (44.4 to 283 mg/L) exceeded the standard, probably due to the soil particles eroded by heavy rain from the open areas in Subic Bay (Woodward-Clyde, 1997).

There is no total dissolved solids (TDS) standard for Class B and Class C waters. The water quality standard for TDS in Class A waters (for sources of water supply that will require complete treatment in order to meet the National Standard for Drinking Water) is 1,000 mg/L. The World Bank Study found that the concentrations of TDS ranged from 23 to a maximum of 27,600 mg/L. The low levels (23 to 291 mg/L) were obtained during the rainy month (September 1995), probably due to the dilution by heavy rain. The TDS levels during the other sampling months did not vary significantly (Woodward-Clyde, 1997).

The levels of settleable solids were very low. JICA study found no detectable level of settleable solids in Cayuag River, while a detected level was found in Kalaklan River (0.2 mg/L).

5) Chlorophyll-*a* Concentrations

The highest value for chlorophyll-*a* was found in Kalaklan River which was attributed to the presence of high amount of growth-promoting nutrients (see total nitrogen and total phosphorous, below). Conversely, Cayuag River contained low concentration of chlorophyll-*a*. High concentrations of chlorophyll-*a* were also observed in Boton River and Binictican River.

6) Biochemical Oxygen Demand

Class C waters are required to maintain biochemical oxygen demand (BOD_5) concentration below 5 mg/L. River waters with a BOD_5 of less than 2 mg/L are considered not polluted; those with BOD_5 greater than 10 mg/L are considered grossly polluted (Clark, 1996). The BOD_5 levels measured in February 1998 ranged from 7.7 mg/L in Cayuag River to 14.3 mg/L in Kalaklan River, which exceeded the standard. By contrast, low levels of BOD_5 were observed in Boton River and Binictican River (1.6 and 2.0 mg/L, respectively). High concentrations of BOD_5 were recorded in September 1995 by World Bank Study, ranging from 10.5 to 97.5 mg/L. High concentrations of BOD_5 were attributed to the influx of organic matter due to heavy rain. However, in the succeeding sampling events (December 1995, February 1996 and May 1996) the BOD_5 content of all the stations were reported to be very low (< 2 mg/L).

7) Chemical Oxygen Demand

Chemical oxygen demand (COD) is not included in the DAO No. 34 as a water quality parameter in freshwater. The COD levels in Kalaklan River and Cayuag River (31 mg/L) were observed to be higher than in Boton River and Binictican River (5 and 8 mg/L, respectively). World Bank Study identified the surface waters to have highest concentration of COD during the first sampling event which was during the rainy season (September 1995, from 23.7 to 126 mg/L) compared to the COD values obtained during the other sampling events (December 1995, from 2 to 46 mg/L; February 1996, from < 1 to 52 mg/L; and May 1996, from 6 to 44 mg/L). The highest levels of COD were usually found in Binictican River (i.e., downstream of the landfill area and golf course).

8) Total Nitrogen

The nitrate (NO_3) standard for Class A waters is 10 mg/L. There is no recommended nitrate standard for Class C waters. World Bank Study reported that all of the freshwater samples had NO_3 concentrations (from < 0.01 up to a maximum of 2.8 mg/L) below the Class A standard. However, one station (Malawaan River) consistently shows higher nitrate values (0.25 to 0.40 mg/L). This may be attributed to the influence of El Kabayo horse stable, which is upstream of this station. Similarly, low total nitrogen (total-N) levels were observed in Cayuag River (0.2 mg/L) and Kalaklan River (4.1 mg/L).The "pool" of nitrogen at Kalaklan River may be a reflection of nutrient inputs from waste and sewage from the high density of human population living along the banks of the river. No detectable levels of total-N were recorded in Boton River and Binictican River.

9) Total Phosphorous

DENR has not set definite limit/standard for total phosphorous (total-P). Levels of total-P in the rivers around Subic Bay were minimal. Values obtained during the February 1998 survey ranged from 0.02 mg/L in Cayuag River to a maximum of 0.48 mg/L in Kalaklan River. The recent survey in January 1999 showed no detectable levels of total-P in Boton River and Binictican River.

10) Oil & Grease, Phenol and Other Parameters

Class A and Class C waters must contain less than 1 mg/L and 2 mg/L of oil & grease, respectively. Data from World Bank Study show that the oil & grease varied from < 1 mg/L to 21.2 mg/L. The highest concentrations of oil & grease were obtained upstream of Malawaan River (7.2 mg/L) and Ilanin River (21.2 mg/L) in September 1995, which was during the rainy season. However, most of the stations showed no detectable levels. Similarly, most of the stations sampled in December 1995 and February 1996 also exhibited no detectable levels. During the last sampling in May 1996 consistently oil & grease was detected in all freshwater samples consistently above the standard.

The World Bank study also conducted water sampling for phenols, but no detectable levels were recorded.

Similarly, other parameters such as halogenated hydrocarbons, BTEX, fumigants, pesticides and herbicides were not detected from the Binictican River stations during the two sampling events in September 1995 and February 1996.

The only organic compound detected at the downstream Binictican River is total petroleum hydrocarbon (TPH), which was sampled in February 1998. Like marine/estuarine water samples, petroleum hydrocarbon C6 to C9 fraction (gasoline) was not detected in the freshwater sample analyzed for TPH. The study noted high level of C15 to C28 fraction (diesel, 267 μg/L) in water. The C10 to C14 fraction (kerosene, jet fuel; 70 μg/L) and C29 to C36 fraction (fuel oil, 26 μg/L) were also detected in the sample. The levels of petroleum hydrocarbon detected are well above FAO's 2.5 μg/L (0.0025 mg/L) water column standard.

11) Heavy Metals

The World Bank Study showed that concentrations of heavy metals in all river samples were low, and were all below the standards (see Table 6.2.3-11). No detectable levels of antimony, arsenic, cadmium, mercury, selenium and vanadium were recorded. Nickel and silver were detected only once in February 1996, while zinc was detected in only few samples in May 1996. For other heavy metals such as barium, chromium, copper and lead, detectable levels were reported for all samples but in very low concentrations. Manganese, which was reported to be naturally occurring in the soils of Subic, had the highest concentration among all the heavy metals analyzed.

6.2.4 Aquatic Flora and Fauna

(1) Plankton

Plankton is a term used to describe collectively small, mostly microscopic organisms, which drift about passively in the water. Plant and animal members are considered separately under the terms phytoplankton and zooplankton, respectively. The location of the sampling stations for plankton are the same as those used in the study of marine/estuarine and river water quality (see Figure 6.2.3-1).

1) Marine Phytoplankton

The phytoplankton biomass and density are presented in Table 6.2.4-1. The phytoplankton volume ranged from a minimum of 1.57 ml/m^3 at Stn. PS3 (off the mouth of Cayuag River) to a maximum of 3.22 ml/m^3 at Stn. PS4 (north of Agusuhin Point). The highest number of phytoplankton was recorded north of Agusuhin Point with 3,353,868 $cells/m^3$; and the lowest with 1,403,230 $cells/m^3$ off the mouth of Cayuag River.

Table 6.2.4-1 Summary of Phytoplankton and Zooplankton Biomasses and Densities (February 1998).

Station	Phytoplankton (20 microns mesh net)		Zooplankton (0.33 mm mesh net)	
	Displacement Volume (ml/m³)	Number of Phytoplankton (No./m³)	Displacement Volume (ml/m³)	Number of Zooplankton (No./m³)
PS-1	2.94	2,958,117	0.10	17,128
PS-2	3.02	1,914,784	0.45	17,007
PS-3	1.57	1,403,230	0.49	17,802
PS-4	3.22	3,353,868	0.53	11,726
Mean	2.69	2,407,499.75	0.39	15,915.75

All the phytoplankton taxa identified from the 20-micron mesh plankton net are shown in Table 6.2.4-2 along with their density and abundance. The major groups of phytoplankton are the diatoms (16 genera), blue-green algae (consisting solely of *Trichodesmium*) and dinoflagellates (9 genera). The diatoms outnumbered the blue-green algae in all stations, averaging 87.41%. The blue-green algae ranked next after diatoms, averaging 12.26%. The dinoflagellates were much less abundant, averaging only 0.33%.

2) Marine Zooplankton

The biomass and density of zooplankton are also shown in Table 6.2.4-1. Biomasses of zooplankton were lower than those of the biomasses of phytoplankton. The lowest volume of zooplankton, 0.10 ml/m³, was recorded at Stn. PS1 (off the mouth of Matain River) while the highest was observed at Stn. PS4 (N of Agusuhin Point), with 0.53 ml/m³. All the stations except for the station north of Agusuhin Point have nearly the same density, which ranged from 17,007 to 17,802 organisms iaceans (0.5%), foraminiferans (0.3%) and fish eggs (0.2%).

Table 6.2.4-2 List of Phytoplankton Taxa Identified from Subic Bay Samples and their Density and Relative Abundance (February 1998)

TAXA	STA. PS-1 (No./m³)	STA. PS-2 (No./m³)	STA. PS-3 (No./m³)	STA. PS-4 (No./m³)	Mean Density (No. of cells/m³)	Mean Relative Abundance (%)
CYANOPHYCEAE (BLUE-GREEN ALGAE)						
Trichodesmium	222,325	26,666	215,000	717,227	295,304	12.26
Sub-Total	222,325	26,666	215,000	717,227	295,304	12.26
Bacillariophyceae (diatoms)						
Amphora	4,055	8,291	2,705	147,692	40,685	1.68
Bacteriastrum	62,196	184,762	31,194	778,449	264,150	10.97
Biddulphia	4,896	4,901	2,450	4,873	4,280	0.17
Chaetoceros	1,457,046	1,313,312	583,333	259,483	903,293	37.52
Cocconeis	13,801	1,947	16,233	173,142	51,280	2.12
Diploneis	24,653	2,450	5,156	-	8,064	0.33
Fragillaria	4,055	1,947	-	-	1,500	0.06
Gyrosigma	15,151	4,901	5,411	31,658	14,280	0.60
Hemediscus	9,466	4,397	-	-	3,465	0.14
Navicula	19,212	13,193	10,623	141,182	46,052	2.00
Nitzschia	702,518	154,640	68,817	562,278	372,063	15.45
Pleurosigma	-	19,034	2,705	302,444	81,045	3.36
Rhizosolenia	18,394	5,841	24,350	50,333	24,729	1.02
Surirella	-	10,742	-	-	2,685	0.11
Thalassiosira	5,411	2,450	-	4,055	2,979	0.12
Thalassiotrix	383,054	145,340	427,361	176,932	283,171	11.76
Sub-Total	2,723,808	1,878,148	1,180,338	2,632,521	2,103,721	87.41
DINOPHYCEAE (DINOFLAGELLATES)						
Ceratium	1,303	1,895	2,766	1,623	1,896	0.07
Eutreptiella	-	-	152	-	38	0.00
Gymnodinium	-	77	-	-	19	0.00
Halosphaera	-	116	-	-	29	0.00
Ornithocercus	-	-	-	97	24	0.00
Polykrikos	9,123	6,849	2,576	746	4,823	0.20
Protoperidinium	941	664	2,128	1,492	1,306	0.05
Prorocentrum	617	292	108	162	294	0.01
Pyrophacus	-	77	162	-	59	0.00
Sub-Total	11,984	9,970	7,892	4,120	8,488	0.33
TOTAL	2,958,117	1,914,784	1,403,230	3,353,868	2,407,513	100.00

Legend: (-) = not present

The survey indicate that the plankton population during the February 1998 collection along the northern portion of Subic Bay are dominated by phytoplankton (over 99%). The zooplankton is only less than 1%. This is to be expected since phytoplankton represent the primary producers or "grass of the sea," forming the base of the food web.

3) River/Freshwater Plankton

Table 6.2.4-3 presents phytoplankton and zooplankton data for the river stations. The density of the phytoplankton groups is generally higher at Stn. PR2 (Cayuag River) than at Stn. PR1 (Kalaklan River). The phytoplankton population for Cayuag River is composed largely of diatoms, green algae and blue-green algae; while Kalaklan River is composed largely of diatoms and green algae. The zooplankton is abundant but less diverse in Kalaklan River than in Cayuag River.

Table 6.2.4-2 List of Zooplankton Taxa identified from Subic Bay Samples and their Density and Relative Abundance (February 1998)

TAXA	STA. PS-1 (No./m³)	STA. PS-2 (No./m³)	STA. PS-3 (No./m³)	STA. PS-4 (No./m³)	Mean Density (No. of organisms/m³)	Mean Relative Abundance(%)
Smaller Zooplankton						
CILIATA						
Codonellopsis	635	233	2,209	1,184	1,065	6.70
Favella	-	38	-	-	9	0.06
Tintinnopsis	6,916	8,842	6,794	3,050	6,400	40.23
FORAMINIFERA						
Globigerina	-	88	54	-	36	0.23
COPEPODA						
Copepod nauplii	833	2,033	1,933	2,166	1,741	10.94
Sub-Total	8,384	11,234	10,990	6,400	9,251	58.16
Larger Zooplankton						
CALANOID COPEPODS	2,594	2,492	2,512	1,806	2,351	14.78
CYCLOPOID COPEPODS						
Oithona	1,686	563	318	259	706	4.44
CLADOCERA						
Evadne	1,054	204	221	64	385	2.42
CIRPIPEDIA						
Barnacle larvae	-	348	-	-	87	0.55
DECAPODA						
Shrimp larvae	437	225	493	307	365	2.30
Lucifer	-	134	-	139	68	0.42
APPENDICULARIA						
Oikopleura	364	784	902	1,923	993	6.24
CHAETOGNATHA						
Sagitta	272	180	2,318	69	709	4.46
MOLLUSCA						
Limacina	194	264	-	129	146	0.92
Creseis	162	-	-	64	56	0.35
ECHINODERMATA						
Ophiuroid larvae(Ophiopluteus)	1,151	-	-	259	352	2.21
Echinoid larvae (Echinopluteus)	668	-	-	-	167	1.05
THALIACEA						
Salpa	-	217	-	-	54	0.34
Doliolum	-	-	48	64	28	0.17
COELENTERATA						
Diphyes	162	-	-	-	40	0.25
Obelia	-	260	-	139	99	0.62
Liriope	-	102	-	-	25	0.16
CHORDATA						
Fish eggs	-	-	-	104	26	0.16
Sub-Total	8,744	5,773	6,812	5,326	6,657	41.84
TOTAL	17,128	17,007	17,802	11,726	15,908	100.00

Legend: (-) = not present

Table 6.2.4-3 List of Phytoplankton and Zooplankton Taxa Identified from River Samples and their Density and Relative Abundance (February 1998)

TAXA	STA. PR-1		STA. PR-2	
	Density (No./L)	Relative Abundance (%)	Density (No./L)	Relative Abundance (%)
PHYTOPLANKTON				
Chlorophyceae (green algae)				
Microsterias	-	-	200	0.49
Scenedesmus	-	-	133	0.32
Spirogyra	12,000	53.11	17,466	42.36
Sub-Total	12,000	53.11	17,799	43.17
Cyanophyceae (blue-green algae)				
Merismopodia	-	-	600	1.45
Nostoc	200	0.88	-	-
Polycystis	2,800	12.40	2,000	4.85
Sub-Total	3,000	13.28	2,600	6.30
Bacillariophyceae (diatoms)				
Amphora	1,000	4.42	5,066	12.30
Closterium	-	-	333	0.80
Cosmarium	400	1.77	133	0.32
Cymbella	800	3.54	6,400	15.52
Cydrocystis	-	-	200	0.49
Diatoma	-	-	200	0.49
Navicula	600	2.65	1,066	2.59
Netrium	-	-	200	0.49
Nitzschia	200	0.88	466	1.13
Penium	-	-	133	0.32
Pleurotaenium	-	-	200	0.49
Spirotaenia	400	1.77	200	0.49
Surirella	200	0.88	66	0.16
Synedra	600	2.65	4,466	10.83
Tetmemorus	-	-	1,300	3.15
Sub-Total	4,200	18.56	20,429	49.57
TOTAL	19,200	84.95	40,828	99.04
ZOOPLANKTON				
Cyclops	-	-	66	0.16
Copepod nauplii	-	-	266	0.64
Shrimp larvae	2,800	12.40	66	0.16
Polychaete larvae	600	2.65	-	-
TOTAL	3,400	15.05	398	0.96
GRAND TOTAL	22,600	100	41,226	100

Legend: (-) = Not present

Sta. PR-1 = Kalaklan River

Sta. PR-2 = Cayuag River

(2) Soft-Bottom Benthos

A sandy seabed containing organic substances, which support a rich habitat for soft-bottom communities, characterizes Subic Bay. These soft-bottom communities support demersal fisheries (bottom-dwelling fishes) in the bay. The composition, count and percentage abundance of the nearshore benthic fauna from 32 stations sampled around Subic Bay in February 1998 are shown in Table 6.2.4-4. The locations of the sampling stations are shown in Figure 6.2.4-1.

Table 6.2.4-4 Total Count and Percentage Composition of Benthic Fauna Sampled in Subic Bay (February 1998)

Taxa	Count	Percent	Total Count	Total Percent
Foraminifera	19	1.51	19	1.51
Cnidaria			5	0.40
Ceriantharia	5	0.40		
Rhynchocoela	51	4.06	51	4.06
Nematoda	61	4.86	61	4.86
Polychaeta			690	54.94
Orbiniidae	5	0.40		
Spionidae	174	13.85		
Magelonidae	1	0.08		
Capitellidae	150	11.94		
Maldanidae	12	0.96		
Opheliidae	32	2.55		
Phyllodocidae	3	0.24		
Polynoidae	2	0.16		
Pilargidae	16	1.27		
Syllidae	15	1.19		
Nereidae	92	7.32		
Glyceridae	56	4.46		
Nephtyidae	13	1.04		
Euphrosinidae	3	0.24		
Onuphidae	14	1.11		
Eunicidae	26	2.07		
Lumbrineridae	36	2.87		
Arabellidae	4	0.32		
Sternaspidae	1	0.08		
Terebellidae	7	0.56		
Sabellidae	28	2.23		
Sipunculida	31	2.47	31	2.47
Mollusca			129	10.27
Gastropoda	10	0.80		
Scaphopoda	1	0.08		
Pelecypoda	118	9.39		
Crustacea			187	14.89
Penaeidea	7	0.56		
Caridea	1	0.08		
Nephropsidea	2	0.16		
Brachyura	2	0.16		
Cumacea	6	0.48		

Taxa	Count	Percent	Total Count	Total Percent
Isopoda	92	7.32		
Gammaridea	75	5.97		
Caprellidea	2	0.16		
Echinodermata			35	2.79
Crinoidea	3	0.24		
Asteroidea	3	0.24		
Echinoidea	9	0.72		
Holothuroidea	2	0.16		
Ophiuroidea	18	1.43		
Cephalochordata	5	0.40	5	0.40
Pisces	4	0.32	4	0.32
Incertae Sedis	39	3.11	39	3.11
Total	1256	100.00	1256	100.00
Number of Taxa	44			

The benthos survey counted a total of 1,256 benthic fauna, represented by 44 animal taxa: 21 taxa of polychaetes, 8 taxa of crustaceans, 5 taxa of echinoderms, 3 taxa of molluscs and 1 taxon of each of the remaining groups. The polychaetes are the most abundant organisms, comprising about 55% of the total collection. Spionids (14%) and capitellids (12%) are among the most commonly encountered polychaetes. Their wide distribution is probably due to their high adaptability to any kind of marine soft-bottom community.

The population density of benthic fauna collected at each sampling station is shown in Figure 6.2.4-2 . The abundance of the soft-bottom fauna ranged from 207 to 2,429 ind/m^2. The highest was found at 1.5 m depth in the sandy bottom of Stn. S13, where nereids (Polychaeta) and gammarids (Crustacea) predominate. Most of the stations at the shallower areas (1.4 to 2.5 m depths) showed higher density and diversity of benthic fauna than at the deeper areas.

Collection of sediment samples from the rivers yielded poor benthic fauna obtaining only one nereid worm (15 ind/m^2) at Stn. WR1 (Kalaklan River) and more at Stn. WR2 (Cayuag River).

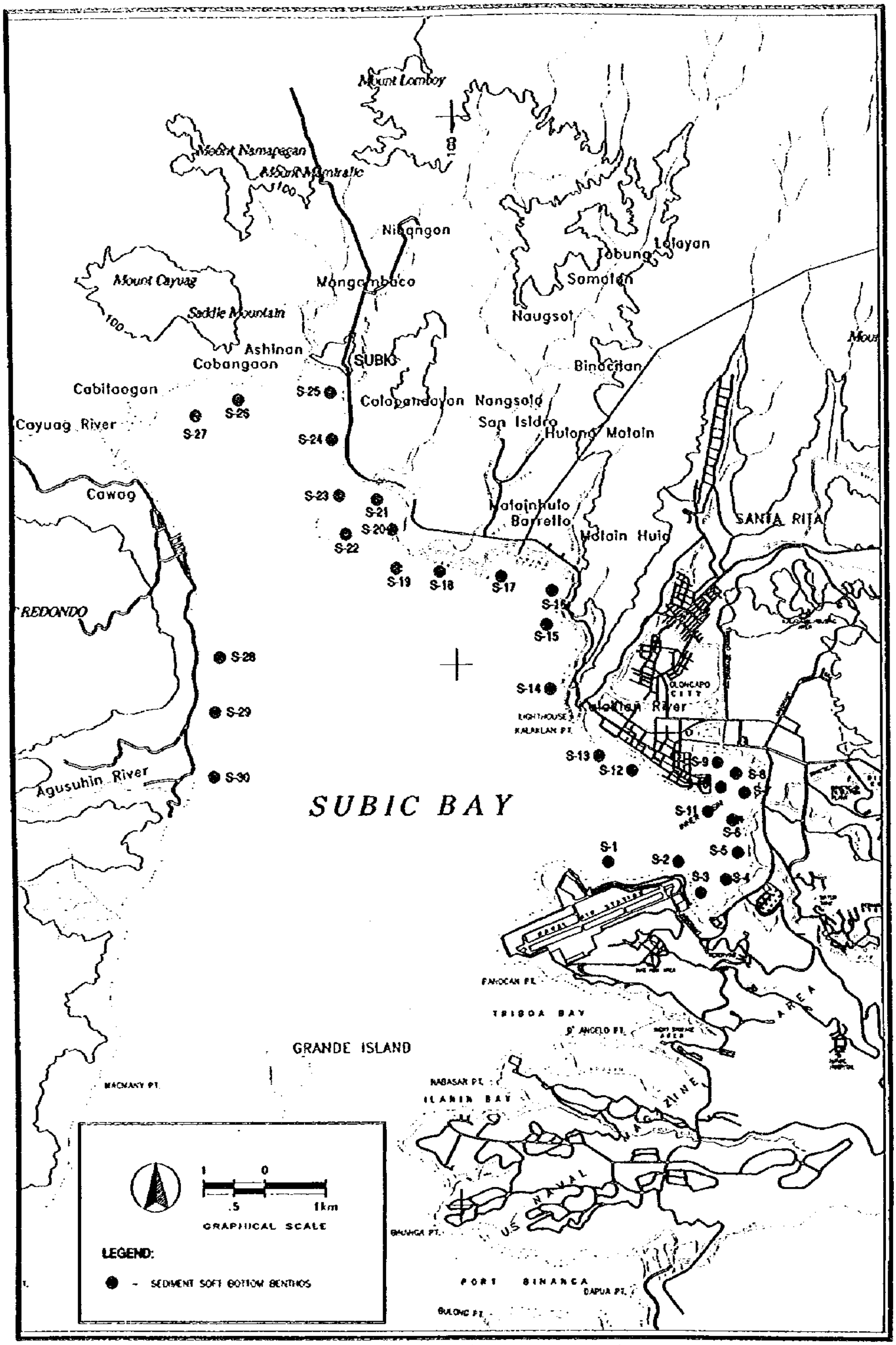


Figure 6.2.4-1 Sediment Soft Bottom Benthos Sampling Stations in Subic Bay

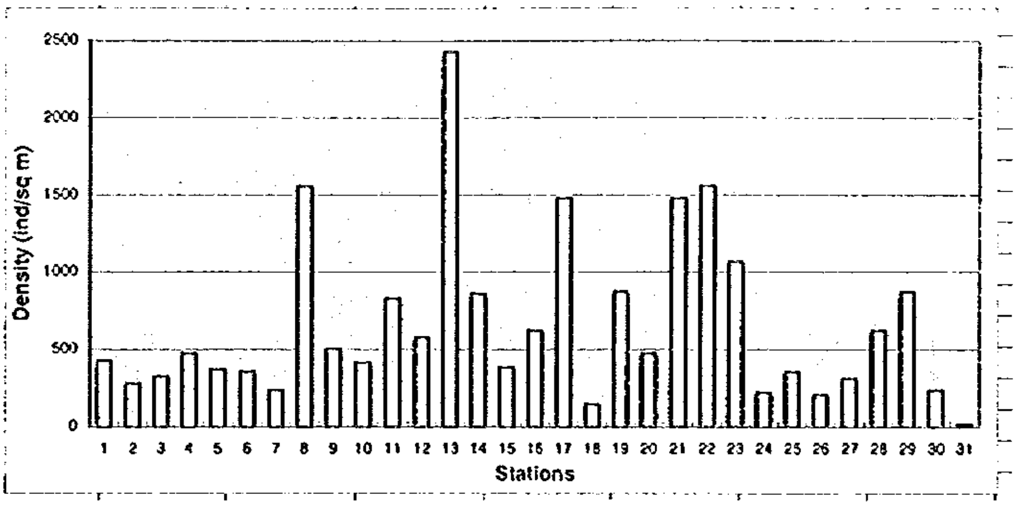


Figure 6.2.4-2 Population Density of Benthic Fauna Sampled at All Stations in Subic Bay

The biomass of benthic fauna at the different stations is shown in Table 6.2.4-5. The biomass ranged from 0.59 to 25.48 g/m^2 having Stn. S17 with the highest biomass. Stns. S8 (10.36 g/m^2), S12 (10.07 g/m^2) and S2 (9.04 g/m^2) ranked second, third and fourth, respectively. All the other stations have biomass ranging from 0.59 to 6.96 g/m^2.

(3) Mangroves

The mangroves are important coastal habitats and nursery grounds which support a significant level of the inshore fisheries (i.e., commercial species of fish, shrimps and crabs). Mangroves in the study area are found at the estuaries (mouths of rivers) which drain into the Olongapo Bay, Triboa Bay, Ilanin Bay and Subic Bay (Figure 6.2.4-3).

A survey conducted by World Wildlife Fund (Philippines) in 1994 estimated that the mangroves in SBMA occupy about 100 hectares. Six mangrove locations are present, namely, Malawaan River, Binictican River, Boton River, Triboa River, Apalin Creek and Ilanin River. The nine major mangrove elements found include *Avicennia marina, A. officinalis, Bruguiera gymmnorhizza, Lumnitzera* sp., *Nypa fruticans, Rhizophora apiculata, R. mucronata, Sonneratia alba* and *S. caseolaris*. The three minor mangrove elements nclude *Heritiera littoralis, Excoecartia agallocha* and *Acrostichum inerme;* while the three mangrove associates include *Acanthus ebrecteatus, Ipomoea pescaprae* and *Sesuvium portulacastrum* (Zamora, 1994). Mangrove trees occur in better condition along the edges of waterways and along the shoreline fronting Olongapo Bay, Triboa Bay and Ilanin Bay (Seastems, 1994).

Table 6.2.4-5 Biomass[1] of Benthic Fauna (g/sq m) at Different Sampling Stations in Subic Bay (February 1988

Stations	Mean wet weight	Biomass (g/sq m.)
S 1	0.03	1.18
S 2	0.20	9.04
S 3	0.07	3.11
S 4	0.05	2.22
S 5	0.05	2.22
S 6	0.07	3.26
S 7	0.10	4.44
S 8	0.23	10.36
S 9	0.11	4.74
S 10	0.11	5.04
S 11	0.16	6.96
S 12	0.23	10.07
S 13	0.13	5.63
S 14	0.11	4.74
S 15	0.08	3.56
S 16	0.07	2.93
S 17	0.57	25.48
S 18	0.01	0.59
S 19	0.05	2.37
S 20	0.03	1.48
S 21	0.10	4.44
S 22	0.05	2.37
S 23	0.04	1.92
S 24	0.05	2.22
S 25	0.01	0.59
S 26	0.05	2.22
S 27	0.05	2.22
S 28	0.05	2.22
S 29	0.09	3.85
S 30	0.02	0.89
WR 1	0.03	1.47
WR 2	0.00	0.00

Values are means of three replicates

The most recent survey on mangroves at the Ilanin River, Apalin Creek and Triboa River was done by Woodward-Clyde in 1996 as part of the World Bank Study. Six major mangrove elements were found, namely: *Rhizopora apiculata, Bruguiera sexangula, Sonneratia alba, S. caseolaris, Avicennia marina and Nypa fruticans.* Two minor mangrove elements and seventeen mangrove associates are also found. The mangrove formations at the mouth of Ilanin and Triboa Rivers are dominated by *Rhizophora apiculata* while the community at the mouth of Triboa River by *Sonneratia alba.*

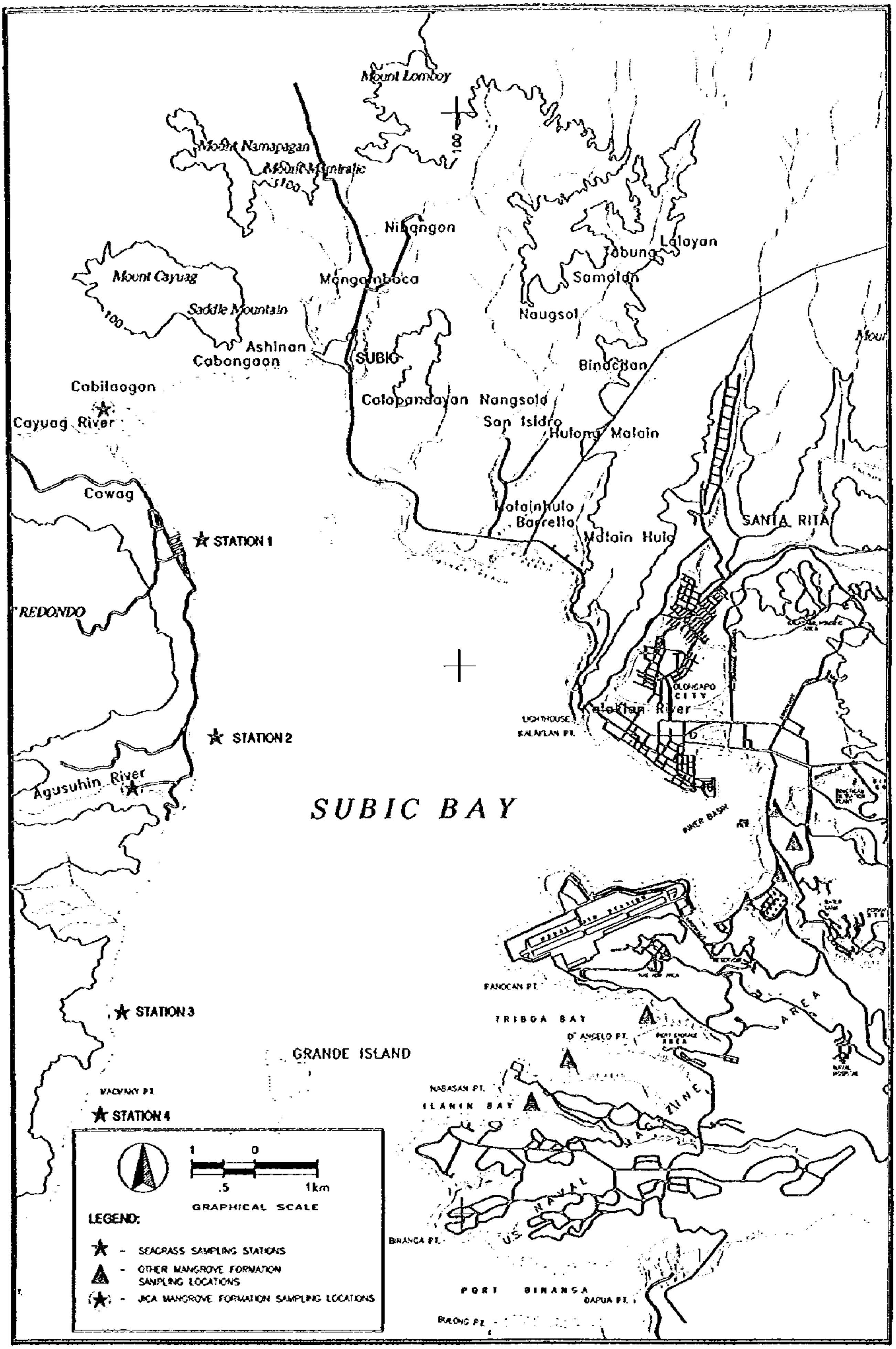


Figure 6.2.4-3 Location of Mangrove Formation and Seagrass Sampling Stations in Subic Bay

Other mangrove habitats are located at the northwestern end of the bay in Cabitaogan and along the east coast of Redondo Peninsula in Agusuhin River. A survey of these mangrove areas was conducted by the JICA Study Team in February 1998 (see Figure 6.2.4-3). A structural comparison of mangrove stands in these two areas is shown in Table 6.2.4-6. The survey confirmed the earlier report by Pajaro and Alino (undated) that Cabitaogan was estimated to have lost about 95% of its mangroves to ponds, specifically of milkfish, tilapia and prawn. Cabitaogan is dominated by *Avicennia officinalis* with very few stands of *Sonneratia caseolaris* in sandy-muddy bottoms and overlain with pyroclastic granules from Mt. Pinatubo eruption. The canopy height ranged from 3 to 5 m. The formation in Agusuhin River is also dominated by *Avicennia officinalis* with the presence of *Sonneratia caseolaris* and *Rhizophora apiculata* stands in sandy-silty bottoms overlain with pyroclastic materials. The canopy height ranged from 4 to 8 m. A number of *Ceriops tagal* individuals and grooves of *Nypa fruticans* including some mangrove associates are also found.

Table 6.2.4-6 Structural Comparison of mangrove stands in two stations surveyed in the Subic Bay Area

Site/ Transect No.	Genus present	Average DBH	Relative density	Relative frequency	Relative dominance
Cabitaogan Point					
Transect 1	Avicennia officinalis	16.36	97.96	98.04	98.60
	Sonneratia caseolaris	14.00	2.04	19.61	1.40
Transect 2	Avicennia officinalis	18.63	100.00	100.00	100.00
Transect 3	Avicennia officinalis	18.58	93.5	98.04	93.75
	Sonneratia caseolaris	18.00	6.45	19.61	6.24
Agusuhin Point					
Transect 1	Avicennia officinalis	15.59	94.11	62.50	97.40
	Sonneratia caseolaris	13.00	1.96	12.50	0.70
	Nypa fruticans		3.92	25.00	1.88
Transect 2	Avicennia officinalis	18.98	80.95	55.00	86.30
	Sonneratia caseolaris	15.66	9.52	22.00	2.64
	Rhizophora apiculata	14.88	7.14	11.00	5.07
	Ceriops tagal	14.00	2.38	11.00	5.99
Transect 3	*no survey conducted due to technical reasons**				

* the site was composed of trees less than 12.0 cm diameter and does not extend to 10 meters in area.

(4) Seagrass Beds

Seagrasses are the only submerged flowering plants in the marine environment. Seagrass beds in Subic Bay are mostly found around the Grande Island and in Triboa Bay (Seastems, 1994). In the western side of the Grande Island, a total of eight seagrass species are found. The more common species include *Syringodium isoetifolium, Thallasia hemprichii* and *Halodule uninervis.* In Triboa Bay, a total of six seagrass species are found. The species *Halodule uninervis, Cymodocea rotundata* and *Halophila ovalis* are the most common.

More seagrass beds were found only recently during the JICA Study along the east coast of Redondo Peninsula. However, these do not form extensive beds, occurring in isolated patches. Their distribution is limited mostly in subtidal regions with depths of 3 to 9 m and, in some cases in intertidal region with depths of 0.6 to1.5 m. Only two species of seagrasses, *Enhalus acoroides* and *Halophila ovalis* were found. Table 6.2.4-7 presents the species composition, density, frequency, percentage cover and biomass of seagrasses in the four stations surveyed. The location of the sampling stations is shown in Figure 6.2.4-3. Three sites are characterized by the dominance of *Halophila ovalis* with Stn. 2 the highest mean density (2,306 shoots/m^2). The site with the lowest density was found at Stn. 1 (52 shoots/m^2), which is an *Enhalus acoroides* bed. In terms of biomass or "standing crop", Stn. 1 showed the highest mean value (60.4 dry wt g/m^2). This is due to the presence of *Enhalus acoroides*, which is characterized by massive and heavy rhizomes. On the other hand, lower biomass were observed at Stns. 2, 3 and 4 (0.04 to 0.06 dry wt g/m^2). These values are generally much lower than the total biomass of selected seagrass communities in the Philippines, which typically range from 8 to 132 dry wt g/m^2 (Rollon and Fortes, 1989). The reason is that the majority of the species composition of the areas surveyed belongs to the smaller seagrass species, *Halophila ovalis*.

Table 6.2.4-7 Species Composition, Density, Frequency and Percentage Cover of Seagrass Beds in the Four Stations Surveyed in Subic Bay

Station / Quadrat No.	Density (no. of shoots/m²)	Relative Frequency	% Cover	No. of shoots /transect	Density (N/A)	TDW (in g.)	TDW/n	Biomass (g/m²)
Station 1 *Enhalus acoroides*	52	20.0	10.33	65	20.0	196.00	3.020	60.4
Station 2 *Halophila ovalis*	2306.4	20.0	26.62	4283	20.0	8.75	0.002	0.04
Station 3 *Halophila ovalis*	1845.6	20.0	10.67	2307	19.4	6.50	0.003	0.06
Station 4 *Halophila ovalis*	1349.6	20.0	13.32	2687	20.0	6.98	0.003	0.06

(5) Coral Reefs

1) Coral Reef Distribution in Subic Bay

Coral reef resources occur in the southern, western and southwestern parts of Subic Bay. The southern reefs are found in Triboa Bay, Camayan Point, and around the Grande and Chiquita Islands. The western reefs are found along the east coast of Redondo Peninsula from Nagyantok down to Sampaloc Point. The southwestern reefs are outside of the bay along the west coast of Redondo Peninsula facing the South China Sea (Port Silanguin, Nazasa Bay and Talisain Bay). Description of the distribution of coral reefs within the study area is shown in Figure 6.2.4-4. Many of the reefs in this area are in the form of fringing reefs, those whose platform is close to or along rocky shorelines. However, there are also some small patch reefs and shoals with scattered or rare coral growths, such as those around Cubi Point. The coral reefs in the Port of Binanga were not included in the environmental assessment.

2) Shoals Around Cubi Point

Within a radius of 2 km from Cubi Point, there are about four shoals, namely: Caiman Shoal, Carrasco Shoal, Sixteen-Foot Shoal and Pamocan Shoal. The World Bank Study carried out a coral transect survey on a sand-silt slope at the end of the Cubi runway (Pamocan Shoal). The results indicate that this coral shoal is in poor condition. Most of the corals were long dead or partly dead. The site is dominated by live fire coral *Millepora* (20% cover), *Acropora* (1.3%) , mushroom corals (0.6%) and remnants of massive and branching *Porites*. The presence of large sea cucumber *(Stichopus* spp.), rays and groupers characterize the site.

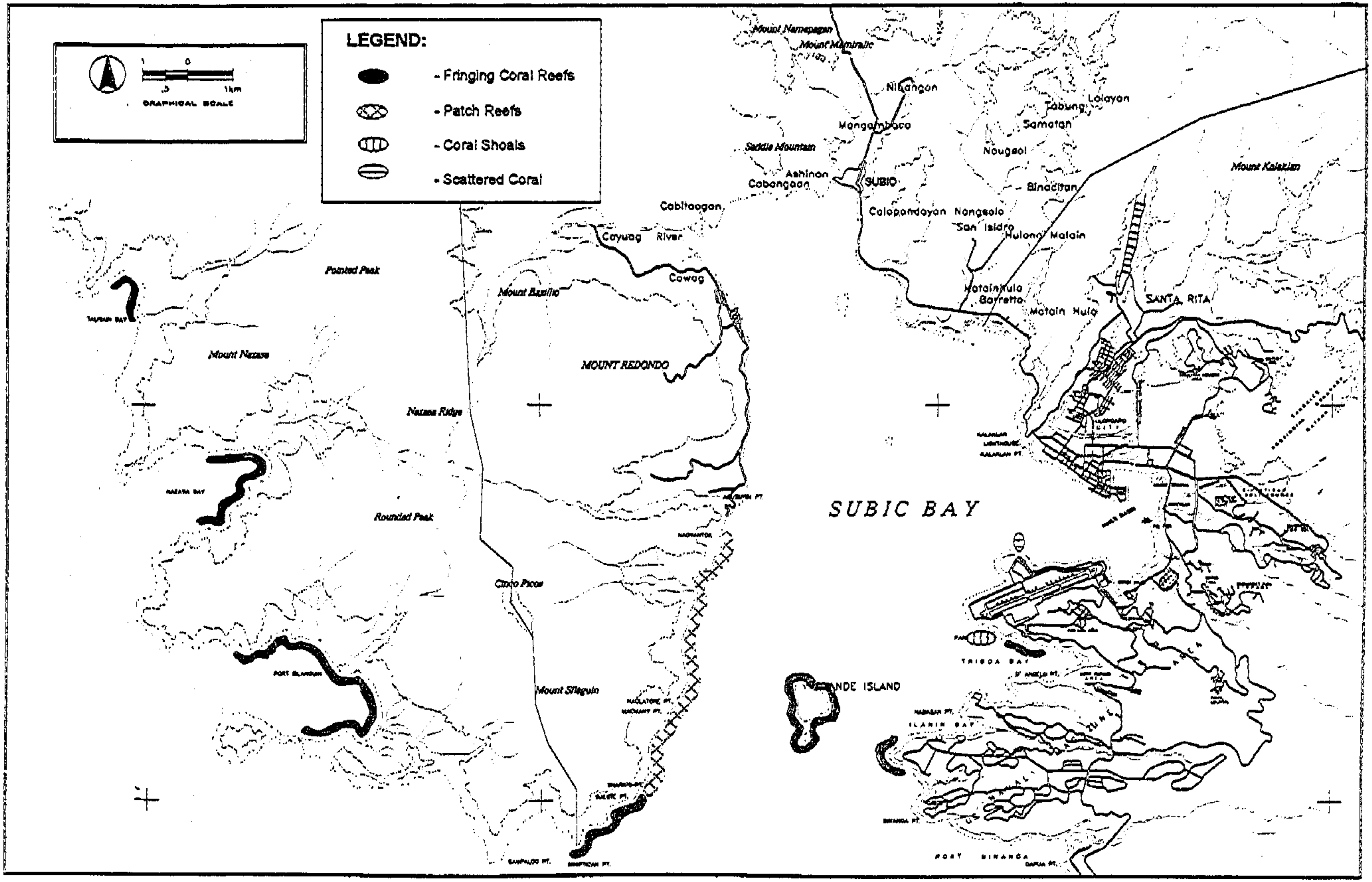


Figure 6.2.4-4 Coral/Coral Reef Distribution in Subic Bay

The JICA Study covered 12 observation tows with a distance of approximately 1 km and depths from 2.3 to 11 m from the Leyte wharf (Lat. 14°48.130 N and Long. 120°16.050 E) towards the direction of the red marker buoy No.8 (Lat. 14°48.292 N and Long. 120°15.492 E). The survey revealed the presence of scattered/rare live coral growths in the vicinity of the proposed project site at the tip of Cubi Point. These scattered coral colonies are located about 300 to 1,000 m NW of Leyte wharf. The site is composed largely of sand and boulders, covering over 55% of the bottom area. Long dead coral substrates make up the remainder of the bottom (about 41%). As a result, the site has only scattered or very low coral cover, ranging 2 to 4%. The corals found consisted of the following genera: *Porites, Acropora, Pocillopora* and *Millepora*. There was ample evidence of previous disturbance on this site. The eruption of Mt. Pinatubo which deposited about 5-20 cm ash around the immediate vicinity of Subic Bay (Atrigenio et al., 1991), most likely caused this disturbance.

3) Coral Reefs of Triboa Bay

Along the hull of a sunken Landing Craft Utility (LCU) near the head of Triboa Bay (14 to 21 m water depth), the reef is in poor condition with only 12% live coral cover (Woodward-Clyde, 1997). Most of the corals are of the encrusting or flattened massive forms of faviids like *Goniastrea, Favia, Favites, Monastrea* and other coral species.

Infront of the APEC village, live coral covers around 50% (Dames & Moore, 1996) of the seabed. The non-*Acropora* coral species accounted for 46%, with massive and branching lifeforms being the dominant types. *Acropora* species, accounted for the remaining 4% of the coral cover.

The vicinity of the Edgewater Project of FBC (Financial Building Corporation) revealed the presence of coral reef, about 10 m SW of the rock causeway (Woodward-Clyde, 1998d). The fringing reef is in poor condition with only 19% of live coral cover. The reef slope had coral community structures consisting of predominantly of encrusting corals (*Montipora*), massive (*Porites*) and branching forms (*Acropora, Stylophora* and *Pocillopora*).

4) Coral Reefs of Camayan Point

The fringing reef at Camayan Point is probably the most diverse in coral species (Woodward-Clyde, 1997). Hard live coral cover (47%) was highest, 13% of which was *Porites* (mainly branching ones with at least two species) and the rest by approximately equal coverage of *Diploastrea heliopora, Echinopora, Favia* (mainly *F. pallida* and *F. favus*), *Favites* (mainly *F. halicora*), *Galaxea fascicularis Stylophora pistillata*, and acroporids. Other corals reported in the reef include *Goniastrea* sp., *Platygyra sinensis, Hydnophora exesa, Scapophyllia cylindrica, Merulina* sp., *Mycedium elephantotus, Pocillopora damicornis, Seriatopora hystrix, Pectinia lactuca, Pactinia* sp., *Podobacia crustacea, Lithophyllon* sp., *Goniopora* sp., *Turbinaria* sp., *Astreopora* sp., *Pavona cactus, Pachyseris speciosa*, and *Echinophyllia* sp.

5) Coral Reefs of Grande and Chiquita Islands

The reef along the western side of Grande Island, assessed by Seastems, Inc. (1994), contained 51 to 75% live coral cover. The western side of the island is a favorite SCUBA diving spot. The shallow reef flat forming a bridge between Grande Island and Camayan Point has a predominantly sandy bottom interspersed with poor live coral cover ranging from 1 to 30%.

Near Chiquita Island, a 9-m deep, small patch reef about 35 m in diameter and surrounded by sand was surveyed (Woodward-Clyde, 1997). The small patch reef is richly developed. The majority of the corals is made up of the branching corals (23% cover) like *Porites nigrescens* and *P. cylindrica;* dead coral cover is high.

6) Coral Reefs of the East Coast of Redondo Peninsula (Nagyantok to Sampaloc Point)

The observation tow reconnaissance survey conducted by JICA Study Team showed that on the western part of the Bay (east coast of Redondo Peninsula), between Nagyantok and Macmany Point insignificant number of coral patch reefs were present. Live coral cover averages only 4.66%. Dead coral covers 12.66% of the area, while 82.66% are generally covered with sand, stone and seagrasses. The coastline between Macmany Point and Shark's Point recorded the lowest percentage of live coral cover at 4.40%.

Fringing coral reefs were found between Shark's Point and Sampaloc Point. The coral reefs from Shark's Point to Sueste Point constituted an average of 34.16% live coral cover while the highest percentage of mean coral cover of 60.50% was recorded from Sueste Point to Biniptican Point. Most of the live corals were found south of the lighthouse of Sueste Point. The reefs between Biniptican Point and Sampaloc Point showed an average coral cover of 23.85% while soft coral was only 0.76%.

SCUBA diving observation through the line transect method (Table 6.2.4-8) showed that Sueste Point had the highest percentage live coral cover of 53.65% while Nagyantok recorded the lowest percentage live coral cover of 17.36%. The overall conditions of these coral reef stations may be classified as poor to fair coral cover. A total of 76 coral species representing 13 families and 32 genera were recorded on these reefs. The dominant coral genera encountered at each coral station is also shown in the table.

Table 6.2.4-8 Percent of live coral and dominant genera at the four (4) study transect line stations at various depths

Transect Line Station	Depth (meters)	Percentage Cover	Depth (3-5 meters)	Depth (8-10 meters)
1. Nagyantok	3-5	16.65 %	Porites	Porites
	8-10	18.08 %	Cyphastrea	Goniopora
	Mean	17.36 %	Goniopora	Galaxea
2. Naglatore	3-5	48.12 %	Porites	Porites
	8-10	43.63 %	Favites	Galaxea
	Mean	45.87 %	Goniopora	Montipora
3. Shark point	3-5	18.73 %	Pocillopora	Goniopora
	8-10	22.80 %	Porites	Porites
	Mean	20.76 %	Goniopora	Montipora
4. Sueste point	3-5	53.07 %	Seriatopora	Seriatopora
	8-10	54.24 %	Pocillopora	Galaxea
	Mean	53.65 %	Hydnopora	Merulina

7) Coral Reefs of the West Coast of Redondo Peninsula (Fronting the South China Sea)

The west coast of Redondo Peninsula is basically coralline. The coastline of Nazasa Bay had 33.33% live coral cover. Dead coral covers 45% of the area and the remaining 32.77% is blanketed with stone and rocks. The average live coral cover observed in Talisain Bay was 21.66%. About 19% of the bottom are covered with rocks with the remaining 75.83% covered with dead corals. From SRI (1997), average of 32.04% coral cover had been recorded at Port Silanguin. The largest and dominant is the non-*Acropora* coral (19.73%) followed by *Acropora* (12.31%). Dead coral constituted 14.05%.

(6) Reef Fishes

Table 6.2.4-9 shows the number and density of fish species recorded, diversity index and number of families at the different sites of Subic Bay (Figure 6.2.4-5). A total of 241 species belonging to 35 families was recorded from the 18 reef sites in Subic Bay including the sites at Port Silanguin. The dominant species in terms of abundance and diversity were mainly from the major or non-commercially important species. They were represented with 143 species from different families in the different sites, which constitutes around 60% of the total species recorded in Subic Bay. The presence of indicator species was poor, constituting only about 7.45% of the fish population. However, indicator species represented 16 species of which *Chaetodon octofasciatus* was the most dominant.

Table 6.2.4-9 Summary of the fish species recorded at the different sites along the Subic Bay

SITE	Area Surveyed	No. of Species	Total Density	Diversity Index (H')	No. of Families	Live coral cover (%)	Surveyor
S1 (Nagyantoc,Subic)	1500	17	50	2.46	9	17	JICA
S1 (Nagyantoc,Subic)	1500	25	314	1.91	11	18	JICA
S2 (Naglatore)	1500	36	106	3.17	15	48	JICA
S2 (Naglatore)	1500	29	197	2.69	14	44	JICA
S3 (Sharks Point)	1500	24	301	2.2	12	19	JICA
S3 (Sharks Point)	1500	45	430	2.91	17	23	JICA
S4 Sueste	1500	24	387	2.64	8	53	JICA
S4 Sueste	1500	28	249	2.81	12	54	JICA
S5 (Camayan Point)	1000	51	394	3.29	14	47	WWC
S6 (Cubi Point)	1000	59	357	3.12	17	20	WWC
S7 (Chiquita Island)	1000	65	711	2.94	19	23	WWC
S8 (MacMany Point)	1000	40	233	2.96	18	12	WWC
S9 (Chiquita)	500	39	204	3.02	8	43	Seastems Inc.
S10 (Camayan Point)	500	10	72	1.53	5	18	Seastems Inc.
S11 (West Grande Is.)	500	38	263	2.51	12	49	Seastems Inc.
S12 Port Silanguin	1000	43	*100*		13	62	SRI
S13 Port Silanguin	1000	46	*100*		6	28	SRI
S14 Port Silanguin	1000	37	*96*		17	23	SRI
S15 Port Silanguin	1000	41	95		11	27	SRI
S16 Port Silanguin	1000	44	*90*		17	20	SRI
S17 Port Silanguin	1000	15	*94*		14	22	SRI
S18 Port Silanguin	1000	44	*92*		12	41	SRI
TOTAL	24500	241	4935		35		

(-) = No data available

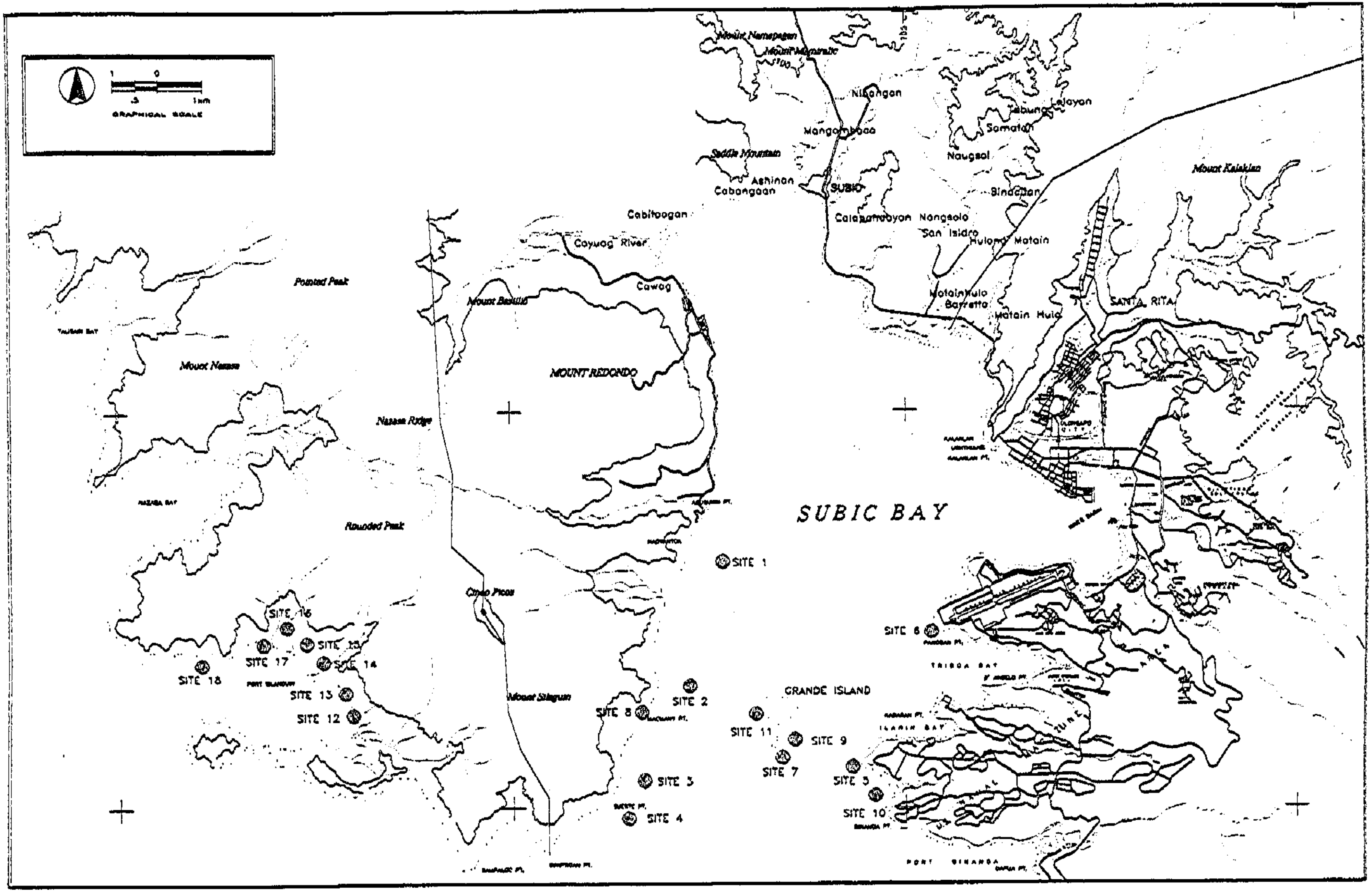


Figure 6.2.4-5 Reef Fish Study Sites in Subic Bay

Generally, the reefs at Subic Bay (Sites S1 to S18) including those of Port Silanguin were dominated by damselfishes and wrasses (Families Pomacentridae and Labridae). With regards to the species diversity, Chiquita Island has the highest species richness (65 species) followed by Cubi Point with 59 species. The reefs are dominated by non-commercially important species of Families Pomacentridae and Labridae. Commercially important species from Families Lutjanidae, Acanthuridae, Nemipteridae, Caesionidae and Scaridae were also present but not in huge volumes due to heavy fishing pressure on the site.

(7) Reef Invertebrates

A macroinvertebrate survey of the four reef sites (Nagyantok, Naglatore, Shark's Point and Sueste Point) along the western part of the Bay was conducted during the JICA Study. Species composition and abundance of macroinvertebrates for each reef are given in Tables 6.2.4-10 to 6.2.4-13. From Nagyantok southward to Sueste Point, there were 42 species of macroinvertebrates recorded. The long-spined black sea urchin, *Diadema setosum*, is the most prominent non-coral organism observed in all the reefs studied. *Diadema setosum* was commonly seen on slope and base sheltering under corals and rocks. The transect sites at Nagyantok Reef (5 and 10 m depth) have relatively the same number of species, although, the 5-m transect has more macroinvertebrates. This reef supports a dense population of *Diadema setosum*. Among the reefs surveyed, Sueste Point Reef had the lowest counts (2-15) of *Diadema setosum*.

6.2.5 Natural Resources Utilization Evaluation

Other than fishing there are not many natural resources around Subic Bay. Land and even water around the area is already urbanized, leaving little for aquaculture or agriculture.

Table 6.2.4-10 Species Composition and Abundance of Macroinvertebrates Species near Sitio Nagyantok, Subic Bay

	Sampling Date		4-Feb-98			
	Station		1			
	Sampling Depth		5 meters		10 meters	
Phylum/Class	Species	Common Name	T1	T2	T1	T2
Porifera						
	Aaptos sp.		0	0	2	7
	Acanthella sp.		0	0	2	2
	Acanthodoryx fibrosa		0	0	3	2
	Adocia sp.	*Soft organ sponge*	0	1	1	2
	Carteriospongia sp.		0	0	0	0
	Cipyllospongia sp.		0	0	0	0
	Diplosaria virens		0	0	0	0
	Gelloides fibulata	*Cactus sponge*	0	0	0	0
	Haliclona sp.		3	1	8	7
	Lissichnum patella		0	0	0	0
	Plakortis lita	*Chicken liver sponge*	2	3	2	4
	Priratrella vagabunda		0	0	0	0
	Pterosis sp.		2	2	2	1
	Xestospongia exigua	*Barrel sponge*	0	0	0	0
	Xestospongia sp.	*Barrel sponge*	0	0	0	0
Cnidaria						
	Cirianthus sp.		0	1	1	1
Echinodermata						
Echinoidea	*Diadema setosum*	*Long spined black sea urchin*	129	259	41	0
Holothuridae	*Bohadschia graeffei*		0	0	0	0
	Bohadschia marmorata		1	0	0	0
Ophidiasteridae	*Linckia laevigata*	*Pacific blue star*	1	0	0	0
Ophiocomidae	*Ophioarthrum pictum*		0	0	0	0
	Ophiomastix sp.		0	0	0	0
Ophiuroidea	*Unidentified ophiuroid*		0	0	0	0
Oreasteridae	*Culcita novaeguineae*	*Pincushion star*	3	0	0	0
Synaptidae	*Opheodosoma spectabilis*		0	0	0	0
Mollusca						
Gastropoda	*Conus geographus*	*Cone shells*	0	0	0	0
	Conus miles	*Cone shells*	0	0	0	0
	Conus nussatella	*Cone shells*	0	0	0	0
	Harpa harpa	*Cone shells*	0	0	1	0
	Turridae sp.	*Harp sheels*	0	0	0	0
	Vexillum plicarium		0	1	0	0
Pelecypoda	*Lopha cristagalli*	*Mitre shells*	0	0	0	0
	Pedum spondyloideum		10	2	0	0
	Pinctada maxima		0	0	0	0
	Spondylus sp.		1	0	0	0
	Tridacna sp.	*Giant clam*	0	0	0	0
Stenopodidae	*Stenopsis hispidus*		0	0	0	0
Annelida						
	Sabellastarte sp.		0	0	0	0
	Sabellidae sp.		1	2	0	0

	Sampling Date		4-Feb-98			
	Station		1			
	Sampling Depth		5 meters		10 meters	
Phylum/Class	Species	Common Name	*T1*	*T2*	*T1*	*T2*
	Spirobranchus gigantos	*Christmas treeworm*	0	0	2	3
Chordata						
	Didemnum molle		0	0	0	0
	Rhopalea sp.		0	0	0	0
	Total species		**153**	**272**	**66**	**29**
	Number of Species		10	9	12	9

Table 6.2.4-11 Species Composition and Abundance of Macroinvertebrates Species Found in Coral Reef of Sitio Naglatore, Subic Bay

	Sampling Date		6-Feb-98			
	Station		2			
	Sampling Depth		5 meters		10 meters	
Phylum/Class	Species	Common Name	T1	T2	T1	T2
Porifera						
	Aaptos sp.		0	0	1	0
	Acanthella sp.		0	0	0	0
	Acanthodoryx fibrosa		0	0	0	0
	Adocia sp.	*Soft organ sponge*	1	0	0	5
	Carteriospongia sp.		0	0	0	0
	Cipyllospongia sp.		0	0	1	1
	Diplosaria virens		0	0	0	0
	Gelloides fibulata	*Cactus sponge*	0	0	0	2
	Haliclona sp.		1	2	2	2
	Lissichnum patella		0	0	0	0
	Plakortis lita	*Chicken liver sponge*	3	2	3	2
	Priratrella vagabunda		1	0	1	1
	Pterosis sp.		2	2	2	3
	Xestospongia exigua	*Barrel sponge*	0	0	0	0
	Xestospongia sp.	*Barrel sponge*	0	4	4	0
Cnidaria						
	Cirianthus sp.		0	2	1	0
Echinodermata						
Echinoidea	*Diadema setosum*	*Long spined black sea urchin*	159	65	0	5
Holothuridae	*Bohadschia graeffei*		1	0	3	0
	Bohadschia marmorata		0	0	0	0
Ophidiasteridae	*Linckia laevigata*	*Pacific blue star*	3	4	0	0
Ophiocomidae	*Ophioarthrum pictum*		0	0	0	0
	Ophiomastix sp.		1	1	6	0
Ophiuroidea	*Unidentified ophiuroid*		0	0	1	0
Oreasteridae	*Culcita novaeguineae*	*Pincushion star*	0	2	0	1
Synaptidae	*Opheodosoma spectabilis*		0	0	0	0
Mollusca						
Gastropoda	*Conus geographus*	*Cone shells*	0	0	1	0
	Conus miles	*Cone shells*	0	0	0	0
	Conus nussatella	*Cone shells*	0	0	0	1
	Conus striatus	*Cone shells*	0	1	0	2
	Harpa harpa	*Harp shells*	0	0	0	0
	Turridae sp.		0	0	1	0
	Vexillum plicarium	*Mitre shells*	0	0	0	0
Pelecypoda	*Lopha cristagalli*		0	1	0	0
	Pedum spondyloideum		0	0	0	0
	Pinctada maxima		1	0	0	0
	Spondylus sp.		0	0	0	0
	Tridacna sp.	*Giant clam*	0	0	0	0
Stenopodidae	*Stenopsis hispidus*		0	0	0	0
Annelida						
	Sabellastarte sp.		0	0	0	0

	Sampling Date		*6-Feb-98*			
	Station		*2*			
	Sampling Depth		*5 meters*		*10 meters*	
Phylum/Class	**Species**	**Common Name**	***T1***	***T2***	***T1***	***T2***
	Sabellidae sp.		1	5	1	2
	Spirobranchus gigantos	*Christmas treeworm*	0	0	0	4
Chordata						
	Didemnum molle		0	1	2	1
	Rhopalea sp.		0	0	0	2
	Total species		174	92	30	34
	Number of Species		11	13	15	15

Table 6.2.4-12 Species Composition and Abundance of Macroinvertebrates Species Founs in Coral Reef near Shark's Point, Subic Bay

	Sampling Date		5-Feb-98			
	Station		3			
	Sampling Depth		5 meters		10 meters	
Phylum/Class	Species	Common Name	T1	T2	T1	T2
Porifera						
	Aaptos sp.		1	0	1	2
	Acanthella sp.		0	0	0	0
	Acanthodoryx fibrosa		0	0	0	0
	Adocia sp.	Soft organ sponge	0	0	0	0
	Carteriospongia sp.		0	0	2	3
	Cipyllospongia sp.		0	0	0	0
	Diplosaria virens		0	0	1	1
	Gelloides fibulata	Cactus sponge	0	0	1	1
	Haliclona sp.		0	0	3	4
	Lissichnum patella		0	0	0	0
	Plakortis lita	Chicken liver sponge	0	0	1	2
	Priratrella vagabunda		0	0	0	0
	Pterosis sp.		1	0	3	4
	Xestospongia exigua	Barrel sponge	0	0	2	3
	Xestospongia sp.	Barrel sponge	0	0	0	0
Cnidaria						
	Cirianthus sp.		0	0	1	0
Echinodermata						
Echinoidea	Diadema setosum	Long spined black sea urchin	60	114	98	35
Holothuridae	Bohadschia graeffei		0	0	0	0
	Bohadschia marmorata		0	0	0	0
Ophidiasteridae	Linckia laevigata	Pacific blue star	1	1	0	0
Ophiocomidae	Ophioarthrum pictum		0	0	0	0
	Ophiomastix sp.		0	0	1	0
Ophiuroidea	Unidentified ophiuroid		0	0	0	0
Oreasteridae	Culcita novaeguineae	Pincushion star	0	0	0	0
Synaptidae	Opheodosoma spectabilis		0	0	1	0
Mollusca						
Gastropoda	Conus geographus	Cone shells	1	0	0	0
	Conus miles	Cone shells	1	3	6	0
	Conus nussatella	Cone shells	0	0	0	0
	Conus striatus	Cone shells	1	1	0	0
	Harpa harpa	Harp shells	0	1	0	0
	Turridae sp.		0	0	0	0
	Vexillum plicarium	Mitre shells	1	2	0	0
Pelecypoda	Lopha cristagalli		0	0	0	0
	Pedum spondyloideum		0	0	13	0
	Pinctada maxima		0	0	0	0
	Spondylus sp.		0	0	0	0
	Tridacna sp.	Giant clam	0	0	0	0
Stenopodidae	Stenopsis hispidus		0	0	0	0
Annelida						
	Sabellastarte sp.		0	0	1	2
	Sabellidae sp.		1	0	0	0
	Spirobranchus gigantos	Christmas treeworm	0	0	4	3
Chordata						
	Didemnum molle		0	0	2	0
	Rhopalea sp.		0	0	0	0
	Total species		68	123	146	62
	Number of Species		9	7	21	14

Table 6.2.4-13 Species Composition and Abundance of Macroinvertebrates Species Found in Coral Reef of Sueste Point (near Parola), Subic Bay

	Sampling Date		8-Feb-98			
	Station		4			
	Sampling Depth		5 meters		10 meters	
Phylum/Class	Species	Common Name	T1	T2	T1	T2
Porifera						
	Aaptos sp.		0	2	0	1
	Acanthella sp.		0	0	0	0
	Acanthodoryx fibrosa		0	0	0	0
	Adocia sp.	*Soft organ sponge*	0	0	0	0
	Carteriospongia sp.		0	0	0	0
	Cipyllospongia sp.		0	0	0	0
	Diplosaria virens		0	0	0	0
	Gelloides fibulata	*Cactus sponge*	0	3	3	5
	Haliclona sp.		3	5	4	9
	Lissichnum patella		0	0	0	1
	Plakortis lita	*Chicken liver sponge*	0	2	2	0
	Priratrella vagabunda		0	0	0	0
	Pterosis sp.		0	0	0	0
	Xestospongia exigua	*Barrel sponge*	0	3	2	2
	Xestospongia sp.	*Barrel sponge*	0	0	0	0
Cnidaria						
	Cirianthus sp.		0	0	0	0
Echinodermata						
Echinoidea	*Diadema setosum*	*Long spined black sea urchin*	3	2	3	15
Holothuridae	*Bohadschia graeffei*		0	0	1	1
	Bohadschia marmorata		0	0	0	0
Asteroidea	*Linckia laevigata*	*Pacific blue star*	0	0	0	0
Ophiocomidae	*Ophioarthrum pictum*		0	0	0	1
	Ophiomastix sp.		0	0	0	1
Ophiuroidea	*Unidentified ophiuroid*		0	0	0	0
Oreasteridae	*Culcita novaeguineae*	*Pincushion star*	0	0	0	0
Synaptidae	*Opheodosoma spectabilis*		0	0	0	0
Mollusca						
Gastropoda	*Conus geographus*	*Cone shells*	0	0	0	0
	Conus miles	*Cone shells*	0	2	0	4
	Conus nussatella	*Cone shells*	0	0	0	0
	Conus striatus	*Cone shells*	1	1	1	0
	Harpa harpa	*Harp shells*	0	0	0	0
	Turridae sp.		0	0	0	0
	Vexillum plicarium	*Mitre shells*	1	3	2	2
Pelecypoda	*Lopha cristagalli*		0	0	0	0
	Pedum spondyloideum		0	2	0	1
	Pinctada maxima		0	0	0	0
	Spondylus sp.		0	1	0	0
	Tridacna sp.	*Giant clam*	0	0	0	3
Stenopodidae	*Stenopsis hispidus*		0	0	0	1
Annelida						
	Sabellastarte sp.		0	0	0	0
	Sabellidae sp.		3	4	1	2
	Spirobranchus gigantos	*Christmas treeworm*	2	3	1	1
Chordata						
	Didemnum molle		11	5	4	2
	Rhopalea sp.		0	0	0	0
	Total species		24	38	24	52
	Number of Species		7	14	11	17

People in the area do not engage in logging or hunting for commercial purposes. Only marine flora and fauna is extensively exploited. Aeta families living within the mangrove area near the mouth of Boton River depend in part upon the mangrove for construction materials and for food (fishes, shellfishes and crustaceans) (Seastems, 1994).

(1) Indigenous Flora and Fauna

A survey of how the local inhabitants utilize the natural resources was conducted during the JICA Study (February 3-6, 1998) in four farming and fishing communities in the periphery of Subic Bay. The indigenous flora and fauna utilized by the respondents in the surveyed area are presented in Table 6.2.5-1.

1) Terrestrial Plants

The terrestrial plants commonly utilized in the Subic Bay area include cogon *(Imperata cylindrica)* Bical/Bocaui *(Dinochloa scandens)*, nipa *(Nypa fruticans)* and gugo *(Entada phasioloides)*.

Cogon is used as a common roofing material for beach resorts and huts in rural Philippines. Rural folk in Barangay Cawag gather cogon during summer and at the start of rainy season when old cogon roofing in their homes has to be replaced.

Bikal/bokaui belongs to the bamboo family and grows between shaded trees near creeks or other wet places. It is used as a fencing material, for decorations and sometimes as flooring material. Most of those interviewed cut bikal for their own use.

Table 6.2.5-1 Indigenous Terrestrial and Marine Flora and Fauna in Subic Bay

Scientific Name	Local Name	Qty. of Source	Qty. of Utilized %	Purpose of Use C-Commercial P-Personal
A. Terrestrial				
Imperata cylindrica	Cogon	Abundant	30%	C/P
Dinochloa scandens	Bikal	Abundant	20%	P
Nypa fruticans	Nipa	Uncommo	10%	P
B. Marine Plants		n		
-	1. Bal-balulang		60-80%	C/P
Caulerpa sp.	2. Anrusep	Seasonal	60-80%	C/P
-	3. Pancit-pancitan	Seasonal	60-80%	C/P
C. Marine Fish		Seasonal		
Mugil cephalus	1. Aligasin		50	Personal
Rastrilleger kanagurta	2. Alumahan	Abundant	30	Commercial
Therapon sp.	3. Bagaong	Abundant	20	C/P
Nemipterus sp.	4. Bisugo	Common	20	C/P
Tetraodon sp.	5. Butete	Common	20	C/P
Caesio sp.	6. Dalagang- bukid	Common	40	C/P
Stolephorus sp.	7. Dilis	Common	20	C/P
Decapterus sp.	8. Galunggong	Abundant	10	C
Rastrelliger brachysoma	9. Hasa-hasa	Common	40	P
Epinephelus sp./Cephalopholis sp.	10. Lapu-lapu	Uncommo	40	P
-	11. Maligasin	n	30	C/P
Polynemus microstoma	12. Mapyaw	Abundant	20	C/P
Selar crumenophthalmus	13. Matang-baka	Abundant	40	C/P
Dasyatis sp.	14. Page	Uncommo	40	C/P
Loligo sp.	15. Pusit	n	30	C/P
Alepes sp.	16. Salay-salay	Uncommo	60	C/P
Siganus sp.	17. Samaral	n	10	C
Leiognathus sp.	18. Sap-sap	Common	80	C
Caranx spp.	19. Talakitok	Abundant	40	P
Chanos chanos	20. Bangus Fry	Common	40	P
Gerres filamentosus	21. Malakapas	Abundant	40	C/P
D. Sea-Shells		Unconmo		
-	1. Balisara	n	40	P
-	2. Susong Itim	Seasonal	40	P
Pagurus sp.	3. Omang	Abundant	50	P
-	4. Susong Dalaga	Common	50	P
Crassostrea sp.	5. Talaba		20	C/P
E. Crustaceans		Abundant		
Portunus sp.	1. Alimasag	Abundant	-	C/P
Scylla serrata	2. Alimango	Abundant	-	-
Thalassina anomala	3. Atla	Abundant		
		Abundant		
		Common		
		Uncommo		
		n		

(-) = Not determined

Nipa is a stemless palm growing in brackish swamps. It is also used as roofing material and as a raincoat during rainy days by farmers. Nipa is commercially supplied by other localities since very few remain in the brackish swamps in the area.

Gugo is part of the bark of a tree gathered and used as local shampoo. Native aetas identify the tree as a source of income.

2) Marine Plants

Marine plants common in Subic Bay are of the seaweed type. These are called in local names as *bal-balulang* (colored green seaweed), *arorosep* or *lato* (*Caulerpa* sp.) and *pancit-pancitan* (elongated fibril-noodle-like seaweed). These are seasonal and common during February to March, and are commonly found attached to underwater rocks 5 to 9 meters deep.

3) Marine/Estuarine and Riverine Fishes

Pelagic and demersal fish are all harvested by capture fishery. The fish stock in the bay consists of the smaller fish such as aligasin (*Mugil cephalus*), *dilis* (*Stolephorus* spp.), *sapsap* (*Leiognathus* spp.), *salay-salay* (*Alepes* sp.), *mapyaw* (*Polynemus microstoma*) and malakapas (*Gerres* spp.). Big species such as *lapu-lapu* (*Cephalopolis* spp.), *talakitok* (*Caranx* spp.) and some members of tuna family are sometimes caught in the bay. Other fish caught are *bisugo* (*Nemipterus* spp.), *alumahan* (*Rastrelliger kanagurta*), *galunggong* (*Decapterus* spp.) and sometimes exotic fish like *tanigue* (*Scomberomorus commersoni*). Big-time fishermen target tunas they locally call *bondying* (yellowfin tuna, averaging 80 kilos) and *diana* (also yellowfin tuna, but usually averaging more than 120 kilos) outside the bay near Palawan and in the South China Sea.

Based on interviews, riverine fish such as *tilapia* (*Tilapia* sp.) *banak* (*Mugil cephalus*), *biya* (*Glossogobius* sp.), *dalag* (*Ophicephalus striatus*) and *hito* (*Clarias* spp.) are now caught in smaller quantities. In rivers where exploitation is mainly for domestic consumption, occasional fishing activities are almost always at subsistence levels.

4) Shellfish and Crustaceans

Most shellfishes are gathered for family consumption or used as fish bait. Examples of shellfishes are *susong itim*, *omang*, *susong dalaga*, *talaba* and *halaan*. Gathering of *halaan* is done during low tide on a sandy intertidal flat near the mouth of Kalaklan River.

Some fishermen sometimes catch *hipon* (*Penaeus* spp.), *alimango* (*Scylla serrata*) and *alimasag* (*Portunus* spp.). The number of *alimasag* caught is typically only two to three pieces, which usually end up in their table.

One notable crustacean, *atla* or mud lobster (*Thalassina anomala*), an exotic burrowing lobster, sells in the local market from as low as P10.00 to as high as P20.00 per piece. This crustacean is indigenous to the restricted zones of Subic Bay (specifically fronting the former American ammo depot).The crustacean is rare and only the native Aetas are given the opportunity to gather it.

(2) Capture Fisheries

The fishing industry has provided jobs for many people. There are about 7,290 fishermen in Subic Town and Olongapo City. Barangays Calapacuan and Calapandayan of Subic Town supply the highest number of fishermen, approximately 75% of the total number of fishermen operating not only inside but also outside of the Subic Bay. There are two fishing sectors within the Subic Bay region: (i) municipal fishery, and (ii) commercial fishery. The first sector refers to fishing within the municipal waters, which is 15-km zone from the shore using boats of 3 gross tons or less and using passive or less mobile fishing gear. Commercial fisheries involve fishing beyond the municipal waters with boats of more than 3 gross tons. There are about 12 commercial fishing boats based in Subic Bay at Wawandue Fishport Incorporated (WFI). These are composed of 5 trawlers, 3 purse seiners and 4 boats engaged in tuna long-line operations. Their catch is sold in Malabon, Metro Manila where they can command higher prices.

1) Municipal Fishing

Under Republic Act 7160 known as the 1991 Local Government Code, territorial waters of municipal governments were enlarged from 3 nautical miles (5.56 km) to 15 km from the shore. As a result, the whole of Subic Bay is now classified as municipal waters under the jurisdiction of the local governments of Subic Town, Olongapo City and Morong Town. Fishing within the bay is thus limited to municipal fishing, and commercial fishing is strictly prohibited.

At present, the status of the fisheries resources of Subic Bay has not been assessed. Fishery statistics are generally absent. Even the inventory of fish stock and other marine resources in the bay is limited.

A perception survey was also conducted during the JICA Study (February 9-13, 1999) in eight fishing communities around Subic Bay. A total of 154 fishermen participated in Focus Group Discussion (FGD), while 120 fishermen participated in interview. The information was to serve as guide in the identification, assessment and mitigation of impacts related to the proposed port development project. In this way, possible conflicts can be avoided and a more balanced water use can be achieved.

Figure 6.2.5-1 shows the approximate location of fishing grounds and areas restricted for fishing in Subic Bay. The fishing grounds in the Bay are named after the nearest identified place. For example, the fishing ground called Cali Beach refers to the waters fronting this resort. Within Subic Bay, fishing grounds are Castle, Quarry, Snake Island, "Pulong maliit" (Mayanga Island), Buoya A, Buoya S, La Serena, Cali Beach and Philseco. On the other hand, the fishing grounds at the mouth and outside of the Bay are the coastal waters south of Redondo Peninsula, Morong and San Antonio. There are about 7,290 fishers in Subic Town and Olongapo City.

Communities engaged in fishing activities are scattered along the coast. These are located near the estuary of Kalaklan, northward to Subic Town Proper and westward to Redondo Peninsula. About 40% of the respondents are engaged in fishing inside and outside of the bay. About the same number of respondents are engaged in fishing outside of the bay only.

Figure 6.2.5-2 shows the approximate routes used by fishermen from their respective communities to the fishing grounds in and out of the bay.

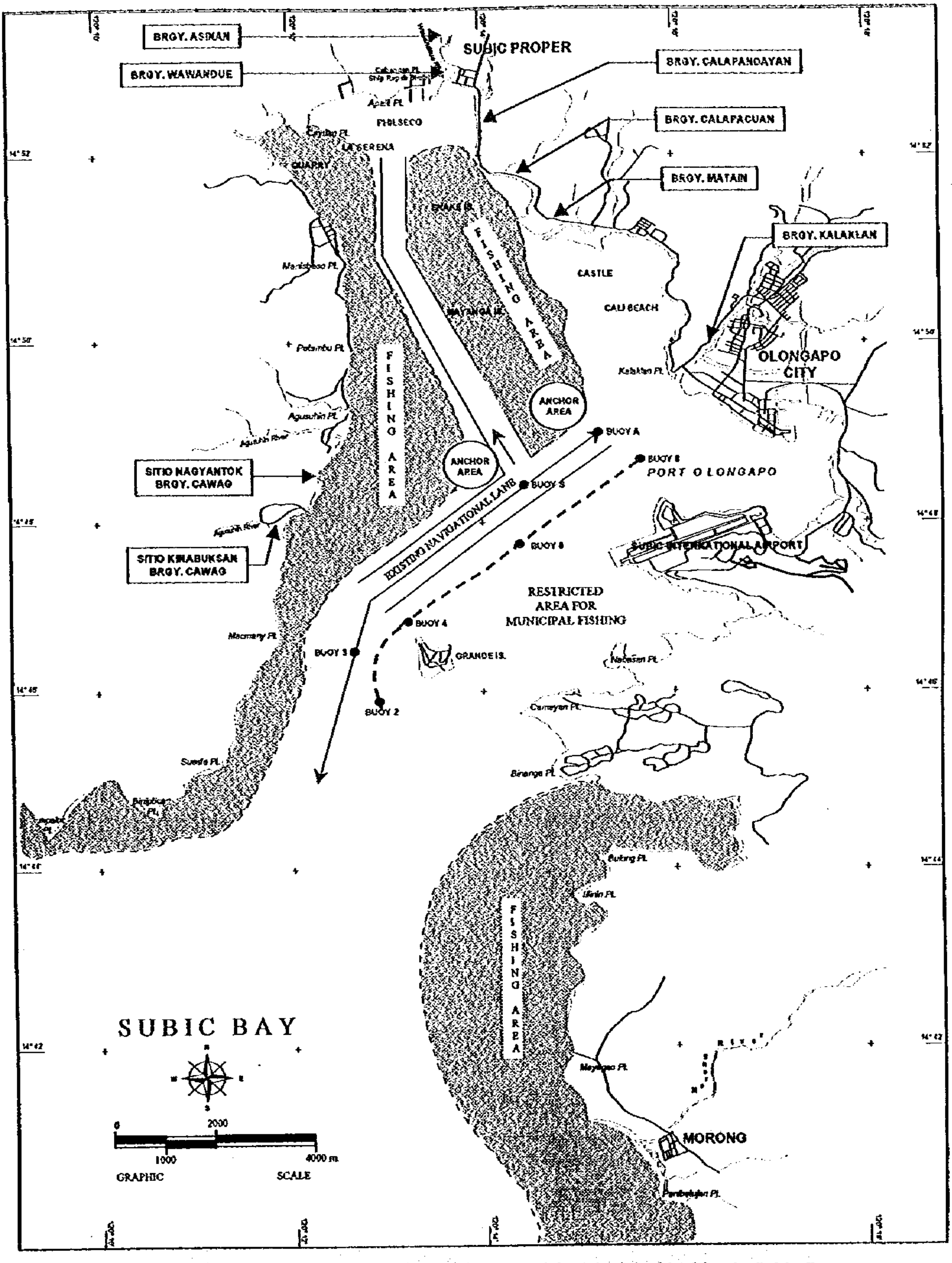


Figure 6.2.5-1 Locations of Fishing Grounds and Area Restricted for Municipal Fishing in Subic Bay

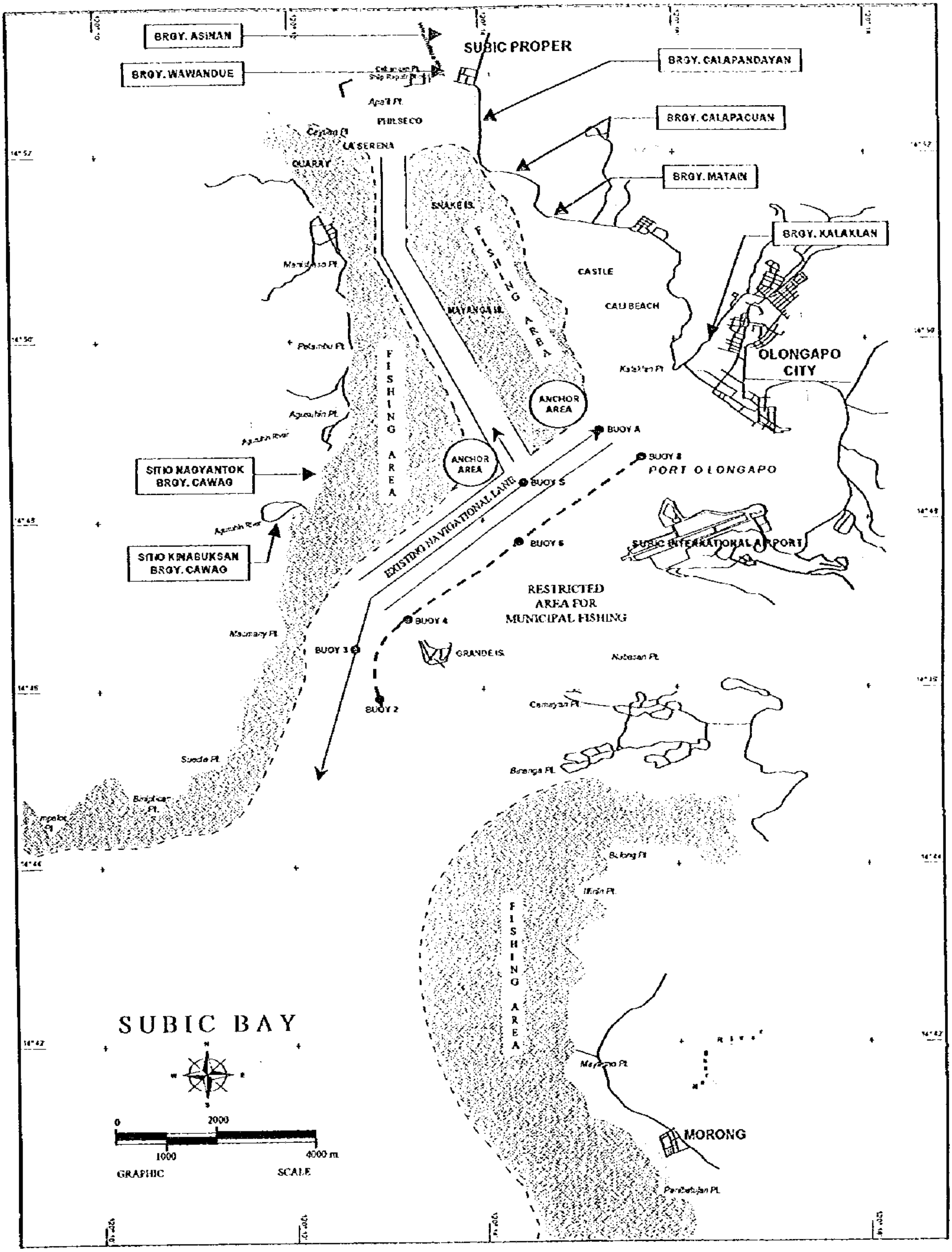


Figure 6.2.5-1 Locations of Fishing Grounds and Area Restricted for Municipal Fishing in Subic Bay

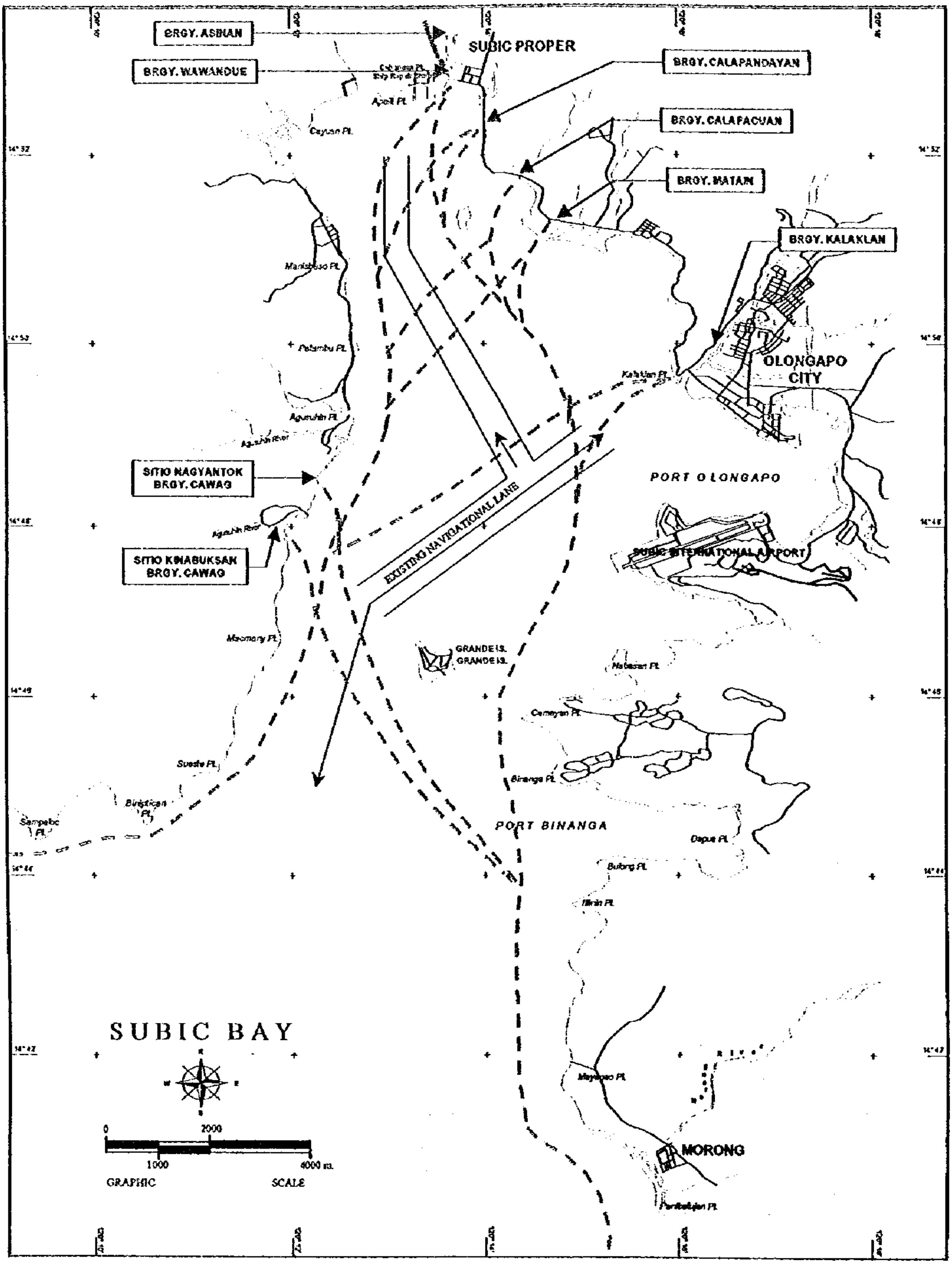


Figure 6.2.5-2 Approximate Routes Taken by Fishermen to Fishing Grounds from their Respective Communities

Table 6.2.5-2 provides data on the types of municipal fishing gear in Subic Bay. The drift and bottom set gill nets are the most commonly used in catching fish along the coastal areas while hand lines are utilized outside the bay into the deeper offshore waters of the South China Sea. Other fishing gear, such as long-line for scads and squid jigs, are also common. More than half (53%) of the respondents use only one type of fishing gear.

Table 6.2.5-2 Types of Fishing Gear in Subic Bay

Responses	Total	
	Freq.	%
Type of fishing gears used		
Handline		
Kawil (hook and line)	49	
Kitang (tuna long line)	40	
Pamilpil (long line for scads)	17	
Pamusit (squid jig)	19	
Gill net		
Pangalabaw (surface drift gill net for offshore use)	16	
Largarete (surface drift gill net for use inside bay)	24	
Panteng Lubog (bottom set gill net)	32	
Tawtaw	31	
Singgapong	3	
Speargun	2	
Compressor (for collecting aquarium fishes)	1	
Single/Multiple users of fishing gear		
Single users	64	53.3
Multiple users	56	46.7
TOTAL	120	100.0

Table 6.2.5-3 provides data (taken in February 1999) on the number of municipal fishing boats and engine types in the area. There are a total of 2,223 (1,988 motorized and 235 non-motorized) boats based in Subic Bay.

The peak season for municipal fishing is October to December. The lean period is from January to March. Concessionaires (middlemen), buyers in the Subic Municipal Fishport and neighbors are the markets for their catch.

Table 6.2.5-3 Estimated Number of Municipal Fishing Boats and Engine Types in the Study Area (February 1999)

Engine Type/Brand	Brgy. Kalaklan	Bgy. Matain	Bgy. Calapacuan	Bgy. Calapan-dayan	Bgy. Wawandue	Bgy. Asinan	Nagyantok Bgy. Cawag	Kinabuksan Bgy. Cawag	TOTAL
Motorized									
*Medium size**									
16 HP (Briggs)	200	350	240	800	30	20	100	40	1780
4 K (Toyota)			10						10
4DR5 (Fuso)		10	10		15		10		45
4BA1 (Isuzu)			10						10
CD 14 (Coolers)	8								8
*Small size***									
10HP (Briggs)		10							10
8 HP (Briggs)		10		20		5		5	40
7 HP (Briggs)		10							10
6 HP (Briggs)				10					10
5 HP (Vanguard)		10				10			20
3 HP (Vanguard)		10		20		10		5	45
Non-motorized	20	100	30	50		15		20	235
TOTAL	228	510	300	900	45	60	110	70	2223

2) Bangus Fry Gathering

Fishermen of Sitio Agusuhin and Barangay Cawag Proper of the Redondo Peninsula consider the gathering of milkfish or *bangus* fry *(Chanos chanos)* as a major source of income even it is seasonal. It is usually conducted from April to August (first cropping) and from October to November (second cropping). Women and children are the ones who gather the fry, using the two-man seine (locally known as *gayad* or *sagap*), a rectangular net made of nylon. The operation is usually done as the tide comes in. Income from this source can be substantial, with catches reaching 5,000-10,000 fry per day sold at an average price of P0.40 per fry. A group of three gatherers can sometimes divide an amount of P2,000 to P4,000 per day among themselves. On lean days, the catch can be as low as 3 to 10 pieces. Since no one is prohibited from engaging in this activity, competition has pushed the price of fry down to P0.20 to P0.30 a piece.

3) Aquarium Fishing

Aquarium fishing is a minor occupation in the coralline areas along the coasts of the Redondo Peninsula. This activity is tolerated along the degraded coral reefs in the area, although from time to time, aquarium fish collectors dive among the rich coral reefs of the protected zones of the Bay. Most of the big-time aquarium fish gathering is done outside of the Bay. The use of cyanide in this activity has almost wiped out reef fishes in the area and has caused extensive damage to coral reef areas. With the help of some NGOs, notably Haribon Foundation, aquarium fish collectors were taught how to use barrier nets in hunting aquarium and live food fishes. The most sought of the reef fishes are seahorse, goldfish, cowfish (*baka-baka*), cometa, and grouper (*lapu-lapu*).

4) Destructive Fishing Activities

Destructive fishing methods, such as the use of explosive and cyanide, are practiced within the vicinity of the Subic Bay, particularly along the east coast of Redondo Peninsula (between Macmanny Point and Sampaloc Point), usually in the coralline areas. Cyanide is used in catching aquarium fishes while explosives are used for catching fishes for food.