Review of the Gwalwa Dariniki Enterprise (GDE) mud crab (*Scylla serrata*) pond farming project at Kulaluk, Darwin and comments on the Bawinanga Aboriginal Corporation (BAC) mangrove pen mud crab farming project at Numungoorda, Maningrida, Northern Territory, Australia

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Australian Government
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Cover Photograph by author: Measurement of pond reared mud crabs at the Mudla farm. Hands are those of project manager and trainee mentor Dr Bob Rose and aquaculture technician trainee, Jacky Treves, March 2007.

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ACKNOWLEDGEMENTS

The reviewer gratefully acknowledges the kind hospitality and assistance of Dr Bob Rose (Pearl Oysters Propagators P/L) in disrupting his busy schedule to provide a comprehensive guided tour of the Mudla mud crab Farm at Kulaluk that stretched over three days; for ferrying me around Darwin and in supplying a very large and diverse array of reports, background information and data documenting all stages and facets of the farm and its operation over the past two years.

I thank Darwin Aquaculture Centre (DAC) staff, Graham Williams (Senior Aquaculture Scientist), Ian Ruscoe (Aquaculture Liaison Officer), Evan Needham (Senior Aquaculture Technician), Jerome Bosmans (Senior Aquaculture Scientist) and Kris Kuo (Extension Officer), for their individual and collective assistance. This assistance included a comprehensive guided tour of mud crab and barramundi R&D and hatchery facilities and operations at the DAC, and commentary on the Mudla farm project and the BAC mangrove pen mud crab farming project at Maningrida and on related mud crab fisheries exploitation and management issues. Invaluable commentary on the implementation and status of the mangrove pen mud crab farming project Maningrida was also provided by staff of the Northern Territory Department of Business Industry & Resource Development (DBIRD), namely Deputy Director, Bill Flaherty and Indigenous Projects Officer, Robert Carn.

I thank Helen Secretary (President of Gwalwa Dariniki Enterprises) and Phil Elsegood (Cross Culture Consultants) for providing valuable insight into the Mudla Farm Trainee program and as I do of three trainees that I met on the Mudla farm, namely Wayne Allum, Jacky Treves and Sylvan Shorty.

NON-TECHNICAL SUMMARY

Title: Review of the Gwalwa Dariniki Enterprise (GDE) mud crab pond farming project at Kulaluk, Darwin and comments on the Bawinanga Aboriginal Corporation (BAC) mangrove pen mud crab farming project at Numungoorda, Maningrida, Northern Territory, Australia

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OBJECTIVES:

1. To assess if current management and operational practices of the GDE and BAC projects are appropriate and if not, how they can be improved.

2. To conduct a skills audit of the GDE project and assess if staff and trainee support needs are being met.

3. To assess suitability (weaknesses and strengths) of the GDE site, especially availability of salt and fresh water and how any deficiencies can be circumvented and attributes made better use of.

4. To evaluate resourcing, capital infrastructure, financial management and husbandry systems biotechnology of the GDE mud crab farm in relation to current best practice.

5. To determine the timeliness, reliability and quality of crablets being sourced by the GDE and BAC projects and potential methods for improvement (if needed).

6. To evaluate methods and performance of the GDE project with respect to processing and packaging, storage and transportation, value adding and marketing of various mud crab products generated in relation to best practice.

7. To advise GDE and BAC stakeholders on how best to take their projects forward based on achievement of the preceding objectives 1 to 6.

NON TECHNICAL SUMMARY:

Outcomes Achieved:

Objective 1 Assessment of current management and operational practices of the GDE mud crab farm

Very thorough and honest reporting has been made of all planning and implementation phases of this project and of its operational and financial management. However, inconsistencies were detected in some key technical and financial assumptions used to develop the original Business Plan and in its subsequent implementation. Revenue shortfalls of around $0.5 million each in relation to farm generated income and from government grants sustained over the past 1.6 years greatly exacerbated difficulties of this already complex and ambitious project. Of greatest impact was the inability of the project Board and Steering Committee to secure funding from DEWR with which to employ up to eight indigenous trainees. Accordingly, cash intended for farm reconstruction and modification and to purchase essential farm equipment was apparently redeployed to "maintain a cash flow for farm operations and employment of staff and trainees. Grant revenue shortfalls were in fact described to the reviewer as… *"leaving the project drastically short of vital capital funds needed to fully recommission farm ponds"*. The reviewer was unable to fully verify this conclusion from audited accounts that suggests surplus funds existed at the end of the close of 2005/2006 financial year and that only a small proportion of $411,000 allocated to farm reconstruction had been expended. By this time all planned and budgeted farm renovation works including installation of electrical supply and main seawater delivery pumps and aeration equipment should have already been completed as a precursor to achieving earliest and greatest possible generation of revenue from the production and sale of crabs. In hindsight, the concept that the Mudla farm could ever be financially self-sustaining on the basis of crab production from between 2.5 and 10 ha of ponds was naïve. The reviewer is nevertheless of the opinion that this project has great socio-economic merit being widely viewed as an unique opportunity for the Gwalwa Dariniki people to pursue financial and social independence and for various government agencies, especially NT DPIF/DAC, DAFF, OIPC and ABA and training institutions, especially Charles Darwin University, to assist them in this quest through provision of crablets (generated using locally developed cutting-edge biotechnology by DAC), technical advice, specialist training and working capital.

Objective 2 Assessment of staff skills and if staff and trainee support needs are being met.

The Trainee program is well structured but has had implementation problems. It comprises two complimentary components namely:

1. On the job/farm individualised training and mentoring provided by the principals of Tropical Aquaculture Australia (Dr bob Rose and Mr Phil Elsegood)
2. Participation of trainees in formal certificate courses provided by the Charles Darwin University

1. On-farm individualised training and mentoring provided by TAA

Fields of instruction provided to trainees, by Dr Rose, have included many aspects of farm planning, design, construction and maintenance, staff management, OH&S and technical operations, including harvesting and marketing. The overall calibre of Dr Rose's performance as a teacher and mentor in terms of professional commitment, energy, perseverance, communication skills, time management and reporting of outcomes, has in the opinion of the reviewer been very good.

Perceived weaknesses and scope for improvement in this aspect of the trainee program were:

- Dr Rose's relative lack of previous hands-on experience in the semi intensive pond aquaculture of crustaceans at the outset of the project.
- Competing demands on Dr Rose's time and energy posed by a daunting array of other farm and project management and reporting duties and responsibilities.
- Lack of supplementary technical advisory services to compliment those of DAC technical support and of the overtaxed farm manager/trainee mentor.
- Funding shortfalls that contributed significantly to deficiencies in farm operational design, infrastructure and equipment that restricted the ability of farm staff and trainees to respond to and/or ameliorate adverse pond conditions if and when they were detected and reported
- Lack of routine daily assessment of water quality in stocked ponds especially at critical times between midnight and dawn exacerbated by the delayed initial purchase of on-farm water quality monitoring equipment.

2. Certificate courses provided by the Charles Darwin University

Seven suitable trainees, all young Larrakia people were recruited from the local Kulaluk community. One was enrolled in the Certificate II in Business (Office Administration) course and the remaining six in a Certificate II in Seafood Industry (Aquaculture) course.

Three trainees have already completed the Certificate II in Seafood Industry (Aquaculture). with a further two expected to finish during the current year (2007) The anticipated graduation of at least 5 and possibly 6 out of the 7 trainees constitutes an excellent result.

The reviewer is nevertheless of the opinion that the trainee program could benefit considerably through development of better communication between the on farm training and mentoring providers and Charles Darwin University, and additional linkages with other organisations such as Bachelor College and other interstate research and training institutes, to host marine science undergraduate and postgraduate based projects that would in turn provide positive interaction between farm trainees and students .

Objective 3 - Assessment of suitability of the Mudla farm to host the project.

The location of the Mudla farm at Kulaluk on the northern outskirts of Darwin is near optimal. It is in close proximity to and has all-weather accessibility by all relevant general and specialist goods and services, its collaborators (DAC and University) and funding agencies. Even more importantly, it lies within the tribal lands of the local Gwalwa Dariniki aboriginal community, who have proactively lobbied for the project.

The previous history of the Mudla farm as a former failed prawn farm has been somewhat of a double-edged sword. On one hand pre-existing (albeit derelict) ponds and infrastructure were perceived as *wasted assets* by the Gwalwa Dariniki community. On the other hand, the original prawn farm had failed because of an array of inherent limitations, particularly its exposure to a very large (7 m) tidal range that restricts opportunities to fill ponds and/or to conduct rapid seawater exchanges for combating poor pond conditions. Another potentially serious limitation of the site is that natural ground level falls within the upper inter-tidal mangrove zone thereby rendering it susceptible to acid sulphate soil issues that in turn cast doubt over proposed future expansion of the farm to 10 ha of ponds.

While there is no evidence that incident seawater is at risk of pollution from surrounding urban areas, its immediate proximity to the *Ludmilla* sewerage/waste water treatment plant is of obvious concern. Although soil type is described as predominately clay loams suitable for pond construction, recent apparent rain erosion of sandy topsoil from atop walls suggests that the walls will need to be further stabilised and/or plastic lined if semi-intensive crab farming and/or related R&D and training activities are to be continued. Continued operation of the farm will also necessitate additional upgrading of the facility (provision of electrical power distribution, improved pond filling, drain harvesting, aeration and waste water recycling capabilities and upgraded access to fresh water with which to combat hyper-salinities during the dry season).

Objective 4 - Assessment of capital infrastructure and farm operating and husbandry systems in relation to current best practice.

Design construction and operation of ponds

Apparent shortcuts taken in the reconstruction and recommissioning of the farm included substitution of drain harvest monks in 1 of the 4 production ponds with simple passive-flow stand pipes to enable both controlled pond filling and draining. All ponds appeared unusually shallow due to apparent long-term erosion and in-washing of sandy topsoil from pond walls and surrounding areas. Instead of removing these pond congesting sediments, canals were excavated around the inner periphery of pond floors to re-enable complete drainage and intercrop drying. Provision of electrical power distribution, main seawater pumps, seawater delivery systems, and aeration equipment, although budgeted for and recognised in various reports as being critical to *best practice* pond management, was not implemented. These observations contrasted with the originally proposed design and operations methodology detailed in the Environmental Management Plan. Thus although the intended design and operational standards for the ponds and associated seawater supply and discharge systems resembled best practice systems used elsewhere in Australia, implementation appears to have fallen well short of such standards.

Water quality monitoring and management

As with farm design and construction, the implementation of water quality monitoring and management varied from that described in the Environmental Management Plan. While a comprehensive schedule of water monitoring was prepared, water quality data collection and analysis appears to have been largely limited to that conducted by a DAC extension officer. Over the 15 month period Dec 2006 to 19 Feb 2007, a total of 29 farm visits were made at intervals of from 1 to 31 days. In all cases data collection was undertaken between 8:30 am to 5:00 pm with most (20 out of 29) between 10 am and noon. Monitoring of water quality of settlement ponds was limited to only 3 occasions, one in each of May, June and December 2006.

Dissolved oxygen (DO) levels in ponds were not measured through full diurnal cycles nor were they measured during critically low DO periods that occur between about midnight and 6 am. In all cases measured parameters were limited to temperature, dissolved oxygen (DO), pH and salinity. Recorded average temperatures of ponds remained within the range 24 – 32° C conducive to good health and high growth performance of mud crabs. Average DO readings remained above levels of 4 mg/L considered as conducive to good health and high growth performance of mud crabs. However minimum recorded DO levels, in spite of having only been measured during the day, were nevertheless found to have fallen to dangerously low levels below 2 mg/L on several occasions.

Average salinity of ponds after rising steadily for 4 months from a post wet season level of 17 g/L (half seawater strength) in May 2006 to 36 g/L (full seawater strength) in September 2006 suddenly rose to extraordinary average levels of 53-58 g/L during the following month of October. Evaporation losses alone cannot account for these dramatic rises. A partial filling of ponds in September (Kuo, field notes 05/09/2006) followed by long delays in topping them up with new seawater was identified as an exacerbating factor. Unfortunately no affordable means was available to add freshwater, which is the only way of restoring pond salinities back to a favourable range at or below 35mg/L (oceanic) during the latter half of the dry season in northern Australia. Instead all 4 production ponds remained at extreme hyper-salinities through to the onset of the wet season in December 2006, i.e. for a total period of 3 to 4 months. Not surprisingly, many crabs were found to have soft (decalcified) shells during this protracted exposure to hyper-salinity. Impact on growth was catastrophic with small third production cycle 3 crabs stocked in September 2006 growing at one tenth the expected rate over their first 3 months while continuously exposed to salinities in the range 43 to 56 g/L .

Only sparse *ad hoc* comments were recorded in relation to health and behaviour of crabs with scant reporting of pathology conducted on moribund crabs. Negligible quantitative data was reported neither on algal bloom density, total nitrogen, ammonia, nitrite total phosphorus or suspended solids nor of potential pollutants such as heavy metals, pesticides or of sewerage pollution indicators.

Crab growth and production on the Mudla farm

Two pond production cycles were completed between December 2005 and December 2006. Average growth rates remained at or close to maximum expected levels for an initial period of about 115 days (from late Dec 2005 to late April 2006) for the first production cycle and of about 160 days (from late March to August, 2006) for the second cycle, before abruptly stopping. Excellent initial growth performance exhibited in both these production cycles would seem to exclude food type or quantity as limiting factors.

An investigation by the reviewer of published mud crab crop yields versus duration of pond production cycles, suggested that the most appropriate time for harvesting pond reared mud crabs is in the range 115 to 190 days after stocking at favourable temperatures in the range 25 to 32°C. These findings are consistent with those from the prawn farming industry where even well managed ponds crops not harvested close to an optimum time suffer progressively elevated and sometimes catastrophic mortality thereafter due to accumulation of oxygen hungry organic sludge and other toxic metabolic waste products, especially ammonia.

It is therefore postulated that actual survival of 13% achieved over the first production cycle could have been as high as 50% and actual yield of 283 kg as high as 700 kg had the crabs had been rapidly harvested at the time of stalled growth 115 days after stocking rather than having been progressively trap harvested over an additional 4 months.

Further analysis of published data suggested that even under well controlled experimental conditions and when operating within a favourable *harvesting window* of 115-190 days after stocking, average mud crab yields have consistently been in the range 0.5 to 2.1 tonnes/ha/crop. Thus average yield expectations of 3.16 tonne/crop built into the original business plan for the Mudla farm are probably about twice those that could have reasonably been expected.

Objective 5 - Assessment of the timeliness, reliability and quality of crablets sourced from DAC

DAC supplied the Mudla farm with 3 consignments of crablets during 2006. The first comprised a total of 4,400 crablets and was supplied in early January 2006. The second much larger consignment of between 45,000 and 50,000 crablets was supplied on 3rd March 2006. The third and final consignment, comprising between 10,000 and 16,110 crablets was supplied on the 29th September 2006. In the opinion of the reviewer, outcomes of pond farming operations at the Mudla farm were not significantly constrained by either the quantity, quality or timing of these consignments.

A study tour of the DAC and technical discussions with key technical staff confirmed the staff and facility as international leaders in the hatchery production of the giant mud crab *Scylla serrata.* DAC currently produces batches of crablets more frequently, on a larger scale and with greater consistency than any other hatchery in Australia. Apart from budgetary and bureaucratic constraints, the most significant deficiency of DAC's ability to supply crablets is a lack of on-site nursery pond facilities with which to mass produce final stage megalopae larvae in pond based hapa nets through to the crab stages 5 or 6 that are of optimum size (15-20 mm and around 1 g) for transporting and releasing into farm grow-out ponds. It is thus recommended that intermediate stage nursery production be shifted from DAC to recipient farms with the Mudla farm being used to demonstrate and refine this weak link in the crablet seed supply chain.

Objective 6 - Assessment of post-harvest processing and packaging, storage and transportation, value adding and marketing of mud crabs.

Marketing development and promotion initiatives have been severely limited by low farm output that totalled only 283 kg from the first pond production cycle and 225 kg from the second production cycle. Bulk handling and processing trials have been prevented by low weekly sales volumes linked to the chosen harvesting policy of progressive baited trap capture from each crop cycle over very protracted periods of 4 to 6 months. Apart from some small-scale trial interstate consignments, crabs have been sold live either as a larger (≥350g) better quality grade to local wholesalers, as smaller (≤350g) second grade or as low grade (missing one or more limbs) to residents of Darwin and to local Asian restaurateurs.

The total revenue from the first pond production cycle was $3,307.68 with the weighted average price at $12/kg. The average overall price during the 'build-up' period was $17.78/kg attained for crabs produced from the second production cycle was more than 50% above that of $12/kg achieved from first production cycle crabs and rewarded a concerted program of personalised client servicing and market promotion of a local home grown graded and quality assured product.

Objective 7 - Conclusions and recommendations on how best to take the projects forward

Mudla mud crab pond farm

Forecast yields of 3.16 tonnes/ha/ crop cycle and associated revenue projections for the Mudla farm used in financial planning and justification for this project were optimistic. In the opinion of the reviewer, best yields that could have reasonably been targeted, had all best practice farm design and operational protocols as specified in the Environmental Management Plan and as budgeted for in the business plan been implemented, were 1.5-1.8 tonnes/ha/crop. In practice, pond design, construction and operational protocols all fell short of prescribed standards. Neither regular high rates of water exchange nor supplementary pond aeration and stirring could be imposed while crops were progressively harvested up to 6 months after growth had ceased. Accordingly, the best yield of 350 kg /ha /crop actually achieved can be viewed as *that to be expected under the circumstances*.

It is acknowledged that although the Mudla farm has fallen short of commercial performance expectations, its very manifestation has served as the focus of considerable community pride and this in conjunction with a well structured and generally successful trainee scheme, has imparted renewed hope especially among the young.

From a national perspective, significant technical hurdles still stand in the way of profitable mud crab farming in Australia. To achieve reasonable returns to investment, future mud crab farms will need to achieve yields in the range 3-5 tonnes/ha/crop and 2 crops per year. Such crop yields will also have be coupled to a minimum production base of 25-50 ha of ponds in order to achieve requisite economies of scale. Yields of 3-5 tonnes/ha/crop and minimum scales of operation of 25-50 ha will also need to be linked to development of new specialist *complete* mud crab diets that can support near optimum growth rates with food conversion efficiency and costs on par with current commercial prawn feeds. Although concerted research effort to develop such a diet is well advanced, its commercial availability may still be several years away. A systematic program of R&D to combat moult and density related cannibalism thereby enabling yields to be raised from the current limits of around 1-2 tonnes/ha/crop to economically viable rates of 3-5 tonnes/ha/crop remains to be tackled.

Comments on the Maningrida mangrove pen farm

This venture though compromised by much lower levels of external funding and of technical and logistic support than the Mudla mud crab pond farm, appears to have a higher probability of success in delivering significant socio-economic benefits and potentially over a much larger number of regional indigenous communities across northern Australia, especially those bordering NT waters of the Gulf of Carpentaria.

In view of the very substantial technical and economic uncertainties and risks, associated with the Mudla mud crab farm, the reviewer recommends that the Mudla Farm Project Board, and/or the Steering Committee give consideration to abandoning the project in its present form and re-vamping it as an adjunct to a much longer-term and more expansive nationally significant program of mud crab fisheries enhancement and/or ranching, mangrove pen farming of the type being trialled at Maningrida. However this recommendation must be linked to an integrated program of R&D, technical training, logistical and financial support over a realistic (commercial scale-up) time frame of 10 to 15 years.

Rationale for this recommendation is based on the following facts and issues:

- More than 80% of coastal land across Northern Australia is vested via native title with regional indigenous communities. Following the Blue Mud Bay decision of the Federal High Court of Australia (subject to the outcome of a pending challenge in the High Court) there is a possibility that this land may be extended to the low water mark. This being the case, indigenous communities will have an increased legal claim to a share of fisheries related resources, including mud crabs.

- The Mudla facility could host R&D of a large-scale, low-cost nursery for production of juvenile mud crabs in the range 0.1 to 1 g suitable as seed for fisheries enhancement, ranching and mangrove pen farming.

- The Mudla facility could also continue to serve as a specialist training centre for extending large-scale lower cost production of seed to other regional indigenous communities and/or as an ecotourism centre based on the above activities and issues of interest.

NB These recommendations remain consistent with the original objects of both the GDE's mud crab pond farming project at Kulaluk and the BAC's mangrove pen farm project at Maningrida, i.e.

- To establish sustainable aquaculture ventures on their own tribal lands.

- To develop technical support training and employment programs especially for their young people.

- For NT DPIFM to develop appropriate models for extending the social and economic benefits of profitable mud crab ventures to a range of additional regional and remote indigenous communities in the longer term.

KEYWORDS: Review, Indigenous Enterprises, Mud Crab Pond Farming, Mangrove Pen, Northern Territory

1. BACKGROUND

After hearing of the success of the Department of Primary Industries Fisheries and Mining, (DPIFM), in rearing young mud crabs (crablets) in its Darwin Aquaculture Centre (DAC) hatchery, the Gwalwa Dariniki Association (GDA) approached the Northern Territory Government. This technology had been developed as the collective outcome of two major R&D projects namely ACIAR/FIS/1992/017 *Development of improved mud crab culture facilities in the Philippines and Australia* and FIS/1999/076 *Development of leading centres for mud crab culture in Indonesia and Vietnam*. FRDC (FRDC project - 2000/210) and GDA with Tropical Aquaculture Australia (TAA) produced a feasibility study and business plan for a commercial venture in 2003 to grow out hatchery crablets purchased from the DAC but were unable to attract government or private funding at that time.

In November 2004, a two-year agreement was signed by the GDA and DPIFM's Fisheries Group to jointly progress the project. It was intended that after this two year establishment phase, GDA would continue the operation as a fully commercial venture through the Gwalwa Dariniki Enterprises P/L (GDE) acting as Trustee for Mudla Farms Charitable & Benevolent Trust (ACN 114 704 666). The original business plan (April 2005) concentrated on the two-year partnership, although financial projections were extended to show apparent profitability in the longer term.

The specific aims or objectives of the project are broad. GDE wishes to establish a long-term sustainable aquaculture venture using a failed prawn farm facility located on their land at Kulaluk (see location map (Figure 1) and aerial photo (Figure 2). DPIFM aims to use the facility, once established, to create appropriate models for the commercial farming of mud crabs on indigenous land in regional and remote communities of the NT. In this way, it is intended that the project use GDE as a model for Indigenous Economic Development (IED). This in turn entails building capacity within the community by supporting training and promoting real, sustainable employment in a commercial venture – the mud crab farm.

In accordance with the major role of DPIFM of stimulating economic and social development of Aboriginal communities across the Northern Territory, crablets produced at the DAC have been used for farm grow-out under a commercial arrangement at the Kulaluk pond facility belonging to the Gwalwa Dariniki people in Darwin. The project has aimed to integrate capacity building exercises of training and meaningful employment, with a commercial aquaculture venture. The longer term intention of the Kulaluk facility has been to act as a model and demonstration farm for remote ventures. The establishment and early operating costs of the project have been funded by a combination of monies and resources derived from the Northern Territory Government, the Federal Government, and the Gwalwa Dariniki people.

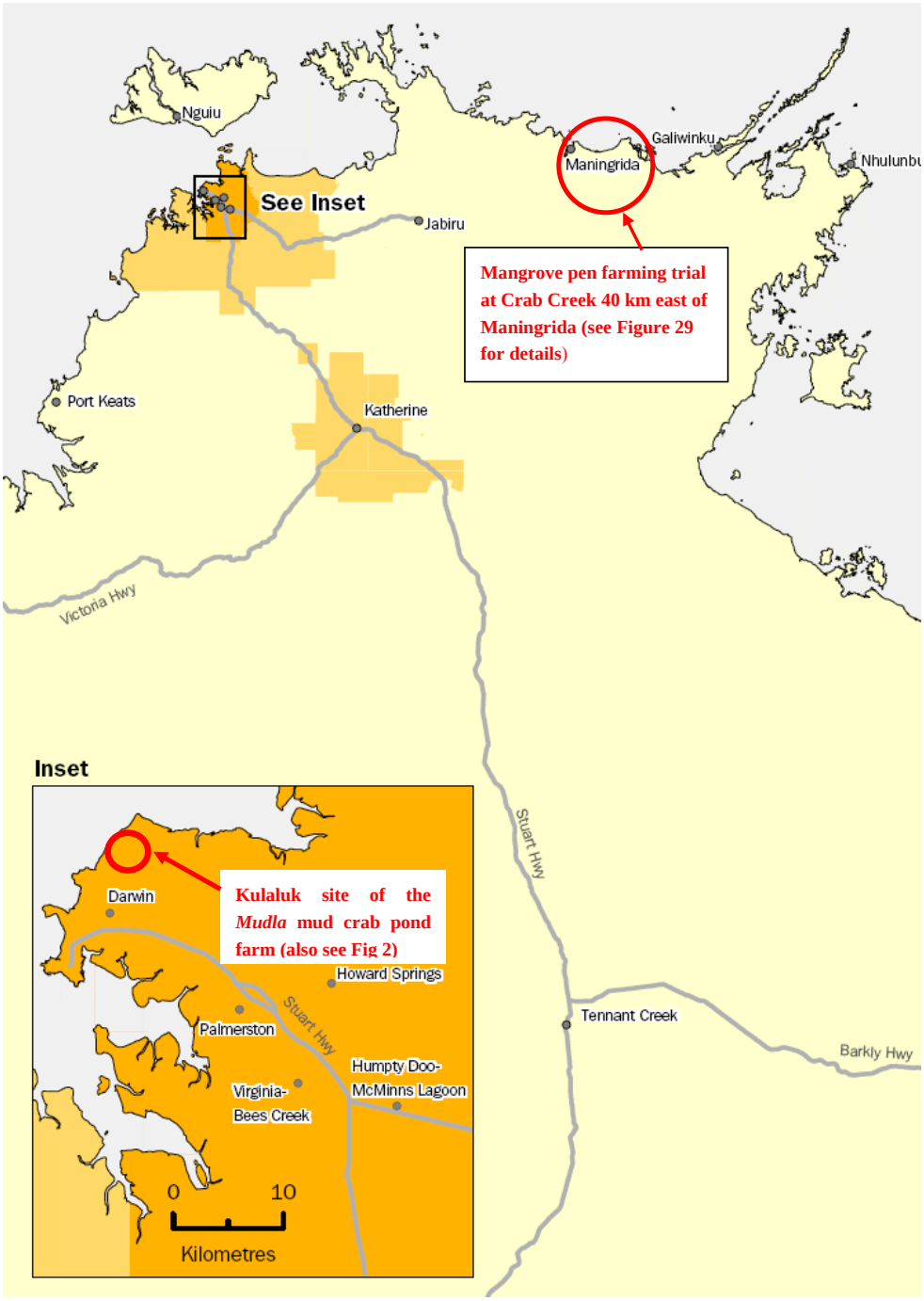


Figure 1 Map showing the location of GDE *Mudla* pond farm at Kulaluk, on the northern outskirts of Darwin and the BAC pen farming trial at Crab Creek 40 km east of Maningrida (about 400 km East of Darwin)

Figure 2 Aerial photo of pond facility on Gwalwa Dariniki land at Kulaluk prior to re-establishment as the Mudla crab farm.
(Source: Appendix 2: Mudla Farm 1st Annual Report, May 2006)

A Steering Committee comprising representatives from relevant stakeholder groups has overseen the project to date. These groups include the GDA, NT Fisheries, the Australian Government Departments of Agriculture, Fisheries and Forestry (DAFF), and Employment and Workplace Relations (DEWR), the Office of Indigenous Policy Coordination (OIPC) within the Australian Department of Immigration, Multicultural and Indigenous Affairs (DIMIA), the NT Department of Employment Education and Training (DEET), Charles Darwin University (CDU), the Northern Territory Area Consultative Committee (NTACC), and Tropical Aquaculture Australia P/L.

A farm manager training mentor, Dr Bob Rose, has been employed to physically run the farm and GDE representatives are undertaking DEWR funded aquaculture traineeships with time spent at the Darwin Aquaculture Centre (DAC) and at the farm. There are also trainees studying business management and Administration. A part time training mentor Mr Phil Elsegood has also be engaged to oversee training outcomes of farm staff. DPIFM has contributed substantial in-kind resources to the project in the form of infrastructure and personnel associated with the operation of the hatchery, and a DAC extension officer (Chris Kuo) has provided on-site hands-on technical assistance on farm on a regular basis.

As a business, the Kulaluk crab farm has aimed to produce mud crabs of a minimum size of 350 g. These are smaller than those caught legally in the wild and thus may represent a market advantage. Asian seafood buyers in particular had expressed an interest in small crabs. Initial production potential estimates suggested that around 15 tons of mud crabs valued $235,000 per annum could be grown in the existing 2.5 ha of ponds. The project intended track to expand pond production area by a further 0.5 ha in the second year (2007) of operation.

From the outset it was recognised that short-term profitability of the project will depend on the ability of the project to ensure operating costs were kept close to the above projected revenue (to allow maximum participation and benefit). It was also anticipated that once production was established, the economic viability of the business could be increased through economies of scale attached to further progressive expansion of the farm.

As with the Kulaluk mud crab pond farm project, representatives of the Bawinanga aboriginal community (BAC) at Numungoorda Maningrida approached DPIFM for assistance to develop the project after hearing of the success of a joint (Qld. DPIF and NT DPIFM) six year mud crab hatchery and nursery development project (FRDC project -2000/210) led locally by Graham Williams (DAC) in being able to routinely produce commercial quantities of crablets.

Strategic projects objectives for both projects have been to:

- Establish sustainable aquaculture ventures on their own tribal lands.
- Develop technical support training and employment programs especially for their young people.

and for DPIFM to:

- Develop appropriate models for extending the social and economic benefits of profitable mud crab aquaculture ventures to a range of additional regional and remote indigenous communities in the longer term.

2. NEED

The Fisheries Research and Development Corporation (FRDC) and the Federal Department of Agriculture, Fisheries and Forestry (DAFF), sought to engage an experienced and qualified consultant to review the management and technical operations of the GDE mud crab pond farming project in Darwin and to comment on the BAC pen farming project in Maningrida since their inception about two years ago. This commission is needed to establish both the present status these projects and how best to take them forward towards achieving socio-economic and environmentally sustainable viability and fulfilling stakeholders' aspirations.

3. OBJECTIVES

(1) To assess if current management and operational practices of the GDE and BAC projects are appropriate and if not, how they can be improved.

(2) To conduct a skills audit, and assess if staff support needs are being met.

(3) To assess suitability (weaknesses and strengths) of sites especially availability of salt and fresh water and how any deficiencies can be circumvented and attributes made better use of.

(4) To evaluate resourcing, capital infrastructure and operating and husbandry systems biotechnology in relation to current best practice.

(5) To determine the timeliness, reliability and quality of crablets being sourced by the GDE and BAC projects and potential methods for improvement (if needed).

(6) To evaluate methods and performance of the GDE and BAC projects with respect to processing and packaging, storage and transportation, value adding and marketing of various mud crab products generated in relation to best practice.

(7) To empower GDE and BAC stakeholders on how best to take their projects forward based on achievement of the preceding objectives 1 to 6.

4. METHODS

4.1. Implementation program

Sequence of planned activities	Description of activities	Status
1	Evaluate key documentation of planning and implementation and operating and economic status of the GDE and BAC projects	Completed
2	Study tour of DAC and mud crablet production and R&D operations / interviews with DAC and other relevant NT DPIF staff	Completed
3	Study tour with Dr Bob Rose and Ian Ruscoe of GDE pond farming operations at Kulaluk /staff interviews	Completed
4	Study tour Ian Ruscoe of BAC pen farming operations at Maningrida / staff interviews	Could not be implemented due to inaccessibility of site (monsoonal rain and flooding)
5	All day discussions and further information gathering with Ian Ruscoe and Dr Bob Rose and others	Completed
6	Study tour of BIARC in relation to current mud crab farming R&D activities and status of commercial mud crab hatchery and farming operations in Qld.	Completed
7	Preparation of draft Report	Completed June 2007
8	Conduct one day workshop in Darwin presenting findings of the review and recommendations for future management and operation of the two farms to all relevant stakeholders (additional meetings with stakeholders on (19/6/2007)	Completed(18/06/2007)
9	Submit final report including stakeholders comments	Completed

4.2. Issues addressed (GDE project only)

1. **Management and operational practices**
   Overview of soundness of original business plan and preparation of production schedules

   Financial and risk Management
   - *Accuracy of costing and revenue*
   - *Contingencies for cash flow shortfalls and other risks*

2. **Skills audit, and assessment of staff management and the trainee scheme**
   - *Organisational chart and skills audit*
   - *Trainee scheme*

3. Suitability of site

- *Location of the Site*
- *Seawater supply (quality and quantity)*

4. Farm design, operating and husbandry systems in relation to best practice

- *Design construction and operation of ponds*
- *Water quality monitoring and management protocols*
  - *Temperature recordings*
  - *Dissolved oxygen (DO)levels*
  - *Salinity levels*

- *Crab growth and production*
- *Assessment of causes of poor yields at the Mudla farm*

5. Reliability and quality of crablets

Assess degree to which best practice protocols identified during the FRDC and ACIAR Mud crab Hatchery and nursery technology development R&D projects have been successfully implemented by crablet suppliers and scope for improvement

6. Marketing, processing and packaging, storage and transportation of product - GDE and BAC projects

- Domestic market scope
- Scope for export marketing

7. Recommendations on how best to take the projects forward – -

NB These will largely depend on:

- Findings of the above
- Likely future access to funds and resources and associated timelines

5. RESULTS

5.1. Results - GDE pond farming project

5.1.1. Management and operational practices

Overview of soundness of original business plan and preparation of production schedules

In its business plan document (see Section 3.8 of Appendix 1), production scheduling was based on the following stated assumptions:

> *"Experimental yields have been around 0.7 crabs/m^2, with an average weight of 250g. This was achieved in five months. There are 4 ponds available at Kulaluk, totalling 2.5 ha or 25,000 m^2, and it should be possible to produce around 7,500 kg per cycle, or just over 15 tons per year from two crops when in full production. However, it will not be possible to fully stock the farm at one time due to limitations in crablet production capacity of the DAC. A staged stocking and production cycle will be necessary. This will also aid in staggering production and marketing. It is probable that a full production cycle encompassing the harvest of approximately 7 tons of crabs and subsequent restocking of all 4 ponds will be achievable within 12 months of the first stocking. Full production will be possible from this point forwards (i.e. 15-16 tonnes pa.)."*

The underlying assumptions used to generate annual production and revenue projections within the business plan can be readily traced to those provided in a report entitled Mud Crab Aquaculture – Overview of Growout Production Research prepared in 2004 by NT DPIFM (full copy attached as Appendix 5). Authors of this report concluded with the following statement:

> *"We believe that by applying pond management Best-Practice, including*
>
> 1. *The screening of intake water*
> 2. *Daily water quality measurement and management*
> 3. *Optimal feeding regimes based on body weight and feed trays*
> 4. *The provision of shelter for protection while moulting*
> 5. *Health monitoring*
> 6. *Predator protection and 24 hr farm security, and*
> 7. *Targeted harvesting of marketable crabs, leaving submarket size animals in the pond -*
>
> *We will be able to attain high growth rates and high survival, resulting in yields in excess of 3150 kg per ha per six month crop. These animals will be robust, healthy and of premium quality and will fetch premium prices in target markets in Darwin, and other capital cities if required."*

Of the seven best practice pond management criteria, only the first and last were in fact adequately addressed within budgetary and other constraints.

Another major flaw in the original business plan was a significant over-estimation of anticipated income from grants that were verbally reported to the reviewer as "*leaving the project drastically short of vital capital funds to fully recommission farm ponds*." The reviewer was unable to fully verify

this conclusion from audited accounts prepared in November 2006 (see Table 4) that suggest very considerable surplus funds existed at the end of the close of 2005/2006 financial year and that only a small proportion of $411,000 allocated to farm reconstruction had been expended. By this time all planned and budgeted farm renovation works, including installation of electrical supply and main seawater delivery pumps and aeration equipment should have already been completed as a precursor to achieving earliest possible significant farm production of crabs and revenue from the sale of such crabs.

Financial and Risk Management

A ten year projection of costs, revenue and operating balances for the Mudla farm (see Table 1) and companion draw-down budget (see Table 2) were prepared as part of the business planning. Projected cost and revenue data suggested that the project could be self funding beyond year 2 and prompted the authors (the Committee) to state that …*"grants or loan funding required to initiate and operate the venture was $867,500 for year 1 and $527,500 for year 2"* and that *"The more money that becomes available the more training and employment outcomes there will be. The committee has agreed that funds will be pursued from a variety of agencies as listed"* and that *"The grant funding shown in Table 12 will support the business as set out in this plan. Surplus funds will support additional infrastructure (e.g. larger shed, semi-permanent residence, training resources and facility) and business resources (vehicle). Additionally, this money could be used to leverage additional funds on behalf of the community to support other businesses or community development initiatives identified under the new Community Development Plan. This will maximize community participation in training and employment activities and build community capacity."*

These opinions and financial projections and the assumptions on which they were based, were in the opinion of the reviewer, highly over-optimistic. As a consequence, wide disparities have emerged between anticipated expenses and revenue streams and those that have eventuated over the past two years.

Accuracy of costing and revenue

Many of the anticipated costs as well as forecast revenue from both projected sales and grant funding provided in the original business plan (Table 1) and the companion draw-down budget (Table 2), have proven inaccurate. The major reasons for this were major shortfalls and delays in capital expenditure due in part to a diversion of human resources in having to address stringent environmental permit requirements and uncertainty in the commitment and receipt of scheduled cash instalments from two out of the five granting agencies, namely ACC and DWRC. Of greatest impact was the inability of the project Committee to secure funding from DWRC with which to employ up to eight indigenous trainees. Accordingly, cash intended for farm reconstruction and modification and to purchase essential farm equipment was apparently either warehoused or redeployed to cover salaries and CDEP wages i.e. to protect the financial well-being of project staff (see budgetary note 11 of Table 2) and trainees. This situation subsequently became further entrenched as it became progressively more evident that major shortfalls in mud crab production and hence sales revenue (due in some part to under capitalisation of the farm) were going to occur.

Other apparent disparities were much lower than anticipated operating costs especially of feed, electrical power and processing and marketing. These arose essentially because of failed crab production. However expenditure shortfalls also extended to a lack of provision of important operational equipment. While $20,000 was ear-marked to purchase vital water quality monitoring equipment, only $3,000 was spent and then not until August 2006. Likewise, while provision of $10,000 was made to buy aeration equipment and $5,000 for crab moulting shelters, neither of these potentially important production input items were purchased.

The best guess revenue projections for year 1 of $236, 250 and of $302,400 have little relevance to those actually generated by sales of mud crabs being reported as only $1,611 in year 1 and $4,563 in year 2.

Contingencies for cash flow shortfalls and other risks

Cash shortfalls (see items 3,4, 5, 7 and 10 of Table 3) and other significant procedural and technical risks, many of which were subsequently encountered in this project, were recognised from the outset These were identified and ranked as part of the original business plan and environmental management plan and are summarised in Table 3. In both the case of possible shortfalls in sales revenue (production and sales of commercially significant quantities of mud crabs) and in securing grants and timely receipt of cash funds, various contingencies such as timely reporting to milestones set by the various granting agencies, though apparently adhered to, did not appear to expedite payment nor to redress massive shortfall in expected level of funding as in the case of trainee wages sought through the DWRC.

Table 1 10 year Financial Plan Summary (Source Table 11 p 20 – Business plan - Appendix 1)

	Yr 1	**Yr 2**	**Yr 3**	**Yr 4**	**Yr 5**	**Yr 6**	**Yr 10**
Farm expansion (ha)	2.5	3	3	3	5	8	10
Farm Capital	411,000	100,000			300,000	400,000	300,000
DAC Capital	21,000						
Operating	128,500	170,500	176,500	184,200	269,700	418,400	498,360
Salaries							
DAC Overtime	10,000	10,000					
DAC T2 extension	70,000	70,000					
Farm manager	84,000	84,000	80,000	80,000	80,000	80,000	80,000
Training mentor	70,000	70,000					
Apprentices x 8 @ 22,000	176,000	176,000					
Technicians (x 3, 3, 4, 5, 8)			120,000	120,000	160,000	200,000	320,000
Total costs	970,500	680,500	376,500	384,200	809,700	1,098,400	1,198,360
Revenue - Crab sales	160,000	302,400	367,200	410,400	684,000	1,152,000	1,440,000
Grant / Loan funding	867,500	527,500					
Yearly Balance	57,000	149,400	-9,300	26,200	-125,700	53,600	241,640
Cumulative Balance	57,000	206,400	197,100	223,300	97,600	151,200	1,753,640
Actual Balance Reported in Tables 3 and 4 of Appendix 4	**$316,370**	**-$54,206**					

Table 2 Mud Crab Project Draw Down Budget (figures include GST) source see Appendix 1

	Notes			
Cash Received		**Year 1**	**Year 2**	**Grand Total**
ABA	1.	313500	141500	
DEWR	2.	64000	64000	
NTACC	3.	130000	259300	
Sales (live crabs)	4.	26253	79400	
Total		533753	544200	1077953

Cash Received (Quarterly Instalment)			**Yr 1**					**Yr 2**			
	Q1 Mar-May06	Q2 Jun-Aug06	Q3 Sep-Nov06	Q4 Dec06-Feb07	Total $	Q1 Mar-May07	Q2 Jun-Aug07	Q3 Sep-Nov07	Q4 Dec07-Feb08	Total $
ABA	94673	93404	67786	57637	313500	55225	55225	18175	12875	141500
DEWR	16000	16000	16000	16000	64000	16000	16000	16000	16000	64000
NTACC	85000	45000	0	0	130000	111283	84266	33126	30626	259300
Sales (live crabs)	7503	0	0	18750	26253	0	0	37050	42350	79400
Total	203176	154404	83786	92387	533753	182508	155491	104350	101851	544200

Monthly Draw Down Budget					YEAR 1									
Cash Payments					2006							2007		Total
		Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	
Staffing Costs	5.	19450	19450	19450	19450	19450	19450	19450	19450	19450	19450	19450	19450	233400
Administration	6.	2188	2188	2188	2188	2188	2188	2188	2188	2188	2188	2188	2188	26253
Infrastructure	7.	12000	46500	47432	47432	7081	10149	10149	0	0	0	0	0	180743
Farm Equipment	8.	0	8052	8052	8052	8052	0	0	0	0	0	0	0	32209
Production Cost	9.	4365	4365	4365	4365	4365	4365	4365	4365	4365	4365	4365	4365	52377
Maintenance	10.	731	731	731	731	731	731	731	731	731	731	731	731	8771
Total Payments		38733	38733	81286	82217	41867	41867	36883	26733	26733	26733	26733	26733	533753

Table 2 Cont'd

YEAR 2

Cash Payments		2007										2008		Total
		Mar	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	
Staffing Costs	11.	19450	19450	19450	19450	19450	19450	19450	19450	19450	19450	19450	19450	233400
Administration	12.	2188	2188	2188	2188	2188	2188	2188	2188	2188	2188	2188	2188	26253
Infrastructure	13.	3000	33829	33829	30829	15312	5000	0	0	0	0	0	0	121798
Farm Equipment	14.	5000	5000	1250	1250	1250	1250	1250	1250	1250	1250	0	0	20000
Production Cost	15.	11062	11062	11062	11062	11062	11062	11062	11062	11062	11062	11062	11062	132749
Maintenance	16.	833	833	833	833	833	833	833	833	833	833	833	833	10000
Total Payments		**41534**	**72362**	**68612**	**65612**	**50096**	**39784**	**34783**	**34784**	**34784**	**34784**	**33534**	**33534**	**544200**

Draw Down Budget (brake-down according to funding entity)

NOTES: 1. To be received in March 2006 for two years

2. Already received (two year contract signed)

3. To be considered and if successful money available before end of 05/06 Fiscal year

4. Year 06/07:1st Harvest: = 2000.8 crabs/2 = 1000.4kg x $15/kg = 15,006/2 = $7,503; 2nd Harvest = 23,000crabs/2 = 115,000kg x $15/kg = 225,000/12 = $18,750
   Year 07/08: 1st and 2nd Harvest = 2646.66kg x $15/kg = $39,700x2 = $79,400

5. Management: Farm/Mentor ($154,00*1.1)/12mo); Staff: (6 farm hands/2 office workers($14,666.67/mo). **14,117** **5,333**

6. Bookeeping/Accountancy, office consumables, rent, insurance, communications, power, promotion. **1,088** **1,100**
   [Bookeeping/Accountancy, office consumables, insurance, communications, power, promotion = $14,250/yr; Office rent: $1,000/mo x 12 = $12,000/yr]

7. Electricity ($132,000 = grid power supply, poles, transformer); plumbing ($16,500 = supply/discharge pipe work), engineering ($12,680 =settlement drains, filters, pond stabilisation, demountable fit-out) and harvesting equipment, workshop ($7,295). **132,000** **16,500** **13,948** **7,295**

8. Aerators, baskets, nets, second hand quad bike, feeding equipment, monitoring equipment = **32,209**

9. Feed (fresh fish = $3.50/kg x120kg/wk x 24 wks = ($10,080*1.1) = $11,088 x 2 = $22,176; **22,176**
   dry food (pellets) = $1.45kg x 125kg/wk x24 = ($4,350*1.1) = $4,785 x 2 = $9,570. **9,570**

Table 2 Cont'd.

Electricity/water costs: (237.12kW-hrs)365 days)($0.163)=$14,107/yr			**14,107**	
Fuel: (diesel @ $1.319/L x 210L = $276.99) + (unleaded @ $1.270L x 210 = $266.70) = $543.69 x 12 months = $6,524.28/yr.			**6,524**	
10. Maintenance and repairs at 664.47/mo x 12 mo = $7,973.64 x1.1= $8,771	**8,771**			
Depreciation is not shown as it is an in-kind cost of GDA's.				
11. Management staff of TAA are having to take a financial risk when all other signatories to the SRA are not. The other SRA signatories except TAA have entered this project with guaranteed incomes from a variety of funding bodies (eg, OIPC, DAFF, DEWR, CDEP, CDU and NT Fisheries). TAA is a service provider only, receiving no equity or bonus. This discrepancy needs addressing before the end of June 06.	**14,117**		**5,333**	
13. Earth works, power supply/connections, harvesting/processing structure, engineering and fabrications of pump structures/screens.	**5,000**	**61,249**	**46,549**	**9,000**
14. Pumps/pipe work, aerators, crab shelters	**10,000**	**5,000**	**5,000**	
15. Food, fuel, freshwater, electrical power, marketing/packaging/processing/transportation	**51,500**	**81,249**		
16. $10,000 of the NTACC funds allocated for farm production have been diverted to maintenance and repairs.		**10,000**		

IMPORTANT:

1/ Budget presented assumes that all funding bodies listed will commit to amounts shown.

2/ Sales are estimations only.

Table 3 Risk Analysis Business Plan (Source – Original Business Plan APPENDIX 1)

Identified Risk	Seriousness 1 = low, 5 = high	Probability 1 = low, 5 = high	Score (seriousness x probability)	Manage risk?	Strategy to manage risk	Responsible agency
1. The necessary leases and licenses are not issued	5	2	10	yes	Applications will be made for the necessary leases and licenses. Relevant authorities will be lobbied to expedite their issue.	GDA
2. Approvals not granted for the upgrading & expansion of the current ponds, including additional infrastructure.	5	2	10	yes	The Lease Holders and the major land user in the area support the project. Relevant planning authorities will have to be approached to gain the necessary approvals. Garner letters of support for the project	GDA
3. The necessary funds are not committed to the project	5	3	15	yes	All potential sources of funds are being explored. Statutory as well as private venture capital will be approached during the expansion phase.	GDA
4. The funds are not delivered in a timely manner;	4	2	8	yes	The venture's project managers will need provide timely milestone reports to funding agencies, and maintain high levels of communication	GDA / NTG
5. The animal cannot be reared to a marketable size in an artificial environment	5	1	5	yes	Grow-out techniques are routine in Asia and have been published in several scientific journals. Preliminary growout trials by the DAC have proved successful, although improvements can be made	GDA / NTG
7. The animal does not grow at the predicted rate;	4	1	4	yes	Growth rates of mud crabs in contained environments are dependent on temperature and food. The grow-out will be closely monitored in the first two years of operation (Research) to assess the growth rates and if necessary adjust the projections. Little can be done to improve temperature of a pond but feed requirements will be closely monitored. Continual improvement is expected	GDA / NTG

Table 3 Cont'd

8. Aboriginal people will not be interested in working in the venture;	4	2	8	yes	The Joint Management Agreement has listed the responsibilities of each partner in relation to local employment. The employment of local people has benefits to the venture. Accredited training will be provided and jobs will be tailored to the needs of local people within the constraints of the venture's viability. Local people have already indicated a strong desire to participate.	GDA / NTG
9. The product will not be marketed as predicted;	5	2	10	yes	The current wholesale price needs to stay above $15 / kg for financial projections to be achieved. Seafood marketing networks must be utilised and steady production volumes must be established	GDA / NTG
10. Payment for the marketed product is not made in a timely manner	4	2	8	yes	The markets for the product are local and international. Payment will be required on a 30 day basis locally and a COD basis internationally. Credit references will be required locally and Letters of Credit or Bank Notes internationally	GDA / NTG
Technical risks						
1. Poor water quality	5	2	10	yes	Daily extension services by experienced aquaculture technicians from GDA's consultants (Tropical Aquaculture P/L), Government and the University. Specialist on-the-job training in pond water quality management. Mud crabs have proven tolerant to moderately poor water quality in preliminary trials.	GDA / NTG
2. Algal Blooms / aquatic weeds	2	3	6	yes	Excessive plant growth is attributed to excess nutrient in the water. Water quality will be tested daily, accurate records kept and problems managed through food reduction or flushing. Aquatic weeds usually develop due to clear water. This can be countered by using soluble fertilisers to establish a beneficial microalgal bloom.	GDA / NTG
3. Animals are poached / equipment vandalised	4	2	8	yes	Plans are in place for the hiring of a small demountable building for a live-in technician. This person will be responsible for security and for emergency response. This was seen as a community role in the deed of agreement	GDA
4. Water pump/aeration failure	3	2	6	yes	The ponds will be run in a moderately extensive fashion and so risks associated with poor water quality / nutrient overloads are minimised. The farm is centrally located in Darwin with easy access to trades and emergency services. Back-up aerators will be available.	GDA

Table 4 Comparison of various documented reports of anticipated and actual levels of funding and expenditure supplied to the reviewer : (Source 1- Table 12 p 20 – Business plan - Appendix 1; Source 2 table 8 p19 Appendix 2) Actual funds received (source 3 data - Tables 3 and 4 of progress report 3 Appendix 5; Source 2 -

CASH CONTRIBUTIONS	**Anticipated funds APPENDIX 1 -** original Business plan	**Anticipated funds** Source 2 – First annual report of Mudla farm – non audited	**Actual funds received** Source 3 –Progress Report 3 -audited accounts	**Actual funds received** Source 2 – First annual report of Mudla farm non audited	**Anticipated grant funds** for 2006/07 Sources 1and 4	**Actual funds received & revenue earned** to-Nov 06 Source 3 Table 4 audited accounts
YEAR	**Yr 1**	**Yr1**	**Yr 1**	**Yr1**	**Yr 2**	**Yr 2**
DAFF	100,000	110,000	100,000	110,000		0
OIPC	297,500	330,000	300,000	330,000		0
ACC	-		-		200,000	
ABA	94,000	313,500	188,077	94600	151,500	67,786
DEWR	176,000	176,000	28,216	28,216	176,00)	8,800
Total grants	**582,900**	**929,500**	**616,293**	**562,889**	**527,500**	**76,586**
Mud crab Sales	160,000	150,000	1611		302,400 (103,000[1])	4576
other			2303			
Total Revenue	**819,150**	**1,079,500**	**620,207**	**562889**	**(829,900)**	**81,162**
					518,989	
PAYMENTS	**Budgeted Yr 1**	**Budgeted Yr 1**	**Spent Yr 1**	**Spent Yr 1**	**Budgeted Y2**	**Spent Y2** to Nov 2006
Capital	432,000	432,000	76,273[2]	181,917	100,000	20,732[3]
General Operating	128,500	128,500	37,067[3]	63,162	170,500	21,441[4]
Farm staff Salaries/	234,000	234,000	178,333[3]	168,483	234,000	64,167[5]

[1] Sourced from Table 5 APPENDIX 4

[2] Based on audited expenses Table 3 Appendix 5

[3] Based on audited expenses Table 4 Appendix 5

[4] Based on audited expenses Table 4 Appendix 5

[5] Based on audited expenses Table 4 Appendix 5

Table 4 Cont'd

Super			8,804[3]			2,397[6]
Trainee wages and super	176,000	0	98,258[3]	68,887	176,000	26,633[7]
Additional costs (office/gst)	0	0	3,000[3]	41,239		
Total	**917,000**		**401,735**	**523,688**	**608,500**	**135,368**
CASH SURPLUS/ SHORTFALL		**285,000**	**218,472**[3]	**39,201**		**-$54,206**

[6] Based on audited expenses Table 4 Appendix 5

[7] Based on audited expenses Table 4 Appendix 5

5.1.2. Skills audit, and assessment of staff management and the trainee scheme

Organisational chart and skills audit

In keeping with the organisational structure prescribed in the business plan (Appendix 1) and elaborated in Figure 3, a daunting array of management duties and responsibilities have been assigned to Dr Robert Rose with largely unpaid (reputedly) administrative support from Helen Secretary. These duties and responsibilities include planning and implementing redevelopment and commissioning of the farm, management of all farm activities including organisation of day to day farm operations including preparation of duty rosters plus most financial and technical reporting, marketing and media promotion tasks and mentoring of trainees.

Considerable technical instruction and support was provided by DAC technical staff during both planning and early implementation stages especially from Ian Ruscoe who has served as the DAC representative on the Project Board and was a co-author of the environmental management and business plans. Extension technical services have been provided on site by Kris Kuo with additional technical support from Ian Ruscoe and from senior fisheries biologist Graham Williams. The latter appeared to have waned by the time the reviewer visited the farm project in March 2007 but may have simply reflected the fact that a contract to supply crablets and technical field services had temporarily lapsed.

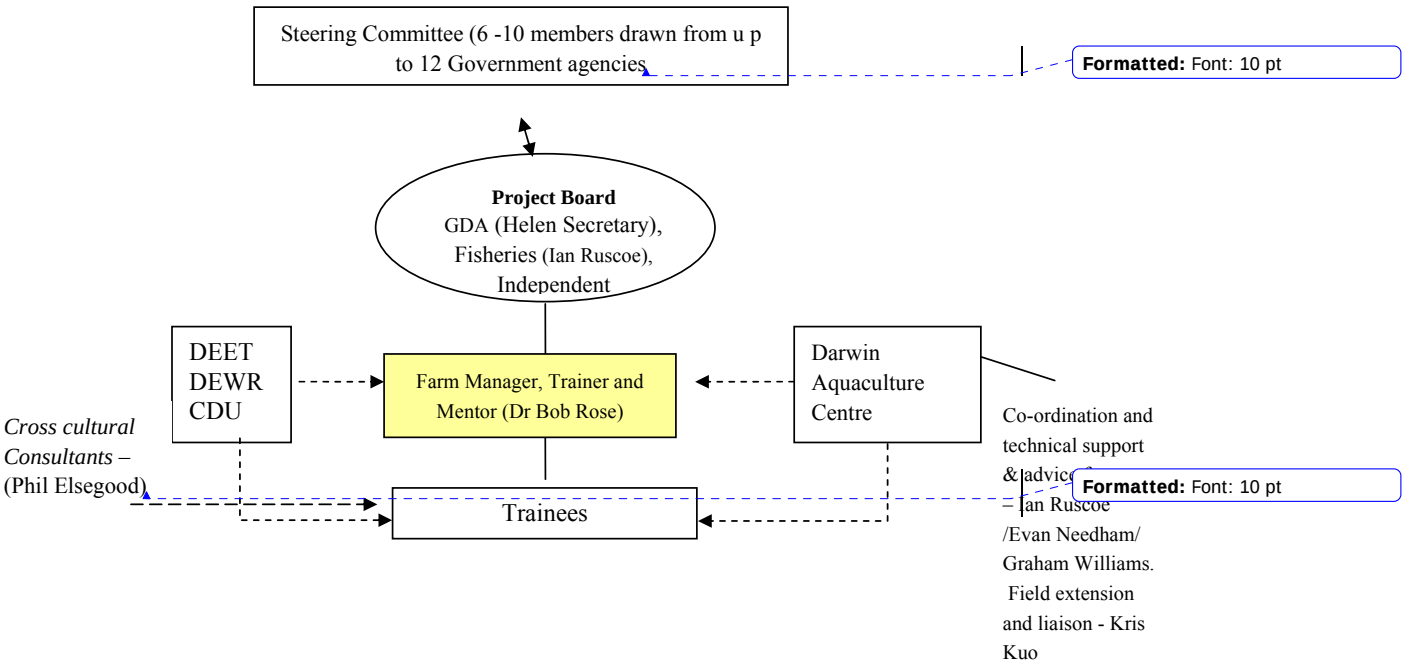


Figure 3 Organisational structure of the Mudla Mud crab farming project at Kulaluk (Source – adapted from chart provided in Business plan, Appendix 1)

The Trainee Program

The following appraisal of the trainee scheme is based on formal documentation provided by, Dr Bob Rose, by observations and discussion made during each of three visits to the Kulaluk farm, of technical operations and communications between Dr Rose and three of the trainees, and on discussions with Mr Phil Elsegood (Cross Culture Consultants), who provided support to Dr Rose in his capacity of Trainer/Mentor.

The formal documentation comprised

- *Training and Mentoring Reports 2* and *3* dated 22/5/2006 and 30/11/2006 respectively and
- an independent report entitled, *An Evaluation of Gwalwa Daraniki Enterprises Mud Crab Farm Employment Program- "How effective is the delivery of the Employment Program?"* prepared by 3rd year Curtin University, Bachelor of Applied Science (Indigenous Community Management & Development) student, Sharon Hewitt **Appendix 6**.

A number of government support initiatives were put in place to ensure the ongoing success of the project including the trainee program. These included a Shared Responsibility Agreement (SRA) between the NT and Commonwealth governments, a Community Development Employment Program (CDEP) administered by Darwin Regional CDEP. The trainee program has been implemented as a STEP (Structured Training Employment Program), administered by Gwalwa Daraniki Association.

The Trainee program comprises two complimentary components that collectively comprise the STEP:

- On the job/farm individualised training and mentoring provided by the principals of Tropical Aquaculture Australia (Dr bob Rose and Mr Phil Elsegood)
- Participation of trainees in formal certificate courses provided by the Charles Darwin University under the direction of Lleyland Campbell Coordinator/Lecturer in charge of Aquaculture Training.

1. On-farm individualised training and mentoring provided by TAA

Fields of instruction provided to trainees by Dr Rose have included many aspects of farm planning, design, construction and maintenance, staff management, OH&S and technical operations, including harvesting and marketing. The overall calibre of Dr Rose's performance as a teacher and mentor in terms of professional commitment, energy, perseverance, communication skills, and reporting of outcomes, though commendable was undermined by several issues discussed below. A measure of Dr Rose's skills as trainer and mentor is provided in his assessment (Source: *Training and Mentoring Report 2)* of the performance of each the seven trainees under his stewardship, taking into account their individual abilities, personalities and social circumstances. viz.

Trainee 1

Trainee 1 has continued his active participation in the program through out 2006 and will soon be graduating with a Certificate II in Seafood Industry (Aquaculture). He/She was presented the Aquaculture Student of the Year Award by CDU for his/her studies last semester. He/She enjoys the farm work, is able to prioritise his/her jobs and can work unsupervised on short-term projects. He/She is competent, safety conscious and mechanically proficient. He/She has a well-rounded knowledge of the farms husbandry and routinely

assists with "educational and information" tours set-up for students, stakeholders and government officials.

Trainee 2

Trainee 2 has been a diligent and organized worker and will be graduating with a Certificate II in Seafood Industry (Aquaculture). He/She is safety conscious, thorough and neat worker willing to experiment with new techniques. He/She is still committed to the project, understands the nature of the business and can work unsupervised on short-term jobs. He/She works well with Trainee 3 and is interested in mud crab culture.

Trainee 3

Trainee *3* terminated his/her training at the mud crab farm mid-October 2006, and shortly thereafter moved interstate. He/She had been undergoing hormone treatment for gender re-alignment and this was impacting on his/her performance. Prior to his/her departure, he/she was having trouble maintaining his/her energy, staying awake and concentrating. The work was difficult, dirty and too manual for his/her liking. This lack of enthusiasm was reflected in his/her studies just before departure. Attached is a cessation advice for DEWR's consideration.

Trainee 4

Trainee 4 has been an outstanding team member and enjoys the work. He/She will be graduating along with trainees 1 and 2 with a Certificate II in Seafood Industry (Aquaculture) this year. As a Council member and Director, he/she has been a great role model for the other trainees. He/She has had to assist with transporting senior community members to meetings, which often clashed with his/her training program. Despite this, he/she has been a conscientious and diligent worker. He/She has the potential to be a team leader and, in partnership with trainee 2, manage the daily farm operations.

Trainee 5

Trainee 5 is a young person who shows the potential to be a very productive member of the team. He/she is hard worker but needs close supervision and direction. Like trainee 6, he/she started the course after trainees 1, 2 and 4. To date, his/her course work "practicals" have included aspects of grow-out culture, water quality monitoring, broodstock/seedstock husbandry, harvesting, transportation, general stock handling/grading, food preparation/hygiene and Occupational Health and workplace Safety.

Trainee 6

Trainee 6's studies are at the same level as trainee 5. He/She is mature and works well unsupervised and often attends to the night pumping, late feeding and weekend jobs. He/She has completed landcare training in the past and is regarded by the community as one of the leaders. He/She presented a paper at an Aquaculture conference in Adelaide. As a community leader, he/she is aware of the importance of setting a good example as a worker.

Trainee 7

Trainee 7 has improved his/her attendance at work only and returned to attending Certificate II Office Management at CDU during this year's second semester. However, he/she still needs close supervision to keep him/her on track and failed to attend most of his/her classes (2.5 out of 18 weeks). He/She has not yet developed the maturity to work unsupervised and needs clear boundaries and instructions. He/She is currently working in the Kulaluk office and supervised by the elderly women in the office.

Perceived weaknesses and scope for improvement in this aspect of the trainee program were:

- funding shortfalls that contributed significantly to deficiencies in farm operational design, infrastructure and equipment that restricted the ability of farm staff and trainees to respond to and/or ameliorate adverse pond conditions if and when they were detected and reported
- lack of routine daily assessment of water quality in stocked ponds especially at critical times between midnight and dawn plus exacerbated by delayed initial purchase of on farm water quality monitoring equipment (see. *Water quality monitoring and management* pp.29 and 30)
- competing demands on Dr Rose's time and energy posed by a daunting array of other farm and project management and reporting duties and responsibilities.
- Dr Rose's relative lack of previous hands-on experience in the semi intensive pond aquaculture of crustaceans at the outset of the project.
- lack of supplementary technically proficient staff and access to technical advisory services to compliment those of DAC technical support and of the overtaxed farm manager/trainee mentor.

Independent vindication of issues raised under the first and the three latter dot points was provided in on pages 30 to 33 of Sharon Hewitt's report viz.

"*There is a lack of essential infrastructure at the mud crab farm which is hindering the progress of the employment program to reach its full potential*…".

"*However, Management has expressed concern that the farm manager's role is restricted because he is undertaking numerous other duties to ensure the farm remains operational and that he only manages this by working astronomical hours each week. They have also identified that more qualified staff are needed to assist the farm manager in the day to day operation of the farm which will allow him to fully commit to providing participants with positive employment outcomes. This was also supported by funding and service providers."*

"Presently, the farm manager is also teacher/tutor, administrator, board member as well as the project manager. In hindsight, a young qualified aqua culturist to assist the farm manager for 6 to 12 months during the construction phase would have been prudent to help set up the husbandry environmental monitoring protocols. This would have allowed the farm manager to devote more of this time to the lengthy red tape associated with the establishment of the business."

2. Certificate courses provided by the Charles Darwin University

It was originally planned to have two students enrolled in the Certificate II in Business (Office Administration) course and six in the Certificate II in the Seafood Industry (Aquaculture) course. However at the outset of the project (August 2005) only seven suitable trainees, all young Larrakia people were able to be recruited from the local Kulaluk community with only one enrolled in the Certificate II in Business (Office Administration) course.

The reviewer did not have access to detailed content (course notes etc) of the Certificate II in the Seafood Industry (Aquaculture) the course. However as judged from the descriptors of units provided in Table 5, the course appears to adequately address basic husbandry, technical, trade and communication skills essential for day to day operations of a semi intensive mud crab farm.

Three trainees graduated this year (2007) with completion of the Certificate II in Seafood Industry. As of 30/11/2006, the Coordinator/ Lecture in charge of the CDU Aquaculture training program, believed that two additional trainees should be able to finish during the current (2007) academic year and that another trainee should be able to continue on next year provided that lack of course attendance difficulties could be overcome. The anticipated graduation of at least 5 and possibly 6 out of the 7 trainees (Table 6) constitutes an excellent result.

The reviewer is nevertheless of the opinion that the trainees could benefit considerably through

- better communications between providers of on-farm individualised training and mentoring (TAA) and providers of formal certificate courses (Charles Darwin University)
- additional linkages with other organisations such as Bachelor College and other interstate research and training institutes, to host more on-farm marine science undergraduate and postgraduate (Honours, MSc and PhD) based projects and to provide work experience opportunities for undergraduates and postgraduates who could in turn positively interact with farm trainees.

Independent vindication of the first of these issues was also provided as Finding 11 on page 33 in Sharon Hewitt's report viz.

"There is insufficient planning and interaction between farm management and the course service provider in relation to the study component for participants."

Table 5 Units undertaken by Trainees in Aquaculture

SFICORE103B	Communicate in the seafood industry
SFICORE106A	Meet workplace OHS requirements
SFISTOR201B	Prepare and pack stock for live transport
SFIAQUA102A	Carry out basic aquaculture activities
SFIAQUA209B	Manipulate stock culture environment
SFIAQUA213B	Monitor stock culture and environmental conditions
SFIAQUA217A	Maintain stock culture and other farm structures
RTC2307A	Operate machinery and equipment
RTC2706A	Apply chemicals under supervision
SFICORE101B	Apply basic food handling and safety practices
SFICORE105A	Work effectively in the seafood industry
SFIAQUA201B	Collect broodstock and seedstock
SFIAQUA205A	Feed stock
SFIAQUA206A	Handle stock
SFIAQUA211A	Undertake routine maintenance of water supply and disposal systems and structures
SFIAQUA214A	Produce algal and/or live-feed cultures
SFIAQUA215A	Carry out on-farm post-harvest operations
SFIAQUA216A	Harvest stock
SFIAQUA218A	Control Predators, pests and diseases
SFICORE103B	Communicate in the seafood industry

Table 6 Work completed or to be completed by trainees (Source Training and mentoring Report 3-30/11/2006)

REFER Table 1 for details	***Trainee 1***	**Trainee 2**	**Trainee 3**	**Trainee 4**	**Trainee 5**	**Trainee 6**
SFICORE106A	Completed	Completed	Completed	Completed	Next yr	Next yr
SFISTOR201B	Completed	Completed	Assg & Prac	Completed	Next yr	Next yr
SFIAQUA102A	Completed	Completed	Assg	Completed	Next yr	Next yr
SFIAQUA209B	Completed	Completed	Assg + T	Completed	Next yr	Next yr
SFIAQUA213B	Completed	Completed	Assg	Completed	Assg	SG & Assg
SFIAQUA217A	Completed	Completed	Completed	Completed	Next yr	Next yr
RTC2307A	Completed	Completed	Completed	Completed	Next yr	Next yr
RTC2706A	Completed	Completed	**Not received**	Completed	Next yr	Next yr
SFICORE105A	Diary	Diary	Diary	Diary	Diary	Diary
SFIAQUA201B	Completed	Completed	Assg 1, SG	Completed	Assg 1,	Assg 1,
SFIAQUA206A	Completed	Completed	Assg 1, SG	Completed	Assg 1, prac, T	Assg 1,prac, T
SFIAQUA211B	Completed	Completed	Prac, Assg,	Completed	Prac, Assg,	Prac, Assg,
SFIAQUA214A	Completed	Completed	Prac, Assg,	Completed	Prac, Assg,	Prac, Assg,
SFIAQUA218A	Completed	Completed	Assg,	Completed	Assg,	, Assg,
SFIAQUA215A	Completed	Completed	Prac, Assg,	Completed	Prac, Assg,	Prac, Assg,
SFIAQUA216A	Completed	Completed	Prac, Assg,	Completed	Prac, Assg,	Prac, Assg,
SFIAQUA205A	Completed	Completed	Assg, SG	Completed	Prac, Assg 1,	Prac, Assg 1,
SFICORE101B	Completed	Completed	SG Done	Completed	Next yr	Next yr
SFICORE103B	Completed	Completed	SG	Completed	Next yr	Prac, Assg

Not enrolled *Not Yet Completed* *Completed*

5.1.3. Suitability of site

Location of the Site

The Mudla farm at Kulaluk is located on the northern outskirts of Darwin, is in close proximity and has all-weather access to all relevant general and specialist goods and services and service providers. Accessible services and public utilities include reticulated water, electrical power, heavy and refrigerated road transport, air freighting, security services, accommodation and all public amenities such as shops, medical services, schools and tertiary training and research institutions. The latter includes the marine science faculty of Charles Darwin University and DAC, at Channel Island within an hour's drive of Kulaluk. Relevant specialist service providers, include building and technical trades and earthworks contractors, all manner R&M services, suppliers of equipment and materials and emergency services (police/fire/ambulance).

An even more important positive attribute of the site of the Mudla farm at Kulaluk, is that it lies within the traditional homeland of the local Gwalwa Dariniki aboriginal community, who actively lobbied for the project. Important socio-economic aspirations of the Gwalwa Dariniki people are clearly linked to longer term prospects and outcomes of the project.

Seawater supply (quality and quantity)

The previous history of the Mudla farm as a failed prawn farm has been somewhat of a double edged sword. On one hand pre-existing (albeit derelict) infrastructure (land clearance, road access and earthen ponds) were perceived as *wasted assets* by the Gwalwa Dariniki community who were highly instrumental in the initiation of the project and in lobbying for financial and logistical support

for it from an array of government agencies. On the other hand, the original prawn farm had failed because of an array of inherent site limitations.

Foremost among the limitations of the site is that it lies at the extreme upper range of a very high annual (7 m) tidal range that is endemic to Darwin and much of the "Top End" of Australia. The practical consequences is that "windows of opportunity" to fill ponds and/or to conduct rapid seawater exchanges to combat poor pond water conditions (especially low oxygen and high ammonia levels encountered towards the end of production cycles in the warmer months), are very limited compared to sites that have access to permanent deep water in the form of natural or dredged channels.

A potentially serious short-coming of the site is that the natural ground level falls within the upper inter-tidal mangrove zone thereby rendering it susceptible to acid sulphate soil issues. This possibility was raised in the Environmental Management Plan (Appendix 3), and casts doubt over a proposed future expansion of the farm to 10 ha of ponds that would need to encroach extensively into adjacent wooded mangrove areas. It is widely recognised that floors of coastal marine aquaculture ponds should be at least 1 m above the local highest astronomical tide level (HAT), as indicated in Figure 6. This provision minimises threats of pond water acidification and also enables operators to be able to drain and/or harvest ponds at any state of the tide and over any duration fast or slow. Although soil type is described as predominately clay and clay loams (see Figure 4) suitable for pond construction, some recent apparent rain erosion of walls suggests that they will need to be further stabilised and/or plastic lined if semi-intensive crab farming and/or related R&D and training activities are to be continued.

While no evidence that incident seawater used on the Mudla farm has remained free of potential sources of pollution from surrounding urban areas, such risk is still of concern. This is especially so because the farm lies adjacent to the *Ludmilla* sewerage/waste water treatment plant and associated facilities including a mangrove creek outfall. Potential risks posed by the treatment plant were raised in the environmental management plan (Appendix 3) but were tempered with an assurance that risks posed would be ameliorated through close communication between farm staff and operators of the plant around all times of pond filling. The reviewer is however unaware of whether this precaution was implemented nor whether any relevant water testing such as human coliform counts (bacterial assays) was conducted on pond fill water or on harvested mud crabs prior to their sale and consumption.

Another potentially serious limitation of the site is access to large volumes of good quality freshwater to combat hyper-saline pond conditions, especially towards the end of the dry season.

Figure 4 Photo of excavated trench at the Mudla farm showing heavy clay subsoil and sand gravel topsoil **(**Source **:** Gwalwa Daraniki Enterprise Pty Ltd ,Mudla farms Mud crab Project,Progress Report 1**,** December 2005)

5.1.4. Farm design, operating and husbandry systems in relation to best practice

Design construction and operation of ponds

Earthworks that restored the structural integrity of original prawn pond walls, floors, drainage equipment and access roads were completed well *within budget* during the early phases of the project. Some apparent shortcuts were nevertheless in evidence, most notably an absence of concrete monks that would otherwise have enabled rapid drain harvesting in one of 4 production ponds. Simple passive-flow stand pipes to enable both pond filling and draining were used in the other 2 production ponds. All ponds appeared unusually shallow (less than 1.2 to 1.5 m typical of such ponds). Presumably this was due to long-term erosion and in-washing of pond wall materials. Instead of removing these pond congesting sediments, canals were excavated around the inner periphery of pond floors to re-enable complete drainage and intercrop drying (Figure 10). Electrical power distribution, main seawater pumps, seawater delivery systems, and aeration equipment, although budgeted for and recognised in various project reports as being critical to *best practice* pond management, were conspicuously absent.

These observations contrasted with the planned design and operation of the farm presented in the Environmental management Plan (Appendix 3). As shown in Figure 7, the main seawater intake pump was to be located on the original concrete pad built for the old prawn farm with seawater `to be pumped from the tidal creek along their eastern border and ducted to the grow-out ponds using a modified and extended version of the original distribution line. The latter, marked as the orange line in Figure 7, was to enter the property in the SW and run along the NE boundary adjacent to the ponds.

The drain pattern proposed for each pond is shown as green lines with arrows in Figure 7. Discharge from settlement ponds, also marked as green lines in Figure 7, was intended to be discharged into a spillway (blue wavy line in Figure 7 and also illustrated in profile in Figure 8). Lowest intended point in each pond was to be the NE corner where wastewater was to be pumped from each pond to the settlement ponds. However as discussed above and as documented through farm reports, this drainage plan was not able to be implemented..

Orange lines in Figure 7 indicate intended supply and waste line from an intake pump intended for location at south western end of ponds on “intake creek” side of the farm. It was not clear to the reviewer whether portable petrol driven pumps seen in storage on the farm had been regularly used to convey waste water from production to settlement ponds prior to being discharged as in compliance with the Environmental management Plan nor whether waste water had been directly discharged into adjacent mangroves via monks or passive fill and drain standpipes located on the eastern (*Intake Creek*) side of the farm.

Thus although the intended design and operation of the ponds and associated seawater supply and discharge systems as described in the Environmental Management Plan resembled best practice systems of the type illustrated in Figures 5 and 6, implementation, in the absence of electrical power main pumps etc. appears to have deviated considerably from such standards.

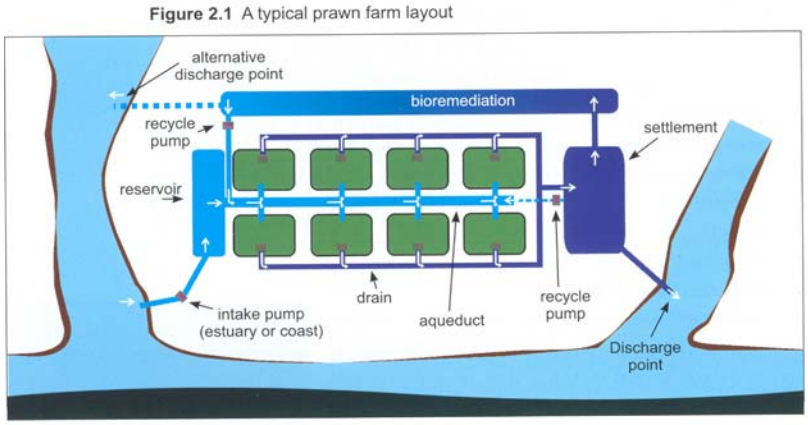


Figure 5 Layout of well designed prawn ponds with widely separated supply and drainage canals provision for seawater pre settlement waste water pre-settlement and/or seawater re-use (reproduced from Australian Prawn Faming manual QDPI, 2006)

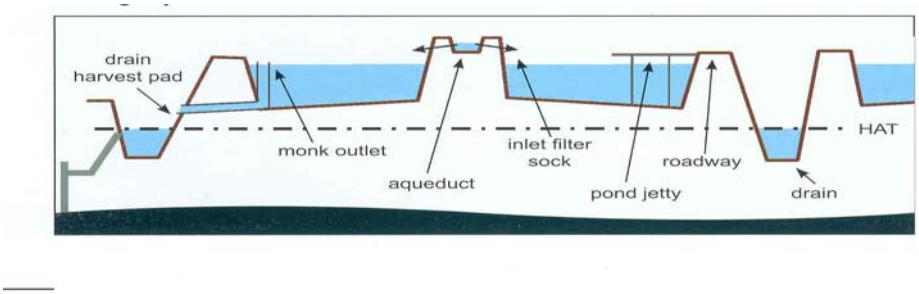


Figure 6 Cross section of well designed prawn pond showing seawater drainage and delivery systems and levels relative to HAT (reproduced from Australian Prawn Faming manual QDPI, 2006)

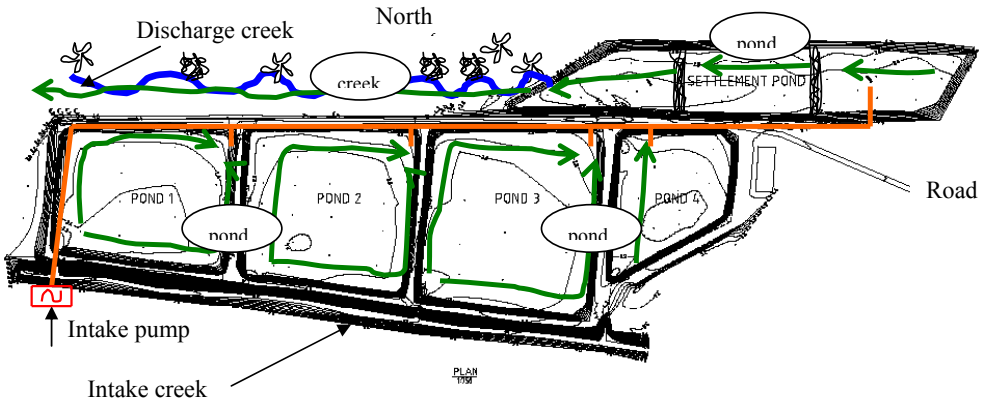


Figure 7 Site Plan of Mudla crab ponds (source Figure 1, Environmental Management Plan. Appendix 3)

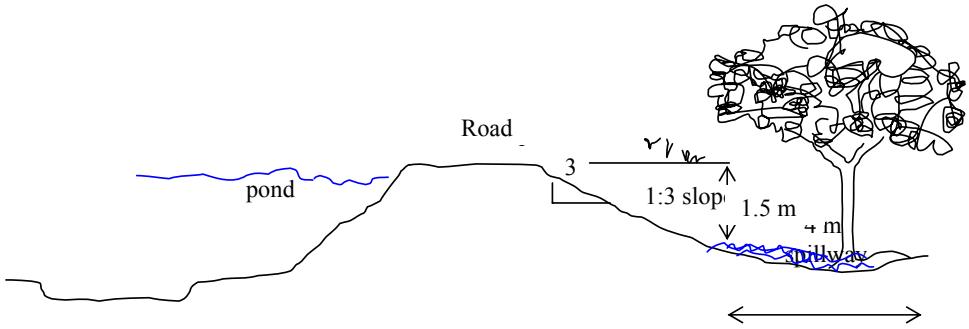


Figure 8 Cross-section of discharge creek's spillway (not to scale) (Source Figure 2, Environmental Management Plan. Appendix 3)

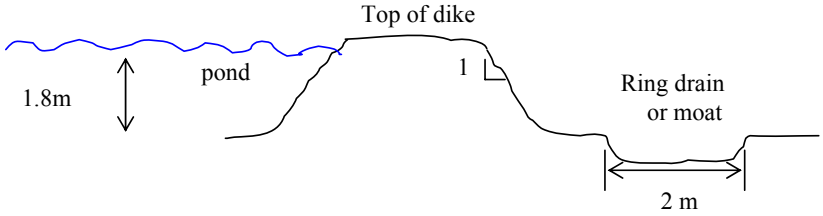


Figure 9 Cross section of ring drains in each pond (not to scale) (Source Figure 3, Environmental Management Plan. Appendix 3)

Figure 10 Draining moat excavated around the internal periphery of production ponds**.** (Source **:** Gwalwa Daraniki Enterprise Pty Ltd , Mudla farms Mud crab Project, Progress Report 1**,** December 2005)

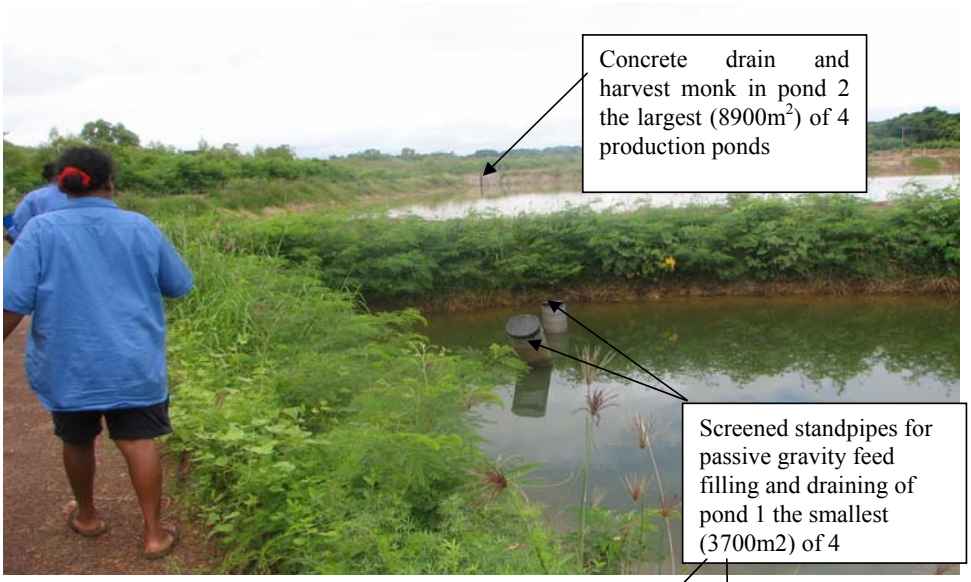


Figure 11 Location of monks and of alternative passive pond drainage and filling structures used on the Mudla crab farm **(Source**: *Above* : Author March 2007**,** *Below***:** Gwalwa Daraniki Enterprise Pty Ltd , Mudla farms Mud crab Project, Progress Report 1**,** December 2005)

Table 7 Collated data and some comments on farm pond design, construction and operation

Farm pond design and construction criteria	**Best practice [8] (optimum)**	**Mudla farm**	**Comments**
Pond floor datum level	1 -10m (1-2m) above HAT (highest astronomical tide level)	Estimated as 1 - 2 m below HAT	Drain harvesting opportunities constrained . Scope for acid sulphate problems especially if farm is to be expanded beyond current boundaries (see Figure 2)
Annual Tidal range	1 - 3m	7m	
Capacity to draw and deliver new seawater to ponds	Average pumping window of 2-4 h per tidal cycle	Severely restricted intermittent access and delivery capability in the absence of mains power and large capacity pumps	It would appear that pond filling and topping up was mainly by passive gravity flow during high tides above 5m
Incident seawater pumping and delivery capacity	Needs to be able to deliver 100 litres/ha /second to enable rapid and emergency filling and exchange	250 litres /second /($900m^3$/hr) Actual capacity unknown but probably less than $100m^3$/hr	It appeared that ponds were mainly being filled and topped up passively via screened inlet pipes on high (>5 m tides
Pre Settlement ponds	10% farm area/pond volume		
Discharge settlement Reservoir	15-20 % of total farm pond area	20% of total pond area	Settlement ponds contained freshwater at time of inspection (rain filled?)
Pond drain harvesting capacity	All ponds need to be fully drainable within 12hr on any day of year	Pond floors below HAT restrictive to drain harvesting as did an absence of proper harvest drainage monks in a 2 of the 4 production ponds	Recommissioning of /settlement ponds in conjunction with installation of electrical pumps and pond aerators ,rebuilding of monks in 1 of the 4 production ponds and /or recycling of seawater could address limited seawater access issues with the site
Other drain/harvest issues	Monk at lowest point /harvest sump	All ponds appeared shallow and in filled with eroded bank soil Floors of drained ponds had peripheral internal canals excavated to facilitate drainage and drying	
Electrical Power supply	5kw /ha of aeration power required to meet BOD demands of feed input rates needed to match targeted production rates of 3 tonnes/ha /crop	Nil power supply or aeration equipment installed at time of visit	Reviewer advised that this deficiency is currently being addressed with receipt of additional funds
Pond Soils	Clay core in walls and sealing layer in floors required to prevent seepage and ground water contamination by pond water . Walls need to be lined to resist erosion by rotational currents generated by aeration	Some sandy and ironstone soils apparent but leakage not confirmed. Some areas of walls stabilisation above water mark by plants but significant rain erosion was evident elsewhere	
Other infrastructure	Stock and pond water quality monitoring access jetties required on 3 of 4 sides of ponds	No access jetties installed	

[8] Source: Australian Prawn Farming Manual QDPIF 2006.

Water quality monitoring and management

As with farm design and construction, implementation of water quality monitoring and management varied from that described in the Environmental Management Plan (EMP). While a comprehensive schedule of water monitoring was prepared (see Table 6), water quality data collection and analysis appears to have been largely limited to that conducted in the presence of DAC extension officer, Kris Kuo. Over the 15 month period from 22 December 2005 to 19 February 2007, a total of 29 farm visits were made at intervals of from 1 to 31 days. In all cases data collection was undertaken between 8:30 am to 5:00 pm with most (20 out of 29) between 10 am and noon. Monitoring of water quality of settlement ponds was limited to only 3 occasions, one in each of May, June and December 2006.

In spite of the comments within the EMP that … " *Some ponds (depending on experimental system) will be aerated using electrical aerators, either paddlewheels or aspirators, usually during the night only"… a*nd that.. " *photosynthesis by micro-algae during the day will provide sufficient oxygen for the crabs"….,* dissolved oxygen (DO) levels in ponds were not measured through full diurnal cycles nor were they measured during critically low DO periods that occur between about midnight and 6 am. In all cases measured parameters were limited to bottom temperature, dissolved oxygen (DO), pH and salinity. Only sparse ad hoc comments were recorded in relation to health and behaviour of crabs with scant reporting of pathology conducted on moribund crabs. Negligible quantitative data was reported of algal bloom density, total nitrogen, ammonia, nitrite total phosphorus or suspended solids nor of potential pollutants such as heavy metals, pesticides or of sewerage pollution indicators such as human coliform bacteria counts.

Table 8 Prescribed schedule of water quality testing for pond aquaculture of mud crabs. (Source Table 3 p.44, Environmental Management Plan. Appendix 3.)

Parameter	**Measurement Tool**	**Measurement frequency**	**Acceptable range**	**Management Method**	***Reviewer's Comments***
Temperature	Thermometer	Daily	20-33^{0}C	-	
Dissolved Oxygen	DO meter	Daily	>4 mg/L	Aeration	*DO measurements made on 29 occasions between Dec 2005 and Feb 2007. All were confined to the period 8:30am to 5:00pm*
pH	Meter	Daily	7-9	Alkalinity – lime	
Salinity	Refractometer	Daily	10-35 ‰S	Water exchange	*Seawater exchange rarely (if ever) imposed and ineffective as management method*
Algal density	Secchi disc,	Daily	>30 cm	Reduce feed rate	*Parameter not apparently*
Chlorophyll a	fluorometer	Weekly	1-5 mg/m^3	water exchange	*monitored water exchange not implemented*
Ammonia	Test kit	Weekly	< 2.0 ppm	Encourage bloom water exchange	*Not apparently recorded*
Nitrite	Test kit	Weekly	< 2.0 ppm	Encourage bloom water exchange	*Not apparently recorded*
Total Suspended Solids (TSS)	Lab analysis	Monthly	Mean 20 mg/L	Increase sedimentation time before release	*Not apparently recorded. Not evident that settlement ponds used*
Total nitrogen (TN)	Lab analysis	Monthly	Mean 1.55 mg/L	Increase sedimentation time before release	*As above*
Total phosphorus (TP)	Lab analysis	Monthly	Mean 0.42 mg/L	Increase sedimentation time before release	*As above*

Temperature recordings

Recorded average temperatures of ponds (see Figure 12) remained within the range 24 – 32° C conducive to good health and high growth performance of *S. serrata*.

Dissolved oxygen (DO) levels

Great caution is required in the interpretation of pond DO data summarised in Figure 13. As already discussed, DO levels were measured only during daytime periods of high photosynthetic activity and never during critically low DO periods of between about midnight and 6 am. Averaged DO readings remained above levels of 4 mg/L considered as conducive to good health and high growth performance of *S serrata.* However minimum recorded DO levels, in spite of having only been measured during the day, were nevertheless found to have fallen to dangerously low levels below 2 mg/L on several occasions.

Salinity levels

Average salinity of ponds after rising steadily for four months from a post wet- season level of 17 g/L (half seawater strength) in May 2006 to 36 g/L (full seawater strength) in September 2006 were rose to an extraordinary levels of 53- 58 g/L during the following month of October. Evaporation losses alone could not account for these dramatic rises. Indeed field notes of the extension officer identify the exacerbating factor as incomplete filling of ponds in September followed by a month's delay in topping them back up with new seawater. A moderate reduction in salinities to levels of 45 to 47 g/l over the following 2 months of November and December 2006 was achieved by seawater exchange. However neither fresh nor brackish water was or could be added, which is the only means of restoring pond salinities back to a favourable range at or below 35mg/L (oceanic) during the latter half of the dry season in northern Australia. Not surprisingly, moribund and dead crabs with decalcified shells were observed during the protracted period of hyper-salinity during the second production cycle.

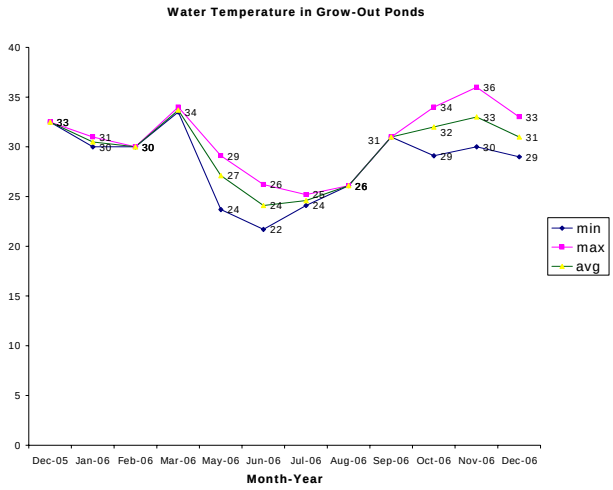


Figure 12 Temperature data for Mudla crab grow-out ponds for 2006 (Source : Appendix 4 :Mudla farms Mud Crab Project Progress Report 3),

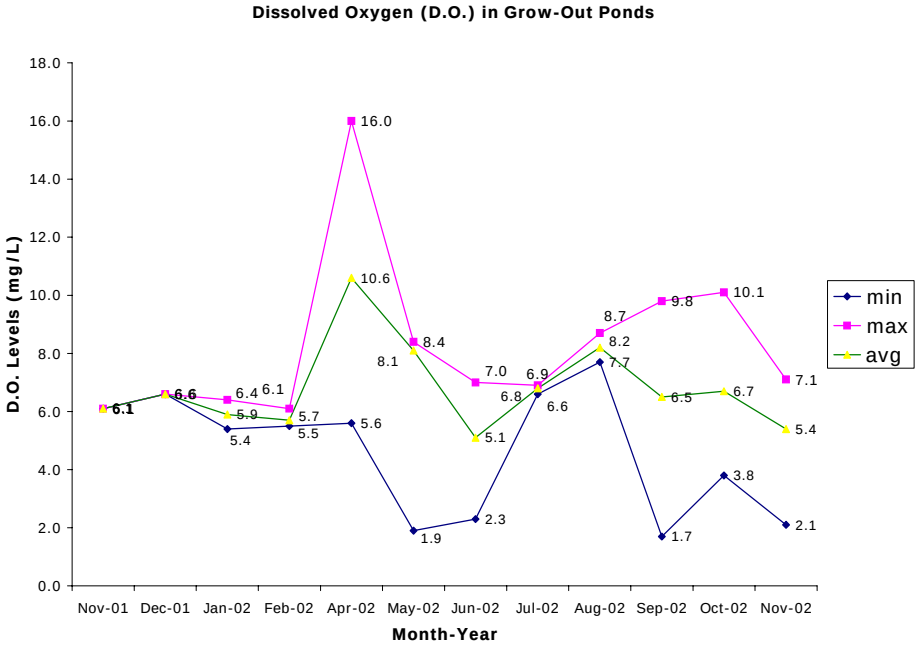


Figure 13 Dissolved oxygen data in Mudla crab grow-out ponds for 2006, (Source : Appendix 4 :Mudla farms Mud Crab Project Progress Report 3),

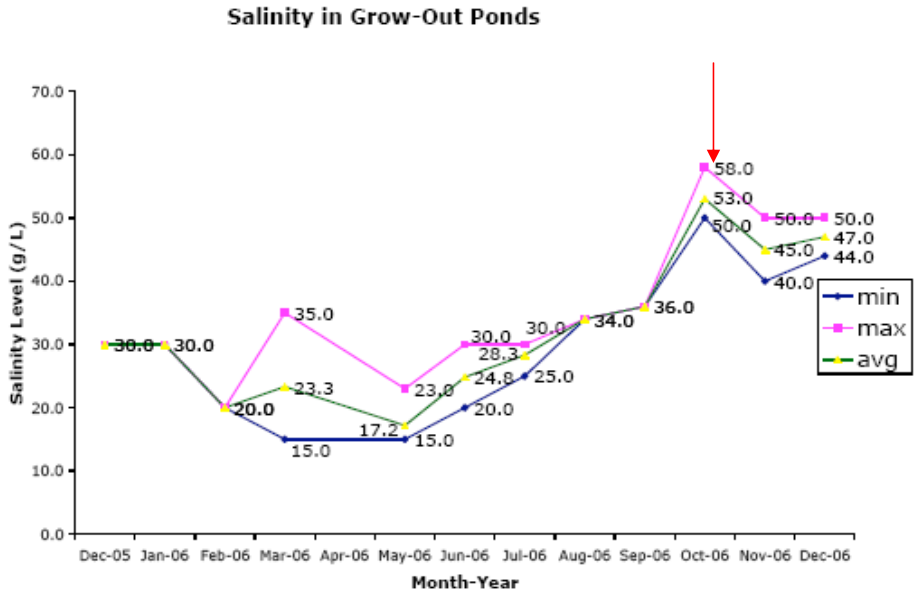


Figure 14 Salinity data in Mudla crab grow out ponds for 2006
(Source: Appendix 4 :Mudla farms Mud Crab Project Progress Report 3),

Crab growth and production

The first pond production cycle (using DAC hatchery crablet *batches 1 and 2*) and the second cycle (involving DAC hatchery *batch 3*) were initiated in December 2005 and March 2006 respectively. Growth data of these two production cycles at the Mudla farm are presented and compared with best to date reference growth data shown as open triangles in Figures 15 and 16. The key point illustrated by both sets of data is that growth rate remained at or close to maximum expected levels for periods of about 115 days (from late December 2005 to late April 2006) for the first production cycle and for about 160 days (from late March to August, 2006) for the second cycle, before abruptly stopping.

Thus in the case of the first but not the second production cycle, abrupt cessation of growth preceded onset of hyper-saline conditions that didn't arise until September/October. Excellent initial growth performance exhibited in both production cycles would seem to exclude food type or quantity as limiting factors.

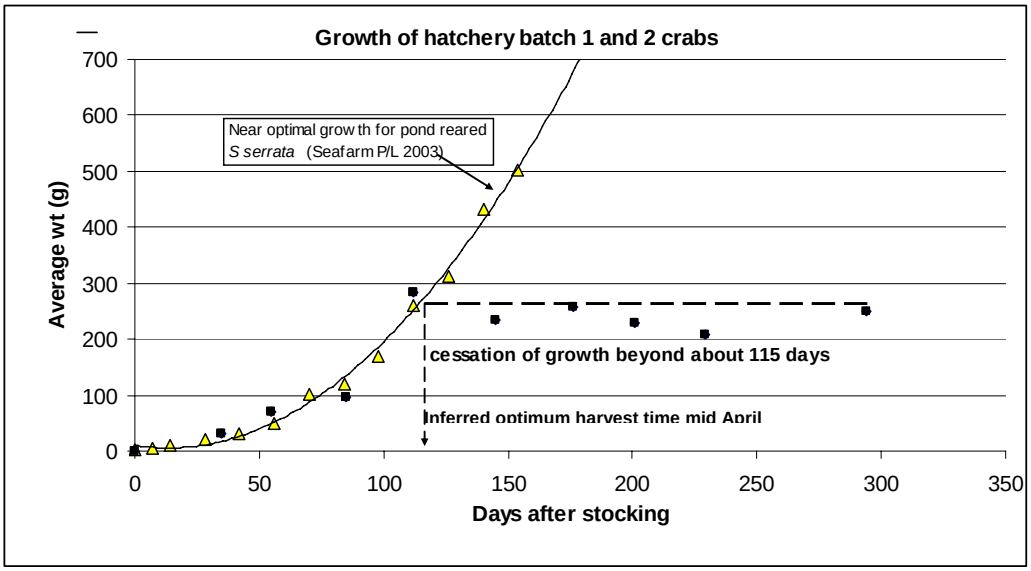


Figure 15 Growth data of the first production cycle (*batch 1 and 2* crablets) (December 2005 – November 2006)

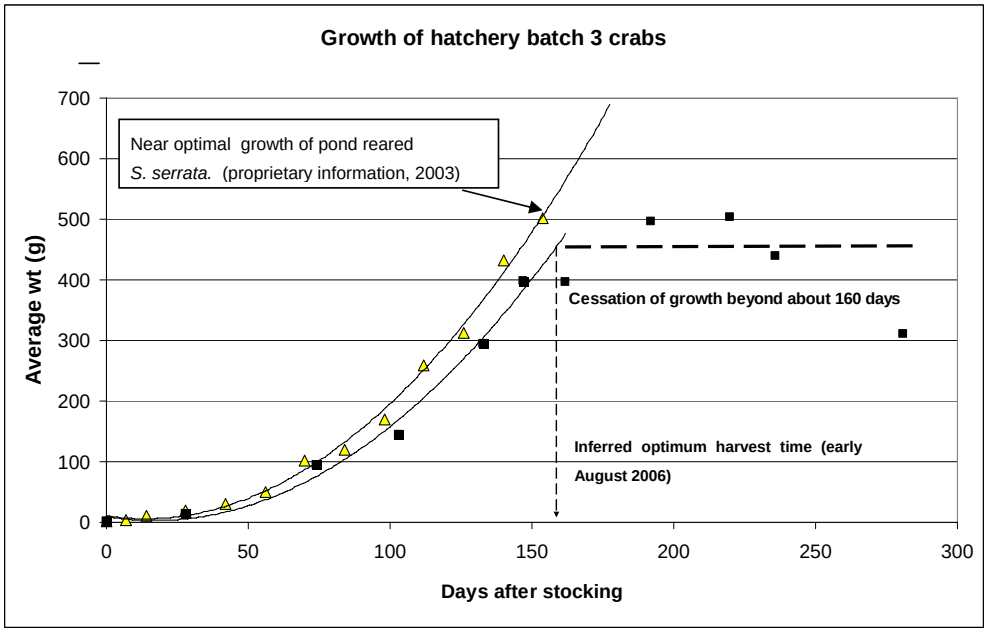


Figure 16 Growth data of the second pond production cycle (hatchery *batch 3* crablets) (March-December, 2006)

A third pond production cycle, comprising between 10,000 and 16,110 crablets, described as DAC *Batch 4*, was stocked into Pond 1 (3600m^2) on 29 of September 2006 and were routinely trapped in 'opera pots' during November and December 2006. The apparent numbers observed in the pond over this period were reported as not appearing high and this observation was supported by low occurrence of crabs sampled on feed-trays. As shown in Figure 17, by day 93 after stocking (31 December 2006) the batch averaged only 13g and had grown at a rate of 0.14g/day. This growth rate was only one tenth that of near maximum growth rates of the previous two production cycles that had both averaged 1.40g/day up to this time. In spite of their stunted growth this batch of crabs were described as "*agile and healthy, showing no obvious signs of physical/behavioural damage or shell deformation due to the harsh water quality conditions".*(Source: 3rd Farm Progress Report - Appendix 4). The harsh conditions referred to were hyper salinities in pond 1 in the range 43 to 56 g/l generated by incomplete initial filling of the pond and high evaporative losses through in September to the beginning of the wet season early in December. However as shown in Figure 17, once salinities returned to a favourable range (33g/L by early January 2007 falling to 25 g/L by mid February) growth rate immediately accelerated to near maximal levels.

A plot of crop yield versus duration of the pond production cycle (Figure 18), based on published data from Australia and elsewhere in SE Asia (see Table 6 for sources), suggests that the most appropriate time for harvesting a crop of pond reared mud crabs is in the range 115 to 190 days after stocking at favourable temperatures in the range 25 to 32°C. These data are consistent with well documented findings from prawn farming that even in well managed ponds (those subjected to appropriate rates of stocking, feeding, stirring, aeration and water exchange), crops not harvested close to an optimum time (case specific but generally within the range 150-200 days after stocking) will suffer progressively elevated and sometimes catastrophic mortality shortly thereafter.

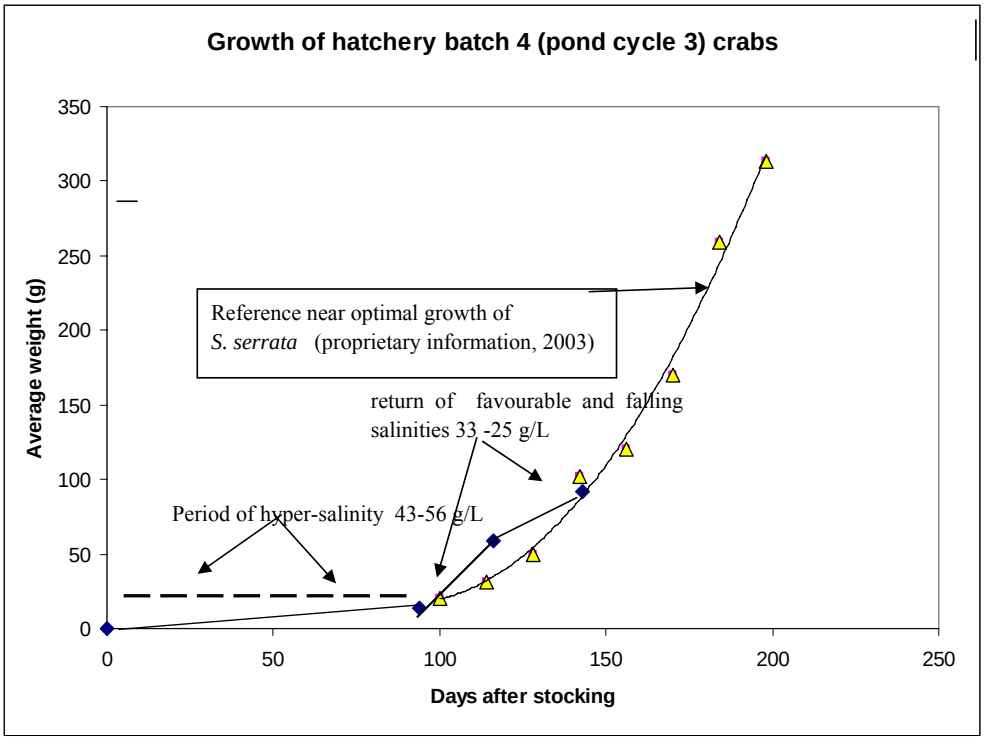


Figure 17 Growth data of the third pond production cycle (hatchery *batch 4* crabs (blue filled diamonds)

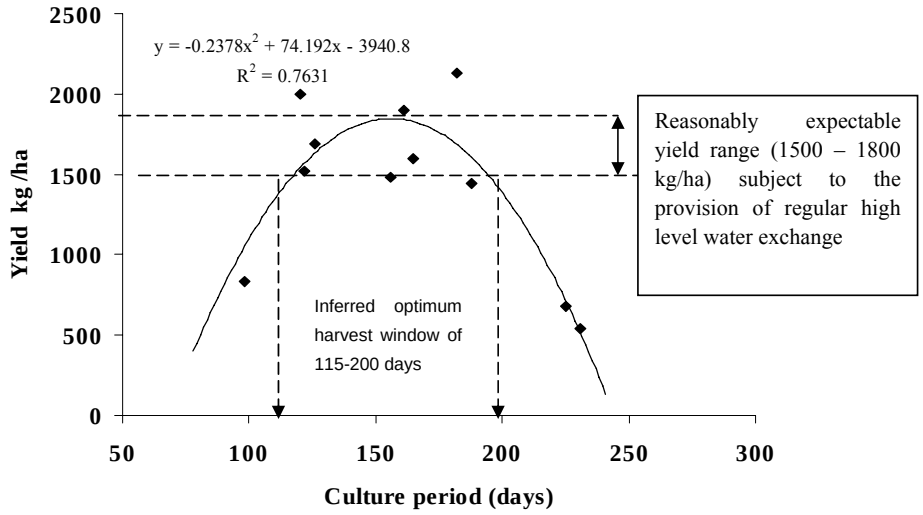


Figure 18 Culture period vs harvest yield for pond reared mud crabs (*Scylla* spp.) Source of data - from Table 7 plus proprietary information

Table 9 Summary of results for recent published mud crab grow-out experimentation. (source Table 1 p.14 Appendix 4)

Source	Origin	Stocking density (ind/m^2)	Stocking size (g)	Pond size m^2	Culture period (days)	Survival (%)	Harvest Wt (g)	Production kg/ha/crop	Feed rate (% per day)	Comments
Trino et al ,1999	Philippines	0.5	7.0 - 11.0	150	120	98	400	2000	8	
		1		150	120	57	375	2130	8	
		1.5		150	120	30	375	1687	8	
Hoang Duc Dat, 1997	Vietnam	3.5	8.3 - 17.0		182		200		4 - 6	
		3	25 - 40		126		350		4 - 6	
		1.5	66.6 - 100		98		500		4 - 6	
Fortes, 1997	Philippines	0.5	45.8	500	165	12 (?)	188		3	no shelter
		1	45.8	500	165	?	170		3	shelter
		0.5	45.8	500	165	?	165		3	no shelter
		1	45.8	500	165	?	150		3	shelter
Baliao, 1999	Philippines	0.5	3.2	10000	122	67	250	837		with milkfish
		1	3.2	10000	122	67	250	1600		with milkfish
Trifiol, 1999	Philippines	1		150	156		412			
DAC, 2004 (Golden Prawn Farm	Darwin	2.4	1.0 - 2.5	700	231	25.4	254	1521		
		2.4	1.0 - 2.5	700	231	24.4	260	1485		Predation, limited food
		2.1	1.0 - 2.5	700	161	16.1	202	542		finished early
		2.5	1.0 - 2.5	700	161	22.4	301	1900		finished early

While detailed discussion of issues controlling the *use by times* of semi-intensive tropical prawn and mud crab ponds is beyond the scope of this review, some noteworthy factors are as follows:

- Even with best practice pond management regimes that return feed conversion efficiencies (FCRs) of 1.5:1, the proportion of dry matter added as food that is assimilated into the tissues of farmed prawns or crabs is only about 10%. Thus 90% of organic matter in added food ends up either as anaerobic bottom sludge (70-80%) or in the water column either as micro-algae and other suspended particulate matter (bio-flocs) or in solution.
- As bottom anaerobic organic sludge accumulates, it emits ever increasing amounts of toxic substances, especially corrosive unionised forms of ammonia (NH_3) and of hydrogen sulphide (= rotten egg gas or H_2S)
- While unionised ammonia levels in pond water initially remain at low innocuous levels due to its adsorption by clay and silt fractions of pond floor sediments or incorporation into heterotrophic bacteria in suspension and in the first few upper millimetres of sediments on the pond floor, these *ammonium sinks* eventually become saturated leading to a sudden surge in pond water NH_3 to toxic levels that in turn herald cessation of growth.

In a similar way, elevated BODs generated by re-suspension of anaerobic sludge, in conjunction with the night-time respiration phase of dense phyto-plankton blooms of ponds, can render such ponds highly eutrophic especially during the warmest months as temperatures exceed 30°C. This can culminate in a plummeting of water column DO to levels below 2 mg/L, typically between midnight and about 6 am. Such DO levels are dangerously low even for the hardiest of estuarine species such as black tiger prawns and mud crabs.

Relevant published mud crab pond production data summarised in Figure 18 also show that even under well controlled experimental conditions and when operating within a favourable *harvesting window* of 115-190 days after stocking, average yields have consistently been in the range 0.5 to 2.1 tonnes/ha/crop. A plot (Figure 19) of crablet seeding density against residual density at harvest based on data from Table 6, also shows that regardless of initial seeding density above about 1.0 crab/m^2, residual density of crabs when harvested does not vary outside the narrow range 0.3 - 0.6 crabs / m^2, averaging about 0.5/m^2.

The clear inference is that optimal crablet stocking rate for free ranging pond-reared mud crabs, in the absence of shelters and other design features that that provide effective protection moult related cannibalism is about 1 crablet/m^2. Plots of crablet seeding density against harvest yield and of seeding density against average weight at harvest, also based on data from Table 7 and other proprietary sources are presented in Figures 20 and 21 respectively. These data show that harvest yield varies haphazardly in the range 0.5 – 2 tonne/ ha and mean harvest size, haphazardly between about 200 and 400 g. Thus neither crop yield nor average size at harvest appears to be correlated to initial crablet seeding density above 1/m^2.

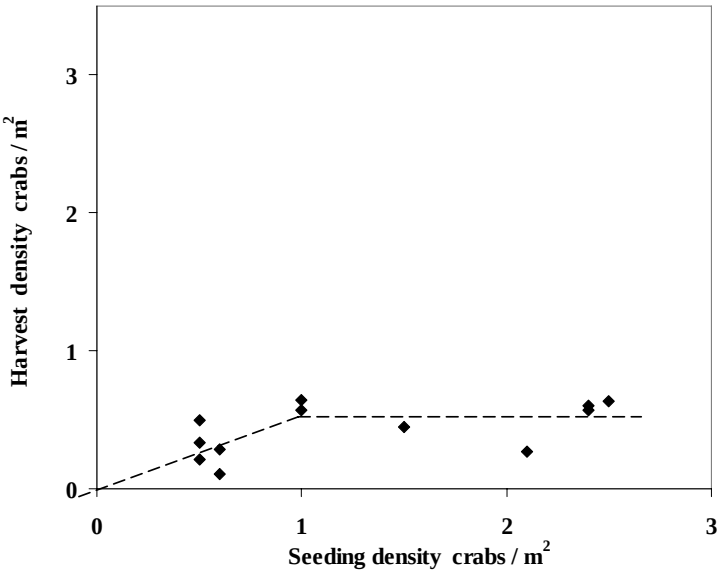


Figure 19 Seeding density vs harvest density for pond reared mud crabs (*Scylla* spp.) Source of data - from Table 7 plus proprietary information

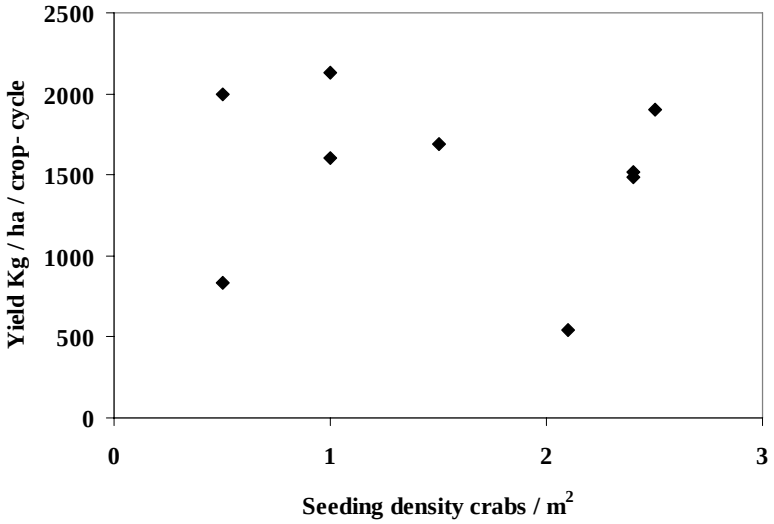


Figure 20 Seeding density vs harvest yield for pond reared mud crabs (*Scylla* spp.) Source of data - from Table 7 and some additional proprietary data.

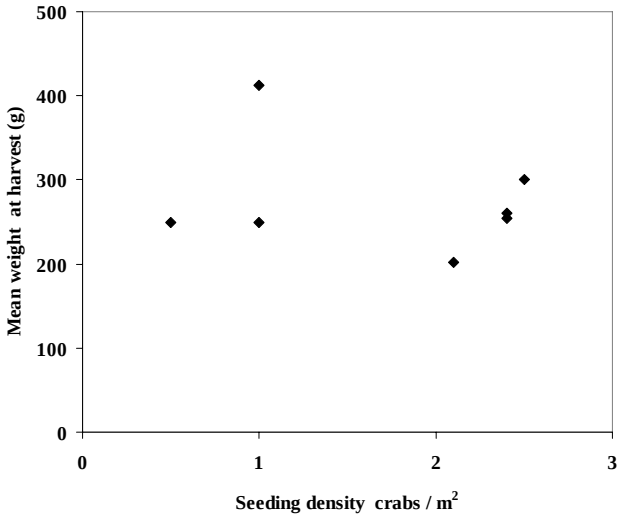


Figure 21 Seeding density vs mean harvest weight for pond reared mud crabs (*Scylla* spp.) Source of data - from Table 7 plus some additional proprietary information

Assessment of causes of poor yields at the Mudla farm

The Mudla farm project received its first consignment of crablets, (designated as *Batches 1 & 2)* from DAC in late December 2005 and early January 2006. These 2 batches that comprised a total of 4,400 crablets averaging about 1g live-weight were combined and reared in pond 2. Pond 2, being 8100m^2 was therefore stocked, at a rate of about 0.5 crablets/m^2.i.e about half optimal density (Figure 18) but still capable, under best practice pond design and management, of yielding up to 0.25 crabs /m^2 at an assumed survival of 50%. As shown in Figure 22, this crop cycle instead of being rapidly harvested at an optimum time of about 115 days in late March 2006, was instead subjected to protracted trap harvesting over the ensuing five months with a peak harvest intensity in July (in essence 4 months too late). It is thus hypothesised that the low yield of 13% (578 marketed crabs from 4400 crablets) achieved from the first crop cycle can be largely attributed to use of a sub-optimal harvesting strategy.

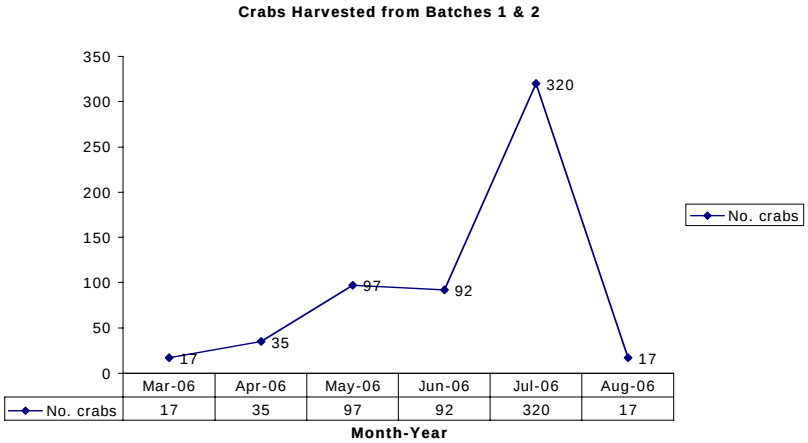
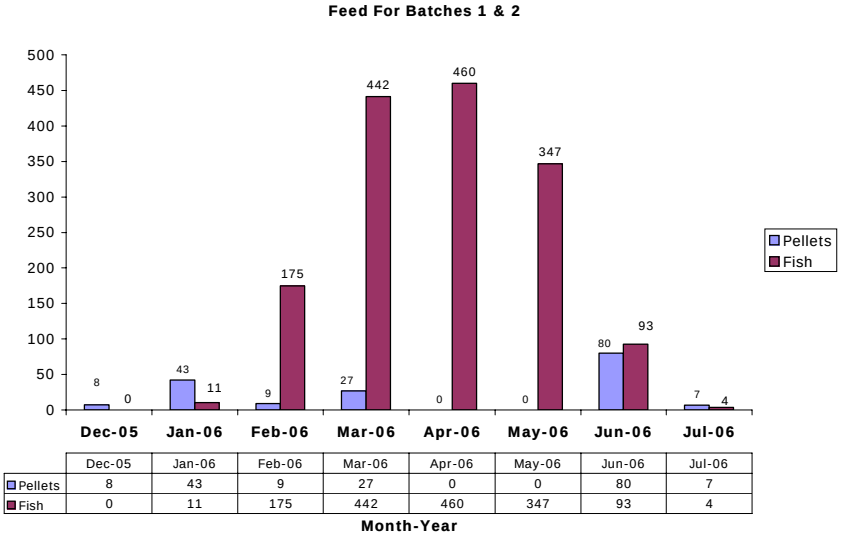


Figure 22 Crabs harvested from the first production cycle (*Batches 1&2)* at the Mudla Farm from March 06 to August 06. (Source: Gwalwa Daraniki Enterprise Pty Ltd, Mudla farms. Mud crab Project, Progress Report 2: August 2006)

Other potential consequences of delayed and protracted trap harvesting after cessation of growth is that it is extremely both labour intensive compared with synchronous (bulk) drain harvesting and will result in poor food conversion efficiencies (FCRs) and many other inefficiencies (sub-optimal use of pond space and other inputs such as power and labour). Concerning food, FCRs for the mixed fish/prawn and formulated diet used on the Mudla farm (Figure 23), need to be standardised to be meaningful. Amounts of fish and prawns that both comprise about 85% moisture fed to the crabs, need to be divided by a factor of 4 to give equivalence to formulated pellet feeds that comprise only about 10% moisture. As growth of the crabs ceased on or about day 115, all food fed after that date was probably wasted. Thus if the total yield of 283 kg crabs that had been progressively trap harvested had instead been synchronously drain harvested on or around day 115, the total adjusted feed consumption to that time (mid May, 2006) of 298 kg (87 kg of pellet plus 847/4 kg of fish and prawns), would have constituted a very respectable FCR of 1.1:1. This compares with the reported rate of 6:1.



	Dec-05	Jan-06	Feb-06	Mar-06	Apr-06	May-06	Jun-06	Jul-06
Pellets	8	43	9	27	0	0	80	7
Fish	0	11	175	442	460	347	93	4

Figure 23 Feed types provided to crabs from Batches 1&2 at Mudla Farms from December 05 to July 06. Fish category includes local prawns cleared of carrying diseases before use**.** (Source: Gwalwa Daraniki Enterprise Pty Ltd, Mudla farms Mud crab Project, Progress Report 2: August 2006)

The second pond production cycle at the Mudla farm entailed much larger consignment of between 45,000 and 50,000 crablets from DAC. This consignment, designated as *Batch 3,* was split into two equal subgroups and stocked into two separate ponds (Ponds 3 and 4) on 3 March 2006. Effective crablet stocking rate in ponds 3 and 4, that were 6900 m^2 and 6100 m^2 respectively in area, were therefore 3.5-4/m^2 which is 3 to 4 times optimal density of about 1 crablet/m^2. In common with the first farm production cycle, trap harvesting was again very protracted (Figure 24) being initiated in July 2006 and continued for 6 months peaking in October and continuing until December 2006. This compared with the inferred optimum harvest time of about 160 days (see Figure 16) that coincided with a date in early August.

The reported total of 224 kg of crabs marketed from the second cycle was lower than that expected on the basis of the 283 kg produced in the first cycle. Contrary to the first production cycle, initial crablet seeding rate was not limiting and production was achieved over a total pond area 13,000 m^2 being around 40% greater than that of 8900 m^2 used in the first production cycle. An obvious contributing factor of this *even poorer than expected yield* is that the second batch of crabs, having stalled in growth beyond day 160 due to unfavourable pond conditions (probably low DOs in

combination with dangerously elevated high ammonia and/or hydrogen sulphide), subsequently suffered protracted exposure to an added stress factor of severe hyper salinity (see Figure 14) from September to December 2006. As already discussed above, this period of management exacerbated hyper-salinity also stunted the first 3 months of growth of the third production cycle (see Figure 17).

Another possible factor contributing the particularly poor performance of second production cycle is apparent overfeeding of crabs during the first one to two months. For example, even if early survival had been at very high levels of 1-2 /m^2, total crab biomass through March would still have only been in the range 100 to 200 kg. Yet as shown in Figure 25, a massive 555 kg of formulated prawn feed was applied to ponds 3 and 4 during the first month. By contrast during the months of highest growth increment in June and July 2006 (see Figure 16), feeding rates were greatly reduced.

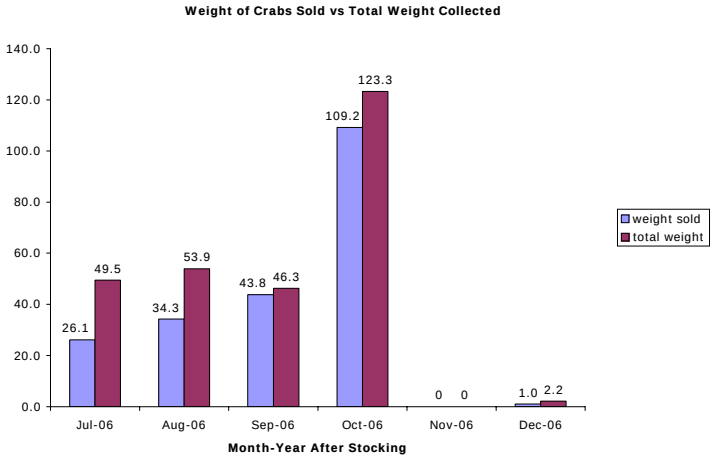


Figure 24 Crabs harvested from *Batch 3* at Mudla Farms from during 2006. The category "weight sold" refers to crabs ≥ 350g while the total weight category includes all undersize and market-size crabs. (Source third farm report -Appendix 4)

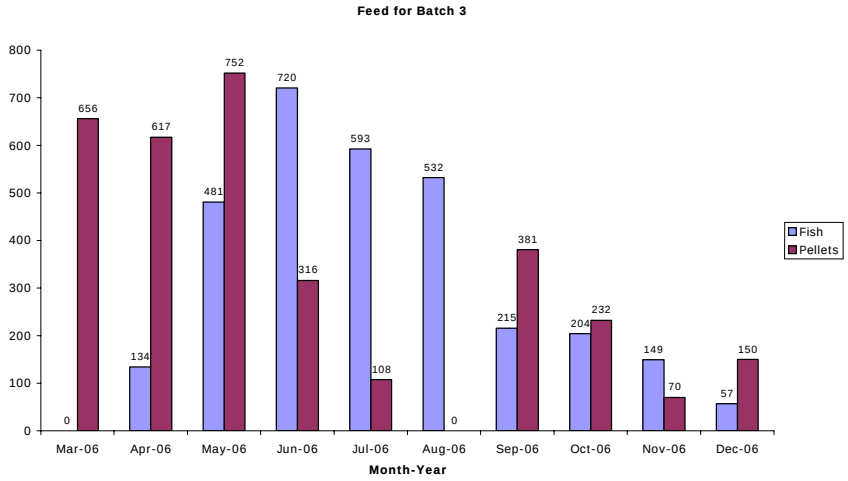


Figure 25 Feed provided to crabs from Batch 3 from March to December 2006.
Fish category for June and July includes local prawns cleared of carrying diseases before use and all other months consist of fresh barra fingerlings or local bait/trash fish. (Source: third farm report - Appendix 4)

5.1.5. Timeliness, reliability, quantity and quality of crablets sourced from DAC

DAC supplied the Mudla farm with 3 consignments of crablets during 2006. The first, (designated as *Batches 1 & 2)* comprised a total of 4,400 crablets and was supplied in early January 2006. The second much larger consignment of between 45,000 and 50,000 crablets, designated as *Batch 3,* was supplied on 3rd March 2006. The third and final consignment, designated *Batch 4* and comprising between 10,000 and 16,110 crablets was supplied on 29 September 2006. In the opinion of the reviewer outcomes of pond farming operations at Mudla were not significantly constrained by either the quantity, quality or timing of these consignments.

A study tour of the DAC and technical discussions with the mud crab hatchery R&D team leader Graham Williams, confirmed that the staff and facility as international leaders in the hatchery production of *S. serrata.* In the opinion of the reviewer, the DAC team can fairly claim to be largely responsible for having overcome a live food associated bacterial disease barrier that has stood in the way of consistent high efficiency hatchery output of *S. serrata* since the pioneering work of the reviewer more than 30 years ago. DAC currently produces batches of crablets more frequently, on a larger scale and with greater consistency than any other hatchery in Australia. Apart from budgetary constraints, most significant deficiency of DAC's ability to supply crablets is a lack of on-site nursery pond facilities with which to mass rear final stage megalopae larvae in pond based hapa nets through to the crab stages 5 or 6. These crab stages (Figure 26 and 27) are of optimum size (15-20 mm and around 1 g) for transporting and releasing into farm grow out ponds. It is thus recommended that intermediate stage nursery production be shifted from DAC to recipient farms with the Mudla farm being used to demonstrate and refine this weak link in the crablet seed supply chain.

Figure 26 Project trainees collecting hatchery crablets at DAC for translocation to the Mudla farm grow-out ponds. (Source: Nomination of the Mudla Farm, for Northern Territory, Research and Innovation Awards, March 2006)

Figure 27 Crablets hand packed for translocation to grow-out ponds.
(Source: Nomination of the Mudla Farm, for Northern Territory, Research and Innovation Awards, March 2006)

5.1.6. Assessment of post harvest processing and packaging, storage and transportation, value adding and marketing of mud crabs.

Marketing development and promotion initiatives have been severely limited by low farm output that totalled only 283kg from the first pond production cycle (from crablet *Batches 1 and 2*) and 225 kg from the second (crablet *batch 3*) production cycle. Bulk handling and processing trials have been precluded by low weekly sales volumes linked to the chosen harvesting policy of progressive trap capture from each crop cycle over very protracted periods of 4 to 6 months. Apart from some small-scale trial interstate consignments crabs have been sold live either as a larger (≥350 g) better quality grade to local wholesalers, as smaller (≤350 g) second grade or as low grade (missing one or more limbs) to residents of Darwin and to local Asian restaurateurs.

The total revenue for pond production cycle I *(crablet Batches 1 & 2)* was $3,307.68 with the weighted average price at $12 kg^{-1} ($3,307.68/283.32 kg). The average monthly price for second pond production batch crabs (Table 7) to wholesalers leading up to Christmas 2006 was $18.01 kg^{-1} (kg^{-1} = per kilogram) and for cash sales to customers it was $17.55. The average overall price during the 'build-up' period was $17.78 kg^{-1} and a total of $3,932.20 had been made from 224.42 kg of crabs.

Weighted average price of $17.5/kg attained for crabs produced from the second production cycle was 50% more than that of $12/kg achieved from first production cycle crabs and rewarded a concerted program of personalised client servicing and promotion of a local home grown, graded and quality assured product.

Table 10 Crabs harvested from the second pond production cycle (from *Batch 3* crablets) at Mudla Farms from July '06 to December '06. (Source 3rd Farm Report - Appendix 4)

Month-Year	Wholesale			Cash			Total		
	Kg	$	avg $/kg	Kg	$	avg $/kg	kg	$	avg $/kg
Jul-06	20.12	333.29	16.57	4.10	80.00	19.51	24.22	413.29	18.04
Aug-06	21.66	382.12	17.64	20.39	375.00	18.39	42.05	757.12	18.02
Sep-06	16.00	322.67	20.17	36.06	616.76	17.10	52.06	939.43	18.64
Oct-06	84.88	1,499.86	17.67	21.21	322.50	15.21	106.09	1,822.36	16.44
Nov-06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dec-06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

5.2. Results – Comments on the BAC Mangrove Pen Farming Project

The Maningrida pilot fenced mangrove enclosure mud crab farm project has been described (Anon 2007) as a low technology-low risk economic development opportunity for Maningrida communities. Fully operated by traditional owners, the project is being jointly funded by the Bawinanga Aboriginal Corporation (BAC) and the Northern Territory Government.

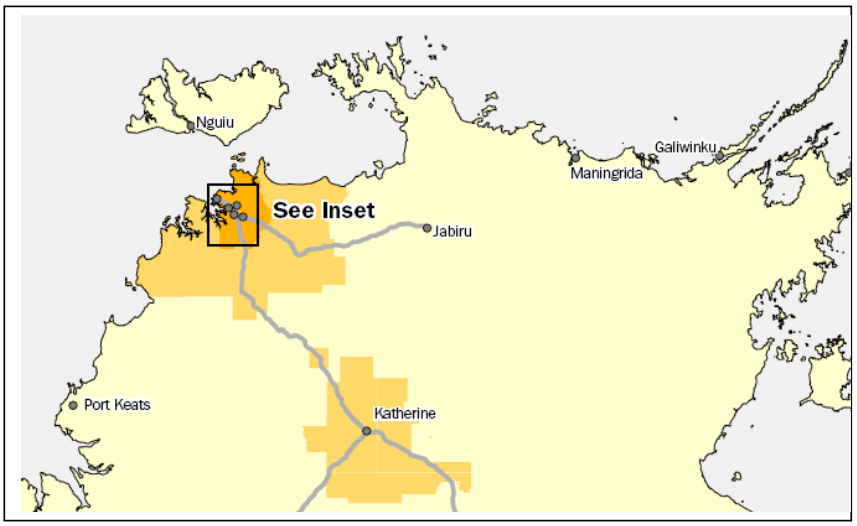


Figure 28 Location map of Maningrida, located in Arnhemland, about 400km east of Darwin

Representatives of the local aboriginal community (BAC) comprising elders Don Wilton (spokesperson), Jimmy Galarminda, plus Michael, George and Bob (family names not divulged), lobbied Graham Williams at the Darwin Aquaculture Centre for assistance to develop the project after hearing of the DAC's success (FRDC project -2000/210) in achieving reliable commercial-scale production of crablets.

Objectives of the BAC's mangrove pen trial have been to:

- Establish sustainable aquaculture ventures on their own tribal lands.
- Develop technical support training and employment programs especially for their young people.
- Securing short and longer term assistance of the NT DPIF&M especially the DAC and of other government agencies especially the NT Department of Business Industry & Resource Development (DBIRD) to develop profitable low tech mud-crab pen aquaculture and ranching methods and to extend the social and economic benefits of the venture to a range of other regional and remote indigenous communities in the longer term.

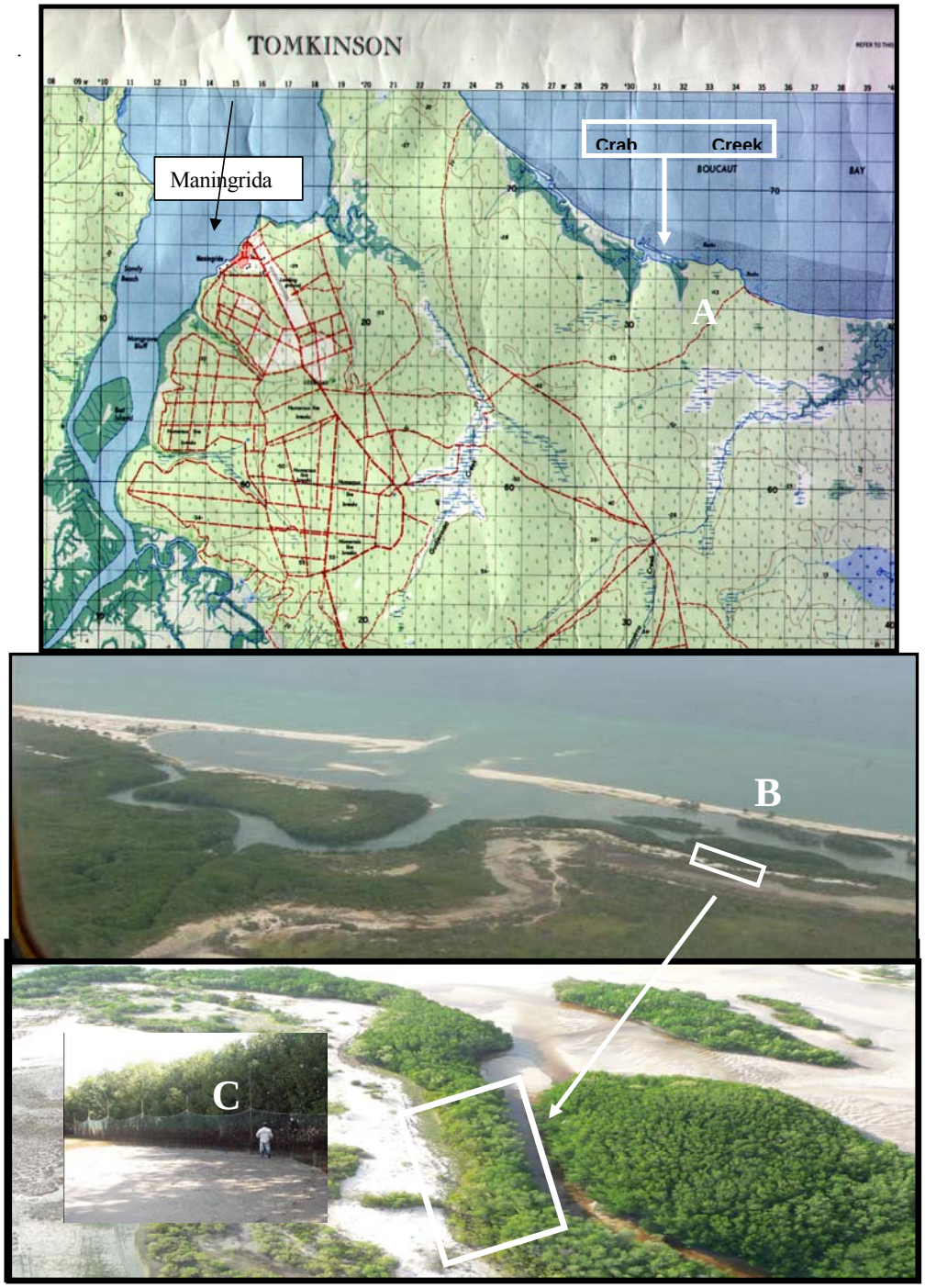


Figure 29 A) Chart showing location of BAC pilot mangrove mud crab pen farming trial at Crab Creek, approximately 40km east of Maningrida, Arnhemland, NT. B) Aerial photograph of penned area and C) netting fence surrounding the pen. (Source: Courtesy of Graham Williams , Darwin Aquaculture Centre, NT /DPIF&M, March 2007)

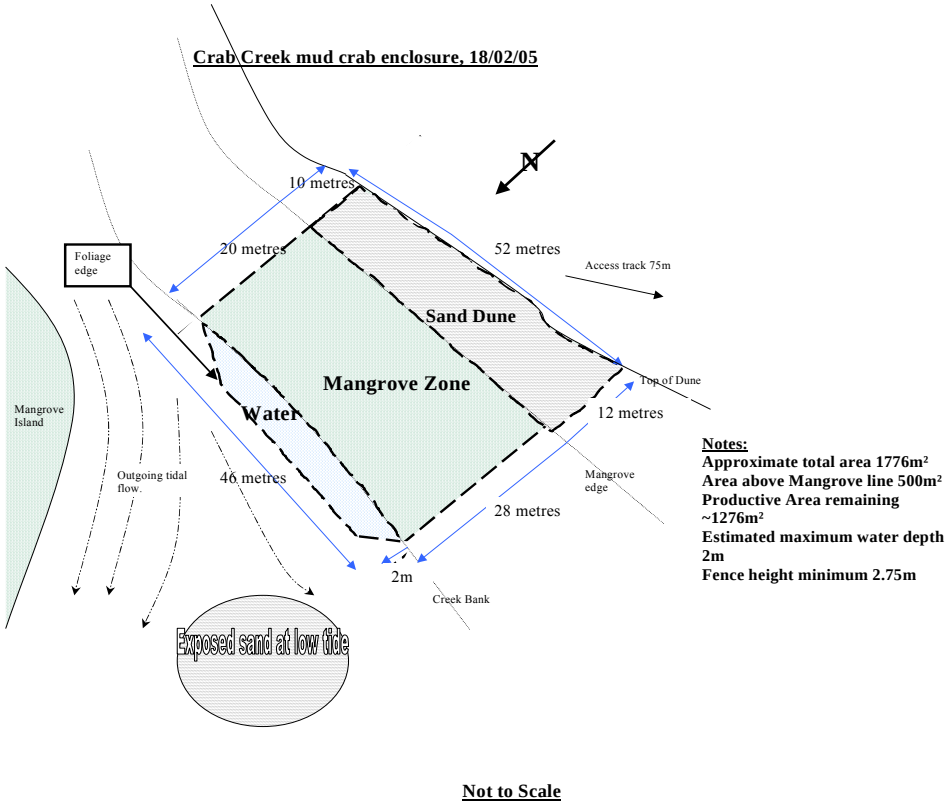


Figure 30 Schematic plan of crab farming enclosure (Source: Courtesy of Graham Williams Darwin Aquaculture Centre, NT/DPIF&M, March 2007)

A study tour of the mangrove pen trial located at Crab Creek, 40 km east Maningrida planned for Tuesday 13 March 2007, had to be cancelled after monsoonal rains and flooding had rendered the final 5km of track site inaccessible even on foot.

Accordingly information used to develop the following assessment of the status of the still current implementation phase of the project was compiled from discussions with DAC and DBIRD staff directly involved with the project.. DAC staff included Senior Aquaculture Scientist, Graham Williams, Aquaculture Liaison Officer, Ian Ruscoe, Senior Aquaculture Technician, Evan Needham, Aquaculture Extension Officer Kris Kuo. DBIRD (Fisheries Group) staff interviewed were Deputy Director, Bill Flaherty and Indigenous Projects Officer, Robert Carn.

The site and pen (Figures 29 and 30)

Selection of Crab Creek to stage this trial, was based partly on its proximity to regular bush camping and beach gill-net fishing and traditional bush craft and cultural activities of the five project proponents. Fishing activities of the group were opportunistically viewed as a source of cheap, abundant and wholesome supplementary food for the crabs. Additionally the site was considered sufficiently remote and inaccessible to deter poaching that was perceived as a major potential risk to the project.

As shown in Figure 29, the 1766 m^2 penned area straddles a 1200 m^2 area of mangroves at the mouth of Crab Creek. Its northern seaward boundary includes a section of deep tidal gutter that provides the crabs with permanent access to seawater. The firm sandy substrates of the site provide easy access on foot during low tide periods. With a tidal range of 3 metres, the entire site is subject to tidal inundation to depths up to 2 m but is sufficiently exposed at low tide for sampling and repair work to be undertaken on most days regardless of stage of lunar tidal cycle. Like-wise addition of fresh palatable food (locally sourced finfish or welks) can be conducted twice daily to coincide with peak flood-tide foraging behaviour of juvenile mud crabs up to 60 mm (50g) that reside permanently within the upper inter-tidal zone (Heasman 1980)**.**

The perimeter of the pen is bounded by a 2.75 m high soft netting barrier wall to exclude, but not to snare, large predatory fish during twice daily periods of tidal inundation. During the first two of three stocking trials, crabs were initially confined to much smaller inner pens described in more detail below.

Methods of seeding and general husbandry and outcomes

At the time of completion of the draft final report (11 July 2007), DAC had provided three consignments of crablets. The first, air freighted to Maningrida on the 03 Oct. 2005, comprised 514, 15-20 mm crablets (crab instars 5 and 6) that were stocked into an open top 5 x 5 m pen located centrally within the outer predator reduction netting fence and shaded beneath the mangrove canopy. As a consequence of the rapid corrosion of the lightweight galvanised *mouse wire* used to construct the inner pen and its lack of a roof to stop crabs swimming out, no crabs were found in the pen beyond the first few weeks after stocking. This in turn prevented assessment of post- release growth or survival. Some occasional additions of food (fish) were made but escapement of crabs probably undermined any significant benefits of this supplementary feeding.

The second consignment of 2459 crablets in the range 10 – 25 mm (instars 3 to 7) were dispatched almost a year later on 22 September 2006. These were also stocked into a 5 x 5 m inner pen but this time constructed of more durable 5 mm plastic *oyster mesh*. While it was intended to fully enclose the pen, oyster mesh sufficient only to build the perimeter fence (one of 3 rolls ordered from a local distributor) was supplied in time for stocking. As a consequence most stocked crabs swam out of the pen and dispersed during twice daily flood tides.

A third pen stocking trial was initiated in early July 2007. In this instance use of an inner pen was dispensed with in favour of dispersing far fewer but larger (50 to 75 mm) juvenile crabs within the larger confines of 1776 m^2 net enclosure. Actual areas of release with the pen have been confined to natural habitat areas for this age class of crabs namely, shaded mangrove canopy and tangled root areas that border the deep tidal gutter. The three consignments of 300 crabs from the DAC were progressively stocked at 1 to 2 week intervals during July.

A number of additional initiatives have been implemented to further enhance prospects of success of this third (and if unsuccessful, final) trial. Foremost has been the trapping out other types of crabs prior to stocking. The trapping aims to reduce prolific numbers of hermit and sesarrmid crabs that present a very high level of competition for available food. The trapping has also been targeting the highly aggressive and territorial crab *Thalamita crenata,* (Figure 31), a ubiquitous predator of other inter-tidal crabs including juvenile mudcrabs up to twice its own size.

Other initiatives of the third trial included:

- the adoption of daily inspections and maintenance of the netting fence
- supplementary feeding using locally caught fin-fish flesh and/or welks. This is timed to coincide with twice daily flooding tides when foraging activity of the mud crabs is greatest.
- regular bait trapping and measurement of mud crabs to track growth and as a guide to survival.

These initiatives demonstrate a high level of enterprise and a sustained commitment to this project by the 5 operatives and their families. These aspects are especially commendable in that up to this time the project has had minimal external funding and a relatively low level of technical and logistical support.

Figure 31 Highly aggressive and territorial crab *Thalamita crenata*

6. PLANNED OUTCOMES

1. Produce a high quality report based on knowledge of understanding of crab culture biotechnology and economics including a draft for consideration by DAFF, GDA, BAC and FRDC (Completed).
2. Produce and present the draft report for discussion in a workshop in Darwin with all stakeholders and incorporate stakeholders' responses in a final report.(Completed).

7. CONCLUSIONS AND RECOMMENDATIONS

Commercial mud crab farming operations in Vietnam (Allan and Fielder 2004) and elsewhere in SE Asia (Keenan and Blackshaw 1999) have consistently achieved yields ranging between 0.1 and 2 tonnes per hectare per crop depending on the level of intensity applied. These are produced using cheap locally sourced trash fish and molluscs as food at farm gate prices in the order of US$3-4. Crop yields of only 0.1-0.5 kg/ha/crop are possible in the absence of high and regular rates of water exchange. As discussed above, with regular high level of water exchange, total crop cycle yields can be increased to 1 to 2 tonnes/ha and theoretically (in the absence of density dependant moult associated cannibalism) at up to 10 tonnes/ha/crop. The latter, based on prawn farm modelling would require high levels of stirring and aeration consuming about 15 Kw.

In the specific case of the Mudla mud crab farm project where neither regular high rates of water exchange nor supplementary pond aeration and stirring have been imposed and where crops were harvested up to 6 months after growth had ceased, best yields of 350 kg/ha/cycle achieved can be viewed as those *to be expected under the circumstances*. Accordingly forecast yields of 3.16 tonnes/ha/crop cycle and associated revenue projections from the Mudla farm used in financial planning and justification for this project were optimistic.

It is however acknowledged that these forecasts were based on the best information then available to the authors of the business plan and other supporting documents. In the opinion of the reviewer, best yields that could have reasonably been expected were 1.5-1.8 tonnes/ha/crop cycle, even had all best practice farm design and operational protocols as specified in the Environmental Management Plan had been able to be implemented over the first two years of operation of the Mudla farm.

It must also be acknowledged that although the Mudla farm has fallen short of expectations attached to the original business plan, its very manifestation has been served as the subject of considerable community pride and has imparted renewed hope, especially among the young.

(Photo: Courtesy of Dr Bob Rose)

Taking a national perspective on the current status of mud crab farming technology and on prospects for establishing profitable mud crab farming in Australia, two significant hurdles still stand in the way. The first (based on proprietary economic modelling information) is that to achieve reasonable returns to investment and to supplant production of black tiger prawns, existing farms will need to achieve mud crab yields in the range 3-5 tonnes/ha/crop and 2 crops per year. Such crop yields will also have be coupled to a minimum production base of 25-50 ha of ponds in order to achieve

requisite economies of scale. Yields of 3-5 tonnes/ha/crop and minimum scales of operation of 25-50 ha will also need to be linked to development of new specialist *complete* mud crab diets that can support near optimum growth rates at food conversion efficiencies of 1.5:1 or better a cost on par with current commercial prawn feeds ($1000-$1300/tonne). Although an R&D program towards a *complete* mud crab diet is already well underway (ACIAR project FIS/2000/065), commercial availability of such a diet may still be several years away. A systematic program of R&D to combat moult related cannibalism thereby enabling yields to be raised from the current limits of around 1-2 tonnes/ha/crop to economically viable rates of 3-5 tonnes/ha/crop while also needed is yet to be initiated.

In reference to the above, the reviewer recommends that the GDE, BAC project stakeholders and all other stakeholders with an interest in further development of mud crab based industries across the Top End of Australia give consideration to:

- adopting the view that semi-intensive mud crab farming in the NT and elsewhere in Northern Australia aimed at suppling the domestic high price markets for live crabs should be left to large existing commercial prawn farms looking to diversify production away from ever increasing competition from cheap imported prawns
- accepting that the GDE pond farming project has little or no prospect of becoming self sustaining on the basis of production and sale of mud crabs alone.

The reviewer also recommends that following the recent "*Blue Mud Bay Decision*" of the Federal Court of Australia, but subject to outcomes of a follow-up appeal to the high court of Australia and outcomes of a National workshop on mud crab fisheries, their exploitation and management and future R&D priorities, held in Darwin on the 17 and 18 June 2007, that….

the Project Board and/or Steering Committee give consideration to a re-vamping the GDE and BAC projects as adjuncts of a much more expansive nationally significant program of mud crab fisheries enhancement, ranching and mangrove pen farming across the Top End of Australia.

The reviewer makes this recommendation in light of the following:

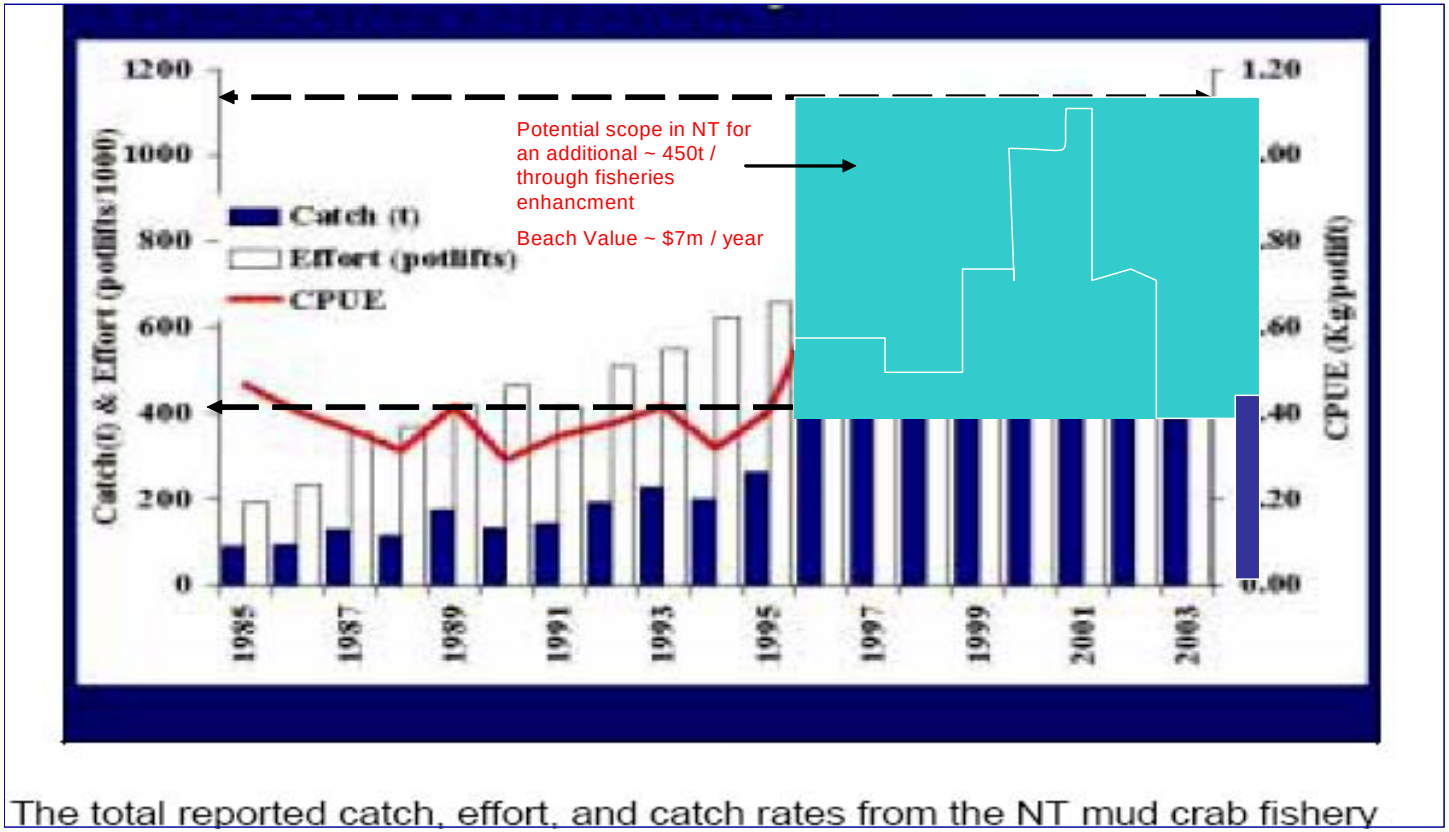
- Large variations in mud crab fisheries yields (Figure 31) both within Qld and NT regions of the Top End of Australia have been ascribed to inter-annual variation in recruitment success and that these fisheries have been over-fished since about 2002 (Haddon et al. 2004). This suggests that these mud crab stocks could be good candidates for cost effective fisheries enhancement and ranching.
- The fact that more than 80% of coastal land across Northern Australia is vested via native title in regional indigenous communities, could (subject to the outcome of an appeal to the high Court of Australia) extend to the low water mark following the *Blue Mud Bay Decision* of the Federal Court of Australia.
- The Mudla facility could serve as a suitable site to host R&D of a large-scale low cost nursery techniques for production of juvenile crabs in the range 0.1 to 1g suitable as seed for fisheries enhancement, ranching and mangrove pen farming.
- The Mudla facility could also continue to serve as a specialist training centre for extending large-scale nursery seed propagation technology for regional indigenous communities to produce and ranch or pen-farm mud crabs in and around their own communities.
- That the Mudla facility could also serve as an ecotourism centre based on the above activities and issues of interest.

It should be noted that theses recommendations remain consistent with the original objects of both the GDE's mud crab pond farming project at Kulaluk and the BAC's mangrove pen farm project at Maningrida, i.e.

- To establish sustainable aquaculture ventures on tribal lands.

- To develop technical support training and employment programs especially for local young people.
- For NT DPIFM to develop appropriate models for extending the social and economic benefits of profitable mud crab ventures to a range of additional regional and remote indigenous communities in the longer term.

Figure 32 Comparison of mud crab catch rates for the NT and Queensland areas of the Gulf of Carpentaria (Haddon et al., 2003) showing potential scope for recruitment limited (Source; Author 2007, presentation to National mud crab Fisheries R&D Strategy Workshop , Darwin, June 2007)



8. REFERENCES

Allan G. and Fielder D. 2004 Mud crab aquaculture in Australia and Southeast Asia. Proceedings of the ACIAR Crab Aquaculture Scoping Study and Workshop 28–29 April 2003, ACIAR Working Paper No. 54.

Haddon M et al., 2004 Mud crab assessment workshop. Fisheries Report No. 79 NT DPIMF ISBN 0 7245 4718 5. 33pp

Heasman, M.P., 1980 Aspects of the general biology and fishery of the mudcrab Scylla serrata (Forskal) in Moreton Bay. PhD Thesis. Queensland. University of Qld, 506 pages

Keenan, C.P.; Blackshaw, A. (1999). Mud crab aquaculture and biology: Proceedings of an international scientific forum held in Darwin, Australia 21-24 April 1997. ACIAR Proceedings, 78. Australian Centre for International Agriculture Research: Canberra, Australia. 216 pp.

9. APPENDICES

9.1. Business Plan – Kulaluk

Appendix 1- BUSINESS PLAN

Establishment of a mud crab aquaculture venture and demonstration site on Gwalwa Daraniki land at Kulaluk

Prepared in Partnership by
The Gwalwa Daraniki Association, and
Northern Territory Department of Business, Industry and Resource Development – Fisheries Group

8 April 2005

Northern Territory Government
Department of Business, Industry and Resource Development

KULALUK MUD CRABS

TABLE OF CONTENTS

EXECUTIVE SUMMARY

- Gwalwa Daraniki Association (GDA) proposes to establish an indigenous owned and operated mud crab aquaculture venture in the currently unused salt-water ponds on their land at Kulaluk, in Darwin.

- After almost two years of attempting to establish a mud crab farm, GDA in November 2004 signed a two-year agreement with the Northern Territory Government's Department of Business, Industry and Industry Development (DBIRD) – Fisheries Group, to jointly progress the project. After the two year period, GDA will continue the operation as a fully commercial venture.

- GDA intends to establish a long-term sustainable aquaculture venture on their land. This will entail building capacity within the community by supporting training and promoting real employment in a commercial venture – the mud crab farm.

- DBIRD aims to use the facility to create appropriate models for the commercial farming of mud crabs on indigenous land in regional and remote communities of the NT and Northern Australia. The facility will also serve as a demonstration site for interested communities.

- A steering committee comprising representatives from DBIRD, the GDA, DAFF, DEWR, the NT Government's DEET, Charles Darwin University, the Office of Indigenous Policy Coordination and the Northern Territory Area Consultative Committee (NTACC), will oversee the development.

- A farm manager and training mentor will be employed during the first two years of operation to physically run the farm and oversee the training outcomes for community staff.

- DBIRD is prepared to contribute substantial in-kind funds, GDA contributes in-kind the costs of the land as well as costs associated with the development of several hectares of marine ponds.

- The crab farm will initially produce approximately 15 tons of mud crabs per annum of a minimum size of 350 g, generating around $235,000.

- The project will expand a further 0.5 ha in the second year and up to ten ha within ten years. Financial projections suggest profitability increases as the farm grows due to economies of scale.

- Grant funding is required to initiate this venture.

1 INTRODUCTION

There are four species of mud crab which inhabit tropical to warm temperate inshore zones and which form the basis of relatively small, yet important commercial fisheries. The most widespread of these, *Scylla serrata*, is usually found in inter tidal and sub tidal zones of estuaries and in mangrove systems. They are easily caught using simple baited traps, grow to a size in excess of 1.5 kg, and have an excellent tolerance to air exposure. They are well-known and readily accepted in seafood markets and are an important source of income throughout their range. Several countries have investigated farming of mud crabs however the major constraint to further expansion of mud crab aquaculture until recently was the current lack of a regular supply of seed stock. Researchers at the Darwin Aquaculture Centre (DAC) have recently been able to produce commercial quantities of these crabs.

This project plan outlines a proposal to establish an indigenous owned and operated mud crab aquaculture venture in the currently unused salt-water ponds on the Gwalwa Daraniki Association (GDA) lands at Kulaluk, in Darwin (Figure 1.). The GDA approached the Northern Territory Government (NTG) after hearing of their success in rearing crablets in the hatchery. GDA produced a feasibility study and business plan for a commercial venture in 2003 to grow-out hatchery crablets purchased from the DAC but were unable to attract government or private funding at that time.

Figure 1. Currently unused saltwater ponds on Gwalwa Daraniki land at Kulaluk.

In November 2004, a two-year agreement was signed by the GDA and DBIRD's Fisheries Group to jointly progress the project. After the two year time period, GDA will continue the operation as a fully commercial venture. This business plan concentrates on the two-year partnership, although financial projections extend to show profitability in the longer term.

In 2003 after several years of FRDC research the Darwin Aquaculture Centre (DAC) began producing commercial quantities of mud crab juveniles ready for pond stocking. These crablets were the outputs of experiments aimed at developing appropriate hatchery protocols. These protocols have been producing crablets for more than a year and already some preliminary pond grow out work has occurred. Coupling this work with that of rudimentary crab farming already established in South East Asia, an opportunity now exists for the Northern Territory to begin commercial scale mud crab aquaculture.

One of the briefs of DBIRD is to stimulate economic and social development of Aboriginal communities across the Northern Territory. It is proposed that crablets produced at the DAC under a commercial arrangement be used for grow out at the Kulaluk pond facility belonging to the Gwalwa Daraniki people in Darwin. The project aims to integrate capacity building exercises of training and meaningful employment with a commercial aquaculture venture. In the longer term, the facility will act as a model and demonstration farm for remote ventures. The development project proposed in this document will assess both the economic and social outcomes of the venture.

The establishment and early operating costs of the project will be funded by a combination of monies and resources derived from the Northern Territory Government, the Federal Government, and the Gwalwa Daraniki people.

The specific aims or objectives of the project proposed here are broad. GDA wants to establish a long-term sustainable aquaculture venture on their land. DBIRD aims to use the facility, once established, to create appropriate models for the commercial farming of mud crabs on indigenous land in regional and remote communities of the NT. In this way the project will use GDA as a model for Indigenous Economic Development (IED) This will entail building capacity within the community by supporting training and promoting real, sustainable employment in a commercial venture – the mud crab farm.

A steering committee comprising representatives from relevant stakeholder groups will oversee the development. It is expected that people within various sections of DBIRD will facilitate and participate in the steering committee which will be made up of people from, the GDA, the Australian Government Departments of Agriculture, Fisheries and Forestry (DAFF), and Employment and Workplace Relations (DEWR), the NT Department of Employment Education and Training (DEET), Charles Darwin University (CDU), the Northern Territory Area Consultative Committee (NTACC), the Office of Indigenous Policy Coordination (OIPC) within the Australian Department of Immigration, Multicultural and Indigenous Affairs (DIMIA), and there may be opportunities for private sector participation.

A farm manager will be employed to physically run the farm. It is also proposed that GDA representatives be engaged in DEET/DEWR funded traineeships with time spent at the Darwin Aquaculture Centre (DAC) and the farm. There is also scope for traineeships in business management, and possibly other streams. A training mentor will also be engaged to oversee training outcomes of farm staff.

DBIRD is prepared to contribute substantial in-kind contributions to the project in the form of infrastructure and personnel associated with the operation of the hatchery. A DAC extension officer will provide technical assistance on farm. The Gwalwa Daraniki Association will be contributing in-kind the costs of the land as well as costs associated with the development and maintenance of several hectares of marine ponds.

As a business, the crab farm will aim to produce mud crabs of a minimum size of 350 g that are smaller than those caught legally in the wild and thus may represent a market advantage. Early results suggest that around 15 tons of mud crabs can be grown in the existing 2.5 ha of ponds and could generate around $235,000 per annum. The project will expand a further 0.5 ha in the second year if capital funding can be secured. Profitability of the project will depend on the ability of the project to:

a) source external funds for the initial capital development and proposed expansion; and
b) ensure operating costs are kept close to the projected revenue (to allow maximum participation and benefit).

Once production is established the profitability of the business should increase as the farm grows due to economies of scale.

2

2. THE OPERATIONAL PLAN

2.1 Organisational Structure

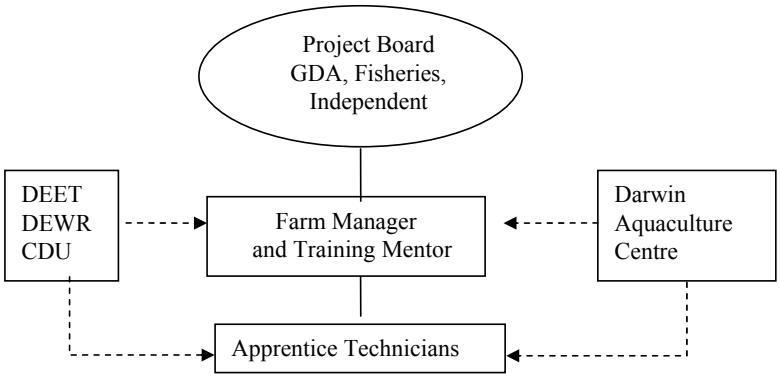
A steering committee has been convened to oversee the development from the planning stage to stand alone commerciality. Membership of the steering committee has been inclusive rather than exclusive, but has been limited to key personnel from the various organizations involved to remain effective.

The structure of the business for the first two years has been determined by an agreement between the two primary agencies, the Gwalwa Daraniki Association and the Northern Territory Government Department of Business, Industry and Resource Development – Fisheries Group. A Project Board will be convened to oversee the planning, development and financial management of the farm. The Board will consist of two persons each from DBIRD and GDA, and at least one independent person (see attached Deed). After the two year time period, GDA will have full control.

The Board will appoint a farm manager and a training mentor to undertake the specified roles. The farm manager will oversee the general management of the farm and will take direction from the board, receiving assistance from the Darwin Aquaculture Centre researchers and technicians. That person will undertake the production and sale of the crabs including employee supervision, all small business management roles, and will be aided in the provision of training by a 'training and employment mentor' (part-time or consultant). The manager will have an active role in OH&S, planning and preparations for harvesting, processing and marketing, and in ensuring quality control measures are in place.

DAC staff and extension officers will provide technical advice for crab aquaculture. The extension officers will oversee the husbandry of crab production (not small business management), and assist by giving technical advice that leads to maximized production, environmental sustainability, accurate record keeping and troubleshooting to aid in future modeling plans for other farms.

The number of employees, trainees, and apprentices will be determined after taking due regard to the resources that become available. Initially there may be up to six farm personnel in addition to administrators, extension officers from fisheries and educational agencies.



2.2 Scope of Operation

The scope of the operation should be as large as is practical and profitable. As well as the crab aquaculture activities, there are opportunities for accredited training and employment in business management, marketing and perhaps the hospitality industry, if the tourism venture is established. It is expected that several members of the GDA will undertake either apprenticeships or training in aquaculture as well as business, and that there is scope for several employees. The number and structure of the workforce will need to be determined by the steering group, considering subsidized wages for Aboriginal development projects and other mechanisms.

The project should turn over in excess of 15 tons of crabs during the first two years, generating revenues of around $235,000. Once profitability has been proven, expansion of the farm to around 10 ha or more over a stepped process will occur, at which time there will be potential for many more jobs and training opportunities. Our ten year forecast is for 10 ha of ponds, producing 72 tons of crabs and generating around $M1.4 in revenue for a business employing nine persons and several trainees.

2.3 Location and Business Premises

The aquaculture business will be located at the Kulaluk site, owned by the GDA, in ponds previously developed for prawn farming. It is expected that this project will fund a full restoration of the facilities including a small building for processing and packing. As such there will be no land purchase or lease costs.

The site currently has 4 ponds totalling 2.5 ha, and previous approvals for a further 0.5 ha, as well as an established intake water channel. A relatively large water pump will be required to supply water to the ponds. Power will also be necessary for the processing area as well as for aeration of the ponds and other normal utilities. Off-peak three-phase power is usually the cheapest form of electricity. There will also be costs involved in re-establishing the electricity and freshwater supply to the site.

It is anticipated that a live-in position will be required for 24 hr management. This person will need to be responsible for emergency responses and maintaining stock security. Fencing will also be required, given its proximity to town. Under the Deed of agreement, GDA has taken responsibility for farm security.

2.4 Production Arrangements

The mud crab grow out will be conducted in a semi-intensive manner, similar to marine prawn aquaculture, but at a lower density. This lower density (stocking at around 2-3 crabs / m^2) is considered appropriate due to the cannibalistic nature of the crabs.

Crabs will be stocked at an early juvenile stage after being produced and nursed at the DAC, and will initially be fed a combination of artificial prawn diets and fresh/frozen marine fish and prawns. It may be possible to utilise one or several of the Aboriginal coastal net licenses to supply the frozen fish for feed. This may reduce the feeding costs and ultimately increase the level of employment and activity created by this project.

Water quality will be monitored twice daily and maintained for the highest quality possible. It is expected that several types of hides or refuges will be supplied in order to maximize growth and survivorship, and detailed growth records will be kept for each batch of crabs.

Harvesting is expected to occur through a combination of baited traps and drain harvests, although other trap types may be trialed during the project. The ability of crabs to survive out of water for extended periods will facilitate storage of crabs for several days whilst continuing with trapping to make up consignments.

The production technology in this nascent industry is still being perfected and some form of experimentation is planned. For this reason, a detailed production plan is not available but the best technologies and practices

will be implemented. A range of stocking densities and stocking sizes will be trialed, as well as a range of feed stuffs, aimed at increasing productivity while reducing production costs. The design and use of refuge structures will also be trialed.

Previously negotiated markets could be serviced weekly with harvesting occurring almost continually for once-a-week packing and transport. The first shipments are envisaged for 5 months post stocking, and with careful management could be almost continual after that time, with drain harvests and intensive trapping to occur in time for peak summer prices.

Another factor worth considering is water discharge. Current best practice suggests the use of a settlement pond prior to discharge. There is a partly constructed discharge pond on site that could be redeveloped. Evidence from other farms suggests that mullet and similar herbivorous/planktivorous species thrive in these ponds. These fish may also be a food source for the crabs. Juvenile mullet are currently produced by a few east coast finfish hatcheries, but this work could be done at the DAC also. Alternately wild stocks of mullet could be stocked and left to maintain their own populations. There is also an opportunity to stock aquatic plants and sea cucumbers as bio-remediators. The latter organism is known as highly valuable Trepang in the Asian Markets.

2.5 Plant and Equipment

An experienced earthmover will be required for the pond redevelopment works. It is expected that the redevelopment, including adjustments to plumbing, might be completed within six weeks of starting.

Fencing, shed erection, water connection and electricity provision could be completed concurrently. If the project begins in the wet season, all infrastructure can be constructed and or installed with the exception of the earth works. These will be undertaken when the soil is dry enough to work.

An overview of the capital infrastructure costs (through estimation and quotes) is tabulated below.

Equipment required at Kulaluk	**Purchase $**
Pond Restoration	330,000
Processing shed	20,000
Aeration equipment	10,000
Shelters	5,000
Farm computer/camera/video	6,000
Monitoring equip	20,000
Fencing	20,000
Total	$411,000

2.6 Quality Control

The steering committee will oversee the quality control of all facets of the venture including OH&S, production processes, monitoring, food quality standards and the environmental management plan.

A designated mentor with experience in vocational training in a cross-cultural context will oversee the training and employment quality processes.

2.7 Regulatory Issues and Insurance

A Northern Territory Aquaculture License issued under the NT *Fisheries Act* will be required in order to undertake aquaculture and sell the product. As part of this license several requirements and permits are required. These are -

- Proof of tenure of the land (Land title or agreement – DIPE)
- Water uptake license (DIPE)
- Discharge permit (DIPE)
- An Aboriginal areas protection authority permit
- A development permit (Development consent authority)
- A business plan
- A security strategy
- An environmental management plan endorsed by the DIPE.

As this is the rejuvenation of the existing facility few hurdles are expected. These regulatory requirements will ensure that the operation is socially and ecologically sustainable in the long term. The various government bodies are currently processing applications for the various permits and licences submitted by GDA. All licenses and permits will be obtained by GDA.

Insurance costs are estimated to be around $9,000, which includes workers compensation and public liability.

2.8 *Commencement Date*

It is expected that the project will be fully funded in April or May 2005, and the redevelopment can occur during May - June 2005. The first batch of crablets may be stocked in June or July 2005, and the first harvests may be in December 2005.

3 MARKETING PLAN

3.1 Market Environment

Mud crab aquaculture is a new industry to Australia, although evidence of it in China goes back almost 100 years. For many years throughout Asia, juvenile crabs were caught and held in enclosures and were fed trash fish and other marine leftovers. This tactic led to over fishing of juvenile age classes and subsequent falls in recruitment. Several countries are now putting research effort into mud crab seed production technology.

Although mud crabs are native to the Asian region, the populations are generally over fished and are thought to pose little threat to the expansion of the mud crab aquaculture or fishing industries in Australia. Also, the premium *live* product cannot be imported into Australia due to legitimate quarantine restrictions, so the *live* domestic market is somewhat protected. Queensland, Western Australia and the Northern

Territory, where mud crabs are found naturally, all have input limits to the mud crab wild fishery and presently the NT harvest is considered sustainable, but fully exploited. This means there is little scope for expansion of the wild harvest sector.

This farming proposal will have no impact on wild crab stocks. Each mature female mud crab can produce up to three million eggs per spawn, and she may spawn three times per summer season. It expected as few as 8 female crabs will be taken from the wild to provide juveniles for this two year project.

3.2 3.2 Product(s)/Service(s)

Several diverse products will result from this project if undertaken appropriately.

It is envisaged that mud crabs will be harvested from the ponds to be sold to domestic markets. As these crabs are aquaculture products they are not restricted to size, sex or seasonal limits imposed on the wild harvest sector. This means that novel products such as smaller 'single serve' crabs, or female 'egg crabs' can be marketed. Also as this is an aquaculture venture, consistent supply throughout the year will aid in establishing regular markets. Specifically targeting the period when wild harvests are minimal (summer) will also improve prices. Having control over all the production processes is preferred to the boom-bust cycle of wild crab harvests, leading to better-negotiated prices for consistent supply.

If undertaken, this project will redevelop the existing pond facilities of the Gwalwa Daraniki and regardless of the eventual outcome of the mud crab aquaculture venture will leave them with multi-purpose marine ponds, which could be used for many forms of marine aquaculture. Completion of this project will enable the Gwalwa Daraniki to farm a variety of species for which markets exist. The redevelopment can also be used to demonstrate the technology, and the entire project development, to other Aboriginal communities not only across the Territory, but also across Australia. The training and employment will also aid in community capacity building.

A future product could be a tourism component to the venture. Guided tours, crab pot pulls and product sampling could be included.

The direct social benefits of this project will take the form of employment, training and revenue raising. The indirect social outcomes are likely to be much more wide ranging.

3.3 Distribution (Place) Arrangements

Local markets in Darwin will be serviced through direct sales to restaurants and wholesalers, but some product could be air freighted south to capital cities. Local markets can be serviced easily by road transport or by courier.

If large markets such as the Sydney Fish Market are used as a sales point, then commissions of up to 5% of sales price must be paid. Also, prices on the Auction floor tend to be lower than when dealing direct with restaurants or wholesalers, so this form of marketing should only be used for low-grade animals (missing legs, one claw etc.) and under a different brand name to protect the premium product.

All product will be processed and packed on site in approved aircraft containers, for 'dry transport'.

3.4 Competition and Competitive Advantage

The projects major competitor is the wild harvest sector. Their strength lies in their volume of production and in the size of their product, but they have some weaknesses. Firstly, they have virtually no control over productivity. The resource they utilise is considered to be fully exploited and there is little scope for expansion. They have limited control over when product will become available and their return on effort is unpredictable.

Wild crabs can come into the market in poor condition after having been in a box for up to a week. Some crabs are missing legs or claws and are sometimes presented poorly. It is expected that aquaculture crabs will be in the restaurants within 2 days of harvest from the ponds. They will be graded and sorted at the farm and packed professionally under strict quality guidelines.

Crab fishermen sell crabs in a range of sizes from legal size to the species' maximum size. Large crabs may fetch high prices due to a 'wow' factor but smaller crabs may suit different dishes. Feedback from some restaurants suggest a single crab approximately 400-500g (under current legal size) might be suitable, rather than using a very large (expensive) crab. It is expected that the size of the crab will have little role in determining the price paid per kilogram. Any mud crab is considered a premium product and commands a high price.

The annual commercial catch in the NT has dropped from record highs in 2000 and 2001, indicating that the demand for the product is increasing relative to current supply. The summer scarcity of mud crabs associated with breeding and migration, which coincides with traditional increases in demand (Christmas and Chinese New Year), makes an attractive target market.

The strength of an aquaculture venture lies in its marketing flexibility in regards to when or what product to sell, and it's ability to regulate the quality and quantity for specific markets. These luxuries are not available to the wild harvest sector, making this a major competitive advantage.

3.5 Customer Demographics

Fresh seafood is fast becoming a luxury item in many regions of the world. The marketing plan is yet to be finalised but in all likelihood the end user will be mid to high-class restaurants in the capital cities of Australia. The product volume will be the limiting factor initially (15,000 kg/yr), therefore niche marketing to large restaurants or chains should not be difficult. People dining in these restaurants expect, and are willing to pay a premium for, quality fresh seafood.

3.6 Market Research

A small number of pond-cultured crabs from a preliminary grow out experiment were made available earlier this year for market evaluation. The feedback was positive. Some of the crabs supplied were less than 300 g and considered to be slightly small. A minimum size of 350 g was considered to be suitable for 1 serve. Regardless of the size, the taste was assessed as excellent.

The Sydney Fish Market was contracted to undertake a market analysis which found that our figure used for sales price ($15/kg) was "not unreasonable as prices significantly in excess of this are achieved at the SFM for most of the year" (SFM, 2005. – confidential report. Available on request)

3.7 Price Strategy

The pricing strategy will be dependant on the wholesale seafood markets. Some product may be auctioned, although this may be reserved for second grade or damaged crabs. Premium product may be sold to wholesalers or direct to restaurants in various cities. It is expected that when in full production, with consistent quality and volume, that a price slightly above wild harvest crabs will be paid.

Currently seafood wholesalers in the NT pay around $13/kg for wild caught mud crabs, although this rises to around $20/kg in peak demand seasons. They then process, clean, pack and transport these crabs to markets or restaurants. If the venture proposed here performs these roles, the average price they can expect to get is around $21.50/kg. This was the average price paid for live, intact, mud crabs on the Sydney Fish Market floor in 2003. Processing, packing and transport may cost up to $4-5/kg. Higher crab prices can be expected from established, negotiated markets.

The economic models used in this proposal are based on an average price of $15/kg which is considered conservative. Live product is GST free.

3.8 Advertising and Promotional Strategy

It is anticipated that very little in the way of promotional activity will be necessary as this is an established market product. Both the Sydney and Melbourne Fish Markets have already been advised that sub-legal sized aquaculture mud crabs from the NT can be expected in the future. Initially it is anticipated that the majority of production will be marketed through existing processors. The NT Seafood Council will also be available to aid in developing networks of people involved in the seafood production and supply chains.

Direct marketing to restaurants may also be an option especially for local and perhaps domestic markets. Care will be taken not to compete directly with wholesalers marketing GDA product.

Recipe cards have proved successful for a range of retail seafood products. Specific farmed mud crab recipe cards, which also expound the benefits of Aboriginal aquaculture, could be developed and made available in markets for uncooked product.

Initially, however, it is expected that the promotional budget would best be spent developing relationships with large wholesalers and restaurant chains.

3.9 Market Targets

Experimental yields have been around 0.7 crabs /m^2, with an average weight of 250g. This was achieved in five months. There are 4 ponds available at Kulaluk, totaling 2.5 ha or 25,000 m^2, and it should be possible to produce around 7,500 kg per cycle, or just over 15 tons per year from two crops when in full production.

However, it will not be possible to fully stock the farm at one time due to limitations in crablet production capacity of the DAC. A staged stocking and production cycle will be necessary. This will also aid in staggering production and marketing. It is probable that a full production cycle encompassing the harvest of approximately 7 tons of crabs and subsequent restocking of all 4 ponds will be achievable within 12 months of the first stocking. Full production will be possible from this point forwards (ie. 15-16 tons pa.).


PRODUCT OF
Northern Territory
AQUACULTURE

4 THE FINANCE PLAN

4.1 Financial Strategy

The enterprise proposed here will need to secure funding for both capital expenses and the first year's operating costs. Below is an itinerary of costs and expected revenues as well as a sensitivity analysis.

Due to the nature and aims of the venture, viz crab production for GDA as well as community capacity building and the establishment of a demonstration or model farm for adaptation in other Aboriginal communities across tropical Australia, a combination of Territory and Federal funding is considered appropriate.

The non-staffing costs for DBIRD of maintaining and operating the crab hatchery as well as crablet production have been estimated at $128,025 per annum (Table 1.). However there are additional resources required, at a cost of $21,000, that are needed for the commercial production of the crablets (Table 2.).

Table 1. GDA and DBIRD in-kind resource contributions to the project

Resources supplied by GDA and DBIRD's DAC		**$**
Gwalwa Daraniki Association (allowing for depreciation over 8 years 1997-2005)		
Land rental		63,012
Pond development, service road and land management		127,644
Over head power lines		2,500
Cement pad for shed		2,025
Farm Administration Office and equipment		5,800
Total		$200,981
Darwin Aquaculture Centre		
Brood stock maturation, larval rearing and nursery facilities		80,000
Salt water + fresh water		7,775
Aeration		1,500
Land Rental		1,200
Stationary and equipment rental (phones Internet)		4,500
Property maintenance (security)		4,000
Vehicle cost (extension)		8,000
R & M		7,900
Depreciation		13,150
	Total	**$128,025**

Table 2. Additional resources required by and DAC for the project commercialization

Darwin Aquaculture Centre		
Hatchery feeds		2,000
Heat/chill pump purchase (yr 1 only)		10,000
Pumps and plumbing purchase (yr 1 only)		5,000
Heaters thermostats (yr 1 only)		4,000
	Total	**$21,000**

Table 3. In-kind staffing costs of GDA and DAC (salaries + 32% on-costs) for the project

Position		$
Gwalwa Daraniki Association		
Chairman of GDA (0.2)		10,560
Management Board Member (0.2)		25,000
Secretary (0.2)		7,920
	subtotal	**43,480**
Darwin Aquaculture Centre		
P2 level Scientist / Manager (0.8)		68,191
T3 Senior Technician		65,485
Aboriginal liaison officer (T3 level) (0.2)		13,097
P2 Extension / Production (0.8)		68,191
	subtotal	**214,964**
	Total	**258,444**

The total in-kind contribution by GDA is $244,461 per annum . The DBIRD total in-kind contribution is $342,989 per annum. Additional funds required in the first year total $21,000.

The project costs are listed in the tables below. Capital expenses for redevelopment are in the order of $411,000 (Table 4.). Further capital, in the order of $100,000, is required in the second year for initiating best-practice techniques and for the proposed expansion.

Table 4. Capital items at the farm

Capital Costs - Essential	**$ Yr 1**	**$ Yr 2**
Pond Restoration and expansion	330,000	100,000
Processing shed	20,000	
Aeration	10,000	
Shelters	5,000	
Monitoring equip	20,000	
Farm computer/camera/video	6,000	
Fencing	20,000	
Total	411,000	100,000
Desirables		
Stand-by Generator / fuel store	20,000	
2nd hand Ute (GDA)	20,000	

Annual operating costs are expected to be around $128,500 for the 2.5 ha farm in the first year (Table 5.), and around $170,500 for the 3.0 ha in the second year.

Table 5. Annual operating expenses for 2.5 ha. Extra costs in food and crablets in the second year.

Operating Expenses pa.	Yr 1	Yr 2
Accountant Fees	5,000	5,000
Solicitor Fees	1,000	1,000
Insurance Premiums	10,000	10,000
Advertising & Promotion	3,000	3,000
Telephone Installation	1,000	1,000
Printing/Stationery	500	500
Registration/Licenses	2,000	2,000
F.O.R.M.	5,000	5,000
Electricity	15,000	15,000
Food	42,000	54,000
Crablets (2 crops 75,000 each @20c/crab)	0	30,000
Demountable workshop/shed/accommodation	10,000	10,000
Fertilisers	1,000	1,000
Chemicals	500	500
Cleaning equipment	200	200
Consumables	300	300
Processing/packing (40c / kg)	6,000	6,000
air freight	24,000	24,000
courier	2,000	2,000
Total	128,500	170,500

Table 6 shows estimates of wages or salaries required to undertake the operations both at the DAC and at the farm. To ensure the trainees successful training outcomes, and to ensure appropriate and effective extension services are maintained on the farm, it is necessary to have an additional person assigned to the crab project. It is intended that a lower level technician (T2) be employed by the DAC to free up the senior technicians and extension staff so they can focus on the agreed service level for the project. It is expected that DEWR will fund the cost of the apprentices.

Table 6. Positions required to run the project at Kulaluk (+ proposed sources of funding)

Positions	$ PA
Overtime weekend work for DAC staff (project funds)	10,000
Farm manager (Funding / revenue) (salary + 32% on-cost + overtime)	84,000
Training mentor (Funding / revenue) (salary + 32% on-cost + overtime)	70,000
DAC T2	70,000
Apprentices x 8 @ $22,000	176,000
Total	410,000

Table 7 looks at expected production and revenue raised. From preliminary work in previous trials, we estimate that if 2 crabs are stocked per square meter and are grown for 6 months, survival can be around 35%, and average weight will be around 450 g. If this is the case then each year a 2.5 – 3.0 ha farm should harvest around 35,000 crabs with a total weight of 15,750 kg. If a price of $15 per kg was paid, then revenue of $236,250 will be obtained.

In the second year an extra 3150 kg of crabs should be produced from the extra 0.5 ha, worth an additional $21,000.

Table 7. Estimated production and revenue

Production				
Hectares stocked	2.5			
Crablets per sqm	2			
Crop period	6 mo.			
Number crablets stocked (yr)	100,000	plus 5%	**Expected**	minus 5%
Survival	35%	40%	**35%**	30%
Avg weight (g)		450	**450**	450
Total weight per crop (kg)		9,000	**7,875**	6,750
Total weight per year.(kg)		18,000	**15,750**	13,500
Revenue				
	($/kg)			
	12	216,000	189,000	162,000
	13	234,000	204,750	175,500
	14	252,000	220,500	189,000
	15	270,000	**236,250**	202,500
	16	288,000	252,000	216,000
	17	306,000	267,750	229,500
	18	324,000	283,500	243,000
	19	342,000	299,250	256,500
	20	360,000	315,000	270,000
	25	450,000	393,750	337,500
	30	540,000	472,500	405,000

Table 8 shows a sensitivity analysis for revenue for the 2.5 ha farm for changes in production and price per kg. If the total weight of production decreased by 10% below projected levels then a price of between $16 - $17 would be required to maintain revenue levels.

Table 8. Sensitivity analysis for changes in production and price per kg.

Sensitivity Analysis

		Price paid ($/kg)								
Prodn. (kg/farm)	% Change	12	13	14	**15**	16	17	18	19	20
9450	-40	113,400	122,850	132,300	141,750	151,200	160,650	170,100	179,550	189,000
11970	-30	143,640	155,610	167,580	179,550	191,520	203,490	215,460	227,430	239,400
12600	-20	151,200	163,800	176,400	189,000	201,600	214,200	226,800	239,400	252,000
14175	-10	170,100	184,275	198,450	212,625	**226,800**	**240,975**	255,150	269,325	283,500
15,750	0	189,000	204,750	220,500	**236,250**	252,000	267,750	283,500	299,250	315,000
17325	10	207,900	225,225	242,550	259,875	277,200	294,525	311,850	329,175	346,500
18900	20	226,800	245,700	264,600	283,500	302,400	321,300	340,200	359,100	378,000
20475	30	245,700	266,175	286,650	307,125	327,600	348,075	368,550	389,025	409,500
22050	40	264,600	286,650	308,700	330,750	352,800	374,850	396,900	418,950	441,000

Table 9 shows the expected farm expansion (hectares stocked) and subsequent increase in revenue for the farm during the first 6 years annually, and then at yr 10. There is a slight increase in survival as husbandry improves around yr 3, however there is no assumed increase in harvest size. Total weight of crabs increases proportionately with the number of hectares stocked. Price per kg is shown to increase from $15/kg to $20/kg over 6 years. In reality we would expect this to happen within 2-3 years as product quality and consistency is realised in the marketplace.

Table 9. Expected Production and **Revenue** for the farm during expansion

	Yr 1	**Yr 2**	**Yr 3**	**Yr 4**	**Yr 5**	**Yr 6**	**Yr 10**
Hectares stocked	2.5	3	3	3	5	8	10
Crop period	6 mo	6 mo	6 mo	6 mo	6 mo	6 mo	6 mo
Survival	35%	35%	40%	40%	40%	40%	40%
Avg weight (g)	450	450	450	450	450	450	450
Wt per crop (kg)	7,875	9,450	10,800	10,800	18,000	28,800	36,000
Wt per year (kg)	15,750	18,900	21,600	21,600	36,000	57,600	72,000
Revenue for farm ($/kg)							
12	189,000	226,800	259,200	259,200	432,000	691,200	864,000
13	204,750	245,700	280,800	280,800	468,000	748,800	936,000
14	220,500	264,600	302,400	302,400	504,000	806,400	1,008,000
15	**236,250**	283,500	324,000	324,000	540,000	864,000	1,080,000
16	252,000	**302,400**	345,600	345,600	576,000	921,600	1,152,000
17	267,750	321,300	**367,200**	367,200	612,000	979,200	1,224,000
18	283,500	340,200	388,800	388,800	648,000	1,036,800	1,296,000
19	299,250	359,100	410,400	**410,400**	**684,000**	1,094,400	1,368,000
20	315,000	378,000	432,000	432,000	720,000	**1,152,000**	**1,440,000**
25	393,750	472,500	540,000	540,000	900,000	1,440,000	1,800,000
30	472,500	567,000	648,000	648,000	1,080,000	1,728,000	2,160,000

4.2 Balance sheet estimates

The estimates shown below have been derived from the previous business plan put together by the Gwalwa Daraniki Association and Tropical Aquaculture Australia, as well as data sourced by the Department of Business, Industry and Resource Development.

There are large capital requirements in the first and second years of the project. In the first year this is to cover the redevelopment works while in the second year expansion of a further 0.5 ha of ponds is expected.

External funding will be required to begin the project, as outlined below (Table 10).

Table 10. Estimated receipts and payments

	Yr 1	Yr 2
Estimated receipts		
Sales*	160,000	302,400
ACC Grant		200,000
OIPC Grant	297,500	
DEWR Funds	176,000	176,000
DAFF Grant	100,000	
ABA Grant	294,000	151,500
Total Grants Funding	867,500	527,500
Total	**1,027,500**	**829,900**
Estimated payments		
Capital	432,000	100,000
Operating	128,500	170,500
Farm & DAC Wages	234,000	234,000
Trainee costs	176,000	176,000
Total	**970,500**	**680,500**
surplus/deficit	**57,000**	**149,400**

*For this model we are assuming that revenue from the first year's harvest will be lower than anticipated due to teething problems and return $160,000.

If all grants are received for two years ($867,500 in yr 1 and $527,500 in year 2), plus the revenue from sales, then profitability is achieved immediately, and farm growth can occur. As the farm grows, more technicians can be trained and employed. A 10-year projection of costs, revenue and balance is shown in Table 11.

Table 11. Ten year projections of costs, revenue and balance for the Kulaluk mud crab farm.

	Yr 1	**Yr 2**	**Yr 3**	**Yr 4**	**Yr 5**	**Yr 6**	**Yr 10**
Farm expansion (ha)	2.5	3	3	3	5	8	10
Farm Capital	411,000	100,000			300,000	400,000	300,000
DAC Capital	21,000						
Operating	128,500	170,500	176,500	184,200	269,700	418,400	498,360
Salaries							
DAC Overtime	10,000	10,000					
DAC T2 extension	70,000	70,000					
Farm manager	84,000	84,000	80,000	80,000	80,000	80,000	80,000
Training mentor	70,000	70,000					
Apprentices x 8 @ 22,000	176,000	176,000					
Technicians (x 3, 3, 4, 5, 8)			120,000	120,000	160,000	200,000	320,000
Total costs	970,500	680,500	376,500	384,200	809,700	1,098,400	1,198,360
Revenue - Crab sales	160,000	302,400	367,200	410,400	684,000	1,152,000	1,440,000
Grant / Loan funding	867,500	527,500					
Yearly Balance	57,000	149,400	-9,300	26,200	-125,700	53,600	241,640
Cumulative Balance	57,000	206,400	197,100	223,300	97,600	151,200	1,753,640

The Grant or loan funding required to initiate and operate the venture is $867,500 for year 1 and $527,500 for year 2. The more money that becomes available the more training and employment outcomes there will be. The committee has agreed that funds will be pursued from a variety of agencies as listed below.

Table 12. Preferred sources of income for the two year project . (Italicized funds are committed as at 8 April 2005)

Cash contributions			
	Yr 1	**Yr 2**	**Total**
DAFF	$100,000		$100,000
OIPC	$297,500		$297,500
ACC		$200,000	$200,000
ABA	$294,000	$151,500	$445,500
Total	$691,500	$351,500	$1,043,000
In-Kind Contributions			
DEWR	$176,000	$176,000	$352,000
DBIRD	342,989	342,989	$685,978
GDA	200,981	0	$200,981
Total	$719,970	$518,989	$1,238,959
		Total	$2,281,959

The grant funding shown in Table 12, will support the business as set out in this plan. Surplus funds will support additional infrastructure (eg larger shed, semi-permanent residence, training resources and facility) and business resources (vehicle). Additionally, this money could be used to leverage additional funds on behalf of the community to support other businesses or community development initiatives identified under the new Community Development Plan. This will maximize community participation in training and employment activities and build community capacity.

4.3 S.W.OT. Analysis

The project's strengths can be maximised by ensuring appropriate planning and management of the partnerships and crab production venture. If the steering committee manages effectively, supply chain networks can be facilitated, production and quality can be maximised and weaknesses and threats can be minimised.

Specifically, minimising risks of the project can be undertaken by,

1. Establishing and maintaining good relationships within steering group membership
2. Prudent planning and management by the steering committee
3. Maintaining a strong commitment by all members, especially the Gwalwa Daraniki and DAC.
4. Establishing firm goals, outcomes, and responsibilities for all parties
5. Ensuring accountability and review processes are in place
6. Addressing under capitalisation as a real threat and sourcing funds appropriately
7. Ensuring the pond structures are rehabilitated appropriately
8. Ensuring the production plan is resourced appropriately
9. Applying research to maximise production
10. Ensuring market plans are in place and networks established
11. Maintaining a high standard of applied technical input from the DAC
12. Addressing security issues and maintaining fences to protect assets
13. Ensuring specific training and employment goals are set and facilitating these outcomes

Below is a tabulated S.W.O.T analysis.

Strengths	***Weaknesses***
Using experienced NT commercial aquaculturists Network of support from various areas Only aquacultured crabs available Larger product diversity More consistent supply Better quality control over all processes Ability to target specific markets Geographically close to • Crablet supply, infrastructure, workforce • Guidance, Training providers Aid in improved land management	New technology Relatively unknown market demand No specific artificial feed available Project not yet fully funded
Opportunities	***Threats***
Training for Aboriginal communities Employment Economic development Community capacity building Future integrated tourism venture Production-type research to improve efficiency. Selection of fast growing strains	Crop failures Productivity not viable No demand Disease Partnership failures Poor security DAC fails to supply crablets Project under capitalisation Importation of cheap crabs

4.4 Risk Assessment of Mud Crab Venture

As with all aquaculture ventures, there is an element of risk that needs to be considered. Projects that are expanding the frontiers of our knowledge tend to involve higher risk and therefore require a more rigorous risk management process. This has been addressed by the inclusion of mud crab experts from the Darwin Aquaculture Centre as scientific advisers/researchers in the first two years, with the expectation that commercialization will take place in Years 3-4. Indigenous staff will train at the Charles Darwin University's Aquaculture Unit. Most importantly, the project is under pinned by experienced private sector participants from the NT that have been working with the Traditional owners of GDA since a mud crab aquaculture venture was proposed almost two year ago. These participants have collectively over 50 years experience developing commercial aquaculture projects and capacity building/training of Indigenous people in aquaculture and business.

The following assumptions have been made about key events that will or could impact on the Mud Crab Aquaculture Venture:-

1. The necessary leases and licenses will be issued;
2. Approvals will be granted for the upgrading/expansion of the current ponds, including additional infrastructure;
3. The necessary funds can be identified for the project;
4. The funds will be delivered in a timely manner;
5. The animal can be reared in an artificial environment to a marketable size;
6. The animal can be successfully transferred from the artificial environment back into the natural environment, i.e. mangrove paddocks;
7. The animal will grow at the predicted rate;
8. Aboriginal people will be interested in working in the venture;

9. The product will be marketed as predicted; and
10. Payment for the marketed product will be made in a timely manner.

- *The necessary approvals will be granted for the upgrading/expansion of the current infrastructure:* The location of the ponds presents some interesting challenges. They are located within a Special Purpose Lease that is surrounded by urban development along the eastern and northern boundaries. The reason the lease has been left relatively undeveloped, apart from a major transport corridor, is that the land is not considered suitable for any urban or industrial development. The Association will need to convince the appropriate authorities that their future social and economic well-being depend on being able to develop the area for aquaculture. Though this may be an arduous process, such a development meets the current Government's policy for encouraging and supporting Indigenous economic independence. Approaches are currently being made to ensure that the economic aspirations of the Traditional Owners of the lease are considered in the new Harbour Management Plan. Without the planning approvals, however, the venture will not be able to proceed.

- *The necessary funds can be identified for the project:* The project presents some unique challengers for potential funding agencies or investors. Mud crab farming has been a "cottage" industry in Asia for nearly three decades. Though it is an important part of the aquaculture economy, it has tended to remain little more than a subsistence activity, due to a lack of a consistent supply of seed stock. With the technology gains by the Darwin Aquaculture Centre, it is now possible to intensify grow-out by utilizing hatchery produced stock and the already available ponds with adjacent mangroves in the Darwin Harbour.

- *Mud crabs can be reared in an artificial environment to a marketable size:* The research from Asia (Keenan and Blackshaw, 2001; and Workshop on Mud Crab Rearing, Ecology and Fisheries; International Forum on the Culture of Portunid Crabs, 1998) clearly demonstrates that mud crabs can be successfully raised in ponds and mangrove paddocks to a marketable size. In Asia this tends to be in the range 350 to 500 grams. The financial projections have been based on harvesting a 380 g crab. Crabs within this range have been successfully farmed in the Philippines, Thailand and Indonesia. The challenge of the researchers in this venture will be to raise crabs to this size with increased densities.

- *Mud crabs will grow at the predicted rate:* The grow-out research has predominantly taken place in Asia, although the DAC has now put through several grow out batches of crablets in ponds and experimental pond grow-out has occurred in Northern Queensland. The Australian focus has predominantly been hatchery research. The Asian research clearly demonstrates the rate at which mud crabs will grow in both ponds and mangrove paddocks. The grow-out however has mostly focused on small subsistence farmers, with some data coming from larger research institutions. This venture will be the first attempt to intensively farm mud crabs in Northern Territory by an Indigenous community. It is expected the research team will be able to duplicate the Asian results, and hopefully improve upon them through the use of ponds as grow-out areas.

- *Aboriginal people will be interested in working in the venture:* The Gwalwa Daraniki Association and some of its members have indicated a strong desire to participate in this venture. In addition there are other Indigenous people in the greater Darwin area with whom the Larrakia leaseholders have strong relationships. The Indigenous research assistants and farm hands will be drawn from the local Darwin Aboriginal population with special preference being given to members who live on the lease. The Association intends to provide assistance through the CDEP (Community Development Employment Program - work for the dole scheme) and a STEP program with top up money coming from the venture. Adult apprentice wages will be paid.

- *The product will be marketed as predicted:* Enquiries with local suppliers and their national networks, as well as seafood wholesalers in Singapore and Hong Kong, indicate that marketing the live mud crabs will not be difficult. Price will tend to fluctuate, and size at harvest will depend on

the intended market. At this time the North American and European markets have not been explored. This will be done during the two-year research component of the venture.

It is possible to make a simple calculation to identify risks that need to be managed. In this system, the seriousness of the potential risk is ranked on a scale of 1 (low) to 5 (high). The probability of the risk occurring is also ranked on a scale of 1 (low) to 5 (high). When the two figures are multiplied, they give a score that allows you to assess how important it is to manage the risk. The maximum score is 25 – a very serious risk, which is very likely to occur. That risk needs to be managed effectively.

RISK ANALYSIS AND MANAGEMENT PLAN

Identified Risk	Seriousness 1 = low, 5 = high	Probability 1 = low, 5 = high	Score (seriousness x probability)	Manage risk?	Strategy to manage risk	Responsible agency
3. The necessary leases and licenses are not issued	5	2	10	yes	Applications will be made for the necessary leases and licenses. Relevant authorities will be lobbied to expedite their issue.	GDA
4. Approvals not granted for the upgrading & expansion of the current ponds, including additional infrastructure.	5	2	10	yes	The Lease Holders and the major land user in the area support the project. Relevant planning authorities will have to be approached to gain the necessary approvals. Garner letters of support for the project	GDA
3. The necessary funds are not committed to the project	5	3	15	yes	All potential sources of funds are being explored. Statutory as well as private venture capital will be approached during the expansion phase.	GDA
4. The funds are not delivered in a timely manner;	4	2	8	yes	The venture's project managers will need provide timely milestone reports to funding agencies, and maintain high levels of communication	GDA / NTG
5. The animal cannot be reared to a marketable size in an artificial environment	5	1	5	yes	Grow-out techniques are routine in Asia and have been published in several scientific journals. Preliminary growout trials by the DAC have proved successful, although improvements can be made	GDA / NTG
7. The animal does not grow at the predicted rate;	4	1	4	yes	Growth rates of mud crabs in contained environments are dependent on temperature and food. The grow-out will be closely monitored in the first two years of operation (Research) to assess the growth rates and if necessary adjust the projections. Little can be done to improve temperature of a pond but feed requirements will be closely monitored. Continual improvement is expected	GDA / NTG
8. Aboriginal people will not be interested in	4	2	8	yes	The Joint Management Agreement has listed the responsibilities of each partner in relation to local employment. The	GDA / NTG

working in the venture;					employment of local people has benefits to the venture. Accredited training will be provided and jobs will be tailored to the needs of local people within the constraints of the venture's viability. Local people have already indicated a strong desire to participate.	
9. The product will not be marketed as predicted;	5	2	10	yes	The current wholesale price needs to stay above $15 / kg for financial projections to be achieved. Seafood marketing networks must be utilised and steady production volumes must be established	GDA / NTG
10. Payment for the marketed product is not made in a timely manner	4	2	8	yes	The markets for the product are local and international. Payment will be required on a 30 day basis locally and a COD basis internationally. Credit references will be required locally and Letters of Credit or Bank Notes internationally	GDA / NTG
Technical risks						
1. Poor water quality	5	2	10	yes	Daily extension services by experienced aquaculture technicians from GDA's consultants (Tropical Aquaculture P/L), Government and the University. Specialist on-the-job training in pond water quality management. Mud crabs have proven tolerant to moderately poor water quality in preliminary trials.	GDA / NTG
2. Algal Blooms / aquatic weeds	2	3	6	yes	Excessive plant growth is attributed to excess nutrient in the water. Water quality will be tested daily, accurate records kept and problems managed through food reduction or flushing. Aquatic weeds usually develop due to clear water. This can be countered by using soluble fertilisers to establish a beneficial microalgal bloom.	GDA / NTG
3. Animals are poached / equipment vandalised	4	2	8	yes	Plans are in place for the hiring of a small demountable building for a live-in technician. This person will be responsible for security and for emergency response. This was seen as a community role in the deed of agreement	GDA
4. Water pump / aeration failure	3	2	6	yes	The ponds will be run in a moderately extensive fashion and so risks associated with poor water quality / nutrient overloads are minimised. The farm is centrally located in Darwin with easy access to trades and emergency services. Back-up aerators will be available.	GDA

APPENDIX 2

9.2. Mudla Farm 1st Annual Report

Mudla Farm

1st Annual Report

(Alias Revised business Plan)

May 2005-April 2006

Prepared by
The Gwalwa Daraniki Association, and
*Northern Territory Department of Primary Industries, **Fisheries** and Mines*

May 2006

Northern Territory Government
Department of Business, Industry and Resource Development

Participation from Beginning to End providing a sense of pride and ownership

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EXECUTIVE SUMMARY

- Gwalwa Daraniki Association (GDA) has established Australia's first indigenous owned and operated mud crab aquaculture venture in salt-water ponds on their land at Kulaluk, in Darwin. To do this the GDA established a separate entity to operate the venture: Gwalwa Daraniki Enterprises (GDE) acting as trustee for Mudla Farms Charitable & Benevolent Trust (ACN 114 704 666).

- After almost two years of attempting to establish a mud crab farm, GDA in November 2004 signed a two-year agreement with the Northern Territory Government through the Department of Primary Industry, **Fisheries** and Mines (DPIFM), to jointly progress the project. After an agreed two year period of operations, GDA (through GDE) will continue the operation as a fully commercial venture through the Mudla Farms Charitable & Benevolent Trust.

- GDA is building capacity within the community by supporting training and promoting real employment in the mud crab farm.

- NT Fisheries in partnership with the GDA is using the facility to create appropriate models for the commercial farming of mud crabs on indigenous land in regional and remote communities of the NT and Northern Australia. The facility is also serving as a demonstration site for interested communities.

- A stakeholder-based steering committee comprising representatives from the GDA, NT Government, through Fisheries and DEET, Charles Darwin University, the Australian Government's DAFF, DEWR, DIMIA Office of Indigenous Policy Coordination, and the Northern Territory Area Consultative Committee (NTACC) are overseeing the development.

- A private company, Tropical Aquaculture Australia (TAA), have been employed during the first two years of operation to physically run the farm and oversee the training outcomes for community staff.

- DPIFM has, and will continue to contribute substantial in-kind funds for a minimum period of two years. GDE contributes in-kind the costs of the land as well as costs associated with the development of several hectares of pre-existing marine ponds.

- The crab farm is expected to produce approximately 15 tons of mud crabs per annum when fully operational, generating around $235,000. These crabs will be of a minimum size of 350 g which are smaller than crabs from the wild and represent a marketing advantage in Asian markets.

- The project will expand a further 0.5 ha in the second year and up to ten ha within ten years. Financial projections suggest profitability increases as the farm grows due to economies of scale.

The Board of Mudla Farm reports that -

- Grant funding has been forthcoming to initiate this venture,
- All permits and licenses have been granted by the various authorities,
- Trainees have been appointed and have successfully completed some units of study towards their certificates,
- The community's pond infrastructure has been rebuilt and is now operational,
- Additional rudimentary infrastructure has been purchased,
- The ponds have been stocked with crablets supplied by the DAC, (4000 in December 2005 as a trial stocking, and 45,000 in February 2006).
- The crabs have been growing as expected, with the front runners going out to market already, and fetching $19 per kilogram, which is 25% higher than initial estimates. Thus far volumes have been relatively low however.
- The site has been used to demonstrate technology to other indigenous communities and a knowledge exchange has occurred between the Kulaluk and Maningrida communities.

1. INTRODUCTION

This 1st Annual Report outlines the establishment of an indigenous owned and operated mud crab aquaculture venture in salt-water ponds on the Gwalwa Daraniki Association (GDA) lands at Kulaluk, in Darwin (Figure 1.). It also hopes to address any potential funding gaps and will make suggestions to ensure profitability and sustainability, and the achievement of initial objectives.

The GDA approached the Northern Territory Government (NTG) after hearing of their success in rearing crablets in the hatchery. GDA with Tropical Aquaculture Australia (TAA) produced a feasibility study and business plan for a commercial venture in 2003 to grow-out hatchery crablets purchased from the DAC but were unable to attract government or private funding at that time.

Figure 1. The pond facility prior to re-establishment as a crab farm, on Gwalwa Daraniki land at Kulaluk.

In November 2004, a two-year agreement was signed by the GDA and DPIFM's Fisheries Group to jointly progress the project. After the two year time period, GDA will continue the operation as a fully commercial venture through the Gwalwa Daraniki Enterprises P/L (GDE) acting as Trustee for Mudla Farms Charitable & Benevolent Trust (ACN 114 704 666). The original business plan (April

2005) concentrated on the two-year partnership, although financial projections extended to show profitability in the longer term.

One of the briefs of DPIFM is to stimulate economic and social development of Aboriginal communities across the Northern Territory. It is proposed that crablets produced at the DAC be used for grow out under a commercial arrangement at the Kulaluk pond facility belonging to the Gwalwa Daraniki people in Darwin. The project aims to integrate capacity building exercises of training and meaningful employment, with a commercial aquaculture venture. In the longer term, the facility will act as a model and demonstration farm for remote ventures.

The establishment and early operating costs of the project have been funded by a combination of monies and resources derived from the Northern Territory Government, the Federal Government, and the Gwalwa Daraniki people.

1.1 Project Objectives

The specific aims or objectives of the project are broad. GDE wants to establish a long-term sustainable aquaculture venture on their land. DPIFM aims to use the facility, once established, to create appropriate models for the commercial farming of mud crabs on indigenous land in regional and remote communities of the NT. In this way, the project will use GDE as a model for Indigenous Economic Development (IED). This will entail building capacity within the community by supporting training and promoting real, sustainable employment in a commercial venture – the mud crab farm.

A steering committee comprising representatives from relevant stakeholder groups have overseen the development to date. These groups include the GDA, NT Fisheries, the Australian Government Departments of Agriculture, Fisheries and Forestry (DAFF), and Employment and Workplace Relations (DEWR), the Office of Indigenous Policy Coordination (OIPC) within the Australian Department of Immigration, Multicultural and Indigenous Affairs (DIMIA), the NT Department of Employment Education and Training (DEET), Charles Darwin University (CDU), the Northern Territory Area Consultative Committee (NTACC), and Tropical Aquaculture Australia P/L.

A farm manager has been employed to physically run the farm and GDE representatives are undertaking DEWR funded aquaculture traineeships with time spent at the Darwin Aquaculture Centre (DAC) and at the farm. There are also trainees studying business management and Administration. A training mentor has also be engaged to oversee training outcomes of farm staff.

DPIFM is contributing substantial in-kind resources to the project in the form of infrastructure and personnel associated with the operation of the hatchery, and a DAC extension officer is providing technical assistance on farm.

As a business, the crab farm aim's to produce mud crabs of a minimum size of 350 g. These are smaller than those caught legally in the wild and thus may represent a market advantage. Asian seafood buyers in particular have expressed an interest in small crabs. Initial estimates suggested that around 15 tons of mud crabs could be grown in the existing 2.5 ha of ponds (this represents 6 tonnes /ha/year or 6000 x 2.5 =15,000 crabs/ha = 1.5 crabs/m^2) and may generate around $235,000 per annum. The project is on track to expand a further 0.5 ha in the second year.

Profitability of the project will depend on the ability of the project to ensure operating costs are kept close to the projected revenue (to allow maximum participation and benefit). Once production is established the profitability of the business should increase as the farm grows due to economies of scale.

Strategic Objectives

For GDE

- Sustainable aquaculture venture on their land
- Training and employment

For DPIFM

- Develop appropriate models for mud crab aquaculture development in regional and remote communities
- Build capacity of indigenous communities for greater economic and social outcomes

Operational Objectives	**Status**
Develop business plan	Achieved
Develop grant applications	Achieved
Secure funding for capital and operations	Achieved Some funding gaps identified
Re-develop infrastructure	Partially complete and on-going
Recruit Farm Manager and Training mentor	Achieved
Recruit trainees	Achieved
Build capacity of community through training and employment	Achieved and on-going
Stock and grow crabs	Achieved
Harvest and market crabs	Achieved and on-going
Produce 15 ton per annum of marketable crabs	Not yet achieved – ongoing (<12 mo growout)
Achieve a market price of $15/kg	Achieved (currently $19/kg)
Trainees gain Certificates	Not Yet Achieved – expected after year 2
Community independently runs farm	Not Yet Achieved – expected after year 2

2. THE OPERATIONAL REPORT

2.1 Organisational Structure

A steering committee has been convened to oversee the development from the planning stage to stand alone commerciality. Membership of the steering committee has been inclusive rather than exclusive, but has been limited to key personnel from the various organizations involved to remain effective.

The structure of the business for the first two years has been determined by an agreement between the two primary agencies, the Gwalwa Daraniki Association (through GDE) and Northern Territory Fisheries. A Project Board has also been established to oversee the planning, development and financial management of the farm for the first two year period. The Board consists of two persons each from NT Fisheries and GDE, and one independent person, Dr John Humphrey, the NT's Senior Aquatic Veterinarian. After the two year time period, GDE will have full control.

Presently the Project board is Ian Ruscoe and Bill Flaherty of NT Fisheries, Helen Secretary and Wayne Alum from GDA and Dr John Humphrey.

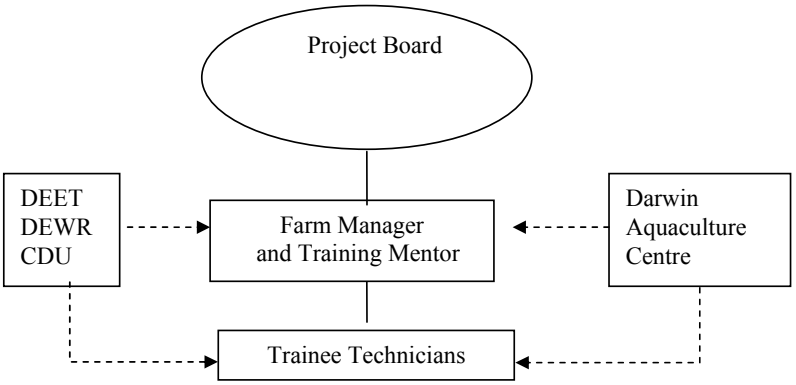
The Board has appointed Tropical Aquaculture Australia to manage the farm and to oversee educational outcomes of the trainees. It was intended that the farm manager would oversee the general management of the farm and would take direction from the board, receiving assistance from the Darwin Aquaculture Centre researchers and technicians. The Farm Manager's role was envisioned to undertake the production and sale of the crabs including some employee training and supervision, and all small business management roles. The manager was to have an active role in OH&S, planning and preparations for harvesting, processing and marketing, and in ensuring quality control measures are in place.

To date the farm manager has completed these roles, however in addition to this, the farm manager has had to take on a role in writing funding applications, administration and reporting on grants on behalf of the project as well as the community, which was not initially envisioned but which is taking up a large part of the manager's time. Other areas of the farm's operations may fail if the farm manager becomes spread too thinly. This situation has been identified by the board as requiring some attention, and is currently being addressed.

The Training Mentor is overseeing the delivery of quality training to the trainees and is ensuring trainees complete required work on time, to an acceptable standard.

DAC staff and extension officers are providing technical advice for crab aquaculture. The extension officers are providing advice on the husbandry of crab production (not small business management), and are assisting by giving technical advice that leads to maximized production, environmental sustainability, accurate record keeping and troubleshooting to aid in future modeling plans for other farms.

There are eight trainees working on the project. Six doing a Certificate III in Aquaculture and 2 doing a Certificate III in Business Administration.



2.2 Scope of Operation

In the long term, the scope of the operation should be as large as is practical and profitable. As well as the crab aquaculture activities, there are opportunities for accredited training and employment in business management, marketing and perhaps the hospitality industry, if a proposed tourism venture is established. The number and structure of the workforce will need to be determined by the operators.

The project is expected to turnover in excess of 15 tons of crabs during the first two years, generating revenues of around $235,000. Once profitability has been proven, expansion of the farm to around 10 ha or more over a stepped process will occur, at which time there will be potential for many more jobs and training opportunities. The ten year forecast (section 4.2) is for 10 ha of ponds, producing 72 tons of crabs and generating around $M1.4 in revenue for a business employing nine persons and several trainees.

2.3 Location and Business Premises

The aquaculture business is located at the Kulaluk site, owned by the GDA, in ponds previously developed for prawn farming. This project is funding a full restoration of the facilities including a shade structure for processing and packing, and a small demountable building for laboratory work, and sleeping quarters.

The site currently has 4 ponds totalling 2.5 ha, and previous approvals for a further 0.5 ha, as well as an established intake water channel. To the present, ponds have been filled passively and with small pumps. There will be significant costs in re-establishing the electricity supply to the site, and grant monies have been approved for this significant cost. It is expected that mains electricity will be connected to the site this dry season (2006).

It is anticipated that a live-in position will be appointed once electricity is connected. This person will need to be responsible for emergency responses and maintaining stock security. Fencing will also be required, given its proximity to town. Under the Deed of agreement, GDA (through GDE) has taken responsibility for farm security.

2.4 Production Arrangements

The mud crab grow out is being conducted in a semi-intensive manner, similar to marine prawn aquaculture, but at a lower density. This lower density (stocking at around 2-3 crabs / m^2) is considered appropriate due to the cannibalistic nature of the crabs.

Crabs have been stocked at an early juvenile stage after being produced and nursed at the DAC, and are being fed a combination of artificial prawn diets and fresh/frozen marine fish and prawns. It may be possible in future to utilise one or several of the Aboriginal coastal net licenses to supply the frozen fish for feed. This may reduce the feeding costs and ultimately increase the level of employment and activity created by this project.

Water quality is being monitored and maintained for the highest quality possible. It is expected that several types of hides or refuges will be trialled in order to maximize growth and survivorship, and detailed growth records are being kept for each batch of crabs.

Harvesting has occurred using baited traps, however drain harvests will also be done in future. Other trap types may be trialed during the project. The ability of crabs to survive out of water for extended periods has allowed storage of crabs for several days whilst continuing with trapping to make up consignments.

The production technology in this nascent industry is still being perfected and some form of experimentation is planned. For this reason, a detailed production plan is not available but the best technologies and practices have been implemented. A range of stocking densities and stocking sizes will be trialed, as well as a range of feed stuffs, aimed at increasing productivity while reducing production costs.

2.5 Plant and Equipment

An experienced earthmover was used for the pond redevelopment works. It was the same operator that constructed the ponds in the early 1990's. Four production ponds totaling 2.5 ha have been re-constructed, and a sump has been dug into the bottom of the ponds to collect the final water and crabs during a drain harvest. Three settlement ponds have also been constructed, and these will be used to condition effluent water prior to discharge.

It is intended that once electricity is connected to the site that the existing distribution infrastructure will be utilized and aerators will be run periodically to further enhance water quality. In addition more professional electronic (rechargeable) water quality measuring equipment will be purchased.

Security fencing was identified by the Board as being essential to prevent theft and is now a priority due to market ready crabs being present. Grant money have been committed for this.

2.6 Permits, Licenses and Insurance

A Northern Territory Aquaculture License issued under the NT *Fisheries Act* was issued to the Community. This allows the community to undertake aquaculture and sell the product. As part of this license several requirements and permits were required. These were -

- Proof of tenure of the land (Land title or agreement – DIPE)
- A water uptake license (DIPE)
- A waste discharge license (waste water) (DIPE)
- An Aboriginal areas protection authority permit
- A development permit (Development consent authority)
- A business plan
- A bio-security strategy (health/disease prevention)
- An environmental management plan endorsed by the EPA.

These regulatory instruments ensure that the operation is socially and ecologically sustainable in the long term.

At present the venture has no insurance. The farm manager and training mentor have their own business and personal insurance, the trainees are covered by the University's insurance, and governmental officers are also covered. The Board has identified that some form of personal injury and third party property insurance may be necessary and this is being investigated.

2.7 Commencement Date

It was expected that the project would be fully funded by May 2005, however the funding application, auditing and reporting for the various grants, as well as slower than expected process through the licensing phases, particularly with regards to planning and environmental approvals, significantly delayed the project.

Stocking of the first batch of crablets was planned for June or July 2005 and the first harvests were expected in December 2005. In reality the first trial stocking occurred in December 2005 while a commercial stocking occurred in January 2006. The first sales began in May 2006.

3. MARKETING REPORT

3.1 Market Environment

There has been no substantial change to the market environment for mud crabs in the last 12 months. Indications are that the wild harvest sector is undergoing another year of lower than expected catches. There is little scope for expansion of the wild harvest sector in Australia, although several inquiries have been fielded from persons interested in mud crab aquaculture. These are not expected to be a threat in the short or medium term.

Also, the premium *live* product continues to be a banned import due to legitimate quarantine restrictions, so the *live* domestic market is somewhat protected.

3.2 Product(s)/Service(s)

Several diverse products will result from this project if undertaken appropriately.

3.2.1 Crabs.
Mud crabs harvested from the ponds are currently being sold to a local seafood wholesaler. As these crabs are aquaculture products they are not restricted to size, sex or seasonal limits imposed on the wild harvest sector. This means that novel products such as smaller 'single serve' crabs, or female 'egg crabs' are being marketed.

Also as this is an aquaculture venture, consistent supply throughout the year will aid in establishing regular markets. Specifically targeting the period when wild harvests are minimal (summer) will also improve prices. Having control over all the production processes is preferred to the boom-bust cycle of wild crab harvests, and this will lead to better negotiated prices for consistent supply.

3.2.2 Pond Facility
This project has redeveloped the existing pond facilities of the Gwalwa Daraniki and regardless of the eventual outcome of the mud crab aquaculture venture, will leave them with multi-purpose marine ponds, which can be used for many forms of marine aquaculture. Completion of this project will enable the Gwalwa Daraniki to farm a variety of species for which markets exist.

The redevelopment can also be used to demonstrate the technology, and the entire project development, to other Aboriginal communities not only across the Territory, but also across Australia. The training and employment will also aid in community capacity building. A future product could be a tourism component to the venture. Guided tours, crab pot pulls and product sampling could be included.

3.2.3 Social development
The direct social benefits of this project will take the form of employment, training and revenue raising. The indirect social outcomes are likely to be much more wide ranging.

3.3 Distribution (Place) Arrangements

Local markets in Darwin are being serviced through direct sales to wholesalers, but some product could be air freighted south to capital cities. Local markets can be serviced easily by road transport or by courier.

All product will be processed and packed on site in approved containers, for 'dry transport'. A paper trail must connect the crabs to the aquaculture facility at all times, even at retail outlets.

3.4 Competition and Competitive Advantage

No major competitors have come forward and none are predicted in the short to medium term. The projects major competitor is the wild harvest sector. Their strength lies in their volume of production and in the size of their product, but they have some weaknesses. Firstly, they have virtually no control over productivity. The resource they utilise is considered to be fully exploited and there is little scope for expansion. They have limited control over when product will become available and their return on effort is unpredictable.

Aquaculture crabs from this farm can be at the wholesalers and in the restaurants on the day of harvest from the ponds. They are graded and sorted at the farm and packed professionally under strict quality guidelines.

Feedback from some restaurants suggest a single crab approximately 400-500g (under current legal size) might be suitable, rather than using a very large (expensive) crab. It is expected that the size of the crab will have little role in determining the price paid per kilogram. Any mud crab is considered a premium product and commands a high price.

The summer scarcity of mud crabs associated with breeding and migration, which coincides with traditional increases in demand (Christmas and Chinese New Year), makes an attractive target market.

The strength of an aquaculture venture lies in its marketing flexibility in regards to when or what product to sell, and it's ability to regulate the quality and quantity for specific markets. These luxuries are not available to the wild harvest sector, making this a major competitive advantage.

3.5 Price Strategy

Currently seafood wholesalers in the NT can pay around $13/kg for wild caught mud crabs, although this rises to around $20/kg in peak demand seasons. They then process, clean, pack and transport these crabs to markets or restaurants. If the venture proposed here performs these roles, the average price they can expect to get is around $21.50/kg. This was the average price paid for live, intact, mud crabs on the Sydney Fish Market floor in 2003. Processing, packing and transport may cost up to $4-5/kg. Higher crab prices can be expected from established, negotiated markets.

Some regular and recent (May 2006) sales of small volumes (around 100 kg) from the farm have been made with a price of $19/kg being paid, at the local wholesalers. There was no box cost and minimal transport cost. It is now hoped we can capitalize on the 'Crustaceans at Christmas' market.

3.6 Advertising and Promotional Strategy

Very little in the way of product promotion has been carried out. We are currently achieving a price of $19/kg which is 25% greater than initial estimates. With increasing volumes, we may need to assess other markets, but at present no promotion has been necessary. There may be some benefit in advertising the Indigenous and aquaculture nature of the product, and this will be investigated.

Direct marketing to restaurants may also be an option especially for local and perhaps domestic markets. Care will be taken not to compete directly with wholesalers marketing GDE product.

Recipe cards have proven successful for a range of retail seafood products. Specific farmed mud crab recipe cards, which also expound the benefits of Aboriginal aquaculture, could be developed and made available in markets for uncooked product. Branding and specific logos may also promote sales.

3.7 Market Targets

Experimental yields have been around 0.7 crabs /m^2, with an average weight of 250g. This was achieved in five months. There are 4 ponds available at Kulaluk, totaling 2.5 ha or 25,000 m^2, and it should be possible to produce around 7,500 kg per cycle, or just over 15 tons per year from two crops when in full production.

It has not been possible to fully stock the farm at one time due to limitations in crablet production capacity of the DAC. A staged stocking and production cycle will be necessary. This will also aid in staggering production and marketing. It is probable that a full production cycle encompassing the harvest of approximately 7 tons of crabs and subsequent restocking of all 4 ponds will be achievable within 12 months of the first stocking. Full production will be possible from this point forwards (ie. 15-16 tons pa.).

4. THE FINANCE REPORT

4.1 Financial Strategy

Due to the nature and aims of the venture, viz crab production for GDE as well as community capacity building and the establishment of a demonstration or model farm for adaptation in other Aboriginal communities across tropical Australia, a combination of Territory and Federal funding was considered appropriate. The enterprise was able to secure funding for part of, both capital expenses and the operating costs.

The total in-kind contribution by DPIFM is $685,978 over two years ($342,989 per annum). GDE total in-kind contribution is $346,000 over two years (yr 1: $241,000 and yr 2: $105,000). Additional funds required by the DAC for infrastructure upgrades in the first year total $21,000 (Table 3). These have yet to be paid. It is expected that these costs will be paid in July 2006.

Table 1. DPIFM in-kind resource contributions to the project

Resources		$
P2 level Scientist / Manager (0.8)		68,191
T3 Senior Technician		65,485
Aboriginal liaison officer (T3 level) (0.2)		13,097
P2 Extension / Production (0.8)		68,191
	Annual subtotal	**$214,964**
Brood stock maturation, larval rearing and nursery facilities		80,000
Salt water + fresh water		7,775
Aeration		1,500
Land Rental		1,200
Stationary and equipment rental (phones Internet)		4,500
Property maintenance (security)		4,000
Vehicle cost (extension)		8,000
R & M		7,900
Depreciation		13,150
	Annual Total	**$128,025**

Table 2. GDA in-kind resource contributions to the project

Resource		**$**
Farm Manager / Training Mentor		68,000
Earthen Ponds		125,000
Electrical infrastructure		15,000
Plumbing Infrastructure		10,000
Cement Slab		15,000
Freshwater supply		5,000
Bookkeeping administration		20,000
Vehicles		26,000
Office Space		24,000
Operating Materials		38,000
	Total	**$346,000**

Table 3. Additional infrastructure resources required by the DAC for the project

Darwin Aquaculture Centre		$
Hatchery feeds		2,000
Heat/chill pump purchase (yr 1 only)		10,000
Pumps and plumbing purchase (yr 1 only)		5,000
Heaters thermostats (yr 1 only)		4,000
	Total	**$21,000**

Project expenses

There were several impacting occurrences that have caused the project to deviate slightly from the initial expenditure plan. These were,

- lengthy delays and extra time (and therefore wages) getting through the licensing and permitting phases of the redevelopment,
- delays in grant funding coming in to the project, which again cost time and wages,
- higher than expected wage costs for the trainees, or put another way, lower than expected support from The Australian Government Department of Employment and Workplace Relations,
- A much higher than expected administrative load associated with applying for, reporting on, and acquitting granted monies.
- A much higher than expected administrative load negotiating environmental, planning and waste discharge permits and licenses, and also in providing reports to the various government departments in complying with license and permit conditions.

These administrative loads have been taken on by the Farm Manager and Training Mentor, and while they have been performing these roles well, it has reduced their ability to supervise the trainees and manage the farm operations to the maximum level of their abilities.

A good example of this is that a greater proportion than expected of the granted money has been spent on wages (administrative loads) than on farm infrastructure. This has led to the stocking of the ponds prior to all planned infrastructure being in place, such as electricity (for aeration), main water pump (no electricity) and plumbing repairs (not needed until electricity and plumbing repaired).

The project costs estimated 12 months ago, are listed in the tables below, as well as actual expenses against those estimates and a Job Analysis showing the difference. Negative figures indicate overspending. Capital expenses for redevelopment were estimated to be in the order of $411,000 (Table 4.). Due to licensing delays and additional administrative loads several planned purchases have not occurred and farm infrastructure has not been completed.

Table 4. Capital items at the farm

Capital Costs - Essential	$ Estimates	* $ Actuals	$ Job Analysis
Pond Restoration, pipes walls etc	330,000	174,478	155,522
Processing shed	20,000	22,112	-2,112
Aeration	10,000	NYP	
Shelters	5,000	NYP	
Monitoring equip	20,000	NYP	
Farm computer/camera/video	6,000	1,554	4,446
Fencing	20,000	NYP	
Total	411,000	198,144	212,856

* NYP = Not yet purchased.

Annual operating costs were expected to be around $128,500 for the 2.5 ha farm in the first year (Table 5.) The project operating costs are listed in the tables below, as well as actual expenses against those estimates, and a Job Analysis showing the difference.

As shown, the Accountant and solicitor's fees are much higher than expected reflecting the need for auditing and accounting services for grant applications. The project also overspent compared to original budget on the purchase of a demountable building – rather than the planned lease costs (purchase price was equal to two year lease costs). At the time there were no suitable demountable buildings for lease in Darwin, and this now becomes an asset for the venture.

The 'consumables' originally planned for did not account for small items of hardware that were budgeted for elsewhere (as well as Fuel Oil, Repairs and Maintenance (F.O.R.M), Fertilisers, Chemicals, cleaning products etc). Also, numerous items were needed to finish off the reconstruction and get the ponds operational. Most of the expense here could be listed under Capital but as they were small items purchased individually, they were listed as consumables in the accounts. This is also the case for crab food. Small quantities purchased frequently, as freezers have not been purchased (still no electricity).

Several other items were not purchased due to infrastructure not being in place. There is no electricity cost, no telephone cost, and as production has been delayed, there are no listed packaging and processing costs. Farm staff have been used rather than couriers to transport the crabs to wholesalers.

Additional unplanned operational expenses include the GST Bill for $26,000 and Office rental needed due to electricity not being in place.

Table 5. Annual operating expenses for 2.5 ha. * indicates unplanned expenses.

Operating Expenses pa.	**Estimates**	**$ Actual**	**$Job Analysis**
Accountant Fees	5,000	13,542	-8,542
Solicitor Fees	1,000	2,104	-1,104
Initial Insurance Premiums (list)	10,000		10,000
Advertising & Promotion	3,000	3,970	-970
Telephone	1,000		1,000
Printing/Stationery	500	693	-193
Registration/Licenses (list)	2,000	920	1,080
Electricity	15,000		15,000
F.O.R.M.	5,000	2,805	2,195
Food	42,000	1,193	40,807
Crablets (2 crops 75k each @20c/crab)	0		0
Demountable	10,000	21,708	-11,708
Fetilisers	1,000		1,000
Chemicals	500		500
Cleaning	200		200
consumables	300	16,227	-15,927
Processing/packing (40c / kg)	6,000		6,000
air freight	24,000		24,000
courier	2,000		2,000
*Office rental	0	14684	-14684
*GST	0	26555	-26555
Total	**128,500**	104,401	24,099

The project's estimated Wage cost is shown in the table below (Table 6), as well as actual expenses against those estimates, and a Job Analysis showing the difference. To ensure the trainees successful training outcomes, and to ensure appropriate and effective extension services are maintained on the farm, it was necessary to have an additional person assigned to the crab project at the Darwin Aquaculture Centre. A lower level technician (T2) was employed by the DAC to free up the senior technicians and extension staff so they could focus on the agreed service level for the project. This extra cost has yet to be paid for by the project. Also there has been additional overtime at the DAC necessary for crablet production. An amount of $10,000 was budgeted for, but again this has not been paid.

It was expected that DEWR would fully fund the cost of the trainees, however, this did not eventuate and has been a significant cost for the project.

Table 6. Wages required at the farm to run the project.

	Salary Estimates	$ Actual	$Job Analysis
Trainees*	0	68,886 (– 28,216)	- 40,670
TAA	154,000	168,483	-14,483
[1]DAC T2	70,000	0	0
[1]DAC Overtime	10,000	0	0
Total			-55,153

*Original Business plan had DEWR funding entire amount of trainee wages. However, we are only receiving approximately $14,000 per 14 weeks in reimbursement, with trainees meeting training milestones. This took around 4 months to negotiate and only 2 payments have been received. DEWR will not fund retrospectively.

[1] DAC wages costs to be paid from July 2006.

Table 7 shows a comparison for the total estimated and actual expenses for the project to the end of April. Initially we did not plan for trainee expenses, an office rental, or for a large GST bill, we therefore had to reduce infrastructure spending. Operational costs are lowered because of delays in complying with regulations and therefore delays in stocking. Overall, actual expenses are lower than was initially expected.

Table 7. Comparison of expenses to April 2006.

Payments	**$ Estimates**	**$ Actuals**
Capital	432,000	181,917
Operating	128,500	63,162
TAA wages	154,000	168,483
Trainee costs	0	68,887
Office rental	0	14,684
GST - ATO	0	26,555
Total	714,500	523,688

Project Revenues

As stated previously the project has been fortunate to have three successful grant applications totaling $895,000, approved. Two of those grants, one from DAFF for $110,000 and one from the OIPC for $330,000 have been fully paid into the Mudla account and have been utilized. The ABA has approved $455,000 funding for the project over two years, to be provided in quarterly installments. The first installment of $94,673 has been provided and the second is due at the end of June 2006.

DEWR has provided some Community Development and Employment Program places in support of this project as well as some Structured Training and Employment Program (STEP) funding for staff trainees wages. This does not cover the trainees full wages and the venture makes up the remaining amount. To the end of April a total of $28,216 has been received from DEWR. No crab sales had occurred during the period up to April 2006, although crab sales commenced in May 2006.

To the end of April 2006 a total of $562,889 has been received for the project.

4.2 Balance sheet

Table 10 shows the project's estimated year one balance sheet and the actual balance sheet to the end of April 2006.

The major discrepancies for the Receipts figures are the zero figure for sales, the lower than expected DEWR commitment to the project, and the ABA grant monies.

The lack of sales can be attributed to major delays in licensing the project and the delayed stocking. The lower than expected commitment from DEWR has meant that a large amount of infrastructure and operational spending has been diverted to trainees wages, and several critical items of infrastructure have yet to be constructed. It is intended that that these will be funded by a new Area Consultative Committee Grant that has been submitted.

Operating expenses have also been lower than expected, but this reflects the delay in beginning operations, and a lack of critical infrastructure (electricity) rather than cheaper running costs. The Farm and DAC wages have also been lower, although it is expected that the project will contribute $70,000 for the technician at DAC and $10,000 in overtime necessary for crablet production runs in July 2006.

There were also $40,000 in additional unplanned expenses, in Office rental (as there was no electricity on site) and a large GST payment.

At the end of April there was a balance of just over $40,000 in the Mudla farm Account.

Table 8. The estimated year 1 balance sheet, and the actual balance sheet for May 2005 - April 2006.

	Yr 1 Estimates	Yr 1 Actuals
Receipts		
Sales*	150,000	0
OIPC Grant	330,000	330,000
DEWR Funds	176,000	28,216
DAFF Grant	110,000	110,000
[1]ABA Grant	313,500	94,673
Total Grants Funding	929,500	562,889
Total	**1,079,500**	**562,889**
Payments		
Capital ($411K + $21K DAC)	432,000	181,917
Operating	128,500	63,162
Farm & DAC Wages	234,000	168,483
Trainee costs	0	68,887
Additional costs (office, GST)		41,239
Total	**794,500**	**523,688**
surplus/deficit	285,000	39,201

*For this model we are assuming that revenue from the harvests will be lower than anticipated due to teething problems and return $150,000.

[1]ABA Grant. Full amount approved but only first instalment received so far.

4. YEAR 2 – ACTIVITIES AND BUDGET

Year two will see the beginning of a fully commercial venture going through a complete budget cycle. There will be full wages and operational costs associated with running the entire venture for the full 12 months. In addition a further 0.5 ha of ponds are expected to be built adjacent to the existing ponds. Additional grant monies have been sought for this purpose.

Due to unexpected delays and additional expenses, the budget has also been modified to more accurately predict financial position. In order to continue to meet the project objectives including a commercially sustainable mud crab aquaculture venture, and a well trained staff, it will be necessary to free the Farm Manager from some of the administrative and reporting requirements. To do this, a part-time project administrator is intended to be employed. That person will write funding applications, will provide milestone reports to funding bodies to ensure committed funds are released, will report on compliance issues regarding planning permits and write environmental reports for the EPA. That person may also assist the community in reaching audit requirements.

As seen in the following Table (Table 10) the Estimated cash flow for the second year of operation shows a deficit of around $25,000. This does not account for cost overruns in infrastructure upgrades and additional costs for best practice training. It will be necessary to source additional funds to employ the project administrator. Breakdowns can be found in the following tables.

Table 9. Estimated cash flows

		Yr 2
Estimated receipts		
	Sales[1]	100,000
	ACC Grant	393,800
	DEWR Funds	50,000
	ABA Grant[2]	274,052
	Total Grants Funding	717,852
	Total	**817,852**
Estimated payments		
Capital (includes $21k DAC)		310,300
Operating		170,500
Farm & DAC Wages		234,000
Trainee costs		68,000
[3]Project Administrator		60,000
	Total	**842,800**
surplus/deficit		**-24,948**

[1]For this model we are assuming that revenue from the year two harvest will consist of one harvest due to late stocking and return approximately $100,000 due to poor infrastructure.
[2]ABA grant is monies coming in within the next 12 months. There will be $86,275 remaining to come to the business between May 2007 and February 2008.
[3]Project Administrator required to reduce admin load currently carried by farm manager. Will work closely with Business administration trainees.

Capital infrastructure spending and Operating Cost estimates can be found in Tables 10 and 11.

Table 10. Year two Capital Estimates

Yr 2Capital estimates		$
Earth works		70,000
Pump, Hydraulics and pipework		20,000
Electricity (High Volt Poles & Trans)		125,000
Aeration		5,000
Grading Shed		55,300
Engineering Plans		9,000
Crab shelters		5,000
DAC upgrades		21,000
	Total	**310,300**

Table 11. Year 2 Operating Cost Estimates.

Yr 2 Operating cost estimates		$
Accountant Fees		10,000
Solicitor Fees		2,000
Insurance Premiums		10,000
Advertising & Promotion		3,000
Telephone		1,000
Printing/Stationery		1000
Registration/Licenses		2,000
electricity		15,000
F.O.R.M.		5,000
Food		42,000
Crablets (2 crops 75,000 each @20¢/crab)		30,000
Demountable workshop/shed/accommodation		0
Fertilisers		1,000
Chemicals		500
Cleaning equipment		200
Consumables		300
Processing/packing (40c / kg)		6,000
air freight		24,000
land stabilisation		15500
courier		2,000
	Total	$170,500

Farm Management and Training Mentor (TAA) salaries and DAC Technician's wages (plus overtime) are $154,000 plus $70,000 plus $10,000. This totals $234,000. Net trainee costs have been estimated on total payments to trainees from the previous 12 months ($68,000).

In order to achieve our objectives a project administrator will be required for the venture. A part time position should be enough to reach the outcomes required and a half time pay rate plus on costs and some expenses should total around $60,000.

5. SUMMARY AND RECOMMENDATIONS

The Board of Mudla Farm reports that -

- Grant funding has been forthcoming to initiate and operate this venture,
- All permits and licenses have been granted by the various authorities,
- Trainees have been appointed and have successfully completed some units of study towards their certificates,
- The community's pond infrastructure has been rebuilt and is now operational,
- Additional rudimentary infrastructure has been purchased,
- The ponds have been stocked with crablets supplied by the DAC, (4000 in December 2005 as a trial stocking, and 45,000 in February 2006).
- The crabs have been growing as expected, with the front runners going out to market already, and fetching $19 per kilogram, which is 25% higher than initial estimates. Thus far volumes have been relatively low however.
- The site has been used to demonstrate technology to other indigenous communities and a knowledge exchange has occurred between the Kulaluk and Maningrida communities.

The Board acknowledges that these outcomes have been achieved despite significant delays in the aquaculture licensing process, environmental assessment and development consent. These delays have led the Board to deviate slightly from the initial business and development plans, however, as listed above, significant outputs have been delivered and the venture is still on track to produce commercial quantities of quality mud crabs and trained and experienced personnel.

It is recommended that the board continues to work to develop the business as originally planned, retaining enough flexibility to efficiently manage hurdles to the development, and to continue to report to the steering committee.

It is further recommended that the Board pursue funding alternatives for the project administrator position as a matter of urgency.

9.3. Environment Management Plan – Mudla Farms

APPENDIX 3

Environment Management Plan

For

Gwalwa Daraniki Enterprises Pty Ltd

Mudla Farms

Prepared by: T Angeles (GDE), I Ruscoe (NT Fisheries) and RA Rose (TAA)

23/08/05

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Environmental Policy Statement

The Gwalwa Daraniki Association (GDA) in 2005 set-up the Gwalwa Daraniki Enterprises Pty Ltd (GDE) as a charitable and benevolent trust to farm premium quality mud crabs (*Scylla serrata*) for domestic and export markets. The newly formed Trust, trading as Mudla Farms, plans to develop an economically viable and ecologically sustainable farm on its SPL 5182 land over the next two years from 2005/06 to 2006/07 by reconstructing/modifying old earthen ponds originally set-up for prawn farming in 1997. Hatchery-produced crablets from the NT Fisheries Darwin Aquaculture Centre will be used at cost price for the first two years.

The farm will initially produce approximately 15 tonnes of mud crabs per annum at a minimum size of 350g, generating around $235,000.The project will expand a further 0.5ha in the second year and up to 10ha within ten years, if practical. Financial projections suggest profitability will occur after the first two years and increase as the farm grows due to economies of scale. (Appendices: Business Plan; Table 11, page 19). Expansion of the farm will occur from year five onwards, using profits previously generated if such a strategy does not impact adversely on the local mangrove/marine environment.

A feasibility study initiated in October 2002 determined that mud crab farming was potentially the most economically viable and ecologically sustainable aquaculture enterprise that could be developed on the Association's country. Board members and office bearers also concluded that farming mud crabs would provide meaningful employment and tangible cultural benefits to the Kulaluk Community's youth. To achieve its goals, the Association developed a simple mission statement that acknowledged the importance of commitment by members to the project: *Participation from beginning to end, providing a sense of pride and ownership in the production of export quality mud crabs from our country*.

The GDE will provide administration, equipment, manpower and project managers for the project to achieve its goal. Further, it will abide by a Deed Agreement of cooperation entered into by the Gwalwa Daraniki Association with the Department of Business, Industry and Resource Development (DBIRD) to ensure that the appropriate biotechnology is forged over the first two years of operation. Further, the Association also became a participant in a Shared Responsibility Agreement (SRA) with the Urban Indigenous Coordination Centre – Darwin, DBIRD and Tropical Aquaculture Australia (TAA) to ensure that the business is adequately funded, managed and governed during these years (Appendices: Deed Agreement and SRA). A committee of funding organizations and stakeholders will advise a project management board on the project's operations during the first two years.

To preserve the biodiversity of the salt and freshwater wetland system on the Association's country, GDE is currently developing in conjunction with its project managers and the NT Fisheries Group operational production/husbandry practices that are environmentally sustainable. These practices will be founded on the cultural knowledge of the Community, research and development of NT Fisheries and the ecological findings of the *Ludmilla Creek- our corridor to the sea, Draft Ludmilla Creek Catchment Management Plan* (Clark, 1998).

To ensure that there is a technical understanding of the impact of all farm operations on the environment*, routine monitoring of important biotic and abiotic factors, training programs and appropriate communication protocols will be developed, implemented and refined. A code of practice or work ethics will be presented to all staff and contractors involved in the project covering the importance of work-health-safety requirements as required by the NT Seafood Council or NT Governmen*t, sacred sites and cultural beliefs of the Kulaluk Community.

1. Executive Summary

After conducting a feasibility study during the last half of 2002, the Gwalwa Daraniki Association (PO Box 746, Nightcliff, NT 0814) has embarked on a mud crab aquaculture project that will use reconstructed earthen ponds previously used for prawn farming on their SPL 5182 land. This coastal land is located in Darwin, east of Dick Ward Drive, south of Kulaluk and north of Minmarama Communities.

The Association feels that this project will provide meaningful employment and socio-economical benefits to the Traditional Owners residing at the **Kulaluk Community**. The Association's newly formed company, Gwalwa Daraniki Enterprises Pty Ltd (a charitable and benevolent trust) and trading as Mudla Farms, will run the operations with Kulaluk Community people to staff and manage the farm. The venture will use its farm manager and training mentor in conjunction with the NT Fisheries and Charles Darwin University to develop and train staff to commercially rear high-quality crabs for domestic and export markets.

A steering committee composed of all funding organization stakeholders will oversee the development of the project while a management board comprised of GDE, Fisheries and Industry experts will be responsible for the project's operations for the first two years. The farm manager will be responsible for implementing the board's directives and reporting on the Environmental Management Plan (EMP). The training mentor will facilitate the development and training of community employees working as administrators, managers and farmhands.

To become economically viable, the GDE will develop ecologically sustainable husbandry and biotechnology during the first two years of operation to preserve the biodiversity of the salt and freshwater wetland system on the Association's country.

As a company policy, all staff will receive government-recognised, vocational training in 'best-workplace practice' in aquaculture, as well as an understanding in the company's code of conduct, responsibilities and communication protocol.

The farm will initially produce approximately 15 tonnes of mud crabs per annum at a minimum size of 350g, generating around $235,000. The project will expand a further 0.5ha in the second year and if feasible up to 10ha within ten years. Financial projections suggest **profitability will occur after the first two years and increase as the farm grows due to economies of scale.**

The project will utilise the existing pond infrastructure at Kulaluk (Figure 1). *Five fully constructed ponds exist at present, totalling approximately 2.5 hectares*. There is an additional area at the southern end of the farm that can provide a further 0.5 hectares of pond, as part of the original Development Consent Approval (Figure 1). There is no intended expansion outside the original development consent for the 2-3 year duration of the current pilot project.

Some clearing of 'weed' vegetation (grasses and coffee bush) has commenced as part of the process to prepare the ponds for farming. To operate the grow-out ponds, mains power will be connected to the farm's electrical grid, fencing erected, pond walls fortified and *hydraulic pumping and pipe work repaired*

The base camp infrastructure that needs to be installed will consist of a 6-metre demountable office-laboratory/night watchman quarters, portable toilets, polyethylene water storage tank, 20-foot storage container and possibly a shade cloth structure covering part or all of the existing concrete pad at the northern end of the ponds. A portable stand-by generator and 200L fuel tank will also be set-up if necessary

The farm operations will assess the most practical and effective methods to rear mud crabs that are healthy, large, full of meat, rapidly growing and robust. The quantity and quality/type of feed will

be determined to produce two crops a year. The effect of hides or shelters will be evaluated in terms of improving survival and appearance of crabs harvested.
All appropriate licences, permits and certificates will be obtained before beginning operations including, an aquaculture licence, a licence to take or use surface water and a development consent permit.

Management of the coastal water resource in a sustainable manner that prevents or reduces any long-term, *detrimental effects on the existing natural mangrove environment will be achieved by* ***discharging waste water*** *at the spring tides that has been passed through settlement/treatment ponds*. This should ensure that there is maximum dilution to reduce any negative impact from 'used' pond water on the local ecosystem.

Water management will use *low-intensity aquaculture principles to reduce the need for large water exchanges over each* ***six-month grow-out period.*** Ponds will be topped-up to compensate for losses from evaporation only as any salinity variations that may occur are still within the safe, natural tolerance range for mud crabs.

'Used' pond water will be held in settlement ponds and monitored prior to release to ensure that the nutrient/bacterial levels are safe and equivalent to natural local levels. Used water will be irrigated into natural mangrove creeks or low lying flats at high tides to ensure dilution.

All waste from animal parts will be incinerated, organic sludge from the pond bottoms will be composted, domestic household waste will be sent to the public refuse, and machinery waste will be removed to recycling facilities in accordance with government work/health standards.

Soil erosion and pest control will be constantly monitored, evaluated and acted upon immediately to minimise any negative impact on the environment. Only 'safe' herbicides or pesticides recommended by NT government authorities will be used if necessary.

Crab hygiene procedures will include *preventive strategies*, constant monitoring and pathology testing in order to keep all animals disease-free. Chemicals used for disinfection will be those approved by the work/health/safety regulations and recognised by NT Fisheries aquatic animal veterinarians as effective and necessary.

Noise and fire control, fuel storage, machinery and storm surge protection will be managed in accordance with local government requirements. The design and planning of infrastructure will be based on 'permaculture' standards and implemented with the view of preserving the natural flora and fauna.

Cultural heritage and social issues have been identified and procedures will be in place to control flow of uninvited people on to the premises and by the fencing-off or use of signs to make all visitors aware of their actions.

A risk management policy has been devised and is defined as anything that prevents the project from achieving its objectives. The policy and procedures apply to safety, health, property, environment, financial reporting and internal control. Within these areas the policy identifies the risks, measures or quantifies the risk, method of control and the action plan or method of implementation.

All supporting documentation is provided in the Appendices at the end of the EMP.

2. Project's Development and Operations

2.1 Development Phase

After completing a feasibility study and business plan to aquaculture the mud crab, *Scylla serrata*, the Gwalwa Daraniki Association (GDA) entered into an agreement with the NT Fisheries Group of the Department of Business Industry and Resource Development (DIRD) to jointly establish a mud crab grow-out farm over the next two years from 2005/06 to 2006/07 (Appendices: Deed Agreement, November 2004). To comply with 'good governance' practices and qualify for A Shared Responsibility Agreement funded by the Urban Indigenous Coordination Centre – Darwin (Commonwealth Dept. Immigration and Multicultural and Indigenous Affairs), the Association established the Gwalwa Daraniki Enterprises Pty Ltd (GDE). This entity consisting solely of Kulaluk Community members is a charitable and benevolent trust that will trade as Mudla Farms for the purpose of cultivating hatchery-reared crablets produced by NT Fisheries in the earthen ponds located on its Special Purpose Land lease 5182.

NT Fisheries Group entered this agreement with GDA as part of the NT Government's Indigenous Economic Development (IED) strategy to stimulate economic and social development of regional and remote Aboriginal communities across the Top End.

Together with GDA (via GDE), the NT Fisheries are working towards seeking funds for infrastructure, training, research and other assistance to establish the mud crab farm To achieve this, a Steering Committee has been formed that consists of people representing: GDE; the Australian Government Department of Agriculture, Fisheries and Forestry (DAFF); the Australian Government Department of Employment and Workplace Relations (DEWR); the Department of Employment Education and Training (DEET); Charles Darwin University (CDU); the Indigenous Land Corporation (ILC); the Northern Territory Area Consultative Committee.. Participation from private sector investors is also being sought .

A steering committee composed of all funding organization stakeholders will oversee the development of the project while a management board comprised of GDE, Fisheries and Industry experts will be responsible for the project's operations for the first two years. The farm manager will be responsible for implementing the board's directives and reporting on the Environmental Management Plan (EMP). The training mentor will facilitate the development and training of community employees working as administrators, managers and farmhands. The technical staff at the NT Fisheries will assist with the development of mud crab husbandry and technology to ensure that an economical and ecological sustainable standard operating procedure is established. Charles Darwin University will run accredited aquaculture certificates, diplomas and degrees for all interested staff.

The farm manager has over 25 years experience as a marine biologist and commercial aquaculturist.. The training mentor has over 30 years as a cross culture consultant trainer/educator. Both have Certificate IV or higher training credentials and have been involved in the conception, planning and implementation of the project as directed by the Managing Director of the Gwalwa Daraniki Enterprises P/L.

As outlined in the business plan, the farm will initially produce 15 tonnes of mud crabs at 350 grams. This probably can be achieved with two harvests annually using disease-free crablets supplied by DBIRD's Darwin Aquaculture Centre. Crabs under 500 g are smaller than those caught legally in the wild and thus may represent an opportunity to develop new markets. Early results from other mud crab grow-out trials suggest that the previously approved area of 3.0 hectares of ponds at Kulaluk could potentially produced in excess of 18 tonnes of mud crabs annually, generating around $280 000 per annum in revenue.

The project will utilise the existing pond infrastructure at Kulaluk (Figure 1). Five fully constructed ponds exist at present, totalling approximately 2.5 hectares. There is an additional 0.5 hectares at the southern end of the farm to construct another three smaller ponds (Figure 1). These smaller ponds were part of the original Development Consent Approval (Appendices: DIPE file No: 96/1131). There is no intended expansion outside the original development consent for the 2-3 year duration of the current project.

Figure 1. Aerial photograph of the farm site showing ponds outlined in black. Solid lines represent fully constructed ponds and broken lines only partially constructed ponds.

Some clearing of vegetation has been undertaken as part of the process to prepare the ponds for farming. The site has been stripped of almost all infrastructure so there will need to be some minor new works undertaken on site. This will include (though not be limited to) the connection of mains power, installation of fencing, repairs to the pond walls, and repairs to the hydraulic pumping and pipe work.

The infrastructure at the base camp will consist of a 6-metre demountable office/laboratory/watchman quarters, portable toilets, polyethylene water storage tank, 20-foot storage container (that could be converted into a temperature controlled unit) and possibly a shade cloth structure covering part or all of the existing concrete pad at the northern end of the ponds. A portable stand-by generator and 200L fuel tank will also be set-up if necessary. The concrete pad will be used to store, fabricate, maintain, repair equipment or to process/grade/pack crabs for market.

2.2 Farming Operations

The project will assess the effects of stocking density on the growth and survival of crablets. Juveniles, approximately 35 days post-hatching (and thumb nail size will be stocked into the ponds at three to five individuals per square meter. Research and development results predict that between one and two crabs per square meter will be harvested after six months of grow-out. This will yield around 8.5 tonnes per six-month cycle. The ponds may be dried and limed between crops to prevent a build up of potentially harmful microbes. This process may take around two weeks, resulting in

two cycles (harvests) occurring every 13-14 months (6mth grow-out + 0.5mth lime treatment x 2 harvests).

The quantity and/or quality/type of feeds will also be assessed. Presently, there is no specific/standard artificial diet for mud crabs like that for prawns, especially in the early stages when the crabs are still quite small. During these stages, artificial prawn pellets may be used. These manufactured diets, however, are simply too small for larger crabs to pick up and ingest. Natural food items such as locally caught fish, prawns and molluscs will also be evaluated as feed for the later, larger stages of development. **Hopefully,** as many Indigenous people as possible, using Aboriginal coastal net licenses, can be employed during this aspect of the project to harvest 'non-managed' aquatic species as a food source. Most of these species such as mullet, school prawns and mud mussels are acceptable food items for culturing mud crabs. Developing local sources of food items will avoid the high expenses and logistic problems associated with providing feed orders at certain times of the year to remote communities that might farm mud crabs in the future, especially during the wet season . For these reasons, frozen or fresh seafood products sourced locally may be cost effective.

Hides or refuges will be placed in the ponds for evaluation. Research and development with mud crabs overseas and other species of clawed crustaceans tend to exhibit better survival if some form of shelter is available for protection during and after moulting.

Fortnightly, crabs will be sampled from each grow-out pond for observations on growth, survival and health. Baited traps (opera house traps, dilly nets, mañana traps and commercial crab traps) will capture individuals to obtain weights and measurements. This information is necessary for calculating the appropriate feed rates to avoid over feeding and excessive eutrophication of the ponds, which ultimately affect pond water quality.

GDE's Farm Manager, in consultation with technical officers and biologists from the Darwin Aquaculture Centre, will facilitate the daily work schedules and programs to ensure that appropriate farm and pond practices are developed, achieved or established. The Training Mentor and instructors from Charles Darwin University's VET Aquaculture will develop the daily work schedules and programs to ensure that appropriate staff training courses are developed, and delivered.

Initially, crabs will be harvested with baited traps, as they tend to capture the largest individuals. Removing crabs that reach market size, will allow smaller individuals to grow. This progressive harvesting technique has been shown to increase production in other clawed crustaceans such as *Macrobrachium rosenbergii* – the native Cherabin. When trap numbers have fallen substantially, the pond will be drained to remove the remaining crabs.

Mud crabs have an ability to survive out of water for extended periods, typically spending a significant amount of time at the edges of ponds. This phenomenon will facilitate the weekly marketing cycle; crabs will be trapped during the week, tied and held in a moist environment before being sent to market.

3. Licences Held by Company or Gwalwa Daraniki Association

The GDE is currently finalising the appropriate permits and licences, such as:

-Aquaculture Licence
-Take or use surface water Licence
-Wastewater discharge Licence
-Development Consent Permit

Future licences and permits may also be required and are listed below:

-Export Licence
-Health Certificates for Crabs
-Development Permits (for expansion)

Photocopies of licences held by GDE are attached to the Appendices.

4. Environmental Considerations

4.1 Water Supply

Ludmilla Creek saltwater from Beagle Gulf, north of Fannie Bay, Darwin, NT.

4.1.2 Objectives

Manage the coastal water resource in a sustainable manner that prevents or reduces any long-term, detrimental effects on the existing natural mangrove environment. Only the minimum amount of water that is practicable will be taken to aquaculture mud crabs. Discharge water from settlement/sedimentation ponds will be released during spring tides. Water-quality parameters will be monitored to ensure that the water discharged follows regional guideline values for tropical Australia estuaries or those specifically for the Northern Territory (see Table 1). Discharging water from settlement ponds on spring tides will ensure maximum dilution and dispersion, to minimize any negative impact on the local ecosystem.

4.1.3 Water balance

The 3.0 hectares of ponds are about 1.5 metres deep, requiring at least 45 mega litres (ML) to fill all ponds. Water management will use low-intensity aquaculture principles to reduce the need for large water exchanges over each six-month grow-out period.

Water will be required to "top-up" the ponds to compensate for losses from evaporation. The addition of freshwater to control salinity levels will probably not be necessary, if top-ups occur routinely as mud crabs have a naturally, wide range of salinity tolerance from 15 mg/L to 40 mg/L (or 15 ‰S to 40 ‰S, respectively. If necessary, top-ups will range between 3-5% of the total pond volume or between 1.35 and 2.25 ML. Daily water exchanges will not occur for all four grow-out ponds, but rather staggered on a rotational basis of every three or four days. Pumping will occur during the high tide period. The amount per pond will range between 0.34 and 0.57 ML (one quarter of 1.35 ML to 2.25 ML, respectively).

In total, the ponds may require only 2-3 exchanges in total volume per six-month grow-out cycle (expected extraction: 45 ML x 3 exchanges = 135 ML x 2 grow-out periods = 270 ML per year). In addition, if top-ups are required over four-day intervals at 4% of the total pond volume, then over two 175-day culture periods (350 days) there will be 88 top-ups x 1.8 ML = 158 ML. Thus, the total yearly extraction of seawater will be 428 ML (= 270 + 158).
The total annual amount requested in the renewal licence to take or use seawater will be similar to the one issued in 1997: 450ML . This figure gives an additional volume of 22 ML (or slightly more that 5% of the 428 ML) as a contingency for unforseen events; eg, higher rate of evaporation and leakage through pond dikes.

Water pumped from a creek will enter the property in the SW and runs NE adjacent to the ponds, along their eastern border. The intake pump will be located on the original concrete pad built for the old prawn farm operations and the same distribution line that is still present will be modified and/or extended to supply seawater to the grow-out ponds.

After approximately 175-day culture period, the majority of this water (not lost to evaporation) will be returned to the creek or sea via the settlement ponds during the harvest period.

Ponds during harvest will be drained over a six to nine day period depending on the volume and nutrient levels of the grow-out pond. Water will be transferred into the first of three settlement ponds and then transferred through an overflow system to the second and third ponds every 1 to 3 days. Water from the third pond will be released into a mangrove tidal creek during high tide and only if the effluent levels conform to NT Government regulations (see Section 4.1.5, below).

4.1.4 Expected impacts

Low intensity aquaculture will affect water quality in only a few ways. The salinity of the water in the ponds will increase through evaporation, although not to toxic levels if top-ups are routine. Crabs will be grown within their optimal range of around 30-35 grams/litre or ‰S)

This range is within the natural occurring salinity levels for the Darwin Harbour, depending on the season (*Aussie Prawns P/L Aquaculture Development, Public Environmental Report, 14 April 2005*, Northern Territory Government, DIPE website).

The annual pH values of intake water at the farm are likely to range between 8 and 9 with the monthly means between 8.3 and 8.7 as reported for the Darwin Harbour during 1990, 1991 and 2001 (*Aussie Prawns P/L Aquaculture Development, Public Environmental Report, 2005*). Similarly, temperature data from Darwin Harbour suggests that the annual water temperatures at the farm site will probably range between 25º and 32ºC. Both of these values are within the range acceptable for normal crab growth and health.

The negative effects of acid-sulphate soils in the mangrove do not appear to be a major concern according to preliminary field tests. Three sample locations from farm's pond bottoms indicate that the mean pH range of the mud/clay soils collected and left to dry for one month did not dramatically change from their original mean levels of pH 8.7 to pH 8.75. Similarly the soils left in situ and exposed to two tidal soaking periods also did not noticeably change from mean pH values of 7.0 to 8.0. However, the two types of soil test kits used relied on colour indicators and individual readings did vary from as low as pH 6.5 to as high as pH 9. To minimise the formation of sulphuric acid from oxidising iron sulphides in the pond soil over time, routine monitoring of the soil will continue and the addition of lime or bentonite will be added to the soil to control low pH values (see Acid-Sulphate Monitoring program in Appendices).

The nutrient levels in aquaculture ponds, especially nitrogen and phosphorous, typically increase during the production cycle. As the cultured organisms grow, more feed is needed to fulfil appetite and to ensure good growth. The rate of nutrient inputs for prawn farming for example, are generally easily calculated from proximate analysis of the feed, feed rates, a knowledge of the rate of ingestion and approximate conversion efficiencies to convert feed to biomass

This project will be feeding natural feed items to the crabs, on an experimental basis, as opposed to artificial feeds. Hence, the amount of feed offered initially, food conversion ratios and subsequent level of nutrient input, is difficult to determine at present. Feeding levels will be monitored using feed trays, as well as visual assessment of the remaining feed items around the edges of the ponds. Routine measurements of the nitrogen and phosphorus levels in the pond's water column will be collected.

A review of the literature suggests that our nutrient inputs will be minimal compared to those of the previous prawn aquaculture at the site (as well as the input levels from prawn farming located in other areas of the NT). Research by NT Fisheries and overseas indicates that the amount of fresh

food (fish/molluscs) consumed by mud crabs is between 3% and 8% of their biomass per day. Smaller crabs require a larger proportion of biomass than larger crabs, so it is estimated that larger crabs approaching harvest will require between 3% and 5% of their biomass per day. For example, if the level of biomass is 3000 kg/ha/crop the amount of feed consumed per day will range between 90 kg and 150kg, respectively.

As reported in *Aussie Prawns P/L Aquaculture Development, Public Environmental Report, 2005*, the three main components of pond effluent pertain to: total suspended solids (TSS); total nitrogen (TN); and total phosphorus (TP). The expected values of each of these parameters shown in Table 1 are based on methods derived from the Queensland EPA 2000, overseas industry, NT Fisheries and *Aggregate Emissions Data Estimation Technique Manual – Tropical Aquaculture, 2000* (from Dept. Environment and Heritage).

Table 1. Pond effluent levels reported in the literature.

Method and Source of Levels		**TSS (mg/L)**	**TN (mg/L)**	**TP (mg/L)**
Queensland EPA 2000	Mean Maximum	20 100	0.8 3	0.1 0.3
Overseas (Thailand, Hawaii)	Range	120-165	0.7-3	0.2-0.45
NT Fisheries		No data	1.55	0.42
Dept Environment and Heritage based on Food Conversion Ratio (FCR) of 1.82		No data	1.25	0.055

Although the levels of effluent are not yet known for this farm, the project plans to pass the pond effluent through three settlement ponds to reduce the nutrient and sediment load before the water is discharged over a spillway and into a mangrove creek. Research by CSIRO has revealed that settlement of most of the suspended solids within the effluent will happen during the first 1-2 days before starting to rise again. Settlement ponds are known to respectively reduce the loads of TSS, TN and TP up to 60%, 30% and 20% (Preston, et al., 2000). If crabs, filter feeders (bivalves, whelks and polychaetes), fish and macroalgae inhabit the settlement ponds, then the nutrient load will be reduced further.

If prawn feeds are used for mud crabs initially, then the TN and TP concentrations based on a Food Conversion Ration (FCR) of 1.82 suggest that these levels will be 1.25mg/L and 0.06mg/L, respectively, before released into settlement ponds (*Aussie Prawns P/L Aquaculture Development, Public Environmental Report, 2005*).

The levels of nutrient input into the ponds and subsequent effluent anticipated will be markedly lower in comparison to those of the Ludmilla sewage treatment plant, situated a few kilometres from the proposed farm site. The water quality of overflows of untreated water can occur up to three percent of the year and during the months of February and March (*Power and Water Corporation, Wastewater Treatment, Reuse and discharge 2004*). During these months the mean value in mg/L of TSS, TN and TP was, respectively, 60, 12 and 2. Data from the Dept. of Natural Resources, Environment and The Arts collected intermittently from 1977 to 1992 for Ludmilla Creek are shown in Table 2. Note that the levels of TSS and TP taken from five locations, although incomplete, tend to vary between locations but are similar to those found in Table 1 above.

Table 2. Comparison of water quality parameters from five different locations along Ludmilla Creek taken over approximately 15 years from August 1977 to may 1992. Dash indicates no data.

Location Number	^{0}C	pH	TSS	TP	Coliform CFU/100ml
Loc 1	28.1	8.1	26.3	0.2	4,187
Loc 2	28.1	8.1	16.8	-	4,122
Loc 3	28.3	8.2	10.0	-	477
Loc 4	28.7	8.2	7.3	-	509
Loc 5	28.9	8.1	5.5	2	270

Any impact on the mangrove environment is likely to be greatest downstream of the spillway. The creek that the settlement pond effluent will be discharged into is 800m to 1km long before reaching the Ludmilla Creek. Typically mangrove wetlands are efficient nutrient recyclers removing sediments and dissolved nutrients from the water largely due to their extensive microbial communities residing in the sediment with only 10% of nutrient uptake attributed to plants. Further, mangroves provide oxygen to the sediment through their root system, improving the habitat for nitrifying bacteria (Danis and O'Sullivan, 2000).

NT Museum studies by R. Hanley have found that farm effluent is equivalent to nutrient-rich sewage and observed that the impact of sewage on mangrove invertebrates at Berrimah, Darwin Harbour was not significantly different to control areas (Kinhill, 1992 in *Aussie Prawns P/L Aquaculture Development, Public Environmental Report, 2005*). Similar studies at Buffalo Creek, however, revealed a decrease in invertebrate diversity downstream of the sewage outfall and an increase in abundance of certain crab spp (Hanley Caswell and Associates, 1997 in *Aussie Prawns P/L Aquaculture Development, Public Environmental Report, 2005*).

In a recent scientific paper published in the Marine Pollution Bulletin examining marine prawn water effluent treatment, Costanzo *et al*. (2004) found that "At all times, physical/chemical parameters at the mouth of the effluent creek were equivalent to control values, indicating effluent was contained within the creek". The discharge water from the intensive prawn farm was effectively being cleaned by the physical, chemical and biological processes naturally occurring within the creek. The same processes will likely occur here, especially since this project will be employing low intensity farming techniques.

This project recognises that the literature to date admits the impact of aquaculture effluent on mangrove systems is not completely understood. Therefore, the monitoring program proposed will assist with improving our understanding of the most suitable management techniques required to maintain an environmentally sustainable mud crab farming operation.

4.1.5 Water quality management within the ponds

Water quality in the ponds will be monitored and recorded daily, weekly, biweekly or monthly depending on the parameter. Acceptable levels will be maintained as set out below in Table 3.

Table 3. Water quality parameters for pond aquaculture of mud crabs.

Parameter	***Measurement Tool***	**Occurrence**	**Acceptable range**	***Management Method***
Temperature	Thermometer	Daily	20-33^{0}C	-
Dissolved Oxygen	DO meter	Daily	>4 mg/L	Aeration
PH	Meter	Daily	7-9	Alkalinity – lime
Salinity	Refractometer	Daily	10-35 ‰S	Water exchange
Algal density	Secchi disc,	Daily	>30 cm	Reduce feed rate
Chlorophyll a	fluorometer	Weekly	1-5 mg/m^3	water exchange
Ammonia	Test kit	Weekly	< 2.0 ppm	Encourage bloom water exchange
Nitrite	Test kit	Weekly	< 2.0 ppm	Encourage bloom water exchange
Total Suspended Solids (TSS)	Lab analysis	Monthly	Mean 20 mg/L	Increase sedimentation time before release
Total nitrogen (TN)	Lab analysis	Monthly	Mean 1.55 mg/L	Increase sedimentation time before release
Total phosphorus (TP)	Lab analysis	Monthly	Mean 0.42 mg/L	Increase sedimentation time before release

Some ponds (depending on experimental system) will be aerated using electrical aerators, either paddlewheels or aspirators, usually during the night only. Photosynthesis by microalgae during the day will provide sufficient oxygen for the crabs. These will also be used to disrupt stratification if necessary during the warmer months. Overflow facilities will be installed in the ponds to control water levels during the wet season.

To ensure accidental sewage bypass does not enter the ponds from the Ludmilla Wastewater Treatment Plant, contact has been made with Power and Water. An agreement has been reached in which the seawater intake schedule of the farm and contact details of two farm employees will be available (on a 24 hour basis) to the Plant's management and daily operators. If there are any potential or actual emergencies that could affect the water quality in the Ludmilla Creek system, the Plant will contact one of these people immediately to stop or prevent the pumping of intake water as scheduled.

The methods of collecting water for testing are detailed in the Power and Water's manual entitled: *Wastewater Quality Sampling Procedure Manual*. 2004.

4.1.6 Waste water procedures

As stated previously, the intended operation will discharge relatively small amounts of wastewater compared to those of the original prawn farming development and the adjacent Ludmilla sewage treatment plant. The period of greatest discharge may occur during the wet season when the ponds could overflow with rainwater. However, the low geographic position (sea level) of the ponds, and their close proximity to the opening of the creek into Ludmilla Bay, suggest that the effect of small volumes of rapidly diluted wastewater with large volumes of coastal seawater will be insignificant.

Moreover, the nutrients will be flushed from the creek during the twice-daily tides, further minimising any potential impact.

All wastewater from the ponds will be passed through three settlement ponds arranged sequentially with the residential time in each pond of 1-3 days. Water discharged will be equal to or less than the TSS, TN and TP nutrients levels and bacterial CFUs stated in Table 2. Each settlement pond will have the capacity to hold 25% of the total volume of the largest grow-out pond. The length of time to drain the largest grow-out pond will be over eight days if the resident time is two days per settlement pond and 12 days if the time is three days per settlement pond.

Discharge will be determined once the effluent loads are known but the actual discharge period from the last settlement pond into a tidal creek will occur over a 4 to 8 hour period relating to high tide. The creek selected for receiving discharged water is approximately 800m long by 4m wide and 0.4m deep running parallel to the farm in a NE-SW direction. The creek's catchment zone has a capacity of at least 1.28ML.

4.1.7 Corrective action

Due to the small size of the operation and the twice daily flushing of the creek, it is not anticipated that any corrective or mitigation strategies will be necessary. However, if nutrient levels of the pond water are above the ambient levels for the tidal creek system, then the water will be stored and monitored in the settlement ponds until its levels are equivalent or less than those that naturally occur. Returning 'used' pond water back into the creek will always be via the settlement pond if there is any doubt or perceived threat advice will be sought from EPA authorities.

4.2 Waste Management

Waste other than effluent from pond water is not expected to impact significantly on the environment if managed under the following regulatory protocols: dangerous Goods Act 1981; Litter Act 1972; Public health Act 1995; and Waste Management and Pollution Control Act 1999.

4.2.1 Objectives

4.2.2 Expected waste sources

The expected waste products from the farming operations are:

Organic sludge from pond walls and bottoms:

Sludge will be biodegraded and stabilised/rejuvenated, flushed with rain and then dried for three to four weeks. If possible, sludge (comprising of 92-96% clay/silt and up to 8% organic matter) will also be tilled and re-compacted to stabilise the pond walls or used in landscaping or as a fertiliser. The amount produced in pond aquaculture can range initially from 20 to 180 tonnes/ha during the first year and progressively decrease in later years (*Aussie Prawns P/L Aquaculture Development, Public Environmental Report, 2005*). Due to the small pond sizes (0.3 to 0.7 hectares) the amount of sludge produced will tend towards the lower end of this range.

Domestic household waste:

There will be a live-in caretaker residing in either a caravan or 'demountable' style accommodation. Domestic refuse will not be great and placed in wheelie-bins for disposal at a registered refuse tip or recycle centre. A portable toilet will be used and emptied according to city council regulations.

Feed/fertiliser bags and process waste:

If used, approximately 943 prawn feed bags per crop will be recycled or disposed of at the local refuse tip or incinerated as required by council regulations. Crabs sold as live product will be transported in re-useable plastic cartons to minimise any waste resulting from processing and packaging. Crabs killed during sampling, grading or unexpected mortalities will be histologically examined, bagged, frozen or disinfected, and disposed of at the council tip or incinerated in accordance with NT Fisheries regulations.

Machinery oils, lubricants and parts:

These items will be stored on site and recycled by a registered oil recycler or wreckers. Minimal amounts of these products will be used or stored, as most maintenance of plant equipment and vehicles will occur off site.

4.3 Soil Management and Erosion Control

Construction activities that are not adequately managed, have the potential for moderate to low levels of soil erosion at the farm site during reconstruction of the grow-out and settlement ponds. The existing ponds are currently in a state of disrepair and will require reparation works to make them useable. If the project expands to the level of the initial development consent (the additional 0.5 ha), then the scale of the earthworks is expected to be minimal. The site for the additional ponds was cleared under the original development permit so it is already disturbed land (Figure 1). The power line easement will be cleared through areas where the vegetation is predominately coffee bush.

4.3.1 Objectives

Minimise the negative effects of soil erosion, perturbation and sedimentation at the farm site.

4.3.2 Construction

Construction works to be undertaken are founded on scaled topographical/contour plans and longitudinal cross-section drawings prepared by engineering and survey firms. The erosion and sediment control plan has been discussed with various NT Government authorities (eg, Dept of Natural Resources, Environment and The Arts). Contractors employed to undertake any earthworks or construction will be experienced with working to government contractual standards.

Although the farm site is low lying and flat, limiting the potential for water borne erosion, the potential exists for erosion during the construction/repair phase through: vegetation clearing (mostly weed species); road works; re-construction of existing pond walls; and construction of new pond walls (if expansion goes ahead). To ameliorate any negative impacts the erosion protection measures will follow a plan considering: sedimentation control measures (silt traps, spillways, batter slopes, surface protection, biofiltration); timing of construction; flooding frequencies; and draining of access tracks/roads.

During the construction period all major earthworks will be confined to the dry season period (May-August) or periods where rain is light (September-October). The impact of rain during late September/October is typically slight, having the beneficial effect of dampening dry soils, and thus reducing formation of dust and loss of top soils created from south easterly winds.

Roads will be constructed or repaired so that drains feed off the roads edge at regular intervals to prevent flooding and to deliver water for overland flows at velocities and volumes that minimise erosion in accordance with best practice procedures. All disturbed soils created during earthworks will be routinely wetted to prevent wind borne erosion as stated above.

Where slopes are created on newly cleared areas for power line easements, control structures will be installed to terrace the landscape or silt fences will be erected. These barriers will be installed according to an erosion and sediment control plan in accordance with NT soil erosion guidelines. The slopes that will be created are gradual, shallow and extend over short lengths and areas. Soil erosion monitoring structures will be erected on slopes to manage any damage that could occur until the earth is stabilised.

Reconstruction of the ponds will use reclaimed clay/silt soil eroded from the walls and deposited onto the floors of the ponds. Additional soils required will be brought in if necessary. The ponds are within a mangrove catchment area and have the potential to produce acid sulphate soils. Three sites are currently being monitored for the production of sulphuric acid from the iron sulphides contained in the waterlogged soil. Table 4 shows the pH values of the soils over a one-month period during the dry season. The soils were tested with hydrogen peroxide (H_2O_2), as well as with a CSIRO soil test kit developed to measure garden soils using colour indicators. The values observed suggest that the soil does not dry sufficiently to generate an excess sulphuric acid run-off problem. However, the mean pH value did drop below 7.0 for Pond 4 suggesting that close monitoring of the soil will be necessary. Liming of the pond walls and floor will be carried out to keep the soil neutral or slightly alkaline (see Appendix for Acid Sulphate Control Measures).

Table 4. The pH levels in pond bottom sediment at the mud crab farm. Each reading is shown as the mean of three samples and range in brackets.

Date	Settlement Pond	Pond 1	Pond 4
06/08/05	8.7 (8.5-9.0)	8.5 (8.5-8.5)	9.0 (9.0-9.0)
16/08/05	9.0 (9.0-9.0)	8.5 (8.5-8.5)	8.8 (9.0-8.5)
15/08/05	7.2 (6.5-8.0)	8.0 (8.0-8.0)	7.3 (8.0-6.5)
07/09/05	8.5 (8.0-9.0)	7.0 (7.0-7.0)	6.8 (6.5-7.0)

4.3.3 Operations

During operation the potential for erosion will be from overland flows during the wet season, and from water movement at pond inlets and outlets. Overland flows will be managed through tested drain designs as stated above.

The erosion of the pond banks at the inlets will be minimised by making the slope of the banks greater than 1:2 and by compacting the clay/silt soils. Plastic liner will be used at the point of entry. Specific piped overflow structures for the ponds will prevent ‘overtopping’ and erosion of the pond walls.

To minimise soil erosion and water pollution in general, pond management husbandry will include:

- The screening of intake water
- Daily water quality measurement and monitoring
- Monthly monitoring of soil erosion gauges located on various earthworks
- Optimal feeding regimes based on body weight and feed trays, and
- Targeted harvesting of marketable crabs, leaving 'submarket' size animals in the pond (biomass reductions).

4.4 Mangrove Monitoring

Monitoring sites will be established up stream and downstream of the discharge point, as well as in control locations. These sites would be monitored at six monthly intervals at the end of the wet season and at the end of the dry season.

Data will be collected along one or more transects and will include:

- Tree health (alive/dead) evaluation;
- Environmental characteristics of the site including any disturbances;
- Sedimentation rates will be measured using a PVC pipe to record levels from the top of the pipe to ground level; and
- Photographic records that include the centre of the site and photos taken looking towards each corner.

The data collected will be compatible with existing information in *2SBI 347 Environmental Assessment and Planning Major Project – Final Report* by Prof. G. Hill circa 1997.

4.5 General Issues

4.5.1 Disease control procedures and actions (see Appendix for Draft Quarantine / Disease Prevention Management Plan: Kulaluk Crab Farm)

TAA's past overseas association with Asian farmers, recent experiences of staff at the Darwin Aquaculture Centre, and anecdotal information with domestic and international aquaculture researchers, suggest that mud crab juveniles and adults are robust animals with a well-developed immune system. There have been few disease out-breaks in grow-out reported to date by crab farmers in Queensland and South East Asia. This data, together with procedures and recommendations for management and control of diseases in other commercial crustacean species (eg, *Health management and biosecurity maintenance in white shrimp (Penaeus vannamei) hatcheries in Latin America*, FAO Fisheries Technical Paper 450, 2003) has been used to develop a quarantine/disease control and prevention management plan. Further, this plan has been developed in conjunction with the Manager, Aquatic Animal Health, Department of Primary Industry, Fisheries and Mines

Health Certification of Seedstock

Seedstock crabs entering the facility will be obtained from Darwin Aquaculture Centre and will be subject to health certification procedures prior to stocking. These procedures will include histological examination, as well as polymerase chain reaction testing (PCR) for major viral diseases.

Origin of Seedstock

Crablets will be derived only from locally harvested broodstock within the local zone of equivalent health status for mud crabs (NT Fisheries), minimising the risk of introducing disease from other regions.

Physical Security

Crabs reared in the ponds will be prevented from escaping into the wider environment by short fences erected along the pond walls. Fences have been used successfully in the redclaw crayfish aquaculture industry for some time. Note also that fences will offer a measure of protection from potential incursions of disease from adjacent wild mud crabs.

Monitoring for Disease

The health status of crabs will be continually monitored throughout the grow-out cycle. Animals showing clinical signs will be submitted for pathological examination. Periodically, crabs may be sacrificed for examination in order to build a database and to develop simple diagnostic, pathology check-list for field and laboratory testing of this relatively new aquaculture species.

Significant Disease Outbreaks

Significant disease outbreaks will be controlled in conjunction with the Manager, Aquatic Animal Health, DPIFM. In the event of the occurrence of a non-endemic disease, facilities are in place to ensure that water flow will cease and to ensure the ponds may be disinfected with chemicals typically proved to be effective and produce little residue in the environment after de-activation. Chlorine, for example, used at a concentration of 100 mg/L (ppm: parts per million), will decompose over a relatively short time period after exposure to sunlight and oxygen. Alternative disinfectants or treatment regimes will be used, as directed by the aquatic animal veterinarian. Any dead animals will be disposed of by incineration at the farm site.

4.5.2 Weeds and exotics, control and actions (see Appendix for Weed Management Plan)

Weeds and exotic plants will be controlled with "safe" herbicides where required. The routine presence and normal farm activities at the site will facilitate better weed control through surveillance and activity.

Weeds and exotics may arrive at the site as seeds through the action of wind, birds or water. The activity proposed here is not expected to increase the risk of seed deposition. All construction and farm plant equipment will be inspected for the presence of vegetation prior to entry to the site.

Any controlled burning of collections of dried coffee bush will be done under supervision from the NT Fire Brigade.

4.5.3 Insect control

During construction special attention will be given to ensuring there are no depressions that could fill with surface water or tidal flows to provide breeding grounds for biting insects, such as mosquitos and sand flies.

The Territory Health Service Medical Entomology Branch will be consulted to ensure all is being done to control biting insects. This group already has some control measures in place on the Kulaluk lease.

4.5.4 Noise control

The site is presently isolated from other human habitation by at least 500 m and the Association does not expected the community and or any businesses to encroach onto the farm site in the foreseeable future. The Association owns all the surrounding land and any adjacent developments will require their consent.

Emergency power that may be generated on site will be insulated to conform to Work/Health's safe noise levels. There will be up to three to six vehicles accessing the farm daily, but no vehicles will be larger than two-three tonnes.

4.5.5 Fire management

Firebreaks will be maintained around the entire farm site. The pond walls and natural creeks will act as firebreaks in areas where the farm's boundary in adjacent to mangroves. In areas of dry predominantly coffee bush standard firebreaks will be maintained in accordance with local government requirements. Contact with a senior officer from the NT Fire Brigade, and the Casuarina Branch and the Darwin Control Centre has been established and the farm's general activities have been outlined so that the Brigade understands the nature of the operations. It is in the

Associations best interests to have a fire plan in place to protect valuable infrastructure, lives and farm stock.

4.5.6 Storm surge protection

The ponds are built on low-lying land adjacent to Ludmilla creek. During the life of the ponds, no tidal surges have breached mangrove forest protecting the ponds or the walls. However, as a precaution, the walls will be raised a further 200mm and capped with a stabilising material to prevent erosion.

4.5.7 Fuel Storage

On site fuel required to run emergency generators will not be greater than one or two 200L drums. They will be stored in accordance with NT dangerous goods legislation, including signage and other requirements related to the volumes stored. Fuel storage infrastructure will be removable.

4.5.8 Environmental safeguards for cessation and site rehabilitation

The operation is considered to be sustainable in the long term and hence there is no expectation for a cessation of operations. The Association's objective is to re-establish a viable commercial farm on its country that will create long-term employment opportunities for the community. If crab farming does not prove profitable in these ponds, then alternate species will be grown (eg, fish or aquatic plants).

The successful undertaking of this project is only practical because it involves redevelopment of a disused facility. If the facility had to be built from undisturbed land (ie, scratch) it is unlikely that the Association would be able to attract enough funding.

The Association intends to develop a sound environmental plan that uses pre-existing native vegetation to stabilise the soil. The established farming principles of 'permaculture' (Mollison, 1988) will help ensure that if the site is no longer used for aquaculture the ponds will not undermine or disturb the mangrove forest adjacent and East of the ponds.

5. Cultural Heritage

The only listed heritage site on the Australian Heritage Database for Coconut Grove is at Strong Point, which is approximately 2-3 kilometres to the North of the development. The historical ruins at Strong Point are a reminder that this real estate was a possible landing site for the Japanese Imperial Army during Darwin's involvement in World War Two.

There is an Aboriginal burial ground near to the entrance to the ponds that was in existence prior to the original development. The Community maintains the grounds and all measures will be undertaken to ensure there is no disturbance to the area.

6. Social Issues

The farm will be developed to blend into the mangrove environment by keeping the elevation of all buildings and structures at a single level. Landscape and seascape will not be disturbed and left alone as much as possible so that the ecology and aesthetic appearance of the vegetation remains sustainable and natural.

The public will be excluded from the farm site for work/health/safety and hygiene reasons. Visitation will be by appointment and all visitors must sign a 'visitor book'. At least one farm staff or Association member will escort guests around the premises. There will be no entertainment functions held at the farm or storage of alcohol. Any antisocial behaviour will not be tolerated and any uninvited guest at the farm will be asked to leave. If this request is not respected, then the farm

manager or staff will contact council members of the Association or police to have the offending person(s) removed.

7. Risk Management Policy or Program

The Venture must have an Environmental Management System and a Risk Management Policy and Procedures programs in place to achieve its goals.

The company's definition of risk management is anything that prevents the organization from achieving its objectives. The policy and procedures apply to the following:

- Safety and Health;
- Property;
- Environment;
- Financial Reporting; and
- Internal Control.

Within each of these areas, the policy should:

- Identify Risk;
- Measure/Quantify;
- Control; and
- Execute (action plan).

Risk Management Policy Summary

Identification	Measure	Control	Execution
1. Power failure	**Minor**/lose smallest crablets in nursery die due to low DO levels	Calculate electrical needs/ buy or lease standby generator	Order/ $10,000 deposit/ install
2. Equipment breakdown	**Moderate**\/reduce quality of stock/ difficulties associated with juvenile, and adult mortality	Build back-up system, have two sets of essential machinery on site/ order or repair equipment quickly	Operation protocol/ suppliers list/ maintenance program/ parts stocked on site
3. Disease	**Catastrophic**/loss of juveniles and young adults	Clean/ grade/ low -density/ monitor/ report	Established husbandry and hygiene protocol/ Vet lab testing
4. Emergencies (injury, sickness, bad weather)	***Moderate****/ loss of productivity/morale*	Preventative programs/ health exam/ first aid	Phone No.'s/ evacuation plan/ first aid kit on site
5. Communication	**Minor**/lose productivity	Purchase radios/ telephones/ computers/ install	Training/maintenance
6. Staff Exodus	**Moderate**/lose experience/productivity	Improve working conditions/ job satisfaction/ fair remuneration	Meetings to address needs/ improve living and work environment/build ablution/fix broken machinery/ support staff
7. Industrial relations	**Minor**/lose productivity	Utilize (join) Chamber of Commerce/ define job roles/ understand requirements	Meetings with staff/ comply with best management practices/ review remuneration
8. Legal dealings with funding bodies/creditors	**Major**/ effects public image/ reputation/ credit rating and marketing	Attend meeting/ semi-annual reports/ address concerns and employment issues	Comply with all obligations immediately, consult on a regular basis
9. Environmental Problems	**Major**/ effects licence/ image/ marketing/ lose productivity/ legal and operational legitimacy/ fines/ imprisonment	Build to cyclone standards/ obtain licences/ comply with NT Government environmental standards/ monitor/ strategy/ reports	Review legal obligations/written protocol/ train staff/ liaise with NT Fisheries
10. Fraud	**Major**/ effects credit rating/ marketing/ licences/ future business/ illegal	Directors/ managers disclose accounts/ accurate and up-to date records available for audit/ routine reports	Review body or accountants/ statutory declarations by Directors
11. Lack of Funding	**Major**/continuous/ insolvent and illegal/ effects credit rating/ marketing/ future business/ strategic planning/ staff morale/ profit loss	Realistic budgets/ accurate accounting of funds deposited/ update of contribution register available to all Directors.	Money in place ahead of schedule/ Protocol established for money transfer from Administration to Operations/ Monthly bank statements available to all directors
12. Inexperience Directors and Managers	**Major** if continuous/ **Moderate** if intermittent/ inconsistent technical, financial, marketing/, managerial business expertise	Protocol for qualifications to be a Director or manager/ list experience/ set of criteria	Justify qualifications/ Proof through resumes/ references/ training program for 2 years if no experience/ reports
13. Inadequate/expensive accounting	**Major**/ continuous/ loss of money/ non-productive /inexperienced/ poorly organized/ secretive / conflict	Consultations with experienced aquaculture accountants/ provide chart of accounts to follow/ monitor/ liaise	Obtained quotes/ select local accountant in Darwin near operations/ independent

	of interest		
14. Poor Communication and Documentation between Directors, Managers and Staff	**Moderate**/ continuous/ loss of time and money/ non-productive	Formal reports following agreed upon format	Set-up scheduled meetings bimonthly/ adhere to protocol for talking to staff/ visit farm once every four months
15. Aggressive, deceitful, behaviour between Directors, Managers, Staff and Stakeholders	**Major**/ continuous/ lose time & money/poor image /marketing/productivity	Set-up protocol for conflict resolution/ prompt action	Develop protocol for communicating to all personal and stakeholders/ quarterly reports

8. Documentation, Reporting and Reviews

Bi-annual and annual reports comparing the performance of the farming operations with the Environmental Management Plan will be either forwarded or filed and sent on request to the Environmental Assessment Officer of the Office of Environment and Heritage in the Department of Infrastructure, Planning and Environment (DIPE).

The Plan will be a work in progress with alterations made to reflect biotechnological improvements, changes in operational/husbandry procedures, or unusual circumstances. Any changes will be submitted to the above officer for consideration and approval.

Copies of the code of conduct, work practice or ethics will be reviewed, updated and attached in Appendices (Section 4) of this Plan.

No expansion, above the size of the original approval, is anticipated for the duration of this two-three year project. The Association recognises that future developments or expansions will require a new or amended environmental assessment prior to the commencement of each stage, including the possibility of an environmental impact report.

9. References

Aussie Prawns P/L Aquaculture Development, Public Environmental Report, 14 April 2005, Northern Territory Government, DIPE website (prepared by Kellogg Brown & Root.

Clark, A. 1998. Ludmilla creek – our corridor to the sea, Draft Ludmilla Creek Catchment Management Plan. Ludmilla Landcare Group Inc. 86pp.

Costanzo,S.D., O'Donohue, M.J. and Dennison, W.C. 2004. Assessing the influence and distribution of shrimp pond effluent in a tidal mangrove creek. Marine Pollution Bulletin 48: 514-525.

Creswell, R., LeRoy. 1993. Aquaculture desk reference, Chapman & Hall, NY 10003, ISBN 0-412-07561-X, pp.1-206

Danis, V and O'Sullivan, D. 2000. Can mangroves solve the problem of nutrient discharge? Austasia Aquaculture, Feb/Mar Issue, pp. 44-46.

Environmental Panning & Suitability analysis of Cultural & Nature-based Tourist Development at Kulaluk, Darwin, circa 1997. 2SBI 347 Env. Assess. And Planning Major Project – Final Rep. Ed/Complier Prof G. Hill.

FAO. 2003. Health management and biosecurity maintenance in white shrimp (Penaeus vannamei) hatcheries in Latin America, FAO Fisheries Technical Paper 450, Rome, FAO. 62pp.

Keenan, C. P. and Blackshaw, A. (eds). 1999. Mud Crab Aquaculture and Biology: Proceedings of an international scientific forum held in Darwin, Australia, 21-24 April 1997. ACIAR Proceedings Number 78. ACIAR Canberra. 216pp

Mollison, W. 1988. Permaculture: a designer's manual. Tagari Publication, NSW, Aust. ISBN 0908228 015.

Power and Water Corporation, Wastewater Treatment, Reuse and discharge 2004. www.powerwater.com.au.

Public Environmental Report for Ludmilla Wastewater Treatment Plant and Associated Facilities. 1998. Consulting Environmental Engineers in association with Sinclair Knight Merz, R01IWDR04292.DOC.

Wastewater Quality Sampling Procedure Manual. 2004. Power and Water Corporation

10. Appendices

Information relevant to the EMP or cited in the text are listed below but not in any order of importance:

1. Application for Exceptional Developmental Permit – Section 38(1), (signed and dated: 28/11/03); DIPE file No: 96/1131
2. Deed Agreement between Gwalwa Daraniki Assoc. and NT Fisheries (dated: November 2004)
3. Business Plan
4. Code of Conduct
5. Communication Protocol
6. Copy Induction Manual
7. Job Profiles (duties and responsibilities)
8. Licence Certificates
9. Shared Responsibility Agreement (dated 24 March 2005)
10. Standard Operation Procedures for farming operations
11. Workshops with management on company goals and strategies
12. Reports to the Steering Committee Board GDA and GDE
13. Acid-Sulphate Control Measures
14. Weed Management plan
15. Waste discharge licence details
16. Draft Quarantine Disease Prevention Management Plan: Kulaluk Crab Farm
17. Miscellaneous (maps, tables, calculations, drawings)

13. Acid Sulphate Control Measures

Introduction

The mud soils used to restore the old pond dikes and floors at the crab farm do not dry out completely and appear not to create a leachate problem during the reconstruction period (September-November 2005). Preliminary pH data presented in the EMP tend to support the notion that if the pond soil remained moist it was likely to maintain a pH level typical of a tropical monsoonal, mangrove environment. Low pH values (6.5-7.0) were recorded during September at the end of the dry and after spring low tides. A similar situation was also reported for developments at Cullen Bay and Port Darwin (*Public Environmental Report for Ludmilla Wastewater Treatment Plant and Associated Facilities* by Consulting Environmental Engineers and Sinclair Knight Merz, 1998).

Objective

Manage the occurrence of acid sulphate soils by removing effluent from ponds and if necessary applying hydrated lime (calcium hydroxide) topically to the soil surface of the pond walls and floors to control pH levels in the soil.

Materials and Method

Monitoring program
The husbandry operations at the crab farm may influence the pH of the soil from the build-up of effluent produced, for example, from uneaten foods, crab carapaces and faeces. To avoid this, the soil's pH (along with the water) will be monitored on a biweekly or monthly basis using a standard commercial aquaculture pH meter.

The soil will be tested at four sites shown in Figures 1 to 3: two in the grow-out ponds, one in the middle settlement pond and one mid-way along the discharge creek. Each site will be monitored before filling the ponds, during the grow-out period when ponds are filled with water and after harvest during the dry-out period.

Managing soil acidity
To control the acid level in the pond soil, hydrated lime (calcium hydroxide, slaked lime, lime hydrated or calcium hydrate) will be applied during or after the pond drying stage. In addition to reducing the acidity, liming will:

- Kill most parasitic microorganisms due to its caustic nature;
- Raise pH of acidic water to neutral or slightly alkaline;
- Increase the alkaline reserve in the water/mud (and thus prevent extreme changes in pH);
- Neutralise the harmful effects of sulphides and acids;
- Promote the breakdown of organic substances by bacteria, creating oxygen and carbon reserves;
- Precipitate suspended or soluble organic particulates;
- Decrease biological oxygen demands (BOD);
- Increase light penetration;
- Enhance nitrification due to the requirement of calcium by nitrifying organisms; and
- Indirectly improve the 'fine-textured' soil of the pond floor.

Every effort will be made to avoid excessive liming since it can cause decreases in available phosphorus through the precipitation of insoluble calcium or magnesium phosphate. Effective dose

rates per unit area will be determined through iterative information obtained from local prawn farmers, trial and error experiments based on recommend dose rates reported in the literature (eg, CE Boyd. 1990. *Water Quality in Ponds for Aquaculture*).

Lime quantities for soils based on the pH and texture of mud

The soils at the crab farm are classified as heavy loams or clays. The actual amounts required to ensure that the total hardness and alkalinity of pond water are maintained at 20 mg/L or greater are not known for the site. However, the initial amount of hydrated lime required per m^2 or hectare for a given mud pH will be those derived from values provided by Schaeperclaus (1933) in *Aquaculture Desk Reference* by R. LeRoy Creswell (1993); Table 7-21, page 168.

Table 1. Amount of lime required for mud soils at different pH levels (modified from Creswell, 1993, above).

Lime required as $CaCo_3$ (kg/ha or kg/m^2)		
Mud pH	**Heavy Loams or clays**	
	Kg/ha	kg/m^2
4.0	14,320	1.432
4.0 to 4.5	10,740	1.074
4.6 to 5.0	8,950	0.895
5.1 to 5.5	5,370	0.537
5.6 to 6.0	3,580	0.358
6.1 to 6.5	1,790	0.179
6.5	0	

Table 2. Amount of Lime (kg/pond) required for mud soils on the bottom of individual grow-out ponds at pH levels found in Table 1.

Lime required as $CaCO_3$ (kg/pond)							
	pH						
Ponds	**Area (m^2)**	**4.0**	**4.0-4.5**	**4.6-5.0**	**5.1-5.5**	**5.6-6.0**	**6.1-6.55**
Pond 1	***2,800***	4,010	3,007	2,506	1,504	1,002	501
Pond 2	***7,304***	10,459	7,844	7,844	6,537	3,922	1,307
Pond 3	***6,225***	8,914	6,686	5,571	3,343	2,229	1,114
Pond 4	***6,375***	9,129	6,847	5,706	3,423	2,282	1,141

To lime the pond floors, hydrated lime is available through a local cement manufacturer within 48 hours upon receipt of order (Northern Cement, Berrimah Rd, Berrimah NT, 0828; Area Manager, Brett Ordner; Ph 08 8984 0600; Fx 8984 0610). Product details, cost per tonne and 20kg bag (based on minimum order of 54 bags per pallet) are listed below:

- Product: Hydrated lime; Specified to AS1672.1;
- Price per Tonne $453.75 (incl. GST); and

- Price per 20kg bag $9.08 per 20kg bag (incl. GST)

Any surplus lime will be covered and held inside a dry, 20-foot storage container for no more than one year.

Testing the pH of pond mud
Although unlikely but if hydrated lime is needed to increase the total hardness and alkalinity of the pond water to levels of 20 mg/L or greater, then the methods for determining the concentration of lime required will be estimated from the pH of pond mud before and after the addition of a buffer solution. The techniques to be used are those of C.E. Boyd (1990) in *Water Quality in Ponds for Aquaculture* (as documented in *Aquaculture Desk Reference* by R. LeRoy Creswell, 1993; Table 7-20, page 168).

A summary of the procedures:

A. Prepare mud sample:-
1. Dry by spreading a thin layer on a plastic sheet;
2. Ground dried sample using pestle and mortar;
3. Pass sample through a 20-mesh screen (0.85mm mesh aperture);
4. Place 20g of dried, ground mud sample into 100mL beaker; and
5. Add 20ml of distilled water and stir intermittently for one hour.

B. Take pH of above solution with a pH meter previously standardised and record reading.

C. Prepare buffer solution:-
1. Dissolve 20g of p-nitrophenol, 15g of boric acid, 74g potassium chloride and 10.5g potassium hydroxide in distilled water; and
2. Dilute to one litre in a volumetric flask.

D. Add 20mL of buffered solution to mud sample, stir vigorously and take pH reading. Prior to taking a reading with a pH meter, set meter to pH 8.0 with 1:1 mixture of buffer solution and distilled water.

E. Use the pH values of the soil sample in distilled water (B.) and soil sample in buffered solution (D.) to determine the dose rate of lime using Table 27.20, page 168 from *Aquaculture Desk Reference* (Creswell, 1993).

Action Plan
1. Monitor sample sites biweekly or monthly
2. If the mud pH drops below 6.5, then drain pond
3. Transfer mud crabs from affected pond to unaffected ponds
4. Dry and collect sludge
5. Order lime from local supplier
6. Apply lime to the pond as estimated in Table 1 and 2
7. Refill to just above bottom and retest (drain and reapply if necessary)
8. When correct pH is achieved refill and recommence grow-out

All corrective activities will be done with advice from NT Fisheries and based on past experiences of local prawn farmers.

Sketches of sampling area (water shed, pond profiles)

Figure 1. **Site Plan of crab ponds**: showing drain pattern in each pond (green lines with arrows) and discharge from settlement ponds (green lines) into spillway (blue wavy line). Lowest point in each pond is the NW corner where wastewater is pumped from each pond to the settlement ponds. Orange lines indicate supply and waste line from intake pump located at southern end of ponds on "intake creek" side.

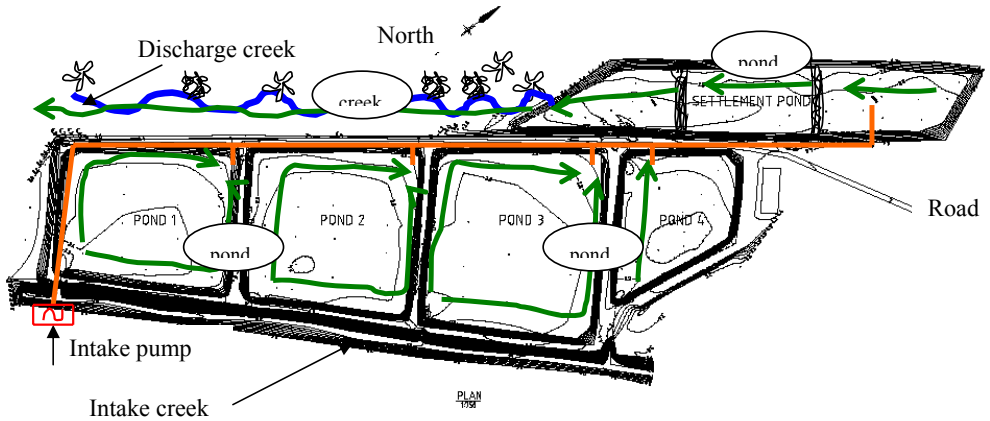


Figure 2. Cross-section of **discharge creek's spillway** (not to scale).

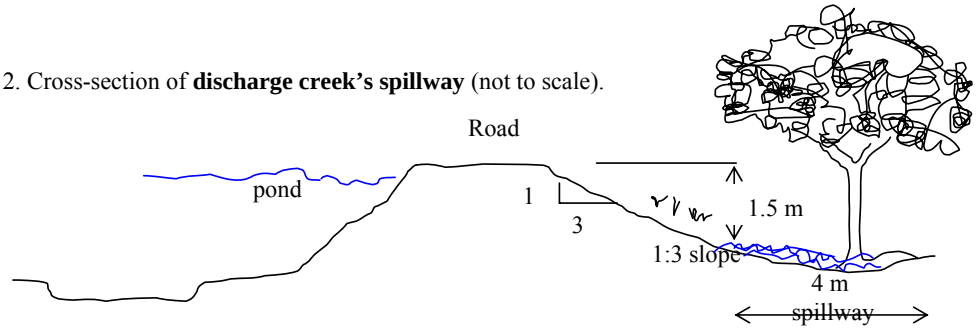
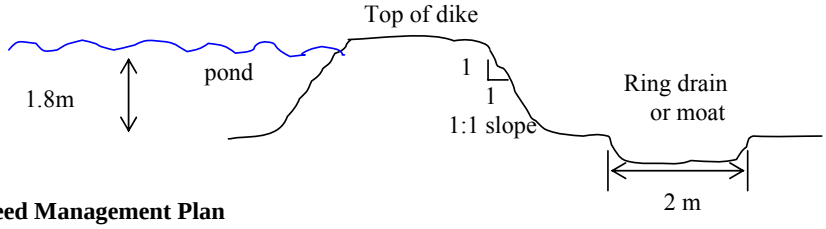


Figure 3. Cross section of **ring drains** in each pond (not to scale).



14. Weed Management Plan

WEEDPLAN

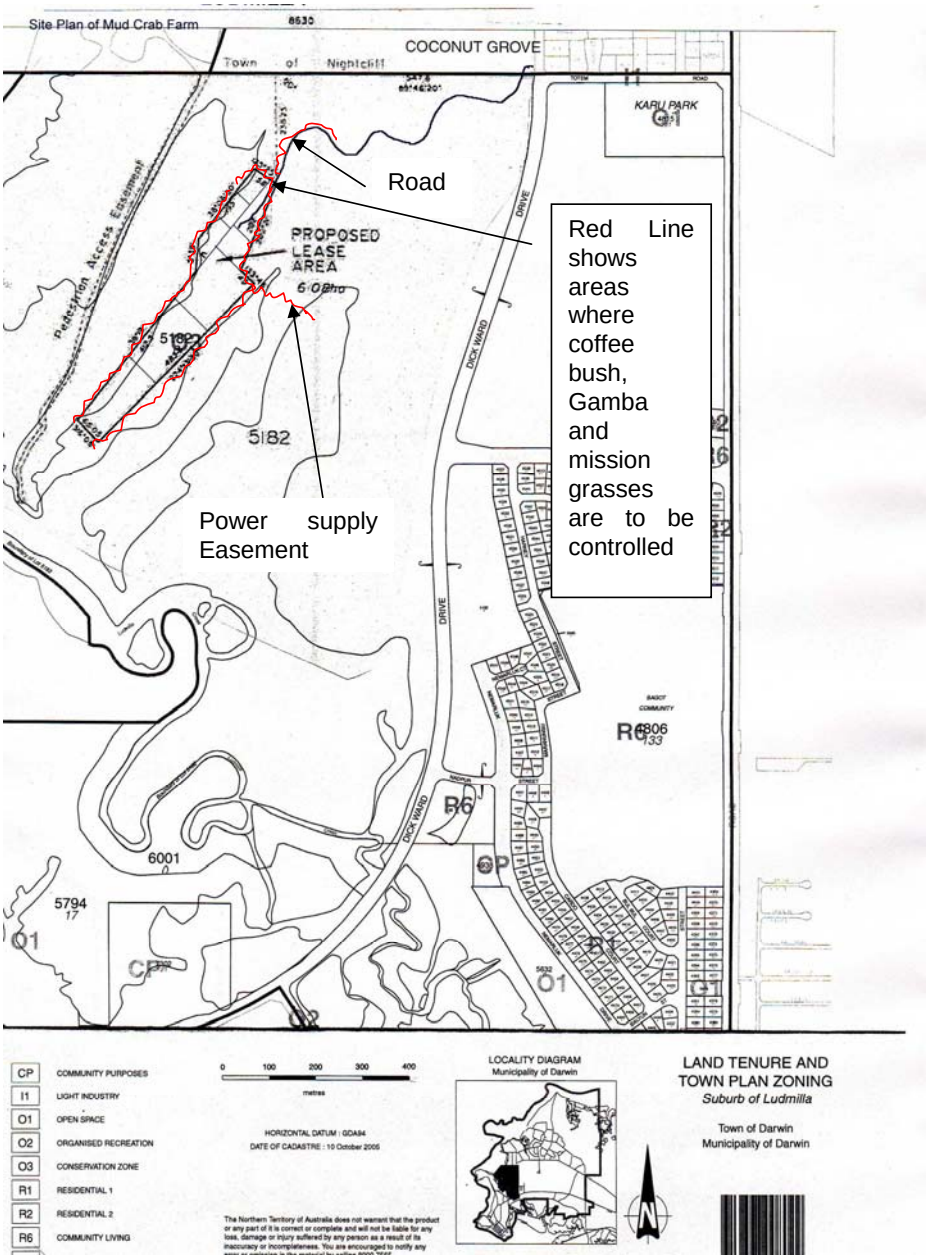
Property owner	Gwalwa Dariniki Association operating as Gwalwa Daraniki Enterprises P/L) ABN 84 870 878 139	
NT Portion	5182	
Contact details	Mailing address	PO Box 746, Nightcliff NT 0814
	Email address	gwalwadaraniki@bigpond.com.au
	Phone	08 8985 5300
	Fax	08 8948 5429
	Mobile	0439 612 652

Region	Darwin
Catchment	Ludmilla
Sub catchment	Ludmilla Creek
Start date	13/12/05
Review date	13/01/06 and every six months thereafter
End date	On going

Step 1: Assess the situation

1: Target species: Which weed species do you plan to manage?	1/ coffee bush (*Luecaena luecocephala*) 2/ Gamba grass (*Andropogon gayanus*) 3/ mission grasses (primarily *Pennisetum polystachion* and secondarily *P. pedicellatum*)
2: Declared plant classification: Are these species declared in your region? What is the requirement for these species under the Act? (If they are not declared, you still may wish to manage them as a weed)	All of the target species listed above are introduced to the area. The coffee bush and Gamba grass are not declare weed species but at least one of the mission grasses (*P. polystchion*) has been declared We will manage these species as "exotic" in order to promote the existence of local native fauna and flora at the site.
3: Describe target plant distribution: record plant density, plant location, paddock/landuse, paddock land unit type. (develop a property map showing weed distribution information)	1/ Coffee Bush: this exotic species has overtaken the native vegetation along all the dirt roads leading into the farm. There are also extensive stands on the South Eastern side of the ponds in areas between the saltwater creek that runs NE to SW and the dirt service road that runs parallel to the creek but 200 to 300m east of the saltwater creek, along the tidal grasslands. Previously, this area was dominated by mixed eucalyptus woodland and shrubland species. 2/ Gamba grass: this species is found in pockets along the pond dikes, road into the farm or in the tidal grasslands referred to above. 3/ mission grasses: These species are also found in patches along the roads leading into the farm, dikes and in the tidal grassland areas with Gamba grass. See Site Plan attached

Map of area under weed management



Assess the situation (continued)

<table>
<tr><td rowspan="4">4: Identify high, medium and low priority weed infestations on your land.

(use the prioritisation sheet to assist you in making a decision)

Think about:

What is the current spread of this weed on my land

What is the potential spread of this weed on my land?

Is the weed hard and/or expensive to manage?

How could this weed impact on land use?</td><td>High priority species</td><td>Property location(s)</td></tr>
<tr><td>Coffee bush
1/ A very rapid coloniser of disturbed woodlands particularly along road corridors and where tree clearance has occurred.
2/ Pond area is suitable for large stands of Coffee bush growth to occur over a short period of time.
3/ Both physical and chemical methods of control are required.
4/ Impact is severe, eliminating all native bush causing fauna to disappear become reduced in richness or abundance due habitat degradation.</td><td>All along roads and where mixed eucalyptus and shrub woodlands occur (above the salt pan), dikes of ponds and power supply easement (see site plan attached).</td></tr>
<tr><td>Medium priority species</td><td>Property location(s)</td></tr>
<tr><td>Gamba and mission grasses
1/ Creates dense growths of grasses in cleared areas with newly turned-over soil.
2/ Pond area is conducive to promoting colonisation by these grasses.
3/ Physical methods of control are required (eg cutting, extirpation, burning removed plants).
4/ Impact is moderate causing a fire hazard.</td><td>Patchy distribution along disturbed or recently turned-over soil is found (ie, dikes, roads, easement for power supply (see site plan attached).</td></tr>
</table>

Step 2: Develop your plan

5: Objectives: Think about what you want to achieve. (Options may include eradication, prevention of seed production, containment of infestation to current site, prevent spread, prevent introduction, reduce impact, control of outlying areas etc)

High priority species	**Property location**	**Objective**
Coffee Bush	Perimeter of ponds, lease area and power supply easement.	Eradication and/or containment of infestation at site through cutting, burning of trees removed and poisoning individual plants recently cut down and prevention of seed production by removal before flowering.
Med priority species	Property location	Objective
Gamba and mission grasses	Perimeter of ponds or farm, banks of dikes and power supply easement.	Remove and/or cut so that grass is not a fire hazard or impediment to regrowth of natural vegetation.

Develop your Plan (continued)

6: Method: What do you have to do to meet your objective for each species in each location? (Think about control work required, survey work, implement biological control program, management of grazing pressure, feral animal management, fire management, livestock quarantine, machinery/equipment and people hygiene, movement of hay etc) Do I have the necessary information to make the best decision? Do I have the resources to meet my needs?

High priority weed & location	**Objective for area/species**	**Method to achieve this**
Coffee Bush located along the perimeter of the ponds, the road leading into the farm site and power supply easement.	Eradicate and/or contain spread of coffee bush into monsoonal rainforest from individual plants or their seeds at the crab farm.	Cut, burn plants and extirpate the roots from the site. For coffee bush located in areas near the ponds, the herbicide, Starane (mixed with diesel at 1 part herbicide to 60 parts diesel) will be applied to the basal bark or cut stump. To avoid contaminating the pond water, a NT Government Weed Control Officer will demonstrate how to safely apply the herbicide. The herbicide, Starane will be purchased in 1 or 2 litre containers to avoid having large quantities of poison on the premises.
Med priority weed & location	**Objective for area/species**	**Method to achieve this**
Gamba and mission grasses located in areas where the soil has been turned over around the edges and tops of pond dikes, road edges or power supply easements.	Extirpate/remove or cut and control so that the grasses do not impede vehicle travel or become a fire hazard.	Dig out of soil and burn when dry and/or cut with a whipper sniper.

Step 3: Implement your Plan

7: Implement your plan: Think about what your objective is for an area, how you are going to achieve this objective, what resources are required, when you will do it?

Do you have the necessary information to get the timing of control right?

Record what you have done for future reference.

Record the results of your action for future reference.

High priority weed & location	**Action taken and date**	**Result of action**
Coffee bush	Cut with chain saw and pull entire plant out of soil with "4-in-1" bucket on a bobcat or backhoe. Piles of bush were dried and burnt under permission from Fire Brigade. Native bushes were planted in area. Clearance occurred during September-October 2005. Planting in November 2005.	Vast majority of bush was cleared. Seedpods were collected from topsoil by rake. Some regrowth is appearing.
Medium priority weed & location	**Action taken and date**	**Result of action**
Gamba and mission grasses	Cut or removed with bobcat/backhoe. Dried and burnt. Clearance began in September-October 2005.	Area was temporarily cleared long enough to plant native bushes. Some regrowth is occurring.

Step 4: Monitor and review your plan

High priority weed & location	Result of action	What change is required
Coffee Bush	Some regrowth is occurring (less than 5% of the original population).	These bushes will be pulled out or cut by hand and/or poisoned with Starane herbicide at a concentration described above (1part Starane: 60parts diesel).
Medium priority weed & location	**Result of action**	**What change is required**
Gamba and mission grasses	Some regrowth has occurred but has not disturbed native bushes recently planted.	Grass seed has germinated and young colonies are appearing after several weeks of rain in late November and early December. These colonies are not encroaching on native bushes and will be cut or removed on a routine basis to ensure that the native bushes take hold.

15. Waste discharge licence details

Introduction (from EMP; 4.1.2 Water balance, pg 8)

The 3.0 hectares of ponds are about 1.5 metres deep, requiring at least 45 mega litres (ML) to fill all ponds. Water management will use low-intensity aquaculture principles to reduce the need for large water exchanges over each six-month grow-out period. Water will be required to "top-up" the ponds to compensate for losses from evaporation. The addition of freshwater to control salinity levels will probably not be necessary, if top-ups occur routinely as mud crabs have a naturally, wide range of salinity tolerance from 15 mg/L to 40 mg/L (or 15 ‰S to 40 ‰S, respectively). If necessary, top-ups will range between 3-5% of the total pond volume or between 1.35 and 2.25 ML. Daily water exchanges will not occur for all four grow-out ponds, but rather staggered on a rotational basis of

every three or four days. Pumping will occur during the high tide period. The amount per pond will range between 0.34 and 0.57 ML (one quarter of 1.35 ML to 2.25 ML, respectively).

In total, the ponds may require only 2-3 exchanges in total volume per six-month grow-out cycle (expected extraction: 45 ML x 3 exchanges = 135 ML x 2 grow-out periods = 270 ML per year). In addition, if top-ups are required over four-day intervals at 4% of the total pond volume, then over two 175-day culture periods (350 days) there will be 88 top-ups x 1.8 ML = 158 ML. Thus, the total yearly extraction of seawater will be 428 ML (= 270 + 158).

The total annual amount requested in the renewal licence to take or use seawater will be similar to the one issued in 1997: 450ML. This figure gives an additional volume of 22 ML (or slightly more that 5% of the 428 ML) as a contingency for unforseen events; eg, higher rate of evaporation and leakage through pond dikes.

Water pumped from a creek will enter the property in the SW and runs NE adjacent to the ponds, along their eastern border. The intake pump will be located on the original concrete pad built for the old prawn farm operations and the same distribution line that is still present will be modified and/or extended to supply seawater to the grow-out ponds.

After approximately 175-day culture period, the majority of this water (not lost to evaporation) will be returned to the creek or sea via the settlement ponds during the harvest period.

Ponds during harvest will be drained over a six to nine day period depending on the volume and nutrient levels of the grow-out pond. Water will be transferred into the first of three settlement ponds and then transferred through an overflow system to the second and third ponds every 1 to 3 days. Water from the third pond will be released into a mangrove tidal creek during high tide and only if the effluent levels conform to NT Government regulations (see Section 4.1.5).

Answers to questions provided in correspondence dated 25 November 2005 from Lyn Allen, EPA:

1. Volumes of effluent being discharged and duration of discharge during a harvest

The volume of Effluent	Duration of Discharge
Pond 1:- 4.2ML	3 - 4 days
Pond 2:- 10.96ML	8 - 9 days
Pond 3:- 9.34ML	6 - 7 days
Pond 4:- 9.56ML	7 - 8 days

Settlement ponds represent 23% of the total volume of grow-out ponds (7.7ML/34.06ML). The discharge creek's catchment zone has a capacity of at least 1.28ML or 4% (1.28ML/34.06ML).

2. Volume of freshwater that is used to manage evaporation

Freshwater will not be used to manage evaporation and top–up of ponds. This will be achieved with tidal creek water only. The only time freshwater will reduce the level of evaporation will be during the wet season when rain or freshwater run-off enters the ponds naturally.

3. Application of the principle of full recirculation rather that discharging saline water

The current technological and financial status of the mud crab farm precludes operating the farm under full recirculation at this point in time (if defined as 95% recycled with 5% exchange). The main reason are summarised below:

- High initial investment costs (eg, construction cost for an omnivorous species of prawn per hectare has been estimated to be US$ 80,000 (~107,000 AUD) and depends on the availability of electricity, local hatcheries and processing plants) (Boyd and Clay, 2002).
- The technology is not well known or developed (eg, crab aquaculture is a nascent industry that has been largely ranching wild crabs overseas until recent local breakthroughs in artificial propagation).
- The system can be characterised as having a very short response time to emergencies since husbandry consists of high-density production in minium volumes of water. Problem areas can be divided into equipment failure, chronic water quality problems and subsequent disease outbreaks.
- There is a poor track record with full recirculation systems with failure common and difficulties with finance. This is largely due to a lack of expertise and scale of economy.

One extremely important consideration is that the farm is a livelihood project with an aim to give an Indigenous community a source of employment and purpose to its members. The farm needs to operate at a level of technology suitable to achieve this. To operate at a fully recirculating farm at this point in time will not be sustainable for the reasons stated above.

Striving for full recirculation in principle, however, is desirable in the long term by the mud crab project because full recirculation systems give more control over production. Although there is not a linear relationship between scaling-up, water quality, stocking densities, equipment technology and expertise, the economical/ecological/cultural viability of the project relies on routine control over the quality and quantity of crabs produced.

The principles of full recirculation will be addressed as the project develops its expertise in the rearing of crabs and appropriate technology. To use them to reduce the discharge of saline water at this time are not practical until the farm staff gain experience through trial and error in determining how much and how often saline waters are to be discharged. Initially the only effective option for the scale of the operation may be the controlled release of pond waters at high tides to maximise dilution and dispersion.

4. Application of the use of solar powered aerators

A review of the solar powered aerators available, suggests that they are more expensive than budgeted for. Electrical paddle wheel aerators (0.75Kw motor and weighing 80kg) and disk aerators (1.5Kw and 80kg) are priced at $645 and $583, respectively. Solar powered aerators, such as the SB1 Solaer (weighing 170kg) for a 0.405 hectare pond is priced at US $4,484 (excluding freight costs), and the SB2 (weighting 252kg) for a 0.810 hectare pond costs US $5,188 (excluding freight costs).

These solar units have equipment that need to be fitted into the pond floor (poly piping and mounting structures) as well as nine components each. The solar units present here are from overseas suggesting repairs and maintenance may be prolonged and expensive. Moreover, these units are for temperature or coldwater conditions and thus may not be suitable for tropical oxygen levels at high temperatures. Solar powered aerators may have difficulty with their power storage over long periods of cloudy/raining days during the wet season. At present solar aerators are probably too expensive.

Charles Darwin University will be contacted by the project to see if a prototype can be prepared. Any locally built solar power aerator would be advantageous but would also require a conventional electrical motor or internal combustion motor to operate during the night and overcast/rainy days.

5. Proposed management measures if the water quality in the sediment ponds does not meet that of the small creek

Pelleted, prawn-food fed to crablets and minced or whole fish/shellfish carcases fed to adult crabs consist of protein, carbohydrates, fat, minerals and water. Any uneaten food or faeces will be broken down by microorganisms such as bacteria, which will result in the consumption of dissolved oxygen and generation of ammonia-nitrogen. To help ameliorate any water quality problems arising from this, uneaten food or faeces will be quickly removed from eating trays and designated feeding stations within four hours of the last feed. (The exact time of removal has yet to be determined.)

The water quality in the sediment ponds will also be monitored and recorded in a similar manner to that reported in Table 3 (Section 4.1.4 of the EMP, pages 11-12). Water from the sediment ponds will not be released until the water parameters tested are within the same range as that recorded for the tidal creek water used to fill or top-up the grow-out ponds. The management strategies proposed to achieve this are listed below. Some of the techniques/systems described are expensive and comparatively sophisticated and will be only used if production is intensified, environmental sustainability improved and/or the cost per unit effort reduced.

<u>Removal of settleable solid waste</u>

- Sedimentation (reduce flow turbulence allowing particulates to drop-out of water column over time).
- Swirl separators (eg, aerators used to create a circular current within the pond).
- Screen filters (eg, drum screen).
- Bead filters (eg, prop- or bubble-wash bead).
- Double drain (eg, “Cornell” waste solids removal with a double drain).

<u>Removal of suspended solid waste</u>

- Screen filtration (eg, stainless steel or polyester mesh through which effluent passes while suspended solids are collected on the screen).
- Expanded granular media filtration (eg, bed of sand or plastic beads through which effluent passes while solids become trapped or attached to the medium).

<u>Removal of fine and dissolved solids</u>

- Foam fractionation (air-stripping or protein skimming using fine air bubbles to physically adsorb dissolved organic compounds onto rising bubbles in a water column and trapping the particulates in foam at the surface).

Controlling the concentration of ammonia and nitrite-nitrogen

- Air stripping (ammonia-nitrogen is removed from the effluent by adjusting the pH to 10, exposing it to air inside a packed column with no standing water allowed in the reactor and readjusting the water exiting to a pH of 7-8).
- Ion-exchange (expensive technology that creates an ammonia-laden brine waste by removing ammonia-nitrogen with salt-brine from a resin filter medium).
- Biofiltration (eg, rotating biological contactors, expandable media and fluidise bed filters and mixed bed reactors that use a large surface area per unit volume substrate, such as gravel, sand and plastic plates to grow nitrifying bacteria (*Nitrosomonas* and *Nitrobacter*), which oxidise ammonia-nitrogen into nitrite and nitrate, respectively).

Aeration and Oxygenation

- Aeration (eg, paddlewheels, propeller-aspirators and vertical-lift pumps will be used to maintain the dissolved oxygen in the sediment ponds between 4mg/L and 6mg/L).
- Oxygenation (eg, down-flow bubble contactor with 90% transfer of oxygen to water, u-tube diffusers below 70% transfer efficiency and pressurised packed column with 50% to 90% transfer efficiency will be set up were effluent enters the sediment pond one in the series of three).

Disinfection to control disease outbreaks

- Ultraviolet irradiation (to be cost effective, effluent entering the first sediment pond will be filtered of suspended particulates to ensure microorganisms are killed before being exposed to UV).
- Ozonation (expensive technology that can be toxic to humans, fish and crustaceans is a strong oxidising agent in water but its effectiveness is dependent upon contact time and residual concentration of O_2 in the water with microorganisms).

Liming to control acid-sulphate in sludge building up in sediment ponds

- Hydrated lime applied topically (to control the following: killing of most parasitic microorganisms due to its caustic nature; raising pH of acidic water to neutral or slightly alkaline; increasing the alkaline reserve in the water/mud (and thus prevent extreme changes in pH); neutralising the harmful effects of sulphides and acids; promoting the breakdown of organic substances by bacteria, creating oxygen and carbon reserves; precipitation of suspended or soluble organic particulates; decreasing biological oxygen demands (BOD); increasing light penetration; enhancing nitrification due to the requirement of calcium by nitrifying organisms; and indirectly improving the 'fine-textured' soil of the pond floor).
- Hydrated lime applied topically to sludge (to prevent re-release of phosphorus within the sludge from being discharged with the effluent, it will be dosed with a lime solution to raise the pH above 10.5).

6. The nutrient and other elemental content of the crab food to be used

Crablet food being used is pelletised prawn feed. Below is information provided on the label (a more detailed breakdown is not yet available):

- *Prawn HR 30*
- 0 PPM GMO free
- Date of manufacture: 02/03/05

- Crude protein (%min) 30%
- Crude Fat (%mim) 6%
- Crude Fibre (%max) 3.0%
- This product contains restricted animal material: Do not feed to cattle, sheep, goat, deer or other ruminants.
- Run # 55032, Formula # 87670 V3
- Pellet size: GR # 2
- Bag # 0855
- Store in a cool dry place. Nett Weight: 20 kg

For a breakdown of the recommended dietary nutrient levels for carnivorous prawns (including the above nutrients, amino acids, major minerals and trace elements) see Table 6-11, pg 112 in A. LeRoy Creswell. 1993. *Aquaculture Desk Reference*. Chapman & Hall, NY, ISBN: 0 412 07561 X; pp 206

Raw fish (group A - <5% lipid; 15-20% protein) showing average composition (% by weight; Table 6-27, pg 142; Creswell, 1993):

- H_2O 81.5
- Crude Protein 17.9
- Lipid or Ether Extract 0.6
- Ash 1.6

Prawns (showing average composition (% by weight; Table 6-17, pg 127; Creswell, 1993):

Shells (exoskeleton/hull; dried)

- Crude Protein 45.9
- Lipid or Ether Extract 0.4
- Crude Fibre 27.2
- Ash 31.7
- Calcium 11.10
- Phosphorus 3.16

Head silage (fresh)

- H_2O 81.0
- Crude Protein 14.1
- Lipid or Ether Extract 1.4
- Ash 3.5
- Calcium 1.08
- Phosphorus 0.30

7. The levels of treatment or removal of nutrients and suspended solids proposed in the settling ponds

As stated previously in Section 4.1.5 Waste water procedures (pages 12-13), the intended operation will discharge relatively small amounts of wastewater compared to those of the original prawn farming development and the adjacent Ludmilla sewage treatment plant. The period of greatest discharge may occur during the wet season when the ponds could overflow with rainwater. However, the low geographic position (sea level) of the ponds, and their close proximity to the

opening of the creek into Ludmilla Bay, suggest that the effect of small volumes of rapidly diluted wastewater with large volumes of coastal seawater will be insignificant. Moreover, the nutrients will be flushed from the creek during the twice-daily tides, further minimising any potential impact.

All wastewater from the ponds will be passed through three settlement ponds arranged sequentially with the residential time in each pond of 1-3 days. Water discharged will be equal to or less than the TSS, TN and TP nutrients levels and bacterial CFUs stated in Tables 1 and 2 (from the EMP). Each settlement pond will have the capacity to hold 23% of the total volume of the largest grow-out pond. The length of time to drain the largest grow-out pond will be over eight days if the resident time is two days per settlement pond and 12 days if the time is three days per settlement pond.

Discharge will be determined once the effluent loads are known but the actual discharge period from the last settlement pond into a tidal creek will occur over a 4 to 8 hour period relating to high tide. The creek selected for receiving discharged water is approximately 800m long by 4m wide and 0.4m deep running parallel to the farm in a NE-SW direction. The creek's catchment zone has a capacity of at least 1.28ML. Alternatively, wastewater will be irrigated into the mangroves.

As mentioned in Section 4.1.6 Corrective action (page 13), the small size of the operation and the twice daily flushing of the creek, suggests that corrective or mitigation strategies may not be necessary. However, if nutrient levels of the pond water are above the ambient levels for the tidal creek system, then the water in the settlement pond will be stored, treated as indicated in question 5 above and monitored until its levels are equivalent to or less than those that naturally occur. Returning 'used' pond water back into the creek will always be via the settlement pond and if there is any doubt or perceived threat, advice will be sought from EPA authorities.

Table 1. Pond effluent levels reported in the literature.

Method and Source of Levels	**TSS (mg/L)**	**TN (mg/L)**	**TP (mg/L)**
Queensland EPA 2000 *Mean* Maximum	20 100	0.8 3	0.1 0.3
Overseas (Thailand, Hawaii) *Range*	120-165	0.7-3	0.2-0.45
NT Fisheries	No data	1.55	0.42
Dept Environment and Heritage based on Food Conversion Ratio (FCR) of 1.82	No data	1.25	0.055

Table 2. Comparison of water quality parameters from five different locations along Ludmilla Creek taken over approximately 15 years from August 1977 to may 1992. Dash indicates no data.

Location Number	**^{0}C**	**pH**	**TSS**	**TP**	**Coliform CFU/100ml**
Loc 1	28.1	8.1	26.3	0.2	4,187
Loc 2	28.1	8.1	16.8	-	4,122
Loc 3	28.3	8.2	10.0	-	477
Loc 4	28.7	8.2	7.3	-	509
Loc 5	28.9	8.1	5.5	2	270

The levels of treatment or removal of nutrients and suspended solids proposed in the settling ponds are as follows initially:

- Sedimentation for settleable suspended solids (> 100µm dia.);
- Mechanical filters for non-settleable suspended solids (between 1 and 100µm);
- Foam fractionation/aeration for dissolved solids (<0.45µm dia.); and
- Liming substances (hydrated lime or Calcium hydroxide) added to the water or applied to the sediment pond floors prior to filling to remove nutrients by enhancing the breakdown of organic substances by bacteria or precipitate soluble organic materials. If ambient levels can not be reached then more sophisticated chemicals will be used after seeking advice from EPA or environmental/aquaculture/engineering consultants.

8. Ambient water quality monitoring

Water quality will be recorded for incoming (ambient), pond and outgoing (effluent) tidal creek waters and monitored daily, weekly, biweekly or monthly depending on the parameter as outlined in the EMP (Section 4.1.4 Water quality management within the ponds; pg 11-12). Acceptable levels will be maintained as set out below in Table 3.

Table 3. Water quality parameters for pond aquaculture of mud crabs.

Parameter	Measurement Tool	Occurrence	Acceptable range	Management Method
Temperature	Thermometer	Daily	20-33^{0}C	-
Dissolved Oxygen	DO meter	Daily	>4 mg/L	Aeration
PH	Meter	Daily	7-9	Alkalinity – lime
Salinity	Refractometer	Daily	10-35 ‰S	Water exchange
Algal density	Secchi disc,	Daily	>30 cm	Reduce feed rate
Chlorophyll a	fluorometer	Weekly	1-5 mg/m^3	water exchange
Ammonia	Test kit	Weekly	< 2.0 ppm	Encourage bloom water exchange
Nitrite	Test kit	Weekly	< 2.0 ppm	Encourage bloom water exchange
Total Suspended Solids (TSS)	Lab analysis	Monthly	Mean 20 mg/L	Increase sedimentation time before release
Total nitrogen (TN)	Lab analysis	Monthly	Mean 1.55 mg/L	Increase sedimentation time before release
Total phosphorus (TP)	Lab analysis	Monthly	Mean 0.42 mg/L	Increase sedimentation time before release

Some ponds (depending on experimental system) will be aerated using electrical aerators, either paddlewheels or aspirators, usually during the night only. Photosynthesis by microalgae during the day will provide sufficient oxygen for the crabs. These will also be used to disrupt stratification if necessary during the warmer months. Overflow facilities will be installed in the ponds to control water levels during the wet season.

To ensure accidental sewage bypass does not enter the ponds from the Ludmilla Wastewater Treatment Plant, contact has been made with Power and Water. An agreement has been reached in which the seawater intake schedule of the farm and contact details of two farm employees will be available (on a 24 hour basis) to the Plant's management and daily operators. If there are any potential or actual emergencies that could affect the water quality in the Ludmilla Creek system, the Plant will contact one of these people immediately to stop or prevent the pumping of intake water as scheduled.

The methods of collecting water for testing are detailed in the Power and Water's manual entitled: *Wastewater Quality Sampling Procedure Manual*. 2004. Further, once the food conversion rates are established, then the nutrient loads released during grow-out, nutrient assimilation, concentrations within receiving waters and the capacity of the environment can be calculated using published procedures, for example, by: Hambrey, J. Phillips, M, Chowdhury, M. A. K., Shivappa, R. B. 1999. *Composite Guidelines for the Environmental Assessment of Coastal Aquaculture Development. Volume 2: Appendices*. Prepared for Secretariat for East Africa Coastal Area Management (SEACAM).

9. Sludge removal

The quality of effluent from the sediment ponds will be tested and monitored to help determine the management protocol for disposing sludge. The parameters monitored will be those recommended by Patterson (1999) and Redding (2004):

- pH;
- EC (electrical conductivity in μS cm^{-1} of all ions in solution); nutrients (cations - Na, K, Ca, Mg; anions – nitrate, phosphate, sulphate, chloride; metal ions – Cu, Zn, Mn, Fe, Al);
- Biochemical Oxygen Demand;
- Total Solids (TS);
- Total Suspended Solids; and
- Total Dissolved Solids (TDS)

To gauge the impact of placing sludge on the top soil of selected areas within the farm's premises, the properties of that soil will be identified as proposed by Patterson (1999) and Redding (2004) and include examining the following:

- Soil depth and profile-horizons;
- Soil drainage (run-off and permeability);
- Soil texture (sand, silt, clay);
- Soil structure (aggregation of soil particles);
- Soil chemistry (including nutrient status);
- Cation exchange capacity (nutrient storage); and
- Exchangeable sodium percentage (ESP).

Some of this information has been collected in the past (eg, *Environmental Panning & Suitability analysis of Cultural & Nature-based Tourist Development at Kulaluk, Darwin*, circa 1997. 2SBI 347 Environ. Assess. And Planning Major Project – Final Rep. Ed/Complier Prof G. Hill; see Reference Section of EMP). Chemical analysis of the soil will be done through a nationally certified laboratory or through the NT Government's Laboratories at Berrimah.

Due to the origin of sludge consisting of largely bio-deposits of faeces, crab exoskeletons, uneaten feeds and natural micro/macro flora and fauna, the sludge will more than likely not create a disruptive impact on the local mangrove environment. During a pond's drying-out period the sediment may be harrowed to aerate the bottom layers and treated with hydrated lime to increase the pH or with sulphur to decrease the pH. By manipulating the pH range towards neutral, the nutrients within the sludge will become more available for uptake by plants (Patterson, 1999).

To keep the impact of the sludge on the soils beneficial, the balance of nutrients within the soil must be maintained to promote microbial and plant growth. Thus, it may be necessary to determine the carbon/nitrogen/sulphur/potassium balance (100:10:1:1), calcium/magnesium ratio (>4) and level of potassium and micronutrients in both the soil and sludge. If the sludge is deficient, supplementary fertilisers may need to be added (Patterson, 1999). This will be done during composting. Salinity levels within the sludge may increase the salts in the soil (eg sulphates, phosphates, bicarbonates, chlorides of cations sodium, calcium, potassium and magnesium) unless rainfall or excess irrigation occurs (see Question 10).

To enhance the process of composting, sludge will be place in windrows (1.5 m high, 2.5 m wide and 10+ m long) or in a circular pile (3 m diameter and 1.5 m deep) (WHO, 1992). In the dry season a cross-section of the windrow will be trapezoidal shaped (Figures 1-2) while during the wet it will be round. Composts may be fitted with aeration tubes (Figure 3). During composting the sludge's volume is likely to reduce by 40-48% and the weight by 20-50% if roughly similar to 'night soil' in composition (WHO. 1992). Before sludge becomes suitable for storage or use, the temperature during aerobic decomposition must reach 60-70 ^{0}C and the refuse must be 'turned' approximately five times over a one-month period. The amount composted will be used to fertilise replanting of the native bush in areas where coffee bush has been removed. The acceptable uses of treated sludge and amounts used over a given area will, however, be derived from "safe" sludge matrixes similar to those presented by the Scottish Executive (2006).

Figure 1. Compost windrow (modified from WHO, 1992)

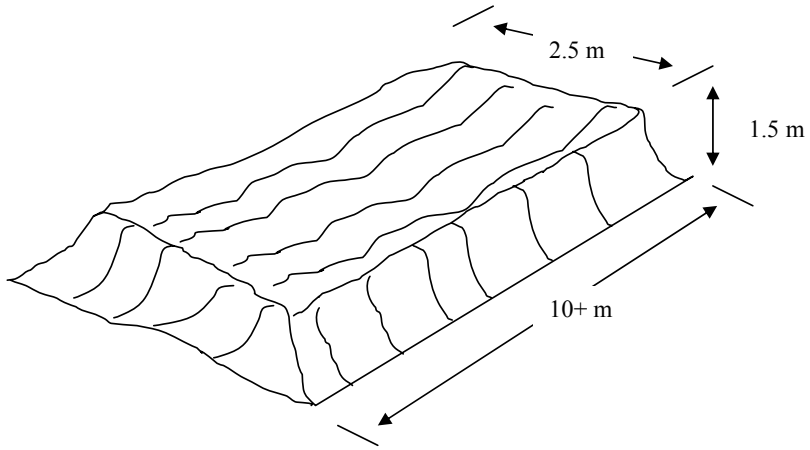


Figure 2. Elevation view (x-section) of windrow (modified from WHO, 1992).

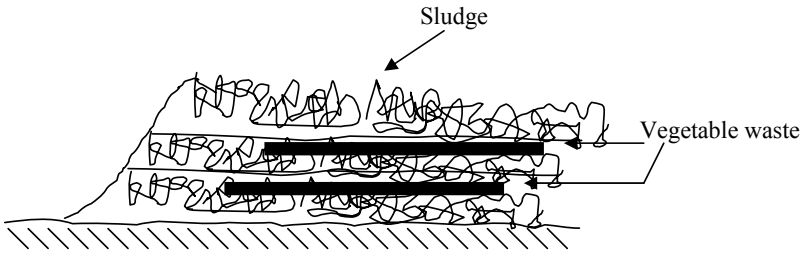
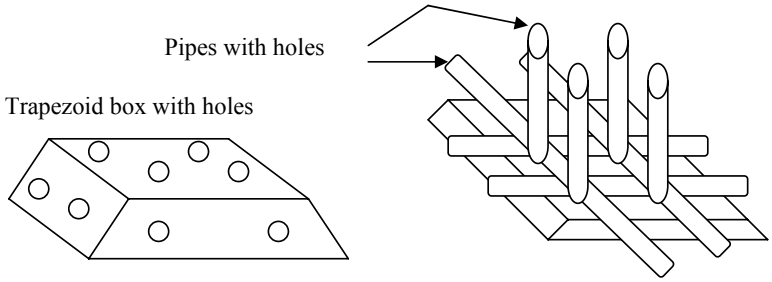


Figure 3. Aeration systems placed within compost heap (modified from WHO, 1992).



10. Final sludge salt content

The literature on salt content of sludge and iterative information from local soil/chemical/environmental laboratories indicate that the electrical conductivity (EC) of the soil (expressed as micoSiemen (µS) or milliSiemen (mS) cm^{-1}) can be influenced by the following factors as identified by Doerge (1999) in Ehsani, R. and Sullivan, M. Fact Sheet Extension on Soil electrical conductivity (EC) Sensors, Ohio State University, Food, Agricultural and Biological Engineering; web site: http://ohioline.osu.edu/aex-fact/0565.html :

- Soil porosity - a/ greater porosity of the soil the easier electricity is conducted; b/ clay soils have a higher porosity than sandy soils; and c/ compaction generally enhances soil EC.
- Water content - soils with a high moisture have a higher conductivity than dry soils;
- Salinity level - increases in concentration of electrolytes (salts) in soil water will markedly increase soil EC.
- Cation exchange capacity (CEC) – a/ mineral soils with high levels of humus and/or 2:1 clay minerals (eg, montmorillonite, illite or vemiculite) have greater retention of positively charged ions (Ca^+, Mg^+, K^+, Na^+, NH_4^+, or H^+) than soils lacking these ions; and b/ the occurrence of these cations in moist-filled soil pores will increase soil EC in the same way as salinity.
- Temperature – soil EC decreases slightly as the temperature drops to freezing point and declines rapidly below freezing due to soil pores becoming insulated from one another resulting in a rapid decline in soil EC.

Local laboratory chemists have found the EC of mangrove mud from the Darwin Harbour to range between 15 and 30 mS cm^{-1}, depending on where the sample was taken within the intertidal zone and/or the tidal conditions present at the time. The EC of Seawater was typically 55 mS cm^{-1}.

The EC values of the incoming seawater and mangrove mud soils at the crab farm devoid of sludge should be similar. The EC of farm soils and any sludge build-up will be monitored routinely to ensure the salt build-up in composting sludge does not cause an environmental problem. Salt levels in the composting sludge that are above ambient values will be rinsed with freshwater or exposed to rain until their levels are similar to those for the mangrove soils at the farm site.

Mud from the ponds and soils at the farm used for composting and receiving treated sludge will be tested as described by Paterson (1999) and a local laboratory chemist. For example, a 20 g sample of mud or soil will be collected and dried in an oven set at 110^0C to determine the loss of moisture by weight. The dried soil sample will then be dissolved in deionised water at a weight-to-weight ratio of 1:5 soil to water, stirred and measured to determine the EC of the solution.

References

Boyd, C.E. and Clay, J.W. 2002. *The evaluation of Belize Aquaculture, Ltd: A Superintensive Shrimp Aquaculture System*. Report prepared under the World Bank, NACA, WWF and FAO consortium Program on Shrimp Farming and the Environment. Work in Progress for Public Discussion. Published by the Consortium. 17 pages.

Hambrey, J. Phillips, M, Chowdhury, M. A. K., Shivappa, R. B. 1999. *Composite Guidelines for the Environmental Assessment of Coastal Aquaculture Development. Volume 2: Appendices*. Prepared for Secretariat for East Africa Coastal Area Management (SEACAM).

Patterson, R.A. 1999. Soil and the Effects of Effluent – What Do We Measure? In: Proceedings of 1999 Production and Environmental Monitoring 'Workshop. University of New England Armidale, March 1999.Paper PEM009.

Redding, M. 2004. Managing effluent and sludge application, Department of Primary Industries and Fisheries, Queensland, www.2.dpi.qld.gov.au/environment/13792.html, Email: callweb@dpi.qld.gov.au.

Scottish Executive. 2006. Prevention of Environmental Pollution from Agricultural Activity: 5 Non-Agricultural Wastes and Other Imported Organic Wastes. Web site: www.scotland.gov.uk/library5/envirionment/pepfaa-05.asp

World Health Organisation (WHO). 1992. A Guide to the Development of on-site Sanitation. Water, Sanitation and health web site: www.sho.int/docstore/water_sanitation_health/onsitesan/ch09.htm#TopOfPage

16. Draft Quarantine / Disease Prevention Management Plan: Kulaluk Crab Farm

The Disease Prevention and Management Plan is based on disease prevention and health certification prior to introductions of seed stock crabs onto the farm in accordance with the Fisheries Zoning Strategy for Disease Control in the Northern Territory and the health certification program conducted by the Darwin Aquaculture Centre in collaboration with Berrimah Veterinary Laboratories.

Broodstock

Only broodstock obtained from the local area will be used as the parent stock of seedstock crabs for the farm. The use of local crabs will minimise the risk of introducing diseases or parasites from other localities in the Territory and will retain the genetic integrity of the crabs in the area.

Broodstock selected for breeding will be taken to DAC for spawning and rearing of juvenile crabs. These crabs will be held in isolation from crabs from other regions in the Territory. The health of the broodstock crabs will be monitored by staff at DAC on a daily basis. Any crab showing signs of disease will not be used for spawning and the cause of the disease will be investigated.

Seedstock

Progeny of broodstock raised at DAC for seeding of crab ponds will be subject to on-going health monitoring at DAC. Prior to stocking of ponds, a sample of the population will be submitted for pathological examination. Stocking of ponds will only occur subject to a satisfactory health examination.

Farm Monitoring

At all times, crabs on the farm will be monitored for evidence of disease. Any crabs showing signs of disease will be collected and submitted to the BVL for pathological examination.

On-farm Disease Control

If disease or parasites occur in crabs on the farm, the use of local broodstock will ensure to a high degree of certainty that such diseases or parasites will reflect the local background spectrum of such agents already present in the area, i.e., diseases or parasites which are endemic to the local region, and not new diseases or parasites from other areas.

In the event of a serious disease, however, provision exists for the closure of water flow, emergency harvesting of crabs in the ponds and decontamination of infected ponds.

Translocation of Crabs

In the event that crabs are to be moved to another location, a program of health certification and laboratory testing will be undertaken in association with Fisheries prior to a Permit to Translocate being issued.

17. Miscellaneous (maps, tables, calculations, drawings)

Mudla P/L Mud Crab Farm Water Requirement Calculations:

1. Ponds total 3.0 hectares in area and are 1.5m deep.

2. Total pond volume: 30,000m^2 x 1.5m = 45,000m^3 = 45,000 tonnes = 45,000,000L = 45,000kL = 45ML

3. Three water exchanges in total volume per six-month grow-out period.

4. Volume required per six-months = 45ML x 3 = 135,000kL = 135ML.

5. Total volume required for entire year (x2 six-month grow-out periods) = 135ML x 2 periods = 270,000kL per year = 270ML.

6. Top-ups over entire pond system is set at 4% of total pond volume (mid-way between a 3% to 5% range) or 1.8ML, and is achieved in 4-day intervals over 350 days (two 175-day culture periods) or 88 top-up intervals (350/4 = approx. 88).

7. Total annual top-ups = 88 top-ups/year x 1.8ML/top-up = 158ML.

8. Annual Kilolitres taken = 270,000kL + 158,000kL = 428,000kL = 428ML.

9. Maximum annual Kilolitres requested = 428ML + 22ML (5% contingency) = 450ML (450,000kL).

Note: The maximum annual figure above is the same as the licence to take or use seawater issued to the farm site in 1997 for prawn culture.

Nutrient Load Calculations (to be determined once food conversion ratios are known)

9.4. Mudla farms Mud Crab Project Progress Report 3

APPENDIX 4

Gwalwa Daraniki Enterprise Pty Ltd

Mudla farms Mud crab Project

Progress Report 3

(September to December 2006)

Prepared by: RA Rose (19-31/12/06)

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Executive Summary

Gwalwa Daraniki Enterprises P/L, Mudla Farms Mud Crab Project has been operating for one year and four months (August '05 to Dec '06).

During this time it has received four batches of crablets totalling 70,510 and has harvested Batches 1&2 and almost completed Batch 3. Batch 4 is two-three months from harvest.

The construction of infrastructure relating to electrical power supply from the metropolitan grid system, installation of intake pumps and water reticulation to each pond is still not completed.

Funding budgeted from NT Area Consultative Committee to date has not been denied or confirmed, preventing the management board from initiating alternative plans.

Staff completed proposed work outlined in Progress Report No. 2: bio-security fencing around ponds, erosion-reducing windrows, testing of feed trays and creating hides in Pond 1 for Batch 4 crablets.

The harvest of the first commercial batch of 50,000 crablets received in March '06 (Batch 3) was disrupted in October due to deterioration in water-quality of ponds, adversely affecting the health and meat-quality/quantity of crabs.

Stagnant water conditions in the culture ponds reached temperatures above 32^0C in combination with fluctuating low/high dissolved oxygen levels, constantly elevated salinities above 45 grams of salt per litre and high pH readings that were above the normal ranges tolerated by crabs.

Somewhere between 10,000 and 16,110 crablets were stocked into Pond 1 at the end of September '06 (Batch 4) when the pond-water was hot and hyper-saline.

Batch 4 Crablets were provided with hides (shelter). The number surviving has been difficult to estimate but crablets observed on feeding trays or trapped appeared to be growing slowly and were healthy.

Batch 4 crabs after 93 days in grow-out averaged 13g wet weight and 34 mm carapace width (growing 0.14g day^{-1} and 0.37mm day^{-1}, respectively). Growth of Batch 4 crabs was notably slower than those of crabs from Batch 1&2 at 92 days, which grew 1.41g day^{-1} and 0.89mm day^{-1} and Batch 3 at 103 days, which grew 1.40g day^{-1} and 0.80mm day^{-1}.

Batch 3 crablets stocked in March '06 averaged growth was 2.7g day^{-1} and 0.8mm day^{-1} over a period of 147 days before reaching harvestable size of $\geq$ 350g.

The average carapace width of crabs harvested did not markedly increase above 7mm from July to October '06. The average wet weight of crabs, in contrast, continued to increase up to 0.5kg in October before dropping below the minimum harvestable size.

The peak harvest period for Batch 3 occurred during October '06 with the amount of crabs harvested during this month 4x, 3x and 2.5x greater than in July, August and September, respectively.

The total number of crabs harvested to date from Batch 3 (which is not yet completed) has been 739 (approximately 464 $\geq$ 350g and 275 $\leq$ 350g). The crabs still to be harvested have been estimated to number from 500 to 1000.

The average overall price during the 'build-up' period was $17.78kg^{-1}$ but peaked at $20.17 in September. A total of $3,932.20 has been made from 224.42kg of crabs sold to date. The total amount of revenue from the sale of crabs is currently $5,756.99 (combination of Batches 1&2 and 3).

The total cost for feeding Batch 3 to date has been $12,396. The Business Plan developed in 2005 for the project budgeted $42,000 and $54,000 for years one and two, respectively.

Due to the delay in the completion of Batch 3's harvest, the feed conversion ration (FRC) for this batch has not been estimated. Preliminary calculations suggest that it may be 1.4x higher than the 6 FRC for Batches 1&2.

Three trainees working at the farm have completed their Certificate II in Aquaculture and two trainees that started late are progressing well and should graduate sometime in 2007.

If all funds from DEWR and ABA, and the latest GST refund are received early January '07, the Project will have $71,664.00 before management/administration fees due for December '06, STEP trainee 'wages' and cost of feed and crablets are paid. The total amount of revenue remaining will be approximately $45,420.37 until February '07.

Financial statements from September-December '06 are attached in Appendix 1.

Plans to receive more crablets for grow-out during February '07 and installation of further infrastructure equipment are proposed once funding is secured.

Introduction

Gwalwa Daraniki Enterprises' Mudla Farms mud crab project is the outcome of one of the first Commonwealth Shared Responsibility Agreements (SRA) in the Northern Territory. Initially, the project originated from a business plan and two-year Deed Agreement developed by the Gwalwa Daraniki Association (GDE) and NT Fisheries (NT Dept Business, Industry and Resource Development). The Deed Agreement expired during November 2006 and the SRA is due to expire on June 30 2007 unless the parties involved agree to extend the current one. Alternatively, another SRA can be created to replace the old agreement.

The project has a steering committee consisting of four government fund-raising agents (Department of Employment Workplace Relations (DEWR), NT Area Consultative Community (NTACC), Aboriginal Benefits Account (ABA), and the Office of Indigenous Policy Coordination (OIPC), and three service providers (Charles Darwin University (CDU), NT Fisheries' Darwin Aquaculture Centre (DAC) and Tropical Aquaculture Australia P/L (TAA).

The project currently operates on funding provided by the Aboriginal Benefit Account (ABA) and the Department of Employment and Workplace Relations (DEWR) through Community Development Employment Projects (CDEP) and Structured Training and Employment Projects (STEP).

The project is still waiting for a decision on a funding application submitted to the NTACC in May '06 to complete construction of infrastructure related to electrical power, installation of intake pumps and seawater reticulation during the dry season (June to August).

The venture has been operating commercially without electrical power for one year and four months (August '05 to December '06). Over this period, the venture has received four batches of one-month-old crablets from DAC totalling 70,510. The numbers received for each batch are: Batches 1&2: 4,400; Batch 3: 50,000; and Batch 4: 16,110.

To date, the project has completed the harvest of Batches 1&2 and should be finalising Batch 3 sometime early February '06. Batch 4 crabs received on the 29th of September are 93 days and (at the time of preparing this document late December '06). Tentative plans have been made to receive a 5th Batch in February '06.

The community members employed in the project have either graduated or still advancing their studies in aquaculture and business through CDU. Some of the farm staff have been interviewed by ABC television and radio, presented a technical paper at a recent international aquaculture conference in Adelaide or provided farm tours to senior Federal and NT Government Ministers in treasury, indigenous affairs, regional trade, and employment. The NTACC and OIPC have completed two consultancy reports and one Student from Curtin University has completed her 3rd year thesis entitled: *An Evaluation of Gwalwa Daraniki Enterprises Mud Crab Farm Employment Program* (S Hewitt, 2006).

This 3rd Progress report summarises the grow-out culture of mud crabs since August/September '06 to the end of December '06 for Batches 3 and 4. Water quality monitoring of the ponds, harvest, sales, feeds, vocational training and financial expenditures over the first half of the 06/07 fiscal year are also presented. Plans for restocking during February 2007 and completion of the infrastructure are proposed for consideration.

Grow-out Results

General

All of the planned activities stated in Progress Report No. 2 have been attended to. Pond maintenance has been ongoing with mesh screens placed over the intake pipes of Pond 1 to prevent predators from entering the pond during filling or crabs from escaping. Bio-security fencing around the perimeter walls of each pond has been completed to prevent any crabs from climbing out of the ponds. "Windrows" around the outside of the pond fences have almost been completed to prevent rainwater from draining into the ponds and creating erosion. The windrows are composed of Hessian material draped along the outside of the fence with hay, rocks and road based, top-soil placed on top of each other. The Hessian is then pulled off the fence and tucked into the soil. Rocks, steel mesh and stakes have been used to fill areas along the dikes where rills (streams caused from water erosion) have formed.

During the 'build-up' period theft of crabs from ponds 3 and 4 (Batch 3) was surreptitious and continuous during the neap tides when staff were not present at the farm during long periods of pumping seawater. The level of pillage was not as intense as during the 'dry season' school holidays.

The settlement ponds all have brick collars to protect the drains between each pond from soil run-off. A garden mulcher has been modified by staff to chop/cut fish or prawns into pieces of various sizes, which are ideal for small or large crabs. Brick paving between the awning slab and freshwater tap have been laid in order to prevent soil erosion around the hose connection and tap. The debris blocking the water flow along the spillway leaving the settlement ponds has been started but not completed. Pond floor restoration around the opening of the monk in Pond 2 has commenced and should be ready for receiving spring tide waters early February in anticipation of the next batch of crablets to be released. All ponds have feeding trays set-up to observe consumption habits of crabs.

The crabs stocked into Pond 1 have had shade-cloth hides constructed for protection. The 'oyster shade-mesh' stretched between star-pickets was held just below the surface by white 'Styrofoam' floats. Weekly reports by the NT Fisheries Extension Officer document the farm activities described above in detail, including the efforts to improve the water quality of the ponds as discussed below. The water quality of each grow-out pond was routinely monitored from December '05 to December '06 with either instruments purchased by Mudla Farms or those used by the NT Fisheries liaison/extension officer. Instruments selected by farm staff were identical to those of Fisheries in order to keep recordings compatible by minimising errors associated with inherent differences between instruments.

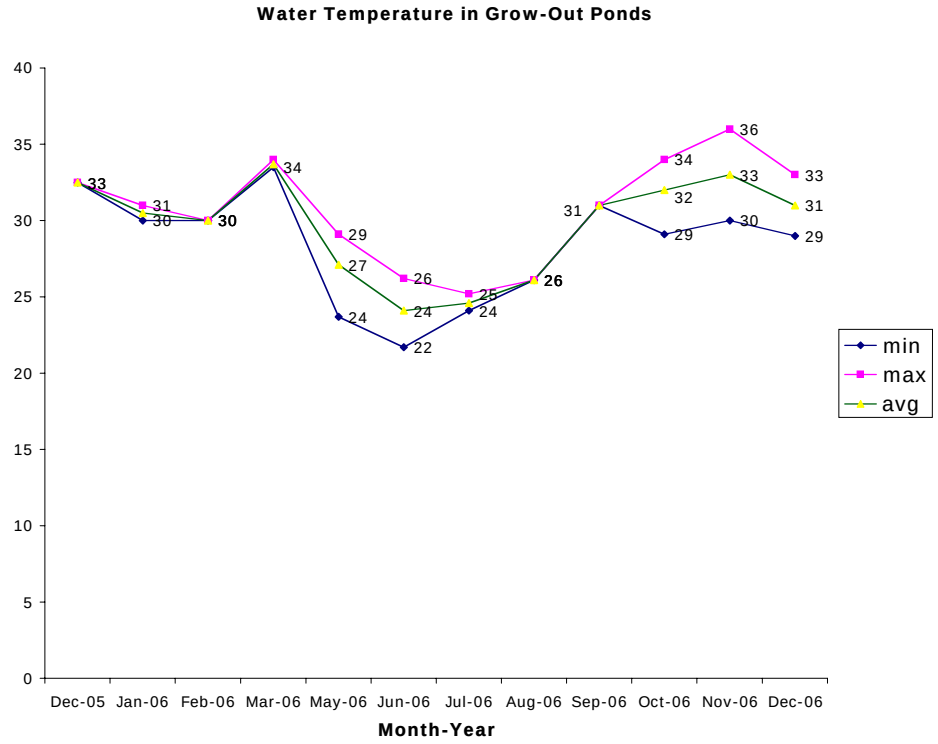
Copies of all Water quality, feed, growth and harvest data recorded by Mudla Farms for all batches of crabs received from the DAC have been provide to Fisheries for their records.

Water Quality

The general water quality values at the farm have been typical of mangrove estuaries in the Northern Territory to which crabs are naturally adapted (Figures 1 to 4). However, due to the inability of the farm to pump fresh seawater into the rearing ponds to control the rate of evaporation (and thus salinity levels) has caused the pond water to remain extraordinarily stagnant during the 'build-up' to the wet season (September to December). Crabs living in hot, saline water with dangerously low, fluctuating dissolved oxygen levels continuously for two months eventually affected their survival, health and meat quality. A situation not normally existing in an 'open, tidal-flushed' mangrove estuary.

During 2006, the warmest average temperatures over September to December ranged from of 31ºC to 33ºC with the maximum recorded at 36ºC in November and minimum at 29ºC (Figure 1). The average increase in temperature ranged 5ºC to 7ºC from August to December '06 (end of the 'dry' season to end of the 'build-up'). The monthly average temperature during the 'build-up' fell below the upper optimal limit of 32ºC for crab culture as reported in the literature. Only during the month of November '06 did the pond water average 1ºC above the limit (Figure 1).

Figure 1. Seawater temperature in grow-out ponds at Mudla Farms during 2006.

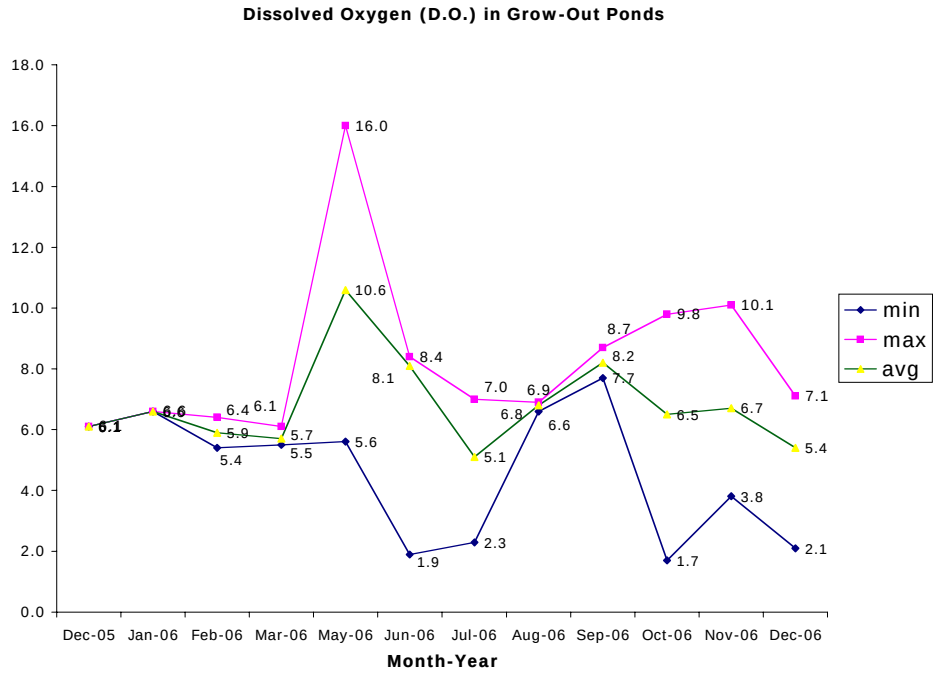


Lethargic, moribund crab that died during harvest October '06

The general pattern of dissolved oxygen (DO) in the ponds through out 2006 shows only four monthly levels below 6 mg/L and eight months above 6 mg/L (Figure 2). The average DO values during the 'build-up' months between August and December '06 remained above 5 mg/L. However, the minimum levels during October through to Mid-December '06 were dangerously low (1.7 to 3.8 mg/L; Figure 2). The values recorded were well below the recognised safe level of 4-5 mg/L for crab culture and may have explained the occurrence of dead crabs along side the pond walls, just above the water level. (These crabs were full of meat and ready for harvest.)

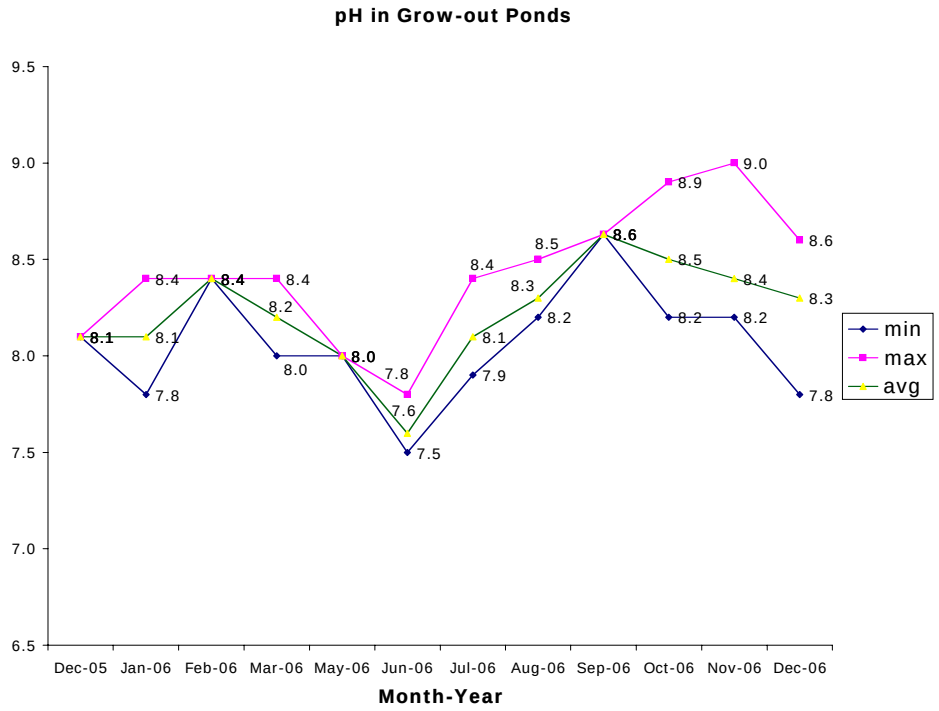
Dense algal blooms observed in the ponds undoubtedly contributed to the fluctuating DO levels which are high during the day when algae photosynthesise (producing oxygen) but low during the night/early morning when algae respire (consuming oxygen). The crabs during the day burrow into the mud to avoid high temperatures but in doing so inadvertently select a refuge where oxygen levels in the pond are at the lowest level. During the night or early morning they compound the effect by foraging outside their refuge at a time when the oxygen levels in the water are also low; behaviour suited to tidal estuaries but not enclosed ponds with stagnant water during the hottest months of the year.

Figure 2. Dissolved oxygen (DO) in grow-out ponds at Mudla Farms during 2006.



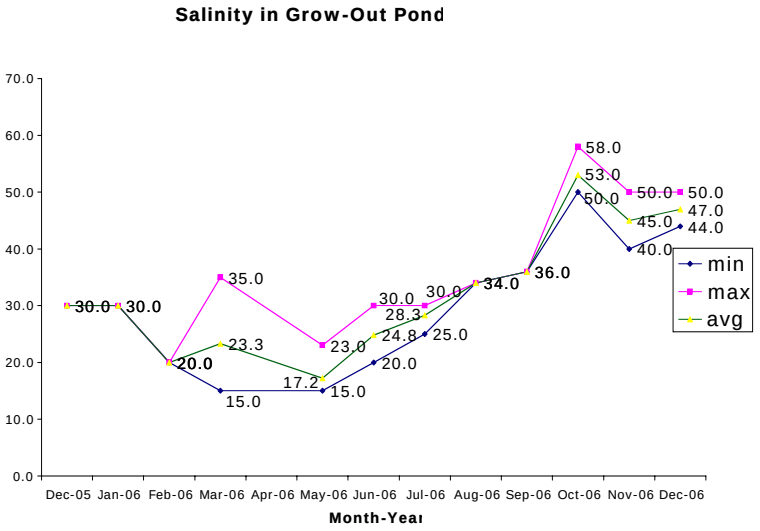
The pH levels (low value acidic / high value alkaline/pH 7 value neutral) recorded for the seawater in the ponds indicated that the seawater generally remained alkaline during the 'build-up' period but well above pH 8.2, the normal level of marine seawater (Figure 3). The maximum levels during the 'build-up' were above a pH 8.6 and peaking during November at 9.0 (Figure 3). The average monthly pH values for the months of August to December ranged between 8.2 and 8.6 while the optimal range reported in the literature for crab culture was 8.0-8.5. Abnormally high or low pH conditions can affect important biological/physiological processes in marine organisms (eg, calcium utilised in skeletal development).

Figure 3. The pH of seawater in grow-out ponds at the Mudla Farms during 2006.



The salinity during the 'build-up' averaged 34 g/L in August to 53 g/L in November (Figure 4). These levels are 4-23 g/L higher than optimal salinity range of 15-30 g/L for crab cultivation and 3-5 g/L above the upper limit of 45 g/L for crab survival (Dept Primary Industries, Qld, 2006: http//www.dec.ctu.edu.vn/sardi/AscrabCWare/DPI_Notes.htm). The salinity of the creek water refilling the ponds during spring tide pumping was 39 g/L early December '06. Without complete or significantly large-volume water changes salt build-up in the ponds could be slowed but not stopped.

Figure 4. The salinity of seawater in grow-out ponds at the Mudla Farms during 2006



Crab Growth

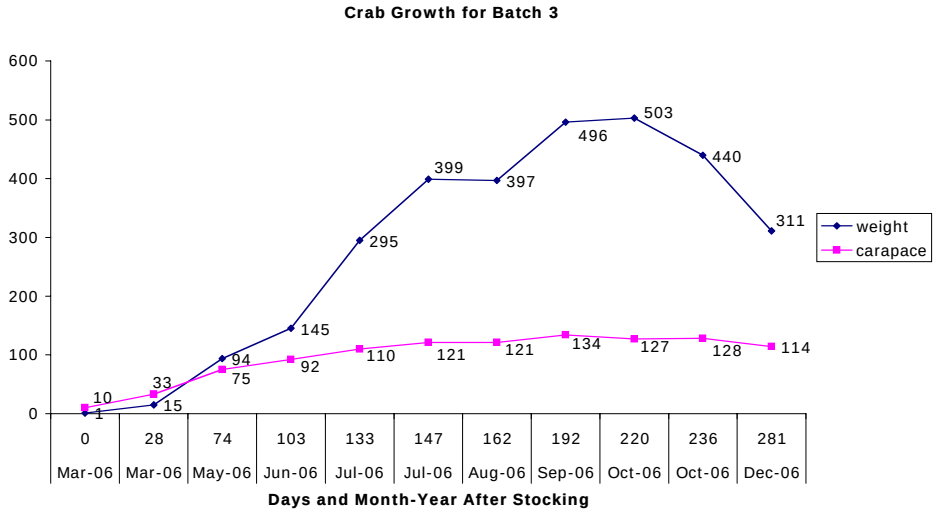
Batch 4 (comprising between 10,000 and 16,110 crablets) was stocked into Pond 1 on the 29th of September '06. Crabs from this batch have been routinely trapped in 'opera pots' during November and December '06. The numbers observed in the pond over the build-up period do not appear to be high even though shade shelters were placed in the pond. After three months, the low occurrence of crabs feeding from the feed-trays suggests that survival may not be high, however, many crabs could be residing under shade shelters well out of view.

Batch 4 crabs were 93 days old at the time of writing and averaged 13g wet weight and 34mm across the carapace with a growth rate of 0.14g day^{-1} and 0.37mm day^{-1}, respectively. In contrast, growth in Batches 1&2 was 1.41g day^{-1} and 0.89mm day^{-1} after 92 days and in Batch 3 it was 1.40g day^{-1} and 0.80mm day^{-1} after 10 days. Although growth rates appeared to be notably slower for Batch 4 crabs at a similar age, they were active, agile and healthy, showing no obvious signs of physical/behavioural damage or shell deformation due to the harsh water quality conditions described for the 'build-up' months of September to December.

During the 'build-up' months crabs from Batch 3 continued to be weighed and measured across the width carapace size when collected during harvest. Figure 5 shows the pooled growth rate of crabs from Batch 3 from Ponds 3 and 4, as there was no noticeable difference in growth between crabs from either pond. Batch 3 crablets stocked in March '06 averaged 2.7g day^{-1} and 0.8mm day^{-1} or 19g wk^{-1} and 5.3mm wk^{-1} over a period of 21 weeks (147 days) before reaching harvestable size of ≥ 350g. The average carapace width of crabs harvested did not markedly increase above 7mm from July to October '06. The average wet weight of crabs, in contrast, continued to increase up to 0.5kg in October before dropping below the minimum harvestable size (Figure 5).

Due to the presence of stressed and dying crabs in Pond 3 during the 'build-up', the pond was drained and all crabs alive (a total of 510) were translocated to either Pond 2 or 3 which contained 'fresh' seawater. These crabs are now being harvested. Crabs in Pond 4 appeared to recover without being transferred as the water replacement in Pond 4 was more effective than that for Pond 3. Pond 3 is now empty and open to tidal flushing during spring tides.

Figure 5. Crab growth in Batch 3 from stocking in March to December '06 (281 days).

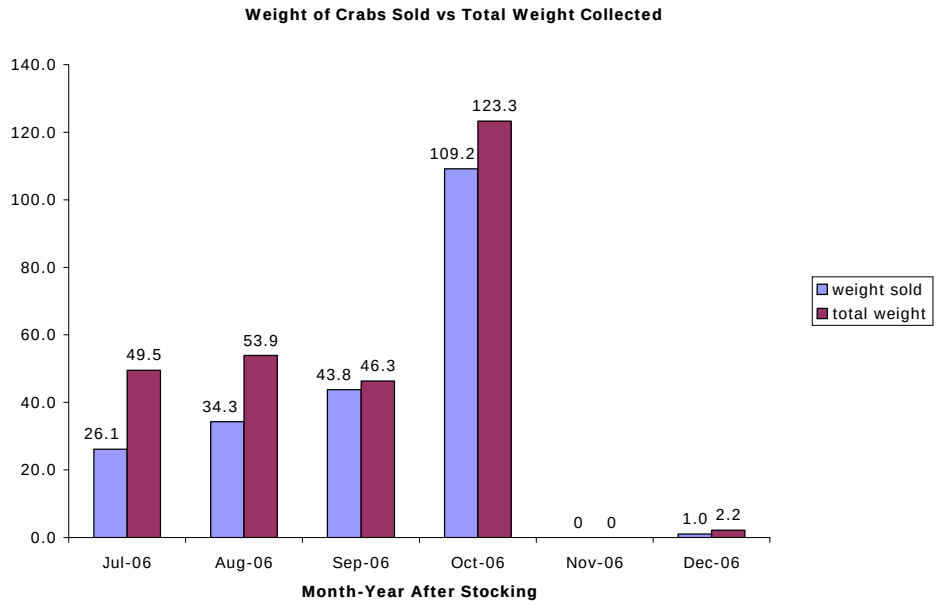


Harvest

The peak harvest period for Batch 3 occurred during October '06 with the amount of crabs harvested during this month 4x, 3x and 2.5x greater than in July, August and September, respectively (Figure 6). The percentage of crabs sold out of the total collected or harvested that were ≥ 350g for each month was 53% in July, 64% in August, 95% in September, and 89% in October. Crabs were not harvested during November due to the poor water quality of the ponds affecting meat quality, health and survival. In December, a trial-harvest less than 3kg was completed to ascertain if crabs were recovering, how 'full' they were and what was the quality of their meat (Figure 6).

The total number of crabs to be harvested from Batch 3 is still not known as there are still crabs being cultured in Ponds 2 and 4. The number of crabs sold to date ≥ 350g has been 464 and the number of crabs sold under this weight has been approximately 275, making the total 739 almost 1.5% of the original 50,000 crablets stocked into Ponds 3 and 4. Recall from Progress Report No. 2, the total number of crabs sold from Batches 1&2 was 13% of the original 4,400 crablets stocked into the pond for grow-out (578 crabs/4400 crablets).

Figure 6. Crabs harvested from Batch 3 at Mudla Farms from during 2006. The category "weight sold" refers to crabs ≥ 350g while the total weight category includes all undersize and market-size crabs.



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All sales of crabs from Batch 3 have been to either local wholesalers (≥350g) or to residences of Darwin and Asian restaurateurs (≤350g). The average monthly price for crabs to wholesalers leading up to Christmas was $\$18.01kg^{-1}$ (kg^{-1} = per kilogram) and for cash sales to customers it was $17.55 (Table 1). The average overall price during the 'build-up' period was $\$17.78kg^{-1}$ and a total of $3,932.20 has been made from 224.42kg of crabs to date (Table 1). The total amount of revenue from the sale of crabs is currently $5,756.99 (combination of Batches 1&2 and 3).

Table 1. Crabs harvested from Batch 3 at Mudla Farms from July '06 to December '06.

Month-Year	Wholesale			Cash			Total		
	Kg	**$**	**avg $/kg**	**Kg**	**$**	**avg $/kg**	**kg**	**$**	**avg $/kg**
Jul-06	20.12	333.29	16.57	4.10	80.00	19.51	24.22	413.29	18.04
Aug-06	21.66	382.12	17.64	20.39	375.00	18.39	42.05	757.12	18.02
Sep-06	16.00	322.67	20.17	36.06	616.76	17.10	52.06	939.43	18.64
Oct-06	84.88	1,499.86	17.67	21.21	322.50	15.21	106.09	1,822.36	16.44
Nov-06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dec-06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**142.66**	**2,537.94**	**18.01**	**81.76**	**1,394.26**	**17.55**	**224.42**	**3,932.20**	**17.78**

Feeds

Crabs were fed *Penaeus monodon* pellets during the first month after stocking and gradually introduced to fresh, trash fish (including local school prawns) during the second month. Batch 3 and 4 crabs are currently feed barra pellets in the morning and fish late afternoon and/or early evening. The deterioration of the quality of pond water put crabs off their food during the 'build-up' and feeds were curtailed for short periods or the amounts reduced. Feeding trays are being tested to estimate the daily ration of fresh fish for each pond.

Batches 1 & 2 were fed comparatively little pellets as opposed to Batches 3 and 4. The higher stocking densities and need to reduce production costs necessitated a greater reliance on pellet feeds for both Batches 3 and 4. Neither feeding regimes appear to affect the sweet meat quality of the crabs sold from any of the batches reared so far. The amounts of fish fed to Batch 3 crabs steadily replaced pellets during the 'dry-season' months to maximise growth and fattening of individuals to be harvested (Figure 7). During the 'build-up' months when pond conditions began to deteriorate, proportionally more pellets (less biomass) than fish were fed to the crabs to minimise the creation of higher pH levels and lower dissolved oxygen levels that could occur with decomposing uneaten fish.

The amount of feed for Batch 3 crabs peaked during May and June, the 3rd and 4th month of grow-out (Table 2; Figure 7). Except during November and December when crabs were still recovering, the total monthly cost of feeds between the 3rd and 8th month remained above $1,000 per month because of the greater proportion of fish fed to the crabs (Table 2). The total cost for feeding Batch 3 to date has been $12,396 (Table 3). The Business Plan developed in 2005 for the project budgeted $42,000 and $54,000 for years one and two, respectively.

The project has sourced new pellet feeds and cheaper-fish suppliers. Feeding regime for Batch 4 has been using less fish than previous batches. The plan for this batch is to use fish as the main diet during the last month to month and a half of grow-out before or during the harvest period.

The costs will be reduced further when barramundi fingerlings from NT Fisheries are phased-out completely or reduced significantly as this feed is 80¢ per kilogram more expensive than equivalent trash fish bought from local fish wholesaler/retailers.

Due to the delay in the completion of Batch 3's harvest, the feed conversion ration (FRC) for this batch has not been estimated. Preliminary findings suggest that it could be 1.4x higher than the 6 FRC for Batches 1&2 due to the equivalent dry weight proportion of less nutritional barra pellets to fresh fish in the diet, an extended culture period due to pond conditions and higher initial stocking density (population) for Batch 3.

Figure 7. Feed provided to crabs from Batch 3 from March to December '06. Fish category for June and July includes local prawns cleared of carrying diseases before use and all other months consist of fresh barra fingerlings or local bait/trash fish.

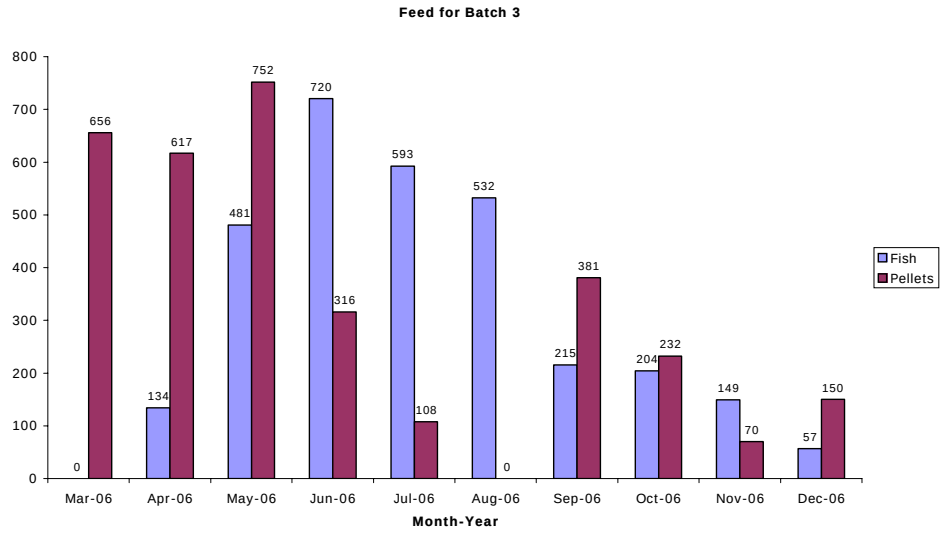

Table 2. Cost of fresh/frozen fish, prawns and dry commercial prawn and barra pellets for Batch 3 crabs reared at Mudla Farms. Costs are calculated on price per kilogram of each feed type and pooled together into either the fresh-fish or dry-pellets category for each month.

Month-Year	Fresh-Fish		Dry-Pellets		**Total**	
	Kg	Cost $	Kg	Cost $	Kg	Cost $
Mar-06	0	0	656	590	656	590
Apr-06	134	382	617	555	751	937
May-06	481	1,371	752	677	1,233	2,048
Jun-06	720	1,500	316	284	1.036	1,784
Jul-06	593	1,219	108	972	701	2,191
Aug-06	532	1,518	0	0	532	1,518
Sep-06	215	614	381	705	596	1,319
Oct-06	204	582	232	429	436	1,011
Nov-06	149	426	70	130	219	556
Dec-06	57	164	150	278	207	442
Total	**3,085**	**7,776**	**3,282**	**4,620**	**6,495**	**12,396**

Training Program

Three of the six trainees enrolled in the Certificate II Seafood Industry, Aquaculture Program (Jackie Treves, Sylvan Shorty and Tim Angeles) have graduated, completing their Certificate II's in November/December '06. Two of the six (Wayne Alum and Setona Shields) have completed 39 weeks of training (Outcome 4) and are progressing well.

One of the six (Serena Toby) dropped out of the program mid-October '06 and moved interstate. Michelle Nelson, the only trainee enrolled in the Certificate II Business, Office Administration, temporarily dropped the course during the 'build-up' months but has re-enrolled to continue her studies in 2007.

The course coordinator at CDU, Leyland Campbell was pleased some of the staff graduated on time and was confident that if Wayne Alum and Setona Shields continue to apply themselves, they will successfully complete the course during 2007.

The work schedule at the farm continues to allocate study time for all staff. In addition, they have been receiving instruction on operating and maintaining instruments used for water-quality monitoring. The youngest trainee has recently obtained his learner's driver permit. Staff will either continue their existing study program or advance to the next program in 2007.

Financial Expenditure and Income

Financial statements are attached in Appendix 1. These statements include: Bank Statements for August, September, October, November and December '06; Profit and Loss Statements; Balance Sheets; Reconciliation Reports; Budget Analysis; Sales and Asset Register.

The monthly financial balances of the GDE, Mudla Farms Charitable and Benevolent Trust, cheque account [NAB: BSP 085-933, Acc No. 58-651-4884] from August to December 2006 are summarised below:

- August '06 $27,018.85
- September '06 $69,901.54
- October '06 $37,121.12
- November '06 $18,327.43
- December '06 $4,494.28

The majority of expenses related to farm operations (eg, repair and maintenance of equipment, crab feeds, farm consumables, pumping, pond structures, administration and management/mentoring fees). Construction materials for fencing and windrows, and water-quality monitoring equipment were also purchased.

Some expenses were unexpected. For example, vehicle registration and a repair bill for a farm vehicle of $3,670.00 during October '06. These costs are normally incurred by GDA (owners of the vehicle) and the repair work related specifically to several years of wear and tear prior to GDE's existence. Not fixing the vehicle, however, would have left the farm without any reliable form of transport.
A 10% deposit on a purchase order of $34,265 for electrical cable and conduit was paid to the supplier late August to hold the original price quoted after approval was gained from the Project's

management board. (The board had anticipated NTACC funding would become available by October '06.)

At the time of preparing this document, $57,637.00 budgeted for the last quarter of the first year of funding by ABA was being processed. DEWR STEP funding of $8,885.00 for staff training was transferred to the GDE cheque account 18th of December '06. If the ABA and DEWR funding and GST refund of $6,553.00 are received (plus the balance at the end of December of $4,494.28), then the Project should have approximately $77,569.28. After the management and administration service fees for December '06, STEP wages for trainees, costs of feed and crablets from NT Fisheries and reimbursements are deducted early January '07, the total amount of income remaining will be $50,275.59 until February '07.

Crabs sales as shown in the December '06 monthly cheque account balance was $5,756.99 [see Appendix 1; NAB: BSP 085-933, Acc No. 79-274-5210]. This represents sales from Batches 1&2 and 3, which may increase by another $1,000 to $5,000, if the total number of crabs remaining weighs up to 250kg at $12.00 per kilogram ($3,000).

Proposed plans until the end of August 2007

The project has progressed despite the unpredictable injections of funds and subsequent inability to follow a planned construction schedule. The farming phase has begun without the infrastructure but data on survival/growth/feed/general crab husbandry, pond water-quality parameters and marketing have been documented. Staff have begun to develop aquaculture and business skills that should improve either their individual chances of finding employment in the seafood industry or to collectively run their community's mud crab farming venture.

Due to the continued delay in obtaining funding from NTACC (one of the principal stakeholders and funding agents), the project proposes the following:

- Complete harvesting Batch 3 by the end of January '07 and cultivate Batch 4 until February/March '07 before harvesting.
- Prepare Pond 3 for a new batch of crablets from DAC during February '07.
- Modify and test a variety of sluice boards and water screens.
- Repair fencing around ponds and pond walls around monks after 'rainy season'.
- Continue to stabilise the pond walls with vegetation to minimise erosion.
- Finish removing debris blocking water flow along spillway leaving the settlement ponds.
- Connect freshwater plumbing from demountable lab/office to freshwater pipe.
- Commence installation of electrical infrastructure, intake pumps, and seawater reticulation pipe work when (if) funding from NTACC becomes available.
- Continue on-the-job training and Seafood Industry or Business administration education with Staff.
- Prepare a new business plan, budget and assist with a new SRA and grant applications between all participating parties.

Appendix 1: Financial Statements

Table 3: Profit & Loss Statement July 2005 to June 2006

Table 4: Profit & Loss Statement July 2006 through November 2006

Table 5: Job Profit & Loss Statement September 2006 through November 2006

Table 6: Balance Sheet as of September 2006

Table 7: Balance Sheet as of October 2006

Table 8: Balance Sheet as of November 2006

Table 9: Jobs (Budget Analysis)

Table 10: NAB Business Cheque Account (Aug 2006) and Reconciliation Report

Table 11: NAB Business Cheque Account (Sept 2006) and Reconciliation Report

Table 12: NAB Business Cheque Account (Oct 2006) and Reconciliation Report

Table 13: NAB Business Cheque Account (Nov 2006) and Reconciliation Report

Table 14: NAB Business Cheque Account (Dec 2006)

Table 15: NAB Business Cheque Account (Dec 2006) for crab sales

Table 16: Sales [Item Detail] July 2006 through October 2006

Table 17: Asset Register

Keenan, C.P. 1999. Aquaculture of the Mud Crab, Genus *Scylla* – past, present and Future. In: Keenan, C.P. and Blackshaw, A. (eds). Mud Crab aquaculture and biology. Proceedings of an international scientific forum held in Darwin, Australia, 21-24 April 1997. ACIAR Proceedings No. 78, 216p.

9.5. Mud crab aquaculture: Overview of growout production research (NT Fisheries)

APPENDIX 5

Mud Crab Aquaculture – Overview of Growout Production Research

Introduction

Mud crabs of the genus *Scylla* have recently been the focus of international collaborative research throughout the Asian region, and progress has now been made in hatchery technology in order to supply seed stock (Williams et al., 1999; Ruscoe et al., 2004a). The most widespread of the four mud crab species *Scylla serrata*, and the only species under investigation in Australia, occurs throughout the indo-west pacific from southern Africa to Tahiti, including the northern half of Australia, north to Okinawa, and south to the bay of Islands in New Zealand (Keenan, 1999). They inhabit tropical to warm temperate inshore zones and form the basis of relatively small, yet important commercial fisheries. In the Northern Territory of Australia, these relatively large crabs are usually found in intertidal and subtidal zones of estuaries and in mangrove systems (O'Grady et al., 2003). The apparent wide temperature and salinity tolerances of *S. serrata*, as evidenced by its natural range and preferred environment, makes this species an attractive candidate for aquaculture.

Mud Crab Growout has been occurring in parts of Asia for more than 100 years (Yalin and Qingsheng, 1994), although until very recently these efforts have relied on wild caught juveniles. In combination with the removal of juvenile crabs prior to spawning age, habitat destruction throughout Asia has decimated wild stocks and has forced several countries to investigate mass culture of juvenile crabs from eggs. Scientists at the Darwin Aquaculture Centre have recently developed technology that will reliably produce commercial quantities of juvenile mud crabs so an opportunity now exists to establish growout farms. Research has been undertaken to evaluate the optimal water quality conditions during nursery culture (Ruscoe et al., 2004b) and several batches of juveniles have been grown out on a commercial prawn farm.

Several indigenous communities have expressed an interest in establishing mud crab farms on their land as this is a well known species with good commercial potential. The product can be marketed live and is easily stored 'dry' to coincide with the limited transport opportunities that exist for remote communities.

Recent research findings

Prior to 2004, very little was known of mud crab growout in Australia. There is a tendency for research to remain in-house in countries where the research is being conducted, justifiably in order to benefit that country's people, and for this reason the data available from overseas nations has tended to be incomplete. A summary published research from the Philippines and Vietnam is shown in Table 1 below.

In 2004, when the DAC was able to being producing commercial quantities of crablets, several growout trials were conducted on a local prawn farm. This data is also presented in Table 1.

It is difficult to directly compare data from different trials due to differences in research methodology as well as differences in genetic stocks, feeding regimes, pond conditions, differing starting sizes and culture periods, and general culture management. Like all crustaceans, mud crab growth is temperature dependent. The warmer the temperature (within species limits) the greater the growth, and the difference can be substantial. As a general rule growth rate doubles for every 10° C rise in temperature. Several research reports are summarised below.

Trino et al. (1999), in the Philippines, published some of the most complete data on the results of a small trial assessing the influence of crab density on growth and survival. In their experiment juvenile crabs approximately 10 g in weight were stocked into 150 m^2 ponds at densities of 0.5, 1.0 or 1.5 crabs / m^2. The crabs were grown for 120 days and were fed 8 % of biomass per day.

After 4 months crab growth was the same in all densities and the crabs weighed 375-400 g. Survival decreased with increasing density, to yield approximately the same total weight from each treatment The highest yield was equivalent to 2,130 kg per hectare, over 120 days. If we hypothesise and extend the growout period for an extra month to 150 days, crab harvest size would easily exceed 450 g, although there may have been a slight decrease in survival. If final crab density was 0.7 crabs per m^2, final yield would have been equal to 3,150 kg per hectare. Figure 1 shows the actual data of crab growth during the experiment and the hypothetical extension to 150 days of culture.

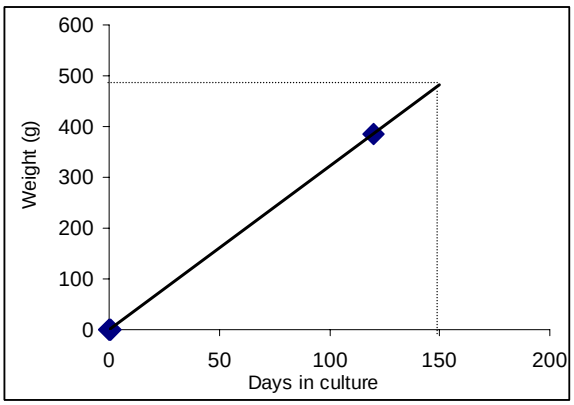

Figure 1. Mud crab growth in the experiment of Trino et al. (1999). Data point signifies the actual mean crab weight after 129 days. A trendline allows extrapolation to 150 days of culture.

Hoang Duc Dat (1997) stocked experimental ponds with mud crabs at densities of 1.5 - 3.5 crabs / m^2 and grew them for between 98-182 days. Several pieces of critical data were omitted from the report, including survivorship and total yields, but the researcher did report that the crabs grew well to around 350-500g. In fact the data suggests that the crabs in one trial grew from less than 100 g to 500 g in around 100 days.

Fortes (1999) also published a report on mud crab growout in 1997 from the Philippines. That author grew crablets from 45 g to around 170 g in 165 days. Reported survival was very low due apparently to escapism from the experimental ponds and therefore yields were also very low. The growth is relatively slow also, just 125g in 165 days, although they were fed only 3% of biomass per day. This probably led to the cannibalism and escapism and therefore the poor survival. The trial also occurred over the winter months, so temperatures were probably lower than optimal, also contributing to lower than expected growth.

In 1999 another Philippine researcher, conducted a growout trial assessing the stocking density of crablets (Baliao, 1999). This researcher used 1 hectare ponds and stocked crabs at 0.5 and 1.0 per m^2. They were initially 3.2 g and were grown for 122 days (4 months). These crabs were grown in polyculture with milkfish, a common Asian cultured food fish. Survival at both densities was 67% and growth was equal with average weights of 250 g. Feed rates were not reported but it is likely that the crabs were well fed, as polyculture feeding systems are frequently designed to support several species. It is also not known why the researcher stopped the trial when the crabs were only 250 g. Perhaps the milkfish and crabs were of a marketable size. We have again projected growth of crabs under culture for an extra 6 weeks or so (to 5 and a half months). After 175 days the crabs would likely be around 350 g (Figure 2).

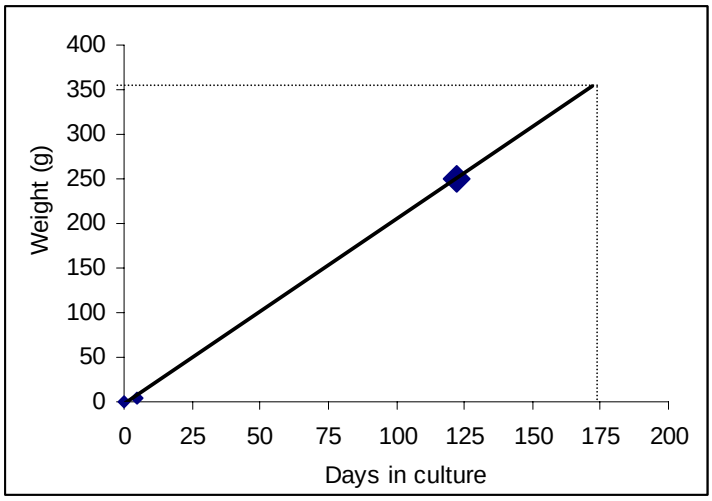

Figure 2. Mud crab growth in the experiment of Baliao et al. (1999). Data point signifies the actual mean crab weight after 122 days. A trendline allows extrapolation to 175 days of culture.

Trifiol (1999) reported on the growth of mud crabs in 150 m^2 experimental ponds, and was able to show excellent growth. Unfortunately much of the data was not reported for commercial reasons, so survival and yield are not known. The crablets were apparently stocked at a small size and were harvested after 156 days at an average weight of 412 g. Again this data is presented in graph form with extrapolated data for up to 175 days. At this time the crabs would have been in excess of 450 g .

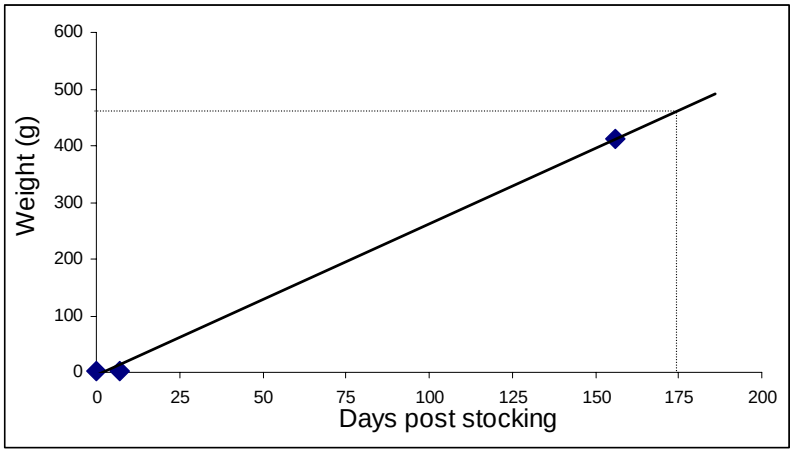

Figure 3. Mud crab growth in the experiment of Trifiol. (1999). Data point signifies the actual mean crab weight after 122 days. A trendline allows extrapolation to 175 days of culture.

Darwin Aquaculture Centre Trials

The most complete data we have access to, is of course our own. An arrangement was made with a local prawn farm to accept and manage four ponds of crablets produced at the Darwin Aquaculture Centre (DAC). The DAC staff were to monitor the crabs fortnightly and provide advice where necessary, but the operation of the ponds was left to the prawn farm staff. The prawn farm was to feed the crabs School Prawns (bait prawns grown on the farm) and local mullet harvested from storage ponds.

The ponds were prepared and filled by the prawn farm staff a week or so before stocking.

Crablets from two batches were stocked to four ponds (2 ponds per batch) in January and February 2004. Ponds 5 and 6 were stocked in January and Ponds 1 and 2 in February. The ponds were rectangular and 700 m^2 in size. The crabs weighed between 1.0 and 2.5 g at stocking, and were stocked at around 2.3 crablets m^{-2}. The crabs from all ponds were monitored regularly for growth using baited traps.

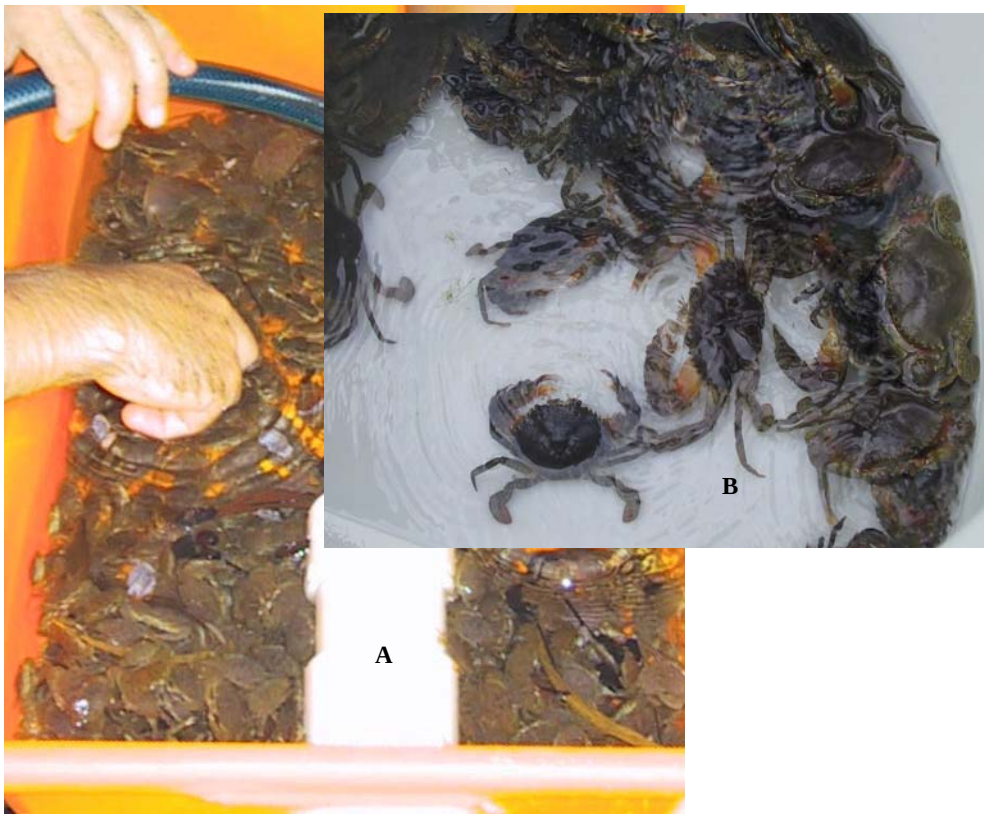

Figure 4. (A) The crablets for stocking at the prawn farm.
(B) Approximately two months post stocking

After several weeks it was noticed that all ponds contained healthy populations of a species of carnivorous perch.

The two ponds representing the first batch of crablets stocked (5&6), were harvested after 16 weeks (112 days), and yielded survivals of 16 and 23%. The average weight of these crabs was 202 g and 301 g respectively (Figure 5). Yields were equivalent to 542 and 1900 kg / ha for the crop, of just 4 months.

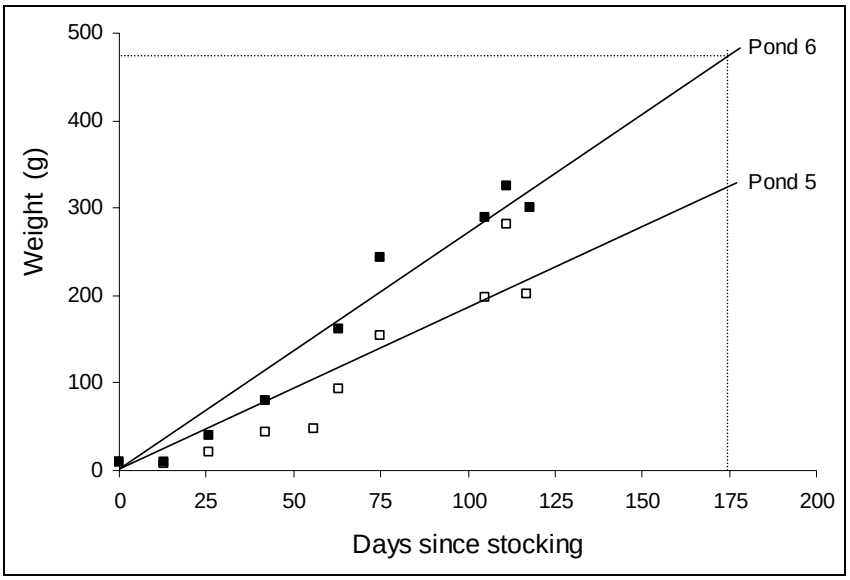

Figure 5. Growth of the first batch of crabs stocked to ponds 5 and 6 at the prawn farm. Data points represent the average weight of crabs during sampling and harvest. Trendlines have been added as a guide to estimating average growth of crabs after 175 days (6 months).

Almost immediately after this first harvest, a period of cold weather and cool water temperatures prevailed. This extended the growout period of the second batch for several weeks.

Around this time the owners of the prawn farm informed us that they needed the ponds for their own operational purposes. So after 231 days the remaining ponds (1&2) were harvested. We would have preferred to continue the growout period into the warmer months, as the crabs had ceased growing, we thought due to very cool water temperatures of June, July and August. The farm was also beginning to run out of food for the ponds and were reducing the feeding rate. They had also stopped chopping the food into pieces as recommended (for a more even distribution), and had resorted to throwing in whole mullet which the crabs were meant to 'fight over'. This feeding method probably increased aggressive interactions and severely decreased survival. This poor feeding regime also likely contributed to the cessation of growth. The farm ceased operations almost immediately after we had left, and is now up for sale.

In any case the crabs grew to an average size of 260 g and 254 g with survival of 25.4% and 24.4%, equivalent to 1521 and 1485 kg / ha respectively (Figure 6).

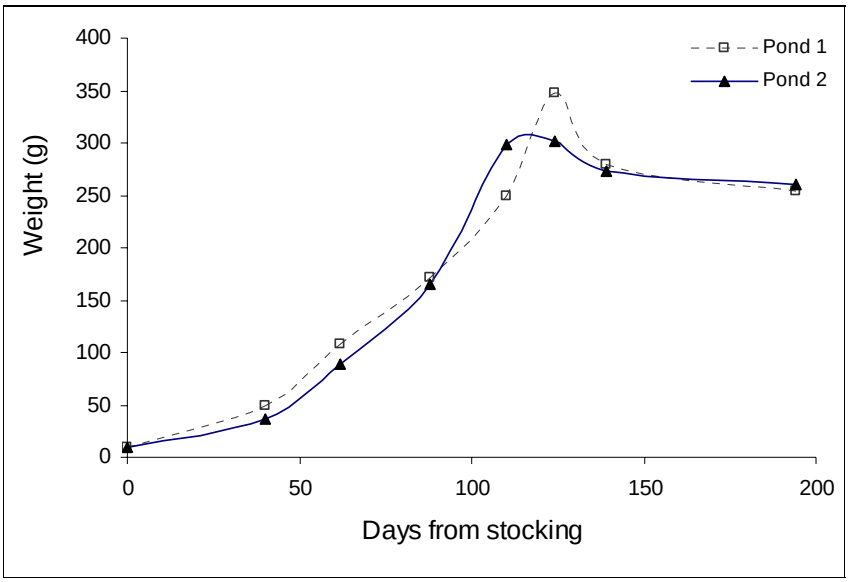

Figure 6. Growth of the second batch of crabs stocked to ponds 1 and 2 at the prawn farm. Data points represent the average weight of crabs during sampling and harvest.

Several operational problems existed during this trial that contributed to the relatively poor survival across all ponds. Simple measures can be implemented to overcome these problems. Firstly, the intake water used to fill the ponds can be screened with fine mesh 'socks', standard practise at most marine prawn farms. This will prevent predatory fish from entering the ponds. The fish likely affected survival in three ways. They would have preyed on juvenile crabs soon after stocking; they would have competed with the crabs for the food provided – causing high levels of competition for food among crabs leading to aggressive encounters; and they may have inhibited normal feeding behaviour (i.e. the presence of predators often inhibits feeding in aquatic animals (Trussel et al., 2003)). It is a fact that the pond with the largest population of fish (Pond 5) yielded the poorest crab growth and survival.

Secondly, the poor feeding regime implemented by the farm (that is a reduction in the feeding rate and the distribution of large pieces of food instead of a greater number of smaller pieces), would have caused high levels of competition for the food items and probably led to cannibalism in the crop. It is highly likely that the larger crabs would have fought over the food items, rather than the smaller crabs, and this probably led to the deaths of larger crabs in the remaining population. Figure 5 shows a decline in average weight between day 120 and harvest. This cannibalism of larger crabs is a likely explanation. Had the food been unrestricted we believe the growth and survival would have been much greater.

The results of this trial show that if 2 or 3 crabs are stocked per square meter and are well fed and protected, then between 0.7-1.0 crabs per m^2 should be harvested with an average weight of 400 - 450 g.

If 0.7 crabs per m^2 are harvested, at 450 g after 6 months, then 3,150 kg of crabs will result from each hectare. Over a year this will amount to 6,300 kg per ha.

In Summary

Several trials have been conducted in various Asian countries and now in Australia. The majority of these trials have shown that mud crabs can be grown in aquaculture ponds from a small size (1- 10 g) to a marketable size (350 – 500g) within 6 months.

The density of the growout does affect survival and yield especially where food and shelter are limiting. None of the Asian research reported the use of hides in the growout trials, even though numerous research reports have found, for many species of crustaceans, that hides or refuges improve survival, probably by providing protection during the moulting process. For redclaw crayfish, another clawed crustacean, survival was improved from 17% (no hides) to 80% with the addition of a preferred refuge (Jones and Ruscoe, 2001). It is thought that the provision of refuges may improve survival, where feeding and predation can be controlled. Under optimal food conditions, refuges may shelter the moulting animals sufficiently to improve survival and therefore yield. Growth may also be improved.

We believe that by applying pond management Best-Practice, including

- The screening of intake water
- Daily water quality measurement and management
- Optimal feeding regimes based on body weight and feed trays
- The provision of shelter for protection while moulting
- Health monitoring
- Predator protection and 24 hr farm security, and
- Targeted harvesting of marketable crabs, leaving submarket size animals in the pond,

we will be able to attain high growth rates and high survival, resulting in yields in excess of 3150 kg per ha per six month crop. These animals will be robust, healthy and of premium quality and will fetch premium prices in target markets in Darwin, and other capital cities if required.

Table 1. Summary of results for recent published mud crab growout experimentation.

Source	Origin	Stocking density (ind/m^2)	Stocking size (g)	Pond size m^2	Culture period (days)	Survival (%)	Harvest Wt (g)	Production kg/ha/crop	Feed rate (% per day)	Comments
Trino et al ,1999	Philippines	0.5	7.0 - 11.0	150	120	98	400	2000	8	
		1		150	120	57	375	2130	8	
		1.5		150	120	30	375	1687	8	
Hoang Duc Dat, 1997	Vietnam	3.5	8.3 - 17.0		182		200		4 - 6	
		3	25 - 40		126		350		4 - 6	
		1.5	66.6 - 100		98		500		4 - 6	
Fortes, 1997	Philippines	0.5	45.8	500	165	12 (?)	188		3	no shelter
		1	45.8	500	165	?	170		3	shelter
		0.5	45.8	500	165	?	165		3	no shelter
		1	45.8	500	165	?	150		3	shelter
Baliao, 1999	Philippines	0.5	3.2	10000	122	67	250	837		with milkfish
		1	3.2	10000	122	67	250	1600		with milkfish
Trifiol, 1999	Philippines	1		150	156		412			
DAC, 2004 (Golden Prawn Farm	Darwin	2.4	1.0 - 2.5	700	231	25.4	254	1521		
		2.4	1.0 - 2.5	700	231	24.4	260	1485		Predation, limited food
		2.1	1.0 - 2.5	700	161	16.1	202	542		finished early
		2.5	1.0 - 2.5	700	161	22.4	301	1900		finished early

References

Anonymous 2006. Australian Prawn Farming Manual- Health management for Profit Publ Qld Dept Primary Ind, & Fish. ISSN 0727-6273:157 pp

Baliao Dan D., Miguel A de Los Santos. 1999. Grow out systems for Mud Crabs. Extended Abstracts: International forum on the culture of Portunid crabs, Boracay, Philippines, 1-4 December 1998.

Fortes, R.D. 1999. Preliminary results of the rearing of Mud Crab, *Scylla olivacea* in brackishwater earthen ponds. In: Keenan, C.P. and Blackshaw, A. (eds). Mud Crab aquaculture and biology. Proceedings of an international scientific forum held in Darwin, Australia, 21-24 April 1997. ACIAR Proceedings No. 78, 216p.

Hoang Duc Dat, 1997. Description of Mud Crab (Scylla spp.) Culture Methods in Vietnam, In Keenan, C.P., Blackshaw, A (Eds). Mud crab aquaculture and biology. Proceedings of an International Scientific Forum held in Darwin, Australia. 21-24 April, 1997. ACIAR proceedings No. 78, pp 67 - 71.

Jones, C.M. & Ruscoe, I.M. 2001**.** Assessment of five shelter types in the production of redclaw crayfish *Cherax quadricarinatus*, (von Martens) (Decapoda: Parastacidae) under earthen pond conditions. Journal of the World Aquaculture Society, 32(1): 41-52.

Keenan, C.P. 1999. Aquaculture of the Mud Crab, Genus *Scylla* – past, present and Future. In: Keenan, C.P. and Blackshaw, A. (eds). Mud Crab aquaculture and biology. Proceedings of an international scientific forum held in Darwin, Australia, 21-24 April 1997. ACIAR Proceedings No. 78, 216p.

O'Grady, A., Hay, T., Coleman, A., 2003. Mud crab fishery status report 2002. In: Coleman, A. (ed.). Fishery Status Reports 2002. Fishery report No. 69. Northern Territory Government, Department of Business, Industry and Resource Development. pp 53-62.

Ruscoe, I.M., Shelley, C.C. and Williams, G.R. 2004a. The combined effects of temperature and salinity on growth and survival of juvenile mud crabs (*Scylla serrata* Forskal). Aquaculture, 238(1-4): 239-247.

Ruscoe, I.M., Williams, G., and Shelley, C. 2004b. Limiting the use of rotifers to the first zoeal stage in mud crab (*Scylla serrata* Forskal) larval rearing. Aquaculture, 231(1-4): 517-527.

Trifiol, A.T., Millamena, O.M. and Keenan, C. 1999. Pond Culture of the Mud Crab (Scylla serrata) fed a formulated diet with or without vitamin and mineral suppplements Extended Abstracts: International forum on the culture of Portunid crabs, Boracay, Philippines, 1-4 December 1998.

Trino, A.T., Millamena, O.M. and Keenan, C.P. 1999. Monosex culture of the Mud Crab *Scylla serrata* at three stocking densities with gracillaria as crab shelter. In: Keenan, C.P. and Blackshaw, A. (eds). Mud Crab aquaculture and biology. Proceedings of an international scientific forum held in Darwin, Australia, 21-24 April 1997. ACIAR Proceedings No. 78, 216p.

Trussell, G.C., Ewanchuk, P.J. and Bertness, M.D. 2003. Trait-mediated effects in rocky intertidal food chains: *Predator* risk cues alter prey *feeding* rates. Ecology, 84(3): 629-640.

Williams, G. R., Wood, J., Dalliston, B., Shelley, C.C. and Kuo, C. 1999. Mud Crab megalopa larvae exhibit high survival rates on *Artemia*-based diets. In: Keenan, C.P. and Blackshaw, A. (eds). Mud Crab aquaculture and biology. Proceedings of an international scientific forum held in Darwin, Australia, 21-24 April 1997. ACIAR Proceedings No. 78, 216p.

Yalin, S. and Qingsheng, L. 1994. Present status of Mangrove Crab (*Scylla serrata* Forskål)) culture in china. NAGA, The ICLARM Quarterly, 17(1): 28-29.

9.6 Sharon Hewitt's evaluation of the employment program

"Our Vision to economic independence and employment and educational opportunities for our Community"

An Evaluation of Gwalwa Daraniki Enterprises Mud Crab Farm Employment Program

"How effective is the delivery of the Employment Program"

Prepared by Sharon Hewitt
To meet course requirements of
3rd year Project
Bachelor of Applied Science
Indigenous Community Management & Development
Curtin University, Perth WA

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Acknowledgements

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The Critical Reference Group member being Dr Bob Rose and Phil Elsegood of Tropical Aquaculture, Rob Manley of OIPC, Leyland Campbell of Charles Darwin University, and four of the participants of Mud Crab Farm employment program Tim, Jackie, Serena and Sylvan.

Thirdly, I would like to acknowledge all the participants of the Mud Crab Farm Employment Program who gave me an insight into their community and work environment and provided valuable information towards the Evaluation.

And finally, I would like to thank my tutor Jason Elsegood for his direction and support throughout the evaluation and for introducing me to the Larrakia people of Kulaluk Community.

Executive Summary

This evaluation study was undertaken at the Gwalwa Daraniki Association (GDA) Mud Crab Farm located on the Kulaluk Community Special Purpose Land Lease at Coconut Grove, Darwin. The program that was evaluated was the GDA Mud Crab Farm Employment program.

The aspects of the employment program that were evaluated were the employment, education and training and mentoring components. The purpose of the evaluation was
to identify any barriers or challenges that may be impeding the progress of the program. The evaluation focus question is "How effective is the delivery of the Gwalwa Daraniki Mud Crab Farm Employment program?

The technique used to collect the data was the qualitative method through recorded interviews and completed questionnaires, observations and policy documents were also used to validate the data collected. Using the qualitative method enabled the evaluator to draw on people's feelings and thoughts about their experience on how the program was being delivered. The sample group used for this evaluation was stakeholders who work closely with the farm management to deliver the program to participants.

The major barrier that was identified was the lack of support from government agencies with adequate funding for essential infrastructure and wages for participants. This support is crucial to enable the employment program to operate to its full potential and generate revenue for the community and the farm.

Although, Gwalwa Daraniki Association lacks the capacity to manage a successful mud crab farm on their own they have developed the appropriate management structures with a board of directors and their project managers Tropical Aquaculture Australia to ensure management of the Mud Crab Farm venture.

The following recommendations have been proposed:

1. Gwalwa Daraniki Association (GDA) and Mud Crab Farm management board to negotiate with government agencies on a regular basis in relation to Capital Funding for essential infrastructure for the mud crab farm.

2. GDA and mud crab farm management board to employ qualified staff to assist the farm manager with the day to day operations of the mud crab farm.

3. Adequate consultation and dialogue between the Farm Manager and participants be implemented in relation to farm and study processes.

4. GDA to negotiate employment agreements with participants of the employment program both administrative and aquaculture to establish roles and responsibilities of both parties.

5. GDA to request further financial and governance training for administrative participants to ensure adequate managing and monitoring of finances of the project.

6. GDA and mud crab farm management board to negotiate with funding agencies for award training wages for participants of employment program by early 2007.

7. GDA and mud crab farm management board in consultation with participants to review employment conditions and develop and implement strategies to improve these services by early 2007.

8. Adequate consultation between Farm Manager, Course Coordinator and participants to develop and implement a structured study plan including mentoring to enhance learning outcomes for participants by early 2007.

The Gwalwa Daraniki Mud Crab Farm employment program is still in its early stages of development and still experiencing a lot of teething problems. Aquaculture farming for Indigenous people is a relatively new concept and because of the educational and technical skills required it will continue to be fairly challenging for the participants of
the program.

The Mud Crab farm in its current form is a livelihood project and until adequate funding is provided and the technical skills of the participants develop it may be some time before the farm generates sufficient revenue for the community.

1. Introduction

1.1 Objective

To gauge how effective is the delivery of the Gwalwa Daraniki Mud Crab Farm employment program and to identify barriers and challenges that maybe impeding its progress.

1.2 Purpose

The purpose of this evaluation is to gauge how effective the delivery of the employment program is and to identify any barriers, concerns, issues and possible constraints that may be hindering its progress. In addition, the evaluation will provide the Gwalwa Daraniki Association (GDA) and Service Providers with valuable information to assist them with improving and further developing the employment program and to potentially enhance the services they provide. Lessons from this evaluation may assist to provide a bench mark from which future employment programs can be measured.

1.3 Rationale

This evaluation has been undertaken with the approval and support of the GDA and its project managers Tropical Aquaculture Australia to assist them in identifying any gaps in the delivery of the GDA Mud Crab Farm employment program.

The evaluation will provide valuable information to GDA and stakeholders on the effectiveness of the delivery of all aspects of the employment program such as, on the job training, mentoring, supporting participants for work, education, government support, community support, family support, participant goals and aspirations. It may also answer the question is this particular program financially, culturally and environmentally suited for the participants. It is the view of the evaluator that these issues are fundamental to the success of Indigenous development opportunities.

The location of the Kulaluk community Mud Crab Farm is in Coconut Grove, in Darwin which is a prime up market residential area of Darwin; it is five to ten minutes from the CBD of Darwin and five to ten minutes from Casuarina which is the major shopping centre in Darwin.

There is belief economic development is the key to self determination for Indigenous people. If Indigenous people utilise the one valuable asset they have which is their land as a bargaining tool to build economic independence this may provide them with the opportunity to break away from the welfare cycle.

"The only way to break the vicious cycle of disadvantage and dysfunction is to build capabilities through economic and social development based on engagement with the real economy."(Pearson. N 2000)

The Kulaluk community have utilised this asset and are committed to achieving economic independence through the development of their Mud Crab Farm venture. This venture is not the first time they have tried to create wealth from their land. They have had several bad experiences with other business people. This project is however, the first time they have created an opportunity in which their members can own and operate their own business. The community's vision is that they become self sufficient and move away from welfare dependency through this project.

"*We want to create a viable business so we don't have to rely on government money." (Secretary, H. 2006, the NT News 5 April 2006).*

In discussions with stakeholders it is evident that a lot of measures and levels of support are already in place to ensure the ongoing success of the program such as the Shared Responsibility Agreement (SRA) with both the NT and Commonwealth government, the Community Development Employment Program (CDEP) which is administered by Darwin Regional CDEP and the on the job training component delivered by Tropical Aquaculture Australia, the Structured Training Employment Program (STEP) which is administered by Gwalwa Daraniki Association, delivered by

Tropical Aquaculture Australia in conjunction with Charles Darwin University that includes both a structured education component and mentoring of participants. Both programs are funded by Department of Employment, Workplace Relations (DEWR).

Yet, with all the varying levels of support from stakeholders and the Mud Crab farm continually being in the media spotlight due to the political agenda of the Government who are promoting the benefits of Shared Responsibility Agreements (SRA's) with Indigenous communities; there are still underlying issues which are hindering the progress of the employment program to reach its full potential.

This evaluation will identify strategies that will assist the Association to provide an employment program which is culturally appropriate, environmentally appropriate and financially sustainable for the community's future.

1.4 Support

This evaluation has the support of the Gwalwa Daraniki Association and key stakeholders such as their project team Tropical Aquaculture Australia (TAA), Office of Indigenous Policy Coordination (OIPC), Charles Darwin University (CDU) and the participants of the program. It has also gathered information and feedback from other stakeholders such as NT Fisheries, Darwin Regional CDEP and Dept Agriculture, Forestry and Fisheries. Support from all these stakeholders is vital to maintain a detailed and unbiased approach to this evaluation.

1.5 Role of the Evaluation Researcher

The role of the Evaluation Researcher is that of an external researcher. The Evaluation Researcher works outside of the program. The advantage of being an outsider is that I will have a fresh and unbiased approach to the evaluation. The disadvantage of being an outsider is that I may not have access to information that would be readily available to an insider or one that has personal connections within the community.

1.6 Evaluation Focus Question

How effective is the delivery of the Gwalwa Daraniki Mud Crab Farm Employment program?

2. Background

2.1 The Broad Context

Cultural

The Kulaluk Mud Crab Farm is owned and operated by the Gwalwa Daraniki Association which is an Aboriginal organisation that was incorporated on 6th June 1973. This organisation represents a small family group of the larger local Aboriginal Larrakia clan of the Darwin area. This family group reside at the Kululuk and Minmirama Communities which are located in the Coconut Grove and Ludmilla areas of Darwin. The current members of the Association are the descendants of the family of Bobby Secretary, his sisters and his brothers who were identified as the traditional owners at the time the Special Purpose lease was granted. However, the Association maintains its membership by allowing people to become members once they have lived at the Kululuk or Minmirama Communities for 12 months or more.

The granting of the Kululuk lease was not a simple process for this small family group but one of many drawn out years of struggling for land rights from the early 1950's. This family group never gave up their struggle for their rights to the land and this resulted in the first land claim being lodged on the 20th May, 1971 and the Special Purpose Lease at Kululuk being granted on the 3rd August, 1979.

Due to a lot of division and tension within the larger local Aboriginal Larrakia clan, this small family group have very little ties or connection with them and any assistance sought through government funding bodies is done independently through the Gwalwa Daraniki Association with no affiliation to the Larrakia Nation.

Demographic

Since 1979 there has been very little economic development in the community and the extent of any opportunities was some what limited due to some parts of the area being mainly mangrove swamp lands and also being in the flight path of the Darwin International
Airport. The latter, had restricted any economic development in the area of commercial or residential ventures. Yet today, this land is seen as prime real estate by the wider Darwin community for commercial ventures and is very much sought after; which may result in further economic independence for the community in the near future.

The main source of income for community residents is unemployment benefits from Centre link or employment under the Community Development Employment Program (CDEP) which are both Government funded programs. The Kulaluk and Minmirama communities has one administration building which is the Kulaluk Office, forty three houses which are maintained under the Indigenous Housing Authority of the NT (IHANT) repairs and maintenance program and has a population of about 150 to 200 people on a permanent basis.

"If we are to survive as a people we have to get passive welfare out of Aboriginal governance. We have to get rid of the passive welfare mentality that has taken over our people. We do not have a right to passive welfare – indeed we can no longer accept it. We have a right to build an economy." (Pearson, N 1999)

Political

The Northern Territory government consists of a legislative assembly which has a membership of twenty five (25). The Australian Labor Party achieved victory in 2001 after twenty seven (27) years of CLP rule. The structure of the new Parliament reflects the multicultural nature of the Territory; there are five Indigenous members and two of ethnic origin. Women have strong positions of importance, winning ten of the twenty five seats.

The Chief Minister, Clare Martin is the member who is responsible for Indigenous Affairs in the Northern Territory and Elliott Mc Adam is the Indigenous member who is responsible for assisting the Chief Minister on Indigenous Affairs. Elliott Mc Adam's portfolio also includes being Minister for Local Government and Minister for Housing which are important areas where Indigenous representation is crucial for Indigenous people.

A political support mechanism for Indigenous people in the top end of the Northern Territory is The Northern Land Council (NLC) which is a large Indigenous organisation that was established in 1973 to represent Indigenous people throughout the Northern Territory. The NLC regional office is located in Casuarina which is a ten minute drive from the Kulaluk Community and mud crab farm. The most important responsibilities of the NLC are to consult with traditional landowners and other Aborigines with an interest in the land. The NLC uses principles which are fundamental to the Aboriginal Land Rights (Northern Territory) Act 1976. The NLC also acts as a representative body for native title claimants in its area under the Native Title Act 1993.

The Gwalwa Daraniki Mud Crab farm is high on both the Territory and Australian Governments political agenda due to the government funding and support that has been injected into the project

and its location in prime residential areas in the middle of Darwin. The location of the mud crab farm also enables easy access for politicians to visit, promote and support Shared Responsibility Agreements (SRA's) in the Top End and Australia wide. Shared Responsibility Agreements are a relatively new funding arrangement which has only been introduced since the demise of the Aboriginal and Torres Strait Islander Commission (ATSIC).

GDA has a Shared Responsibility Agreement with both OIPC and the NT Department of Business Industry and Resource Development (DBIRD) which enables all parties to benefit from a positive outcome. GDA a successful business, Commonwealth Government another successful SRA which supports the implementation of SRA's and the NT Department of

Business, Industry and Resource Development (DBIRD) can utilise the facility to create appropriate models for commercial farming of mud crabs on Indigenous land in Northern Australia as well as the farm being used as a demonstration site for other interested Indigenous communities. The media portrays that the community is striving towards success and continually mentions the government support it is receiving, yet there is no mention of all the underlying issues which occur on a daily basis at the farm and the ongoing pressure to keep it operational.

"*It is great to be here at the Mudla Crab Farm, to try what were the most delicious crabs I have ever eaten in my life and to see a project like this which is a real commercial project giving training, giving jobs, making a profit and providing for the local people an economic base and that is what I think indigenous affairs is going to be about in the future, real economic opportunity, real jobs, real investment and real businesses*". (Costello, P 2006)

Economic

In 1997, a local business negotiated a lease with the Association to rent a small piece of land to establish a prawn farm business. The business went bankrupt in 1999 and several prawn ponds and a shed still remain from this venture. Since then a number of businesses had approached the Association to access the prawn ponds to develop aquaculture businesses. However, due to the experience with the failed prawn business they were reluctant to go into any new joint ventures with outsiders. The Association identified this as an opportunity to develop an economic enterprise for themselves and Tropical Aquaculture Australia was employed to conduct a feasibility study on whether an aquaculture venture may be commercially viable for them.

With the support mechanisms in place from NT Fisheries and Tropical Aquaculture Australia as potential project managers this provided the organisation with the foundations to start negotiating with government agencies for funding for this project. As a result of this the Mud Crab Farm was established in November 2004 with the support of both the Commonwealth and NT Government. This venture is the first attempt by the Association to manage their own business, create employment and educational opportunities for their own
members and strive towards a sound economic base for their community instead of relying solely on government money.

In August 2005 the Mud Crab Farm employment program was established by the Gwalwa Daraniki and their stakeholders and if successful the program will provide the community with a viable business which will assist them to strive towards their vision of a self supported organisation moving off welfare. The ongoing success of the employment

program is vital to provide the members with ongoing employment, education and training opportunities and as the demand in the market grows both locally and nationally so will the employment and educational opportunities for the members.

"At a practical level, Indigenous economic development is simply about including indigenous Territorians in the economic and social fabric of society. It is the next step in self-determination, where enterprises are owned, run and managed by Indigenous Territorians." (M. Kilgariff, 2004)

Social

The Kulaluk and Minmirama communities are located in prime residential areas of Ludmilla and Coconut Grove in the heart of Darwin; they are within walking distance to the sea and beautiful beaches. On one side of the Kulaluk community there is a large prominent residential area and within walking distance are large shopping centres, health centre, public transport, renal unit, alcohol rehabilitation centre, aged care home for

Indigenous people which is owned my GDA, banks, service stations and recreational facilities such as bowling alley, skating rink, sporting oval, local swimming pool and across the road from the Kulaluk community is a large industrial area.

Despite all these facilities at their finger tips the community still appears to have little access to services due to major barriers such as lack of income, education and employment opportunities,

alcohol related problems including domestic violence issues. Having experienced life in a remote community for the past 3 1/2 years with limited access to mainstream services it was very surprising to see that a community right in the middle of Darwin has very similar characteristics. It is also visible that Indigenous people in Darwin are still facing the same barriers, challenges and issues that Indigenous people in remote areas of the Top End face on a daily basis.

The Organisational Context

Gwalwa Daraniki Association (GDA) is the organisation that represents the members of Kulaluk and Minmirama communities**.** Gwalwa Daraniki Enterprises (GDE) was established to represent the business enterprises of the Association. A board of Directors (Steering committee) was formed which includes all stakeholders that were involved in the creation of the venture.

The committee guides the overall operations of the venture including identifying funding sources, maintaining funding arrangements for the life of the project; act as the strategic planner and as a forum for contributing agencies and other stakeholders. The Gwalwa Daraniki Association (GDA) is responsible for managing the day to day operations of the farm through their chosen project managers, TAA. GDA is also responsible for all administration aspects of the Mud Crab Farm including time sheets, employing and dismissing of participants and decision making processes in consultation with the project managers.

The project managers, Tropical Aquaculture Australia are responsible for the day to day operations of the Mud Crab farm including the delivery of the employment program components which include on the job training, mentoring and support, the education training component (STEP) delivered in conjunction with Charles Darwin University and is supported and funded by DEWR. Support is also provided by NT Fisheries which includes providing crab lets, technical support, and training for Indigenous trainees both at the farm and in the hatchery on how to grow crabs in a farm environment and sell to the available market.

The Mud Crab farm employment program currently has eight (8) participants with six (6) new participants signed up to commence in the near future. Six participants work at the mud crab farm and are currently undertaking the Certificate 3 & 4 in Aquaculture; two participants work in the Kulaluk office and are undertaking the Certificate 2 in Business Administration; both courses are for a period of one to two years. The participants will

have the opportunity to continue in their studies at a higher level to increase their education and employment opportunities in this area.

At this stage, because the Mud Crab farm is not generating a viable income; payment of award wages is not possible so participants are paid Community Development Employment Program (CDEP) and the Structured Training Education Program (STEP) wages on a fortnightly basis which is funded by the Department of Employment and Workplace Relations.

These below award wages does very little to assist the association or the project managers to keep the participants committed and motivated to the long hours of work they endure including shift work as the crabs need to be fed three times a day with the last feed sometimes at midnight.

"I think CDEP was a good idea and there are successes with CDEP in the sense that it does give you part-time employment. It does give the community some money to spend on community projects, but it locks you in." (Professor R Bob Gregory, 2005)

Program Rationale, Aims, Objectives and Strategies.

The aims of the employment program are to provide an economic base for the community as well as providing ongoing employment and educational opportunities for its members. Farming is not a natural skill for Indigenous people and this program will provide participants with scientific farming skills as well as incorporating their own natural skills as hunters and gatherers which is a part of their cultural lifestyle as salt water people searching in the mangroves and fishing the tidal creeks for seafood.

The program provides ongoing employment through on the job education and training in the area of aquaculture which includes tertiary based training in Certificate 3 and 4 of Aquaculture at Charles Darwin University. This requires participants to demonstrate their ability to meet the requirements of the competency based components such as; prepare and pack stock for live transport, work effectively in the seafood industry, control pests, predators and diseases, produce algal and live feed cultures, undertake routine maintenance of water supply and disposal systems and structures, handle stock and collect brood stock and seed stock.

Participants also receive on the job training in scientific experimenting of growing mud crabs in a farming environment this training is delivered by NT Fisheries within their daily routines.

Appropriate mentoring support is also provided to participants as part of the program in all aspects of their employment, education and training by the farm managers, Tropical Aquaculture Australia. The mentoring is to encourage, motivate and support participants through each step of their chosen career pathways and also includes general work ethics.

The objective of both the CDEP and STEP programs is to provide participants with quality employment outcomes which will be evident when they finalise their training and receive their formal qualifications in the field of aquaculture.

These qualifications will enable participants to have the necessary formal qualifications and skills to work effectively and efficiently for the benefit of the mud crab farm and the community. This will also result in participants being competitive in the seafood industry for employment opportunities if they chose to leave the mud crab farm. Employment opportunities in the area of aquaculture are available at the Darwin Aquaculture Centre, several prawn farms, in the fishing industry, barramundi farms and in all areas of storing, packing and transporting of seafood in Darwin.

The long term goal of the program is to provide economic independence for the community through owning and operating their own competitive viable business which will provide ongoing employment opportunities and income being generated back into the community to provide a better quality of life for its members.

There appears to be a lot of commitment and support from the Association and key stakeholders to ensure the ongoing success of the employment program. The aspirations and commitment of the community as a whole will be tested throughout these early stages of the project for it to remain a community driven project. From this evaluation we hope to identify any underlying issues and provide strategies that will allow the employment program to continue to be a flourishing venture for the Gwalwa Daraniki Association and its members.

"Aboriginal and Torres Strait Islander people experience substantial economic disadvantage in the areas of wealth, employment and income in comparison with other Australians. In part, this disadvantage is due to a legacy of limited employment opportunities, a history of working for rations rather than wages, educational disadvantage and location barriers. These factors limit the opportunity for Aboriginal and Torres Strait Islander people to achieve a greater level of economic independence. With economic independence, individuals and communities will have increased opportunities, a broader range of life choices and a great sense of empowerment and achievement" (Thorpe. M, 2000).

3. Methodology

3.1 Introduction

This section describes how the research was conducted including the evaluators standpoint, the units of analysis, the sample group, data sources both primary and secondary, methods of data collection, methodological triangulation and data analysis.

3.2 Evaluator Standpoint

Throughout this evaluation the researcher is primarily an external researcher who does not work or live in the community. The researcher is a Commonwealth Public Servant on a study scholarship who has been fortunate enough to have been given the opportunity to undertake this research project at the Kulaluk Community Mud Crab Farm in Coconut Grove in Darwin.

There is belief and that of the research evaluator that economic development is the key to self determination for Indigenous people and it is evident that through sheer determination the Kulaluk and Minmirama Communities have taken an opportunity to utilize their land, existing resources and assistance from the Government to strive towards economic independence by developing a viable business for their people which will assist them to break away from government handouts and to maintain control of their lives.

The purpose of this evaluation is to gauge how effective is the delivery of the Gwalwa Daraniki Mud Crab Farm Employment Program and to identify any barriers and challenges that maybe impeding its progress. This will be carried out by practicing high ethical standards, building relationships and supporting groups for action within the community and their supporting stakeholders throughout the evaluation process.

The following steps were taken to ensure that this evaluation was conducted in an ethical manner which was acceptable to the community:

Step 1

Approval and support in writing was sought from the Gwalwa Daraniki Association prior to the commencement of the research project. This is imperative to the research evaluator as an Indigenous person to gain acceptance, approval and trust from the community to undertake this evaluation research project on their country.

Step 2

To formalise the establishment of the CRG a letter was sent to all participants informing them of the purpose of the evaluation and to seek their approval and support throughout the evaluation project.

Step 3

Research Principles were developed to guide me throughout the evaluation process.

These principles focus on the importance of community participation, consent and involvement in decision making for the duration of the evaluation research project. Throughout the evaluation I will use the Indigenous Terms of Reference framework (ITR) and Community Development principles (CD) to guide me and this will be evident where I have regularly consulted with the CRG group and the Chairperson of the Organisation throughout each phase of the evaluation to obtain feedback, approval of information to be used, direction and to maintain the focus of the evaluation.

Step 4

A letter of consent to conduct interviews with participants was developed and was used to obtain and maintain consent throughout the research process. This letter of consent provides both ethical and legal protection for the evaluation researcher and the participants as some information could be of a sensitive nature and if not dealt with appropriately could result in physical, social or psychological harm to people who have participated in the evaluation.

3.3 Units of Analysis

This evaluation consists of three units of analysis which are the:

- Community Development Employment Program (CDEP).
- Education component, and the
- Mentoring component

These units of analysis are the particular areas within the two major programs that the evaluation researcher will be analysing. The two major programs are Community Development Employment Program (CDEP) and the Structured Training Employment

Program (STEP) both Tropical Aquaculture Australia and Gwalwa Daraniki Association

abide by these policies and guidelines to deliver the employment program at the Mud Crab Farm. Department of Employment and Workplace Relations (DEWR) is the funding body and policy developers and these policies include milestones that participants of the programs must achieve to ensure continuous funding of the project.

3.4 Sample Group

The sample group will consist of four participants and five key stakeholders of the project. The participants are local aboriginal residents, their ages range from sixteen years to thirty five years, both male and female and most commenced on the employment program in August 2005 but were previously on CDEP in the Kulaluk Community, although a couple only commenced in April or May of 2006, Helen Secretary the Chairperson of Gwalwa Daraniki Association who manages the administration of the project, timesheets and employing of participants.

Bob Rose and Phil Elsegood, project management staff of Tropical Aquaculture Australia who are responsible for the day to day operations of the mud crab farm including delivery of all aspects of the employment program, the Lecturer from Charles Darwin University

who delivers the competency based training in Cert 2 & 3 of Aquaculture , Ian Ruscoe,
Project Officer from NT Fisheries the department that provides crab lets for grow out, technical and experimental support and ongoing support to obtain funding from various
government departments, Rob Manley, Project Officer from Office of Indigenous Policy Coordination whom the Organisation is in a Shared Responsibility Agreement (SRA) with the Association for the Mud Crab Farm.

3.5 Data Sources

Primary data Sources:

The primary data sources are the participants of the employment program, the Chairperson of the Organisation, Management practitioners of Tropical Aquaculture Australia the Mud Crab Farm Managers, Coordinator and Lecturer at Charles Darwin University, Senior Project Officer from Office of Indigenous Policy Coordination whom are policy makers of Shared Responsibility Agreements and Senior Project Officer of NT Fisheries whom is a practitioner in the field of experimental aquaculture.

Secondary Data Sources:

The secondary data sources are documents collected on CDEP and STEP Policy Guidelines, Shared Responsibility Agreement document between OIPC and Gwalwa Daraniki Association and the Establishment of the Mud Crab Farm Aquaculture venture and Demonstration Site on Gwalwa Daraniki Land at Kulaluk document.

3.6 Methods of data collection

The methods of data collection will be by interviews, questionnaires, observations and documents.

Structured interviews will be conducted with staff from TAA, OIPC and CDU and a couple of the participants as these respondents are willing to participate in recorded interview sessions.

The research evaluator is aiming to gather a lot more background information from the respondents from TAA, OIPC and CDU as they are very committed to the ongoing success of the program and work closely with the participants of the employment program. Two of the respondents have advised that if time does not permit they will complete questionnaires by email.

Questionnaires will be completed by some of the participants of the program who are shy and lack confidence in participating in a recorded interview. A couple of stakeholders may complete questionnaires by email if time does not permit them to participate in recorded interviews. All interviewing of participants will be conducted either at the Mud Crab farm during working hours or in their study sessions at the Tropical Aquaculture Australia office.

Observations Covert and open observations were conducted on informal visits to the Mud Crab farm whilst the participants and Farm Managers were working and also at Critical Reference Group meetings of members. All sample group members will be made aware of the observations prior to them taking place.

Documents were sought from relevant stakeholders.

3.7 Methodological triangulation (validity)

This evaluation project will involve the collection of data and information using several different methods such as interviews, questionnaires, observations and supported by documents. By gathering relevant documentation from stakeholders this strengthens the credibility and validity of the research results.

3.8 Data Analysis

The data will be analysed using the "content analysis method" which allows the evaluation researcher to easily identify common patterns or themes in the data.

3.9 Limitations to the research design

The research evaluator found being an external evaluator was a huge disadvantage because the evaluator was often forgotten about when meetings or crab harvests occurred at the farm. Attending meetings or crab harvests would have provided the evaluator with a real insight into the day to day operations and highlights of the crab farm.

Gaining access to relevant policy documentation for the purpose of the evaluation such as GDA's business plan, GDA's constitution, the service level agreement between GDA and TAA, a community development plan or minutes to meetings of the Gwalwa Daraniki Enterprises board of directors was another setback. Access to these documents would have provided the research evaluator with a broader overview of the overall operations and projections of the mud crab farm.

Some of the participants appeared to be holding back on providing their true feelings or experiences when answering some of the questions. The research evaluator reflected on this and felt that it may have been due to the design of the questionnaires or interview schedules, they may have lacked trust or felt uncomfortable with the evaluator due to no prior relationship with their community or as the mud crab farm is continually in the spotlight with media and funding agencies they are unconsciously portraying that everything is great.

Another difficulty the research evaluator encountered midway through the evaluation was that the project team appeared to be divided over the direction of the project and this lack of stability was impacting on the program and the evaluation. Also the Course Coordinator was no longer available for CRG meetings or to provide feedback to support the evaluation.

4. Data Analysis

The data collected was qualitative and was gathered from three different groups:

- Funding and Service Providers (both State and Commonwealth)
- Management/Project Team,
- Indigenous participants/community members

From the data analysis six themes emerged:

- Funding and Infrastructure
- Self Determination and Governance
- Farm Management
- Employment Conditions and Opportunities
- Education and Training
- Mentoring

Funding and infrastructure

Most participants expressed concerns about the lack of infrastructure and resources available at the mud crab farm to enable them to carry out their jobs effectively and in a timely manner. This was also supported by Management.

Management also identified that funding is a major barrier to providing the necessary infrastructure to enable the farm to reach its full potential. Although, Management did acknowledge that the amount of money that has been received by Government agencies has been quite considerable; the method in which they deliver those funds has not been beneficial to the Organisation.

However, some Funding and Service Providers have confirmed that funding and support from various agencies has been quite substantial. Yet, other funding agencies have not delivered their guaranteed funds which has hindered the project.

"I think if we had power it would make our jobs easier" (Participant)

"If we can't do it, it usually costs money and it's up to Bob the Farm Manager to buy or hire equipment" (Participant)

"If we got all the funding at the very beginning of the project, we would have power and fencing and more input from the trainees." (Management)

I think, in terms of some of the stuff we want to do, the money is there, it's how they choose to deliver it. They're delivering it in what they call drip-feed. So every quarter we get a bit of money." (m2)

Self Determination and Governance

Gwalwa Daraniki members have a long term goal of becoming fully self-sufficient and economically independent of government funds through the success of the mud crab farm venture. This is also evident in the views of the participants and the Management of the Mud Crab Farm.

However, Management has expressed concerns that there is a lack of skills and interest within the community to be able to appropriately manage the project which is evident in the business administration component of the employment program which has not been meeting training outcomes.

Funding and Service providers have also expressed concerns that there is a lack of skills in the community to meet the demands of managing and operating a business.

"Me and my sisters are like traditional owners and well to me I hope that this thing does work out because we have been longing to have this thing for how many years now." (Participant)

"Because their and our long term goals for the community are to be self sufficient with no help from government." (Management team)

Part of the reason we created an admin arm was to provide some succession planning for the Gwalwa Daraniki Association (GDA). What we thought was that we could train the girls to do admin and sort of pick up the governance stuff they'd be able to take over, they haven't." (Management Team)

"In terms of running a business I think the business side of it is a big challenge for participants to come to term with. The business side of it which is all unfamiliar ground, so I think running the business is perhaps not so appropriate and I guess, easy for people to work with." (Funding or Service Provider)

Farm Management

Participants are supervised by the farm manager and carry out their tasks by following a roster system which indicates what tasks have to be carried out each day and by whom. Participants also conduct informal meetings with the farm manager in a group environment and discuss their work rosters and any issues affecting the farm or their employment, this system appeared to be working work. Although, it was mentioned that the farm manager does listen to their ideas but doesn't always pursue them.

However, Management has expressed concern that the farm manager's role is restricted because he is undertaking numerous other duties to ensure the farm remains operational and that he only manages this by working astronomical hours each week. They have also identified that more qualified staff are needed to assist the farm manager in the day to day operation of the farm which will allow him to fully commit to providing participants with positive employment outcomes. This was also supported by funding and service providers.

Funding and Services Providers also expressed concerns that there may be staff management issues which are evident in acquiring and retaining participants in the employment program.

"We mainly have rosters and we now just use the rosters which is good because before that we would just do one thing and then go onto something else but now it is all organised and we just keep going on with each task we have to do for that day" (Participant)

"Yes, we sit in a group and discuss what's happening with our employment and work. It's good because we all have our individual say and talk in a group, we all get along." (Participant)

"Presently, the farm manager is also teacher/tutor, administrator, board member as well as the project manager. In hindsight, a young qualified aqua culturist to assist the farm manager for 6 to

12 months during the construction phase would have been prudent to help set up the husbandry environmental monitoring protocols. This would have allowed the farm manager to devote more of this time to the lengthy red tape associated with the establishment of the business." (Management)

"The staff management has probably not been adequate to solve all the issues associated with gaining and retaining motivated community employees.
Evidenced as high levels of staff changeover". (Funding or service providers)

Employment Opportunities and Conditions

Participants envisage the employment program as a means for full time employment, fulltime award wages and providing them with the necessary skills and knowledge in the area of aquaculture to manage the mud crab farm for their community in the future.

However, the participants have recognized a lot of obstacles along the way which is diminishing their enthusiasm. Obstacles such as low wages, working long hours including shift work with no remuneration, lack of team work and commitment. This is supported by both Management and Funding and Service Providers.

"Get a fully qualified job with my degrees and certificates in aquaculture" (Participant)

*"No, we are not on a lot of pay, minimal pay. I come back after hours at night time, sometimes at 7pm as well as 5 or 6am in the morning to pump water into the ponds. Our hours are usually 8.30am to 4pm but that can vary too. I used to be on $520 CDEP supervisor rate plus $320 top up. I work shifts and Sundays with no extra pay, no extra shift money. Still had to work Christmas Day as well. We get paid for 18hrs a week and work another 18 to 20 hrs and still only have two thirds of the pay. " (*participant)

"I think if there is more team work it would be going great" (Participant)

"The trainees pay them a proper wage, I think their underpaid" (Management team)

"The problem I've got with the employment program is that I think people are vastly underpaid and because they're underpaid it's really hard to put it to them about when they should come to work, how they should come etcetera." (Management Team)

Education and Training

Participants are aware of the long term benefits of the education and training they are undertaking such as obtaining certificates, work experience and fully qualified employment. Yet, participants have indicated that the study can be challenging and due to farm commitments they have not been attending university on a regular basis and are falling behind with their study which further disadvantages them.

Management and funding and service providers have also identified that there are barriers and challenges to participants succeeding in the education and training component such as low levels of education, dropping out or not attending the course, lack of transportation to access technical expertise and hatchery practices at Channel Island and lack of interaction and planning by management and service providers.

"Would like to end up with a couple of certificates and experience with equipment such as bobcat, excavators, front end loaders, get my chainsaw tickets and more work experience." (Participant)

"We haven't been able to Uni because of harvests. Harvests depend on the size of the crabs and they can't wait because we are studying. If you leave them too long they go soft. We started going to Uni 3 times a week, then 1 day and then don't go at all, rarely. (Participant)

*Considering the participants have never been aquaculture farmers or terrestrial farmers, very well. The various funding and educational agencies are also on a very step learning curve in terms of understanding how to remedy, ameliorate and improve their services provided to people with challenging socio-economic conditions and attitudes. (*management team)

"Going to University for people, you know, some of those who are engaged on the project haven't had a great grounding I guess academically, and to be thrown in at the deep end at university is such a huge step, and I see that as being a fairly major challenge and barrier to people succeeding." (funding or service provider)

Mentoring

The participants of the program have indicated the importance of receiving the mentoring and ongoing support for their education and on the job training and that the assistance has been valuable to them. However, Management has pointed out that mentoring at the farm hand level and mentoring of the Chairperson has been excellent; yet, the business administration component of the employment program has not been so successful.

However, Funding and Service Providers have identified that the mentoring has not been very effective which is evident through a lack of commitment to the farm and a high turnover of participants dropping out of the program and that there is definitely a need to improve the mentoring component.

"Yes, it helps with study; we all work in a group environment so that we know what to do. I try to do some at home to get through it. The mentoring helps when you get behind." (Participant)

At the farm level, yes. I think the mentoring at the farm hand level, I'd say Bob's doing a great job even though he has some cultural issues, I think he's done a great job and he does it by doing a 60 hour week." (Management team)

If the training mentor was doing his job well, there may be better levels of staff retention as well as better levels of employability. That is, lower absenteeism, better numbers turning up on time, higher

levels of initiative etc, but these are expected to improve in the longer term. (Funding or service provider)

"I think the training/mentoring; we've recognized that we might be able to do that a little bit better." (Funding or service provider)

5. Findings

1. There is a lack of adequate capital funding to purchase essential infrastructure for the mud crab farm.

2. There is a lack of essential infrastructure at the mud crab farm which is hindering the progress of the employment program to reach its full potential.

3. The community and participants envisage the employment program as the key to self sufficiency, revenue and ongoing employment for the community.

4. There is a lack of adequate skills in the community to assist in managing the financial administration of the project.

5. The farm manager is overloaded with roles and responsibilities which prevent him from implementing a structured management plan for participants.

6. There is a lack of consultation with participants about work and study processes.

7. The current participants are committed to the employment program because they see the long term employment and training opportunities for themselves and the community.

8. There is a lack of community commitment in relation to participation on the employment program both administrative and aquaculture.

9. The participants feel that they are not adequately remunerated and have inadequate work conditions.

10. There is a lack of government support in relation to award wages for participants of the employment program.

11. There is insufficient planning and interaction between farm management and the course service provider in relation to the study component for participants.

12. Management, funding and service providers have identified gaps in the mentoring and support program for participants of the employment program.

13. Management, funding and service providers have identified that the mentoring program needs to be improved to increase commitment and retention rates of participants
on the employment program.

6. Recommendations

(DRAFT)

1. Gwalwa Daraniki Association (GDA) and Mud Crab Farm management board to continue negotiating with government agencies in relation to Capital Funding for essential infrastructure for the mud crab farm.

2. GDA and management board to discuss and develop a strategy to employ qualified staff to assist the farm manager with the day to day operations of the mud crab farm.

3. Ongoing consultation between the Farm Manager and participants in relation to work and study processes and implement procedures to monitor outcomes.

4. GDA to negotiate employment agreements with participants of the employment program both administrative and aquaculture to establish roles and responsibilities of both parties.

5. GDA to request further financial and governance training for administrative participants to ensure adequate managing and monitoring of finances for the project.

6. GDA and mud crab farm management board to continue negotiating with funding agencies for award training wages for participants of employment program by early 2007.

7. GDA and mud crab farm management board in consultation with participants to review employment conditions at the farm and develop and implement strategies to improve these services by early 2007.

8. Implement ongoing consultation between Farm Manager, Course and participants to develop and implement a structured study plan including mentoring to enhance learning outcomes for participants by early 2007.

7. Conclusion

This evaluation has highlighted that the employment program is still in its early stages as it has only been in operation for twelve months and is still experiencing a lot of teething problems. However, it has highlighted that this is the ideal opportunity to evaluate the current procedures and practices of the program and make any necessary changes or implement new strategies that will assist in improving the employment and educational outcomes for participants.

It is the evaluator's opinion that the employment program in its current form is operating as a livelihood project that is providing a means of employment for a small number of community members. The overall project will not generate the revenue the community envisages without a number of supporting factors such as adequate funding and support from government agencies, ongoing commitment from the project team and community and ongoing commitment from the participants as their educational and technical levels increase.

This evaluation has also shown that stakeholders believe the program is financially viable and some have acknowledged that funding delivery has not always been to the advantage of the project but with monitoring and review mechanisms in place this may improve.

The one factor that has been astonishing throughout this whole evaluation is the sheer dedication and determination of the farm manager and some participants to make it viable.

8. References:

Day, B. 1994, 'BUNJI', A story of the Gwalwa Daraniki Movement. Aboriginal Studies Press: Canberra.

NT Department of Business, Industry and Resource Development – Fisheries Group. 2005, Establishment of a Mud Crab Aquaculture Venture and Demonstration site on Gwalwa Daraniki land at Kulaluk. (Unpublished)

Shared Responsibility Agreement between the Kulaluk/Minmarama Community and the Australian Government, NT Government and Tropical Aquaculture Australia. 2005 (unpublished)

Structured Training and Employment Program (STEP) contract between DEWR and Gwalwa Daraniki Association (unpublished)

(Professor R Bob Gregory, 2005*)* Pearson, N. 2005, **Pearson calls for end to passive welfare**http://www.abc.net.au/7.30/content/2005/s1506518.htm

Thorpe, M. 2000, **the Role of the Welfare Sector in Advancing the Position of Aboriginal People in the Broader Australian Community**
http://austlii.law.uts.edu.au/au/other/IndigLRes/car/2000/20001005.html

Kilgariff, M. **Indigenous Economic Development is a Winner for all Territorians**
Retrieved: June 10, 2006, from *http://www.darwinresearchcentre.com/features001.asp?id=180*

Treasurer, Costello, P. **Doorstop Interview Kulaluk Mudla Farms, Darwin**
http://www.treasurer.gov.au/tsr/content/transcripts/2006/074.asp

9. Bibliography

Seafood Industry Training Package Assessment Plans (unpublished)

Pearson, N. 2005, **Peace and Prosperity for Indigenous Australians**
http://www.onlineopinion.com.au/view/asp?Article=42.

Pearson, N, “Our Right to take Responsibility”

Cross Cultural Consultants. 2004, “**Aboriginal Cross Cultural Training – Working with Aboriginal Cultural Difference”.**

12th April, 2006

Sharon Hewitt
PO Box 1051
HUMPTY DOO NT 0836

Helen Secretary
Chairperson
Gwalwa Daraniki Association

Re: Permission to undertake an evaluation of the Gwalwa Daraniki Enterprises Mud Crab Employment Program.

My name is Sharon Hewitt and I am a 3rd year student of the Bachelor of Applied Science (Indigenous Community Management and Development) course at the Centre for Aboriginal Studies Curtin University of Technology Perth, WA. An imperative part of this course is to evaluate a program, service or project that operates within an Indigenous community context.

I am seeking permission and support from your organisation to undertake my evaluation on the employment component of the Gwalwa Daraniki Enterprises Mud Crab Farm which has been operational for sometime. My interest in this project is due to my own beliefs in economic development in Indigenous communities being the key to self determination.

This evaluation will require me to collect data, obtain information, conduct interviews, document information and develop evaluation strategies which are core elements of the course which will enable me to complete my degree. All materials will be used for this purpose only. All information gathered is strictly confidential.

The period of this evaluation will be from the 20th March 2006 to 10th November 2006 and an Evaluation Report and all materials used will be provided to your organisation at the end of this period.

This Evaluation Report will provide invaluable information to your organisation to assist in the ongoing success of your program.

If you require any further information on the evaluation process you can contact my Lecturer, Lynette Mallard at the Centre for Aboriginal Studies, Curtin University of Technology, Perth, WA on 08 9266 3538, Fax: 08 9266 2888 or email: l.mallard@gunada.curtin.edu.au.

SHARON HEWITT

5 Phone: 0428 810 997

Email: sharon.hewitt@student.curtin.edu.au

Appendix 2
Formal Approval from Gwalwa Daraniki to undertake evaluation

Appendix 3
Letter to Critical Reference Group Members

Sharon Hewitt
PO Box 1051
HUMPTY DOO NT 0836

Phil Elsegood
Tropical Aquaculture Australia

Dear Phil,

I would like to take this opportunity to thank you for agreeing to be a member of the Critical Reference Group for the Evaluation Research Project.

As you are aware the Chairperson of the Gwalwa Daraniki Enterprises Mud Crab Farm has approved the evaluation of the Employment program to identify any barriers, concerns or issues that may be hindering the progress of the program. My role in this evaluation will be to facilitate a series of problem solving meetings with key stakeholders of the program.

The benefits of solving any problems are to:

- Identify any gaps in the program and provide possible solutions through the CRG,
- Assist in providing job satisfaction to participants,
- Encourage participant involvement in decision making processes,
- Assist in the ongoing success of the Employment Program to provide an economic base for their Community.

Our first meeting will be held at 10am on Friday 21st April at the Kulaluk Mud Crab Farm at Coconut Grove.

Before the meeting, please review the information provided and be prepared to brainstorm and make decisions on group processes for the Evaluation Research Project. I will be a neutral facilitator and my primary aim is to assist the group to identify items that need to be actioned to ensure a smooth and efficient approach to the Evaluation.

If you have any queries in regards to the meeting agenda or facilitation process please ring me on 89 88 2529 and I will answer any questions.

Thank you for assisting the Gwalwa Daraniki Mud Crab Farm to strive towards providing a successful program for their Community.

Yours Sincerely

Sharon Hewitt
0428 810 997
Sharon.hewitt@student.curtin.edu.au

Appendix 4

Research Principles

The Research Principles are guidelines for the Researcher to adhere to whilst undertaking this Evaluation Research Project.

Community Approval

- Community approval in writing before the Evaluation commences.

Participation

- Participants must sign a Consent form to take part in the research process.
- The Evaluation Researcher shall exercise consideration, politeness and sensitivity in all dealings with the community.
- All participation will be appreciated, respected and valued.

Information Sharing

- Researcher to remain open, honest and inform community of all intentions.
- Regular feedback will be provided to the Community on the progress of the research.
- All information must be discussed and approved by the CRG at monthly meetings to use in the evaluation**.**

Confidentiality

- All information and discussions will be confidential and no matters will be discussed outside the organisation.
- Ensure participants identities are not revealed unless authorised.
- The researcher shall take care to maintain the security of the information gathered.

Community Ownership

Gwalwa Daraniki Association will have ownership over all material gathered and the final report and will control the distribution of the evaluation research project.

Appendix 5

Consent Form

Dear Participant

My name is Sharon Hewitt and I am a 3rd year student studying in the Bachelor of Applied Science (Indigenous Community Management and Development) at the Centre for Aboriginal Studies, Curtin University of Technology Perth, WA. An imperative part of this course is to conduct an Evaluation research project that operates within an Indigenous community context.

I am conducting an evaluation on the Gwalwa Daraniki Enterprises Mud Crab Farm Employment Program that provides Indigenous people with the opportunity to increase their education, training and skills in the area of aquaculture. This evaluation aims to identify any barriers, concerns or issues that may be hindering the progress of this program.

I would like to invite you to participate in this Evaluation by completing a questionnaire or a tape recorded interview that may take about 30 minutes.

I wish to advise that all information you provide:

- Will be held in strict confidence,
- That direct quotes can be used without disclosing your identity,
- Will be locked in a secure location at my address: 2151 Ridley Rd, Humpty Doo,
- Will remain the property of Gwalwa Daraniki Association, and
- The only people who have access to this data will be myself and my lecturer, Lynette Mallard.

I respect your rights as a participant and advise that you may withdraw from the interview at any point without prejudice.

If you sign this consent form it means you have given me permission to use the information you have provided including photos and images in your interview in my report.

I…….have read the above and agree to participate in this Evaluation. I fully understand the purpose of this consent form as it has been explained to be in detail by the Evaluation Researcher.

……. ……

Signature of Participant Sharon Hewitt

Date: Evaluation Researcher

Date:

Thank you for taking the time to participate in this evaluation.

9.7 Response to draft review from Dr Bob Rose (June 2007)

Comments to draft consultancy report commissioned by DAFF and FRDC on mud crab pond culture and mangrove pen ranching in the NT by M Heasman (May 2007).

General Comments:

1/ Points to consider:

- Social context (livelihood or triple bottom line);
- Education level and lack of aquaculture experience of trainees;
- Funding timing: supplied so far into project's time schedule that to achieve goals was extremely difficult;
- Local regulatory authorities ponderously slow;
- No funding for basic farm staff other than CDEP trainee and STEP;
- Community politics prevent replacing staff with new ones from outside;
- TAA employed its own staff from contract fee to assist trainees to study and train; and work farm
- Expectations of 1 farm manager and 8 trainees to run commercial farm optimistic;
- Social barrier interaction with biotechnical aspects of crab farming
- Way forward: partnerships and private JV's as pathways to consultant's conclusions and recommendations.

2/ Pen culture in Maningrida:

- Information on Bawinanga Aboriginal Corporation, Maningrida project is scant.

3/ Information to be considered:

- The Mudla Fams' project has experienced protracted delays (eight months) in obtaining development approval from several Northern Territory Government agencies: Environment Protection Authority for the project's Environmental Management Plan (EMP), Licence to Take or Use Water (No. 815017) and Waste Discharge Licence (No. 130); Exceptional Development Permit (EDP 05/0011); and the Aboriginal Areas Protection Authority (Cert. C2006/024). These licences and permits were mandatory before the project could secure an Aquaculture Licence (No. 544/C1) from the NT Fisheries, finalise a sublease agreement for the farm site and obtain necessary funding to operate.

- As an outcome of the above delays, the construction period was severely reduced with on-set of the wet season. Thus, the ponds were not ready at the beginning of the spawning season to receive large, commercial quantities of crablets (100,000 plus). Instead, an experimental quantity was released into one pond during December 2005/January 2006 (batches 1 and 2) under a Special Permit (No. 2005-2006/S16/2087). The first commercial batch was released during March 2006 (batch 3) under the Aquaculture Licence issued 23/03/06. The consequence of these unforseen events has affected the anticipated timing of crablet production upon which revenue from crab sales has been derived in the Business Plan for year 1.

4/ Referencing of data provided

- No consistent acknowledgement of Photographs or Figures extracted from the Kulaluk project or from their source (eg, Figure 2 aerial photograph from EMP or Business Plan, Appendix …)

Specific comments relating to text:

Non Technical Summary

Page vii

Objective 1: Assessment of current management and operational practices of the GDE mud crab farm

Note: No comment on the Bawinanga-Maningrida pen culture operation has been made.

No comment on current management and operational practices (ie, at time of visit DOTARS funding contract was in processing stage, construction of powerline was to begin, 3 of 4 ponds were being rested (exposed to tidal inundation).

Line 2: Dramatisation. *serious flaws* could be changed to "important misconceptions" or "misunderstandings".

Line 5: Detail. *past 2 years* should read 1 year and 7 months or 1.6 years
(Aug 05-Aug06 = 1yr; Aug06-Mar07 = 7/12 = 0.6).

Line 7: Typo. *DWRC* ? This probably should read DEWR (Dept of Employment and Work Relations).

Line 9: Suggestion. …was apparently either ~~warehoused~~ or *redeployed* could be "reallocated" to ~~protect the financial well-being of project staff~~ "maintain a cash flow for farm operations and employment of staff and trainees" as this is more to the point.

Line 10: Incorrect assumption. Funds remaining were provided for construction and could not be spent because of the onset of the wet season and the board decision not to spend any more money on capital works until all permits and licences had been issued (eg, Development Consent Authority, EPA, Fisheries, etc). Also the reconciled balance of the cheque account was 81K in bank and subsequent sub-account (sales) was 1.8K and not a *considerable surplus*. This amount, by the way, was to be saved for power line (approx. 60% of actual cost). Other *surplus* included the unrealised capital assets (stock in hand) and at the time was based on the accountant's estimated value of 97.9K for 10mm crablets.

Line 24 (last line): Suggestion. Needed experienced farm labours not more "technical advice" as this was abundant (although not locally or specifically related to crab farming). Farm manager was project manager, construction manager, farm manager, administrator, advocate, mentor, labourer, purchaser and marketer. This was not the original plan or desire but none of these positions were filled or funded by funding bodies. The project needed a farm mechanic/assistant manager or leading hand to assist with routine farm operations, which would have allowed the farm manager to carry out the above more effectively.

Objective 2: Assessment of staff skills and if staff and trainee support needs are being met

Line 1: Comment. The strategic decision by the board was made to off-set the delays in permits issued but still adhered to the fundamental purpose of this livelihood or triple-bottom project as stated in Kulaluk's mission statement: *Participation from beginning to end, providing a sense of pride and ownership in the production of export quality mud crabs from our country*.

To severely cut expenditure on the reconstruction and recommissioning of the farm was disappointing but necessary in order to start the training of staff (or capacity building) during the normal academic year. Waiting for the wet to end to complete the *commissioning* (and not accept crablets available during the prime grow-out season) would disrupted the project's program even further. Especially given the unpredictable and arduous funding arrangements and two-year "partnership" agreements that were locked in place. Pulling staff and trainee off the project because there were no funds for remuneration was not practical or reasonable.

Line 4: Misleading. The statement *inappropriate harvesting strategy and failure to address serious pond hyper-salinity problems* implies negligence by the farm staff whether intended or unwittingly by the author. The harvesting strategy adopted was not inappropriate when there was no other option available due to the lack of experienced labour to harvest and electricity to operate bulk water storage containers for crabs. The *potting* strategy used at the farm is commonly practiced by another NT crab farm, as they believe it keeps the crabs undamaged by minimising contact before tying. Further, this low-tech procedure (also used in Asia) was the only collection method reliably successful with trainee farm staff with family commitments, working hours restricted to day light periods, transportation constraints and wholesaler business hours.

Failure to address pond hyper-salinity problems was going to occur with or without experienced staff if there was no method of cost-effectively changing the water or adding freshwater. Many crabs, by the way, were transferred out of the first hyper-saline ponds to better ones. Money was not available for hiring large pumps or trucking in water. Rainwater could not be collected as there was none during the build-up.

Line 6: Correction: There is no <u>local</u> private sector technical expertise in semi-aquaculture available that could solve the hyper-saline problem with out technology. All local expertise has been developed with power-supplied infrastructure available.

Line 11: Correction. Only 3 people have passed their certificate II training in aquaculture and seafood technology.

Page viii

Lines 3 to 4. Comment. Relative lack of prior practical experience: The farm manager does have sufficient experience in aquaculture to train people in semi-intensive pond culture effectively, has a Cert. IV In Work Place Training and Assessment, 12 months work in a local commercial hatchery-prawn farm and has trained staff in aquaculture for more than 15 years including non-English employees with low education levels. Moreover, acted as external supervisor for postgraduate and 1st degree students. It is common knowledge that apprenticeships or similar training programs have an extremely poor retention and/or completion rate due to the low wages offered, with candidates leaving for higher paid labouring jobs. For example, the most suitable candidate (Tim Angeles who won an Indigenous high achievement award) left after graduating from the Certificate II Aquaculture and Seafood program. The *relative lack of prior experience* is not an impediment or compromising the technical training of staff, particularly in light of the lack of expertise generally in the nascent crab farming industry in the NT. Note that according to DEET, Workforce NT Report, 2005; pages

10, 27 and 39 (Figure 4.2) the project's trainee completion rate to date has been 37.5% as opposed to the Darwin region rate of 33.3% in 2004.

The fundamental compromises have been related to the level of education of most trainees and are confounded by their poor attendance and participation in the learning process. Importance of routine chores in husbandry, harvesting and marketing are understood but not appreciated due to low financial incentives offered and the income provided not performance or attendance based.

Lines 5 to 8. Misconception. All locally based experience does not have demonstrable commercial expertise in mud crabs. Those with prawns have exited the industry or changing to fish. These corporations are chronically understaffed or experiencing high turnover.

Line 12 to 13. Comment. Daily interpretations of pond conditions were done by observation. Records were generally weekly or bi-weekly and taken largely with Fisheries Extension Officer. Monitoring equipment was the same model as Fisheries used to minimise variations in reading due to differences in brands. Records were taken in tandem outside his visit periods or when something dramatic was observed. Daily records were abandoned simply because staff could not reliably monitor unattended or keep to a schedule. Records by staff were often misplaced or lost. There was not enough staff to supervise the procedure. The exercise became counter productive and was dropped.

Page ix

Objective 4. Assessment of capital infrastructure and farm operating and husbandry systems in relation to current best practice.

Design construction and operations of ponds

1st paragraph. Comment. EMP plans could not be fully implemented due to delays in granting of permits and increasing wet season conditions, which shortened the time frame to restore ponds.

Water quality monitoring and management

3rd paragraph. Comment. Attempts were made to top up ponds with small transfer pumps during spring tides both night and day, and to introduce fresh seawater by removing sluice boards at peak high tides. One pond was drained to harvest crabs and transfer them to another pond. This pond was not refilled and crabs were slowly removed over a period of two-three days. There were not sufficient funds to hire large equipment to pump or cart in freshwater. The tone of this paragraph ("no apparent attempt"; line 7) suggests negligence or incompetence and a-lack-of-due care by both trainees and staff, despite their efforts described above.

3rd Paragraph, Line 4-6. Not correct. These statements are not recalled in progress report 3. Please explain how this was derived.

Page x

Objective 4 (continued)

Crab growth and production on the Mudla farm

3rd paragraph. Comment. Not practical to bulk harvest given the lack of facilities to hold crabs at this point in time. Moreover, bulk harvesting would have cause damage to crabs as early harvest

trials revealed. Given the labour force available and experience, slow steady potting ensured better quality crabs and higher price per crab sold.

Page x

Objective 5. Assessment of the timeliness, reliability and quality of crablets sourced from DAC.

1st Paragraph. Comment. All batches to date had a noticeable percentage of deformed abdominal tails which were apparently common physical features (according to hatchery staff) associated with both juvenile and adult hatchery-produced crabs. The effect of this deformity on growth and survival or quality of the crablets is yet to be determined at the pond cultivation level. To date this deformity has not affected the sale but is highest in runts of undersized crabs after 4-5 months. Hatchery production is still in its infancy.

Page xi

Objective 7 Conclusions and recommendations on how best to take the project forward

Entire Section: Comment. Conclusions are derived before the project has actually operated with infrastructure in place (see above general comments).

Page 10

1st paragraph. Comment. The financial accounts do not show that only a small proportion of the $411,000 allocated to farm reconstruction was expend on reconstruction. Bank statement shows approximately $80,000 left at the end of the 05/06 fiscal year and, as stated above, was unspent funds to be saved for power line construction. The funds supplied at beginning of the build-up and wet season so the construction schedule was compressed. Most importantly, the equity of the project remains high for the money spent and the debt to equity ratio is low. All capital works to date have "value added" the business and property. Money spent on operations was due to no funds being provided to run the operations.

Extract from Progress Report No. 1	
Contractors -	$167,805.75 (including $55,000 paid to TAA for previous work)
Administration -	$25,465.70
Power Supply –	$9,798.00
Re-construction of ponds -	$41,066.41
Consumables –	$18,146.88
Base Camp infrastructure -	$40,440.49
Plumbing and equipment –	$1,652.80
Total	$304,376.93 incl GST

Table 3 shows the expenses incurred according to the Business Plan's budget. The figures extracted from the actual project's cost were adjusted to exclude GST for various items. They show that the project has spent $276,706 ex GST. Of that approximately 64% in capital/consumable items and 40% in operations (labour, consumables).

Preliminary comparison between the Business Plan's Budget and the actual activities suggest that a review of the planned budget by funding bodies/providers is due. Moreover, this is a livelihood project that by definition encompasses three objectives: economic viability, environmental sustainability and cultural benefit.

Accuracy of costing and revenue

Line 6. Correction. DWRC should read DEWR.

Last paragraph. Comment. Board was told that lab equipment purchased without a place of safe storage would be delayed. Aerators and shelters have been purchased as planned with DOTARS funding. This occurred at the time of consultant's preparation of report.

Page 20

The Trainee Program

Line 5. Correction. 3 graduated not 5

5th Dot point. Correction. Water quality data provided were those set-up by farm manager. Copies were routinely sent to DAC, along with feed schedules and growth data (all prepared by Mudla farms). The farm manager has not received data (or analysis of data generated by DAC).

Page 21

3rd Paragraph, line 10. Comment. The rills observed on pond walls were are old and have been halted by mounds running along top of pond walls. Walls are steep and vegetation is being encouraged to grow along gradient.

Page 23

Design construction and operation of ponds

1st Paragraph.

Line 4. Correction. Only pond 1 does not have a concrete monk (ponds 2,3 and 4 have monks). A monk was not install as it was decided that pond 1 could be used as a nursery and/or experimental live feed pond during the early stages rather than a grow-out pond. A monk would be a waste of money in view of the plan to drain all ponds on the NW side.

Lines 9-12. Comment. This report is written as if the project had achieved its goals and produced crabs with a functional farm in place. The information provided, however, is based on the efforts of a community growing crabs held in ponds with no water management and aeration. The results from this perspective are encouraging. Criticism before money was allocated by DOTARS to complete infrastructure needs to be acknowledged. Over the 1.7 years, funds have been received out of phase with the requirements of the project. There was no concern for the deadlines imposed on the project that related to the wet season, legal "partnerships" between Fisheries and the community, or training schedules linked to "academic years".

3rd Paragraph.

Line 6. Correction. The drainage plan was *not abandoned* as described in the EMP and the moat or perimeter trench is a spoon drain that has its lowest point on the NW side in order to pump waste water to the settlement ponds.

Page 29

Water quality monitoring and management

Line 5. Correction. Data was made as a group and when equipment was available in tandem. These periods were used as a training session and a time to have trainees focus on water quality issues. Lack of power prevented being able to view water microscopically.

Page 30

Salinity levels

Lines 3 and 8. Correction. The rise in salinity was not *allowed* as stated in Line 3. It was a natural event with attempts to ameliorate the rise by both transferring water at high tides through lowered sluice boards and pumping. Pumping was initially with hired pumps and then later with purchased pumps. While this method was not particularly effective as the wet season was delayed, to write *allowed* and no *apparent attempt* on Line 8, implies we had the resources to manage the event more effectively and chose not to. The emotive language throughout this report is likely to provide barriers rather than a pathway towards improvement.

Page 34

1st Paragraph, Line 12. Correction. The mentioning of *half draining* pond 1 did not occur. There appears to be some confusion with ponds 1 and 2. The latter pond was harvested, drained and left "fallow" (ie, exposed to tidal movement and was no longer in production). A salinity reading was taken from pond 2 near its monk as a matter of interest and recorded in the farm records, which were provided. When ponds are half drained it is usually part of the harvest program. If stopped it is because market price or condition of crabs is suboptimal. The ponds are then refilled as quickly as possible.

Page 37

Last paragraph, line 4. Correction. Table 6 should read 7.

Page 39

Assessment of causes of poor yields at the Mudla farm

Line 10. Comment. Again not: *inadvertent use of inappropriate harvesting strategy*. This again implies negligence and lack of due care. The strategy was consciously decided as the only one that was practical given the lack of infrastructure and unskilled trainee labour force capacity to participate. This project is consciously designed for participation and ownership by Indigenous staff.

Page 40

1st Paragraph. Comment. Again by *protracted trap harvest* (which works effectively in third world areas) is derogative. The strategy was something that was within the "comfort zone" of the staff. They actually discussed this with the farm manager and realised that to harvest continuously over a long period was more practical given their community commitments and level of pay. As a triple bottom line project, this report takes in none of the constraints or barriers toward training and capacity building of pond culture husbandry. Furthermore, as stated early trap harvesting is the preferred amongst the wholesalers as they are able to purchase and buy less stressed animals.

1st Paragraph. Comment. Discussions on FCRs presented in Progress Report 2 were intended as a rough estimate of the food conversion efficiencies to produce crabs under "static" pond conditions. The figure generated (and defined) gave the reader an idea of the amount of wet feed in kilograms it took to produce one wet kilogram of crabs harvested. The ratio used gave an estimation of the efficiency of the overall culture process and was intended to give the stake holders an idea of the current economic status of the operations after the first harvest. The information was not intended to be a precise scientific measure. Interestingly, DAC personnel commented that such conversion efficiencies were not usual for crustacean culture. However, it was *meaningful* in the sense that the project had a rough bottom line or bench mark, and that the use of barra fingerlings at $3/kg from DAC was not an economically viable source of feed.

Page 49

7. Conclusions and Recommendations

2nd Paragraph Line 3. Comment. *Left unharvested* again is accusatory and dismisses the reasons why. Trainee staff consciously selected a harvest strategy that was based on culling out larger individuals over a long period as the most practical way for them to regularly participate and harvest-out the best quality crabs. The hyper-saline conditions, however, helped over-extend this strategy for the third batch.

No mention that equity to debt ratio ranged between 3% and 18% through out the 1.7 years, indicating that despite the biotechnical challenges the capital works were value adding the farm.

Page 51

Suggestion

Insert a closing picture with large crabs harvested like the following (with appropriate acknowledgement).

Mission Statement: *Participation from beginning to end, providing a sense of pride and ownership in the production of export quality mud crabs from our country*.