Assessment of the production capacity of ELCOMEX Aqua Srl

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Summary

In this report an estimate is given of the production capacity of the turbot farm of ELCOMEX in Constanta (Romania) based on available literature and a visit to the farm. With regard to the capacity for providing oxygen to the fish the farm has the potential to reach the targeted production capacity although the dosing system is inefficient. The self-cleaning of the tanks is insufficient resulting in an increased risk for health problems. The capacity of removal of ammonium limited. Most importantly, the available rearing surface will allow a production of only 110 tons per year of 1.5 kg fish which is well below the target of 150 tons.

1. Introduction

ELCOMEX is a turbot farm based in Constanta (Romania) which was established in 2011. In January 2013 the first stocking of fingerling took place. The farm has been built for a production capacity of 150 tons per year for fish of an average weight of 1.5 kg. The management has doubt about the production capacity of the farm and has asked IMARES to provide an independent opinion on the production capacity of the farm.
The main question put forward by ELCOMEX is what the yearly production capacity of the turbot farm is, given the infrastructure that is in place.

2. Methodology

In order to provide an assessment of the production capacity of the farm, the site has been visited by the author of this report on June 18 and 19, 2014. Data on the infrastructure were sent before the visit and further explanation of the system was provided on site. Based on available literature an estimate of the production capacity is made.
The potential production capacity of a fish farm is mainly determined by the three factors: the available rearing space, the capacity to bring oxygen to the fish and the capacity the remove water pollution caused by the fish production.
In order to calculate the production capacity of a farm based on the rearing area available a number of elements are needed:
a) - A growth curve of the fish showing the time fish need to reach a certain weight
b) - The maximum density allowed for a certain fish weight
c) - A production plan describing the stocking, grading/splitting and harvest of the fish

3. Production capacity based on the rearing area

Figure 1 shows a number of growth curves which have been published for on-growing of turbot. Data on fish larger than 1000 gram are scarce. Danielssen (1991) has published a complete dataset for a batch of turbot covering a whole weight range. This was done on lab-scale in flow-through. In the period 2006-2008, growth of turbot was also studied intensively in a European project named GRASS: Towards elimination of growth retardation in marine recirculating aquaculture systems for turbot (Anonymus, 2008). This project was started to investigate the reason for the slow growth of larger sizes of turbot in recirculation systems. In the project, data from two large existing farms were analysed which are shown (anonymously) as GRASS1 and GRASS2.

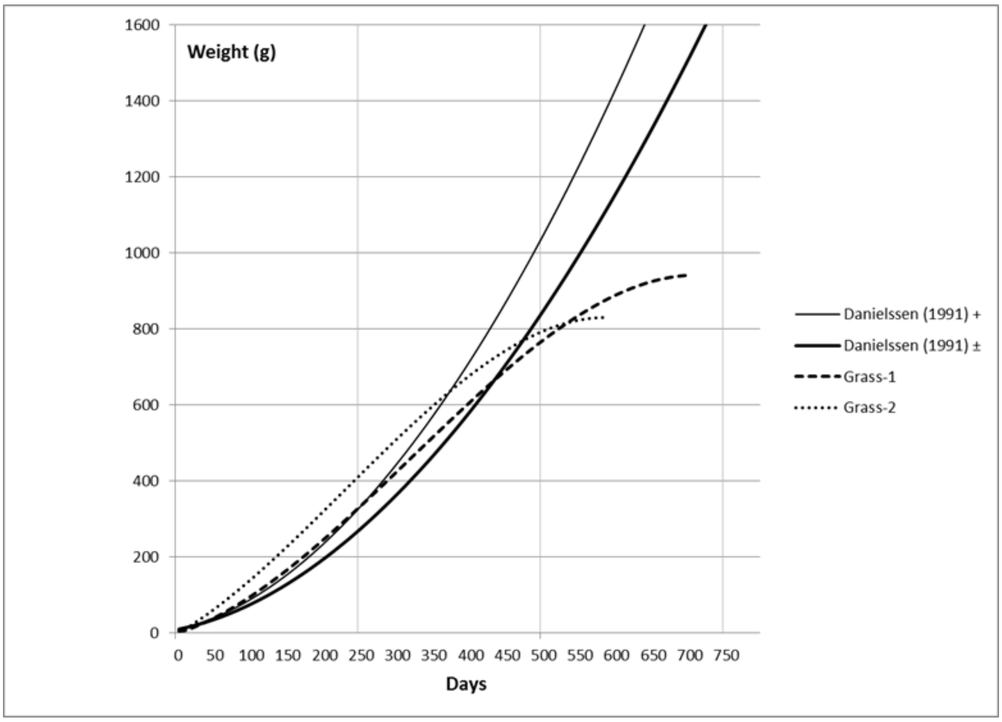


Figure 1. The growth curves of a batch of turbot based on different sources.

The data from the GRASS project show a strong slowing down of growth at a weight of 1000 grams in RAS. From the data of Danielssen (1991) a growth curve and a relation between body weight and the specific growth rate (SGR, %/day) can be described as:

$$SGR = 11.6*W^{-0.525} \quad (1)$$

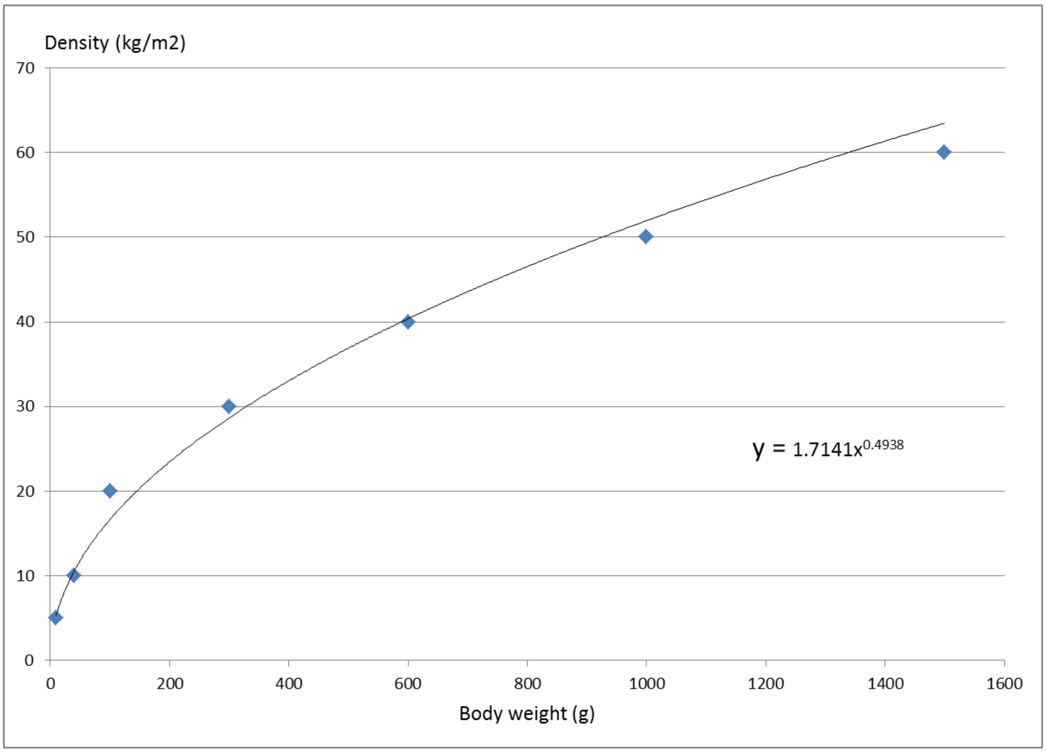
Starting at a body weight of 10 g and calculating with 10 day growth periods, this rate results in a body weight of 1518 grams after 23 months. This growth seems to be attainable in flow-through although the GRASS project shows that it can be difficult in RAS. The exact nature of this growth retardation in RAS is still unknown.

The relationship between body weight and maximum density is shown in figure 2 and can be described as:

$$D = 1.7141*W^{0.4938} \quad (2)$$

Although higher densities are technically possible with turbot, this will slow down growth. The curve shown in figure 2 results in a final density of 60 kg/m^2 at a body weight of 1500 grams. Smaller specimen have to be kept at a lower density.

Figure 2. The relationship between body weight and maximum density.



The flow of fish in a farm will be determined by the number of times new fish are taken in, the number of gradings during the on-growing and the timing of sales. We assume that new fish of 10 grams are introduced in the farm four times a year and that batches are split or graded when the maximum stocking density as described in figure 2 is reached. Fish from a single batch will not all grow with the same rate and time to reach 1.5 kg will differ. We assume that the sales of one batch will be extended over 3 months.

Mortality will usually be highest with the small sizes. In our model we calculate with the surviving fish needed to reach a certain level of production. For a production of 110 tonnes of fish of 1500 grams we need: 110,000/1.5 = 73,333 pieces. This means 18,333 pieces per batch. As will be discussed later, a production of 110 tons per year is the maximum possible with the amount of rearing area available.

In table 1 the growth of one batch of fish has been described based on the Danielssen (1991) scenario. Based on formulas (1) and (2) the growth rates and maximum densities are calculated. The average weight combined with the number of fish results in a needed surface area. Dividing this area by the area of one tank (48 $m^{2,}$ including inproductive corner of 1 m^2) results in the number of tanks needed. For a growth cycle up to 1500 grams, two moments of splitting/grading of batch are needed to redistribute the fish and avoid overcrowding of the tanks. This means that right after splitting, tanks will have a relatively low density which will increase to the maximum before the next grading. Table 1 shows that the moments for splitting are at the end of month 6 and month 14 and this will determine the actual amount of tanks in use over time as shown in table 1. The final number of tanks needed is 9 for one batch. The biomass and a feed conversion rate (FCR) will allow an estimate of the feed consumption of one batch of fish over time.

Based on a stocking of fish every 3 months, the number of tanks in use has been calculated and is shown in table 2.

Table 1. An overview of the production data of one batch of fish based on eq. 1 and 2.

Month (end)	Avg wt (g, end)	SGR (%/day)	# fish	Max density (kg/m2)	Area needed (m2)	# tanks needed	# actual tanks	biomass (tons)	FCR	Feed load (kg/day)
0	10.0	3.46	18333	5.3	34	0.7	3	0.18	0.8	5
1	24.2	2.18	18333	8.2	54	1.1	3	0.44	0.8	8
2	43.5	1.60	18333	11.0	72	1.5	3	0.80	0.8	10
3	67.8	1.27	18333	13.7	91	1.9	3	1.24	0.8	13
4	96.9	1.05	18333	16.4	109	2.3	3	1.78	0.8	15
5	130.6	0.90	18333	19.0	126	2.6	3	2.40	0.9	19
6	169.0	0.78	18333	21.5	144	3.0	3	3.10	0.9	22
7	211.9	0.70	18333	24.1	161	3.4	6	3.89	0.9	24
8	259.3	0.63	18333	26.6	179	3.7	6	4.75	0.9	27
9	311.1	0.57	18333	29.1	196	4.1	6	5.70	1	32
10	367.2	0.52	18333	31.6	213	4.4	6	6.73	1	35
11	427.7	0.48	18333	34.1	230	4.8	6	7.84	1	38
12	492.5	0.45	18333	36.5	247	5.2	6	9.03	1.1	44
13	561.6	0.42	18333	39.0	264	5.5	6	10.30	1.1	47
14	660.3	0.38	18333	42.2	287	6.0	6	12.11	1.1	51
15	739.2	0.36	18333	44.6	304	6.3	9	13.55	1.2	59
16	822.2	0.34	18333	47.0	320	6.7	9	15.07	1.2	62
17	909.4	0.32	18333	49.4	337	7.0	9	16.67	1.2	65
18	1000.8	0.31	18333	51.8	354	7.4	9	18.35	1.2	68
19	1096.2	0.29	18333	54.2	371	7.7	9	20.10	1.3	77
20	1195.7	0.28	18333	56.6	387	8.1	9	21.92	1.3	80
21	1299.3	0.27	18333	59.0	404	8.4	9	23.82	1.3	83
22	1406.9	0.26	18333	61.3	421	8.8	9	25.79	1.3	87
23	1518.6	0.25	18333	63.7	437	9.1	9	27.84	1.3	90

The timing of the sales at the end of the growth period of a batch will determine the amount of tanks needed at that stage. We assume that three of the 9 tanks can be sold during month 23, another 3 in month 24 and the last fish in month 25.
Table 2 shows that from the moment the farm reaches full capacity, the number of tanks in use fluctuates between 48 and 51. Taking into account that for purposes of grading and cleaning there are always one or two empty tanks needed , the capacity as calculated based on 110 tons per year can be considered a maximum.

Table 2. The production plan of the turbot farm showing the number of tanks in use to accommodate each batch based on the production model.

Production (T/Y)				Batch no.										# tanks total
110	1	2	3	4	5	6	7	8	9	10	11			
Month	# tanks													0
0	3													3
1	3													3
2	3													3
3	3	3												6
4	3	3												6
5	3	3												6
6	3	3	3											9
7	6	3	3											12
8	6	3	3											12
9	6	3	3	3										15
10	6	6	3	3										18
11	6	6	3	3										18
12	6	6	3	3	3									21
13	6	6	6	3	3									24
14	6	6	6	3	3									24
15	9	6	6	3	3	3								30
16	9	6	6	6	3	3								33
17	9	6	6	6	3	3								33
18	9	9	6	6	3	3	3							39
19	9	9	6	6	6	3	3							42
20	9	9	6	6	6	3	3							42
21	9	9	9	6	6	3	3	3						48
22	9	9	9	6	6	6	3	3						51
23	6	9	9	6	6	6	3	3						48
24	3	9	9	9	6	6	3	3	3					51
25	0	9	9	9	6	6	6	3	3					51
26		6	9	9	6	6	6	3	3					48
27		3	9	9	9	6	6	3	3	3				51
28		0	9	9	9	6	6	6	3	3				51
29		0	6	9	9	6	6	6	3	3				48
30			3	9	9	9	6	6	3	3	3			51
31			0	9	9	9	6	6	6	3	3			51
32			0	6	9	9	6	6	6	3	3			48
33				3	9	9	9	6	6	3	3	3		51
34				0	9	9	9	6	6	6	3	3		51
35				0	6	9	9	6	6	6	3	3		48

The development of the biomass of each batch of fish can be calculated from the individual weight and the number of fish (table 3). At the moment the farm is starting to sell, the standing stock will vary between 84.1 and 84.9 tons resulting in an average density at the farm of 84500/2400= 35.1 kg/m^2. With this standing stock a production of 110 tons per year will be gained.

Table 3. The monthly development of the standing stock.

Poduction (T/Y)														
110		2	3	4	5	6	7							**Standing stock**
Month														**(ton)**
0	0.2													
1	0.4													0.4
2	0.8													0.8
3	1.2	0.2												1.4
4	1.8	0.4												2.2
5	2.4	0.8												3.2
6	3.1	1.2	0.2											4.5
7	3.9	1.8	0.4											6.1
8	4.8	2.4	0.8											7.9
9	5.7	3.1	1.2	0.2										10.2
10	6.7	3.9	1.8	0.4										12.8
11	7.8	4.8	2.4	0.8										15.8
12	9.0	5.7	3.1	1.2	0.2									19.3
13	10.3	6.7	3.9	1.8	0.4									23.1
14	12.1	7.8	4.8	2.4	0.8									27.9
15	13.6	9.0	5.7	3.1	1.2	0.2								32.8
16	15.1	10.3	6.7	3.9	1.8	0.4								38.2
17	16.7	12.1	7.8	4.8	2.4	0.8								44.6
18	18.3	13.6	9.0	5.7	3.1	1.2	0.2							51.2
19	20.1	15.1	10.3	6.7	3.9	1.8	0.4							58.3
20	21.9	16.7	12.1	7.8	4.8	2.4	0.8							66.5
21	23.8	18.3	13.6	9.0	5.7	3.1	1.2	0.2						75.0
22	25.8	20.1	15.1	10.3	6.7	3.9	1.8	0.4						84.1
23	18.4	21.9	16.7	12.1	7.8	4.8	2.4	0.8						84.9
24	9.2	23.8	18.3	13.6	9.0	5.7	3.1	1.2	0.2					84.2
25	0.0	25.8	20.1	15.1	10.3	6.7	3.9	1.8	0.4					84.1
26		18.4	21.9	16.7	12.1	7.8	4.8	2.4	0.8					84.9
27		9.2	23.8	18.3	13.6	9.0	5.7	3.1	1.2	0.2				84.2
28		0.0	25.8	20.1	15.1	10.3	6.7	3.9	1.8	0.4				84.1
29			18.4	21.9	16.7	12.1	7.8	4.8	2.4	0.8				84.9
30			9.2	23.8	18.3	13.6	9.0	5.7	3.1	1.2	0.2			84.2
31			0.0	25.8	20.1	15.1	10.3	6.7	3.9	1.8	0.4			84.1
32				18.4	21.9	16.7	12.1	7.8	4.8	2.4	0.8			84.9

Table 4. The development of the daily feed load over time.

Production (T/Y)			Batch no.											
110		2	3	4	5	6	7							
Month													**Feed load (kg/d)**	
0	5.1													
1	7.7													8
2	10.2													10
3	14.9	5.1												20
4	19.4	7.7												27
5	21.9	10.2												32
6	24.4	14.9	5.1											44
7	26.8	19.4	7.7											54
8	32.5	21.9	10.2											65
9	35.2	24.4	14.9	5.1										80
10	37.8	26.8	19.4	7.7										92
11	44.5	32.5	21.9	10.2										109
12	47.3	35.2	24.4	14.9	5.1									127
13	51.1	37.8	26.8	19.4	7.7									143
14	58.8	44.5	32.5	21.9	10.2									168
15	61.9	47.3	35.2	24.4	14.9	5.1								189
16	64.9	51.1	37.8	26.8	19.4	7.7								208
17	67.9	58.8	44.5	32.5	21.9	10.2								236
18	76.8	61.9	47.3	35.2	24.4	14.9	5.1							266
19	80.1	64.9	51.1	37.8	26.8	19.4	7.7							288
20	83.3	67.9	58.8	44.5	32.5	21.9	10.2							319
21	86.5	76.8	61.9	47.3	35.2	24.4	14.9	5.1						352
22	89.7	80.1	64.9	51.1	37.8	26.8	19.4	7.7						378
23	59.2	83.3	67.9	58.8	44.5	32.5	21.9	10.2						378
24	29.6	86.5	76.8	61.9	47.3	35.2	24.4	14.9	5.1					382
25	0.0	89.7	80.1	64.9	51.1	37.8	26.8	19.4	7.7					378
26		59.2	83.3	67.9	58.8	44.5	32.5	21.9	10.2					378
27		29.6	86.5	76.8	61.9	47.3	35.2	24.4	14.9	5.1				382
28		0.0	89.7	80.1	64.9	51.1	37.8	26.8	19.4	7.7				378
29			59.2	83.3	67.9	58.8	44.5	32.5	21.9	10.2				378
30			29.6	86.5	76.8	61.9	47.3	35.2	24.4	14.9	5.1			382
31			0.0	89.7	80.1	64.9	51.1	37.8	26.8	19.4	7.7			378
32				59.2	83.3	67.9	58.8	44.5	32.5	21.9	10.2			378

The feed load to the system will vary according to table 3 between 378 and 382 kg/day. This amounts to an average feeding rate of the biomass of 380*100/85500= 0.44 %/day.

4. Production capacity based on oxygen and water treatment

For the envisioned production of 150 tons per year a daily feed load in the order of 534 kg/day is needed at a feed conversion rate of 1.3. Assuming an oxygen consumption of 500 g/kg feed, this results in a needed oxygen supply of 534/2= 267 kg per day. The tank flow is according to the data sheet provided 1500 m^3/hr. If we allow an oxygen level of 7 g/m^3 in the outlet of the tank, this would mean that a level of 14.7 g/m^3 is needed on average in the inlet to satisfy the needs of the fish. Currently, the oxygen injection system in the inlet is not able to deliver this level and additional oxygenation has to be provided in the tanks. Although this method seems sufficient to deliver oxygen to the fish, the method of diffusion in shallow water is very inefficient.

A major element of the water treatment system is removal of suspended solids (feces) produced by the fish. This starts with design of a self-cleaning tank in which the current is sufficient to carry-away the suspended material. In a shallow-raceway a water speed of 2 cm/sec is needed at least to ensure efficient removal of solids. In this farm the water speed is in the order of 0.3 cm/sec which results in a dirty rearing environment which was clearly visible during the farm visit. The results of this will be an increased risk for diseases and health problems with an eventual bearing on productivity.

The feed provided contains according to the data sheet 50% protein. At an FCR of 1.3 and a protein digestibility of 90% this will result in a production of app. 50 g NH_4-N per kg of feed. At a feeding level of 534 kg/day this results in a load of 26.7 kg NH_4-N. The amount of biofilter surface available is difficult to assess in the farm but amounts according to the data sheet to 36.000 m^2. This would indicate that on average a removal rate in the order of 0.74 g/m^2/day is needed for total removal of ammonium. According to Nijhof & Bovendeur (1990), the maximum removal rate for ammonium in seawater of 18°C will be in the order of 0.2 g/m^2/day. This indicates that the production capacity with regard to removal of ammonium is not sufficient for a production of 150 tons per year.

Removal of suspended solids by drum filtration and degassing can be considered adequate in this system.

6. Conclusions

- The rearing area available at the farm of ELCOMEX can support a production of 110 tons per year of turbot of 1.5 kg which is far below the targeted capacity of 150 tons.
- Oxygenation capacity is sufficient for a production of 150 tons per year although the system is very inefficient.
- Self-cleaning of the tanks is inadequate and results in a high risk for disease problems.
- The capacity for ammonium removal is insufficient based on the data available.

Quality Assurance

IMARES utilises an ISO 9001:2008 certified quality management system (certificate number: 124296-2012-AQ-NLD-RvA). This certificate is valid until 15 December 2015. The organisation has been certified since 27 February 2001. The certification was issued by DNV Certification B.V. Furthermore, the chemical laboratory of the Fish Division has NEN-EN-ISO/IEC 17025:2005 accreditation for test laboratories with number L097. This accreditation is valid until 1th of April 2017 and was first issued on 27 March 1997. Accreditation was granted by the Council for Accreditation.

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Justification

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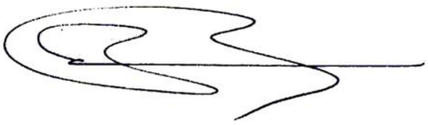
The scientific quality of this report has been peer reviewed by the a colleague scientist and the head of the department of IMARES.

Approved: Dr. R. Blonk
Project manager, researcher genetics



Signature:

Date: 9 July 2014

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