Animal production research for the shellfish aquaculture industry

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ABSTRACT

Aquaculture is a globally significant food production industry. Aquaculture in New Zealand has grown rapidly over the past decade, and it is widely considered as an area of significant growth potential within the country's economy. The mussel industry is the biggest sector, followed by salmon, oyster and paua. The Mussel Industry Council has a Sextant database that allows continuous interactive planning among all stakeholders and demonstrates the crucial role of R&D in the realisation of strategic goals. The industry is expected to grow at 7% pa within the next decade. This growth will require new animal production activities such as hatchery spat production, selective breeding and husbandry for animal health and condition. These activities will be based on R&D outputs such as the ability to condition broodstock, cost-effective methods for early spat rearing, and methods for the cryopreservation of gametes and embryos. To achieve these outputs, the industry supports research on the biology, ecology and genetics of the mussel, hatchery and nursery technology, shellfish selective breeding and cryopreservation, stress and disease physiology. New areas of research on shellfish production provide opportunities for the application of generic animal production expertise.

Keywords: aquaculture; Greenshell™ mussel; spat production; selective breeding; animal health.

INTRODUCTION

Aquaculture has been the world's fastest growing source of food for nearly 20 years. In 1997, global aquaculture production was 36 million metric tons worth US$50 billion. New Zealand aquaculture exports grew from $25 million in 1989 to $170 million in 1999 and are expected to exceed $500 million by 2010.

The major species farmed in New Zealand are Greenshell™ mussel, Chinook salmon, Pacific oyster and Blackfoot paua. Mussel aquaculture is the biggest sector of the industry. It is well organised and known for its forward-looking attitude. This paper will focus on the mussel industry as an example of a new industry offering opportunities for input by R&D expertise in animal production. Some of these opportunities are already being realised in other parts of the aquaculture industry; for example the salmon industry is using selective breeding expertise developed in the sheep and cattle industry.

The Foresight exercise (MRST, 1998) encouraged all sectors of the New Zealand economy to plan for the future and to pay particular attention to the contribution of science and technology towards the realisation of the plans. One major result of this massive planning exercise was a complete re-organisation of the Government's investment in RS&T (Webb, 1999).

The mussel industry has bought into the Foresight approach to strategic planning and produced its own Foresight strategy (Lupi, 1998). It has gone further than most industries by following up on this document with a database which serves as an interactive planning tool for all stakeholders of the industry (Sextant: www.sextant.co.nz). This paper is largely based on information available in this database.

A simple model of the industry development process

The principles of Foresight (MRST, 1998) lead to a simple model of the general process of industrial development that is assisted by R&D. The first box of the model describes the expected **socio-economic benefits** of an industry to New Zealand. The second box contains the **industrial applications** and processes required to achieve the benefits. The third box describes the **R&D outputs** required to implement the applications. The fourth box lists the **R&D activities** required to generate the R&D outputs.

Although it is generally "against the grain" to think back from the future to the present, this paper will follow this path, leading from expected benefits back to research activities which are required now, in order to obtain the future benefits. Thus the paper will end with examples of animal production research currently required by the mussel industry.

Benefits of the mussel industry to New Zealand

The people of New Zealand expect the mussel industry to become a nationally significant, prosperous industry. This means that the industry generates significant export earnings and is a significant employer, particularly in rural areas.

To achieve this goal, the industry has to attain financial stability and sustainability. This will be achieved through success in high-value markets. The industry will offer high quality products that command markedly higher prices than commodity products from other producers. The industry will offer a range of products that is balanced so that the crop can always be optimally processed and sold. The supply of these products will be reliable.

To fulfil the expectations of the country, the industry will also need to attain stability and sustainability of its resources. This includes the workforce, the technology applied by the industry, the environment in which the crop is grown and processed, and the animal itself.

The following sections will focus on major elements of success relating to animal production: the animal itself; technology; product quality, quantity and supply.

The current industry and its growth potential

This section is largely based on the Foresight Strategy

of the NZ Mussel Industry Council Ltd. (Lupi, 1998) and a recent economic study of the mussel industry (Donnelly and Associates, 1999).

Table 1 describes the size of the industry in 1985 and 1997 and gives a likely size for the year 2010:

TABLE 1: Growth of the mussel industry in New Zealand (Lupi, 1998)

	1985	**1997**	**2010**
Production			
(Greenweight tonnes)	14,300	66,000	140,000
(Processed tonnes)	3,000	26,953	47,000
Receipts			
(Export NZ$FOB)	$10 million	$86 million	$250 million
(Domestic)	$ 1million	$10 million	$35 million
Farm numbers	300	600	900
Farm area	1,000 Hectares	2,600 Hectares	4,000 Hectares

In 1998, the industry employed 1,587 FTEs (full time equivalents), mostly in Marlborough and Nelson. The total salary and wages bill was $31.4 million. The industry purchased $68million worth of inputs and capital items from other industries, and the book value of assets was $124.8million. The industry's total impact on the NZ economy was estimated at $222million from 2630 FTEs. While these figures are modest at a national level, the mussel industry is significant at a regional level. For example, it constituted about 9% of Marlborough's primary production and food manufacturing activities (comparable to the region's wine industry).

The above table shows that the mussel industry plans significant growth over the coming decade (7% pa). The Greenshell mussel is likely to become the species making the single biggest contribution to the New Zealand seafood industry. In the past two years, it was second only to hoki. In 2000, the export earnings of the industry were $169.55million (P. Lupi, pers. comm.), and it appears that the goal for 2010 in the above table will be reached well before that year.

There is a strong demand in overseas markets for Greenshell mussel products. The major product is the 'fresh frozen Greenshell™ on the half shell'. Other products are live mussels, IQF (individually quick frozen) mussels, bulk frozen mussels, smoked, pickled or otherwise processed mussels, and last but not least the products for the health food market based on the mussel's anti-inflammatory property.

Growth will follow the market demand and occur in various ways. In 1998 it was estimated that an additional 19% could be produced in the unutilized existing farm space. More space will become available in established and new farming areas, and the limits to growth will probably be set by decisions on the use of New Zealand's coastal waters. Mussel production will also increase due to improved technology and the complete domestication of the mussel. Innovation in mussel processing and marketing will contribute to growth.

There is a broad-based understanding in the mussel industry of the crucial role that R&D plays in the realisation of its growth potential.

New applications of R&D outputs in mussel production

In the area of animal production, the mussel industry will introduce at least three major new activities: hatchery spat production, selective breeding, and husbandry for animal health and condition.

Hatchery spat production: This will guarantee the supply of animals for on growing. The mussel industry is currently New Zealand's biggest animal production industry dependent on wild-caught juveniles. Recent problems with this wild spat supply (ban on movement of Kaitaia spat due to *Gymnodinium catenatum* contamination, loss of spat caught on ropes) have painfully demonstrated the need for a guaranteed spat supply if stability of the industry is to be attained. By ensuring product supply, hatchery spat production will make a significant contribution to the financial stability of the industry. New Zealand's mussel spat production will be the largest in the world, and world-leading technology will be applied.

Selective breeding: The mussel industry is probably also New Zealand's biggest animal production industry not taking advantage of genetic selection. Yet there are indications in the literature that selective breeding of shellfish can bring substantial gains within just a few generations. Special lines will be bred to contribute to the optimisation of production in terms of volume and time of harvest (reliability of supply), quality and range of products.

Husbandry for animal health and condition: To date, the mussel appears to have accepted the farming practices rather well, but there is an increasing danger of animal health problems as the farming gets more intensive. It will be necessary to farm the mussel so that sub-optimal environmental conditions, stress or even disease will not lead to losses of productivity and product quality.

The development of these three main areas of new industry activity will be closely linked. For example, selective breeding will improve the animal's resistance to diseases, and hatchery spat production technology will be required to carry out and exploit selective breeding.

Key outputs relating to mussel production

The new applications described in the previous section require clearly identifiable research outputs. Some of these outputs are currently within reach; others will take several years to achieve.

Hatchery spat production: A reliable broodstock supply will require in-depth knowledge of the mussel life cycle. Hatchery technology, developed on the basis of larval biology knowledge, will allow the design of cost-effective hatcheries. Methods for the early nursery stage (small spat) will be developed on the basis of new knowledge of the early post-settlement stage in the life cycle. Cryopreservation of embryos will allow the year-round use of hatcheries.

Selective breeding: A breeding scheme will be designed on the basis of mussel biology and market/industry selection criteria. For example, knowledge of the biotoxin dynamics in mussel gut and tissue will indicate whether biotoxin problems can be bred out of mussels. Research on hatchery spat production will provide the methodology for broodstock conditioning and industrial spat production. Molecular tools for stock identification and pedigree confirmation will be developed. Cryopreservation of eggs and sperm will allow the pairing of parents that come into condition at different times of the year and the storage of

valuable gametes for later use.

Husbandry for animal health and condition: Methods of measuring stress will provide the means to assess whether the farming conditions and procedures are optimal with respect to the animal's requirements. Methods for disease recognition and management will be developed. In addition to these specific methods, selective breeding and improved knowledge of mussel biology will contribute to the optimisation of mussel husbandry.

Key R&D activities relating to mussel production

From the previous two sections, we can derive R&D activities that are required if the industry wants to achieve the goals identified in its Foresight exercise. Most of these activities are currently carried out.

Hatchery spat production: Broodstock conditioning research includes endocrinology studies and the establishment of correlations between environmental parameters (e.g. food quantity, temperature) and spawning condition. Larval biology work focuses on nutrition and environmental parameters for optimal growth, and on the prevention of disease and protozoan infection. R&D on hatchery technology combines the fields of larval biology, chemical engineering and bioreactor sciences. In spat biology research, the causes of post-settlement migration are of particular interest. Cryopreservation work in the context of commercial spat production focuses on embryos and early larval stages.

Selective breeding: Market research, operations research and mussel biology research contribute to the definition of breeding goals. Genetic evaluation systems are being developed. The methodology for producing mussel families is being tested. Molecular genetic studies focus on tool development and genetic characterisation of wild and farmed mussels. Cryopreservation research aims at the storage of sperm and eggs.

Husbandry for animal health and condition: Research on stress physiology and diseases provides the knowledge necessary to detect and quantify health and condition problems before they are visible to the farmer. The more subtle effects of environmental conditions (particularly those created by the mussel farms themselves) on animal health and condition will be studied as soon as these detection methods are available.

CONCLUSION

Over the past three years, the mussel industry has established a well-functioning process of R&D planning. This process has identified new areas of animal production and associated R&D requiring skills, expertise and technology not currently used in the industry. However, the development of an animal production industry from the basis of wild-caught animals to complete domestication is not new to New Zealand, and the skills required for this process are probably available, at least at a generic level. Cryopreservation is a good example: experts in livestock gamete cryopreservation from AgResearch Ltd have teamed up with the Aquaculture Group from Cawthron Institute. This team has achieved considerable progress towards the mussel industry's goals in a short time.

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