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Geoduck Aquaculture: Estimated Costs and Returns for Sub-tidal Culture in B.C.

Introduction

The purpose of this report is to provide a summary of background information and estimated production economics for seeded sub-tidal geoduck grow-out production in order to develop a general awareness of the business potential and the risks associated with geoduck culture.

Data Sources and Methodology: The assumptions and basic data for this analysis were developed from the author's own knowledge, consultations with other Ministry staff, industry members and from published data (e.g. Pinfold 2001). The report generally follows a format and approach used in the earlier factsheet on "Estimated Costs and Returns for a Seeded Clam Grow-out Enterprise" (Heath and Gubbels 1993). A companion report, "Estimated Costs and Returns for a Sub-tidal Geoduck Enterprise" (Heath 2005) describes the farm model, underlying assumptions and estimated costs and returns and related calculations in more detail.

Geoduck Biology: The geoduck (*Panopea abrupta; Panope generosa*) is the world's largest burrowing clam (up to 206 mm shell length) and one of the longest lived species: maximum age recorded is over 140 years (Shaul and Goodwin 1982). Its native range is from Kodiak AK (58 deg N) to Newport Bay CA (34 deg N) buried in a variety of substrates from mud to sand to gravel, low intertidal to 100m or more [Harbo 1997].

Growth in natural populations is relatively fast in the first 7-10 years (20-30 mm SL; Anderson 1971; Goodwin 1976), but is insignificant in larger geoducks. Growth rates and size display strong spatial variation. For example, in Puget Sound average size decreases from south to north, and from shallow to deep (Goodwin and Pease 1991).

Natural mortality from predation is very high during early benthic (bottom) life of geoducks (Goodwin and Shaul 1984) but decreases rapidly after the age of one year (Sloan and Robinson 1984). Predation on adult geoducks appears to be rare, except by sea otters and man. However, natural events causing anoxic conditions at the sediment water interface can also negatively affect geoducks (e.g. following massive squid spawning [Fyfe 1984] and drifting masses of marine vegetation [Anderson 1971].

Natural recruitment of geoduck (i.e. the replacement process of reproduction, growth and survival) appears to be very low or sporadic in recent decades in Washington and BC geoduck populations (studies summarized in Orensanz et al. 2000). Concerns over low estimates of recruitment and significant cumulative fishing pressure, as well as high market prices, have lead to research into geoduck culture methods for enhancement and aquaculture.

Geoduck Enhancement and Culture: In the early 1970's at the Point Whitney Laboratory in Washington State, research started into geoduck hatchery, nursery and grow-out methods (Beattie 1992). In the 1990's, the technology for geoduck culture was transferred to British Columbia by Fan Seafoods Ltd and the Underwater Harvesters Association (UHA) which represents the commercial geoduck fishers in BC. Further refinements to hatchery, nursery and sub-tidal grow-out methods have been developed by industry companies and the UHA in the intervening years.

Habitat Conditions and Seed Production :

The following information is a summary of currently available knowledge on appropriate habitat characteristics and options for nursery and grow-out phases (Beattie, 1992; Pinfold 2001.)

Table 1. Summary of optimal biophysical parameters for geoduck culture (after Pinfold 2001)

Substrate	**mud/sand/pea gravel (penetration to 1m)**
Depth	**3-20 m**
Temperature	**8-18 C**
Salinity	**26-31 ppt**
Transparency (Secchi)	**2->10m**
Current velocity	**<1.5 kn (<0.75 cm/s)**
Productivity	**15-200 mgC/m2/day**

Seed Production: Hatchery-produced seed (juveniles) is a basic requirement of commercial geoduck culture and is in high demand, with limited supply currently. Seed is generally grown to 3-6 mm in the hatchery before transport to a nursery site.

Nursery: Since early studies suggested that survival in field plantings during the first year tends to increase with size of the seed (Beattie 1992), nursery systems have been developed in Washington and BC to boost the juveniles from 3-6 mm to 12-20 mm for sub-tidal planting. However, the added costs of prolonged nursery rearing are substantial, so a variety of nursery strategies, including predation control, have been tried. These nursery strategies include:

- Land-based ponds and raceways with seed in sand substrate, with supplemental feeding of cultured algae (from 6-12 mm SL); good survival, but costs are significant for large capacity systems..
- Floating upwelling system (FLUPSY): water-based raceway nursery with sand-filled trays and forced circulation (paddlewheel), bringing natural phytoplankton and removing wastes; seed grown from 6-18 mm under considerable control, but with relatively high capital and operating costs.

- Benthic tables at marine sites (sand-filled net bags on raised platforms), using natural phytoplankton for feed and netting for protection, initially over-winter (from 6-20 mm); managed by diving; effective, but cumbersome. .
- BOBs (Bags-on the-Bottom) at marine sites; zippered net bags installed on bottom sites and planted by divers; lower costs, but variable survival.

Seeding: Upon reaching a size of 12-20mm, the geoduck seed are diver-planted into suitable marine substrate for the grow-out phase. Mechanized seeding machines have been developed by the UHA and Fan Seafoods Ltd that are capable of planting between 20,000 and 50,000 seed/day, depending on seed size, substrate type, tenure size, and conditions of water and weather at the site. Seeded areas are generally protected (e.g. through use of nets) for the first 1-2 years to reduce losses to predation. Crabs, moonsnails, seastars, and bottom fish are among the most significant predators of geoduck juveniles (Beattie 1992).

Culture Model for Estimation of Costs and Returns for a Geoduck Culture Enterprise

The following model and estimated data are for discussion and illustrative purposes only. They cannot be applied directly to other situations. The results must be interpreted and modified for a large number of factors, such as site productivity, location, investment costs, as well as management, production and marketing practices, which will affect quantity and quality of production and varying costs and returns for production.

Selected Background Information and Assumptions:

The farm: a 10 hectare (24.7 acre) geoduck (*Panope abrupta*) grow-out enterprise located in the Strait of Georgia, BC.

Analysis type and scope: an economic analysis providing annual costs and returns, as of January 2005, for on-going full production. Results are summarized in Table 2.

Grow-out site characteristics: 10 hectares (24.7 acres) in 6-12m depth range, substrate composed of mud/sand with adequate penetration (1m) and no eelgrass/10m buffer on 80% of the area (i.e.useable area = 8 ha or 19.8 acres), water temperatures ranging from 8-18 C, salinity ranging from 26-30 ppt. In summary, the site has conditions necessary for moderately good geoduck growth (i.e. it can grow market-sized geoducks of 0.7 kg in 6 to 9 years; average of 7.5 y).

Production system: a rotational system with eight 1.0 ha (2.5 acre) plots. Each plot is in a different phase of geoduck production, from first year seeding and growth to second through seventh year growth and, finally, eighth year growth and harvesting.

Methods applied for the 1.0 ha (2.5 acre) plot in the first year of the cycle: protection from predators is provided by installation of net panels at the time of planting. Seed in the size range from 12-16 mm in shell length are planted at 20/m2 once a year from March to May. The total number of geoducks seeded per year is calculated as: 20/m2 x 10,000 m2 = 200,000 geoduck. The cost for geoduck seed is assumed to be $1000 per thousand (hatchery + nursery costs) = $200,000.

Post-seeding practices on the full 8 ha (19.8 acres): the site is maintained by checking that netting is intact, not biofouled heavily and properly secured as well as equipped with net floats to prevent coverage by substrate. Site monitoring is conducted to provide inventory assessment and to prevent poaching.

Estimated losses: 70% losses from all causes occur over the eight year grow-out period; and 85% harvest efficiency, resulting in 25% recovery at harvest stage..

Harvesting: each year the 10,000 square meter area containing the geoducks that have grown for 8 years is harvested by contract diver-harvesters. About five geoducks averaging 700 g are harvested per square metre. Thus, the total number and weight harvested are 50,000 geoducks and 35,000 kg (77,093 lb.), respectively. Contract harvesting cost, based on 900kg/day/diver @ $500/day/diver, is about 39 days x $500/day = $19,500 (or $0.56/kg).

Table 2. Summary of Estimated Costs & Returns for a Sub-tidal Geoduck Enterprise

1 Item Description	2 Total (10ha) $	3 Per ha. $	4 Per ac. $	5 Per kg. $	6 Per lb. $
RETURN at $20.00/kg	700000	70000	28340.08	20.00	9.09
Cash operating costs:					
Seed	200000	20000	8097.17	5.71	2.60
Hired Labour	15000	1500	607.29	0.43	0.19
Licence, fees, prop. Taxes	993	99.3	40.20	0.03	0.01
Repair, Maint. & Fuel	8390	839	339.68	0.24	0.11
Miscellaneous	6050	605	244.94	0.17	0.08
Contract seeding	20000	2000	809.72	0.57	0.26
Contract harvesting	19500	1950	789.47	0.56	0.25
TOTAL CASH OP. COSTS	269933	26993.3	10928.46	7.71	3.51
Depreciation	31710	3171	1283.81	0.91	0.41
TOTAL CASH OP. COSTS + DEPR.	301643	30164.3	12212.27	8.62	3.92
NET FARM INCOME	398358	39835.8	16127.85	11.38	5.17
Interest on capital investment	297276	29727.6	12035.47	8.49	3.86
Interest on operating capital	13111	1311.1	530.81	0.37	0.17
RETURN TO OPERATOR MANAGEMENT & LABOUR	87971	8797.1	3561.58	2.51	1.14
Rate as $/hr	73.31				

Alternative Geoduck Prices and Yields:

The market price and survival rate of geoducks can have a major impact on the economic and financial outcome of a geoduck business. Table 3 provides the estimated net farm incomes per hectare for a range of alternative geoduck yields and prices.

Table 3. Geoduck Enterprise Estimated Net Farm Income (NFI) per hectare with Alternative Prices and Yields (Kg/m2).*

Prices per kg of harvested geoducks

	12.00	14.00	16.00	18.00	20.00	22.00	24.00	26.00	28.00	30.00
Kg/m2										
2.10	**-4964**	**-764**	**3436**	**7636**	**11836**	**16036**	**20236**	**24436**	**28636**	**32836**
3.50	**11836**	**18836**	**25838**	**32836**	**39836**	**46836**	**53836**	**60836**	**67836**	**74836**
4.90	**28636**	**38436**	**48436**	**58036**	**67836**	**77636**	**87436**	**97236**	**107036**	**116836**

Breakeven Prices and Yields to Achieve a Specified Net Farm Income:

The data in Table 3 are plotted in Figure 1 along with a specified Net Farm Income line to illustrate the sensitivity of NFI to price and yield. The specified line indicates the level required in order to reach certain returns to operator labour and management, interest on capital investment and interest on operating capital. It is based entirely on imputed or specified data at levels that might be realistic goals for developing a geoduck enterprise. The per hectare specified NFI depicted in Figure 1 was derived as follows:

- 120 hours of operator labour and management per ha x $30.00/hour = $3,600
- Interest on capital investment (see Table 2, col. 3) $30,000
- Interest on operating capital (see Table 2, col. 3) $1,300

Specified Net Farm Income (NFI) per ha $34,900

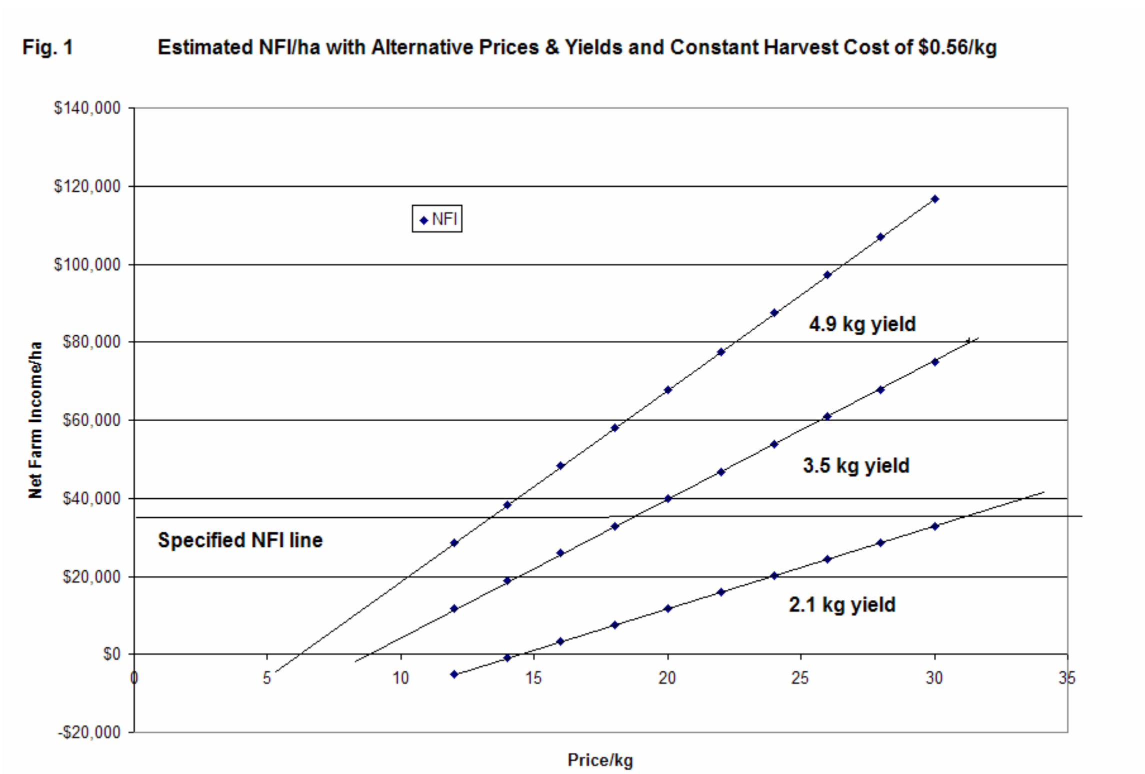

Figure 1. Estimated Net Farm Income per Hectare with Alternative Market Prices and Yields and a Constant Harvest Cost of $0.56 per kg (based on 900 kg/diver day X $500 per diver day).

Graph Interpretation:

At a yield of 2.1 kg/sq. m (3 geoduck/sq. m), the breakeven price is not achieved until the price is over $32.00/kg (i.e. the specified NFI is reached when price is over $32.00 /kg.). At a yield of 3.5 kg/sq. m or 5 geoducks/sq. m, the breakeven price is achieved at about $18.00/kg since this is the price at which the specified NFI is reached.
At a yield of 4.9 kg/sq. m or 7 geoducks/sq. m, the breakeven price is about $13/kg. Below this price, the specified NFI is not attained and above this price, the NFI will be higher than the specified level.

Alternative Geoduck Seed Costs and Harvest Yields:

The largest single cost of growing geoduck in the current study is the cost of seed. Here it is assumed that the cost of seed ready to plant (6 -16mm shell length) averages $1.00 per geoduck juvenile. At this level, the cost of seed accounts for 66% of the total cash operating costs and depreciation.
Table 4 gives the estimated NFIs per hectare for a range of alternative seed costs from $0.33 to $1.67 per juvenile, and for geoduck harvest yields from 2.1 to 4.9 kg per sq. m., while keeping the market price constant at $20.00/kg.

Table 4. Geoduck Enterprise Estimated Net Farm Income per Hectare with Alternative Seed Costs and Geoduck Yields*

	Geoduck Seed Cost ($ per juvenile)				
.	**0.33**	**0.67**	**1.00**	**1.33**	**1.67**
Kg/m2					
2.1	**25130**	**17990**	**11836**	**4130**	**-3010**
3.5	**53130**	**45990**	**39836**	**32130**	**24990**
4.9	**81130**	**73990**	**67836**	**60130**	**52990**

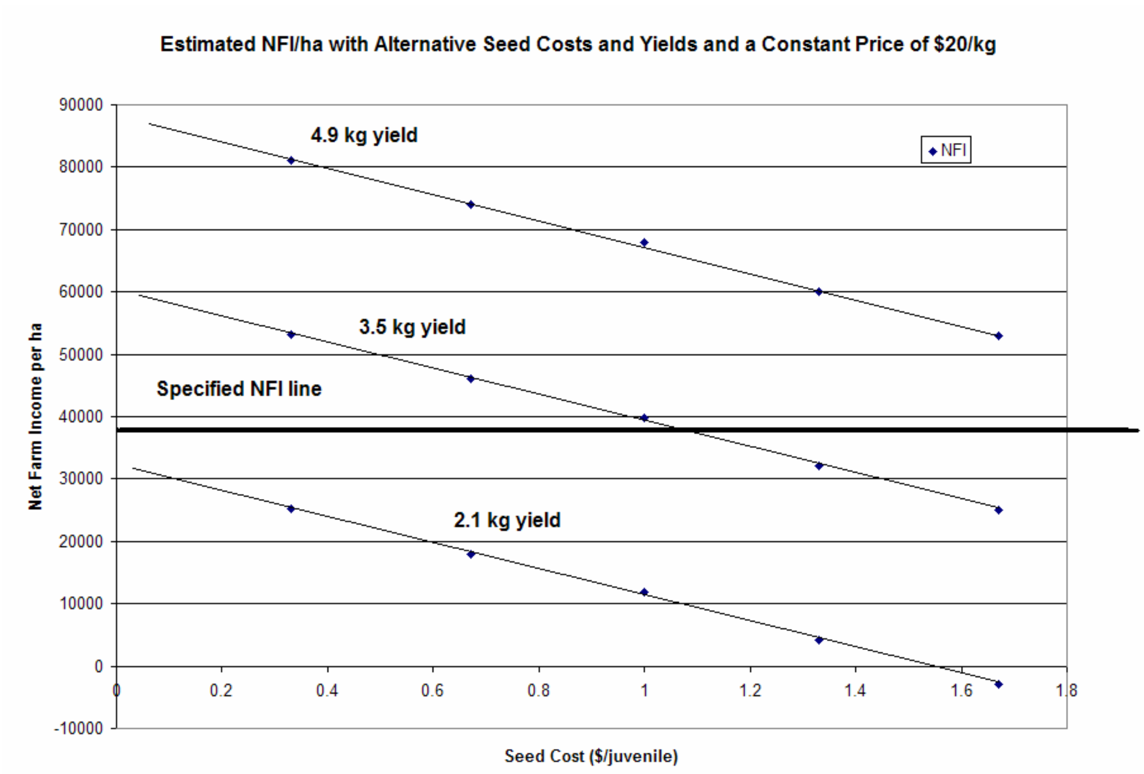

Figure 2. Estimated Net Farm Income per Hectare with Alternative Seed Costs and Yields at a Constant Market Price of $20.00 per kg.

Graph Interpretation:

Figure 2 indicates that for a yield of 2.1 kg per square metre, the specified NFI cannot be reached at any seed cost. For a yield of 3.5 kg per square metre, the breakeven point is at $1.05 per seed, whereas for a yield of 4.9 kg per square metre, the specified NFI is exceeded at all seed costs below $1.80 per juvenile.

Conclusion:

With the current level of knowledge regarding sub-tidal geoduck culture, differences in operator and management ability and a range of seed and market prices that might be expected in the future, it is likely that the financial outcomes for entrepreneurs developing geoduck farms could vary considerably. The results could range from highly successful businesses to unfortunate business failures. **Prospective geoduck farmers will need to carefully consider the opportunities and risks associated with developing a sub-tidal geoduck enterprise. Particular attention should be paid to thorough business planning and assessment of site productivity before initiating a sub-tidal geoduck enterprise.**

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