**Economic Impact Assessment**

**Appendix 1:**

**An Economic Analysis of FRDC’s Investment in Theme 1: Abalone, Yellowtail Kingfish and Oysters (Pearls and Edible)**

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Project Number: 2011/504 - Round 2 Evaluations

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# Executive Summary – Overview of all reports

The FRDC Five Year Plan (FRDC, 2010) divides its investment into 14 themes. The Corporation has set an impact assessment objective of evaluating in economic terms all projects in all themes over the five year period commencing in March 2011. Projects were defined as those having been completed (or substantially completed) in the five years prior to 2011.

The first population of projects was defined in January 2011 and projects were placed into each of the 14 themes. Some of the 14 themes had far more projects than others and those themes with high numbers of projects were divided into two or more clusters of projects. This resulted in 25 clusters across the 14 themes.

Evaluation of the first eight clusters was completed in October 2012 and the evaluation report provided to FRDC. In the second 18 months period (i.e. July 2013 to December 2014) a further nine of the 25 clusters were subjected to impact assessment resulting in the current summary report. The impact assessment used cost-benefit analysis (CBA) to estimate investment criteria for each cluster of projects. The nine clusters evaluated in this second round comprised:

1 cluster from theme 1 (Biosecurity and aquatic animal health),

1 cluster from theme 4 (Ecologically sustainable development),

1 cluster from theme 5 (Governance and regulatory systems),

1 cluster from theme 6 (Resource access and allocation),

4 clusters from theme 7 (Production, growth and profitability), and

1 cluster from theme 8 (Consumers, products and markets).

Each cluster comprised between seven and 50 projects. As the entity for evaluation reporting was the cluster, costs and benefits for each cluster had to be built up from information on the individual projects in the cluster. This was achieved largely through access to the FRDC data base and contact with Principal Investigators of projects, government agencies and industry personnel.

The value of total funding for each of the nine clusters (FRDC plus other investment) ranged from $3.7 million to $44.2 million, with a total value for all clusters of $137.4 million (in nominal $ terms). The FRDC nominal investment in the nine clusters analysed varied for each cluster (32.6% to 62.4% of the cluster total). FRDC contributed 40% of the total nominal investment across all nine clusters.

The majority of the benefits identified from the nine clusters (202 projects in total) were economic in nature although significant numbers of environmental and social/community benefits also were identified. The major beneficiary of the impacts of the nine clusters of research investment has been the fishing industry (51% of the number of benefits identified), with 43% of the identified number of benefits being public in nature and 6% to overseas interests. The results demonstrate the significant spillovers of benefits to the public sector from research targeted at the fishing industry. Insignificant spillover benefits to other Australian industries were identified.

A number of the identified benefits were valued, and investment criteria for each of the clusters of investment calculated. Benefits were estimated over 30 years from the final year of investment in the research. Benefits and costs were expressed in 2013/14 dollar terms, and discounted to 2013/14 using a discount rate of 5%.

The net present values (NPVs) for total investment for the individual clusters ranged from $6 million to $124 million and the Benefit-Cost Ratios (BCRs) ranged from 1.8:1 to 3.9:1. FRDC investment made up 37.9% of the total investment in present value terms, and the NPVs for FRDC investment in individual clusters ranged from $4 million to $60 million.

When all nine clusters are aggregated, the BCR for the $266.5 million investment in the nine clusters (present value terms) was 2.6:1, with the Present Value of Benefits (PVB) of $684.0 million and an NPV of $417.5 million. For the FRDC investment of $101.0 million (present value terms), the NPV was $170.2 million.

**Appendix 1: An Economic Analysis of FRDC’s Investment in Theme 1: Abalone, Yellowtail Kingfish and Oysters (Pearls and Edible)**

**Background**

Abalone, oyster and Yellowtail Kingfish (YTK) represent significant value in the Australian Fisheries industry. Wild production and aquaculture combined had a gross value of production of $178.3 million in 2010/11 (ABARES, 2012). Oyster production is among the largest five species in terms of volume totalling 13,951 tonnes during 2010/11 (ABARES, 2012).

In recent years, abalone and oysters particularly have been plagued by disease outbreaks associated with high mortality rates. In 2004/05, oyster production in the Hawkesbury River was significantly affected by an outbreak of QX disease. An outbreak of Oyster Oedema disease (OOD) occurred in 2006 affecting pearl oysters and Pacific Oyster Mortality (POMS) was detected in NSW in late 2010. Similarly in late 2005, Abalone Viral Ganglioneurities (AVG), a herpes-like abalone virus, spread through the Victorian abalone industry, causing mortalities through farmed and wild-catch populations. AVG was also detected in seafood processing facilities in Tasmania during 2011 (DPI NSW, 2012a).

Currently the FRDC has five programs:

1. Environment

2. Industry

3. Communities

4. People development

5. Extension and adoption

Within the Environment program is Theme 1, Biosecurity and Animal Health. This analysis includes a cluster of investments made as part of Theme 1 in the abalone, YTK and oyster industries from 2002 through to 2011. Benefits from this cluster predominantly stem from preventing, managing and containing disease, in addition to generally increasing the understanding of health of the species. The benefits can be translated to increases in yield (or avoiding yield loss), decreases in production costs from better managing disease and animal health, and increasing the general sustainability of wildstock through minimising the spread of disease. The cluster contains seven projects relevant to abalone, three pearl oyster projects, two meat oyster projects and one project relevant to YTK.

**Summary of Projects**

There are 13 projects in the Theme 1: Abalone, YTK and Oysters cluster. Table 1 gives a list of projects in the cluster and Table 2 provides a summary of each project in the cluster.

Table 1: Projects Included in Cluster

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| **FRDC Project Number** | **Project Title** |
| 2002/200 | Abalone Aquaculture Subprogram: preventing summer mortality of abalone in aquaculture systems by understanding interactions between nutrition and water temperature |
| 2002/201 | Abalone Aquaculture Subprogram: a national survey of diseases of commercially exploited abalone species to support trade and translocation issues and the development of health surveillance programs |
| 2003/220 | Innovative Solutions for Aquaculture: potential for parasite interactions between wild and farmed kingfish, discrimination of farmed and wild fish and assessment of migratory behaviour |
| 2004/080 | Aquatic Animal Health Subprogram: development of a national translocation policy using abalone and prawns as templates for other aquatic species |
| 2004/084 | Aquatic Animal Health Subprogram: investigating and managing the *Perkinsus* related mortality of blacklip abalone in NSW - phase 1 |
| 2004/086 | Aquatic Animal Health Subprogram: identification and distribution of an intracellular ciliate in pearl oysters |
| 2004/233 | Abalone Aquaculture Subprogram: investigating the immunology of stressed abalone (Haliotis species) |
| 2005/074 | Management of bioeroding sponges in wild stocks of *Pinctada maxima* in Western Australia |
| 2005/076 | QX resistant oyster challenge trial 2005 - 2006 |
| 2006/062 | Aquatic Animal Health Subprogram: identification of host interactions in the life-cycle of QX disease |
| 2006/064 | Aquatic Animal Health Subprogram: development of diagnostic tests to assess the impact of Haplosporidium infections in pearl oysters |
| 2006/243 | Aquatic Animal Health Subprogram: development of management strategies for herpes-like virus infection of abalone |
| 2007/006 | Aquatic Animal Health Subprogram: development of molecular diagnostic procedures for the detection and identification of herpes-like virus of abalone (Haliotis spp.) |

Table 2: Description of Each of the 13 Projects

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| **Project 2002/200: Abalone Aquaculture Subprogram: preventing summer mortality of abalone in aquaculture systems by understanding interactions between nutrition and water temperature** | |
| Project details | Research Organisation: South Australian Research and Development Institute  Period: Mar 2002 to Dec 2006  Principal Investigator: Meegan Vandepeer |
| Rationale | As the abalone aquaculture sector had grown, it had become apparent that high mortalities can occur during the summer months as water temperatures increase. At that time, farmers were addressing summer mortalities by reducing feeding rates to ensure maximum water quality. While this reduces mortalities, production levels suffer, hence other options are desirable. |
| Objectives | 1. To induce abalone mortality and/or bloat under experimental conditions to ensure a “control” exists for subsequent experiments. 2. To examine the interaction between high levels of fermentable carbohydrate and temperature on abalone growth rates, mortality and haemocyte counts. 3. To define nutritional treatments that may alleviate the effects of increased water temperature on abalone mortality, including extrusion of dietary ingredients and immune enhancing diet additives such as antioxidants and mannan oligosaccharides. 4. To apply the results of objectives 2 and 3 to black lip abalone. |
| Outputs | * The original objectives of the project were to induce mortality and bloat in laboratory held animals so that a control existed for further studies to investigate diet manipulation. * Mortality and/or bloat could not be induced in the experiments conducted. * In addition to the two laboratory experiments, a mortality survey was sent out to several farms but only 3 farms completed and returned the survey. * Based on the experiments, survey reporting and numerous conversations with different farmers about mortalities, it became apparent that many mortality events over summer were likely to be linked to water quality and tank husbandry issues rather than nutritional composition of manufactured diets per se. * The project’s planned outcomes were then changed to an understanding of the effect of water quality on abalone health and water quality parameters influencing abalone health and how these could be measured. * A water quality manual for abalone farmers was produced. |
| Outcomes | * This project has alerted the abalone industry to some of the factors that are likely to predispose abalone to summer mortality and provided them with suggestions as to actions they can take to prevent it. * The production of the water quality manual has provided the industry with a guide to improved management for abalone farming. * Increasing knowledge on water quality and optimising management may lead to lower mortality rates by reducing abalone stress and promoting a cleaner production environment. * The manual and the exercise greatly focused the minds of commercial farmers on water quality and animal husbandry issues; this has resulted in greatly improved stock management standards on land based abalone systems (Steven Clarke, pers. comm., 2009). * Abalone farmers have greatly improved the way in which they manage their farm’s environment and stock and this has helped reduce abnormal mortalities under normal summer conditions. * Summer mortalities are still an issue on many farms in Australia due to occasional more extreme climate conditions or other factors. For example, the occurrence of extremely high water temperatures experienced during heat waves has been a problem in some areas; disease has been a problem in others. * The extent to which mortalities have been reduced due to the project alone is positive but not easily measurable. |
| Benefits | * Improved management of abalone stock and their environment leading to reduction in production costs for some farmers. |

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| **Project 2002/201 Abalone Aquaculture Subprogram: a national survey of diseases of commercially exploited abalone species to support trade and translocation issues in the development of health and surveillance programs** | |
| Project details | Research Organisation: University of Tasmania  Period: Dec 2002 to Aug 2006  Principal Investigator: Judith Handlinger |
| Rationale | Establishment of health monitoring programs of both farmed and wild stock for abalone were seen as helping to prevent disease and meeting future market expectations in relation to health accreditation. This process was threatened by inadequate data on diseases in wild stock, and in some states by limited experience in the diagnostic assessment of abalone. |
| Objectives | 1. To undertake, over approximately one year, a single-round health survey of abalone from representative wild groups of commercial abalone species throughout their range in 5 states, using statistically relevant samples appropriate to maximise the chances of detection of serious diseases and define the disease agents present. 2. To similarly examine equivalent samples from all abalone farms and reseeding operations in these states. 3. To develop a database of abalone disease, their location and apparent prevalence (with confidence limits), then to present these findings to the wild and aquaculture industries and State and National government agencies, and to record them pictorially in accessible electronic format. 4. To expand the pool of abalone health expertise by holding an initial training workshop for collaborating pathologists to facilitate the survey, and a national abalone health meeting to present disease and pathology findings to all relevant pathologists and health service providers, to ensure their adoption. 5. To ensure the resulting information and skills are fully utilised by assisting in the development of cost-effective on-going health surveillance programs through collaboration with the abalone aquaculture industry and state authorities. |
| Outputs | * The health survey included the abalone aquaculture industry and the wild fishery in South Australia (SA), Victoria, Tasmania, New South Wales (NSW) and Western Australia (WA), and was undertaken by the major aquatic animal diagnostic laboratory in each of these States. * Over 3,000 abalone were examined from the systematic sampling program, comprising 1,841 wild and 1,322 cultured abalone. Additional animals were examined from groups subsequently showing pathology that was not seen in that area during the survey. * The findings from each State disease survey were consolidated and tabulated and made available through presentation including photographs. * The capacity of abalone health expertise has been increased and an inter-laboratory network established that is on-going. |
| Outcomes | * The overall outcome from this project has been a considerable expansion of knowledge on abalone diseases within Australia, knowledge of abalone pathology, a considerable expansion of the diagnostic resources available to the Australian abalone industries, and heightened awareness of both industry sectors. * The information from this survey has been widely distributed to industry, researchers and regulatory authorities, together with advice to assist in the establishment of ongoing abalone health surveillance programs. * This knowledge and capacity has the potential to lead to earlier diagnosis of diseases and therefore more appropriate and more rapid treatment decisions if a disease outbreak occurs in future. * The results have been used in the industry health surveillance program and the survey may have brought forward the surveillance program. * The project may provide a basis for developing a future translocation policy for the industry. * The survey also provided baseline knowledge to better understand the how the AVG virus was introduced. |
| Benefits | * Potential for reduced cost of production in future due to improved recognition and identification of diseases. |

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| **Project 2003/220 Innovative Solutions for Aquaculture: potential for parasite interactions between wild and farmed kingfish, discrimination of farmed and wild fish and assessment of migratory behaviour** | |
| Project details | Organisation: Department of Primary Industries and Regions South Australia  Period: August 2003 to June 2007  Principal Investigator: Colin Johnston |
| Rationale | A lack of scientific information regarding interactions between wild and farmed stock has the potential to affect growth in the Australian Yellow Tail kingfish (YTK) industry. Monogenean parasites pose the most significant threat to the industry, with the potential to increase production costs by at least 20%. Scientific information regarding interactions between wild and farmed fish stock could provide a basis for forming aquatic animal health policy, license conditions and operating standards to safeguard fish stocks. |
| Objectives | 1. To determine the nature of parasite interactions between wild and farmed kingfish. 2. To determine potential impact that escaped, farmed fish have on wild populations of kingfish and other species. 3. To determine the seasonal migratory habits of the wild kingfish population in Spencer Gulf. |
| Outputs | * Qualitative risk assessment of 54 metazoan parasite species infecting wild *Seriola* spp in southern Australia and the risk they may face to farmed kingfish. * Two parasite species, *Benedenia seriolae* and *Zeuxapta seriolae* were found to be extremely likely to establish and proliferate. * *Benedenia seriolae* posed the greatest threat to sea-cage farming of YTK in Australia, however it can be managed somewhat by bathing fish in hydrogen peroxide or fresh water. * Although posing less of a risk in terms of establishment and proliferation, parasites *Paradeontacylix* spp, *Kudoa* sp. and *Unicapsula seriolae* were found to hold the largest negative consequences for sea-cage farming due to a lack of mitigation or management options. * Naturally occurring elemental signatures were analysed of wild and farmed fish ear stones (otoliths) using Laser Ablation Inductively Coupled Plasma Mass Spectrometry. It was possible to distinguish between wild and farmed fish with a high degree of accuracy. * Fluorescent dyes were used to mark hatchery reared fish and distinguish them from wild populations. Dyes were found to be the most inexpensive and effective method for distinguishing between the wild and farmed fish stock. * Through tagging wild kingfish and Samson fish it was possible to track their migratory path between 2004 and 2006 to give an indication of their potential interactions with farmed fish. This allowed for the first collection of data on migratory habits of kingfish in the Spencer Gulf. It was established that heightened interaction between farmed fish in Fitzgerald Bay occurred in the summer. * The local fishing community’s involvement in the tagging program allowed for an unprecedented number of wild kingfish and Samson fish to be tagged in South Australia. * One PhD student was trained in the area of aquatic animal health and an honours student was trained in the area of otolith chemistry. |
| Outcomes | * Results were disseminated through Australian kingfish aquaculture through meetings and workshops. * Presentations on the outputs of the project were delivered to the Australian Society for Parasitology and Australasian Aquaculture conferences. * The identification of parasite species that pose the greatest threat to the profitability and sustainability of the YTK industry. * The standard sampling method used in the project can be used as a model for ongoing assessment of parasite prevalence and intensity in fish stocks. * The dye found to be most inexpensive and effective in marking hatchery fish could potentially be developed to mark batches at the two kingfish hatcheries in South Australia and enable scientists to better distinguish between farmed and wild fish. * Promotion of tag and release fishing by recreational anglers has the potential to help mitigate the local depletion of stocks in the northern Spencer Gulf. * Parasite management protocols were provided to the industry and the project also informed policy development for response protocols to parasite incursions in South Australia (Kate Hutson, pers. comm., 2013). |
| Benefits | * Avoided restriction on expansion of the YTK aquaculture industry * Increased sustainable recreational fishing practices in South Australia. * Increased scientific capacity through the identification of an effective dye marking system and training of researchers. * Increased industry capacity to be prepared for disease outbreaks. |

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| **Project 2004/080: Aquatic Animal Health Subprogram: development of a national translocation policy using abalone and prawns as templates for other species** | |
| Project details | Organisation: Department of Fisheries Western Australia  Period: May 2004 to Jan 2007  Principal Investigator: Brian Jones |
| Rationale | A nationally agreed upon translocation process was not in place for aquaculture, limiting the movement of stock. Translocation of aquatic animal occurs for several reasons such as restocking waterways, environmental restoration, movement of breeding stock and recreational fishing. Translocation holds a number of risks such as spread of disease and parasites. A simple risk assessment methodology and standard policy could reduce the frequency and severity of quarantine incursions associated with interstate translocation. |
| Objectives | 1. To develop a single consistent translocation policy document for live temperate abalone, involving Victoria, Tasmania, South Australia and Western Australia, which is based on scientific risk assessment principles, recognises that the disease status of wild abalone populations is still unclear, may recognise different zones of “risk” and is consistent with Australia’s international obligations. 2. To develop a single consistent translocation policy document for live prawns, involving Queensland, Northern Territory, New South Wales and Western Australia, which is based on scientific risk assessment principles, recognises that the disease status of wild prawn populations is still unclear; may recognise different zones of “risk” and is consistent with Australia’s international obligations. 3. To indicate how these policies can be a template for other translocation issues. |
| Outputs | * A workshop of key personnel was conducted to identify hazards and assign scores to the likelihood and consequences of hazard events, excluding genetic issues. * A consensus view was reached on levels of perceived risk. * Development of a simple risk assessment process document “*The application of risk assessment to interstate and aquatic animal movements”.* * Documentation of the main disease hazards facing both Australian abalone and prawn translocation as at December 2004 was produced. * The risk assessment process identified *Perkinsus olensi* and shell fouling organisms as risks requiring management for the translocation of abalone. * The risk assessment process for prawns was not completed however Gill-associated virus (GAV) was identified as a disease that requirement management during prawn translocation. * A single translocation policy document could not be produced. |
| Outcomes | * The simple risk assessment process can be used to assess the likelihood and consequences of any translocation hazard. * Several jurisdictions have incorporated principles developed during the workshop process into their own policy documents. * Awareness was raised of the states and territories need for documenting their risk assessment processes that are required to underpin all management measures applied to translocations. * Several key recommendations were identified in the workshop process for future research to underpin and streamline translocation and management policies. * Identification of GAV as a disease risk in translocation of prawns has resulted in testing of post-larvae and broodstock (WA, NT, QLD); movement controls (WA and NT); and use of quarantine premises (WA and QLD). |
| Benefits | * Contributions to decreasing negative impacts resulting from translocation of aquatic animals, including spread of disease and parasites and adverse effects on population genetics. |

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| **Project 2004/084: Aquatic Animal Health Subprogram: investigating and managing the Perkinsus related mortality of blacklip abalone** | |
| Project details | Organisation: Department of Primary Industries (NSW)  Period: April 2005 to Sep 2007  Principal Investigator: Geoff Liggins |
| Rationale | A significant proportion of blacklip abalone has died since the early 1990s. The disease Perkinsosis has been linked to the mortalities, but it is unclear to what extent it is responsible. A need existed to document the historical evidence of *Perkinsus*-related mortality of abalone in NSW and contribute to the development of management strategies of abalone that have been, or might be, affected by *Perkinsus*-related mortality. Areas for further research could be identified using the information produced. |
| Objectives | 1. To compile and document the historical evidence about the spread of the *Perkinsus*-related mortality of abalone in NSW. 2. To describe the pathogenesis and make initial (Phase I) investigations of the epidemiology of the mortality of abalone, with particular reference to the role of *Perkinsus*. 3. To contribute to the development of strategies to manage populations of abalone that have, or might be, affected by *Perkinsus*-related mortality and, in particular, evaluate the need for a second phase of research. |
| Outputs | * Evidence of abalone mortality events and their locations was collected through interviews with divers. * Depletion of abalone stocks before and after mortality events was estimated using interviews with divers, fishery-dependent catch and effort data from the fishery and fishery-independent survey data. * A broad-scale survey of the prevalence and intensity of *Perkinsus* infections in abalone and related analyses. The survey provided direct evidence that *Perkinsus sp*. and specifically, *P. olseni*, is pathogenic to blacklip abalone in NSW. * A variant of *Perkinsus*, genetically different to *P. olseni*, was identified at several survey sites, suggesting that a previously undescribed species of *Perkinsus* or a different strain of *P. olseni* was present. * Investigations of the epizootiology of perkinsosis and associated mortalities of abalone were undertaken. * Amongst a range of alternative hypotheses concerning the cause of the mortality events during the 1990s, the most likely cause was found to be *Perkinsus*, in combination with water temperature above some threshold and possibly an additional unidentified factor. * Options for management of abalone and fisheries in NSW were developed based on knowledge of the geographic distribution of *Perkinsus sp.*, pathogenesis and epizootiology of *Perkinsus sp.* in NSW and findings from other studies locally and abroad. * The project identified a range of alternative management strategies to minimise risks of transmission of *Perkinsus* including closures to fishing, modifications to fishing practices, implementation of decontamination procedures, the need to review procedures used by abalone processors and prohibiting the distribution and use of abalone viscera as bait or burley. * Areas for further research were identified, such as identifying the geographic range of *Perkinsus*, how the disease progresses and causes death, the role water temperature plays in the transmission and further development of molecular assays for the identification of *Perkinsus* species. |
| Outcomes | * Evidence was provided that a precautionary approach should still be taken towards *Perkinsus*, despite no reports of mortalities from the disease since the mid-2000s (NSW DPI, 2012a). |
| Benefits | * Potential for decreased production losses in the event of future *Perkinsus* disease outbreaks in abalone. |

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| **Project 2004/086: Aquatic Animal Health Subprogram: identification and distribution of an intracellular ciliate in pearl oysters** | |
| Project details | Organisation: Murdoch University  Period: April 2005 to Jul 2008  Principal Investigator: Shane Raidal |
| Rationale | A parasite was detected in 2001 in Western Australian pearl oysters that previously had not been detected in the area. The parasite had the potential to cause mortalities in shell under 70mm, impede the movement of stock between fishing zones and affect the biosecurity of hatchery stock. Further investigation was warranted to formally identify the parasite, determine its effect on the oyster and other shellfish species in the area and determine whether it occurred in the wild piggyback spat in Zone 1. |
| Objectives | 1. To train a postgraduate in molluscan and aquatic animal health pathology. 2. To describe what the parasite is doing to the cells in the oyster including host-ciliate interactions and host specificity. 3. To survey other species of bivalves occurring within an affected farm, i.e. determine the site of the “index case”. 4. To survey piggyback spat collected from Zone 1 during the Department of Fisheries piggyback spat research project. 5. To formally describe the intracellular ciliate parasite, its ultrastructure, life cycle and giving it a scientific name. |
| Outputs | * The parasite was found to be a ciliate organism infecting the cytoplasm of digestive gland cells. * Preserved samples of Canadian mussels effected by intracellular ciliate were obtained and analysed, with the morphological characteristics proving to be almost identical to the Western Australian oyster ciliate. * Investigation into the pathology associated with the presence of ciliate in the oysters was carried out. A positive relationship between ciliate and the oyster’s inflammatory response of the digestive gland was found. * New methods for culturing pearl oyster cells were developed during attempts to culture the pear oyster ciliate in laboratory cell cultures. * Field trials were conducted where naïve spat was placed in pearl farm leases that had prior ciliate infections. * No intracellular ciliates were found in the *P. Maxima* oyster species. * Bivalve species from the same region were examined for health and parasites. Only one oyster from 345 bivalves surveyed was found to have the ciliate intracellular parasite. * From those bivalves surveyed one protozoal parasite was identified in a novel host bivalve species and a previously undescribed single celled organism was also discovered. * An experimental design for a cross infection trial using oysters in aquarium tanks at Murdoch University was completed. * Attempts to develop DNA-tests to detect the ciliate parasite were unsuccessful. * A DNA probe using the Ciliophora 16s ssu gene was developed. * There was little evidence to suggest that the infection on its own could cause significant rates of mortality or morbidity across commercial production. * It was suggested that the infection could potentially be significant if it were to become established in an artificial hatchery. |
| Outcomes | * The project assisted in training of a postgraduate in veterinary science molluscan pathology. The trained postgraduate has continued to pursue higher education in the Veterinary Pathology area. * The new technique developed for culturing pearl oysters cells can potentially be useful for other researchers. * Evidence from the project confirmed that the ciliate parasite has the potential to affect the productivity of bivalves, however damage was unlikely to be significant enough to interrupt commercial operations. * Improved information on which to base policy and regulations regarding stock movement between pearling zones in Western Australia. |
| Benefits | * Increased scientific capacity. |

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| **Project 2004/233: Abalone Aquaculture Subprogram: investigating the immunology of stressed abalone (Haliotis species)** | |
| Project details | Organisation: University of Melbourne  Period: June 2005 to Dec 2009  Principal Investigator: Rob Day |
| Rationale | Disease is a significant issue in abalone aquaculture, with the potential to have devastating effects on profits and industry viability. As a relatively new industry, little was known about the immune system of abalone. Improving knowledge surrounding abalone health and how the abalone protect themselves from disease had the potential to improve the productivity of the Australian industry. |
| Objectives | 1. To establish the best immunological parameters of abalone haemolymph (blood), and the best methods to use to measure immune function in abalone on abalone farms. 2. To determine the effects of normal farm stressors by monitoring the changes in immune function and histology (micro-structure of body tissues). 3. To establish a list of repeatable laboratory tests on abalone haemolymph and see if these indices correlate with the development of histological changes. |
| Outputs | * Small samples of blood were drawn from the abalone and used in assays that measure aspects of disease resistance. * Laboratory tests and on-farm assays were developed and trialled. The neutral red assay was found to be too sensitive and subjective for on-farm work. * Quantitative histology is required to detect stress damage, as normal abalone also have some damage. * Using the assays, experiments and monitoring were conducted to determine the effect of common stressors on abalone immune system defence. * An early response to all the stressors investigated was an increase in circulating blood cells (haemocytes), which subsided after a day. * Abalone severely affected by infectious disease (viral, parasitic, bacterial) have reduced circulating haemocytes. * Antibacterial activity was a useful measure of stress from all the factors studied, including mild stress from high density. * The farm noted that abalone mortality rose when farm staff moved them from one tank to another. * The most stressful component of movement for the abalone was a commonly used anaesthetic. This led to both reduced immune function (which can lead to bacterial disease outbreaks) and damage to the skin of the foot, which would allow bacterial infection. * Abalone were found to be affected by high temperatures only when the temperatures were severe (over 24 degrees C) or prolonged. This opens the possibility of selection of abalone more resistant to hot conditions. * Severe heat stress led to infiltration of haemocytes into the digestive gland and damage to the gills (which will allow bacterial infection). In contrast to stress from anaesthesia, phagocytosis increased for a short period. * It was considered likely that although the abalone showed some adjustment to heat stress, other factors such as reduced dissolved oxygen and increased numbers of bacteria in the warmer water also contributed to the increased mortality seen with warmer temperatures in summer. * Growth rates were suggested as a long term measure of permanent stress damage. |
| Outcomes | * Assays that are convenient to use on farm can be accessed by abalone farmers to monitor the health of the stock. * Some growers had sent staff to receive training on how to take haemolymph samples for assays and samples for histopathology processing. This has allowed more effective surveillance programs to be set up (Rob Day, pers. comm., 2013). * Biosecurity surveillance via Gribbles Pathology services commenced during the period of the project. At least 6 farms continue to send in haemolymph and/or tissue samples for routine checks or for directed investigation of health problems (Rob Day, pers. comm., 2013). * Work from the project was distributed to growers via workshops, reports and presentations. Responses from growers at the Abalone Growers Association workshop was favourable. * The results have shown farmers that tank hygiene is essential to reduce mortality during hot periods. * Research projects in France, South Australia and Tasmania have built on outputs from the project. |
| Benefits | * Increased yields for growers resulting from improved abalone health and avoided mortality. * Increased biosecurity resulting from methods to detect new disease early via sending samples for analysis. |

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| **Project 2005/074: Management of bioeroding sponges in wild stocks of Pinctada maxima in Western Australia** | |
| Project details | Organisation: Department of Fisheries Western Australia  Period: June 2005 to Oct 2008  Principal Investigator: Sabine Daume |
| Rationale | Bio-eroding sponges, or *Cliona* sp were found to be infesting wild stocks of Silver-lipped pearl oysters transferred to farms in WA and NT. Bio-eroding sponges have the potential to damage the shell of oysters and reduce pearl value. A hypothesis for the cause of these infestations was that previously unexploited niches were being created for *Clinoa* sp via industry harvesting and cleaning practices, allowing for populations to increase from what would occur naturally. |
| Objective | 1. To develop a field guide for identifying bioeroding sponges present in *Pinctada maxima*. 2. To develop sampling techniques for estimating the biomass and reproductive capacity of bioeroding sponges in pearl oyster shells and benthic substrate. 3. To estimate the effect of size/age, location, and time, on infection rates of bioeroding sponges in the wild stocks of *Pinctada maxima* for key fishing locations. 4. To establish a sponge infestation database, including both oysters and the habitat in which they live, for representative fishing grounds. 5. To evaluate management options to maintain the health of the wild stocks and ameliorate the economic impact of bioeroding sponge infestation on the industry. |
| Outputs | * Data was collected on infestation rates across age/size classes of shell from the main fishing grounds in North Western Australia over three consecutive fishing seasons. * Seven bioeroding sponge species were found in the samples collected. * Sponge infestations rates increased with size. Infestations were found to be minimal in smaller shells. * Infestations in calcareous substrates were estimated and compared on an area basis with shell infestations, including shell density and calcareous substrate density estimates of the fishing grounds. * Calcareous substrates were found to be at least two orders of magnitude more available than shell habitat. However, results indicate that bioeroding sponges may have a preference for pearl oyster shell. * Calcareous substrate was found less likely to contribute to spreading sponges than discarded large shells. * A relationship was found between the internal erosion volume of eroding sponge and the estimated eroded area on the surface of pearl oyster shells. * Techniques were developed in the project to estimate the volume of bioeroding sponge erosions in pearl oyster shells. The results were compared between sponge species and fishing grounds. * To demonstrate the appearance of bioeroding sponge infestations, a field guide was developed that could be used by industry and researchers to assess the grades of infestation. |
| Outcomes | * Researchers and farmers have the ability to visually assess for infestation of oysters using the field guide produced. * Potentially pearl farmers avoid infestations on farm through lowering the size of oysters collected from the wild. * Potentially data collected from the project are utilised to develop further management options. * No evidence could be found that outputs from the research were being used by the industry. |
| Benefits | * Limited direct benefits, however potential for a decrease in yield losses for pearl farmers through early recognition and mitigation of *Cliona* sp infection. |

|  |  |
| --- | --- |
| **Project 2005/076: QX resistant oyster challenge trial 2005-2006** | |
| Project details | Organisation: Department of Primary Industries (NSW)  Period: March 2005 to Oct 2007  Principal Investigator: Ian Lyall |
| Rationale | The commercial viability of the Hawkesbury River oyster industry was seriously threatened in 2004 when QX disease caused mass mortalities. Oyster farming in the Hawkesbury River is reliant on wild caught (QX susceptible) Sydney rock oyster (SRO) seed stock. An existing line of QX resistant SRO had been previously developed and tested experimentally in the Georges River by the NSW DPI. This resistant SRO could assist in maintaining the Hawkesbury River industry, however marketability and performance of the line in Hawkesbury River conditions was unknown. |
| Objectives | 1. To demonstrate under normal commercial practice the commercial viability of hatchery reared QX resistant Sydney rock oysters on QX disease affected oyster leases in the Hawkesbury River NSW. 2. To assist the uptake by Hawkesbury River oyster farmers of handling and growing technology. |
| Outputs | * QX resistant and control SRO were placed in three QX affected Hawkesbury River leases. They were exposed to two consecutive QX infections. * Survival, growth and marketable condition were maintained by the QX resistant SRO. * QX was not detected in the digestive gland of any of the oysters examined during meat condition assessments. * A majority of the QX resistant SRO was able to be sold on Hawkesbury River fattening leases at 24 months of age. This is significantly faster than the three to four years it took wild caught SRO to reach a premium market threshold prior to the QX infections. * Single seed oyster production technology was able to be demonstrated to farmers through working with NSW DPI staff during the project. * A QX disease and surveillance methodology was developed. |
| Outcomes | * Proof of performance, survival and marketability of the QX resistant SRO can assist in maintaining the viability of the Hawkesbury River oyster industry along with other SRO farmers in estuaries affected by QX, such as Botany Bay, Macleay River and Moreton Bay. * Participating Hawkesbury River farmers were able to quickly grasp the principles and techniques required to handle small hatchery produced oyster spat and adapt these principles to their growing conditions. * The developed disease and surveillance methodology can assist in future management of QX disease in the Hawkesbury River. * The uptake of the QX resistant SRO was limited by spat availability and the cost efficiency of producing the triploid pacific oysters (Ian Lyall, pers. comm., 2013), which after environmental impact assessments, were allowed to be imported from hatcheries in Tasmania. * Since this project ended, Hawkesbury River oyster producers have been subjected to Pacific Oyster Mortality Syndrome (POMS). The POMS outbreak in the Hawkesbury was detected in January 2013 and has caused significant mortalities of farmed and wild Pacific oysters (DPI NSW, 2013). * It is anticipated that since the outbreak of POMS, interest and production of QX resistant SRO is likely to increase in the Hawkesbury River estuary (Ian Lyall and Jane Clout pers. comm., 2013). |
| Benefits | * Decreased production losses and potentially avoided closure of QX affected southern rock oyster industries. |

|  |  |
| --- | --- |
| **Project 2006/062: Aquatic Animal Health Subprogram: identification of host interactions in the life-cycle of QX disease** | |
| Project details | Organisation: Queensland Museum  Period: August 2006 to July 2008  Principal Investigator: Robert Adlard |
| Rationale | QX disease has the potential to devastate affected oyster industries, as demonstrated by the 2004 outbreak in the Hawkesbury River estuary. Precautionary measures had been taken to control spread of the disease, mainly in the form of quarantine. It had become known that the organism causing QX disease, the protistan parasite *Marteilia sydneyi*, exists in most estuaries in which major rock oyster culture is undertaken even though many have not yet suffered from significant disease events. Limited data existed on the transmission and causative elements that actually combined to cause disease outbreaks. |
| Objectives | 1. To determine what members of the macrofauna contribute as intermediate hosts in the life-cycle of *Marteilia sydneyi*, agent of QX disease. 2. To identify and characterise previously unknown stages of *Marteilia sydneyi* through in-situ DNA probe hybridisation and histological examination. |
| Outputs | * Two lease areas in the Hawkesbury River where QX disease had been present since 2004 were used as study sites. * Random samples of bottom sediment grabs were collected, covering areas within and adjacent to existing oyster culture leases. The sediment was sieved to retain bottom dwelling invertebrates. * Segmented marine worms were the main species found within the sediment, with 21 different type of this species identified. Samples of each worm species were preserved for initial DNA screening of the presence of parasite DNA, and for DNA probe straining and confirmation of parasite development in alternate host tissues. * A total of 75 from 1,247 worms tested for *M. Sydneyi* were found to have the parasite DNA present. * The life-cycle of *Marteilia sydneyi* (the causative organism of QX in oysters) was found to require two hosts for its completion. * The marine bristle worm was found to be an alternate host for *M. sydneyi*. |
| Outcomes | * An increased understanding of the way in which the QX disease cycles. * The outputs from the project can potentially be used to develop an experimental model of infection for QX disease. * Results from the project have been publicised through television programs, newspaper articles and radio interviews and presented at scientific conferences. |
| Benefits | * Potentially future decreased production losses in QX affected oyster production due to the control of QX infections. |

|  |  |
| --- | --- |
| **Project 2006/064: Aquatic Animal Health Subprogram: development of diagnostic tests to assess the impact of Haplosporidium** | |
| Project details | Organisation: Murdoch University  Period: Sep 2006 to July 2009  Principal Investigator: Philip Nicholls |
| Rationale | Two exotic species of Haplosporidium (internal parasites of lower vertebrates and invertebrates that can infect bivalves) have been associated with significant mortality in the pearl oyster industry. Pearl oysters infected by undescribed Haplosporidium have occurred on three occasions. Precautionary measures were taken in these three cases through destroying all the pearl oysters of the infected batch. This project sought to address a lack of diagnostic tools and understanding on the parasite’s biology and pathology. |
| Objectives | 1. Complete DNA isolation and PCR amplification of material from previous WA outbreaks, with molecular identification of species. 2. Complete survey with DNA isolation and PCR amplification of material from spats deployed in, and/or collection of wild shell from various sites, including previous outbreak locations. 3. To determine whether the parasite is still present in the original outbreak sites and in other sites not historically affected by the deployment and assessment of spat in these locations. 4. To develop a means for the assessment of infectivity and pathogenicity using rock oysters and their endemic *Minchinia occulta* as a model. 5. Completion of a PhD thesis. |
| Outputs | * Over the course of the study, DNA was detected from a cryptic haplospordian parasite in rock oysters in the Montebello Islands in north-western Australia. * The DNA was sequenced allowing a phylogenetic analysis of the parasites and identification of the parasite as a *Minchinia* species (Haplosporidia). * Generated DNA sequences were also used to develop a series of assays to detect the parasite. The assays were assessed for specificity and sensitivity and used to compare the parasite to previous haplosporidian parasite infections of pearl oysters. * Two exotic parasites were formally described and named through electron microscopy analysis performed on spores. The parasites were named as *Haplosporidium hinei* and *Minchinia occulta.* * Data from the project suggested that pearl oysters were co-infected with *Haplosporidium hinei* and *Minchinia occulta.* * Samples of wild rock and pearl oysters were collected from the previous infection sites. All samples were found to be negative for both haplosporidium parasites. * Analysis was conducted of archived tropical oysters from Koolan Island in WA. Positive results were detected from these samples using the assays developed in the project and indicated the likely parasite was *Minchinia occulta*. * The parasite *Minchinia occulta* has in the past been linked with up 80% mortality in infected rock oysters, however samples from the project suggested that the parasite was not causing any mortalities. |
| Outcomes | * The project assisted in training a biologist in the field of molluscan pathology. * The biologist has since secured a position as a research scientist at CSIRO Marine & Atmospheric Research, and has held it since late 1998. * Results from the project were published in scientific journals and presented at the Virginia Institute of Marine Science (VIMS) and at the Paspaley Pearls Pty Ltd Research and Development forum. The work has been cited multiples times and is being built upon through other research (Philip Nicholls, pers. comm., 2013). * Pearl Oyster spat was deployed at Willie Creek (a site of previous infection) in Western Australia. No cases of infection had been reported at the time the final project report was written (2009). |
| Benefits | * Increased research and scientific capacity in the fisheries industry. |

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| --- | --- |
| **Project 2006/243: Aquatic Animal Health Subprogram: development of management strategies for herpes-like virus infection of abalone** | |
| Project details | Organisation: Department of Primary Industries (VIC)  Period: Nov 2006 to July 2008  Principal Investigator: Mehdi Doroudi |
| Rationale | Abalone Viral Ganglioneuritis or AVG, caused by abalone herpes-like virus (AbHV) has been responsible for mass mortalities in the abalone industry since being first detected on farms in Victoria in 2006. The virus was eventually detected in wild abalone populations in the vicinity of infected farms. Specific management strategies, which incorporate disease monitoring, detection, response and control measures, can be valuable in protecting both farmed and wild abalone stocks. |
| Objectives | 1. To develop a code of practice by improving physical, chemical and biological measures of biosecurity for abalone farms to prevent the introduction and spread of virus. 2. To develop a code of practice for commercial divers to avoid the introduction and further spread of virus in wild populations of abalone. 3. To develop a practical biosecurity program for abalone processing plants. |
| Outputs | * A literature search was conducted that reviewed the current information on molluscan viruses, with a focus on herpes type viruses and shellfish health management. * Pathways of transmission, vehicles of transmission and key risk issues were identified by the project team. * A risk assessment workshop was held and attended by an expert panel where key issues for all abalone sectors were assessed and prioritised. * The key issues for each sector of the industry were identified. * Control measures were developed given the issues identified and bearing in mind that knowledge on the virus was incomplete. * Consultation with industry saw the control measures developed into Codes of Practice, which consist of Standard Operating Procedures for each industry sector. * The Codes of Practice were produced as a stand-alone document to be disseminated to stakeholders. |
| Outcomes | * The outputs from this project prompted the development of a National emergency response plan for AVG (Mehdi Doroudi, pers. comm., 2013). * The project also provided the initial framework for the South Australian government AVG emergency response plan to AVG and also some industry specific plans. * The research also prompted further research work to develop PCR techniques for diagnosis of AVG (Project 2007/006, see below) (Mehdi Doroudi, pers. comm., 2013). |
| Benefits | * Avoided production losses with the adoption of procedures that minimise the risk of disease outbreaks or contain an AVG outbreak should it occur. * Increased sustainability of wild abalone stocks with procedures for containing AVG should an outbreak occur. |

|  |  |
| --- | --- |
| **Project 2007/006: Aquatic Animal Health Subprogram: Development of molecular diagnostic procedures for the detection and of herpes-like virus of abalone (Haliotis spp.)** | |
| Project details | Organisation: CSIRO Animal, Food and Health Services  Period: June 2007 to Oct 2008  Principal Investigator: Mark Crane |
| Rationale | Abalone Viral Ganglioneuritis (AVG), caused by abalone herpes-like virus (AbHV) has been responsible for mass mortalities in the abalone industry since being first detected on farms in Victoria in 2006.The disease later spread to wild abalone within the vicinity of infected farms. Attempts to eliminate the disease were met with failure, which was partly attributed to a lack of methods for detection of the aetiological agent that would allow for infected animals to be diagnosed. Molecular diagnostic tools are recognised as essential in the control and management of disease outbreaks. |
| Objectives | 1. To purify the herpes-like virus from infected abalone. 2. To extract, clone and sequence the entire viral genome and align it to the Ostreid herpesvirus-1 genome. 3. To develop a sensitive and specific PCR assay for detection and identification of abalone herpes virus. 4. To develop an in situ hybridisation assay specific for the abalone herpes virus. 5. To document a draft Australian and New Zealand Standard Diagnostic Procedure (ANZSDP) and submit for external review. |
| Outputs | * The herpes-like virus from infected abalone was concentrated and sequenced. * Greater than 90% of the herpes-like virus genome was sequenced and compared to Oyster herpesvirus-1, the only other known and sequenced herpes virus of molluscs. * The generated sequence allowed the development of a sensitive and specific polymerase chain reaction (PCR) assay for the detection and identification of abalone herpes-like virus. * An in-situ hybridisation (ISH) assay specifically for the herpes-like virus was also developed through the generated sequence. |
| Outcomes | * The tests were documented in a draft Australian and New Zealand Standard Diagnostic Procedure ready for external review. * The real-time PCR was transferred to diagnostic labs in Australia and New Zealand. It has become the preferred test detecting and identifying AbHV for surveillance programs and used for confirmatory diagnosis of AVG. * The real-time PCR has been used as the primary or confirmatory test for AVG in state diagnostic laboratories in Tasmania, Victoria, South Australia and Western Australia. * The tests can be used for identification of infected and uninfected stock, allowing for appropriate management measures to take place based on accurate information. * Reporting of herpes-like disease is required by the World Organisation for Animal Health (OIE). The tests can better ensure Australian authorities are reporting correct information to the OIE, international trading partners and other international agencies. * The work conducted in this project won the Victoria DPI science award for research. * Biosecurity between the states was significantly improved due to the availability of the tests. |
| Benefits | * Avoidance of production losses with the use of the developed diagnostic tests to appropriately diagnose and detect the herpes-like virus. * Increased sustainability of wild abalone stocks through early detection of AVG. * Increased scientific capacity to meet international biosecurity obligations. |

**Project Investment**

The following tables show the annual investment by project for both the FRDC (Table 2) and for researchers and other investors (Table 3). Table 4 provides the total investment by year from both sources.

Table 2: Investment by FRDC by Project for Years Ending June 2002 to June 2011 (nominal $)

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Project** | **2002** | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** | **Total** |
| 2002/200 | 20,868 | 62,828 | 0 | 0 | 12,210 | 8,434 | 0 | 0 | 0 | 0 | 104,340 |
| 2002/201 | 0 | 75,831 | 44,806 | 29,882 | 0 | 63,594 | 0 | 0 | 0 | 0 | 214,113 |
| 2003/220 | 0 | 0 | 97,341 | 0 | 82,002 | 0 | 0 | 13,616 | 7306.36 | 0 | 200,265 |
| 2004/080 | 0 | 0 | 0 | 16,620 | 7,771 | 0 | 0 | 0 | 0 | 0 | 24,391 |
| 2004/084 | 0 | 0 | 0 | 17,027 | 0 | 51,081 | 0 | 8,513 | 0 | 8,482 | 85,103 |
| 2004/086 | 0 | 0 | 0 | 0 | 98,176 | 0 | 0 | 0 | 12808.33 | 0 | 110,984 |
| 2004/233 | 0 | 0 | 0 | 0 | 14,282 | 17,357 | 0 | 8,624 | 15,189 | 6,195 | 61,647 |
| 2005/074 | 0 | 0 | 0 | 0 | 145,282 | 274,066 | 45,912 | 188,509 | 72640.8 | 0 | 726,409 |
| 2005/076 | 0 | 0 | 0 | 8,000 | 2,000 | 0 | 0 | 0 | 0 | 0 | 10,000 |
| 2006/062 | 0 | 0 | 0 | 0 | 0 | 31,677 | 30,735 | 18,236 | 8227.04 | 0 | 88,874 |
| 2006/064 | 0 | 0 | 0 | 0 | 0 | 86,220 | 12,956 | 34,541 | 0 | 0 | 76,452 |
| 2006/243 | 0 | 0 | 0 | 0 | 0 | 50,384 | 6298 | 0 | 6298 | 0 | 62,980 |
| 2007/006 | 0 | 0 | 0 | 0 | 0 | 48,884 | 63,665 | 143,212 | 88,371 | 0 | 344,133 |
| **Total** | **20,868** | **138,659** | **142,147** | **71,529** | **361,722** | **631,697** | **159,565** | **415,250** | **210,841** | **14,677** | 2,109,691 |

Source: FRDC project management database

Table 3: Investment by Researchers and Others by Project for Years Ending June 2002 to June 2011 (nominal $)

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Project** | **2002** | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** | **Total** |
| 2002/200 | 33,403 | 16,702 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 50,105 |
| 2002/201 | 0 | 152,003 | 137,193 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 289,196 |
| 2003/220 | 0 | 0 | 97,621 | 97,621 | 97,621 | 0 | 0 | 0 | 0 | 0 | 292,863 |
| 2004/080 | 0 | 0 | 0 | 75,697 | 2,671 | 0 | 0 | 0 | 0 | 0 | 78,368 |
| 2004/084 | 0 | 0 | 0 | 120,000 | 0 | 0 | 0 | 0 | 0 | 0 | 120,000 |
| 2004/086 | 0 | 0 | 0 | 88,714 | 80,616 | 79,356 | 0 | 0 | 0 | 0 | 248,686 |
| 2004/233 | 0 | 0 | 0 | 57,474 | 72,592 | 77,714 | 57,714 | 0 | 0 | 0 | 265,494 |
| 2005/074 | 0 | 0 | 0 | 0 | 150,673 | 153,233 | 154,189 | 0 | 0 | 0 | 458,095 |
| 2005/076 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2006/062 | 0 | 0 | 0 | 0 | 0 | 18,022 | 12,079 | 0 | 0 | 0 | 30,101 |
| 2006/064 | 0 | 0 | 0 | 0 | 0 | 87,825 | 86,825 | 85,825 | 0 | 0 | 260,475 |
| 2006/243 | 0 | 0 | 0 | 0 | 0 | 7,450 | 0 | 0 | 0 | 0 | 7,450 |
| 2007/006 | 0 | 0 | 0 | 0 | 0 | 62,408 | 111,971 | 0 | 0 | 0 | 174,379 |
| **Total** | **33,403** | **168,705** | **234,814** | **439,506** | **404,173** | **486,008** | **422,778** | **85,825** | 0 | 0 | **2,275,212** |

Source: FRDC project management database

Table 4: Annual Investment in Cluster (nominal $)

|  |  |  |  |
| --- | --- | --- | --- |
| **Year ending June** | **FRDC** | **Researchers and Others** | **Total** |
| 2002 | 20,868 | 33,403 | 54,271 |
| 2003 | 138,659 | 168,705 | 307,364 |
| 2004 | 142,147 | 234,814 | 376,961 |
| 2005 | 71,529 | 439,506 | 511,035 |
| 2006 | 361,722 | 404,173 | 765,895 |
| 2007 | 594,773 | 486,008 | 1,080,781 |
| 2008 | 154,017 | 422,778 | 576,795 |
| 2009 | 400,458 | 85,825 | 486,283 |
| 2010 | 210,841 | - | 210,841 |
| 2011 | 14,677 | - | 14,677 |
| **Total** | 2,109,691 | 2,275,212 | 4,384,903 |

**Benefits**

The various projects and studies undergone in this cluster have helped generate a number of actual and potential economic, environmental and social benefits. Table 5 summarises the major benefits by category delivered by each of the projects.

Table 5: Type of Benefit Delivered by Projects

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Project** | **Benefit Category** | | | | | |
| Increased yield/avoided yield loss | Avoided restriction on aquaculture expansion | Reduced production costs | Enhanced sustainability of fisheries and ecosystems | Increased scientific capacity | Increased industry capacity to be prepared for disease outbreaks |
| 2002/200 |  |  |  |  |  |  |
| 2002/201 |  |  |  |  |  |  |
| 2003/220 |  |  |  |  |  |  |
| 2004/080 |  |  |  |  |  |  |
| 2004/084 |  |  |  |  |  |  |
| 2004/086 |  |  |  |  |  |  |
| 2004/233 |  |  |  |  |  |  |
| 2005/074 |  |  |  |  |  |  |
| 2005/076 |  |  |  |  |  |  |
| 2006/062 |  |  |  |  |  |  |
| 2006/064 |  |  |  |  |  |  |
| 2006/243 |  |  |  |  |  |  |
| 2007/006 |  |  |  |  |  |  |
| Frequency | 8 | 1 | 3 | 4 | 4 | 3 |

**Summary of Benefits**

Table 6 provides in a triple bottom line framework a summary of the principal types of benefits associated with the outcomes of the investment.

Table 6: Summary of Benefits in a Triple Bottom Line Framework

|  |  |  |
| --- | --- | --- |
| **Industry** | **Environmental** | **Social** |
| 1. Increased yields/avoided yield loss | 6. Enhanced sustainability of ecosystems and the environment | 7. Increased technical and scientific capacity |
| 2. Avoided restriction on aquaculture expansion |  |  |
| 3. Decreased production costs |  |  |
| 4. Increased technical and scientific capacity |  |  |
| 5. Increased industry capacity to be prepared for disease outbreaks |  |  |

The benefits identified above have been classified into subjective beneficiary categories and a subjective estimate of their magnitudes is provided in Table 7. Benefit numbers in Table 7 refer to the benefit numbers in Table 6.

Table 7: Categories of Benefits from the Investment

|  |  |  |  |
| --- | --- | --- | --- |
| **Fishing industry** | **Spillovers** | | |
| **Other industries** | **Public** | **Overseas** |
| 1. \*\*\*  2. \*\*  3. \*\*  4. \*  5. \*\* |  | 4. \*  6. \*\*  7. \* | 4. \* |

\*\*\* Major contribution \*\* Some contribution \* Minor contribution

**Public versus Private Benefits**

Both private and public benefits will arise from the investment. On the basis of the distribution of the eight benefits to Australia listed in Table 7, and equal weighting for each benefit, it could be concluded that public benefits to Australia could make up 38% of the total benefits. If the subjective weightings are taken into account, the public benefits would still make up about 27% of the total benefits.

**Distribution of Benefits Along the Supply Chain**

The direct beneficiaries of the projects are likely to be producers mainly through diagnosis and prevention of disease and subsequent avoided production losses. However some of the benefits accruing to producers are likely to be captured along the supply chain including by consumers.

**Benefits to Other Industries**

It is unlikely that benefits will accrue to industries beyond the fisheries industry.

**Benefits Overseas**

Outputs from some of the projects have been used in overseas research. Overseas producers and consumers may therefore benefit from technical and scientific capacity created from the investments.

**Additionality and Marginality**

The projects within the cluster relate to threats of disease and biosecurity which have the potential to force closure of production and have implications for the health of other aquatic species. Therefore the investments within this cluster have been categorised as high priority. It is likely that the projects still would have been funded if public funding was not available, but at a lesser scale. Further detail is provided in Table 8.

Table 8: Potential Response to Reduced Public Funding to FRDC

|  |  |
| --- | --- |
| What priority were the projects in this cluster when funded? | High |
| Would FRDC have funded this cluster if only half of public funding of FRDC had been available? | Yes, but with a lesser total investment (75% -100%) of actual total investment. |
| Would the cluster have been funded if no public funding for FRDC had been available? | Yes, but with a lesser total investment (50%-75%) of actual total investment |

**Match with National Priorities**

The Australian Government’s national and rural R&D priorities are reproduced in Table 9.

Table 9: National and Rural R&D Research Priorities

|  |  |
| --- | --- |
| **Australian Government** | |
| **National Research Priorities** | **Rural Research Priorities** |
| 1. An environmentally sustainable Australia  2. Promoting and maintaining good health  3. Frontier technologies for building and transforming Australian industries  4. Safeguarding Australia | 1.Productivity and adding value  2. Supply chain and markets  3. Natural resource management  4.Climate variability and climate change  5. Biosecurity  *Supporting the priorities:*  1. Innovation skills  2. Technology |

The cluster contributes directly to National Research Priorities 1, 3 and 4. The cluster investment was strongly associated with Rural Research Priorities 1, 3 and 5. Both supporting priorities were also addressed.

**Quantification of Benefits**

**Benefits Valued**

Three separate benefits are valued**:**

* Decreased yield losses for abalone
* Decreased yield losses in meat oysters
* Avoided restriction on expansion of the YTK aquaculture industry

**Benefits not Valued**

The following benefits were not valued:

* Increased technical and scientific capacity
* Increased industry capacity to be prepared for future disease outbreaks
* Enhanced sustainability of ecosystems and the environment

The above benefits were not valued due to difficulties in valuation or a perceived weak linkage between projects and their impact. Some of the above benefits were also envisaged to have a small or insignificant impact. Elements of increased industry capacity and decreased production costs were valued in the benefits of decreased yield loss in abalone.

***Decreased yield loss in abalone***

Several projects within the cluster addressed abalone health. Difficulties surround quantitatively assessing the impact of some of the investments, given that they are often made in response to major disease outbreaks that have already occurred (e.g. AVG or *Perkinsus*) and involve protocols, management options for prevention and diagnostic tools that may benefit the future should another outbreak of the relevant disease occur. AVG and *Perkinsus* have both been associated with 90% mortality rates (DPI NSW, 2012b and Liggins and Upston, 2010). However, these high incidences of mortality rates have not occurred regularly. *Perkinsus* related moralities for instance have not been reported since the mid-2000s (DPI NSW, 2012a), with the last major outbreak (associated with high 90% mortality rates) being recorded in 2002. A conservative estimate of yield loss is assumed of 5% that may be avoided per annum. Estimates of 5% yield gain were found from adoption of practices from Project 2004/233which addressed heat and movement stress of abalone (Rob Day, pers. comm., 2013). The proportion of the industry to which the benefit can be applied is uncertain, given that not all parts of the industry may be affected by a disease incident and that some may adopt other management practices developed to prevent mortalities. The benefit is applied to 20% of abalone production and the assumption subject to sensitivity analysis. Table 11 summarises assumptions used in valuing this benefit.

***Decreased yield loss in meat oysters***

The analysis has restricted the benefits to the Hawkesbury River estuary, as this is focus of the main benefit from the contributing project (Project 2005/076). Although other QX affected estuaries could benefit from this project, difficulties surround quantifying such an impact due to data constraints and attribution considerations. The projects within this cluster contributed to proving the viability of producing and marketing the QX resistant strain and also provided understanding on the hosts of the QX disease.

This benefit can be split into two parts. The first is for early adoption of QX resistant SRO, that is, between the periods of 2007 to 2013. To date, production of QX resistant SRO in the Hawkesbury has not been significant. This can be attributed partially to supply of QX resistant SRO spat and the relatively high returns that were gained from switching to the triploid pacific oyster variety after the 2005 QX outbreak. Approval was given to Hawkesbury River farmers to import and cultivate triploid pacific oysters from Tasmanian commercial hatcheries (Nell, et. al 2007). QX resistant SRO production was unaffected by the 2013 outbreak of POMS. It is assumed that the small amount of Sydney Rock Oyster produced in the Hawkesbury after the QX outbreak, was from the QX resistant strain. Table 12 provides specific data on the price and quantity of SRO production between 2009 and 2013. A period of two years to grow out QX resistant SRO spat is used in measurement of the benefit.

The second benefit is the future adoption QX resistant SRO. With the arrival of POMS and its impact on Pacific Oysters, it is likely that QX resistant SRO production will substantially increase in the Hawkesbury River (Ian Lyall and Jane Clout, pers. comm., 2013). It is assumed that a proportion of Hawkesbury River oyster production can be rebuilt from the QX resistant SRO strain over the period of 2013 to 2023. An estimate of this proportion is given as 50%. The amount of production rebuilt after the 2013 POMS outbreak is estimated to reach a total of 300,000 dozens per annum over a 10 period, based on the approximate amount of production (SRO and Triploid Pacific Oysters) that has occurred over 2009-2012 (See Tables 12 and 13). The maximum benefit of QX resistant SRO is assumed to last until 2023 after which point it is assumed that a POMS resistant Pacific oyster will be available for commercial production (Oysters Australia, 2013). The faster growing Pacific oyster variety is assumed to curtail production of QX resistant SRO in subsequent years. General assumptions regarding this benefit can be found in Table 11. Specific price and quantity assumptions are based on currently available data from NSW DPI (various years) and are provided in Table 12.

***Benefit 3: Avoided restriction on expansion of the YTK aquaculture industry***

Without the research investment in this cluster, it is possible that the size of the Yellowtail Kingfish industry could have been capped artificially low, due to the absence of appropriate scientific data on the threat of parasites from farmed YTK escaping to the environment. Project 2003/220 contributed knowledge relevant to improved management of parasites. How much the industry might have been capped in the absence of this project is an uncertain variable. Expansion of the industry may have faced restrictions through the perceptions of poorly managed aquaculture having an influence on wildstocks or through lack of producer knowledge regarding parasite risks and management.

The recent large scale reductions for 2013/14 YTK production were caused in response to health and nutrition related mortalities (Seafood CRC, 2013), however it is anticipated that production levels will reach 3,000 tonnes (as it has in previous years) within the next five years (Cleanseas, 2013). By comparison any scale-back or restriction of expansion of the industry in response to the parasites examined in Project 2003/220 is anticipated to be small. The value of the project is measured by assuming it made a small contribution to the size and thus value of the industry.

**Summary of Assumptions**

A summary of the key assumptions made is shown in Table 11.

Table 11: Summary of Assumptions

|  |  |  |
| --- | --- | --- |
| **Variable** | **Assumption** | **Source** |
| ***Benefit 1: Decreased production losses in abalone*** | | |
| Abalone farmgate price | $36,000/tonne | ABARES (2012 and 2011) 5 year average 2007-2011 |
| Abalone production tonnes per annum | 5,004 tonnes per annum | ABARES (2012 and 2011) 5 year average 2007-2011 |
| Avoided yield loss | 5% | Agtrans Research |
| Applicable proportion of industry | 20% | Agtrans Research |
| First year of benefits | 2010 | Agtrans Research, assuming high impact projects’ information output will start influencing investment decisions from its 2010 completion. |
| Time to maximum benefits | 10 years | Agtrans Research |
| ***Benefit 2: Reduced production losses from QX disease in Sydney Rock Oysters*** | | |
| Applicable area of production | New South Wales Hawkesbury estuary | Agtrans Research based on Nell et al. (2007) |
| Time to fully grow and sell SRO from spat | 2 years | Nell et al. (2007) |
| Attribution | 10% | Agtrans Research, based on a subjective estimate of the project’s contribution to the benefit relative to other contributing investments |
| *Benefit 2a: Early adoption of QX resistant SRO* | | |
| Production and value of SRO pre 2013 | See Table 12 | DPI NSW (2009-2012) |
| First year of benefits | 2009 | Agtrans Research, based on the two year time period to grow oysters to market size and assuming project information output will start influencing investment decisions from project completion. |
| Last year of benefits | 2014 | Agtrans Research, based on year before increased production begins in response to POMS outbreak |
| *Benefit 2a: Future adoption of QX resistant SRO* | | |
| Weighted average price per dozen of SRO | $7.25 | Weighted average based on average data from Table 12 below. |
| Potential production in estuary | 300,000 dozens of oysters per annum | Agtrans Research, based on Hawkesbury oyster production over 2009-2012 from DPI NSW (2009-2012). See Tables 12 and 13. |
| Time to reach maximum of production potential (300,000 dozens) | 10 years from 2015 (2 years after POMS outbreak) | Agtrans Research |
| Anticipated release of POMS resistant Pacific Oyster spat | 2021 | Based on 8 years from 2013 (Oysters Australia, 2013) |
| POMS resistant oyster production begins, curtailing benefit from QX resistant SRO Lines | 2023 | Agtrans Research, based on two years after release of POMS resistant oyster spat |
| Proportion of potential production rebuilt with QX resistant SRO | 50% up to 2023 after which proportion of total production reduces to 20% over 5 years | Agtrans Research |
| ***Benefit 3: Avoided restriction on expansion of the YTK aquaculture industry*** | | |
| Farm gate price | $11.15 /kg | ERA (2009) |
| Average production per annum | 3,000 tonnes per annum | Seafood CRC (2013) |
| Proportion of revenue that is profit | 20% | Agtrans Research based on Cleanseas (2013) |
| Project’s contribution to current average production | 1% | Agtrans Research |
| First year of benefits | 2008 | Agtrans Research, based on one year after the project’s completion |

Table 12: Production of Sydney Rock Oysters 2009-2012

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Year** | **2009** | **2010** | **2011** | **2012** | **Average** |
| *Plate grade dozens* | | | | | |
| Quantity (dozens) | 2,900 | 3,926 | 3,428 | 274 | **2,632** |
| % of total dozens | 54% | 59% | 51% | 16% | **45%** |
| Farmgate Value $ | 23,258 | 32,429 | 28,898 | 2,362 | **21,737** |
| Price per dozen $ | 8.02 | 8.26 | 8.43 | 8.62 | **8.33** |
| *Bistro grade dozens* | | | | | |
| Quantity (dozens) | 2,175 | 2,724 | 3,327 | 1,398 | **2,406** |
| % of total dozens | 40% | 41% | 49% | 84% | **54%** |
| Farmgate Value $ | 13,485 | 17,461 | 21,459 | 9,255 | **15,415** |
| Price per dozen $ | 6.20 | 6.41 | 6.45 | 6.62 | **6.42** |
| *Bottle grade dozens* | | | | | |
| Quantity (dozens) | 300 | 0 | 0 | 0 | **75** |
| % of total dozens | 0.06 | 0 | 0 | 0 | **0.01** |
| Farmgate Value $ | 1320 |  |  |  | **1,320** |
| Price per dozen $ | 4.40 |  |  |  | **4.40** |
| **Total Quantity (dozens)** | 5,375 | 6,650 | 6,755 | 1,672 | **5,113** |
| **Total value $** | 40,810 | 51,875 | 51,574 | 11,617 | **37,482** |

*Source: DPI NSW (2009-2012)*

Table 13: Production of Triploid Pacific Oysters 2009-2012

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Year** | **2009** | **2010** | **2011** | **2012** | **Average** |
| **Total Quantity (dozens)** | 264,794 | 300,875 | 296,620 | 274,181 | **284,118** |

*Source: DPI NSW (2009-2012)*

**Results**

All past costs and benefits were expressed in 2013/2014 dollar terms using the CPI. All benefits after 2013/2014 were expressed in 2013/2014 dollar terms. All costs and benefits were discounted to 2013/2014 using a discount rate of 5%. The base run used the best estimates of each variable, notwithstanding a high level of uncertainty for many of the estimates. Investment criteria were estimated for both total investment and for the FRDC investment alone. All ana\*lyses ran for the length of the investment period plus 30 years from the last year of investment (2010/2011) to the final year of benefits assumed*.*

Tables 14 and 15 show the investment criteria for the different periods of benefits for both the total investment and the FRDC investment.

Table 14: Investment Criteria for Total Investment

(discount rate 5%)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Years** | **0** | **5** | **10** | **15** | **20** | **25** | **30** |
| Present value of benefits ($m) | 0.49 | 5.78 | 12.87 | 18.82 | 23.43 | 27.04 | 29.87 |
| Present value of costs ($m) | 7.80 | 7.80 | 7.80 | 7.80 | 7.80 | 7.80 | 7.80 |
| Net present value ($m) | -7.31 | -2.02 | 5.07 | 11.02 | 15.63 | 19.24 | 22.07 |
| Benefit cost ratio | 0.06 | 0.74 | 1.65 | 2.41 | 3.00 | 3.47 | 3.83 |
| Internal rate of return (%) | Negative | 0.8 | 10.3 | 12.9 | 13.9 | 14.3 | 14.5 |

Table 15: Investment Criteria for FRDC Investment

(discount rate 5%)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Years** | **0** | **5** | **10** | **15** | **20** | **25** | **30** |
| Present value of benefits ($m) | 0.47 | 2.73 | 6.08 | 8.90 | 11.07 | 12.78 | 14.12 |
| Present value of costs ($m) | 3.61 | 3.61 | 3.61 | 3.61 | 3.61 | 3.61 | 3.61 |
| Net present value ($m) | -3.14 | -0.88 | 2.47 | 5.29 | 7.46 | 9.17 | 10.51 |
| Benefit cost ratio | 0.13 | 0.76 | 1.69 | 2.46 | 3.07 | 3.54 | 3.91 |
| Internal rate of return (%) | Negative | 0.8 | 10.8 | 13.5 | 14.4 | 14.9 | 15.0 |

The annual cash flow of undiscounted benefits is shown in Figure 1 for both the total investment and for the FRDC investment.

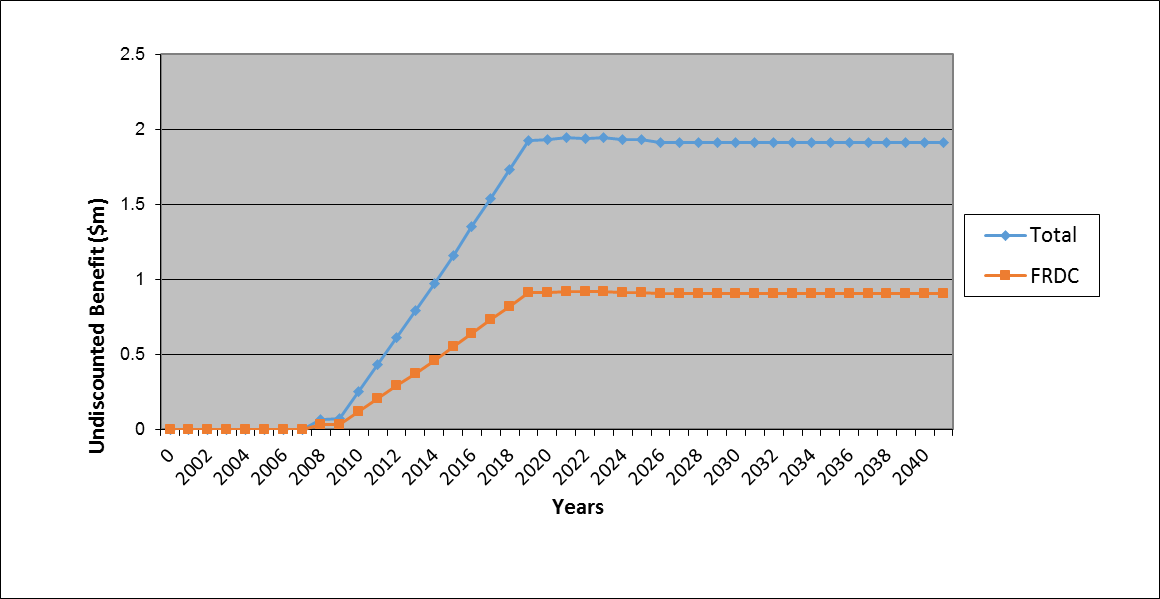


Figure 1: Annual Cash Flow of Benefits

The present value of benefits (PVB) from each source of benefits was estimated separately and then summed to provide an estimate of the total value of benefits. Table 16 shows the sources of benefits, expressed as the PVB and the percentage of total benefits.

Table 16: Source of Benefits (discount rate 5%, 30 year period)

|  |  |  |
| --- | --- | --- |
| **Benefit** | **PVB**  **($m)** | **% Total** |
| Avoided yield loss in abalone | 27.63 | 93 |
| Avoided yield loss in meat oysters | 0.71 | 2 |
| Avoided restriction on expansion of the YTK aquaculture industry | 1.52 | 5 |
| Total | 29.87 | 100 |

Table 17 shows a subjective assessment of the different benefits against the rural research priorities. Bear in mind that this assessment refers only to those benefits that were valued.

Table 17: Benefits Valued and Rural Research Priorities

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Benefit** | **PVB**  **($m)** | **Productivity and Adding Value** | **Supply Chain and Markets** | **Natural Resource Management** | **Climate Variability and Climate Change** | **Biosecurity** |
| % subjective allocation to each priority | | | | |
| Avoided yield loss in abalone | 27.63 | 50 | 0 | 0 | 0 | 50 |
| Avoided yield loss in meat oysters | 0.71 | 100 | 0 | 0 | 0 | 0 |
| Avoided restriction on expansion of the YTK aquaculture industry | 1.52 | 90 | 0 | 10 | 0 | 0 |
| Total $(m) | 29.87 | 15.89 | 0 | 0.15 | 0 | 13.82 |

**Sensitivity Analyses**

The sensitivity analysis on the discount rate (Table 18) demonstrates that the investment criteria are only moderately sensitive to the discount rate over the range considered.

Table 18: Sensitivity to Discount Rate

(Total investment, 30 years)

|  |  |  |  |
| --- | --- | --- | --- |
| **Criterion** | **Discount Rate** | | |
| **0%** | **5%** | **10%** |
| Present value of benefits (m$) | 53.11 | 29.87 | 19.94 |
| Present value of costs (m$) | 5.36 | 7.80 | 11.25 |
| Net present value (m$) | 47.75 | 22.07 | 8.69 |
| Benefit cost ratio | 9.91 | 3.83 | 1.77 |

The benefit of avoiding yield loss in abalone made up a significant amount of the benefits valued (93%), as shown in Table 16 above. Table 19 and 20 show the sensitivity of the investment criteria to two uncertain variables associated with this benefit. First, to the assumed avoided yield loss and second, to the proportion of the abalone assumed to be avoiding that yield loss.

Table 19: Sensitivity to Avoided Yield Loss in the Abalone Industry

(Total investment, 30 years)

|  |  |  |  |
| --- | --- | --- | --- |
| **Criterion** | **Avoided Yield Loss** | | |
| **2.5%** | **5% (base)** | **7.5%** |
| Present value of benefits (m$) | 16.05 | 29.87 | 43.68 |
| Present value of costs (m$) | 7.80 | 7.80 | 7.80 |
| Net present value (m$) | 8.25 | 22.07 | 35.88 |
| Benefit cost ratio | 2.06 | 3.83 | 5.60 |

Table 20: Sensitivity to Proportion of Abalone Industry Avoiding a 5% Yield Loss

(Total investment, 30 years)

|  |  |  |  |
| --- | --- | --- | --- |
| **Criterion** | **Proportion of Abalone Industry** | | |
| **10%** | **20% (base)** | **40%** |
| Present value of benefits (m$) | 16.05 | 29.87 | 57.50 |
| Present value of costs (m$) | 7.80 | 7.80 | 7.80 |
| Net present value (m$) | 8.25 | 22.07 | 49.70 |
| Benefit cost ratio | 2.06 | 3.83 | 7.37 |

**Confidence Rating**

The results produced are highly dependent on the assumptions made, many of which are uncertain. There are two factors that warrant recognition. The first factor is the coverage of benefits. Where there are multiple types of benefits it is often not possible to quantify all the benefits that may be linked to the investment. The second factor involves uncertainty regarding the assumptions made, including the linkage between the research and the assumed outcomes.

A confidence rating based on these two factors has been given to the results of the investment analysis (Table 21). The rating categories used are High, Medium and Low, where:

High: denotes a good coverage of benefits or reasonable confidence in the assumptions made

Medium: denotes only a reasonable coverage of benefits or some uncertainties in assumptions made

Low: denotes a poor coverage of benefits or many uncertainties in assumptions made

Table 21: Confidence in Analysis of Cluster

|  |  |
| --- | --- |
| **Coverage of Benefits** | **Confidence in Assumptions** |
| Medium | Low |

**Observations for Future Investment and Evaluation**

Observations for future investment and evaluation include:

1. It would be of value to economic assessments such as this if industry information on disease costs, including treatment, mortality, and productivity losses could be monitored more comprehensively over time. As well as aiding evaluation of past research, such information may be useful in priority setting for future research investment. Also, as aquaculture industries are growing in importance, it would be helpful to evaluation if representative gross margin budgets could be compiled for the various aquaculture industries.

2. Some difficulties were found in contacting relevant personnel to verify impacts of selected projects. This created time lags in completing evaluations and lessened the degree of confidence in assumptions.

The number of projects in the cluster that contribute to the two Theme 1 key performance indicators (KPIs) is shown in Table 22.

Table 22: Key Performance Indicators for Theme 1

|  |  |  |
| --- | --- | --- |
| **KPI** | **Description** | **Number of projects contributing** |
| 1 | Development and dissemination of protocols, techniques and technologies to mitigate and minimise the impact of disease outbreaks. | 13 |
| 2 | Development of knowledge to assist industry to register vaccines and veterinary chemicals. | 0 |

**Conclusions**

In general the outputs from projects were not always immediately usable, however significant scientific capacity and industry preparedness have been built by many of the projects. In some respects this has made for difficulties in quantifying benefits from the cluster, due to various assumptions that would have to be made regarding future disease incursions and difficulties in linking projects with impacts.

Of the 13 projects within this cluster, 7 were relevant to abalone, 3 to pearl oysters, 2 to meat oysters and one was relevant to Yellow Tail Kingfish. Although the cluster included multiple species, abalone projects largely dominated the cluster in terms of the number of projects. To gain coverage across the different species it was necessary to evaluate some projects (such as the only one applicable to YTK) almost individually. The species are also vastly different in terms of production and the diseases affecting them so this did not allow for easy grouping for the purposes of quantification of benefits.

The principal benefits from the cluster largely focussed on attempting to avoid yield losses through protocols, diagnostic techniques and increased understanding of disease and general health. Three impacts were valued from the investment in this group of projects. A majority of the benefits stemmed from the investments were from the abalone projects, contributing to 93% of the total benefits valued. Some benefits were not quantified due to difficulty in valuing or linking impacts to the project. For this reason the resulting investment criteria could be viewed as conservative. Also, there was considerable industry and scientific capacity built for future disease management initiatives but only a part of this was valued.

Total funding from all sources for the 13 projects in the cluster totalled $7.80 million (present value terms). This investment was estimated to produce aggregate total benefits of $29.87 million (present value terms). The project group produced a benefit cost ratio of 3.83 to 1.

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