Centre for Shellfish Research

Feasibility of a

Shared Shellfish Hatchery

for the

BC Shellfish Aquaculture Industry

Preliminary Draft
for Discussion Purposes Only
Ver: June 06, 2008

VANCOUVER ISLAND UNIVERSITY

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Executive Summary

Note: This draft discussion document of preliminary findings has been released to obtain further feedback and consultation on this issue. Please forward comments to the Centre for Shellfish Research c/o Brian Kingzett (kingzettb@mala.ca). A formal meeting(s) as well as informal discussions will be held to discuss these draft findings and guide the production of a final report.

Although sufficient hatchery capacity has existed in British Columbia at various times, stand-alone hatcheries have not been economic when not integrated as part of a larger operation. In general stand alone hatcheries have not been able to compete with lower US seed price or to develop seed products that would support a seed price structure required to sustain hatchery costs. Inevitably the lack of adequate finances has resulted in seed crop failures and/or poor seed quality – inconsistencies which do not support customer loyalty. US seed suppliers have filled the gap, but have created a dependency that places the BC shellfish industry at risk.

Shortages of shellfish seed from hatcheries in the US during 2005 -2007 have highlighted this risk. In 2007 alone, the BC Shellfish Growers Association estimated that 50% of the growers received only 50% of their seed requirements. This shortage represents an estimated loss of between $5-$10 million farm-gate sales. The viability of individual shellfish businesses is threatened. Seed shortages have also limited the development of emerging sub-sectors e.g. scallops and geoducks, and will limit production of new species for commercialization e.g. native cockles.

In response to this critical need, the BC Ministry of Agriculture and Lands funded this study to determine the economic feasibility a new stand alone shellfish hatchery in BC. The study involved a team of CSR staff and external experts. Through consultations with industry and other stakeholders the initial objectives were to document seed shortages plaguing the industry – both species and amounts, and to determine the support for a new hatchery. Using this information the consultant team was to undertake a preliminary design for an appropriately sized hatchery; estimate the capital and operating costs to construct such a facility; estimate revenues based on current seed prices and determine the economic feasibility of the facility. Additional objectives included: review potential organizational structures for operating the hatchery including a “shared” hatchery model; document a business case for the hatchery and examine the potential for the CSR Deep Bay Field Station site as one potential location.

As the BC industry is primarily composed of small operators which are typically under capitalized themselves, developing investment and operating capital for a commercial hatchery operation is a significant limiting factor for this development. For a successful hatchery that serves the entire BC industry to be constructed and operated, some sort of a shared model may be the best opportunity at this point in the industries development.

Shellfish hatcheries are complex and comprised of 2 major activities – algae (food) production and animal (larvae, seed) production. Hatchery design and incorporates production strategies for both algae and larvae/seed using high density, low density, a combination of high and low density. Personal experience, risk tolerance and costs shape design decisions; and production approaches continue to evolve. International hatchery expert Jim Donaldson from Olympus Aquaculture Ltd., outlined the hatchery design and cost requirements to construct a new hatchery to meet BC needs and this is used as the basis for our analysis and a straw man for further discussion.

To meet the wide scope of industry needs, the hatchery would have to produce seed for all of the established culture species (oysters (including larvae); manila clams; mussels, geoducks, scallops) and in the future, emerging species (cockles, Olympia oysters etc.).

A new multi-species commercial hatchery constructed in BC is uneconomic at current market prices for shellfish seed. Capital costs for a new hatchery, including fees and a contingency, are estimated at $4,535,541. Annual operating costs (including depreciation on capital (straight line at 15 yr depreciation) but with not including cost of borrowing or land purchase) are $180,000 greater than revenues from seed sales. Capital cost estimates recognize the challenging building cost environment in BC and include equipment quotes without the benefit of negotiation.

This conclusion supports the original premise that if a stand alone hatchery were economically feasible at current market prices for seed then there would be a viable hatchery in operation.

A new BC stand alone hatchery is only economically feasible if funding for capital costs (for building construction and equipment) and purchase/ lease of a suitable site can be obtained from other sources. Given the economic potential of shellfish aquaculture for revitalizing coastal economies and First Nations communities, a strategic investment by governments should be considered.

Research has shown that many operational models have been utilized to run shellfish hatcheries and that each situation is different. A strategic investment by governments can only provide under certain conditions. There is also a requirement for working capital for at least two years until the new hatchery has proven its reliability.

A review of the potential for co-locating a commercial hatchery at the Deep Bay Field Station site found many advantages including: significant synergies and reciprocal benefits can be generated for both the commercial hatchery and CSR researchers and students; savings on land purchase costs; sharing physical infrastructure costs (e.g. seawater systems); acceleration of the ramp-up time for hatchery construction as permitting process is complete and seawater intakes have been installed; improved business risk management because hatchery problems can immediately be brought to the attention of CSR scientists and technicians. A major advantage is the potential increased comfort level for government to invest in a university based joint venture. The site is, however, limited by the footprint available requiring consideration of a two-floor hatchery design.

Conditions imposed by government for financial support for a new shellfish hatchery may be the determining factor. In addition, interested parties will have their own preferences for hatchery design and operation. Because of this, it is recommended that a Request for Proposals that sets out terms and conditions for a joint venture hatchery with government financial support with the aims of filling the identified see shortage needs of the BC industry and made generally available for response. In this manner any of the business models that have been discussed in this document may be used as a template by respondents without limitation.

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1.0 Situational Analysis / Business Case

Shortages of shellfish seed from hatcheries in the US during 2005 -2007 have highlighted the established fact that the BC shellfish aquaculture industry is overly dependent on foreign sources of seed. In 2007 alone, the BC Shellfish Growers Association estimated that only 50% of seed requirements were met. This shortage represents an estimated loss of between $5-$10 million farm-gate sales. The viability of individual shellfish businesses is threatened.

Also at risk due to seed shortages is a scallop aquaculture economic development initiative supported by eleven North Coast First Nations and with the potential to create 350 jobs and an annual payroll of $7.1 million.

The current seed shortage is partially the result of:

a) Washington seed producers redirecting surplus seed to for internal growth to capture market opportunities made available because Hurricane Katrina wiped out the Gulf Oyster Industry and; b) High hatchery mortalities in Washington seed suppliers due to the impact of *Vibrio tubiashi.*

b) Hatchery mortality from *V. tubiashi* is now affecting 2008 hatchery production. Paul Taylor, VP of Taylor Shellfish USA which is a major supplier of seed to Canada has stated that the seed supply shortages experienced to date will continue for the foreseeable future until a solution to the *V. tubiashi* problem is found

Past U.S. seed shortage events have resulted from Border closures due to disease transfer risks and tariff barriers resulting from a trade dispute in another sector (forestry). The BC shellfish industry has recognized reliance on foreign seed sources as a key issue, most recently discussed in their 2006 Strategic Plan:

> *"Lack of seed production capacity is a significant weakness of the industry that BC farmers have identified. While there are three hatcheries in the Province, they are limited due to the small size of the existing shellfish industry. Currently, seed is obtained from other jurisdictions which make the industry highly vulnerable to trade disputes or supply issues."*[1]

This discussion is also active in the Alaska shellfish industry which also relies on seed from Washington State. The Alaska Mariculture Report (April, 2008) stated "The *vibriosis* issue for Alaskan shellfish farmers brings up a recurrent matter of discussion, " Is the Alaska oyster farming industry at risk by relying entirely on one source of oyster seed for the entire industry?" Considering the uncertainty of climate change, its potential to impact on selfish hatchery operations, and the devastating consequence of oyster seed shipments to Alaska are interrupted, a serious effort is needed to secure sources of shellfish seed."

In response to this critical need, the BC Ministry of Agriculture and Lands and the BC Shellfish Growers Association (BCSGA) are supporting a feasibility study for a new shellfish hatchery in BC which is being undertaken by the Malaspina University-College Centre for Shellfish Research (CSR).

1.1 Highlights of BC industry consultation

As a key component of the development of the hatchery feasibility analysis the CSR held an industry workshop on February 29, 2008. The following were highlights of the Shellfish Hatchery Workshop.

Broad industry representation was in attendance including 35 industry participants from as far away as Lax Kw'alaams. This included: BCSGA members, non BCSGA industry members, First Nations, Eric Gant (shellfish nursery operator) and Barb Bunting (Island Scallops -hatchery producer), Yomi Alabi (Geoduck Seed supplier) and Paul Taylor (Taylor Shellfish/Fanny Bay Oysters – major seed supplier).

David McCallum (BCSGA) presented the results of a survey of seed imports by 11 major BC producers/seed suppliers. After discussion, the group concluded that BC seed imports in 2007 were 50% below previous levels.

Paul Taylor of Taylor shellfish indicated that they cannot produce enough seed for themselves - let alone supply BC. Paul supported a new BC hatchery. He also indicted that an industry needs 150% capacity for seed production because hatcheries can fail in any given year for a variety of reasons.

Barb Bunting indicated that Island Scallops is unable to switch to oyster seed production until they have produced their scallop seed crop - and by that time it is too late to produce oysters.

Many growers indicated that seed shortages were ruining their businesses. *"We cannot stay in business without seed"*. Kevin Vautier of Nootka Sound indicated that 75% of his trays were sitting out of the water and "it's hard to make money in that situation".

There was strong support for a new hatchery. Small growers are desperate for seed. There is a real urgency to have a new seed supply. Growers also felt that a hatchery must be multi-species i.e. produce all the major shellfish species (oysters (and larvae); manila clams; mussels and geoducks)

Poor seed quality from US suppliers was a common theme. The value of quality seed was recognized and a willingness to pay a premium for guaranteed seed quality. One grower indicated that it costs 85% more than the value of the seed to get it from the US source to Fanny Bay for pick-up. This indicates that the 85% could be added to the cost of BC seed increasing hatchery revenues.

Many participants stated that constructing the Deep Bay Field Station location will reduce the ramp-up time because the regulatory process has been completed and seawater supply lines installed providing a head start of 1-2 years. There was broad recognition of the value of co-locating a commercial hatchery next to a research facility.

Access to seed produced from a new hatchery is a huge concern i.e. it is no use to increase seed production unless a mechanism is found to make seed available to everyone. Many ideas were briefly discussed (including the requirement for deposits) and it was agreed that this is a major item to address.

There was some discussion regarding who should run the facility. Someone proposed that the BCSGA run the hatchery. Keith Reid indicated (strongly) that it was not in the BCSGA mandate. Everyone agreed it should be operated by competent shellfish hatchery professionals.

As to who should direct the facility, the creation of a Board of Directors was suggested which would consist of all the major parties to ensure that the interests of the industry overall were considered. It was also suggested that the Board would also include government agencies that provide capital funding.

1.2 Overview of northwest seed producers

USA is the major supplier

The majority of the demand for seed by the BC shellfish aquaculture industry, thought to exceed 90% for clams and oysters, is met by two companies with headquarters in Washington State but with complementary, extended season, facilities in Hawaii: Coast Seafoods Company and Taylor Shellfish Farms. Coast Seafoods Company claims that its Quilcene Hatchery is the largest oyster hatchery in the world and is capable of producing more than 30 billion oysters per year, while its Kona Hawaii operations is capable of producing more than 250 million seed per year.

A number of smaller operators have also provided seed to the BC industry through the years and some might be uniquely positioned for business in the future, i.e., Alutiiq Pride Shellfish Hatchery in Alaska, and shellfish culture development in the northern Coast of BC (Table 1). Oregon State University Molluscan Broodstock Program has been at the forefront of

Pacific oyster broodstock management with breeding program of select lines of oysters breeding from the Pacific coast of the US, Alaska to California, producing genetic lines that have been selected for enhanced growth in particular environments, as well as other characteristics that shellfish growers might prefer.

Existing BC Hatchery Suppliers

A number of shellfish hatcheries, all located on Vancouver Island, currently make some selective contributions of seed to the shellfish aquaculture industry of British Columbia, but none has been able to become a major supplier to the industry (Table 1).

- Island Scallops – devoted primarily to production of scallops to support publicly traded development of its own operations.
- Island Seafarms – Small facility devoted solely to production of gallo mussels for its own operations.
- Innovative Aquaculture – small facility on Lasqueti Island primarily producing preserved algal pastes and *trocho-feed"* starter diets for marine fish.
- Seed Science – Small barged based facility located north of Campbell River producing geoduck seed specifically for the Underwater Harvesters Association and Fan Seafoods.
- Bamfield Huuyu-ay-aht Community Abalone Project – Hatchery devoted only to production of abalone on pilot basis.

Each hatchery in BC was developed with a specific species as the focus of its production schedule, i.e., Island Scallops and the Japanese scallop, Island Seafarms and the gallo mussel, and the Bamfield Huuyu-ay-aht Community Abalone Project, or has come to be selective in its efforts, i.e. Innovative Aquaculture Products and Trocho feeds. While, Innovative Aquaculture Products has the capability of producing a wide array of species of larvae and seed, it has limited seasonal capacity, and Island Scallops has acquired the ability to produce many other species through its years of operation but has returned to making scallops a priority for scheduling in the hatchery.

In previous years Island Scallops attempted to provide some growers with selected strains of oyster seed but the program was cancelled because the addition costs were not acceptable to growers (B. Bunting, pers. comm.). The last facility built specifically to supply seed to local producers was Unique Seafarms in Nanaimo. This facility subsequently shut down its shellfish operations in favour of producing algal paste health supplements.

Is the BC industry large enough to support a commercial hatchery?

A common argument is that the BC industry is not large enough to support a multi-species hatchery(BCSGA 2006). It is important to recognize that the hatchery business is capital and labour intensive, technology intensive, seasonal and risky. Most US hatcheries have been in business for a long time and generally are devoted to supplying seed for their own grow-out operations. As such they are well capitalized, have paid off their capital and have significant economies of scale with decreased costs of production. As a result it has been difficult for new BC hatcheries to compete economically or to develop a consistent market share.

Table 1. List of seed suppliers contributing to Pacific Northwest Industry.

British Columbia		
Island Scallops	Qualicum Beach	Japanese scallops; geoduck clam; Manila clam; Pacific oyster, European flat oyster, Eastern blue mussel; weathervane scallop; sea urchins; pinto abalone.
Innovative Aquaculture Products	Lasqueti Island	Trocho feeds (cryopreserved oyster trochophore larvae); setting larvae of Pacific oyster, European flat oyster, Manila clam, gallo mussel, geoduck clam, and Japanese scallops; various sizes of oyster and clam seed; algae paste.
Island Seafarms	Saltspring Island	Gallo mussels
Seed Science Ltd.	N. Campbell River	Geoducks – floating barge hatchery
Bamfield Huuyu-ay-aht Community Abalone Project	Bamfield	Pinto abalone (culture and wild enhancement).
United States		
Taylor Shellfish Farms	Washington, Hawaii	Pacific oyster larvae and single oyster seed (diploid and triploid); clam, mussel and geoduck seed; and bags of oyster spat on cultch.
Whiskey Creek Shellfish Hatchery	Oregon	Pacific oyster larvae and single oyster seed (diploid and triploid). Manila and Geoduck Seed
Coast Seafoods Company	Washington, California, Hawaii	Pacific oyster (diploid and triploid), Kumamoto oyster diploids, Asari (Manila) clams, algae diets.
Kona Coast Shellfish (Coast+Penn **Cove Shellfish LLC)**	Hawaii	Pacific oyster seed and eyed larvae (diploid and triploid oysters); Kumamoto oyster seed and larvae; Manila clam seed and larvae.
Kuiper Mariculture, Inc. **(Setting and nursery rearing only)**	California	Manila clam seed: 2-3 mm to 6-8 mm; Pacific oyster seed singles, 2-3 mm to 35 mm (triploid and diploid).
Lummi Shellfish Hatchery	Washington	Manila clam larvae and seed; geoduck seed; basket cockles; and soft-shelled clams; Pacific oyster eyed larvae, single seed (1-30mm), bagged shells (all oyster seed/larvae diploid or triploid); European flat oyster larvae and seed.
Oregon State University, Molluscan Broodstock Program	Oregon	Pacific oyster broodstock seed lines.
Alutiiq Pride Shellfish Hatchery	Alaska	Pacific oyster, geoduck clam, littleneck clam, basket cockle, razor clam seed.

1.3 Overview of BC seed requirements

Seed requirements of the BC shellfish industry have been estimated from information derived from various sources and are shown in the Table below. A representative segment of shellfish seed imports for 2007 was acquired through a voluntary telephone survey of BCSGA members holding import permits conducted by D. McCallum of the BCSGA in February of 2008. Eleven companies imported seed in 2007 and all but two minor importers contributed to the survey results. These results do not include importers who are non-members.

While 85 million was the actual amount of oyster seed imported, it was suggested that growers only received 50% of the seed ordered, so a possible requirement of 170 million oysters is shown in brackets. Seed required for production results was derived from BC shellfish production records for 2003 – 2007 which were provided by BC Ministry of Environment (MOE) (C. Matthews, pers. comm.). Average production amounts were calculated from 2002-2006 figures only, since 2007 data were preliminary. The amount of seed that would be required to produce that average amount of product was estimated by back calculating survival using various survival estimates (Appendix 1).

Table 2. Seed requirements of BC shellfish industry from different sources.

Note: All seed considered here is 2-3 mm.

Species and type	2007 Seed Imports (millions)	Seed Required for Production Results (millions)
Pacific oyster larvae	550 + 250*	741 - 883
Pacific oyster single seed	170**	42
Manila clam seed	230	122 - 308
Geoduck clam seed	0	0***
Gallo mussel seed	50	>16
Blue mussels seed	150	>3

** 10,000 cultch bag equivalents*
*** It estimated that orders were foras much as 170M but only 85M were shipped.*
****Farm grown geoducks had not reached harvest size by 2007.*

An estimate of the total annual amount of shellfish larvae and 2-3 mm seed currently required by the BC shellfish industry has been constructed from these sources of information:

- Pacific oyster larvae — 1000 million
- Pacific oyster single seed — 170 million
- Manila clam seed — 250 million

- Geoduck seed 7.4 million
- Gallo mussel seed 50 million
- Blue mussel seed 150 million

This does not take into account existing internal demands for scallop seed by Island Scallops or new developments in the scallop industry; for example the North Coast First Nations shellfish project which is anticipating requiring significant amounts of scallop seed.

These estimates take the upper value in any range; given that some of the seed imported in 2007 was not included in the survey results and that seed and larvae provided by local hatcheries has not been included. The number of geoduck seed was estimated from potential subtidal geoduck farm tenures (Appendix 1).

A hatchery capable of producing the quantity of shellfish larvae and seed proposed in the Donaldson Deep Bay Hatchery Scenario would not meet all of the current industry needs but could remove the dependence on imported seed, and could ultimately contribute more than $26 million dollars (2006 wholesale value) of shellfish into the BC economy (Table 3).

Table 3. Potential wholesale value of product raised from projected seed from a conceptual hatchery.

	# seed millions	% survival	survival # millions	# per kg	kg	$/kg	$$ wholesale potential
oyster larvae	200	0.0162	3.24	5.879	551,114	2.387	1,315,509
oyster seed	50	0.85	42.5	5.879	7,229,121	2.387	17,255,911
man clam	100	0.22	22	41.05	535,932	7.625	4,086,480
geo clam	1	0.25	0.25	1.428	175,070	20	3,501,401
gallo mussel	100	0.12	12	52.36	229,183	1.7	389,610
scallops							
TOTAL							**26,548,911**

Notes: a)$1.70 is the wholesale value of mussels for Taylor's in 2006.

b) Geoducks at $20/kg is a BC MAL 2001 estimate; oyster and clam wholesale prices are back calculated from total tonnage and wholesale values given in BC MOE production tables

c) the recovered oyster wholesale value is high possibly due oyster seed survival rate being too high, also value for shucked oysters is problematic.

1.4 Projected industry growth

Shellfish farming has been practiced on the coast of British Columbia for over 100 years. In the past fifteen years there has been a shift to more intensive culture systems (e.g. rafts) and husbandry innovations (e.g. tray culture). While production has increased there has been little foundation in science and crop mortality rates and seed supplies remain as key constraints. In these respects it is a young and vital industry, one that holds great promise for providing sustainable economic opportunities to coastal communities in BC. In 2006 the industry had a wholesale value of $33.9 Million[2].

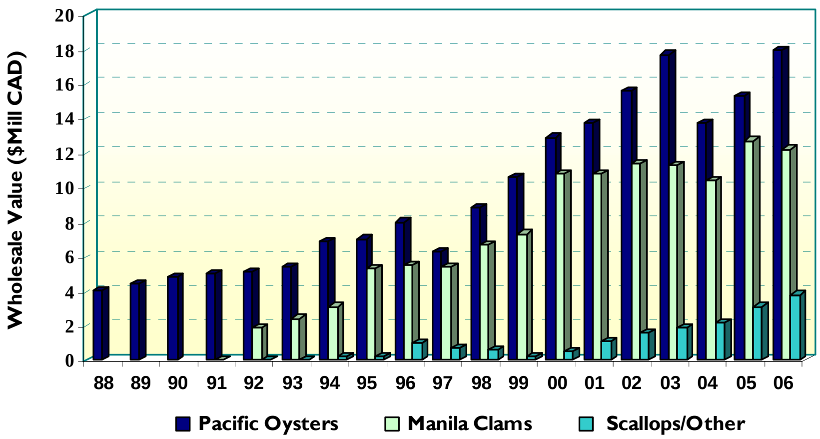

Figure 1. Wholesale value of the BC Shellfish farming industry 1988-2006.
Source data: BC Ministry of Environment.

When the government of BC introduced the Shellfish Development Initiative in 1998, it planned to double the amount of Crown land that was available for shellfish aquaculture to 4,230 hectares within 10 years, and expected that the industry would then be able to generate as much as $100 million annually. As of 2006, the industry had not reached this potential; only some 3000 hectares of foreshore land was tenured for shellfish culture, and though the wholesale value of cultured shellfish at $33 million was double that of 1998 (i.e., $16 million) it did not come near government expectations.

The predicted growth of the BC shellfish aquaculture industry came in part out of a report on the economic potential of British Columbia aquaculture industry, produced by Coopers and Lybrand in 1998, which predicted,

> "*On the basis of market trends, productivity increases, and the estimates of capable lands, the shellfish farming industry could contribute substantially to the provincial economy and the balance of trade with seafood. The BC shellfish farming industry has the potential to become as large as, or larger than, the Washington State shellfish farming industry*".[3]

Many economic studies have indicated that the expansion of the shellfish aquaculture industry could contribute significantly to the economic revitalization of coastal communities. In responding to a request from Western Diversification in 1997, Coopers and Lybrand calculated that the BC shellfish aquaculture industry has the potential to undergo an economic expansion to $100 million, creating 1000 new jobs within a decade[4]. Subsequent studies have confirmed this potential[5]

Since 1997, moderate growth has occurred in the shellfish industry, but much less than the documented potential. In a SWOT (i.e. strengths, weaknesses, opportunities and threats) analysis of the BC Seafood industry, Gislason *et al*. (2004) indicated that the primary constraints on industry expansion were[6]:

- Lack of innovation and reliance upon outdated technologies,
- Poorly trained workforce,
- Limited social license to practice aquaculture; and
- ***Reliance on foreign sources of shellfish seed.***

In a report published by the BCSGA in 2006, the industry described itself as,

> "*being about 1/6 the size of the industry in Washington State and smaller than just the mussel industry in Prince Edward Island.*" [7]

In this report the BCSGA described the following threats to future growth of the BC shellfish industry as:

- Complicated regulatory requirements;
- Potential for disease outbreak and loss of consumer confidence;
- Lack of quality labour at reasonable cost; and
- Anti-marine farming pressures.

Some current weaknesses in the shellfish industry identified by the BCSGA included:

- Industry inertia with regards to identified changes that need to be made;
- Limited access to working capital;
- Lack of cohesive effort by different industry players (e.g. growers and processors);
- Inconsistent product quality; and
- ***Lack of seed production capacity and security.***

At the time that report was prepared, the industry was comprised of approximately 309 licensed marine shellfish companies controlling over 548 culture sites on crown land, mainly on Vancouver Island, that was tenured from the provincial government. Since that time nine First Nations on the Central and North Coast have begun to the process to tenure new sites and develop a significant shellfish farming industry in BC based on scallops.

The crippling effects of insufficient oyster, clam and mussel seed on production goals in 2005-7, the dependence on US supplies affects trade security and competitiveness by exposure to permitting/regulatory decisions and heightened market competition.

BC shellfish production history and species specific scope for growth

The main shellfish products of the BC industry are oysters and clams, with oysters dominating in terms of overall tonnage and value until 2001, when although the amount of oyster product far outweighed that of clams, the overall landed value of clams almost equalled that of oysters, and in 2005 exceeded it (Figures 1,2).

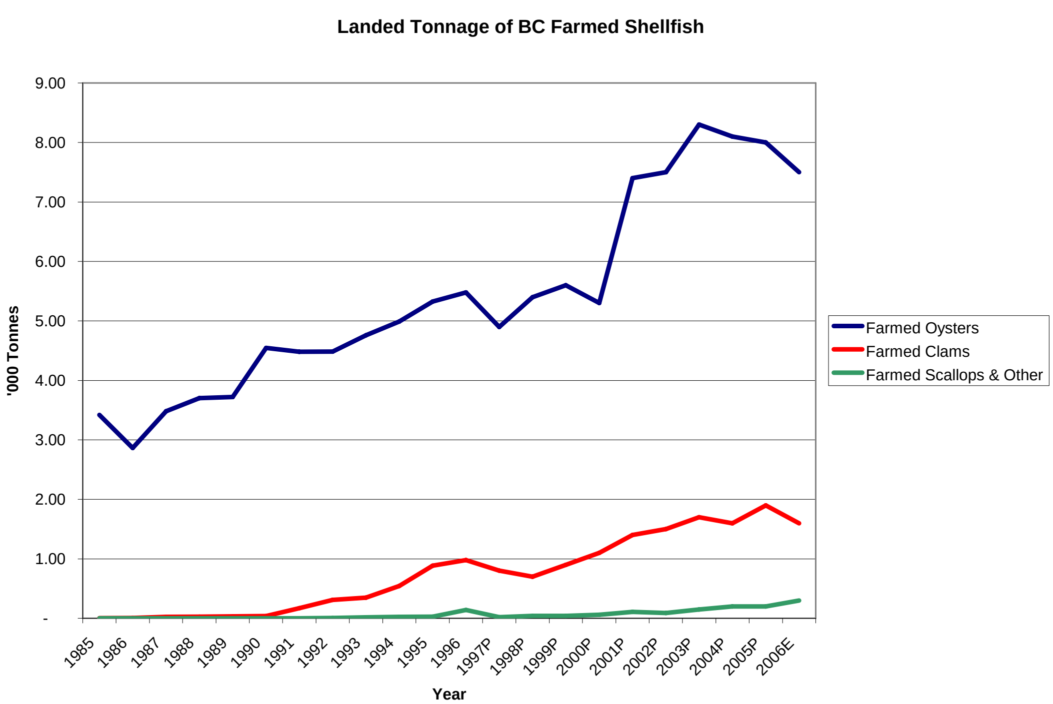

Figure 2. BC farmed shellfish: historical landed tonnage
Source: BC Ministry of Environment [8].

Oyster Farming

Farming of mussels and scallops has been a limited but growing area and a recently introduced scallop aquaculture development initiative should contribute to production values. Farm production of geoduck clams is currently in the development phase, and experimental production of cockles, abalone, sea cucumbers, and sea urchins is also underway. The Centre for Shellfish Research is currently in the process of initiating commercialization grow-out trials for cockles.

The oyster industry is dominated by the Pacific oyster, *Crassostrea gigas*, but small amounts of the Eastern oyster *Crassostrea virginica*, kumamoto oysters *Crassostrea sikamea,* and the European (Belon) oyster *Ostrea edulis*, have also been produced as well as. Oyster production has grown steadily since the mid 1980s, with small declines only in 1986 and 1997, but appears to have peaked in 2003 with 8,300 tonnes produced. In 1992, only 4,480 tonnes worth $3.5 million landed value ($797 per tonne landed value) were produced, and in 1995 shellfish product reached $1000 per tonne.

The first significant increase in production came about in 2001 when 7,400 tonnes worth $8.5 million ($1148 per tonne) were produced. This increase in productivity and landed value, both total and per tonne, probably coincided with an increase in the production of single oysters. Landed and wholesale values have also continued to increase through those years, and while landed weight has been in a decline since 2004, landed values dropped in 2004 but recovered in 2005 and 2006.

The expansion of oyster growing beyond the beach into the water column, which began with rope oysters but expanded significantly with tray-grown single oysters suspended from rafts, means that growth of the industry is no longer dependent on gaining access to highly contested intertidal areas and has seen continued innovation in production methods on deep water leases. Increases in production should continue if more deep water leases become available or production is intensified on existing Deep water leases, many of which are underutilized.

Manila Clam Farming

Manila clam production has grown rapidly since it began in 1986: with just 40 tonnes landed in 1990 ($4140 per tonne landed value), increasing more than four-fold to 170 tonnes in 1991 ($3294 per tonne), jumping to 1,100 tonnes ($5545 per tonne) in 2000, and peaking in 2005 with 1,900 tonnes ($4526 per tonne). From 1998 through 2001 the landed value had a peak range of from $5200 to $5800 per tonne, then dropped to $4800 per tonne in 2002, continued to decline to $4526 per tonne in 2005 but bounced up to $5188 per tonne in 2006. There is likely to not be significant increases in tenured area for Manila clams however First Nations currently control significant intertidal areas much of which has been tenured and is underutilized in terms of husbandry practices to improve productivity.

Scallop and Mussel Farming

Production of scallops, principally Japanese scallop, *Patinopecten yessoensis*, and other shellfish, primarily Eastern Blue, *Mytilus edulis*, and gallo, *M. galloprovincialis*, mussels, has also increased since values were first recorded in 1992, but value of product has remained constant throughout that time: 10 tonnes worth $20,000 in 1992 ($5000 per tonne) to 110 tonnes worth $500,000 in 2001, to 300 tonnes worth $1.5 million in 2006 ($5000 per tonne) (Note that production values for scallops and mussels have been lumped together historically in MOE shellfish production reports).

Scallop production has ranged from only 48 tonnes in 2005 to 148 tonnes in 2007 (preliminary data). The recent scallop aquaculture development initiative that is supported by eleven North Coast First Nations should contribute to expansion of the scallop farming industry if scallop seed requirements are met. Small but continually increasing production of Gallo mussels has climbed steadily from 66 tonnes in 2003 to 302 tonnes in 2007 (preliminary data). Eastern blue mussel production has fluctuated between 7 and 28 tonnes between 2003 and 2007.

Geoduck farming

Geoduck culture began in Washington State after the State of Washington developed hatchery and culture methods beginning in the 1970's. Culture production increased to over 300,000 lbs in 2005 by farmers that include both non-native and native (tribe) owned operations. In Washington State all geoduck aquaculture has occurred in the intertidal area. In Alaska, subtidal geoduck aquaculture is just beginning with 10 new aquaculture sites for farms allowed by the State senate.

Geoduck aquaculture activities in BC began in 1995, with 5 deep-water tenure sites initiated by FAN Seafoods a consortium of geoduck licence holders. The Underwater Harvesters Association Research Society (UHA) also began an experimental geoduck enhancement program in 1995, which involved seeding subtidal sites in the Strait of Georgia. The stated goal of this enhancement program is to increase the recruitment of juveniles into the wild fishery. The enhancement sites will not be removed from the commercial fishery and when they are actually harvested, the harvest will be part of the coast wide quotas.

Since 1995, industry companies and the UHA have developed further refinements in hatchery, grow-out and harvest techniques. Intertidal geoduck aquaculture has only recently been implemented in B.C. and primarily on an experimental basis. Intertidal aquaculture does not overlap with the commercial fishery areas because the commercial fishery does not go any shallower then 10 feet (3 meters).

Table 4. Geoduck Aquaculture Production (as of 2005)

	British Columbia	Washington	Alaska
Aquaculture commencement	1995	1997	2003
Number of ducks seeded	*Unknown*	>6 million	*Unknown*
Number leases	19	37	2
Annual Production	41,000	300,000 lbs	None yet

Geoduck clam aquaculture has unrealized potential in BC at this time. Some subtidal culture has begun but product is only now beginning to be harvested. *Up to February 10, 2006, applications for 368 ha of new geoduck aquaculture sites in BC were being accepted.* A plan to allow the addition of geoducks to aquaculture licenses for existing intertidal shellfish sites is currently under review by BC MAL and applications for new intertidal geoduck aquaculture are not currently being accepted due to gaps in understanding of geoduck aquaculture techniques on fish habitat[9].

Conclusion of scope for growth and supply need

The potential of the BC shellfish industry has been well documented at a minimum of $100 million annually. The Washington shellfish industry is currently $100 million and is supplied by 4 major seed producers and is experiencing problems with seed supply. Multiple hatcheries are essential for industry risk management and it is therefore conceivable to consider that BC will require 3-4 modern fully operational and reliable shellfish hatcheries in order to achieve its full potential if supplies from US seed suppliers are not increased or are cut-off for any reason.

US seed suppliers have filled the gap, but have created a dependency that places the BC shellfish industry at risk. Shortages of shellfish seed available from hatcheries in the US during 2005 and 2006 highlighted the established fact that the development of the BC shellfish aquaculture industry is overly dependant on foreign sources of seed – and vulnerable.

1.5 Risk Factors

The following risk factors have been identified to the development of new hatchery capacity in British Columbia

Economic Viability

Although sufficient hatchery capacity has existed in British Columbia at various times, stand-alone hatcheries have not been economic when not integrated as part of a larger operation. In general stand alone hatcheries have not been able to compete with lower US seed price or to develop seed products that would support a seed price structure required to sustain hatchery costs. Inevitably the lack of adequate finances has resulted in seed crop failures and/or poor seed quality – inconsistencies which do not support customer loyalty.

Customer Fidelity

Historically shellfish seed stock has not been forward purchased as happens in many other agricultural industries. Customers have generally been made up of small growers and (according to seed suppliers) wait until the last minute to order, order small quantities, and demonstrate little supplier loyalty. Without forward ordering or long term contracts it is very difficult for hatcheries to pre plan production and often end up carrying more risk than they are comfortable with or can handle. This has been a significant factor in the economic viability of BC facilities as described above.

Shellfish hatcheries must have the support of local growers especially for new facilities in British Columbia for long term success. As an example of this is how currently customers, industry association, other hatcheries, research, government and NGO communities have pulled together to assist the Whiskey Creek Shellfish Hatchery in overcoming technical problems (below).

High Capital Costs and Site Costs

Hatcheries as are discussed in following sections are capital intensive requiring very specific equipment and seawater systems. They require relatively large buildings and outdoor space (usually) and have specific site requirements requiring access to high quality seawater, power and other utilities. This is discussed in further sections.

Human Resources

Ultimately successful hatcheries are very much the product of their larval and algal culturists. While not highly scientific in the day to day operation, there is substantial technical skill and understanding required by critical staff. Most hatchery operators will also convey that there is as much “art” as science in operating a successful facility. It cannot be overstated that a successful hatchery must be able to recruit, train and maintain good managers, larval and algal culturists. This also means that there is considerable staff training and potentially consulting requirements in the start-up “commissioning” of a facility. It is not possible to simply build a turn-key facility and expect it to operate successfully.

***Vibrio tubiashii* and other production risk management**

In recent years the Whiskey Creek Shellfish Hatchery in Netarts Oregon has been experiencing major production failures which are now believed to be linked to the naturally occurring bacterium *Vibrio tubiashii.* This bacteria is associated with low oxygen seawater and may be the result of large anaerobic "dead zones" that have been appearing off the Oregon Coast. This problem may now be spreading to other facilities and is regarded by the US industry as a significant crisis. According to Robin Downey, executive director of the Pacific Coast Shellfish Growers Association, and Sue Cudd, Hatchery manager, in a May 2008 article:

> *"According to Downey, if a solution to the pandemic is not unearthed, "we're going to have farmers declaring bankruptcy." In a worst-case scenario, she added, "there will be no product at all," and shellfish prices along West Coast states will climb dramatically due to costly overseas importation.*
>
> *"Our customers are starting to panic," Cudd said and explained that in years past, when one commercial hatchery had supply shortages, another usually stepped in to fill customer needs. "There's never been a case when we are all hit at the same time."*[10]

A research project support by government, industry, Oregon State University and the Nature Conservancy is addressing this issue and constructing and testing water sterilization systems. The existence or pervasiveness of this bacterium into BC waters is at this time not known.

Ultimately however this reinforces that shellfish hatcheries are subject to water quality, disease and many other physical, chemical and biological risk factors and it is not unusual for hatcheries to report production failures. All US hatchery operators contacted during the course of this project stressed this and emphasized the need for having multiple facilities in multiple locations for production risk management.

This also stresses the need for continued research and technical scientific support to for improving hatchery technology and troubleshooting.

2.0 Review of comparable facilities

During the course of this investigation a number of shellfish seed facilities were identified that had aspects comparable to shared hatchery options being considering during discussions. Eight facilities were identified that had either:

- Received government support;
- Encompassed some sort of public private partnership (P3);

- Were associated with a publicly funded institution (university or research facility) and produced commercial seed; or
- Entailed multiple producers coming together to create seed production facilities.

Two facilities the NIWA Bream Bay Aquaculture Park located on the North Island of New Zealand[1] and the Tasmanian company Shellfish Culture Ltd.[2] Were contacted and investigated in detail. Each is briefly profiled below with comments received form the companies about their practices and organizational makeup.

Six other organizations are also briefly reviewed. These include:

- Cawthron Hatchery and Aquaculture Park - New Zealand
- North Carolina Oyster Hatchery Program – US East Coast
- Martha's Vineyard Shellfish Group, Inc., - Massachusetts
- Luther Blunt Shellfish Hatchery and Oyster Restoration Center – New England
- Harbour Branch Clam Hatchery – Florida
- Alutiiq Shellfish Hatchery – Seward, Alaska

The key point is that a number of options have been successfully implemented or are in process, for developing less than traditional (i.e. single private ownership) of shellfish seed facilities.

2.1 Detailed Case Studies

NIWA Bream Bay Aquaculture Park - New Zealand

Bream Bay Aquaculture Park is the New Zealand National Institute of Water & Atmospheric Research Limited's latest aquaculture research centre. Located 20 minutes' drive south of Whangarei, the Bream Bay centre is New Zealand's largest facility for marine aquaculture research and development.

Aquaculture in New Zealand is dominated by mussels and salmon. The Bream Bay facility was established to focus on several new species including kingfish, snapper, seahorses, eels and oysters.

A unique feature of this facility is the way in which industry and NIWA work closely together on developing new and innovative

[1] http://www.niwa.cri.nz/rc/aqua/bream

[2] http://www.shellfishculture.com.au/

production methods. In time, it is planned that NIWA's Bream Bay Aquaculture Research Park will develop into a cluster concept with marine farmers, scientists and students working in unison to create a centre for excellence in aquaculture.

Notes:

- One of 9 Crown Research Institutes established in 1992.
- NIWA is a stand-alone company with its own board of directors and its shares held by the Crown Facility for marine aquaculture R & D.
- NIWA has a staff of around 680, annual revenue of around $114 million derived from competition-based research grants and commercial enterprise, and assets of around $74 million
- Industry and NIWA work together to develop new and innovative production methods, including onsite partnerships.
- Makes use of power station infrastructure
- Facilities for abalone, mussel, oyster, algae, as well as, some finfish and larval live (rotifers and artemia) feeds.
- One onsite client, Sealord Shellfish Ltd, has recently introduced the layflat bag system for producing algae to feed greenshell mussel broodstock and spat.
- NIWA acts as a landlord to private tenants who construct facilities to their standards with NIWA purchasing the "fixed assets" and then leasing these back to the operators.

Comments provided by facility

The following points are taken from 'Draft Bream Bay Business Case Study 2006', authored by Kathryn Nemec, provided by Ian Cameron, Hatchery Manager at Bream Bay, NIWA).

Lack of Formal Agreements during Set Up Phase

- Written agreements would have made resolution easier.
- Agreed service specifications for algae supply was an area that could have been formally agreed at the beginning.

Impact of Growth of the Aquaculture Park on Relationships

- New entrants to the aquaculture park should have their own compound, which may in fact be a necessity for biosecurity reasons.
- Mechanisms should be considered for ensuring regular contact between companies and NIWA, and between companies.

Developing Commercial Experience

- Requirements for some services are highly timing dependant and delivery of services by NIWA cannot be delayed.
- A customer service ethos towards companies on site should be developed.
- Develop long term markets for species being developed on site. At this stage, aquaculture systems are being developed to produce fish without established markets.
- Develop plans for scaling up from experimental aquaculture system and scaling up to commercial level production.
- Maximise marketing opportunities from the number of national and international visitors to the aquaculture park.
- Attract more companies on site.

Shellfish Culture Ltd - Tasmania / South Australia

- Private commercial operation, with industry, government, education and research affiliations.
- Public company, with shareholders comprising of a mix of aquaculture producers and private investors.
- Set up by oyster growers in 1979 to supply the seed requirements of the growout industry in Tasmania
- Land and sea based hatchery and nursery facilities at a number of sites in Tasmania and South Australia
- Fully integrated production - hatchery, nursery and growout.
- Seed product: oyster, mussel, scallop, and abalone.
- Converted to high-density, continuous flow, 200 litre larval tanks and bottle-type spat upwellers used by Seasalter.
- Formed company, South Australian Oyster Growers Association Inc. in 2005, with Cameron of Tas., the South Australia Oyster Hatchery and others, for R&D funding, and have divided hatchery research projects with Cameron (i.e. Cameron developing breeding lines, Shellfish Culture developing triploids)
- Employ system of forward ordering.

Comments from Richard Pugh, CEO

Shellfish Culture currently has 80 shareholders. Whilst most are farmers, there are shareholders who are purely investors and *anyone can buy shares. As the Company is not big enough to be listed on stock exchange the shares are traded directly between parties. For those who want to buy or sell shares we provide a central contact point to link traders together but we take no part in the negotiations or financial exchanges.*

The Board consists of five Directors. Four are elected directly by shareholders (each has a four year tenure). These Directors are entitled to hold a marine farm license. The four elected Directors then select a Chairman, who is independent and cannot hold a marine farm license or have shareholdings, or interests, in a shellfish business. Since 1993 each Chair has been independent and all have come from the business sector and knew nothing about shellfisheries when they came on board. But they learnt quickly!

Board meetings are held monthly. Management and financial reports are provided for each meeting. There is no involvement whatsoever of directors in the daily running of the Company. The Directors' role is to keep a check on management to ensure they are delivering on Company objectives, ensure the Company is financially solvent, ensure the Company is compliant with laws and regulations and reviewing or deciding strategic direction. I've been with Shellfish Culture for nine years and found the corporate governance to be very professional.

In the early days (1980's) of the Company, shareholding provided you with an allocation of seed in the event of a supply shortfall, i.e., if you had 10% of the shares you got 10% of the seed produced. Overtime this was removed and shareholder farmers were provided with discounts or extended terms of trade above that of non-shareholders. By the late 1990's this too was removed and now days the only benefit of shareholding is dividends or capital growth of shares. Shareholder farmers have no claims on supply of seed.

Our order book is run by the financial year (1 July to 30 June). It opens 12 months before the start of the new financial year. This helps us plan production and set over winter targets for seed supply in spring. For the most part, orders and supply are ranked on a chronological basis, i.e., first in first served. There are other considerations that also come in to play such as size of customer, history of supply and payment history. The trick, however, is not to get your self in a supply shortfall situation in the first place. Occasionally this does happen and is usually short lived but can have a longer impact on farms if the under supply occurs during the growth season. In an under supply situation we share it around on a pro rata basis, i.e., a farmer will be supplied a percentage of their order and we make it up within a few months. With several hatcheries operating in Australia there is always some seed available if the farmers' supplier of choice is unable to supply.

2.2 Other Hatchery and Aquaculture park Examples

The following includes brief notes on six other facilities that were examined during the course of the investigation that provide examples in support of the current exercise.

Cawthron Hatchery and Aquaculture Park - New Zealand

- Cawthron Institute is a private commercial R & D company, established upon a bequest in 1919 as an independent, community-owned research centre managed by a board of directors.
- Aquaculture Park is a large facility built for the purpose of R&D also features all elements of a hatchery and nursery operation and is capable of commercial-scale seed production.
- Proven ability to produce mussels, oysters and abalone, and converting this knowledge into technology that is applicable at industrial scale; build cost-effective seed production systems.
- Provide commercial quantities of selectively bred oyster spat (30% of New Zealand product grown from Cawthron seed). Aim to have oyster spat available year-round.

North Carolina Oyster Hatchery Program – US East Coast

- Proposed - A system of three hatcheries and two remote-setting sites, to support education, research, and oyster production in varying degrees, run by the state.
- A request to the state gov't for $16.3 million to help build three oyster hatcheries was rejected in August 2007.
- The aim of the program is to restore North Carolina's native oyster population in seed oyster sanctuaries, establish new reefs, enhance existing reefs, and support and promote mariculture.
- Consider producing other shellfish species, such as clams and bay scallops.
- Attractive presentation with scale plans available online at http://www.ncaquaculture.org/2007Presentations/Harcke.pdf
- To fill the gap until the first state-constructed shellfish hatcheries are built, the Oyster Hatchery Program (OHP) of the North Carolina Aquariums has obtained oyster seed from a private commercial seed company, Millpoint Aquaculture.

Martha's Vineyard Shellfish Group, Inc., - Massachusetts

- A non-profit organization (Mass. corporation) governed by a twelve member executive board consisting of the shellfish constable and selectman's appointees from shellfish departments each of the six member towns.
- A Shellfish Biologist/Director who oversees a year round staff of two assistants and a summer staff that may increase up to six during the hatchery production season; some volunteers.
- A thirty year community-based resource management program aiming to protect and enhance the Island's traditional shellfisheries for quahogs, bay scallops, and oysters.
- Operates a solar-assisted shellfish hatchery that incorporates both passive and active solar components; built into a south facing bluff on the shore of the 535-acre Lagoon Pond embayment.
- For enhancement of public shellfish stocks, and to develop and apply innovative aquaculture technology (aqua eco-tourism, tidal-powered shellfish industries, green industries, triploidy, shellfish health and disease).

Luther Blunt Shellfish Hatchery and Oyster Restoration Center – New England

- Roger Williams University is using a dedicated donation and gov't funding to build a $3 million, 12,000-square-foot facility on the university's Mt. Hope Bay waterfront.
- The state-of-the-art facility will house laboratories, a research library and extensive greenhouse facilities.
- Will enable the University to double the shellfish production for its oyster restoration program.

Harbor Branch Clam Hatchery - Florida

- Aquaculture park housing commercial clam seed hatchery, education facilities, and tropical fish culture.
- Part of Harbor Branch Oceanographic Institute, a private, non-profit oceanographic institution that was privately endowed until 2004, now government funded, merged with university, and building economic base through lands sales.
- Producing hard clam seed, *Mercenaria mercenaria*
- *See comparison between Florida hard clam and BC Manila clam industry*

Alutiiq Shellfish Hatchery – Seward, Alaska

- Formerly Qutekcak Shellfish Hatchery, which was established in 1994.
- Government budget cuts saw hatchery turned over to Chugach Regional Resources, a native consortium of eight tribes, to be run as a commercial operation financed by sales of seed.
- Variety of R&D projects and funding sources including rock scallops, basket cockles, geoduck clams, and king crab.
- 3 person hatchery managed by Jeff Hettrick (Hatchery International 2005).
- Has been listed as Alaska DFG certified seed source for Pacific oysters, little neck clams, geoduck clams, basket cockles and razor clams, but only for Pacific oysters and geoduck clams up to Feb. 2008.

3.0 Facility Requirements

There is no set method or blueprint for shellfish hatchery design. Modern hatchery technology is relatively new and continues to evolve. There are few design experts and there are multiple schools of thought on specific issues. While no one is wrong, no one method or approach may be the best either. In order to test assumptions this project retained hatchery design expert Jim Donaldson (Olympus Aquaculture Consulting) to provide conceptual hatchery design and programming services.

As a starting place this conceptual exercise was conducted as if the hatchery was going to be established at the Deep Bay Field Station operated by the Centre for Shellfish Research. This does not preclude however that information gained during this exercise would not be exportable to other locations. Neither does this exercise conclude that the recommended options are the most appropriate for a specific species, species mix or site.

Results of this conceptual design are summarized in this section and are detailed in Appendix 2. Because of intellectual property issues relating to design information provided by Jim Donaldson, public dissemination of detailed information in Appendix 2,3 may be restricted.

3.1 Conceptual objectives and overview

Objectives

For the design exercise it was assumed that this would need to be a multi-species hatchery for the BC shellfish industry of a size that can meet the following objectives:

- Address current seed shortfalls;
- Be a strategic option for some of BC seed production in case US sources cease;
- Spread and manage risk from US and Canadian hatchery failures;
- Be a teaching hatchery at commercial scale to build workforce for new commercial hatchery development;
- Potentially move to stock restoration (e.g., abalone; cockles, Olympia oysters) and new species research when new commercial hatcheries are built; and
- Maximize the site available without exceeding the physical limits of the site.

Limiting Factors

Given a sufficient supply of good quality seawater and the acquisition of targeted funding, the following factors limit total production capabilities of the hatchery.

- Season of peak demand for oyster and clam seed by growers and nurseries is late spring and summer
- Limited nursery capacity for geoduck seed boosting; and
- The Deep Bay site currently has a maximum area available for building of 504 sq m (18m x 28m).

A number of decisions that affect the efficiency and effectiveness of the hatchery processes must be made during the planning phase of designing a shellfish hatchery.

1. Production targets - determine industry needs in terms of species and quantity of seed;
2. Microalgae production method - continuous vs. batch; live vs. processed; quality vs. quantity for different stages;
3. Larva rearing method – low density rearing in large, static (batch) tanks vs. high density rearing in smaller, flow-through tanks;
4. Extent of nursery care – size limits per species;
5. Filtration – quality of treatments of water to different sections; and
6. If a multi- story structure, then what sections can be modified for each floor;

Overall production numbers are further limited by the amount of product that can be growing at any one time in the facility, which is constrained by space, food and seawater availability, but also by the environmental seasonality imposed on the hatchery operation. The schedule of hatchery operations is defined by the seasonality of the conditioning and spawning period of broodstock but also by the seasonality of seed sales to nurseries and farmers who want seed early enough in the growing season that it will reach an optimal size before winter arrives with its low food and temperatures levels.

Preliminary design and costing requirements for conceptual design

The conceptual hatchery design describes the design of a shellfish hatchery that would meet the following estimated final product targets which are assumed to represent half of the industry requirements[11].

- Pacific Oysters, 50 million 2-3 mm single seed and 200 million larvae for remote setting;
- Manila Clams, 100 million 2-3 mm seed;

- Geoduck clams, 1 million 2-3 mm seed; and
- Gallo Mussels: 100 million.

Given the seed requirements mentioned above and the estimated survival rates from larvae to 2-3 mm juvenile, the number of larvae and broodstock required are shown in Table 1.

Table 5. Broodstock, seasonality and larval survival assumptions.

Species	2-3 mm seed # in millions	Survival rate %	Larvae # in millions	Brood-stock #	Broodstock season
Pacific oyster	50	12.5	400	64	Dec- Aug (8 months)
	0	-	200		
Manila clam	100	25	400	244	Dec- June (7 months)
Geoduck clam	1	5	20	54	Nov- Apr (6 months)
Gallo mussel	100	56.2	178	120	Sep- Dec (4 months)

Seasonality of the shellfish life cycle and the shellfish growing industry is reflected in the proposed annual production schedule shown below. Because of overlap in a multi-species hatchery and demand for oyster and clam seed in the spring difficulties immediately arise that significantly increase the required capacity of a hatchery. For example it immediately becomes apparent that significant space and capital costs may be saved by dropping either oysters or Manila clams from the species mix.

Table 6. Proposed annual production schedule for conceptual shellfish hatchery.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Comments
Pacific Oyster BS	X	X	X	X	X	X	X	X				X		Conditioning period 0-60 days
Spawning		X	X	X	X	X	X	X						Larvae period 20 days, 12.5% setting size to 2-3 mm seed
Larvae			100	100	100	100	100	100					600	400 million for setting single seed, 200 million for sales
2-3 mm seed				12.5	12.5	12.5	12.5						50	
Manila Clam BS	X	X	X	X	X	X						X		Conditioning period 0-60 days
Spawning		X	X	X	X	X								Larvae period 14 days, 25% setting size to 2-3 mm seed
Larvae			100	100	100	100							400	
2-3 mm seed					25	25	25	25					100	
Geoduck Clam BS	X	X	X	X							X	X		Conditioning period 0-60 days
Spawning	X	X	X	X										Larvae period 25 days, 5% setting size to 2-3 mm seed
Larvae		5	5	5	5								20	
2-3 mm seed					0.25	0.25	0.25	0.25					1	
Gallo Mussel BS									X	X	X	X		Conditioning period 0-60 days
Spawning										X	X	X		Larvae period 18 days, 56% setting size to 2-3 mm seed
Larvae	60										59	59	178	
2-3 mm seed	33	34										33	100	

3.2 Summary of hatchery Sections

A shellfish hatchery is composed of a number of integrated sections, each of which is important and has its own unique set of requirements but is also tied to the capability of each other section. These sections are: seawater provisioning, treatment and heating; microalgae (i.e. phytoplankton) production; broodstock conditioning and spawning; larval rearing; and some level of nursery culture for juveniles (i.e. spat). The association between these sections in the generalized shellfish hatchery production cycle is shown in Figure 3. The design of a hatchery requires that decisions be made regarding the quality and efficiency of the procedures and equipment used in of these sections.

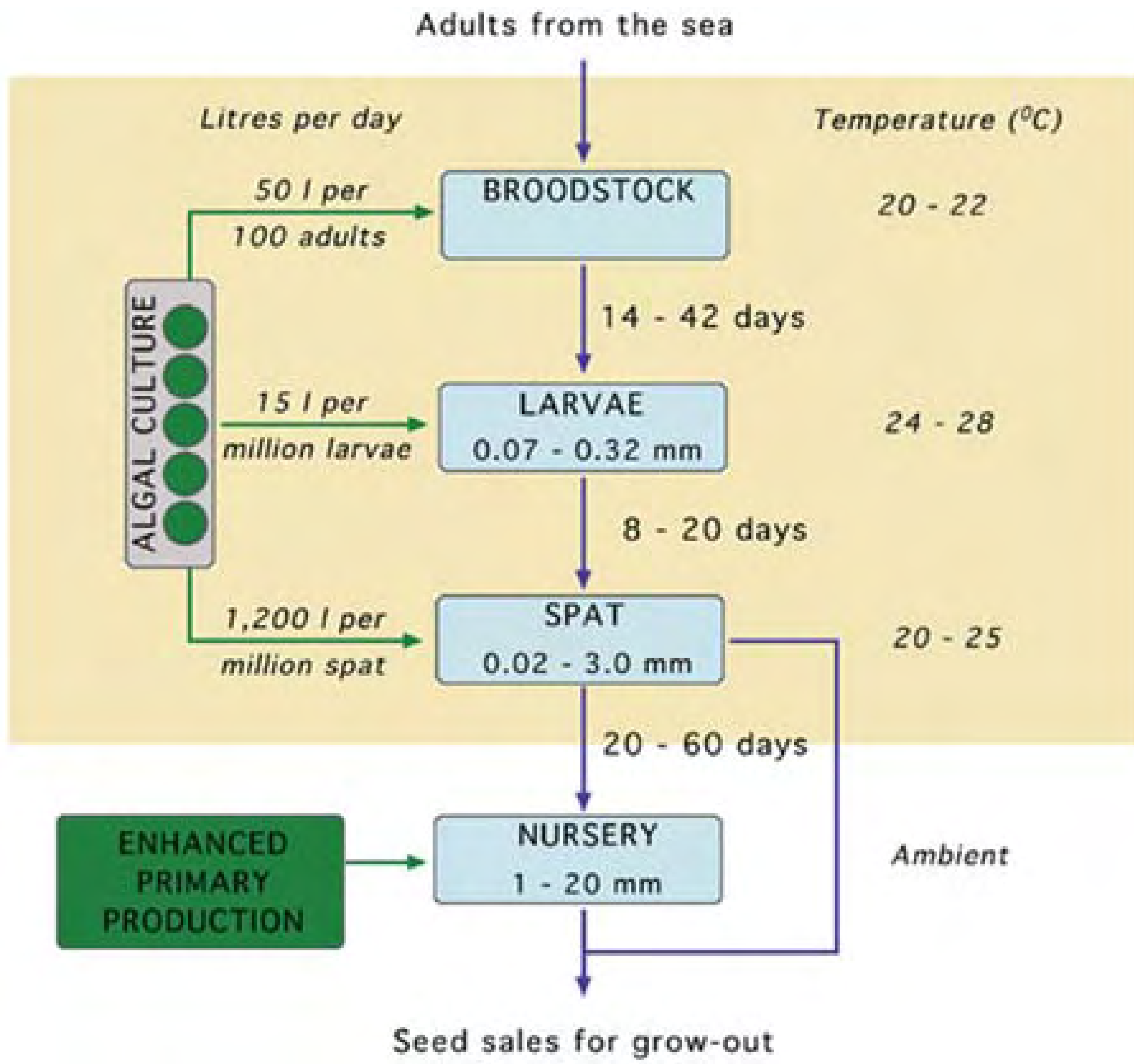

Figure 3. The generalized shellfish hatchery production cycle.

Source:. Taken from the 2006 FAO publication "Hatchery culture of bivalves: a practical manual", written by M. M. Helm and N. Bourne.

Broodstock

The year round production schedule of a hatchery is constrained by the natural spawning season of the mature shellfish. Each shellfish species has a particular spawning season which can be accelerated or extended under prescribed conditions in a process called ‘conditioning’. Conditioning requires management of the temperature and flow rate of seawater and the feeding ration of live microalgae to meet the particular needs of each species.

A room for broodstock measuring 24' x 16', 384 sq. ft. room is proposed. The room will also been outfitted with a 3200 litre tank as a reservoir for microalgae and a pump for delivering microalgae to the broodstock trays.

Larval Rearing

Larvae are second to algae in terms of their requirements for heated seawater and over all cleanliness and attention to minimize and monitor for contamination. If end product targets are used as the basis for determining what size of hatchery then the decision about which method of larval rearing is an important one. There are two methods of larval rearing to be considered: the traditional methods, also called batch culture, in which larvae are cultured at low density (1 to 5 per ml) in large, up to 35,000 litre, static tanks in which seawater is changed and feeding of microalgae are done in batches. The other method involves culturing larvae at relatively high density (100 to 150 per ml) in smaller, i.e. 200 litre, flow-through conical-bottomed tanks, in which seawater and microalgal feed is constantly flowing. The flow-through method is more complex, requires more staff attention and can be complex to operate but produces healthier larvae at a higher density and therefore requires less overall space for tanks. In the scenario presented here, aspects of each of these methods are incorporated:

A larval room measuring 24' x 52' and occupying 1,248 sq. ft. is proposed to house twelve 6' x 4', 3,200 litre conical bottom tanks. The room would contain two additional 6' x 4' 3,200 litre tanks that would act as reservoirs of filtered seawater and microalgae for the single setting room.

Single Setting Room

The room for setting single Pacific oysters, Manila clams and geoducks clams will contain 180 downwells held in eighteen, 11' x 5' trays. The downwells are 22" diameter plastic rings with mesh attached near the bottom, on which the larvae settle, and through which water flows in from the top creating a downward flow which constrains the juvenile shellfish near the fine mesh screen. A single setting room measuring 50' x 44' and occupying 2200 sq. ft. is proposed.

Seed Nurseries

Single Oyster and Manila clam Seed Nursery

The nursery for growing Pacific oyster and Manila clam juveniles (seed) from post-setting up to 2-3 mm size will be carried out in upwellers made of 22" diameter plastic rings with mesh attached near the bottom, over which the seed are suspended by the upward flow of water.

Geoduck Nursery

Two raceways (30' x 4') containing 250,000 2-3 mm size clams per raceway with, operated from May through August, with a 2 month standing crop supply of 250, 000 clams per month.

Gallo Mussel Nursery

This is estimated to require four 12,000 litre round tanks (or outside algae system in winter months) to function as a nursery system for setting on nursery lines and growth up to 2-3 mm size.

Microalgae

Some might consider the first step in the decision making process to be whether or not to grow live phytoplankton, but the benefits of live food for successfully raising larvae and for conditioning broodstock is well documented. However the benefits associated with providing live microalgae are reduced for juveniles and the increasing expense with the growing demand for food is not justified.

The expense of providing microalgal food for the growing juveniles often dictates the stage at which the juveniles or seed are sold, and in this scenario all seed is to leave the hatchery by 2-3 mm size. The method by which the microalgae will be grown must be decided upon and this is dependent upon the quality of microalgae that will be provided to the ravenous nursery. The methods employed in the production of microalgae range from extensive batch culture, through levels of semi-batch culture, to intensive continuous or flow-through culture

The microalgae production system proposed here is a combination of the three methods beginning with continuous bag culture would be supplied directly to larvae and setting stages of all species and would be collected as starter for batches of cultures in 3,200 litre tanks housed in a greenhouse.

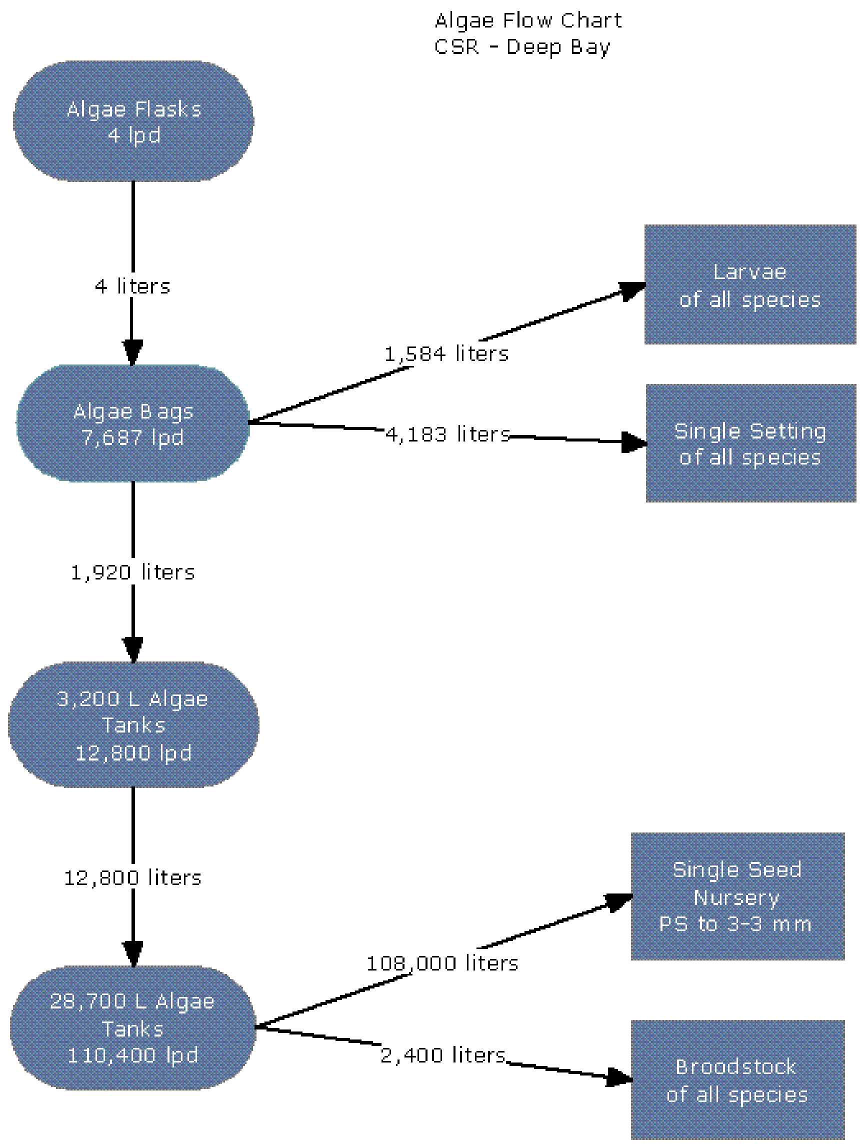

Figure 4. Algal production flow chart for conceptual hatchery

Wet lab

The microalgae production cycle begins with flask cultures of pure stock that would be held separate from the rest of the hatchery in an effort to minimize contamination. The wet lab room will also be outfitted with an autoclave for sterilizing all seawater, nutrients, and equipment used in the early culture stages of algae production, up to and including the continuous bag stage. An algae transfer hood is also needed in order to minimize contamination when transferring algae from flask to flask during the maintenance and up-growing of cultures. A 20' x 10', 200 sq. ft. room containing a freshwater sink and counter space is proposed as a wet room for the hatchery.

Continuous bag culture

A set up of sixty bags (450 litre, 24" diameter, 72" high), in six modules of ten bags, is proposed for the continuous bag culture system The proposed algae bag room would measure 20' x 60' and occupy 1200 sq. ft.

Figure 5. Bags of microalgae held up by fiberglass base and wire mesh cages.

Algae Tank Greenhouse

Algae from the bags is collected continuously and used to start batch cultures in sixteen, 6' x 4' 3,200 litre tanks in a greenhouse. The proposed algae tank greenhouse would measure 62' x 52' and 3224 sq. ft. and would also contain an air blower, two transfer pumps, and storage bins for nutrients.

Algae Tank Outside Culture Pad

Taking full advantage of ambient light and temperatures, algae would also be grown in twelve, 18' x 4' 28,700 litre tanks set on an outside pad measuring some 72' x 62' or 4464 sq. ft. Each tank would be equipped with 4 metal halide overhead lights to enhance algal growth. Algae from these tanks will be fed to seed, post set to 2-3 mm, in the nursery and to broodstock.

Seawater Filtration and Treatment

The hatchery will require up to 300 gallons per minute (gpm) post filtered seawater and the nursery system will require up to 600 gpm. A flow diagram of seawater use in the entire hatchery is shown below. The total seawater flow is the maximum flow with all systems running at peak time in the spring/summer. It is only single pass through which is recommended for all oysters and Geoducks.

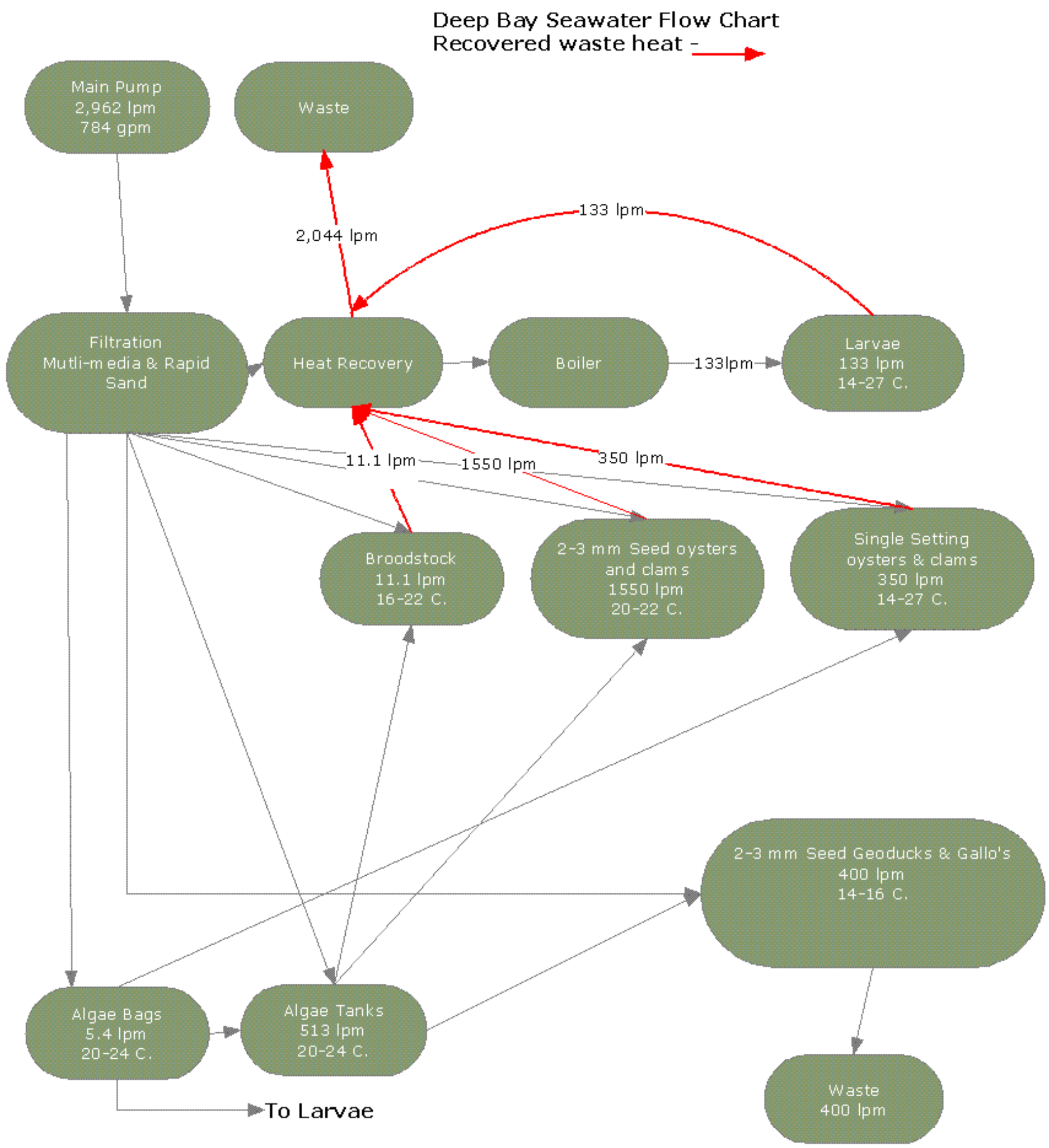

Figure 6. Seawater demands by hatchery section (flow in Lpm).

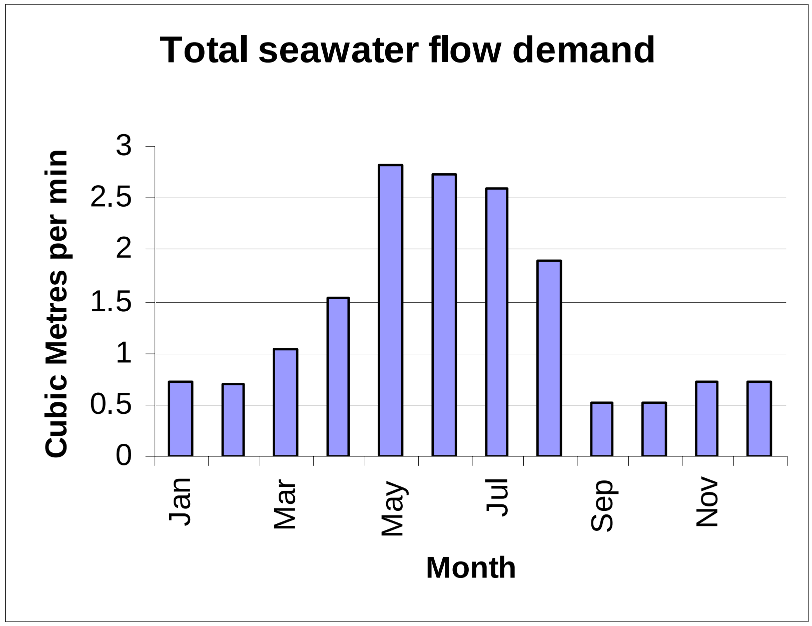

Figure 7. Total monthly seawater demand by average daily demand in cubic metres per minute.

Filtration

A multi-media filter system will need to be installed to supply the entire hatchery with seawater. This system will need to be able to handle about 300 gpm (1135 lpm) continuously. A Rapid Sand filter system has a lower capital cost than the multi-media system but would meet the coarse filter requirements of the seawater for all nursery culture of seed to the 2-3 mm seed size. This will require a filter capacity of 600 gpm (2271 lpm).

Treatment

The primary treatment of seawater will be by mechanical filtration. This multi-media filtration system is described in the previous section. Seawater for use in algae culture of flasks and continuous flow bags will be heat sterilized to a minimum of 90°C. It is not expected that bacteria will be a water source problem at this site due to the intake location and the management of the seawater system. Therefore, sterilization of culture water through the use of Ozone or UV systems should not be necessary although room for potential future use should be incorporated.

Recirculation and heat recapture

Two levels of heat are recovered from seawater that has passed through sections of the hatchery prior to leaving the system as wastewater: the 14°-27° C seawater from the larvae and single setting oysters and clams; and the 16°-22° C from the broodstock and the 2-3 mm seed oysters and clams. Incoming seawater is preheated by recovered heat in the heat exchangers before it passes through the boiler for final heating. Some recycling of seawater can take place in the nursery rearing of clams and oysters, post set to 2-3mm.

At this time of rising fuel costs, building efficiency into the seawater heating system is of paramount importance to make seed production cost effective. Ed Jones at Taylor Shellfish Hatchery in Quilcene, WA. says the small flow-through tanks are particularly useful because of their heat recovery system.

Hatchery Footprint

The estimated programming breakdown for the conceptual hatchery is shown in the following table. It is important to note that this does not include circulation or administrative space which must be accounted for. It also assumes that filtration, pumping, main seawater heating and recovery takes place in a separate pump house facility.

Table 7. Square footage of conceptual hatchery layout.

Building	ft x ft	sq ft	Outside	ft x ft	sq ft
algae bag	20 x 60	1200	algae greenhouse	62 x 52	3224
wet room	20 x 10	200	algae tank pad	62 x 72	4464
broodstock	24 x 16	384	nursery up/down	~41 x 43	1850
larvae	24 x 52	1248	geoduck raceways	~36 x 15	544
setting	50 x 44	2200			
Total		**5,232**			**10,082**

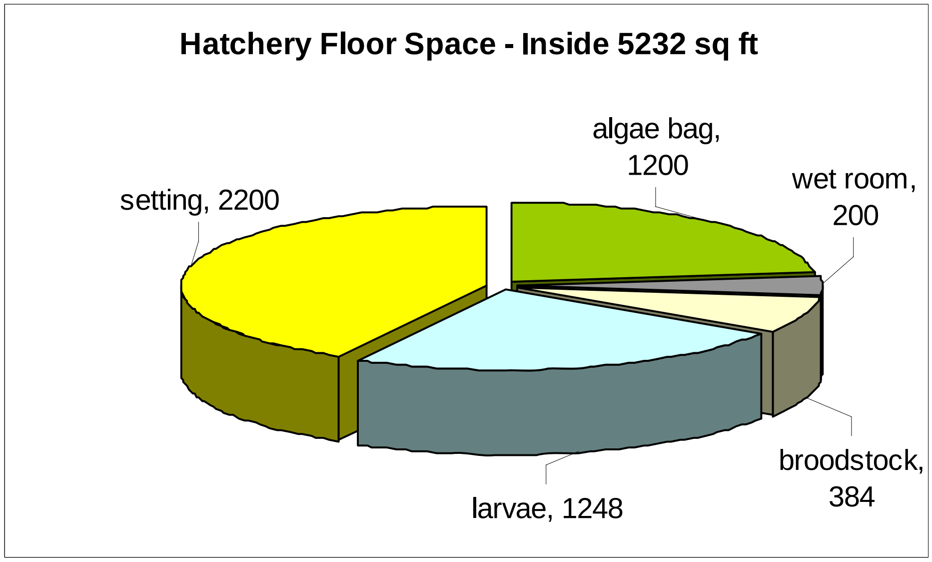

Figure 8. Breakdown of space utilization within the conceptual hatchery building

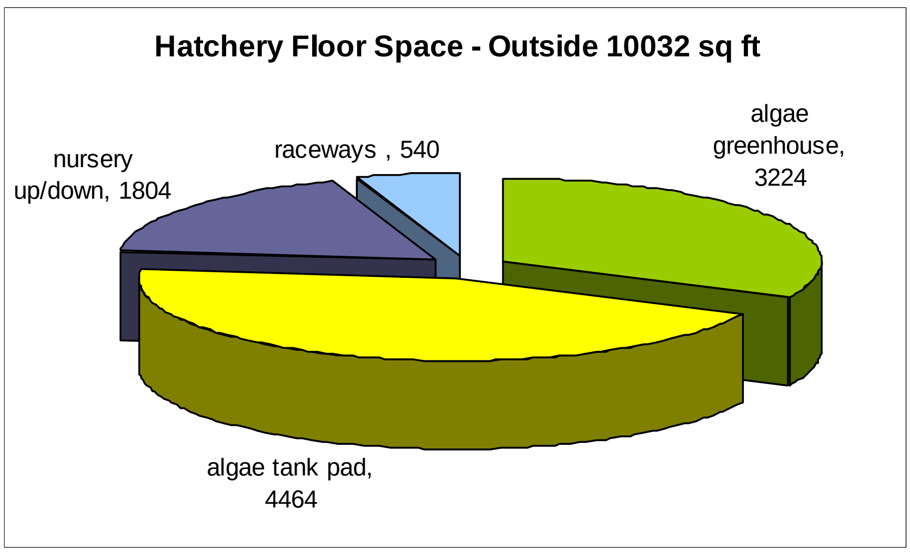

Figure 9. Breakdown of space utilization outside the conceptual hatchery building

The area available for a hatchery building at the CSR Deep Bay Field Station is approximately 5400 sq. ft. (60' x 90') or 504 sq. m. (18m x 28m). The total area required for the various rooms described in this hatchery scenario far exceeds the footprint of space available for a single story facility of this type.

Modifications would have to be made to accommodate this conceptual facility on the CSR Deep Bay site. One possible layout for the rooms is, where broodstock, larvae, setting, bag algae are housed inside a building structure along with a wet room and the remaining sections would be placed outside. The inside space would be dominated by the setting operation, followed by rooms for algae bag culture and larvae culture.

Outside space is predominately needed for extended batch culture of algae in large tanks and the intermediated stage of algae extension in a greenhouse.

Other modifications that could be made to reduce the footprint of the hatchery operations are:

- ❑ Increase to two floors and open roof to allow light in for algae culture on top floor.
- ❑ Reduce size of larval room by 50% by opting for mostly 200 L flow-through tanks then larvae and algae culture can move to top floor. Then can move all nursery systems into bottom floor with setting room. This would still leave an algae greenhouse outside.
- ❑ Convert large outside algae tanks to lay-flat algae bags and place them on half of the roof of the hatchery leaving the other half open as skylights for upright bag algae growing on top floor. The use of ambient light by lay-flat bags would also reduce the electrical costs of lighting considerably.

Building Outfit and Equipment Pricing

The total cost of outfitting the conceptual hatchery facility described here with equipment, and electrical and plumbing infrastructure has been estimated to be $1,807,802.

Table 8. Estimated equipment costs

Hatchery Section	Equipment	Comm/Train	Utilities Infra.	Total
Seawater Heating & Distribution	$124,557		$31,200	$155,757
Broodstock System	$16,614	$5,000	$19,968	$41,582
Algae Bag Room	$85,831	$30,000	$62,400	$178,231
Algae Tank Greenhouse	$70,990	$5,000	$167,648	$243,638
Algae Tank Outside	$123,300	$5,000	$232,128	$360,428
Larvae Culture System	$144,440	$30,000	$64,896	$239,336
Single oyster/clam Setting	$79,786	$5,000	$114,400	$199,186
Nursery Upwells Postset to 2-3mm	$66,048	$5,000	$96,200	$167,248
Geoduck Nursery	$11,644	$7,000	$28,288	$46,932
Mussel Setting and Nursery	$29,500	$7,000	$34,944	$71,444
Wet Lab	$45,425		$10,400	$55,825
Dry Lab	$22,195		$10,400	$32,595
Office			$10,400	$10,400
Bathroom			$5,200	$5,200
TOTAL	**$820,330**	**$99,000**	**$888,472**	**$1,807,802**

Notes: Equipment costs included taxes and shipping where necessary
Utilities were calculated at $52 per sq. ft.

Options for development and influence on capital costs

In increasingly popular method of rearing larvae makes use of small (i.e. 200 L) conical bottom tanks through which warmed seawater and algal food pass continuously. This larval rearing system also employs a heat recovery system which includes a heat exchanger for removing heat from waste water from the larval tanks and a heat pump to move heated seawater through the larval system efficiently. Although this method requires more attention to monitoring and has the potential for disaster in the event of any water flow problems, it has lower demands for labour, space, and heating/energy. One analysis of the requirements of the tradition larval rearing method using large static tanks compared to a high density system with continuous flow and heat recovery estimated that half the amount of seawater, one tenth the energy and one third of the square footage would be required.

Table 9. Comparison of traditional static tank larval rearing method to high density continuous flow method with heat recovery

Source: Eudeline *et al*. 2007[12].

Feature	Traditional	High Density w heat recovery
Tank capacity	35,000 L (10,000 gal) flat bottom	200 L conical-bottom
Larval density	1-5 larvae per ml.	100-250 larvae per ml.
Rearing time and volumes	21 days 35,000 L	7 days in 35,000 L* 14 days in 200 L
Tank fill equivalents	51 tanks	9 tanks
Total water volume	1,800,000 L	870,000 L
Temperature differential	14 C° (11 – 25°C)	3 C° (22 – 25°C)
Calories required	30 billion	2.61 billion
B.T.U.	120 million	12 million
Diesel gallons	923	92
Diesel cost	10x	1x
Space	3x (22,500 sq ft)	1x (7,600 sq ft)
Notes	Static, drained 2-3 days	Flow through of food, water, and waste
	Temperature drops	Temperature stable
	Batch feed 2x day, algae concentrations decreases over time	Continuous supply of food and water, and waste removal
		Small tanks reduce time cleaning and filling
		Harvest flexibility

** In the Eudeline et al. 2007 scenario the first 7 larval days were spent in large tanks but some other hatcheries use the smaller conical-bottom tanks throughout the larval period.*

Some other users of high density larval culture are Shellfish Culture Limited, of Tasmania (saves time, labour, space; mussels and oysters), Taylor Resources, Inc. Quilcene Hatchery in Washington (oysters, geoducks, mussels, and clams), Seasalter hatcheries at Whitstable and Walney in the UK (oysters and clams), and Coast Oyster at Kona, HI.

Figure 10. Taylor hatchery at Quilcene; Coast hatchery at Kona.

A comparison of the capital equipment and utilities infrastructure (i.e. plumbing, mechanical and electrical) costs and the operating costs of a high density continuous flow larval rearing system to the low density continuous larval rearing system proposed by Donaldson, both employing heat recovery systems, are discussed below.

The growing of microalgae in the Donaldson scenario hatchery is accomplished by using a combination of continuous flow polyethylene bags to produce algae of high quality and density at a continuous harvest rate and two sizes of large fibreglass tanks to grow large quantities of algae of lower quality and density. It is suggested that the key to maintaining a consistent and flexible supply of microalgae is diversification of growing methods. Some of the advantages and disadvantages of common methods of growing algae are shown in Table. Some modifications of the algae production system described in the Donaldson hatchery scenario are also considered; for example, using only upright algae bags or using some lay-flat algae bags.

Table 10. Common algae growing methods

Source: Eudeline *et al*. 2007.

Algae growing method	Harvest cell concentration (cells per ml.)	Advantage	Disadvantage
Batch tanks in greenhouse w lights	1-2 million	Large volumes ideal for seed; year round	Year round but most efficient in season
Upright bags in greenhouse w lights; continuous harvest	5-15 million	High quality, continuous harvest ideal for larvae; year round	High diversity; tricky to operate; whole system can get contaminated; costly to remediate.
Lay-flat bags; outside w natural light; continuous harvest	1-5 million	Good quality, continuous harvest; cheaper than indoor	Lower density; seasonal
Outdoor natural bloom large tanks/ponds; continuous harvest	<1 million	Cheap	Low quality for seed only; low density; seasonal

The possibility of growing algae for all stages of shellfish at the hatchery in an expanded system of upright bags was considered. Assuming that the concentration of algae growing upright bags would average 3 million cells per ml (3 x as dense as from tanks), then a maximum of 44,091 Lpd would be required for broodstock and seed during the peak demand months of May, June, and July; 38,060 Lpd for broodstock and seed, and a maximum of 6,031 Lpd larvae and setting. At a harvest rate of 150 per bag per day, that would require 294 harvestable bags plus 10% in-progress bags (29), for a total of 323. Since approximately 8,100 Lpd of algae can be provided by a 60 bag system (10% down), 5.4 x 60 bag systems would be needed to meet all of the hatchery demand in peak season. While some of the equipment costs and space requirements could be reduced by sharing pasteurizers and filtering equipment amongst the multiple 60-bag units, maintaining the units separately reduces the risk of cross contamination and the enormous potential problems of complete contamination of the algae growing system and the costs of remediation.

The replacement of the 12 large static tanks (27,8000 Litre) growing algae outside with artificial lights by a system of 16 lay-flat continuous flow polyethylene bags (2 m x 10 m) for providing the large amounts of algae required during the high demand season (May, June, and July; also the best time for growing algae outside) was also considered.

The lack of dependability of this method of algae production, which is wholly dependent on ambient light and temperature levels, in the unpredictable Pacific Northwest climate is not recommended (by J. Donaldson)

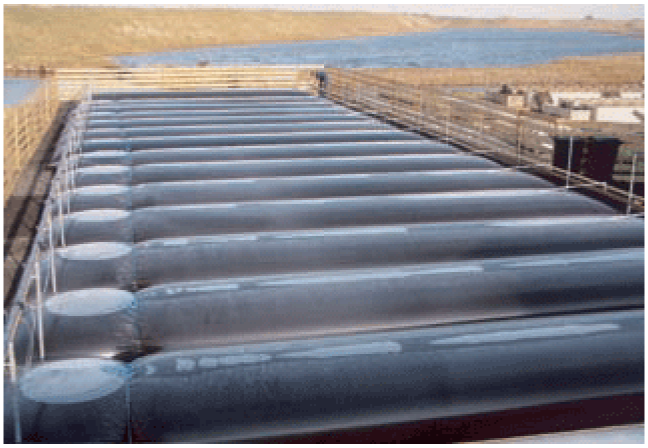

Figure 11. Lay-flat bag system at Seasalter (Walney) Ltd in the UK[13].

3.3 Permitting and regulatory issues

The conceptual hatchery building will have to be constructed on land that is zoned for commercial purposes and comply with municipal (building inspection, zoning, permits) and other appropriate regulations including but not limited to the Riparian Area Regulations, Heritage Act (in event there are middens or other archaeological features), and Fisheries act for modifications to foreshore etc.

Crown land tenure (BCMAL) and Fisheries Habitat Assessment and Authorization and potentially including Canadian Environmental Assessment Act approval will all be required for the installation of intake and discharge structures.

Note that this has all been conducted for the Dep Bay Field Station, a process that took approximately two years.

For operations an aquaculture license will be required from the BC Ministry of Agriculture and Lands. As well transplant permits and disease free certification will need to be obtained for seed shipments.

The BC Ministry of Environment will require a description of wastewater effluent and a provincial waste water discharge permit may be required, although currently this has not been required of shellfish hatcheries.

3.4 Human resources requirements

Typically labour costs may take up to 60% of hatchery operating budget. For the possible hatchery schedule and production levels outlined in the Donaldson hatchery scenario, the following employees might be required.

- ❑ Full time, permanent
- ❑ 1 manager/technician

- 1 algae tech
- 1 algae/broodstock tech
- 1 larval tech
- 1 nursery tech
- Part time, permanent
- 1 maintenance person (if the tech's are not able)
- Full time, temporary
- 1 nursery tech (summer student)

Overlap of job function would potentially allow for reductions in total employee number. In the conceptual design process Donaldson estimated 5 people at $200,000 per year (average $19.38/hr if 8 hr/day, 21.5 days/month, 12 months/year)

The wage structure of aquaculture technicians according projected by the Vancouver Island University Think Trades and Technology program[14] is as follows:

Entry level	$14.00 - $18.00
Experience (+5 years)	$18.00 - $24.00
Management (Senior)	$25.00 - $35.00

3.5 Operational capital requirements

The following list of operational capital requirements must be taken into account as well. These are detailed (where they may be predicted for this exercise) in the business plan outline.

Variable Operational Costs
- Feed
- Supplies
- Energy
- Facilities Rent
- Labour - Maintenance
- General Excise Taxes

Total Variable Costs

Fixed Costs (Annualized)
- Equipment Depreciation
- Development Depreciation

Total Fixed Costs

Contingency

Total Operational Expenses

Interest Expense

4.0 Business Plan – Outline

4.1 Capital Costs –

<u>Conceptual Hatchery Scenario</u>

The conceptual hatchery design described in Section 2.2, has a main hatchery building area of 5132 sq. ft, greenhouse spaces occupying 4424 sq. ft., and 7530 sq. ft of serviced outside areas. The placement of the various sections of the hatchery in these building categories is shown in Table 2. Building construction costs were estimated based on building rates of $200 per sq. ft. for the main hatchery building, $100 per sq. ft. for greenhouse buildings, and $25 per sq. ft for serviced outside areas. The 17,076 sq. ft. of space is required by the three categories of buildings outlined for conceptual hatchery is estimated to cost $1,657,050.

Table 11. Estimated building construction costs

Hatchery Area	**Area of square footage**			
	Building	**Greenhouse**	**Outside**	
Seawater Heating & Distribution	600			
Broodstock System	384			
Algae Bag Room		1200		
Algae Tank Greenhouse		3224		
Algae Tank Outside			4464	
Larvae Culture System	1248			
Single oyster/clam Setting	2200			
Nursery Upwells Post-set to 2-3mm			1850	
Geoduck Nursery			544	
Mussel Set/Nursery and Cultch			672	
Wet Lab	200			
Dry Lab	200			
Office	200			
Washroom	100			
Total sq. ft.	5132	4424	7530	**17,086**
Building construction costs per sq. ft.	$200	$100	$25	
Total costs	$1,026,400	$442,400	$188,250	**$1,657,050**

The costs of utilities infrastructure were determined to average at $16 per sq. ft. for mechanical (plumbing, drainage, HVAC, controls, and fire protection) and $36 per sq. ft. for electrical. The costs of utilities infrastructure for each hatchery area are summarized in Table 12, and were estimated to cost a total of $888,472.

Table 12. Utilities (plumbing, mechanical and electrical) infrastructure capital costs.

Hatchery Area	Sq. ft.	Cost
Seawater Heating & Distribution	600	$31,200
Broodstock	384	$19,968
Bag Algae	1200	$62,400
Tank Algae Greenhouse	3224	$167,648
Tank Algae outside (unheated)	4464	$232,128
Larvae Culture	1248	$64,896
Single Setting	2200	$114,400
2-3 mm Nursery (unheated)	1850	$96,200
Geoduck Nursery (unheated)	544	$28,288
Cultch and Mussel Nursery (unheated)	672	$34,944
Wet Lab	200	$10,400
Dry Lab	200	$10,400
Office	200	$10,400
Washroom	100	$5,200
Total	**17,086**	**$888,472**

Note: estimated at $52 per sq. ft.

The capital costs of equipment for the conceptual hatchery and training and commissioning for installation and use of the equipment are summarized by hatchery area in Table 13. A detailed list of the equipment and various cost quotations are presented in Appendix 3. Equipment costs are based on Canadian prices and include taxes and shipping costs where necessary. The quotations of local suppliers were used wherever they were competitive with the shipped costs of foreign suppliers. For example, three categories of fibreglass tanks (i.e. 31 – 6' x 4'; 16 – 18' x 4'; 33 upwell tanks) comprise 40% of capital equipment costs. A local supplier has provided a quote that would reduce the cost of having these manufactured and shipped from Washington State by approx. 8% ($26,000).

Table 13. Capital costs of equipment and commissioning for the conceptual hatchery.

Hatchery area	Equipment	Commission /training	Total
Seawater Heating & Distribution	$124,557		$124,557
Broodstock System	$16,614	$5,000	$21,614
Algae Bag Room	$85,831	$30,000	$115,831
Algae Tank Greenhouse	$70,990	$5,000	$75,990
Algae Tank Outside	$123,300	$5,000	$128,300
Larvae Culture System	$144,440	$30,000	$174,440
Single oyster/clam Setting	$79,786	$7,000	$86,786
Nursery Upwells Post-set to 2-3mm	$66,048	$7,000	$73,048
Geoduck Nursery	$11,644		$11,644
Mussel Set/Nursery and Cultch	$29,500		$29,500
Wet Lab	$45,425	$5,000	$50,425
Dry Lab	$22,195	$5,000	$27,195
Total	**$820,329**	**$99,000**	**$919,329**

<u>Summary of capital costs for conceptual hatchery</u>

The capital costs of building, equipping and operating the conceptual hatchery, described in section 3.0 Facility Requirements, are summarized in Table 14.
A 5132 sq. ft. main hatchery building, 4424 sq. ft. of greenhouse buildings, and 7530 sq. ft. of serviced outside spaces would cost approximately $1,660,000 to construct (at May 2008 building prices). Building services for electrical and mechanical (plumbing and heating) infrastructure based on the square footage of the building areas is estimated to cost an additional $889,000. The capital costs of equipping the hatchery (including pump house and filters) and providing training and commissioning for equipment installation and use are estimated to be $1,170,000. Allowing 15% for contingencies, 9% for architectural fees, and 1.5% monthly for construction inflation, the total of capital costs of the conceptual hatchery is estimated to be approximately $4,536,000.

The financial costs and benefits of adapting some of the higher density methods for rearing larvae and growing algae were determined were determined.

Table 14. Summary of all capital costs of the conceptual hatchery.

Buildings (5100 ft^2 inside) + greenhouse and outside develop	$1,657,050
Building services - electrical and mechanical (plumbing and heating)	$888,472
Architect/consultant fees- 9%	$229,097
Pump house and filters	$250,000
Hatchery equipment and commissioning	$919,330
capital cost subtotal	$3,943,949
Contingency - 15%	$591,592
Project total subtotal	**$3,943,949**
Construction Inflation @1.5% per month - Jan 09 start date	$591,592
Grand total	**$4,535,541**

4.2 Comparison of optional high density culture scenario

High density larval culture could involve replacing the twelve 3200 L larval rearing tanks with nine 200 L tanks and four 3200 L tanks (note that both systems of tanks had conical bottoms and allow flow-through). Higher density algae production could consist of more intensive culture using polyethylene bags and less extensive cultivation in large tanks. The most obvious benefit of high density culture methods for both larvae and algae is the reduction in space requirements.

If 9 x 200 L high density tanks plus 4 x 3,200 L tanks are used to rear larvae, then tank costs would be reduced by at least $5,415. Floor space requirements could be reduced by 50%, which would reduce the plumbing, mechanical, and electric costs by $32,448 and building costs by $124,800.

If all algae demands of the hatchery were met with high density production in upright bags then five complete replica bag systems would be required. Replication of the systems is recommended over simple expansion of the number of bags because it allows a mechanism to limit the spread of contaminants. The 5 x 60 bags systems could occupy approximately 6000 sq ft of greenhouse space whereas the bag and tanks system of the conceptual hatchery occupy 8888 sq ft, 1200 sq. ft of building space, 3224 sq. ft. of greenhouse, and 4464 sq. ft. outside. The overall lower square footage required for the algal bag systems could bring a reduction in building costs of $78,800. Capital costs for equipment and utilities infrastructure of for a complete algae bags system is estimated to come to $741,155 (equipment $429,155; utilities $312,000), whereas the algae bag plus tank system would cost a total of $742,298 (equipment $280,122; utilities $462,176).

Table 15. Capital equipment cost estimated for conceptual hatchery compared to and a

hatchery employing high density methods for larvae and algae.

Equipment	Conceptual	High Density
Seawater Mechanical	$124,557	$124,557
Broodstock System	$16,614	$16,614
Algae Bag Room	$85,831	$429,155
Algae Tank Greenhouse	$70,990	0
Algae Tank Outside	$123,300	0
Larvae Culture System	$144,440	$144,440
Single oyster/clam Setting	$79,786	$79,786
Nursery Upwells Post-set to 2-3mm	$66,048	$66,048
Geoduck Nursery	$11,644	$11,644
Mussel Set/Nursery and Cultch	$29,500	$29,500
Wet Lab	$45,425	$45,425
Dry Lab	$22,195	$22,195
Total	**$820,329**	**$ 947,169**

Note: Details in Appendix 3.

Table 16. Building and utilities infrastructure costs conceptual hatchery described and a hatchery employing high density methods

	Concept hatchery			High density		
Hatchery area	Floor area (sq.ft.)	Infra-structure Costs	Building Costs	Floor area (sq.ft.)	Infra-structure Costs	Building Costs
Seawater Mechanical	600	$31,200	$120,000	600	$31,200	$120,000
Broodstock System	384	$19,968	$76,800	384	$19,968	$76,800
Bag Algae Room	1200	$62,400	$120,000	6000	312,000	$600,000
Tank Algae Ghouse	3224	$167,648	$322,400	0	$0	$0
Tank Algae outside	4464	$232,128	$111,600	0	$0	$0
Larvae Culture	1248	$64,896	$249,600	624	$32,448	$124,800
Single Setting	2200	$114,400	$440,000	2200	$114,400	$440,000
2-3 mm Nursery	1850	$96,200	$46,250	1850	$96,200	$46,250
Geoduck Nursery	544	$28,288	$13,600	544	$28,288	$13,600
Cult/Muss Nursery	672	$34,944	$16,800	672	$34,944	$16,800
Wet Lab	200	$10,400	$40,000	200	$10,400	$40,000
Dry Lab	200	$10,400	$40,000	200	$10,400	$40,000
Office	200	$10,400	$40,000	200	$10,400	$40,000
Bathroom	100	$5,200	$20,000	100	$5,200	$20,000
Total	**17,086**	**$888,472**	**$1,657,050**	**13,574**	**$705,848**	**$1,578,250**

Another more limited move to high density algae production could involve replacing the outside algae tanks with lay-flat algae bags. This would see a 60% reduction in space required, and the size of the algae tank space inside the building could also be reduced by 30% because 12 of the 3200 L tanks would no longer be required. If the lay-flat bags are grown under ambient conditions then no capital or operational costs for lighting would be required and although there would be ongoing costs for replacing bags, the high initial outlay for large tanks ($113,200) could compensate for this.

Summary of comparison

Converting most of the larval culture and all of the algal culture to high density production methods would not reduce the capital building and equipment cost tremendously, at $138,097, but the overall reduction in space requirements, as well as the lower labour demands and the increase in quality of the algae and larvae would be significant. A comparison of all capital costs for the conceptual hatchery to those of the high density hatchery shows a possible overall savings of $295,680 or 6.8% from the high density approach (Table 17).

Table 17. Capital costs comparison between conceptual hatchery and a hatchery employing high density methods for larvae and algae.

	Conceptual	High Density
Space (sq. ft.)	17,086	13,574
Buildings Inside+ greenhouse and outside develop	$1,657,050	$1,578,250
Building services - electrical and mechanical (plumbing and heating)	$888,472	$705,848
Architect/consultant fees- 9%	$229,097	$205,569
Pump house and filters	$250,000	$250,000
Hatchery equipment and commissioning	$919,330	$947,169
capital cost subtotal	$3,943,949	$3,686,836
Contingency - 15%	$591,592	$553,025
Project total subtotal	**$3,943,949**	**$3,686,836**
Construction Inflation @1.5% per month - Jan 09 start date	$591,592	$553,025
Grand total	**$4,535,541**	**$4,239,861**
Difference		$295,680
Percent Difference		6.52%

4.3 Operational Costs

Conceptual Hatchery Scenario

The various costs that may be incurred annually during operations of the conceptual hatchery described in Section 3.0 are summarized in Table 18. It is important to note that land cost or “lease” cost has not been included in this calculation as the manner in which it would be calculated has not yet been determined. Capital amortization/depreciation has been grossly estimated as 15yr straight line depreciation over 15 years (as estimate only) for a value of $233,333/ year. Contingency or additional administration and legal costs have not been included in this calculation either and as such this table of operating costs can be considered incomplete or an underestimation of real operational costs.

Table 18. Estimated annual operational expenses for conceptual hatchery scenario.

	Inside Space	Outside Space	Total
Floor Area (sq. ft.)	9,556	7,530	17,086
Utility costs ($/year)	$ 28,668	$ 8,283	$ 36,951
Process oil or gas (seawater)			$ 106,581
Process electric (lights, pumps, heaters)			$ 89,212
Materials& supplies			$ 124,228
Labour (5 people)			$ 200,000
Lease/rent			?
Capital amortization/depreciation (15yr at 3.5M est)			$ 233,333
Total Costs			**$ 807,391**

Notes:

Utility costs include electricity or gas for air conditioning, ventilation, lighting, space heating, domestic hot water and miscellaneous loads.
Labour costs are calculated at an average of $40,000 per person not including BC benefits and taxes.
Materials and Supplies include chemicals, lab supplies and all other supplies
Process costs are determined by process seawater flow as follows: Larvae 133 lpm, Broodstock 11.1 lpm, 2-3 mm seed 1550 lpm,
Single setting 350 lpm, 2-3 mm geoducks and mussels 400 lpm, Algae tanks 513 lpm and Algae bags 5.4 lpm
Process oil includes gas/oil for process water heating
Process electric includes electricity for pumps, controls, algae lighting, immersion heaters and heat pumps; BC hydro rates.

High Density Scenario

While a fully static system may have heating fuel costs that are ten fold greater than a high density larval system with heat recovery, comparison of heating costs between the large tank system with continuous flow and heat recovery described for the conceptual hatchery and a high density larval system with heat recovery was not possible. Labour requirements and therefore costs are described by other users as being lower with the high density system but the amount of reduction has not been quantified.

4.4 Revenues

Anticipated revenues from seed sales at full production in the conceptual hatchery plan are shown in the following table. At current seed prices this would equate to approximately $627,500/year (FOB facility at 2007 quoted import prices).

Table 19. Total potential revenue from seed production at Deep Bay hatchery.

Product	Production Unit	Units of Production	Market Price	Revenue
Pacific oyster eyed larvae	Millions	200	$100	$20,000
Pacific oyster 2-3 mm seed	Thousands	50,000	$2.55	$127,000
Manila clam 2-3 mm seed	Thousands	100,000	$2.33	$230,000
Geoduck clam 2-3 mm seed	Thousands	1,000	$100	$100,000
Gallo mussel 2-3 mm seed	Millions	100	$1500	$150,000
Total				**$627,500**

What is immediately apparent is that at current market prices with this mix of production is that revenues can be anticipated to fall short of operational costs by more than $180,000 per year.

4.5 Relative comparison of resources required by each seed species.

When some of the rearing requirements of the four species of shellfish seed are compared it is obvious that Pacific oysters and Manila clams are the most expensive in terms of algae production. IN order to test the relative cost of each species an estimated cost of algal production was used as an indicator of relative production cost for each species.

In this analysis the cost of producing algae was taken to be $0.01 per litre; a figure based on an the comparatively low estimated average of $200 per kg dry wt, and a conversion ratio of 1 g dry weight of *Isochrysis* to 20 litre live algae equivalents. The selling price of seed was based on the current prices posted by Kona Coast Shellfish, LLC[3] Mussel seed has the lowest selling price but production costs in terms of space, time and algae are also low, the only drawback being the cost and effort of setting the mussels on strings. Geoduck seed would bring in the largest dollar value but they require a longer time to be reared and broodstock takes up considerably more room than the other species. Both time and space have associated costs, in labour for maintenance and in energy for

[3] <http://www.konacoastshellfish.com/pricing.htm> Accessed March 29, 2008

heating seawater, that are not considered in the analysis shown in this table, but it is not likely that these costs would greatly reduce the high potential profit margin in producing geoduck seed. There is however, still considerable risk in growing geoduck seed and the aquaculture of geoducks has met some roadblocks to development. A comprehensive comparative analysis of the cost per seed of each species is not possible without a better understanding of the breakdown of hatchery operating costs by activity, particularly labour.

Table 20. Relative comparison of production costs

	Algae (L) per million seed*	Algae cost per million seed	Selling price of seed per million	Algae cost as % of sales price	Handling time (days)	Broodstock per million seed (# tanks)	Nursery space and comments
Pacific oyster	10,498	$1,049.85	$2,550	41.2	125	5.12 (0.2)	2.5 M per nursery tank (11' x 5') for 30 days
Manila clam	96,391	$963.91	$2,300	41.9	132	8.53 (0.1)	2.5 M per nursery tank (11' x 5') for 30 days
Geoduck clam	749,430	$7,494.30	$100,000	7.5	162	160 (32)	0.25 M per raceway (30' x 4') for 60 days
Gallo mussel	14,666	$146.66	$1,500	9.8	126	2.37 (0.1)	13.3 M per 12,000 L tank; must set on string

**Algae (L) per million seed: includes feeding at all stages of development including broodstock.*

5.0 Pros and Cons of locating a commercial shellfish hatchery at the Deep Bay Field Station

The CSR has emerged as the focus for an integrated, strategic and cohesive approach to shellfish aquaculture research and innovation, technology development and training in BC. Based on the agriculture model, the CSR has, over the last four years, begun to construct the research and development infrastructure necessary to support the needs of the shellfish aquaculture industry. In October 2004 a new CSR research building was officially opened at Malaspina University-College campus in Nanaimo.

In 2006, site development and planning for a field station was begun on a 7 acre waterfront parcel in Deep Bay. Upon completion, the university based research facility, coupled with the field station and operating shellfish farm adjacent to a major shellfish growing area, will provide infrastructure that is unparalleled, both in Canada and on the west coast of the US. These facilities will form the core of a research cluster which includes the DFO Pacific Biological Station.

The pending construction of the Deep Bay Field Station provides the right opportunity at the right time to address the critical seed shortage issue. There is a possibility to construct a new commercial shellfish hatchery on the Field Station property which could supply the seed requirements of the BC industry.

The Deep Bay facility is also limited in its available size and many potential hurdles (economic, organizational and political) need to be overcome in order for this site to provide a solution to the current seed shortage. It should also be recognized that in the long term a commercial seed facility located with at the Deep Bay Field Station should be only one aspect of an integrated approach to stabilizing the supply of seed in British Columbia.

5.1 Site development and Biophysical Suitability

The Deep Bay Field Station is located at the southern end of Baynes Sound, arguably the most productive shellfish growing area in British Columbia with over half of BC's production.

Much is known about the oceanography of the sound from work conducted by BCMAL (ref carrying capacity study) and others. Seawater is considered high quality with temperature ranging between 8-15 degrees and salinity typically in the range of 24-30 ppt. (sample CTD cast data? – in appendix?). Further investigations of water quality however are warranted however.

Previous industry results would suggest that water quality is high and at worst, adequate. Fanny Bay Oysters has successfully operated a remote setting approximately 2 kilometres away for more than two decades. Odyssey Shellfish and Paradise Oyster Company have operated oyster nurseries in the bay and the Island Scallops water source is close by outside the Baynes Sound system.

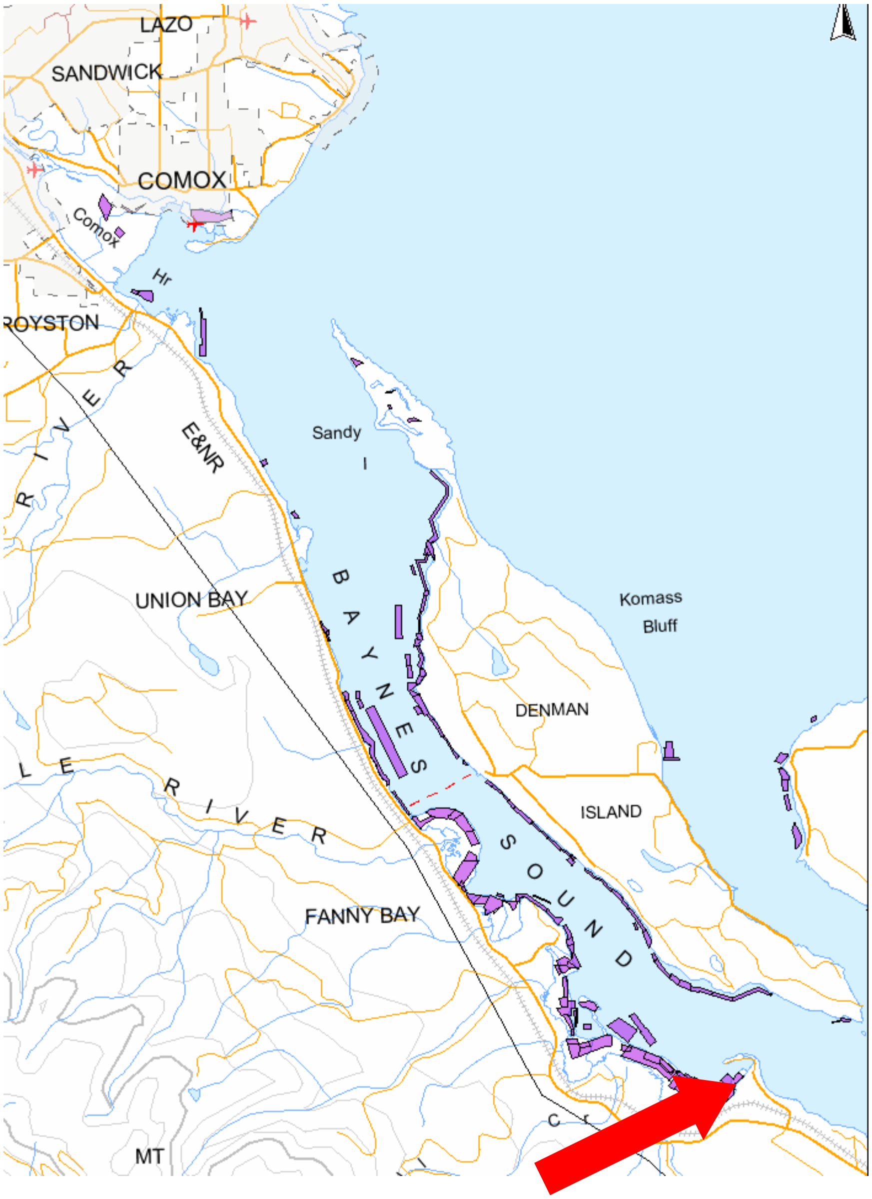

Figure 12. Map of Baynes Sound with location of Deep Bay Field Station and shellfish farming tenures indicated.

Anthropogenic sources of pollution in the vicinity is confined to potential sewage inputs from failing septic fields (the area is currently considered “approved” by Environment Canada) and the small craft harbour of Deep Bay. There are no sources of industrial, chemical or agricultural effluents and the area can be considered unpolluted.

Existing developments include the construction of an engineered building pad in close proximity to the ocean and the installation of four seawater intake lines: two above thermocline (approximately 10 metres depth) and two below the thermocline (approximately 25 metres depth.). These four intakes are capable of providing in excess of 800 GPM 800 M^3/min under worse case circumstances and are equivalent or larger than the intake systems of Coast Oysters and Taylor Shellfish's Washington State hatcheries, both of which were consulted during prior to the design and construction of the intakes.

Figure 13. Lower Building site at Deep Bay Field Station

Other aspects of the site include:

- The ability to obtain utilities – 600volt electricity, data and telephone lines.
- Good freshwater supply
- Possibility of additional upland development areas
- Associated research and training facilities (see below)
- Proximity to significant portion of industry in Baynes Sound and central to Vancouver Island shellfish industry

5.2 Associated Benefits

In addition to the benefit of seed production security, by co-locating a commercial shellfish hatchery adjacent to an R&D facility, significant synergies and reciprocal benefits can be generated for both entities. The NIWA funded Bream Bay Aquaculture Park in New Zealand provides an established example.

The economies of co-locating include the opportunity to build a commercial hatchery on an ideal waterfront location without having to purchase the land. By constructing both the hatchery and the R&D facility on the same lot, both facilities could share the physical infrastructure e.g. the seawater pump-ashore system, water filtration plant, algae culture facilities, hydro, water and sewer etc.

Co-location will also condense the lead time to seed production. The Field Station has already completed the required and lengthy (2 year) permitting process and has installed seawater pipelines. As a result the ramp-up time for hatchery construction is significantly reduced.

Business risk management will also be improved through co-location. Problems experienced in the hatchery can immediately be brought to the attention of CSR scientists and technicians for investigation and resolution.

There will also be significant knowledge benefits to the hatchery as a result of its location adjacent to the Field Station. For example the development of genomic science health management tools by CSR scientists will be of critical importance in understanding shellfish seed health in relation to hatchery management practices. This insight will be the foundation for rapid innovation in hatchery management practices which will significantly increase both seed production and seed quality. A reliable source of high quality seed will unlock the biophysical potential of the BC coast. This knowledge premium will also ensure BC shellfish farmers are prepared to adjust for climate change impacts on their farming operations.

Selective breeding programs are the foundation on which modern agri-business industries are built. The co-location of science, commercial seed production and the adjacent Deep Bay Field Station shellfish farm together provide the necessary infrastructure to enter into this activity which is vital to long-term productivity and economic competitiveness.

Malaspina University-College has a 30-year history in shellfish aquaculture training producing Certificate, Diploma, and B.Sc. candidates and, more recently through the CSR, graduate students. The availability of students to conduct targeted research projects in both a research (Field Station) and commercial (hatchery) setting would be of direct benefit to the students, to Malaspina and to the hatchery operation. The CSR's successful Shellfish Aquaculture Certificate training programs for First Nations could be expanded to include a practicum in the commercial hatchery increasing the capacity of First Nations.

The Deep Bay Field Station and adjacent commercial hatchery will enhance the opportunities for DFO researchers. The CSR and DFO already have a strong research relationship undertaking collaborative projects on species diversification, water quality management, shellfish health, environmental interactions, and R&D priority setting. DFO and CSR scientists together can focus bright young undergraduate and graduate students on priority research areas, host other research network partners and accelerate research and innovation.

5.3 Alternate locations

A comprehensive analysis of alternate locations is beyond the initial project scope of this exercise. Further discussion on alternate locations is anticipated during consultation on the current draft.

In order for an alternate site to be considered it would require the following:

- Commercial property with access to high quality seawater;
- Suitable zoning and permitting;
- Available land and space;
- In British Columbia in order to protect against potential future regulatory changes in moving seed across borders;
- Available utilities; and
- Access to industry and human resources.

5.4 SWOT Analysis

A preliminary SWOT analysis (Strength Weaknesses, Threats and Opportunities)[15] has been prepared for establishing a potential facility at the Deep Bay Field Station. It is the hope of the authors that this will serve as a point of discussion for further discussion on the current draft.

Table 21. Preliminary results of SWOT Analysis for Hatchery at Deep Bay Field Station

STRENGTHS	WEAKNESSES
❑ Developed and permitted site ❑ Location in terms of water quality ❑ Close proximity and access to industry ❑ Site and building owned and designed with input from CSR means that the capital investment remains with CSR and quality of design and construction will meet CSR guidelines. ❑	❑ Uncertain future competition ❑ Limited season ❑ Limited space for a building site ❑ Industry acceptance/buy-in ❑ High capital cost of new buildings in current construction climate
OPPORTUNITIES	**THREATS**
❑ Bring stability to seed availability ❑ Training site for industry for future additional facilities. ❑ Strong R&D link by close access to research and analytical services ❑ Close access to students may reduce operational costs ❑ Strengthen industry-research relationship ❑ Work with growers to develop site-selected best families with desirable attributes	❑ Possible future degradation of water quality in Baynes Sound through upland development ❑ Disease and bacterial contamination affect all hatcheries ❑ Unsuccessful hatchery processes ❑ Potential conflict and competition with current BC and Washington hatcheries ❑ Supply from competitors in Hawaii has broader season so can provide a great amount of seed to meet that early season demand that would be difficult to provide locally.

6.0 Recommended organizational options for locating a shellfish hatchery at Deep Bay Field Station

6.1 Background and intent

The Centre for Shellfish Research (CSR) at Malaspina University-College is in the process of developing an experimental Field Station in Deep Bay (Baynes Sound) that could be used for genetic and hatchery research. The lower building area of the Deep Bay Site was originally intended for high volume seawater research needs and future research facility development.

Using this engineered building pad to assist in offsetting industry hatchery needs in the long or short term may however be the highest and best use of this site however for supporting industry development.

While the mandate of the CSR is broad, there is no plan or interest by the CSR to engage in commercial hatchery production operating as the Centre for Shellfish Research or Vancouver Island University.

If this was to happen, it is the opinion of Vancouver Island University/Centre for Shellfish Research that the best arrangement would be one modelled on the NIWA Bream Bay Aquaculture Park scenario where the CSR as property would own the fixed assets; building seawater system, pump house etc. The hatchery building(s) would be built by the CSR in consultation with an identified leaseholder to meet jointly agreed requirements of both CSR (site) and a tenant. The CSR would then provide seawater and other services on a fee basis.

Identification of a commercial operator would be through a transparent and public RFP (request for proposal) process (Section 6.2), this would allow any of a number of organizational structures to respond (Section 6.3). The UVIC Innovation and Development Corporation has provided recommendations on the type of organization that might be most suitable (Section 6.4) and provided a detailed example of a cooperative model that might be used to respond and operate the facility (Section 6.5).

6.2 Recommendation - Request for Proposals for private operators (RFP Option)

Development and Evaluation of RFP

The CSR would propose that committee chaired by the CSR be struck to develop and evaluate proposals for hatchery operators. This committee would be made up of representatives to be determined such as:

- Vancouver Island University Administration
- Centre for Shellfish Research
- Contributing Government Agencies (Fed/Prov)
- Industry Representatives

The committee would develop and evaluate proposals based on terms including, but not limited to:

- A proposal for increasing province wide seed supply security
- Qualifications that will enable the successful operation of the facility
- Demonstrated financial plan and backing to ensure sufficient working capital
- Ability and plan for compliance with other general terms and conditions

Example general terms and conditions

Malaspina will provide

- Lease of X square feet of space at a rate of $X/square foot per year
- Utilities including power (hook-ip, telephone
- Building shell of required size designed to the point where the general shape and size of the building are determined (Schematic Design)
- Filtered Sea Water on a cost per usage basis ($/M^3)
- Work with the lessee to design the interior programming portions of the building
- Build the building and provide a fixed equipment budget (fixed equipment, includes heating system, heat recovery system and other non-removable parts of the building
- Research, analytical and technical support on a fee basis

Tenant will provide

- Equipment beyond CSR fixed equipment
- Liability Insurance
- Maintain performance parameters regarding cleanliness/biosecurity etc.
- Management within the CSR standard
- Research and Training opportunities for Malaspina staff, faculty and students and First Nations

Example Conditions

- There must be access for the public to viewing the facility and hatchery operations
- Supply algae, seed and services to the CSR at negotiated rates
- Willing signatory in the Bio-security agreement

- Willing signatory in the Maintenance and Repair Agreement
- Willing signatory in the Dispute Resolution Mechanism laid out in the general agreement

6.3 Overview of potential organizational structures for a shared hatchery.

The following options for potential hatchery development have been provided by Jeff Richards of the University of Victoria Innovation Development Corporation.

An Incorporated Association

An incorporated association provides the necessary protection to allow this hatchery to come together without incurring significant risk for Malaspina or any shellfish growers who will become shareholders (or members). The benefits of incorporation are:

- Shared Ownership
- Limited Liability
- Continuity of the organization when the leadership/membership changes
- Increases chances of getting government grants due to increased stability
- Corporation can own property

The downside of incorporation is paper work. Incorporating creates a new legal entity and with the benefits outlined above, requires regular tax returns and other government communication.

For-profit corporation

For-profit corporations are owned by shareholders, and give the power to vote on a per share basis. For-profit corporations offer the most advantageous structure for raising capital from investors. This model is the only model that allows members who invest in the corporation to have votes in equal measure to the amount of money they have invested.

If the corporation needs to raise investor funds (as opposed to government grants) for its start-up and operations, this is the best choice. In the case of a surplus at the end of the year, management has the option to distribute the surplus to the investors on a per share basis, that is, the more shares you own the more of the surplus you would receive.

Non-Profit Corporation

A non-profit corporation is governed generally on a one person, one vote model. In a non-profit there is generally no ownership of the organization, instead there is membership in the organization. Membership is given when the member pays their annual dues.

In this case a non-profit would need to determine how it could go about raising the funds to operate, usual methods are through donations or government grants. Any potential surplus will be funnelled into improving facilities, training staff and doing further research into shellfish hatchery techniques.

Co-operative Corporation

Co-operatives are well described by seven guiding principles that govern co-ops:

1. Voluntary and Open Membership
2. Democratic Member Control – one member, one vote
3. Member Economic Participation – surplus redistributed on the basis of patronage
4. Autonomy and Independence
5. Increase Industry Education, Training and Information
6. Co-operation among Co-operatives
7. Concern for Community

This organization works well in a team atmosphere where the results of the co-operative are a benefit to all members and can only be accomplished by the members working together. Democratic governance is one of the key features of a co-operative.

Raising funds can be done through memberships, annual fees, government grants and even investment shares. Surplus funds at year end are delivered to the members of the co-operative on a patronage basis. Therefore, the more a person uses (or buys from) the co-op the larger the percentage of the surplus is delivered back to the person.

Previous shellfish coop experience: Powell River

During the Shellfish Strategic Planning Workshop, the idea of developing a shellfish cooperative was discussed. The response from the attendees was less than enthusiastic due to negative experiences with the establishment of the Wilderness Shellfish Co-op in Lund several years ago. The collapse of this shellfish cooperative seriously undermined the credibility of this organizational structure as a valid way of achieving economic sustainability for the industry. The participants identified a number of reasons for the disaster of the Wilderness Shellfish Co-op.

Despite this negative experience, the Cooperative Model remains the best and most flexible way of addressing the current needs of the shellfish industry in the Powell River Region. This document is suggesting that if a co-op model that a comprehensive shellfish cooperative that will be immune to the problems that besieged the past attempts.

What about getting Charitable Status?

This venture doesn't fit the requirements for a charitable non-profit corporation. Therefore the hatchery organization will not be able to provide tax receipts for donations.

6.4 Innovation and Development Corporation Recommendations

The IDC favours incorporation of the hatchery entity to provide legal protection for the people making decisions for the hatchery.

For a specific business model the IDC offers two scenarios.

1. If an existing large investing partner will back the hatchery

   A for-profit corporation is the most appropriate structure. This will give the funding company enough shares in the company to warrant spending their money. From the industries perspective the level of control that the funding company has may be worrisome as they may make choices for their own benefit rather than the benefit of the industry. However, the funding company will be active and motivated to make the hatchery succeed.

2. If the shellfish growers community is largely in support of the hatchery

   A Co-operative corporation will be the most beneficial structure as it gives control of the hatchery and its policies into the hands of the entire membership. This provides a democratic decision making process, which should ensure decisions benefit the industry as a whole. In addition, co-operative's surplus distribution encourages people to use the seed from the co-operative's hatchery. However, co-operative corporations require active membership to succeed. Without strong proponents for this option, who are willing to put in time and effort to get the co-operative up and running this structure will not succeed.

6.5 Hatchery Co-op Business Structure Outline

The following is a conceptual arrangement of an industry cooperative board structure that could respond to a RFP issued by the Vancouver Island University/CSR for operations of a facility at the Deep Bay Field Station. This could also serve as a basis for a cooperative arrangement located at another site.

Board of Directors (7)

Two possible arrangements for the board of directors are:

Regional Elected Board

6 - Regional Split – have smaller elections for a regional representative (regions could include Baynes Sound, Barkley Sound, North Coast/West Coast Vancouver Island, Sunshine Coast and Lasqueti and Lund, Cortes/Read/Redonda and South Coast Vancouver Island)
- AND -
1 - Vancouver Island University/CSR Member

- OR –

Open Board

6 - Elected Representatives from any region
- AND -
1 - Vancouver Island University/CSR Member

It was well established that the hatchery must be free to operate under the guidance of the paid professionals who are hired to care for the facility. The board of directors' responsibilities will be restricted to caring for the fiscal responsibility of the hatchery and for setting in place policy under which the hatchery will function.

The board of directors will not have the right to dictate the day to day operations of the hatchery. Nor will the directors have the right to consider the release of the hatchery manager except at regular board meetings and under extenuating circumstances.

Managing Customer Deliveries

All growers would prefer to have seed delivered at the same time; however, practical limits on the growing of seed make it impossible to deliver the desired seed to each grower at the same time. Consequently, the hatchery will require a method to distribute seed such that all members have a fair chance to receive seed at the prime time. All members will be entered into a draw stating their preferred delivery time. Names will be drawn at random and the delivery calendar filled accordingly. If a member's 1st choice desired delivery time is taken, their 2nd choice will be granted to them, if their 2nd choice is taken their 3rd choice will be granted, etc.

Shellfish seed requires a certain minimum order to be worth producing and the seed is produced at different times during the year, each member will be required to make an estimate of the type and amount of seed that they would like to purchase over the course of the year and the board of directors and hatchery manager will chart out the seeding goals for the year.

Preserving Customer Fidelity

One of the clear challenges in starting the hatchery is making certain that the hatchery product is used. The worst situation would be the case where the hatchery produces good seed but due to a flooded market the shellfish growers choose to buy seed elsewhere to lower their costs.

To ensure customer fidelity:

1. Offer reduced rates to members, the standard co-op model would be to charge all users the same rate, but to offer a rebate to members based on the success of the co-op. If the co-op generates revenues over the course of the year than a portion of these revenues would be redistributed based on how much of seed the member bought from the co-op.
2. Require a deposit on seed. Where members would like to buy seed from the co-op in the upcoming year, a deposit should be put down on the seed. This deposit would give the hatchery a good estimate of the amount of seed that they need to produce and a non-refundable portion of this deposit would ensure that the customers do in fact buy from the hatchery. The deposit shall NOT be used to support operating expenses of the current year as the money is not effectively the hatcheries until the seed has been delivered.
3. Only membership and a deposit will allow a member to enter the draw for the most popular seed delivery times.

Raising Operating Funds

Generally speaking a Co-op raises their first round of equity through membership shares. At $2000/share and 100 members we would be able to raise $200 000.

CDI is a government initiative that offers co-ops a chance at up to $75 000 per year until March 31, 2009 (at the moment). The funds are aimed at innovative and research related applications of the co-op model so there could be opportunities for the hatchery here. This could be a source for an additional $75 000

Operating expenses for the hatchery need to come from the shellfish growers and other parties that would be interested in the development of the hatchery co-op. Ideally, the hatchery would start with enough financial backing to support itself through the first 2 years. This will allow the hatchery to find its stride and focus on the art and science of producing top quality seed rather than using resources to track down new sources of funding.

We expect that once the hatchery has ramped up to full production that the hatchery will be able to support itself. The hatchery co-op will be expected to work towards a three year operations fund reserve. Once the three year operations fund reserve has been achieved any excess funds will be distributed to the members.

Raising Capital Funds

Building the hatchery is going to require a substantial initial outlay of capital, the ownership of the hatchery building structure and large scale equipment needs to rest with the Vancouver Island University/CSR. Therefore, it makes the most sense for this expenditure to be supported through Western Economic Diversification, Ministry of Advanced Education, Department of Fisheries and Oceans, Federal Ministry for Agriculture or BC Ministry of Agriculture and Lands. The best possible scenario is that the government funding bodies provide Malaspina a grant to build the facilities which will serve not only as a local hatchery to the industry but also as a training facility for new graduates interested in shellfish aquaculture.

Land Lease Arrangement

Vancouver Island University/CSR then would lease this land and building to the hatchery organization for a reasonable rate. In addition, to the cost of leasing the space, the hatchery agrees to pay for the services that the hatchery requires. This will be an at cost expense managed by Malaspina and regularly billed to the hatchery.

Hatchery Management

The board of directors will select a hatchery manager who will be charged with the day-to-day operations of the hatchery. The output goals for the hatchery will be determined by the board and the hatchery manager as the result of the orders which have deposits of the members. The hatchery manager will then be in charge of making a budget for the hatchery operations for the year. The board of directors will approve that budget and the hatchery manager will be free to do his work within the confines of the budget. The hatchery manager will be responsible to the board through reports at the quarterly meetings.

A contingency fund will be setup to deal with special expenses; this contingency fund will be accessible through the board of directors.

Hatchery Operations

It is understood that while Vancouver Island University/CSR faculty and students will be involved in the hatchery, the hatchery will need to have enough staff that it does not depend student labour for its' day-to-day operations.

7.0 Conclusions

Final conclusions have not been drawn at this time but will be completed after consultation and discussion of the current draft document. The following points have been noted by the authors and are expected to guide conclusions.

- Analysis of Capital Cost Depreciation + Operational Cost versus revenues leads to conclusion – New hatchery (as proposed) is not viable - It is NOT economically feasible to build and operate a new hatchery facility based on current market prices.
- Full business planning will need to recognize that two (or more) years of working capital will be required.
- Question – If it is not economically feasible, what are the alternatives?

  Alternative Revenue Scenarios
    - Seed pricing sensitivity
    - Equity participation
    - Focus on high value/low cost species
    - Other???

  Alternative Cost Scenarios
  - Reduce Capital Costs
    - Capital Costs Reduced - through high density approach
    - Capital Costs Contributed - through government grant
    - Other
  - Operational Cost Efficiencies
    - Focus on low-cost species
    - Reduce species produced
    - Increase use of technology to reduce labour and operating costs
    - Use students as labour force
    - Customer participation as labour force
    - Other??
- Final design should be based on recognition of other factors
  - Personal/Corporate Preferences (high vs. low density)
  - Evolving field – new technologies and approaches
  - Risk Management
  - Production cost per species - Relative comparison
- Risk Evaluation of Alternate Scenarios
  - Constraint of multi-species hatchery reduces options for cost efficiencies.

  - Use of high density rearing strategy for both larvae and algae reduces capital costs but may increase risk.
  - Increased use of heat pump technology increases capital costs but reduces operating costs.
  - Minimizing the risk of production failures should be the main driver of decision-making.
  - Recommend the increased use of technology to reduce operating costs.
- Economic viability of seed production and the BC Shellfish industry will be affected by continued R&D into:
  - Seed Quality Assurance
  - Science- Genomics
  - Best Management Practices – Seed Transport
  - Extension Support and Training
  - Seed Quality Assessment – NIR
  - Seed Quality Certificate and Guarantee
- Recommend seeking government support to fund the capital costs of a new hatchery
  - Government funding to cover the capital costs of the new hatchery will require specific conditions be met. For example:
  - Government cannot provide a capital grant to an individual company;
  - Government support will require fairness and equity in distribution of benefits of this initiative i.e. access to seed; fair market pricing; multi-species production to meet industry needs.

8.0 References and Notes

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[9]http://www.agf.gov.bc.ca/fisheries/Shellfish/geoduck/main.htm Accessed March 29, 2007)

[10] Porter, D. 2008. Bacteria hit shellfish larvae; Major West Coast industry threatened if remedy isn't found soon. Tillamook Headlight Herald. Accessed at: http://tillamookheadlightherald.com/main.asp?SectionID=8&subsectionID=8&articleID=9550

[11] This was an estimate made prior to the analysis of production and import data as described in section1.3.

[12] Eudeline, B., Jones, V., Jones, D., Jones, E., Williamson, B. and C. Jensen, 2007. Hatchery innovations related to high density larval rearing and supplemental feeding of juveniles. Presentation at PCSGA 2007 for Taylor Resource, Inc., Quilcene, WA.

[13] http://www.seasalter.org.uk/hatchery.htm

[14] http://t3vi.ca/career/technologies/aquaculture-techs.php

[15] SWOT Analysis, is a strategic planning tool used to evaluate the Strengths, Weaknesses, Opportunities, and Threats involved in a project or in a business venture. It involves specifying the objective of the business venture or project and identifying the internal and external factors that are favorable and unfavorable to achieving that objective.

If SWOT analysis does not start with defining a desired end state or objective, it runs the risk of being useless. A SWOT analysis may be incorporated into the strategic planning model. An example of a strategic planning technique that incorporates an objective-driven SWOT analysis is SCAN analysis. Strategic Planning, including SWOT and SCAN analysis, has been the subject of much research.

* Strengths: attributes of the organization that are helpful to achieving the objective.
* Weaknesses: attributes of the organization that are harmful to achieving the objective.
* Opportunities: external conditions that are helpful to achieving the objective.
* Threats: external conditions that are harmful to achieving the objective.

Identification of SWOTs is essential because subsequent steps in the process of planning for achievement of the selected objective may be derived from the SWOTs.

First, the decision makers have to determine whether the objective is attainable, given the SWOTs. If the objective is NOT attainable a different objective must be selected and the process repeated. (from Wikipedia)