Facilitation, administration and promotion of the FRDC Rock Lobster Enhancement and Aquaculture Subprogram

Dr Robert van Barneveld
Principal Investigator

Australian Government
Fisheries Research and Development Corporation

Project No. 2001/211

2001/211: Facilitation, administration and promotion of the FRDC Rock Lobster Enhancement and Aquaculture Subprogram.

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OBJECTIVES:

1. Development and implantation of strategic plans and the facilitation of research and extension to assist the establishment of rock lobster aquaculture and enhancement systems in Australia

2. Coordination of a wide range of discipline-based (ie nutrition, reproduction, husbandry) research projects across a range of rock lobster species relevant to different regions of Australia.

3. Identification and procurement of funding from a variety of sources additional to FRDC to compliment or enhance existing rock lobster enhancement and aquaculture research in Australia and New Zealand.

4. Identification and procurement of funding from a variety of sources to assist the commercialisation of technologies developed within the RLEAS research program in partnership with the commercial sector and research agencies participating in the RLEAS.

5. Facilitate the delivery of outcomes from the RLEAS in the form of annual workshops, newsletters, media releases, final reports, workshop proceedings and scientific publications.

6. Provide a single point of contact for rock lobster enhancement and aquaculture research in Australia.

7. Facilitate the functions of a RLEAS Steering Committee to ensure ongoing research programs have a high degree of industry relevance and focus.

NON TECHNICAL SUMMARY:

OUTCOMES ACHIEVED

The value of the subprogram approach and the RLEAS was clearly demonstrated through this project. The RLEAS initiated reviews of core research programs and made significant changes to the direction of some of these projects as a result of the reviews. MG Kailis became an active participant in the subprogram, firstly through a private investment in research through the Queensland Department of Primary Industries, and secondly, as the lead agency in project 2003/211. The RLEAS convened three national workshops (Cairns, Geelong (in conjunction with the Second National Lobster Congress and the Rock Lobster Post-Harvest Subprogram) and Fremantle (in conjunction with the Third National Lobster Congress and the Rock Lobster Post-Harvest Subprogram)), a number of research planning forums and participated in the World Aquaculture Society meeting in Beijing in 2002. Again, the presence of the RLEAS resulted in significant improvements in the delivery of

relevant outcomes and cost savings in the projects through enhanced collaboration and coordination.

Through the RLEAS, the strategic research areas have focussed on techniques for puerulus collection from the wild, biological neutrality of wild stocks, larval rearing/propagation of tropical and temperate species of rock lobsters, capacity for hormonal manipulation of the larval cycle, nutrition of juveniles and adult lobsters, on-growing of juveniles and system requirements, health of aquaculture reared juveniles, enhancement of wild stocks through reseeding or resettlement and capacity to increase the natural settlement of puerulus in the wild through the provision of artificial substrates. Outcomes from this research that have provided technical capacity for commercial rock lobster aquaculture systems in Australia include:

Biological neutrality:
Because of the high natural mortality, a regional investigation using historical data revealed that the impact of puerulus removals on subsequent catches was estimated to be minimal except in the case of removal of very large quantities in low settlement years, but even this could be countered by effort reductions in the wild capture sector. While regional, this outcome suggests that there is potential to base rock lobster aquaculture on puerulus collection in the short term.

Puerulus collection:
Investigations into developing methods to catch large numbers of pueruli found that pueruli of the western rock lobster are easiest to catch near the shore (depths <5 metres) and in locations with fringing reefs using a modified sandwich collector. Studies in Tasmania showed that southern rock lobster pueruli could be caught in a range of locations using both sandwich and bag collectors.

Nutrition:
Research has generated an enhanced knowledge of the factors influencing the acceptability of dry pelleted food by juvenile and adult rock lobsters plus an improved understanding of the protein and protein:energy requirements of juvenile rock lobsters. A database on the digestibility of ingredients for rock lobsters has been prepared and a pelleted diet that induces growth rates in tropical lobsters equivalent to that achieved with mussels is now available.

Health:
Autopsy and health monitoring procedures have been developed. A study on tail fan necrosis that develops in some situations with adult caught lobsters held in aquaculture systems has revealed that abrasions during capture predispose the tail fan to infection with naturally occurring vibrio species. Methods were assessed for the prevention of tail fan abrasion during capture.

On-growing juveniles and adults:
A range of systems for on-growing juvenile and adult tropical and temperate species of lobsters have been assessed. These assessments have demonstrated that lobsters are fairly robust in a variety of systems. Studies with adult southern rock lobsters have demonstrated that rates of gain in sea-based systems and have outlined the effect of photoperiod and temperature on growth and survival in juvenile southern rock lobsters.

Propagation
A significant amount of research has been undertaken into the propagation of southern and tropical rock lobsters. It is clear that nutrition and health are primary limitations to the rearing process. Progress is also being made in the hormonal manipulation of larval phases.

Enhancement:
Enhancement and reseeding experiments undertaken with the southern rock lobster have successfully demonstrated that aquaculture reared juveniles behave in a similar way to wild lobsters when returned to their natural habitat. This research has also investigated movement of reseeded juveniles and clearly indicates that reseeding programs are likely to result in an increase in viable adults within the fishery.

This project represented Phase II of the Rock Lobster Enhancement and Aquaculture Subprogram (2001-2004). This phase was characterized by an increase in focus and strategic research direction. The RLEAS published research priorities with an increased focus on closure of the life cycle and enhancement, while maintaining a firm research base in priority areas such as health and nutrition. During Phase II of the program a total of 11 new projects were funded, including:

2000/185: Evaluating the release and survival of juvenile rock lobsters released for enhancement purposes. Principal Investigator: Dr Caleb Gardner. (Tasmanian Aquaculture and Fisheries Institute, Marine Research Laboratories, Nubeena Crescent, Taroona, TAS, 7053)

2000/211: Investigation into tail rot necrosis in live-held adult rock lobsters. Principal Investigator: soc Prof Mike Geddes. (University of Adelaide, Department of Zoology, GPO Box 498, Adelaide, SA, 5001)

2000/212: The nutrition of juvenile and adult lobsters to optimise survival, growth and condition. Principal Investigator: Dr Kevin Williams. (CSIRO Division of Marine Research, Marine Laboratory, 233 Middle Street, Cleveland, Qld, 4163).

2000/214: Advancing the hatchery propagation of rock lobsters. Principal Investigator: Dr Bradley Crear. (Tasmanian Aquaculture and Fisheries Institute, Marine Research Laboratories, Nubeena Crescent, Taroona, TAS, 7053).

2000/263: Reducing rock lobster larval rearing time through hormonal manipulation. Principal Investigator: Dr Mike Hall. (Australian Institute of Marine Science, Marine Biotechnology, PMB No 3, Townsville Mail Centre, Qld, 4810).

2001/094: Health assurance for Southern rock lobsters. Principal Investigator: Dr Judith Handlinger. (Tasmanian Aquaculture and Fisheries Institute, Marine Research Laboratories, Nubeena Crescent, Taroona, Tasmania, 7053).

2001/211: Strategic planning, project development and facilitation of research and extension towards the establishment and maintenance of rock lobster aquaculture and enhancement systems in Australia. Principal Investigator: Dr Robert van Barneveld. (Barneveld Nutrition Pty ltd, 19-27 Coonan Rd, South Maclean, Qld, 4280)

2002/045 – Assessing the possibilities for the natural settlement of western rock lobster. Principal Investigator: Dr Bruce Phillips. (Fisheries WA, WA Marine Research Laboratories, PO Box 20, North Beach, WA, 6020).

2003/211 - Advancing the hatchery propagation of tropical rock lobsters (*Panulirus ornatus*). Principal Investigator: Mr Richard McCulloch – BSc(Hons). (MG Kailis Group, 50 Mews Rd, Fremantle, WA 6160).

2003/212 - Propagation of southern rock lobster (*Jasus edwardsii*) in Tasmania. Principal Investigator: Dr Arthur Ritar. (Tasmanian Aquaculture and Fisheries Institute, Marine Research Laboratories, Nubeena Crescent, Taroona, TAS, 7053).

2003/213 – Establishing post-pueruli growout data for western rock lobster. Principal Investigator: Dr Roy Melville-Smith. (Fisheries WA, WA Marine Research Laboratories, PO Box 20, North Beach, WA, 6020).

As well as an extended research program, a number of commercial rock lobster activities began during this phase of the RLEAS. A basis for collection of puerulus from the wild and on-growing to a marketable size was established in Tasmania. This form of aquaculture and enhancement is based on high mortality of wild puerulus in their first year post settlement (anywhere from 75-97%) compared

with animals brought ashore and ongrown in tanks where the mortality is minimal (2% in Tasmania). This gives rise to the theory aquaculturists can ongrow the 'excess' that would have died in the wild. In 2001 in Tasmania, 7 licences were issued for the collection of 50,000 puerulus each, but to date, there has been limited commercial activity surrounding the use of these licenses. Aquaculture activities in South Australia continued to focus on on-growing and value adding to adult wild-caught lobsters. Activities included investigations into the holding and feeding of lobsters in land-based tanks using both existing flow through systems and infrastructure or recirculation systems. M G Kailis forged an alliance with the Queensland Department of Primary Industries to investigate the potential of culturing and growing tropical rock lobsters. Rock lobster aquaculture based on quota buy-out schemes in return for puerulus collection licenses (in the order of 1 tonne of quota in return for 40,000 puerulus) continued to be assessed in New Zealand.

KEYWORDS: Rock lobster, aquaculture.

BACKGROUND

The status of rock lobster enhancement and aquaculture

The Australian rock lobster fishery is an important marine resource making up 25% of Australia's total fishery landings and presently worth around $450 million per annum. However, while many are currently well managed, most Australian rock lobster fisheries are at their full production potential. Small increases in the value of production may be made in the future by increasing sales of live lobsters and/or targeting periods of high demand, but total gains are likely to be minimal. The real potential for significant growth appears to be through some form of aquaculture and enhancement.

There is growing interest around the world in aquaculture of rock lobsters and this has recently extended to Australia. A number of States are investigating rock lobster aquaculture potential in various forms, the dominant methods including:

1. On-growing of adults through a moult to increase weight whilst allowing sale at periods of peak demand/ value;
2. On-growing of wild-caught puerulus (newly-settled juveniles) to a small (and potentially very valuable) market size of around 200-300 g; and
3. Culture of phyllosoma from eggs through the 11 larval stages to puerulus and subsequent ongrowing to market size as above.

In addition, the potential exists through improved survival rates, for aquaculture to provide stock for reseeding and enhancement of the wild fishery. In all cases there are many issues that require further research. Some specific aspects relevant to the various aquaculture and enhancement opportunities include:

Ongrowing of adults

Investigations into the ongrowing of adult southern rock lobsters (*Jasus edwardsii*) have been ongoing since 1994, mainly in South Australia. The lobsters are held in cages at sea and are presently being fed with natural diets (trash fish/mussels). There is the potential to achieve weight gains of around 20% by growing the animals through the annual moult, representing a 60% return on investment.

Ongrowing of wild-caught juveniles

In Tasmania (southern rock lobster, *J. edwardsii*), Western Australia (Western rock lobster, *Panulirus cygnus*) and Queensland (tropical spiny lobster, Panulirus ornatus) there is some interest in the potential for capturing wild puerulus and ongrowing them to a small market size. The basis for this is that there is thought to be high mortality of wild puerulus in their first year post settlement (anywhere from 75-97%). However, recent results are showing that, if these animals are brought ashore and ongrown in tanks, the mortality is minimal (2% in Tasmania). Therefore the theory is that aquaculturists can ongrow the 'excess' that would have died in the wild. The animals are caught in collectors deployed at sea and quite large numbers have been caught in Tasmania.

This potential form of aquaculture is causing significant unrest within the wild fishing sector. A major issue associated with the on-growing of wild caught juveniles is how to compensate the wild fishery for their removal. There is also concern that scientists will not be able to accurately determine the number of puerulus that can be collected from the wild while maintaining biological neutrality.

The success of this method obviously depends on the survival rate of released juveniles. Despite some initial interest and following more detailed discussion most States are losing enthusiasm for this form of aquaculture, and it appears they would strongly prefer aquaculture systems based on a closed life cycle.

Culture of puerulus from eggs

Spiny rock lobsters have a complicated life cycle. The eggs hatch as tiny spider-like transparent larvae or phyllosoma. The phyllosoma drift in ocean currents for up to two years until they are ready to settle on a substrate and metamorphose into puerulus. The phyllosoma phase involves 11 distinct morphological stages and up to 17 moults (*J. edwardsii*). Culture of phyllosoma to puerulus has been successfully achieved in Japan and New Zealand in very small numbers. The phyllosoma can be fed on Artemia or chopped mussel flesh, but nutrition seems to be the major problem. The time to settlement can be greatly reduced in culture compared to that of wild larvae. In the long term, the culture of lobsters from eggs may prove to be the answer to the future sustainability of rock lobster aquaculture.

Subprogram mission and content

To address the growing interest in rock lobster enhancement and aquaculture, the Fisheries Research and Development Corporation established the Rock Lobster Enhancement and Aquaculture Subprogram (RLEAS) in July, 1998 following consultation with industry and scientists. The Subprogram was established with the following objective or “mission":

"To provide technology for use in Australian rock lobster enhancement and aquaculture systems so they can be internationally competitive and can operate in harmony with the wild fisheries".

"Enhancement" is being used to describe processes that could improve the market value of an adult rock lobster collected from the wild (under existing guidelines) usually through supplementary feeding in sea-based cages or land-based tanks. Enhancement is also being used to describe the potential for aquaculture systems to produce additional puerulus or juveniles for use in reseeding programs for the wild fishery. "Aquaculture" describes the rearing of rock lobster from eggs to a marketable size in an intensive culture system or the ongrowing of juvenile lobsters to a marketable size in intensive culture systems.

At the time of establishment, the RLEAS consisted of 6 core projects:

98/300: Propagation of rock lobster - development of a collaborative national project with international partners. Principal Investigator: Dr Piers Hart (Tasmanian Aquaculture and Fisheries Institute, Marine Research Laboratories, Nubeena Crescent, Taroona, TAS, 7053)

98/301: Facilitation, administration and promotion of the FRDC Rock Lobster Enhancement and Aquaculture Subprogram. Principal Investigator: Dr Robert van Barneveld (Barneveld Nutrition Pty Ltd, PO Box 42, Lyndoch, SA, 5351)

98/302: Towards establishing techniques for large-scale harvesting of pueruli and obtaining a better understanding of mortality rates. Principal Investigator: Dr Bruce Phillips (Fisheries WA, WA Marine Research Laboratories, PO Box 20, North Beach, WA, 6020)

98/303: Feed development for rock lobster aquaculture. Principal Investigator: Dr Kevin Williams (CSIRO Division of Marine Research, Marine Laboratory, 233 Middle Street, Cleveland, Qicl, 4163)

98/304: Pilot study of disease conditions in all potential rock lobster aquaculture species at different growth stages. Principal Investigator: Assoc Prof Louis Evans (Curtin University of Technology, Aquatic Sciences Research Unit, GPO Box U1987, Perth, WA, 6001)

98/305: Determination of optimum environmental and system requirements for juvenile and adult rock lobster holding and grow-out. Principal Investigator: Assoc Prof Mike Geddes (University of Adelaide, Department of Zoology, GPO Box 498, Adelaide, SA, 5001)

During the course of the first phase of the Subprogram, an additional two projects were approved by the FRDC Board, including:

99/314: Preliminary investigation towards ongrowing puerulus to enhance rock lobster stocks while providing animals for commercial culture. Principal investigator: Dr Caleb Gardner (Tasmanian Aquaculture and Fisheries Institute, Marine Research laboratories, Nubeena Crescent, Taroona, TAS, 7053)

99/315: Propagation techniques. Principal Investigator: Dr Piers Hart (Tasmanian Aquaculture and Fisheries Institute, Marine Research laboratories, Nubeena Crescent, Taroona, TAS, 7053)

As part of the above research program, the RLEAS has now convened two national workshops, has hosted a lobster health workshop in Western Australia, a lobster propagation workshop in Tasmania, and an international symposium on lobster health management in South Australia in conjunction with the Third International Lobster Congress. In addition, a number of the initial subprogram projects have now been completed including those investigating lobster nutrition, lobster health, system design and husbandry, enhancement of wild stocks with aquaculture reared juveniles and preliminary investigations into lobster propagation.

Subprogram management and operating procedures

The RLEAS is highly responsive to the views of industry and understands the need to accommodate both the research requirements of the future and the needs of the existing wild fisheries and aquaculture industries. To ensure that research conducted within the Subprogram is relevant and meets the above criteria, a Steering Committee was established to:

1. Provide industry feedback and views;
2. Review existing research based on FRDC contractual obligations;
3. Prioritise new proposals and provide a priority list for other agencies;
4. Ensure outcomes are commercially focussed;
5. Coordinate industry and research provider involvement - optimum use of resources;
6. Facilitate extension and technology transfer.

Membership of the Steering Committee includes Robert van Barneveld (Chair), Patrick Hone (FRDC), Pheroze Jungalwalla (TAS), Neil Stump (TAS), Andrew Ferguson (SA), Greg Ward (SA), Barry Spurrier (VIC), David Lucas (VIC), Jim Fogarty (QLD), Steven Gill (WA), John Newby (WA), Neil Dorrington (WA), Larnce Wichman (NZ), Andrew Jeffs (NZ, Scientific Advisor) and Bruce Phillips (FRDC Rock Lobster Post-Harvest Subprogram Leader).

The Steering Committee meets in March and September each year to review project progress and establish research priorities. Advice from the September Steering Committee is sent to all Fisheries Research Advisory Bodies so that they are aware of the subprogram research priorities. All new projects relating to rock lobster enhancement and aquaculture are assessed by the Steering Committee and are submitted to the FRDC Board via the subprogram. An annual subprogram workshop is held each March to extend research results to industry and researchers.

Based on research completed to date, and trends in the emergence of rock lobster aquaculture activities in Australia and New Zealand, the RLEAS Steering Committee identified the following outcomes as critical to the success of the Subprogram beyond the year 2000:

1. Propagation: The ability to produce puerulus from eggs from captive broodstock on a commercially viable scale with a focus on *P.ornatus* and *J.edwardsii*.

2. Live-holding/grow-out: Identification of the factors that influence tail fan necrosis in *J.edwardsii* for juveniles and adults and whether these factors can be influenced in a management context with a research focus on prevention management.

Based on these priorities and indicative budget allocations, the RLEAS Steering Committee sought key applications in the areas of:

1. Broodstock and culture of rock lobsters;
2. Live-holding and grow-out of rock lobsters;
3. Economics and marketing considerations for rock lobster products produced from aquaculture and the potential impacts on the wild sector.

Using project 98/301 to facilitate the development of project applications, a number of new projects were subsequently approved by the FRDC Board in the 2000/2001 funding round. A large collaborative project between the Tasmanian Aquaculture and Fisheries Institute (TAFI), CSIRO Marine Science, and the National Institute of Water and Atmospheric (NIWA) Research in New Zealand investigated ways to improve our capacity to propagate rock lobsters from eggs to puerulus in a commercially viable time frame. Another project involving CSIRO Marine Science, N1WA, TAFI and the University of Adelaide examined the nutrition of juveniles in their first year of development. Dr Mike Hall from AIMS in Townsville investigated the hormonal manipulation of rock lobster larval phases in an attempt to shorten the length of the larval phases while Dr Caleb Gardner from TAFI continued to investigate the survival of aquaculture reared juveniles when released back to the wild. Tail fan damage was investigated by the University of Adelaide and the South Australian Research and Development Institute.

The RLEAS has now developed into a highly coordinated research program with core projects focussing on key limitations to the establishment of rock lobster and enhancement and aquaculture systems in Australia. Through a research subprogram, representatives of the wild fishing sector and aquaculture enterprises have contributed to the strategic planning for this research program and this application sought to ensure that strategic planning, project development and the facilitation of research and extension continued to ensure the successful establishment and maintenance of rock lobster enhancement and aquaculture in Australia.

NEED

1. Research relevance and acceptance

The purpose of the RLEAS is to provide technology for use in Australian rock lobster enhancement and aquaculture systems so they can be internationally competitive while operating in harmony with the wild fisheries. Since its inception, the RLEAS has been coordinated by Dr Robert van Barneveld. The Subprogram has evolved from being actively opposed by the wild fishing sector in many States, to being an integral part of the future development of the rock lobster sector. A degree of harmony has been established between the wild fishery and the aquaculture sector, and a high degree of research coordination has been established between States and internationally with researchers in New Zealand and Japan. None of this would have been possible without an independent Subprogram Leader and a highly responsive Steering Committee that is strongly represented by industry members from across Australia.

2. Research efficiency and output

The presence of a coordination component within the RLEAS has resulted in savings in the operation of new and existing projects far exceeding $500,000 and it is likely that this trend will exist in the future. To this end, the RLEAS Steering Committee will continue to support a coordination project for the operation of the RLEAS. In addition, since 1998 the RLEAS has delivered outcomes from 4 core projects with outcomes pending from another four projects in June, 2000. In April 2000, the FRDC funded an additional 5 projects within the Subprogram that ran concurrently until June, 2003. It is unlikely that this level of highly focussed research and productivity would have been possible without a coordinated subprogram.

In the past, the establishment of subprograms has resulted in considerable savings in travel and operating expenditure by centralising expenditure for workshops, publications and extension within a coordination project. The new projects approved within the RLEAS in April, 2000 do not contain any travel or operating budgets for attendance at subprogram workshops, attendance of the Principal Investigators at Steering Committee meetings, or extension of research results. Hence, there is a need to ensure these projects have an ongoing capacity to maintain a degree of integration and to deliver results to end-users.

OBJECTIVES

1. Coordinate the FRDC Rock Lobster Enhancement and Aquaculture Subprogram (applications, workshops, communication).

2. Coordination of a wide range of discipline-based (ie nutrition, reproduction, husbandry) research projects across a range of rock lobster enhancement and aquaculture research in Australia and New Zealand.

3. Identification and procurement of funding from a variety of sources additional to FRDC to compliment or enhance existing rock lobster enhancement and aquaculture research in Australia and New Zealand.

4. Identification and procurement of funding from a variety of sources to assist the commercialisation of technologies developed within the RLEAS research program in partnership with the commercial sector and research agencies participating in the RLEAS.

5. Facilitate the delivery of outcomes from the RLEAS in the form of annual workshops, newsletters, media releases, final reports, workshop proceedings and scientific publications.

6. Provide a single point of contact for rock lobster enhancement and aquaculture research in Australia.

7. Facilitate the functions of a RLEAS Steering Committee to ensure ongoing research programs have a high degree of industry relevance and focus.

GENERAL METHODS

Industry consultation and communication

The Subprogram Leader, Dr van Barneveld, continued to promote the activities of the RLEAS through a website, industry newsletters, and direct communication with industry organisations and representatives. Heavy reliance was placed upon ongoing maintenance of the Steering Committee with representatives from the rock lobster wild fishing sectors and the aquaculture sectors across Australia and New Zealand for the provision of strategic direction and advice.

Strategic planning

Strategic planning for the RLEAS was based on outcomes from the previous research program and ongoing consultation between the Subprogram Leader and members of industry and researchers in Australia and New Zealand. The strategic plan was maintained and updated annually using the website and electronic distribution. The strategic planning process identifies those factors that represent restrictions to the initial establishment of rock lobster aquaculture (eg. propagation, nutrition) and enhancement (eg. monitoring survival, prevention of disease introduction to the wild fishery) processes, and then utilises a relative ranking score from the various rock lobster fisheries across Australia.

Communication with FRAB's

Communication with FRAB's was via distribution of an annual operating plan for the RLEAS in December of each year combined with direct communications. The Subprogram Leader also attended the annual FRDC FRAB workshop to promote the activities and objectives of the RLEAS.

Development of new research proposals

New research proposals were developed through the use of facilitated strategic planning meetings. Using priorities published in the RLEAS Strategic Plan, the Subprogram Leader convened meetings with relevant researchers and research institutions to:

1. Define the planned outcomes of the new proposal;
2. Manage an indicative budget for the research as defined by the Steering Committee;
3. Identify which researchers/institutions are best placed to undertake the research;
4. Promote collaboration between researchers and institutions where appropriate;
5. Seek external expertise and inputs as required;
6. Ensure the new proposals meets the objectives of the subprogram and that the research remains relevant and focussed.

The Subprogram Leader ensured new research proposals were distributed to FRABS and the RLEAS Steering Committee for comment and ratification before submitting the proposals to FRDC on behalf of the lead agencies, or facilitating adjustments to the proposals prior to submission.

Coordination of research reports

The Subprogram Leader continued to collate progress and final reports from projects within the Subprogram in March and September each year for delivery in a common format to FRDC. These reports were distributed to members of the Steering Committee for comment and review.

Review of research progress and direction

The RLEAS Steering Committee interviewed the Principal Investigator of each project within the Subprogram once annually as part of the Steering Committee meeting. Principal Investigators were expected to report progress against contracted milestones, justify any changes in research direction, and demonstrate that the research program is making a valuable contribution towards the achievement of the subprogram objectives. The Steering Committee made recommendations to the FRDC Board in relation to potential changes to the objectives of the research program, or instances where project progress was unsatisfactory.

Coordination of research extension

A major function of the Subprogram Leader was the organisation and delivery of an annual research workshop to highlight the activities and outputs of the RLEAS. Workshops were convened with presentations from invited speakers and researchers aimed at delivering key messages to end-users for use in practical rock lobster aquaculture and enhancement systems.

The Subprogram Leader compiled a subprogram newsletter "Lob ReLEASe" at least annually or as required highlighting research outcomes, developments in rock lobster enhancement and aquaculture and events relevant to the RLEAS. The Subprogram Leader was also responsible for the approval of all media releases and scientific publications arising from research projects within the Subprogram using the RLEAS Steering Committee communication policy as a guide.

Collaboration with international partners

The Subprogram Leader has already established a major international collaboration between researchers in Australia and New Zealand through project 98/301. This was achieved through direct interaction with researchers in New Zealand and involvement of these scientists in the RLEAS research program. There is further opportunity to build on relationships initiated with Japanese researchers by AIMS, CSIRO and TAFI as the RLEAS continues to evolve. In all cases, international collaborations will be based on a two-way flow of information and where possible, research funds.

Identification and procurement of additional funding

The RLEAS is committed to ensuring the research program remains commercially focussed. In keeping with this, the Steering Committee and Subprogram Leader examined numerous options for future management of the Subprogram including commercial entities and alliances.

Liaison with FRDC

The Subprogram Leader was the conduit for communications between FRDC and subprogram participants in relation to project contracts, project reports, new submissions and general correspondence. The Subprogram Leader also represented the RLEAS at the annual FIRDC FRAB and Subprogram meetings in Canberra.

RESULTS/DISCUSSION

Coordination of the FRDC Rock Lobster Enhancement and Aquaculture Subprogram (applications, workshops, communication).

- The Subprogram Leader and external consultants were used to review final reports submitted during the lifetime of this project. This included reviews on final reports from projects 98/302 (Towards establishing techniques for large-scale harvesting of pueruli and obtaining a better understanding of mortality rates), 98/304 (Pilot study of disease conditions in all potential rock lobster aquaculture species at different growth stages), 2000/214 (Advancing the hatchery propagation of rock lobsters), 2000/185 (Evaluating the release and survival of juvenile jock lobsters released for enhancement purposes) and 2000/212 (The nutrition of juvenile and adult lobsters to optimise survival, growth and condition).

- Annual Operating Plans for the RLEAS were prepared for 2002, 2003 and 2004 and were distributed to FRABs and other relevant groups via FRDC. These annual operating plans are presented in **Appendix III**.

- Strategic directions for the RLEAS were finalised and distributed to FRAB's and a call for research proposals was made based on the strategic plan. A copy of the strategic plan is presented in **Appendix IV**.

Coordination of a wide range of discipline-based (ie nutrition, reproduction, husbandry) research projects across a range of rock lobster enhancement and aquaculture research in Australia and New Zealand.

- A meeting was convened on September 16, 2002 to facilitate discussion between those organisations that had submitted preliminary research proposals on propagation research. This was an attempt to enhance the quality of these applications and to ensure there was a sufficient degree of coordination between the submissions.

- A meeting was convened on March 13, 2003 to establish a basis for re-submission of projects focussing on rock lobster propagation by MG Kailis and TAFI. The meeting took into account feedback from the FRDC Board on preliminary applications. New projects were defined based on an increase in cash funding from MG Kailis via the WA FRAB and involving NIWA in the TAFI proposal to investigate the efficacy of probiotics in propagation systems.

Identification and procurement of funding from a variety of sources additional to FRDC to compliment or enhance existing rock lobster enhancement and aquaculture research in Australia and New Zealand.

- A review of the propagation components of the RLEAS was finalised, recommendations were presented to FRDC and adjustments were made to the final year of FRDC project 2000-214. Contract adjustments were made to incorporate **new** investment from MG Kailis into the program and the QDPI as a full research partner.

- A review of an ACIAR submission by CSIRO was undertaken and submitted to ACIAR for consideration on behalf of the RLEAS.

Identification and procurement of funding from a variety of sources to assist the commercialisation of technologies developed within the RLEAS research program in partnership with the commercial sector and research agencies participating in the RLEAS.

- Facilitated discussions and meetings with Argentinean investors in Cairns, Townsville and Hobart. It became clear from these discussions that these investors, introduced through the Argentinean Chamber of Commerce, were of the impression that research was further progressed than it was, and that the current Subprogram structure made it difficult to recommend a mode of investment by external commercial parties at this stage of the research program.

Facilitate the delivery of outcomes from the RLEAS in the form of annual workshops, newsletters, media releases, final reports, workshop proceedings and scientific publications.

- Two "Lob ReLEASe" newsletters were prepared for distribution during the course of this project. Copies of these newsletters are contained in **Appendix V.**

- An annual workshop was convened in May, 2002 in Cairns in conjunction with the FRDC Rock Lobster Post-Harvest Subprogram. The workshop was convened with support from MG Kailis Pty Ltd and the Queensland Department of Primary Industries. Full proceedings from this workshop have been published and are available from FRDC.

- An annual workshop was convened in conjunction with the Rock Lobster Post-Harvest Subprogram and the National Rock Lobster Congress in Fremantle on September 15, 2003. Full proceedings from this workshop have been published and are available from FRDC.

- An annual workshop was convened in Port Lincoln on September 15, 2004 in conjunction with the Rock Lobster Post-Harvest Subprogram. Full proceedings from this workshop have been published and are available from FRDC.

Provide a single point of contact for rock lobster enhancement and aquaculture research in Australia.

- Robert van Barneveld presented a paper at the 2nd National Lobster Congress outlining the strategic directions of the RLEAS.

- Robert van Barneveld presented a paper entitled "Development of spiny lobster enhancement and aquaculture systems in Australia and New Zealand" at the World Aquaculture Society Conference in Beijing, China in April, 2002.

- Robert van Barneveld presented a paper on rock lobster enhancement and aquaculture in Australia at the Aquafest 2002 conference in Hobart in September, 2002.

- A presentation was made to the FRDC Board outlining the activities and future directions of the RLEAS.

- Robert van Barneveld attended the World Aquaculture Conference in Hawaii and co-chaired a workshop on rock lobster aquaculture.

Facilitate the functions of a RLEAS Steering Committee to ensure ongoing research programs have a high degree of industry relevance and focus.

- A Steering Committee meeting was held in Geelong, Victoria in conjunction with the 2nd National Lobster Congress in September, 2001. The Steering Committee remained unchanged from that used during project 98/301 with the exception that a new member representing New Zealand was introduced.

- A Steering Committee meeting was convened in conjunction with the 2002 annual workshop in Cairns.

- A Steering Committee meeting was convened in Hobart on September 18, 2002 in conjunction with Aquafest 2002 and the FRDC Rock Lobster Post-Harvest Steering Committee meeting.

- A Steering Committee meeting was convened in Glenelg in South Australia on March 12, 2003.

- A Steering Committee meeting was convened in Cairns on September 14, 2003 and a Scientific Committee meeting to discuss propagation project-related issues was convened on September 16, 2003.

- Terms of reference were drafted for Steering Committee membership and a call for 4 new members was made via the FRDC R&D News, the RLEAS website and direct mail-out to relevant industry bodies.

- Steering and Scientific Committee meetings were arranged to coincide with the International Conference on Rock Lobster Biology and Management in Hobart in February, 2004.

- A Steering Committee convened in Port Lincoln to coincide with the 2004 Annual conference and the Rock Lobster Post-Harvest Subprogram Steering Committee meeting.

BENEFITS

Benefits arising from this project include:

1. High levels of interaction and cooperation between research providers, scientists and commercial partners located across Australia with the common goal of establishing rock lobster aquaculture technologies through facilitation of workshops, meetings and strategic planning exercises.

2. Mechanisms for the longer term, self-sustainable coordination and management of research relevant to rock lobster enhancement and aquaculture.

3. Technology for the successful commercial culture of a variety of rock lobster species from eggs, capacity to reseed the wild fishery using aquaculture reared juvenile lobsters, procedures and equipment for the large-scale harvesting of rock lobster puerulus while maintaining biological neutrality, and knowledge and techniques that allow the successful feeding, health management, husbandry, harvesting and sale of rock lobsters from puerulus to market size through the implementation and facilitation of strategic research and extension for the net benefit of the Australian rock lobster aquaculture and wild fishing sectors.

4. Reductions in the cost of conducting highly focussed research into rock lobster aquaculture and enhancement while improving the quality and quantity of outputs from the research program for the net benefit of the Australian rock lobster aquaculture and wild fishing sectors.

5. Improvements in the extension of research results arising from research into rock lobster aquaculture and enhancement and an increase in the commercialisation of research results leading to the establishment of commercial rock lobster aquaculture and enhancement systems.

Coordination of existing and new projects in rock lobster aquaculture and enhancement will result in continual savings in the operation of projects with a common research goal (through coordinated travel and workshop budgets combined with more efficient use of limited research funds). At a cost of only 3.5% of the total funds invested in the subprogram, the RLEAS will continue to enhance the return on investment in rock lobster aquaculture through an improvement in research efficiency and research collaboration. Industries benefiting from the existence of the RLEAS include the emerging aquaculture sectors and the wild fishing sector (through projects on enhancement, reseeding and biological neutrality), and end-users of rock lobster products.

FURTHER DEVELOPMENT

As a result of this project, a further submission was made to FRDC for continuation of the RLEAS. This project was funded and will be on-going until June, 2007.

CONCLUSION

The RLEAS developed into a highly coordinated research program with core projects focussing on key limitations to the establishment of rock lobster and enhancement and aquaculture systems in Australia. Through a research subprogram, representatives of the wild fishing sector and aquaculture enterprises have contributed to the strategic planning for this research program.

APPENDIX I – Intellectual Property

There is no intellectual property arising from this project.

APPENDIX II - Staff

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Appendix III – Annual Operating Plans 2002-2004

Rock Lobster Enhancement and Aquaculture Subprogram

Annual Operating Plan - 2002

Prepared by **Dr Robert van Barneveld**
Subprogram Leader

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A) ACTIVITY DESCRIPTION FOR 2000-2001

i) Sector Progress

Rock lobster enhancement and aquaculture is now a reality in Australia and has existed in New Zealand for some years. The following outlines some of the current activities by region:

Tasmania

Collection of puerulus from the wild and on-growing to a marketable size is now underway in Tasmania. This form of aquaculture and enhancement is based on high mortality of wild puerulus in their first year post settlement (anywhere from 75-97%) compared with animals brought ashore and ongrown in tanks where the mortality is minimal (2% in Tasmania). This gives rise to the theory aquaculturists can ongrow the 'excess' that would have died in the wild. This year in Tasmania, 7 licences were issued for the collection of 50,000 puerulus each. The licences are for an initial 12 month period, after which time they will be reviewed (in terms of successful application and commitment to use) by the Tasmanian Department of Primary Industries. The licences were issued at a cost of $5,000 each and a condition of use is that approximately 25% of the total number of puerulus collected are re-seeded into the wild fishery as juveniles at 1 year. An officer will be appointed within the DPI to monitor both the collection and reseeding processes. The development of conditions associated with the issuing of licences was in full consultation with the existing wild capture sector. At present, collection of puerulus has commenced, with collection from salmon nets alone (all of which would have otherwise died during normal net cleaning processes) already yielding 2000 puerulus which have been provided to the Tasmanian Aquaculture and Fisheries Institute for re-seeding research.

There are a number of interesting points to note in relation to issuing of puerulus collection licences in Tasmania:

- There were at least 20 applicants for the 7 licenses on offer signalling significant interest in rock lobster aquaculture;
- Of the 7 licenses issued, none are currently held by commercial rock lobster fishermen.

South Australia

Aquaculture activities in South Australia continue to focus on on-growing and value adding to adult wild-caught lobsters. In the past, pontoons have been used to hold and feed lobsters prior to sale facilitating more control over the market the lobsters are sold into and the timing of the sale. There is the potential to achieve weight gains of around 20% by growing the animals through the annual moult, representing a 60% return on investment. Some difficulties have been encountered with the renewal of leases for sea cages in South Australia, and hence interest in this form of aquaculture is changing focus to land-based raceway systems. Current activities include investigations into the

holding and feeding of lobsters in land-based tanks using both existing flow through systems and infrastructure or recirculation systems.

Queensland

M G Kailis have forged an alliance with the Queensland Department of Primary Industries to investigate the potential of culturing and growing tropical rock lobsters. To date, research has focused on many aspects of production, but propagation of tropical lobsters remains the highest priority. Phyllosoma have been grown to Stage 9 over a period of 85 days, with each attempt improving survival rates.

New Zealand

Rock lobster aquaculture based on quota buy-out schemes in return for puerulus collection licenses (in the order of 1 tonne of quota in return for 40,000 puerulus) has been in place in New Zealand for some years. The success of these ventures has been variable.

Other developments

Interest continues to grow in other Australian states. Opportunities to develop rock lobster aquaculture enterprises in conjunction with existing aquaculture infrastructure is being investigated in both the Northern Territory and Western Australia. For example, management of pearl lines involves regular inspection and it is clear that puerulus are regularly brought to the surface with the lines. The frequency of appearance, the dominant species present and the potential to harvest and on-grow these puerulus requires further investigation, but is an existing consideration.

ii) Major research outputs of the Subprogram

A number of Subprogram projects have now been completed. A short summary of the outcomes from some of these projects and the status of final reports is presented below. Copies of final reports that have been accepted by FRDC can be obtained from the Subprogram Leader.

98/300: Propagation of rock lobster – development of a collaborative national project with international partners

***Principal Investigator*:** Dr Piers Hart
(Tasmanian Aquaculture and Fisheries Institute, Marine Research Laboratories, Nubeena Crescent, Taroona, TAS, 7053)

Final Report Status: A final report in the form of workshop proceedings has been accepted by FRDC.
Outcomes: The outcome of the workshop was that, while many questions remain unanswered, sufficient information is currently available to suggest that rock lobster propagation is not only practically feasible, but there are string indications that a rock lobster hatchery could be commercially viable. On this basis, it was agreed that a research and development plan should be pursued and a funding application submitted to FRDC for an initial 1 year research project with an expectation of a longer and more elaborate project to follow. These recommendations were obviously endorsed with these two projects subsequently being funded by FRDC.

98/301: Rock Lobster Enhancement and Aquaculture Subprogram: Facilitation, administration and promotion of the FRDC Rock Lobster Enhancement and Aquaculture Subprogram.

Principal Investigator: Dr Robert van Barneveld
(Barneveld Nutrition Pty Ltd, 19-27 Coonan Rd, South Maclean, QLD, 4280)

Final Report Status: A draft final report has been prepared for consideration by FRDC.
Outcomes: This project was successful in establishing a functional subprogram with inputs from a wide range of industry sectors. It convened a total of three workshops in Australia and New Zealand and forged the development of international research collaborations. By focusing research priorities, this project has ensured that the technology will exist for the development of Australian rock lobster enhancement and aquaculture systems.

98/303: Feed development for rock lobster aquaculture

Principal Investigator: Dr Kevin Williams
(CSIRO Division of Marine Research, Marine Laboratory, 233 Middle Street, Cleveland, Qld, 4163)

Final Report Status: Draft final report submitted for consideration by the Steering Committee and FRDC.
Outcomes: This project has addressed a range of issues associated with the nutrition of juvenile and adult lobsters including the successful development of manufactured feeds for captive lobsters.

98/304: Pilot study of disease conditions in all potential rock lobster aquaculture species at different growth stages

Principal Investigator: Assoc Prof Louis Evans
(Curtin University of Technology, Aquatic Sciences Research Unit, GPO Box U1987, Perth, WA, 6001)

Final Report Status: Pending
Outcomes: A lobster health network was successfully established as part of this project and an international symposium on lobster health management was convened in conjunction with the Third International Lobster Congress in South Australia.

98/305: Determination of optimum environmental and system requirements for juvenile and adult rock lobster holding and grow-out

Principal Investigator: Assoc Prof Mike Geddes
(University of Adelaide, Department of Zoology, GPO Box 498, Adelaide, SA, 5001)

Final Report Status: Draft final report submitted for consideration by the RLEAS Steering Committee and FRDC.
Outcomes: Outcomes from this project will allow aquaculturalists, rock lobster fishers and processors to make better informed decisions about holding systems, holding times, feeding regimes, feed types and selection of lobsters and long term live-holding of *Jasus edwardsii*. In addition, the project has defined temperature, salinity and density optima for the tank culture of *P. ornatus*, basic production protocols for *P. ornatus*, and the commercial aquaculture potential of *P, ornatus*.

99/314: Preliminary investigation towards ongrowing puerulus to enhance rock lobster stocks while providing animals for commercial culture

Principal Investigator: **Dr Caleb Gardner**
(Tasmanian Aquaculture and Fisheries Institute, Marine Research laboratories, Nubeena Crescent, Taroona, TAS, 7053)

Final Report Status: Draft final report submitted for consideration by the RLEAS Steering Committee and FRDC.
Outcomes: Survival results from this project are encouraging for the future of reseeding aquaculture grown juveniles, however, caution is urged in their interpretation. There is evidence that survival varies greatly between habitats and/or regions, and seasonal effects are also likely. Most importantly, this study has shown that obtaining accurate estimates of short term survival of juvenile lobsters is

both possible and practical. There is confidence that results from the model, and new knowledge on juvenile lobster movement can be used to design a robust study to predict likely survival of reseeded lobsters across habitats, geographic regions and seasons.

99/315: The development of rock lobster propagation techniques for aquaculture in Australia
Principal Investigator: Dr Piers Hart
(Tasmanian Aquaculture and Fisheries Institute, Marine Research laboratories, Nubeena Crescent, Taroona, TAS, 7053)

Final Report Status: Pending
Outcomes: The results from this project have begum the construction of a picture of phyllosoma development over time, which can be related to the structure of a potential culture technology. This information has been used to develop a further submission to FRDC for continued research into the propagation of lobsters with a focus on nutrition.

iii) Related projects and research linkages

The RLEAS currently maintains close research linkages with the following related projects:

1. MG Kailis/Queensland Department of Primary Industries research program into rock lobster aquaculture;
2. National Institute of Water and Atmospheric Research, NZ, research into rock lobster aquaculture and enhancement (independent of the research being conducted within the Subprogram).
3. Ferguson Fisheries research into the live-holding and feeding of Southern Rock Lobsters in recirculation systems.
4. All projects being managed by the Rock Lobster Post-Harvest Subprogram.

iv) Role RLEAS has played in industry development

Via the Subprogram Leader and the Steering Committee, the RLEAS has attempted to have an active role in all industry developments to date, either through providing research outcomes to support industry development, or by providing direct assistance with the procurement of funds or strategies to assist industry development.

v) Operating procedures

This Subprogram is highly responsive to the views of industry and understands the need to accommodate both the research requirements of the future and the needs of the existing wild fisheries and aquaculture industries. To ensure that research conducted within the Subprogram is relevant and meets the above criteria, a Steering Committee has been established to:

- Provide industry feedback and views;
- Review existing research based on FRDC contractual obligations;
- Prioritise new proposals and provide a priority list for other agencies;
- Ensure outcomes are commercially focussed;
- Coordinate industry and research provider involvement - optimum use of resources;
- Facilitate extension and technology transfer.

Membership of the Steering Committee includes Robert van Barneveld (Chair), Patrick Hone (FRDC), Pheroze Jungalwalla (TAS), Neil Stump (TAS), Lionel Carrison (SA), Greg Ward (SA), Barry Spurrier (VIC), David Lucas (VIC), Jim Fogarty (QLD), Ian Finlay (WA), John Newby (WA), Neil Dorrington (WA), Trevor Burkhart (NZ), Piers Hart (Scientific Adviser), Wayne Hosking (Scientific Adviser) and Bruce Phillips (FRDC Rock Lobster Post-Harvest Subprogram Leader).

The Steering Committee meets in March and September each year to review project progress and establish research priorities. Advice from the September Steering Committee is sent to all Fisheries Research Advisory Bodies so that they are aware of the subprogram research priorities. All new projects relating to rock lobster enhancement and aquaculture are assessed by the Steering Committee and are submitted to the FRDC Board via the Subprogram.

Industry consultation and communication: The Subprogram Leader, Dr van Barneveld, promotes the activities of the RLEAS through a website, industry newsletters, and direct communication with industry organisations and representatives.

Strategic planning: Strategic planning for the RLEAS will be based on outcomes from the existing research program and ongoing consultation between the Subprogram Leader and members of industry and researchers in Australia and New Zealand. The strategic plan will be maintained and updated annually using CD-ROM for distribution. The strategic planning process will identify those factors that represent restrictions to the initial establishment of rock lobster aquaculture (eg. propagation, nutrition) and enhancement (eg. monitoring survival, prevention of disease introduction to the wild fishery) processes, and then will utilise a relative ranking score from the various rock lobster fisheries across Australia.

Communication with FRABS: Communication with FRAB's is via distribution of an annual operating plan for the RLEAS in December of each year combined with direct communications. The Subprogram Leader will also attend the annual FRDC FRAB workshop to promote the activities and objectives of the RLEAS.

Development of new research proposals: New research proposals are developed through the use of facilitated strategic planning meetings. Using priorities published in the RLEAS Strategic Plan, the Subprogram Leader convenes meetings with relevant researchers and research institutions to:

1. Define the planned outcomes of the new proposal;
2. Manage an indicative budget for the research as defined by the Steering Committee;
3. Identify which researchers/institutions are best placed to undertake the research;
4. Promote collaboration between researchers and institutions where appropriate;
5. Seek external expertise and inputs as required.
6. Ensure the new proposal meets the objectives of the subprogram and that the research remains relevant and focussed.

The Subprogram Leader ensures new research proposals are distributed to FRABS and the RLEAS Steering Committee for comment and ratification before submitting the proposals to FRDC on behalf of the lead agencies, or facilitating adjustments to the proposals prior to submission.

Coordination of research reports: The Subprogram Leader collates progress and final reports from projects within the Subprogram in March and September each year for delivery in a common format to FRDC. These reports are distributed to members of the Steering Committee for comment and review.

Review of research progress and direction: The RLEAS Steering Committee interviews the Principal Investigator of each project within the Subprogram at least once annually as part of the Steering Committee meeting. Principal Investigators are expected to report progress against contracted milestones, justify any changes in research direction, and demonstrate that the research program is making a valuable contribution towards the achievement of the Subprogram objectives. The Steering Committee makes recommendations to the FRDC Board in relation to potential changes to the objectives of the research program, or instances where project progress is unsatisfactory.

Coordination of research extension: A major function of the Subprogram Leader is the organisation and delivery of an annual research workshop to highlight the activities and outputs of the RLEAS. Workshops are convened with presentations from invited speakers and researchers aimed at

delivering key messages to end-users for use in practical rock lobster aquaculture and enhancement systems.

The Subprogram Leader compiles a subprogram newsletter "Lob ReLEASe" at least annually or as required highlighting research outcomes, developments in rock lobster enhancement and aquaculture and events relevant to the RLEAS. The Subprogram Leader is also responsible for the approval of all media releases and scientific publications arising from research projects within the Subprogram using the RLEAS Steering Committee communication policy as a guide.

Collaboration with international partners: The Subprogram Leader has established a major international collaboration between researchers in Australia and New Zealand through project 98/301. This was achieved through direct interaction with researchers in New Zealand and involvement of these scientists in the RLEAS research program. There is further opportunity to build on relationships initiated with Japanese researchers by AIMS, CSIRO and TAFI as the RLEAS continues to evolve. In all cases, international collaborations will be based on a two-way flow of information and where possible, research funds.

Identification and procurement of additional funding: Additional funding from sources such as the Public Good Science Fund in New Zealand and AUSIndustry in Australia will be procured with the assistance of the Subprogram Leader and relevant end-users. The Subprogram Leader is already involved with the development of AUSIndustry COMET proposals for the commercialisation of existing technology for rock lobster aquaculture. There are also opportunities for commercial investment in the development of technologies for rock lobster aquaculture in conjunction with the existing research program.

Liaison with FRDC: The Subprogram Leader is the conduit for communications between FRDC and subprogram participants in relation to project contracts, project reports, new submissions and general correspondence. The Subprogram Leader also represents the RLEAS at the annual FRDC FRAB and Subprogram meetings in Canberra.

vi) Meetings and Workshops

The next RLEAS workshop will be held in Cairns on May 29, 2002 in conjunction with the Rock Lobster Post-Harvest Subprogram. The workshop will highlight developments in aquaculture and enhancement and will provide an opportunity for the inspection of the new QDPI aquaculture research facilities. Further details will be made available by the Subprogram Leader.

vii) Summary of current project status

Two new projects were approved by the FRDC Board to commence in July, 2001. The first of these projects (2001/211) maintains the management of the RLEAS for a further 3 years. The second (2001/094) is the first stage in a health assurance program that is closely linked with industry developments in Tasmania where there is a requirement for a proportion of aquaculture-reared wild-caught puerulus to be released back to the wild as year-old juveniles.

A summary of the current core projects within the Subprogram and their duration is presented below:

Project	Year			
	00/01	01/02	02/03	03/04
98/302 – Towards establishing techniques for large scale harvesting of pueruli and obtaining a better understanding of mortality rates.				
2000/185 – Evaluating the release and survival of juvenile rock lobsters released for enhancement purposes.				
2000/211 – Investigation into tail-rot necrosis in live-held adult lobsters.				
2000/212 – The nutrition of juvenile and adult lobsters to optimise survival, growth and condition.				
2000/214 – Advancing the hatchery propagation of rock lobsters				
2000/263 – Reducing rock lobster larval rearing time through hormonal manipulation.				
2001/211 – Strategic planning, project development, and facilitation of research and extension towards establishment and maintenance of commercial rock lobster aquaculture and enhancement systems in Australia.				
2001/094 – Health assurance for southern rock lobsters				

B) SUMMARY OF STRATEGIC PLAN

The Rock Lobster Enhancement and Aquaculture Subprogram (RLEAS) was established in July, 1998 with the following objective or "mission":

"To provide technology for use in Australian rock lobster enhancement and aquaculture systems so they can be internationally competitive and can operate in harmony with the wild fisheries".

It is important to note that the role of the RLEAS is not necessarily to promote aquaculture development, but to ensure the existing rock lobster industries have the capacity to pursue enhancement and aquaculture of rock lobsters if the net benefits clearly exceed any negative aspects. The Subprogram also ensures that the research and development program gives due consideration for the following:

- Protection of the wild fishery in terms of economic and social viability;
- Neutral or positive impact on the wild fishery in terms of stock numbers;
- Commercial viability of closing the life cycle of rock lobsters;
- Increasing profitability and wealth for Australasia;

The key research areas within the Subprogram are presented below:

- Species selection for aquaculture;
- Puerulus collection from the wild;
- Biological neutrality of wild stocks;
- Larval rearing/propagation of all species of rock lobsters;
- Nutrition of juveniles and adult lobsters;
- On-growing of juveniles and system requirements;
- Health of aquaculture reared juveniles;
- Economics and marketing;
- Enhancement of wild stocks through reseeding or resettlement.

At its last meeting in September, the RLEAS Steering Committee re-addressed the following questions in an attempt to update the existing strategic directions:

1. Where is the RLEAS going?
2. What is the RLEAS looking for?
3. Is the RLEAS over committed?
4. Is the RLEAS meeting its objectives?

The outcomes from discussions based on these questions were as follows:

- The Steering Committee deemed the propagation question as still being critical and deemed that more outcomes from this research were required before additional strategic decisions could be made.
- A key target for the RLEAS was to derive technologies that allowed enhancement of rock lobster populations through aquaculture, and the maintenance of a rock lobster population in an aquaculture system.
- The Steering Committee decided to use and maintain the original RLEAS research priority list until more outcomes from propagation research were realized and a revised research direction could be formulated.
- For information, the initial priority matrix established by the Steering Committee in relation to the allocation of funds was:
    - Broodstock 19%
    - Culture 30%
    - Wild Collection 14%
    - Ongrowing 16%
    - Enhancement 11%
    - Economics/Marketing 13%

- The Steering Committee were able to further define some aspects of the RLEAS research priority list. Having completed research into puerulus collection and biological neutrality, it was made clear that enhancement of existing habitats to improve puerulus survival was still unresolved. It was also decided that the economics and marketing priority should be divided into two sections. Issues dealing with the costs of undertaking aquaculture activities and issues dealing with the impact of aquaculture products on existing markets, and markets for aquaculture products themselves. It was felt that those planning to undertake aquaculture activities are in the best position to define the costs and hence this should not form part of the RLEAS funding priorities. In additional, different states have different policies and directions as to where they want to go with aquaculture, and hence it is difficult to conduct research into this aspect that will be relevant for all areas.

- The Steering Committee identified a number of additional areas that needed to be addressed by the RLEAS, including:
    1. Concern re the perception of aquaculture product vs wild product;
    2. Continued resistance from the wild fishery;
    3. Highlighting the fact that collecting peurulus will never be a serious industry;
    4. Puerulus are seen in Taiwan as an aquaculture product

C) COMMUNICATION AND TECHNOLOGY TRANSFER

The Steering Committee has defined a policy for the distribution of information arising from research conducted within the Subprogram. The following guidelines will be applied when publishing research:

- Distribution of information must have a net benefit for the Australian industry.
- Dissemination of information to international partners will be approved when there is a two way flow of information.
- *Ad hoc* requests for results or information will not be accepted.

- Special cases for the supply of information will have to be approved by the Steering Committee and where appropriate, Memorandums of Understanding will be prepared.

The Subprogram publishes an annual newsletter called "Lob ReLEASe". The newsletter is the principal industry communication of the subprogram and has received good feedback from all sectors of the rock lobster industry.

A number publications are available or are pending from the Subprogram including:

- Proceedings of a lobster health workshop held in Perth in July, 1998.
- Proceedings of the Rock Lobster Propagation workshop held in Hobart in January, 1999.
- Proceedings of the first annual RLEAS workshop held in Geraldton in March, 1999.
- Proceedings of the second annual RLEAS workshop held in Hobart in February, 2000.
- Proceedings of the third annual RLEAS workshop held in New Zealand in April, 2001.
- Final reports from completed projects.
- "Lob ReLEASe" Volume 1, Issues 1, 2 and 3.
- Scientific publications from completed and existing research projects.

D) PROPOSED NEW RESEARCH

Based on the current project base, and the outstanding priorities, the RLEAS was only seeking projects relating to the economic issues associated with the entry of aquaculture product into traditional markets. Despite this, a total of seven preliminary research proposals were submitted. The RLEAS Steering Committee offered the following comments on these proposals:

1. Studies of diseases and disease syndromes of cultured and captive lobsters – Ben Diggles, NZ.

Priority: Low. Turgid lobster syndrome was not seen as a major industry problem. Many aspects of the proposal were more relevant to the Rock Lobster Post-Harvest Subprogram and accordingly, the PRP was forwarded to this Subprogram for comment. The RLEAS did not support progression of this application to a full proposal.

1. Economic assessment of the potential for aquaculture of the Western rock lobster – Tim Martella.
2. Pilot scale production of Western rock lobster in onshore flow through tanks – Justin Bellanger.
3. Economic feasibility of the enhancement or culture of Western rock lobsters – Richard Stevens.

Priority: Low: These PRP's were considered simultaneously given their similar nature. Based on the discussions outlined under the summary of the strategic plan, the Steering Committee felt that these research areas were either already being covered within the RLEAS, or that this type of information was best collected by those planning to establish rock lobster aquaculture facilities. The RLEAS did not support progression to a full proposal.

5. Enhancement of the survival of juvenile Western rock lobsters – Bruce Phillips

Priority: High: This project seeks to further explore habitat enhancement to increase survival of WA rock lobster puerulus. This has always been recognised as a key research priority for the WA industry and the project was strongly supported by the Steering Committee. Progression to full proposal was endorsed while it was recognised that there is a need to address the environmental concerns regarding artificial environment modifications.

6. Impacts of aquaculture lobster in major Australian markets and industry – Roger Edwards

Priority: Medium: This topic is important to the wider subprogram but the Steering Committee are uncertain whether too many assumptions would have to be made during the conduct of the work. It

was recommended that a number of case studies be prepared based on other aquaculture industries for presentation at the Subprogram workshop planned for Cairns in May, 2002 before further work be undertaken. The RLEAS supported development of a modified proposal for consideration by FRDC.

7. Developing tropical rock lobster aquaculture in conjunction with existing aquaculture farms in Northern Territory – Ram Mohan

Priority: Medium: While this proposal was innovative, it was though to conflict with a number of commercial pursuits. The Steering Committee supported preparation of a modified full proposal that addressed the surveying component of the research.

E) WORKPLAN FOR THE NEXT 12 MONTHS

Workplans have been developed for the first 12 months of each project. As most of these projects are very large in nature with a number of collaborators, it is not possible to include detail in this document. If further information is required on the workplans for each project, the Subprogram Leader can provide this information from the Steering Committee minutes.

F) BUDGET

Existing RLEAS projects and budgets are as follows:

		00/02	02/03	03/04
2000/185	Enhancement	$139,000		
2000/211	Disease	$20,000		
2000/212	Nutrition	$66,000	$65,000	
2000/214	Propagation/Hatching	$208,000	$172,239	
2000/263	Propagation/Hatching	$60,000	$62,000	
2001/211	Co-ordination	$100,000	$100,000	$100,000
2001/094	Health	$67,000	$10,100	
		$661,000	$409,000	$100,000

- RLEAS has allocated rock lobster propagation as our highest priority and currently work on an indicative research budget of $0.5 million per year. We have done well in defining our budget and research program in the past but now need to adjust it for the future. RLEAS has existing commitments of $415,000 and is in the process of defining a vision beyond 2002.

G) VARIATIONS

Nil.

Dr Robert van Barneveld
RLEAS Leader
December, 2001

Rock Lobster Enhancement and Aquaculture Subprogram

Annual Operating Plan - 2003

Prepared by **Dr Robert van Barneveld**
Subprogram Leader

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A) ACTIVITY DESCRIPTION FOR 2001-2002

i) Sector Progress

Rock lobster enhancement and aquaculture maintains a high profile in Australia and New Zealand despite an absence of commercial entities devoted to rock lobster production in aquaculture systems. Development of the sector has been slow since the inception of this Subprogram in 1998, but a large contributor to this is the fact that we are yet to close the life cycle of either a temperate or tropical spiny lobster species (hence the high priorities for this research within this subprogram).

Sector progress in 2001-02 can be summarised as follows:

Tasmania

In 2001, 7 licences were issued in Tasmania for the collection of 50,000 puerulus each. Issue of these licenses was based on the premise that there is a high mortality of wild puerulus in their first year post settlement (anywhere from 75-97%) compared with animals brought ashore and ongrown in tanks where the mortality is minimal (2% in Tasmania). This gives rise to the theory aquaculturists can ongrow the 'excess' that would have died in the wild. The licences were issued for an initial 12 month period, but it is understood that this may be extended to accommodate some delays that have occurred with the commercial assessment process. A condition of use of the licenses is that approximately 25% of the total number of puerulus collected are re-seeded into the wild fishery as juveniles at 1 year.

South Australia

Aquaculture activities in South Australia continue to focus on on-growing and value adding to adult wild-caught lobsters. In the past, pontoons have been used to hold and feed lobsters prior to sale facilitating more control over the market the lobsters are sold into and the timing of the sale. There is the potential to achieve weight gains of around 20% by growing the animals through the annual moult, representing a 60% return on investment. Current activities include investigations into the holding and feeding of lobsters in land-based tanks using both existing flow through systems and infrastructure or recirculation systems with a view to value-adding to wild caught lobsters.

Queensland

MG Kailis have had an active rock lobster aquaculture research program underway since 2000. This investigated all aspects of rock lobster aquaculture with *P. ornatus* and was completed in collaboration with the Queensland Department of Primary Industries Northern Fisheries Centre. In 2002, MG Kailis decided to fully integrate their research program with the RLEAS and became full partners in the existing rock lobster propagation project being managed by Dr Bradley Crear. In 2002,

MG Kailis have submitted a subsequent research proposal in collaboration with the QDPI and AIMS aimed at furthering the research into propagation of the tropical rock lobster.

Western Australia

In 2001-02 new interest was shown from Western Australia in assessing the commercial potential of the Western Rock Lobster. A lot of this interest was via the Department of Fisheries and Universities rather than the wild capture sector of the western rock lobster fishery or commercial entities in Western Australia.

New Zealand

Rock lobster aquaculture based on quota buy-out schemes in return for puerulus collection licenses (in the order of 1 tonne of quota in return for 40,000 puerulus) has been in place in New Zealand for some years. The success of these ventures has been variable. Research in New Zealand continues to focus primarily on the potential of *J.verreauxi* as a temperate aquaculture species.

Other developments

Interest continues to grow in other Australian states. Opportunities to develop rock lobster aquaculture enterprises in conjunction with existing aquaculture infrastructure is being investigated in both the Northern Territory and Western Australia. For example, management of pearl lines involves regular inspection and it is clear that puerulus are regularly brought to the surface with the lines. The frequency of appearance, the dominant species present and the potential to harvest and on-grow these puerulus requires further investigation, but is an existing consideration.

ii) Major research outputs of the Subprogram

Research reviews:

In 2001-02, the RLEAS commissioned a review of propagation research as a strategic initiative. The review was completed by Mr Rodney Grove Jones, Dr Sagiv Kolkovski and Dr Robert van Barneveld. This review examined progress in FRDC projects 2000/214 and 2000/263 to ensure that objectives were being met, the approach was robust, and to identify gaps in the approach.

It was clear that the objectives as reflected in the milestones were set with the expectation that the life cycle of the phyllosoma would be closed and large numbers of phyllosoma would be available at each stage. Other comments arising from the review were as follows:

At this stage, the inability to raise healthy larvae in the hatchery through all stages of development and in reasonable numbers is an absolute barrier to achieving the objectives of these projects.

Nutrition

While the level of understanding of phyllosoma nutrition is increasing, there does not appear to be a coordinated approach to incorporate this knowledge into an actual diet and assess it empirically as the knowledge is generated. There is no sense of urgency or strategic plan to develop a base diet.

The nutrition team must identify and prioritise the key obstacles to developing a base diet together with a plan to modify and assess the diet concurrently.

Starvation trial to determine critical nutrients
Identification of critical nutrients by this method should be used to refine a base diet (live or formulated) rather than to develop a base diet. Starvation trials are a useful, if somewhat controversial tool in identifying critical nutrients, but should be conducted after completing the lifecycle and obtaining reasonable growth and survival throughout all the larval stages rather than before. For

reasons of efficient use of resources, it should only be necessary to conduct these trials on one or two species and at one site.

Enzyme study to identify nutrients phyllosoma are able to digest
The current study is confined to cultured phyllosoma because wild phyllosoma are not available to the investigators. However, cultured phyllosoma are not available in sufficient numbers in all but the earliest stages of development or in an adequate state of health to be of practical use in this project. It is considered that this study should have been conducted only when an adequate supply of healthy larvae in all stages of development were available either from the wild or from hatchery sources. That is to say, after the life cycle has been completed under culture conditions and a supply of sufficient numbers of larvae reared on a base diet can be assured. Further investigations with enzyme ontogeny of phyllosoma should be put on hold until a reliable supply of phyllosoma in relatively good health and a nutritionally balanced diet are available.

Manipulation of growth through manipulating the food supply
This project has not yet succeeded in achieving changes in larval growth or survival using various *Artemia* enrichments or formulated feed additives. Moreover, this is unlikely to be achieved because there is no base diet available for manipulation. Research in this area needs to focus on achieving the base diet before manipulating its composition.

It was considered the investigators should review and standardise their technique for handling and enriching *Artemia*. One of the reviewers (Sagiv Kolkovski) is conducting a parallel project similar to this one and would be available to assist with such a review.

Certain aspects of the formulated feed development such as assessing the different binders need to be more closely coordinated as there appears to be a lack of communication and consistency of protocols between different institutions.

Feed intake evaluation and attractants
At this stage of development it should be sufficient to measure qualitative feed intake levels by microscopic examination rather than by more elaborate quantitative methods. Knowledge of feed attractants does not appear to be an obstacle to producing the base diet and should be deferred until a base diet has been developed.

These studies should be on hold until a reliable diet is available and further re-fining is needed.

Gap analysis and recommendations

The critical gap in this program is the lack of a base diet that will provide adequate nutrition for the growth of larvae through all stages of development. Most of the current research appears to be targeted towards refining a diet that does not yet exist rather than creating the base diet itself.

Parallel to this is the need for techniques to control bacteria and create a tank environment that is healthy and in which high levels of survival can be expected.

It is clear that further nutritional research need to focus on two aspects:

1. Early stage phyllosoma (stage V) using Artemia and,
2. Later stage phyllosoma shifting to formulated diets or co-feeding Artemia and formulated diets.

The most important objective is to develop a base diet and Artemia enrichment based on existing information. As stated earlier, the health issues are an integral part of the attempt to close the life cycle of rock lobster. Introducing live or formulated feeds to the rearing system will, in most cases, involve the introduction of large numbers of bacteria, some harmless and some harmful to the phyllosoma. Any further dietary research needs to address this issue. It is, therefore, recommended that:

Artemia

1. Artemia enrichment development be based on information collected in the current and previous projects (ie. mussel oil or phospholipid enriched oils, essential fatty acids etc.). Base enrichment should be developed and other micronutrients such as vitamins (C, E and others) should be tested.
2. Protocols for on-growing Artemia should be re-fined and standardised among the institutes.
3. Enriching, harvesting, cleaning, disinfecting and feeding of Artemia should be standardised.
4. Bacteria control of Artemia and enrichments should be further developed, using disinfectants (environmentally friendly), probiotics and/or mechanical methods.

Formulated diets

1. A base diet be developed with already known ingredients and matrices (alginate and/or other binders) and other ingredients known to be digestible and/or support growth with fish and other crustacean larvae (squid meal, krill, copepods etc.). Initially this phase can be without the phyllosoma and the chemical and physical characteristics of the particles will be determined.
2. Since it is anticipated that formulated diets will reduce water quality and increase bacteria numbers, water quality and bacteria levels should be monitored and a bacteria control system developed. This can be related to systems development and done by using a variety of methods including the usual water treatments together with a system of stabilizing bacterial communities eg matured or green water technique, probiotics, mesocosm, etc.

Hormones

This project is adding to the understanding of moulting triggers as a possible route to shortening the larval period. However, the panel considered this project to be ahead of its time because larvae are dying well before metamorphosis due to health and nutritional problems. It appears premature then, to try to enhance the growth rate with hormones while it is still not possible to grow healthy larvae.

The panel does not believe this project will contribute to the immediate goal of producing puerulus, however, as a strategic element to achieving the overall goal of producing puerulus commercially the project could make a contribution by shortening the larval developmental stage. Project 2000/263 should therefore continue to the end of its funding cycle with emphasis on the application of the hormones i.e. incorporate into enrichment and trace it through the Artemia and phyllosoma.

- To recommend strategies for the commercialisation of intellectual property arising from propagation research;
- To provide a research and development plan for rock lobster propagation that provides the steering committee with guidance for future research, including major deficiencies in the existing approach.

The immediate goal should be to develop the capability to produce tens of thousands of healthy stage V larvae within 3 years by concentrating on

- Developing broodstock conditioning to a level where stage I larvae are produced monthly.
- Development of a base enrichment and base larval rearing system.
- Refinement of Artemia handling techniques.
- Development of culture systems incorporating stable bacterial communities.

To do this we recommend the project be divided into segments focussing on broodstock conditioning, larval rearing systems (including microbiology) and Stage I through V nutrition studies as outlined in the following revised project goals. Development of the formulated feed should be delayed until sufficient numbers of healthy later stage phyllosoma are available.

Species

Research should be focussed on finding solutions using a narrower range of species than are being used at present. Taking into account growth rate and an increasing commercial interest, the panel believes the research effort should include studies on *P ornatus*.

Wild Collection

The timing of commencement of any pilot scale experiments involving systems design, ongrowing and husbandry of juveniles through to saleable size should not be tied to successful tank production of puerulus even though the upscaling to a commercial industry may have to await the successful hatchery production of juveniles.

Research Providers

Funding should be restricted to a smaller number of institutes and closer ties should be developed between the institutes.

Full details of the revised propagation research program are provided later in this annual operating plan. The Steering Committee considered all aspects of this review and where possible adopted the recommendations.

Completed projects 2002:

A number of Subprogram projects were completed in 2001-02. A short summary of the outcomes from some of these projects and the status of final reports is presented below. Copies of final reports that have been accepted by FRDC can be obtained via the Subprogram Leader.

99/302: Examining pueruli harvesting and the question of biological neutrality in the western rock lobster, and techniques for large-scale harvesting of lobster pueruli.
Principal Investigator: Prof Bruce Phillips
(Curtin University of Technology, GPO Box U1987,Perth, WA, 6001)

Final Report Status: Draft accepted – final submission pending.

Outcomes:
This project was undertaken in four parts. In the first part, a study examined the impact of possible puerulus exploitation on the future catches in the wild fishery for the western rock lobster, Panulirus cygnus, in Western Australia, and determined management measures which might be required to maintain 'biological neutrality'. A primary aim of management to maintain sustainability of the Western Rock Lobster Fishery is to maintain the reproductive capacity of the breeding stock at a level sufficient to replenish itself Biological neutrality is in this context, the level of catch that would be needed to be forgone to compensate the reproductive capacity of the breeding stock if pueruli were removed for aquaculture.

Because of constraints on time and resources, it was not possible to undertake a study of all areas of the fishery. However, data were available to permit examination of the $29^{O}S$ – $30^{O}S$ area to examine the potential for puerulus harvesting. These latitudes encompass the area between Dongara and Geraldton, which are near the centre of the Western Rock Lobster Fishery.

Catch-puerulus relationships were used to assess relative mortality differences between different regions and different levels of puerulus settlement in the same region. The conclusion from this analysis was that if pueruli are to be harvested in the future, that because of the different contributions to the fishery made by pueruli settling three and four years before recruitment in different regions, and because of differences in stock dependent mortalities in different regions, these factors would need to be taken into account in establishing harvesting procedures.

An estimate was made of the rates of survival between settlement of the pueruli and recruitment into the fishery. The results indicated that pueruli and post pueruli are subject to very high mortality, particularly in the first year after settlement. Mortality estimates in the first year were as high as 97-98%, and at least 80-84%.

The impact of puerulus removals on subsequent catch was estimated to be minimal except in the case of removal of very large numbers of pueruli. It is would be possible to counter these losses by effort reductions, and a set of tables allowing the calculation of these reductions has been provided.

In the second part of this project, methods were investigated to catch large numbers of pueruli. This work showed that the pueruli will be easiest to catch near the shore (depths >5m), and in locations with fringing reefs.

The investigators tested (i) modified western rock lobster collectors, sandwich collectors, at different depths and distances offshore, (ii) different collector designs, (iii) the effect of collector size, and (iv) the effect of frequency of servicing the collectors on catch. Data from studies, in the 1970s on the effect on catches of collector arrays and locations were reexamined with a general linear model. The analysis revealed marginally significant corner and layer effects, carry-over effects, and square-of-time effects. Five collector designs were therefore set in the shallows, two of which had replicates of three different sizes, and were checked over four lunar months during peak settlement in 2000/2001. Sandwich collectors had significantly better catch rates than others and settlement rates were highly correlated with collector dimensions. Daily servicing for seven days around the time of new moon, yielded catches 170% higher than those from a single monthly servicing. Results indicate that tests for collectors must take into account corner, carry-over, neighbour, and layer effects and that to do so they must be set out in an array and repositioned after each sampling.

Other pueruli harvesting methods were trialled. Neither fixed, pump or mid-water trawling proved to be effective methods of catching pueruli in quantity. Mid-water trawling was the most effective of the three methods and tens of pueruli were caught in inshore areas between the Abrolhos Islands and the coast over four nights when this method was trailed.

In the third part of the project the effect of collector position on localized pueruli catch rates was tested at Shark Bay and Seven Mile Beach. Pueruli collectors set along a 3 km stretch of coastline at Seven Mile Beach did not show uniform linear trend in variation in catch rates in a longshore direction, but neighbourhood effects were shown to exist between individual collectors. Some of the longshore collector sites tended to consistently perform better than others, indicating that in addition to the macro environmental factors that influence puerli collector catch rates, there are likely to also be very localized affects.

The fourth part of this project focused on southern rock lobster *(Jasus edwardsii)* and was done in Hobart, Tasmania, by the Tasmanian Aquaculture and Fisheries Institute (TAFI). Research at TAFI has highlighted the need for continued development of collector designs and servicing protocols. Sandwich collectors, previously(1991) thought to be unsuitable for *J. edwardsii,* were shown in this study (from August 2000 to February 2001) to achieve good catch rates when deployed in an alternative fashion (on the seafloor versus at the surface). For the considerable advantages of sandwich type collectors to be realised, a cost-effective method of manufacture will need to be devised. The use of midwater longlines for deploying collectors proved unsuitable, with low catch rates. Whilst the use and rigging methods for bottom-set longlines will require further investigation.

Some pueruli emigrate from collectors after settlement and yield was shown to be greatest when the collectors were serviced at intervals of one week or less during peak settlement periods. Pueruli were lost during the hauling of collectors from the seafloor to the boat, with some escaping whilst hauling to the surface and others being washed from collectors as they were hauled clear of the surface. The use of a scoop net to lift collectors into the boat would go some way towards reducing this loss, and avoids the complication and expense of bagging collectors on the seafloor.

Although it is unlikely that the catch of *J. edwardsii* pueruli per collector will increase substantially with other alternative collector types, collection cost per puerulus might be significantly reduced. Thus it would be economically viable to deploy greater numbers of collectors, resulting in an increased total puerulus catch. It might be possible to achieve cost reductions through the construction of cheaper collectors, increased ease of deployment and servicing, and increased retention of puerulus without the need for bagging or dip-netting.

2000/211: Investigation of tail fan necrosis of live held adult rock lobsters
Principal Investigator: Dr Michael Geddes
(University of Adelaide SA)

Final Report Status: Accepted and submitted.

Outcomes:
- Demonstrated long term holding of adult southern rock lobsters and developed a feed that maintains lobsters in good condition;
- Provided understanding of the likely weight gain at moult in adult southern rock lobsters;
- Shown the tolerance and high growth potential of the tropical rock lobster;
- Outlined the effects of photoperiod and temperature on growth and survival in juvenile southern rock lobsters.

There is growing interest in Australia in the commercial potential for on-growing and culture of rock lobster. A major development initiative is currently being implemented in Tasmania for southern rock lobster *(Jasus edwardsii)* and similar plans are being developed for the tropical rock lobster *(Panulirus ornatus)* in Queensland. There is also a fledgling industry in South Australia based on value-adding through live-holding of fishery-caught adult *J. edwardsii.* For each of these areas to reach full commercialisation, it is necessary to determine the optimum environmental and system requirements for grow-out and liveholding. The present project aimed to address these areas and was comprised of three components: I. Live-holding of adult *J. edwardsii,* II. Grow-out of juvenile P. *ornatus,* and III. Grow-out of juvenile *J. edwardsii.*

Component 1 of the project investigated the effectiveness of different 'natural' and manufactured diets in maintaining/improving condition and in promoting growth at moult in adult *J. edwardsii* held in sea-based and land-based systems. Trials were run over "summer" (November 1998 to March 1999) and "wintee' (April to November 1999) on industry facilities at Port Lincoln and Kangaroo Island. These provided information on diets and feeding regimes, comparison of holding systems, the growth, mortality and biology of lobsters under long-term liveholding and the product quality of live-held lobsters.

The various diets used, live mussel, octopus, and manufactured pellets were all successful in keeping lobsters alive, promoting growth at moult, and maintaining/improving the condition of lobsters. Diets were formulated in consultation with RLEAS Project 98-303 Lobster Nutrition. Diets were initially extruded and supplied as moist or dry pellets. In the later part of the Project, diets were steam pelleted and this method produced an easily stored and handled pellet that had good water stability and that was well accepted by the lobsters in seacages and raceways. Addition of mussel mince to pellets as a feeding stimulant did not increase survival or growth. Different inclusions of carophyll pink, a carotenoid necessary to maintain red colouration in lobsters, were trialled and the lower level of 0.07% proved sufficient to maintain and improve colour in sea-based and land-based live holding. Lobsters were fed to excess in these trials and further work on pellet dimension and feeding strategy needs to be undertaken. Overall natural feeds slightly outperformed pellet feeds, although in some cases survival was better on pellet diets. These results were pleasing as improvements in formulation, pellet production and food delivery can be expected.

Lobsters were held successfully in both sea-based cages and land-based raceways. The sea-based systems were purpose built for commercial industry use. They allow the holding of high densities of

lobsters without water quality deterioration. They are difficult to service and it is difficult to follow the fate of food fed to the cages. Raceways offer advantages in management, however water quality and system failure are key issues to be addressed. In the present study sea-based cages performed better than the raceways, although the performance of both can be improved.

Lobsters were successfully held over both "summer" and "winter" periods in both raceways and seacages under varying temperature (12.3 to 24.7 'C), water quality and feeding conditions, including no feed provided for 30 weeks. This demonstrates that *J. edwardsii* is a robust species with substantial environmental tolerances. In summer only male lobsters were held and they showed high survival in all of the "FeE treatments and up to 71 % of lobsters moulted. Average individual weight gains were 4.7 to 8.0% in fed treatments. In winter both males and females were held. All lobsters in the sea-cages at Port Lincoln and Kangaroo Island moulted between July and October. Males showed substantially greater growth at moult than females, mean of 8% for females and 17% for males. The winter moult increments were greater that those recorded in summer, 8% in summer and 18% in winter for lobsters fed live mussels. Over an extended winter holding period of 30 weeks duration, one experimental treatment had 100% survival, 100% moulting activity, and an average individual weight gain at moult of 17%. The biomass of male lobsters increased in the pellet fed winter trials at Kangaroo Island (approximately 16% biomass gain) and the pellet fed treatment in the Port Lincoln sea-cages (12% gain), where growth of individual lobsters more than compensated for weight loss via mortality. Where females were held separately but in cages adjacent to males, there was some spawning activity in the winter trial, resulting in small batches of infertile eggs on 13% of the females. The groups of lobsters at Port Lincoln that were held for 50 weeks showed good survival (80-95%) and substantial growth (ranging from 20-30% by weight) when fed on artificial diets over this long term demonstrating the success of this formulated diet.

Speckled/white lobsters that were fed on either octopus or manufactured pellet diets with inclusion of 0.07 to 0.25% carophyll pink changed to a more red colouration. Long-term liveheld lobsters survived a simulated overseas export, and the taste of these lobsters was excellent. The one negative outcome of the project was that tail fan damage was found to be a major problem with live-held lobsters. Tail fan damage occurred in sea-based and land-based trials and across all diets without apparent pattern. In some lobsters, tail fan damage progressed to unacceptable condition within the first month on live holding. The condition was generally worse/more progressed in the summer- held lobsters. The causes and management of tail fan necrosis need to be addressed before a long term live holding industry can be developed.

Component II of the project investigated the effects of temperature, salinity, and density/biomass on the growth and survival of juvenile P. *ornatus.* Results of the experiments completed and the experience of conducting the experiments and the associated collection, handling and processing of lobsters, collectively confirm the excellent aquaculture potential for ornate lobsters, P. *ornatus,* in land-based tank systems. Although many important biological and physico-chernical factors need to be addressed in further defining the most effective production technologies for this species, the basic protocols for tank-based culture have now been established. An optimal temperature range of 25 to 30'C was clearly defined and a moderate tolerance to reduced salinity was revealed. P. *ornatus* was shown to be a robust species, with a range of attributes that will suit commercial aquaculture circumstances, including resistance to compromised water quality, tolerance of frequent handling, low susceptibility to stress and health problems. Results of the density experiment provided an assessment of the species likely performance under commercial aquaculture conditions, in that the experiment covered a protracted period and a growth phase from small juvenile (3g) to moderate-size pre-adult (225g). Of the densities applied, none had any significant effect on survival or growth, and there is capacity to culture this species at higher levels, greater than 4 kg per square metre. Although survival (52%) was less than ideal, the mortality experienced was attributed to causes that can be overcome. Growth was excellent for the experimental period, and can be confidently extrapolated to permit growth to 1 kg within 18 months, at commercially relevant densities. There is a priority however on defining growth for the post-puerulus to 3g phase.

Component III of the project investigated the effects of temperature and photoperiod on the growth and survival of juvenile *J. edwardsii*. A temperature range of between 19 and 2PC is optimal for post-puerulus *J. edwardsii* in terms of survival, growth and feed conversion ratio. At higher temperatures the measured performance criteria were reduced and the upper thermal limits appeared to be 24'C. Culturists would need to consider the economic advantages of lobsters reaching market size in the shortest possible time against the increased costs associated with heating water. In addition, at higher temperatures lobsters have a greater respiratory requirement and excrete higher levels of ammonia. If lobsters are to be cultured at elevated temperatures in intensive recirculating aquaculture systems then there will be even greater reliance on water treatment, to ensure water quality is not limiting growth. Finally, if lobsters were to be grown in flow-through systems, or in cages in the sea these results indicate that it will be necessary to select sites where summer water temperatures do not rise above 22'C. Photoperiod appears to have only minimal influence on growth and survival compared to other factors, such as temperature and diet. It is possible to subject the lobsters to reasonably long light periods without affecting growth or survival. If J *edwardsii* were to be cultured in an indoor system with artificial light regimes, then husbandry practices can be significantly simplified, as there will be no need to undertake those practices in the dark.

Completed Projects 1998-2001

The following projects were completed between 1998 and 2001. More information on these projects can be found on the RLEAS website (www.frdc.com.au/research/programs/rleas)

Project	**Title**	***Principal Investigator***
98/300	Propagation of rock lobster – development of a collaborative national project with international partners	Dr Piers Hart (Tasmanian Aquaculture and Fisheries Institute, Marine Research Laboratories, Nubeena Crescent, Taroona, TAS, 7053)
98/301	Rock Lobster Enhancement and Aquaculture Subprogram: Facilitation, administration and promotion of the FRDC Rock Lobster Enhancement and Aquaculture Subprogram.	Dr Robert van Barneveld (Barneveld Nutrition Pty Ltd, 19-27 Coonan Rd, South Maclean, QLD, 4280)
98/303	Feed development for rock lobster aquaculture	Dr Kevin Williams (CSIRO Division of Marine Research, Marine Laboratory, 233 Middle Street, Cleveland, Qld, 4163)
98/304	Pilot study of disease conditions in all potential rock lobster aquaculture species at different growth stages	Assoc Prof Louis Evans (Curtin University of Technology, Aquatic Sciences Research Unit, GPO Box U1987, Perth, WA, 6001)
98/305	Determination of optimum environmental and system requirements for juvenile and adult rock lobster holding and grow-out	Assoc Prof Mike Geddes (University of Adelaide, Department of Zoology, GPO Box 498, Adelaide, SA, 5001)
99/314	Preliminary investigation towards ongrowing puerulus to enhance rock lobster stocks while providing animals for commercial culture	Dr Caleb Gardner (Tasmanian Aquaculture and Fisheries Institute, Marine Research laboratories, Nubeena Crescent, Taroona, TAS, 7053)
99/315	The development of rock lobster propagation techniques for aquaculture in Australia	Dr Bradley Crear (Tasmanian Aquaculture and Fisheries Institute, Marine Research laboratories, Nubeena Crescent, Taroona, TAS, 7053)

iii) Related projects and research linkages

The RLEAS currently maintains close research linkages with the following related projects:

5. National Institute of Water and Atmospheric Research, NZ, research into rock lobster aquaculture and enhancement (independent of the research being conducted within the Subprogram).
6. Ferguson Fisheries research into the live-holding and feeding of Southern Rock Lobsters in recirculation systems.
7. All projects being managed by the Rock Lobster Post-Harvest Subprogram.

iv) Role RLEAS has played in industry development

Via the Subprogram Leader and the Steering Committee, the RLEAS has attempted to have an active role in all industry developments to date, either through providing research outcomes to support industry development, or by providing direct assistance with the procurement of funds or strategies to assist industry development.

v) Operating procedures

This Subprogram is highly responsive to the views of industry and understands the need to accommodate both the research requirements of the future and the needs of the existing wild fisheries and aquaculture industries. To ensure that research conducted within the Subprogram is relevant and meets the above criteria, a Steering Committee has been established to:

- To establish and review strategic directions for the Subprogram;
- To review existing research directions within the guidelines of the FRDC contractual agreements;
- To prioritise new research proposals and develop a priority list that can be used by other funding agencies;
- To ensure that research outcomes are commercially focused where relevant;
- To coordinate industry and research provider involvement so as to maximise usage of available resources;
- To facilitate industry extension and technology transfer;
- To advise on flexible components of budget expenditure;
- The convening of regular meetings (6 monthly);
- To develop an appropriate and approved communications policy;
- Ensure efficient and effective reporting structures;
- To promote the Subprogram and its achievements so that it can become the focus for all research on rock lobster aquaculture and enhancement.

At a minimum Steering Committee members are expected to attend at least two Subprogram meetings per year (one meeting per year will include a Subprogram workshop). Members are also required to comment (out of session) on all written project progress reports, final reports and new project proposals. Sitting fees are not paid to Steering Committee members, but the Subprogram covers travel expenses associated with attendance at the two annual meetings. Subprogram meetings are held at various locations around Australia.

The Steering Committee is comprised of:

- Subprogram Leader;
- FRDC Representative;
- Eleven industry representatives;
- Two Scientific Advisors.

The following should be noted in relation to membership:

- In general, Scientific Advisors will not have active research projects within the Subprogram;
- Proxies are not accepted for Steering Committee members who are unable to attend a particular meeting;
- Membership of the Steering Committee is expertise based;

- Periodically, the Subprogram Leader may invite relevant observers to Subprogram meetings, at his discretion.

Steering Committee members are selected to contribute expertise in one or more of the following areas:

- The marine aquaculture sector;
- The rock lobster wild capture fisheries;
- Seafood processing and marketing;
- Knowledge of the fishing industry and resource allocation;
- Research and development in marine science or aquaculture;
- Communication and technology transfer.

At present, the RLEAS Steering Committee members include:

- Dr Robert van Barneveld (Chair)
- Dr Patrick Hone (FRDC)
- Pheroze Jungalwalla (TAS)
- Neil Stump (TAS)
- Lionel Carrison (SA)
- Greg Ward (SA)
- Barry Spurrier (VIC)
- David Lucas (VIC)
- Jim Fogarty (QLD)
- Ian Finlay (WA)
- John Newby (WA)
- Neil Dorrington (WA)
- Trevor Burkhart (NZ)
- Dr Piers Hart (Scientific Adviser)
- Dr Bruce Phillips (FRDC Rock Lobster Post-Harvest Subprogram Leader).

Wayne Hosking (Scientific Adviser) resigned his position in September 2002 due to new work-related commitments.

Steering Committee Membership turnover: From 2003, to ensure the RLEAS Steering Committee remains relevant, one third of the industry representative positions will be declared vacant and will be recalled. Existing or new members will be reappointed as per the above guidelines at the discretion of FRDC.

Industry consultation and communication: The Subprogram Leader, Dr van Barneveld, promotes the activities of the RLEAS through a website, industry newsletters, and direct communication with industry organisations and representatives.

Strategic planning: Strategic planning for the RLEAS is based on outcomes from the existing research program and ongoing consultation between the Subprogram Leader and members of industry and researchers in Australia and New Zealand. The strategic plan is maintained and updated annually using CD-ROM for distribution. The strategic planning process identifies those factors that represent restrictions to the initial establishment of rock lobster aquaculture (eg. propagation, nutrition) and enhancement (eg. monitoring survival, prevention of disease introduction to the wild fishery) processes, and then utilises a relative ranking score from the various rock lobster fisheries across Australia.

Communication with FRABS: Communication with FRAB's is via distribution of an annual operating plan for the RLEAS in December of each year combined with direct communications. The

Subprogram Leader will also attend the annual FRDC FRAB workshop to promote the activities and objectives of the RLEAS.

Development of new research proposals: New research proposals are developed through the use of facilitated strategic planning meetings. Using priorities published in the RLEAS Strategic Plan, the Subprogram Leader convenes meetings with relevant researchers and research institutions to:

1. Define the planned outcomes of the new proposal;
2. Manage an indicative budget for the research as defined by the Steering Committee;
3. Identify which researchers/institutions are best placed to undertake the research;
4. Promote collaboration between researchers and institutions where appropriate;
5. Seek external expertise and inputs as required.
6. Ensure the new proposal meets the objectives of the subprogram and that the research remains relevant and focussed.

The Subprogram Leader ensures new research proposals are distributed to FRABS and the RLEAS Steering Committee for comment and ratification before submitting the proposals to FRDC on behalf of the lead agencies, or facilitating adjustments to the proposals prior to submission.
Coordination of research reports: The Subprogram Leader collates progress and final reports from projects within the Subprogram in March and September each year for delivery in a common format to FRDC. These reports are distributed to members of the Steering Committee for comment and review.

Review of research progress and direction: The RLEAS Steering Committee interviews the Principal Investigator of each project within the Subprogram at least once annually as part of the Steering Committee meeting. Principal Investigators are expected to report progress against contracted milestones, justify any changes in research direction, and demonstrate that the research program is making a valuable contribution towards the achievement of the Subprogram objectives. The Steering Committee makes recommendations to the FRDC Board in relation to potential changes to the objectives of the research program, or instances where project progress is unsatisfactory.

Coordination of research extension: A major function of the Subprogram Leader is the organisation and delivery of an annual research workshop to highlight the activities and outputs of the RLEAS. Workshops are convened with presentations from invited speakers and researchers aimed at delivering key messages to end-users for use in practical rock lobster aquaculture and enhancement systems.

The Subprogram Leader compiles a subprogram newsletter "Lob ReLEASe" at least annually or as required highlighting research outcomes, developments in rock lobster enhancement and aquaculture and events relevant to the RLEAS. The Subprogram Leader is also responsible for the approval of all media releases and scientific publications arising from research projects within the Subprogram using the RLEAS Steering Committee communication policy as a guide.

Collaboration with international partners: The Subprogram Leader has established a major international collaboration between researchers in Australia and New Zealand through project initially through project 98/301 and subsequent projects. This was achieved through direct interaction with researchers in New Zealand and involvement of these scientists in the RLEAS research program. There is further opportunity to build on relationships initiated with Japanese researchers by AIMS, CSIRO and TAFI as the RLEAS continues to evolve. In all cases, international collaborations will be based on a two-way flow of information and where possible, research funds.

Identification and procurement of additional funding: Additional funding from sources such as the Public Good Science Fund in New Zealand and AUSIndustry in Australia will be procured with the assistance of the Subprogram Leader and relevant end-users. The Subprogram Leader is already involved with the development of AUSIndustry COMET proposals for the commercialisation of existing technology for rock lobster aquaculture. There are also opportunities for commercial

investment in the development of technologies for rock lobster aquaculture in conjunction with the existing research program.

Liaison with FRDC: The Subprogram Leader is the conduit for communications between FRDC and subprogram participants in relation to project contracts, project reports, new submissions and general correspondence. The Subprogram Leader also represents the RLEAS at the annual FRDC FRAB and Subprogram meetings in Canberra.

vi) Meetings and Workshops

The next RLEAS workshop will be held in Perth in September 2003 in conjunction with the Rock Lobster Post-Harvest Subprogram. The workshop will highlight developments in aquaculture and enhancement. Further details will be made available by the Subprogram Leader.

vii) Summary of current project status

A summary of the current core projects within the Subprogram and their duration is presented below:

Project	Year				
	00/01	01/02	02/03	03/04	04/05
2000/185 – Evaluating the release and survival of juvenile rock lobsters released for enhancement purposes.					
2000/212 – The nutrition of juvenile and adult lobsters to optimise survival, growth and condition.					
2000/214 – Advancing the hatchery propagation of rock lobsters					
2000/263 – Reducing rock lobster larval rearing time through hormonal manipulation.					
2001/211 – Strategic planning, project development, and facilitation of research and extension towards establishment and maintenance of commercial rock lobster aquaculture and enhancement systems in Australia.					
2001/094 – Health assurance for southern rock lobsters					
2002/045 – Assessing the possibilities for enhancing the natural settlement of western rock lobsters					

One new project was approved by the FRDC Board to commence in July, 2002. This project (2002/045) is aimed at enhancing the natural settlement of western rock lobsters.

B) SUMMARY OF STRATEGIC PLAN

Based on research outcomes to date, the RLEAS Steering Committee recently reviewed the research and development priorities for the Subprogram.

To date, given the many unknowns associated with an emerging aquaculture sector such as rock lobster, the research focus has been comparatively short term. It is now clear that development of technical capacity in the field of rock lobster enhancement and aquaculture will require a long term research and development effort over a period of 5-10 years. In addition, the RLEAS Steering Committee believe that the best chance of meeting the Subprogram and industry goals will result from an allocation of any research investment in the following way:

Research focus	Resource allocation (%)
1. Broodstock culture and propagation	**80**
2. On-growing	**10**
a) Puerulus – market size	*Maximum 10%*
- Nutrition	*(0-10)*
- Health	*(0-10)*
- System design	*(0-10)*
b) Adult enhancement	*Maximum 5%*
3. Wild fishery enhancement with aquaculture reared lobsters	**10**

Based on the above allocation of resources, the following specific research objectives are priorities for the Rock Lobster Enhancement and Aquaculture Subprogram:

Propagation

The task of rearing of large numbers of rock lobster larvae to metamorphosis at will is undoubtedly one of the greatest challenges in aquaculture today. Success will only be achieved if there is an intense focus on achieving results that take the project closer to its final goal, if there is genuine collaboration between those involved and a great deal of innovation and willingness to explore new approaches.

The overall goal of propagation research within the RLEAS is to develop the technical ability to produce puerulus at will in any number required and each milestone of each project should contribute measurably to the achievement of this goal. It will likely take more than five years to reach the overall goal given a coordinated and determined effort and may yet prove too difficult at the current level of technical understanding of larval production systems. It is clear that new base survival diets (both for *Artemia* enrichment and for inclusion in a manufactured diet), improved larval husbandry techniques and systems that minimize the proliferation of bacteria will have to be developed. Investigators will need to demonstrate a high level of innovation and determination to overcome these obstacles.

The immediate goal for the propagation research program is to provide the technical ability to spawn adults during any month of the year, and to produce healthy and nutritionally balanced larvae to stage V. Completion of this goal will require the development and implementation of a dedicated broodstock conditioning program, the adoption of standardized *Artemia* husbandry techniques and the development of a base enrichment for *Artemia* that provides at least the minimum nutrition for small larvae, as well as the development of rearing systems and culture techniques that reduce bacterial proliferation in the culture tanks. These projects can run concurrently and should be achieved within three to five years.

Once the base survival enrichment formula has been developed and healthy larvae can be produced to stage V in large quantity, it will be necessary to develop a diet for larger larvae and refine the culture procedures. At present, the most likely candidate for late phyllosoma nutrition appears to be a manufactured diet with a composition based initially on the *Artemia* enrichment formula but progressively modified to meet the needs of larger larvae. Culture systems will be scaled up to commercial size and modified as necessary.

The results of any research undertaken will be evaluated according to their ability to contribute measurably to achieving the immediate goal.

A recent review of propagation research within the RLEAS has resulted in the development of a revised propagation research program which will contain three distinct phases:

PHASE I

- Develop detailed project proposals and milestones consistent with revised goals.
- Primary focus on achieving high growth and survival through to phyllosoma stage V.

The suggested time frame for the completion of stage I is three years.

Goal 1 ***Establish a reliable supply of stage one larvae at any time of year using the following suggested method:***

a) Manipulate photoperiod to control gonad maturation and timing of extrusion.
b) Manipulate incubation temperature to control the developmental period of embryos.
c) Produce larvae monthly.
d) Assess the effect of broodstock diet on phyllosoma quality.

Goal 2 ***Develop a base Artemia enrichment diet that provides adequate nutrition to support growth at a minimum predetermined level from phyllosoma stages I through V using the following suggested method:***

a) Identify and prioritise key obstacles to developing a base enrichment diet.
b) Develop base *Artemia* enrichments incorporating knowledge gained to date.
c) Assess the effect of enrichments on growth of phyllosoma initially in static culture using anti microbial agents if necessary and report results.
d) Continually modify test diets according to results of trials until pre-determined growth and survival standards are met.

Goal 3 ***Develop a culture system that suppresses undesirable bacterial blooms and is suitable for use over periods of several months using the following suggested method:***

a) Review and standardise all aspects of *Artemia* husbandry including decapsulation, hatching, on-growing, enriching, and delivery with a view to reducing the bacterial load in *Artemia* and phyllosoma culture systems.
b) Review literature for recent developments in methods of bacterial control in marine larval rearing systems with an emphasis on low intervention techniques suitable for long culture periods.
c) Construct several prototype culture systems based on the review and assess the development of bacterial communities and numbers while culturing early stage phyllosomas. Parallel studies using the larvae of other species readily available and familiar to the investigator and for which the husbandry techniques and larval nutrition are known may also be beneficial.
d) Raise lobster larvae produced in goal 1 and fed *Artemia* enriched in goal 2 using a variety of bacterio-suppressant rearing techniques identified in part b) and developed in part c) of goal 3.

PHASE II

Commencement of stage II is contingent upon successful completion of the second year milestones in stage I. That is Stage II should start one year before the end of stage I. This is to ensure a smooth transition to stage three.

The primary focus of this stage is on the physical and chemical assessment of formulated diets ready for assessment with stage V+ phyllosoma.

Goal 1 ***Commence preliminary work developing a formulated feed for stage V+ phyllosoma.***

This goal should be addressed through a project with a 12 month duration and should be contingent upon the successful completion of goals to produce phyllosoma to stage V and above. The suggested methodology is:

a) Assess binders.
b) Produce a test diet based on the knowledge of ingredients gained from the development of *Artemia* enrichments but incorporated into an artificial pellet. The goal is to produce a base survival diet that provides adequate nutrition to support growth and survival at a level predetermined by the research team.

PHASE III

Diet optimisation studies and commercialisation of culture techniques.

Goal 1 ***Upscale larval rearing systems developed in Stage I to semi-commercial scale and capability to produce tens of thousands of puerulus.***

Goal 2 ***Optimise diet for Stage V+ phyllosoma.***

The research objectives and outcomes of the RLEAS propagation research program are summarised in the table below:

Goal	Impediments	Research Approach	Key performance indicators	Time frame
Technical ability to culture spiny lobster puerulus from eggs, at will and in any number.	1. Regular supply of larvae. 2. Larval nutrition. 3. Larval rearing systems. 4. Larval health.	1. Establish a reliable supply of stage I larvae through improved broodstock management. 2. Develop enriched *Artemia* diets to support phyllosoma growth from stages I-V. 3. Develop *Artemia* husbandry and phyllosoma culture systems to suppress undesirable bacterial blooms. 4. Develop manufactured diets to support phyllosoma stages V and above. 5. Initially focus on 1-2 rock lobster species.	1. Capacity to produce Stage I larvae throughout the year. 2. Enriched *Artemia* diets that support phyllosoma growth from stages I-V. 3. Culture systems that suppress bacterial blooms. 4. Capacity to produce healthy stage V larvae predictably and reliably. 5. Manufactured diets for rearing phyllosoma stages V+. 6. Capacity to produce puerulus at will and in any number.	2002-2007
Efficient production of spiny lobster puerulus from eggs, at will and in any number.	1. Larval nutrition. 2. Control of larval phases.	1. Optimisation of manufactured diets for phyllosoma stages V+. 2. Hormonal manipulation of larval phases.	1. Efficient production of puerulus at will and in any number using manufactured diets and *Artemia*. 2. Reduction in larval rearing time through manipulation of larval phases.	2005-2010
Commercial production of puerulus from eggs at will and in any number.	1. Larval rearing systems. 2. Larval health. 3. Larval nutrition.	1. Upscale research-scale production focusing on rearing systems, survival and the cost-effectiveness of supplying manufactured diets. 2. Expand the number of spiny lobster species cultured.	1. Economically-viable commercial production of a variety of species of spiny lobster puerulus from eggs at will and in any number.	2010+

Any research project addressing the above priorities should give due to consideration to RLEAS Projects 2000/214 and 2000/263 and all prospective Principal Investigators should be aware that the RLEAS will facilitate a propagation research planning meeting in Tasmania on September 16, 2002.

NUTRITION

Nutrition research is required to facilitate delivery of:

- Multiple sources of nutrients for all growth phases.
- Robust diets that can be altered depending on the availability of raw materials while still supplying the same nutrients.
- A manufactured diet that is water stable, attractive, easy to handle, store and transport, shelf stable and cost-effective.
- Diets suitable to support optimum growth of all phases of the production cycle.
- Minimal impact on surrounding water quality through nutrient loads.
- Diets that support optimum survival of juveniles during their first year of development.
- Technical capacity for nutritional manipulation of moult cycles.
- Technical capacity for nutritional enhancement of lobster product quality in live-held adults.

Where possible, nutrition related projects should be developed in conjunction with the Aquaculture Nutrition Subprogram (see strategic directions for the Aquaculture Nutrition Subprogram on www.frdc.com.au/research/programs/ans).

HEALTH

- Disease-free aquaculture environment.
- Disease-monitoring to ensure disease transfer to the wild fishery is not possible.

In the absence of identifiable diseases, it is difficult to prioritise health research. Linkages with the Aquatic Animal Health Subprogram may provide the best opportunities to ensure the above requirements are met.

On-growing of juveniles and system requirements

- Husbandry procedures to ensure optimal growth (stocking density, water temperature, water quality, light, feeding regimes etc).
- Definition of the interaction between system design, nutrition and health of all life stages of rock lobster, and the relative importance.

ENHANCEMENT

- Reseeding of juvenile aquaculture reared juveniles that survive to increase wild fishery stocks and natural egg production levels.

C) COMMUNICATION AND TECHNOLOGY TRANSFER

The Steering Committee has defined a policy for the distribution of information arising from research conducted within the Subprogram. The following guidelines will be applied when publishing research:

- Distribution of information must have a net benefit for the Australian industry.
- Dissemination of information to international partners will be approved when there is a two way flow of information.
- *Ad hoc* requests for results or information will not be accepted.
- Special cases for the supply of information will have to be approved by the Steering Committee and where appropriate, Memorandums of Understanding will be prepared.

The Subprogram publishes an annual newsletter called "Lob ReLEASe". The newsletter is the principal industry communication of the subprogram and has received good feedback from all sectors of the rock lobster industry.

A number publications are available or are pending from the Subprogram including:

- Proceedings of a lobster health workshop held in Perth in July, 1998.
- Proceedings of the Rock Lobster Propagation workshop held in Hobart in January, 1999.
- Proceedings of the first annual RLEAS workshop held in Geraldton in March, 1999.
- Proceedings of the second annual RLEAS workshop held in Hobart in February, 2000.
- Proceedings of the third annual RLEAS workshop held in New Zealand in April, 2001.
- Proceedings of the first RLEAS/RLPHS combined Workshop held in Cairns in May 2002.
- Final reports from completed projects.
- "Lob ReLEASe" Volume 1, Issues 1, 2 and 3.
- Scientific publications from completed and existing research projects.

Additional information on the Rock Lobster Enhancement and Aquaculture Subprogram including newsletters, annual operating plans and workshop proceedings can be accessed by visiting the web-site www.frdc.com.au/research/programs/rleas or by contacting the Subprogram Leader:

D) PROPOSED NEW RESEARCH

In response to publication of the RLEAS Strategic Plan, the following pre-proposals were received by the Subprogram for consideration at their Steering Committee meeting in September, 2003.

1. RLEAS Southern Rock Lobster Propagation
   Principal Investigator: Dr Brad Crear
   Priority: High

Proposed Objectives
The overall objective is to understand the essential requirements of early stage phyllosoma of the southern rock lobster. We aim to achieve that through:

- The identification and assessment of broodstock conditioning protocols that permit routine production of high quality, viable larvae;
- The development of pilot scale larval rearing systems which result in high survival of large numbers of Stage 5 phyllosoma;
- The development of diets and feeding protocols which optimize the growth potential of phyllosoma to Stage 5;
- Understanding the role of water quality and controlling microbial contamination as one of the key bottlenecks to survival and growth of phyllosoma.

The Steering Committee offered the following comments and advice in relation to this proposal:

- This PRP addressed a research priority identified by the RLEAS.
- The Steering Committee endorsed a multi-species approach to rock lobster propagation which includes *J.edwardsii.*
- The Steering Committee supported development of your PRP into a full proposal for consideration by the FRDC board. However, as you are aware, there are other proposals dealing with rock lobster propagation that need to be aligned with your own if the RLEAS is to maintain an efficient research and development program. To this end the RLEAS Leader will assist where possible with the development of these full proposals.
- Prior to progressing your full proposal, the RLEAS would like to assess costs per unit output and identify possible overlaps between projects. To facilitate this it would be appreciated if you

could complete the objectives, methodology and budget sections of your full proposal only and forward them to the RLEAS Leader by October 28, 2002.

- At this point the RLEAS is unable to provide guidance as to an appropriate budget for this project, and will not be able to do so until all of the relevant propagation proposal budgets have been received and assessed against outputs. Regardless, you should be mindful that the RLEAS Steering Committee will pay particular attention to the request for funds for salaries relative to operating costs.
- Full proposal will need to be considered by the relevant FRAB's when it is complete.

2. Propagation Of The Western Rock Lobster Broodstock Maturation
Principal Investigator: Prof. Bruce Phillips
Priority: complementary to other projects

Proposed Objectives
To better understand the requirements of phyllosoma larvae of the western rock lobster (*P. cygnus*) to allow completion of the larval life cycle from hatching of the eggs to the puerulus stage in the laboratory. These requirements includes:

1. Nutrition requirements.
2. Bacteria flora and hygiene requirements.
3. System requirements such as type, flow rate, protocols etc.

The Steering Committee offered the following comments and advice in relation to this proposal:

- The PRP has addressed RLEAS priorities in rock lobster propagation but were viewed as being complimentary to some core projects proposed by the QDPI and TAFI.
- If your organization has existing infrastructure that can enhance research proposed for *J.edwardsii* and *P.ornatus* then the Steering Committee endorse development of your projects into full proposals.
- It is suggested that you liaise with Dr Bradley Crear from TAFI and Dr Clive Jones from QDPI to identify possible areas of complimentary research that could be completed in your facilities using *P.cygnus*. This should be done before you consider developing a full proposal.
- If possible, the separate proposals on broodstock maturation and propagation should be addressed within a single project.

3. RLEAS Density Dependent Processes Influencing The Success Of Rock Lobster Reseeding Operations Preliminary Research Proposal
Principal Investigator: Dr Caleb Gardner
Priority: Medium (in current form)

Proposed Objectives

1. To understand the effects of mass-release on predation intensity.
2. To assess if competition between reseeded lobsters affects success of reseeding operations.
3. To assess if competition between resident juvenile lobsters and reseeded juveniles compromises enhancement operations.

The Steering Committee offered the following comments and advice in relation to this proposal:

- PRP addressed a research priority identified by the RLEAS, however, this priority is lower than others addressing issues such as rock lobster propagation.
- The Steering Committee was advised that this PRP was not endorsed by the TASFRAB.
- The Steering Committee did not endorse progression of this preliminary proposal into a full application for consideration by the FRDC Board **in its currents form**. In particular, the Steering Committee was concerned about the budget requested and the capacity to meet the project objectives within the stated budget. The Steering Committee was also concerned about the number of potential variables (predator type, density, season etc) that could influence the

results and how all of these variables would be accounted for in the course of a project of this nature.

- If there is potential to reduce the scope of this project in terms of budget and objectives, and a stronger case can be presented detailing how the outcomes from project 2000/185 could be significantly enhanced through minimal additional investment, then the Steering Committee would consider endorsing a full application for presentation to the FRDC Board.
- Any full proposal will need to be considered by the relevant FRAB's when it is complete.

4. Advancing Hatchery Propagation Of Tropical Rock Lobsters Preliminary Research Proposal
   Principal Investigator: Dr Clive Jones
   Priority: High

Proposed Objectives

Larval Rearing

- Implement standardised techniques for production of Artemia.
- Implement standardised techniques for enrichment of Artemia.
- Utilise stock tank systems as pilot-scale systems to incorporate outcomes from concurrent propagation research to continually improve tank designs and rearing techniques for the production of large quantities of larvae.
- Progress the development of practical diets and feed delivery systems suited to early stage larvae.
- Examine the influence of Artemia size on performance of larvae to stage V.
- Investigate feeding frequency on performance of larvae to stage V.
- Examine influence of light regime on performance of larvae to stage V.

Microbiological

- Identify microbiological changes during larval rearing runs seek correlations between mass mortalities and bacterial community.
- Identify endemic bacterial species.
- Test commercial probiotic approaches and their relative suitability for long term larval rearing.
- Develop a bacteria assessment protocol that can be used to assess the utility of various probiotic approaches to larval rearing.
- Implement practical systems for microbial control in rearing systems (including Artemia and phyllosoma).

Broodstock Management

- Identify & assess broodstock conditioning protocols that permit routine production of high quality, viable larvae.
- Determine optimal photoperiod and temperature regime for gonad maturation and egg extrusion.
- Determine optimal incubation temperature for production of high quality larvae.

The Steering Committee offered the following comments and advice in relation to this proposal:

- PRP addressed a research priority identified by the RLEAS.
- The Steering Committee endorsed a multi-species approach to rock lobster propagation which includes *J.edwardsii*.
- The Steering Committee supported development of your PRP into a full proposal for consideration by the FRDC board. However, as you are aware, there are other proposals dealing with rock lobster propagation that need to be aligned with your own if the RLEAS is to maintain an efficient research and development program. To this end the RLEAS Leader will assist where possible with the development of these full proposals.
- Prior to progressing your full proposal, the RLEAS would like to assess costs per unit output and identify possible overlaps between projects. To facilitate this it would be appreciated if you

could complete the objectives, methodology and budget sections of your full proposal only and forward them to the RLEAS Leader by October 28, 2002.

- At this point the RLEAS is unable to provide guidance as to an appropriate budget for this project, and will not be able to do so until all of the relevant propagation proposal budgets have been received and assessed against outputs. Regardless, you should be mindful that the RLEAS Steering Committee will pay particular attention to the request for funds for salaries relative to operating costs.
- Your full proposal will need to be considered by the relevant FRAB's when it is complete.

5. Tail Fan Necrosis In SRL – Disease Development And Prophylaxis
   Principal Investigator: Dr Connor Thomas
   Priority: Low

Proposed Objectives

1. Use methods of molecular microbiology to determine the sequence of events that lead to establishment of TFN lesions in rock lobsters.
2. Investigate the potential for prophylactic agents in control of TFN post harvest.

The Steering Committee offered the following comments and advice in relation to this proposal:

- The RLEAS Steering Committee believes an adequate amount of research into tail fan necrosis has been completed for the aquaculture sector to progress.
- The value of the research completed into tail fan necrosis in the past was recognized.
- The Steering Committee does not endorse development of this PRP into a full application for consideration by the FRDC Board.
- If the application were prepared for another funding body (ARC etc.) than the RLEAS would be prepared to offer a letter of support.

6. Tropical Rock Lobster Grow-Out Preliminary Research Proposal
   Principal Investigator: Dr Kevin Williams
   Priority: Medium

Proposed Objectives

The research priorities for tropical rock lobster grow-out technology development in overseas partner countries (Vietnam and possibly Philippines) are quite different to those for Australia. Sustainability of the unrestricted collection of wild lobster seed is a key priority for overseas countries whereas for Australia, the development of cost-effective pelleted feeds, optimising culture conditions, particularly for land-based culture systems, and demonstrating the feasibility of lobster juvenile grow-out in the Torres Strait, are more pressing needs. Detailed below are objectives that relate specifically to the Australian-oriented research, which would be done for an integrated ACIAR and FRDC rock lobster grow-out project. The objectives build on findings from earlier FRDC multi-lobster species projects (98/303 and 2000/212) where 'best guess' pelleted dry diets were developed and studies subsequently carried out to improve the acceptability of the pelleted diet as a prerequisite for determining nutrient requirements. A current experiment that integrates information on lobster food preferences and the chemical composition of substances leaching from natural food items is enabling P. *ornatus* juveniles to grow 20-25% faster when fed on formulated dry pelleted diets than on fresh mussel. This success with dry pelleted diets provides a foundation for targeted nutrient requirement research.

1. Feeds development

1.1 Define requirements for critical nutrients (protein to lipid, essential fatty acids, carotenoid and cholesterol being the most important to be defined in the context of cost-effective diet development).

1.2. Determine the apparent digestibility and acceptability of readily-available terrestrial feedstocks that might be suitable as more cost-effective feed ingredients for partial replacement of fishmeal in formulated feeds for lobsters.

1.3 Demonstrate the cost effectiveness of rearing P. ornatus juveniles on pelleted dry feeds compared with alternative fresh natural foods.

2. Optimizing culture conditions
Develop alternative land-based culture systems that contributes to the maintenance of high growth rates, health condition and survival during grow-out of juvenile P. *ornatus* rock lobsters.

3. Pilot-scale grow-out of tropical rock lobsters in Torres Strait
Assist the Torres Strait islanders to establish a pilot-scale sea-cage facility to demonstrate the feasibility of grow-out of juvenile tropical rock lobsters. Integral to this goal would be training of islanders in lobster culture and the provision of pelleted feeds.

4. Technology transfer Critical to the uptake of research findings is active extension of the research to industry. This will be achieved by reporting of research progress at annual ACIAR and RLEAS workshops, preparation of technical and scientific papers, and presenting findings at national and international forums.

The Steering Committee offered the following comments and advice in relation to this proposal:

- PRP addressed a research priority identified by the RLEAS, however, this priority is lower than others addressing issues such as rock lobster propagation.
- The Steering Committee felt that references to tropical lobster aquaculture developments in the Torres Strait were premature. The Steering Committee is seeking more information on the proposed Torres Strait CRC that is being progressed before commenting on the relevance of this aspect of the proposed project to the RLEAS.
- The Steering Committee were not opposed to co-investment with ACIAR in a project of this nature, however, further negotiations would be required in relation to the RLEAS involvement in this project. Obviously, everything depends on the pending CSIRO decision on whether to maintain an involvement in rock lobster aquaculture research in the future.
- The RLEAS would be keen to examine opportunities for involvement in this ACIAR research, but it may be more useful to convene a meeting between the CSIRO, ACIAR and the RLEAS to discuss these opportunities before progressing this PRP into a full FRDC application. This would also depend on outcomes from a planned meeting to discuss this project between the CSIRO and ACIAR in Brisbane on October 9, 2002.
- Any full proposal will need to be considered by the relevant FRAB's when it is complete.

7. Disease Management And System Design To Facilitate Successful Propagation Of Rock Lobster In Australasia Preliminary Research Proposal
Principal Investigator: Dr Michael Bruce
Priority: High

Proposed Objectives

1. To review and standardise current *Artemia* production practices and determine the efficacy and subsequent production protocols for removing surface contaminating bacteria from *Artemia* and phyllosoma larvae using a range of chemical treatments alone or in combination.
2. To determine whether probiotic, biocontrol or bioremedial bacteria can be used to significantly enhance phyllosoma production by modifying the internal and external bacterial flora of both *Artemia* and phyllosoma larvae.
3. To review and apply the successful larval rearing systems currently used for the culture of finfish and crustacean species with the intention of improving the systems currently used by researchers in Australasia.

The Steering Committee offered the following comments and advice in relation to this proposal:

- PRP addresses a priority research area identified by the RLEAS

- The RLEAS Steering Committee would like you to develop a full proposal for the project with the following qualifications:
    - The project should be modified to address objective 2 alone (ie. *To determine whether probiotic, biocontrol or bioremedial bacteria can be used to significantly enhance phyllosoma production by modifying the internal and external bacterial flow of both Artemia and phyllosoma larvae*.)
    - Significant justification is required for this project to proceed independently of the two core propagation projects proposed by Dr Brad Crear from TAFI and Dr Clive Jones from QDPI. It would be preferred if your proposal could be integrated fully with these other projects rather than existing in isolation.
    - The budget for this project will need to be reduced.

8. Growth Models For Juvenile Srl Held Under Industry Conditions
   Principal Investigator: Dr Michael Geddes
   Priority: Low

Proposed Objectives

1. To identify "best practice" in juvenile growout of SRL.
2. To undertake industry-based field trials of best practice growout and produce a growth model.
3. To use the biological information to produce an economic model for juvenile growout.
4. Via Workshops, to evaluate the biology and economics of growout and provide advice to industry.

The Steering Committee offered the following comments and advice in relation to this proposal:

- This PRP does not address a research and development priority identified by the RLEAS.
- The RLEAS Steering Committee does not endorse development of this PRP to a full application while a primary outcome is directed towards economic assessment.
- If research with juvenile rock lobsters can be redirected to address research and development priorities identified by the RLEAS then the RLEAS would consider a full application. You should contact the RLEAS Leader to discuss this.
- Dr Clive Jones from the QDPI has an economic model that may have potential for adaption for use with the southern rock lobster.

9. Establishing Post-Pueruli Grow-Out Data For Western Rock Lobster To Assess Economic Viability
   Principal Investigator: Roy Melville-Smith
   Priority: Low

Proposed Objectives

1. Determine optimal flow rates for pueruli and juvenile western rock lobsters held at high biomasses in flow through tanks.
2. Evaluation of growth rates of pueruli to market sized lobsters with and without refuges and under two levels of biomass per unit volume of water.
3. Estimation of the expected survival rate and period required to produce a marketable size animal from post-puerulus.
4. Establish the basic running costs for growing out western rock lobsters from post-puerulus to marketable size.

The Steering Committee offered the following comments and advice in relation to this proposal:

- This PRP does not address research and development priorities identified by the RLEAS.
- The cost for the project is high and the proposed objectives are unlikely to deliver outcomes that will allow true economic assessment of the potential for rock lobster aquaculture with *P.cygnus*.
- The RLEAS Steering Committee does not endorse development of the PRP into a full application.

- The RLEAS Steering Committee felt that an industry partner would be an essential component of a project of this nature.
- It appears that the views and priorities relating to rock lobster aquaculture in WA are changing. If these views are adequately conveyed to the RLEAS via industry and industry bodies such as the Western Rock Lobster Council, the RLEAS would welcome the opportunity to work with research providers and industry to establish an R&D program that builds on work completed within the RLEAS over the past 5 years.
- Dr Clive Jones from QDPI has developed an economic assessment model for rock lobsters that may have potential for use in WA with some modification.

10. Pilot Scale Juvenile Rock Lobster Ongrowing Trials
    Principal Investigator: Dr Bradley Crear
    Priority: Low (In Current Form)

Proposed Objectives

1. To determine system design and husbandry protocols which optimise the economic feasibility (optimise growth, minimise mortality, minimise costs) of southern rock lobster, Jasus edwardsii during commercial scale juvenile growout.
2. To provide information to allow an economic analysis of the commercial growout of *J. edwardsii.*

Steering Committee offered the following comments and advice in relation to this proposal:

- This PRP does not address a research and development priority identified by the RLEAS.
- The RLEAS Steering Committee does not endorse development of this PRP to a full application while a primary outcome is directed towards economic assessment.
- If research with juvenile rock lobsters can be redirected to address research and development priorities identified by the RLEAS and there are economies associated with running this research in conjunction with a larger rock lobster project then the RLEAS would consider a full application. You should contact the RLEAS Leader to discuss this.
- Dr Clive Jones from the QDPI has an economic model that may have potential for adaption for use with the southern rock lobster.

E) WORKPLAN FOR 2003

In 2003, the RLEAS has a number of specific objectives:

- Identify additional ways to attract research funds and commercial involvement in the Subprogram.
- Develop links with the proposed Southern Rock Lobster Subprogram.
- Participate in a wider range of industry meetings (aquaculture and wild-capture sector of the rock lobster fishery) to promote the activities and outcomes of the Subprogram.
- Develop pilot scale propagation facilities at participating research institutions.

F) BUDGET

Existing RLEAS projects and budgets are as follows:

		00/02	02/03	03/04
2000/185	Enhancement	$139,000		
2000/211	Disease	$20,000		
2000/212	Nutrition	$66,000	$65,000	
2000/214	Propagation/Hatching	$208,000	$172,239	
2000/263	Propagation/Hatching	$60,000	$62,000	

2001/211	Co-ordination	$100,000	$100,000	$100,000
2001/094	Health	$67,000	$10,100	
2002/045	Enhancement		$147,999	$59,793
		$661,000	$556,999	$159,793

RLEAS has allocated rock lobster propagation as its highest priority. It needs to be recognised that rock lobster propagation is a long term research objective and it is anticipated that investment in propagation alone will need to be in the order of $0.5 million per annum for at least the next 10 years. This needs to be clear when allocating scarce research resources, given that a short term research program is unlikely to yield significant outcomes. It must also be noted that the rewards arising from a long term research program are likely to be great and this is reflected by the strong industry financial commitment to the propagation program.

G) VARIATIONS

MG Kailis became a full partner in project 2000/214. The project was varied to accommodate a cash contribution from MG Kailis and matching funds from FRDC for 2002-03.

Dr Robert van Barneveld
RLEAS Leader
December, 2002

Rock Lobster Enhancement and Aquaculture Subprogram

Annual Operating Plan - 2004

Prepared by **Dr Robert van Barneveld**
Subprogram Leader

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A) ACTIVITY DESCRIPTION FOR 2002-2003

i) Sector Progress

Commercial rock lobster enhancement and aquaculture is in its infancy in Australia and it is not yet possible to attribute a GVP to this sector. A number of States are investigating rock lobster aquaculture potential in various forms, the dominant methods including 1) on-growing of adults through a moult to increase weight whilst allowing sale at periods of peak demand/value; 2) on-growing of wild-caught puerulus (newly-settled juveniles) to a small (and potentially very valuable) market size of around 200-300 g, and 3) culture of phyllosoma from eggs through the 11 larval stages to puerulus and subsequent ongrowing to market size as above. In addition, the potential exists through improved survival rates, for aquaculture to provide stock for reseeding and enhancement of the wild fishery.

Further short-term development of a rock lobster aquaculture industry in Australia based on on-growing of wild-caught puerulus is technically feasible based on research completed to date within the FRDC Rock Lobster Enhancement and Aquaculture Subprogram, but will depend on the capacity of commercial aquaculture groups to liaise and work with the wild capture sector and to invest in the development of these aquaculture systems.

On-growing of wild-caught adult lobsters through a moult to increase weight whilst allowing sale at periods of peak demand/value is also technically feasible based on research completed within the FRDC Rock Lobster Enhancement and Aquaculture Subprogram and commercial activities to date. Further development of this sector will depend on the capacity of the wild capture sector to adopt on-growing techniques in aquaculture systems and to develop cost-effective value-adding procedures.

Despite technical and commercial potential existing for short-term developments in rock lobster aquaculture in Australia, long-term viability of a rock lobster aquaculture industry in Australia vests with closure of the life cycle of spiny lobsters. This is a difficult area of research that will consume a significant amount of resources over a long period of time (at least 5-10 years). It will require inputs from individuals and organisations with a wide range of expertise and a mechanism to facilitate collaborative research and development is essential if an outcome is to be achieved. This represents one of the fundamental functions of the Rock Lobster Enhancement and Aquaculture Subprogram.

ii) Major research outputs of the Subprogram

To date, the strategic research areas have focussed on techniques for puerulus collection from the wild, biological neutrality of wild stocks, larval rearing/propagation of tropical and temperate species of rock lobsters, capacity for hormonal manipulation of the larval cycle, nutrition of juveniles and adult lobsters, on-growing of juveniles and system requirements, health of aquaculture reared juveniles, enhancement of wild stocks through reseeding or resettlement and capacity to increase the natural settlement of puerulus in the wild through the provision of artificial substrates. Outcomes

from this research that have provided technical capacity for commercial rock lobster aquaculture systems in Australia include:

Biological neutrality:

Because of the high natural mortality, a regional investigation using historical data revealed that the impact of puerulus removals on subsequent catches was estimated to be minimal except in the case of removal of very large quantities in low settlement years, but even this could be countered by effort reductions in the wild capture sector. While regional, this outcome suggests that there is potential to base rock lobster aquaculture on puerulus collection in the short term.

Puerulus collection:

Investigations into developing methods to catch large numbers of pueruli found that pueruli of the western rock lobster are easiest to catch near the shore (depths <5 metres) and in locations with fringing reefs using a modified sandwich collector. Studies in Tasmania showed that southern rock lobster pueruli could be caught in a range of locations using both sandwich and bag collectors.

Nutrition:

Research has generated an enhanced knowledge of the factors influencing the acceptability of dry pelleted food by juvenile and adult rock lobsters plus an improved understanding of the protein and protein:energy requirements of juvenile rock lobsters. A database on the digestibility of ingredients for rock lobsters has been prepared and a pelleted diet that induces growth rates in tropical lobsters equivalent to that achieved with mussels is now available.

Health:

Autopsy and health monitoring procedures have been developed. A study on tail fan necrosis that develops in some situations with adult caught lobsters held in aquaculture systems has revealed that abrasions during capture predispose the tail fan to infection with naturally occurring vibrio species. Methods were assessed for the prevention of tail fan abrasion during capture.

On-growing juveniles and adults:

A range of systems for on-growing juvenile and adult tropical and temperate species of lobsters have been assessed. These assessments have demonstrated that lobsters are fairly robust in a variety of systems. Studies with adult southern rock lobsters have demonstrated that rates of gain in sea-based systems and have outlined the effect of photoperiod and temperature on growth and survival in juvenile southern rock lobsters.

Propagation:

A significant amount of research has been undertaken into the propagation of southern and tropical rock lobsters. It is clear that nutrition and health are primary limitations to the rearing process. Progress is also being made in the hormonal manipulation of larval phases.

Enhancement:

Enhancement and reseeding experiments undertaken with the southern rock lobster have successfully demonstrated that aquaculture reared juveniles behave in a similar way to wild lobsters when returned to their natural habitat. This research has also investigated movement of reseeded juveniles and clearly indicates that reseeding programs are likely to result in an increase in viable adults within the fishery.

The RLEAS has now completed two 3-year phases and significant scope exists to enter a third. A broad summary of these phases is presented below:

Phase I (1998-2001)

A subprogram approach to the management of this research portfolio was considered necessary by the FRDC given the potential for overlap between research projects, differing views from different sectors of the rock lobster industry in Australia, and the need to ensure adequate levels of communication between all stakeholders. At the time of establishment, the RLEAS consisted of 6 core projects investigating a range of challenges associated with the technical capacity for rearing spiny lobsters in aquaculture systems with no clearly defined strategy for further development. The core projects included:

98/300: Propagation of rock lobster – development of a collaborative national project with international partners. Principal Investigator: Dr Piers Hart (Tasmanian Aquaculture and Fisheries Institute, Marine Research Laboratories, Nubeena Crescent, Taroona, TAS, 7053)

98/301: Facilitation, administration and promotion of the FRDC Rock Lobster Enhancement and Aquaculture Subprogram. Principal Investigator: Dr Robert van Barneveld (Barneveld Nutrition Pty Ltd, PO Box 42, Lyndoch, SA, 5351)

98/302: Towards establishing techniques for large-scale harvesting of pueruli and obtaining a better understanding of mortality rates. Principal Investigator: Dr Bruce Phillips (Fisheries WA, WA Marine Research Laboratories, PO Box 20, North Beach, WA, 6020)

98/303: Feed development for rock lobster aquaculture. Principal Investigator: Dr Kevin Williams (CSIRO Division of Marine Research, Marine Laboratory, 233 Middle Street, Cleveland, Qld, 4163)

98/304: Pilot study of disease conditions in all potential rock lobster aquaculture species at different growth stages. Principal Investigator: Assoc Prof Louis Evans (Curtin University of Technology, Aquatic Sciences Research Unit, GPO Box U1987, Perth, WA, 6001)

98/305: Determination of optimum environmental and system requirements for juvenile and adult rock lobster holding and grow-out. Principal Investigator: Assoc Prof Mike Geddes (University of Adelaide, Department of Zoology, GPO Box 498, Adelaide, SA, 5001)

During the course of the first phase of the Subprogram, an additional two projects were approved by the FRDC Board, including:

99/314: Preliminary investigation towards ongrowing puerulus to enhance rock lobster stocks while providing animals for commercial culture. Principal Investigator: Dr Caleb Gardner (Tasmanian Aquaculture and Fisheries Institute, Marine Research laboratories, Nubeena Crescent, Taroona, TAS, 7053)

99/315: Propagation techniques. Principal Investigator: Dr Piers Hart (Tasmanian Aquaculture and Fisheries Institute, Marine Research laboratories, Nubeena Crescent, Taroona, TAS, 7053)

As part of the above research program, the RLEAS convened three national workshops (Geraldton, Hobart, New Zealand), hosted a lobster health workshop in Perth, Western Australia, a lobster propagation workshop in Hobart, Tasmania, and an international symposium on lobster health management in Adelaide, South Australia in conjunction with the Third International Lobster Congress.

The Subprogram evolved from being actively opposed by the wild fishing sector in many states, to being an integral part in the future development of the rock lobster sector. A degree of harmony was established between the wild fishery and the aquaculture sector, and a high degree of research

coordination was established between states and internationally with researchers in New Zealand and Japan. None of this would have been possible without an independent Subprogram Leader and a highly responsive Steering Committee that is strongly represented by industry members from across Australia. The presence of a coordination component within the RLEAS resulted in savings in the operation of new and existing projects far exceeding $500,000. During this phase of the program, outcomes were delivered from 4 core projects.

Phase II (2001-2004)

Phase II of the RLEAS was characterized by an increase in focus and strategic research direction. The RLEAS published research priorities with an increased focus on closure of the life cycle and enhancement, while maintaining a firm research base in priority areas such as health and nutrition. During Phase II of the program a total of 11 new projects were funded, including:

2000/185: Evaluating the release and survival of juvenile rock lobsters released for enhancement purposes. Principal Investigator: Dr Caleb Gardner. (Tasmanian Aquaculture and Fisheries Institute, Marine Research Laboratories, Nubeena Crescent, Taroona, TAS, 7053)

2000/211: Investigation into tail rot necrosis in live-held adult rock lobsters. Principal Investigator: soc Prof Mike Geddes. (University of Adelaide, Department of Zoology, GPO Box 498, Adelaide, SA, 5001)

2000/212: The nutrition of juvenile and adult lobsters to optimise survival, growth and condition. Principal Investigator: Dr Kevin Williams. (CSIRO Division of Marine Research, Marine Laboratory, 233 Middle Street, Cleveland, Qld, 4163).

2000/214: Advancing the hatchery propagation of rock lobsters. Principal Investigator: Dr Bradley Crear. (Tasmanian Aquaculture and Fisheries Institute, Marine Research Laboratories, Nubeena Crescent, Taroona, TAS, 7053).

2000/263: Reducing rock lobster larval rearing time through hormonal manipulation. Principal Investigator: Dr Mike Hall. (Australian Institute of Marine Science, Marine Biotechnology, PMB No 3, Townsville Mail Centre, Qld, 4810).

2001/094: Health assurance for Southern rock lobsters. Principal Investigator: Dr Judith Handlinger. (Tasmanian Aquaculture and Fisheries Institute, Marine Research Laboratories, Nubeena Crescent, Taroona, Tasmania, 7053).

2001/211: Strategic planning, project development and facilitation of research and extension towards the establishment and maintenance of rock lobster aquaculture and enhancement systems in Australia. Principal Investigator: Dr Robert van Barneveld. (Barneveld Nutrition Pty ltd, 19-27 Coonan Rd, South Maclean, Qld, 4280)

2002/045 – Assessing the possibilities for the natural settlement of western rock lobster. Principal Investigator: Dr Bruce Phillips. (Fisheries WA, WA Marine Research Laboratories, PO Box 20, North Beach, WA, 6020).

2003/211 - Advancing the hatchery propagation of tropical rock lobsters (*Panulirus ornatus*). Principal Investigator: Mr Richard McCulloch – BSc(Hons). (MG Kailis Group, 50 Mews Rd, Fremantle, WA 6160).

2003/212 - Propagation of southern rock lobster (*Jasus edwardsii*) in Tasmania. Principal Investigator: Dr Arthur Ritar. (Tasmanian Aquaculture and Fisheries Institute, Marine Research Laboratories, Nubeena Crescent, Taroona, TAS, 7053).

2003/213 – Establishing post-pueruli growout data for western rock lobster. Principal Investigator: Dr Roy Melville-Smith. (Fisheries WA, WA Marine Research Laboratories, PO Box 20, North Beach, WA, 6020).

As well as an extended research program, a number of commercial rock lobster activities began during this phase of the RLEAS. A basis for collection of puerulus from the wild and on-growing to a marketable size was established in Tasmania. This form of aquaculture and enhancement is based on high mortality of wild puerulus in their first year post settlement (anywhere from 75-97%) compared with animals brought ashore and ongrown in tanks where the mortality is minimal (2% in Tasmania). This gives rise to the theory aquaculturists can ongrow the 'excess' that would have died in the wild. In 2001 in Tasmania, 7 licences were issued for the collection of 50,000 puerulus each, but to date, there has been limited commercial activity surrounding the use of these licenses. Aquaculture activities in South Australia continued to focus on on-growing and value adding to adult wild-caught lobsters. Activities included investigations into the holding and feeding of lobsters in land-based tanks using both existing flow through systems and infrastructure or recirculation systems. M G Kailis forged an alliance with the Queensland Department of Primary Industries to investigate the potential of culturing and growing tropical rock lobsters. Rock lobster aquaculture based on quota buy-out schemes in return for puerulus collection licenses (in the order of 1 tonne of quota in return for 40,000 puerulus) continued to be assessed in New Zealand.

The value of the subprogram approach and the RLEAS was clearly demonstrated during this phase. The RLEAS initiated reviews of core research programs and made significant changes to the direction of some of these projects as a result of the reviews. MG Kailis became an active participant in the subprogram, firstly through a private investment in research through the Queensland Department of Primary Industries, and secondly, as the lead agency in project 2003/211. The RLEAS convened (or is convening) three national workshops (Cairns, Geelong (in conjunction with the Second National Lobster Congress and the Rock Lobster Post-Harvest Subprogram) and Fremantle (in conjunction with the Third National Lobster Congress and the Rock Lobster Post-Harvest Subprogram)), a number of research planning forums and participated in the World Aquaculture Society meeting in Beijing in 2002. Again, the presence of the RLEAS resulted in significant improvements in the delivery of relevant outcomes and cost savings in the projects through enhanced collaboration and coordination.

Phase III (2004-2007)

An opportunity exists to take the RLEAS into its third and probably most critical phase. The strategic research areas are increasingly focusing on propagation and the outcomes from existing and subsequent research will dictate how the subprogram exists in the future.

The potential value of rock lobster aquaculture to Australia is reflected in the investment in this Subprogram to date. Between 1998 and 2006 a total of $6.14 million has been invested by FRDC, $6.32 million has been invested by research agencies and $4.49 million has been contributed as cash by commercial and other sources. With a total investment of $16.96 million, it is important that we embrace mechanisms that will ensure rock lobster enhancement and aquaculture becomes a commercial reality in Australia in the near future.

iii) Related projects and research linkages

The RLEAS currently maintains close research linkages with the following related projects:

8. National Institute of Water and Atmospheric Research, NZ, research into rock lobster aquaculture and enhancement (independent of the research being conducted within the Subprogram).
9. Ferguson Fisheries research into the live-holding and feeding of Southern Rock Lobsters in recirculation systems.
10. All projects being managed by the Rock Lobster Post-Harvest Subprogram.

iv) Role RLEAS has played in industry development

Via the Subprogram Leader and the Steering Committee, the RLEAS has attempted to have an active role in all industry developments to date, either through providing research outcomes to support industry development, or by providing direct assistance with the procurement of funds or strategies to assist industry development.

v) Operating procedures

This Subprogram is highly responsive to the views of industry and understands the need to accommodate both the research requirements of the future and the needs of the existing wild fisheries and aquaculture industries. To ensure that research conducted within the Subprogram is relevant and meets the above criteria, a Steering Committee has been established to:

- To establish and review strategic directions for the Subprogram;
- To review existing research directions within the guidelines of the FRDC contractual agreements;
- To prioritise new research proposals and develop a priority list that can be used by other funding agencies;
- To ensure that research outcomes are commercially focused where relevant;
- To coordinate industry and research provider involvement so as to maximise usage of available resources;
- To facilitate industry extension and technology transfer;
- To advise on flexible components of budget expenditure;
- The convening of regular meetings (6 monthly);
- To develop an appropriate and approved communications policy;
- Ensure efficient and effective reporting structures;
- To promote the Subprogram and its achievements so that it can become the focus for all research on rock lobster aquaculture and enhancement.

At a minimum Steering Committee members are expected to attend at least two Subprogram meetings per year (one meeting per year will include a Subprogram workshop). Members are also required to comment (out of session) on all written project progress reports, final reports and new project proposals. Sitting fees are not paid to Steering Committee members, but the Subprogram covers travel expenses associated with attendance at the two annual meetings. Subprogram meetings are held at various locations around Australia.

The Steering Committee is comprised of:

- Subprogram Leader;
- FRDC Representative;
- Eleven industry representatives;
- Two Scientific Advisors.

The following should be noted in relation to membership:

- In general, Scientific Advisors will not have active research projects within the Subprogram.
- Proxies are not accepted for Steering Committee members who are unable to attend a particular meeting.
- Membership of the Steering Committee is expertise based.
- Periodically, the Subprogram Leader may invite relevant observers to Subprogram meetings, at his discretion.

Steering Committee members are selected to contribute expertise in one or more of the following areas:

- The marine aquaculture sector;
- The rock lobster wild capture fisheries;
- Seafood processing and marketing;
- Knowledge of the fishing industry and resource allocation;
- Research and development in marine science or aquaculture;
- Communication and technology transfer.

At present, the RLEAS Steering Committee members include:

- Dr Robert van Barneveld (Chair)
- Dr Patrick Hone (FRDC)
- Pheroze Jungalwalla (TAS)
- Neil Stump (TAS)
- Andrew Ferguson (SA)
- Greg Ward (SA)
- Barry Spurrier (VIC)
- David Lucas (VIC)
- Jim Fogarty (QLD)
- Steven Gill (WA)
- John Newby (WA)
- Neil Dorrington (WA)
- Trevor Burkhart (NZ)
- Dr Andrew Jeffs (Scientific Adviser)
- Dr Bruce Phillips (FRDC Rock Lobster Post-Harvest Subprogram Leader).

Steering Committee Membership turnover: From 2003, to ensure the RLEAS Steering Committee remains relevant, one third of the industry representative positions will be declared vacant and will be recalled. Existing or new members will be reappointed as per the above guidelines at the discretion of FRDC.

Industry consultation and communication: The Subprogram Leader, Dr van Barneveld, promotes the activities of the RLEAS through a website, industry newsletters, and direct communication with industry organisations and representatives.

Strategic planning: Strategic planning for the RLEAS is based on outcomes from the existing research program and ongoing consultation between the Subprogram Leader and members of industry and researchers in Australia and New Zealand. The strategic plan is maintained and updated annually using CD-ROM and the web-site for distribution. The strategic planning process identifies those factors that represent restrictions to the initial establishment of rock lobster aquaculture (eg. propagation, nutrition) and enhancement (eg. monitoring survival, prevention of disease introduction to the wild fishery) processes, and then utilises a relative ranking score from the various rock lobster fisheries across Australia.

Communication with FRABS: Communication with FRAB's is via distribution of an annual operating plan for the RLEAS in December of each year combined with direct communications. The Subprogram Leader will also attend the annual FRDC FRAB workshop to promote the activities and objectives of the RLEAS.

Development of new research proposals: New research proposals are developed through the use of facilitated strategic planning meetings. Using priorities published in the RLEAS Strategic Plan, the Subprogram Leader convenes meetings with relevant researchers and research institutions to:

1. Define the planned outcomes of the new proposal;
2. Manage an indicative budget for the research as defined by the Steering Committee;
3. Identify which researchers/institutions are best placed to undertake the research;

4. Promote collaboration between researchers and institutions where appropriate;
5. Seek external expertise and inputs as required.
6. Ensure the new proposal meets the objectives of the subprogram and that the research remains relevant and focussed.

The Subprogram Leader ensures new research proposals are distributed to FRABS and the RLEAS Steering Committee for comment and ratification before submitting the proposals to FRDC on behalf of the lead agencies, or facilitating adjustments to the proposals prior to submission.

Coordination of research reports: The Subprogram Leader collates progress and final reports from projects within the Subprogram in March and September each year for delivery in a common format to FRDC. These reports are distributed to members of the Steering Committee for comment and review.

Review of research progress and direction: The RLEAS Steering Committee interviews the Principal Investigator of each project within the Subprogram at least once annually as part of the Steering Committee meeting. Principal Investigators are expected to report progress against contracted milestones, justify any changes in research direction, and demonstrate that the research program is making a valuable contribution towards the achievement of the Subprogram objectives. The Steering Committee makes recommendations to the FRDC Board in relation to potential changes to the objectives of the research program, or instances where project progress is unsatisfactory.

Coordination of research extension: A major function of the Subprogram Leader is the organisation and delivery of an annual research workshop to highlight the activities and outputs of the RLEAS. Workshops are convened with presentations from invited speakers and researchers aimed at delivering key messages to end-users for use in practical rock lobster aquaculture and enhancement systems.

The Subprogram Leader compiles a subprogram newsletter "Lob ReLEASe" at least annually or as required highlighting research outcomes, developments in rock lobster enhancement and aquaculture and events relevant to the RLEAS. The Subprogram Leader is also responsible for the approval of all media releases and scientific publications arising from research projects within the Subprogram using the RLEAS Steering Committee communication policy as a guide.

Collaboration with international partners: The Subprogram Leader has established a major international collaboration between researchers in Australia and New Zealand through project initially through project 98/301 and subsequent projects. This was achieved through direct interaction with researchers in New Zealand and involvement of these scientists in the RLEAS research program. There is further opportunity to build on relationships initiated with Japanese researchers by AIMS, CSIRO and TAFI as the RLEAS continues to evolve. In all cases, international collaborations will be based on a two-way flow of information and where possible, research funds.

Identification and procurement of additional funding: Additional funding from sources such as the Public Good Science Fund in New Zealand and AUSIndustry in Australia will be sought with the assistance of the Subprogram Leader and relevant end-users. The Subprogram Leader is already involved with the development of AUSIndustry COMET proposals for the commercialisation of existing technology for rock lobster aquaculture. There are also opportunities for commercial investment in the development of technologies for rock lobster aquaculture in conjunction with the existing research program.

Liaison with FRDC: The Subprogram Leader is the conduit for communications between FRDC and subprogram participants in relation to project contracts, project reports, new submissions and general correspondence. The Subprogram Leader also represents the RLEAS at the annual FRDC FRAB and Subprogram meetings in Canberra.

vi) Meetings and Workshops

The next RLEAS workshop will be held in Tasmania in February 2004 in conjunction with the Rock Lobster Post-Harvest Subprogram and the 7th International Congress on Lobster Biology. The workshop will highlight developments in aquaculture and enhancement. Further details will be made available by the Subprogram Leader.

vii) Summary of current project status

A summary of the status of all RLEAS research projects and their duration is presented in Table 1.

B) SUMMARY OF STRATEGIC PLAN

The RLEAS Steering Committee has reviewed the strategic directions of the Subprogram to ensure that there is a balance between longer term basic research, such as that directed towards propagation, and shorter term, more applied research that may be more closely aligned with regional priorities.

From research completed to date, it is clear that development of technical capacity in the field of rock lobster enhancement and aquaculture will require a long term research and development effort over a period of 5-10 years, with this effort focussing primarily on closure of the life-cycle of spiny lobsters. It is recognised that this type of research requires significant investment, and falls into a "public good" portfolio given there is no existing capacity or industry. With this in mind, the RLEAS is attempting to secure investment into rock lobster propagation research from the FRDC and other stakeholders that is exclusive of budgets relevant to more regional, shorter-term priorities.

While the RLEAS Steering Committee is well placed to define the key limitations to the development of the rock lobster enhancement and aquaculture sector in Australia, it recognises that shorter term priorities are better identified by state-based fisheries research advisory bodies and relevant industry associations. To this end, the RLEAS Steering Committee will respond to regional priorities as advised by the former on an annual basis. In the absence of this advice, the RLEAS views on the key research areas for rock lobster enhancement and aquaculture in Australia in priority order are presented in Table 2.

Table 1. ***RLEAS Project Summary 1998-2006***

Project	**97-98**	**98-99**	**99-00**	**00-01**	**01-02**	**02-03**	**03-04**	**04-05**	**05-06**
98/300 – Propagation of rock lobster – development of a collaborative national project with international partners.		•							
98/301 – Facilitation, administration and promotion of the FRDC Rock Lobster Enhancement and Aquaculture Subprogram.	•	•	•	•					
98/302 – Towards establishing techniques for large scale harvesting of pueruli and obtaining a better understanding of mortality rates.		•	•	•					
98/303 – Feed development for rock lobster aquaculture.		•	•						
98/304 – Pilot study of disease conditions in all potential rock lobster aquaculture species at different growth stages.		•							
98/305 – Determination of optimum environmental and system requirements for juvenile and adult rock lobster holding and grow-out.		•	•						
99/314 – Preliminary investigation towards ongrowing puerulus to enhance rock lobster stocks while providing animals for aquaculture.			•						
99/315 – Propagation techniques.			•						
2000/185 – Evaluating the release and survival of juvenile rock lobsters released for enhancement purposes.				•	•				
2000/211 – Investigation into tail-rot necrosis in live-held adult lobsters.					•				
2000/212 – The nutrition of juvenile and adult lobsters to optimise survival, growth and condition.				•	•	•			
2000/214 – Advancing the hatchery propagation of rock lobsters				•	•	•			

2000/263 – Reducing rock lobster larval rearing time through hormonal manipulation.				•	•	•			
2001/094 – Health assurance for southern rock lobsters					•	•			
2001/211 – Strategic planning, project development, and facilitation of research and extension towards establishment and maintenance of commercial rock lobster aquaculture and enhancement systems in Australia.					•	•	•		
2002/045 – Assessing the possibilities for the natural settlement of western rock lobster							•	•	
2003/213 – Establishing post-pueruli growout data for western rock lobster							•	•	•
2003/211 - Advancing the hatchery propagation of tropical rock lobsters (Panulirus ornatus)							•	•	•
2003/212 - Propagation of southern rock lobster (*Jasus edwardsii*) in Tasmania							•	•	•

Table 2. *RLEAS priority research portfolios*

Research focus
1. Broodstock culture and propagation 2. On-growing a) Puerulus – market size - Nutrition - Health - System design b) Adult enhancement 3. Wild fishery enhancement with aquaculture reared lobsters

Propagation

The task of rearing of large numbers of rock lobster larvae to metamorphosis at will is undoubtedly one of the greatest challenges in aquaculture today. Success will only be achieved if there is an intense focus on achieving results that take the project closer to its final goal, if there is genuine collaboration between those involved and a great deal of innovation and willingness to explore new approaches.

The overall goal of propagation research within the RLEAS is to develop the technical ability to produce puerulus at will in any number required and each milestone of each project should contribute measurably to the achievement of this goal. It will likely take more than five years to reach the overall goal given a coordinated and determined effort and may yet prove too difficult at the current level of technical understanding of larval production systems. It is clear that new base survival diets (both for *Artemia* enrichment and for inclusion in a manufactured diet), improved larval husbandry techniques and systems that minimize the proliferation of bacteria will have to be developed. Investigators will need to demonstrate a high level of innovation and determination to overcome these obstacles.

The immediate goal for the propagation research program is to provide the technical ability to spawn adults during any month of the year, and to produce healthy and nutritionally balanced larvae to stage V. Completion of this goal will require the development and implementation of a dedicated broodstock conditioning program, the adoption of standardized *Artemia* husbandry techniques and the development of a base enrichment for *Artemia* that provides at least the minimum nutrition for small larvae, as well as the development of rearing systems and culture techniques that reduce bacterial proliferation in the culture tanks. These projects can run concurrently and should be achieved within three to five years.

Once the base survival enrichment formula has been developed and healthy larvae can be produced to stage V in large quantity, it will be necessary to develop a diet for larger larvae and refine the culture procedures. At present, the most likely candidate for late phyllosoma nutrition appears to be a manufactured diet with a composition based initially on the *Artemia* enrichment formula but progressively modified to meet the needs of larger larvae. Culture systems will be scaled up to commercial size and modified as necessary.

The results of any research undertaken will be evaluated according to their ability to contribute measurably to achieving the immediate goal.

A recent review of propagation research within the RLEAS has resulted in the development of a revised propagation research program which will contain three distinct phases:

PHASE I

- Develop detailed project proposals and milestones consistent with revised goals.
- Primary focus on achieving high growth and survival through to phyllosoma stage V.

The suggested time frame for the completion of stage I is three years.

Goal 1 ***Establish a reliable supply of stage one larvae at any time of year using the following suggested method:***

e) Manipulate photoperiod to control gonad maturation and timing of extrusion.
f) Manipulate incubation temperature to control the developmental period of embryos.
g) Produce larvae monthly.
h) Assess the effect of broodstock diet on phyllosoma quality.

Goal 2 ***Develop a base Artemia enrichment diet that provides adequate nutrition to support growth at a minimum predetermined level from phyllosoma stages I through V using the following suggested method:***

e) Identify and prioritise key obstacles to developing a base enrichment diet.
f) Develop base *Artemia* enrichments incorporating knowledge gained to date.
g) Assess the effect of enrichments on growth of phyllosoma initially in static culture using anti microbial agents if necessary and report results.
h) Continually modify test diets according to results of trials until pre-determined growth and survival standards are met

Goal 3 ***Develop a culture system that suppresses undesirable bacterial blooms and is suitable for use over periods of several months using the following suggested method:***

e) Review and standardise all aspects of *Artemia* husbandry including decapsulation, hatching, on-growing, enriching, and delivery with a view to reducing the bacterial load in *Artemia* and phyllosoma culture systems.
f) Review literature for recent developments in methods of bacterial control in marine larval rearing systems with an emphasis on low intervention techniques suitable for long culture periods.
g) Construct several prototype culture systems based on the review and assess the development of bacterial communities and numbers while culturing early stage phyllosomas. Parallel studies using the larvae of other species readily available and familiar to the investigator and for which the husbandry techniques and larval nutrition are known may also be beneficial.
h) Raise lobster larvae produced in goal 1 and fed *Artemia* enriched in goal 2 using a variety of bacterio-suppressant rearing techniques identified in part b) and developed in part c) of goal 3.

PHASE II

Commencement of stage II is contingent upon successful completion of the second year milestones in stage I. That is Stage II should start one year before the end of stage I. This is to ensure a smooth transition to stage three.

The primary focus of this stage is on the physical and chemical assessment of formulated diets ready for assessment with stage V+ phyllosoma.

Goal 1 ***Commence preliminary work developing a formulated feed for stage V+ phyllosoma***

This goal should be addressed through a project with a 12 month duration and should be contingent upon the successful completion of goals to produce phyllosoma to stage V and above. The suggested methodology is:

c) Assess binders.
d) Produce a test diet based on the knowledge of ingredients gained from the development of *Artemia* enrichments but incorporated into an artificial pellet. The goal is to produce a base survival diet that provides adequate nutrition to support growth and survival at a level predetermined by the research team.

PHASE III

Diet optimisation studies and commercialisation of culture techniques

Goal 1 ***Upscale larval rearing systems developed in Stage I to semi-commercial scale and capability to produce tens of thousands of puerulus***.

Goal 2 ***Optimise diet for Stage V+ phyllosoma.***

The research objectives and outcomes of the RLEAS propagation research program are summarised in the table below:

Goal	**Impediments**	**Research Approach**	**Key performance indicators**	**Time frame**
Technical ability to culture spiny lobster puerulus from eggs, at will and in any number.	5. Regular supply of larvae. 6. Larval nutrition. 7. Larval rearing systems. 8. Larval health.	6. Establish a reliable supply of stage I larvae through improved broodstock management. 7. Develop enriched *Artemia* diets to support phyllosoma growth from stages I-V. 8. Develop *Artemia* husbandry and phyllosoma culture systems to suppress undesirable bacterial blooms. 9. Develop manufactured diets to support phyllosoma stages V and above. 10. Initially focus on 1-2 rock lobster species.	7. Capacity to produce Stage I larvae throughout the year. 8. Enriched *Artemia* diets that support phyllosoma growth from stages I-V. 9. Culture systems that suppress bacterial blooms. 10. Capacity to produce healthy stage V larvae predictably and reliably. 11. Manufactured diets for rearing phyllosoma stages V+. 12. Capacity to produce puerulus at will and in any number.	2002-2007
Efficient production of spiny lobster puerulus from eggs, at will and in any number.	3. Larval nutrition. 4. Control of larval phases.	3. Optimisation of manufactured diets for phyllosoma stages V+. 4. Hormonal manipulation of larval phases.	3. Efficient production of puerulus at will and in any number using manufactured diets and *Artemia*. 4. Reduction in larval rearing time through manipulation of larval phases.	2005-2010
Commercial production of puerulus from eggs at will and in any number.	4. Larval rearing systems. 5. Larval health. 6. Larval nutrition.	3. Upscale research-scale production focusing on rearing systems, survival and the cost-effectiveness of supplying manufactured diets. 4. Expand the number of spiny lobster species cultured.	2. Economically-viable commercial production of a variety of species of spiny lobster puerulus from eggs at will and in any number.	2010+

NUTRITION

Nutrition research is required to facilitate delivery of:

- Multiple sources of nutrients for all growth phases.
- Robust diets that can be altered depending on the availability of raw materials while still supplying the same nutrients.
- A manufactured diet that is water stable, attractive, easy to handle, store and transport, shelf stable and cost-effective.
- Diets suitable to support optimum growth of all phases of the production cycle.
- Minimal impact on surrounding water quality through nutrient loads.
- Diets that support optimum survival of juveniles during their first year of development.
- Technical capacity for nutritional manipulation of moult cycles.
- Technical capacity for nutritional enhancement of lobster product quality in live-held adults.

Where possible, nutrition related projects should be developed in conjunction with the Aquaculture Nutrition Subprogram (see strategic directions for the Aquaculture Nutrition Subprogram on www.frdc.com.au/research/programs/ans).

HEALTH

- Disease-free aquaculture environment.
- Disease-monitoring to ensure disease transfer to the wild fishery is not possible.

In the absence of identifiable diseases, it is difficult to prioritise health research. Linkages with Aquatic Animal Health Subprogram may provide the best opportunities to ensure the above requirements are met.

On-growing of juveniles and system requirements

- Husbandry procedures to ensure optimal growth (stocking density, water temperature, water quality, light, feeding regimes etc).
- Definition of the interaction between system design, nutrition and health of all life stages of rock lobster, and the relative importance.

ENHANCEMENT

- Reseeding of juvenile aquaculture reared juveniles that survive to increase wild fishery stocks and natural egg production levels.

C) COMMUNICATION AND TECHNOLOGY TRANSFER

The RLEAS Steering Committee has defined a policy for the distribution of information arising from research conducted within the Subprogram that forms the basis of the communication plan for this project. This project distributes information on behalf of all projects within the Subprogram with the following objectives:

1. To distribute research outputs (technologies and knowledge) that has a net benefit for the Australian industry and to distribute that information in a timely manner to achieve rapid adoption by industry.
2. To disseminate information about the subprogram's role, activities and achievements to relevant stakeholders.
3. To disseminate information to the general public when it contributes to a positive perception of the sector and/or the FRDC and contributes to the public good.

4. To disseminate information to international partners when there is a two-way flow of information

Target audiences:

1. The Australian wild capture rock lobster sectors, aquaculture stakeholders, aquafeed manufacturers, infrastructure manufacturers and FRDC stakeholders.
2. General public.

Key messages:

1. Research outputs from the projects managed under the subprogram.
2. Role, activities and achievements of the subprogram.
3. Positive image of rock lobster aquaculture (clean and green, environmentally sustainable, economically beneficial for Australia, provides employment in regional Australia etc)

Communication/Extension methods

Annual workshop:

The workshop's primary aim is to deliver information on research outputs to industry stakeholders as it becomes available. It also serves to raise the public perception of the industry in the host state as a body of local media is encouraged to attend and report on the workshop and the development of the industry in that state.

Workshop proceedings:

The proceedings serve to deliver a summary report and research results available from component projects within the subprogram to date. The collection of past proceedings serves as an extensive and valuable resource of knowledge and technologies that can be accessed by the industry on a needs basis. Sales of proceedings are restricted to Australia. However, the Steering Committee may allow overseas sales of past proceedings if it is decided their content no longer provides a competitive advantage to the Australian industry.

Website:

The website serves to communicate current and past research outputs, subprogram activities, industry related events, information on the industry, to provide advice to current researchers, advice to research applicants and information on publications that are available. As such, it serves industry stakeholders, potential farmers and investors, the general public, and research providers. The website can be viewed at www.frdc.com.au/research/programs/rleas.

Newsletter:

The Subprogram publishes an annual/biannual newsletter called "Lob ReLEASe". The newsletter is the principal industry communication of the subprogram and has received good feedback from all sectors of the rock lobster industry. "Lob ReLEASe" communicates information on current and past projects, relevant research outputs, subprogram activities and industry events.

Media releases:

Media releases will be sent from the subprogram when key messages that contribute to public perception or public good arise. The annual workshop provides a key opportunity to achieve extensive media coverage of the industry, the subprogram and the FRDC.

Articles in magazines/newsletters:

Articles on research activities and outputs are regularly submitted to various magazines and newsletters, including the FRDC R&D News.

Conference proceedings:

This project contributes papers on behalf of the subprogram to national and international conferences. These papers highlight the status of Australian rock lobster enhancement and aquaculture and research underway within the subprogram that is contributing to the development of this sector.

The RLEAS communications policy aims to facilitate the orderly release of information produced by research providers managed under the subprogram. This policy covers the publication of final reports and scientific papers and the release of media articles, unsolicited media inquiries/interviews and films. Release of information is based on the following criteria:

- Distribution of information must have a net benefit for the Australian industry.
- Dissemination of information to international partners will be approved when there is a two way flow of information.
- *Ad hoc* requests for results or information will not be accepted.
- Special cases for the supply of information will have to be approved by the Steering Committee and where appropriate, Memorandums of Understanding will be prepared.

A number publications are available or are pending from the Subprogram including:

- Proceedings of a lobster health workshop held in Perth in July, 1998.
- Proceedings of the Rock Lobster Propagation workshop held in Hobart in January, 1999.
- Proceedings of the first annual RLEAS workshop held in Geraldton in March, 1999.
- Proceedings of the second annual RLEAS workshop held in Hobart in February, 2000.
- Proceedings of the third annual RLEAS workshop held in New Zealand in April, 2001.
- Proceedings of the first RLEAS/RLPHS combined Workshop held in Cairns in May 2002.
- Proceedings of the second annual RLEAS/RLPHS combined Workshop held in Fremantle September 03
- Final reports from completed projects.
- "Lob ReLEASe" Volume 1, Issues 1, 2 and 3.
- "Lob ReLEASe" Volume 2, Issue 3
- Scientific publications from completed and existing research projects.

Additional information on the Rock Lobster Enhancement and Aquaculture Subprogram including newsletters, annual operating plans and workshop proceedings can be accessed by visiting the web-site www.frdc.com.au/research/programs/rleas or by contacting the Subprogram Leader:

D) PROPOSED NEW RESEARCH

In response to publication of the RLEAS Strategic Plan, the following pre-proposals were received by the Subprogram for consideration at their Steering Committee meeting in September, 2003.

1. Subprogram management

The RLEAS Steering Committee considered options for the ongoing management of the subprogram given project 2001/211 is due for completion in June 2004. Dr van Barneveld offered suggestions as to how the subprogram could examine options for incorporation so that it could attract additional external funds and so that the management component could possibly become self-sustainable in the long term. The Steering Committee felt that this option was premature and that the best way forward was for the RLEAS to submit a management proposal to FRDC similar to projects 1998/301 and

2001/211. The Steering Committee also offered full support for the on-going management of the core projects within the RLEAS given the extent of the funding that has been invested and the multi-disciplinary nature of the research.

2. RLEAS Development of tropical lobster grow-out technology
   Principal Investigator: Dr Kevin Williams, CSIRO

Proposed Objectives

1. Coordinate and communicate the research of the joint ACIAR/FRDC project relevant to industry, wild fishery and other relevant stakeholders and to the wider community.
2. Develop cost effective and water stable pelleted lobster feeds that are derived from an understanding of the nutrient requirements of the animal during all phases of the production cycle and the determined nutritive value of available and suitable feed ingredients.
3. Develop land- and/or sea-based culture systems that contribute to the maintenance of high growth rates, good health and high survival of the lobsters during all production phases.
4. Assist indigenous and other commercial tropical rock lobster growout aquaculture establishment in Australia.

The Steering Committee offered the following comments and advice in relation to this proposal:

The RLEAS are keen to maintain an involvement in all research associated with rock lobster aquaculture in Australia. To this end, a small investment as a collaborator in an ACIAR initiated project may be appropriate, however, a decision could not be reached on the current application due to insufficient information relating to the ACIAR and Torres Strait objectives. It was also noted that it is difficult to justify Australian involvement in projects with countries such as Vietnam given the potential competition in the market place, even if there is a two way flow of information as claimed by CSIRO.

E) WORKPLAN FOR 2003

In 2003, the RLEAS has a number of specific objectives:

- Identify additional ways to attract research funds and commercial involvement in the Subprogram.
- Develop further links with the proposed Southern Rock Lobster Industry body.
- Participate in a wider range of industry meetings (aquaculture and wild-capture sector of the rock lobster fishery) to promote the activities and outcomes of the Subprogram.
- Develop pilot scale propagation facilities at participating research institutions.

F) BUDGET

Existing and proposed RLEAS projects and budgets are as follows:

Project ID	02/03	03/04	04/05	05/06
2000/212	$65,000			
2000/214	$172,239			
2000/263	$62,000			
2001/211	$100,000	100,000		
2001/094	$10,100			
2002/045	$147,999	59,793		
2003/213		198,736	167,086	128,326
2003/211		273,616	482,427	578,337

2002/212		232,600	277,433	261,461
2004/239*			119,278	123,069
2004/240*			47,048	46,595
TOTAL	557,338	864,745	926,946	968,124

*Current applications being considered by FRDC

RLEAS has allocated rock lobster propagation as its highest priority. It needs to be recognised that rock lobster propagation is a long term research objective and it is anticipated that investment in propagation alone will need to be in the order of $0.5 million per annum for at least the next 10 years. This needs to be clear when allocating scarce research resources, given that a short term research program is unlikely to yield significant outcomes. It must also be noted that the rewards arising from a long term research program are likely to be great and this is reflected by the strong industry financial commitment to the propagation program.

G) VARIATIONS

Nil.

Dr Robert van Barneveld
RLEAS Leader
December, 2003

Appendix IV – RLEAS Strategic Directions 2002-2007

Rock Lobster Enhancement and Aquaculture Research in Australia. Strategic Directions 2002-2007

Prepared by **Dr Robert van Barneveld**
Leader, Rock Lobster Enhancement and Aquaculture Subprogram

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Vision

Delivery of technologies that facilitate the development of a viable rock lobster aquaculture industry in Australia, with adequate consideration and contingency for:

- Protection of the wild fishery in terms of economic and social viability;
- Neutral or positive impact on the wild fishery in terms of stock numbers;
- Commercial viability of closing the life cycle of rock lobsters;
- Increasing profitability and wealth for Australasia.

Introduction

There is growing interest around the world in aquaculture of rock lobsters and this has recently extended to Australia and New Zealand. A number of States are investigating rock lobster aquaculture potential in various forms, the dominant methods including 1) on-growing of adults through a moult to increase weight whilst allowing sale at periods of peak demand/ value; 2) on-growing of wild-caught puerulus (newly-settled juveniles) to a small (and potentially very valuable) market size of around 200-300 g, and 3) culture of phyllosoma from eggs through the 11 larval stages to puerulus and subsequent ongrowing to market size as above. In addition, the potential exists through improved survival rates, for aquaculture to provide stock for reseeding and enhancement of the wild fishery.

Collection of puerulus from the wild and on-growing to a marketable size is now underway in Tasmania. In 2001 in Tasmania, 7 licences were issued for the collection of 50,000 puerulus each. The licences were issued with a condition of use that approximately 25% of the total number of puerulus collected are re-seeded into the wild fishery as juveniles at one year. Aquaculture activities in South Australia focus on on-growing and value adding to adult wild-caught lobsters. In the past, sea-based pontoons have been used to hold and feed lobsters with potential to achieve weight gains of around 20% by growing the animals through the annual moult, representing a 60% return on investment. A commercial fishing company in Queensland is actively investing in research to assess the potential of culturing and growing tropical rock lobsters. Rock lobster aquaculture based on quota buy-out schemes in return for puerulus collection licenses (in the order of 1 tonne of quota in return for 40,000 puerulus) has been in place in New Zealand for some years. The success of these ventures has been variable.

Despite significant progress in both the research and development and commercial sectors, long term viability of this industry vests firmly with closure of the life cycle of spiny lobsters.

Rock Lobster Enhancement and Aquaculture Subprogram

The Fisheries Research and Development Corporation established the Rock Lobster Enhancement and Aquaculture Subprogram (RLEAS) in July, 1998 following consultation with industry and scientists. A summary of the Subprogram projects and activities since its inception is presented below:

Project	97-98	98-99	99-00	00-01	01-02	02-03	03-04
98/300 – Propagation of rock lobster – development of a collaborative national project with international partners.							
98/301 – Facilitation, administration and promotion of the FRDC Rock Lobster Enhancement and Aquaculture Subprogram.							
98/302 – Towards establishing techniques for large scale harvesting of pueruli and obtaining a better understanding of mortality rates.							
98/303 – Feed development for rock lobster aquaculture.							
98/304 – Pilot study of disease conditions in all potential rock lobster aquaculture species at different growth stages.							
98/305 – Determination of optimum environmental and system requirements for juvenile and adult rock lobster holding and grow-out.							
99/314 – Preliminary investigation towards ongrowing puerulus to enhance rock lobster stocks while providing animals for aquaculture.							
99/315 – Propagation techniques.							
2000/185 – Evaluating the release and survival of juvenile rock lobsters released for enhancement purposes.							
2000/211 – Investigation into tail-rot necrosis in live-held adult lobsters.							
2000/212 – The nutrition of juvenile and adult lobsters to optimise survival, growth and condition.							
2000/214 – Advancing the hatchery propagation of rock lobsters							
2000/263 – Reducing rock lobster larval rearing time through hormonal manipulation.							
2001/211 – Strategic planning, project development, and facilitation of research and extension towards establishment and maintenance of commercial rock lobster aquaculture and enhancement systems in Australia.							
2001/094 – Health assurance for southern rock lobsters							
2002/045-Assessing the possibilities for enhancing natural settlement of western rock lobster							

Subprogram Mission

To provide technology for use in Australian rock lobster enhancement and aquaculture systems so they can be internationally competitive and can operate in harmony with the wild fisheries.

Role of the Rock Lobster Enhancement and Aquaculture Subprogram

The Australian rock lobster fishery is a valuable resource because it represents a unique source of a number of high quality, high value rock lobster species grown in a pristine environment and hence sought after in many markets. It is clear that a number of overseas countries are investigating the potential for rock lobster aquaculture and if successful in developing aquaculture systems through closure of the life cycle, the current Australian market for spiny lobsters could be threatened. Success in culturing lobsters overseas would also result in a "reactive" research program in Australia that may not result in beneficial outcomes for all potential stakeholders in the rock lobster industry. Further to this, given the diversity of rock lobster species in Australia it is unlikely that development of aquaculture systems will be the same in each state, hence a coordinated research approach is desirable to ensure limited research resources are optimised and that the Australian industry as a whole pursues common goals.

Development of a proactive Australian research program for rock lobster enhancement and aquaculture allows:

- Representatives of the wild capture fishery and aquaculture sector to work together to ensure the highest research priorities are pursued and that all consequences associated with the development of a rock lobster aquaculture sector are considered;

- An national approach to the research using rock lobster species from across Australia;

- Development of strategic international research alliances with countries such as New Zealand who have an advanced research program, and who share similar industries issues to Australia;

- An identifiable centre for rock lobster aquaculture research and a focal point for representatives of the wild fishery, aquaculture sectors and government agencies.

Core Research and Development

Based on research outcomes to date, the RLEAS Steering Committee recently reviewed the research and development priorities for the Subprogram. To date, given the many unknowns associated with an emerging aquaculture sector such as rock lobster, the research focus has been comparatively short term. It is now clear that development of technical capacity in the field of rock lobster enhancement and aquaculture will require a long term research and development effort over a period of 5-10 years. In addition, the RLEAS Steering Committee believe that the best chance of meeting the Subprogram and industry goals will result from an allocation of any research investment in the following way:

Research focus	Resource allocation (%)
1. Broodstock culture and propagation	**80**
2. On-growing	**10**
a) Puerulus – market size	*Maximum 10%*
- Nutrition	*(0-10)*
- Health	*(0-10)*
- System design	*(0-10)*
b) Adult enhancement	*Maximum 5%*
3. Wild fishery enhancement with aquaculture reared lobsters	**10**

Based on the above allocation of resources, the following specific research objectives are priorities for the Rock Lobster Enhancement and Aquaculture Subprogram:

Propagation

The task of rearing of large numbers of rock lobster larvae to metamorphosis at will is undoubtedly one of the greatest challenges in aquaculture today. Success will only be achieved if there is an intense focus on achieving results that take the project closer to its final goal, if there is genuine collaboration between those involved and a great deal of innovation and willingness to explore new approaches.

The **overall goal** of propagation research within the RLEAS is to **develop the technical ability to produce puerulus at will in any number required** and each milestone of each project should contribute measurably to the achievement of this goal. It will likely take more than five years to reach the overall goal given a coordinated and determined effort and may yet prove too difficult at the current level of technical understanding of larval production systems. It is clear that new base survival diets (both for *Artemia* enrichment and for inclusion in a manufactured diet), improved larval husbandry techniques and systems that minimize the proliferation of bacteria will have to be

developed. Investigators will need to demonstrate a high level of innovation and determination to overcome these obstacles.

The **immediate goal** for the propagation research program is to **provide the technical ability to spawn adults during any month of the year, and to produce healthy and nutritionally balanced larvae to stage V.** Completion of this goal will require the development and implementation of a dedicated broodstock conditioning program, the adoption of standardized *Artemia* husbandry techniques and the development of a base enrichment for *Artemia* that provides at least the minimum nutrition for small larvae, as well as the development of rearing systems and culture techniques that reduce bacterial proliferation in the culture tanks. These projects can run concurrently and should be achieved within three to five years.

Once the base survival enrichment formula has been developed and healthy larvae can be produced to stage V in large quantity, it will be necessary to develop a diet for larger larvae and refine the culture procedures. At present, the most likely candidate for late phyllosoma nutrition appears to be a manufactured diet with a composition based initially on the *Artemia* enrichment formula but progressively modified to meet the needs of larger larvae. Culture systems will be scaled up to commercial size and modified as necessary.

The results of any research undertaken will be evaluated according to their ability to contribute measurably to achieving the immediate goal.

A recent review of propagation research within the RLEAS has resulted in the development of a revised propagation research program which will contain three distinct phases:

PHASE I

- Develop detailed project proposals and milestones consistent with revised goals.
- Primary focus on achieving high growth and survival through to phyllosoma stage V.

The suggested time frame for the completion of stage I is three years.

Goal 1 **Establish a reliable supply of stage one larvae at any time of year using the following suggested method:**

i) Manipulate photoperiod to control gonad maturation and timing of extrusion.
j) Manipulate incubation temperature to control the developmental period of embryos.
k) Produce larvae monthly.
l) Assess the effect of broodstock diet on phyllosoma quality.

Goal 2 ***Develop a base Artemia enrichment diet that provides adequate nutrition to support growth at a minimum predetermined level from phyllosoma stages I through V using the following suggested method:***

i) Identify and prioritise key obstacles to developing a base enrichment diet.
j) Develop base *Artemia* enrichments incorporating knowledge gained to date.
k) Assess the effect of enrichments on growth of phyllosoma initially in static culture using anti microbial agents if necessary and report results.
l) Continually modify test diets according to results of trials until pre-determined growth and survival standards are met

Goal 3 Develop a culture system that suppresses undesirable bacterial blooms and is suitable for use over periods of several months using the following suggested method:

i) Review and standardise all aspects of *Artemia* husbandry including decapsulation, hatching, on-growing, enriching, and delivery with a view to reducing the bacterial load in *Artemia* and phyllosoma culture systems.
j) Review literature for recent developments in methods of bacterial control in marine larval rearing systems with an emphasis on low intervention techniques suitable for long culture periods.
k) Construct several prototype culture systems based on the review and assess the development of bacterial communities and numbers while culturing early stage phyllosomas. Parallel studies using the larvae of other species readily available and familiar to the investigator and for which the husbandry techniques and larval nutrition are known may also be beneficial.
l) Raise lobster larvae produced in goal 1 and fed *Artemia* enriched in goal 2 using a variety of bacterio-suppressant rearing techniques identified in part b) and developed in part c) of goal 3.

PHASE II

Commencement of stage II is contingent upon successful completion of the second year milestones in stage I. That is Stage II should start one year before the end of stage I. This is to ensure a smooth transition to stage three.

The primary focus of this stage is on the physical and chemical assessment of formulated diets ready for assessment with stage V+ phyllosoma.

Goal 1 Commence preliminary work developing a formulated feed for stage V+ phyllosoma

This goal should be addressed through a project with a 12 month duration and should be contingent upon the successful completion of goals to produce phyllosoma to stage V and above. The suggested methodology is:

e) Assess binders.
f) Produce a test diet based on the knowledge of ingredients gained from the development of *Artemia* enrichments but incorporated into an artificial pellet. The goal is to produce a base survival diet that provides adequate nutrition to support growth and survival at a level predetermined by the research team.

PHASE III

Diet optimisation studies and commercialisation of culture techniques

Goal 1 Upscale larval rearing systems developed in Stage I to semi-commercial scale and capability to produce tens of thousands of puerulus.

Goal 2 Optimise diet for Stage V+ phyllosoma.

The research objectives and outcomes of the RLEAS propagation research program are summarised in the table below:

Goal	Impediments	Research Approach	Key performance indicators	Time frame
Technical ability to culture spiny lobster puerulus from eggs, at will and in any number.	1. Regular supply of larvae. 2. Larval nutrition. 3. Larval rearing systems. 4. Larval health.	1. Establish a reliable supply of stage I larvae through improved broodstock management. 2. Develop enriched *Artemia* diets to support phyllosoma growth from stages I-V. 3. Develop *Artemia* husbandry and phyllosoma culture systems to suppress	1. Capacity to produce Stage I larvae throughout the year. 2. Enriched *Artemia* diets that support phyllosoma growth from stages I-V. 3. Culture systems that suppress bacterial blooms. 4. Capacity to produce	2002-2007

		undesirable bacterial blooms. 4. Develop manufactured diets to support phyllosoma stages V and above. 5. Initially focus on 1-2 rock lobster species.	healthy stage V larvae predictably and reliably. 5. Manufactured diets for rearing phyllosoma stages V+. 6. Capacity to produce puerulus at will and in any number.	
Efficient production of spiny lobster puerulus from eggs, at will and in any number.	1. Larval nutrition. 2. Control of larval phases.	1. Optimisation of manufactured diets for phyllosoma stages V+. 2. Hormonal manipulation of larval phases.	1. Efficient production of puerulus at will and in any number using manufactured diets and *Artemia*. 2. Reduction in larval rearing time through manipulation of larval phases.	2005-2010
Commercial production of puerulus from eggs at will and in any number.	1. Larval rearing systems. 2. Larval health. 3. Larval nutrition.	1. Upscale research-scale production focusing on rearing systems, survival and the cost-effectiveness of supplying manufactured diets. 2. Expand the number of spiny lobster species cultured.	1. Economically-viable commercial production of a variety of species of spiny lobster puerulus from eggs at will and in any number.	2010+

Any research project addressing the above priorities should give due to consideration to RLEAS Projects 2000/214 and 2000/263 and all prospective Principal Investigators should be aware that the RLEAS will facilitate a propagation research planning meeting in Tasmania on September 16, 2002.

Nutrition

Nutrition research is required to facilitate delivery of:

- Multiple sources of nutrients for all growth phases.
- Robust diets that can be altered depending on the availability of raw materials while still supplying the same nutrients.
- A manufactured diet that is water stable, attractive, easy to handle, store and transport, shelf stable and cost-effective.
- Diets suitable to support optimum growth of all phases of the production cycle.
- Minimal impact on surrounding water quality through nutrient loads.
- Diets that support optimum survival of juveniles during their first year of development.
- Technical capacity for nutritional manipulation of moult cycles.
- Technical capacity for nutritional enhancement of lobster product quality in live-held adults.

Where possible, nutrition related projects should be developed in conjunction with the Aquaculture Nutrition Subprogram (see strategic directions for the Aquaculture Nutrition Subprogram on www.frdc.com.au/research/programs/ans).

Health

- Disease-free aquaculture environment.
- Disease-monitoring to ensure disease transfer to the wild fishery is not possible.

In the absence of identifiable diseases, it is difficult to prioritise health research. Linkages with Aquatic Animal Health Subprogram may provide the best opportunities to ensure the above requirements are met.

On-growing of juveniles and system requirements

- Husbandry procedures to ensure optimal growth (stocking density, water temperature, water quality, light, feeding regimes etc).
- Definition of the interaction between system design, nutrition and health of all life stages of rock lobster, and the relative importance.

Enhancement

- Reseeding of juvenile aquaculture reared juveniles that survive to increase wild fishery stocks and natural egg production levels.

Further Information

Additional information on the Rock Lobster Enhancement and Aquaculture Subprogram including newsletters, annual operating plans and workshop proceedings can be accessed by visiting the web-site www.frdc.com.au/research/programs/rleas or by contacting the Subprogram Leader:

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Appendix V – Newsletters

Appendix VI – Subprogram Publications

Rock Lobster Enhancement and Aquaculture Subprogram
Papers Published as at July 2004

Contact	Project	Publication / Reference
Caleb Gardner University of Tasmania PO Box 252-01 Hobart, Tas 7000 Phone: 03 6227 7233	2000/185 & 1999/314	Gardner, C. (2003). Southern rock lobster aquaculture. Hatchery International**:** 12-13. Gardner, C. (2003). Southern rock lobster culture makes progress. Austasia Aquaculture. **17:** 49-52. Gardner, C. Mills, D. Ibbott, S. Wilcox, S. Crear, B. (2000). Preliminary investigation towards ongrowing puerulus to enhance rock lobster stocks while providing animals for commercial culture. Tasmanian Aquaculture and Fisheries Institute Report 13. Gardner, C. Mills, D. MacDiarmid, A. Oliver, M. Stewart, R. (2001). Opportunities for the rock lobster industry through re-seeding. 2nd National Lobster Congress, Geelong Victoria. Mills, D. 1998. Rock Lobster puerulus for aquaculture? Fishing Today. **11:** 9-11. Mills, D. 2001. Lobster puerulus collection information. Fishing Today **14**(3): 21. Mills, D. 2002. Gem of an idea for rock lobsters. The Mercury. Hobart**:** 3. Mills, D. Gardner, C. Ibbott, S. Willcox, S. (1999). Acoustic tracking of small-scale movement in juvenile southern rock lobster (*Jasus edwardsii*). Fish Movement and Migration, Bendigo, Victoria, Australian Society for Fish Biology. Mills, D. Gardner, C. Ibbott, S., (in press). Behaviour of ongrown juvenile Jasus edwardsii after reseeding to coastal reef. Stock Enhancement and Sea Ranching: Developments, Pitfalls and Opportunities. K. M. Leber, J. Kitada, H. L. Blackenship and T. Svåsand. London, Blackwell Scientific**:** 576. Mills, D. Gardner, C. Oliver, M. (2002). Lobster survival assessment turns to high-tech surveillance. Fishing Today. **15:** 22-23. Oliver, M. Gardner, C. Mills, D. MacDiarmid, A. (2003). The high-tech world of lobster surveillance. Water and Atmosphere. **11:** 5. Oliver, M. Stewart, R. MacDiarmid, A. Gardner, C. Mills, D. (2001). Lobsters in captivity: house angel or street devil? Seafood New Zealand. **9:** 24-26. Oliver, M. Stewart, R. MacDiarmid, A. Gardner, C. Mills, D. (2002). Lobsters in captivity: house angel or street devil? Fishing Today. **15:** 34-35. Oliver, M. Stewart, R. MacDiarmid, A. Gardner, C. Mills, D. (2002). Behaviour of Jasus edwardsii reared in captivity. The Lobster Newsletter **15**(1): 9-11.
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Roy Melville-Smith Rock Lobster and Crab Research Western Australian Marine Research Laboratories P.O. Box 20, North Beach, WA6020 Phone: +61 (08) 92468406	1998/302	Phillips, B.F. and Melville-Smith, R. Biological neutrality and catching pueruli in the Western Rock Lobster Fishery. Brochure

RLEAS Workshop Publications

Title	Editors	Date published
RLEAS Publication No.7 Developments in Rock Lobster Enhancements, Aquaculture and Post Harvest Practices (RLEAS/RLPHS Workshop 2002)	Dr Robert van Barneveld & Dr Bruce Phillips	June 2002
RLEAS Publication No.8 Developments in Lobster Enhancement, Aquaculture and Post Harvest Practices (RLEAS/RLPHS Workshop 2003)	Dr Robert van Barneveld & Dr Bruce Phillips	October 2003
RLEAS Publication No. 9 Developments in Lobster Enhancement, Aquaculture and Post Harvest Practices (RLEAS/RLPHS Workshop 2004)	Dr Robert van Barneveld & Dr Bruce Phillips	October 2004