A general comment on sustainability

Cooke Aquaculture funds extensive research programs in all aspects of its husbandry cycle from hatchery to net pen. This includes (a) establishment of sustainability criteria and thresholds at its culture sites (b) new methods of measuring ecological impacts at field sites, (c) predictive models fish growth and nutrient/fecal loss, (d) circulation/dispersion at culture sites and the wider ecosystem, and (e) fish health studies employing epi-informatics and models of treatment strategies. Specifically, Cooke has partnered with the Natural Sciences and Engineering Research Council of Canada to fund the NSERC-Cooke Industrial Research Chair in Sustainable Aquaculture at Dalhousie University. This is an on-going multi-million dollar investment in aquaculture sustainability and ecosystem-based management. The Chair, Dr. Jon Grant, is an oceanographer and marine ecologist with decades of aquaculture experience who developed among the first carrying capacity models applied to aquaculture. In reading the MBA methodology criteria document, we see reference to the principles of aquaculture management that we have embraced through the Chair research and are incorporating into our farming practices. Much allusion is made to the importance of models of assimilative and carrying capacity. Cooke's researchers have pioneered these approaches and continue to develop their application into decision support systems. We emphasize that Cooke has embraced research into sustainability to an extent that rivals any aquaculture company in the world. While the results have not been applied to every farm yet, we are utilizing approaches that are applicable to all of our farms worldwide, and indeed any shellfish or finfish growing operation. We would be pleased to share any of this progress with MBA, including seminar presentations from Dr. Grant in Monterey.

3. Effluents – solids

Cooke has worked closely with Maine state agencies to develop effluent criteria that ensure environmental protection. Sampling is carried out with a team of consultants and other scientists with extensive experience in aquaculture impacts. In addition, Cooke funds cooperative research with the Canadian Dept. of Fisheries and Oceans to refine methodology applied to geochemical impact assessment such as sulfides. This includes further refinement of modelling approaches such as DEPOMOD for application to fish farms. These data as well as models consistently show that farm effects cannot be detected beyond 10's of meter from the site, i.e. the footprint is tight to the farm. For these reasons we maintain that effluents from fish farming are in the low to low-moderate category.

Effluents – dissolved

Dissolved nutrient discharged may be even less of a concern. It has been our experience when attempting to sample ammonia near farms, that it is undetectable even within the net pen. The dispersion is extremely rapid. This topic has been reviewed in other MBA documents. Specific studies of Cobscook Bay (Sowles and Churchill 2004) suggest that the nutrient loading of salmon farms is low compared to other inputs in the bay and would not stimulate phytoplankton blooms.

Sowles, J. W., Churchill, L.. 2004. Predicted nutrient enrichment by salmon aquaculture and potential for effects in Cobscook Bay, Maine. Northeastern Naturalist 11 (Special Issue 2): 87-100.

3.1 Habitat

The preservation of ecosystem services is the core of sustainability. Cooke Aquaculture funds research that measures ecosystem services directly, a task that it not carried out by any other company to our knowledge. Specifically, the assimilative capacity of different habitats is measured as fluxes of benthic nitrogen and carbon, and then mapped via acoustic survey of habitat type. We conduct these studies at baywide scales. In support of this work, ecosystem models have been developed which include the benthic and pelagic food webs as well as relevant geochemistry. Oceanographic circulation models are used as the underlying basis for applying the ecosystem models. This research is conducted in the context of marine spatial planning and ecosystem-based management, essential foci in sustainability science.

5. Feed

There are no mistakes in Jennifer's calculation of the FIFO ratio for Criterion 5.1a. Feed requires fishmeal and fish oil. The idea is to calculate the amount of wild fish needed to produce aquaculture fish. To do that, the following information is needed:

- % fishmeal/fish oil in the feed (a and b in page 19 of MBA methods)
- % extraction efficiency of fishmeal/fish oil from wild fish (c and d on page 19)
- FCR (e on page 19)

FIFO is calculated as follows:

FIFO-fishmeal = [%fishmeal in feed/%extraction efficiency of fishmeal] x FCR

Cooke data = 2.051/22.5*1.5 = 0.137

FIFO-fish oil is calculated in the same way = 11.114/5*1.5 = 3.334.

MBA chooses the worst FIFO, that is, FIFO-fish oil, which suggests that Cooke needs 3.334 kilograms of wild fish to produce 1 kilogram of salmon. Verlasso scores high on this point because they use a genetically modified yeast instead of fish oil.

SOURCES OF UNCERTAINTY

A) Cooke knows their own feed composition and FCR very well. However, the calculations used generic values for % extraction efficiency of fishmeal/fish oil, 22.5 and 5% respectively (values that are suggested by MBA and that come from Tacon and Metian (2008)). Cooke's specific values may be more accurate.

B) The other aspect that could be criticized is that the conversion from FIFO value to FIFO score is a bit extreme. The conversion follows:

FIFO score = 10 – (2.5 x FIFO value)

With this equation: (1) only feed without wild fish components would receive the maximum score, and (2) a FIFO value of 4 would get the worst score, 0. However, according to Tacon and Metian (2008), the most updated FIFO for salmon is 4.9 which could result in scores >10. The equation should be reformulated accordingly, because the scale is clearly defined between 0 and 10. A revision is suggested:

FIFO score = 10 – (2 x FIFO value)

This change is reasonable and objective taking into account Tacon and Metian (2008), bringing Cooke's FIFO score from 1.66 to 3.33.

C) Another aspect mentioned by Jennifer is that they could use the GAA BAP criterion, which is the same as that proposed by Jackson (International Fishmeal and Fish Oil Organization):

FIFO= (%fishmeal + %fish oil in the feed) / (%extraction efficiency of fishmeal + %fish oil from wild fish) x FCR

However, the math behind this approach is odd since different types of quantities (%) are added together.

Criterion 6. Escape

Factor 6.1a Escape Risk Score

Cooke employs state-of-the-art Best Management Practices to prevent escapes. GMG Fish Services, a subsidiary of Cooke Aquaculture, is at the forefront of net and cage design, including manufacturing and materials testing. Recently, they have contracted engineers from Dalhousie University and the US Naval Academy to undertake modelling studies of cage structure and mooring stresses under waves and currents. While this work is still underway, it will eventually be incorporated into all pen design, creating new standards for biosecurity via sea cage technology.

Escape score = 2. An open system is a high concern but the work described above brings the concern to Moderate-high category, that is, 2 (Table in page 25).

The magnitude of escapes should also be discussed with regard to the number of individuals in a cage and the error in the counter systems. The average escape is probably not significant.

This value can be improved if we know the recapture and mortality rates of escapees. In Whoriskey et al. (2006), mortality rate of farmed Atlantic salmon released in Cobscook Bay is 56% in winter and 84% in spring. Taking the worst case scenario: 56% mortality, assuming a 0% recapture rate (if recapture not permitted):

Escape risk score = 2 + [(10-2)*0.56) = 6.48 (Formula on page 26)

Factor 6.1b Invasiveness

Part A: Native species: Cooke scores 1 here (Hatchery raised for four or more generations). Not sure the meaning of "Evidence of loss of genetic fitness in wild populations" (Last category of Part A in page 27)

Part B: only for non-native species. Not applicable.

Part C: answers to the table: Do escapees have a significant impact on any wild species by:

- Competing for food and habitat? Theoretically, yes (0.5) – Escapees could compete with wild salmon but due to the low numbers of wild populations as well as the low numbers of escapees, intraspecific competition for food and habitat does not seem probable.
- Providing additional predation pressure? No (1) – The number of escapees is not enough to modify predation pressure on other species. The number of wild salmon in the past was much higher than the current numbers of the wild population plus potential escapees. So, the problems caused by escapees are limited to modification of the genetic pool and potentially to intraspecific competition. Interspecific effects are minimal.
- Competing for breeding partners or disturbing breeding behavior…? Yes (0) There are evidences of mature escapees in nature.
- Modifying habitats? No (1) – The number of escapees is not enough to modify habitat.
- Some other impact on species or habitats? No (1) – Impacts of escapees are limited to wild salmon populations

Papers are needed to justify these values. Total of Part C = 3.5

Invasiveness score: Part A (1) + Part C (3.5) = 4.5

<u>Final escape criterion</u>

Escape risk score = 2 + [(10-2)*0.56) = 6.48

Invasiveness score: Part A (1) + Part C (3.5) = 4.5

These two values in page 28 table provide a final escape criterion score of 4, assuming that 6.48 ~ 6.

Uncertainty in the data

Factor 6.1a

Escapee's mortality. If we use 84% (spring mortality from Whoriskey et al. (2006):

Escape risk score = 2 + [(10-2)*0.84) = 8.72, which would bring the final score to 5.

Averaged mortality (56% - 84%)/2=70%:

Escape risk score = 2 + [(10-2)*0.70) = 7.6, the final score would be 5.

Factor 6.1b

Part A and Part C have a bit of overlap, especially on breeding aspects. Growing a native species is penalized twice in this criterion, therefore it is suggested to remove "competing for breeding partners or disturbing…" from Part C because it is already included in Part A. Potentially reorganize the questions as follows (more generic):

- Impact on habitat?
- Intraspecific competition?
- Interspecific competition?
- Some other impact on species or habitats?

Each evidence-based Yes: 0 points, each theoretical Yes: 0.625 points, and each No: 1.25 points.

According to this, Cooke would score 1.25 + 0.625 + 1.25 + 1.25 = 4.375 in Part C. Therefore:

Escape risk score = 2 + [(10-2)*0.56) = 6.48

Invasiveness score: Part A (1) + Part C (4.375) = 5.375

This would represent a final escape criterion score of 5.

7. Pathogen and parasite interaction

It is agreed that this section mixes criteria in implausible ways. For example, net pen systems are open to water exchange, but there is no vertical transmission of sea lice, i.e. from the hatchery. For moderate-high, a criterion is 'increased mortality of wild species due to infection from farm-derived pathogens', yet for Atlantic salmon, there is no evidence that there is a change in wild mortality due to farm interaction.

11. LCA

It is agreed that factors such as distance to market must be considered in the specifics of LCA. Transport of salmon throughout the US from Maine is faster and less GHG-intensive than from any other supplier.