

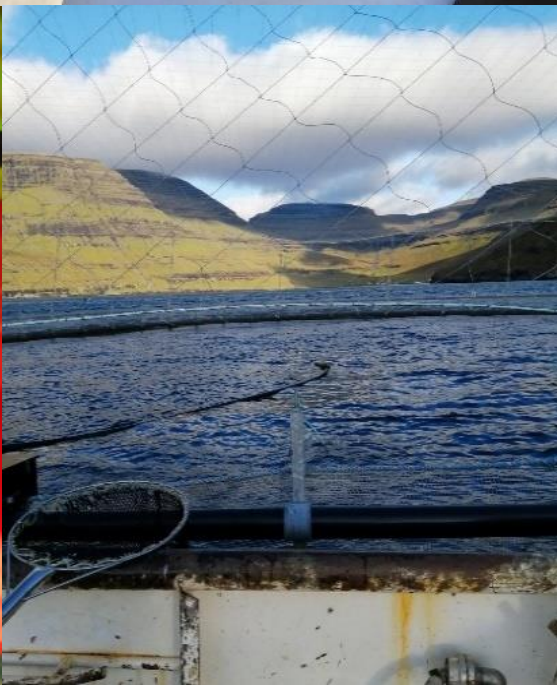
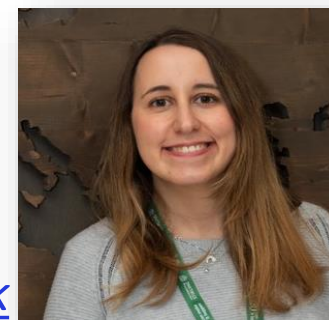
LUMPFISH WELFARE AND NUTRITION IN ON GROWING FARMS:

developing optimal nutritional requirements for juvenile lumpfish in farm conditions and when deployed in salmon sea farms based on a survey of wild populations

Start date: 1st August 2019

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AKER BIOMARINE

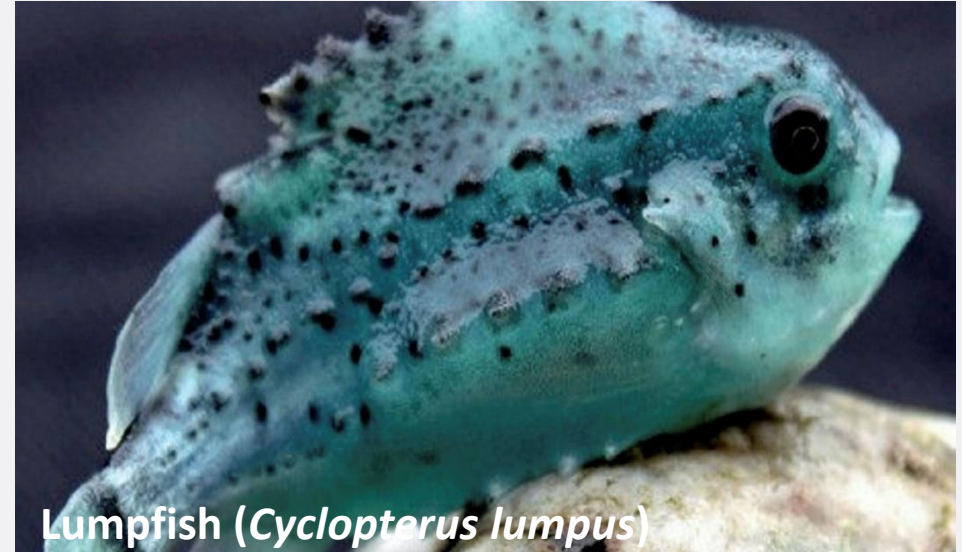
Background of the Project



The use of Cleaner fish



Ballan wrasse (*Labrus Bergylta*)



Lumpfish (*Cyclopterus lumpus*)

Deployment window:	Spring/Summer, increasing water T
Deployment size:	40-50 g
Stocking rate:	5 %
Feeding behaviour:	Will not feed below 6°C, winter dormancy
Time to deployment:	1.5 years

Late autumn/winter, decreasing water T
15-30 g
10 %
Will feed as low as 4°C
5-7 months

Lumpfish deployed in salmon sea cages

- **High mortalities** in the post deployment stage



- **Poor health and welfare conditions** (bacterial infections, high level of fin damage, liver color)
- **Nutritional deficits**



Source: Internet

Objectives:

1. Investigate **nutritional differences** between wild and farmed lumpfish.
2. Identify differences between wild and farmed lumpfish in terms of **welfare indicators**.
3. Investigate whether lumpfish have some **prey preferences** by an assessment of the nutritional content of their natural diet.
4. Establish **optimal nutritional requirements**, optimal physical properties of the feed and best delivery protocols.
5. A **tailored lumpfish diet** will improve the health and welfare of lumpfish and increase the survival rates at the deployment stage.



Experimental Plan:

4 sampling periods:

winter, spring, summer, autumn

6 size classes:

< 50 g, 50-150 g, 150-300 g, >300g-1kg, 1-3 kg, 3-5 kg

✓ Survey of wild lumpfish

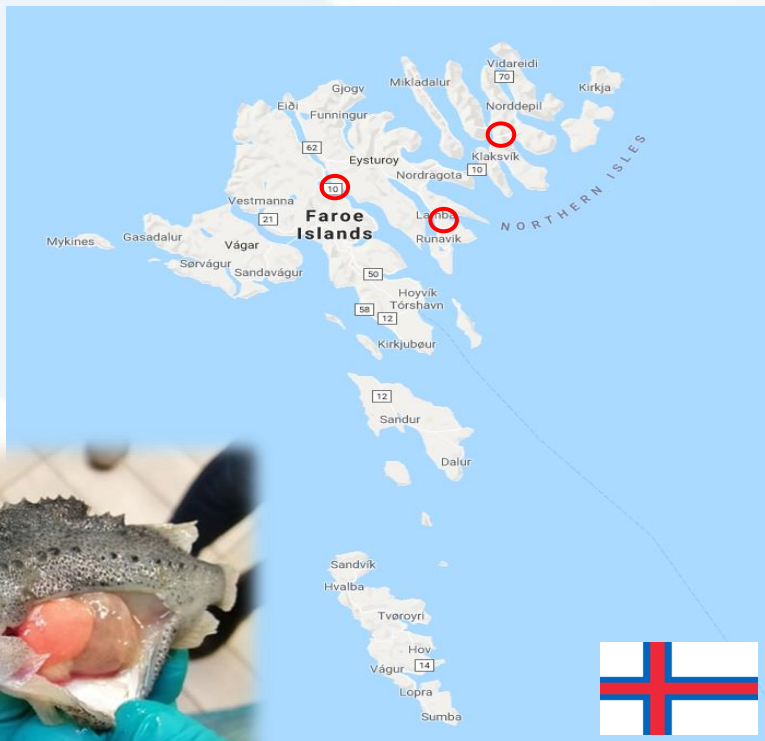
Pelagic fisheries, coastal lumpfish and research surveys.

✓ Sampling farmed lumpfish

Hatcheries and marine sites, different environmental conditions

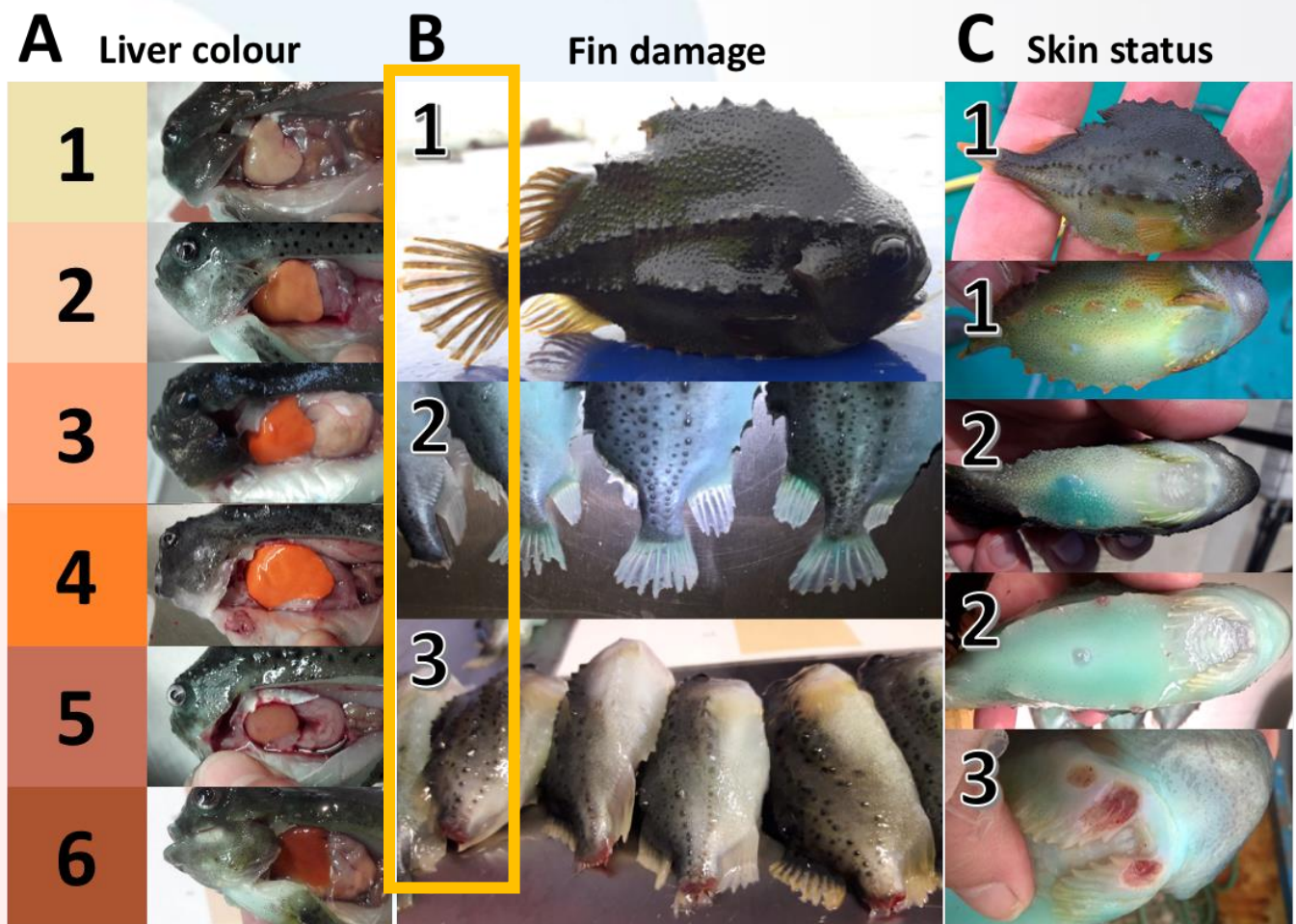
✓ Feed trial

- Two commercially available feeds
- A feed that resembles the wild diet of lumpfish



Sample and data collection:

- Morphometric data, sex



Operational Welfare Indicators:

- Fin damage
- Eyes integrity
- Deformities in the suction disc
- Skin status
- Liver colour

SCIENTIFIC REPORTS
nature research



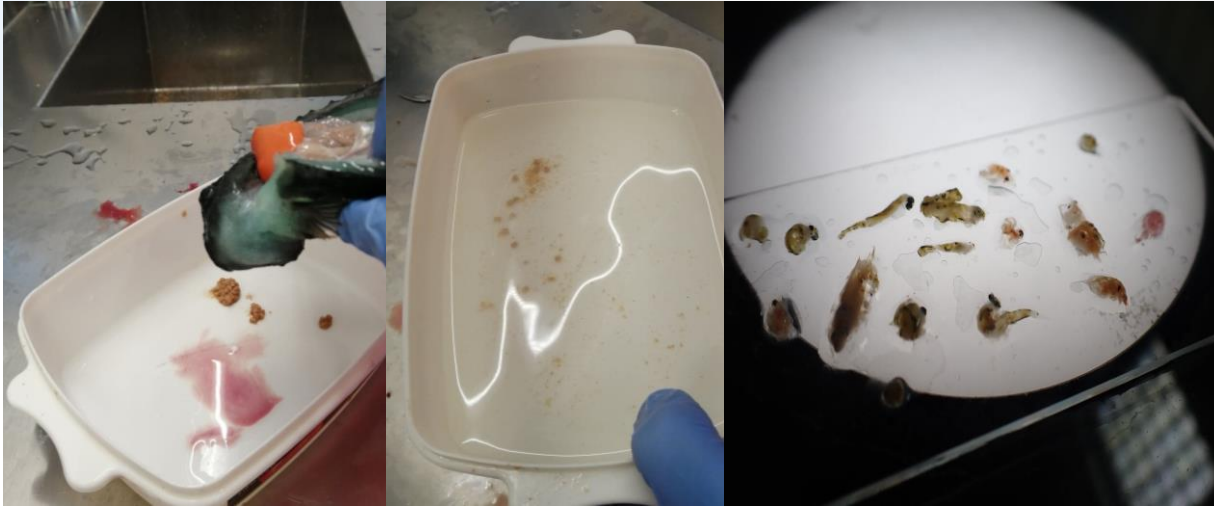
OPEN

Liver colour scoring index, carotenoids and lipid content assessment as a proxy for lumpfish (*Cyclopterus lumpus* L.) health and welfare condition

Kirstin Eliassen¹, Esbern J. Patursson², Bruce J. McAdam³, Enrique Pino⁴, Bernat Morro³, Monica Betancor³, Johanna Bailly³ & Sonia Rey³

Sample and data collection:

- **Stomach content**



1: lice

2: lumpfish feed

3: salmon feed

4: species on the net (gammarid, sea weed)

5: other

6: planktonic species (jellyfish)

Farmed lumpfish:



Wild lumpfish:

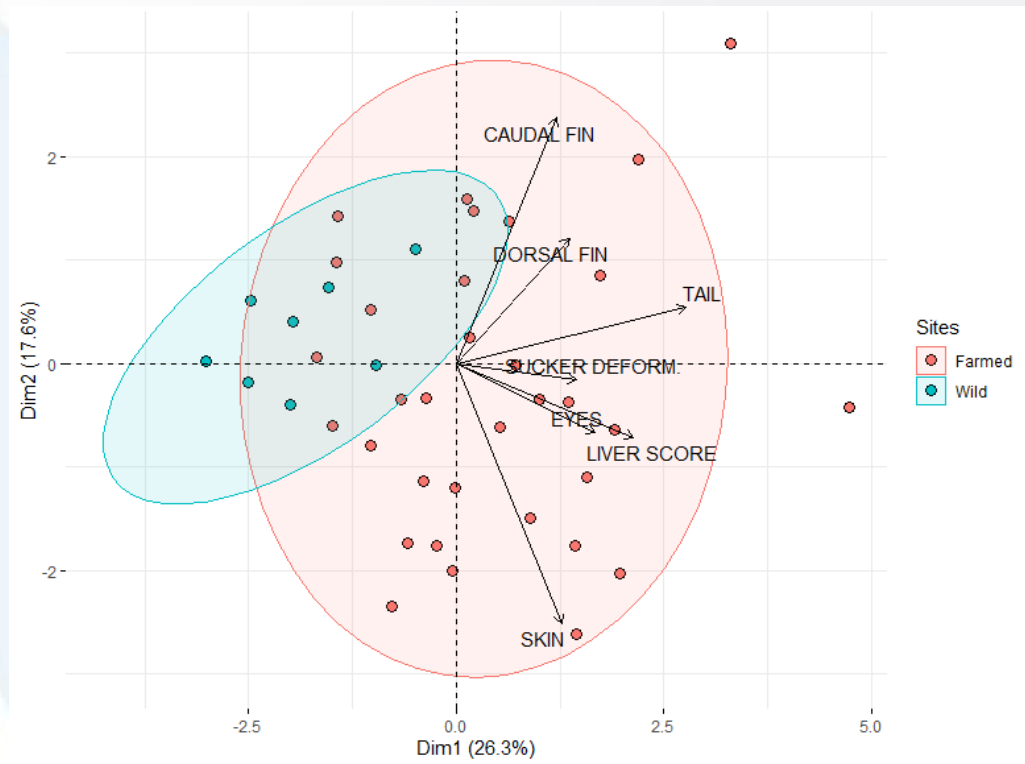


Laboratory analyses:

- Nutritional analysis on livers:
lipid content, fatty acid profile, lipid classes and pigments determination
- Proximate analysis on whole lumpfish and feeds (moisture, ash, protein, oil), fatty acid and amino acids
- Histological analysis on spleen, intestine and liver
- Liver and intestine for gene expression



Operational Welfare indicators:



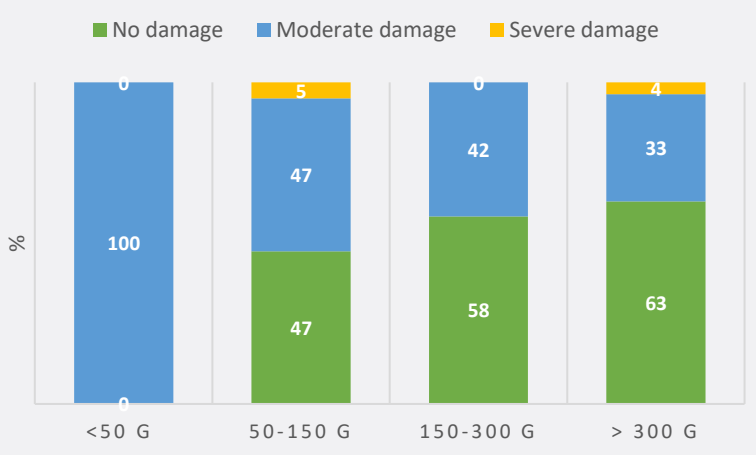
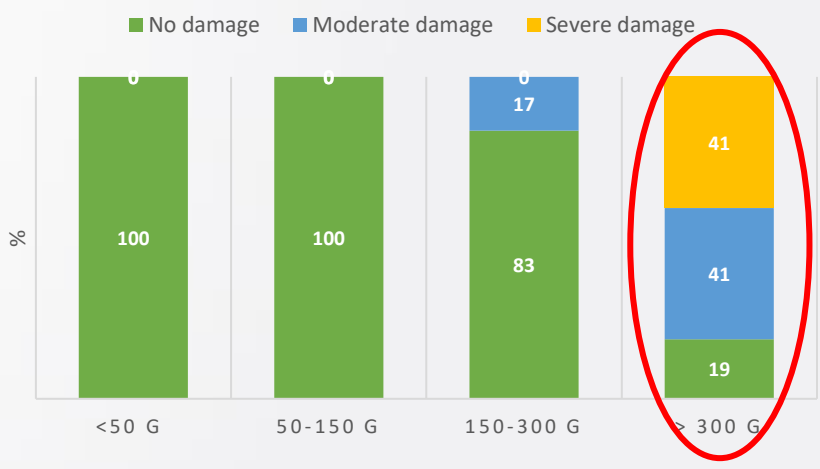
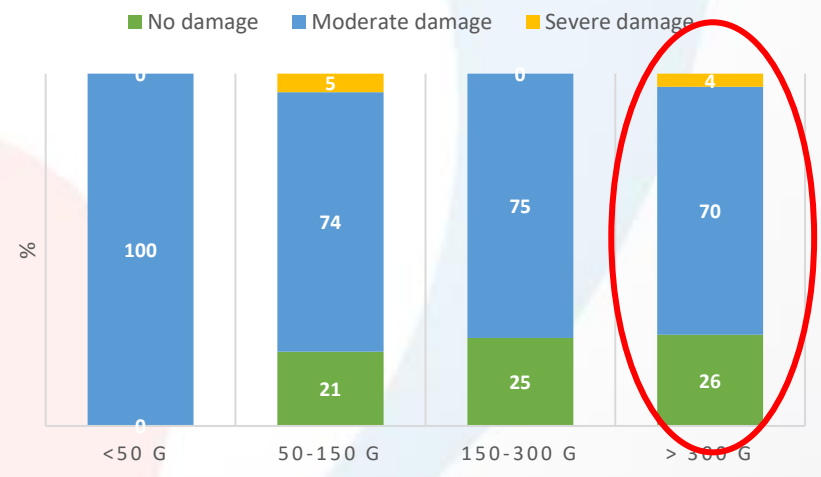
Wild

Farmed

TAIL

SKIN

CAUDAL FIN



Whole fish composition and fatty acid profile

Wild lumpfish – July 2020

Table 1. Carcass composition of wild lumpfish. Fish are divided by size classes (50-150 g, n=1; 300 g-1kg, n=8; 1kg – 3kg, n=8; 3-5 kg, n=7) and values shown are percentages.

Size class	50-150 g	300 g-1 kg	1 kg - 3 kg	3-5 kg	P-value
Moisture	86.8	85.0 ± 2.2	86.7 ± 2.9	86.2 ± 2.1	0.529
Ash	1.6	1.67 ± 0.19 ^a	1.57 ± 0.13 ^{ab}	1.47 ± 0.12 ^b	0.05
Oil	3.5	4.3 ± 2.06	3.4 ± 1.68	4.4 ± 1.33	0.672



Table 2. Fatty acid composition of whole wild lumpfish by size class (>300g-1kg, n=5; 1-3 kg, n=7; 3-5 kg, n=8).

Whole fish	>300g-1kg (Wild)	1-3 kg (Wild)	3-5 kg (Wild)
Total lipid	4.07 ± 2.39	3.30 ± 1.78	4.4 ± 1.2
14:0	5.81 ± 1.3	6.87 ± 1.2	6.76 ± 0.9
16:0	16.26 ± 0.8	15.90 ± 1.7	16.65 ± 1.9
18:0	4.47 ± 0.9	4.43 ± 1.4	4.21 ± 1.1
ΣSAFA¹	27.13 ± 2.4	27.94 ± 3.2	28.33 ± 2.6
16:1n-7	5.27 ± 1.5	5.45 ± 0.9	5.52 ± 1.31
18:1n-9	25.34 ± 7.1	21.81 ± 4.0	23.35 ± 6.17
18:1n-7	4.31 ± 0.5	3.73 ± 0.5	4.00 ± 0.53
20:1n-9	9.32 ± 1.9	11.27 ± 1.2	10.63 ± 3.09
22:1n-11	5.71 ± 2.6	7.63 ± 1.4	7.10 ± 2.2
ΣMUFA²	58.99 ± 12.6	62.01 ± 3.3	62.15 ± 3.6
18:2n-6	1.66 ± 0.6	1.60 ± 0.5	1.72 ± 0.4
20:4n-6	0.43 ± 0.6	0.31 ± 0.2	0.22 ± 0.1
Σn-6			
PUFA³	2.65 ± 1.3	2.36 ± 0.9	2.39 ± 0.5
18:3n-3	0.67 ± 0.2	0.61 ± 0.2	0.68 ± 0.2
18:4n-3	0.67 ± 0.5	0.74 ± 0.5	0.69 ± 0.3
20:5n-3	4.05 ± 5.0	2.53 ± 1.3	2.20 ± 0.9
22:5n-3	0.34 ± 0.3	0.23 ± 0.1	0.22 ± 0.1
22:6n-3	4.46 ± 5.8	2.60 ± 1.4	2.34 ± 1.2
Σn-3			
PUFA⁴	10.74 ± 12.2	7.23 ± 3.5	6.64 ± 2.8
ΣPUFA	13.87 ± 13.5	10.06 ± 4.4	9.52 ± 3.0
ΣLC-PUFA			
EPA/DH	9.92 ± 2.1	6.42 ± 1.2	5.82 ± 1.0
A	0.91 ± 0.3	0.97 ± 0.1	0.94 ± 0.1

Preliminary results - Livers

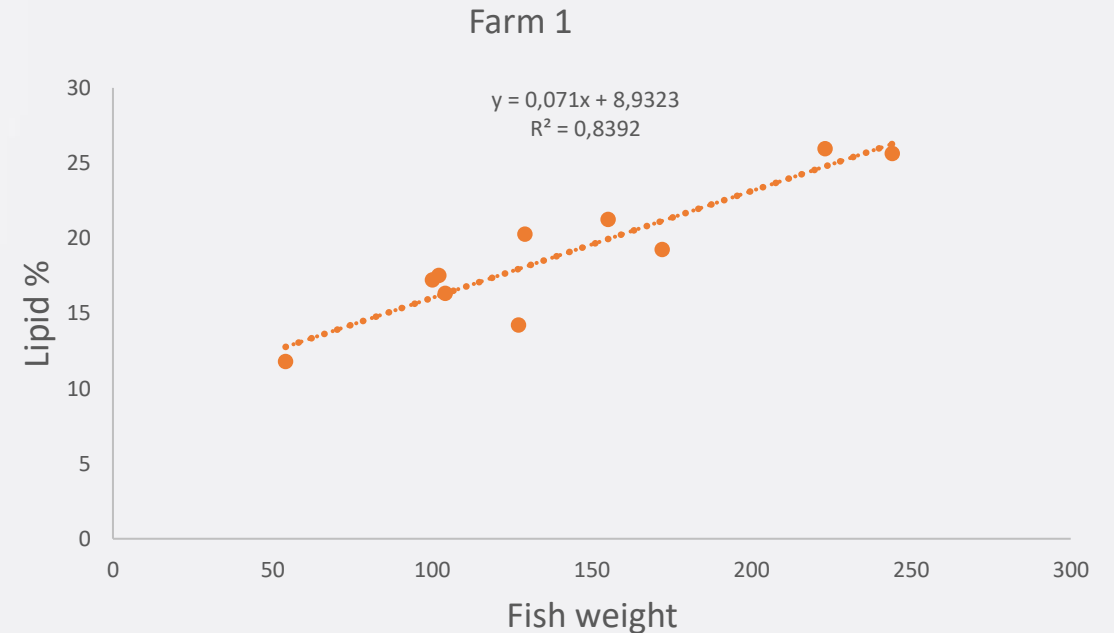
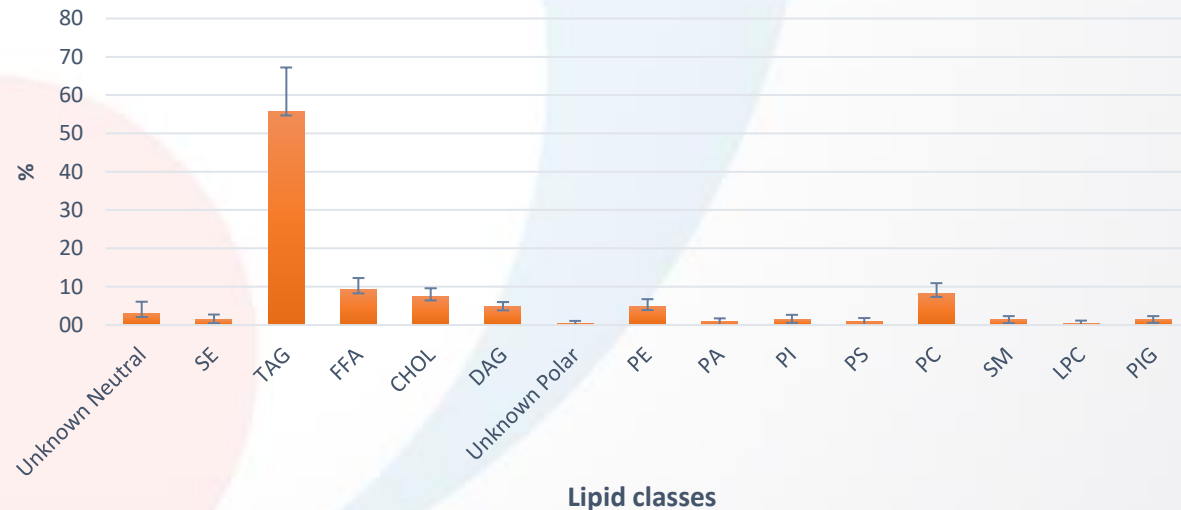


Size class	50-150 g (Farm 1)	150-300 g (Farm 1)	>300 g-1kg (Farm 2)
Astaxanthin (Ax norm, 9z, 13z and 15z)	76.20 ± 12.2	122.02 ± 42.5	93.44 ± 16.5
Lutein	0.97 ± 0.4	1.08 ± 0.5	0.77 ± 0.5
Astacene/Adonirubin	2.57 ± 0.4	2.40 ± 2.2	3.34 ± 0.3

Lipid content of farmed lumpfish livers

Pigment determination of lumpfish livers

LIPID CLASSES OF FARMED LUMPFISH LIVERS



Feeds

Table 3. Proximate composition and selected fatty acids of lumpfish feed deployed in the farms Lambavik and Arnafjordur.

FEED	Commercial Feed A
Moisture	9.97
Ash	7.66
Crude protein	47.79
Crude lipid	17.03
14:0	5.40
16:0	19.10
18:0	2.96
ΣSAFA¹	28.43
16:1n-7	5.59
18:1n-9	15.73
18:1n-7	3.54
20:1n-9	2.62
22:1n-11	3.02
ΣMUFA²	32.81
18:2n-6	12.37
20:4n-6	0.73
Σn-6 PUFA³	13.71
18:3n-3	1.82
18:4n-3	1.61
20:5n-3	9.57
22:5n-3	0.91
22:6n-3	8.93
Σn-3 PUFA⁴	23.68
ΣPUFA	37.39
ΣLC-PUFA	19.84
EPA/DHA	1.07



Species	Site	MOISTURE	ASH	PROTEIN	OIL
Salmon feed	Lambavik 15/10/2019	9.23	7.94	44.07	29.78
Salmon feed	Arnafjordur 12/8/2020	5.99	6.47	41.52	34.04
Lumpfish feed	Lambavik 15/10/2019 Arnafjordur 12/8/2020	9.97	7.66	47.79	17.03
Lumpfish feed	Nesvik	7.79	11.32	54.29	14.96
Lumpfish feed	Nesvik	8.59	11.90	48.38	12.51

Next steps:

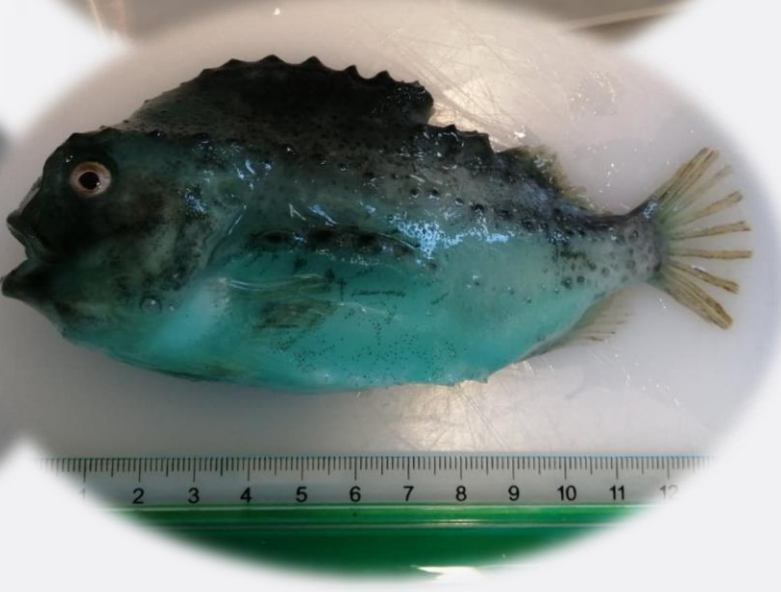
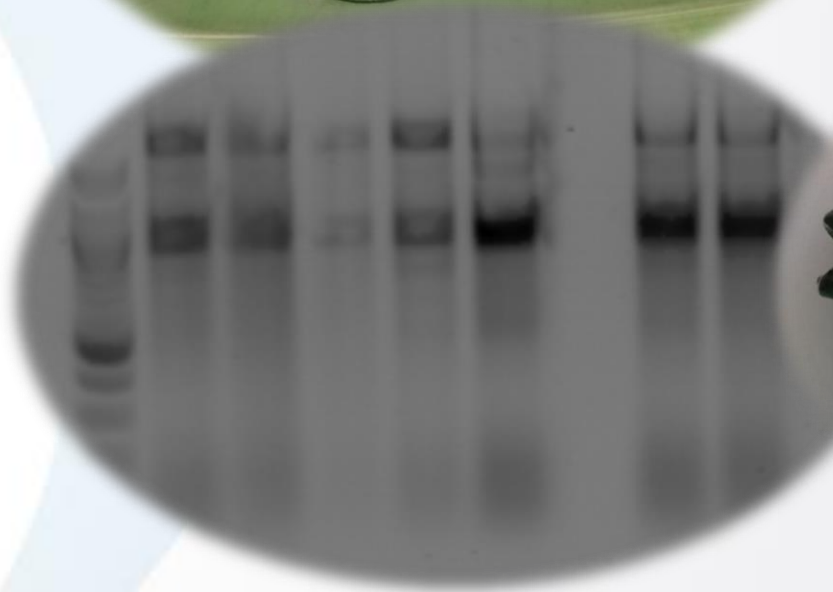
Feed trial



Histological analysis



Gene expression



Samples and data collection:

- Winter sampling
- Spring sampling

Thank
you

