SALMON COLOR:
Minimizing cost and keeping consumers happy

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2005

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PRESENTATION OUTLINE

- Motivation and background.
- Short biological introduction
  - Salmon farming and feeding practice
  - Astaxhantin, Canta and beyond
- Step 1: Establishing the link between chemical and visible color
- Step 2: Developing a model for cost effective ”coloring”
- Step 3: Finding the willingness to pay for color
- Step 4: Combining step 2 and 3
- Conclusion

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MOTIVATION:
WHY IS SALMON COLOR INTERESTING ?

- Coloring is costly for salmon producers.
- Little knowledge about the relationship between adding color in the feed and resulting fillet color.
- Market and consumer studies have consistently demonstrated that visual perception of muscle color is one of the most important quality traits in farmed salmon
- Coloring of salmon is an issue for US “anti” salmon farming groups
- Color and coloring is a very good example on the difference between farming and fisheries (and is an example for why fisheries should be afraid of farmed products)

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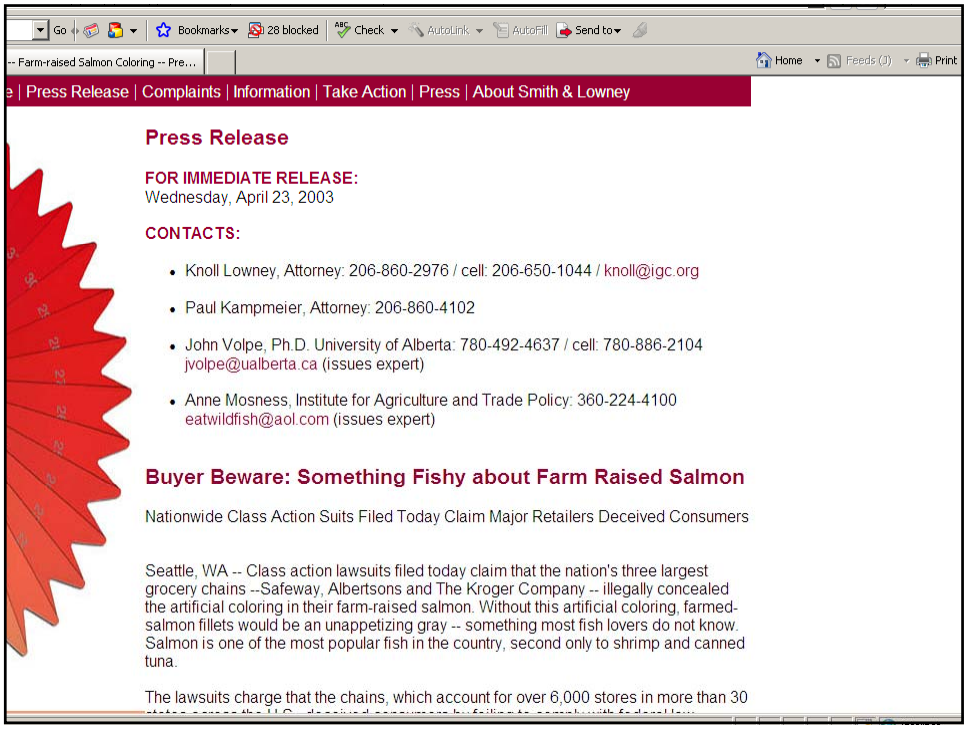
COLOR COSTS

- Feed account for approximately 50% of production cost
- Color account for between 12 and 20% of feed cost
- i.e., color account for 6-10% of production cost
- For the Norwegian industry between 100 million and 150 million USD each year

⇨ Important to “color the fish” as effective as possible

DEBATED ISSUE

- The U.S Food and Drug Administration requires grocery stores to label farm-raised salmon so that consumers are aware of the presence of artificial coloring. The fish should be labeled in the retail case and in individual packages with the words “color added” or artificially colored
- In 2003, consumers in the United States filed a lawsuit against three major grocery chains to force them to label the farm salmon as “color added”.



Press Release | Complaints | Information | Take Action | Press | About Smith & Lowney

Press Release

FOR IMMEDIATE RELEASE:
Wednesday, April 23, 2003

CONTACTS:

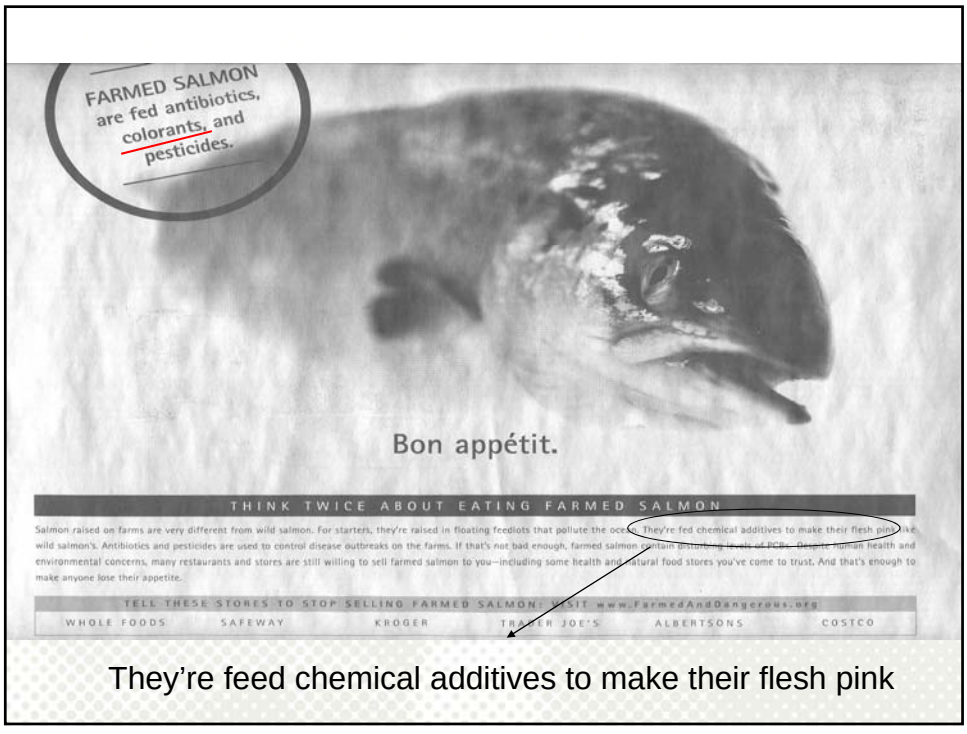
- Knoll Lowney, Attorney: 206-860-2976 / cell: 206-650-1044 / knoll@igc.org
- Paul Kampmeier, Attorney: 206-860-4102
- John Volpe, Ph.D. University of Alberta: 780-492-4637 / cell: 780-886-2104 jvolpe@ualberta.ca (issues expert)
- Anne Mosness, Institute for Agriculture and Trade Policy: 360-224-4100 eatwildfish@aol.com (issues expert)

Buyer Beware: Something Fishy about Farm Raised Salmon

Nationwide Class Action Suits Filed Today Claim Major Retailers Deceived Consumers

Seattle, WA -- Class action lawsuits filed today claim that the nation's three largest grocery chains --Safeway, Albertsons and The Kroger Company -- illegally concealed the artificial coloring in their farm-raised salmon. Without this artificial coloring, farmed-salmon fillets would be an unappetizing gray -- something most fish lovers do not know. Salmon is one of the most popular fish in the country, second only to shrimp and canned tuna.

The lawsuits charge that the chains, which account for over 6,000 stores in more than 30



They're feed chemical additives to make their flesh pink

SALMON COLOR BIOLOGY

- The fillets from wild salmon are usually pink, red, or orange. The strength of the color can vary from salmon to salmon. The color originates from carotenoids in the fish's diet. Carotenoids are widespread in living organisms.
- The most important carotenoid for the color of salmon is astaxanthin. Astaxanthin is a common substance in both fresh water and marine organisms. Wild salmon get carotenoids from eating crustaceans, or small fish that themselves have recently eaten such animals.
- To create similar color in farmed salmon, synthetically produced astaxanthin is added to their feed. No negative side effects have been reported from the use of astaxanthin

(Source: Bellona Foundation, a multi-disciplinary international environmental NGO.)

MEASURING COLOR

- Chemically (pigment concentration, ppm),
- Instrumentally (Minolta a*, b*, L values)
- Visually aided by color charts such as the *Roche Color Card for Salmonids* and the *SalmoFan* (Hoffmann-La Roche, Basel, Switzerland).
- Chemical and instrumental measurements are widely used by scientists due to its objective methods, which is not interfered by subjective impressions of the human eye
- The *SalmoFan* score card range over 14 red colors with varying intensity of redness. Each of the colors are associated with a numerical value ranging from 20 (very pale red) to 34 (very intense red). In farmed Atlantic salmon fillets, *SalmoFan* score usually range between 23 and 29.

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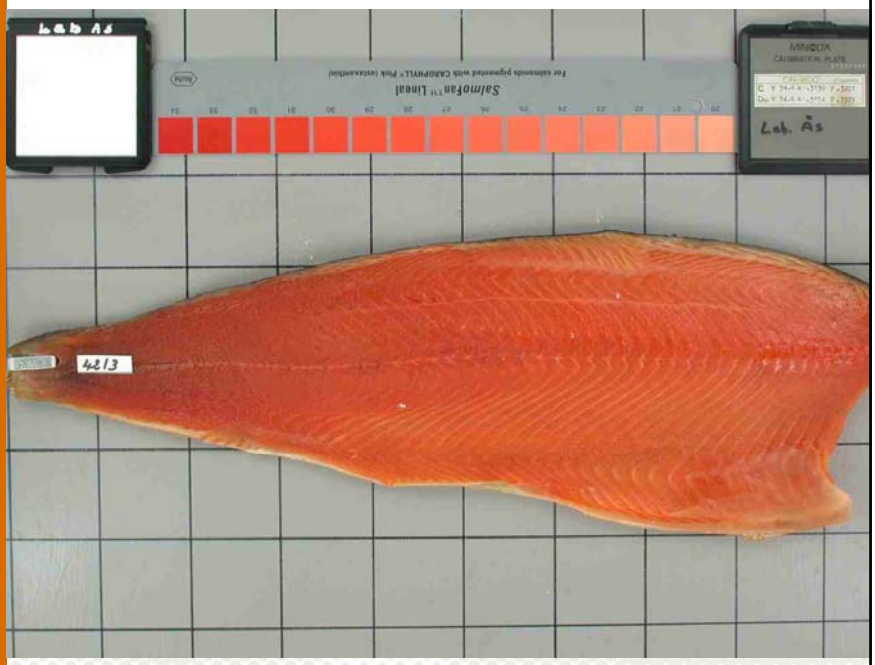

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PROJECT OUTLINE

- Develop a model that shows the relationship between visual color and chemical fillet content
- Develop a cost minimizing model for how to reach the appropriate color at minimum cost
- Describe a method to find WTP for an attribute not well priced in the market, i.e., color
- Illustrate how WTP and consumer studies can be used to tailor made the product to consumers demand at minimum cost

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STEP 1

- Based on published literature data, Forsberg and Guttormsen (2006a) modeled the effect on dietary pigment concentration and fish size on visual color perception of Atlantic salmon. Model outputs show that the red color intensity increases curve-linearly both with increasing dietary pigment concentrations and to increasing fish size.

FORSBERG, O.I., AND A.G. GUTTORMSEN. (2006a) " A pigmentation model for farmed Atlantic salmon: Non-linear regression analysis of published experimental data." *Aquaculture*, 253: 415-420

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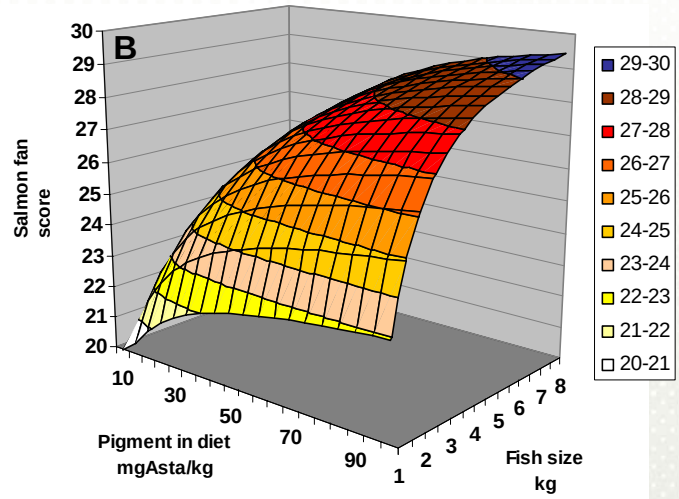
RELATIONSHIP



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STEP 2

- Based on step 1 we built a mathematical programming model designed to optimize dietary astaxanthin concentrations throughout the grow-out period that results in well-pigmented fish at minimum cost.
- We applied a mixed-integer non-linear programming algorithm to solve the problem.
- Result: A model that present the feeding regimes that minimize cost for producing a salmon with a given vector of minimum color for different sizes,

FORSBERG, O.I., AND A.G. GUTTORMSEN. (2006b). " Modeling optimal dietary pigmentation strategies in farmed Atlantic salmon: Application of mixed-integer non-linear mathematical programming techniques." *Aquaculture,* 261(1), 118-124.

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STEP 2

Objective $$\min C_T^{\text{Asta}} = 0.94 c_A \sum_{t=1}^{T-1} \text{Ad}_t \cdot (W_{t+1} - W_t) \cdot W_t^{0.119} \quad (7)$$

subjected to $$\text{SF}_t = \frac{1.49}{W_t} \left(W_1 f(\text{Ad}_1) + \sum_{t=1}^{T-1} \frac{W_{t+1} f(\text{Ad}_{t+1}) - W_t f(\text{Ad}_t)}{W_{t+1} - W_t} \right) + 16.17 \quad \forall t \quad (8)$$

$$f(\text{Ad}_t) = 11.1 \cdot \exp^{-0.829/W_t} \frac{\text{Ad}_t}{11.9 + \text{Ad}_t} \quad \forall t \quad (9)$$

$$\text{SF}_t \geq \text{SF}_t^{\min} \quad \forall t \quad (10)$$

$$\text{Ad}_t = 10 y_t \quad \forall t \quad (11)$$

$$y_t \geq 2 \quad \forall t \quad (12)$$

$$y_t \leq 7 \quad \forall t \quad (13)$$

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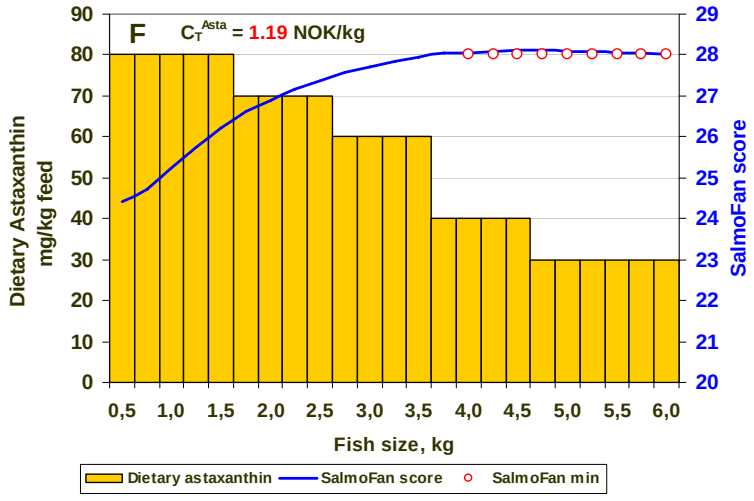

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STEP 3, THE MARKET EXPERIMENT

- Described in
  - Alfnes, F., Guttormsen, A.G., Steine, G., and K. Kolstad. (2006). "Consumers' willingness to pay for the color of salmon: a choice experiment with real economic incentives." *American Journal of Agricultural Economics*, 88(4):1050–1061.
  - Steine, G., F. Alfnes, and M.B. Rørå. "The Effect of Color on Consumer WTP for Farmed Salmon." *Marine Resource Economics* 22(2007):211-219.

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EXPERIMENTAL MARKETS

- 115 participants
- Each participant got NOK 300 when arriving at the experiment
- Each organization got NOK 200 per participant

Survey

- Real Choice: Posted prices and real economic incentives, salmon fillets varying in color and prices
- Stated choice: Pictures of salmon fillets with different color and prices

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REAL CHOICE (Alfnes et. al 2006)

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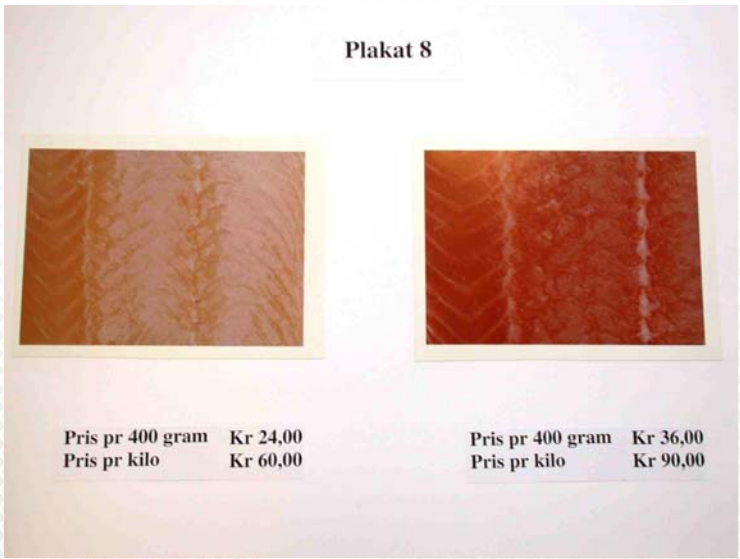
STATED CHOICE (Steine et al 2007)



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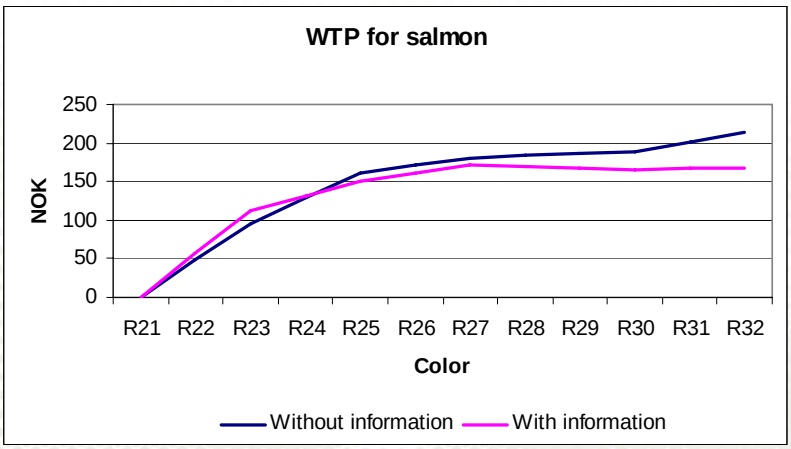
RESULTS FROM EXPERIMENTAL MARKETS COMBINING REAL AND STATED CHOICE



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STEP 4, COMBINING STEP 1 - 3

- Corrected for the fact that the producer do not get all the WTP
- Looking only at revenue for one single fish, color 27 is optimal.
- Given that there are some distribution in color, the average fish should be more red
- Combining with cost minimization, color 26,7 is optimal
- How we should reach 26,7 depend on risk aversion and preferred size.

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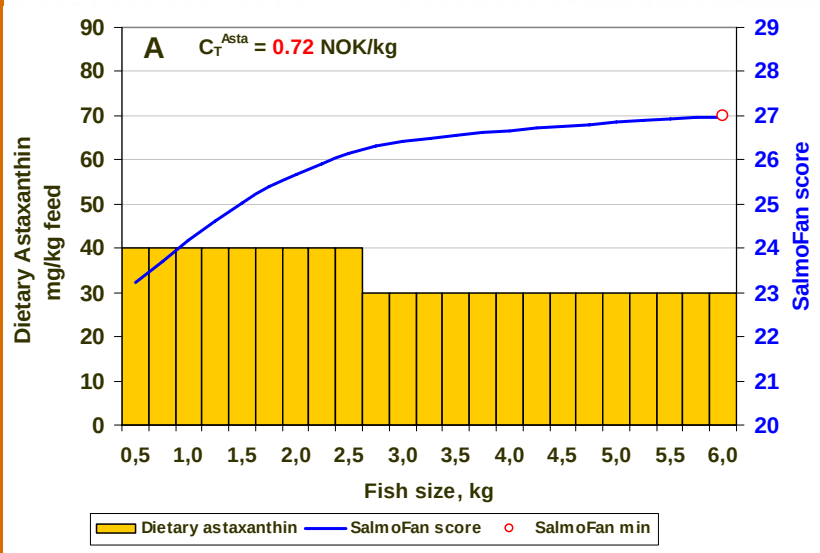

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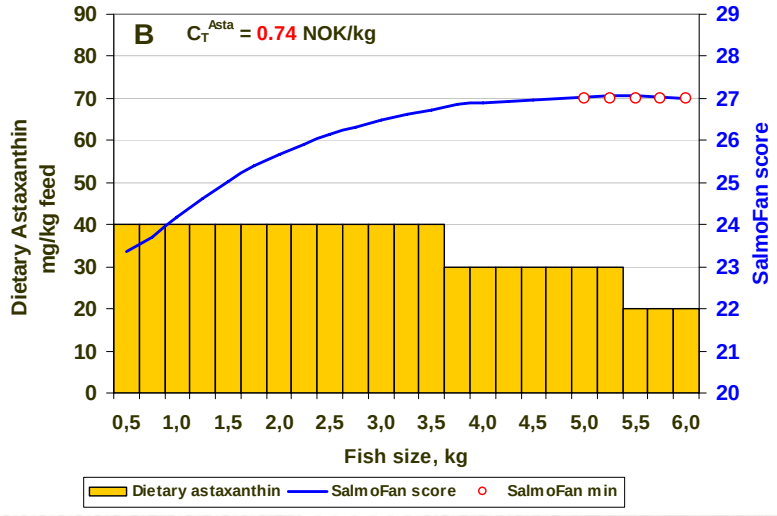

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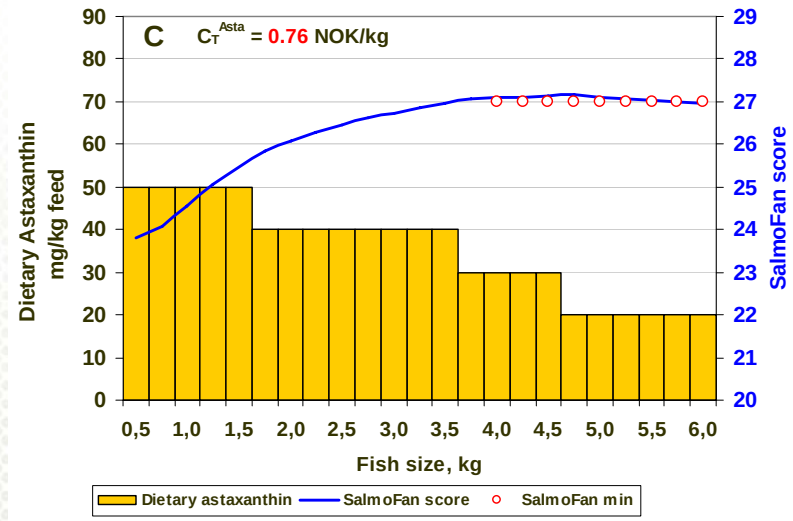

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CONCLUSION

- Farmed salmon can be tailor-made to meet consumers demand.
- It is possible to deliver the right quality (size, color, texture etc.) to the right time to the right market.
- Farmers need to know the WTP of different markets
- Optimization is not only about optimal harvesting time. The optimization problem is also about optimizing quality.
- Given that consumers will be more demanding, farmers need to focus on product quality more than just reducing cost

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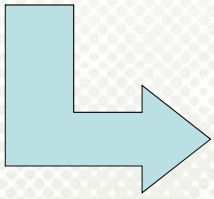

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