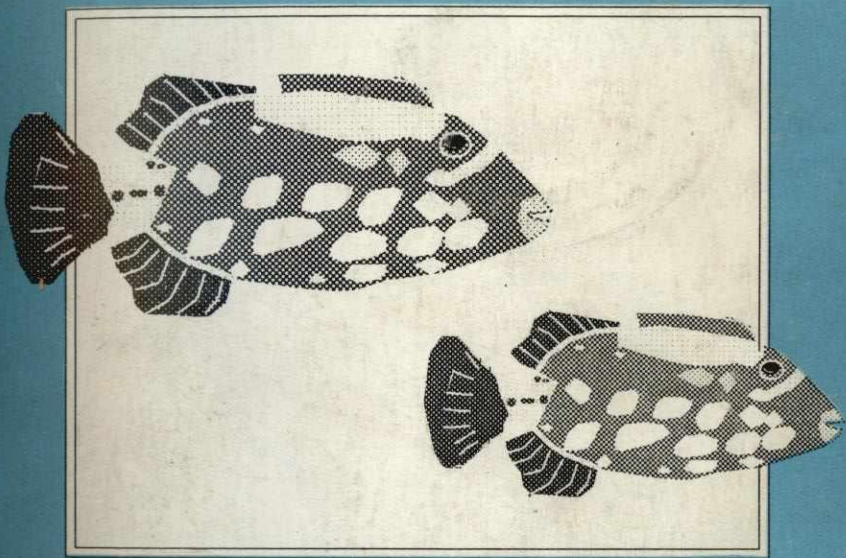
THE PHILIPPINE JOURNAL OF FISHERIES



VOLUME 21 1990

BUREAU OF FISHERIES AND AQUATIC RESOURCES

The Philippine Journal of Fisheries

ISSN 0048-377X

VOLUME 21, 1990

Effects of Mine Tailings on the Fishery Resources of Calancan Bay

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ABSTRACT

An investigation on the effects of mine tailings on the coral reef ecosystem of Calancan Bay in Sta. Cruz, Marinduque, was conducted to establish the veracity of local fishermen's complaint about the decreasing fish productivity.

Physico-chemical and biological analysis of seawater, fish, benthic, and plankton samples were carried out. The results indicated a deteriorating environment. Samples of fish tissues were also subjected to analysis by atomic-absorption spectrophotometer at the National Pollution Control Commission laboratory. Concentrations of heavy metal ions in fish flesh were found to be within permissible limits.

Underwater survey of coral reef formations by SCUBA divers disclosed the presence of dead colonies of soft corals and invertebrates in all sampling stations.

The adverse effects of mine tailings on the fishery resources of Calancan Bay were confirmed by the decreased number of fish population and diversity in the area. Only 108 species of fish were confirmed to be present in the reefs.

The once flourishing anchovy fishery was replaced by glassfish. These shifts in species composition and structure in the coral reef ecosystem suggest a stressed environment.

Keywords: coral reef, ecosystem, marine tailings, fishery, Calancan Bay

INTRODUCTION

Calancan Bay in Sta. Cruz, Marinduque, was noted for its luxuriant marine resources, particularly its anchovy fishery. However, the continuous dumping of approximately 25,000 metric tons of tailings and effluents per day by Marcopper Corporation since the start of its operation in 1975 has drastically altered its distinction.

In 1981, a group of 300 local subsistence fishermen reacted to this situation by filing formal complaints and claims for compensation to damages with the National Pollution Control Commission. The complaints were: destruction of coral reefs; disappearance of some fish species like the anchovy; decreased catch; destruction of fish spawning areas and deterioration of seawater quality. To investigate this problem, an inter-governmental agency task force was created by the Office of the President. BFAR was assigned the following tasks:

General: To ascertain the present degree of degradation of the bay from the viewpoint of agencies concerned and to recommend an acceptable method of correcting or minimizing said degradation.

Specific: To assess the present state of marine resources particularly coral reefs, mangroves and other aquatic life at Calancan Bay. To evaluate various proposals of tailings disposal in the bay vis-a-vis effects on marine resources.

MATERIALS AND METHOD

A team composed of BFAR fishery biologist and SCUBA divers conducted this hydrobiological evaluation of the coral reef ecosystem. The study was undertaken by the highest level of biological organization, i.e., the community level. For purposes of this study, the ecosystem concept was considered.

ESTABLISHMENT OF SAMPLING POINTS

Based on data gathered from an intensive ocular survey of the site, using maps and charts as reference, sampling locations for hydrobiological study and underwater survey were established. A reference station was situated in relatively unaffected spots in the bay. There were nine stations for the underwater survey and eight stations for collection of fish, benthic and seawater samples (Fig. 1).

MEASUREMENT OF WATER QUALITY

The basic parameters for water quality and methods of analysis for each determination are presented on Table 1. Seawater samples were collected from each of the eight stations and analyzed in situ.

PLANKTON ANALYSES

Qualitative and quantitative plankton analyses were conducted on water samples collected from the eight stations. Quantitative determination was done by means of the volume displacement method. Total plankton count was made by measuring an aliquot portion using a plankton splitter. Plankton density and percentage occurrence were computed for every sample and then plotted.

Qualitative plankton analysis involved identification and enumeration of the organisms into groups and generic levels.

METAL CONTENT DETERMINATION OF FISH SAMPLES

Seven species of commercial fishes present in Calancan Bay were tested for the presence of heavy metals, zinc (Zn) and mercury (Hg). Tests were conducted at the NPCC laboratory where the fish samples were subjected to atomic absorption spectrophotometer (AA) analysis.

UNDERWATER SURVEY OF CORAL REEFS

Bounce divers using SCUBA equipment conducted underwater study of the coral reef formations at depth ranging from 3 - 19.8 m. Each of nine stations was observed for a period of 10 - 30 minutes.

SOCIO-ECONOMIC AND FISH LANDING SURVEYS

Informal interviews were conducted among the residents and complainants. The main purpose of the survey was to gather comparative data on fish catch before and during the operation of Marcopper Corporation. The type of gear and fishing method employed by the fishermen were included in the unstructured interviews.

Data on the first catch before and after the onset of pollution in the Bay, including quantity and type of fish as to species, were gathered from several fish landings in the vicinity.

RESULTS AND DISCUSSION

Meteorological Observations (July 9-10, 1981):

During the hydro-biological investigation, weather conditions were relatively fair but alternately hazy and windy. Skies were overcast but not rainy. Cloud formations like cumulus, cirrus, cumulo-nimbus and cirro-cumulus were prevalent. Cloud cover varied from 65 - 90%. East to southeast winds prevailed. Sea conditions were smooth.

Hydrobiological data gathered from Calancan Bay (July 9-10, 1981)

Results of the physico-chemical analyses of seawater are presented on Table 2.

The actual depth of water was found to range from 1.8 - 16.0 m. Surface water temperature varied from 29.0°C to 32.0 °C. Water coloration varied from bluish green to green. Transparency was greatest at Station 3 in Hacupan islet, the control station. Seawater in Station 5 was found to be slightly turbid with transparency estimated at 1.5 m. This station was located near the tip of the causeway where mine tailings were discharged into the bay. Siltation was manifested in this area.

All pH readings were in the alkaline range from 8.4 - 9.5. Highest pH was recorded in Station 5, near the causeway. Surface dissolved oxygen was found to be below normal in Station 5. DO measurements in this area only averaged 5.0 mg/l while DO in all the other stations were fair.

Generally, values of parameters of water quality were still within permissible limits for Class C waters (coastal and marine waters) as prescribed by the NPCC, except for surface DO and pH of waters in Station 5, the sampling point nearest the causeway. Abnormal DO, pH and turbidity of these waters seem to indicate a disturbed state in the ecosystem.

Fish Survey

A list of 85 fish species, representatives of 21 families, was recorded through visual counting in sampling sites. The most dominant families of fish were the following:

1. Pomacentriade (21 species)
2. Labriade (14 species)
3. Scariade (6 species)
4. Acanthuridae (4 species)
5. Chaetodontidae (3 species)
6. Cerrhitidae (3 species)

The fish index of Calancan Bay as compiled from data gathered through visual observations, socio-economic and fish landing surveys showed a lower

species diversity compared to those of other pristine coral reef formations in areas with no siltation problems. Fish population number and diversity have been apparently affected by the chronic siltation in some parts of the bay. For a reef formation in the West Pacific Region, around 700 species of fish would be considered typical (Jones and Endean, 1967).

As listed in the Fish Index only 108 fish species were found to be present in the area. Around 13 to 20 species abound in commercial quantities. Another notable change was in species domination. Before the onset of pollution, anchovy fishery was flourishing in the bay but was replaced by glass fish in recent times (Table 3).

Results of heavy metals analyses by means of the atomic absorption spectrophotometer (AA) at the NPCC laboratory revealed that zinc and mercury were present in all fish samples. Zinc (Zn) was found to be present in greatest concentration in the flesh of big-scaled mullet (18.00 mg/g). Mercury (Hg) was detected in concentrations varying from 0.01 to 0.04 mg/g. The amounts of metals present in fish tissues were all within permissible limits set up by NPCC.

PLANKTON COMPOSITION OF CALANCAN BAY WATERS

Plankton density was measured to range from 0.06 to 0.22 ml/m³. Results of the quantitative analysis revealed phytoplankton domination over the total plankton composition (see Fig. 2) Phytoplankton was found to comprise 64.52% of the entire plankton population. Zooplankton constituted only 35.46%.

Mollusks ranked next in abundance as represented by heteropods and bivalve larvae. This phylum contributed 7.95% of the plankton composition of bay waters. Other components were identified as follows: Oikopleura (Tunicata), 1.5%; Crustacea, 0.59%; Cnidaria, 0.10% and Polychaeta, 0.06% (Table 3).

Results of plankton analyses indicated an apparently normal distribution of planktonic groups within the plankton population. Evidently, the dumping of mine tailings and effluents had not yet adversely affected the plankton community of Calancan Bay. This is attributed to the fact that tidal flushings assure continuous removal and replacement of water and its content in shallow coastal areas such as Calancan Bay. Thus the impact of pollution is likely to be felt first in bottom communities such as the coral reef formations. It is noteworthy that while reef communities were being destroyed by mine tailings and sediments, only "subtle" changes were observed in the plankton community.

SURVEY OF CORAL REEF FORMATION

Underwater study conducted by two teams of SCUBA divers in nine stations around Calancan Bay disclosed the presence of dead colonies of soft corals and invertebrates in all sampling areas. It was noted that only massive brain corals and solitary fungids were able to survive pollution.

In shallow coastal communities like Calancan Bay, the bottom serves as reservoir for pollutants which accumulate there through settling and sorption. The impact of pollution is thus likely to be felt first by the bottom communities. Thus coral reefs were found to have been already destroyed by siltation of mining effluents while the plankton and fish communities were still reacting in less obvious ways.

CONCLUSION

The results of tests, surveys and observations confirmed that the complaints of the 300 local fishermen that nightly fish catch in Calancan Bay since the operation of the new waste disposal system had been reduced by 50 - 80% are valid and reasonable.

RECOMMENDATIONS

1. An alternative method of mine tailings and effluents disposal should be drawn up by MARCOPPER Corporation in coordination with government agencies such as NPC, BFAR and the Bureau of Mines.
2. Rehabilitation program for coral reef ecosystem in Calancan Bay should be initiated by recruiting local fishermen as paid labor for the various projects such as construction of fish aggregation devices; fish shelters or modules.
3. Displaced fishermen should be organized into cooperatives to engage in viable livelihood projects to compensate for loss of income. Projects of this nature include deep sea fishing cooperatives; floating sea cages; fishing coves and fish pens; cottage industries; small-scale animal husbandry projects such as poultry, piggery and cattle fattening.
4. Compensation for damages to livelihood should be provided by MARCOPPER Corporation. The financial settlement could be in the form of a trust fund or revolving fund to finance various livelihood projects to alleviate poverty in Calancan.
5. Follow-up studies on the physico-chemical and biological water analysis should be conducted in the bay.

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ACKNOWLEDGEMENT

The assistance of the scuba divers and fishery biologist from the Fisheries Research Division is gratefully acknowledged.

The help and cooperation of Abundio Galicia, Jr. in the analysis of water samples is also acknowledged.

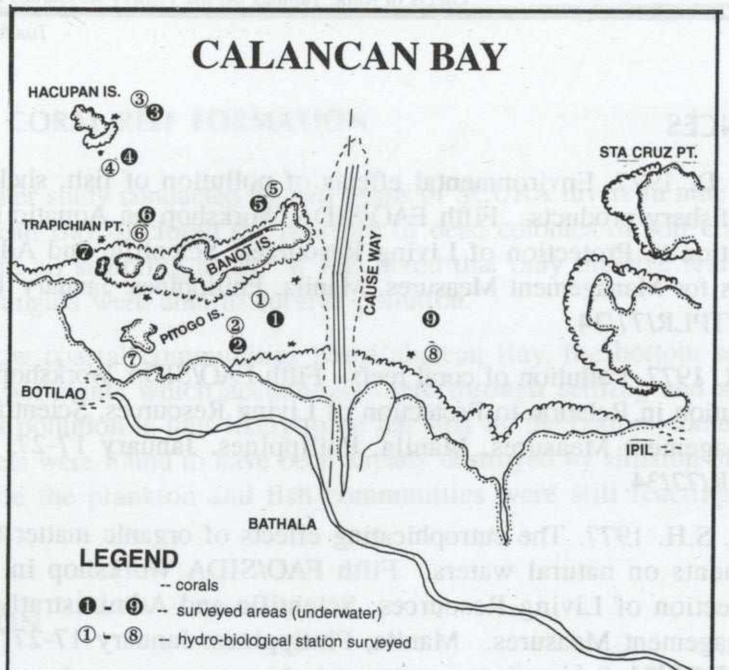

Figure 1. **Hydro-Biological and Underwater Stations Surveyed**

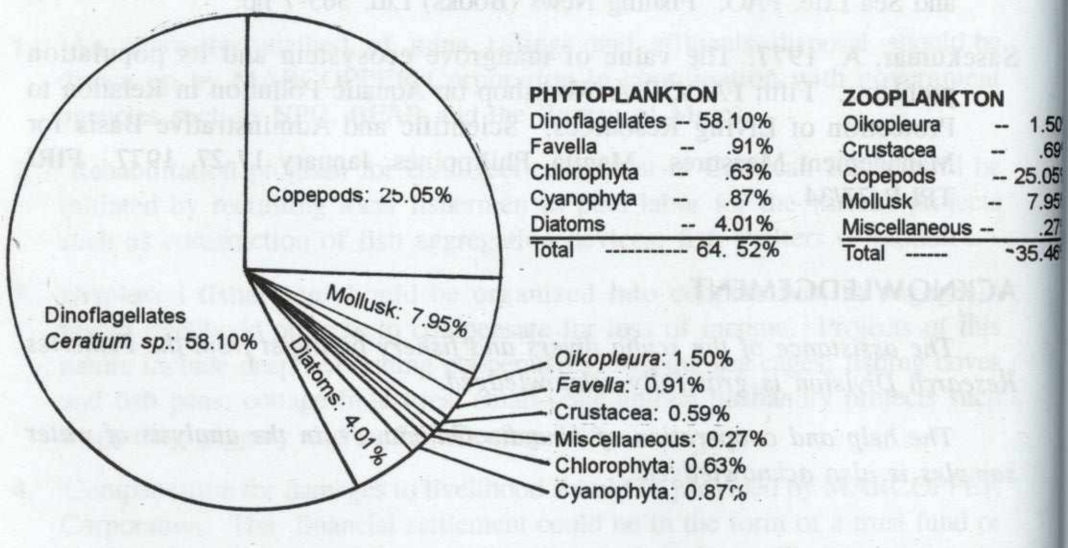

Figure 2. **Percentage Composition of Phytoplankton and Zooplankton (Horizontal Distribution) in Calancan Bay. July 9 and 10, 1981**

Parameter	Instrument/Method Used
Water Depth	Calibrated rope
Water visibility (transparency)	Secchi disc
Water temperature, surface, bottom	Reversing thermometer
Water coloration	Visual observation
Dissolved oxygen content (DO)	Basic Winkler
Salinity	Refractometer
pH	Portable pH meter

Table 2. **Hydro-biological data gathered from Calancan Bay (July 10.1981)**

Station No.	Date	Time	Actual depth (m)	Ave.temp. (°C)	Water temp. (°C)	Water Coloration	Water transparency (m)	Sal. (%)	pH	Surface D.O. mg/l	Plankton vol.ml.m3
1	7/9	1515H-1606H	3.7	32.0	25.0	Bluish-green	3.5	35.0	9.5	7.0	0.10
2	7/9	1612H-1654H	4.8	29.0	25.0	Bluish-green	4.8	35.0	8.4	7.0	0.22
3	7/10	1015H-1100H	6.0	30.0	28.0	Blue	11.5	36.67	9.0	7.0	0.11
4	7/10	1105H-1202H	16.0	30.0	27.5	Bluish-green	6.0	35.0	9.0	7.0	0.06
5	7/10	1345H-1420H	1.8	32.0	30.0	Green	1.5	33.75	9.0	5.0	0.16
6	7/10	1445H-1530H	5.0	31.5	29.0	Blue	5.0	33.75	9.0	8.0	0.12
7	7/10	1540H-1610H	2.0	31.0	28.0	Bluish-green	2.0	35.0	9.0	9.0	0.18
8	7/10	1655H-1730H	3.5	29.0	28.0	Bluish-green	0.5	35.0	9.0	9.0	0.09

Table 3. **Plankton Composition of Calancan Bay Waters (July 9 to July 10, 1981)**

Station Number		1	2	3	4	5	6	7	8	Total	% Occurrences
Plankton Volume ml/m3		0.10	0.22	0.11	0.06	0.16	0.12	0.18	0.09	1.04	
Taxonomic Groupings		No. of organisms per cubic meter of water strained									
Zooplankton Present		1	2	3	4	5	6	7	8	Total	% Occurences
1) Calanoid group (Copepods)		25,216	63,104	6,464	10,240	7,744	26,240	67,072	88,688	294,768	23.64
2) Cyclopoid group (Copepods)		-	8,064	192	898	832	1,920	1,280	768	13,954	1.14
3) Harpacticoid group (Copepods)		256	384	256	64	896	1,024	256	128	3,264	0.27
4) Lucifer zoea (Crustacea)		512	384	-	-	64	-	-	256	1,216	0.10
5) Balanus naupluis (Crustacea)		896	-	128	64	448	2,304	1,280	640	5,760	0.47
6) Cladocera (Crustacea)		-	-	-	128	-	-	-	-	128	0.01
7) Amphipoda (Crustacea)		-	-	-	-	-	-	-	128	128	0.01
8) Oikopleura (Tunicata)		1,408	640	1,920	1,644	1,408	3,200	1,709	6,272	18,201	1.50
9) Polychaeta (Annelida)		128	256	64	64	-	128	-	128	768	0.06
10) Cnidaria		-	-	380	312	204	-	-	336	1,200	0.10
11) Molluscan larvae		-	21,000	702	5,610	5,420	14,001	12,040	8,600	20,100	7.95

Table 4. **Fish Index of Calancan Bay (as compiled from visual observations, interviews with fishermen and survey of Sampling Stations and fish landing)**

Pomacentridae

1. *Dascyllus reticulatus*
2. *Amphiprion clarkii*
3. *Pomacentrus moluccensis*
4. *P. taeniurus*
5. *P. brachialis*
6. *P. notopthalmus*
7. *Chromia lepidolepis*
8. *Paraglyphydodon melas*
9. *P. nigrosiss*
10. *Glyphydodontrops* spp.
11. *Pomacentrus coelestis*
12. *Amphiprion notatus*
13. *A. coelestinus*
14. *A.* spp.
15. *Glyphydodontops rollandi*
16. *Amblyglyphidodon curacao*
17. *A. aureus*
18. *Plectroglyphidodon dickii*
19. *P.* spp.
20. Pomacentriadae sp. (blue)
21. Pomacentriadae sp.

II. **Labridae**

1. *Thalassoma hardwicke*
2. *T. lunare*
3. *T.* spp.
4. *Labroides dimidiatus*
5. *Hemigymus melaptenus*
6. *Stethojulis trilineata*
7. *S. bandanensis* (Male and Female)
8. *Halicoeres margaritaceous*
9. *H. hoeveni*
10. *H. melanurus*
11. *Coris variegata*
12. *C. gairmardi*
13. *Cheilinus bimaculatus*
14. *C. diagrammus*

III. **Scaridae**

1. *Scarus venosus*
2. *S. bicolor* (young)
3. *S. bleekerii*
4. *S. niger*
5. *S. scaber*
6. *S.* spp.

IV. **Parapercidae (Sand perches)**

1. *Parapercis cylindrica*
2. *P.* spp.

V. **Chaetodontidae (Butterfly fishes)**

1. *Chaetodon vegabundus*
2. *C. octofasciatus*
3. *C. Kleini*

Continued . . .

Table 4 continued . . .

VI. Acanthuridae

1. *Acanthurus dussumiere*
2. A. spp.
3. *A. Xanthopterus*
4. *Zebrasoma scopes*

VII. Cirrhitidae

1. *Paracirrhites forsteri*
2. *Cirritichys falco*
3. *C. serratus*

VIII. Serranidae

1. *Cepphadopholis* sp.
2. *Anthias* mortani

IX. Nemipteridae

1. *Scolopsis bilineata*
2. *S.* sp.

X. Caesionidae

1. *Caesio sp.*

XI. Lutjanidae

1. *Lutjanus decussatus*
2. *L. russelli*
3. *Caesio erythrogasteo*

XII. Pomacanthidae (Angel Fish)

1. *Centropyge vroliçki*

XIII. Gobiidae

1. *Ptereleotris avides*

XIV. Tetraondontidae (Puffer)

1. *Canthigaster valentini*
2. *Arothron nigropunctuatus*

XV. Synodontidae (Lizard fishes)

1. *Synodus variegatus*

XVI. Pomadasyidae

XVII. Apogonidae

1. *Apogon quinquilineata*
2. *A.* sp.

XVIII. Mullidae

1. *Parupeneus barbarinoides*
2. *P. barbarinus*

XIX. Balistidae

1. *Rhinecanthus* sp.

XX. Carangidae sp.

XXI. Plotosidae

1. *Plotosus anguillaris*