

The Benefish Consortium 24 month report
WP6: Productivity modelling of
OWI's and welfare intervention
measures.

D6.3: Report on the effects of feed intake on productivity
and attributed costs and benefits of welfare interventions

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Contents

1	Introduction.....	4
1.1	Feed intake OWI	4
2	Methods.....	5
3	Results	5
3.1	Datasets entering WP6 from Block 1.....	5
3.2	Productivity modelling	8
3.3	Intervention case study: Introduction of ozone and protein skimmer as water treatment units in sole RAS	8
3.3.1	General notes and description of the intervention	8
3.3.2	Productivity modelling – collated data.....	8
4	Concluding discussion.....	13
5	Outputs.....	13
6	Literature and selected reading	13
7	Justification.....	15

1 Introduction

In order to accurately model all costs and benefits associated with welfare interventions for farmed fish it is necessary to establish how any welfare actions affect productivity. Productivity modelling within Benefish has been conducted in WP6 (Block 2).

WP6 aimed to model relationships between welfare interventions, changes in OWI's and measures of productivity. It did so focusing only on the effects which were biological in nature: economic costs and benefits attributed to changes in productivity are addressed in WP8.

WP6 has 4 objectives addressing productivity modelling for each OWI:

1. To relate OWI's to productivity indicators.
2. To determine the relative costs and benefits of interventions to improve welfare on productivity.
3. To explore the relationships between different OWI's, productivity and welfare interventions.
4. To consolidate outputs from WP's 2-5 to facilitate smooth transfer into WP8 & 9.

Objectives 1 to 3 aimed to understand the biological relationships between a) each OWI, b) any welfare interventions linked to that OWI and c) productivity. Objective 4 (which is ongoing) focuses on the transfer of those data and information to Block 3 for bio-economic modelling.

Productivity modelling within WP6 was reliant on the successful completion and transfer of outputs from Block 1 to WP6: it was not until risks to farmed fish welfare for each specific OWI, and interventions to address those risks, had been identified within Block 1 that productivity modelling could commence. Therefore, although WP6 worked within Block 2, considerable interaction between WP6, Block 1 and Block 3 has been necessary throughout the project.

WP6 has focused on the relationships between OWI's, interventions and three commonly used measures of productivity: growth, feed efficiency and survival. Whilst other measures of productivity are available these were considered the most widely-used, practical and appropriate for inclusion in Benefish. Data on growth, feed efficiency and survival are widely available from commercial and experimental datasets, as well as in the literature.

This report details productivity modelling relative to the feed intake OWI (data originating from WP4 in Block 1). Consequently this report serves to address the following deliverable:

D6.3: Report on the effects of feed intake on productivity and attributed costs and benefits of welfare interventions.

1.1 Feed intake OWI

Commercial fish farmers often state that their fish are doing just fine as they relate the fish feed intake or realized feeding level with their expectations (Vis, Lamboi and Schneider 2008). However, fish feed intake is not necessary stable and might vary due to different reasons. A number of commercial aquaculture species exhibit daily feeding rhythms in food intake and appetite (Noble et al., 2005) and there is variability in daily feed intake between days and groups. Feed intake can be defined as the amount of food an animal actually consumes. Feed intake can be affected by a number of abiotic variables including, but not limited to: changes in the daily light/dark cycle (Boujard and Leatherland, 1992); temperature (Fraser et al., 1993); light intensity (Noble et al., 2005); oxygen levels (Thetmeyer et al., 1999); ammonium concentrations (Beamish and Tandler, 1990); wave

action (Bégout Anras, 1995); wind speed, rainfall (Bégout and Lagardère, 1993) and turbidity (Ang and Petrell, 1997). Biotic factors might include: gastric emptying time (Ruohonen et al., 1997); disease or increased parasite loads (Bloch and Larsen, 1993); group size (Boujard, 1995) and intraspecific competition (Brännäs and Alanära, 1997). Other management variables that might impact upon feed intake can include water refreshment rate of the system, handling, disturbance and system cleaning (Strand et al, 2007 and references therein). These changes in feed intake can either be structural, so a deviation from expected feed intake can be observed over several days or be incidental, as during a meal or during a short period of time. Based on these considerations, it is of scientific and commercial interest to investigate the hypothesis that feed intake is affected by the welfare status of fish. If this can be validated for aquaculture species a simple but effective operational welfare indicator becomes available and the - above named- empirical observations by fish farmers are confirmed. To prove that hypothesis it is necessary not only to investigate data that might be obtained in rather artificial situations in laboratories but as well under commercial conditions. The objective of the present study is therefore to relate deviations in expected feed intake to farm management practices for various species and culture systems.

2 Methods

Productivity modelling was conducted only on those datasets from which practical welfare interventions had been identified. Each intervention case study moving into Block 2 for productivity modelling had undergone rigorous screening to ensure suitability for bio-economic modelling. This screening had taken place both within each OWI WP (Block 1) and during the 3rd and 4th Benefish meetings (Turku and Faro). Therefore by the time the intervention case studies were transferred into Block 2 (WP6) it was envisaged that all could progress through to Block 3 for bio-economic modelling.

Modelling to identify relationships between the feed intake OWI (see WP4) and productivity indicators was conducted using different statistical methods that are describe in deliverable 4.1 (Deviation from expected feed intake in relation to farm management at turbot, sole, trout, salmon, seabass farms). Through ongoing discussions between the WP6 leader and Block 3 (Objective 4), FGFRI developed a spreadsheet which outlined indicated all the data requirements for bio-economic modelling. To transfer productivity modelling data to Block 3, WP6 partners completed all relevant components of that spreadsheet. Outputs from WP6 have now been entered onto this spreadsheet and sent for inclusion into the bio-economic model (Block 3).

3 Results

3.1 Datasets entering WP6 from Block 1.

WP4 (Block 1) identified a list of datasets early in the project and from this list a number of practical welfare intervention case studies were considered for bio-economic modelling. The datasets that were identified by WP4, the risk factors for deviation from expected feed intake and proposed intervention strategies to address those risks are shown in Table 1.

Table 1. Details of the datasets identified in Block 1, risk factors for deviation from expected feed intake identified from those datasets and proposed welfare interventions to address those risk factors. Commercial (1) or experimental dataset (2)

Dataset	Dataset details (species, country, life stage, system)	Risk factors identified	Possible welfare interventions	Proposed welfare interventions for Benefish
ba-lab-T°	Juvenile seabass Tanks2	No risk factors identified	No interventions identified	No practical intervention identified
ETHIQUAL	Juvenile seabass Tanks2	No risk factors identified	No interventions identified	No practical intervention identified
FASTIFSH 1	Juvenile seabass Tanks2	No risk factors identified	No interventions identified	No practical intervention identified
FASTIFSH 2	Juvenile seabass Tanks2	No risk factors identified	No interventions identified	No practical intervention identified
BC1/ Heritabolum	Juvenile seabass Tanks2	No risk factors identified	No interventions identified	No practical intervention identified
Density 1	Juvenile & Adult Seabass Tanks2	No risk factors identified	No interventions identified	No practical intervention identified
Density 2	Junvenile Seabass Tanks2	No risk factors identified	No interventions identified	No practical intervention identified
Hypercarbo x	Juvenile seabass Tanks2	No risk factors identified	No interventions identified	No practical intervention identified
Cortisol	Juvenile seabass Tanks2	No risk factors identified	No interventions identified	No practical intervention identified
DEB_SOLE	Dover sole Aquaria2	No risk factors identified	No interventions identified	No practical intervention identified
FT Benefish EXP	Turbot Different Flow through and RAS2	No risk factors identified	No interventions identified	No practical intervention identified

ZLV Benefish	juvenile/adult turbot RAS1	No risk factors identified	No interventions identified	No practical intervention identified
Solea	juvenile/adult Dover Sole RAS1	Water quality	Improvement of water quality through ozone and protein skimmer	idem
GF10	juvenile 0+ Atlantic salmon 3 x 12x12x4m Freshwater production cages2	No risk factors identified	No interventions identified	No practical intervention identified
GF11	juvenile Atlantic salmon 3 x 12x12x4m freshwater production cages 2	No risk factors identified	No interventions identified	No practical intervention identified
LEFI	Atlantic salmon post-smolts 5x5x4m marine cage2	No risk factors identified	No interventions identified	No practical intervention identified
RTFI	juvenile rainbow trout 3x 200 l RAS tanks2	No risk factors identified	No interventions identified	No practical intervention identified
cagesalmon	Adult atlantic Salmon Cage system1	No risk factors identified	No interventions identified	No practical intervention identified
IPN2002	Juvenile atlantic Salmon Flow through tank system2	No risk factors identified	No interventions identified	No practical intervention identified
AW1205	juvenile/adult rainbow trout Freshwater ponds, raceways, tanks and cages1	No risk factors identified	No interventions identified	No practical intervention identified
RTGE	juvenile/adult rainbow trout Freshwater ponds, raceways, tanks and cages1	No risk factors identified	No interventions identified	No practical intervention identified

One welfare intervention case studies (solea) relating to deviations from expected feed intake was identified by WP4 (Block 1) as appropriate for bio-economic modelling. These were transferred to Block 2 for productivity modelling.

3.2 Productivity modelling

Details of the intervention case study identified and the outputs of productivity modelling are provided below.

3.3 Intervention case study: Introduction of ozone and protein skimmer as water treatment units in sole RAS

3.3.1 General notes and description of the intervention

Water quality expressed as concentration of suspended solids, turbidity and other parameters can significantly be improved through the use of ozone and protein skimmers. This holds especially in marine recirculation aquaculture systems, where often pristine water quality is required. Sole seems to be sensitive to decreased water quality and reacts to it with decreased feed intake. In addition particles and organic loads that can be removed easily by protein skimming enhanced by ozone, affect nitrification filter performance through shifts in the C:N ratio in the water. This leads again to decreased water quality through increased concentrations of ammonia nitrogen in the water, which impacts the fish again negatively. Low feed intake and in connection with overfeeding then relates to bad water quality in a self enforcing spiral lowering fish performance leading to bad water quality leading to less feed intake, which results again in lower water quality.

3.3.2 Productivity modelling – collated data

Production data was available for analysis from dataset solea (IMARES) as described in detail in deliverable 4.1 and 4.3. The data is based on direct reports from the farm (as this is the only RAS farm for Dover sole worldwide at the time of production). The communicated data was:

Table 1:

Case description report	"Appendix1:"	
Species	Dover sole	
Production environment	tanks & raceways	
Production type	table production	
Total market production volume	100	tonnes/year
Of which intervention affects		%
Ave, starting weight	5	gram
Ave, end weight in period	250	gram
Ave, Production cycle	100	weeks
Ave, mortality	5	%/totalpieces/period
(Cumulative mort biomass for period)		%/production volume
Ave. FCR	1.5	feedkg/fishkg

Overall cost structure	"Appendix1:"
Ave production farm volume	100
Ave personel in farm	3
Ave producer price	8
Break-down to cost factors	
fingerling	19%
feed	20%
other	31%
work	10%
investment	10%
capital	10%
profit	
	100%

Table 2:

Intervention description report	"Appendix1: "
Presumed welfare effect:	Decreased deviations from expected feed intake
Intervention:	Improved water quality
Intervention efficacy:	100%
Implementation:	we use protein skimmer and ozone as additional water treatment
<i>Option A</i>	
<i>Option B</i>	
<i>Option C</i>	

Implementation costs

		Uncertainties			%change in cost factor				
		Option A	Option B	Option C	Option A	Option B	Option C		
<i>change in fry costs</i>	€/kgfry/year of totals	0.00					0.00%	0.00%	0.00%
<i>change in feed costs</i>	€/kgfeed/year of totals	0.00					0.00%	0.00%	0.00%
<i>change in other costs</i>	€/year	1971					0.79%	0.00%	0.00%
<i>change in labour costs</i>	€/year	564					0.71%	0.00%	0.00%
<i>change in investment costs</i>	€/year						0.00%	0.00%	0.00%
<i>change in capital costs</i>	€/year						0.00%	0.00%	0.00%

Calculation models for cost factors

Change in fry costs	0	€/kg/year costs
Actual change in fry cost		€/kg
Implementation option effectiveness		annual fry costs
Change in feed costs	0	€/kg/year costs
Actual change in feed cost		€/kg
Implementation option effectiveness	0%	annual feed costs

Additional cost:
 Investment
 Capital
 Other costs (electricity)

Change in other costs	1971	€/year
Energy	1971	€/year
Vaccination/other medicine	0	€/year
External services	0	€/year
Oxygen	0	€/year
Other	0	€/year

Installed power	1.5	kW
Consumption	13140	kWh/year
Unit price	0.15	E/kWh
Total costs	1971	Euro/yr

Change in labour costs	564	€/year
Added work activities	365	occations/year
Time of one occation	0.1	hours

Change in investment costs	#NAME?	year
Value of intervention investment	10000	€
Write of period/depreciation	10	years
Old investment resale value	0	€
Long term rate	5.00%	

Change in capital costs	#NAME?	year
Long term capital rate	5.00%	
Value of intervention investment	10000	
Write of period	10	
Old investment resale value	0	

Table 3

Productivity description report

Effect on growth: Better growth due to increased feed intake

Effect on feed efficiency: Reduction of feed loss, therefore improved feed efficiency

Effect on survival: None

Option A Apply protein skimmer and ozone

Option B not used

Option C not used

Productivity factor change

	Productivity factor change			Uncertainties		
	Option A	Option B	Option C	Option A	Option B	Option C
change in growth	5%					
change in feed efficiency	10%					
change in survival	0%					

Change in growth productivity costs

		Option A	Option B	Option C
<i>change in fry costs</i>	€/kgfry/year of totals	0.00	0	0
<i>change in feed costs</i>	€/kgfeed/year of totals	0.00	0	0
<i>change in other costs</i>	€/year	0		
<i>change in labour costs</i>	€/year	0		
<i>change in investment costs</i>	€/year	0		
<i>change in capital costs</i>	€/year	0		

Change in feed efficiency productivity costs

		Option A	Option B	Option C
<i>change in fry costs</i>	€/kgfry/year of totals	0.00	0	0
<i>change in feed costs</i>	€/kgfeed/year of totals	16000	0	0
<i>change in other costs</i>	€/year	0		
<i>change in labour costs</i>	€/year	0		
<i>change in investment costs</i>	€/year	0		
<i>change in capital costs</i>	€/year	0		

4 Concluding discussion

Fish feed intake and within limits realized feed load can be related to expected feed intake and therefore translated to deviation of expected feed intake. This can within limits be related to fish welfare, when fish welfare data are measured or established to the observed conditions a-priori. Feed intake might therefore serve as operational welfare indicator on fish farms under certain conditions. It has to be remarked that several datasets which are related back to fish welfare do this based on literature data and circumstantial evidence.

5 Outputs

There are no specific other outputs in relation to deliverable 6.3.

6 Literature and selected reading

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7 Justification

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The scientific quality of this report has been peer reviewed by the a colleague scientist and the head of the department of Wageningen IMARES.

Approved: Henk van der Mheen
Head Department of Aquaculture

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