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AQUATIC ECO-SYSTEMS

CASE STUDY

EFFICIENT USE OF BIOMASS ESTIMATOR FRAMES FOR WEIGHT AND GROWTH CONTROL OF THE ATLANTIC SALMON (*Salmo salar L.*) IN MARINE SEA PENS

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INTRODUCTION

Accurate biomass control is one of the major challenges facing the salmon industry worldwide (Haugholt et al., 2010). Companies need a high level of certainty regarding fish count, average weight measurement, conversion factor, and growth rate of their production systems. The development of a reliable control system for the number and biomass of farmed fish is essential for sustainable and cost-effective aquaculture (Little et al., 2015).

Notwithstanding the above, the global salmon industry faces differences in inventory and biomass control that persist to this day. For example, data obtained in Chile between 2006 and 2008 reports inventory differences in Atlantic Salmon throughout all months of production (Solis, 2009). Losing control of the fish count and biomass is attributable to a number of factors, such as smolt reception recording errors, inaccurate body weight estimation, lack of supervision in the transport of fish, problems with fish counting equipment, theft of fish in cages, escape of fish due to damaged nets and, lastly, events of harmful algal blooms that affect an accurate quantification of dead biomass (Solis, 2009; Aunsmo et al., 2013; AQUA, 2016). To mention just an example, in 2013, the Chilean industry presented the largest record of fish escapes of the last 5 years. Only in the Aysén Region, 1.28 million salmon were lost (Sernapesca, 2014).

GROWING FISH IN A PRODUCTIVE SYSTEM

Growth is a central parameter of interest in the production operations of the salmon industry (Aunsmo et al., 2014). Important areas of improvement and management of fish growth include: identification of causal factors, quantifying effects that predict fish growth, as well as comparative evaluation between growth in cages, sites, genetic strains and companies (Aunsmo et al., 2014).

Image 1. Marine site in Chile.

The millions of fish farmed in industrial production sites make it impossible to measure the body weight of all the individual fish, so we must use sampling methods that allow us to estimate the average weight and growth of a productive unit by means of a representative sample of the fish population (Beddow et al., 1996; Zion, 2012; VAKI, 2016).

The measurement methods used in the salmon industry to estimate the weight and distribution of fish in the marine sea pens are as follows:

1. Scale (Manual sampling).
2. Biomass estimation by image technology.
3. Estimators by acoustic systems (ultrasound).

CHARACTERISTICS OF WEIGHT SAMPLING USING SCALE

During the seawater phase, salmon companies sample the weight of fish in the production cages using traditional methods, which, from a statistical point of view and degree of confidence of the information, do not always offer a high level of accuracy (Haugholt et al., 2010; Aunsmo et al., 2013).

The widely used and accepted sampling method by salmon farmers consists of measuring the weight of individual fish with a scale. Although manual scale sampling has been a measurement method used since the beginning of aquaculture, it is not devoid of errors and inaccuracies. However, the main advantage that has been maintained over time is that it allows inspecting the body and sanitary condition of the fish (Forsberg, 1995; Pennel and Barton, 1996; Jones et al., 1999).

Among the disadvantages of scales sampling are the low frequency of sampling that prevents a continuous record of weight and timely detection of actual inventory differences or production deficiencies (low growth, high conversion factor), high stress and manipulation of the fish does not make this method of sampling recommendable in adverse sanitary situations, reduction of food consumption associated with sampling, permanent scale calibration with standard weights, inability to sample the weight in bad weather conditions—in some cases 2 or more months may elapse before a sample can be taken– high man- hour requirement, human error in weight data recording, use of feed to attract the fish, which increases the degree of error in the sample, low sample number that does not exceed 1% of the total population of the cage (Haugholt et al., 2010).

Image 2. Scale Sampling

SAMPLING METHOD USING BIOMASS ESTIMATORS

Biomass estimator frames, bio-estimators, or size estimators are specialized measuring instruments that have been used for several years in world aquaculture (Løvik, 1987). At the global level there are two main companies that manufacture and commercialize biomass estimator frames for aquaculture. One of them is located in Iceland and the other, in Norway. The electronic operating principles employed by both manufacturers are very similar; however, the Icelandic technology has a wireless data transmission system from the frames, which allows instant access to daily weight data on a website available to all users that have a computer with Internet connection (VAKI, 2016).

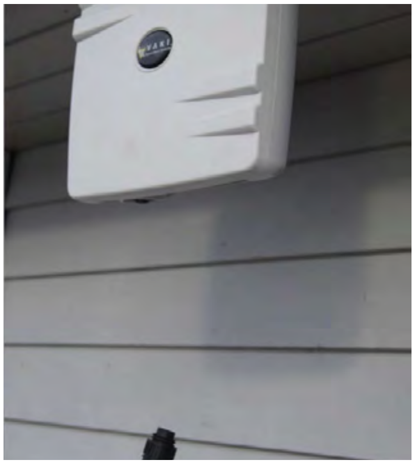
The size estimator frame is a square shaped measuring instrument which is made up of the following components: four rectangular faces containing a cluster of infrared light diodes, a stainless steel frame that assembles and protects these faces from blows, a handling metal bar, a clamping bush, and an underwater connecting cable (VAKI, 2016). In marine production cages, the frames must be installed through an attachment rope and are submerged to a standard depth and location in the pen needed for the specific sampling (Folkedal et al., 2012).

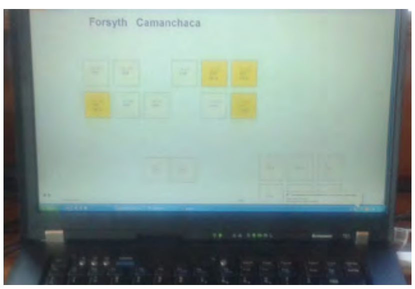
When the equipment is correctly positioned and a salmon swims and passes through the infrared scanner, an instant image of the fish is obtained, and an automatic image analysis software estimates its size (Lekang, 2007; Haugholt et al., 2010; Zion, 2012).

In the case of VAKI Biomassdaily technology, the equipment remains submerged in the sea pen from post-smolt phase until fish harvest with the purpose of obtaining daily weight samples (Folkedal et al., 2012) and to build a historical growth trend of the population (see graph of growth over time).

By placing the frame inside the same cage during the entire seawater cycle, the farmer is able to collect reliable and real-time productive information and can know with certainty the evolution of growth, condition factor, weight distribution and even analyze the evolution of the conversion factor of the productive unit.

In weight sampling with biomass estimators, as opposed to scale sampling, to achieve high sample accuracy and representativeness, the farming site must position the frames to achieve a high N sample number or number of valid samples (Folkedal et al., 2012). From the experience gained with these devices in Chile, the minimum number of fish measurements to ensure a good estimate with an accuracy >97% should be at least 1% of the total population of fish in the pen (VAKI, 2016). For example, a productive unit of 45,000 fish requires about 600 fish per day to pass through the frame (VAKI, 2016). This number rises up to 2.000 fish sampled in bigger open cages of population of 200.000 salmon.



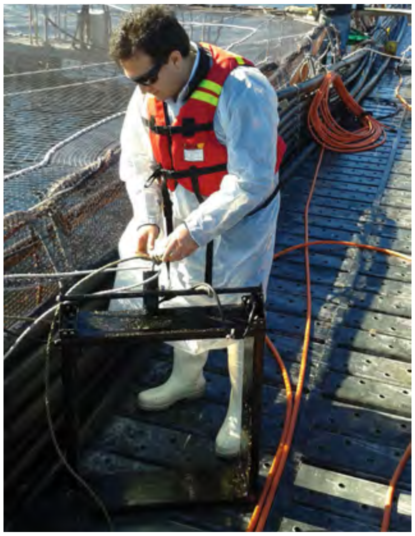


Biomassdaily Technology
(Image 3. VAKI Remote Box Antennas,
Image 4. Reception Base Antenna,
Image 5. Biomassdaily Laptop with VAKI
Frames Software Bio3000).

FACTORS TO CONSIDER TO ACHIEVE A HIGH NUMBER OF SAMPLES BY THE FRAME

In order to achieve an optimal location of the frame and a high number of fish samples, the fish farmer should take into consideration some factors or variables that affect the salmon's swimming pattern and behavior in the sea pens (Dempster et al., 2009; Bui et al., 2013).

The site variables that most affect the salmon swimming behavior and, therefore, the number of samples obtained with the estimator frames are: feeding (Smith et al., 1993; Fernö et al., 1995), current speed and direction (Johansson et al., 2014), photoperiod (Juell et al., 2004; Oppedal et al., 2007; Davidsen et al., 2008; Føre et al., 2013) and density of fish in the cage (Juell et al., 2003; Folkedal et al., 2012).



Images 6 and 7. Installation of the frame in the sea pen.

FUTURE GLOBAL PERSPECTIVES

The biomass estimating technology, despite being marketed for years in global commercial aquaculture, has not been massified as a method of high accuracy weight estimation with respect to traditional sampling. The reasons behind this can be attributed to factors such as a poor reputation of the estimator due to previous bad experiences, old paradigms still unresolved, lack of formal studies or solid and objective databases with accurate users results, high confidence in scale sampling because it is a known and empirically accepted method by the industry, human factor

of not becoming familiar with the use of equipment in the sea pens, poor training and incorrect use of the technology, little transparency and accuracy of weighing methods in processing plants post-harvest, as well as opinion of the author, biased and misinformed views that biomass estimator frames are an unnecessary expense and added work for the site personnel (the lease of 4 frames does not reach 1% of the monthly operational costs of a sea farm) vs. the incorporation of an exact control technology for weight and biomass evolution during the growth cycle, thus avoiding the great variations that exist between the declared living biomass and the available real biomass to fulfill the commercial commitments.

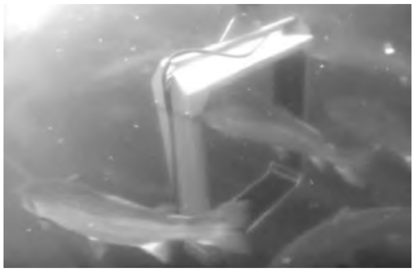


Image 8. Salmon swimming through the estimator frame.

Image 9. Swimming structure of cultured salmon observed at different tidal current speeds. Circular swim (A, circular movement), Mixed swim (B, circular and against-current) and against-current swim (C, static swim).

Drawing by Stein Mortensen (Paper by Johansson et al., 2014).

By aspiring to an aquaculture of high productivity, competitiveness and sustainability, it will become increasingly necessary to have tools that accurately measure the biomass of fish in the sea cages; for this reason, at present, as European countries do, there are salmon farming companies operating in Chile that are validating this technology in order to incorporate it as a standard of productive control. In the near future, biomass estimators should become the measuring instrument that replaces the old-school sampling method in farming operations, leaving these traditional handling methods to be used only to confirm certain milestones during the cycle.

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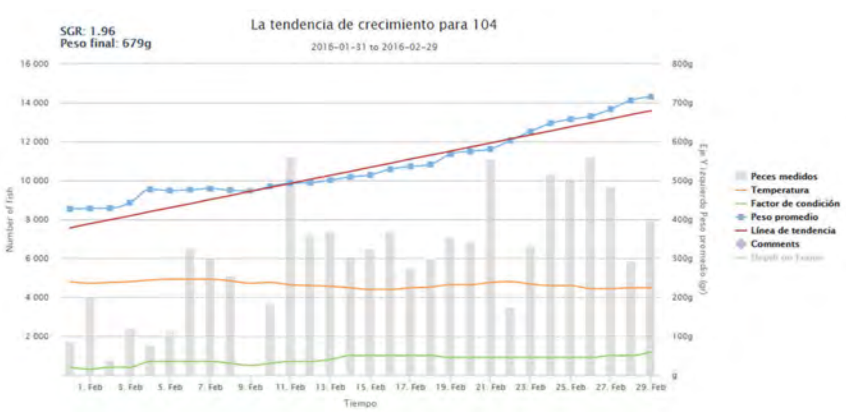

Trend graph of growth based on average daily weight measurement.

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