Participatory Monitoring and Feedback System: An Important Entry Towards Sustainable Aquaculture in Bolinao, Northern Philippines

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ABSTRACT

The aquaculture industry in Caquiputan Channel contributed P2.3M to municipal revenues in 1998. However, the uncontrolled construction of fish pens and fish cages have contributed to the deterioration of the water quality in the Caquiputan Channel. Despite monitoring of parameters (e.g. DO, salinity, and temperature), low production was implicated because of limited dissolved oxygen supply.

A participatory monitoring of fish pens and fish cages was facilitated to pave the way for sustainable aquaculture. A system for monitoring and disseminating information on water quality, production and zonation of pens and cages, has been pursued to assess the situation and identify mechanisms to regulate aquaculture activities. The feedback system adopted has raised and facilitated environmental awareness, issue identification, and implementation, of solutions to some major issues. Furthermore, the results have resulted in policy reforms, as embodied in the provisions on aquaculture in the Municipal Fisheries Ordinance.

Keywords: participatory monitoring, fishpens and fishcages, Caquiputan Channel

INTRODUCTION

Aquaculture in Bolinao , northern Philippines, started in the early 1970's through brackish-water fishponds. The semi-intensive form of milkfish culture was adopted. Supplemental food in the form of bread crumbs and commercial feeds were given to the fish when natural food (lab-lab) in the pond was exhausted. To maximize income, shrimps and other fishes entering the pond during inflow of seawater were grown out together with the milkfish. This type of aquaculture accelerated in Bolinao in the 1980's and many mangrove areas were converted to fishponds.

In 1995, the culture of milkfish on brackish-water fishponds was expanded to coastal waters through the use of fishpens and fish cages. Since then, fishpens and fish cages have proliferated in the Caquiputan Channel, reaching Tambac Bay and parts of Victory and Dewey. To regulate the coastal aquaculture of finfishes in Bolinao, the municipal council passed on October 5, 1995 Ordinance number 1-series of 1995 regulating the establishment, erection, and/or construction of fishpens and fish cages in the municipal waters of Bolinao, Pangasinan and the granting of permits for their operation.

Despite the passage of the ordinance, fishpens and fish cages have continued to be illegally constructed and operated. Many fishpens have exceeded the maximum

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pen area at which water flow and quality in the channel could be maintained. Because of the shortcomings of the local government unit (LGU) in implementing the ordinance, several issues have been raised regarding the proliferation of fishpens and fish cages, and their ecological and socioeconomic impacts on the different sectors. Among these issues are: (1) reduction of traditional fishing grounds; (2) unregulated construction and expansion of fishpens and fish cages; (3) constriction of navigational routes; (4) conflicts in the allocation of water space and; (5) deterioration of water quality.

In 1997, 703 permits (around 88 hectares) were given to individuals to operate fishpens and fish cages (Municipality of Bolinao,1997), excluding expansions. The number of permits granted decreased to 476 units in 1998, but ocular inspection in 1999 showed a total of 797units (around 165 hectares), excluding those inaccessible by boat (Fig. 1). This trend showed that the number of permitees exceeded the 544 units (130 hectares) estimated as the carrying capacity of the channel and proposed in the Coastal Development Plan (CDP) (Fig. 2). With the high stocking density and excessive feeding, the water quality of the channel has been degraded, as indicated by fish kills and phytoplankton blooms. Because of low fish growth, the number of pens and cages decreased by 43% from 1997 to 1999 (Table 1).

This paper documents how a mechanism for participatory monitoring of aquaculture was established in Bolinao. Results obtained on the first monitoring year in 1999 are presented. The monitoring scheme is evaluated for its sustainability and impact in making finfish grow-out a viable source of income.

MATERIALS AND METHODS

Setting up a mechanism for participatory aquaculture monitoring

Beginning in 1996, the number of coastal aquaculture facilities in Caquiputan Channel has been increasing. The channel has been identified as a multiple-use

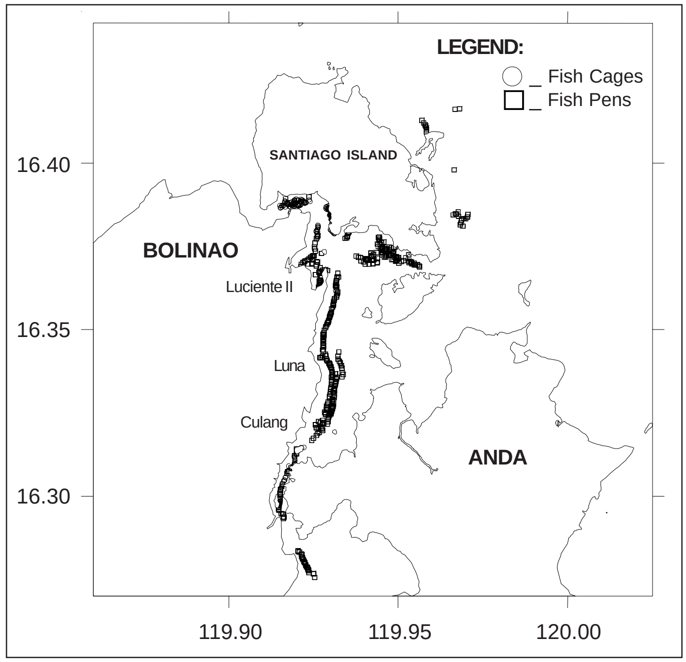

Fig. 1. Location of fishpens and fish cages (as of February 1999)

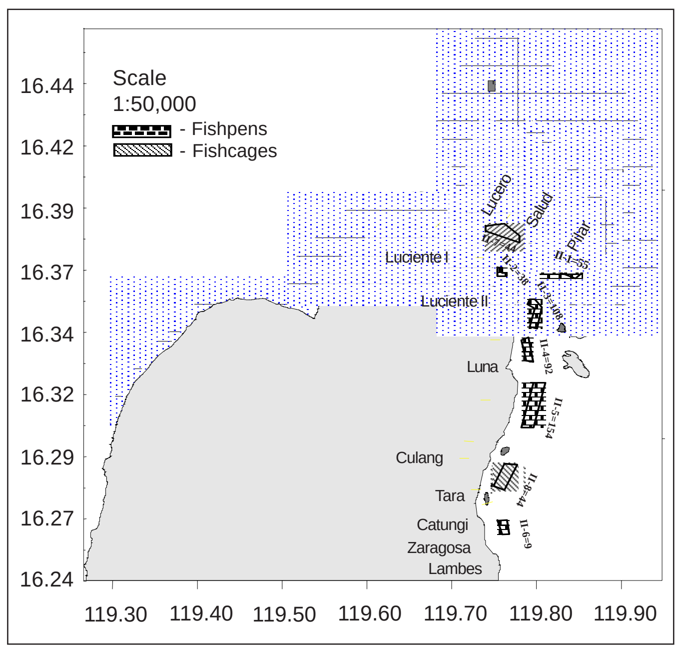

Fig. 2. Proposed areas for fishpens and fish cages in the CDP

Table 1. Status of milkfish aquaculture in Bolinao (1997-1999)

	Ocular 1997	Permit 1997	Permit 1998	Ocular 1999	
				Operational	Non- Operational
Pen	No data	No data	362	277	283
Cage	No data	No data	114	147	90
Total	1,076	703	476	424	373

zone (Zone II) in the coastal development planning exercise that was conducted from 1996-1999. The Marine Fisheries Resources Management Project (MFRMP) initiated a series of meetings in Zone II to begin the implementation of the plan, particularly the regulation of coastal aquaculture. A major step was to begin the monitoring of Caquiputan Channel and to engender the participation of the community in this activity. Villages belonging to Zone II include Luciente 1 and 2, Luna, Culang, Tara, Zaragoza, Lambes, Catungi, part of Pilar, part of Salud, and part of Lucero. Discussed below are the major activities carried out in creating the monitoring team and setting up their operation.

A "Seminar on the Sustainable Management of Milkfish Aquaculture" was held on 5 November 1998 It was attended by 65 participants, including fishpen and fish cage owners, students of the Bolinao School of Fisheries, municipal officials, barangay officials, and marginal fishers of Zone II. It aimed to: (a) orient the participants on methods and practices of sustainable coastal aquaculture; (b) identify issues/problems and their solutions in Zone II and; (c) form a multi-sectoral monitoring team. On 28 November 1998, the team members –(students from Bolinao School of Fisheries, fisahpen/cage owners/operators, fishers, members of barangay councils, and the Municipal Aquaculture Technician) – underwent training on the use of water quality monitoring instruments, including a dissolved oxygen (DO) meter, refractometer, secchi disk, and thermometer. The group scheduled their first zone visit and water sampling (three fishpens) on 2 December 1998 and implemented regular monitoring since.

Monitoring proper

Site Selection. The team started monitoring water quality in two sites (one fish cage in Lucero and one fishpen in Luna). The number of monitoring sites has increased through informal information campaigns with other pen/cage owners and caretakers. During the first half of 1999, the team established two cages (one each in Lucero and Salud) and five pens (one each in Pilar, Luciente 2, and Culang; two in Luna) as sampling sites.

Fig. 3 shows the locations of the sampling sites, and Table 2 lists information about them. C1 and C2 were about 1 to 2 m apart. P1 is found beside other pens while P2 is located adjacent to a navigational route. P3 has a small fingerling enclosure attached to it and is located at the center of many pens (at about 4m distance). P4 is situated at the outermost row of fishpens in Luna. P5 is just 3 m away from the shore, and is the most shallow, especially at low tide. It is also the most turbid. (Fig. 3 and Table 2).

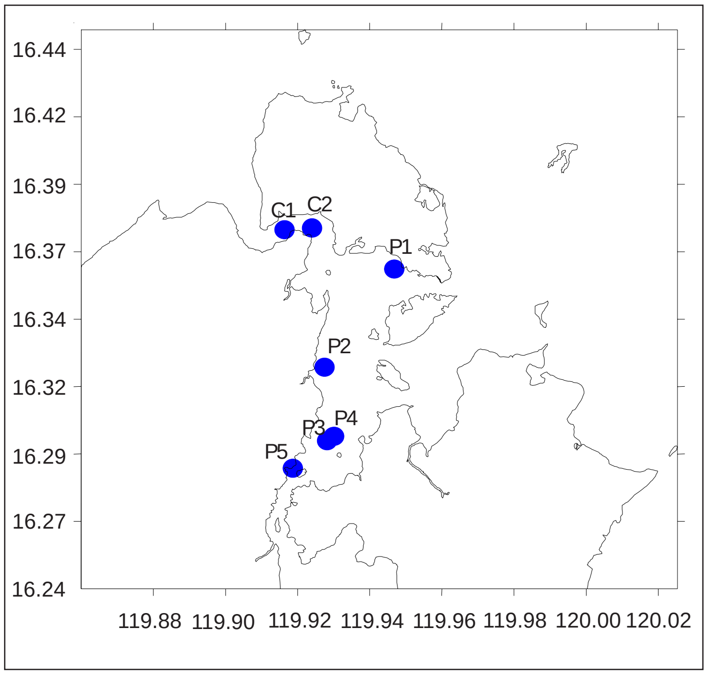

Fig. 3. Sampling sites

Table 2. Location and designs of the sampling pens and cages

Station	Location	Depth	Area (sqm)	Distance from shore (m)	Water Residence Time (unobstructed flow)
C1	N16 23.189 E119 54.961	13 m	225	25	0-4 days
C1	N16 23.304 E119 55.425	18 m	324	60	0-4 days
P1*	N16 22.488 E119 56.810	5 m	3,000	250	16-18 days
P2	N16 20.745 E119 55.646	3 m	4,800	25	10-12 days
P3*	N16 19.438 E119 55.693	3 m	3,200	400	10-12 days
P4	N16 19.515 E119 55.808	3 m	2,800	500	10-12 days
P5	N16.31578 E119.91873	2 m	4,800	3	14-16 days

c--cage: p--pen: *-- 24 hour sampling station

Protocols. The water quality parameters of dissolved oxygen, pH, salinity, temperature, and transparency were monitored monthly using DO meter, pH paper, refractometer, and sechi disk, respectively. In P1 and P2, temperature, dissolved oxygen, and salinity were measured every 4 hours over 24 hours.

For milkfish production, the frequency and amount of feeding, stocking density, growth, and harvest yields were recorded once a month in P2, P3, and P4, to evaluate production levels.

Census of aquaculture structures was conducted twice a year, while the number of licenses and permits issued by the municipality was assessed yearly using municipal records. Monitoring of water quality was conducted between 9:30AM to 3:00PM. The monitoring scheme is shown in Fig. 4.

Information campaigns

The monitoring results were discussed quarterly with stakeholders from the barangays of Tara, Luna, Luciente 2, and Culang.

The Municipal Aquaculture Technician, the Office of the Mayor, and the Bolinao School of Fisheries were given copies of the report of the results of monitoring. The data would serve as a basis for aquaculture policy reforms that would need to be made by the government of Bolinao. The feedback system adopted is illustrated in Fig. 5.

RESULTS AND DISCUSSION

Biophysical factors

Temperature and salinity changes over a monitoring period of 12 months showed seasonal trends (Fig. 6 and Table 3). During the dry months (January to May; November - December), temperature ranged from 27°C, recorded in C2 in February, to 33°C, observed in P5 in May. During this period, salinity changed in P3 from 28 ppt in February to 40 ppt in May.

With the onset of rains in June, temperature was at or above 31°C in mid-June, dipping to below 29°C in late September, and then increasing to nearly 34°C in P3 in mid-October. During the humid and rainy period, salinity decreased in all stations, with P5 in Culang experiencing the most fresh salinity values among all 7 stations at 7 ppt in late September.

Over an annual period, the temperature changes were from a two-degree difference in P2 to as much as six-degree change in C1. Fish cages located at 13 to 18 m depth had a 10-15 ppt change in salinity. The pens in shallow waters experienced a change ranging from 16 to 28 ppt over a year.

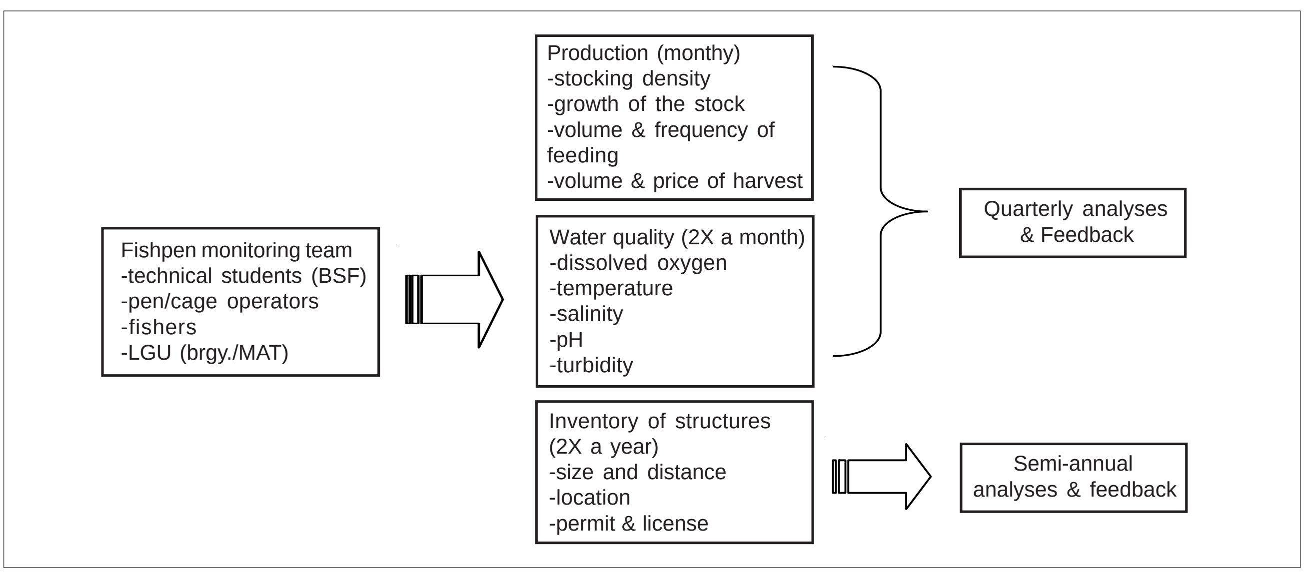

Fig. 4. The flowchart of the monitoring scheme

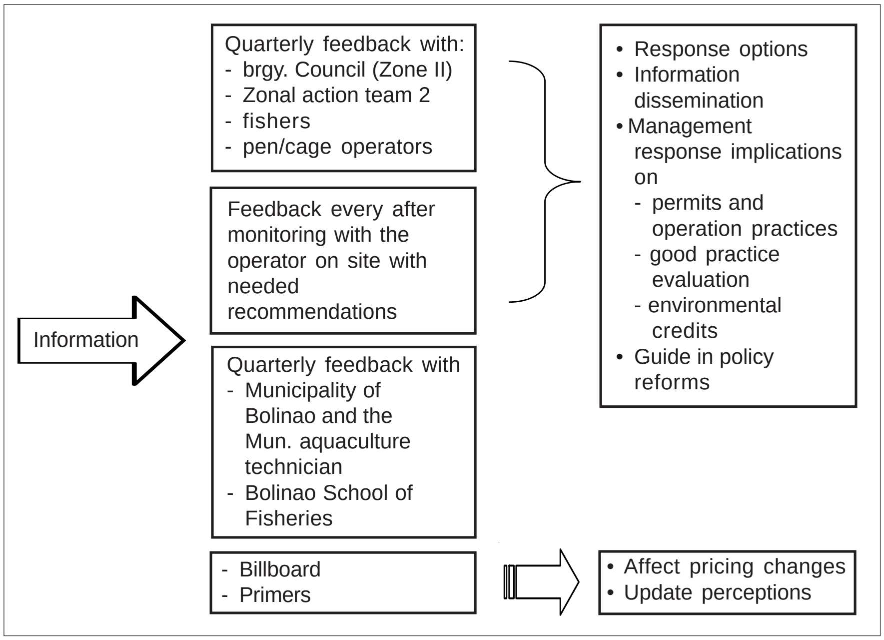

Fig. 5. Flowchart on the feedback system

Table 3. Annual range of water quality parameters

Station (Depth m)	Temp. (C)	Salinity (ppt)	DO (mg/L)	Secchi Disk Depth (m)
C1 (13)	28-34	21-36	4.2-7	2-3
C2 (18)	27-32	28-38	5-6.8	1.5-3
P1 * (5)	28-33	21-38	1.5-7.6	1.5-4.5
P2 (3)	30-32	12-40	2.5-7.8	.5-1.9
P3 * (3)	30-34	14-35	3.5-6.9	1-2
P4 (3)	29-33	20-36	4.3-7.8	1.5-2
P5 (2)	28-33	7-35	3.8-8.5	.8-1

C - cage; P- pen; DO - dissolved oxygen; * - 24 hour sampling station

Fluctuations in dissolved oxygen indicated the interactions between water residence time in the study sites, the influence of monsoon winds, and the prevailing temperature. During the northeast monsoons that prevailed during the dry months (November to March), oxygen values across stations were tighter and ranged from over 5 mg/L to 7 mg/L. With the onset of the doldrums (April to May) and the rains brought about by the southwest monsoon, dissolved oxygen, in general, decreased in value in all stations from June to late November. It increased beginning in December with the shift to the northeast winds. Over an annual cycle, fish cages in deep waters had dissolved oxygen concentrations greater than 4.0 mg/L. All the fishpen sites in shallow waters had an annual minimum of less than 4.0 mg/L for their annual minimum, except in the case of P4.

P1 and P3 sites, were monitored during the wet season (Fig. 7 & Table 4). Over a 24-hour cycle, temperature ranged from 27 to 31°C, and salinity changed from 15 to 24 ppt. Dissolved oxygen fluctuated from 4 to 7 mg/L in P1 and from 2.9 to 4.5 mg/L in P3.

Boyd and Lichtkoppler (1979) gave optional levels of dissolved oxygen (about 5 mg/L), temperature (25-32°C), and salinity (<32 ppt) for milkfish growth in tropical waters. Given that milkfish is euryhaline and can tolerate brackish conditions, salinity is probably the least limiting factor for its growth. Provided that salinity does not exceed 36 ppt, during which feeding is reduced, growth is not hampered (Bautista and others 1994).

Dissolved oxygen and temperature, because of its effect on gas solubility, are both critical determinants of growth rates. Dissolved oxygen is replenished via photosynthesis and diffusion; the latter enhanced by fast flow and turbulent regimes. In a 24-hour period, the dissolved oxygen is miimized during the night hours when respiration dominates, until photosynthesis produces oxygen by mid-morning. The strong northeast wind, which blows during the cool months from December to early March, creates sufficient turbulence to also enhance solubility of oxygen; hence, the high dissolved oxygen levels during the dry and cool months.

Low dissolved oxygen values dominate during the warm and humid rainy months. Although runoff from land

Table 4. Daily range of water parameters

Station	Date of Sampling	Temp (C)	Salinity	DO
P1	Sept. 21-22, 99	27-30	17-21	4-7
P3	Sept. 25-26, 200	27-31	15-24	2.9-4.5

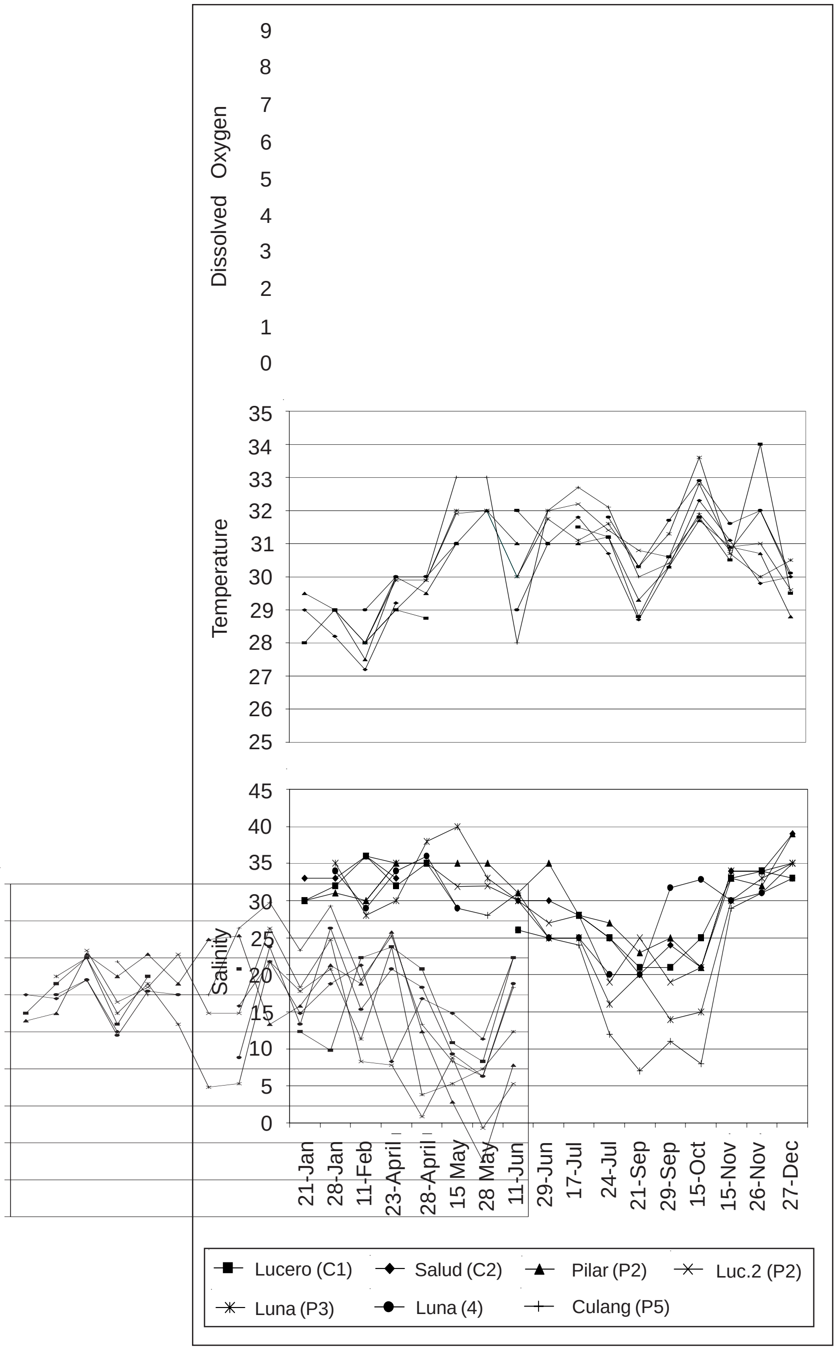

Fig. 6. Dissolved Oxygen (DO), salinity and temperature fluctuation

brings nutrients, siltation limits oxygen production by reducing photosynthesis.In addition, warm temperature decreases gas solubility. However, temperature enhances growth rates provided that food is provided.

Thus, in terms of overall effect on biomass production, harvest was higher for the August to November period at 14 tons, compared to 11 tons for the same stocking density in the January-April culture cycle in P3. This result needs further validation. The effects of the aquaculture facilities on water flow and exchange, as well as those of stocking and feeding practices would need to be considered in determining overall production. In the case of P3 for example, extremely low dissolved oxygen levels were obtained in November. The fish were given feeds at the rate of 680 kg/day with a stocking density of 14 fingerlings per square meter in a 3,200 m^2 pen. The excess feeds used up oxygen for decomposition and caused it to reach sub-optimal concentrations. In general, Chiu et al. (1986) found that milkfish stops feeding when dissolved oxygen is <1.0 mg/L, but feeds before sunrise and continues after sunset provided dissolved oxygen is maintained at >3.0 mg/L.

To assess better growth differences, additional pen sites with variable biophysical conditions would be established and monitored, in collaboration with in-depth technical studies looking at water column and sediment parameters as influenced by aquaculture.

Production from milkfish grow-out

Two-month old fingerlings (about 3-5 centimeters) sold at P2.40 to P2.50/fingerling were stocked at a stocking density of 10-16 and 110 - 123 per square meter in pens and cages, respectively. Fingerlings come from suppliers in Anda, Bani, Bolinao, or Bulacan. Other operators who have fishponds buy milkfish fry for PhP 0.35 to PhP 0.70/fry from fry catchers or PhP 1.00 to PhP 1.25/fry from milkfish fry dealers, and grow these out in a nursery pond or small net enclosures within the pond.

Mortality occurs during transport especially when the fry come from distant sources. Cage number 2 (C2) experienced 15% mortality rate of milkfish fry from Bulacan during stocking while only 2% mortality occurred for stocks coming from nearby sources like Santiago Island, Anda, and Bani. Higher mortality rates were observed during stocking when fry were not properly acclimatized. The fingerlings could not quickly adapt to the water conditions in the cage which were different from those in the seed stock container. Where mortalities were caused by parasites (e.g., pen number 4 experienced 0.33% mortality due to blood spots in

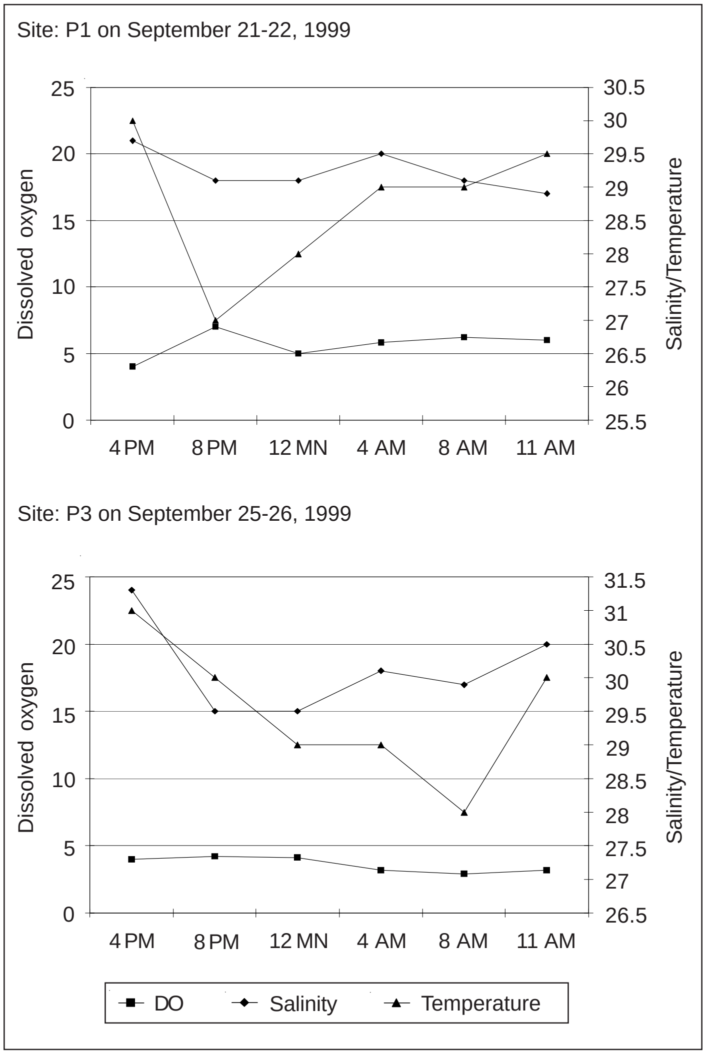

Fig. 7. 24 Hours of dissolved oxygen fluctuation

gills of fish in the third month of the culture period), Blue Water and Vetracin antibiotics were administered to the stock.

P4 and P5 were given commercial feeds (Vitarich, Tateh, Ram, or Welgrow) three times a day (morning, noon, and afternoon) at .01kg/fingerling/day during the first three to four months. Starter mash and crumble were offered on the first month, grower feeds in the second and third months; and finisher feeds in the fourth month. Two weeks before the harvest, noodles or bread crumbs were given to the stock as food supplement at 10:00 AM and 3:00 PM. In certain instances such as in C2, as much as 10 sacks of feeds per day (or 250 kg/ day) were given to 65,000 fingerlings on the third month. This amounted to 300 sacks or 7,500 kilograms per month. At the other extreme are cases where feeds could not be given because of budgetary limitations.

Marketable weight for one milkfish was usually about 0.35 to 0.75 kg/fish (wet weight). Selective harvesting took place in fishpens and fish cages where a small portion of the stock was left in the structure for the following harvest. Instances of unexpected harvesting also occurred in cases of typhoons and strong winds.

Operators in Culang revealed that harvesting in 1995-1996 required only 3 months for fingerlings to reach marketable size (about 2-5 pieces/kilo). In 1999, grow-out cycle took 4 to 5 months. Some operators reported that they needed 6 months of grow-out period in order to produce a viable harvest. They were not able to reach the expected output of three culture cycles in a year. In addition to poor water quality, other reasons for low production include miscounting of fry during trading, poaching and food limitations, and calamities.

Operators preferred the culture cycle where harvest took place during Christmas, fiestas, and Holy Week (December, March, and April) when the demand for milkfish was high; The increased demand resulted in the high price of milkfish. A systematic way of harvesting was done by encircling the stock with a net, driving them to the center for scooping. After harvest, the milkfish were landed at Catubig, Picocobuan, and Guiguiwanen for sorting (according to size) and packing (with ice in a tub).

Benefits from fishpen and fish cage culture

An average net income for each pen was Ph P 174,000 per cropping (Table 5). Market destination for harvests were usually Dagupan and Metro Manila. Milkfish aquaculture benefited not only the owners of fishpens and fish cages, but also the people of Bolinao and other municipalities. They were hired (and paid as contract laborers) as caretakers, fishpen/cage fixers, harvesters, classifiers, packers, and laborers during transport. Likewise, the municipality earns from annual fees. In

1998, it earned an estimated amount of Ph P 2.3 M from these fees (Table 6).

Evaluation of participatory monitoring

Impact of monitoring. The essence of motivating the participation of the community is to allow its members to direct their resources in solving problems collectively. Their participation is important not only for their personal interests on the resource but also in consideration of the interests of other sectors.

A participatory process adopted in the monitoring (and also in the formulation of the CDP) played a major role in raising the awareness among the major stakeholders in Zone II. An awareness on the need for sustainable aquaculture practices was initiated, especially on the part of the fishpen cooperators.

Sustaining monitoring. The best reward received by the monitoring team was the recognition by the municipality of the activities of the team. The data shared with the municipality helped to facilitate deliberations on the CDP ordinance. This recognition was manifested when the municipal mayor approved the team's request for a monitoring boat and gasoline.

A major concern now is how to sustain monitoring efforts. Given the voluntary and ad hoc nature of the monitoring team, it was expected that levels of participation would vary. For the BSF students, their participation waned when they had to start their on-the-job training. Among operators, only a few had time for post monitoring work. Technical constraints were also expected. The participatory monitoring team lacked the technical expertise in data analysis so that the assistance of the MFRMP was vital during the quarterly information campaigns.

The maintenance of water quality, size, and distance and zonation of pens and cages are among the critical provisions in the CDP that should be monitored regularly. As the lead officer in the CDP, the role of the Coastal Resource Management (CRM) officer is crucial in its implementation. However, the CRM officer would need assistance from the major stakeholders. The ad hoc Zonal Action Team for Zone II that was formed to facilitate the information campaigns and the implementation of CDP would particularly be a major partner. There is, therefore a need to mobilize the whole Zone II so that provisions on coastal aquaculture could be properly and successfully implemented.

Implementing the Municipal Fishery Ordinance provisions. The implementation of the previous ordinance on milkfish pen and cage regulation (especially on the issuance of permits) since its approval on October 9, 1995 has not been effective.

The Bolinao Coastal Development Plan, now called the Municipal Fishery Ordinance, provides clear guidelines on how to regulate coastal aquaculture, the most controversial part of the ordinance. Since its submission to the Municipal Council on October 1998 until its enactment in December 1999, several consultations and public hearings were conducted by the Municipal Fisheries and Aquatic Resources Management Council and the Municipal Council regarding

Table 5. Average production per cropping
Source: MFRMP Data, December 1998 to October 1999

Pen no.	Stocking density (fingerlings/ sqm)	Grow-out Period	Mortality Rate	Harvest (tons)	Pen Area (sqm)	Income/ Pen (PhP)
P1	7	Dec '98-Mar '99	25 %	10	3,000	170,000
P2	9	Jan-April '99	16 %	10.8	3.200	150,000
	7	May-July '99	12 %	8.1		70,000
	9	Aug-Nov '99	14 %	13.8		230,000
P3	13	June-Oct '99	14 %	12	2,800	202,133

Table 6. Estimated revenues of the LGU from milkfish aquaculture in Bolinao (1998) *Source: Municipality of Bolinao, 1996. Revenue Ordinance No. 01 s-1996, MFRMP, 1998*

	Filing fee (in PhP)	Annual fee (in PhP)	Number of structures	Wharfage fee	
Pen (5 yr.)	6,000	1,000	116	P2.5 per tub	
Pen (3 yr.)	4,000	1,000	246	of during	
Cage (5 yr.)	3,000	500	28	harvest	
Cage (3 yr.)	2,000	500	86		
Total	P1,936,000	P419,000	476	P1,190,00	PhP 2.3M

its provisions. Recommendations on aquaculture include the following:

1) revision in sizes from 2,400 to 1,200-4000 square meters in pens and from 225 to 144-324 square meters for cages.

2) construction of fish cages in clusters (10 units per cluster), with, a distance of 100 meters between clusters.

3) change in the maximum number of allowed pens and cages from 1 unit to 5 units per permitee.

Provisions on the issuance of permits, maintenance of water quality, and monitoring of fish production which are broadly stated should likewise be addressed in the Implementing Rules and Regulations.

SUMMARY

Enjoining the community's participation is an effective strategy to any coastal resource management initiative. Other initiatives like the coastal development planning, a participatory aquaculture monitoring mechanism was set up through information dissemination. A group of pen/cage owners, barangay council members, technical students, fishers, and representatives from the municipality comprised the monitoring body.

The monitoring of the parameters dissolved oxygen, salinity, and temperature, showed that low production of milkfish was caused by limited dissolved oxygen supply. Regulation is needed to ensure optimal production of pens and cages which would need to be located in optimal environmental conditions where dissolved oxygen remains high for fish growth.

The monitoring scheme allowed the formulation of policies to regulate milkfish grow-out. Sustaining monitoring efforts remains to be seen, but the Municipal Fishery Ordinance provisions at least ensure that the industry is regulated by law.

Municipal Coastal Development Plans would be operational if coastal aquaculture is squarely addressed. Although often contentious because of intense conflicts, the Bolinao experience indicates that advocacy and biophysical participatory monitoring of water quality, production, and incomes are vital in ensuring sustainable coastal aquacutlure.

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