PHILMINAQ

Mitigating Impact from Aquaculture in the Philippines

Report on monitoring survey methodology

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Training in monitoring methodology

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Introduction

As part of the Philminaq project, a training course and workshop titled was undertaken on the predictive modelling of aquaculture impact in the Philippines (*Trainors' Training on Field Surveys and Modelling Course for Mitigation of Aquaculture Impact*). The activity was held on May 22-25, 2007 at the Bolinao Marine Laboratory of the University of the Philippines' Marine Science Institute in Bolinao, Pangasinan. The objectives of the Training were:

- To demonstrate field survey and modelling techniques suitable for assessment of aquaculture impacts (this will be a combination of techniques developed in the Philippines, Norway, and Scotland);
- To demonstrate three different types of surveys, ranging from a low-cost survey that can be undertaken by LGUs or farmers, to a detailed comprehensive survey that can be undertaken by scientists or government agencies; and
- To consult participants on the suitability of the techniques and the most effective method for implementation and management of aquaculture sectors.

1.0 Survey methodology for benthos

Participants were introduced to benthic survey techniques on the small boats provided by UPMSI. On arrival at the fish cages in the Bolinao channel, participants were given a brief lecture on the importance of taking accurate data on cage layouts and dimensions. These important modelling requirements were obtained by using handheld GPS units to position fix the cage corners.

The participants were also urged to gather as much husbandry information at this time from the caretakers working on the cage, as this information would be difficult to obtain at a later date. Cultured species, estimated weight, biomass and daily feed input was noted. In addition, distance to nearby cages was also assessed by taking GPS coordinates of the nearest cage corners.

The importance of relating cage position to residual current direction was also stressed, and the need to consider the position of benthic sampling stations prior to arrival on site. This requirement for hydrographic data and possible preliminary modelling of solids output was encouraged, as the optimal sampling transect could only be selected by a reasonable *a priori* knowledge of depositional gradients. The participants were then instructed on methods for sampling transect deployment and station position fixing *via* measured line and handheld GPS. The importance of accurate position fixing for monitoring studies was stressed; participants were instructed in how to use a handheld compass to determine the bearing of the sampling transect from the cage.

Participants were then reminded of the 3 different categories of survey, the benthic survey components of each category, and the use of each item of equipment:

Category 1 surveys
Depth by weighted line
Mini-corer

- Broad categories of enrichment, e.g. visual, smell, presence/absence of fauna
- Water content determination (simple)

Category 2 surveys
Depth by hand held electronic meter
Mini-corer

- Water content (using balance and drying oven), Particle Size Analysis (PSA) (using sieves)
- Broad categories of enrichment, e.g. visual, smell, presence/absence of fauna
- 0.025 m^{-2} van Veen grab

- Macrofauna (identification to major taxa only)

Category 3 surveys
Depth by hand held electronic meter

Mini-corer

- Broad categories of enrichment, e.g. visual, smell, presence/absence of fauna
- LOI/CHN
- Water content (using balance and drying oven)
- Redox
- PSA (using analyser or sieves)
- 0.05 m^{-2} van Veen grab
- Macrofauna (identification to family level)

With the survey boat positioned at 0 m from the cage edge, GPS position and depth noted, the participants were then instructed in the use of the mini-corer to take sediment samples, taking care to use the correct speed of deployment. After retrieval, the participants noted the characteristics of the sediment sample, e.g. the colour, smell, depth of overlaying organic matter, etc. The 0.025 m^{-2} van Veen grab was then explained, deployed and retrieved. The participants were instructed in correct sieving technique to obtain quantitative macrofaunal samples, and the use of different mesh sizes for sieving. Preservation with formalin and Rose Bengal vital stain was also shown.

The mini-corer was then demonstrated, and samples for visual analysis were obtained. Participants observed the sediment cores and described them in terms of depth of overlaying organic layer, colour of any underlaying sediment, sulphur smell, presence of *Beggiatoa* sp., and presence/absence of fauna. Pictures were taken of representative cores for future comparisons.

Other cores were taken for water content and PSA, and the technique for extruding and slicing cores to obtain the top 4 cm was demonstrated. All of the above techniques were then replicated along a transect leading from the cage edge to a maximum distance of 500 m from farm inputs, until some form of relatively unimpacted benthic community could be found. The participants were then shown the greater diversity of animals retained on the sieve, and the different visual appearance of cores in these relatively unimpacted areas.

2.0 Benthos

The use of different size grabs (0.025 m^{-2} for Category 2, 0.05 m^{-2} for Category 3) for different surveys was explained, and the level of taxonomic resolution for each category also discussed. A brief lecture on the effects of organic enrichment on the benthos was given, and the changes in number of species, individual abundance and biomass along enrichment gradients explained.

2.1 Grain size

The use of PSA to measure changes in surface sediment layers was explained. The different means of assessing PSA (using sieves and/or laser mastersizer or Coulter counter) according to category of survey was also explained.

2.2 Loss On Ignition

The desirability of monitoring total organic matter in sediments was explained, and the method of determining the labile and refractory portions in sediment by combustion at 250˚ and 500˚ C was described for Category 3 surveys.

2.3 Redox potential

The use of measuring redox potential as a broad indicator of enrichment and a monitoring tool for Category 3 surveys was explained. The insertion of the redox probe into sediment cores and use of associated meter was described.

2.4 Sediment Dry weight

As a common measurement across the 3 survey categories, the assessment of water content of surface sediments was a potentially useful indicator, with more enriched sediments possessing a higher water content than unenriched sediments. The method of collecting a 4 cm slice from the surface of a sediment core was demonstrated, and the method of weighing a subsample, drying overnight and the weighing again was described.

3.0 Survey methodology for water column

First the participants were introduced to bathymetric surveying, using the Category 3 method. It was explained that surveying required an extensive grid if the bottom topography varied greatly, but this was not crucial if the bottom was fairly level. The local bathymetry around Bolinao was not very widely surveyed, and where covered was largely based on navigational hazards, thus the fish farming areas were not well surveyed. Two alternative bathymetric survey methods were described; using the handheld electronic sounder and handheld GPS (Category 2), and using a map with leadline. It was explained that the map and leadline method was not practical without good navigational expertise.

The importance of noting all relevant details e.g. position, accurate time was repeatedly stressed. The water sampler (Niskin 5 L) was explained, and the importance of properly cocking the bottle. The participants were shown the triggering of the bottle mechanism by release of the messenger at the required depth. On retrieval, the importance of flushing sample bottle several times was stressed, and it was explained that many water samples could be obtained from same depth using the water sampler. The parameters that could be measured using water sampler in the 3 categories of survey were also described, viz. nutrients, dissolved oxygen and chl a.

The CTDO probe was then explained, especially noting the magnetic on/off switch and the importance of ensuring the device was measuring before deployment. It was explained that salinity was not measured directly but was calculated from the conductivity. The dissolved oxygen, turbidity and fluorescence sensors were also explained, and that they were programmable to measure from once per second to once per 120 min. A 5 second window used as the best balance between frequency and accuracy. Proper deployment and retrieval speeds were explained for areas of strong current: the probe should be deployed down quickly, and retrieved slowly, allowing the probe to remain at depth for 10-15 seconds. In shallow water it is important to have measurements in the surface layer, so extra care was be taken on retrieval in these areas to ensure these measurements were taken.

Water turbidity was measured using a Secchi disk to estimate suspended particulate/algal material causing extinction of light from surface. The Secchi disk was lowered from the surface until no longer visible, lifted until visible again, then lowered until no longer visible again; the average depth of these measurements was taken as the Secchi depth.

Current meters were described briefly, and the importance of using accurate, low threshold devices in low energy environments. The importance of using good quality meters for model validation was also stressed. The placement of current meters at fish cages to adequately measure water layers relevant to particles, e.g. at surface, net depth, bottom etc. was also explained.

Drogues were then demonstrated, showing the dispersion of the water column. The simultaneous release of a number of drogues was demonstrated, taking handheld GPS positions at intervals. It was explained that drogues could be set at different depths or the same depth, and could be used to assess current speed. It was also possible to attach GPS units to drogue floats and use the tracking facility to accurately track drogue movement.

4.0 Three categories of survey

	CATEGORY I **Simple**	CATEGORY II **Intermediate**	CATEGORY III **Full Quantitative**
Client	Large Farmer/LGU	BFAR Regional, IFARMC, PAMBI	Science + NIFTDC
Equipment Cost	US $ 1,000	US $10,000	US $ 100,000
Consumables Survey cost	US$ 25	US$ 250	US$ 2,500
Bathymetry	Lead-line and chart	Hand-held sounder + GPS	Echo sounder + GPS
Turbidity	Secchi	Secchi	Secchi + Turbidimeter
Salinity/temp/depth/O_2/	Temp/Salinity (hydrometer), O_2 test kit	Temp/Salinity (hydrometer/refractometer?/O_2 (DO meter)	CTDO
Water column Nutrients	Water sampler (Marpet?)	Water sampler (?), Niskin (?)	Niskin bottle (field) + lab analysis (any depth)
Benthos sampling	Mini-corer	Grab (0.025 m^2) or corer	Grab (0.05 m^2)/corer + equipment + chemicals
Taxonomy	Sensory/presence/absence	Semi quantitative - major taxa	Quantitative (families)
Sediment (physical and chemical)		Water content/PSA (sieve?)	PSA/water content Redox/LOI (CHN?)
Hydrography	--	Drogues CM (cheap)	CM Drogues
Met. data	--	Met. station/handheld anemometer	Met. station
Waste feed	Tray	Tray	Tray
Analysis of results	Analysis of aquaculture impact into basic categories Low Intermediate High Matrix	Semi-quantitative analysis of aquaculture impact	Baseline survey. Quantitative analysis of impact

Data source	Secchi O_2 Temp/salinity (nutrients?) Waste feed Qualitative assessment of sediments	Secchi O_2 Temp/salinity Nutrients Semi-quantitative benthos Sediment physical (Particle size) Circulation/current speed/degree of flushing Meteorological Waste feed	Depth profile Quantitative fauna Secci O_2 Temp/salinity Nutrients Semi-quant Benthos Sediment physical (Particle size) Circulation/curent speed/direction /degree of flushing Meteriological Waste feed Redox
Use			Assimiltive carrying capacity.
Warnings	Warnings		Predictive warnings
	Use in models		
	Secchi warning heavy turbidity or algae levels compared to reference		

4.1 Category 1 survey (draft example – final will be given in the field manual)

Scope: Simple cheap, cost effective survey
Aimed at: LGU/Farmer
Survey summary
This survey measures the following parameters:

- Cage layout and sizes
- Depth recordings (bathymetry) of the area around the cages
- Condition of the sea bed sediments
- Oxygen levels in the water column
- Turbidity of the water column

These parameters are important because:

- Cage layouts and dimensions give crucial information for interpretation of survey results and also for modelling of the area.
- Depth recordings provide information to assist the sampling of the water column and seabed during the survey. Accurate depth measurements are also important for management of the site so that mooring ropes and nets can be set at the correct depth. Cage nets should not be dragging on the seabed. Also, computer modelling of cages requires accurate depth measurements.
- The condition of the sea bed sediments is important as too much organic input to the sea bed causes oxygen to be absent resulting in no fauna living there. If no fauna are living in the sediment, waste from the cages above is not eaten and it builds up on the sea bed. This results in chemical reactions where gas bubbles from the sediments rise to the cages above and cause stress to the fish. It is important to monitor the biological and chemical condition of the seabed.
- Oxygen levels in the water column are important as very low levels result in fish kills. Also, low levels of oxygen stress the fish and cause poor growth. Oxygen levels in the water column are affected by many things, including water temperature, concentration of phytoplankton (algae), current and condition of the seabed as described above.

The turbidity of the water column relates to how much algae and suspended solid material is in the water column. High turbidity may be linked to high levels of nutrients which cause excess algal growth, or seasonal effects such as high suspended material from runoff caused by rain. This is important as high concentrations of algae and suspended material (high turbidity) can lead to reduced oxygen in the water column if this material starts to decay.

Survey methods

- Note down the layout of cages being surveyed (for example 2 by 2 square cages, size 10m by 10m by 6m net depth). In addition, note the layouts of surrounding cages and the approximate distances between cages.
- Photographs of the cage group and surrounding area taken with a digital camera are very useful.

- Depth recordings

Equipment needed - rope (up to 50 m) and weight; digital camera.
The rope should be marked at intervals so that the user can easily measure the depth as shown in Figure 1. The rope can be marked by using tape and a permanent marker pen or by placing a marker such as a cable tie or a piece of string in the lay of the rope. An alternative is to use a large tape measure which allows very accurate measurements to be taken.

The person taking the measurement lowers the weight to the seabed, pulls the rope until it is tight without lifting the weight from the sea bed, and then notes the measurement. Measurements should be taken around the four corners of the cage group and the edges of the cage group, where there are four or more cages together. Some measurements should also be taken away from the cages at distances of 10, 25 and 50 m. The length of a cage or the boat can be used to judge these distances from the cages. A measurement should be taken in the middle of the cages, if possible.

It is important to note down the location of the depth measurements in relation to the cages.

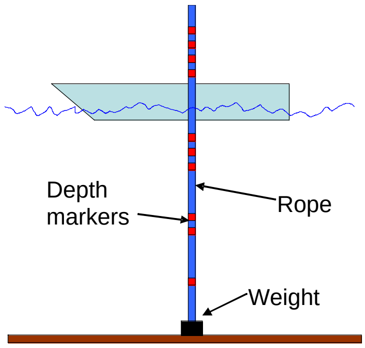

Figure 1. Marked and weighted line used for measuring depth.

This depth information can then be collected to make a depth or bathymetry map of the area (Figure 2).

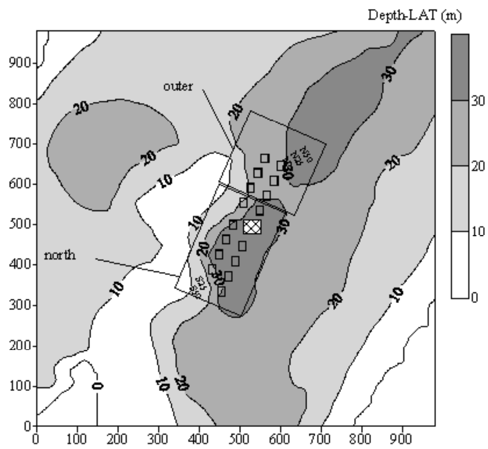

Figure 2. Sample chart showing bathymetry around a fish farm.

Condition of the sea bed sediment

Equipment needed - miniature gravity corer (mini-corer) (Figure 3).

To survey the sea bed sediment, an undisturbed sample is required. Collection of sediment in a clear core tube allows the colour of the sample to be inspected along the depth of the core.

Figure 3. Miniature gravity corer (mini-corer) (left) and retrieving sample (right).

The sampling should be done at the edge of the cage, 10, 25 and 50 m from the cages. A diagram should be drawn in the note book to show the location of the sampling stations.

A photograph of each core should be taken if a digital camera is available.

Figure 4. Sediment cores of the seabed taken underneath (middle photograph) and 40 m away (right photograph). The dark colour of the sediment in the middle photograph indicates heavy impact, and this was also smelly - there were no animals living in this sediment. The lighter colour of the core on the right indicates healthy sediments and there is a boundary at 7 cm - the surface layer above this is mixed by the animals living there.

The following information should be recorded during the survey:
Sediment type - describe the sediment in terms of the grain size - Is the sediment sandy or muddy?

Sediment colour - what is the colour of the sediment and describe this with depth. In the cores shown in Figure 4 the sediment would be described as: Middle photo - “black the whole depth of the core, with white mat on surface” and right photo - “light brown to a depth of 7 cm and then a darker brown colour below this depth”

Smell - does the sediment smell of rotten eggs? If it smells, can gas bubbles be seen in the sediment?

Larger living animals - are there any large animals on the surface or just below the surface of the sediment? Describe these animals, e.g. worms or worm tubes, snails etc.

Other features - look for waste fish feed and faecal pellets on the surface of the sediment, a bacterial mat (Figure 5) and other features such as different layers in the sediment.

Figure 5. Photo of bacterial mat, faecal and food pellets on the sea bed, taken from under fish cages.

5.0 Target costs of the surveys

5.1 Category 1. (US$ 440 capital/ US$25 operational)

Equipment	Price (US$)
Thin rope + marker + weight	10
Secchi disk + rope + marker	20
Thermometer	5
Hydrometer	10
O_2 test kit	50
Nutrient test kit	200
Water sampler (cheap)	200
Coring device	75
Feeding tray	20
Ropes	25
Digital camera	250

5.2 Category 2. (US $ 7,170 capital/ US$ 200 operational)

Equipment	Price (US$)
Handheld sounder	250
GPS	350
Secchi disk + rope	20
Temperature/salinity/DO meter	800
5 L water sampler/Niskin	600
Grab (0.025m^2) or corer	800
Drying oven	800

Scales + 0.001	500
PSA sieves (?)0.50, shaker (2 mm, 1 mm, 0.5, 0.25, 0.125)	2,000
Drogues	125
Met. station	1,000
Handheld anemometer	200
Feeding tray	25
Rope	50
Weights	50
Nutrient test kits	200
Storage boxes	500

5.3 Category 3 (US$ 100,000 Capital/ US$ 2,000 operational)

Equipment	**US$**
Echo sounder + GPS (integrated)	1,500
Secchi disk	20
Turbidimeter + CTDO	16,000
Niskin	600
Chemicals/filters, Lab equipment for chemical analysis	200
Grab (0.05 m^2), core + sieves + equipment for benthos sampling chemicals	200
Coulter counter or equivalent	25,000
Redox meter + probe + sol.	2,000
Muffle furnace	4,000
Current meters (3)	18,000
Profiler + frame + batteries (50 pcs per deploy)	34,000
Mooring equipment	400
Drogues	125
Met. Station	1,000
Feeding tray	25
Storage boxes	500