Agenda item 6.2
For information

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Closed containment: recent developments - costs and benefits

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Aquaculture has since the mid 1980's been the fastest growing industry within food production. One sector that has had rapid growth is the salmon farming industry gaining foothold in all global markets. The main salmon farming countries are Norway, Chile, Scotland and Canada.

With the future demand for salmon, and other fish species, alternative production methods and strategies will be required so the industry can produce fish sustainably and be able to service all markets.

One such potential is land based salmon production in contained systems, i.e. recirculation aquaculture systems (RAS). RAS has many advantages as follows:

- Complete control of rearing environment
- Potential for disease free production
- Can be located close to markets
- Minimum environment impact

A number of pilot scale RAS plants, as well as some commercial sized ones, have been built in recent years.

The production systems built today are all of different concepts and not all have been free from problems, as expected. However, based on the observations and experiences from especially two pilot scale projects in North America; Namgis on Vancouver Island and the Freshwater Institute in West Virginia, some very important observations have been made. The conclusions of this is that RAS technology for land based salmon grow-out is available, i.e. systems where it is technical possible to produce salmon in them. The observations from the pilot scale project has further shown that it is possible to produce a high quality salmon in RAS.

There are however, with production to date both in the pilot scale projects and the commercial ones, still a number of technical and biological obstacles to overcome. The first one is the phenomena of precocious or early maturing males. There is a relatively large proportion of males that mature early in RAS production, up to 30% of the male population has been. This happens when the fish are around 1.5 to 2 kg. The problem is that they stop growing (despite being fed) and they lose their silvery color and flesh quality becomes inferior - in other words they are not marketable. This is a loss factor and inconvenient for any operation. The main reason for the early maturation is most likely because of accumulation of female sex pheromones in a RAS. In a self-contained system as in a RAS, there will not be any flushing or dilution effects as in ambient systems. There has so far not been found means of eradicating the phenomena of pheromone accumulation, but one commercial RAS has reduced the occurrence of early maturing male fish by certain light regimes. There are also now trials with different salmon strains, and latest with all female stock.

The second constraint for successful production is the RAS concept. There are being used some bio filter types which probably are not the most optimum for saltwater RAS, mainly certain so-called submerged stationary filters. These types of filter's objective are, apart from biological filtration, also to entrap solids or fish feces. This can create pockets in the bio filters where oxygen levels will inevitable be lowered with potential for Sulphate Reducing Bacteria (SRB) activity. This means that there can be risk of Sulphide formation. Maybe not in concentrations entailing mortalities, but in concentrations that could well inhibit fish growth. It is recommended in saltwater RAS the use of bio filters where no sludge accumulates and instead for solids control, to use mechanical filtration concepts where sludge exit the system.

To be viable, aquaculture has to, like any animal production, be approached in an industrial or commercial scale. This presentation deals with 6,000 thousand tons per annum production. The system design is based on a standalone system with the ability to supply the markets weekly.

The capital costs for the 6,000 tons per annum system described is € 35,000,000. This figure corresponds well with capital costs pro rata with existing projects and other projected ones. In comparison, and when the shorter replacement period for net cage systems is taken into consideration, this is approximately 2.5 times that of net cage systems.

Capital requirements:

Total capital requirements are shown in Table 1.

Capital needs: CAPEX (incl. incubation and smolt prod, DN, EOPT)		€ 37.000.000
	1st year direct production costs	€ 13.000.000
		€ 50.000.000
Financing:	Private equity	€ 12.000.000
	Loan equity	€ 38.000.000
Depreciation: CAPEX € 37.000.000 15 years		€ 2.466.677
Financial costs: € 38.000.000 10 years 5%		€ 4.921.173

Table 1, Financial requirements for 6,000 tons of annual production

The total capital requirements for a 6,000 tons' annual production is around € 50 million. In this example, it is assumed a private equity of € 12 million.

Operational costs:

Operational costs and cost to market is shown in Table 2.

	6,000 tons/a		(2,000 tons/a)
Direct OPEX costs	€ 13.200.000	€ 2.19/kg	(€2.53/kg)
Depreciation 15 years	€ 2.466.667	€ 0.41/kg	
Financial costs 10 years 5%	€ 4.920.000	€ 0.82/kg	
Total OPEX whole weight fish			€ 3.42/kg
Price HOG (88% yield) – 5.280.000kg		€ 3.89/kg	
Processing (€ 0.30/kg) + Freight (€ 0.20/kg)		€ 0.50/kg	
Total cost to market (Brussels from mainland Europe		€ 4.39/kg	(€ 4.77/kg)

Table 2. Operational costs and costs to market.

Fish processing and dispatch to markets is anticipated to be done externally. The operational cost before depreciation and financial costs is € 2.19/kg whole weight. With depreciation and financial costs, it is € 3.42. With an anticipated gutting loss of 12% of whole weight, this equals € 3.89/kg head on gutted (HOG), which is the form salmon are sold in. Add to this costs for gutting, boxing, icing and dispatch of € 0.50/kg, (on mainland Europe), this gives a price to market of €4.39/kg HOG. The standard price, and which is given in the weekly salmon prices and forecasting indices, is delivered to Brussels. To break even one would need a price delivered to Brussels of € 4.39/kg HOG.

The price for salmon varies over the year depending on demand/supply and from year to year. In Table 3., the price for 2014 is shown and more recent prices for 2016.

Sales price	ROI% on € 12 mio private equity	(2000ton/a)
€ 4.84/kg*	19.9%	(2.9%)
€ 5.50/kg**	48.0%	(31.9%)

Table 3. *Average price achieved Brussels for 2014. ** indicative price for 2016.

It can be seen from above table, that when prices are low, i.e. 2014 prices, it is borderline acceptance for return on investment. Prices in 2016 have so far been high, lying between € 5.50 to 6.50 and returns on investment can be attractive.

RAS technology and economics improve gradually all the time, though it is seldom that one sees sudden major breakthroughs. There are however, some recent ideas, the so-called concentric tank concept that could well change the economics in RAS production quite significantly. This new concentric tank concept is based on shared tank walls both inter tank and for treatment system. These type plants are erected on a flat concrete slab, with no expensive underground pipe work. There are neither any expensive concrete constructions, which at times has been a “killer” in the costs of some RAS constructions.

The future of land based salmon grow-out in RAS:

It can be concluded that RAS concepts suitable for land based salmon production exists and that it is possible to produce a quality salmon in RAS. At present, operational costs exclusive of depreciation and financial costs can compare with cage rearing.

Capital costs are relatively high for RAS and hence also capitalization and depreciation. When market prices for salmon are at present high levels, land based production will be economically viable and a very good business proposition. Low market prices (as seen in 2014) could however, still leave a land based entity vulnerable. New RAS concepts are emerging that will have a positive effect on land based salmon production.

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