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Final report

Project

Evaluation of production technology, product quality and market potential for the development of bivalve mollusc aquaculture in the Philippines

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We hope that this work will provide a useful basis for the future development of bivalve aquaculture in the Philippines, as we strongly believe it has great potential to provide coastal people with sustainable employment, economic and nutritional opportunities, with minimal environmental impacts.

Peter Duncan, Merlina Andalecio, Liberato Laureta, Ernestina Peralta, Aklani Rose Hidalgo, Ruby Napata, Erish Estante, Marnelie Gadong and Kristal Kae Ombrog

2 Executive summary

The bivalve mollusc industry is one of the most significant global aquaculture sectors and has undergone significant growth in recent decades. This industry is well established throughout the Philippine archipelago, and is based principally on oyster and mussel culture. However, considering the overall importance of aquaculture in the country, and the well-developed research and regional administration networks which exist, mollusc culture has not shown the same level of growth as elsewhere. In addition, there exist significant regional differences within the Philippines, for example, Luzon typically obtains better prices for their product than Western Visayas, and production volumes are also variable between regions. Furthermore, there is no export market for Philippine bivalves, despite increasing international demand. This industry has the potential to support local coastal communities and enhance national income, with relatively low environmental impacts, if development constraints can be overcome.

This scoping study was conducted to obtain an industry overview of the two regions mentioned above, to assess various factors considered to contribute to regional differences in bivalve production, and to identify constraints to overall development. The areas of investigation included; water quality parameters, sediment characteristics, temporal and spatial morphometric parameters of culture species, microbial assessment of water and mollusc tissue, as well as an in-depth survey of industry practices, demographics and organisational structures. Finally, reviews of local regulatory processes and international aspects of bivalve aquaculture were conducted.

Field sampling was attempted during wet (approx. June - November) and dry (December - May) seasons at 60 individual stations, covering 9 municipalities across the two regions. Although some limitations were encountered a good overview of the main parameters was obtained. Furthermore, a total of 388 producer surveys and 119 market surveys were conducted during the study, providing the most comprehensive data set yet collected on this industry in the Philippines. Additional information on industry legislation and governance was gathered from interviews and communication with local and national government agencies.

In summary, data collected indicated that differences exist between Luzon and Western Visayas which may explain some of the differences in production output and value, notably higher growth rates, differences in culture systems, different demographic profiles of industry participants, as well as differences in microbiological status.

The results are discussed in the context of developing a proposal for implementing industry development programmes in Western Visayas in the medium term, with a view to both equalizing and enhancing the prospects for regional production, as well as developing export markets for bivalve products in the longer term.

3 Background

As global harvest fishery production continues to decline, aquaculture has grown in importance, reporting an average annual growth rate of around 9% between 1970 and 2004 (FAO 2006). Over this same period, contributing species groups have shown different industry-expansion rates, ranging from 18.9% for crustaceans to 7.3% for diadromous fish. However, questions of food supply versus economic gain and long-term environmental sustainability are being directed at some aquaculture sectors, and a longer-term view, considering aspects of food security, lower environmental impacts, industry sustainability and regionally-appropriate aquaculture may be more important in future.

Of the major species groups reported most recently by the FAO (2006), molluscs were the third most important sector by both volume and value at 13.2 million tonnes and US$9.8 billion, respectively. Bivalves constitute the vast majority of cultured molluscs worldwide and comprise 5 of the top 10 species groups by overall production, including oysters, clams, mussels and scallops. They also provide the highest production for an individual species with the Pacific Oyster (*Crassostrea gigas*) at 4.4 million tonnes in 2004 (FAO 2006). Bivalve mollusc aquaculture also fits well into the potential future aquaculture scenario outlined above and, as such, may well increase in importance at both local and international levels.

In line with global trends, aquaculture in the Philippines is also the fastest growing sector of primary production and increased by 18% between 2003 and 2004. Total aquaculture production is currently around 2.2 million tonnes (Table 3.1) (BAS 2008), approximately 19% of domestic aquatic food supply, and includes a variety of species groups including finfish, crustaceans, algae and molluscs.

Table 3.1 Philippines Fisheries Production by Volume

(Metric Tons)

Sector	2005	2006	2007
All Sectors	**4,161,869.83**	**4,408,472.27**	**4,711,252.43**
Commercial	**1,133,976.21**	**1,080,667.70**	**1,192,069.78**
Municipal	**1,132,046.31**	**1,235,528.77**	**1,304,356.47**
Marine	988,239.87	1,074,134.37	1,136,079.19
Inland	143,806.44	161,394.40	168,277.28
Aquaculture	**1,895,847.31**	**2,092,275.80**	**2,214,826.18**
Brackishwater Fish cage	4,845.89	4,383.37	3,563.49
Brackishwater Fish pen	4,787.03	4,769.64	5,337.61
Brackishwater Fishpond	267,596.70	272,163.41	285,593.89
Freshwater Fish cage	61,043.63	72,282.68	95,177.61
Freshwater Fish pen	53,320.66	54,270.44	63,674.29
Freshwater Fishpond	84,499.57	118,269.24	135,186.99
Marine Fish cage	31,033.00	46,827.55	62,096.93
Marine Fish pen	13,442.67	13,794.21	18,417.92
Oyster	16,494.89	16,838.35	20,508.05
Mussel	20,159.44	19,690.29	20,113.61
Seaweed	1,336,597.32	1,468,906.01	1,505,069.58
Small Farm Reservoir	26.51	80.60	83.17
Rice Fish			3.04

In general terms, and in comparison to finfish and crustacean culture, bivalve mollusc aquaculture is characterized by relatively high production volumes per unit area, a low value product, requiring relatively little infrastructure, financial, management or exogenous nutritional inputs and having low environmental impacts.

As such, and given the large number of suitable coastal areas available in the Philippines, bivalve mollusc farming would appear to have significant potential as a local cash crop, and as a means of sustaining small-scale coastal fishing communities, which face reduced wild-harvest catches. The high costs of finfish or crustacean aquaculture operations are prohibitive to poor individuals and families, but the lower cost of bivalve culture offers a feasible alternative, and government regulations concerning lease arrangements in coastal waters also favour small-scale, community-based aquaculture developments.

However, despite a long history of aquaculture in the Philippines, and the presence of well-developed fisheries/aquaculture research and training institutions, mollusc aquaculture has not received significant coordinated development effort and the contribution of oysters and mussels to total Philippines aquaculture production is relatively small. Table 3.1 also shows oyster production in 2007 was 20,508t (0.9% of total aquaculture production). For mussels, production amounted to 20,113t (also 0.9% of the total) (BAS 2008). The majority of oyster production is derived from the extensive culture of Crassostrea iredalei, and very limited production from the subtrigonal oyster C. malabonensis. The Asian green mussel, Perna viridis, provides all reported mussel production.

Philippine mollusc aquaculture is currently not sufficiently developed to supply even the domestic market, and within the country there is considerable variability in production and value between regions. For example, Luzon (northern regions I to V) has moderate production, but high value; PhP 6.36-19.40/kg (AU$ 0.16 – 0.51) and PhP 5.00-13.03/kg (AU$0.13 – 0.34) for oysters and mussels respectively. By comparison, the Visayas (central regions VI to VIII) has some high production areas, but generally low value, PhP 3.06/kg and PhP 2.76/kg (AU$ 0.08 & 0.07) for oysters and mussels respectively.

Unsurprisingly perhaps, Philippine mollusc aquaculture also has no significant input into the global seafood market due to the low production volume, as well as additional issues of product quality, food safety, eco-labelling and traceability.

3.1 Key Issues

For bivalve aquaculture to more effectively supplement small-scale communities across the whole country, and to meet its potential to contribute to overall economic growth in the Philippines, both domestically and internationally, there is a requirement to;

- obtain up-to-date background information on the industry, including; the current status and organization of the oyster and mussel industries in both high and low producing regions, environmental factors, production systems, industry regulation, post-harvest practices, food safety and marketing issues

- attempt to identify the principal factors affecting industry productivity. For example, determine whether areas of regulation, management or production practice are not being addressed, identify examples of poor or inefficient practice, and identify any other aspects which may be limiting the development of bivalve mollusc aquaculture within particular regions, or within the Philippines as a whole

- consider these data in an international context, with a view to assessing the potential for future export development, and how this might be achieved

- develop medium and long-term strategies for implementing recommended changes to industry regulation and practice and to quantify improvements in industry performance

This scoping project will therefore assess the bivalve mollusc industries of Western Visayas (region VI) through surveys, site visits and preliminary environmental sampling and compare them with better performing regions in Luzon (regions I, III and IVa). Collected data will then be analysed and used to develop a comprehensive research plan for potential funding of a second-phase project (see Expected Outputs section).

3.2 Project Justification

This project is justified on the basis that the Philippines appear to have suitable culture environments, suitable species and the suitable technical skills to develop bivalve mollusc aquaculture to a significant level. However, industry development is both variable and less than expected. This sector of aquaculture has not received significant levels of research or development support in the past and, in order to address this shortfall, and realise its full potential, some fundamental information needs to be obtained if the reasons for underperformance are to be identified and addressed.

If this project can provide the basis for future and more appropriate levels of capital and technical investment then the development of bivalve aquaculture in the Philippines could be both economically and environmentally sustainable, and provide a significant opportunity for declining fishing communities to maintain local living standards and diversify into alternative, but related industries.

4 Objectives

This project aimed to compare and better understand the relative performances of oyster and mussel growing areas in the Western Visayas and Luzon by collecting data on; the environmental and microbiological status of culture waters, fundamental biological parameters of the molluscs, food safety status of molluscs and culture waters, the production practices, demographic and organisational structure of the industry, the regulatory framework managing the industry and, finally, to develop a mechanism of delivering improvements in these areas where appropriate. To this end the following objectives were formulated;

1. Collect comparative information, including preliminary quantitative data and site selection issues, on bivalve production methods in Western Visayas and Luzon.
2. Collect and compare information on product quality, safety and post-harvest aspects of bivalve production between these regions and compare with international standards.
3. Determine domestic and international market potential for Philippine bivalve species.
4. Analyse existing legal and policy frameworks for aquaculture management, environmental impact, production, processing and marketing to determine compliance and regulatory influence on regional production and competitiveness.
5. Develop second-phase proposal for quantitative assessment of critical factors affecting quantity and value of bivalve aquaculture.

5 Methodology

Objective 1 Collect comparative information, including preliminary quantitative data and site selection issues, on bivalve production methods in Western Visayas and Luzon

Selection of Sampling Sites

A major project aim was the comparison of production areas in Luzon and the Western Visayas of the Philippines. Initial selection of suitable study areas was based on relative significance of bivalve mollusc aquaculture, assessed by regional production volume between 2001 and 2004 (BAS, 2005). The highest producing areas in Luzon were; Region 1 (Pangasinan Province), Region 3 (Bulacan Province) and Region 4a (Cavite Province). For Western Visayas (Region 6), the highest producing areas were; Negros Occidental, Iloilo, Capiz and Aklan Provinces.

On a finer scale, selection of municipalities and actual site selection was subsequently based on several criteria including;

- established and locally significant mollusc aquaculture activity
- an approximate balance of both oyster and mussel sites across the municipality
- suitable site access by vehicle and/or boat
- broadly similar depth and hydrological characteristics
- cooperation of community organisations (e.g. Barangay Councils) and local government organisations
- sufficient production area to provide broadly replicate stations (n=5-10) which characterised local conditions, e.g. proximity to settlement, proximity to river mouth, proximity to mangroves, fish culture or trapping operations.

In addition, a related UPV research project in the Western Visayas, for which similar site selection had already occurred, provided the justification for 3 municipalities; i.e. Dumangas, Roxas and Hinigaran.

A total of 4 regions, 7 provinces, 9 local municipalities and 60 individual stations were sampled, during both wet (approx. June - November) and dry (December - May) seasons, during the course of this study (Table 5.1).

Table 5.1 Project sampling sites, including number of sampling stations and sampling periods. See also Figure 5.1.

Region -Province	Municipality	No. of Stations	Sampling periods (date and season)
1 - Pangasinan	Anda	5	April 15, 2008 (dry) August 21, 2008 (wet)
4 – Cavite	Bacoor	5	April 10, 2008 (wet) August 26, 2008 (wet)
1 - Pangasinan	Bolinao	5	April 14, 2008 (dry) August 19, 2008 (wet)
3 – Bulacan	Malolos	5	April 8, 2008 (wet) August 27, 2008 (wet)
6 – Aklan	Batan	5	November 28, 2007 (dry) March 12, 2008 (dry) October 2, 2008 (wet)
6 – Iloilo	Dumangas	10	May 2, 2007 (wet) February 12, 2008 (dry) February 26, 2008
6 - Negros Occidental	Himamaylan	5	December 5, 2007 (dry) July 10, 2008 (wet)
6 - Negros Occidental	Hinigaran	10	March 20, 2007 (dry) March 25, 2008 (dry)
6 – Capiz	Roxas City	10	March 27, 2007 (dry) February 20, 2008 (dry) October 2, 2008 (wet)

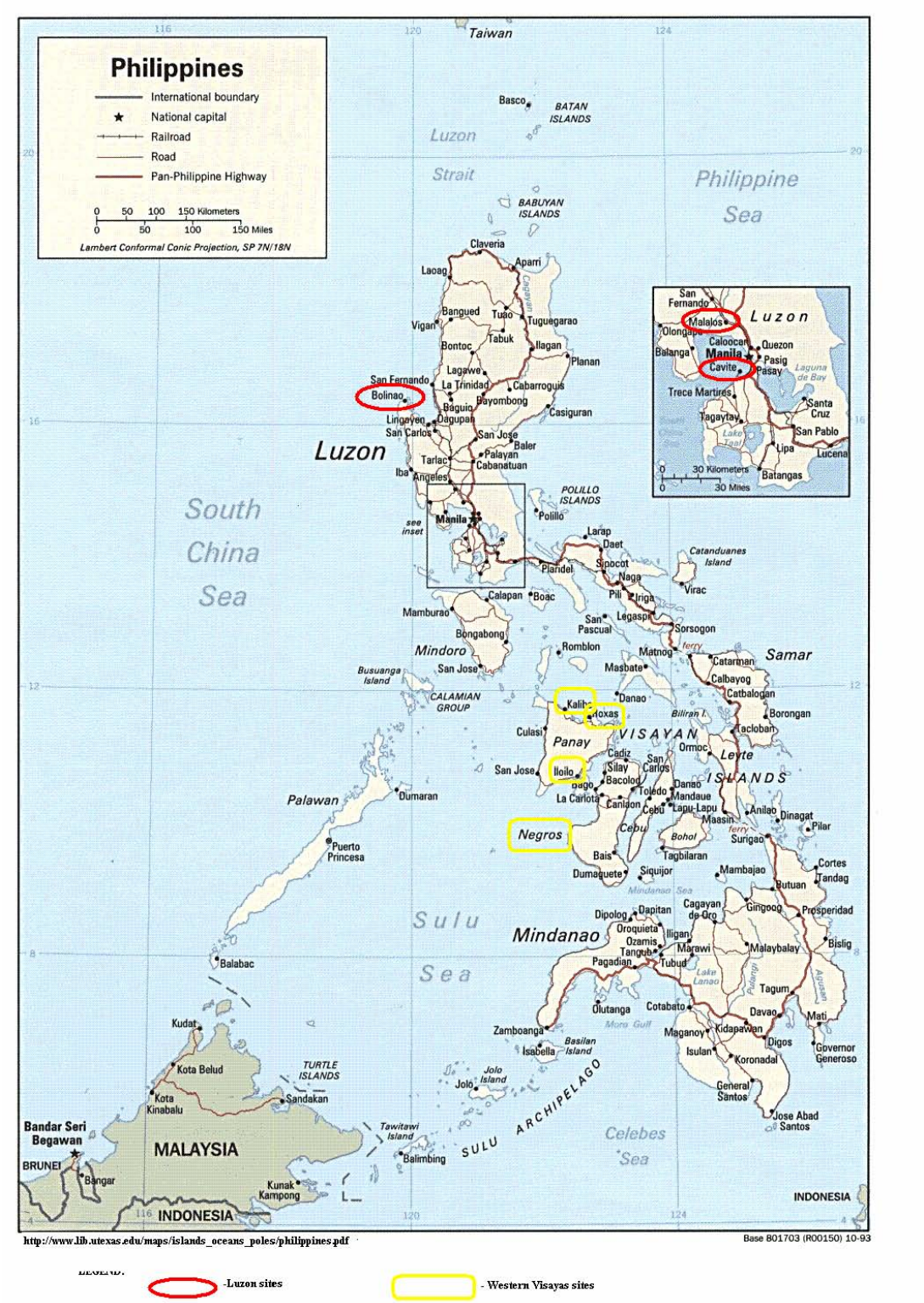

Fig 5.1 Map of the Philippines showing regions/provinces (*Source: http://www.lib.utexas.edu/maps/islands_oceans_poles/philippines.pdf*).

Water Quality Monitoring

Measurements of the following physico-chemical water quality parameters were conducted at each sampling station at approximately 1m depth intervals from the surface to approximately 0.5m above the sediment surface. Depth was measured using a marked plumb line.

- Dissolved oxygen (mg l-1), Temperature (oC), pH, Conductivity (mS/cm), Salinity (ppt), Turbidity (ppk)

Measurements were made using a portable water quality meter (TPS WP-91 Waterproof Dissolved Oxygen-pH-mV-Temperature Meter and Aqua-CP Waterproof Conductivity-TDS-pH-Temperature Meter) and specific probes for DO/temp/pH and conductivity/ TDS.

Bivalve Morphometrics

Samples of 70 mussel and/or oysters (depending on local industry characteristics) were obtained from approximately 1-2m depth at each sampling site, scraped of epifouling organisms, scrubbed clean and the following morphometric data collected; total shell length, width, wet weight (whole and tissue) and shell dry weight. Some additional samples from the related UPV project were also utilized in this ACIAR study to augment or supplement samplings. This accounts for occasional deviation from the standard 70 individuals.

Tissue was removed from the shell valves using an oyster knife, and shell valves were sun-dried for approximately 1 hour. Length measurements were taken to the nearest millimetre using Vernier calipers and weights in grams were measured to 2 decimal places on a portable digital balance. A tissue to total weight ratio was also calculated.

Sediment Analysis

Sediment samples, from the seabed adjacent to each culture site, were collected using a 50mm sediment corer, transferred to re-sealable plastic bags, stored at chilled temperatures and analysed for organic matter (%), available phosphorus (ppm) and also total organic carbon (where laboratory facilities allowed). Analytical laboratories used were as follows; Negros Prawn Producers Marketing Cooperative (ACIAR Western Visayas sites 1st and 2nd samplings, and UPV project sites 2nd sampling), Bureau of Soils and Water Management (ACIAR Luzon 1st and 2nd sampling) and SEAFDEC (UPV project sites 1st sampling).

Industry Survey Instruments and Secondary Data Collection

A survey instrument was prepared and pre-tested to determine the production technology and practices for oyster and mussel aquaculture (Appendix 1). Oyster and mussel producers from the growing areas were randomly interviewed. Another survey instrument specific to the harvesters of Anda and Bolinao was developed, since these 2 municipalities have unique harvesting arrangements compared to the other areas (Appendix 2).

Secondary data such as municipal fisheries profile, community profile, ordinances, and lists of mussel and oyster operators were gathered from each municipality and national government agencies (e.g., Bureau of Agricultural Statistics, Bureau of Fisheries and Aquatic Resources, etc.). Additional information concerning the statistics of production was collected form published reports.

Objective 2: Collect and compare information on product quality, safety and post harvest aspects of bivalve production between regions / sites and compare with international standards

Shellfish and water sample collection and treatment

Oysters and mussels were collected from four pre-determined sites in three provinces of Luzon; Bolinao and Anda, (Pangasinan Province); Malolos, (Bulacan Province) and Bacoor, (Cavite Province). Similarly, samples were collected from five sites in four provinces in Western Visayas; Batan (Aklan Province); Roxas (Capiz Province); Dumangas (Iloilo Province) and Hinigaran, Himamaylan (Negros Occidental Province) (Figure 5.1). Mud and sediment adhering to shell valves were removed by scrubbing brush and clean seawater. Samples were then allowed to drain before placing them in

clean sample container/bag. The samples were then transported on ice for immediate analysis in the nearest available analytical laboratory.

Near-surface (approximately 15cm depth) water samples were collected in clean sterile bottles (100-200ml ground-glass screw-cap bottles). Sample bottles were held at temperatures below 5oC (on ice) until analyzed.

Microbiological analysis of water and shellfish tissue

On arrival at the laboratory, shellfish tissue samples were analyzed for the following microorganisms*; Escherichia coli*, (MPN quantitative method), *Salmonella spp*, (detection only), *Vibrio cholerae*, (detection only) and *V. parahaemolyticus* (MPN quantitative method).

Water samples from the growing area were analyzed for faecal coliforms (APHA, 1985).

Objective 3 Determine domestic and international market potential for Philippine bivalve species

Domestic consumer requirements and expectations from Philippine-produced bivalves were determined via a validated survey instrument and interviews. The survey instruments examined consumer preference (Appendix 3) and market (Appendix 4) for oyster and mussel culture. All samples were randomly drawn from Luzon and Western Visayas.

A review of literature was done to identify product requirements and standards for bivalve molluscs in selected foreign markets. Published documents, government reports, and other secondary information were collected.

Objective 4 Analyse legal and policy framework for aquaculture management, environmental impact, production, processing and marketing to determine compliance and regulatory influence on regional production and competitiveness

The legal, policy, regulatory and compliance documents from government agencies were reviewed. Producers were interviewed regarding the permitting process, regulations, resource management and environment. Whereas, traders were queried on the infrastructure and organisational development as an overall development constraint.

Objective 5 Develop second-phase proposal for quantitative assessment of critical factors affecting quantity and value of bivalve aquaculture

The development of the second phase proposal was primarily achieved through meetings and discussions during the course of the project.

Concepts were broadly developed and discussed with ACIAR staff and potential collaborators.

The principal meetings occurred as follows;

- April 2008. Bolinao. Meeting with Barney Smith, ACIAR.
- April 2008. Baguio. Project meeting with team members (Duncan, Andalecio, Laureta, Peralta, Hidalgo, project research assistants)
- September 2008. Brisbane. Meeting with Barney Smith, ACIAR
- October 25, 2008. Barney Smith, Fisheries Program Manager (ACIAR) met with UPV project team and mayor and local officials of Roxas City, Capiz
- November 14, 2008. Project team and UPV staff workshop to discuss potential second phase project (Shellfish BEDS). Miagao, Iloilo
- January 16, 2009. John Skerritt, (Deputy CEO ACIAR) and Ms. Mara Faylon (ACIAR Assistant Manager- Philippines met with UPV project members. Miagao.

- February 3, 2009. Barney Smith, Fisheries Program Manager (ACIAR) met with UPV project members. Miagao, Iloilo

6 Achievements against activities and outputs/milestones

Objective 1: To collect comparative information, including preliminary quantitative data and site selection issues, on bivalve production methods in Western Visayas and Luzon

no.	Activity	outputs/ milestones	completion date	Comments
1.1	Site identification and initial visits conducted	Well-defined process to select suitable sites Identified sites in Western Visayas are Batan, Himamaylan, Hinigaran, Dumangas and Roxas; while sites in Luzon are Bacoor, Malolos, Bolinao and Anda	December 2007	Identified sites are coastal cities and municipalities
1.2	Established sampling stations per site	5 to 10 stations were set-up	December 2007	For analysis of water and sediment quality and microbiological samples
1.3	Developed survey instruments on production practices, management, harvest, socio-economics and trainings	Survey instruments developed and pre-tested prior to use	August 2007	
1.4	Collected secondary data	Compilation of secondary data such as municipal fisheries profile, ordinances, list of mussel and oyster operators, statistics of production were gathered from each municipality and national government agencies (e.g., Bureau of Agricultural Statistics, Bureau of Fisheries and Aquatic Resources, etc.)	December 2008	
1.5	Collected information on environmental, biological and organisational aspects of the bivalve mollusc aquaculture industry in Luzon and Western Visayas	- quantitative measurement of representative samples of water, sediment, molluscs and microorganisms - quantitative and qualitative data on the social and organisational aspects of the industry collected using validated survey instruments administered via personal interview	December 2008	achieved through the proposed methodologies outlined in this report Subsequent assessment and analysis of this information has provided the most comprehensive overview ever undertaken of the Philippine oyster and mussel industries, and enabled initial comparative conclusions to be drawn relating to the differences between the two areas

PC = partner country, A = Australia

Objective 2: To collect and compare information on product quality, safety and post-harvest aspects of bivalve production between these regions and compare with international standards

no.	Activity	outputs/ milestones	completion date	Comments
2.1	Collected secondary data and literature review	Compilation of documents relating to product quality and safety and international standards for bivalve aquacuture	December 2008	The production of a review of some aspects of the Australian bivalve aquaculture industry's experience in these matters will also be useful as an insight into international approaches to the issues of food safety and industry regulation.
2.2	Collected and analysed shellfish meat water and sediment samples from the identified stations	Microbiological analysis of shellfish meat and water collected from the sites Water quality analysis (i.e. dissolved oxygen, pH, salinity, temperature) and sediment quality (i.e., total phosphorus and organic matter) Sampled mollusc tissue and site-adjacent waters to gauge microbial pathogen diversity and abundance as an assessment of product quality and safety	April 2008	Field-based consideration given to pathogenic organisms in relation to molluscs and water samples; colliforms, Salmonella, Vibrio spp., viruses (Hepatitis), protozoans and microalgae Practicalities and cost of viral, protozoan and algae analysis indicate that this will not be attempted during this scoping study Although the sampling regime was limited in that only two samples from each site was possible during the year, the data collected, when compared to international food safety and quality standards, is at least indicative of the issues facing the long-term development of the Philippines industry
2.3	Conducted survey interviews	substantial information about the harvest, post-harvest and supply chains	December 2008	Quantifying the microbiological status of waters and animals, along with identification of current industry practices is the first step in being able to develop effective monitoring and regulatory policy and operating procedures that will lead to improved industry standards

PC = partner country, A = Australia

Objective 3: To determine domestic and international market potential for Philippine bivalve species

no.	Activity	outputs/ milestones	completion date	Comments
3.1	Developed survey instruments on marketing and domestic consumer requirements and expectations from Philippine-produced bivalves	Survey instruments developed and pre-tested prior to use	July 2008	survey instrument specifically addressed marketing and retailers associated with the oyster and mussel industries in both Luzon and Western Visayas

3.2	Conducted survey interviews and analysis	Results of survey interviews (n=119) provided a good overview of the industry following initial sale by the producer. A clearer picture of the various linkages and association was obtained and diagrammatic flow charts were produced as a fundamental first stage in understanding these relationships.	January 2009	
3.3	Conducted literature review to identify product requirements and standards for bivalve molluscs in selected foreign markets	An overview of the international market for these products indicated the scale of this industry. A report on the current status of the Australian bivalve aquaculture industries was compiled by an undergraduate student at the University of the Sunshine Coast. While Australia does not probably represent a significant market for future Philippine mollusc production, the report does provide a valuable insight into the requirements and risks associated with international marketing of such products, and the consequences of poorly-developed regulatory procedures and accountability within the shellfish industry	January 2009	Details of these reviews are provided in the Appendices (5 & 8)

PC = partner country, A = Australia

Objective 4: To analyse legal and policy framework for aquaculture management, environmental impact, production, processing and marketing to determine compliance and regulatory influence on regional production and competitiveness

no.	Activity	outputs/ milestones	completion date	Comments
4.1	Reviewed and analysed legal, policy, regulatory and compliance documents from government agencies	Regulations on oyster and mussel farming are insufficient especially at the local level. This aquaculture sector appears to be marginalized since the oyster and mussel industry does not contribute substantially to the income of the municipality and city.	February 2009	The review of policies and regulations, though not comprehensive, will assist the future of research planning for the industry
4.2	Survey interviews on regulations and compliance conducted		December 2007	Questions on regulations and compliance included in the production survey instrument (Objective 1)

PC = partner country, A = Australia

Objective 5: To develop second-phase proposal for quantitative assessment of critical factors affecting quantity and value of bivalve aquaculture

no.	Activity	outputs/ milestones	completion date	Comments
5.1	Conducted series of meetings to discuss ideas for the second-phase proposal	- several options developed and considered including that contained in Appendix 9	February 2009	Based on the results obtained during this research and the field work experience obtained by the project team, we have developed a much better understanding of both the current differences between the two production areas, and the possible reasons for them. The issues are complex and strongly associated with wider areas of governance, social, economic and environmental considerations in the Philippines. Any subsequent research projects must therefore take this into account, whilst also recognizing that a multi-disciplinary approach, along with the active collaboration of local government and industry will be essential in achieving long-term successful outcomes. As such, principally through engaging with potential collaborators and undertaking focused discussion meetings, we have developed several related proposals, varying principally in scale, to achieve implementation of the finding from this preliminary study. We believe we have found the necessary collaborative partners, multi-disciplinary team members, and potentially, a closely-related programme of similar research, which complements the overall objectives of an implementation scheme to enable development of the bivalve mollusc industry in the Philippines.

PC = partner country, A = Australia

7 Key results and discussion

Objective 1: Collect comparative information, including quantitative data and site selection issues, on bivalve production methods in Western Visayas and Luzon

Luzon and Western Visayas Bivalve Aquaculture Overview

Oysters

Crassostrea iredalei (or slipper-shaped oyster)(see also Appendix 5) was found to be the major culture species in all areas surveyed in Luzon and Western Visayas. However, it was noted that certain species of oysters, e.g, *Saccostrea cucullata*, (Fig. 7.1) and *S. palmipes* (Fig. 7.2) (the palm-rooted oysters) had also settled with the culture species, and therefore become part of oyster production in the area. Table 7.1 shows the distribution of these additional oyster species in the surveyed farms. Where these incidental species are found, their abundance is negligible, except in Himamaylan (Negros Occidental) where the count usually constituted about 10-30% of oyster density in the stake or string line sampled. These secondary species are not deliberately cultured, but are gathered and sold, usually as a pickled or fermented product.

It was also noted that the green mussel, *Perna viridis*, was associated with the oysters, particularly in Batan, Malolos, Bolinao and Anda. In most sampled sites, a few tree oysters, *Isognomon ephippium*, also occurred with the cultured species. *Crassostrea malabonensis* is also reported from the Philippines but was not seen during our surveys.

Fig. 7.1 *Saccostrea cucullata*

Fig. 7.2 *Saccostrea palmipes*

Table 7.1 Occurrence of *S. cucullata* and *S. palmipes*, absent (-) or present (+) in the oyster areas surveyed in Luzon and Western Visayas during 2007 / 2008.

AREAS SURVEYED	*S. cucullata*	*S. palmipes*
Luzon Area		
Bacoor (Cavite)	-	-
Malolos (Bulacan)	-	-
Bolinao (Pangasinan)	-	-
Anda (Pangasinan)	-	-
Western Visayas Area		
Dumangas (Iloilo)	+	+
Roxas City (Capiz)	-	-
Batan (Aklan)	+	+
Hinigaran (Negros Occidental)	-	-

Himamaylan (Negros Occidental)	+	+

Mussels

The green mussel, *Perna viridis*, is the only mussel species cultured in the Philippines and noted as such in the surveyed areas in Luzon and Western Visayas. In many farms, this single species is harvested, but in areas like Malolos and those mentioned earlier, the green mussel is harvested together with *Crassostrea iredalei*. One problem that affects the mussel industry, particularly in the Pangasinan area, is the proliferation of an unidentified mussel species (Fig. 7.3) which has become a pest and usually out-competes settled spat and affects growth of the green mussel. The maximum size observed was approximately 40mm.

Fig. 7.3 Mussel species (tentatively identified as Musculus sp.) found as pest in the culture of Perna viridis at Anda and Bolina (Pangasinan province).

Cultured Bivalve Morphometric Data

Cultured mussels and oysters were intended to be collected during wet and dry seasons in each sample site. Delays, related mostly to weather, prevented scheduled sampling from occurring in every case, and so the data collected is less comprehensive than originally intended. There is also considerable variability in the timing and extent of seasonal weather patterns across the Philippine archipelago, and so relative duration of rain events may influence some morphometric parameters, e.g. flesh weights. In addition, it was not always possible to accurately determine the relative ages of molluscs, and so this may contribute to inaccuracies in the data. However, sample sizes were relatively large, and so indicative base-line data for each site is instructive for the purposes of a preliminary study. Tables 7.2a and b detail comparative results for mussels, *Perna viridis*, at each site in either Luzon or Western Visayas, generally in both wet and dry seasons.

Table 7.2a Mussel (*Perna viridis*) morphometric data (shell and tissue) from mollusc aquaculture sites in Luzon. Samples collected during first and second sampling periods, respectively, with month and season indicated at left. Values are pooled mean values (±SD) (sample sizes indicated at left). No data are available for Malolos because mussel sites are offshore.

LUZON Municipality	Length (cm)	Width (cm)	Whole wt (g)	Flesh wt (g)	Shell wt (g)	Flesh:Whole weight Ratio
Anda (n=140) (Apr, Dry)	6.15±0.75	2.85±0.33	12.26±3.87	4.867±1.31	7.399±2.72	0.406±0.05
Anda (n=140) (Aug, Wet)	8.31±1.15	3.74±0.56	25.57±10.43	8.92±3.55	16.65±7.38	0.35±0.05
Bacoor (n=280) (Apr, Wet)	5.18±1.43	2.58±0.66	9.44±5.69	4.13±2.49	5.31±3.40	0.45±0.08
Bacoor (n=280) (Aug, Wet)	7.20±0.80	4.38±19.47	18.02±11.01	7.17±2.49	10.85±10.11	0.41±0.05
Bolinao (n=210) (Apr, Dry)	6.60±1.52	3.13±0.57	18.08±10.30	7.85±4.21	10.23±6.22	0.44±0.53
Bolinao (n=280) (Aug, Wet)	7.90±0.86	3.70±0.32	26.53±7.18	10.60±3.09	15.93±4.49	0.40±0.04

Table 7.2b Mussel (*Perna viridis*) morphometric data (shell and tissue) from mollusc aquaculture sites in Western Visayas. Samples collected during first and second sampling periods, respectively, with month and season indicated at left. Values are pooled mean values (±SD)(sample sizes indicated at left).

W. VISAYAS Municipality	Length (cm)	Width (cm)	Whole wt (g)	Flesh wt (g)	Shell wt (g)	Flesh:Whole weight Ratio
Batan (n=140) (Nov, Dry)	8.14±0.67	3.43±0.26	20.29±4.40	7.56±1.90	12.72±3.10	0.37±0.05
Batan (n=70) (Mar, Dry and Oct, Wet)	6.19±0.64	2.75±0.28	10.31±2.47	3.29±0.90	7.02±1.69	0.32±0.04
Dumangas (n=54) (May, Wet)	6.42±1.08	3.33±0.77	33.54±20.35	4.67±1.18	14.97±20.66	0.18±0.08
Dumangas (n=60) (Feb, Dry)	6.69±2.32	3.13±0.89	19.23±15.08	6.10±4.68	13.13±10.47	0.33±0.04
Himamaylan (n=140) (Dec, Dry)	5.50±0.51	2.63±0.43	7.98±1.90	3.03±0.77	4.95±1.23	0.38±.038
Himamaylan (n=140) (Jul, Wet)	4.86±1.66	2.27±0.87	7.70±5.67	2.21±1.55	5.49±4.17	0.30±.06
Hinigaran (n=20-42) (Mar, Dry)	5.53±1.06	2.68±0.52	17.73±6.92	4.16±1.78	15.75±6.09	0.10±0.11
Hinigaran (n=61) (Mar, Dry)	5.10±0.85	2.92±0.86	11.46±7.51	2.69±1.00	8.75±6.80	0.30±0.12
Roxas (n=49-100) (Mar, Dry)	6.68±0.74	2.97±0.27	17.20±5.38	5.03±1.25	14.74±4.80	0.14±0.15
Roxas (n=120) (Mar, Dry and Oct, Wet)	6.28±0.49	2.71±0.24	10.00±2.13	3.66±0.83	6.35±1.42	0.37±0.03

Similarly, Tables 7.2 c and d provide the equivalent data for the oyster, *Crassostrea iredalei*.

Table 7.2c Oyster (*Crassostrea iredalei*) morphometric data (shell and tissue) from mollusc aquaculture sites in Luzon. Samples collected during first and second sampling periods respectively, with month and season indicated at left. Values are pooled mean values (±SD)(sample sizes indicated at left). Only one sample available for Bacoor.

LUZON Municipality	Length (cm)	Width (cm)	Whole wt (g)	Flesh wt (g)	Shell wt (g)	Flesh:Whole weight Ratio

Anda n=210 (Apr, Dry)	7.67±1.47	5.32±0.83	52.26±25.26	8.60±3.47	43.66±22.46	0.17±0.05
Anda (n=170) (Aug, Wet)	6.96±1.86	5.36±1.12	46.08±30.45	7.94±3.42	38.14±27.98	0.19±0.06
Bacoor n=70 (Apr, Wet)	7.62±1.58	5.45±0.86	50.02±19.26	7.25±2.91	42.77±17.39	0.15±0.04
Bolinao n =140 (Apr, Dry)	7.36±1.60	5.24±0.98	45.32±25.06	7.90±4.03	37.41±21.44	0.18±0.04
Bolinao (n=63) (Aug, Wet)	6.94±1.28	4.96±0.86	47.47±19.59	9.94±4.18	37.53±16.13	0.21±0.04
Malolos n=350 (Apr, Wet)	6.37±1.97	3.90±0.80	22.84±15.9	3.67±1.67	19.17±14.56	0.18±0.05
Malolos (n=280) (Aug, Wet)	7.11±1.73	4.53±0.84	33.57±17.61	3.92±1.50	29.64±17.06	0.13±0.05

Table7.2d Oyster (*Crassostrea iredalei*) morphometric data (shell and tissue) from mollusc aquaculture sites in Western Visayas. Samples collected during first and second sampling periods respectively, with month and season indicated at left. Values are pooled mean values (±SD)(sample sizes indicated at left).

W. VISAYAS Municipality	Length (cm)	Width (cm)	Whole wt (g)	Flesh wt (g)	Shell wt (g)	Flesh:Whole weight Ratio
Batan n=280 (Nov, Dry)	7.70±1.41	5.12±0.99	50.61±20.79	6.01±2.61	44.60±19.02	0.12±0.04
Batan (n=140) (Mar, Dry)	9.15±1.46	5.72±0.85	75.45±29.75	7.50±3.14	67.94±27.90	0.11±0.05
Dumangas n=78 (May, Wet)	7.12±1.52	4.23±0.80	80.99±49.34	4.92±2.12	66.58±54.06	0.08±0.08
Dumangas (n=250) (Feb, Dry)	7.66±1.63	4.90±0.83	50.35±25.15	5.18±1.78	45.17±23.95	0.11±0.03
Himamaylan n=211 (Dec, Dry)	4.67±1.15	3.00±0.71	10.24±7.73	1.45±1.03	8.78±6.89	0.15±0.04
Himamaylan (n=210) (Jul, Wet)	5.65±0.96	3.57±0.68	22.40±10.82	2.80±1.37	19.60±9.67	0.13±0.03
Hinigaran n=79-169 (Mar 07, Dry)	5.59±2.42	2.74±0.67	16.34±10.63	2.89±3.07	14.98±9.11	0.065±0.08
Hinigaran (n=240) (Mar 08, Dry)	5.14±0.92	3.08±0.66	12.04±6.63	2.21±1.03	9.82±5.78	0.21±0.08
Roxas n=52-91 (Mar, Dry)	8.38±2.18	5.13±1.12	100.60±54.12	7.97±3.50	96.03±53.92	0.05±0.05
Roxas (n=150) (Oct, Wet)	9.18±1.98	5.32±0.87	74.88±36.42	7.17±3.18	67.70±34.27	0.10±0.03

The second sampling, generally, though not always during the wet season, was after the first sampling so increases in mean shell sizes are to be expected, and without accurate ageing or growth rate data, it is difficult to say anything conclusive about growth rates in different areas.

However, parameters which are independent of normal growth trends are potentially more informative. In this regard, there is an apparent trend in the data suggesting that for mussels, dry season flesh to total weight ratios are higher than wet season values. This may relate to either a change in flesh weight or in shell weight, and in general it appears that flesh weights are higher in the second samples, but that shell weights have increased proportionately more, providing an overall decrease in flesh to total weight ratio. While these results are not definitive, it may be a useful area of further study in relation to optimizing harvest time for maximum flesh recovery yields. Bivalves are well known to mobilize somatic resources in response to breeding cycles or environmental changes, and therefore it is possible that calcification processes are boosted during the wet season, with somatic growth more stable or increased in the dry season.

This trend is perhaps less apparent in oysters and may reflect the much heavier shell calcification in this species, which in turn may result in less seasonally-influenced shell growth. No obvious trends are apparent in the oyster data, either between seasons or region.

One of the main aims of the current study was to attempt to find potential explanations for the observed difference in production volume and value for oysters and mussels from Luzon and Visayas. Comparisons between regions are difficult as there are clearly many uncontrollable spatial and temporal variables between sites and regions, e.g. the timing and extent of the wet season, or controlling for growth period between sites when producers are reliant on natural settlement. However, an attempt was made to compare the two main areas, and to group samples into either wet or dry seasons. The results are shown in Table 7.3.

The general trends are fairly clear, indicating a strong tendency for Luzon bivalves to be larger in every parameter measured, and in both wet and dry season comparisons, except for some shell weights, or related parameters (which are of no commercial importance). In particular, important economic factors, such as flesh weight and flesh to total weight ratios are significantly higher ($p << 0.01$)(ANOVA) for both species in Luzon.

There is also a tendency towards higher values in almost all parameters for dry season versus wet season, except for Luzon mussel data which are not significantly different between seasons. Although this trend is less definitive than the Luzon:Western Visayas effect, and appears not to be statistically significant, it is broadly in agreement with the site specific data presented above, although here is it better corrected for the seasonal variability and hence perhaps more credible. It is certainly true that the data presented in Table 7.3 shows significant variability within the parameters measured which has not been accounted for within the data collection process, or has inherent strong variability. However, it is a potentially interesting, and commercially important trend, and may warrant further investigation in future.

Table 7.3 Comparison of mussel and oyster morphometric data, based on region (Luzon or Visayas) and season (Dry or Wet). Data are pooled means of all samples from all sites within each region ±SD (n= numbers in parentheses).

Region Species/Season	Shell Length (cm)	Shell Width (cm)	Whole Wet Wt (g)	Flesh wt (g)	Shell Wt (g)	Flesh:Whole weight Ratio (g)
Luzon						
Mussel/Dry (350)	6.42±1.3	3.01±0.5	15.76±8.8	6.66±3.7	9.10±5.3	0.43±0.1
Mussel/Wet (980)	6.98±1.6	3.58±10.4	19.08±11.1	7.53±3.8	11.55±8.1	0.41±0.1
Western Visayas						
Mussel/Dry (673)	6.44±1.4	2.95±0.6	14.30±7.8	4.68±2.7	10.13±6.1	0.31±0.1
Mussel/Wet (254)	5.52±1.5	2.58±0.8	11.36±11.8	2.84±1.6	7.64±10.7	0.30±0.1
Luzon						
Oyster/Dry (350)	7.55±1.5	5.29±0.9	49.49±25.4	8.32±3.7	41.16±22.2	0.18±0.04
Oyster/Wet (933)	6.83±1.8	4.54±1.1	34.00±22.6	5.21±3.2	28.78±20.5	0.17±0.1
Western Visayas						
Oyster/Dry (1611)	7.09±2.3	4.39±1.4	44.73±37.5	4.85±3.2	40.26±35.3	0.12±0.1
Oyster/Wet (344)	6.51±1.8	3.93±0.9	41.66±37.7	4.00±2.1	36.71±36.4	0.12±0.05

In general it should be noted that although these trends are consistent and statistically significant in some cases, it was not possible to control for all variables during sampling. In particular, the Luzon sampling was much more consistent, occurring in either April or August for all sites. By comparison, sampling in Western Visayas was confounded by weather, and sampling periods were generally more variable. Sample sizes for each category are also variable due to sampling opportunities and regional variability in seasonal rain. It was also not possible to accurately measure either age or growth rates during this short study, and we were reliant on age estimates provided by farmers. However, it might be expected that this variability would be constant between the two areas.

With these caveats in mind, however, it is tempting to speculate on possible reasons for these apparent differences and observed trends. Bivalve molluscs are dependant for growth and condition on phytoplankton and hence upon aquatic nutrient inputs. The primary 'plant' nutrients are nitrogen and phosphorus, which are commonly associated with both agricultural and anthropogenic-derived sewage or runoff inputs. On the assumption that rain runoff is not significantly different between Luzon and Western Visayas, and so not a significant factor in explaining large nutrient runoff differences, perhaps coastal population densities can account for higher nutrients and hence presumed higher aquatic productivity in Luzon. Sediment data collected during this study does lend some support to higher phosphate levels in Luzon (Table 7.5), although the sources and flux pathways are unknown. However, the hypothesis that human or agricultural sewage wastes may contribute to potential eutrophication is not supported by the microbiological data, which indicates lower faecal coliform counts in Luzon than in Visayas (see Tables 7.10 and 7.12). The possible contributions of fertilizer inputs from agricultural crops or domestic detergents may justify further investigation. Future work might also usefully concentrate on quantifying aquatic nitrogen, phosphorus and phytoplankton concentrations to better elucidate these variables. Whatever their cause (s), the morphometric differences between Luzon and Western Visayas are notable.

Water Quality Data

Water quality data collected from mollusc production sites in Luzon and Western Visayas during wet and dry seasons are presented in Tables 7.4a and b. Once again, the frequency of sampling does not lend itself to definitive conclusions, and so general trends are discussed.

In general, water quality parameters improved during the wet season; DO, pH and suspended solids are all closer to accepted optimal levels. By contrast, salinity and conductivity, both closely related, do decrease, presumably in response to increased fresh water inputs. There are no other significant trends, in terms of regional or site specific differences to report, although the variability in some parameters, notably dissolved oxygen, attest to the remarkable physiological tolerance of both mollusc species. Although not specifically shown in these tables, depth profiles at several sites showed DO concentrations ranging from 6-7mgL-1 at the surface to <1mgL-1 close to the sediment surface. Mollusc culture extends close to the bottom in most production systems. This apparent tolerance supports the view that this form of aquaculture appears well suited to the variable coastal environments of the Philippines.

Sediment Analysis

Analysis of sediment samples collected from beneath mollusc production systems are presented in Table 7.5. The extent of analytical services in some areas limited the extent of this investigation, although some instructive information was produced.

No significant differences were indicated between areas, or seasonally, in either organic matter or organic carbon. The values recorded are normal for sub-tropical/tropical estuarine and coastal systems. Of most significance perhaps was available phosphorus concentration, which showed a mean value for all Luzon sites of 54.17 ±24.7 ppm, compared with 28.58 ±20.1 ppm for the pooled Western Visayas sites. As discussed

earlier, the availability of nutrients such as phosphorus (as phosphate) is important for primary productivity and consequently-associated molluscan trophic dynamics. There is also some indication of raised phosphorus levels during the wet season. This is not entirely consistent, but as indicated elsewhere, there are numerous confounding factors making such a small data series indicative rather than definitive. However, wet season peaks in phosphorus might be expected since mixing of the water column due to storm activity is an important feature of phosphate mobilization in sediments. How influential this seasonal mixing will be on the molluscan food chain ultimately depends upon original inputs of nutrients, but mobilization of phosphate due to storm events, followed by conversion into primary productivity following more settled weather is well established in both freshwater and marine systems, and the lag effect may account for the relative increase in dry season mollusc flesh weights.

Table 7.4a Water quality data for Luzon; dissolved oxygen (DO), pH, temperature, TDS, salinity and conductivity from mollusc aquaculture sites at indicated municipalities. Samples (1) and (2) collected during the month and season indicated at left and represent pooled means (±SD). Sample sizes are equal, or relate to (1) and (2) respectively.

Municipality	DO (ppm)(1)	DO (ppm)(2)	pH (1)	pH (2)	Temp (°C)(1)	Temp (°C)(2)	TDS (ppk)(1)	TDS (ppk)(2)	Salinity (ppt)(1)	Salinity (ppt)(2)	Cond. (mS/cm)(1)	Cond. (mS/cm)(2)
Anda (n=16) (1=Apr,Dry) (2=Aug,Wet)	3.28±0.7	5.59±1.6	6.63±0.8	6.44±0.8	31.31±0.4	27.04±1.1	33.98±0.6	13.74±7.0	32.58±0.4	18.35±9.4	56.08±0.1	30.74±14.9
Bacoor (n=10+12) (1=Apr,Wet) (2=Aug,Wet)	5.39±1.5	3.8±2.4	5.38±1.4	6.76±0.7	29.54±0.4	29.77±0.4	30.72±0.9	22.7±2.8	28.00±5.4	29.57±4.0	47.32±8.3	49.95±5.7
Bolinao (n=20+24) (1=Apr,Dry) (2=Aug,Wet)	4.98±1.5	5.78±1.4	5.99±1.2	7.50±0.1	31.38±0.6	30.24±0.5	32.46±2.4	25.86±3.3	31.60±0.7	33.18±4.3	54.64±1.0	53.75±12.2
Malolos (n=5) (1=Apr,Wet) (2=Aug,Wet)	2.83±0.9	3.39±0.2	7.51±0.1	6.98±0.1	31.22±0.2	29.24±0.5	27.04±2.6	20.08±2.4	25.85±2.5	26.2±3.4	45.50±4.0	44.38±5.0

Table 7.4b Water quality data for Western Visayas; dissolved oxygen (DO), pH, temperature, TDS, salinity and conductivity from mollusc aquaculture sites at indicated municipalities. Samples (1) and (2) collected during the month and season indicated at left and represent pooled means (±SD). Sample sizes are equal, or relate to (1) and (2) respectively.

Municipality	DO (ppm)(1)	DO (ppm)(2)	pH (1)	pH (2)	Temp (°C)(1)	Temp (°C)(2)	TDS (ppk)(1)	TDS (ppk)(2)	Salinity (ppt)(1)	Salinity (ppt)(2)	Cond. (mS/cm)(1)	Cond. (mS/cm)(2)
Batan (n=6+9) (1=Nov, Dry) (2=Mar, Dry)	4.41±1.3	5.57±0.5	7.72±0.2	7.30±0.7	28.2±0.3	29.42±0.5	/	29.57±0.05	22.66±4.9	27.58±11.2	/	63.40±0.2
Dumangas (n=10+9) (1=May, Wet) (2=Feb, Dry)	5.32±1.1	/	9.03±0.4	7.54±0.1	28.70±0.8	28.1±0.4	/	/	36.10±1.6	28.22±5.14	/	/
Himamaylan (n=5) (1=Dec,Dry) (2=Jul, Wet)	4.45±0.6	/	7.83±0.3	7.49±0.5	28.2±1.0	30.4±0.4	/	20.42±3.8	26.40±6.1	19.52±3.7	/	34.75±6.2
Hinigaran (n=10) (1=Mar, Dry) (2=Mar, Dry)	4.85±1.5	3.53±1.6	/	7.41±0.3	28.07±0.3	31.06±0.7	/	/	/	27.00±4.6	/	/
Roxas (n=10) (1=Mar, Dry) (2=Oct, Wet)	4.61±1.7	6.29±1.0	7.41±0.1	7.62±0.3	28.90±1.5	28.12±1.0	/	19.00±1.1	35.50±1.0	25.69±3.6	/	42.13±2.5

Table 7.5 Benthic sediment data; total organic matter, total available phosphorus and organic carbon from mollusc aquaculture sites at various municipalities in Luzon and Western Visayas. Samples (1) and (2) collected during the month and season indicated at left and represent pooled means (±SD). Sample sizes are equal, or relate to (1) and (2) respectively. Organic carbon data available for selected sites only.

Municipality	Organic Matter (%) (1)	Organic Matter (%) (2)	Avail. P (ppm) (1)	Avail. P (ppm) (2)	Org Carbon (%) (1)	Org Carbon (%) (2)
Luzon						
Anda (n=5) (Apr, Dry/Aug, Wet)	3.72± 1.2	3.55± 0.9	53.34 ±31.6	75.64 ±26.7	2.17 ±1.0	2.00 ± 2.8
Bacoor (n=5+4) (Apr, Wet/Aug, Wet)	3.58 ±0.9	5.33± 0.3	46.58 ± 15.8	56.48 ± 3.5	2.08 ± 0.5	3.1 ± 2.3
Bolinao (n=5) (Apr, Dry/Aug, Wet)	4.25 ± 0.4	4.31 ± 1.4	56.82 ± 33.7	63.76 ± 16.6	2.47± 0.2	2.50± 2.4
Malolos (n=5) (Apr, Wet/Aug, Wet)	3.38 ± 0.7	2.92 ± 1.2	54.62 ± 16.4	39.98 ± 12.7	1.96± 0.4	1.70± 0.6
WESTERN VISAYAS						
Batan (n=6) (Nov,Dry/ Mar, Dry)	3.76 ± 0.4	2.33 ± 0.6	22.0 ± 3.3	6.50 ± 3.8	/	/
Dumangas (n=10+9) (May, Wet/Feb, Dry)	3.11 ± 1.2	2.52 ± 0.3	32.67 ± 6.5	19.56 ± 5.7	/	/
Himamaylan (n=5) (Dec, Dry/Jul, Wet)	3.00 ± 0.1	1.94± 0.9	24.00 ± 6.4	2.00 ± 1.4	/	/
Hinigaran (n=10) (Mar, Dry/Mar, Dry)	4.33 ± 1.3	2.45 ± 0.3	65.92 ± 8.0	27.50 ± 4.8	/	/
Roxas (n=10) (Mar, Dry/Oct, Wet)	3.36 ± 1.6	2.09 ± 0.4	43.85 ± 10.1	7.20 ± 12.4	/	/

Industry Survey Instrument

A total of 388 production surveys were conducted during the course of this study, attributed to the municipalities in Western Visayas (64.4% of total) (i.e., Batan 15.2 %, Dumangas 19.8%, Himamaylan 8.5%, Hinigaran 9.3%, Roxas City 11.6%) and Luzon (35.5% of total)(i.e., Anda 9.3%, Bolinao 9.3%, Malolos 8.5%, Bacoor 8.5%) (Table 7.6a). The surveys related to either mussel (32.5%), oysters (54.1%) or combined mussel and oyster farms (13.4%).

Table 7.6a Statistical breakdown of areas surveyed for production and operational data. Municipalities, (Provinces) and number of valid responses are shown.

AREAS SURVEYED	Number of Responses
Luzon Area	
Bacoor (Cavite)	33
Malolos (Bulacan)	33
Bolinao (Pangasinan)	36
Anda (Pangasinan)	36
Total	138
W. Visayas Area	
Dumangas (Iloilo)	77
Roxas City (Capiz)	45
Batan (Aklan)	59
Hinigaran (Negros Occidental)	36
Himamaylan (Negros Occidental)	33
Total	250
Overall Total Survey Responses	388

Table 7.6b Statistical breakdown of areas surveyed for production and operational data. Municipalities, (Provinces) and number of respondents per cultured organism are shown.

AREAS SURVEYED	Number of Respondents		
	Oyster	Mussel	Oyster and Mussel
Luzon Area			
Bacoor (Cavite)	1	32	-
Malolos (Bulacan)	33	-	-
Bolinao (Pangasinan)	2	29	5
Anda (Pangasinan)	6	23	7
Total	42	84	12
Western Visayas Area			
Dumangas (Iloilo)	71	1	5
Roxas City (Capiz)	3	31	11
Batan (Aklan)	75	2	12
Hinigaran (Negros Occidental)	30	-	6
Himamaylan (Negros Occidental)	19	8	6
Total	168	42	40
Overall Total Survey Responses	210	126	52

Demographics

Gender, Civil Status and Educational Attainment

The typical profile of a bivalve mollusc farmer interviewed during this study was male (76%), average age 44, married (91%) and with an education level up to elementary (25.8%) or high school graduation (21.7%). Of those same males surveyed, 13.5% had reached college-level education, with 7.5% having graduated. Relatively few had undertaken vocational training (1.7%).

Age Distribution

The average age of respondents was 44, mostly (31%) within the age range 41-50. Under 30 years old accounted for 16.2%, and producers over 50 accounted for 22.4%. The age distribution differed significantly between Luzon and Western Visayas, with 49% being

over 44 in Western Visayas, compared with 42% in Luzon (Chi square=1.306, phi=0.058, df= 1, p>0.05).

Household Size

The average number per household in both Luzon and Western Visayas was 4. Households of 1 or 2 people constituted 25% of the total, and those more than 4 accounted for 36.6%. Maximum household size was 12 (1 case). The confidence interval for Malolos was below 0.00 indicating that the average household number in this municipality was considerably lower than 4.

Occupation

The respondents participate in a variety of economic activities including fishing, farming, fish/shellfish trading, fishing, aquaculture/mariculture operation, oyster and mussel farming. About 45% respondents indicated oyster and mussel farming as their major source of income, while only 36% indicated fishing. This is especially true in the municipality of Bacoor where fishing is no longer as productive, due to continued development and environmental degradation. However, 92% of those who indicated fishing as their primary source of income also indicated oyster/mussel farming as their secondary. Of those who indicated oyster/mussel farming as their primary source of income, 35% considered fishing as secondary, while 30% had no other source of income except bivalve farming.

Commencement of Oyster and Mussel Farming Operations

Many respondents (43%) started oyster and mussel farming between 2000 and 2007. However, about 11% started as early as in the 1970s, mainly in Western Visayas, and 20% in the 1980s. The respondents learned oyster and mussel farming through experience (39%), introduced by their parents (39%), or they merely followed others (20%). Only very few (2%) received encouragement or technical and financial assistance from government and non-government organizations (e.g., BFAR, SEAFDEC), or from their local Barangay (1.3%). Such assistance was mainly extended to respondents in Western Visayas. Similar values were obtained in relation to who introduced them to bivalve farming.

The respondents engaged in this venture mainly for supplemental income (69%), inherited the operation from parents (7%), or there was no other available work due to lack of education (7%). These reasons are common for both Luzon and Western Visayas. However, availability of stock has been identified by some farmers in Western Visayas (especially in Dumangas, Batan and Roxas) as a reason for starting bivalve aquaculture, this was never given as a reason by Luzon farmers.

Culture Site Description

Farm Location

Farms are distributed throughout rivers (52%) and coastal areas, including bays, (46%) with significant concentrations along river banks up to the mid-point of the river. More than half (64%) of oyster farmers interviewed had their operations within rivers; these are mostly found in Western Visayas. By comparison, mussel farms are mostly found in coastal areas or the middle of the bay/channel (67%), more of which are in Luzon area.

Farm size and potential for expansion

The average size of oyster and mussel farms for both areas surveyed was 2,669m2 (n=380), although the average farming area in Luzon are much bigger (mean area= 5,844 m2, n=138) compared to Western Visayas (mean area= 858 m2, n=242). In general, farm size tends to be relatively small, with only around 23% of farms larger than 1000m2. However, there are again clear differences between Luzon and Western Visayas, since of the farms surveyed, 43% were greater than 1000 m2 in Luzon, compared to 11.5% in Western Visayas. In general, about 67% of oyster and mussel farms across both areas

occupy an area of 500m2 or less, although Western Visayas clearly comprises more, smaller farms.

Most respondents (74%) believed they can no longer expand production area because of limited space, local government designated specific area, lack of financial capital, presence of navigational areas or site characteristic problems. For those intending to expand their operations, the dependant considerations would be availability of financial capital and culture space.

Water Depth

The depths of 54% of the farms during high tide are between 2 and 4 metres; whereas 35% are less than 1 metre depth during low tide. Some farms (14%), mostly oyster farms in Western Visayas, are completely without water during low tide. The shallow water areas are mostly in Batan, Dumangas and Hinigaran. This is understandable since most operations are situated in rivers and estuaries. Most oyster farms are located in shallower areas (between 2-4 metres) compared to the mussels (between 4-6 metres).

In general, across all surveyed areas, 81% of mussel sites had a high tide greater than 4m, compared with 37% of oyster operations. Similarly, only 12% of mussel sites had a low tide less than 1m depth, compared with 52% of oyster operations.

Choice of Area

Typical oyster and mussel aquaculture operations in the Philippines have key characteristics that can potentially affect the environment. While there may be specific site selection criteria, 71% of farms across the study sites were chosen mainly because of the following factors; availability of the area (25.3%), perceived suitability of the site (16.2%), traditionally farmed by the family (inherited) (12.6%), area was sold to the respondent (8.8%), site accessibility (8%). Perhaps significantly, only 5.7% of respondents indicated that their site was chosen because it had been designated for aquaculture purposes by local government.

Some regional differences were apparent, for example, site selection due to ‘area availability’ was 31% in Western Visayas, but 14.5% in Luzon. Those respondent who had purchased their site (‘area sold to respondent’, indicating perhaps both availability and deliberate business venture) was 15.2% in Luzon, compared to 5.2% in Western Visayas. Site accessibility was more important in Western Visayas compared to Luzon, 9.6% and 5% respectively, as was site water depth, with 6.8% and 0.7% respectively. Other factors were broadly equivalent in both areas.

Species specific issues for site selection are not very pronounced with ‘site availability’ being the largest consideration at 25% for both types of producer. The most prominent differences between species recorded from the survey are shown in Table 7.7.

Aquaculture Production Schedule

The operation of 86% of all oyster and mussel farms is continuous throughout the year; and approximately equal between Western Visayas (84%) and Luzon (88%). Farms whose operations were not continuous mainly attributed this to lack of financial capital for the purchase of materials and that the culture area is becoming too shallow. Batan, in the Western Visayas had the highest proportion of non-continuous production at 33%.

Both oyster and mussel operations showed broadly similar continuity of production, with 86.5% and 84% respectively.

Table 7.7 Main species specific differences for site selection based on respondents to survey instrument. Data are percentages of total number of respondents (listed) indicating the main choice for site selection and are pooled values for each species from both Luzon and Western Visayas. Full details of survey instrument are provided in the Appendices.

Site Choice Consideration	Mussel Growers (% of total respondents)	Oyster Growers (% of total respondents)
Accessibility	6	9
Better growing area (eg spatfall)	1.9	4.3
Government designated area	3.2	7.3
Inherited from family	5.2	17.5
Site suitability	22.7	11.9
Area formerly used for fish traps	4.5	<0.5
Total respondents (n)	154	234

Production System Types and Practices

Organizational Structure of Farm

About 91% respondents are the sole proprietor of the oyster and mussel farms. Those who have partners, do so with either relatives or friends. Bacoor (Luzon) is the only municipality with hired caretakers for their operations, but represents only 1% of organisational structures.

People Involved in the Operation

The operation and management of oyster and mussel farms in Luzon and Western Visayas is mainly family-based. The main activities include; boring and stringing shells, marketing, harvesting, shucking, cleaning, sorting, monitoring, repair, labour, financial support, raft and rack construction, provides capital, setting of substrate, packing and staking. The mother or wife is mainly involved in marketing the products while the father or husband is in charge of the operation of the farm (i.e. from setting up the structure to harvesting), also with the assistance of their children. Other members of the family, (e.g. cousins, brothers, nephews), friends or hired labourers also participate in activities, ranging from setting up of stake to harvesting. Some respondents from Bacoor hire labourers mainly for harvesting, rack construction, setting of substrate, marketing and staking.

Culture method(s)

The oyster and mussel culture methods in Luzon and Western Visayas can be broadly classified into the bottom/broadcast, stake, rack and raft methods. It is also very common to find them being cultured and harvested from fish traps and fish cages, providing an additional source of income to the caretakers of the operations. The following describes the most commonly used culture methods:

1. *Bottom/Broadcast method* is the oldest and least practiced method of culture. Spat settle on rocks, stones, gravel or any solid substrates on the oyster bed. The basic substrates for this method are soil, sand, empty shells, stones and bamboo. Harvesting is done manually through diving and hand picking.
2. *Stake method* is usually established in soft, muddy and shallow beds. Bamboo stakes are stuck in the oyster bed and serve as spat settlement substrates. The bamboo stakes are aligned and spaced at 1metre between rows and approximately 1 metre between stakes.
3. *Rack method*- the foundation, commonly bamboo or other wooden frame, is embedded into the sediment. This becomes the substrate for oyster or mussel spat. Some farmers make use of rack hanging method where strings made of nylon or

polyethylene twine are hung onto bamboo or wooden frame at 0.35 metres apart. The most common types of collector are:

3.1. Empty oyster shells strung together by a polyethylene rope or monofilament nylon line at 0.25 metre intervals and hung with no specific clearance from the bottom to avoid siltation and bottom predation.

3.2. Old rubber tyres-these are cut into halves and tied to the horizontal bamboo by nylon ropes at 0.50 metre space.

3.3. Sacks – either braided or whole sack hung vertically on bamboo posts.

4. *Raft method*- floating and usually with or without hanging structures. If there are no hanging strings, the structure (e.g., bamboo) becomes the substrate for oyster or mussel spat.

A summary of culture methods in the study sites are found in Appendix 6.

Results of the interviews showed that culture methods in Western Visayas are more variable (involving a combination of methods) compared to Luzon; e.g. the raft method is not common in Luzon. However, rack (34%) and stake (33%) methods are the most commonly used type in both localities (Table 7.8).

Table 7.8 Proportion of main bivalve culture methods used by survey respondents in each area.

Culture Method	Luzon (%)	Western Visayas (%)	Overall (%)
Bottom/Broadcast	1.5	1.5	1
Stakes	42	27.5	33
Racks	42	29	34
Rafts	0	25.5	16.5
Combination methods	13	16	15
On fishing structures	1.5	1.5	1
Total Respondents (n)	138	250	388

Both stake and rack methods are common for mussel culture in Luzon, whereas racks are much preferred for oyster culture. In the Western Visayas, rafts are preferred for mussels, while oysters are commonly grown using several methods, with a preference for stakes and rafts (Table 7.9a). Details of municipality specific culture methods are presented in Appendix 7.

Table 7.9a Preferred main culture methods by area and species. Numbers are individual respondents to survey questionnaire.

Region	Method	Mussels	Oysters	Mussel & Oysters	Total
Luzon	Bottom/Broadcast	/	2	/	2
	Stakes	48	3	7	58
	Racks	31	22	5	58
	Rafts	/	/	/	/
	Combination methods	4	14		18
Western Visayas	Bottom/Broadcast	/	2	/	
	Stakes	4	61	4	69
	Racks	6	57	10	73
	Rafts	28	24	12	64
	Combination methods	4	23	13	40

Reasons for choice of culture method

Respondents provided a number of reasons for their choice of culture method, the main reasons for the three main culture methods were;

1. Stake method
   - Cheap and affordable, raw materials are readily available
   - Integrated with fish trap or fish pens
   - Spat easily attach
   - Only method known
   - Followed others
2. Rack method
   - Followed others (especially in Anda and Himamaylan)
   - Easy to harvest
   - Fast growth
   - Higher production
   - Spat attach easily
   - Traditional method
3. Raft Method
   - Higher production
   - Spat easily attached
   - Appropriate (established) method

The principal reasons provided (including % of those respondents indicating a preference (n=486)) for choosing any culture method were as follows;

- Spat easily attach (10%)
- Followed others (9%)
- Traditional method (8.5%)
- Higher production (6.5%)
- Fast growth (6.5%)
- Cheap and affordable (6%)

Production cycle description

The average culture period for oyster and mussel farming is about 8.7 months at an average of 1.3 crops per year. The number of months of culture in Western Visayas (9 months) was not significantly different from Western Visayas (8.2 months) (Chi square=4.232, phi=0.096, df= 1, $p>0.05$).

Production quantity

Comparison of production between areas was done for each culture method (Table 9b). Analysis showed that production from stake method in both areas does not differ significantly. However, production from rack method in Luzon is statistically higher than that of Western Visayas (ANOVA, $p<0.01$).

Table 7.9b Production (kg/m) between areas according to culture methods. Data are pooled means of samples from all sites within each region ±SD (n= numbers in parentheses)

Culture Method	Production (kg/m)	
	Stake	Rack
Luzon	3.357±3.2	5.906±4.93
Western Visayas	3.662±5.03	2.622±3.93

Stock Management

Spat Collection

About 66% of the respondents said they have a method of determining spatfall which is mainly based on observations and experience. These included; assumption of seasonality of spatfall (19.5%), spat becoming visible on substrates (34%) or observed changes in the characteristics of the water (3%). Some farmers in Western Visayas normally set up spat collectors a month before assumed spatfall. Also, 66% of the respondents know the sources of spat.

The types of spat collectors vary between areas, but in general, all culture methods make use of bamboo. Other spat collectors include oyster shells, old tyres, nets (screen), ropes, rattan, wood, mud, rocks/stones and sacks. Some mussel growers from Bacoor with insufficient spat at the culture sites purchase spats from neighbouring municipalities like Malabon, Bataan and Paombong Bulacan. In Western Visayas, a number of operators (especially those whose culture sites are located upstream) also purchase oyster spats from operators whose sites are near the mouth of the river or at the coast. The respondents from Luzon and Western Visayas attributed the problem in spat collection mainly to lack of spats and poor spat attachment. The average costs of spats in Luzon and Western Visayas are PhP153/sack and P151/sack respectively.

Grow-out Management

There are more oyster farmers (69%) who estimated that less than 30% mortality rate for oysters occurred during the culture period. However, only 48% of the mussel farmers estimated that mortality rate for mussel is less than 30% during the culture period.

Only 35% of farmers in Luzon and Western Visayas do thinning, which was usually done during harvest or when too many organisms per cultch is observed. The thinned organisms are broadcast to the sediment, re-fixed to another bamboo, transferred to other areas, consumed or marketed.

Harvesting and Marketing

In general, harvesting and marketing of oysters and mussels in Western Visayas are demand driven. However, in Luzon, this is not commonly the case as there are regular buyers. Sizes between 5-7 cm are ready for harvest. In Western Visayas, family members are usually involved in harvesting. They seldom hire labourers, only when there is no available family member or respondents have to take care of other responsibilities.

Special Harvesting System

The municipalities of Anda and Bolinao have a special harvesting system. A total of 16 harvesters were interviewed. Aside from being harvesters, the respondents were also involved in fishing, mussel farming, shellfish trading, portering and pig selling, and as caretakers of shellfish traders. Many respondents are fishermen who harvest oysters and mussels for additional income. About 31% respondents started harvesting oysters and mussels in 2003 while 6.3% began as long ago as 1984. Aside from oysters and mussels, the harvesters are also harvesting assorted fish such as siganids, milkfish, mackerel, scad, slipmouth, and snapper.

There are three harvesting systems in these municipalities. In the pakyaw system, the harvester either pays the operator for the cost of the produce before or after harvesting. In the sharing system, profits from the harvest are divided between owner of the produce and harvester (50:50), but profit sharing may also vary at times depending on the parties concerned. In the daily wage system, the harvester receives a daily wage (Php200-300/day) from the owner of the farm.

Harvesters from Anda go to the same operators (about 5 operators) whenever they harvest (58%), while harvesters from Bolinao have no preference to conduct their harvesting. About 65% of all respondents do not operate oyster/mussel farms. Harvesting months are continuous from January to December for 81% of harvesters. The peak harvesting month is during April (26.9%). Results from the interviews revealed that 4 people are involved in harvesting at an average of 5 hours/day for 14 sacks of produce. There are about 55 harvesters in Anda and Bolinao.

Objective 2: Collect and compare information on product quality, safety and post-harvest aspects of bivalve production between regions / sites and compare with international standards

In this scoping study, the quality and safety of shellfish and shellfish-growing water from selected sites were assessed for bacterial pathogens in shellfish meat and total faecal coliforms in surrounding waters. Because sampling was conducted only twice in a year, rather than monitoring at more frequent time intervals, results of the microbiological quality of shellfish and shellfish growing water can only provide information on the bacterial load of the representative sample at the time of collection from a specific area of the site.

Western Visayas

Table 7.10 shows the microbiological quality of shellfish and shellfish culture water samples collected from the three areas in Panay (Western Visayas). Stations in the two sites (Roxas and Dumangas) in Panay were located in a river system, while Batan stations were in a bay area. Results show that faecal coliform in the three sites selected in Panay are generally higher than the standard (14 MPN faecal coliform/100 ml, USFDA).

Stations R1 to R4 were located at the mouth of the Palina River and several aquaculture structures and residential houses were also present upstream. The high coliform count could be due to the constant flushing of domestic wastes towards the mouth of the river. It was also observed the river was quite shallow. In the second sampling period a very high coliform count was obtained, perhaps due to the heavy rains experienced prior to actual sampling, which would tend to flush large volumes of various wastes into the river. Samples were collected during low tide and the water was observed to be turbid. Stations R5, R6 and R7 were situated in Punta Cogon River. It was observed that the area was densely populated and the river was also used as a navigational lane for commercial boats transporting their products to Roxas City market. The shellfish sites were also located close to the mouth of the river. Coliform counts in R6 and R7 were almost the same for the first and second sampling. However, the very high count (2300 MPN) in station R5 in the second sampling is quite puzzling and cannot be obviously explained, considering R5 and R6 were just a few metres apart. R8 and R9 stations were located upstream in the Culajao River, where the river bank had very high density of residential houses. R10 station was situated where there were no residents, but the set-up was close to the river bank. Several biological, chemical, physical and biochemical factors such as temperature, pH, turbidity, nutrients, could have played a role in the survival of microorganisms in the water environment.

Table 7.10 Microbiological quality of shellfish and shellfish growing waters collected from sites in Panay (Western Visayas)

Sample Code	Municipality	Date of Sampling		Organism	Shellfish meat								Water	
					E.coli (MPN/100g)		Salmonella		V. cholerae		V. parahaemolyticus (MPN/g)		Faecal coliform (MPN/100ml)	
		(S1)	(S2)		(S1)	(S2)	(S1)	(S2)	(S1)	(S2)	(S1)	(S2)	(S1)	(S2)
R1	Roxas	3/27/2007	10/2/2008	mussel	54	23	positive	negative	positive	negative	110	NT	230	920
R2	Roxas	3/27/2007	2/20/2008	oyster	35	33	NT	positive	NT	positive	NT	23	230	>2400
R3	Roxas	3/27/2007	10/2/2008	mussel	13	NT	positive	NT	positive	NT	460	NT	700	>2400
R4	Roxas	3/27/2007	10/2/2008	mussel	54	79	positive	negative	positive	negative	240	NT	460	1600
R5	Roxas	3/27/2007	2/20/2008	mussel	35	14	positive	positive	positive	positive	2400	11	50	2300
R6	Roxas	3/27/2007	2/20/2008	oyster	17	540	positive	positive	positive	positive	430	20	230	170
R7	Roxas	3/27/2007	2/20/2008	mussel	22	170	positive	positive	positive	positive	210	11	230	230
R8	Roxas	3/27/2007	2/20/2008	oyster	35	140	positive	positive	positive	positive	1100	28	80	330
R9	Roxas	3/27/2007	2/20/2008	oyster	350	70	positive	positive	positive	negative	110	11	170	3500
R10	Roxas	3/27/2007	2/20/2008	oyster	7.9	34	positive	positive	positive	positive	150	11	110	2200
D1	Dumangas	5/02/2007	2/12/2008	oyster	23	130	NT	positive	positive	positive	<3	150	920	5400
D2	Dumangas	5/02/2007	(b)	mussel	26		NT		positive		<3		130	
D3	Dumangas	5/02/2007	2/12/2008	mussel	130	140	NT	positive	positive	negative	<3	<3	130	3500
D4	Dumangas	5/02/2007	2/12/2008	oyster	17	>2400	NT	positive	positive	positive	<3	<3	170	9200
D5	Dumangas	5/02/2007	2/12/2008	mussel	21	>2400	NT	positive	positive	positive	<3	1100	33	5400
D6	Dumangas	5/02/2007	2/12/2008	oyster	34	17	NT	positive	positive	positive	<3	21	8	490
D7	Dumangas	5/02/2007	2/26/2008	oyster	9	17	NT	positive	positive	positive	<3	23	33	490
D8	Dumangas	5/02/2007	2/26/2008	oyster	70	350	NT	positive	positive	negative	<3	<3	79	2200
D9	Dumangas	5/02/2007	2/26/2008	oyster	46	49	NT	negative	positive	positive	<3	<3	350	5400
D10	Dumangas	5/02/2007	2/12/2008	oyster	350	8	NT	negative	NT	negative	NT	<3	240	9200
BAT-1	Batan	11/30/2007	3/12/2008	oyster	92	33	NT	positive	NT	positive	28	150	790	110
BAT-2	Batan	11/30/2007	3/12/2008	oyster	>240	23	NT	positive	NT	positive	28	1100	270	5400

BAT-3	Batan	11/30/2007	(c)	mussel	2.1		NT		NT		11		220	
BAT-4	Batan	11/30/2007	3/12/2008	oyster	3.4	33	NT	positive	NT	positive	7	>2400	1400	70
	Batan	11/30/2007	(d)	mussel	3.4		NT		NT		460			
BAT-5	Batan	11/30/2007	3/12/2008	oyster	1.3	17	NT	positive	NT	positive	43	>2400	940	20
BAT-6	Batan		10/2/2008	mussel		140		negative		negative		NT		350

Legend: (S1)= first sampling ; (S2) = seconding sampling ; NT= not tested, (b)= mussel set-up was removed and culturing was discontinued by the grower; (c) = shellfish unavailable so sample (BAT-6) collected from another grower; (d) = oyster set-up was removed and discontinued

Bivalves are filter feeders and have the ability to concentrate bacteria from surrounding seawater in their digestive system. *Escherichia coli* is commonly found in faeces of human and other warm-blooded animals and has survival characteristics in water which have led to the adoption of *E. coli* as an indicator of faecal contamination. The presence of *E. coli*, *Salmonella* and *Vibrio cholerae* in shellfish meat also indicates the presence of these pathogens in the culture environment. *Escherichia coli* present in the shellfish samples was within the standard (230 MPN/100 g) except for R9 and R6 in the first and second sampling respectively. High levels (up to 100 colony forming unit (cfu)/g) of *V. parahaemolyticus* in shellfish may be expected because it is a naturally occurring organism in the marine environment. However, levels of *V. parahaemolyticus* of > 1000 cfu/g are considered potentially hazardous, as consumption of the seafood may result in illness (ICMSF, 1986). However, based on the results, counts of this bacterium were not above the required level.

Another sampling site in Panay was Dumangas (Iloilo Province). Stations in Dumangas contained faecal coliform above the standard, except for station D6 in the first sampling. Stations from D1 to D5 were located at the shallower part of the river. Fish ponds present upstream could have contributed to the high level count. Coliform count in D6 to D8 was relatively lower compared to the rest of the sampling stations. These stations were located in another river of Dumangas, but residential houses were a couple of kilometres away. The high count in D9 and D10 could be attributed to the residential and commercial activities along the shoreline. Several restaurants were operating around the area where the D9 and D10 stations were located. Bacterial counts on the second sampling (usually wet season) increased dramatically in most of the stations. Samples in stations D1 to D5 were collected during low tide. In this condition, water movement from upstream carrying domestic and agricultural wastes towards the outlet or mouth of the river could be an explanation for the high coliform count. It was also observed during sampling that water from the fishponds was being released into the river. Rains experienced from previous days could have also contributed to the high count for most of the stations. *Escherichia coli* counts in shellfish meat were low except in D10 and D5 for the first and second sampling, respectively. *Salmonella* was not analyzed in the first sampling due to logistical circumstances. In the second sampling *Salmonella* was detected, which can be attributed to the high faecal count in water. *Vibrio cholerae* was also present in most of the samples, but low *V. parahaemolyticus* counts were recorded, perhaps reflecting their different sources, the former being largely associated with human wastes.

Batan (Aklan) was the third site in Panay and the shellfish farms are mostly located along Batan Bay. High faecal counts in water collected from the different stations in Batan Bay were also observed. Station BAT-1 was located at the mouth of the river while BAT-2, BAT-4 and BAT-5 were situated closer to the shore. BAT-3 was set-up towards the middle of the bay. *Escherichia coli* in the shellfish meat for both sampling periods were at relatively low levels, except samples collected at BAT-2 in the first sampling. BAT-2 was close to the shore where residential houses are present, which could have contributed to the high level. However, it has been suggested that *E. coli* may be present, or even multiply, in tropical waters not subject to human faecal contamination suggesting that source could have been from wild animals, including birds (WHO, 1997). Salmonella and *Vibrio cholerae* were also present, but only analyzed during the seconding sampling. *Vibrio parahaemolyticus* count was at <1000 MPN/g for most of the shellfish, and is a naturally occurring bacterium in sub/tropical marine waters. However, favourable conditions, e.g. warm temperatures, could increase numbers and can subsequently increase counts in the shellfish meat.

Negros, another island of Western Visayas, was a selected site and results of analysis for the two sites (Hinigaran and Himalaylan) are presented in Table 7.11.

Water samples from Hinigaran contained relatively very high faecal coliform during the first and second sampling. Identified stations can be generally described as mostly located along the river, adjacent to residential houses, which are major sources of domestic

wastes such as human sewage and animal faeces. Frequent supply of fresh wastes into the river can greatly affect the quality of the water. Aside from this, the river is basically crowded with aquaculture operations such as fish pens and traps, which could hinder the efficient flow and exchange of water. Land-based aquaculture (fish ponds) was also one of the businesses in the municipality and its waste water is usually discharged into the river during low tide. These activities can greatly contribute to degradation of microbial water quality.

The high levels *E. coli* obtained in shellfish samples could be attributed to the high faecal coliform count in water. It was also observed that the shellfish were exposed to heat (sunlight) during low tide for most shellfish sites. Although the heat may have affected the survival of the organism (shellfish), such condition may also be favourable for the multiplication of bacteria, especially during post-harvest, when subsequent flushing would not be possible. Bacterial counts in the second sampling period for some samples were relatively low and below the recommended safety standards (230MPN/ 100 g). However, shellfish from stations H8 and H9 consistently showed high *E. coli* counts. The station was a few metres away from the river bank with a pig cage close by. It was observed that when the cage is cleansed, the waste water goes directly into the river. This is aside from the observation that houses are built very close to, even over the river, at this station.

Vibrio cholerae was present in all samples in the first sampling and can be introduced into the water column through discharges from humans, who in turn may be affected with a disease brought about by the organism. On the other hand, *V. parahaemolyticus* was lower than the recommended level in both sampling periods. The absence of *Salmonella* in most samples during the first and second sampling, despite the numerous activities along the river and high faecal count in water, is quite hard to explain. It has been shown by researches that with faecal concentrations of less than 200 MPN/ 100ml, *Salmonella* occurrences ranged from 6.5-31%, and at higher concentration of faecal coliforms, the frequency of *Salmonella* occurrence is doubled. However, this may not always be the case in shellfish. Evidence from many studies indicates that a constant relationship between pathogen (bacterial or viral) content of shellfish and overlying water does not exist.

Table 7.11 Microbiological quality of shellfish and shellfish growing waters collected from different stations in Hinigaran and Himamaylan (Negros Occidental, Western Visayas)

Sample Code	Municipality	Date of Sampling		Organism	Shellfish meat								Water	
					E.coli (MPN/100g)		Salmonella		V. cholerae		V. parahaemolyticus (MPN/g)		Faecal coliform (MPN/100ml)	
		S1	S2		S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
H1	Hinigaran	3/20/2007	3/25/2008	oyster	94	34	NT	positive	positive	positive	930	<3	2400	1000
H2	Hinigaran	3/20/2007	3/25/2008	oyster	>2400	11	NT	negative	positive	positive	210	<3	490	1400
H3	Hinigaran	3/20/2007	3/25/2008	oyster	79	14	negative	negative	positive	negative	150	<3	9200	170
H4	Hinigaran	3/20/2007	3/25/2008	oyster	240	350	negative	negative	positive	negative	<3	<3	2800	300
H5	Hinigaran	3/20/2007	3/25/2008	oyster	170	33	negative	negative	positive	negative	11	<3	1600	5000
H6	Hinigaran	3/20/2007	3/25/2008	oyster	1600	22	NT	negative	positive	positive	210	<3	1100	400
H7	Hinigaran	3/20/2007	3/25/2008	oyster	1600	240	negative	positive	positive	negative	280	<3	2400	400
H8	Hinigaran	3/20/2007	3/25/2008	oyster	920	920	negative	positive	positive	negative	23	<3	5400	1600
H9*	Hinigaran	3/20/2007	3/25/2008	mussel	540	350	negative	negative	positive	negative	4	<3		
H10	Hinigaran	3/20/2007	3/25/2008	mussel	>2400	22	negative	negative	positive	negative	<3	<3	1400	110
HIM-1	Himamaylan	12/5/2007	7/10/2008	oyster	92	34	NT	negative	NT	positive	29	<3	2200	700
HIM-2	Himamaylan	12/5/2007	7/10/2008	oyster	>240	350	NT	negative	NT	negative	17	<3	9200	500
HIM-3	Himamaylan	12/5/2007	7/10/2008	mussel	>240	34	NT	negative	NT	negative	28	<3	490	80
HIM-4	Himamaylan	12/5/2007	7/10/2008	oyster	>240	>2400	NT	negative	NT	positive	9	<3	330	800
HIM-5	Himamaylan	12/5/2007	7/10/2008	mussels	20	34	NT	negative	NT	negative	28	<3	330	200

*Legend: (S1)= first sampling ; (S2) = seconding sampling ; NT= not tested, *sample was collected in the same station as H8*

Faecal coliforms in the water samples from Himamaylan ranged from 330-9200 MPN/100 ml sample for the first sampling and 80-800 MPN/100 ml in the second sampling. Counts for both periods were above the recommended standards. HIM-1 and HIM-2 stations were both located alongside fishpens along the river, and residential houses along the river bank were also observed. Station HIM-3 was situated at the mouth of the river where flushing from upstream can affect water quality. Station HIM-4 station is located close to the port and residential area. These factors can potentially contribute to the low quality of water in the municipality. *Escherichia coli* in shellfish meat collected from HM-1 and HM-5 was consistently lower than the standard (230MPN/ 100g, USFDA) in both sampling periods. Studies have shown that enteric bacteria in seawater may survive from a few hours to a few days, depending on several factors that may play a role in the survival or removal of bacteria. *Salmonella* was absent in the shellfish samples during the second sampling.

Vibrio parahaemolyticus count in all stations was lower than the unacceptable or hazardous level (1000 cfu/g) (ICMSF, 1986) for both sampling periods. *Vibrio cholerae* was detected in stations HIM-1 and HIM-4, possibly due to their proximity to residential area and could be regularly subjected to domestic wastes.

Based on the results, the microbial content of the shellfish growing areas in Western Visayas was variable, but with sufficiently high counts, temporally and/or spatially, that the microbiological quality of the shellfish meat could be affected. It is important, therefore, to employ safety measures to reduce the microbial load of the shellfish prior to consumption.

Luzon Area

In the Luzon region, four sites were selected. Shellfish farms in Malolos and Bacoor were located in Manila Bay, while those in Bolinao and Anda were along a coastal marine water channel. Results of the evaluation are summarized in Table 7.12.

Faecal coliforms for the water samples collected in Malolos for the first and second sampling periods were >16 and >24 MPN/100 ml, respectively. However, the analytical laboratory where the samples were taken followed the protocol for analyzing drinking water standards and did not provide actual values. However, comparing with standards for faecal coliform (14 MPN/100 ml), the content was relatively high in all samples. The higher count in the second sampling could be attributed mainly due to the waste water runoff brought about by the storms during the time of sampling. Most of the oyster and mussel operations were also located close to the mouth of the river. The *E. coli* content of the shellfish meat collected from the five stations in Malolos was also high for both sampling periods.

Salmonella was not detected for both samplings despite the various aquaculture and agricultural activities along the river where its wastes can be flushed into the bay. There was also the presence of a hospital in one of the barangay located close to Manila Bay. Other pathogens such as *Vibrio spp* was not tested due to the limitation of the analytical laboratory in Malolos.

Table 7.12 Microbiological quality of shellfish and adjacent waters collected from different sites in Luzon

Sample Code	Site	Sampling Date		Organism	Shellfish Meat								Water	
					E coli (MPN/100g)		Salmonella		V. cholerae		V. parahaemolyticus (MPN/g)		Faecal coliform (MPN/100ml)	
		(S1)	(S2)		(S1)	(S2)	(S1)	(S2)	(S1)	(S2)	(S1)	(S2)	(S1)	(S2)
MAL-1	Malolos	4/8/08	8/27/08	oyster	>1600	>1600	-	-	NT	NT	NT	NT	>16	>24
MAL-2	Malolos	4/8/08	8/27/08	oyster	>1600	>1600	-	-	NT	NT	NT	NT	>16	>24
MAL-3	Malolos	4/8/08	8/27/08	oyster	>1600	>1600	-	-	NT	NT	NT	NT	>16	>24
MAL-4	Malolos	4/8/08	8/27/08	oyster	>1600	>1600	-	-	NT	NT	NT	NT	>16	>24
MAL-5	Malolos	4/8/08	(a)		>1600		-		NT		NT		>16	
BAC-1	Bacoor	4/10/08	8/26/08	mussel	<3	<3	-	-	-	-	NT	NT	<2	50
BAC-2	Bacoor	4/10/08	8/26/08	mussel	<3	<3		-	-	-	NT	NT	<2	50
BAC-3	Bacoor	4/10/08	8/26/08	mussel	<3	<3	-	-	-	-	NT	NT	<2	900
BAC-4	Bacoor	4/10/08	8/26/08	mussel	<3	<3	-	-	-	-	NT	NT	4	900
BAC-5	Bacoor	4/10/08	(b)	oyster	<3		-		-		NT		<2	
BOL-1	Bolinao	4/14/08	8/19/08	mussel	<3	<3	-	-	-	-	-	-	93	43
BOL-2	Bolinao	4/14/08	8/19/08	oyster	<3	<3	-	-	-	-	-	-	43	43
BOL-3	Bolinao	4/14/08		oyster	<3		-		-		-		93	
			8/19/08	mussel		<3		-		-		-		460
BOL-4	Bolinao	4/14/08	8/19/08	mussel	<3	<3	-	-	-	-	-	-	9.1	9.1
BOL-5	Bolinao	4/14/08	8/19/08	mussel	<3	<3	-	-	-	-	-	-	<2	9.1
AND-1	Anda	4/15/08	(c)	mussel	<3		-		-		-		93	
AND-2	Anda	4/15/08		mussel	<3		-		-		-		1100	
	Anda		8/21/08	oyster		<3		-		-		-		>1100
AND-3	Anda	4/15/08	8/21/08	mussel	<3	<3	-	-	-	-	-	-	93	>1100
AND-4	Anda	4/15/08	8/21/08	oyster	<3	<3	-	-	-	-	-	-	240	>1100
AND-5	Anda	4/15/08	8/21/08	oyster	<3	<3	-	-	-	-	-	-	93	>1100
AND-6	Anda		8/21/08	mussels		<3		-		-		-		>1100

Legend: (S1) = first sampling ; (S2) = seconding sampling; NT= not tested; - = negative, (a)= oyster set-up was removed; (b) oyster culture discontinued; (c)= mussel grower not available; sample AND-6 collected in the same area as AND-1 but from different grower

Oyster and mussel farms in Bacoor (Cavite) were located much farther away from the shoreline of Manila Bay. Faecal coliform of the water samples were relatively low in the first sampling. Likewise, *E. coli*, *Salmonella* and V. cholerae were not detected in the shellfish meat analyzed. *Vibrio parahaemolyticus* was not requested for testing due to the additional fee to be incurred, and the fee for analyzing the three pathogens was already quite high. These pathogens were also not detected during the second sampling, although faecal coliform was significantly high in two sampling stations. It was observed during the sampling that a coastal road had been recently built, passing through several barangays of Bacoor. It has an outlet for the passage of boats and limited water exchange during high and low tide. Bacterial load of the water in the enclosed part of the bay would likely be high due to domestic wastes from the congested residential area along the shoreline and during low tide. This would ultimately diffuse into the outer bay. The two stations with high faecal coliform were in proximity to this outlet and could have been affected by this restricted-flushing factor.

Analyzing the results for the first and second samplings, it can be assumed that oysters and mussels harvested from Bacoor (Cavite) are microbiologically safe. However, because the study was limited to the analysis of specific bacterial pathogen, the shellfish may not be chemically safe. It was observed there were commercial plants and shipyards along the shoreline and industrial wastes such as heavy metals and hydrocarbons are likely to be present and can be readily absorbed in the shellfish meat. In a study by Pengson (2001), total mercury levels of oysters from Naic and Bacoor (Cavite) were <0.05 ppm and 0.138 ppm, respectively. Fabia (2001) determined mercury levels in mussels from Naic and Bacoor (Cavite) also and found to contain <0.05ppm (wet wt) and 0.185ppm (dry wt), respectively. Although the levels were below the permissible level set by WHO (<0.3 ppm total mercury), shellfish has the ability to accumulate it through time and eventually can hazard to the consumers. On the other hand, the presence of heavy metals such as mercury and lead in Manila Bay could be partly responsible for the low bacterial count of faecal coliforms and other bacterial pathogens. Research has shown that microbial inactivation appears to be associated with the action of heavy metals and other substances aside from other biological and physical factors (USFDA-CFSAN, 2001).

Faecal coliforms in samples from Bolinao were relatively low, although it does comply with standards, except for two stations in the first sampling. Shellfish farms are located along the side of the channel along with other aquaculture structures, such as fish pens, while fish cages are in the middle part. It was also observed that fish pens and cages are manned and provided with small huts as living quarters for the caretakers and their domestic pets. Human activities in these aquaculture set-ups could have contributed to the localized bacterial loading of the water, despite the better exchange of water along the channel. In the second sampling period, faecal coliform was also low except for sample at BOL-3, where it was noted to be near a fish pen and a hut where the family of the caretaker resides. *Escherichia coli*, *Salmonella* and *Vibrio spp.* were not detected in the shellfish collected from the five sampling stations for both sampling periods.

Faecal coliform content in three samples collected from Anda were also low, similar to Bolinao, while two stations contained relatively high faecal coliform in the first sampling. Sample AND-4 was collected in an area near to a fish pen and just a few metres away from the shore with a number of residents. Sample AND-2 was also in the vicinity of fish pens where the caretakers reside. The very high faecal coliform count in all the sampling station in the second sampling could also have been influenced by storm water run-off from the shoreline. During the second sampling, a strong typhoon affected the area that brought strong rains for almost two days. Likewise, shellfish samples collected from the five stations did not contain bacterial pathogens for both sampling periods.

In general, it can be concluded that the wet-season sampling in the Luzon area showed an increased faecal coliform count, likely due to the flushing action from the shoreline, as compared to the count during dry season.

Discussion

The quality of shellfish is dependent upon the water quality of the growing environment. The quality of the water is usually determined by bacteriological monitoring using coliforms as indicators of faecal contamination. Faecal coliforms indicate the presence of bacterial pathogens such as *Salmonella, Shigella, V. cholerae, Campylobacter jejuni, Campylobacter coli, Yersinia enterocolitica* and *E. coli*. These pathogens can be introduced into the water through shoreline pollution such as domestic and agricultural sewage.

Product safety is primarily based on the sanitary evaluation of the production area. European Union and USA classification programs are based on conventional bacterial pollution indicators for measuring water quality. It has been generally accepted that it is better to monitor for the indicators of faecal pollution than for specific bacterial pathogens. The coliform standard has been effective in enhancing the safety of shellfish through its focus on harvesting waters that are free of faecal contamination, ensured both through the sanitary survey and microbiological testing (IFT, 2004).

The total coliform standard is a geometric mean MPN of 70 per 100 mL of water in growing/harvest areas, and not more than 10% of the samples exceeding 230 MPN/100 mL (NSSP/ISSC/HHS/PHS/FDA, 2003). On the other hand, faecal coliform density in water used for growing and harvesting shellfish for human consumption should not exceed a median MPN of 14/100ml or 90% of the water samples in a 30-day period should not exceed 43/100ml (NSSP, 1999).

Based on the results of the study, faecal coliform content of water samples from various sites in the Visayas region have higher counts compared to samples from Luzon region. The shellfish growing areas in the Visayas, especially in the municipalities of Hinigaran, Himamaylan, Roxas and Dumangas are mainly located along river systems and would be heavily influenced by the various nearby activities and structures. It should be noted, however, that sampling conducted in this study was limited to only twice in the year and the findings are only indicative of the conditions of the sites at the time of samplling.

On the other hand, the coliform standard in water does not totally guarantee shellfish safety. Enteric viruses, e.g. hepatitis A, have also contributed to outbreaks in other countries (see Appendices for review of Wallis Lakes Incident). Viral pathogens are more resistant to environmental conditions, sewage and water treatment processes compared to coliform organisms (Leclerc et al, 2000) and can also survive for months in the marine environment, which is far longer than any bacterial indicator (Lees, 2000).

In addition, *Vibrio spp* (*V. parahaemolyticus, V. cholerae, V. vulnifus*) which occur naturally in the estuarine environment, also contribute to illnesses and deaths associated with the consumption of shellfish. Based on this study, however, there is little apparent relationship between the presence of the above-mentioned pathogens and the levels of the faecal indicator organisms in the production area.

Because shellfish are filter feeders, pathogens that are naturally occurring in growing areas or by faecal contamination can be found in shellfish, concentrated in numbers, and subsequently contribute to food-borne illness if the shellfish are consumed raw or undercooked. In this study, shellfish meat analysis was limited to bacterial pathogens such as *E. coli, Salmonella, Vibrio cholerae* and *Vibrio parahaemolyticus*. Enteric viruses were not assessed due to cost and absence of facilities available for their analysis. Virus outbreaks have not occurred in the past and it is often quite difficult to link with mollusc consumption.

Results reveal that bacterial pathogens (*Salmonella, V. cholerae, V. parahaemolyticus* and *E. coli*) in shellfish collected from the Visayas region were present in most samples as compared to samples from Luzon (Tables 7.10-7.12). Food regulating bodies commonly use microbiological criteria for these bacterial pathogens in shellfish meat to ensure quality and safety for human consumption (Table 7.13).

Table 7.13 Microbiological standards for shellfish

Organism	Microbial limit	Reference
E. coli	< 20 MPN/g 16 cfu/ g 11 MPN/ g 230 MPN / 100g <300 / 100 ml 4.0 cfu/ g	Singapore Guideline, 1995 ICMSF, 1986 FAO No 211 sec 8, BFAR USFDA Guideline, 1996 Council Directive 79/923/EEC SEAFDEC,1998
Salmonella	Absent in 25 g	ICMSF, 1986; FAO No 211 sec 8, BFAR ; USFDA Guideline, 1996
V. cholerae	Absent	USFDA, Guideline, 1996
V. parahaemolyticus	<100 MPN /g 100 cfu/g	Singapore Guideline, 1995; ICMSF, 1986

Based on these microbial limits, most of the shellfish from the Visayas region did not comply. It can be observed in the table that the limit would also depend on the requirement of the importing country. In other regulatory areas, like the EU, the sanitary control of shellfish is primarily addressed through classification of growing areas (Table 7.14) before it can be approved for harvest and sale.

Table 7.14 Classification of harvesting areas for shellfish in the EU (EC, 1991)

	Classification	Microbiological criteria (cfu/100 g shellfish)	Method
A	No restriction. Shellfish acceptable for immediate consumption	<230 *E. coli* or <300 faecal coliforms No *Salmonella* in 25 g	5 tube 3 dilutions MPN-test
B	Shellfish must be depurated or re-laid until they meet category A standard	<4600 E. coli or <6000 faecal coliforms in 90 % samples	5 tube 3 dilutions MPN-test
C	Shellfish must be re-laid over a long period (>2 months) until they meet category A standard	<60,000 faecal coliforms	5 tube 3 dilutions MPN-test

The microbial loads in shellfish assessed in this study are relatively high and could pose risks to would-be consumers. Thus, measures should be taken to render the shellfish safe for consumption. One practical way of reducing the load to safer levels is relaying / purification / depuration, wherein the shellfish are allowed to cleanse themselves in their natural habitat from polluted to clean circulating seawater. Depuration can also be applied where the process of cleansing shellfish is done in tanks by flow-through or circulating water systems. Gacutan et al (1987) undertook depuration experiments using fiberglass-coated tanks with a capacity of 230-310 kg oyster and found gross decontamination after 48 hr or less in a moderate flow (710 L/min) of water. However, the latter method would be quite expensive, especially for small-scale growers. Guevarra (1982) made a study on home deputation using clean seawater with 3% iodine salt solution for 18-24 hr and bacterial load was effectively reduced. This method could be easily adopted at the household level. Post-harvest processing techniques such as heat processing or fermentation can also be applied to reduce bacterial load and transforming it into an alternative marketable product form.

Another concern that should be addressed is improving the post-harvest handling of shellfish. It is possible that the microbial load in the production area could be within the quality standard, but because of the poor handling practices during transport and distribution, microorganisms could proliferate to hazardous levels.

The bacterial load of shellfish should also be minimized during the marketing of shellfish. It was observed that the shellfish are packed in unclean plastic sacks and sediment is not usually removed after harvest. No measures are done from harvesting to market distribution to minimize bacterial proliferation. Shellfish are also usually displayed in vending stalls, uncleaned of sediment and other debris, at the same time exposed to conditions favourable for bacterial growth, aside from being subjected to numerous contaminations from the environment. Despite these microbiological concerns that the

shellfish industry faces, there is insufficient information of the microbiology of retailed shellfish. Thus, it is also suggested for the long-term project to review and assess the current post-harvest handling and marketing practices of shellfish and how it affects the bacterial load of the product. With this information, proper handling practices and possibly appropriate shellfish containers during transport and distribution can be recommended.

Generally, product safety should not only address bacterial pathogens but also viral agents such as hepatitis, harmful algal blooms, pesticides from agricultural wastes, heavy metals and total hydrocarbons from industrial waste which are equally important and should be considered in a long-term monitoring project.

Objective 3 Determine domestic & International market potential for Philippine bivalves

The supply chain for oyster and mussel is shown in Fig. 7.4. A total of 119 respondents for the market surveys were conducted in Luzon (38%) and Western Visayas (62%). Most respondents are male (63%) and about 58% are between 31-50 years old. Respondents are mainly traders of seafood, especially oysters and mussels. The average monthly income from marketing of oysters and mussels amounted to PhP12,930 (mean income for oysters= PhP11,386; mean income for mussels= PhP8,620). The average number of years that the respondents had been marketing oysters and mussels was about 12.7 years.

Oysters and mussels are sold in raw or shucked form. About 85% of those involved in marketing know where the oysters and mussels were harvested, but only 50% have been to the growing sites. The top 3 producing areas identified by the respondents were Roxas City, Cavite and Bolinao, which they mainly attribute to the taste. As traders, they prefer products that are large and ‘fatty’, and they determine this at the time of purchase when they ask the operators to open samples. Very few traders or buyers (8%) participated in harvesting. Both Luzon and Western Visayas respondents market oysters and mussels throughout the year, but more are sold during special events such as Christmas time or town fiestas.

Almost half of the respondents indicated that they have problems with the purchase of oysters and mussels; these include lack of supply and poor quality of product. There is no formal arrangement in marketing the products, most transactions are verbal. From the growing areas, the buyers or traders transport the products through tricycle, jeepney, truck or boat depending on the distance to the market area. Most traders (97%) know the final destination of the products they sell.

The price of mussels in Luzon is higher (PhP462/sack) than that of Western Visayas (PhP360/sack). On the other hand, the price of oysters in Western Visayas is significantly higher (PhP295/sack) than that of Luzon (PhP226) ($p<0.05$). While some traders calculate the costs to determine the selling price, some just follow other traders.

Only 9% of the respondents are members of trading organisations and no support for the industry is given by government agencies.

A total of 163 consumers were interviewed from different parts of the country. The respondents were 53% female, single (51.5%), with an average age of 34 and many have reached College level (54%). Most respondents (72.4%) are not part of any environmental group or social association and 76.7% have not heard of eco-labelled products. Most respondents (66%) eat fish and seafood daily. About 71% eat oysters and mussels, 5.5% do not eat mussels and 3.7% do not eat oysters. Only 19.6% of the respondents do not eat both oysters and mussels. The reasons for not eating oysters/mussels include allergies, stomach problems (e.g. diarrhea, indigestion), appearance, smell and taste of the product (e.g. dirty, mucus-like, raw flavour, unpleasant odour), financial reasons (e.g. high price), health reasons (e.g. old age, high blood pressure, allergies), accessibility and not used to eating oysters/mussels.

The respondents preferred eating oysters (36.2%) than mussels (24.2%) because of the taste (e.g. meaty, flavourful, juicier), availability in the area, appearance (e.g. appealing, bigger, 'fatty', softer meat), and nutritional value (e.g. with calcium and protein, gives strength, 'good for the brain').

More than half of the respondents (53.4%) observed that oysters and mussels are available throughout the year. However, there is no specific time when oysters or mussels are best consumed. The products are consumed at home, usually steamed. Very few respondents had tried eating products made from oyster and mussels (e.g., oyster sauce, canned oyster/mussel, bottled mussel, mussel chips, etc.). These products are commonly bought from groceries and markets. The quality attributes that respondents consider when buying oysters and mussels include appearance and taste (e.g. large, fresh, flavourful and clean), price, source and cooking method (e.g. half-cooked, well-cooked). Oysters and mussels are usually bought from wet markets/supermarkets and restaurants. Based on buying price, the respondents said oysters are more expensive than mussels because the former is difficult to produce, lesser quantity per serving, and high demand. About 60% of the respondents consider the price of oysters and mussels reasonable because they are affordable.

Based on the interviews, the three major places where oysters and mussels come from are Roxas City, Capiz, and Hinigaran. It was noted that since Roxas City is the seafood capital of the Philippines, this makes it famous for its oyster and mussel products.

The market for oysters and mussels is mainly domestic and the potential for international market is yet to be examined especially since the conditions of the growing environment is critical for export products. Examination of international market potential and issues is presented in Appendices 5 & 8. A market flow chart, based on the survey, is shown in Appendix 12.

Supply chain for oysters and mussels

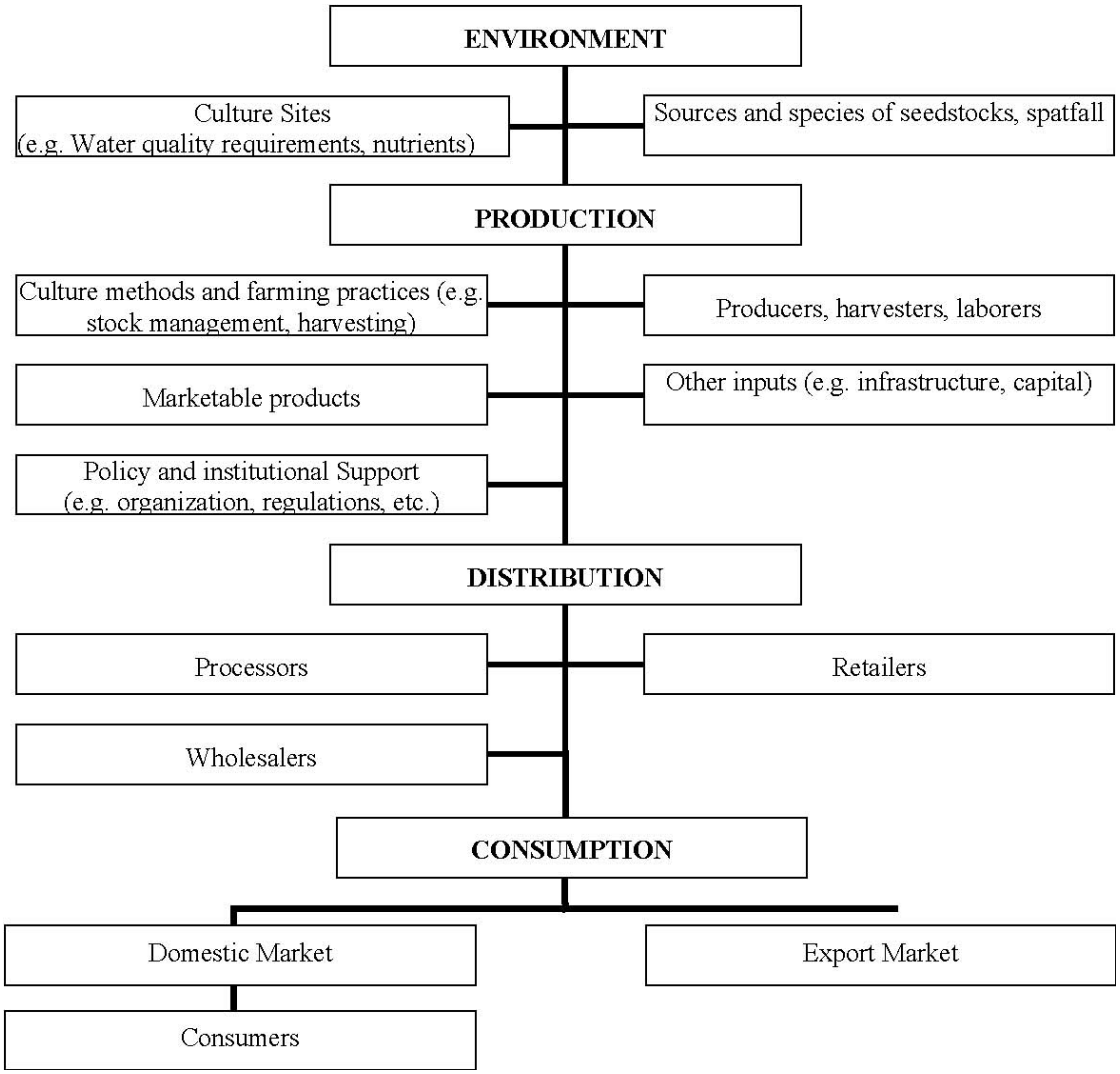

Fig. 7.4 Supply chain for oysters and mussels

Objective 4. Analysis of legal and policy framework for aquaculture management, environmental impact, production, processing and marketing to determine compliance and regulatory influence on regional production and competitiveness

Mollusc aquaculture is an important economic activity in coastal fishing communities in the Philippines, although it has been of lower priority in the strategic development plans of local and national governments. While the growth of the finfish aquaculture sector is economically positive, mollusc aquaculture presents certain challenges to government agencies such as the Bureau of Fisheries and Aquatic Resources (BFAR) (part of the Department of Agriculture) that seek to find a balance between promoting sustainable growth in the industry while minimizing environmental effects to fish and fish habitat.

Production of cultured shellfish in the Philippines is low compared to other parts of the world. While the global production of marine bivalve aquaculture, including mussels, oysters, clams, and scallops, has increased, bivalve aquaculture in the Philippines has stagnated.

Legislative provisions for aquaculture

In the Philippines, there are a number of national laws that in many ways govern the aquaculture sector, including the Philippine Fisheries Code of 1998 (Republic Act 8550), Agriculture and Fisheries Modernization Act of 1997 (Republic Act 8435), Philippine Clean Water Act of 2004 (Republic Act 9275), The Philippine Environment Code (Presidential

Decree No. 1152) among others. The Philippine Fisheries Code is the most comprehensive legislation on fisheries and aquaculture that supersedes Fisheries Decree of 1975 (Presidential Decree No. 704). Herein, aquaculture is legally defined as 'fishery operations involving all forms of raising and culturing fish and other fishery species in fresh, brackish and marine water areas' (Section 4, No. 3, Republic Act 8550). The whole text of Article III of the Code lays down directives for the conduct of aquaculture in the country. It includes provisions on the granting of fishpond lease agreements (sections 45, 46, 49 and 50), codes of practice for aquaculture (section 47), incentives and disincentives for sustainable aquaculture (section 48), grant of licenses and privilege to operate fish capture and aquaculture structures (sections 51, 52, 53), aquaculture insurance (section 54), non-obstruction to navigation and defined migration paths (sections 55 and 56), and registration of aquaculture facilities (section 57). Pursuant provisions include Implementing Rules and Regulations (IRR) and Fisheries Administrative Orders (FAOs) were released to provide guidelines in the implementation of the Code. The national law then presents a framework for guiding regulators, in particular the local government units, in the management of fisheries and aquaculture.

With the decentralized system of governance in the Philippines in view of the implementation of the Local Government Code of 1991 (Republic Act 7160), the management and utilization of aquatic resources within the municipal waters are vested upon the local government units (LGUs). Thus, all coastal activities including aquaculture within the municipal waters are governed by local laws and regulations in the form of ordinances and resolutions. The municipal waters 'include not only streams, lakes, inland bodies of water and tidal waters within the municipality which are not included within the protected areas as defined under Republic Act No. 7586 (The NIPAS Law), public forest, timber lands, forest reserves or fishery reserves, but also marine waters included between two (2) lines drawn perpendicular to the general coastline from points where the boundary lines of the municipality touch the sea at low tide and a third line parallel with the general coastline including offshore inlands and fifteen (15) kilometers from such coastline. Where two (2) municipalities are so situated on opposite shores that there is less than thirty (30) kilometers of marine waters between them, the third line shall be equally distant from opposite shore of the respective municipalities' (section 4, no. 58, Republic Act 8550). Each coastal city or municipality enacts coastal or fisheries ordinance (which also contains aquaculture provisions) that is in harmony with the national legislation, albeit LGUs may also be creative in formulating such ordinance relevant to the unique conditions of the area. Shellfish aquaculture is a sector within aquaculture and therefore, most shellfish regulations in place were developed as subset of aquaculture.

While there are national legislation which support the aquaculture industry, the challenging part would be the enactment and implementation of local legislation. Most local ordinances relating to shellfish aquaculture are intended for revenue generation (e.g., collection of permit fees for the operation of oyster or mussel beds), while to manage and regulate the operation of the industry would be secondary in purpose. This is perhaps understandable as the industry does not contribute substantially to the local economy of many coastal municipalities and cities, and costs without benefits are not conducive to long-term industry development.

The preceding sections analyze the national and local laws and policies in relation to their function and contribution to shellfish aquaculture. Legal provisions direct LGUs in designating areas for oyster and mussel culture and these are exemplified in each coastal city/municipality's Fisheries Ordinance (Appendix 13).

Regulatory agencies/institutions in aquaculture

Aquaculture management has been a combination of local government and national government regulations. Both national and local governments are charged with roles and responsibilities including regulatory, compliance and inspection, planning, research and development, monitoring, and coordination. At the national level, the Bureau of Fisheries and Aquatic Resources (BFAR) under the Department of Agriculture has the central role

in regulating aquaculture development in the country. It also interacts with other national agencies such as the Bureau of Agricultural and Fisheries Product Standards (BAFPS), Bureau of Animal Industry (BAI), Environmental Management Bureau (EMB) on issues concerning food quality and safety, fish feeds, and environmental impacts, respectively. BFAR is responsible in overseeing and implementing regulations relating to the country's finfish and shellfish aquaculture industries, and generally serves as the primary agency that assists the local government units and fishing communities. On the other hand, the local government rather than national agencies is responsible for many issues such as providing permits, licenses and regulating environmental issues at the local level.

The local government unit (LGU) has the main responsibility to manage aquaculture within its territorial waters. Exclusive authority to implement laws and regulations within municipal waters is vested upon the LGU concerned, specifically the local chief executive or the Mayor, who with regards to the aquaculture industry, has the power to grant permits, leases and licenses upon review of submitted application. The granting of lease provides a shellfish farmer (i.e. oyster/mussel farmer) with a right to use portion of the coastal waters. In addition, the local government also has exclusive authority to establish conditions for compatible use of each lease site, as well as to implement programs for research, development, and marketing. The decentralization somehow reduced tensions and conflicts between national and local authorities because the law already defines respective mandates with regards to aquaculture management based on geographical jurisdiction. It however, places heavy responsibility on the LGU, who oftentimes is inexperienced in coastal affairs. The regulatory authority granted to the LGU assumed that it has the required expertise or has access to appropriate expertise to make well-informed decisions. Responsibilities such as determination of carrying capacity, environmental assessment, etc. may have been overwhelming to LGUs having limited resources and expertise.

To assist the local government in decision-making, the Fisheries and Aquatic Resource Management Councils (FARMCs) have been created in all coastal cities and municipalities which will serve in an advisory capacity pursuant to Article II, Republic Act 8550 and Executive Order 240 (1996). The establishment of FARMCs is a promising mechanism to integrate fishers in coastal management since over 50% of its members are fisherfolk representatives. Although the FARMCs' role is advisory in nature, its recommendatory function in the enactment of fishery ordinance and enforcement of fishery laws, rules and regulations is important for shellfish aquaculture.

Main players in the oyster and mussel industry

Producers/Farmers

Much of the shellfish aquaculture industry has been developed by coastal fishing communities. Oyster and mussel culture is closely related to small-scale fishing as discussed in the other section of this report, and often considered as secondary source of livelihood for a fishing community. The major stakeholders in this sector include small-scale fishermen, laborers and harvesters who belong to the economically and socially marginalized group. By contrast, the group of powerful players includes local officials, influential leaders, middlemen/traders and processors. The oyster/mussel farmer's access to sites is determined by regulations and social network. Although it cannot be denied that due to unequal power relationship access of the marginalized group to the sites may be restricted. In order to overcome this, it is important for the oyster and mussel farmers to be organized, so their interests and concerns may also draw attention. Aarset (2002) argues that institutional structure promotes and restricts interests, and thus decides the government's ability to implement and enforce policies. Interviews with oyster and mussel farmers revealed that only 19% and 28% (N=440) of the respondents are aware of existing oyster and mussel growers associations and fisherfolk organizations, respectively. Such low values only indicate that oyster and mussel farmers who are affected by shellfish aquaculture policy outcomes may not have the power to collectively bargain in favor of their interests and objectives.

In general, access to shellfish aquaculture in Philippine waters is restricted by law. Specifically, only the following are allowed:

- Citizens of the Philippines
- Partnerships, associations or corporations duly registered in accordance with law, at least sixty per centum (60%) of the authorized capital stock of which belongs to citizens of the Philippines;
- Cooperatives duly registered in accordance with law, at least sixty per centum (60%) of the authorized capital stock of which belongs to citizens of the Philippines;
- Cooperatives duly registered in accordance with law

The above is not discounting the fact that subsistence fishermen have preferential rights on the use of communal marine and fishing resources pursuant Article 13, Section 7 of the Philippine Constitution and strengthened in succeeding legislation such as Republic Act 8550.

Siting and planning for shellfish aquaculture

The legal basis for the location of shellfish aquaculture facilities is found in Section 51, Republic Act 8550. The provision directs LGUs in consultation with FARMCs to designate oyster and mussel growing areas. Further, these potential sites have to be thoroughly evaluated by BFAR in consultation with the Department of Environment and Natural Resources (DENR) and National FARMC (NFARMC) to ensure that ecological and social conditions are sustained and protected (Section 2, FAO 214). The evaluation may be supported by a sanitary survey of the shellfish growing areas referred to in FAO 209. The survey considers potential pollution sources from domestic/land based and industrial waste discharges, septic tanks and other aquaculture activities; water quality based on bacteriological criteria for faecal coliform, and other pathogens; and meteorological and geographical evaluation such as salinity, depth, rainfall patterns and intensity and prevailing winds.

Coastal Zoning

Coastal zoning is an important consideration in identifying potential aquaculture sites. It reduces conflicts and ensures equitable access to a common resource, among others. Executive Order 533 (2006) provides for the adoption of integrated coastal management (ICM) as a national management policy framework for the sustainable development of coastal and marine resources. The Order recognizes coastal and marine use zonation as a management tool, and such shall be applied when LGUs formulate, plan and implement ICM programmes in their respective coastal and marine areas. This means that LGUS would have to apportion their coastal waters according to zones (e.g., fisheries, aquaculture, marine reserves, conservation and preservation, etc.) wherein descriptions are contained in the Coastal Zone Management Plan document. There are specific laws that govern aquaculture zones in municipal waters. For instance, section 51 of Republic Act 8550 states ‘that not over ten percent (10%) of the suitable water surface area of all lakes and rivers shall be allotted for aquaculture purposes like fish pens, fish cages and fish traps’. This provision is very important when situating shellfish farms since rivers are favorable environment for oyster and mussel culture. However, most rivers in this current research are not in good state. Many were congested with structures and may have been in violation of the provisions on obstruction to navigation and free flow of tide (FAO 216) and defined migration paths (FAO 217). Apparently, fixed structures (whether fish traps or aquaculture structures) occupy more than 10% of the river area. Without a legislated zoning plan, structures are commonly established anywhere in the rivers.

Oyster and Mussel Sites

The choice for shellfish growing areas is guided by FAO 209, series of 2001. Rivermouths and estuaries are considered the most productive and favorable sites for oyster and mussel culture because of their nutrient-rich environments. Thus, many farms visited

during this research are located near rivermouths, which are the recommended sites in FAO 209. However, the uncontrolled proliferation of structures becomes a problem with respect to flushing and water circulation. In some cases, the prescribed depth of 3 to 4 meters and 0.5 to 3 meters for mussels and oysters, respectively using pole or stake method, and 8 to 10 meters for floating raft (FAO 209) may no longer be true in many growing areas as some rivers and bays have become shallow. There are even oyster farms (especially those using stake and rack method) which during low tide are exposed. In addition, it has been a common practice not to remove oyster and mussel structures (especially the stake method). Instead, old bamboo structures are pushed down and buried further in the sediment to give way to new structures. This practice leads to shallower area and sedimentation. The scope of the existing law, especially at the local level, can be extended to cover issues such as dismantling. Some municipalities (e.g. Dumangas) restrict or prohibit the use of stake and broadcast methods per Fisheries Ordinance of 2004-01.

About 72% of the survey respondents (N=440) observed the degradation of the culture environment. They attribute it mainly to several factors; too many structures constructed in the area which slows water exchange, faecal wastes coming from agricultural and residential areas, excess nutrients from fishpens and cages, etc. These factors are also considered major threats to the long-term survival of the oyster and mussel industries.

Water and Sediment Quality

The water and sediment quality of growing areas are important determinants of the quality of oyster and mussel meat. The Philippine waters are classified according to beneficial usages as stipulated in DENR Administrative Order No. 1990-34 and DENR Administrative Order No. 97-23. Designation of water usage and classification is administered by the Department of Environment and Natural Resources (DENR), which through memorandum circular would normally issue the list of classified/reclassified water bodies. There is one classification which pertains to oyster and mussel culture, i.e. Class SA or waters suitable for the propagation, survival and harvesting of shellfish for commercial purposes, having generally the most stringent water quality. Moreover, Class SA would also refer to national marine parks and marine reserves established under existing laws and/or declared as such by the appropriate government agency; and coral reef parks and reserves designated by law and concerned authorities. Examination of DENR Memorandum Circular No. 2003-12, Series of 2003 and DENR Memorandum Circular No. 13, Series of 2004 that list classified/reclassified water bodies in 2002 and 2003, respectively, revealed that very few water bodies are identified under Class SA. Should there be areas which fall under Class SA, these are most likely national parks or marine reserves, such as the Olango Channel (within Olango Island bird sanctuary), and less likely shellfish farms. To ensure water quality is maintained under Class SA, the following parameters are measured: dissolved oxygen (minimum 5.0 mg/l), temperature (maximum rise of 3oC), biological oxygen demand (3mg/l, 5-day 20oC), pH (6.5-8.5), and total coliforms (70MPN/100ml).

FAO 209 prescribes the optimum temperature and salinity as well as types of substrates for shellfish culture. While no specifics were indicated, further provision states that evaluation of water quality be based on bacteriological criteria for faecal coliform and other pathogens.

Environmental Impact Assessment

For any aquaculture project, the law requires the submission of an Environmental Impact Statements (EIS) to the Department of Environment and Natural Resources for review and evaluation before initiating any development activity or construction, pursuant to the provisions of Presidential Decree No. 1586. It is only upon completion of the requirement of an EIS that the DENR Secretary shall issue an Environmental Compliance Certificate (ECC) in order for the development project to proceed (Sections 12 and 13, Republic Act 8550; FAO 214). However, the consideration given to aquaculture projects for the need of

an EIS as required by law has in many cases been weak in comparison to other coastal development projects. This is primarily evident from the fact that although aquaculture applicants are legally required to submit an EIS on the proposed farm sites, in many instances, no such requirement must be satisfied when securing a permit from the municipality/city where the aquaculture farm is to be located.

Strictly, aquaculture projects have to pass through an environmental impact assessment process. Earlier issuances (e.g., Office Circular 3, Series of 1983; DENR Administrative Order 96-37, Series of 1996) considered fishpond development utilizing areas equal to or greater than 25 hectares , and fishery projects (i.e., dikes for/and fishpond development projects) under Environmentally Critical Projects thus would require an ECC. There are projects which may be exempted from the Philippine EIS system per Article II, Section 2.1.3b of DENR Administrative Order 21, Series of 1992. These include projects which: a) discharges minimal amount of wastes and the management of such wastes and the management of such wastes are relatively easy, b) has a capitalization of not more than P500,000, and c) employs not more than 20 persons. Later issuance, i.e. DENR Administrative Order 30-2003, only requires Certificate of Non-Coverage (CNC) for projects unlikely to cause adverse environmental impacts (under Category D). CNC is a certification issued by the Environmental Management Bureau (EMB) certifying that, based on the submitted project description, the project is not covered by the EIS System and is not required to secure an ECC. Although Memorandum Circular No. 1, Series of 2004 mentioned only inland based fishery project with less than 300 square meters area is covered by CNC, it may be assumed that small scale aquaculture/mariculture projects are also included provided they do not generate toxic and hazardous wastes and/or strongly/highly pollutive wastes as prescribed in Memorandum Circular No. 2, Series of 2004. Thus, oyster and mussel farmers would then be required to apply for a CNC even without barangay and/or local government unit endorsements and locational clearances per Memorandum Circular No. 1, Series of 2004. While it is not included as one of the requirements when securing a permit for oyster/mussel culture from the municipality/city, a CNC may be useful for the LGU in monitoring and evaluating aquaculture activities in the area.

Permitting process (leases and licenses)

Prior to the passage of the Philippine Fisheries Code, the application for shellfish culture is filed with the office of the Regional Director concerned where the area is located (FAO 168). The application was accompanied with the Bureau of Technical Survey Map (BTSM) chart indicating the approximate location and boundaries (longitude and latitude) of the area, and a copy of the Articles of Incorporation and/or Certificate of Registration duly approved by the offices concerned. With a decentralized system, the application process now proceeds at the local level.

Permit Procedure

The grant of permits for shellfish aquaculture operation generally proceeds through a public bidding process. The City/Municipal Council through its Committee on Bidding advertises notices for the grant of exclusive fishery rights to duly registered fisherfolk organizations/cooperatives in the areas of zones of the municipal waters available for aquaculture, sea ranching and farming; operation of fish aggregating devices, fixed and passive fishing gears; and fry and fingerling gathering (Sections 17, 22, Republic Act 8550). Specifically, for erecting corrals, taking or catching bangus (milkfish) fry or fry of other species for propagation, or the construction and operation of mussel or oyster culture beds. The notices are posted in conspicuous place in the city/municipality for a designated period of time (e.g., not less than 15 days) or published once in a newspaper of general circulation in the city/municipality, if available. Should there be no interested bidder opting to lease any fishing area within the city/municipal waters, the Mayor upon recommendation of the City/Municipal Council or legislative body (locally known as Sangguniang Bayan) is authorized to award the privilege to operate oyster and mussel culture beds within a specified area or portion of the municipal waters to individuals, upon

payment of license therefore, at the rates not exceeding those prescribed by the city/municipality. Permits are only granted to licensed individuals, organizations or cooperatives. In some cases (e.g. Dumangas municipality), in order to apply for a permit an applicant is also required to submit a Barangay Clearance, Articles of Incorporation or Partnership, By-laws and Certificate of Registration in case the applicant is a corporation, association or partnership and a sketch plan/map of the area applied for. Also, in certain circumstances, the city/municipality may find it necessary to inspect the area being applied through its authorized city/municipal representative prior to the issuance of permit. Aside from complying with the provisions non-obstruction to navigation, flee flow of tide and defined migration paths, oyster and mussel structures should also observe distance from each other and also buffer zones. The LGU, through its Mayor, may issue a standard lease with duration of usually one year, covering a site of not more than 1.0 hectare for individuals while 5-10 hectares for partnership, associations, corporations or cooperatives depending on the city/municipality.

Responsibilities of Oyster and Mussel Farmers

During the duration of the permit/license, the lessee is responsible for any and all acts of his agents, employees or laborers in the establishment, management, or operation of the shellfish farm lots (Sec 11b, FAO 168) and also in keeping a record indicating the date of culture, quantity, date of harvest, and the capital invested (Sec. 11c FAO 168), The information contained in the record book will be used in the preparation of an annual report to be submitted not later than January 31 of each year to BFAR, through the local government unit, indicating the volume of production (FAO 218; FAO 214). The LGU may opt not to issue licenses for renewal should the leasee fail to comply with the reporting requirement. Although such provisions of the law exist, in reality reporting of shellfish aquaculture production has not been a practice. Collection of information through regulatory means does not seem to work and the reason for non-compliance maybe that farmers find very little or no incentive to conscientiously collect monitoring data.

Shellfish quality and safety

Postharvest Handling

Section 4, FAO 209 lays down the guidelines for handling, transporting and packaging of shellfish, including prohibition of personnel with health concerns (i.e., personnel with cuts, open wounds or suffering from communicable disease) to handle the shellfish. This provision, though very important, is difficult to implement unless the city/municipality regularly monitors the activity.

Safety and Quality

Most oyster and mussel produced in the country are marketed domestically. In other countries, in order to assure that the shellfish grown in local waters came from properly classified waters and are harvested, packed, and shipped under sanitary conditions tagging or product certification is commonly practiced. Presently, domestic market for oyster and mussel (similar to other fishery products) in the Philippines does not require such certification. But when it concerns export, FAO 210, series of 2001 sets the requirements for the exportation of fish products which follow a certification system in compliance with the Standard Sanitation Operating Procedures (SSOP) and Hazard Analysis Critical Control Point (HACCP). Section 2c outlines the biological, chemical and microbiological standards. Further, FAO 212, series of 2001 specifies requirements for the processors and exporters so that their products are compliant with national and international regulations. Eco-labelling however, was already introduced in FAO 214 as one of the incentives to encourage compliance with the environment standards and promote sustainable management practices on aquaculture.

The requirements for pre-processing and processing establishments, and processing of shellfish and shellfish products are listed in FAO 211, series of 2001. Section 8 lists the quality requirements both for domestic and export which include acceptable

microbiological levels, acceptable levels of PSP toxins, and chemical contaminants. While Section 10 directs local governments to enact appropriate ordinance with penalty clause, this has yet to be incorporated in local fisheries ordinance.

Since red tide is a regular occurrence in many coastal waters in the country and has been a continuous threat to the oyster and mussel industry, the National Red Tide Task Force headed by the Bureau of Fisheries and Aquatic Resources has been created at the national level. The Task Force monitors toxic red tides and regularly issues red tide update to ensure that the public is protected from illness or death caused by the red tide toxin and mitigate its impact to the shellfish industry. Shellfish ban is imposed on areas found to be contaminated with toxic red tides.

Institutional support

The bivalve aquaculture in the Philippines may be considered as a marginal industry, compared to the more established finfish or crustacean aquaculture. The finfish and shrimp farming industries, being matured industries are surrounded by supportive institutions. In contrast, the oyster and mussel industry lacks supportive institutions and thus, has to survive on its own without institutional support.

The success of any business venture depends largely on marketing opportunities. Based on this present research, the oyster and mussel industry lacks market support as well as a market framework. While some cities/municipalities have established postharvest facilities, the manner by which oysters and mussel farmers, traders and processors could avail of such support should be clear.

Logistical problems related to data and information collection often causes a lag time in available information and thus production data is often delayed or incomplete. However, the local governments are instructed to issue auxiliary invoice as a requirement for shipment of fishery and aquaculture products from the point of origin. When strictly implemented, the information generated from the issuance of auxiliary invoice can be useful.

Also monitoring and enforcement of laws and regulations both at the national and local levels seem to be too difficult because of limited regulatory staff and LGUs have to deal with a wide range of concerns.

FAO 192, series of 1997 created the Fisheries Quarantine Service which regulates the domestic movement of fish and fishery products including oysters and mussels.

FAO 215, series of 2001 provides guidelines on the insurance of crops/stocks in aquaculture projects. The coverage is limited against crops/stock loss due to natural disasters and an extended coverage due to fortuitous events and force majeure/natural calamities. While this has been long enacted, oyster and mussel growers are unable to access insurance for their products.

Conclusion

In the Philippines, bivalve shellfish aquaculture has not experienced regulatory scrutiny. As indicated previously, while it is clear that appropriate legislation and regulatory capacity exists, the actual practice and enforcement in local areas appears quite variable. Our site visits indicated significant coastal areas utilized by mollusc aquaculture, but equally clearly they appear not to have designated areas, instead sharing with other activities such as fish culture and fish trapping, often rather haphazardly constructed and opportunistic. Oftentimes, low-valued industry such as oyster and mussel culture is relegated on the side. Localised commitment to sector specific aquaculture, ideally based on appropriate scientific, economic and social assessment within areas has been internationally demonstrated to provide security and opportunity for long-term industry development. This approach is also recommended for mollusc aquaculture in the Philippines.

Objective 5 Second Phase Project Development

As a result of this current project a number of conclusions have been drawn as to how to implement the findings of this work. Factors affecting mollusc aquaculture productivity in different areas do have some common features;

- Environmental variables are not clearly linked to variable production, although sampling of water quality parameters was limited, so definitive conclusions are not possible. However, the somewhat haphazard allocation and enforcement of aquaculture zoning does not assist industry development if incompatible or unsuitable operations or activities are conducted together, or in sub-optimal sites. Sector-specific site identification and allocation may be a key to improving environmental and production outcomes.
- The supply chains are not clearly defined in most areas, at least in the sense of having producer groups, intermediate traders (middle men) and wholesalers or specific customers. Individual farmer productivity is variable and not necessarily seasonal, with harvesting activity based on reaching marketable size (often quite small) or the need for immediate money, rather than customer demand and regular orders. There are, therefore, no producer-marketing groups and price is controlled by intermediate traders.
- Farmers do not have well-defined industry groups and appear to behave as individual businesses. Local government does not appear to have strong regulation, either for specific aquaculture zoned areas, or in terms of where mollusc culture can, or cannot, take place in the areas which do support farming. Milk fish culture and harvest fishing appear to complete directly with each other in many areas, and it appears that mollusc culture often has the lowest priority.
- Most mollusc culture operations are very low input, with little evidence of stock management, coordinated seed supply, harvesting, marketing or food safety considerations. Many operations appear to be thought of as supplementary crops, and are not the primary source of income. Low product value does not justify additional investment.
- As ‘bottom of the food chain’, both in terms of industry priority and trophic dynamics, bivalve aquaculture is vulnerable to external influences on water quality and product safety. With no significant or coordinated sanitation monitoring programmes in place, limited sewerage infrastructure, abundant untreated sewage inputs, no marketing or industry peak body, it seem unlikely that individual producers can have any significant effect on large-scale improvement efforts. It requires both ‘top down’ and ‘bottom up’ approaches, and therefore the cooperation and commitment of both local government and producers.

Several potential approaches to future industry development are therefore proposed, based on these conclusions.

Option 1

The Municipality of Roxas City, in northern Panay (Visayas) is well known throughout the Philippines as the ‘Seafood Capital’ and the area supports numerous fishing, aquaculture and seafood industries. Preliminary discussions with the Roxas City Mayor, the Honorable Vicente Bermejo and City Coastal Resource Management Coordinator, Mrs. Belinda Garrido, in October 2008 indicated strong support for the concept of a ‘model’ bivalve mollusc aquaculture industry development programme being based in the area. The concept is to develop a 3-5 year collaboration between researchers, aquaculturists and local government to achieve a significant improvement in the management, industry coordination, status, production output and economic and social value of the local industry. This may be achieved through improving production practices (eg, spat supply and stock management), improving allocations and enforcement of shellfish growing

areas, monitoring and improving water quality, development and coordination of industry organizations, identification of marketing strategies and opportunities, and finally through quantifying indicators of economic or social value.

While Roxas City have indicated support for this to be developed in their area, it would clearly be beneficial to identify and develop several comparative sites during the project (Maqueda Bay in Samar is an additional possibility).

Option 2

An alternative, though conceptually related option has been develop and was discussed in conjunction with various staff members at UPV (Miag-ao) in November 2008. The concept is called “Shellfish BED” (Shellfish Based Economic Development) and would take a multidisciplinary approach, using the existing project team in collaboration with associated UPV researchers and NGOs etc, essentially an enhanced version of Option 1, but with multiple sites and multi-disciplinary expertise. The concept note on Shellfish BED is provided in Appendix 9.

Option 3

Finally, ACIAR, as part of its ongoing commitment to aquaculture and fisheries development in the Philippines is currently proposing the development of a new, long-term project; ACIAR-Philippines Mariculture Enterprise development Project (FIS/2006/143)

This project proposes National Maritime Science Centre (Southern Cross University/ University of New England) as the Australian organisation, under Prof Alistair McIlgorm (NMSC Director) and with SEAFDEC Aquaculture Division, Iloilo, as the Philippines organisation. This project will incorporate several sub-projects; seaweed, mudcrabs, molluscs, marine finfish and holothurians, all with broadly related issues of improving industry development. It is an opportunity to incorporate Options 1 & 2 into a much larger scale programme of research, with the potential for increased collaboration and shared outcomes. Both Barney Smith and Alistair Mcligorm visited the project team at Iloilo in early 2009 to discuss the development of this project.

A project proposal on Philippine Mariculture Enterprise Development Project (FIS/2006/143) is provided in Appendix 10.

8 Impacts

At this time, the impacts of the project are difficult to quantify since we are still in the reporting phase of the project. We anticipate however, that relevant government agencies and local officials will utilize the results to improve decision-making processes and the socioeconomic conditions of oyster and mussel farmers without compromising the environment. One important consideration is how to effectively integrate bivalve aquaculture in a coastal zoning plan and provide coordination to the industry to improve production, post-harvest handling and marketing systems.

8.1 Scientific impacts – now and in 5 years

Now

There have been no identifiable changes in scientific practice outside the project.

However, in terms of scientific knowledge, this project has undertaken the most thorough survey of Philippines bivalve aquaculture yet conducted. Although limited to specific sites in Luzon and Western Visayas, these are the principal producing regions, and a total of 388 surveys were conducted, encompassing all aspects of the production and supply chains. An overview of these data are presented in this report, although it is clear that such a large, validated and potentially important data set requires and a more comprehensive presentation. As such, the project team is planning two publications on the current status of production and demography of Philippine bivalve aquaculture.

5 Years

The survey data mentioned above should provide a valuable base for future research and planning associated with bivalve aquaculture in the Philippines.

If a second phase of this work, involving the development of a pilot scale ‘best practice’ culture operation(s) is developed and implemented, then this work will provide an important starting point for more focused bivalve aquaculture in the future. This will be especially likely as part of a larger scale, multi-species project which is one option currently being explored.

8.2 Capacity impacts – now and in 5 years

Now

Duncan: has gained new experience and knowledge working in an industry sector, and in a country which is significantly different from his own, or that previously experienced. The scale of aquaculture generally in the Philippines is far greater than previously encountered, as are some of the management, social and environmental issues. Duncan has utilised this knowledge as part of his teaching role with examples and information being used in advanced level undergraduate courses at USC. This project has also provided an opportunity to enable a 3rd year undergraduate student (Mr Mahdi Green) at USC to document aspects of the existing mollusc aquaculture practices and regulation in Australia. The resulting report has been included in the Appendices of this final ACIAR project report, where it is intended to provide some additional international perspective for the Philippines project team, but has also significantly enhanced the students experience and knowledge in this area.

Duncan has also enhanced existing field work and project management capacity, which will be valuable beyond the context of this project.

The project provided opportunities for the team of the partner institution (UP Visayas) to undertake collaborative works with local officials/leaders and coastal communities.

Informal discussions were conducted to discuss the project and share information on the status of the oyster and mussel industry either at the local or national level.

Two (2) project team members (Andalecio and Laureta) undertook short-term training workshop organised by ACIAR and increased their capacity in economic research methods and project management.

Hidalgo: being a specialist in fisheries post-harvest, the project has provided experience of the oyster and mussel aquaculture industries in the Philippines. A better understanding has been gained regarding how aquaculture practices affect quality and food safety of these aquatic organisms which is useful for teaching and research purposes.

Previous research on oyster and mussel processing conducted by Hidalgo, indicated that qualities of raw materials varied depending on the source. In addition, Hidalgo had also recently undergone training on food safety and quality assurance. Such experiences became useful for this current project in assessing how the mollusc industry in the Philippines could possibly be competitive in terms of quality food safety in both domestic and international markets. Relating the effects of aquaculture practices to quality and food safety of the product is very useful in enabling recommendations to local government units for improvements in the mollusc industry. Future researches could also be geared towards how production (aquaculture) and post-harvest aspects could be approached holistically for the safety of the consumers.

Research Assistants: the project currently employs several early-career scientists in the Philippines and has provided opportunities for them to undertake a diverse range of scientific data collection including producer interviews, water quality parameters, mollusc tissue and shell sample processing for microbial and biometric parameters, as well as components of this final report.

The project has provided several items of sampling and analytical equipment to the partner institution (University of the Philippines in the Visayas) which will build capacity in environmental and water quality monitoring. Specifically, the project has provided water quality meters for the measurement of dissolved oxygen, temperature, conductivity, pH and turbidity. The project has also supplied various sampling equipment including; sediment corer, portable weighing scale etc. This equipment will provide scientific R & D capacity and technical assistance to the aquaculture industry beyond the current project.

5 Years

It is reasonably foreseeable that the outcomes of this project will enable the development of further work in the field of bivalve mollusc aquaculture, both for the current project team, and as a stimulus for future research projects in the Philippines. It also seems likely that the extensive survey undertaken for this study will become a benchmark for the next 5 years, particularly so if it is published in an international, peer-reviewed journal. This publication would be a priority outcome for the next year.

Beyond this obvious short-term goal, the opportunity to utilize the data and experience gained during this project is to a large extent dependant on the successful development of a second implementation project. If this can be developed then it would seem likely that team members will gain enormous opportunity to develop expertise in this industry sector, and to develop and enhance the current aquaculture production and its contribution to small-scale coastal community development. Current team members would be in a strong position to contribute significantly to a large-scale, multidisciplinary aquaculture project.

8.3 Community impacts – now and in 5 years

Now

Community impacts have yet to be recognized since no result dissemination has been conducted. However, when local fishers found out that oyster and mussel farming is being

given attention through this project, they showed great enthusiasm and support. They agreed to be interviewed (388 surveys conducted) and offered significant assistance in the collection of samples.

5 Years

As indicated above, we strongly believe that the survey results themselves represent an important contribution to the development of the Philippines bivalve aquaculture industry. As such, it seems possible that this work will be a stimulus for future, related projects which should be beneficial to coastal communities with an interest in developing or sustaining their mollusc aquaculture operations. In the face of more commercially valuable, but potentially more environmentally-damaging coastal activities, the enhancement of low-cost, low-impact industries can only be positive. This project has successfully quantified aspects of the current industry and provided valuable information to enable future planning and development of mollusc aquaculture.

8.3.1 Economic impacts

Now

There have been no changes in monetary wellbeing as a result of this project, as it is currently in a reporting, rather than dissemination phase.

5 Years

It seems clear from our study that the low value, low imput nature of bivalve aquaculture, as well as the competition from other more valuable sectors, such as finfish farming, results in the industry having relatively little coordination, consideration or political influence. As such the industry is perhaps the coastal equivalent of subsistence farming. There appears little opportunity to break this cycle, unless a more coordinated and supportive attitude is taken, both by industry members and by management authorities. Thus, the intention of any second-phase implementation project would be to attempt such a change, albeit on a small scale, test the concept and then, if favourable, disseminate the model to other areas. Such a proposal would require a multi-disciplinary science team, along with the collaboration of farmers and local government, and a directed approach to the problems production management, product safety and marketing. The potential to make major economic gains, and employment opportunities for local economies could be significant.

8.3.2 Social impacts

Now

The project has made the local government and national government officials in some of coastal municipalities more aware of the problems relating to oyster and mussel culture. They have now signified willingness to find solutions to the problems. For example, the mayor of Roxas City is willing to invest in projects that will assist the oyster and mussel operators improve their industry. Through presentations of preliminary results of the project in seminars (e.g. Panaad Festival and Coastal Water Use Zoning Workshop on March 24-26, 2009), local governments are encouraged to do something for the oyster and mussel industry, commencing work at the environment level.

5 Years

If implementation of a second phase project occurs, then social impacts, particularly at the chosen sites, are likely to be significant. If a major, multi-disciplinary research project is directed towards improving industry production and value, through water quality improvements, sanitation, increased environmental awareness, reduced conflict between resource users, increased and more valuable production, then social benefit seems likely. For example, Luzon has more valuable and better production output, and also a younger farmer demographic. Perhaps there is a link between maintaining younger people in rural

coastal areas and the provision of a viable industry option for employment and wealth generation. If so, social benefit may follow.

8.3.3 Environmental impacts

Now

There have been no changes to current management practices or impacts on the state of natural resources as a result of this project at this time, although it is reasonably anticipated that this may occur after completion. We have however, obtained some information as to the current environmental status in some bivalve mollusc growing areas.

5 Years

Part of any longer-term, large-scale implementation project would be the enhancement of environmental awareness for producers and managers in the trial areas. This project has collected environmental data, both water quality and microbiological, and while it is apparent that the organisms are tolerant of a wide range of conditions, it is also clear that there are limits (mass mortalities have been reported anecdotally, and within the survey responses), and bacterial, algal or chemical contamination could damage both local and international markets. Product safety, environmental quality and long-term environmental monitoring programmes would be an integral part of any second phase project.

8.4 Communication and dissemination activities

There have been no project-related publications from this work to date, although discussions about potentially suitable articles have occurred; two possible papers on Philippine bivalve aquaculture survey results (possibly for Journal of Shellfish Research).

Prior to field work activities, meetings with local government officials especially the mayor (or local chief executive) and staff of the Municipal Agriculture Office in each municipality were conducted to orient them about the project, request collaboration, explain their involvement, and also for the provision of secondary information that the project required.

Preliminary results of the microbiological and water and sediment quality analyses were provided to Roxas City, Capiz in response to the request of the city mayor to provide them with a copy. It was made clear however, that these results should only be utilized for reference purposes and not for decision-making since these are preliminary results.

October 25, 2008- visit of Dr. Barney Smith to explore partnerships for the development and implementation of a long-term research project on oyster and mussel aquaculture.

Seminars and Articles

- Duncan delivered a seminar on "Scallop Fisheries, Aquaculture and Seabed Ranching in Queensland" on November 26, 2008, during his visit for the first field collection in Visayas.
- Andalecio presented the project in a seminar during the Panaad Festival 2008 held on April 28, 2008 in Negros. This was attended by agricultural scientists and farmers.
- The project has been featured in a brief article in the USC Science, Health and Education Faculty newsletter.
- The project has also been featured in an article in the UPV campus newspaper.
- February 2009, ACIAR Newsletter article to report on visit by ACIAR staff to UPV for update and discussion about project

Project coordination/reporting/planning meetings

- December 2007, UPV, Iloilo City. Project meeting with team members (Duncan, Andalecio, Hidalgo, Peralta, Agbayani)

- April 2008, Bolinao. Progress meeting with Barney Smith ACIAR and project team
- April 2008, Baguio. Project meeting with team members (Duncan, Andalecio, Laureta, Peralta, Hidalgo, project research assistants)
- November 14, 2008 Project team and UPV staff workshop to discuss potential second phase project. Miagao, Iloilo
- January 16, 2009 Dr. John Skerritt, (Deputy CEO ACIAR) and Ms. Mara Faylon (ACIAR Assistant Manager- Philippines met with UPV project members. Miagao.
- February 3, 2009. Dr. Barney Smith, Fisheries Program Manager (ACIAR) met with UPV project members. Miagao

9 Conclusions and recommendations

9.1 Conclusions

This scoping study intended to obtain basic information about the current status of mussel and oyster aquaculture in Luzon and Western Visayas in order to understand and explain differences in production and value between the two areas. Assuming that some potential reasons would become evident, the study would form the basis of a longer-term implementation project, with the aim of achieving better equity for Western Visayas, and a model for the long–term, sustainable development of the Philippines industry as a whole.

Bivalve samples collected provided evidence that there are differences in relative size and weight between the two areas, consistent across sampling sites. There is also some indication that oysters and mussels are perhaps in better condition during the dry season, compared to the wet season. However, this is complicated, since there are not simply two seasons, but rather 4 seasons during the year, and so the observed effects may lag somewhat relative to their causes. Although somewhat speculative, since the trend was not consistent across all sample sites, there does appear to be an increased phosphorus concentration in sediment samples during the wet season. This may result in improved growth rates during the subsequent dry season. Phosphorus levels were also significantly higher in Luzon than Visayas, perhaps offering some explanation for different productivities. However, the sources of such nutrients are not clear, nor have we been able to discount factors such as farming practice differences (see below). Water quality differences between the areas appear unremarkable, nor is there any obvious difference between wet and dry seasons, although water quality does tend to stabilize for most parameters in the wet season, probably due to better mixing.

We have presented mean values for water quality, but of note were the sometimes extremely low individual values recorded for both dissolved oxygen and pH, particularly towards the bottom of depth profiles. Values at many sites reached as low as 1.7-2.5 ppm for DO, and 4-4.5 for pH, particularly during the dry season, presumably due to stratification. While this may account for some reported mortality events, it is also clear that the bivalves are quite tolerant to extreme water quality conditions. In this regard they perhaps represent good culture options in areas of high environmental variability due to hydrological or climatic characteristics.

Microbiological data from water and molluscs indicated typical results for an anthropogenically-influenced sub-tropical marine system. Again, data collection frequency prevents conclusive statements, but clearly significant food safety risks exist in both areas (eg. high faecal coliform counts (and probable associated pathogens) and Vibrio species). The Visayas appear to show more consistently elevated bacterial levels, although reasons for this are unclear. Most areas do not comply with international standards of shellfish safety. There is good justification for increased monitoring of potentially harmful micropathogens, including bacteria, viruses and microalgae, especially if export markets are the ultimate goal for industry development.

The survey results, which, for the first time, document Philippines mollusc aquaculture from practices to personnel perspectives, provide significant insight into the industry. In relation to differences between areas, there is a tendency towards more culture-method diversity in the Visayas, compared with Luzon, which tends to use stakes or racks for mussels, compared with rafts in the Visayas. Similarly, Luzon tends to favour rack methods for oysters, whereas in the Visayas, stakes, racks, rafts and combination methods are all used to a large extent. The significance, if any, of these differences requires further investigation, although it is possible that Luzon systems are more efficient for particular species, having developed aquaculture practices over a longer period. Similarly, Luzon tends towards younger farmers and larger areas under cultivation, with

implications for long-term industry prospects. There is some indication of a more 'business-like' approach in Luzon, with greater financial commitment (deliberate purchase), larger farm areas, and more productive methods per unit area.

A low proportion of farmers in both areas undertake significant stock management practices, reflected in activities like thinning and spat collection. This was confirmed by survey, and is indicative of industry investment, and perhaps the absence of significant extension activities.

There is little formal industry organization, i.e. producer, marketing or product quality associations. Harvest and marketing of bivalves in Western Visayas is demand driven, and price is set by buyers, not producers. Industry organization is no better developed in Luzon.

In general, some of the factors which contribute to production differences between the regions have been elucidated, although the short time scale and somewhat limited approach to field sampling means that we cannot be definitive. However, in summary, some environmental variables (possibly nutrient inputs), some industry practices (notably dedicated production methods, stock management, 'economies of scale' factors such as farm size, business attitude and product demand and marketing), a commitment to equitable industry-regulation, as well as microbiological issues warrant further investigation or dedicated research if mollusc culture in Western Visayas and the Philippines are to meet their potential.

9.2 Recommendations

As indicated in Objective 5 results and discussion, we believe that the diverse range of probable causes of variable production makes large-scale, detailed investigation and implementation both difficult and unlikely to succeed. We therefore recommend that smaller scale, selected localities are used to focus the multi-disciplinary requirements of industry improvement, that clear assessment parameters can be identified and quantified during the process, and that a dedicated stakeholder project organization is established to represent, inform and help implement the project. The more likely success of such an approach could then be used as a model to assist the restructure of local industries throughout the Philippines.

It is necessary to have supportive local government, industry and researchers involved, and the possibility of integrating such a programme with other industry sectors, sharing many of the same issues (see option 3), appears desirable. Possible areas of investigation may include;

Industry Practices

- Assessment and optimization of production techniques
- Introduction of appropriate stock management practices

Industry Organization

- Formation of producer organization (for communication and coordination purposes)
- Subsequent development of coordinated marketing practices
- Assessment of site-specific suitability for aquaculture activities and subsequent implementation of dedicated zonation plan.

Product Safety

- Assessment of environmental risks to sustainable bivalve aquaculture (includes Government, industry and research representatives)
- Coordination and implementation of long-term environmental monitoring (e.g. microorganisms)

- Review and assess the current post-harvest handling and marketing practices of shellfish in relation to microbial activity

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10.2 List of publications produced by project

None at the time when this report is being prepared

11 Appendixes

11.1 Appendix 1: Oyster and Mussel Production Survey Form

CODE: _____
GPS LOCATION NO.: _____

Date_____
Enumerator: _____

I. General Information

Name of respondent	
Address of respondent	
Location of Farm (indicate if more than 1 farm is being operated and locations of the farms) Barangay/river middle of the river, near river bank, coastal, river mouth	
Age	
Sex	☐Male ☐Female
Civil status	☐Single ☐Married ☐Widow ☐Separated
Highest educational attainment	
Major Occupation	
Minor Occupation	
When did you start oyster/mussel farming?	
Who introduced you to oyster/mussel farming?	
Why did you venture into oyster/mussel farming?	
Ownership of oyster/mussel farm	☐ Sole proprietorship/respondent only ☐ partnership ☐ others _____
What is your initial capital for set up?	
If sole proprietorship, what is the amount of capital invested in 2006	
If partnership, number of partners including respondent	
Nature of contribution per partner (cash or kind—bamboo, labor, etc.)	
What is your source of capital?	☐Own money ☐Loan ☐ Investors
If loan, sources	☐Bank (name) _____ ☐Private lenders
Amount (PhP)	
Date borrowed	
Interest rate	
Collateral	
Maturity (duration of loan)	
schedule of payment	☐every 15 days ☐quarterly ☐monthly ☐annual ☐others
Mode of payment	☐cash ☐others, specify _____

Are you paying the municipality rental fees for operation of mussel/oyster farms? If yes, how much?	

II. Description of the farm

	OYSTERS	MUSSELS
Local name of oysters/mussels (How many classes?)		
Total area occupied /Farm size		
Water depth		
High tide		
Low tide		
Why did you choose it? (did you consider sediment characteristics, water quality characteristics, pollution inputs, anything else?		
Is it possible to expand area? Why/why not?		
Was oyster mussel operation continuous? If no, why?		

III. Seed Collection

	OYSTERS	MUSSELS
Do you use any method of forecasting spatfall		
What materials do you use for collecting spat on? (cultch material)		
Cost of spat if bought from a hatchery? Estimate cost if self collected		
Do you obtain any spat from other areas for production on your site? (Yes or No)		
How many spats do you usually buy?		
Do your spat suppliers use any method of forecasting spatfall		
What materials do you use for collecting spat on? (cultch material)		
Method of transport & handling spat		
Refixing? (yes or no)		
Hardening/conditioning method and period (if any) number of hours		
Cost of spat		
Months of spatfall		
Peak		
Medium Low		
Do you have problems with supply of spat?		

IV. Culture practice

Method of culture (specify if oyster or mussel)	
Bottom (broadcast?)	Substrate: ☐empty shells ☐stones ☐old tires (what kind?, pretreatment (cleaning))

Stake DRAW…	No. of rows _____ Distance between rows _____ No. of stakes/row _____ Distance between stakes _____ Height of stake _____ Length of embedded portion of stake _____ Substrate: ☐bamboo ☐wood (kind) ☐fishnet ☐others
Rack DRAW…	Materials as post: ☐bamboo ☐wood ☐others Vertical post/rack: number _____ height _____ Horizontal bar: length _____ Total number of racks _____ Number of strings per rack _____ Distance between strings Substrate: ☐empty shells: length of string _____ distance between shells _____ ☐old tires: Type: Description:
Raft, submerged or fixed: DRAW….	How is raft fixed in water column: ☐tide to bamboo posts: Number _____ Length _____ ☐anchored: material _____ Height of raft from bottom _____ Number of rafts _____ Length of raft _____ Width of raft _____ Number of poles per raft _____ Number of strings _____ Length of strings _____ Distance between strings _____ Substrate: ☐rope (what type) _____ ☐stringed shells: (what kind of shell) _____
OTHERS (describe) DRAW…	☐tray ☐raft, floating ☐long-line ☐rope-web ☐lattice
Reasons for choice of culture method (e.g., Cost, Easily available equipment, Other farmer/government advice, Etc)	
Culture cycle (in 2006) (Months)	Spatfall _____ Setting of spat collectors _____ First harvest _____

	Last harvest _____
Number of crops/yr	
What was your production in 2006?	

V. Harvesting/Postharvest

	OYSTERS	MUSSELS
Which months do oysters/mussels grow faster? Why?		
Which months do oysters/mussels experience slow growth? Why?		
Method of harvesting per culture method (indicate procedure and tools used)		
Reasons for harvesting? (Size and age (specify), fat, need for cash, bad weather/typhoon, orders from buyers, good market prices, holiday period etc)indicate in order of likelihood		
How often do you harvest during the peak period?		
Number of times/wk		
Number of weeks/month		
How many months do you harvest until stock is totally harvested?		
Size at first harvest		
Length		
Width		
Weight		
Estimated Mortality from spat to market size (%)		
Who is responsible for harvesting?	☐respondent ☐other family members (specify) ☐buyer (specify) ☐ other farmers _____	☐respondent ☐other family members (specify) ☐buyer (specify) ☐ other farmers _____
Expenses incurred during harvesting (specify kind and amount)		
Estimated quantity harvested per pole or string during last harvest (specify unit)		
Can you distinguish live oyster/mussel from dead ones? How do you distinguish (ie do you sort harvest ?)		
Do you do cleaning of attached organisms? If yes, what method?		
Do you do sorting (by size, species, etc)? What about grading for quality?		
Do you count or weigh the harvest? If yes, what method?		
What are the materials used in packaging?		
Who does the packaging?		
How are the oysters/mussels transported?		
Who transport oysters/mussels?		
When was your last harvest?		
How many kg did you harvest last time?		
Disposition of last harvest (quantity, specify unit). How many kg or how much goes to the ff:		
Home consumption		
Given away		

	OYSTERS	MUSSELS
Sharing		
Sold		
Others		

NOTE: 1 sack = _____ kg 1 box/case = _____ kg
1 kerosene can= _____ kg 1 basket/kaing= _____ kg

VI. Marketing

	OYSTERS	MUSSELS
What months do you harvest and market more volume? PEAK		
What months do you harvest and market less volume? LEAN		
What shell size is marketable?		
Where do you market your products? Give all markets in order of most common first		
How far are your main markets from the source? (give approximate distances and transport time to each)/ Market accessibility?		
Who is responsible for marketing?	☐respondent ☐other family members (specify) ☐buyer (specify) ☐farmer collective	☐respondent ☐other family members (specify) ☐buyer (specify) ☐farmer collective
Who buys your mussels and/or oysters? (Indicate the town/province where your buyers came from)		
Processor		
Restaurant owner		
Retailer/Vendor		
Middlemen		
Exporter		
Others (specify)		
Product form (indicate if shell-on (fresh or cooked) or shucked (fresh or preserved)) – or approximate proportion of each		
Selling price per unit (specify what unit)		
Do buyers have specific preference/requirements for your products? What kind? Give examples? Size, weight, packing method, live appearance, cleaned shells etc		

VII. Socio-economics

	OYSTERS	MUSSELS
Who manages the farming operation? (family, corporation)		
Who are involved in the operation? (indicate husband, wife, children) What kind of involvement do they have?		
Do you receive government support/technical assistance? What?		

Have you attended any training in farming of oysters & mussels? IF yes, what was it about and who organised it? If no, do you think it would be useful and would you attend if it was available What content would you find most useful		
Is the income derived from oyster/mussel culture adequate? Why/why not?		
Do your children show interest in oyster/mussel culture? Why/why not?		
Would you encourage your children to enter the same business (oyster/mussel culture? Why/why not?		

VIII. Production Costs

Assets Used in Oyster/ Mussel Farming (2006)

Item	Description* (Capacity, length, etc.)	Number	Acquisition Cost/Unit	Economic Life
Bamboo Raft				
Boat				
Engine				
Hut				
Tools				

Structural Materials

Item	Description* (Capacity, length, etc.)	Number	Acquisition Cost/Unit	Economic Life
Wood				
Bamboo*				
Floats				
Anchors				
Rope				
Others				

* For rack and raft culture only.

Substrate

Item	Description* (Capacity, length, etc.)	Number	Acquisition Cost/Unit	Economic Life
Bamboo				
Tires				
Shells				
Fish Nets				
Others				

Containers

Item	Description* (Capacity, length, etc.)	Number	Acquisition Cost/Unit	Economic Life
Baskets				
Sacks				
Case				
Can				
Glass				

Bottles				
Others				

Assets Used in Oyster/ Mussel Farming (2006)

Item	Description* (Capacity, length, etc.)	Number	Acquisition Cost/Unit	Economic Life
Bamboo Raft				
Boat				
Engine				
Hut				
Tools				

Structural Materials

Item	Description* (Capacity, length, etc.)	Number	Acquisition Cost/Unit	Economic Life
Wood				
Bamboo*				
Floats				
Anchors				
Rope				
Others				

* For rack and raft culture only.

Substrate

Item	Description* (Capacity, length, etc.)	Number	Acquisition Cost/Unit	Economic Life
Bamboo				
Tires				
Shells				
Fish Nets				
Others				

Containers

Item	Description* (Capacity, length, etc.)	Number	Acquisition Cost/Unit	Economic Life
Baskets				
Sacks				
Case				
Can				
Glass				
Bottles				
Others				

Variable Costs Per Cropping (1990)

Cash Expenses

Labor	No. of Persons	No. of Days	No. of Hrs/Day	Wage Rate
Caretaker				
Hired Labor				
Staking				
Rack/Raft construction				

Boring shells				
Stringing shells				
Setting of substrate				
Harvesting and Cleaning				
Packing				
Marketing				
Repairs				
Others				

Other Expenses Amount
Repairs _____
Marketing/transport _____
Others _____ _____
_____ _____
_____ _____

Non- cash Expenses:

Labor	Owner		Family		
	No. of days	No. of hrs/day	No of family members	No. of days	No. of hrs/day
Staking					
Rack/raft construction					
Boring shells					
Setting substrates					
Harvesting/Cleaning					
Packing					
Marketing					
Others					

Fixed Costs (2006)

Mayor's Permit _____ (peso/year)
Municipal Permit _____(peso/year)
Boat Rental _____ (peso/_____)
Raft Rental _____ (peso/_____)
Others_____ _____ (peso/_____)

IX. Resource Management

Are you aware of an association for oyster/mussel farmers in your area?	
If yes, what is the name of the association?	
What are the objectives of the association?	
Are you a member? If no, why not?	
Are you aware of a Fisherfolk Association in your locality?	
If yes, what is the name of the association?	
Are you a member? Why or why not?	
Do you know where the source of spat is? What specific location	
Do you maintain broodstock animals?	
If yes, what is the size of the area of broodstock	
Is the broodstock in fixed location? If it is moved, how often?	
Do you do thinning of stock?	
If yes, what size is being thinned and how often?	

Do you try to maintain a specific density?	
Where do you dispose the thinned animals? (e.g., home consumption, marketed, refixed (for mussel), placed in tray (for oyster))	
Pest control (specify control measure) for the following?	
Predator	
Substrate borer	
Other (fouling organism)	
Do you clean attached organisms?	
What is the main fouling organism at your site Cleaning method used	
Frequency (days/wk)	
Do you notice seabed degradation?	
Cause of degradation/sedimentation	
Prevention	
Remedy	
Do you observe or measure pollution in the water?	
Sources	
Nature of pollution (e.g., industrial, domestic, agricultural)	
Composition (e.g., solid, chemical)	
Prevention	
Remedy	
What do you think are the major threats to your business?	

X. Additional Information

Sources of Income

	No. of Days/Week	No. of Hours/Day	Est. Monthly income
Major			
Minor			
Others			

Household information:

Number of children _____

Number of persons living in household _____

Information regarding all household members

Name	Relation to Respondent	Sex	Age	Educational Attainment	Occupation	Nature of Involvement in Oyster/ Mussel Culture

* Staking/raft construction, boring/stringing shells, harvesting, repairs/maintenance, etc. or indicate none.

11.2 Appendix 2: Harvesters of Oyster/Mussel Survey

CODE: _____
GPS LOCATION NO.: _____

Date: _____

Name of Enumerator:_____

Respondent's Profile

Name of the Respondent : _____
Address:_____
Number of years in current residence: _____
Age : _____
Sex: ( ) Male ( ) Female
Civil Status: ( ) Single ( ) Married ( ) Widow ( ) Separated
Highest Educational Attainment:
( ) College Level ( ) College Graduate ( ) Vocational
( ) High School Level ( ) High School Graduate ( ) Elementary Level
( ) Elementary Graduate ( ) Others _____
What is your main source of income? _____

Income from different sources:

Income Sources	Average monthly income

Members of the Family:

Name	Relationship to the respondents	Gender	Age	Highest Educational Attainment	Major source of income	Living with the respondents (YES/NO)

Fish and shellfish products that you harvest? ( ) oyster ( ) mussel ( ) others, pls. specify _____
Aside from being harvester, are you also a ( ) Retailer ( ) Wholesaler ( ) Processor ( ) Store owner ( ) Restaurant owner ( ) Others, specify _____
Name of business (if any) _____
Location of the business/Address _____
How many years have you been in the business? (Indicate year started) _____

Other than you, who else participates in oyster/mussel harvesting?

Name	Relationship to the Respondent	Place of Residence

2. Harvesting Profile

Harvesting Profile	Oyster	Mussel
Describe the harvesting system in your area?		
Where do you usually harvest? Location		
Do you go to the same operators whenever you harvest?		
If you harvest from the same operators, about how many of them and from where?		
How do you connect with the operators?		
Do you also operate an oyster/mussel farm? If yes, why do you still harvest from other operators?		
Months of the year harvesting is done		
Peak harvest months		
Number of hours per day harvesting is done		
Average number of persons harvesting		
Average quantity harvested per day		
Average number of days in a week when harvest is done		
How many harvesters do you think are there in your market area?		
How do you pay the operator? Describe your arrangement?		
Buying price		
Do you pay in cash or credit?		
If on credit, what is the arrangement?		
Do you employ other modes of payment?	☐ In advance ☐ In kind ☐ Deferred ☐ Check ☐ Others (pls specify) _____	☐ In advance ☐ In kind ☐ Deferred ☐ Check ☐ Others (pls specify) _____
What is your arrangement with the operator/s? Specify.		

Harvesting Profile	Oyster	Mussel
What personal or economic benefits do you get from them?		
Method of transport	☐ None ☐ Motorcycle ☐ Bicycles ☐ Tricycles ☐ Truck ☐ Bus ☐ Boat ☐ others, specify _____	☐ None ☐ Motorcycle ☐ Bicycles ☐ Tricycles ☐ Truck ☐ Bus ☐ Boat ☐ others, specify _____
Transport cost per method		
Are you particular about where oysters or mussels are harvested?		
When you harvest, what quality attributes of products are most important to you?		
How do you know that you are getting good products?		
Which place would you prefer to harvest from?		
What area in the Philippines do you think are the oyster/mussel production highest?		
Where in the Philippines produces the best oyster and mussel?		
What problems do you encounter in harvesting oysters and/or mussels? Pls. Specify		
Do you also have conflicts with other harvesters? What kinds?		
How do you deal with competition?		

3. Selling Profile

Selling Profile	Oyster	Mussel
Do you have regular buyers?		
From where are your buyers?		
Average quantity sold per buyer and unit price		
What is your arrangement with the buyer?		
Months when prices are high		
Reasons these are peak selling months?		
How do you sell the products?	☐ with auction ☐ without auction ☐ cash ☐ Others Specify how _____	☐ with auction ☐ without auction ☐ cash ☐ Others Specify how _____
How are products paid?	☐ In advance ☐ cash ☐ In kind	☐ In advance ☐ cash ☐ In kind

Selling Profile	Oyster	Mussel
	☐ deferred ☐ check ☐ on credit (how many days) _____ ☐ Others (pls specify) _____	☐ deferred ☐ check ☐ on credit (how many days) _____ ☐ Others (pls specify) _____
Average quantity sold per day		
How are the products priced?		
Average selling price?		
Where are products mainly sold? (specify location). Check as many as you can	☐ Store Owner ☐ Restaurant ☐ Park Street vendor ☐ Public fish market (Where?) _____ ☐ Dealers who sell to other areas _____ ☐ Retailers who sell them locally ☐ Local consumers ☐ Neighbors ☐ Processors ☐ Exporters ☐ Others, specify _____	☐ Store Owner ☐ Restaurant ☐ Park Street vendor ☐ Public fish market (Where?) _____ ☐ Dealers who sell to other areas _____ ☐ Retailers who sell them locally ☐ Local consumers ☐ Neighbors ☐ Processors ☐ Exporters ☐ Others, specify _____
How are they prepared when you sell them (check as many as applicable)?	☐ raw ☐ steamed ☐ fried ☐ broiled ☐ stewed ☐ Others (pls specify) _____	☐ raw ☐ steamed ☐ fried ☐ broiled ☐ stewed ☐ Others (pls specify) _____
Do you have problems in selling them? If yes, what kinds?		
How is price information disseminated?		
Do you know where the final destination of the oyster/mussel you market? If yes, where?		

4. How are the oysters/mussels...

	HARVESTING STATION	SELLING STATION
Handled		
Packaged		
Stored		
Transported		
Graded/classified		

5. Harvesting and Marketing Investments and Costs

Assets/Materials

Item	Description* (Capacity, length, etc.)	Number/Volume	Acquisition Cost/Unit	Economic Life
Storage				
Boxes				
Ice				
Vehicles				

Variable costs

Labor

Type of labor	Total number	Salary (indicate if per day/month/job contract)	Incentives

Other Expenses

Item	Cost	Remarks
Shop rent/land tax		
Fuel		
Materials (e.g., ice, salt, water, etc.)		
Repairs and maintenance		
Transportation		
Transaction (tel. bill, etc.)		
Interests		
Commodity/cost of raw materials		
Advertisement		

Fixed costs

What are the types of fees that you pay related to fish marketing and processing and how much?

Type of fees	Paid to…	How much
Market fees		
Tax		
Auctioneer commission		
Mayor's Permit		

6. Credit Facilities

What is your source of capital? ☐ Own money ☐ Loan ☐ Investors

If loan, sources? ☐Bank (name) _____ ☐Private lenders _____

Amount (PhP) _____

Date borrowed _____

Interest rate _____
Collateral _____
Maturity (duration of loan) _____
Schedule of payment ☐every 15 days ☐quarterly ☐monthly
☐annual ☐others
Mode of payment ☐cash ☐others, specify _____
Do you also borrow in kind? ( ) Yes ( ) No
If yes, please enumerate, where and how are they paid?

Items borrowed	From where or whom borrowed	Mode of payment

Do you have overdue loans? ( ) Yes ( ) No
If yes, why? _____

Name the credit or lending institutions that you know and assess their accessibility (put a check)

Lending/credit institutions	Very easy	Easy	Difficult	Very difficult	Reasons

I. Resource Management

Are you aware of an association for oyster/mussel farmers in your area?	
If yes, what is the name of the association?	
What are the objectives of the association?	
Are you a member? If no, why not?	
Are you aware of a Fisherfolk Association in your locality?	
If yes, what is the name of the association?	
Are you a member? Why or why not?	
Do you notice seabed degradation?	
Cause of degradation/sedimentation	
Prevention	
Remedy	
Do you observe or measure pollution in the water?	
Sources	
Nature of pollution (e.g., industrial, domestic, agricultural)	
Composition (e.g., solid, chemical)	
Prevention	
Remedy	
What do you think are the major threats to your business?	

Are there problems in oyster/mussel culture? What are these?

PROBLEMS	PROPOSED SOLUTIONS
Seed Collection	
Culture	

Harvesting	
Postharvest	
Marketing	
Financing	
Others	

11.3 Appendix 3: Consumer Preference Survey

CODE: _____
Date: _____
Enumerator: _____
Name: _____
Address: _____
Age: _____
Sex: ☐ Male ☐ Female
Civil Status: ☐Single ☐Married ☐ Widow ☐ Separated
Highest Educational Attainment:
☐ Elementary ☐ High School ☐ College ☐ Graduate
☐ Post Graduate ☐ Vocational ☐ Others, pls. specify _____
Occupation: _____
Employer: _____
Monthly Household Income Range:
☐≤P6,000 ☐ P6,000-10,000 ☐P10,000-15,000 ☐P15,000-20,000
☐P20,000-25,000 ☐ P25,000-30,000 ☐P≥30,000
Religious Affiliation: ( ) Catholic ( ) Protestant ( ) Aglipay ( ) Islam
( ) Others _____
Ethnic origin: ( ) Tagalog ( ) Cebuano ( ) Boholano ( ) Ilonggo
( ) Waray ( ) Others _____
Number of household members _____
Status of respondent in the household ☐ Father ☐ Mother ☐ Daughter
☐ Son ☐ Others _____
Are you a member of any environmental group or social association? Which group?
_____
Have you heard about eco-labelled products? What is it about?
_____
How often does your family eat fish and seafoods?
☐ Daily
☐ Weekly
☐ Every two weeks
☐ Monthly
☐ Never
☐ _____
DO YOU EAT THE FOLLOWING?
OYSTER ☐ YES ☐ NO
MUSSEL ☐ YES ☐ NO
IF NO, WHY NOT? _____
IF YES, PROCEED TO SUCCEEDING SECTION…

A. Consumption Patterns

Questions	OYSTERS	MUSSELS
Which would you prefer? Oyster or mussel? Why?		
Which months do you usually eat oyster or mussel?		
Have you observed if available whole year round?		
Are these the best time to eat them? Why?		
When is the best time to eat?		

Questions	OYSTERS	MUSSELS
How often, on average, do you consume during season (please check ONE)	☐ Daily ☐ Weekly ☐ Every two weeks ☐ Monthly ☐ Never _____	☐ Daily ☐ Weekly ☐ Every two weeks ☐ Monthly ☐ Never _____
Where do you eat them (check as many as apply)?	☐ Home ☐ Community gatherings/party ☐ Restaurant ☐ Park street ☐ Others (pls specify) _____	☐ Home ☐ Community gatherings/party ☐ Restaurant ☐ Park street ☐ Others (pls specify) _____
How do you consume them (check as many as apply)?	☐ raw ☐ steamed ☐ fried ☐ broiled ☐ stewed ☐ Others (pls specify) _____	☐ raw ☐ steamed ☐ fried ☐ broiled ☐ stewed ☐ Others (pls specify) _____
What other oyster and mussel products have you tried? (e.g., oyster sauce, mussel chips, etc.)		
Where did you get them?		
With whom do you eat oyster or mussel?	☐ father/mother ☐ husband/wife ☐ children ☐ brother/sister ☐ colleagues ☐ friends ☐ Others, specify _____	☐ father/mother ☐ husband/wife ☐ children ☐ brother/sister ☐ colleagues ☐ friends ☐ Others, specify _____
When you eat either at home or in a restaurant, what quality attributes of products are most important to you?		
Is oyster/mussel part of your meal?		
How would you like your oyster/mussel served?		
How would you usually prepare/cook oyster/mussel?		
Can you estimate how many pieces can you eat in one sitting?		
What other food/drinks do you eat with oysters/mussels?		
Do you have problems with eating them?		
Can you eat anywhere? Is		

Questions	OYSTERS	MUSSELS
the source important to you?		
When was the last time you had eaten them?		

B. Purchase and Pricing

Questions	OYSTERS	MUSSELS
Place where you are MOST LIKELY to buy the product. (Specify location)	☐ Convenience Store ☐ Retailer ☐ Wet market/ Supermarket ☐ Restaurant ☐ Park Street vendor ☐ Others, specify _____	☐ Convenience Store ☐ Retailer ☐ Wet market/ Supermarket ☐ Restaurant ☐ Park Street vendor ☐ Others, specify _____
How often do you buy during peak season	☐ Daily ☐ Weekly ☐ Bi-weekly ☐ Monthly ☐ Never _____	☐ Daily ☐ Weekly ☐ Bi-weekly ☐ Monthly ☐ Never _____
Which is more expensive? Oyster or mussel?		
Are they reasonably priced? Yes or No Why do you think?		
How much do you pay?	Per plate _____ Per kg _____ no. of pcs/plate_____	Per plate _____ Per kg _____ no. of pcs/plate_____
Would you be prepared to pay more than you would usually pay? By how much additional?		
Why? In what instance?		
When buying oyster and mussel which quality attributes do you consider? (e.g., price, taste, appearance, size, etc.)		
How does a fatty oyster/mussel look like? What color or texture?		

C. Product Source

Questions	OYSTERS	MUSSELS
Place where you are MOST LIKELY to buy the product. (Specify location)	☐ Convenience Store ☐ Retailer ☐ Wet market/ Supermarket ☐ Restaurant ☐ Park Street vendor ☐ Others, specify	☐ Convenience Store ☐ Retailer ☐ Wet market/ Supermarket ☐ Restaurant ☐ Park Street vendor ☐ Others, specify

Questions	OYSTERS	MUSSELS
	_____	_____
How often do you buy during peak season	☐ Daily ☐ Weekly ☐ Bi-weekly ☐ Monthly ☐ Never _____	☐ Daily ☐ Weekly ☐ Bi-weekly ☐ Monthly ☐ Never _____
Which is more expensive? Oyster or mussel?		
Are they reasonably priced? Yes or No Why do you think?		
How much do you pay?	Per plate _____ Per kg _____ no. of pcs/plate_____	Per plate _____ Per kg _____ no. of pcs/plate_____
Would you be prepared to pay more than you would usually pay? By how much additional?		
Why? In what instance?		
When buying oyster and mussel which quality attributes do you consider? (e.g., price, taste, appearance, size, etc.)		
How does a fatty oyster/mussel look like? What color or texture?		

D. Postharvest, Processing and Quality

	Strongly disagree (1)	Disagree (2)	Undecided (3)	Agree (4)	Strongly Agree (5)
I have already tried oyster and mussel products before					
I am willing to try new product of oysters and mussels					
Public agencies have exaggerated the risk of eating oyster and mussels					
Adequate information is available about the safety of eating oysters and mussels					
The water where the oysters and mussels are collected are free of pollution					
I am concerned with eating raw oyster/mussel					

11.4 Appendix 4: Oyster/Mussel Market Survey

CODE: _____
GPS LOCATION NO.: _____
Date: _____

Name of Enumerator:_____

I. RESPONDENT'S PROFILE

Name of the Respondent : _____
Address:_____
Number of years in current residence: _____
Age : _____
Sex: ( ) Male ( ) Female
Civil Status: ( )Single ( )Married ( ) Widow ( ) Separated
Highest Educational Attainment :
( ) College Level ( ) College Graduate ( ) Vocational
( ) High School Level ( ) High School Graduate ( ) Elementary Level
( ) Elementary Graduate ( ) Others _____
What is your main source of income? _____
Income from different sources:

Income Sources	Average monthly income

Members of the Family:

Name	Relationship to the respondents	Gender	Age	Highest Educational Attainment	Major source of income	Living with the respondents (YES/NO)

Fish and shellfish products that you market? ( ) oyster ( ) mussel
( ) others, pls. specify _____
Do you also operate an oyster/mussel farm? ( ) No ( ) oyster ( ) mussel
Role in oyster/mussel market: ( ) Retailer ( ) Wholesaler ( ) Processor ( ) Exporter ( ) Store owner ( ) Restaurant owner ( ) Others, specify _____
Name of business (if any) _____
Location of the business/Address _____
How many years have you been in the business? (Indicate year started) _____
Average monthly income from oyster/mussel marketing _____
Other than you, who else participates in oyster/mussel marketing?
_____

II. Oyster/Mussel Buying Profile

Buying Profile	Oyster	Mussel
Method of purchase- do you go to the place where to purchase or someone brings the oyster/mussel to you?		
Do you know where the specific area/location the oyster/mussel you buy was harvested? If yes, where?		
Have you been to the area where oyster/mussel is harvested?		
Do you know how they are cultured?		
When you purchase, what quality attributes of products are most important to you?		
How do you know that you are getting good products?		
Do you participate in harvesting?		
Are you particular as to where oysters or mussels are grown?		
Which place would you prefer the product to come from? Why? Be specific as to site		
What area in the Philippines do you think is oyster/mussel production highest in terms of quantity? How do you know?		
Where in the Philippines produces the best oyster and mussel? How do you know?		
Months of the year you normally purchase. Reasons why purchase is done during these months.		
Peak buying months		
Average number of days in a week when purchase is done		
Average quantity bought per day		
Do you have problems in buying them? If yes, what?		
What type of sale agreement do you follow?	☐ oral ☐ legal contract ☐ handwritten ☐ others, specify _____	☐ oral ☐ legal contract ☐ handwritten ☐ others, specify _____
When was the last time you bought?		
Method of transport	☐ None ☐ Motorcycle ☐ Bicycles ☐ Tricycles ☐ Truck ☐ Bus ☐ Boat ☐ others, specify _____	☐ None ☐ Motorcycle ☐ Bicycles ☐ Tricycles ☐ Truck ☐ Bus ☐ Boat ☐ others, specify _____
Transport cost per method		

Buying Profile	Oyster	Mussel
How are they prepared when you buy them (check as many applicable)?	☐ raw ☐ steamed ☐ fried ☐ broiled ☐ stewed ☐ Others (pls specify) _____	☐ raw ☐ steamed ☐ fried ☐ broiled ☐ stewed ☐ Others (pls specify) _____
Buying price?		
Do you pay in cash or credit?		
If on credit, what is the arrangement?		
Do you employ other modes of payment?	☐ In advance ☐ In kind ☐ Deferred ☐ Check ☐ Others (pls specify) _____	☐ In advance ☐ In kind ☐ Deferred ☐ Check ☐ Others (pls specify) _____
Do you buy from the same persons regularly (suki)?		
If you buy from the same persons, about how many of them and from where?		
What is your arrangement with your suki? Specify.		
What personal or economic benefits do you get from your suki?		
What difficulties/problems have you encountered with your suki?		
What problems do you encounter in buying oysters and/or mussels? Pls. Specify		

III. Oyster/Mussel Selling Profile

Selling Profile	Oyster	Mussel
Months of the year you normally sell		
Peak selling months		
Reasons these are peak selling months?		
How do you sell the products?	☐ with auction ☐ without auction ☐ cash ☐ Others Specify how _____	☐ with auction ☐ without auction ☐ cash ☐ Others Specify how _____
Average number of days in a week when you sell these products		
Average quantity sold per day		
Until how many days do you sell oyster or mussel?		

Selling Profile	Oyster	Mussel
For how many days can you maintain quality of oyster/mussel? Why?		
Are you concerned of the quality of what you sell?		
How are the products priced? Describe pricing system and forecast		
Average selling price?		
Does the price vary within the day? For example, those sold in the morning are more expensive than those sold in the afternoon or later. Why?		
In a typical day, how long does it take to sell? (Indicate time start to finish)		
Is there a particular time of the day that they are in demand? Which time? Why do you think?		
Where are products mainly sold? (specify location). Check as many as you can	☐ Store Owner ☐ Restaurant ☐ Park Street vendor ☐ Public fish market (Where?) _____ ☐ Dealers who sell to other areas _____ ☐ Retailers who sell them locally ☐ Local consumers ☐ Neighbors ☐ Processors ☐ Exporters ☐ Others, specify _____	☐ Store Owner ☐ Restaurant ☐ Park Street vendor ☐ Public fish market (Where?) _____ ☐ Dealers who sell to other areas _____ ☐ Retailers who sell them locally ☐ Local consumers ☐ Neighbors ☐ Processors ☐ Exporters ☐ Others, specify _____
Do you have a stall or specific area for selling? If yes, where? Specify location and name of place		
Do you own or rent the place where product is sold?		
If you are renting the place, how much do you pay? And to whom?		
How many people do you think sell oysters and mussels within your market area?		
Do you have the same selling price?		
Do you also have conflicts with other sellers? What kinds?		

Selling Profile	Oyster	Mussel
How do you deal with competition?		
How are they prepared when you sell them (check as many as applicable)?	☐ raw ☐ steamed ☐ fried ☐ broiled ☐ stewed ☐ Others (pls specify) _____	☐ raw ☐ steamed ☐ fried ☐ broiled ☐ stewed ☐ Others (pls specify) _____
Do you have regular customers (or suki)?		
Who are your customers? From where are they?		
Average number of customers in a day?		
Average quantity sold per customer and unit price		
How are products paid?	☐ In advance ☐ cash ☐ In kind ☐ deferred ☐ check ☐ on credit (how many days) _____ ☐ Others (pls specify) _____	☐ In advance ☐ cash ☐ In kind ☐ deferred ☐ check ☐ on credit (how many days) _____ ☐ Others (pls specify) _____
Do you have problems in selling them? If yes, what kinds?		
How is price information disseminated?		

Do you know where the final destination of the oyster/mussel you market? If yes, where?
_____

How are the oysters/mussels….

	BUYING STATION	SELLING STATION
Handled		
Packaged		
Stored		
Transported		
Graded/classified		

IV. Processing of Oyster/Mussel

Processing Profile	Oyster	Mussel
Do you also do processing?	☐ YES ☐ NO	☐ YES ☐ NO
Type of ownership of fish processing enterprise	☐ small-scale household ☐ private enterprise ☐ government-owned enterprise ☐ joint stock	☐ small-scale household ☐ private enterprise ☐ government-owned enterprise ☐ joint stock

	☐ company ☐ others, specify _____	☐ company ☐ others, specify _____
What is the name of fish processing enterprise?		
Type of processed products. Check as many as applicable.	☐ salted ☐ smoked ☐ sauce ☐ chips ☐ others, specify _____	☐ salted ☐ smoked ☐ sauce ☐ chips ☐ others, specify _____
Price per processed product		
Who among the members of your household participate in processing fish?	☐ none ☐ wife ☐ husbands ☐ sons ☐ daughters ☐ others, specify _____	
Income from processing		

V. Marketing and Processing Investments and Costs

Assets/materials

Item	Description* (Capacity, length, etc.)	Number/Volume	Acquisition Cost/Unit	Economic Life
Storage				
Boxes				
Ice				
Vehicles				

Variable costs

Labor

Type of labor	Total number	Salary (indicate if per day/month/job contract)	Incentives

Other expenses

Item	Cost	Remarks
Shop rent/land tax		
Fuel		
Materials (e.g., ice, salt, water, etc.)		

Repairs and maintenance		
Transportation		
Transaction (tel. bill, etc.)		
Interests		
Commodity/cost of raw materials		
Advertisement		

Fixed costs

What are the types of fees that you pay related to fish marketing and processing and how much?

Type of fees	Paid to…	How much
Market fees		
Tax		
Auctioneer commission		
Mayor's Permit		

VI. Credit Facilities

What is your source of capital? ☐ Own money ☐ Loan ☐ Investors

If loan, sources? ☐Bank (name) _____ ☐Private lenders _____

Amount (PhP) _____

Date borrowed _____

Interest rate _____

Collateral _____

Maturity (duration of loan) _____

Schedule of payment ☐every 15 days ☐quarterly ☐monthly ☐annual ☐others

Mode of payment ☐cash ☐others, specify _____

Do you also borrow in kind? ( ) Yes ( ) No

If yes, please enumerate, where and how are they paid?

Items borrowed	From where or whom borrowed	Mode of payment

Do you have overdue loans? ( ) Yes ( ) No

If yes, why? _____

Name the credit or lending institutions that you know and assess their accessibility (put a check)

Lending/credit institutions	Very easy	Easy	Difficult	Very difficult	Reasons/Remarks

VII. Marketing/Processing Facilities

Indicate if the following facilities are present and name them

	In your barangay	Municipality	Other localities
Market outlets (location)			
Transportation			
Road networks			

Landing sites			
Port areas			
Processing plant			
Ice plant			
Chill			
Cold storage			
Others, specify			

What marketing facilities do you think should be present and beneficial to oyster/mussel trade?

_____

VIII. Information Requirement and Regulations

Type of information do you access for marketing (check as many as possible)

☐ None
☐ Price
☐ Quality requirement
☐ Quantity
☐ Technical know-how
☐ Time and location of sale
☐ Demand forecast
☐ Policy and regulation
☐ Others, specify _____

Type of information you need for marketing (check as many as possible)

☐ Price
☐ Quality requirement
☐ Quantity
☐ Technical know-how
☐ Time and location of sale
☐ Demand forecast
☐ Policy and regulation
☐ Others, specify _____

If you are receiving information on oyster/mussel market, what are your sources? Check as many as possible.

☐ Fisherfolks
☐ Producers
☐ Processors
☐ Retailers
☐ Exporters
☐ TV
☐ Books
☐ Leaflets
☐ Local government
☐ Others, specify _____

Do you advertise your products? If yes, in what form?

☐ Printed newspaper
☐ Radio/TV
☐ Calendar
☐ Leaflet
☐ Trade fair
Web page
☐ Others, specify _____

Have you attended any seminar/training/for a on oyster/mussel?

NAME OF SEMINAR/TRAINING	TRAINORS	TITLE/KIND OF TRAINING	DATE	PLACE	REMARKS

Do you know of any regulations or restrictions in fish marketing? What are these?

_____

_____

Name the organization to which oyster/mussel traders and processors belong.

	Name of organization	Are you a member?	Why or why not?
Traders			
Processors			
Producers			

X. Perceptions on the Following

Degree of market competitions (high, medium, low, no competition, don't know)—do pairwise comparison

Competitors	Wholesalers	Retailers	Processors	Restaurant Owner	Others, specify
Wholesalers					
Retailers					
Processors					
Restaurant Owner					
Others, specify					

How often do oyster/mussel prices changed?

☐ Always (everyday to every week) ☐ Most of the time (every month)

☐ Sometimes (every change in weather) ☐ Seldom (once a year)

☐ Rarely to Never

How is price information disseminated?

_____

_____

Price profile all throughout the year? (high, low, medium)

	BUYING		SELLING	
	Oyster	Mussel	Oyster	Mussel
Jan				
Feb				
Mar				
Apr				
May				
June				
July				
Aug				
Sept				
Oct				
Nov				
Dec				

What do you think are the factors affecting oyster/mussel price?

_____

_____

XI. Problems in Fish Marketing and Processing

Enumerate problems, causes, solutions recommended

PROBLEMS	CAUSES	RECOMMENDED SOLUTIONS

11.5 Appendix 5: Principal Cultured Species in the Philippines

Crassostrea iredalei (Faustino 1928)

Common English Name: Slipper-shaped oyster

Local Name: Talaba

Morphological Features: Shell somewhat solid, medium sized but can reach a large size (around 150 mm); the shell is irregularly elongate-ovate-slipper shaped in outline with sinus. Internally the surface is irregular, has a dark brown semi-circular adductor muscle scar impression and chalky white color.

Distribution: C. iredalei are found in lagoons and coastal areas of the country. They are particularly abundant in Bacoor Bay in Cavite, and extend to the Manila Bay, from Ternate, Cavite to Malolos, Bulacan and suburbs up to Mariveles, Bataan; along the coast of Northern Luzon, Lingayen Gulf, Tayabas and Sorsogon; and to some extent in Batangas Bay, Banate Bay in Iloilo, Binalbagan, Hinigaran and Himamaylan in Negros Occidental and regions around Catbalogan in Western Samar, Northern Leyte and Palawan.

This oyster is also found in lagoon areas of the east coast of Peninsular Malaysia and also extends into the southern part of Thailand.

Habitat and Biology: The slipper shaped oysters are estuarine species that prefers firm bottom substrates where their existence is sedentary attached to rocks, debris and shells in their natural habitat. The spats are commonly seen attached from 30 to 40 cm below sea level down to the bottom. Optimum salinity ranges between 17 to 26 ppt although the species can occur even at lower salinities and higher than 35 ppt but growth and reproduction are impaired. This bivalve in the adult and larval stages is filter feeding, feeding on planktons, organic particles and bacteria suspended in the water column. Oysters may be dioecious or protandric hermaprhrodite, most commonly maturing first as males. They spawn throughout the year with peaks from late January to end of February, and from July to early September, or from May to August. They can reach a length of 7.6 cm in 8 to 12 months from setting.

Perna viridis (L., 1758)

Common English Name: Green mussel

Local Name: Tahong

Morphological Features: Perna viridis is a large mussel, 80-100 mm in length, occasionally reaching 165 mm. The shell tapers to a sharp, down-turned beak and has a smooth periostracum that can be vivid green to dark-brownish near the outer edge and olive green near the point of attachment. The shell is elongate ovate in outline with rounded posterior margin and the ventral margin is straight or weakly concave. The interior of the shell is nacreous silver color with bluish-green toning. The beak has interlocking teeth: one in the right valve and the two in the left.

Distribution: The green mussel, or tahong, was once reported to be found only in the Many Bay-Bacoor area. However, now it occurs in bays and inlets along the Northern Coast of Panay from Tinagong Dagat, President Roxasd extending as far west as Makato in Aklan; to a very limited extent in Banate, Iloilo; in several places from Bacolod to Himamaylan in Negros Occidental; and in Maqueda Bay in Samar. Because of invasive characteristics of the species, it is now found in most Southeast Asian countries.

Habitat and Biology: Perna viridis form dense populations on a variety of attachment structures like vessels, wharves, buoys, mariculture equipment and other hard substrata. They are primarily found in estuarine areas with depth up to about 8m and thrive best at salinity range between 27 to 35 ppt but could also tolerate at slightly lower and higher to

the optimum salinity requirement. This species is an efficient filter feeder, feeding on small zooplankton and phytoplankton and other fine suspended organic material. Sexes are separate and fertilization is external. Spawning generally occurs twice a year between early spring and late autumn, however in the Philippines and Thailand spawning occurs all year round. Fertilized eggs developed into larvae and remain in the water column in two weeks before settling. Sexually maturity typically occurs at 15-30 mm shell length (2-3 months age). A 9 cm mussel can release as many as 12 million eggs in a single spawning period of 15 minutes. The life span of this species is typically 2-3 years.

The Global Market for Oysters and Mussels

Oysters (Family Ostreidae), along with mussels (Family Mytilidae), have been important sources of human food and livelihood for thousands of years and, in a global context, these two taxa dominate commercial exploitation of molluscs today. In 1998, oysters alone contributed 3.7 million tonnes, or about 37.8% of the 9.8 million tonnes of total world bivalve production (aquaculture + capture) (Globefish 2000). The production of oyster worldwide increased to 4.7 million tonnes in 2003 (Fig. 3), with Crassostrea gigas (97%) overwhelmingly dominating global production (Fig. 4) (FAO 2005).

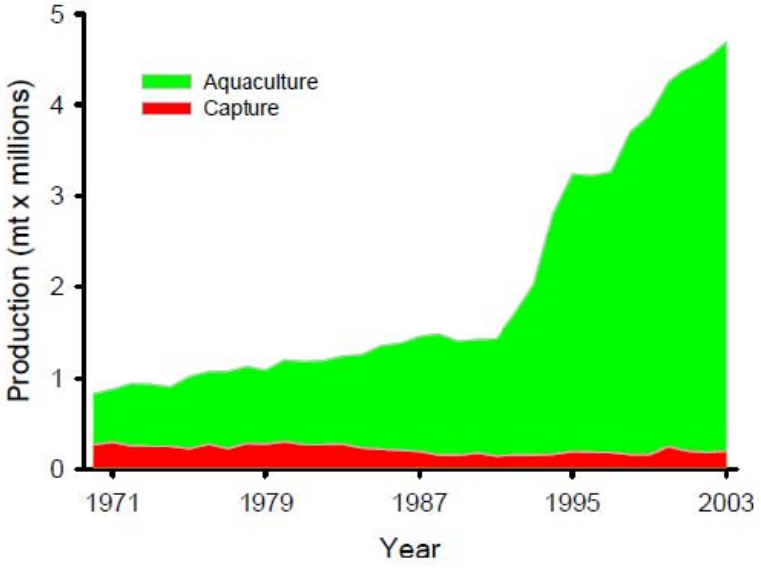


Figure 3. Comparison of oyster capture fisheries and aquaculture production. Source: FAO 2005.

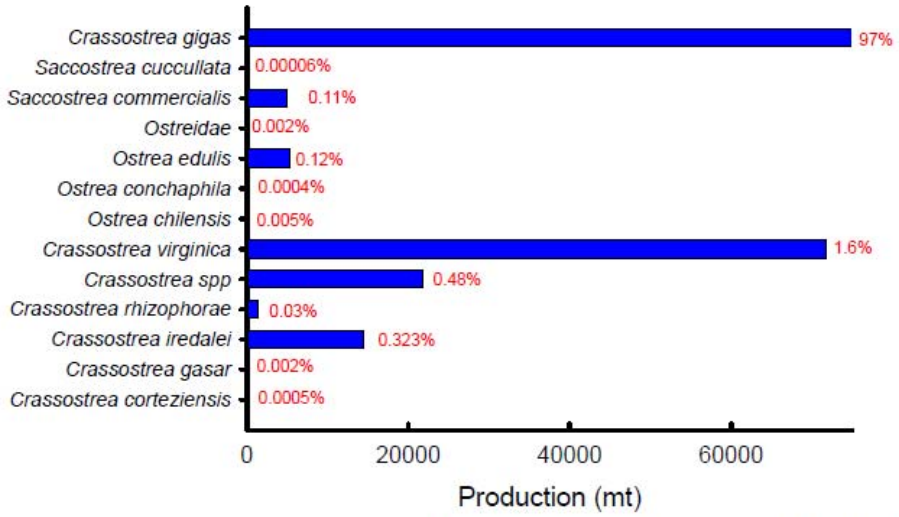


Figure 4. Oyster species and production quantities globally (note: *C. gigas* data are outside of the scale of this graph). Percentages are given as fraction of total oyster aquaculture production in 2003. Source: FAO 2005.

According to the UN FAO, 46 countries produced oysters in 2003. Table 1 shows some of the producing countries and their respective oyster species.

Table 1: Species and area of oyster aquaculture production for 2003. Source: FAO 2005.

Country	Species
Algeria	*C. gigas**
Argentina	*C. gigas**
Australia	*C. gigas*, C. spp, O. spp, Saccostrea commercialis*
Bosnia and Herzegovina	*O. edulis*
Brazil	*C. spp*
Canada	*C. gigas*, C. virginica*
Channel Islands	*C. gigas**
Chile	*C. gigas*, O. chilensis*
China	*C. gigas, C. rivularis, S. cucullata*
Croatia	*O. edulis*
Cuba	*C. rhizophorae*
France	*C. gigas*, O. edulis*
Germany	*C. gigas**
Greece	*O. edulis*
Ireland	*C. gigas*, O. edulis*
Japan	*C. gigas*
Republic of Korea	*C. gigas*
Malaysia	*C. spp*
Mauritius	*S. cucullata*
Mexico	*C. corteziensis, C. virginica, C. gigas**
Morocco	*C. gigas*, O. edulis*
Namibia	*C. gigas**
Netherlands	*C. spp, O. edulis*
New Caledonia	*C. gigas**
New Zealand	*C. gigas**
Norway	*C. gigas*, O. edulis*
Papua New Guinea	*C. rhizophorae*
Peru	*C. gigas**
Philippines	*C. iredalei*
Portugal	*C. gigas*, O. edulis,*
Senegal	*C. gasar*, C. spp*
South Africa	*C. gigas*, O. edulis**
Spain	*C. gigas*, C. spp, O. edulis*
Taiwan	*C. gigas*
Thailand	*C. spp*
Tunisia	*C. gigas*, O. edulis*
United Kingdom	*C. gigas*, C. spp, O. edulis*
United States of America	*C. gigas*, C. spp, C. virginica, O. conchaphila, O. edulis*, O. spp*

*Non-native species in the area cultured

Among the many countries producing cultured oysters, the major producing areas are in the Pacific Ocean along the coasts of China, Japan and Korea. Undoubtedly, China is the world leader in oyster production (Fig. 5).

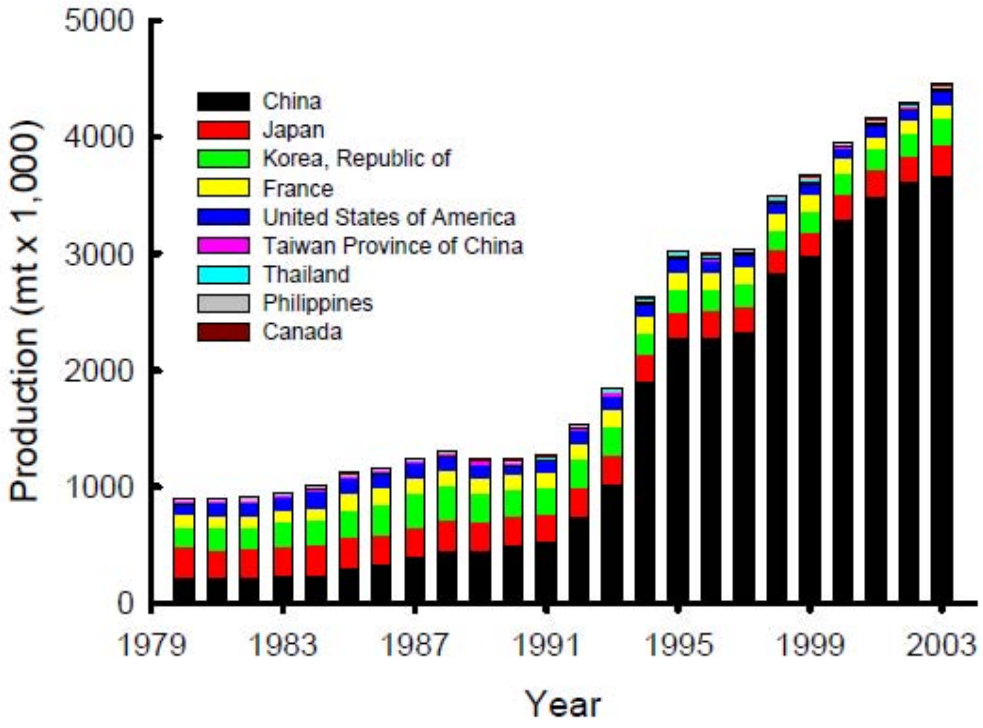
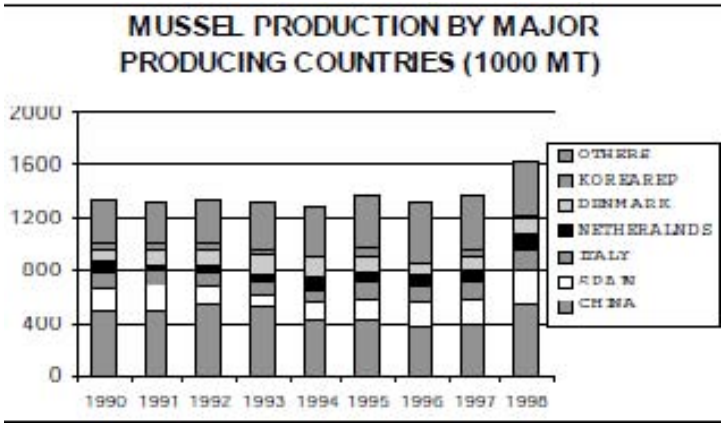


Figure 5. Oyster aquaculture production trends of selected countries. Source: FAO 2005.

By contrast, mussels (Family Mytilidae) contributed about 1.6 million tonnes of the 9.8 million tonnes of bivalve production in 1998. The main mussel produced globally is the blue mussel, Mytilus edulis, (39% of the total mussel produced). China is likewise the leader in mussel production, followed by Spain (Fig. 6) (Globefish 2000) which again mainly cultures M. edulis and, in the Mediterranean, M. galloprovincialis.



11.6 Appendix 6: Culture Methods per Municipality

BOLINAO, PANGASINAN

In Bolinao, a culture set-up (using either stake or hanging rack method) would usually have both mussel and oyster. In the stake method, farmers use either bamboo or wood, or a combination of both as substrate for attachment of mussel/oyster spats. Some operators place bamboo braces across the vertical pole for stability while others add two bamboo poles for every vertical post, placed with an angle and tied with nylon rope, to increase stability of poles. These additional poles also increased surface area for attachment of spat.

The length of the stakes, usually ranging from 3.7-12.8 m, is dependent on water depth or tidal ranges in the area. Distance between stakes ranged from 0.30- 1.8 m and are usually arranged in rows; although some respondents do not do this. Others attach old fish nets and/or sacks to their stakes for more attachment.

In the hanging rack method, racks are usually made of bamboo poles and its vertical post ranges from 3.7 to 12.8 m in height and are 0.5-1 m apart. Most operators use sacks (whole; halved; or braided) and strips of truck tires as hangings or whole/halved motorcycle (old) tires. Distance between sacks is 0.2-0.6 m.

Pens and cages for fish culture are also utilized for oyster and mussel attachment. Mussels and oysters attach to the bamboos of the pen and sometimes to the nets surrounding the pen. They also attach to the floating buoys (drums) of the cages and the mooring system of the cages.

ANDA, PANGASINAN

The methods of oyster and mussel culture in Anda do not differ much from that of Bolinao. Most respondents use stake method and hanging rack method for the culture of oysters and mussels.

The length of the stakes, usually ranging from 3.7 to 12.8 m, is dependent on water depth or tidal ranges in the area. Others attach old fish nets and/ or sacks to their stakes for more attachment.

Some respondents use hanging rack method for their oyster set-up. Empty oyster shells are tied in strings at a distance of 6 inches from each other in a 1-m nylon string. Other operators use old tires (halved or whole) of motorcycles and trucks as hangings, or sacks in the rack method.

MALOLOS, BULACAN

Most respondents in Malolos use the rack method or bottom (or broadcast) method for growing oysters. In the rack method, bamboos with average length of 8.2 m (range 3.7 to 12.8 m) are used as vertical post and arranged in rows. For economic reasons, aside from using bamboos, some respondents opt to use ropes (nylon #8 and #5) as horizontal bars. The choice substrate is then tied to these horizontal bars. The substrate is either empty oyster shells tied in strings; old motorcycle tires; or a combination of both.

In the bottom method, oyster spats obtained from thinning the stake or rack method are broadcasted to the river bed. The area for broadcast method is usually adjacent to the area of a rack or stake set-up. The spats are left for a year or two to grow.

BACOOR, CAVITE

In Bacoor, Cavite, stake method is commonly used. Spats are obtained in situ when this method is used. Bamboos, with length average of 10 m (range of 7.3-12.8 m), are staked into the muddy substrate and used as cultch material. Area covered for this set-up ranged from 15 sq m up to 2 hectares. While the number of bamboo poles staked in one area is not a concern, in general the intervals between posts would usually range from 0.3 – 1 m. Some operators add 2 bamboo poles for every vertical post, placed at an angle and tied with nylon rope, to increase stability of poles. These additional poles also increase surface area for spat attachment.

Another method used is the hanging method. Bamboo is used as structural post. The length of vertical posts range from 9.2-12.8 m; horizontal bars are arranged in grids with lengths depending on the area covered by each set-up. Each set-up covers an area of 0.2 - to 2 has. Spats are either obtained in situ or from other areas (e..g., Bulacan, Malabon or nearby towns of Cavite). In this method, sacks, nets, straw rope, or “plehe” (plastic binder rope) are commonly used substrate for mussel culture while empty oyster shells are used for oyster culture.

BATAN, AKLAN

The culture methods in Batan, Aklan are stake, rack and raft. Some farmers also culture oyster in their fish traps because oyster culture is not permitted in some areas of Batan. Strings with empty shells and old rubber tires are hung at the sides of the fish trap.

The most common method is the stake method wherein bamboo (5.5- 12.8 m) is the only substrate used where organisms are left to grow for almost a year. Most farmers have 1-2 rows of stakes only but others put up to 10-30 rows. This depends on the size of the area. In the rack method, the farmers place bamboos as horizontal bars where strings with empty shells are hung. Other farmers use old rubber tires as substrates in the rack method. The distance between substrate is 0.5 meters.

Raft method is also used; the length of the raft is approximately 12 meters. Some farmers use strings and old rubber tires as substrate but others just let the oysters and mussels attach directly to the raft.

ROXAS CITY, CAPIZ

In Roxas City, broadcast, rack, raft and stake methods are commonly used. The farmers broadcast oyster and mussel collected from thinning the stakes, rack or raft. The area for broadcasting is usually near their stake, rack or raft set up. The raft method in Roxas City is with or without hangings. In raft without hangings, oyster and mussel attached directly to the raft while in raft with hangings, old rubber tires, whole or cut in half, are used as substrate.

The stake method uses a 1-3 m long bamboo as substrate spaced at 1-2 meters. An average of 1 meter of the stake is embedded in the mud.

In the rack method, the strings with empty shells, 6 inches apart and old rubber tires (tricycle and motorcycle tires) cut into half, are used as substrates. The height of the

bamboos ranged from 5-10 meters. Most culture sites in Roxas are situated near river banks.

DUMANGAS, ILOILO

The methods of culture in Dumangas are bottom, rack, raft and stake method. Racks are made of bamboo poles with an average height of 2 meters. It has horizontal bars with an average length of 23 meters. The substrate used in rack method is empty shells at 8-10 pieces per string. The organisms are exposed during low tide because Dumangas has shallow waters.

The raft method in Dumangas uses nylon or rattan as substrate. Some farmers do not use substrates other than the raft made of bamboo.

The stake method in this area uses a 1-2 meter long bamboo as substrate spaced at 1-3 meters apart. Usually oysters or mussels collected from thinning are broadcasted within or near the farm area.

HINIGARAN, NEGROS OCCIDENTAL

Hinigaran farmers use two methods: rack and raft method. Both methods use empty oyster shells tied in nylon or plastic strap strings as substrate. In the raft method, the height of raft from the bottom ranges from 1-2 meters. Other farmers allow their raft to go with the tide. The string with empty oyster shells is 0.5-1 meter in length and does not reach the sediment

The length of the bamboo used in the rack method is 5-10 meters which serves as posts to the horizontal bar. The horizontal bar ranges from 5-30 meters depending on the size of the farm. Oysters and mussels are visible during low tide because river is already shallow.

HIMAMAYLAN, NEGROS OCCIDENTAL

In Himamaylan, the farmers use bottom, rack and raft method. Rack method uses empty shells and old nets as substrates. Old nets (0.9 m long) are hung in horizontal bars approximately 15 meters long and are spaced at 6 inches apart. Some rack set-ups are situated near fish cages and fish pens.

Raft method with hangings use plastic strap as substrate. Other farmers do not place plastic strap in their raft. The organism just attaches to a 12-meter long bamboo directly. Oysters are usually cultured in raft with hangings and mussels are usually cultured in raft without hangings. When farmers do thinning, thinned oyster and mussel are broadcasted to areas near their set ups.

11.7 Appendix 7: Summary of Oyster and Mussel Culture Methods per Municipality

Count

Regions	Municipality			Organism		Total
				mussel	oyster	
Luzon	Anda	Type of culture method	others (fish cage/fish trap)		1	1
			rack	19	7	26
			stake	11	5	16
		Total		30	13	43
	Bacoor	Type of culture method	rack	10	1	11
			stake	26		26
		Total		36	1	37
	Bolinao	Type of culture method	others (fish cage/fish trap)	1		1
			rack	11	2	13
			stake	22	5	27
		Total		34	7	41
	Malolos	Type of culture method	bottom/broadcast		16	16
			rack		31	31
		Total			47	47
Western Visayas	Batan	Type of culture method	others (fish cage/fish trap)		2	2
			rack	6	6	12
			raft with hangings	3	6	9
			raft without hangings		3	3
			stake	5	41	46
		Total		14	58	72
	Dumangas	Type of culture method	bottom/broadcast		12	12
			rack	2	25	27
			raft with hangings	1	20	21
			raft without hangings	3	3	6
			stake	1	37	38
		Total		7	97	104
	Himamaylan	Type of culture method	bottom/broadcast	2	2	4
			rack	2	22	24
			raft with hangings		3	3
			raft without hangings	12		12
		Total		16	27	43
	Hinigaran	Type of culture method	rack	5	25	30
			raft with hangings	1	11	12
		Total		6	36	42
	Roxas City	Type of culture method	bottom/broadcast	1		1
			rack	7	5	12
			raft with hangings	14	3	17
			raft without hangings	17	2	19
			stake	4	4	8
		Total		43	14	57

11.8 Appendix 8: An Overview of the Australian Oyster and Mussel Aquaculture Industries

Please note that this document is an uncorrected draft and represents the work of an undergraduate student from the University of the Sunshine Coast, Australia. As such it is provided for information and has not been produced by the ACIAR project team.

An Overview of the Australian Oyster and Mussel Aquaculture Industries; current status, production, cultivation methods and industry extension

Produced as independent supplementary information for the ACIAR Project FIS/2007/045: Evaluation of production technology, product quality and market potential for the development of bivalve mollusc aquaculture in the Philippines

Compiled by Mahdi Green

Map showing Australian States and Territories and Tropic of Capricorn

11.8.1 Introduction

Global aquaculture production has been growing rapidly for more than 40 years (UN, 2007). Declines in wild harvest fisheries and exponential global population growth have driven the demand and the development of these new aquatic industries and their

markets, and aquaculture now provides more than 30 % of all fisheries products for human consumption, and is approximately 50% of total capture fisheries production (UN, 2007).

Global aquaculture production provides a variety of product types and species, including finfish, algae, molluscs and crustaceans, variously produced as either predominantly food or cash crops. The growth in some of these product sectors, notably penaeid crustaceans and salmonid finfish species, has caused concern in relation to sustainability and environmental impacts (e.g. Naylor et al, 2000), since their reliance on fishmeal and fish oil, coupled with disease issues and unsustainable production methods may limit the continued development and success of some forms of aquaculture production. Environmental degradation has occurred globally as coastlines, estuaries, freshwater bodies and their associated habitat types, ecological assemblages and ecosystem services are modified or destroyed to establish some types of aquaculture operation.

However, not all aquaculture species or production methods degrade the environment. Bivalve mollusc aquaculture for example is considered to be environmentally benign, and even beneficial in some situations, as these filter feeding species are not reliant on external inputs. Correctly positioned and maintained bivalve production systems may be highly sustainable as they provide marketable products for economic profit without creating environmental harm and without the significant input of technology or exogenous energy inputs. As such, they may represent a good aquaculture option for developing economies or in areas of high environmental value.

This report has been produced to aid the development of bivalve mollusc aquaculture in the Philippines, by providing an overview of the current state of the industry sector in Australia. While the environmental, population, regulatory and industry development practices and characteristics in both countries are often quite different, there are clearly some common areas of activity which may benefit from the exchange of experiences, problems and solutions.

As such, information from each Australian State and Territory (not including ACT which does not produce mollusc aquaculture products) has been collated to provide an overview of the Australian oyster and mussel industries.

A comparison of the production value, cultivation methods, industry extension and current status of each State is included as a potential guide to selecting alternative options for the development of a more effective and efficient industry structure, based on the different experiences found within Australia.

Information relating to oyster disease outbreaks in Australia and a case study on oyster contamination identifies issues relating to aquatic and human health issues and risks. The report concludes with a summary of the key areas that the Australian governments, both National and State, industry bodies and individual producers have addressed during the development of the Australian industry.

To ensure that the principals of economically sustainable development are upheld, aquaculture industry planning by nature should not only encompasses a wide range of environmental, social and economic elements, but also the varied needs of many stakeholders. To achieve a sustainable and profitable oyster or mussel industry, collaboration between stakeholders is integral. This can lead to the effective development of best management practices which can be monitored and regulated through sound governance and industry extension.

Queensland

Background

Prior to European Settlement

Oyster culture in Australia dates back to approximately 6000 BC. Aboriginal communities cultivated a native flat oyster, now known as Ostrea angasi, on rocks placed in the shallow intertidal reaches of estuaries. Although the production was primitive, the sustainable methods of wild harvest and cultivation continued until European settlement in Australia (FRDC 2008).

European Settlement

During colonisation, European settlers displaced many aboriginal communities from their traditional land. Settlers discovered large aboriginal kitchen middens, with oyster shell deposits, over four metres deep and four hundred metres long (Bailey 1975). Deposits of shells were so extensive that until the 1820's all the lime used for building-construction mortar was derived from the excavation of a series of shell middens (Nell 2001). However, by the late 1870's, the supply of shells were exhausted from these aboriginal kitchen middens (Malcom 1987; Roughley 1922 & Smith 1982).

Early Commercial Exploitation of Oysters

Australia has a variable history relating to wild harvested and aquacultured oysters. In 1822 rock oysters (Saccostrea commercialis) were officially reported in Moreton Bay, near Brisbane and in 1824 commercial exploitation began. Oysters were hand picked in shallow water, with dredging being the preferred option for deeper water. This is where the term "bank" and "dredge oysters" was first coined in Queensland. Oysters in less than 60cm of water were termed "bank oysters", with oysters deeper than 60cm classed as dredge oysters (Department of Primary Industries 2001).

Early Oyster Industry

Many aquaculture licences and oyster leases were established during the 1800's to produce oysters for consumption. However, disease limited the early industry which fluctuated in production volumes. Regulation was applied and in 1863 the Oyster Act, the first piece of fisheries legislation in Queensland, introduced certificates for "bank" and "dredge" operations, and banned the burning of live oysters for lime production (Department of Primary Industries 2001). The Southern Queensland oyster industry, based on wild harvesting, flourished until 1910, however the rate of extraction was unsustainable and the practice continued until the supply of wild oysters was extensively depleted (Smith 1982).

Oyster Production

Today oyster production volumes are one-tenth of the volume they were between 1880-1910 (Department of Primary Industries 2001). Compulsory statistical returns submitted by licence holders reveal that around 70% of licensed oyster areas, also referred to as oyster leases, have had no production during the period 1997/2007. Many of the remaining areas have had production levels of less than 500 dozen (6000 individual shells) per year. Less than 10 oyster areas produced more than 5000 dozen oysters for any year during this period (Department of Primary Industries 2001).

At present the rock oyster industry in Queensland is dominated by a small number of full and part time growers who are responsible for the majority of production.

However, the production of the industry is restricted by many leases not producing oysters or only producing limited numbers (Lobegeiger & Wingfield 2007). Furthermore, the Queensland industry relies on seed stock from New South Wales (NSW). When outbreaks of QX disease occur, seed stock may become a limiting factor in production. A bivalve hatchery is under construction in Hervey Bay, in central Queensland which will service the state, however it is not currently in production at present (Lobegeiger & Wingfield 2007).

The information in the following section relating to oyster (Saccostrea commercialis) production was collated from a series of Department of Primary Industries and Fisheries publications entitled “Report to Farmers” ranging from 2004 to 2007 (Lobegeiger & Wingfield 2004; Lobegeiger & Wingfield 2007).

Edible Oysters

Annual production and value

Edible oyster production in Queensland between 1997 and 2007 ranged between 111,700 dozen to 220,400 dozen with an average production of 173,500 dozen (Figure 1). The total production value during this period ranged between Au$360,100 and Au$687,500 with an average annual value of Au$574,630 (Figure 2).

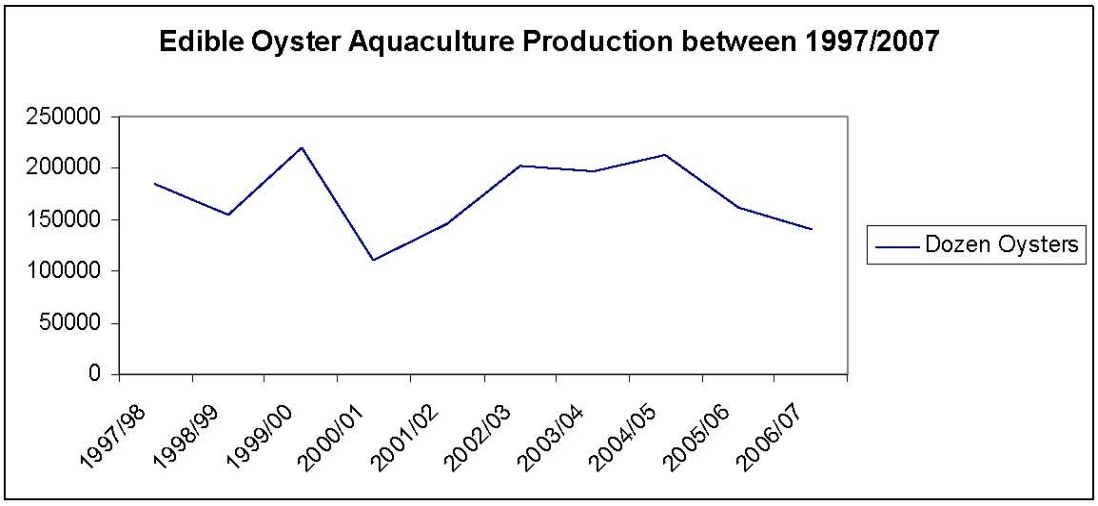


Figure 1, Queensland Edible Oyster Production Volume 1997 to 2007

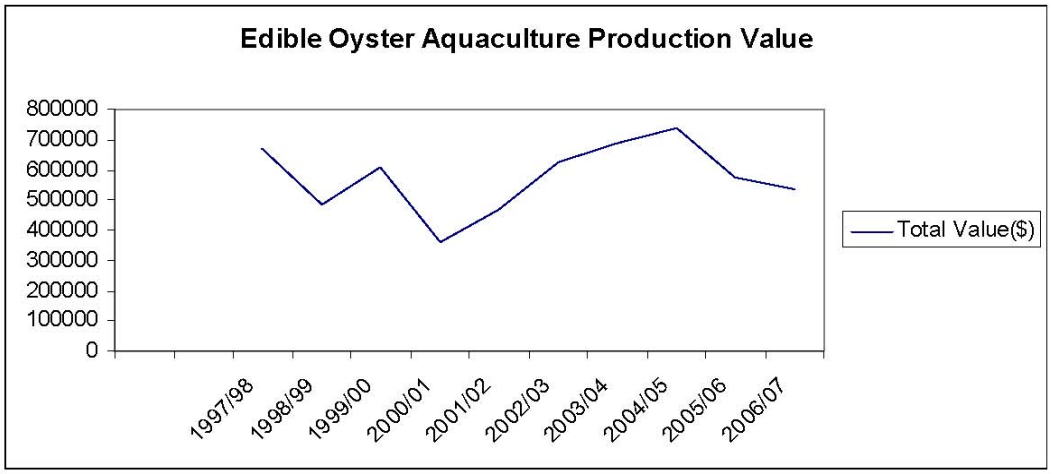


Figure 2, Queensland Edible Oyster Production Value 1997 to 2007

Average price per dozen

The average price per dozen oysters sold from 2003 to 2007 ranged from AU$3.45 to $3.79, (Include AU$ throughout, remember the report will not only be read in Australia) with the price steadily increasing since 2004. Oysters are sold in a variety of sizes to meet the requirements of different markets; the break down of sales incorporates four general sizes; Bottlers, Bistro, Plate and Others (Figure 3). By creating a more even market share for each grade of oyster the industry can support a greater range of buyers and improve consistency within the market.

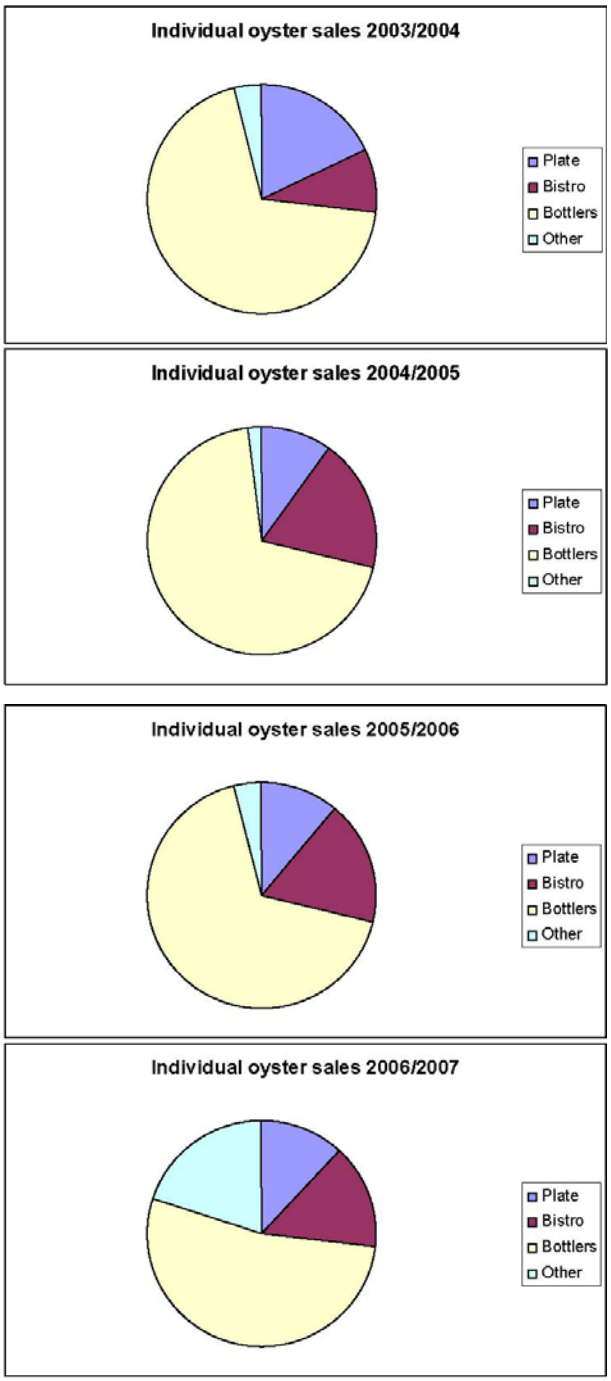


Figure 3, Increasing consistency through improving the market share of each grade.

Labour

The number of fulltime employees in the Queensland oyster industry increased from 15 in 2005/2006 to 17 in 2006/2007. Additionally, casual employment increased from 1050 hours to 1200 hours in the 2006/2007 period. Labour efficiency can be calculated by dividing the total production by the number of fulltime employees. Between the reporting period 2005/2006 to 2006/2007 the production efficiency reduced from 10400 to 8100 dozen oysters. Therefore the value of the total industry output in Queensland reduced from $37,000 per fulltime employee to $30,700 in 2006/2007.

Wild Harvested Edible Oysters

Previously, oysters that were harvested on a rotational basis from rocky shores in North Queensland were classed as Aquaculture production; however the Government now classes this resource as wild-caught fisheries production. The species that are suitable for

this form of harvest are the milky oyster (Saccostrea amasa) and the black-lip oyster (S. echinata). Wild harvests are limited by maintenance of the areas, selective harvesting, retention of broodstock and environmental conditions which are monitored by the The Australian Shellfish Quality Assurance Program (ASQAP).

Pearl Oysters

Queensland not only produces edible oysters, but also diversifies production by producing pearl oysters. The main species are the black-lip oyster (P. margaritifera), gold lip oyster (Pinctada maxima) and the penguin oyster (Pteria penguin). The Akoya pearl oysters (Pinctada imbricata or P. fucata) are cultivated in many regions of the world and a production trial is currently being undertaken in Queensland with three new lease areas now stocking the species. The industry's total production in 2006/07 was estimated at 42,200 pearls, of which 95% were sold in Australia at a total value of $1.7 Million.

Cultivation Methods

Spat Collection

Although the majority of spat (oyster larvae) are currently collected through wild harvest, many growers source spat from NSW, the majority of spat are supplied by the NSW DPI and come from Port Stephens (hatchery or wild collected?), on the NSW south-central coast. Wooden stakes or sticks, usually coated in tar, are used to collect spat and are nailed to cross beams of timber to form frames which are grouped into batches and placed in the mid to low reaches of the tidal range. As the oyster larvae drift in the tidal current they attach themselves to the sticks where the farmer can then relocate the sticks of spat to different growout leases throughout the lifecycle. This method of stick placement allows the farmer to then move the stock, reducing the density of the batches and increasing the nutrients available to each oyster. In Moreton Bay oyster spawning, larval settlement or "spat fall,", occurs throughout the year, peaking between November and March. This "season" also coincides with the end of the production period for the mature oysters, allowing growers to restock and reconstruct lease areas.

Oyster Growout

The sticks used for spat collection from each batch are laid 15 to 20cm apart on timber racks, which have been erected in the intertidal zone. Correct spacing encourages marketable shape and healthy growth. Regular inspection and 'culling' (separation) of oyster clumps ensures fast growth and regular shapes. Additional spat settlement on oyster shells during growout is removed or killed by a 3-second immersion in water heated to 82ºC, as markets will not accept oyster shells covered with spat.

Tray culture is used to produce well-shaped oysters in the final stage of maturation before marketing. Oysters are placed concave side up on the trays. Market-size oysters are laid out at about 35 dozen to a tray (tray size 900 mm x 1800 mm) where they remain for 4 to 8 months. Trays are then placed on racks in the intertidal zone and are often covered with wire netting to protect the oysters from predators.

Other growout methods, such as suspended bags on longlines, are also used for rock-oyster culture.

Oyster Disease Issues

In 1985 the first reported infestations of Polydora websteri (mud worm) in the Queensland oyster industry caused major losses.

Subsequently, oyster culture in some areas of southern Queensland has been constrained by the seasonal occurrence of QX disease, caused by the haplosporidean parasite Marteilia sydneyi.

The risk of infection by the microscopic disease parasite is highest between the summer months of December and March. To avoid loss of stock, operators generally harvest their crop before Christmas and carry out maintenance of the oyster area over this period.

Alternatively, movement of stock to offshore areas (up to X km offshore) during this period has been shown to be effective in reducing the occurrence of QX outbreaks.

More detailed descriptions of these diseases are included in the oyster disease section later in this report (Department of Primary Industries 2001).

Industry Extension

Australian Shellfish Quality Assurance Program

An Australian national program called “The Australian Shellfish Quality Assurance Program” (ASQAP) was developed to ensure the quality of shellfish for domestic and export markets. Each State and Territory has separate programs that are managed through the guidelines developed by ASQAP. All growing areas in Australia have been surveyed and are monitored to assure the quality of shellfish products and to promote consumer confidence, both domestically and internationally.

In 1993, The Queensland Shellfish Water Assurance Monitoring Program (QSWAMP) was established as the state branch of the ASQAP. QSWAMP developed criteria to meet the United States Food and Drug Administration (USFDA) requirements for exportation into the United States, as well as meeting similar requirements for oyster export to Japan.

However, the focus is now directed towards local markets as less than five percent of Queensland’s shellfish production is exported annually. The local demand for shellfish products, especially edible oysters, outstrips supply and only a small amount of plate-sized oysters are exported at a premium price.

The ASQAP have surveyed all oyster-growing areas in Australia and, through Federal and State legislation, ASQAP now regulate and control the growing areas, harvesting, processing, and distribution of all shellfish products in Australia. The health of shellfish consumers is protected through the administration and application of activities and legislation that;

- Monitors pathogenic bacteria, viruses, biotoxins and chemicals that may impact on shellfish or shellfish growing areas and determine the risk of shellfish contamination for consumers
- Imposes adequate and appropriate harvesting controls
- Regulates and ensures that products are of adequate health and free of post harvest contamination, but prior to the products entering the retail chain.

Based on the outcomes of the long-term water-quality monitoring completed by ASQAP, oyster-growing areas are categorised into Approved, Conditionally Approved, Restricted, Conditionally Restricted and Prohibited. Additionally, depuration procedures can be imposed on products that are deemed to be unsafe or products can be prohibited from being sold for consumption (Australian Quarantine and Inspection Service 2008).

The Department of Primary Industries & Fisheries

Queensland oyster cultivation is licensed by the Department of Primary Industries and Fisheries (DPI&F) in accordance with the provisions of the Queensland Fisheries Act 1994 and the Queensland Fisheries Regulation 1995 (Queensland Parliamentary Council 2008). Oyster growing areas are licensed through the use of oyster leases which are regulated for the specific purpose of exclusively producing oysters. Leases are issued for up to 15 years and are fully transferable (Department of Primary Industries 2008a).

Each State and Territory has an equivalent organization to the Queensland DPIF, along with legislation to enable the management of fisheries and aquaculture activities.

The Australian government supports the development, and sustains the growth, of primary industries throughout Australia, in part through funding given to the State and Territory fisheries agencies. As the regulatory body for Aquaculture throughout Australia, the State fisheries departments provide industry extension and support in the form of

research and development, training and education, monitoring and evaluation, industry consultation, licensing and regulation. In addition, each year Queensland DPIF conducts research and provides the Industry with a “Report to Farmers”. This is a valuable tool for the industry and investors to utilise, as is, the information provided by the DFI&F website (Department of Primary Industries 2008a). Similarly, all State and Territory fisheries departments provide annual production statistics to the Commonwealth Government agricultural statistics organization, the Australian Bureau of Agricultural Resource Economics (ABARE 2008).

Queensland Oyster Growers Association

The Queensland DPI&F work closely with the Queensland Oyster Growers Association (QOGA) to develop effective management plans that combine the best interests of all stakeholders within the region and the community. The association strives to promote the long-term sustainability and quality of oysters produced in Queensland. The QOGA also assisted in the development of the Queensland Shellfish Water Assurance Monitoring Program and provides farmers with valuable industry information, government liaison and networking capabilities (Department of Primary Industries 2007a).

Queensland Oyster Industry Development Plan

Developed by the QOGA and DPI&F, the Queensland Oyster Development Plan was released in 2004 and was implemented for a two-year period. The plan was developed using workshops with both industry and government representatives, where eight key areas/actions were developed;

- Marketing
- QX disease management
- Latent effort
- Safe Food Queensland/Queensland Shellfish Water Assurance Monitoring Program (QSWAMP)
- Administrative issues
- Communication
- Environmental issues
- Moreton Bay Marine Park Plan.

The plan expired in December 2006, and was later revised. An estimated 78% of the actions had been completed and provided the framework for industry growth, enhanced development, culture, harvest, marketing and regulation of the Industry. QOGA membership has increased by over 300% and the association is now the peak oyster-growing industry body representing 80% of oyster growers in Queensland.

The DPI&F have also developed research links with the Queensland Museum to monitor and research QX disease and resistance. A Memorandum of Understanding (MoU) was also signed with NSW to report and monitor QX disease more efficiently, especially in relation to stock exchange from state to state (Department of Primary Industries 2004; Department of Primary Industries 2007a).

Policy for Maximising Rock Oyster Production: Management of Non-Productive Oyster Areas

The Department of Primary Industries and Fisheries? (DPIF) (is this still Qld or NSW. If so it should be DPIF) has also developed a “Policy for Maximising Rock Oyster Production: Management of Non-Productive Oyster Areas”. The aim is to maximize the use and production of oyster growing areas in a way that enhances economically sustainable development within the state (Department of Primary Industries 2007b).

Currently the industry's economic potential is restricted due to the production of the oyster lease areas; the policy will reallocate oyster leases that do not produce a sufficient total of marketable oysters annually (Department of Primary Industries 2007b).

Due to the low costs of the licences for oyster leases, many lease holders simply pay for the lease with the intention to sell the area in the future, when the area is more valuable, never intending to actually produce commercial quantities of oysters. It is estimated that production could triple if the leases were reallocated effectively (Department of Primary Industries 2007b).

The policy states that different areas are used for different processes during production; some are used for spat collection and others for oyster growout. The overall intention is to ensure that each farmer should produce 300 dozen market-size oysters per hectare annually. A business plan is needed for each producer, with clear milestones if a grower wishes to expand into new leases. Each plan is then accepted or rejected by the DPI&F (Department of Primary Industries 2007b).

If a licence is terminated the lease holder is responsible for cleaning the lease area of all equipment and old aquaculture 'furniture', removing and disposing of everything used within two months of termination. In theory this policy will better manage the growth of the industry and improve entry opportunities into the industry for new producers and investors. The water quality and aesthetics of areas that are not producing adequate numbers of oysters will be improved enabling more sustainable culture methods that feature recycled plastic instead of the traditional tarred wooded stakes and aquaculture 'furniture' (Department of Primary Industries 2007b).

New South Wales

Background

In relation to oyster cultivation, NSW has had a similar history to Queensland. Unsustainable dredging contributed to the development of the 1884 Oyster Fisheries Act. The industry steadily grew until its peak in 1976/77, production has since declined due to multiple supply and demand factors. Based on which species?

The supply has been affected by disease, pacific oyster introductions and declining water quality in many NSW water bodies due to urban development and land use issues. The demand for oysters has also been reduced due to competition from the production from other states, as well as changes in consumer tastes and perceptions (Sakker 2007).

This overview contains a case study of Wallis Lakes where a contamination event caused by failing septic sewage treatment systems, caused a Hepatitis A outbreak, killing one man and infecting 467 other consumers. This event had a devastating effect on the perception of the quality of NSW oysters and, combined with other demand factors, has caused a reduction in sales.

Oyster Production

The oyster industry accounts for over 70% of the total aquaculture production in New South Wales. The industry dates back over 100 years, providing coastal regions with employment and economic opportunities (Sakker 2007). The information in the following section relating to oyster production was collated from the New South Wales Department of Primary Industries, Aquaculture production report 2005/06, and from the New South Wales Oyster Industry Sustainable Aquaculture Strategy (Sakker 2007; Department of Primary Industries 2006).

Annual Production Value

Over the past eight years a fairly stable trend has emerged in NSW oyster production. The average production of 70,000 to 75,000 bags of oysters (one bag contains 100-110 dozen oysters) has been achieved throughout this time, with a peak season during 1976/77 when 146,500 bags were produced. Industry and government have established that

120,000 bags per annum is sustainable in the long term. This estimated carrying capacity couples environmental and socio-economic drivers and impacts, with ongoing research and development into new and emerging technologies, the aim is to increase the efficiency and lower the impact from current management techniques.

To achieve an ecologically sustainable maximum yield, best management practices are being developed and revised with the aid of various state government agencies, including NSW DPI&F, catchment management authorities, community interest groups and the local communities. The emphasis is on communication, research and practical application through industry extension and education.

The value of the total annual oyster production between 2005/06 totalled AU$35.98m which represents 74.9% of the total aquaculture production for the state of New South Wales (Figure 4).

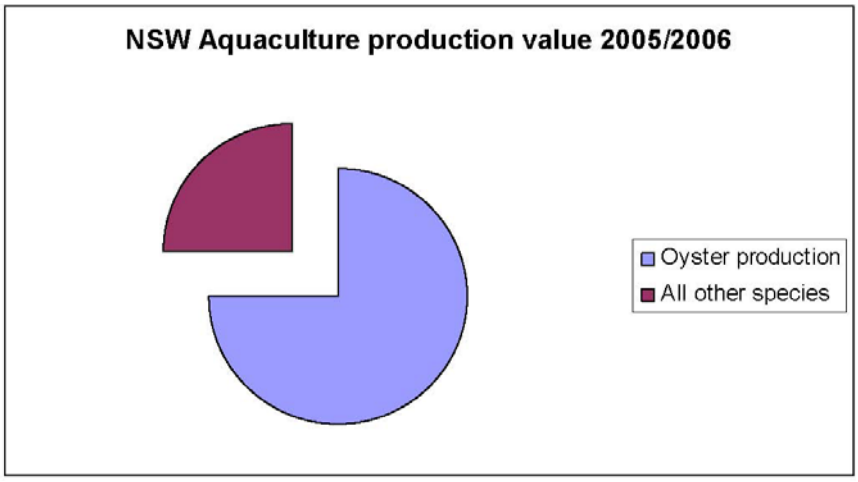


Figure 4, Comparison of NSW aquaculture production value 2005 to 2006.

The Sydney Rock Oyster, Saccostrea commercialis contributed 91% of the total value of oysters sold in the 2005/2006 period. The Pacific oyster, Crassostrea gigas, contributed 3.8%, flat oysters, Ostrea angasi, contributed 0.28% and Oyster Spat contributed 5.2% (Figure 5).

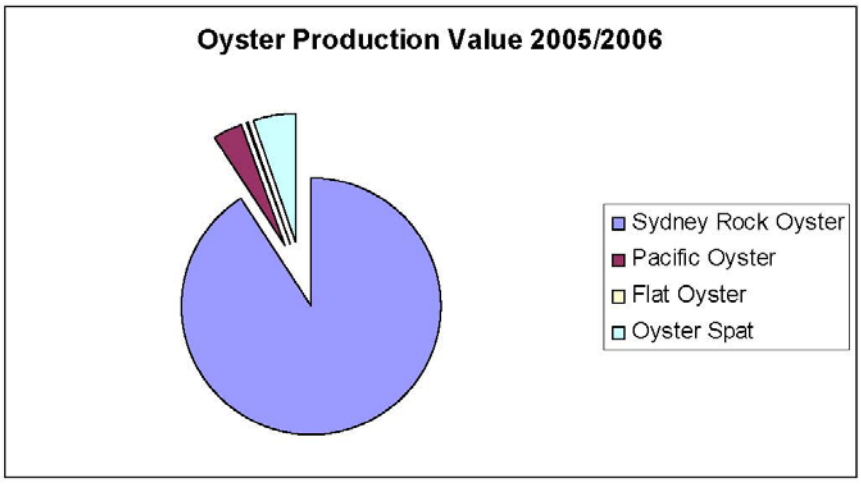


Figure 5, Species composition of NSW oyster production 2005/2006

Comparison of Production Volume between 2002 and 2006

The volume of oyster production ranged from 6,567,493 dozen oysters to 8,000,265 between 2002 and 2006 (Figure 6).

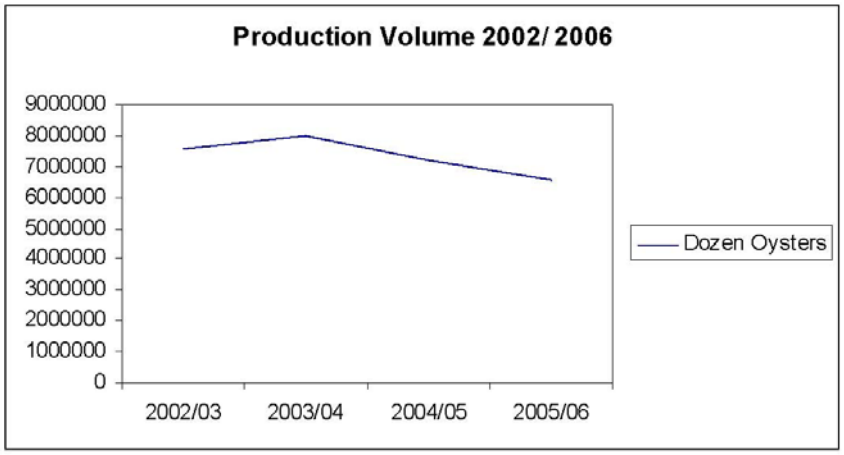


Figure 6, NSW oyster production volume 2002/2006

NSW Oysters are sold in Plate, Bistro and Bottler sizes –can you quantify these sizes again, or if similar to QLD sizes then indicate this.. In 2006, the market share of plate oysters contributed 34.9% of the total production value, 31.2% were bistro and 33.9% were bottlers.

Price per Dozen

Sydney Rock Oysters

During the 2005/2006 season a total of 6,567,493 dozen oysters were produced and sold at a total value of AU$32,589,877. The average price per dozen was AU$4.96. Plate oysters sold locally and interstate averaged AU$6.97 per dozen, Bistro oysters averaged AU$5.24 per dozen and Bottler oysters averaged AU$3.69 (Figure 7)

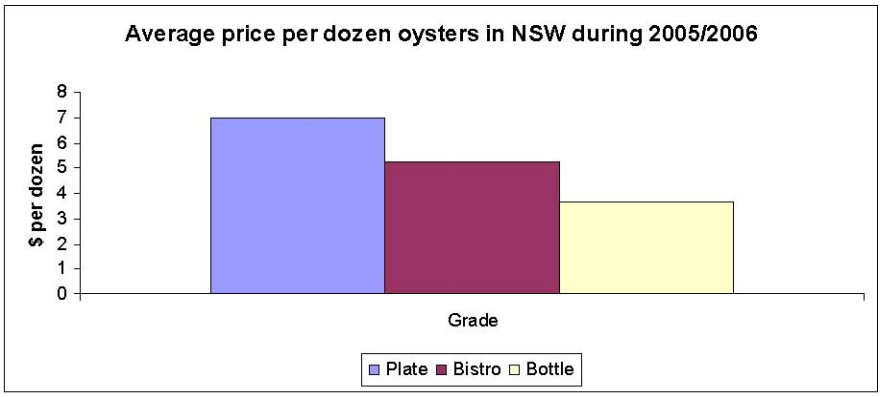


Figure 7, Average price per dozen Sydney rock oysters 2005/2006.

Pacific Oysters

All of the Pacific Oysters were produced at Port Stevens. During the 2005/2006 season a total of 285,042 dozen oysters were produced and sold for a total of AU$1,402,922, averaging AU$5.50 per dozen. The most to least efficient culture methods were; tray (158,123 dozen), long-line (113,201 dozen), baskets (11,019 dozen) and stick (2 700).

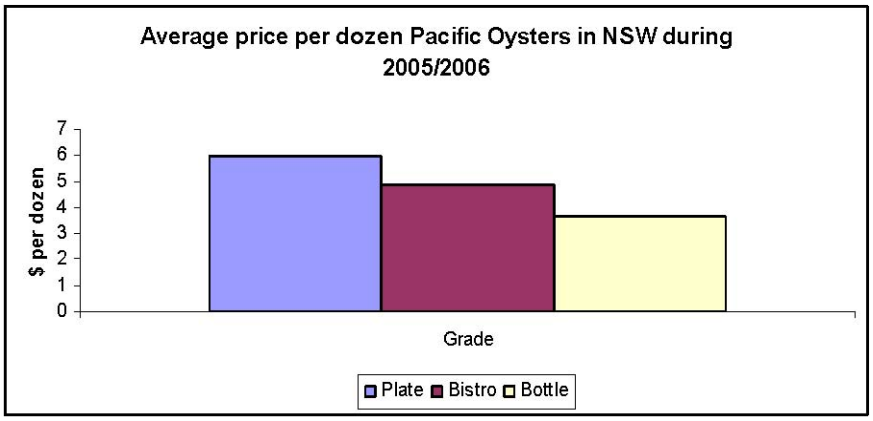


Figure 8, Average price per dozen Pacific oysters by marketing grade in 2005/2006.

Cultivation Methods

NSW provides detailed information relating to the cultivation methods used to produce Sydney Rock Oysters, Saccostrea glomerata, and Pacific Oysters, *Crassostrea gigas*. The methods are compared in this document based on the sales and production from each species. A brief description of each method is provided in Table 1.

Table 1, NSW oyster industry production methods glossary

Production Method	Description
Catching	The collection of wild juvenile shellfish spat - settled onto 'catching' sticks or plastic slats.
Depoting	The practice of using blocks of catching sticks bound together. The protection of the block enables oysters to grow to a size that can withstand predation by fish, prior to separation into a single layer of sticks.
Dredge Bed	An area leased for the harvest of oysters directly from the bed sediments. No oyster farming infrastructure is placed on oyster dredge bed leases.
Floating Cultivation	Sub-tidal cultivation of oysters, on sticks or in baskets suspended from tethered, low buoyancy systems that may include lines and/or polyethylene floats.
Post supported intertidal cultivation	A series of parallel vertical posts that support horizontal rails or lines on which oyster sticks, trays and/or baskets that are placed so the oysters are submerged for varying periods of the tidal cycle.
Raft/Pontoon	Sub-tidal cultivation of oysters in trays or baskets suspended from a permanently anchored, rigid, high buoyancy structure.
Single seed	An individual unattached oyster that is grown from small spat produced by removing wild oysters at a very early age from plastic collectors or produced as single oysters in a shellfish hatchery.
Stick cultivation	Growing out wild caught oysters on the sticks they are caught on. Suitable method for areas subject to significant wave action. 'Stick oysters' may be removed from sticks and fattened on trays prior to harvest.
Tray cultivation	Growing out single seed oysters on trays. Suitable method for sheltered areas. Often used for the final stage of growth prior to harvest.

Sourced directly from NSW Oyster Industry Sustainable Aquaculture Strategy 2006 (Department of Primary Industries 2006)

Cultivation Methods: Sydney Rock Oyster (Saccostrea commercialis)

Tray cultivation accounted for 76% of the total Sydney Rock Oysters produced in 2005/2006, and represents the most utilised production method by growers in NSW. The ease of separating the oysters and the promotion of consistent and regular shapes and sizes makes the method the most effective. The other productive methods in order of production volume were raft/pontoon, sticks and baskets, followed by floating, long line and dredge (Table 2, Figure 9).

Table 2, Sydney Rock Oyster *Saccostrea commercialis*, Sales by Method

Method	Sales (AU$)	% of Total

Tray	24 876 976	76.3
Raft/Pontoon	2 788 676	8.6
Stick	2 018 176	6.2
Basket	1 381 614	4.2
Floating	852 366	2.6
Long line	464 696	1.4
Dredge	198 080	0.6
Total	32 589 878	

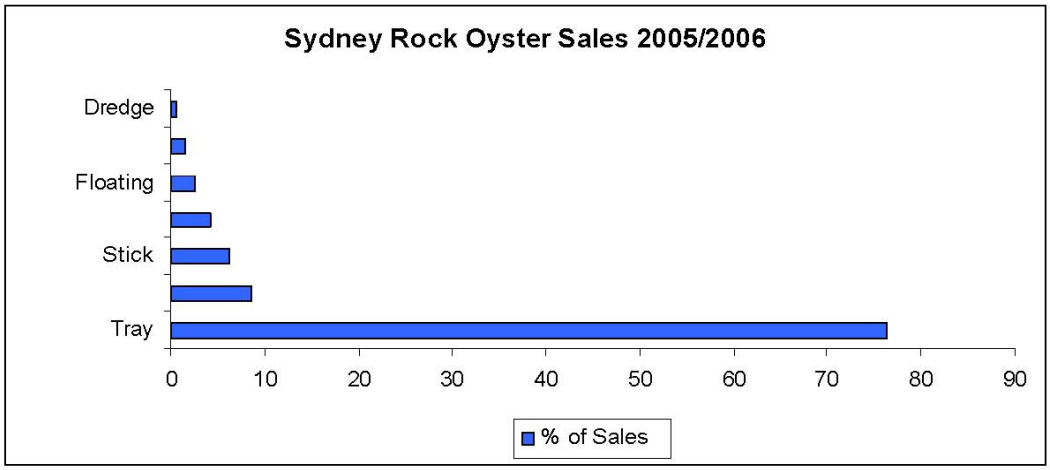


Figure 9, Sydney rock oyster sales by method 2005/2006.

Cultivation Methods: Pacific Oyster (Crassostrea gigas)

Tray cultivation of pacific oysters provided the highest percentage of production at 53.1% of the total, closely followed by long lines at 42%. Baskets/tumblers (4.1%) and stick (0.8%) were the least productive methods in terms of volume (Table 3, Figure 10).

Table 3, Pacific Oyster sales by method 2005/2006.

Method	Sales ($)	% of Total
Tray	744,442	53.1
Long line	589,843	42
Baskets/Tumblers	57,339	4.1
Stick	11,298	0.8
Total	1 402 922	

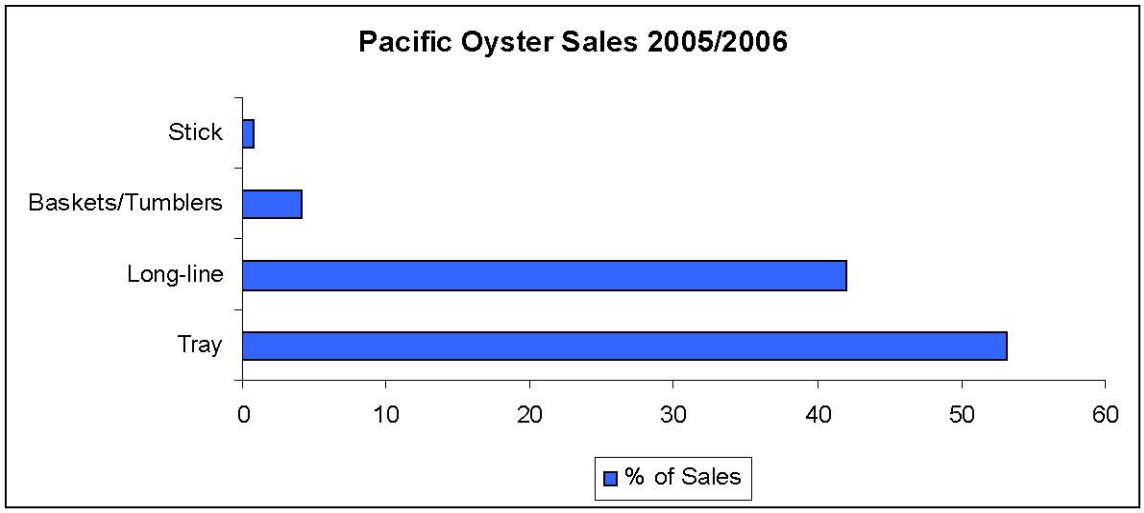


Figure 10, Pacific oyster sales by method 2005/2006

The NSW DPI managed Port Stephens Fisheries Centre and the Port Stephens Research Centre provided the figures in the above table and Figure relating to Pacific Oyster production by cultivation method, and may reflect the outcomes of research goals and commercial production.

Spat Collection and Production Value

In NSW the “wild caught single seed” collection method contributed 81.1% of the total volume of spat production followed by hatchery-produced seed at 13.1% and stick spat collection at 5.8% (Table 4).

Table 4, Spat Collection and Production Value.

Method	Sales ($)	% of Total
Wild Caught Single Seed	1 536 789	81.1
Hatchery Single Seed	249 031	13.1
Stick	108 710	5.8
Total	1 894 530	

Mussel Production

The Blue Mussel, *Mytilus galloprovincialis* is wild harvested and farmed commercially in NSW. Mussels (Family Mytilidae) are farmed internationally, however in Australia the native Mytilus galloprovincialis is the only farmed species. Blue mussel shell deposits have been found in Aboriginal middens alongside native oyster shells (Department of Primary Industries 2008b).

Commercial aquaculture production began in 1976 in NSW; on the southern coast at Eden where the farms are located. Estuaries are utilised to produce mussels via long-line and raft culture, where mussels are grown in long mesh sleeves to protect them from predation and allow efficient harvesting (Department of Primary Industries 2008b; Sydney Fish Market 2008).

The production value in the 2005/2006 period was AU$206,535. During the same period, 34,117 Kg of mussels were produced from 19.02 ha of commercial production area, at an average first sale value of AU$6.05 per kg Department of Primary Industries 2008b).

The NSW DPI has detailed information relating to the culture of Blue mussels in Australia, the website link is; http://www.dpi.nsw.gov.au/fisheries/aquaculture/publications/species-saltwater/blue-mussel---aquaculture-prospects > (Department of Primary Industries 2008b).

Industry Extension

New South Wales Department of Primary Industries

The role of the NSW DPI is very similar to the role of the Queensland DPIF. Through industry inspection, extension and research the NSW DPI develop, authorises and regulates aquaculture production methods and cultivation. The department operates under the legislation of the Fisheries Act 1994 which is administered through enforcement and regulation. As the oyster industry accounts for over 70% of aquaculture production and value in NSW, the DPI assists in various projects including research, marketing and extension to promote community and industry confidence through sustainable aquaculture management (Department of Primary Industries 2008c).

New South Wales Oyster Industry Sustainable Aquaculture Strategy (OISAS)

Much of the information relating to NSW in this report is derived from information provided in the sustainable aquaculture strategy. The OISAS outlines management strategies that are designed to promote investment opportunities and enhance current best-management practices within the industry. The oyster industry is iconic in NSW; production provides economic growth and employment in many small coastal communities. State government initiatives have been coupled with the goals of the local government and community groups to enhance the industry and improve the long-term sustainability of aquaculture operations within the state (Department of Primary Industries 2006).

Victoria

Background

Victoria has traditionally been the largest production of freshwater aquaculture species in Australia, although in recent years the severe drought has limited water availability, which in turn has limited freshwater production. Marine aquaculture is now expected to increase, with a greater number of lease sites being made available by the state government.. For example, 1700 hectares of new waters is becoming available to producers of mussels, scallops, finfish and abalone. These new ventures are intended to strengthen the Victorian aquaculture industry through diversification and by offsetting the reduction in freshwater species production.

Oyster Production

The information in the following section relating to Oyster and Mussel Production was collated from the Victorian Aquaculture Strategy and Action Plan, Victorian Marine Fisheries Reserves Report and the 2007 Victorian Commercial Fish Production Information Bulletin (Department of Primary Industries 2008d; Department of Primary Industries 2008e; Department of Primary Industries 2008f)

The gross value of aquaculture in Victoria in 2005/2006 was AU$21.9m, representing 22% of the total AU$97.9m fisheries production. Victoria only contributed 3% to the total

Australian aquaculture production, largely because around 66% of the species are freshwater, and so production has been heavily impacted by the drought. The major growth sectors in the Victorian Aquaculture Industry have been in heated closed recirculation systems focusing on finfish and eels.

Combined, bivalve shellfish contributed 8% to the total aquaculture industry in 2005/2006.

Opportunities for scallop culture in coastal marine waters have been limited, due to factors such as competition for coastal land, river frontage, and sustainable water supplies have restricted land based aquaculture production. Production is expected to increase substantially as new marine waters are leased to the industry. Reword this last paragraph, it doesn't make complete sense.

A 'Strategic Mussel Plan' has been proposed for the development of the mussel industry in Victoria as part of the Victorian Aquaculture Strategy Action Plan, combined with a $1.7m collaborative shellfish research project.

Oyster production is included in the combined 'Other Mollusc' category in aquaculture production figures for the state of Victoria, reflecting its relativeley low production contribution. The combined 'other mollusc' category produced 4 tonnes in 2005/2006 at a total value of $19,000 representing 0.02% of the total aquaculture production. Due to the colder water the main species of edible oyster produced in Victoria is Ostrea angasi (the Native Flat Oyster), although in very limited numbers (Department of Primary Industries 2008b)(Table 6).

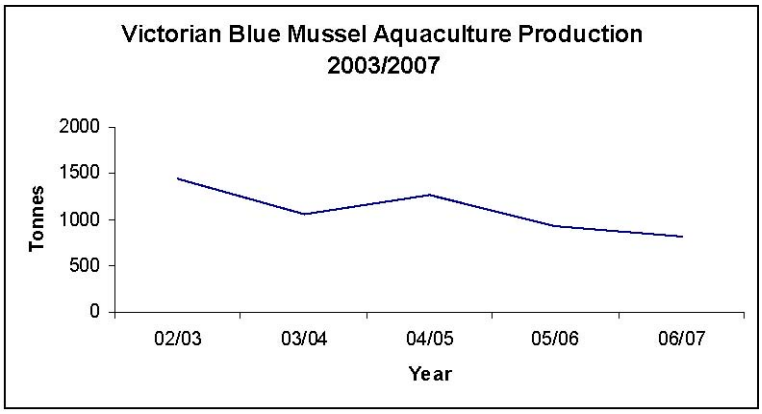
Table 6, 'Other Molluscs' production in Victorian Aquaculture (Source: Department of Primary Industries 2008)

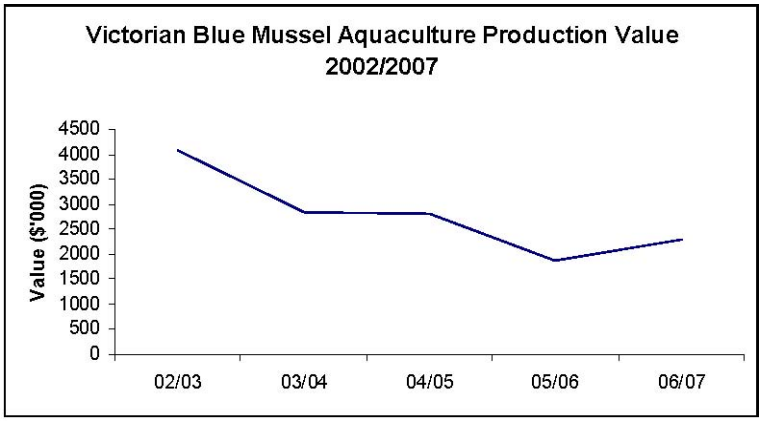
Year	2002/03	2003/04	2004/05	2005/06	2006/07
Tonnes	2	2	2	4	3
Value $	7000	1000	4000	19000	6000

Mussel Production

Annual Production and Value

Between 2002 and 2007 blue mussel production value ranged between AU$1,865,000 and AU$4,092,000 per annum. Victorian mussel production is shown in Figures 12a and b, and indicates a peak in 2002/03, followed by an increase in 2004/05 and declining slightly over the following two years. The total value of mussel aquaculture has shown a similar trend (include some actual values), although prices rose slightly in 2006/07. This increase was attributed to the drought affecting the quality and volume of freshwater species which comprise 66% of the industry.





Figures 12a and b, Victorian Blue Mussel production volume and value 2003/2007.

The peak production in 2002/2003 of 1600 tonnes produced AU$3.7m.

It has been suggested that the reliance on wild spawning and collection for spat supply limits the growth of the industry. As such the Victorian DPI, based at the Queenscliff Fisheries Centre, has established a joint research project to enhance the industry's sustainability through hatchery-spat production and product marketing.

Price per Kilogram

Due to the drought, the value per kilogram of mussels increased between 2005/06 to 2006/07 due to the decrease in production value and quantity of freshwater species, reducing competition within the marketplace.

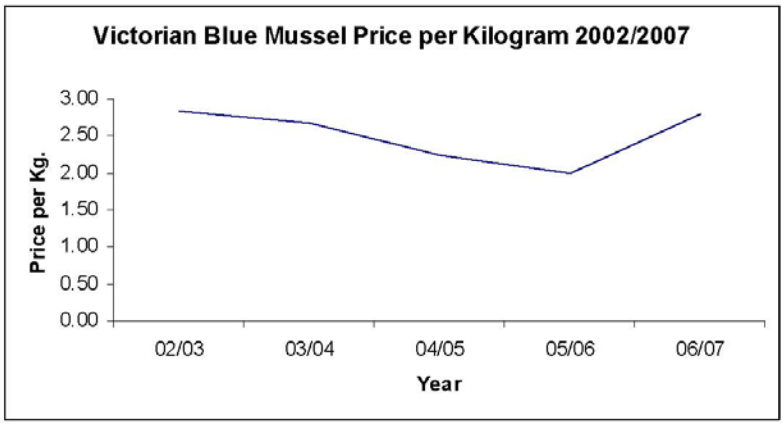


Figure 13, Victorian Blue Mussel Price per Kilogram 2002 - 2007.

Labour

During the 2002 - 2007 period, bivalve aquaculture licences increased from 28 to 47. The industry directly employs 100 fulltime staff who service a production area of over 400ha.

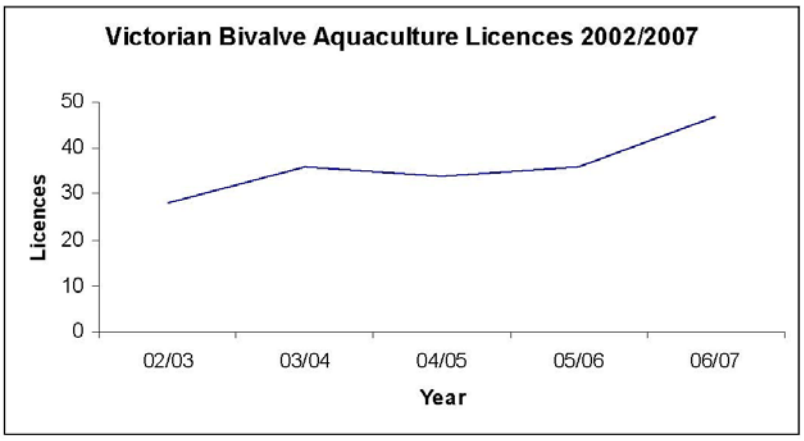


Figure 14, Changes in Victorian Bivalve Aquaculture Licences 2002-2007.

Cultivation Methods

Blue Mussels are cultivated using long-line methods. Ropes are suspended in the water column using floats and weights. Net stockings are also frequently used to help protect from predation and increase harvesting efficiency.

Much of the growout production is automated and hatcheries are employing more staff as the industry is moving from natural rope settlement to hatchery-seeded culture ropes. Hatchery produced seed is creating opportunities for sustainable growth within the industry, due to the greater reliability of seed production..

Table 7, Average annual ratio of naturally settled spat to hatchery-seeded rope cultures for growout operations in Victorian mussle aquaculture.

Average Ratio Natural:Hatchery Settled Spat				
Year	03/04	04/05	05/06	06/07
Ratio	1:7	1:5	1:6	1:4

Ratio shows the number of stock cultured ropes to natural settlement ropes

Industry Extension

Victorian Climate Change Strategy for Fisheries and Aquaculture 2008-2018

This draft document is part of a AU$203m package included in the Future Farming Strategy. Farming and fisheries will undergo a challenging restructure of the current management best practices in a coordinated approach by the state government to assist primary industries adapt to potential climate change effects. The project will address the risks and opportunities, and develop actions that fisheries sectors can adopt to mitigate the predicted impacts associated with global climate change (Department of Primary Industries 2008g).

Consultative Arrangements for Victorian Fisheries Resources Review

Between 2005 and 2008 the Victorian state government reviewed the use and conservation of Victoria's fisheries resources. A wide range of stakeholders were engaged to include community views, and allow all levels of the community and government to contribute to the current consultative processes.

The investigation was first introduced in 1995 to create the present statutory framework for fisheries resources and through the recommendations of the review the efficiency and effectiveness of stakeholder engagement continues to be improved (Department of Primary Industries 2008h).

Review of Fisheries Regulations

The current fisheries regulations which were developed in 1998 are due to expire early in 2009. New regulations are being developed and must be finalised before March 2009. A draft will be presented for public consultation 60 days prior to implementation, coupled with a Regulatory Impact Statement (RIS). Over 800 submissions have already been received, indicating the challenging nature of redeveloping fisheries regulations and addressing the needs of a large number of stakeholders (Department of Primary Industries 2008i).

Victorian Aquaculture Strategy and Action Plan

The strategy aims to facilitate industry growth in the fisheries sector through sustainable management practices. The current $22m aquaculture industry has a target of a three fold increase in production value by 2015. Only 20% of the seafood consumed by the state is produced or harvested in Victoria. A panel of scientific, community, environment, industry, finance and government representatives have implemented the strategy which aims to improve the Victoria's sustainable supply of high-value seafood for future generations. Investment in technology will be promoted through capital investment which will support regional economic growth, and the expansion of the current aquaculture industry (Department of Primary Industries 2008j).

Tasmania

Background

The native flat oyster *Ostrea angasi* were produced commercially in the late 1880's during Australia's "Oyster Boom" period. As in many regions of mussel and oyster farming globally, the reliance on wild spat collection ultimately limited the industry. This may have been enhanced by the practice of many operators returning to traditional oyster dredging which depleted wild broodstocks at an unsustainable rate (Department of Primary Industries and Water 2008).

Post World War II, in the late 1940's, the pacific oyster Crassostrea gigas was introduced into Tasmania and commercial production began. The industry struggled to sustain production growth until the 1980's when hatcheries were constructed to produce oyster spat for the industry. Constant growth within the industry was enabled through reliable spat supply and the development of improved cultivation methods (Department of Primary Industries and Water 2008).

Oyster Production

The 1994-2004 Tasmanian Aquaculture Strategy strengthened the industry as a whole, and by 2002 the total fisheries industry had increased to AU$327 million per annum, 40% of which was from aquaculture production. During this period salmonids (principally Salmo salar) showed the greatest increase in production, increasing in value by 300%. Molluscan shellfish as a whole increased by 20% and now represent roughly 10% of Tasmanian aquaculture production. The industry has developed new leases in marine waters and continues to identify new lease areas to enable industry growth (Department of Primary Industries, Water and Environment 2004).

Stick culture was replaced by mesh bag and envelope culture. The current industry is primarily based on hatchery spat growout of C. gigas, although there are also plans to develop hatchery capacity to produce Ostrea angasi spat to enable species diversification and additional industry investment opportunities (Department of Primary Industries and Water 2008).

Historically, Tasmanian oysters have supplied the Victorian market and have been exported to foreign markets such as Japan. Tasmanian Pacific Oysters are also supplied to New South Wales and Queensland during periods of low production in NSW or

increased consumer demand within the states (Department of Primary Industries, Water and Environment 2004).

Between 1997-2007 pacific oyster production increased in value by 63% from AU$9.6m to AU$16.7m, although this increase was not linear and for the first five years growth was only 2%pa (Figure 15). Overshadowed by the growth of Salmonid aquaculture, Pacific oysters represent 5.3% of the AU$295.2m annual Tasmanian aquaculture production value (ABARE 2008; Department of Primary Industries, Water and Environment 2004).

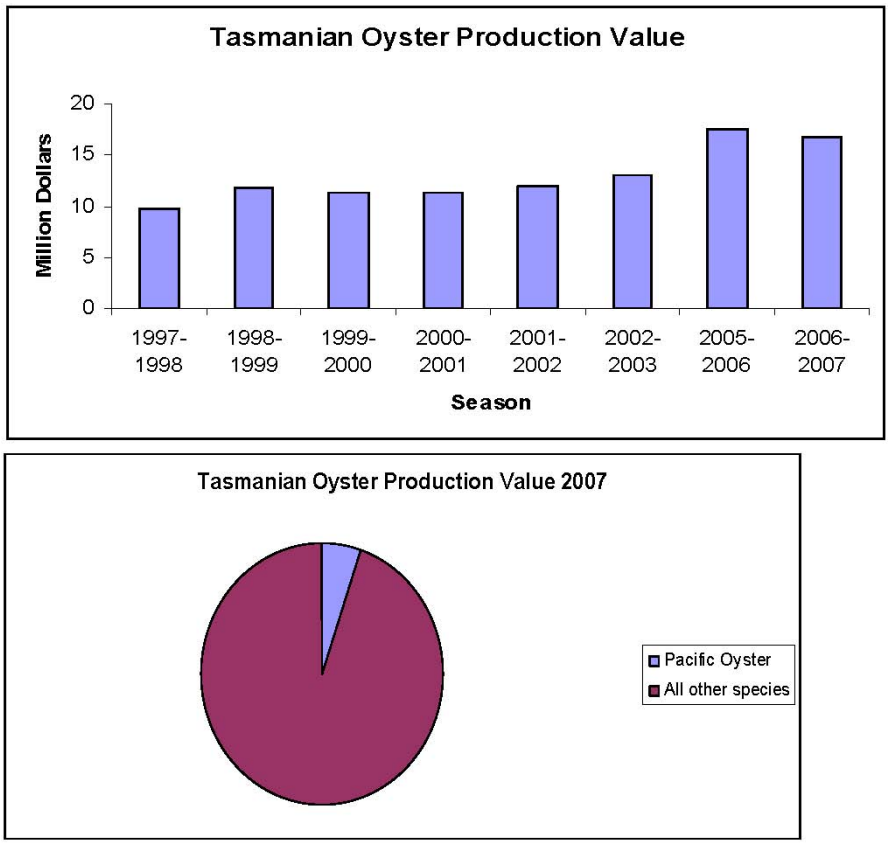


Figure 15, Tasmanian Oyster Production Value 1997/2007, Tasmanian Oyster Market Share 2007.

Mussel Production

Between 1997 and 2007 production of Blue Mussels in Tasmania increased by 81.3% from 185t to 988t. Improvements in culture methods, marketing, increased production area and new leases enabled industry growth. The local market is supplied with adequate product, and Australian domestic and international export is supplied with the remaining volume. The industry has a proven track record of quality and consistency (ABARE 2008).

The increase in production volume also resulted in a 82.5% increase production value between 1997 and 2007. The industry is now valued at AU$3.7m pa, which represents 1.3% of the Tasmania's total aquaculture value. Blue Mussels were valued at $3.75 per kg.

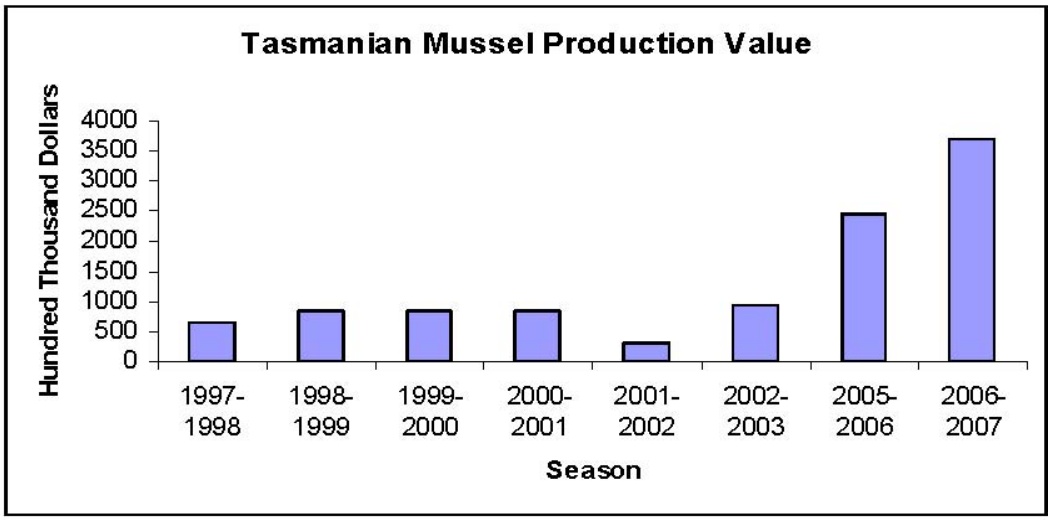
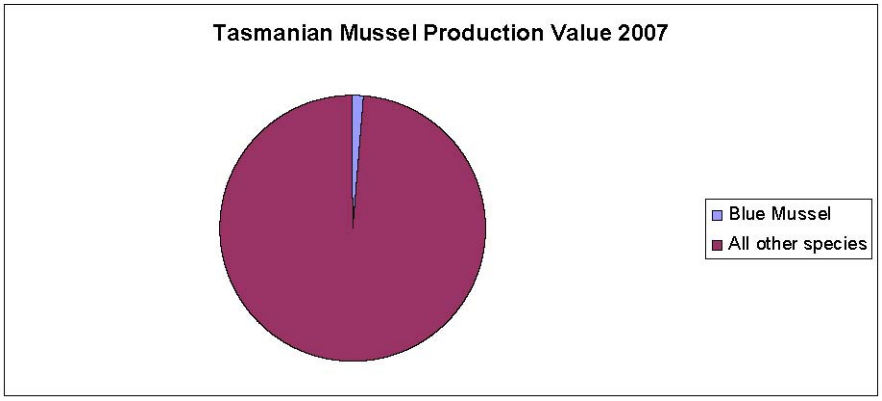


Figure 16, Tasmanian Blue Mussel Production Value 1997/2007, Tasmanian Blue Mussel Market Share 2007.



Industry Extension

The Tasmanian Aquaculture Council & Tasmanian Aquaculture Institute

Both organisations help increase industry productivity and efficiency. New technologies and marketing are developed to provide the industry with extension and management best practices.

Each company is individual however their vision to improve the Tasmanian aquaculture industry is combined.

Department of Primary Industries, Water and the Environment

As the Tasmanian Government's administrative department for aquaculture, DPIWE provides industry support and extension through research, development and regulation. The 1994-2004 aquaculture strategy was successful, since then the department facilitated the strong growth in the aquaculture industry. The Tasmanian Salmonid industry is now Australia's most valuable aquaculture finfish sector. Through strong management and the provision of additional production areas, the department continues to add value to the states primary industries.

South Australia

Background

The current oyster industry was established in the late 1980's. The state is renowned for clean oceanic waters and estuarine environments. High quality pacific oysters (Crassostrea gigas) are now produced in seven major growing regions that supply local, national and international markets.

South Australia has developed a strong industry reputation through effective marketing and product quality. Industry research has increased production efficiency through combining government and industry projects. South Australia's low population density and annual rainfall minimises pollutants entering waterways which reduces contamination events, and consistent monitoring ensures safe, high-quality oysters. Unlike many other states South Australia markets each individual growing area to create branding and increase consumer demand.

Blue Mussels (Mytilus edulis) are farmed in Port Lincoln and on the west coast. The industry is in its infancy, and although production volumes still fluctuate, the annual trend is increasing (see below). Expansive growth is expected as land-based infrastructure and markets are developed throughout the state.

Oyster Production

In the period between 1999 and 2007, oyster production increased by 308% from 2500t to 7720t. The total production value during this period increased from AU$9.4m to AU$37.8m, with an annual average increase in value of AU$4.1m (Figure 17).

In 2007 oysters constituted a market share of 8.87% of South Australia's total aquaculture production value.

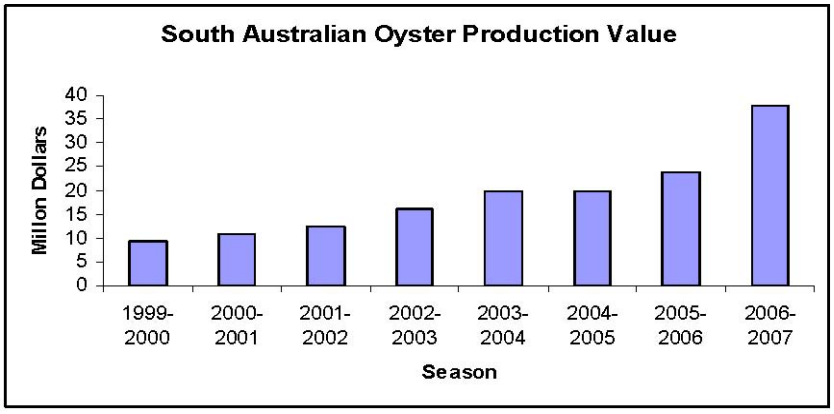
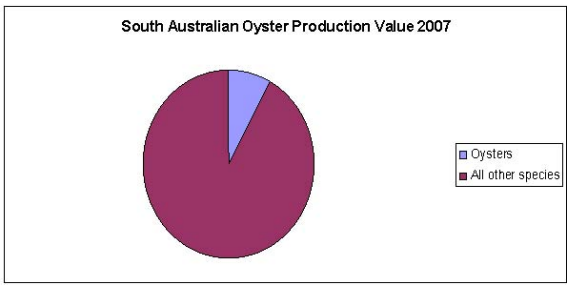


Figure 17, South Australian Oyster Production Value 1999/2007, Oyster Market Share of total aquaculture in 2007.



Mussel Production

In the period between 1999 and 2007, mussel production increased by 1275% from 81t to 1032t. The total annual production value during this period increased from $0.2m to $1.9m.

In 2007 mussels constituted a market share of 0.45% of South Australia's total aquaculture production value.

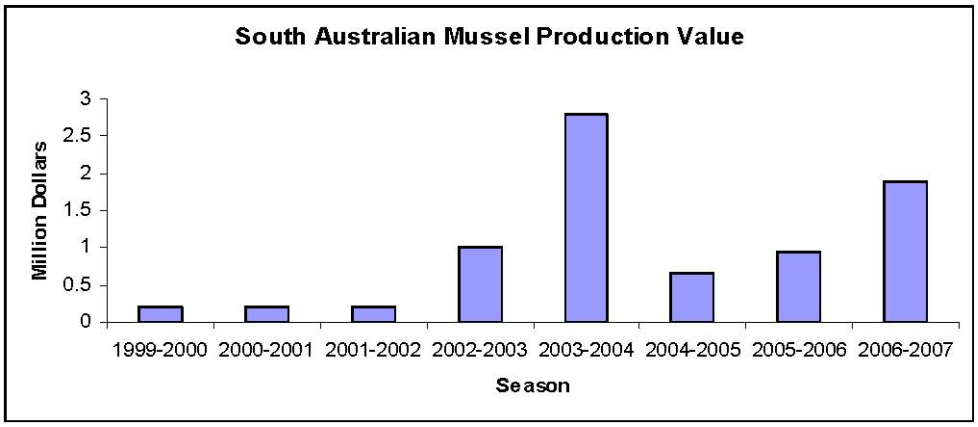
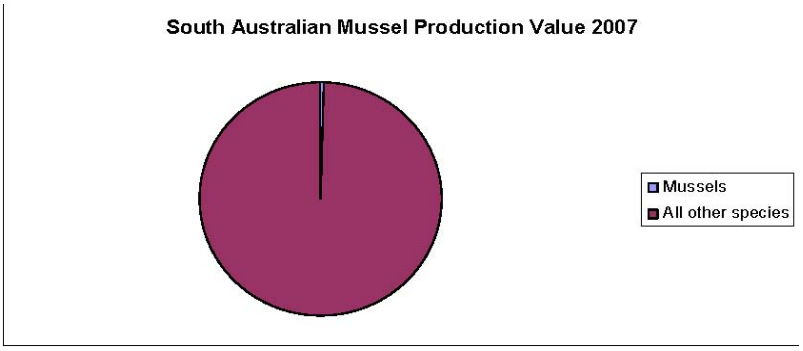


Figure 18, South Australian Blue Mussel Production Value 1999/2007, Blue Mussel Market Share 2007.



Cultivation methods

Oysters are produced using a combination of rack and rail systems and longlines. Hybrid systems are engineered to suit each individual growing area. Hatchery seed supplies the industry which also utilises natural recruitment to minimize operational costs and maximise production efficiency.

To maximise growth and minimise parasite settlement oysters are graded several times during maturation. To meet the needs of different markets, oysters are graded into additional sizes compared to the eastern states. Oysters are sold as; standard, bistro, large, plate and jumbo to value add and ensure a constant market supply. A growout period of 18 to 30 months is achievable due to the minimal rainfall and stock rotation practices, reducing sub-optimal conditions, stress and disease outbreaks.

Mussels are cultured on suspended longlines and producers rely on natural recruitment and hatchery-cultured spat on ropes to stock growing areas. A trend toward cultured rope is occurring as production volumes are more consistent and less labour is needed to grade and maintain natural settlement ropes.

Industry Extension

Primary Industries Resources of South Australia (PIRSA)

PIRSA is the government department that regulates primary industries within South Australia. Industry extension and support is provided to producers and combined research projects are undertaken with industry bodies and associations to promote sustainable aquaculture production within the state.

The South Australian Mussel Growers Association (SAMGA)

The South Australian Mussel Growers Association was established by a group of mussel producers to provide the industry with consistent and collaborative management –and probably for better access to government through a representative organisation. This allows consultation with government relating to best management practices, marketing

and monitoring programs. The association is also represented by the South Australian Aquaculture Council (SAAC) who liaise with license holders and PIRSA.

South Australian Oyster Growers Association (SAOGA)

The SAOGA was developed in 1998 as the oyster industry body to represent and support the oyster industry at local, state and national levels. The association is actively involved in the South Australian Shellfish Quality Assurance Programme (SASQAP).

The South Australian Oyster Growers Association recognised that for the industry to remain competitive and dynamic, research and development must be a priority. As a result, the South Australian Oyster Research Council Pty Ltd known as SAORC was established. This organisation consisted of nominated licensed oyster growers and SAOGA as the sole shareholder. SAORC is an industry body funded by a levy on the sale of hatchery-reared spat.

The central purpose of SAORC is to promote, encourage and co-ordinate scientific research and development for the benefit of the South Australian oyster industry. SAORC, through consultation with industry, identifies projects to be undertaken, sources funding from State and Federal Governments, allocates resources and administers research and development projects and extension of research results.

South Australian Shellfish Quality Assurance Program (SASQAP)

This program was established as a joint initiative between Primary Industries and Resources South Australia (PIRSA) and the shellfish industry of South Australia in 1994. It provides the same service as similar programmes in other states (eg, QSWAMP) to ensure environmental and aquatic health is maintained.

Western Australia

Background

New Zealand Rock Oysters Saccostrea commercialis (formerly known as S. glomerata) were introduced from New Zealand in 1888 (Saccostrea commercialis is the same species as the Sydney Rock Oyster) to mitigate stock loss due to Polydora sp. mud worm infestation (Anderson and Adlard 1994, Roughley 1922). These introduced oysters were distributed from Queensland through to Western Australia and, although stocks were imported in the belief that they were free of any disease or parasite, many outbreaks of Polydora sp. began to occur, creating large fluctuations in production and affecting industry viability. Due to minimal natural spat fall and recruitment, coupled with Polydora sp. Infestations, oyster production in Western Australia has remained low. In 1997 a single hatchery was established at Albany, the facility was far south of the natural distribution of rock oysters and to this day production volumes are so low that they remain unreported in government statistics (Nell 2001).

Aquaculture production of Blue Mussels (Mytilus edulis) began in the early 1970's to supply local markets with small volumes of product which were reliant on natural settlement. The distribution of growing areas is limited by the optimal water temperature (14oC to 20oC) which occurs in the cooler southern waters of the state. Currently, the industry is showing growth which is expected to increase as new production areas are secured on the southern coastline. Western Australia contributed 19.8% of Australia's total Blue Mussel output during the 2006-2007 season (ABARE, 2008). Thirteen species of native mussel are found in the waters of Western Australia, although the Blue Mussel is the only species that is produced commercially due to its marketability as an established product, as well as other factors such as size and growth rate.

Western Australia has established a very successful pearl oyster industry and is Australia's leading pearl producer. The industry is centred on Broome on the tropical, north Kimberly coast, and was established in the 1880's as a diver-based, wild-collection industry supplying mother of pearl and pearls to international markets. The cultured pearl

industry has developed in the last 30-40 years as a result of overexploitation of wild stocks and technology transfer from Japan. Advances in hatchery production now allow each pearl oyster to be seeded multiple times and produce three pearls throughout its lifetime. Since the 1950's high quality south sea pearls (based on Pinctada maxima) have been developed and the industry has grown into a stable, sustainable sector that is managed through quotas for both wild and hatchery-produced stocks. Sixteen pearling licences cover 184 nautical miles of growout area. Temperate species of pearl oyster are also being developed in the southern waters to increase the industry within the state and the country.

Mussel and Pearl Oyster Production

During the period 2004 to 2007 mussel production ranged from 531t to 765t. The total annual production value ranged from AU$1.5m to AU$2.16m. In 2007, Blue Mussels represented 0.38% of the WA total aquaculture production value.

South Sea Pearl Oysters (Pinctada maxima) are controlled by quotas and over the period 2004 to 2007 the industry consistently produced AU$122m of south sea pearls which supplied domestic and international markets. This industry is clearly the most consistent aquaculture venture relating to production quality, volume and value. The industry represented 25.4% of the state's total aquaculture production value in 2007.

Cultivation Methods

Mussels and pearls are cultured on suspended longlines in the open ocean. Both species are susceptible to low levels of salinity and therefore farming occurs along the coastline instead of in estuaries. Due to the specific biological needs of each species south sea, or gold-lipped pearl oysters (Pinctada maxima) are produced in warm waters, while Black-lipped Pearl Oysters (Pinctada. margaritifera), Shark Bay Pearl Oysters (Pinctada albina), Winged Oysters (Pteria penguin), Akoya Pearl Oysters (Pinctada imbricata) and Blue mussels are produced in the more temperate southern waters.

Industry Extension

Aquaculture Council of Western Australia

The council was established to promote aquaculture to the community and the State government, acting as a communications hub for the industry. The aim was to couple the economic and legislative needs of both the industry and the community creating cost effective support and services while maintaining ecologically sustainable development.

Western Australia Shellfish Quality Assurance Program

As previously mentioned, local components of the Australian Government's shellfish quality assurance program have been established in each state and territory in Australia. In Western Australia the program ensures the safe production of edible products to commercial markets.

Northern Territory

Background

The aquaculture industry in Northern Territory produces South Sea Pearls, Barramundi, Mud Crab, Reef Finfish, Redclaw Crayfish, Sponges, Prawns and Cherabin (Freshwater Prawn). Indigenous ownership is becoming more common as the industry develops and large coastal land tenures allow indigenous communities to establish profitable rural industries.

Pearl Production

South Sea Pearl Oysters (Pinctada maxima) are the only species of mollusc produced in the Northern Territory. During the period 2004 to 2007 the total value of pearls, combined

with aquarium production (volumes not individual due to confidentiality restrictions) ranged from AU$24.6m to AU$26m.

Cultivation Methods

Suspended longlines are used to cultivate pearl oysters as in the other producing states. This simple method has been proven over time to be the most effective method of production.

Industry Extension

Darwin Aquaculture Centre

The Darwin Aquaculture Centre was established in 1998 to enable the commercial production of fish, crustacean, algae and live feeds. The centre supports the established industry and also new investors starting production through information extension and support. With a staff of 16 at the centre, knowledge management and sharing with other states producing similar species of product, algae or live feeds is undertaken. The centre excels in the culture of small strain rotifers, which are being used in trials with Southern Blue Fin Tuna larvae in South Australia.

Oyster Disease

Introduction of Mud Worm (Polydora websteri)

In 1895 the industry suffered major losses from predation by mud worms (Polydora websteri) which brought the industry to a standstill. Any oysters which were not killed were often unmarketable (Department of Primary Industries 2001; Smith 1982).

It is believed that the practice of bringing oysters from New Zealand into Australia for “fattening” and restocking was responsible for introducing a pandemic in the form of the mud worm. The industry was forced to adopt avoidance farming techniques including lease rotation and intertidal farming to manage the affects of the mud worm (Ogburn, White & Mcphee 2007; Nell 2001). The worm can be managed through either drying out the oysters or moving the oysters into fresh water for several days. This practice kills the worm, without killing the oyster (Department of Primary Industries 2001).

Research discovered that muddy substrates were the areas of highest infestation. Farmers developed intertidal structures or ‘furniture’ to elevate the oysters from the substrate, and by 1903 the industry had returned to original production levels (Department of Primary Industries 2001). However, the pressure of dredging coupled with mud worm-related mortality depleted both wild and farmed stocks. The industry managed to continue producing oysters, although many leases were abandoned. The harvest of wild oysters from rocky shores (bank oysters) and dredging for human consumption continued (Nell 2001).

QX Disease (Marteilia sydneyi)

A new threat to the industry manifested in the form of a mystery disease now known as QX Disease. The “Q” stands for Queensland and the “X” stands for the fact that for a long time the cause of the disease was a mystery (Nell 2001).

In 1976 it was discovered that the disease was caused by the halposporidian parasite Marteilia sydneyi, and once infected the oysters have a mortality rate of up to ninety percent. The digestive gland becomes infested with thousands of spores which stop the gland functioning, resulting in starvation within around sixty days. The disease is easily diagnosed due to very consistent symptoms; first the tissue of the oyster becomes colourless and translucent, followed by the digestive gland turning from green to a dull yellow (Department of Primary Industries 2004).

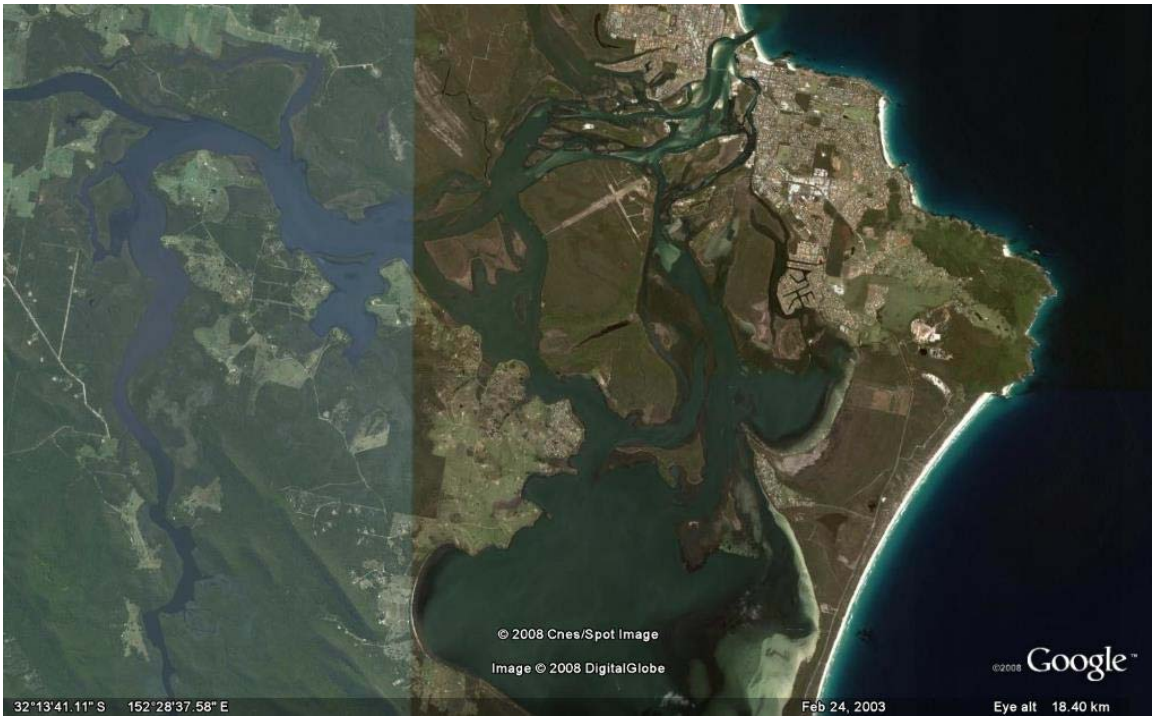
The parasite lives in muddy substrates and infection is triggered by sub-optimal environmental conditions, such as low salinity and high temperature. These conditions commonly occur during summer rain and flood events (Nell 2001).

The industry has developed management techniques to reduce the rate of infection. While generally successful, these techniques increase the cost of production, and limit peak production in estuaries, to a six to eight week period between September and November (Department of Primary Industries 2004). Lease rotation has proven to be an effective tool in limiting the rate of infection, and research into disease-resistant oysters is well underway and appears very promising. Through selective breeding the progeny of second generation Sydney Rock Oyster breeding lines, mortality has reduced by 22% and the surviving oysters, on average, have increased in weight by 21% (Nell & Hand 2003).

Although the rock oyster (Saccostrea commercialis) is the host for the disease in Australia, a similar disease which causes mortalities in European oysters is caused by Marteilia refingens (Nell 2001 & Department of Primary Industries 2004).

Oyster Contamination: Wallis Lake Case Study

Wallis Lake is between Forster and Tuncurry on the coast of Northern New South Wales. The region is picturesque with beautiful natural features including temperate rainforests and sandy beaches. The western side of the lake is backed by extensive forested hinterland, comprising of State Forest and National Parks, while the eastern side of the lake is bordered by the Pacific Ocean. The “Lake” is actually an estuary which receives both fresh and marine inflows of water. The area has a rich cultural history with development dating as far back as convict settlement in the late 18th and early 19th centuries.



Recreation and Tourism

The catchment supports many diverse stakeholders ranging from commercial aquaculture operators, tourism and accommodation providers to holiday makers, locals and tourists. The economy of the region is not solely driven by inflows of tourism. Tourism, however, is solely driven by the attraction of the regions history and environment (Fowlie 1999).

Catchment Management

Farming and aquaculture, urban development, land use and commercial and industrial areas within the catchment create catchment management issues and ecological pressures. While some of these pressures are constant, others are more seasonal and often relate to tourism activities (O’Sullivan 2008).

Seasonal Population Peaks

As in many coastal regions on the east coast of Australia, the peak times for tourism is during the December (Christmas) and March/April (Easter) holidays. Tourist accommodation developments have been constructed in this rural area for many years and, partly due to their age, but also to the absence of comprehensive urban sewage treatment systems, many septic-tank sewerage systems exist in the region. Poorly maintained septic systems, and particularly during rain events, human-derived faecal contamination can flow from failing systems through ground water flows and into the lakes, posing human health risks (Parliament of NSW 1997).

Faecal Contamination Event

In 1996, as usual, the area was frequented by holiday makers and by the local public over the Christmas holiday period. Failed septic systems in the surrounding areas around the lakes caused aquatic contamination of groundwater which flowed into the lakes. Sewage-contaminated oysters produced in the lakes were subsequently sold to the public, affecting hundreds of consumers (Fowlie 1999; Conaty et al 2000; Richardson & George 2000).

Hepatitis A Infection

One man died and another 467 people contracted hepatitis A directly from consuming contaminated oysters. NSW Department of Health observed that the number of individual cases rapidly increased and surveyed the patients to find a link throughout the community. The survey identified that the vast majority of patients had consumed oysters over the holiday period, or early in 1997. A link was then established between failed septic systems and faecal-oral contamination. By the 14th of February, 1997 all local oyster farmers voluntarily recalled their produce and ceased harvesting (Conaty et al 2000).

Septic System Inspection and Regulation

The NSW state government then undertook a study that identified that up to 70% of the septic systems had some form of failure resulting from either faulty installation, maintenance or management. The local Great Lakes Council responded to the contamination event by surveying all 11,000 septic systems in the region, and now monitors and regulates every system in the shire. Public education initiatives have also helped ensure that failing systems are reported and private evaluators and consultants have been trained to help oversee and facilitate the monitoring program (Fowlie 1999).

Litigation

A class action lawsuit, i.e one comprising of multiple people pursuing compensation, was filed and the case of Grant Ryan was heard. Mr Ryan became bedridden for over five weeks and was unable to support his wife or his family of five children. The court found in favour of Mr. Ryan who was awarded AU$ 30,000 in damages. The remaining 174 cases were subsequently to be individually accessed to determine the merit of each case (Fowlie 1999).

Organisational Culture, Mismanagement and Duty of Care

The entire industry, including the governing bodies, was investigated during the legal trials. The oyster growers were reliant on the council for water quality monitoring, and the council had the necessary equipment to complete the task, however, the council relied on the Department of Primary Industries for this task. The Department of Primary Industries, who had extensive equipment and technical experience, even had the power to stop harvesting based on real or perceived human health risk. All bodies knew that contamination was occurring and that it posed a risk, and all bodies knew that they could be doing more, however, all thought that it was someone else's responsibility. The council and the DPI even wrote and published articles relating to the possible human health risks of oysters in the area, but did not act externally and solve the problem before the apparently predictable outbreak occurred (Fowlie 1999).

The culture of the organisations involved was not to effectively monitor and regulate their areas of responsibility, instead probably assuming or expecting other organisations to undertake these tasks. There was a breakdown in communication between farmers, council and state government combined with a total breakdown of industry management. The three parties had a duty of care to the consumers of the oysters and to the community to provide a safe product, free of contamination (Fowlie 2000; Parliament of NSW 1997).

Ruling

In 2000 the legal decision found the Great Lakes Council, the State of New South Wales and various oyster producers all responsible for the contamination. All three were negligent and all had the equipment to test for contamination (Richardson & George 2000).

Lessons for Oyster Producers

During the class action lawsuit the judge said that the producers should not only ensure that the minimum requirements were met, “the growers need to go beyond government regulations to ensure that products are safe for human consumption” (Fowlie 1999).

The court recognized that it was impossible to ensure that all oysters are free from viral or other contamination stating that;

“Barclay's (one of the aquaculture producers) oysters were not obliged to ensure the absence of viruses, but it was obliged to take the steps reasonably open to it to obtain a virus-free growing environment and, if this was impossible, to refrain from selling oysters for human consumption, except perhaps with a warning about the risk in eating them”.

Subsequent Changes to Industry Practice (remember it's not a newspaper article)

> Eleven years since the sewerage contamination and disease outbreak, widespread changes have been made to the management of the Lakes and the NSW oyster Industry. The community has recovered from the incident which strained the local economy and relationships within the community. The incident prompted a combined? approach to Catchment Management considering all levels of the community from ministers and state government down through the council and the community. One hundred and thirty km of fencing to buffer riparian vegetation, 150 off-stream water points for cattle, extensive natural revegetation and hundreds of acres of wetland rehabilitation have so far been promised, although the community estimates that only 10% of the sensitive riparian vegetation has been fenced (Fowlie 1999; O’Sullivan 2008; Gippsland Aquaculture Industry Network 2008). Check the sense of this last sentence. It did not read properly , so I have interpreted and rewritten it. Not sure if its correct though.

2004 National River prize for Community Engagement

In 2004 the region was awarded the National River prize for community engagement which is testament to the entire community helping and being involved in the consultation process and during the project. The community raised AU$300,000 toward developing an Estuary Management Plan. The plan combines land use and aquatic management to achieve effective management of the whole catchment (O’Sullivan 2008).

Clean Waters Model

The approach to Catchment Management has been so successful that the area now supplies one third of the NSW total oyster production. The project is now being coined the “Clean Waters Model” and is being adapted for use in other areas. The water quality is now so high that the growers do not have to use depuration procedures which lowers overall production costs. The amount of wet day closures has reduced by over 60%. The oysters can also be used as an indicator species, and the quality of the oysters being produced reinforces the effort that has been taken by the community to rehabilitate the estuary, and the catchment (O’Sullivan 2008).

11.8.2 Summary

Oyster Production Value

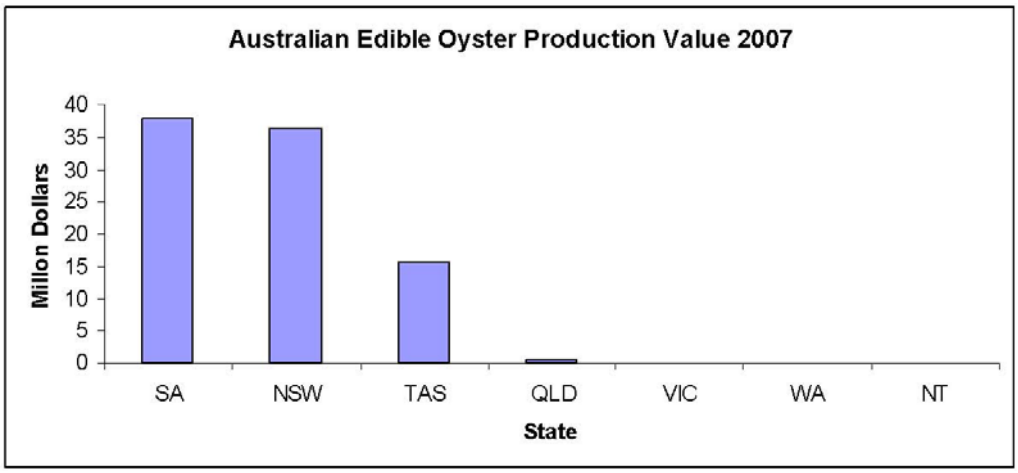


Figure 19, Comparison of Australian edible oyster aquaculture production value in 2007 by state. Edible oysters comprise C. gigas, S. commercialis, O. angasi.

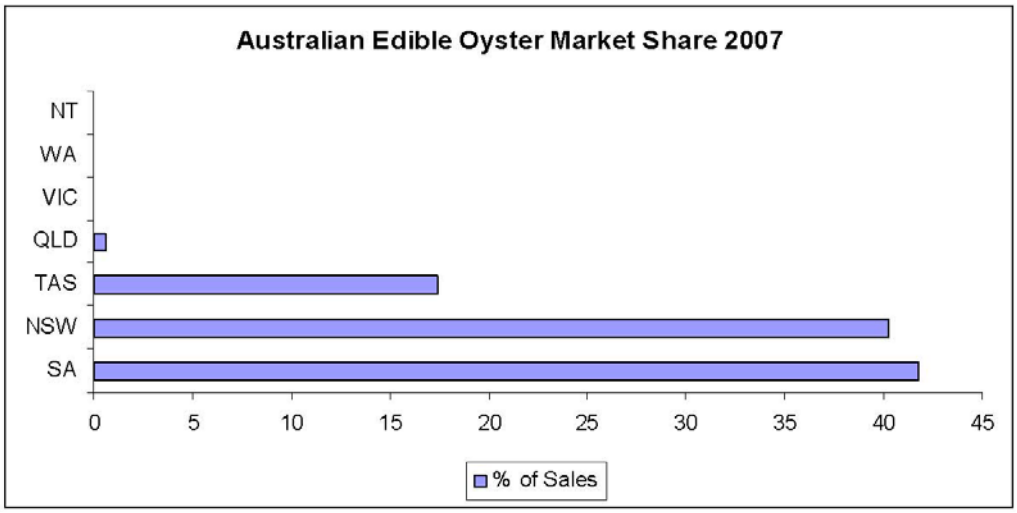


Figure 20, Aquacultured australian edible oyster market share by state 2007.

In 2007 the value of Australian aquacultured edible oysters sold both domestically and internationally totalled AU$90.57. With large coastlines and many available growing areas both New South Wales and South Australia have provided the majority of edible oysters for the Australian market. South Australia achieved the greatest volume due to the states low population density and annual rainfall, while New South Wales increased production through the utilisation of new growing areas in the Wallis Lake and Hunter Valley regions.

Mussel Production Value

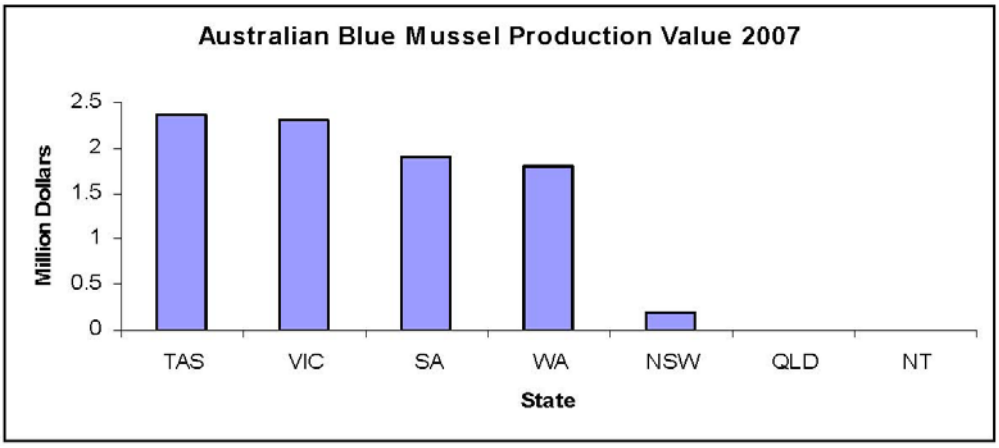


Figure 21, Comparison of Australian Blue Mussel Production Value 2007.

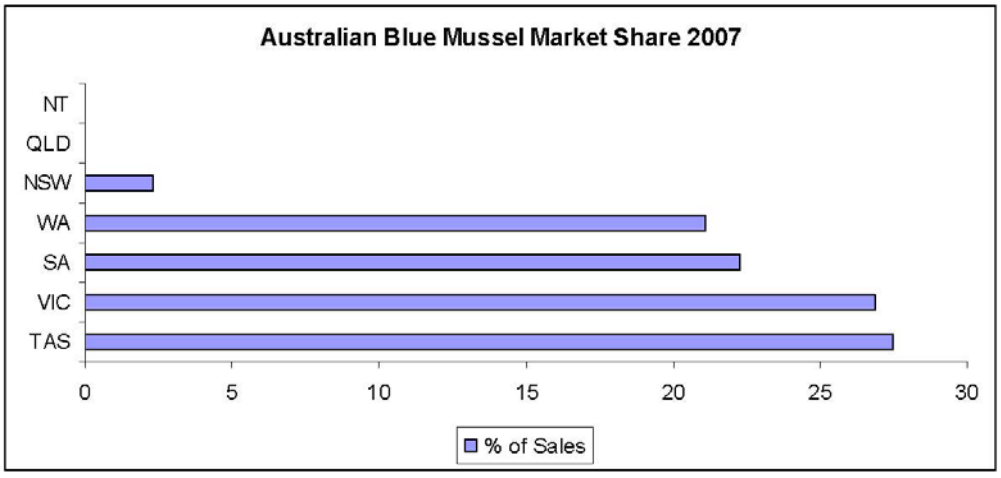


Figure 22, Australian Blue Mussel Market Share 2007.

In 2007 the value of the Blue Mussel industry reached AU$8.6m. Due to the temperature tolerance of Blue Mussels the southern states of Australia were the highest producers. Although Tasmania is the smallest state of Australia it has a proactive aquaculture strategy combined with a suitable climate for Blue Mussel production. A trend in the southern states toward the use of hatchery-cultured spat ropes is enabling industry growth and providing consistent volumes within the marketplace.

Pearl Production Value

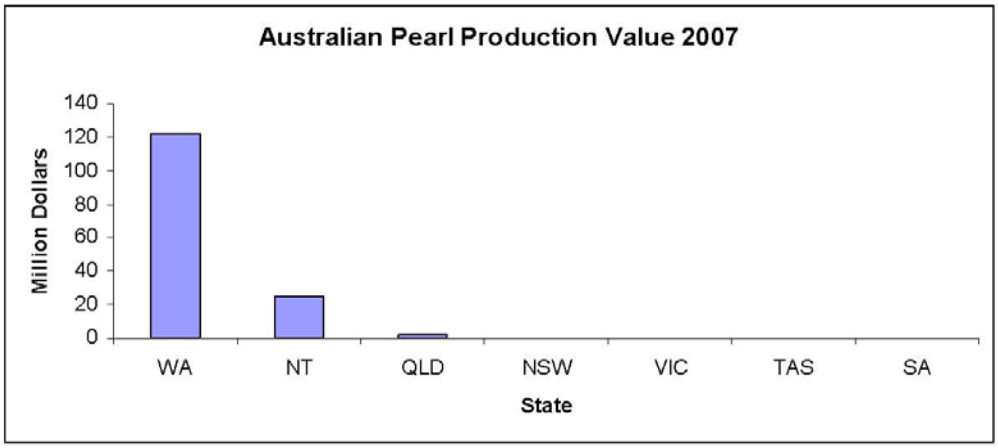


Figure 23, Comparison of Australian Pearl Production Value 2007.

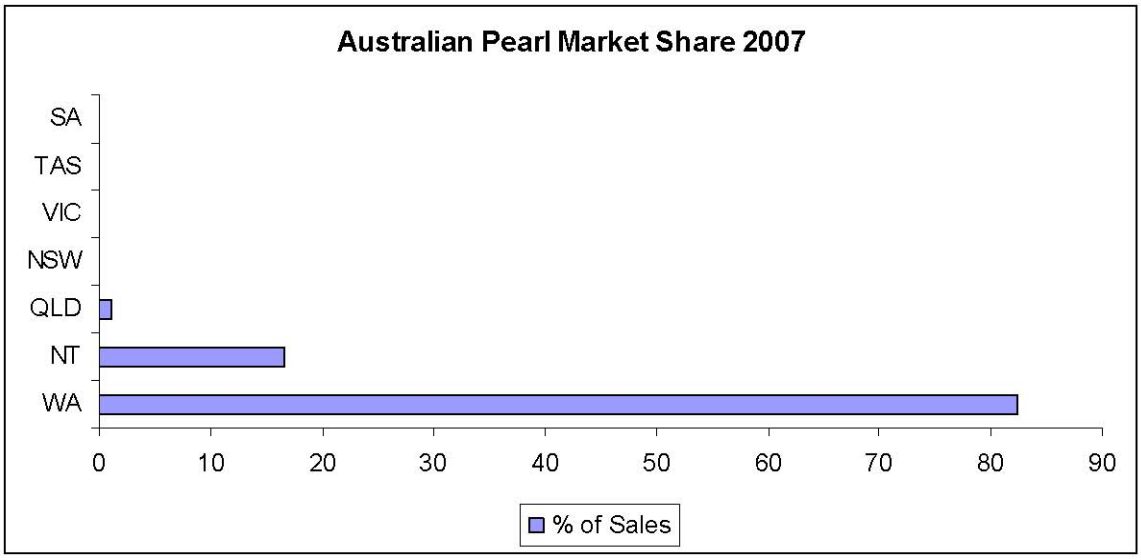


Figure 24, Australian Pearl Market Share 2007.

Data for Northern Territory includes aquarium production of finfish and therefore the figures in these graphs are not solely related to pearl production. Through the use of quotas, Western Australia has consistently produced AU$122m of products annually for the past three years. Production practices have been refined and hatcheries enable marketable pearls from each oyster once every two years. Pearls produced in the warm waters of northern Australia are of high quality, the industry supplies domestic and international markets and with an expected increase in the Northern Territory and Queensland the industry is expected to strengthen in years to come. All pearls are produced in individual baskets or net panels attached to suspended lines; this method is simple yet proven to be the most effective cultivation method.

Industry Structure

In summary the model for the Australian oyster and mussel industry was developed by addressing these key areas;

The first priority in establishing a viable and profitable bivalve aquaculture industry is to assess the catchment management issues and land-use patterns within each catchment of interest to build a SWOT analysis (strengths, weaknesses, opportunities and threats). Estuaries and embayments that are suitable for culture operations based on their physical geography need to be surveyed, and a comprehensive list of all catchment management issues need to be identified. Activities such as farming practices and effluent runoff need to be carefully addressed and mitigation strategies designed to ensure that safe, high-quality products can be produced in commercial quantities.

Secondly, government and industry bodies are needed to develop and regulate aquaculture operations. These bodies should provide information extension to producers and a communication hub for the community to interact with the industry and government. Both water quality and product monitoring is essential to avoid negative impacts associated with environmental and human health issues. These programs need to be regulated through government legislation to provide the industry with consistency and to meet regulatory standards, in addition to creating a positive reputation relating to farming practices and production safety and quality. This approach needs to come from a “top down” management structure with the governing bodies remaining accountable for the continued monitoring and regulation of the industry. This is not to say that producers are not accountable for their actions, however, consistent monitoring and extension can overcome many localised issues through the use of best management practices and effective long-term monitoring programs.

Thirdly, industry and Government have to work together to identify the most suitable amount of available coastal and marine leasing area to accommodate industry growth,

while also applying the principals of ecologically-sustainable development. Consistent growth from a small developing industry can ensure that the environmental, social and economic issues associated with oyster and mussel aquaculture are dealt with appropriately. Addressing production issues on a small scale and then increasing production allows the industry to remain viable and sustainable. Rapid growth can cause a collapse in regulation and also create over-supply issues which can. outstrip demand and local markets will become unprofitable for producers.

For the export of product, either to expand industry production or value, certain additional requirements need to be implemented. In Australia, the Shellfish Quality Assurance Monitoring Program ensures that produce is safe and of high quality, this allows Australian producers to export any high value products such as plate oysters to value add and create new markets for the sale of products. Although it may take some time for any industry to develop, limiting the production volume to domestic markets will ultimately limit the industry's growth and future viability.

Cultivation Methods

Dredging is an unsustainable fishing practice and should not be used a collection method for either wild harvest or aquaculture products. To increase the available wild caught seed natural beds should be preserved and protected.

Although hatchery seed is produced, wild-caught seed is the most utilised method of spat collection for oysters, combined with tray culture for the growout phase. This method of production is proven to produce commercial quantities of high quality rock oysters (Saccostrea spp.). Pacific oysters (Crassostrea spp.) are also produced on suspended longlines in plastic baskets; this method allows the suspended line to be repositioned in the water column and reduces labour during production and harvesting.

Oysters are produced in the intertidal reaches of estuaries in areas of relatively high salinity. Stock rotation is necessary to ensure that oysters are free of parasites and develop to their full potential. Oyster leases need to include areas of low salinity to mitigate any parasitic events such as mud worm infestation or QX disease. Imported stock can also cause parasites to be introduced, if there is a need for new stock hatchery produced seed is far more reliable than imported stock.

Blue Mussels are produced in the intertidal reaches of estuaries and calm embayment's on suspended longlines, which are seeded from wild seed and hatchery produced cultured spat rope. Some producers utilise protective, degradeable "stockings" to encase the mussel ropes and reduce predation and storm impacts. This method allows more efficient harvesting and reduces fouling of the mussel shells.

Neither species tolerate extended periods of low salinity. Rainfall events and high temperatures can cause disease and mass mortalities, in areas of high rainfall lease areas need to be in the lower reaches of estuaries.

A constant supply of product is needed to create a strong market and increase the industry's viability. Wild spat collection can be inconsistent and creates seasonal growing periods. To improve industry viability in Australia hatchery production appears to be an important component in providing a regular annual supply of seed and consequently consistent volumes of finished product in the market place. Australian operations that rely on hatchery seed are far more consistent and show better industry growth.

Producing many different grades of oysters has also improved growth within Australian markets, especially in South Australia where alternate grades have created new markets with specialised needs. Value adding has been achieved through year round supply of alternate grades of high quality oysters and through positive marketing such as product branding, consumer awareness and education.

11.8.3 Conclusion

Although all the species in this report may not be available for cultivation in the Philippines, the information in this report may be adaptable to local species of oysters and mussels. Further detailed information relating to the most effective cultivation methods are readily available on the internet or through private aquaculture consultation. This is the first report of this nature that I have completed, and I thankyou for the opportunity to contribute to the project. If any additional information is needed or you have any queries relating to the content please email me directly at; mahdigreen@hotmail.com and I will reply promptly. I have enjoyed compiling this report and send my best wishes to everyone involved in the project.

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11.9 Appendix 9: Shellfish-Based Economs Development Support Program (SHELLFISH BEDS)

Shellfish-based Economic Development Support Program
(Shellfish BEDS)

Proponent: College of Fisheries and Ocean Sciences (c/o Prof. Ricardo Babaran)

The production systems for shellfish, such as mussels and oysters, are generally called beds, and the title that is used for this research program symbolically refers to these production systems. However, SHELLFISH BEDS takes a much larger meaning because it seeks to provide a direction for the growth and development of the shellfish industry that can be used to spur and sustain local economic development of coastal communities in archipelagic developing countries like the Philippines.

Considering all the potential commodities that can be developed, the Philippine shellfish industry is still in its incipient stages, and this is probably due to the absence of a support mechanism to realize its development. The problems of the industry are also enormous; many of these problems can be addressed through research.

Research is necessary for this industry to develop and mature, and contribute to support local or regional development. Undoubtedly, the inadequacy of research support is partly the reason for the failure of the shellfish industry to develop. The limited number of available information generated through research explains the artisanal or sustenance nature of existing mussels and oysters production systems, which remains small, insignificant, and under-developed (Figure 1, top). This condition can be improved with a well-defined research agenda that focuses on the problems besetting an industry during its development and even after it stabilizes into a fully-developed industry (Fig. 1, bottom). Thus, SHELLFISH BEDS seeks to define the research agenda and the appropriate research activities to support the development and management of the shellfish industry.

Phases

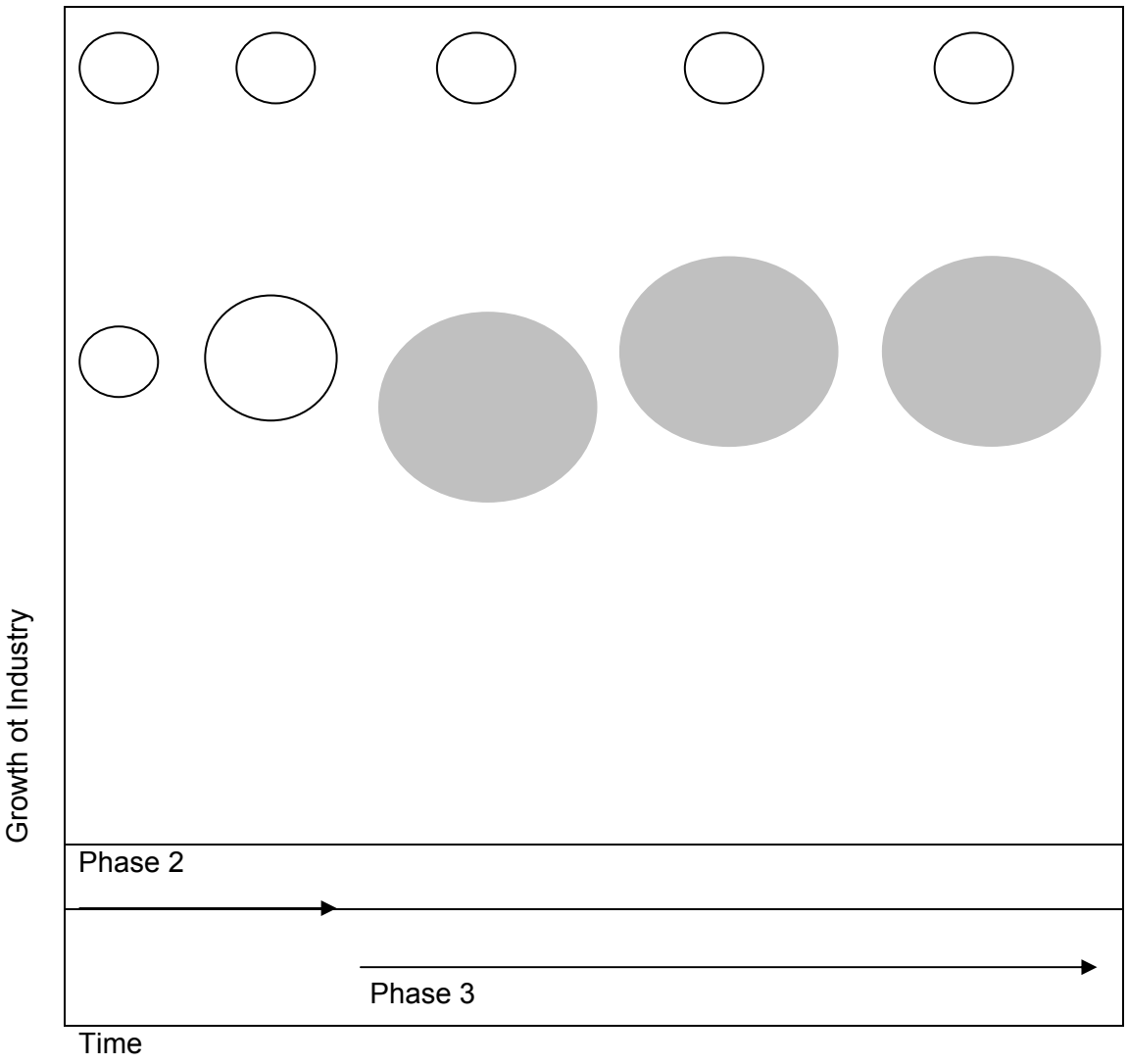
For practical purposes, the implementation of the program should be done in phases. Phase 1, industry profiling is important because it will define some baselines, probably including a pre-project assessment against which the results of all forthcoming activities will eventually be gauged to determine the impact of the SHELLFISH program; for mussels and oysters, this phase is now being finalized. A similar activity should be pursued for other commodities like scallops and other bivalve species.

Phase 2 (3 year period) may deal with a focused set of interrelated research activities on production, stock assessment and management, product development, market development, among other areas for research. Results from these activities should lead towards the development of an industry, which will ostensibly be stable after the 3rd year.

During Phase 3, a certain set of guidelines for shellfish quality management should already be in place. Moreover, an agenda to expand the program to other areas using the lessons learned in Phase 2 may be considered during Phase 3. In addition, a component for capacity-building, in coordination with national agencies like DOST, will have to be pursued to ensure that trained manpower would available to support the requirements of the industry. As an institutional partner in stewarding this industry's progress, CFOS is expected to be always on CUE in all these phases of the project and play a major role not only in research but also in capacity-building.

For all the phases indicated above, perhaps a parallel set of activities should be conducted to prepare the host communities where production systems will be established. Certain policies will have to be formulated to address regulatory concerns such as the types production systems to adopt and their sizes, distance between adjacent production systems, among other concerns. These may involve local government units and other appropriate national agencies like BFAR/BFAD.

Figure 1. (Top) Schematic diagram depicting the progress of a potential industry without research support. (Bottom) Desired or projected development of the same industry with research support until it matures and stabilizes into a fully-developed industry (shaded).



11.10 Appendix 10 Proposed ACIAR-Philippines Mariculture Enterprise development Project

Proposed ACIAR-Philippines Mariculture Enterprise development Project (FIS/2006/143) - Barney Smith and John Skerritt, 12 January 2009

Proposed Australian Commissioned Organisation:

National Maritime Science Centre (Southern Cross University/ University of New England)

Proposed Australian Project Coordinator: Prof Alistair McIlgorm, NMSC Director
(he will visit Ilo Ilo and Samar in February 2009)

Proposed Philippines Coordinating Organisation:

SEAFDEC Aquaculture Division, Ilo Ilo, Philippines

Proposed Philippines Project Coordinator/s: Joebert Toledo (Director AQD) and Dr Bing Ayson (Research Director)

Anticipated project components and potential team members are shown below. It will be important to complement the proposed teams with individual/s who have agribusiness/ marketing expertise :

1. Seaweed (Dr Symon Dworjanyn (NMSC) and Dr Ann Hutado (SEAFDEC))

This component would aim to identify and field test more productive strains of Kappaphycus through tissue culture, protoblast fusion and sporulation. Other areas such as the identification of useful byproducts from the seaweed additional to the usual marine biocolloids fall outside the ACIAR mandate. What is proposed is largely research-station based although the location of the field work should be better clarified. We also need to take into account seaweed work being done by the BFAR National Integrated Fisheries Technology Development Centre, Dagupan and also what UPMSI's plans are in this area.. BFAR do collaborate with SEAFDEC on strain evaluation and polyculture with other species.

Dr Dworjanyn visited the Philippines in December 2008 and his report (summary attached) provides some useful guidance. ACIAR is currently reviewing the report and on initial reflection concurs with a proposed focus on productivity decline issues (strain performance and environmental effects) but we will need to work through the scale and focus of the activities to be supported. Given limited resources, we believe that work on disease defence mechanisms would detract from the focus of the project.

Seaweed utilisation work funded from the Indonesian project SMAR/2008/025 (and potentially MARS Ltd) has a focus primarily on post harvest technology. The Philippines work would instead have a primary focus on addressing issues related to the declining productivity of established farming areas. The linkages between the Indonesian and Philippines activities have yet to be worked through but it is anticipated that by having a common Australian Project Leader sharing of information between the Philippines and Indonesian teams through joint meetings etc would take place.

2. Mudcrabs (Drs Rene Agbayani, Emilia "Babes" Quinitio, SEAFDEC; Ms Sheliah Vergara, CATP; need to identify marketing and Australian expertise – Mike Heasman (ex NSW DPIF, if available). Chao Shui, JCU may possibly contribute on hatchery technology but we are aware that SEAFDEC already have high level hatchery skills.

This component would build on the initial work under the current CATP mudcrab project and work done under the earlier mudcrabs projects in the Philippines. It is currently based in Northern Samar, and works through NGOs (Action for Community Empowerment/ ACE) but with a link to the BFAR hatchery facility at Lavezares. The visit by Barney Smith and Philippines colleagues in October 2008 identified a number of improvements needed to focus the project. Separate from the current CATP work the sustainability of expanding

production needs to be explored; improved husbandry to improve existing fattening operations and development of nursery technology to provide crablets for sale for grow out. There is a need to look at the latter from an agribusiness perspective, especially if trade to other provinces is planned.

Next steps: A project planning meeting will be held in Catarman, Samar on February 4-6 and look at levels of community engagement, focus of the current project, future research needs and engagement of the private sector. At SEAFDEC Babes has established lab and research station skills, and SEAFDEC do have good extension level technicians. In Samar the need is for SME/ industry development skills to better integrate growers with available markets. Barney Smith have asked Maripaz Perez to participate in the workshop with the private sector to benefit from her experience and networks, and will also have Alastair McIlgorm attend. The meetings in February are critical as check on the potential for achieving real impact in Samar and provide a potential stop/go step for expanded involvement.

At this stage we would not anticipate involving UPV as technology is not the issue but rather adaption and adoption constraints along with related market chain issues/constraints. With the recent retirement of Romy Fortes, UPV's capacity in mudcrabs is also limited.

3. Molluscs (Dr Peter Duncan (Univ Sunshine Coast) and Dr Merlina Andalecio (UP Visayas))

The small FIS 2007/045 project completed in December 2008. The main sites to date have been in Panay (Ilo Ilo) and Negros. While the research has progressed reasonably well, and identified potential interventions to improve productivity, the main constraint is that molluscs are a relatively low-priced product. In this situation there may be limited incentive by farmers to improve production practices, although if training could be provided that could improve productivity without additional inputs the profitability of the industry could be better. There seem to be some non-technical policy issues of zoning for production that need to be addressed.

Selection of sites for future work – and commercialisation of the industry - will be a challenge. There is enthusiasm by UPV and other collaborators in Panay (such as the local mayor) for sites near Roxas City but because of pollution and tidal factors these do not seem to be suitable for industry development.

Separate to the work done with UPV, Juan Albaladejo (BFAR Region 8, Tacloban) has proposed a coastal resource management initiative for Maqueda Bay in the Eastern Visayas. They have an existing mussel industry there but there have recently been massive mortalities. He is keen also to expand seaweed farming there. Juan has a successful record in past ACIAR projects (EUS work in the 1990s), and I think that Merlina is happy to collaborate with him, but the researchable issues would need to be clarified much better for us to involve him.

Australian project leader Peter Duncan visited the project in late 2008 and discussed future plans with Merlina. The concept is called "Shellfish BED" (shellfish based economic development) and would be a multidisciplinary approach using UPV and associated researchers and NGOs etc (basically an enhanced and more attractive version of the Roxas City idea, but with much more opportunity). We would need to investigate the potential of this idea further before ACIAR would commit to it.

4. Marine Finfish (Groupers) (Rene Agbayani SEAFDEC, GTAT Daku Multipurpose Cooperative; possibility of involvement of Mike Rimmer/ JCU ??)

This is a CATP project building on PACAP activities (GDMPL NGO) in Misamis Occidental. It has been affected by lack of access to juveniles due to poor broodstock spawning; the PALS program is now funding a local hatchery. The focus is on nursery and grow out trials for groupers, to establish safe stocking levels while maintaining the environmental health of the production areas. Need to do more proving of the technology

before further scale out – initial work on the latter under the Iligan Bay Coastal resource Management FOCAS network (PACAP) may have been premature. ACIAR support needs to be for the technology work rather than roll-out at this stage. Market issues also need consideration in the initiative. Note that the case for further research and financial support by ACIAR needs careful evaluation and consideration before any action is taken.

5. Sandfish

Sandfish work through WorldFish will continue to be funded and managed separately (FIS/2003/059). The involvement of SEAFDEC in sea cucumber work (the Igang site on Guimeras looks suitable for proposed growout trials) and is being progressed as one component under an enlarged activity under overall WorldFish coordination (David Mills supported by Maripaz Perez and Les Garces in the Philippines), and will combine the pond aquaculture and sandfish ranching work.

Some Cross-cutting issues

- Geographic focus: given the broad commodity focus this is a challenge but the coverage is consistent with ACIAR's current areas of interest in central and southern Philippines.
- Selection of species –is dictated in the main by past investments but there is some rationale for diversification of production to reduce risk for small mariculture enterprises and abalone would certainly be a candidate in this context.
- The rationale for the new initiative, as for CATP, is delivery of benefits from past research investments to needy communities, and the researchable issue is the identification of effective modalities to achieve this in the Philippines context with its many significant challenges.
- What private sector partners are interested in/ suitable for involvement ? This is a very important issue and one that will start to be addressed in the Samar workshop.
- Access to agribusiness R&D expertise – who in the Philippines has these skills when it comes to mariculture? We are aware that UP Visayas has been involved in GTZ-funded work on milkfish with a focus on product targeted for EU markets, but this is only of limited relevance to the proposed work. We also need to check possible Australian/ international consultants.
- Project coordination- this is an area requiring careful attention both in terms of the capabilities of NMSC and in Philippines. SEAFDEC would be the logical coordinating partner country agency and comes with the advantage of greater flexibility and transparency than many other institutions but managing the institutional issues and relationships with other partners will be an issue. There is the need to ensure effective integration with relevant national initiatives
- BFAR links in Region 8 (Samar) are sound, and given the strong LGU networks of SEAFDEC and UPV, not as critical in regions 7 (Iloilo) and 10 (Misamis Occidental).

11.10.1 Appendix 11: Research recommendations for the Philippines seaweed aquaculture industry

Dr Symon Dworjanyn, National Marine Science Centre, University of New England and Southern Cross University, Coffs Harbour, Australia

Introduction

The following recommendations come from two scoping missions by the National Marine Science Centre investigating the research needs of the seaweed aquaculture industry in Eastern Indonesia and the Philippines. Two of the recommendations of the Indonesian study related to the critical need to halt the dramatic reductions in productivity of established farm sites through the a) development of new disease resistant, productive, seaweed strains and b) investigation of the environmental factors that are inducing bacterial disease ('ice-ice') and epiphyte infestations in cultivated seaweeds. These two recommendations were investigated in a later scoping mission conducted in the Philippines. This mission involved meetings with the key research, government and industry representatives related to the seaweed aquaculture industry.

Background on the Industry

In the Philippines seaweed farming accounts for about 75% of the aquaculture industry and about 20% of the total fishery exports. Annual production over the last few years has hovered around 1.5 million tonnes per annum and was worth an estimated $USD 73 million in 2005. Seaweed farming is seen as one of the most productive and environmentally sustainable forms of aquaculture in the world and as it often revolves around small to medium sized family businesses it is one of the most effective tools for poverty alleviation in tropical coastal communities. It is estimated the seaweed industry in the Philippines provides a working income for 120 000 people.

Decline

Despite the successes of the seaweed aquaculture industry there are endemic problems in the industry that are curtailing its growth and in the future are likely to result in its decline. It is expected that his decline will become evident only after new areas suitable for production have been fully exploited. Over the last ten or more years the seaweed aquaculture industry has been blighted by the occurrence of a bacterial disease colloquially known as 'ice-ice' that slows growth of plants, renders them unmarketable and ultimately kills whole crops. Infestations of epiphytes (and endophytes) are having similar effects reducing productivity and destroying crops.

It is difficult to get hard data on the impact of these problems. The only government figures available are total production figures that hide regional declines amongst increases resulting from the spread of the industry to new regions. Anecdotally, there are consistent reports that some previously productive regions have virtually stopped producing any seaweed. It is now an industry wide practice to only grow seaweeds for up to four weeks to avoid disease and epiphytes rather than the six weeks need for optimum productivity. It is important to note here that some regions have managed to maintain relatively steady production; however the reasons for this are unknown.

Causes of decline

There is general consensus that two interacting factors have been the main drivers of the decline in productivity of seaweed farming.

Seaweed strains

All seaweed seed in the aquaculture industry is produced by vegetative reproduction, effectively producing clones of a single plant. This has the advantage that the production of seed is easy and there is uniformity in the crop, however there is one very significant disadvantage. In the Philippines it is probable that perhaps one to three strains are used across the entire industry. These strains are from single original plants that were possibly

collected from the wild more than twenty years ago. Moreover, it is thought that throughout almost the entire Indonesian seaweed aquaculture industry only one clone from one original plant sourced in the Philippines is used. This massive reliance on an extremely narrow gene pool in such a large industry is a great cause for concern.

The lack of strain diversity allows disease and epiphytes to adapt to a single invariable host, currently this may be one of the reasons for the chronic disease problems in the industry. There is also a real possibility that an acute disease outbreak will decimate the entire industry if it relies on such a small number cloned strains.

The other problem with repeated vegetative reproduction is that the immune system, that defends bacterial and epiphyte attacks may be slowly degraded with repeated vegetative reproduction. Essentially there is a possibility each new clone's immune system is slightly less vigorous than the last.

Environmental effects

There is evidence that some single environmental conditions adversely affect the productivity of farmed seaweeds and can induce the incidence of the disease ice-ice and epiphyte infestations. It is most likely that these environmental effects interact with the problems related to the use of compromised strains. What is not known is how different environmental variables (e.g. water flow, temperature, salinity, light) interact to affect the seaweeds. As an extension to this there is no knowledge as to the carrying capacity of farm sites. Indeed it has not been established whether the effects on water flow, nutrient conditions and density of seaweed plantings have any adverse effects on the productivity of seaweed crops.

Research recommendations

Strain selection

Exploiting wild variability. The quickest and possibly the most reliable method to increase the number of strains available to farmers is to do an extensive survey of wild strains. This would involve the collection of wild strains from around the Philippines and then testing these for productivity, carrageenan yield, disease and epiphyte resistance, and robustness to environmental variables in field trial. The SEAFDEC seaweed team has already found one promising strain using this technique.

Laboratory based strain development. Three laboratory techniques could be used to generate new strains. These are 1) induction of gametophytic plants, followed by standard crossing of existing and wild strains, 2) the creation of protoplasts followed by fusion of existing and wild strains, 3) chemical induction of mutagenesis in current strains. (A recommendation as to whether to pursue one or all of these techniques will require further desktop research) These new strains would need to be tested under field conditions in the same way as the wild collected strains (above).

Scaling up strain production- creation of a nursery system. In order to produce enough seed of any of the newly developed strains a nursery system capable of mass production will need to be developed. To do this will require the a) optimisation tissue culture techniques already available for seaweed, b) design and fine tuning of growth conditions for a large scale bioreactor and c) creation of a land based nursery system for the production of seed plants. It is expected that that this technology will be low cost and easily extended to regional seaweed growing areas.

Environmental effects

Using commercial farm sites a multifactorial experiment should be conducted that tests the productivity of plants and the occurrence of disease and epiphytes in relation to a) water temperature, b) flow regime, c) salinity and d) nutrient environment. Seasonality of production output and disease will also be monitored during this experiment.

A carrying capacity model should be constructed by varying stocking densities at farm sites and correlating this with flow regimes, nutrient environment, seaweed productivity and disease prevalence.

Mechanisms of disease and epiphyte resistance

It is clear that the natural disease and epiphyte defence systems of cultivated seaweeds in the tropics is failing. To solve this problem in the long term requires a better understanding of the disease resistance mechanisms of these seaweeds. For seaweeds (and other vascular plants) resistance to epiphytes and bacterial disease is mediated by an acute production of reactive oxygen species called an “oxidative burst”. This resistance mechanism is well documented for the species of seaweeds used in the seaweed aquaculture industry. It is also known that the reactive oxygen metabolism in seaweeds can be affected by environmental factors.

The factors responsible for the failure of the cultured seaweed defence system should be tested laboratory experiments. To do this the efficacy of the oxidative burst defence system can be assessed by challenging it with disease and epiphytes models. The efficacy of the seaweeds defence system can then be tested on 1) plants that have been vegetatively reproduced over multiple generations and 2) on plants that have been exposed to variation in environmental variables (temperature, salinity etc.). It is expected that these experiments will unravel the effects of prolonged vegetative production and environmental factors on the failure seaweed defence systems. They will also provide information on the number of generations that strains can be recycled vegetatively without compromising their natural defence systems.

11.11Appendix 11: Sampling Site Description and Maps

Luzon Sites

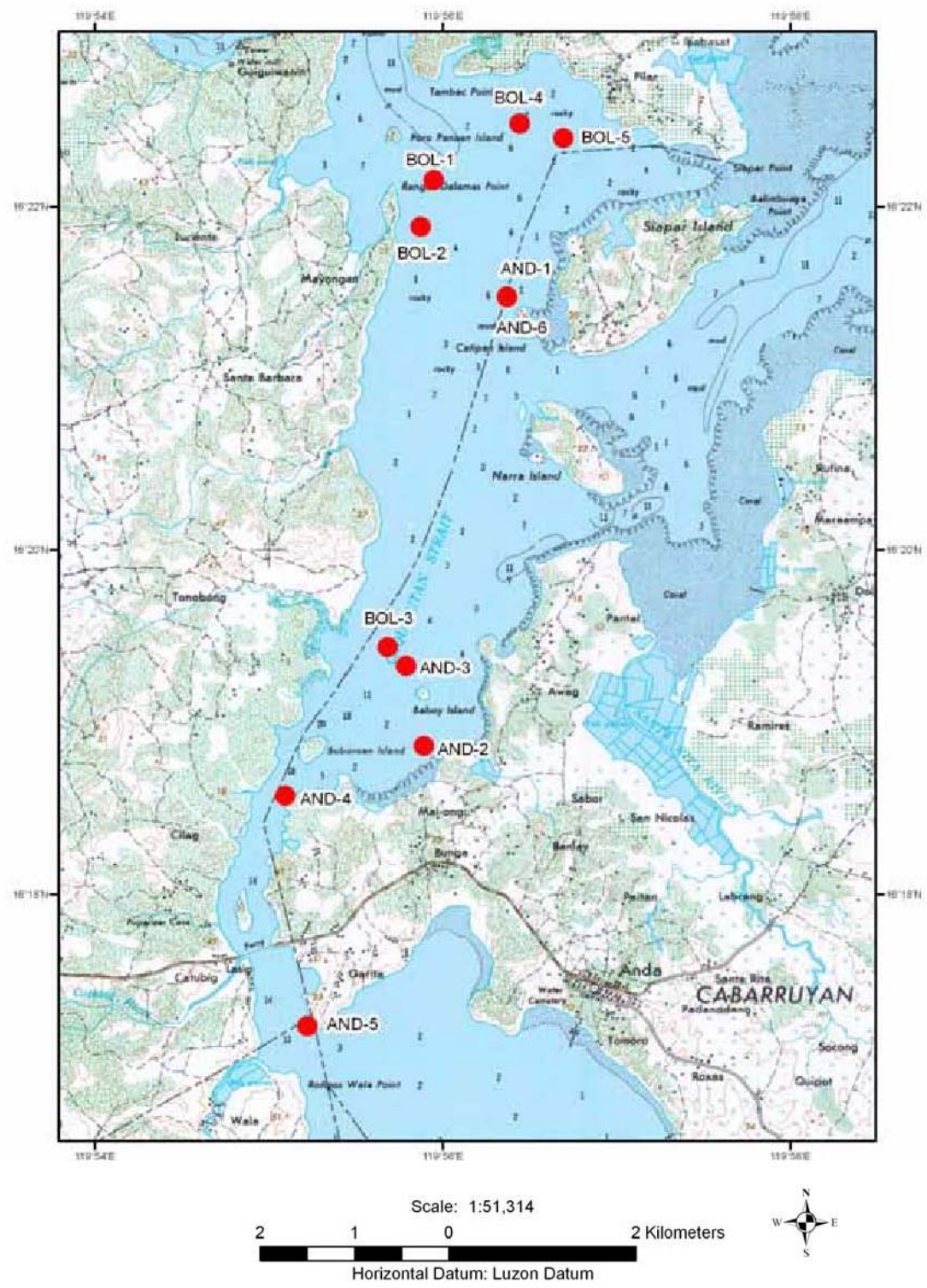
Anda

CODE	MUNICIPALITY	COORDINATES	DESCRIPTION
AND-1	ANDA	16° 21’ 23’’ N 119° 56’ 27’’ E	Near fishpens, Mussels attached on stakes, Close to other mussel set up, Near shore of Siapar
AND-2	ANDA	16° 18’ 46’’ N 119° 55’ 59’’ E	Near the shore of Mal-ong, Oyster mixed with mussel, Near fish pens, Near fish trap
AND-3	ANDA	16° 19’ 14’’ N 119° 55’ 52’’ E	Surrounded by other mussel set up, set up near the island of Pulubaboy, Mussels attached to stakes
AND-4	ANDA	16° 18’ 29’’ N 119° 55’ 11’’ E	Oyster attached to stakes. Near the shore, Near the fishpen, Near baklad, Too many attaching organism (bayander)
AND-5	ANDA	16° 17’ 80’’ N 119° 55’ 19’’ E	Near the shore of Mal-ong, Mouth of the channel going to Tambac Bay, Oysters attached to stakes, Near fish trap, Presence of attached organism (bayander)
AND-6	ANDA	16° 21’ 24’’ N 119° 56’ 25’’ E	Near island of Siapar, near fishpen, near other set ups

Bolinao

CODE	MUNICIPALITY	COORDINATES	DESCRIPTION
BOL-1	BOLINAO	16° 22’ 30’’ N 119° 56’ 20’’ E	First set up entering the channel, Hanging method, near other set up, Set up with hut, Samples from stake only, not from the string
BOL-2	BOLINAO	16° 21’ 47’’ N 119° 55’ 58’’ E	Set up with hut, near fishpen, oysters attached to stakes, set up near Vice fishpen, with mussels on strings and stakes
BOL-3	BOLINAO	16° 19’ 20’’ N 119° 55’ 46’’ E	Near owner’s fishpen, near filter net, mixed oyster and mussel in set up, stake method
BOL-4	BOLINAO	16° 22’ 23’’ N 119° 56’ 32’’ E	Set up within fishpen, fishpen near other fishpens, growth of oyster in bamboos five feet from the surface
BOL-5	BOLINAO	16° 22’ 18’’ N 119° 56’ 47’’ E	Near fishpens, shore visible from set up, stake method, middle of the channel

Anda and Bolinao Site Map

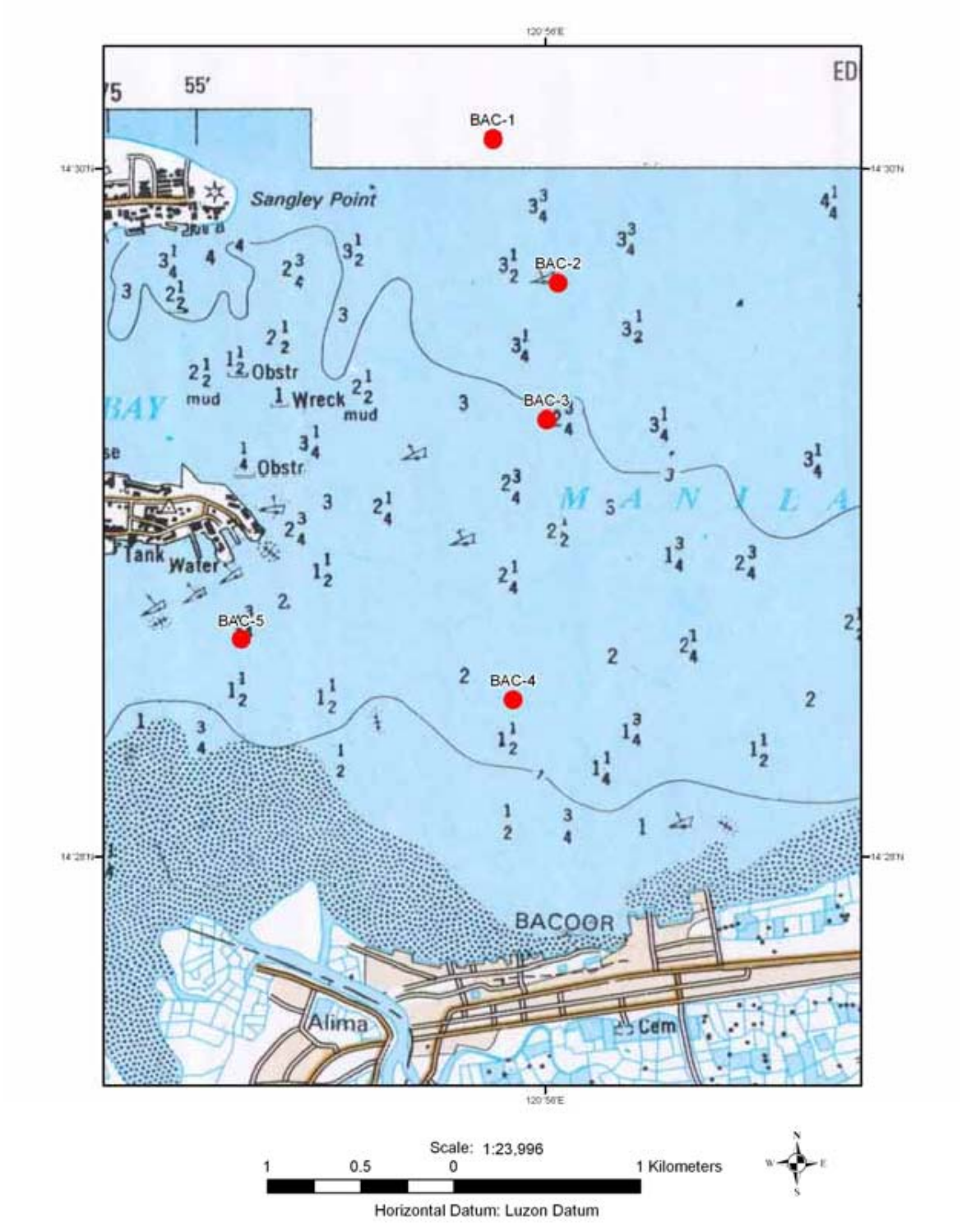


Bacoor

CODE	MUNICIPALITY	LAT	LONG	DESCRIPTION
BAC-1	BACOOR	14.4994	120.93224	With six liftnets around, near other mussel/oyster set up, sea calm, with a lot of algae which lights up during night
BAC-2	BACOOR	14.49299	120.93538	Middle of bay, near hut, sea calm, lift net near the set up, presence of algae in the water
BAC-3	BACOOR	14.48634	120.93483	Hanging method, near hut, near other

				oyster/mussel set up, water is clear, no algae visible
BAC-4	BACOOR	14.47281	120.93321	Set up at the side, near three fish traps
BAC-5	BACOOR	14.47573	120.92007	Area has narrow navigatioal way, many fish traps and oyster/mussel set ups, near naval base, area with hut

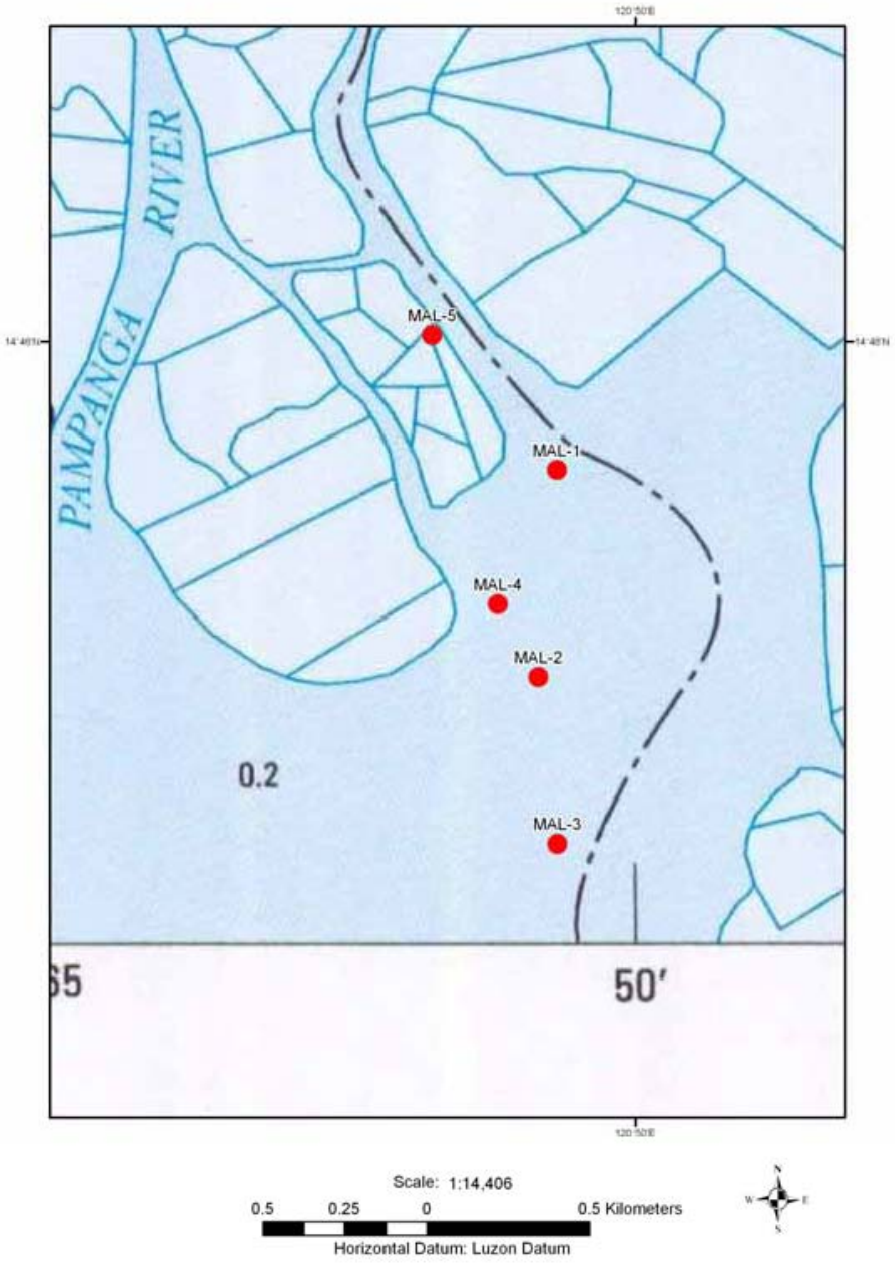
Bacoor Site Map



Malolos

CODE	MUNICIPALITY	LAT	LONG	DESCRIPTION
MAL-1	MALOLOS	14.76162	120.83259	Near fish trap, set up near hut, middle of the river
MAL-2	MALOLOS	14.75589	120.83207	Near fish trap, hanging method, oyster growth 3 inches from the ground, set up with hut
MAL-3	MALOLOS	14.75128	120.83260	Hanging method, middle of the river, near other oyster set ups
MAL-4	MALOLOS	14.75789	120.83095	Broadcast method, near owner's hut, near river bank
MAL-5	MALOLOS	14.76535	120.82913	Hanging method, near fishpond, near hut

Malolos Site Map

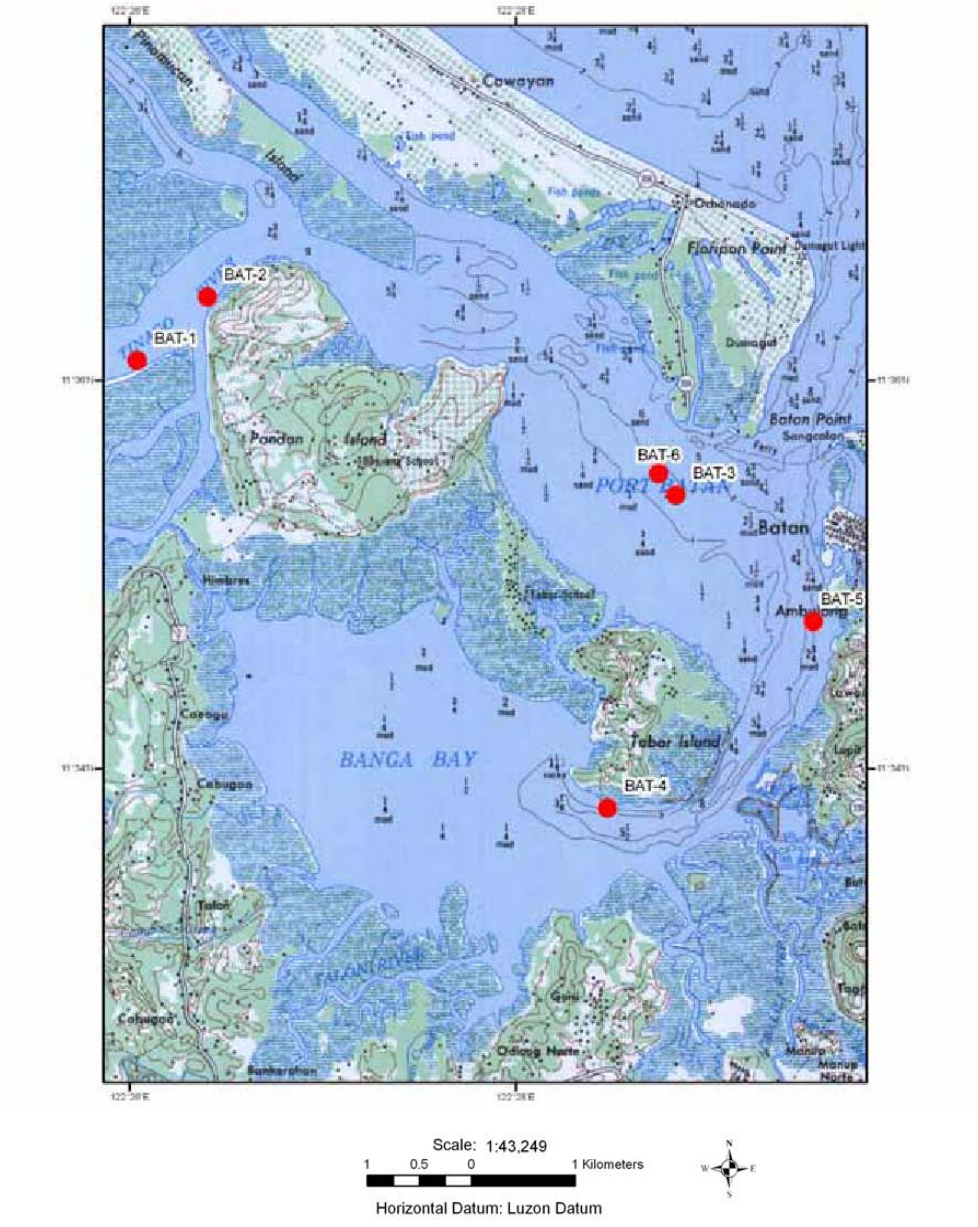


Western Visayas Sites

Batan

CODE	MUNICIPALITY	LAT	LONG	DESCRIPTION
BAT-1	BATAN	11.6003457	122.43539337	Surrounded by fish corral and lift net on one side, near oyster set up with coconut husk as substrate
BAT-2	BATAN	11.60581305	122.44143639	Tyres exposed if tide is 1m, tyres attached to horizontal bar between two crisscross bamboo poles of fish corral
BAT-3	BATAN	11.58878546	122.4819613	Middle part, mussels on stakes
BAT-4	BATAN	11.56193085	122.47602448	Raft 30 m away from mangrove area, lift net 20m away from raft set up
BAT-5	BATAN	11.56193085	122.47602448	3 m lengths of rope (regular rope, twine) uses net and sacks as substrate, surrounded by liftnet and fish corral
BAT-6	BATAN	11.59064	122.48044	Near lift net, strong current, stake method, middle of bay

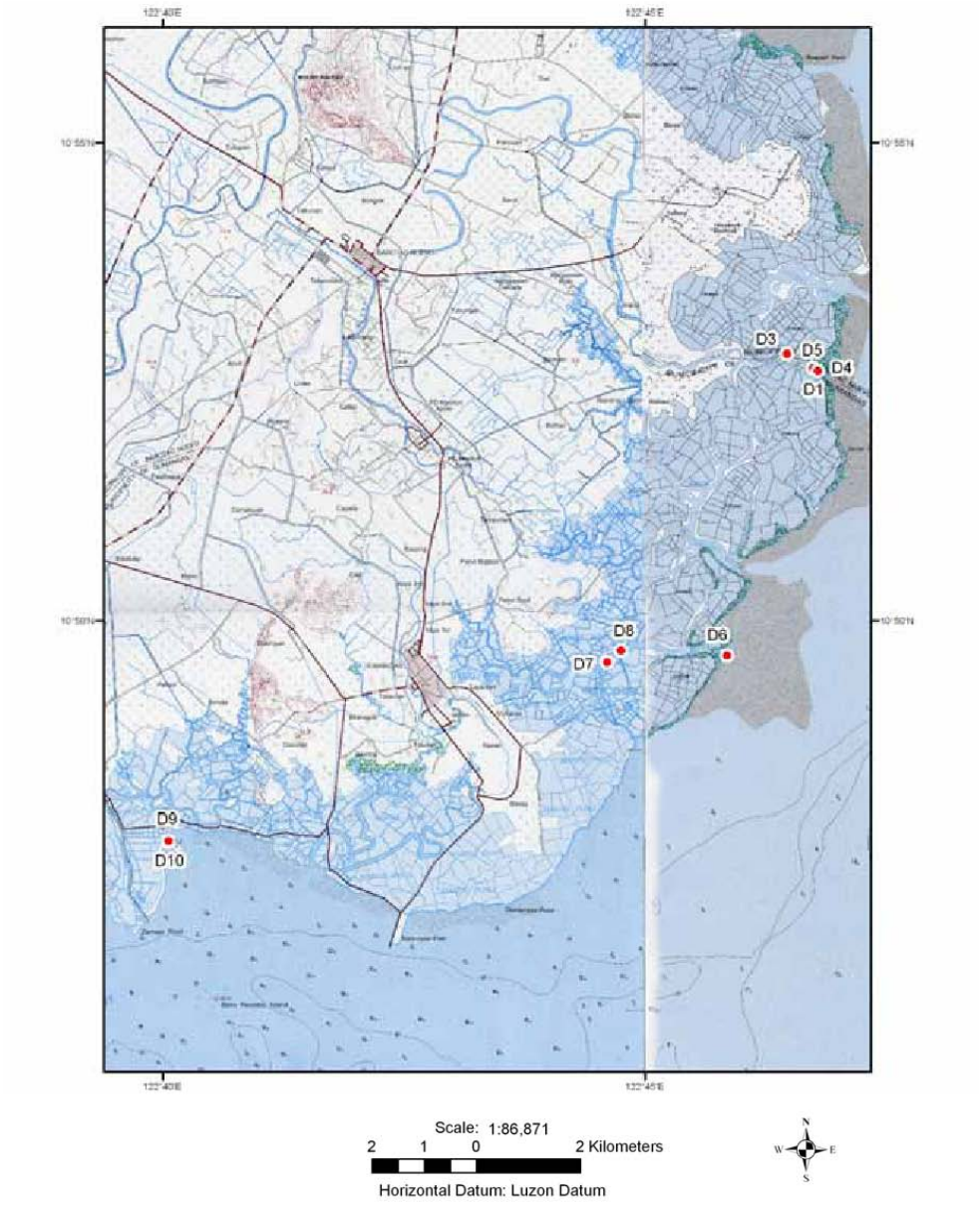
Batan Site Map



Dumangas

CODE	MUNICIPALITY	LAT	LONG	DESCRIPTION
D1	DUMANGAS	10.87724838	122.77334022	Near mangroves, rack method
2	DUMANGAS	10.87791072	122.77431906	Near mangroves, inside filter net
D3	DUMANGAS	10.87868697	122.77592780	Inside filter net
D4	DUMANGAS	10.87625370	122.78047280	Near mangroves
D5	DUMANGAS	10.87562229	122.78131661	Inside filternet
D6	DUMANGAS	10.82477281	122.74481300	Near mangroves, near other oyster set up
D7	DUMANGAS	10.82476778	122.74476430	Near fishponds with mangroves, near shrimp pots
D8	DUMANGAS	10.82693928	122.74739522	Near mangroves, big river system, near other oyster set up
D9	DUMANGAS	10.79374208	122.66943119	Floating set up, near oyster set up, near bridge
D10	DUMANGAS	10.79374208	122.66943119	Middle of the river, 7 feet deep water if high tide

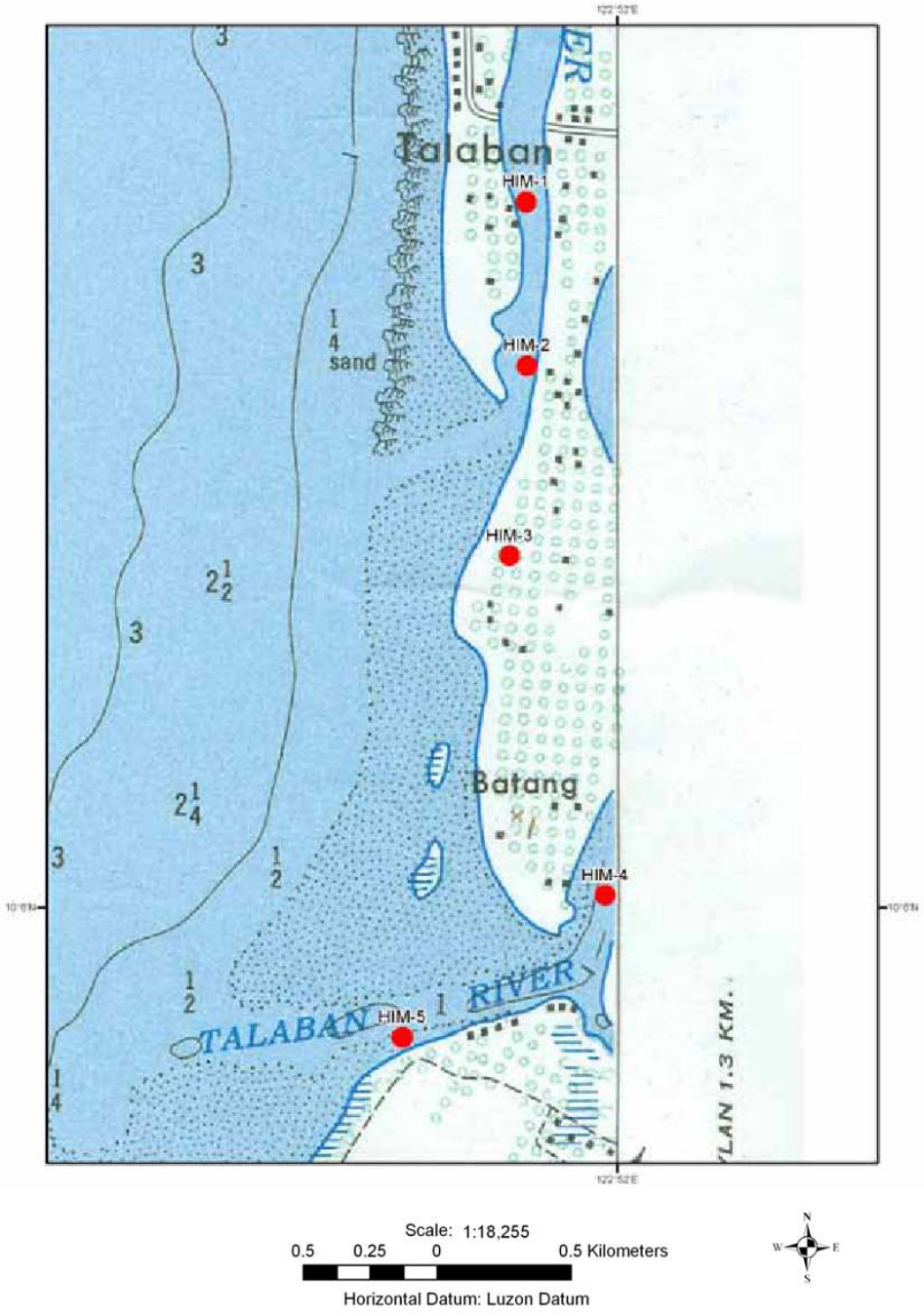
Dumangas Site Map



Himamylan

CODE	MUNICIPALITY	LAT	LONG	Description
HIM-1	HIMAMAYLAN	10.12261	122.86500	Oyster hang at the side of fish cages of grouper and lison-lison, with screens for shrimp, near the shore
HIM-2	HIMAMAYLAN	10.11710	122.86504	Near fish cages, near the shore, mangrove areas and prawn fishponds (not operating)
HIM-3	HIMAMAYLAN	10.11067	122.86445	Approximately 8m away from the shore, near other oyster set ups
HIM-4	HIMAMAYLAN	10.09921	122.86767	Near mangrove areas, near fish cages and oyster set ups
HIM-5	HIMAMAYLAN	10.09441	122.86086	Near the shore, mangrove area

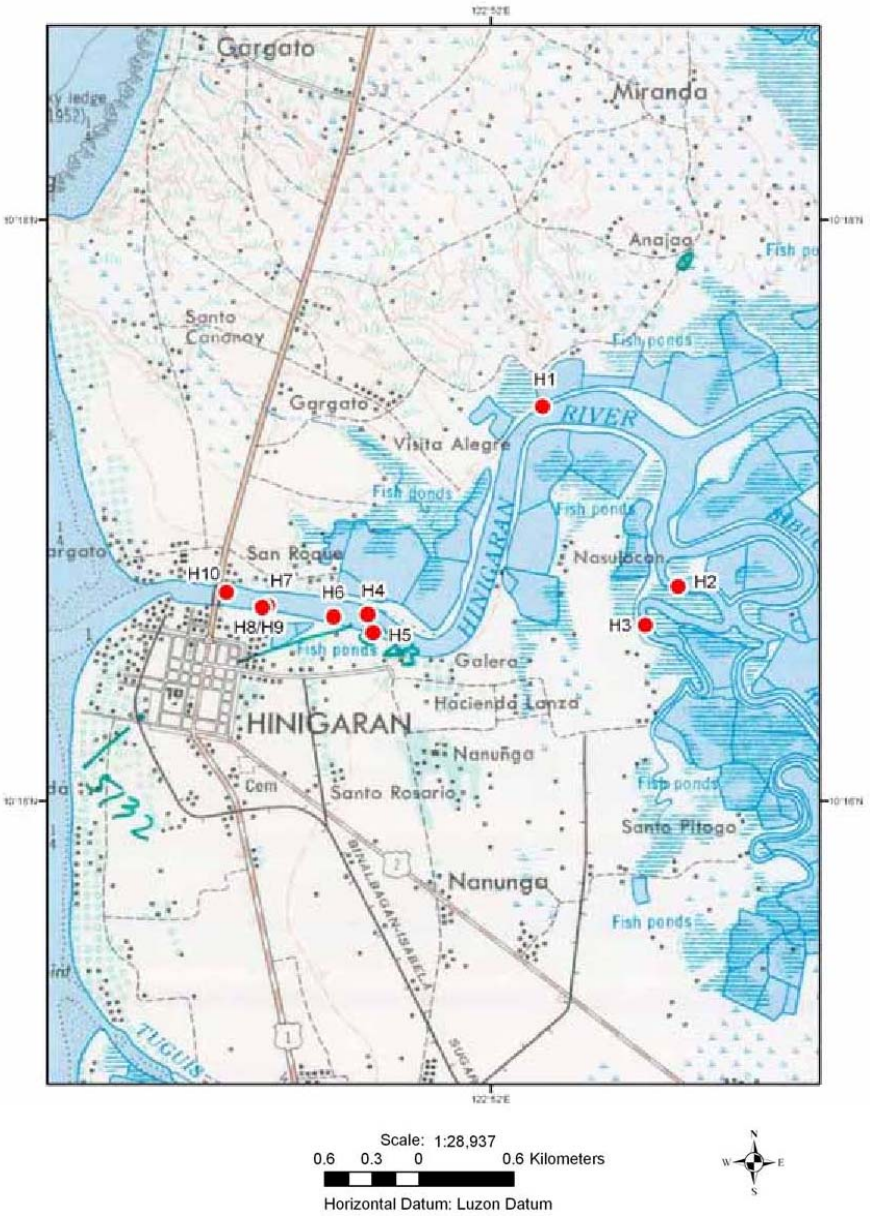
Himamaylan Site Map



Hinigaran

CODE	MUNICIPALITY	LAT	LONG	DESCRIPTION
H1	HINIGARAN	10.28811282	122.87101923	Close to the fishpond with patches of mangroves, oyster site near filter net
H2	HINIGARAN	10.27778624	122.87879932	Near fishpond, middle of ponds with less mangroves
H3	HINIGARAN	10.27778448	122.87885581	Near the river bank
H4	HINIGARAN	10.27561574	122.87692211	Near riverbank, near fishpond and mangroves
H5	HINIGARAN	10.27561449	122.87691272	Near river bank, hanging method
H6	HINIGARAN	10.27515323	122.86134543	Near riverbank, near fishpond and mangroves
H7	HINIGARAN	10.27515633	122.86135130	Middle of the river
H8/H9	HINIGARAN	10.27515365	122.86135146	Near filter net, within cages
H10	HINIGARAN	10.27619191	122.86104821	Cage area, mussels under the cage

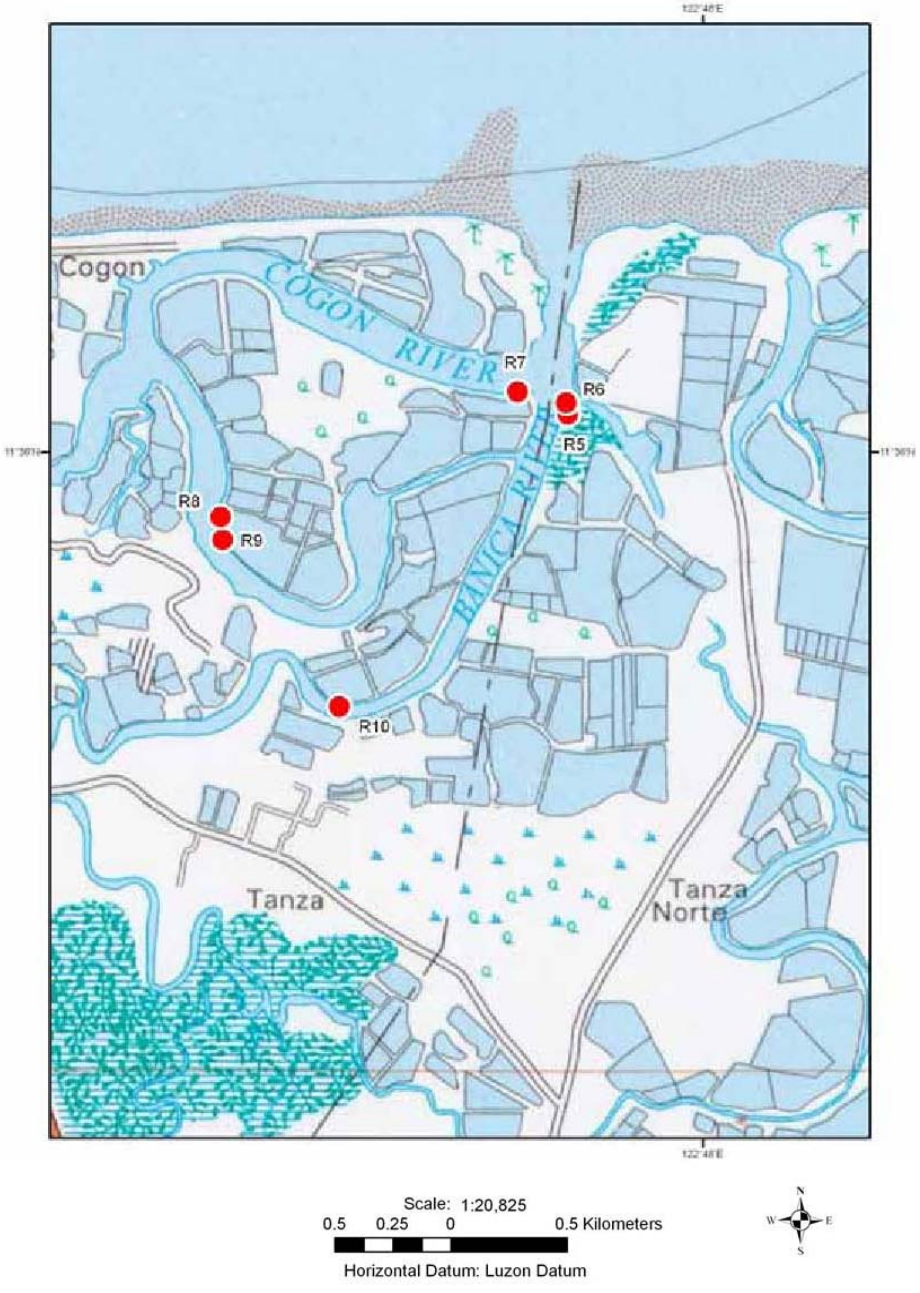
Hinigaran Site Map



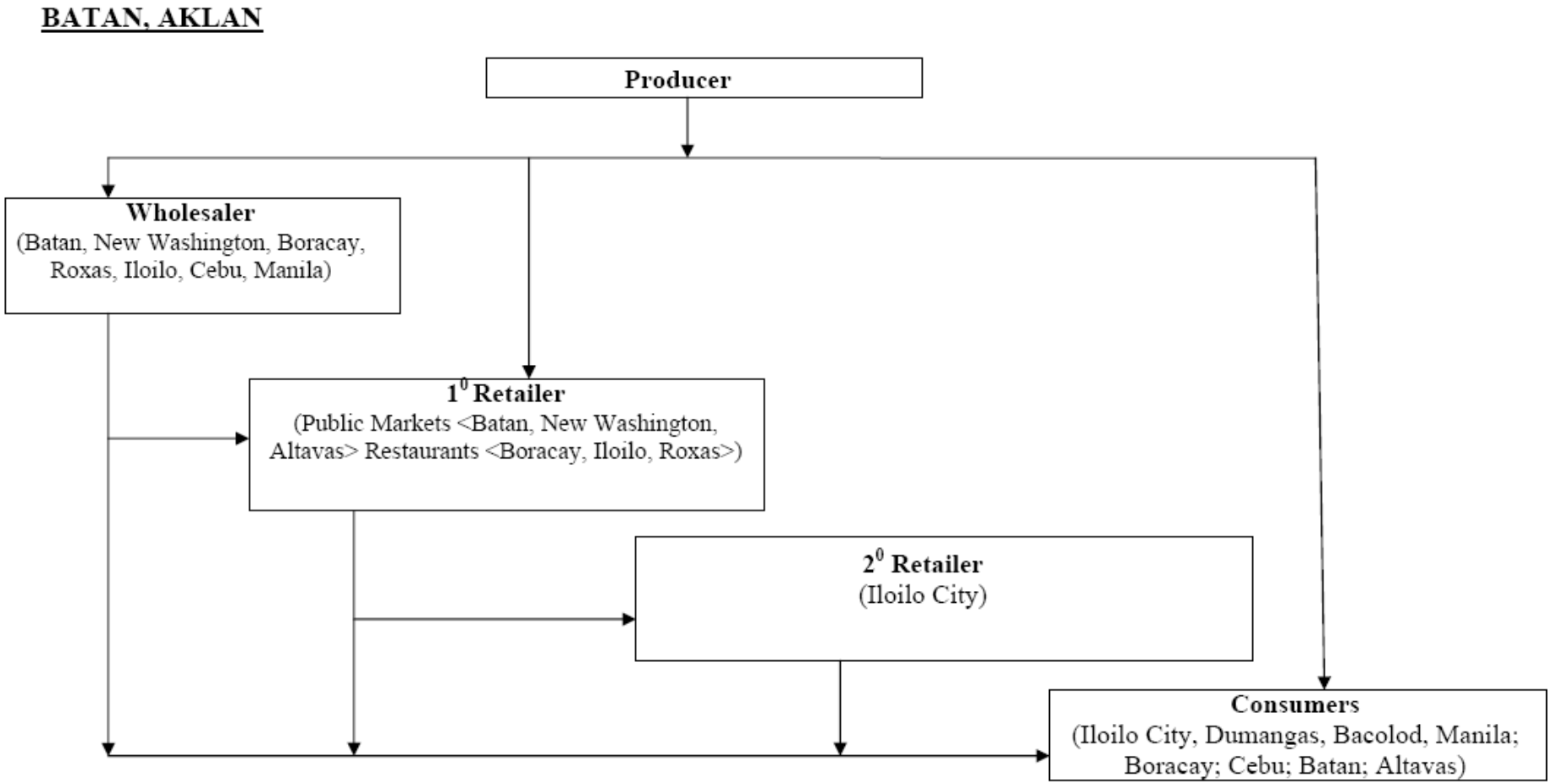
Roxas

CODE	MUNICIPALITY	LAT	LONG	DESCRIPTION
R1/R2	ROXAS	11.57590315	122.71113988	Middle of the river, the oyster and mussels stick on bamboo
R3	ROXAS	11.57306713	122.71111364	Near filter net, close to mangroves
R4	ROXAS	11.57493437	122.71111364	Middle of the river, near lift net
R5	ROXAS	11.60019357	122.79616582	Middle of the river, between mangroves
R6	ROXAS	11.60061476	122.79611754	Close to R5 set up (30m), near filter net
R7	ROXAS	11.60104601	122.79421686	Near fishpond, harvested from bamboo stakes
R8	ROXAS	11.59614896	122.78272150	Close to fishpond with mangroves
R9	ROXAS	11.59524087	122.78280306	Middle of the river, near mangroves
R10	ROXAS	11.58871698	122.78731395	Near fishpond, near river bank

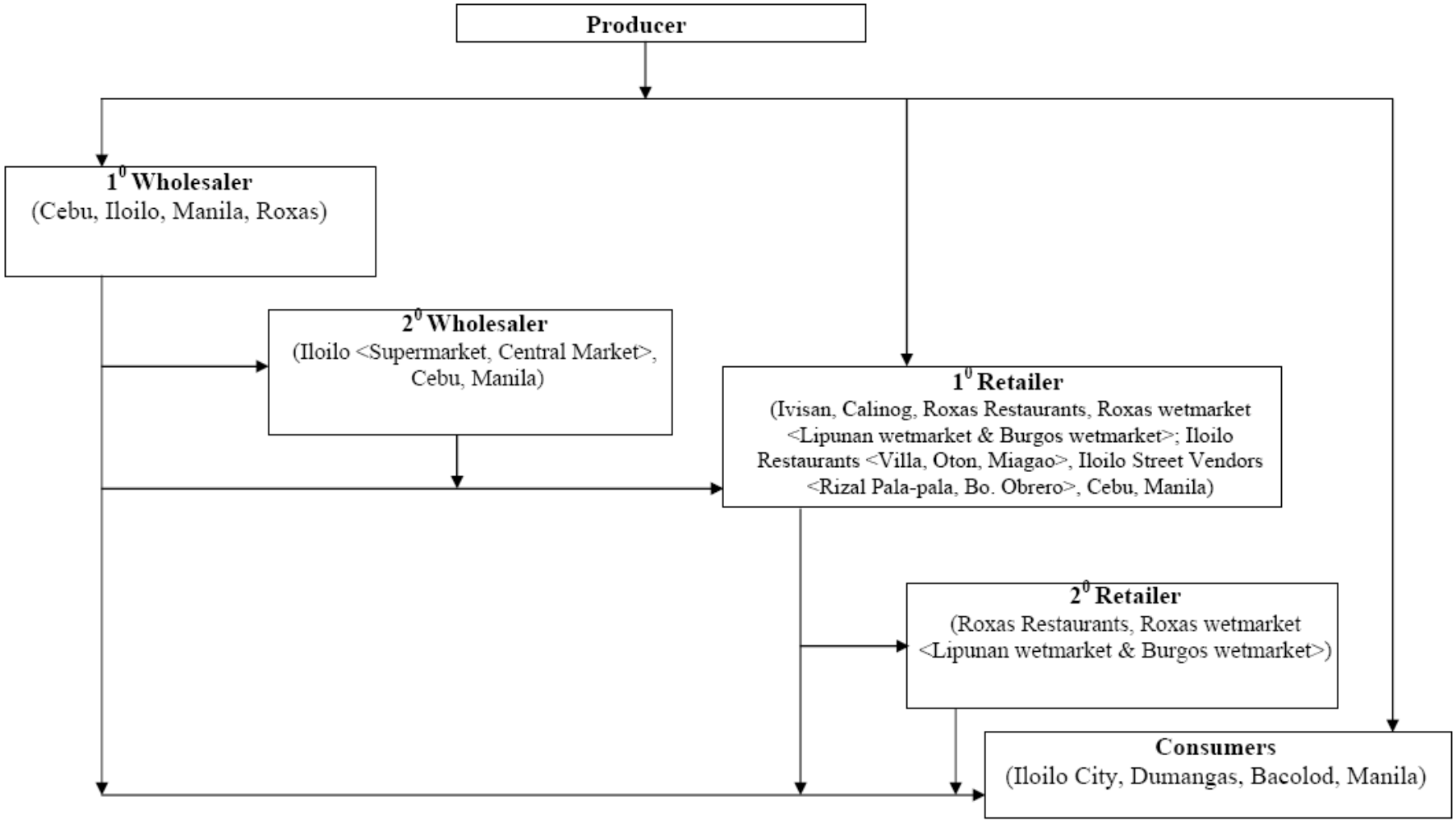
Roxas Site Map



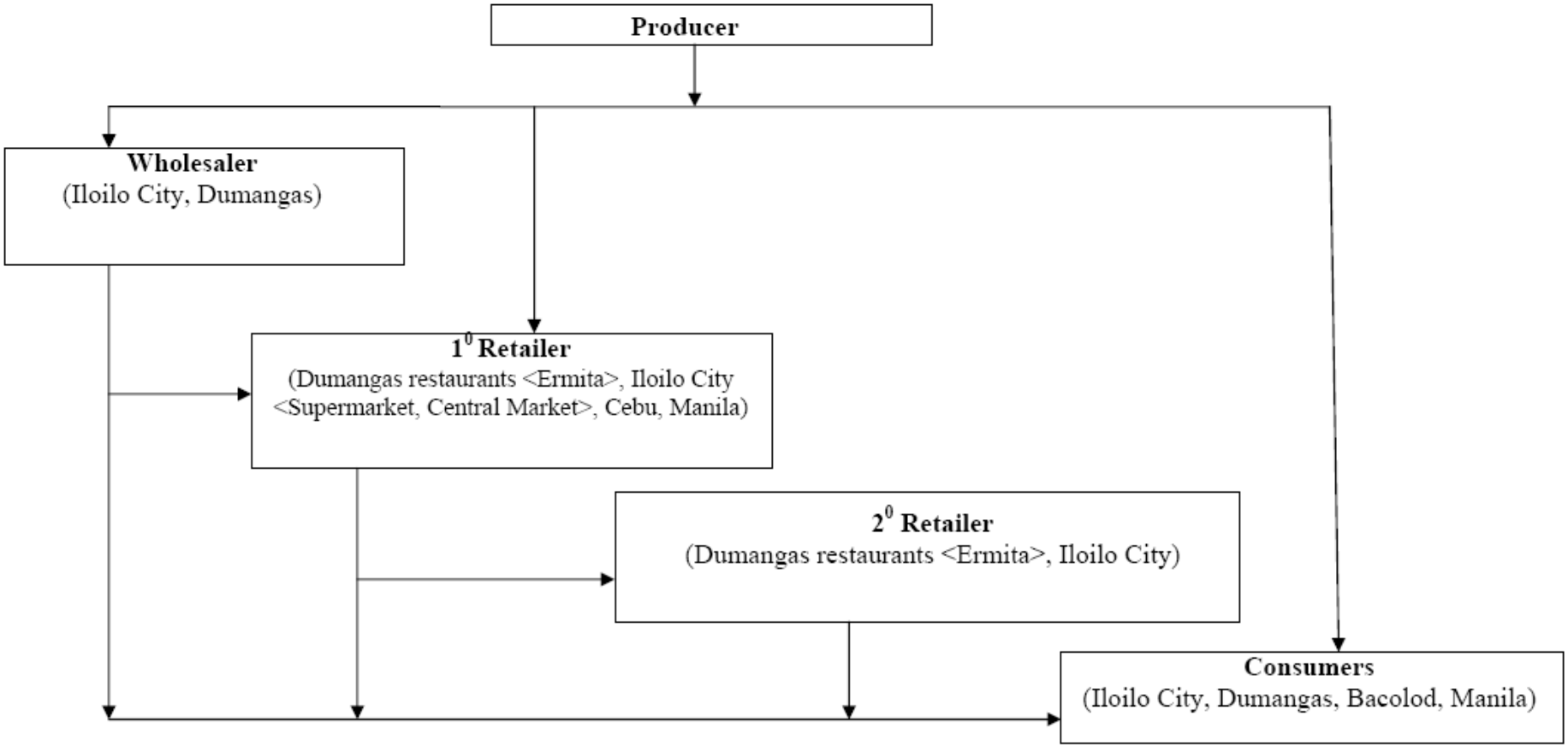
11.12Appendix 12: Market Flow



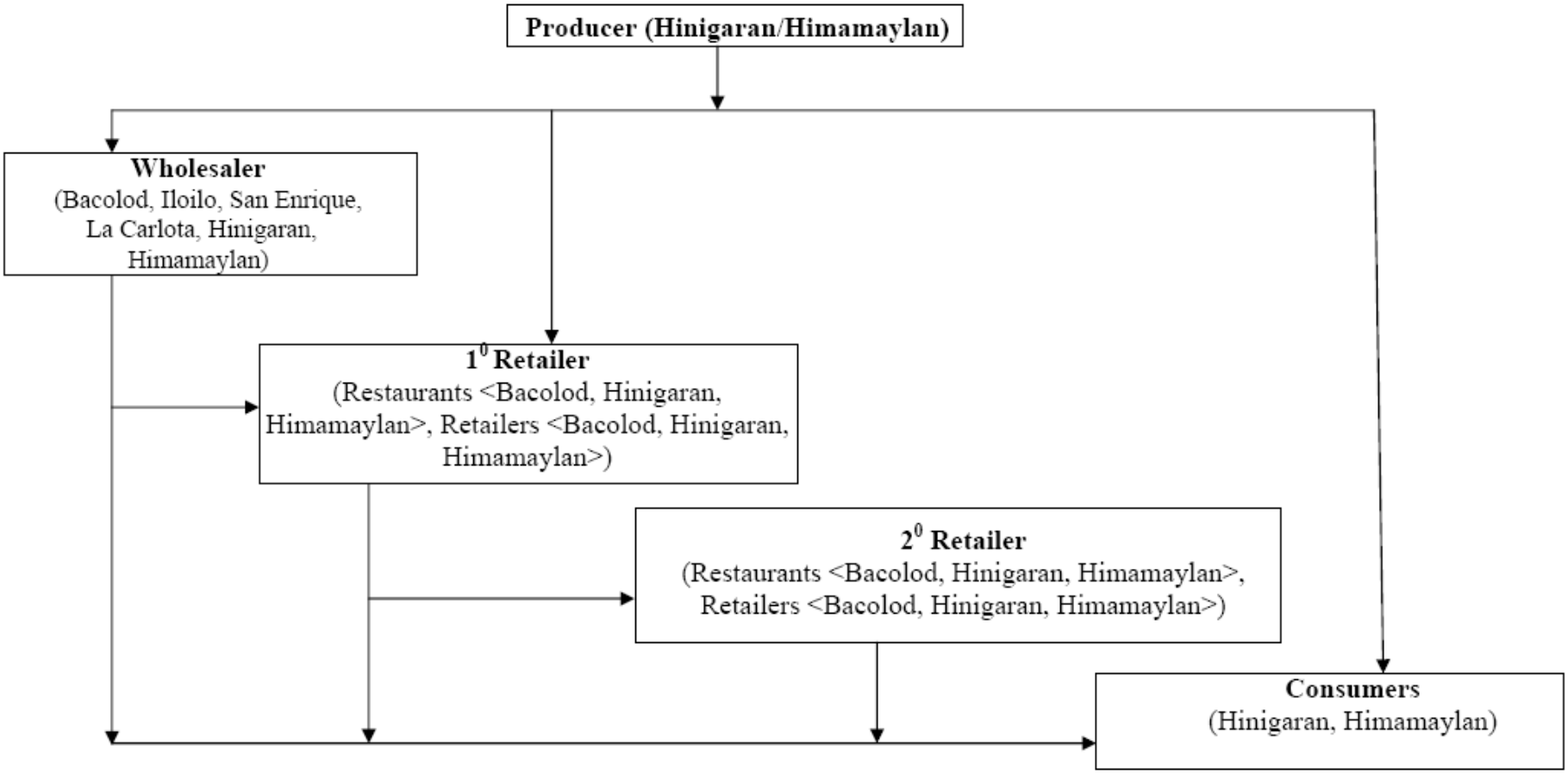
ROXAS CITY, CAPIZ



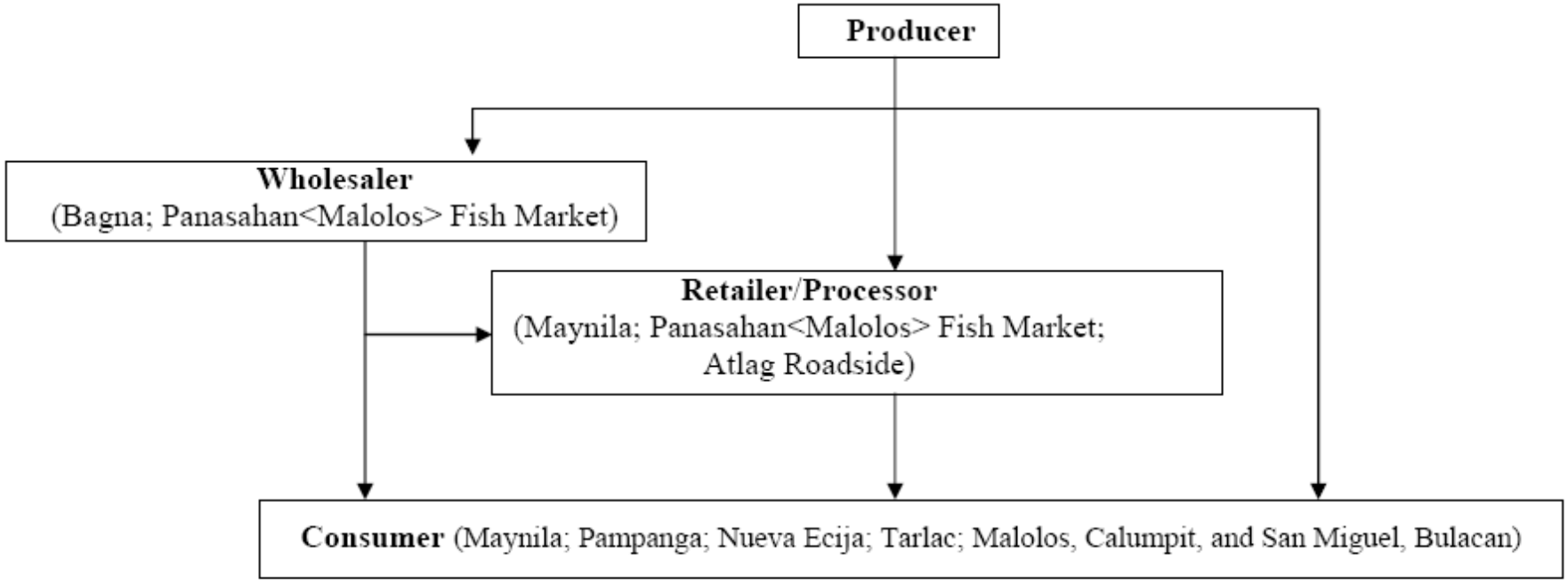
DUMANGAS, ILOILO



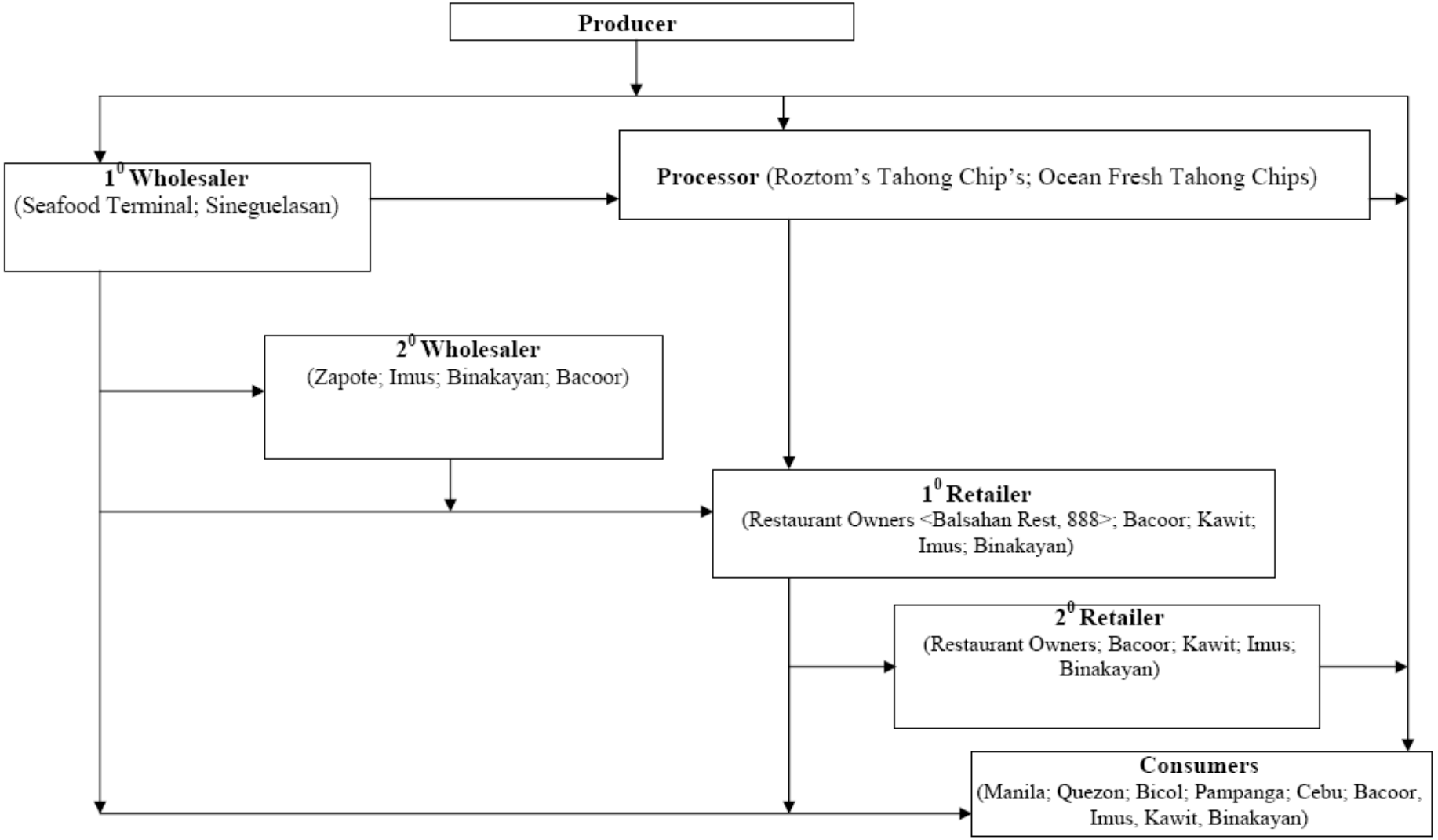
NEGROS OCCIDENTAL



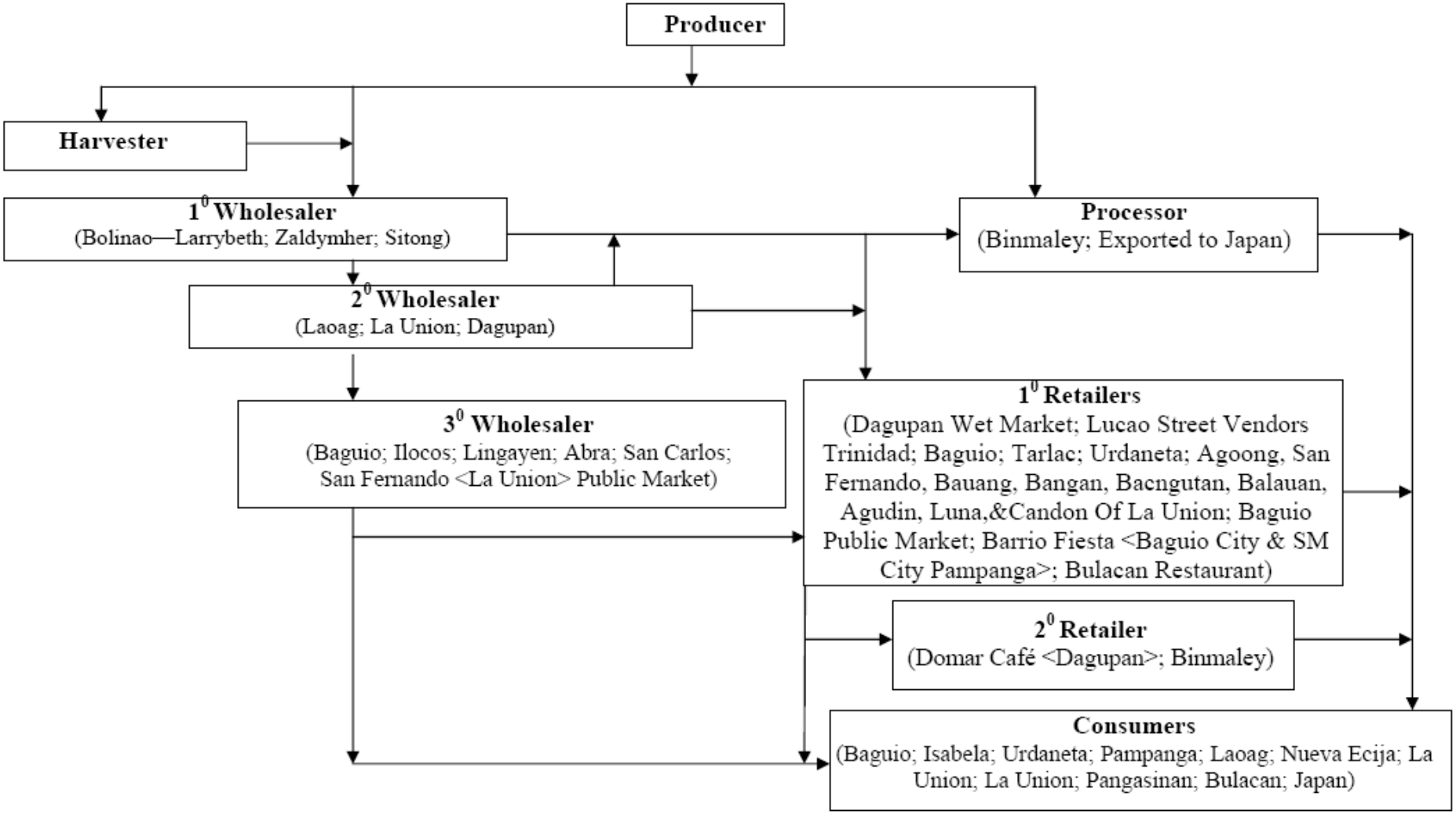
MALOLOS, BULACAN



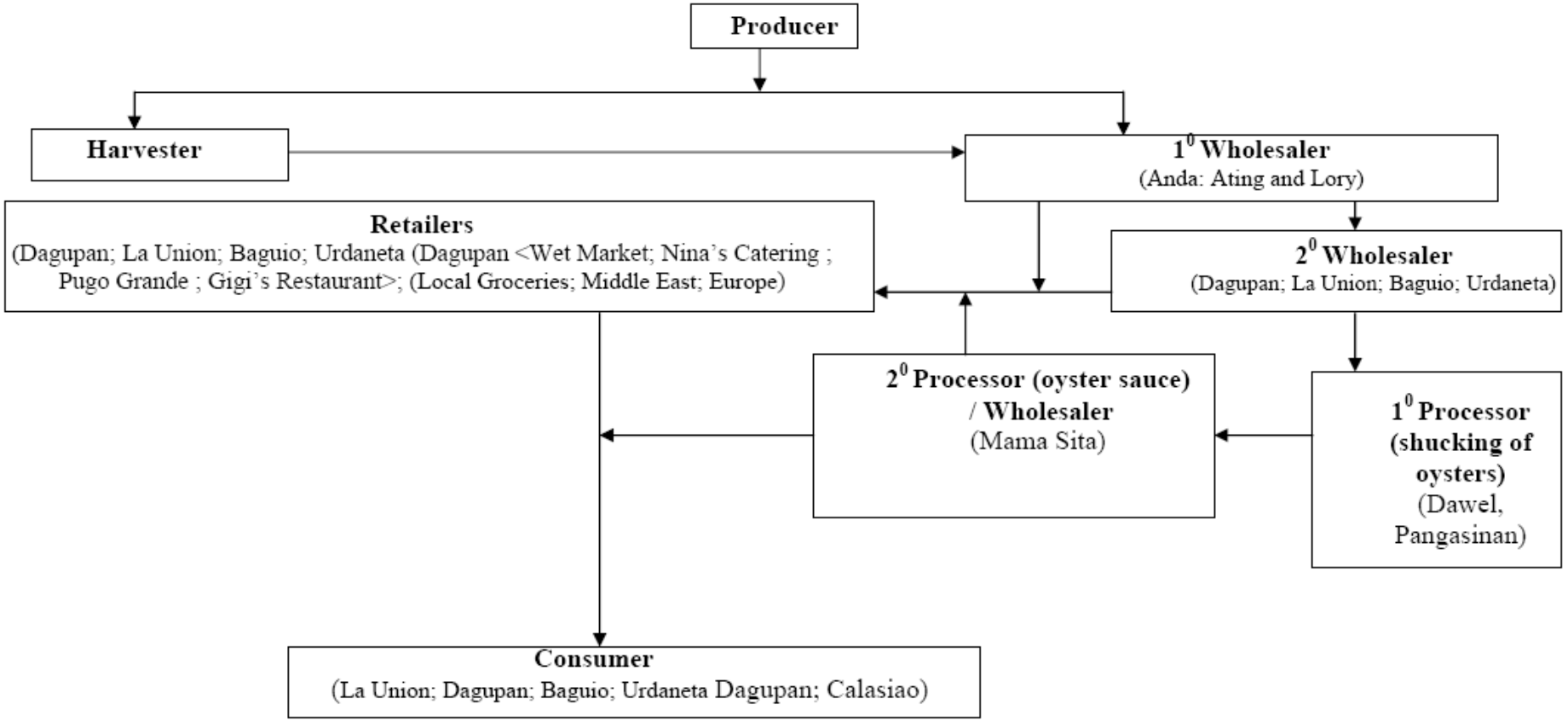
BACOOR, CAVITE



BOLINAO, PANGASINAN



ANDA, PANGASINAN



11.13 Appendix 13: Legal Provisions from the City/Municipality Ordinance related to Oyster and Mussel Culture

Municipality: ANDA

ORDINANCE NO.	DATE OF APPROVAL	SECTION	TITLE	PROVISIONS
01 series of 2002	14-Feb-02	12	Water Quality Monitoring and Surveillance	The Municipal government shall seek assistance from the various agencies and institutions concerned with environmental protection in establishing to the great extent practicable water quality monitoring and surveillance.
01 series of 2002	14-Feb-02	14	Protection of Spawners or Breeders	The Municipal government shall ensure that spawners or breeders of any fish and shellfish be protected. Fishing or taking of any spawners or breeders of any fish and shellfish shall be strictly regulated.
01 series of 2002	14-Feb-02	20	Auxiliary Invoices	All fish and fishery products produced, cultured, gathered/collected, processed and made must have an auxiliary invoice to be issued by the Municipal Government of Anda or their duly authorized representatives prior to their transport from their point of origin to their point of destination in the Philippines and/or export purposes upon payment of fees to be determined by the municipal government to defray administrative cost thereof.
01 series of 2002	14-Feb-02	23	Zonation of the Municipal Waters	The municipal waters of anda shall be designated into three (3) priority coastal zones : ZONE II: Aquaculture/Mariculture zone covers the municipal waters from the shoreline, bordering Brgy. Mal-ong, Awag, San Jose, Dolaoan and Siapar, the nylon shell reserve project at Mal-ong, the Oyster culture at Dolaoan and the mangrove rehabilitation project at Sta. Rita (San Jose) River.

ORDINANCE NO.	DATE OF APPROVAL	SECTION	TITLE	PROVISIONS
01 series of 2002	14-Feb-02	33	Demarcated Fishery Rights	Anda shall grant demarcated fishery rights to fishery organizations/cooperatives for sea farming operation in specific area.
01 series of 2002	14-Feb-02	38	Fees and Other Fishery Charges	The municipal government shall prescribed fees and other fishery charges and issue corresponding fishery license permit for fishing boat, fishing gear, fishing accessories and other fishery activities engaged in commercial scale within the municipal waters of Anda; Provided that license fees of fishery activities shall be determined by the Municipal Government in consultation with the FARMC. Provided further, that the Municipal Treasurer may deputized the Barangay Treasurer in the collection of fees and other fishery charges. Provided finally, that license permits are prepared in the barangay and submitted to the Municipal Agriculturist Officer for security and recommendation before it will be signed by the Mayor.
01 series of 2002	14-Feb-02	39	Schedule of Fishing License Fee, Permit Fee for Fishing Gears, Permit fee for fishing boat and Other Fees	Table C. ANNUAL PERMIT FEES: Gathering shells without compressor (Php50.00) Gathering shells with compressor (Php100.00); Oyster or "tirem" Operation of Oyster Farm (Php200.00) Table D. OTHER FEES: Auxiliary Invoice (Transport Fees) for Didila/other shells (Php0.50/liter) Fish Inspection Fee (Php25.00) Docking Fee Banca (Php2.00)

ORDINANCE NO.	DATE OF APPROVAL	SECTION	TITLE	PROVISIONS
				Fishing Boat (Php5.00)
01 series of 2002	14-Feb-02	47	Municipal fishing, fish cages for Malaga, Lapulapu and Talakitok culture and Oyster farming in zone 1	The Multiple Fishery zone bordering Poblacion, Roxas, Awile, Macandocandong and Toritori shall be used for municipal fishing. The demarcated areas in Poblacion, Roxas, Awile, Macandocandong and Toritori shall be used for fish cages for Malaga, lapulapu and talakitok and oyster farming. Provided that limited fishing shall be done on mangrove demarcated areas.
01 series of 2002	14-Feb-02	50	Demarcated areas for fish cages of Malaga, lapulapu and talakitok and oyster farming	The Municipal government in consultation with the FARMC and the barangays concerned shall designate sites for fish cages of Malaga, lapulapu and talakitok and shall be classified and divided to wit: 2. Fishery of Roxas bordering Poblacion and Awile shall be demarcated for fish cages of lapulapu, talakitok and oyster culture. 4. Fishery of Macandocandong located at the southern and western portion of the fishing port shall be demarcated for fish cages of lapulapu, talakitok and oyster culture.
01 series of 2002	14-Feb-02	60	Other Aquaculture/Mariculture Activities	The Municipal Government in coordination with the FARMC, the people and their organizations, subject to existing laws and as may be determined, may allow establishment of other aquaculture/mariculture development other than for milkfish fish pens and fish cages such as grouper, sea bass, malaga and other cultivable fin fishes, oyster and invertebrate culture, seaweed culture, etc. in other zones of the municipal waters. Provided however, that the establishment, operation and management of aquaculture structures shall

ORDINANCE NO.	DATE OF APPROVAL	SECTION	TITLE	PROVISIONS
				not exceed the carrying capacity of the area and observe proper distancing, size or area, stocking density and feeding.
01 series of 2002	14-Feb-02	70	Maintenance of water quality and cleanliness	The Municipal Government in coordination with the operators, owners and caretakers of fish pen, fish cage and other aquaculture activities shall maintain the quality of the water at the optimal level relative to natural relativity and the cleanliness of the areas devoted to aquaculture development. The operators, owners and caretakers of fish pens, fish cage and other aquaculture activities shall develop a mechanism of proper waste disposal. Violations of this section constitute a ground for the cancellation of the permit to operate fish pen, fish cage and other aquaculture activities.
01 series of 2002	14-Feb-02	110	Gathering and marketing of shellfish	It shall be unlawful for any person to take, transfer or have possession of any shellfish, which is sexually mature or below the minimum size or above the maximum qualities prescribed for the particular species. Violation of this section shall be punished by a fine ranging from two thousand pesos (Php2,000.00) to ten thousand pesos (Php10,000.00) or imprisonment from one month and one (1) day to six (6) months, or both, such fine and imprisonment, upon the discretion of the court.
01 series of 2002	14-Feb-02	111	Illegal construction and operation of fish corral/fyke nets, Oyster and Seaweed farms	It shall be unlawful to construct and operate fish corrals, fyke nets, oyster farms and seaweed farms without license or permit. Likewise, it is unlawful to construct the same outside the demarcated areas and/or within distance of less than one hundred (100) meters from another structure. Violation of this section shall be punished by a fine ranging from two thousand pesos (Php2,000.00) to ten thousand pesos (Php10,000.00) or imprisonment from

ORDINANCE NO.	DATE OF APPROVAL	SECTION	TITLE	PROVISIONS
				one (1) month and one (1) day to six (6) months, or both, such fine and imprisonment upon the discretion of the court.

Municipality: BATAN

ORDINANCE NO.	DATE OF APPROVAL	SECTION	TITLE	PROVISIONS
001 series of 1997	16-Sep-97	26	Issuance of individual license in case no bidder opt to lease fishing areas	If after, two notices for the grant to exclusive fishery rights through public bidding no interested bidder opt to lease any fishing area within the municipal waters, the Local Chief Executive upon recommendation of the Sangguniang Bayan is authorized to award privileges of erecting fish corrals, operating oyster culture beds or catching "bangus fry" or "kawag-kawag" and establishment of seaweeds farms within the specified area within a definite area or portion of the municipal waters to individuals, upon payment of license therefore at the rates not exceeding those fixed here under. 3. Operation of oyster/mussel culture beds: Per hectare-Php1,000.00
001 series of 1997	16-Sep-97	30	Conduct of Public Bidding	The Committee on Bidding shall advertise notice for sealed bids for exclusive fishery privilege in the areas or zones of the municipal waters available for erecting corrals taking or catching "bangus" fry or fry of other species for propagation, or the construction and operation of mussel or oyster culture beds posting said notice three (3) conspicuous place in the municipality for a period of not less than fifteen (15) days or published once in a newspaper of general circulation in the municipality if available.

ORDINANCE NO.	DATE OF APPROVAL	SECTION	TITLE	PROVISIONS
001 series of 1997	16-Sep-97	34	Zoning of Municipal Waters	The Municipal Waters of the municipality shall be divided into zones to be indicated by the Sangguniang Bayan in a separate ordinance after proper consultation with the Coastal Resource Management of the municipality
001 series of 1997	16-Sep-97	42	Of Mussel and Oyster Belt Area	There shall be declared based on zoning recommended by the Municipal Coastal Resource Management Body a mussel and oyster belt area in this municipality
001 series of 1997	16-Sep-97	46	Issuance of permits to culture shelled mollusk within the municipal waters	It shall be unlawful to construct, maintain, and operate cultured shell mollusk in the municipal waters of this municipality upon favorable recommendation of Municipal Mayor's permit.
001 series of 1997	16-Sep-97	49	Issuance of Auxiliary Invoice to transport fish and other fishery aquatic products	The Municipal treasurer or the authorized representative shall issue an auxiliary invoice for the transport of fish and other fishery products outside of the municipality.

Municipality: BOLINAO

ORDINANCE NO.	DATE OF APPROVAL	ARTICLE	SECTION	TITLE	PROVISIONS
01 series of 1999	10-Dec-99	1	19	Protection of Spawners or Breeders	The Municipal government shall ensure that spawners or breeders of any fish and shellfish be protected. Fishing or taking of any spawners or breeders of any fish and shellfish shall be strictly regulated.

ORDINANCE NO.	DATE OF APPROVAL	ARTICLE	SECTION	TITLE	PROVISIONS
01 series of 1999	10-Dec-99	13	67	Establishment of Post-harvest Facilities	The municipal government shall coordinate with the private sector and other concerned agencies and MFARMC in the establishment of post-harvest facilities such as, but not limited to, municipal landing sites, fish ports, ice plants and cold storage and other fish processing establishment to serve primarily the needs of the municipal fishers. Provided, however, that such post-harvest facilities shall be consistent with the Comprehensive Post-Harvest and Ancillary Industries Plan.
01 series of 1999	10-Dec-99	13	68	Exportation and Importation of Fish and Fishery Products	Export of fish and fishery products shall be regulated whenever such exportation affects the food security and production. Provided, however, the exportation of live fish shall be prohibited except those which are hatched or propagated in accredited hatcheries and ponds. Provided, further, that to protect and maintain the local biodiversity or ensure the sufficiency of supply, spawners, breeders, eggs and fry of bangus, prawn and other endemic species, as may be determined by the Department, shall not be exported or caused to be exported by any person. Provided, finally, that no person shall import fish and fish products of whatever size, stage or form, for any purpose without securing the necessary permit.
01 series of 1999	10-Dec-99	13	69	Auxiliary Invoices	All fish and fishery products must have an auxiliary invoice to be issued by the Municipal CRM Office prior to their transport from the point of origin to their point of destination in the Philippines and/or export purposes upon payment of the prescribed fee to defray administrative costs thereof. Provided, that fish and fishery products caught or otherwise obtained in

ORDINANCE NO.	DATE OF APPROVAL	ARTICLE	SECTION	TITLE	PROVISIONS
					violation of the provisions of national laws, rules and regulations, and this ordinance, or are declared as health hazards by concerned institutions, shall not be issued auxiliary invoices for nor allowed to be transported.
01 series of 1999	10-Dec-99	14	74	Schedule of permit fees and other charges	Permit fee for specific fishery activity shall be granted only to licensed individuals, organizations, cooperatives, partnerships and corporations upon payment of corresponding fees at the rate not exceeding those fixed hereunder: Construction and Operation of Oyster and Other Culture beds/ha (Php500-1000)

Municipality: HIMAMAYLAN

ORDINANCE NO.	SECTION	TITLE	PROVISIONS
99-03A	3	Municipal Coastal Zoning Plan	The municipal waters of this municipality are divided and classified to different zones attached hereto and forming an integral part of this ordinance is the zoning map. ZONE IX-Regulation Areas for Talabahan and Greenshelan-refers to areas outside the shoreline during the lowest low tide. Areas stated are reserved to Butas gathering. ZONE X-Operation of oyster culture beds, mussel culture beds and other aquatic beds (2.00/meter). Areas not otherwise classified or included on the aforementioned zones shall be intended for the general fishing activities exclusively for the local fisherman unless a fishing permit have been issued by the municipality for the non-resident fishermen. No area within the definite zones classified under section shall be granted or licensed to non-resident person of the municipality.
99-03A	8	Requirements for Municipal Fishing Boat License,	An applicant for a license or permit shall comply the following requirements prior to issuance of the same; FISHING BOAT LICENSE a. duly accomplished application form

ORDINANCE NO.	SECTION	TITLE	PROVISIONS
		Fishermen's License and fishing Permits	b. copy of MARINA registration (duly authenticated) c. payment of appropriate fee FISHERMEN'S LICENSE a. duly accomplished application form b. certification from the barangay that the applicant is a resident for at least six months c. payment of appropriate fee FISHING PERMIT a. copy of fishermen's license issued by his place of residence b. payment of appropriate fee. The municipality shall give priority to resident fishermen within the KAHIL-ICAMCI Area and issuance of authority to utilize fishery resources of the municipality. Fishermen's license shall only be issued to resident fishermen within the KAHIL-ICAMCI Area while fishing permit shall be required to non-resident fishermen. The holder of a fishing permit issued by the municipality shall be allowed to use a licensed municipality fishing boat and fishing gears authorized by the municipality to be used within municipal waters.
99-03A	17	Fees and Charges	In the absence of such organizations or cooperatives or their failure to exercise their preferential rights or after 2 notices for the grant of exclusive fishing zone within municipal waters, the municipality may grant the privilege of catching or taking of bangus fry or fry of other species, operation of oyster culture beds or other aquatic beds and the erecting of fish corrals within the definite zone of the municipal waters to individuals upon payment of license fees thereof not exceeding those fixed thereunder: Operation of oyster culture beds, mussel culture beds, or other aquatic beds An annual license shall be imposed upon oyster, talaba and greenshell concessionaires within the jurisdiction of KAHIL-ICAMCI area under the following schedule: Php2.00/meter provided however, the width shall not exceed on the navigational lines of the flow and ebb of tide with a measurement of 20 meters on the centerline. Provided, that the concession to be applied for shall not exceed 200 sq. m and shall be for the period of one year and renewable for another year. Any violation of this ordinance shall upon conviction suffer a penalty of Php1,000.00 fine or imprisonment of not more than fifteen (15) days or both and fine at the discretion of the court.

Municipality: DUMANGAS

ORDINANCE NO.	DATE OF APPROVAL	CHAPTER	SECTION	TITLE	PROVISIONS
2004-01	17-Nov-05	3	8	Classification of Municipal Waters: Zone 4-Shallow water fishing area	Refers to the inter-island area of Municipal waters with a water depth of 0.5 meters to twenty-two (22) fathoms during lowest low tide as determined and shown by the NAMRIA map. This area is reserved for shallow water fish corrals, stationary lift nets, crab pots, fish pots, cast nets, non-destructive nets or gill nets and push nets (for catching "hipon" season only) and the culture of mussel, oyster, seaweeds, fish and other fishery/aquatic products.
2004-01	17-Nov-05	4	15	Utilization of Fish and other Fishery/Aquatic Products	No person, corporation, cooperative, partnership, organizations or groups shall exploit, occupy, produce, culture, capture or gather fish or fry or fingerlings of any species of fish and other fishery/aquatic products without license, lease or permits. Provided, however, that the Municipal Mayor, in consultation with the Municipal FARMC and the Sangguniang Bayan, upon the recommendation of the Municipal Agriculturist, shall issue an order providing any regulatory measures in the utilization and disposition of fish and other fishery/aquatic products, based on approved national fishery policies (i.e. FAOs, Inter-Department/joint Administrative Order, etc.)
2004-01	17-Nov-05	4	18	Fisherfolk Organisations and/or Cooperatives	Fisherfolk organization and/or cooperatives whose members are listed in the registry of municipal fisherfolk and fish worker, may be granted use of demarcated fishery areas to engage in fish capture, mariculture and/or fish farming; Provided, however, that an organization/cooperative member whose household is already in possession of a fishery right other than for fish capture cannot enjoy the fishing rights granted to the organization or cooperative.

ORDINANCE NO.	DATE OF APPROVAL	CHAPTER	SECTION	TITLE	PROVISIONS
2004-01	17-Nov-05	6	34	Establishment of Oyster and Mussel Beds/Farms	1. No person, partnership, association, corporation, cooperative shall gather or culture oyster and mussel within the Municipal waters without permit or license issued by the Mayor in accordance with the provisions of this ordinance. 2. Restriction on oyster/mussel culture: 1. Size of Oyster/Mussel Farm- a.) For individual-not more than an aggregate area of one (1) hectare, provided that only one (1) license shall be issued to a family, either to a husband or the wife unless they are living separately and independently from each other. Provided further, that any member of the family and living independently, may also apply for a license. b.) For partnership, associations, corporations or cooperatives-not more than an aggregate area of ten (10) hectares. 2. No oyster/mussel beds shall be established within a distance of not less than twenty (20) meters from each other nor shall they be so established as to obstruct free navigation. Provided, however, that such a distance shall apply only in case of different ownership for the said bed/s. 3. No oyster/mussel beds shall be established utilizing a stake and broadcast methods after the approval of this ordinance. 4. Form and Content of Application- All applications shall be accompanied by documents consisting of a brgy. Clearance, Articles of Incorporation or Partnership, By-laws and Certificate of Registration in case the applicant is a corporation, association or partnership and a sketch plan/map of the area applied for. No permit shall be issued unless otherwise the area being applied has been inspected by authorized municipal representative.

ORDINANCE NO.	DATE OF APPROVAL	CHAPTER	SECTION	TITLE	PROVISIONS
2004-01	17-Nov-05	7	39	Schedule of Annual Fees	d.) Concession and culture of mussel, oyster and other shelled mollusk- --- Php3.00 per sq. m plus Php100.00 for Mayor's Permit g.) Auxiliary Invoices- --- An amount of Php50.00 will be charged per 50 kilos for the issuance of Auxiliary invoiceto transport fish and other fishery/aquatic products
2004-01	17-Nov-05	10	75	Prohibition for scallop (Tikab) and other Mollusk or Shelled fishes	It shall be unlawful for any person or entity to collect, gather or sell scallop locally knownas "tikab" less than five (5) inches measured from the hinge of the shell, and other molluskor shelled-fishes which does not reached thematurity stage or as may be determined by the national government and or accredited research institutions.

Municipality: MALOLOS

ORDINANCE NO.	DATE OF APPROVAL	SECTION	TITLE	PROVISIONS
04-2000	8-Aug-02	5	Opisyal na pahintulot, pakakaloob ng Karapatang Pangisda (License Permit; Fishery Grant)	Walang sinumang tao, bakasan (partnership), kooperatiba, samahan o korporasyon na pinapayagang manguha o manghuli ng isda o iba pang produktong pantubig (aquatic products) mula sa katubigan ng Munisipyo sa pamamagitan ng mga lambat, umang o ibang gamit pangisda, gumamit o hindi gumamit ng bangkang pangisda na may timbang o bigat humigit-kumulang sa tatlong (3) tonelada, maliban kung mayroong lisensya o pahintulot sa ganitong layunin. Gayundin, ipinagbabawal sa sinoman na mag-operasyon ng mga lamba-pangisda, kama-kamang nililinang talaba o kaya'y manghuli o kumuha ng iba't-ibang uri ng isda upang magpalaki (brood) o magkalat (propagate) sa loob ng

ORDINANCE NO.	DATE OF APPROVAL	SECTION	TITLE	PROVISIONS
				nasasakupan ng Munisipyo ng Malolos ng walang kaukulang pahintulot buhat sa tanggapan ng Punong-Bayan (Mayor's Permit).
04-2000	8-Aug-02	9	Pag-uuri at paghahati ng tubig pangisdaan ng munisipyo (Zonation of Municipal Waters)	Ang mga tubig pangisdaan sa loob ng nasasakupan ng Munisipyo ng Malolos ay uuriin at hahatiin sang-ayon sa sumusunod na sukat at bayarin: Annual Fee Zona 20 Pulo-pulo, kay kalabaw, pinagbantayan escuelahan -600meters in length, 550cm width . Baklad – Talabahan…….165.00 Zona 23 Pulong kahoy, Agupan, Wawang Maluyao - Talabahan . Baklad – Lambatan…….165.00
04-2000	8-Aug-02	10	Itinatakdang Bayarin (Imposition of fees)	Pagkaraan ng dalawang ulit (2) ng pagpapatalastas at walang makilahok sa pangmadlang subasta o public bidding para sa tanging gawad karapatan sa pagpapatakbo ng fish corrals o umupa sa anumang zonang pangisdaan ng Munisipyo, ang Sangguniang Bayan ay may karapatang ibigay ang tanging gawad karapatang ito (exclusive privileges) sa sinumang tao pagkaraang makapagbayad ng naitakdang halaga hinggil dito, sang-ayon sa sumusunod: Kapasiyahang Oyster.....Php 200.00

City: ROXAS

ORDINANCE NO.	DATE OF APPROVAL	CHAPTER	SECTION	TITLE	PROVISIONS
104-2002	17-Dec-02	2	5	Zoning of City Waters	The City Waters of Roxas are designated into the following zones: Zone 1: Marine Protected Areas/ Habitat Protection Zone Zone 2: Shellfish Reservation Zone Zone 3: Multiple Use Zone Zone 4: Tourism/Recreation Zone Zone 5: Mangrove Reservation Zone
104-2002	17-Dec-02	2	6	Resource and Zoning Plan of Roxas City Waters	To ensure consistent, cohesive and harmonious planning and management, and in order to promote the sustainable development through integrated coastal resource management, the waters of the City of Roxas are hereby divided, and areas are classified in Annex B. these areas may be rezoned or reclassified when monitoring data/results warrant such actions. The Roxas City Coastal Zoning Map attached to this Ordinance is hereby made an integral part of this Ordinance.
104-2002	17-Dec-02	2	12	Protection and Conservation of Rivers, Streams, and Wetlands	The City government, in coordination with national government agencies, the FARMCs and other concerned organizations, shall ensure the protection and conservation of rivers, streams, waterways, and wetlands. The City government shall regulate all activities which result or will likely result to the degradation of fishery and aquatic resources within rivers, streams, and wetlands following provisions of DILG Memorandum circular No. 2002-64 and in consonance with FAO 216.

ORDINANCE NO.	DATE OF APPROVAL	CHAPTER	SECTION	TITLE	PROVISIONS
104-2002	17-Dec-02	2	13	Aquaculture Development	Ensure that aquaculture development is pursued responsibly and with minimal impacts on the diversity and ecosystem integrity of City waters and local communities. Establish procedures to undertake appropriate environmental assessment, monitoring and mitigation with the aim of minimizing adverse ecological changes and socio-economic impacts as a result of excessive water extraction, discharge of effluents, use of chemicals and other harmful activities. Designate areas for the establishment and operation of aquaculture. Navigational lane of rivers shall not be obstructed or impeded. Such aquaculture operations shall not make use of toles/fish traps, bakong, taba, saluran, fishpens or paduyan. No structures shall be allowed in rivers less than 30 m in width and not over 10% of the suitable water area of all rivers shall be allotted for aquaculture relative to its carrying capacity. Existing fishery structures in riverine area shall be inspected and monitored for compliance. Those located outside the designated one shall be abated and cleared. Marginal fisherfolks are given preferential right to occupy riverine area adjacent to fishponds provided their structures do not obstruct the water gates.
104-2002	17-Dec-02	2	14	Compliance with water Quality and Food Safety Standards	City Agricultural Services Office shall monitor compliance with water and seafood quality standards in accordance with existing standards set by regulatory agencies according to resource use and in compliance with international standard relevant to seafood trade. It shall be the responsibility of the polluters to contain, remove and clean up such pollutants a his expense. In case of failure to do so, the city government, in coordination with other concerned government agencies, the FARMCs and the other organizations, shall undertake containment, removal and clean up operations, the expenses for the aid operations to be charged against the persons responsible for pollution. The operators and owners of aquaculture facilities and structures shall develop a mechanism of proper waste reduction and disposal

ORDINANCE NO.	DATE OF APPROVAL	CHAPTER	SECTION	TITLE	PROVISIONS
104-2002	17-Dec-02	2	19	City Agricultural Services Office	To encourage compliance with fishery regulations and ensure efficient and orderly processing, evaluation, and issuance of license and permits, the City Agricultural Services Office is hereby designated as the lead unit for coastal resource and fishery management.
104-2002	17-Dec-02	2	22	General Schedule of License and Permit Fees	License to use, occupy, produce, culture, capture or gather any fish and other fishery products in city waters shall be granted by the City Mayor upon payment of the corresponding fees specified in Annex D:.License for using and/or engaging in the ff: RIVER-oyster/mussel (floating)- Php 100.00/unit/year (10x10m). Marginal fisherfolks are exempted from payment of City Fishery License fees. Municipal fisherfolks with motorized bancas using 10 hp engine and more shall be assessed Php210.00 as fishery license fees. A fee of Php1.00/kg from sale of Kapis shell shall be imposed upon the buyer for investment in CRM. Fish wardens on duty will be paid Php0.50/kg from said fees for monitoring and managing gathering activities. One year after the effectivity of this ordinance and at the beginning of every fiscal year thereafter, the CASO shall evaluate fees, entails and charges and make appropriate recommendations. Such recommendations shall be submitted to the Committee on Fisheries, who shall there after consult with the FARMCs on the same day before a request is made to the Sangguniang Panglungsod to pass an ordinance approving the new schedule of Fees. The new Fees may be collected by the CASO only at the beginning of next fiscal year subsequent to their approval.
104-2002	17-Dec-02	2	23	Report of Fish Catch/ Harvest	Individuals and entities, who have obtained licenses to catch and culture in city waters, shall conform with the provisions of FAO 218 and shall further submit to the City Agriculture Office an annual report of their fish catch showing the kind, quantity and value sold on a monthly basis, in triplicate copies. The City mayor shall not issue licenses for renewal of delinquent licenses.

ORDINANCE NO.	DATE OF APPROVAL	CHAPTER	SECTION	TITLE	PROVISIONS
104-2002	17-Dec-02	3	29	Post-harvest Facilities	The city government, with the active participation of cooperatives, non-governmental organizations, private sectors and other concerned agencies, and the BFARMC, shall initiate the establishment post-harvest facilities such as, but not limited to, fish landing sites, fish ports, ice plants and cold storage facilities shall be consistent with the comprehensive post harvest and ancillary industries plan.
104-2002	17-Dec-02	5	37	Exportation and Importation of Fish and Fishery Products	Export of fish and fishery products shall be regulated whenever such exportation affects the food security,supply, production, and public health. Provided, that exportation of live fish shall be prohibited except those which are hatched or propagated in accredited hatcheries and fishponds; Provide, however, that to protect and maintain the local biodiversity or ensure the suffieciency of supply, spawners, breeders, eggs, and fry of bangus, prawn, and other endemic species, as may be determined by the Department, shall not be exported or caused to be exported by any person; Provide, further, that no person shall import fish and fish products of whatever size, stage, or form, for any purpose without securing the necessary permit.
104-2002	17-Dec-02	5	38	Auxiliary Invoice	All fish and fishery products, except those caught in violation of the provisions of this ordinance or are declared as health hazards by concerned institutions, must have an auxiliary invoice to be issued by the city government or CASO prior to their transport from the point of origin to their point of destination in the Philippines and/or export purposes upon payment of the prescribed fee to defray administrative costs therefor. All shipping companies operating aircrafts, sea vessels, and buses/PUJ shall ask the shipper to present a valid auxiliary invoice issued by CASO and shall not transport fishery products without the same. Fishery products without pertinent documents will be made to pay double the rates of the corresponding goods as specified in this ordinance. Shipping companies that transport fishery products without auxiliary invoices shall be held jointly liable with the shippers.

ORDINANCE NO.	DATE OF APPROVAL	CHAPTER	SECTION	TITLE	PROVISIONS
104-2002	17-Dec-02	6	Annex C	Schedule of License, Permits, Fees, and Charges	AUXILIARY INVOICE - Transport Fees Item Transport Fee Oyster (Talaba) 5.00/sack Mussel (tahong, abahong) 5.00/sack Shellfish Meat 20.00/10 kg License for engaging in the following: RIVER Particulars Fees Oyster / Mussel (floating) 100.00/unit /year (10m x 10m) License for engaging in Aquaculture: OPEN SEA (50M from low tide mark up to 15km) Particulars Fees Oyster / Mussel 100.00/unit/year (10m x 10m)