Update on two floating bag closed-containment projects in Norway

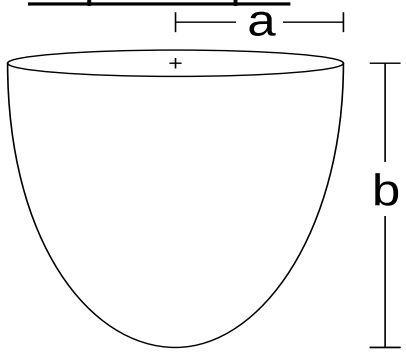
(I.) Closed Flexible Cage

(Financed by Norwegian Research Council)

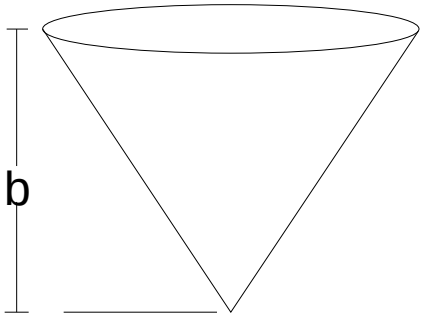
Pascal Klebert , Trond W. Rosten, Zsolt Volent, Pål Lader
Sintef Fisheries and Aquaculture

Design of tested configuration

Ellipse shape



Conic shape



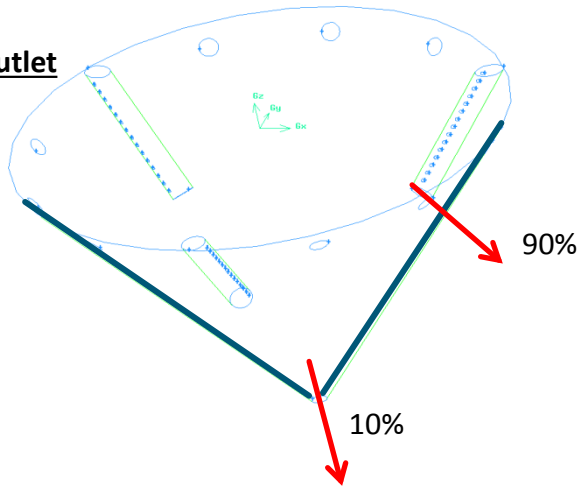
a = 6,5 m
b = 9m – 16 m
Holes (upper) = 1 , 3 , 9

Inlet Flow Rates = 5 , 20 , 40 m^3/min

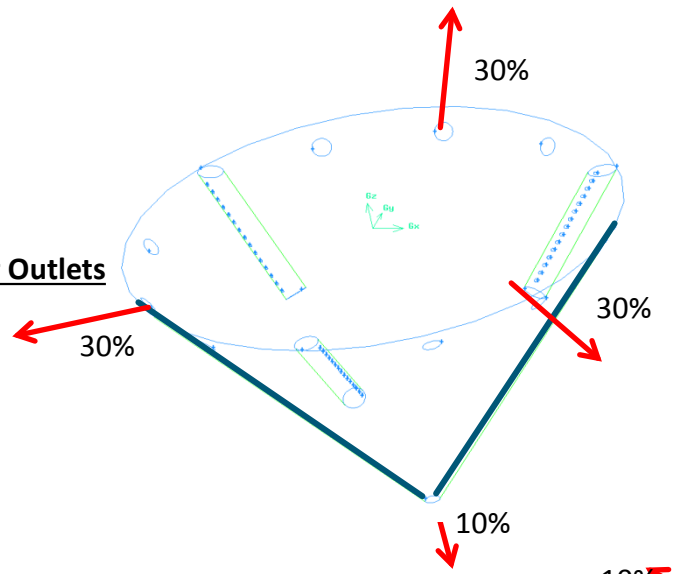
Design of simulated configuration : Conic Shape

Surfaces visualization for Velocity field

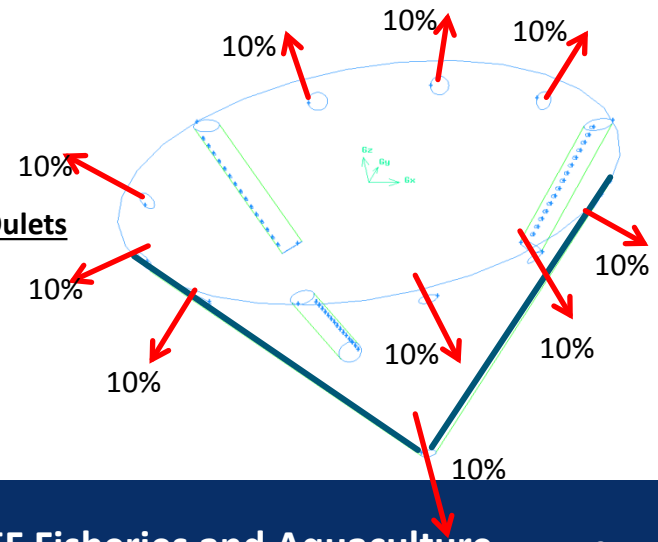
One upper Outlet



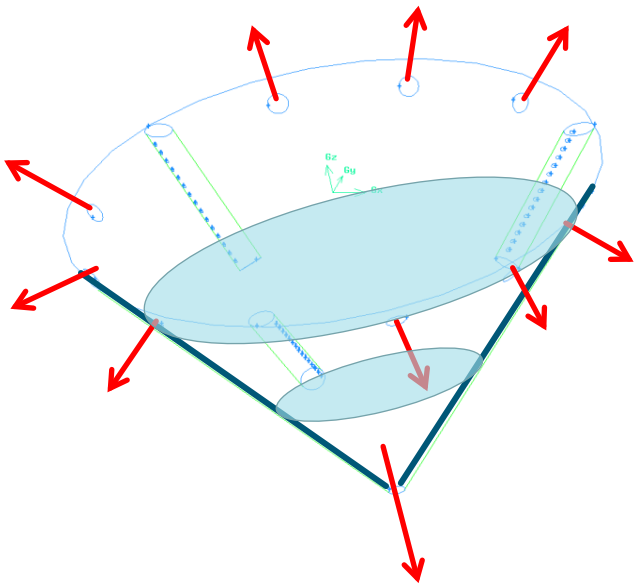
Three upper Outlets

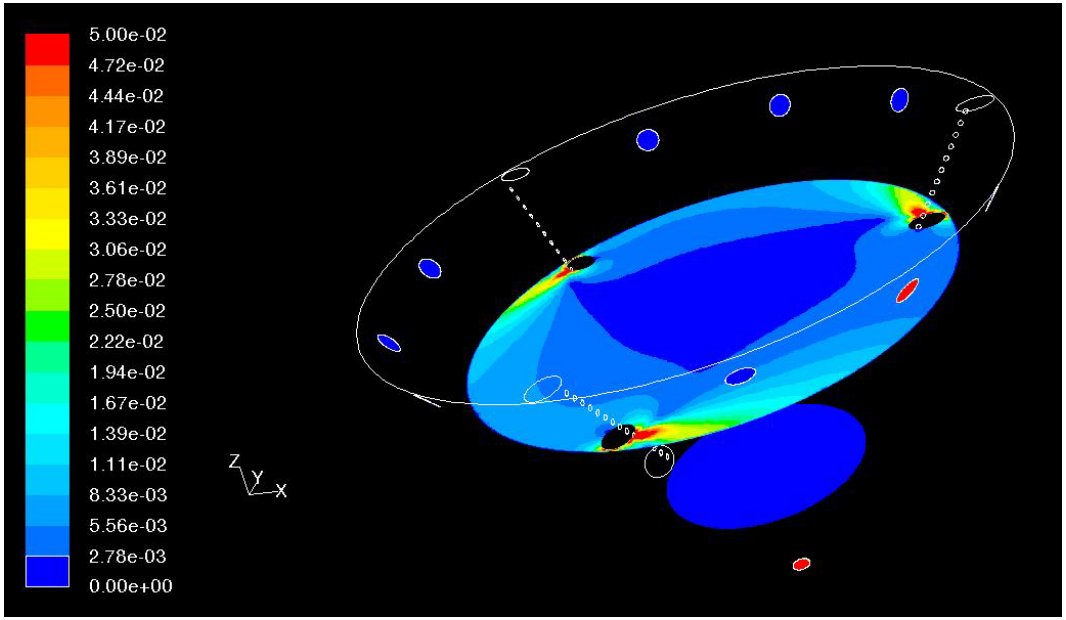


Nine upper Oulets

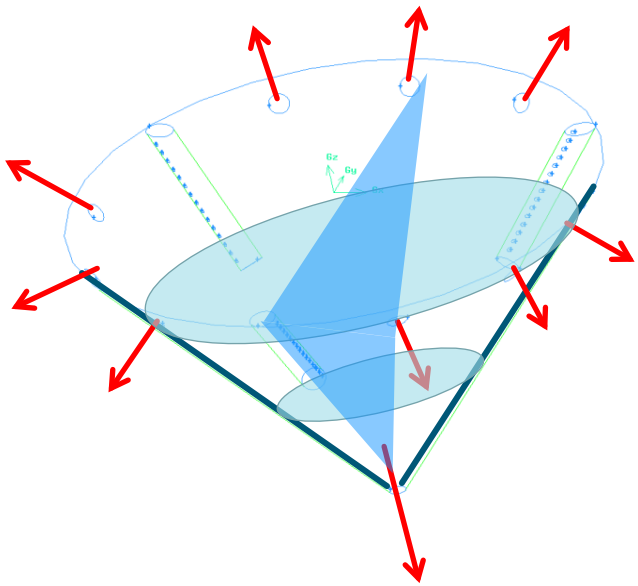


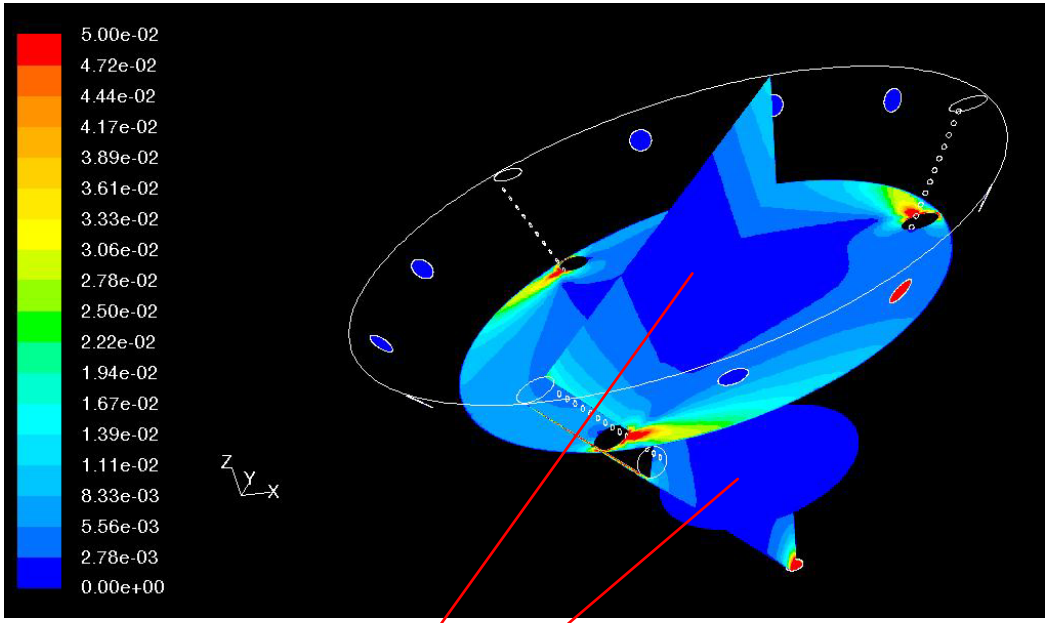
"Horizontal" Surfaces





"Horizontal" and vertical" Surfaces





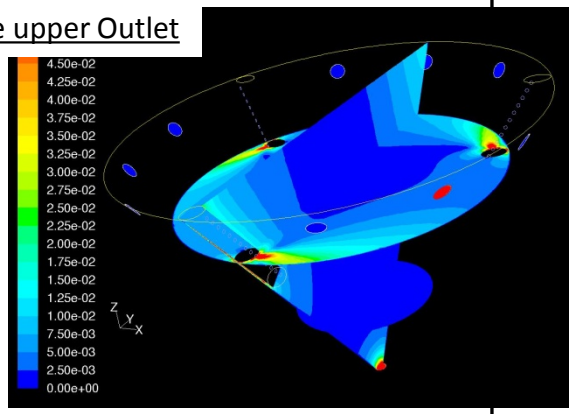
Low Velocity

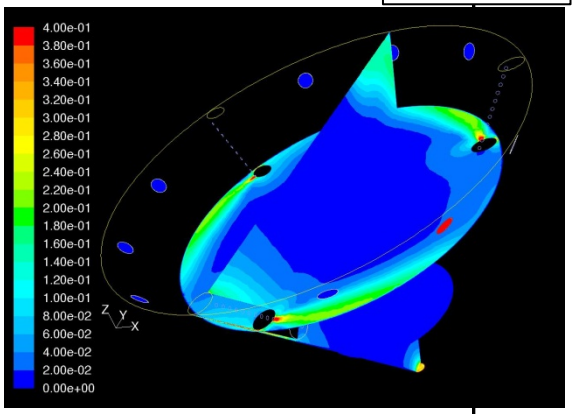
Design of simulated configuration : Conic Shape

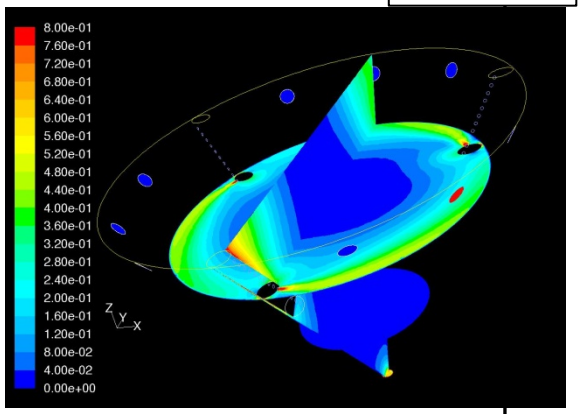
Surfaces visualization for Velocity field

5 m3/min | 20 m3/min | 40 m3/min

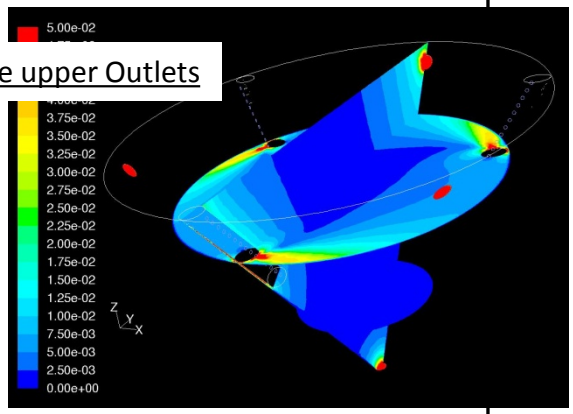
One upper Outlet

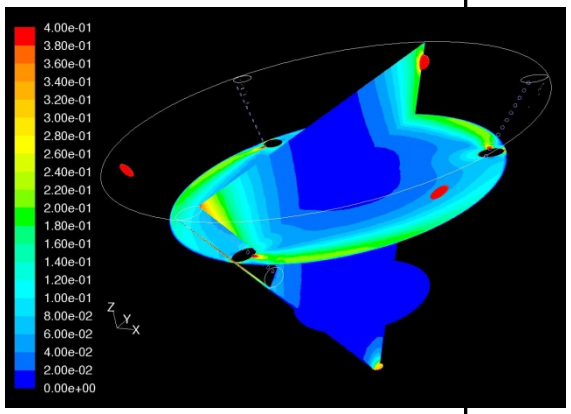


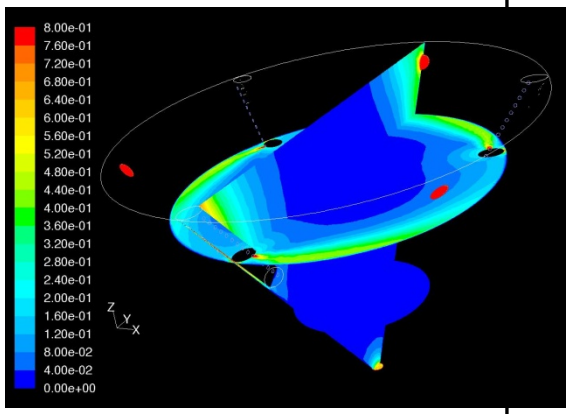




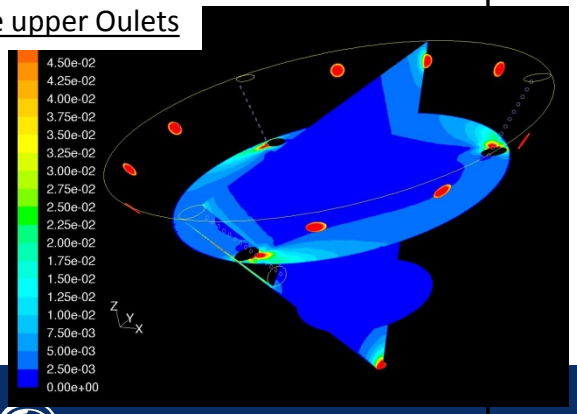
Three upper Outlets

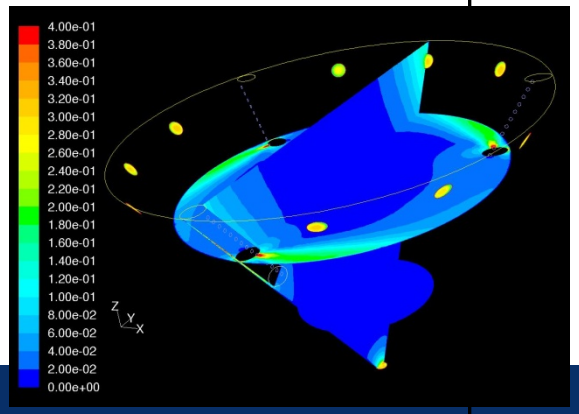


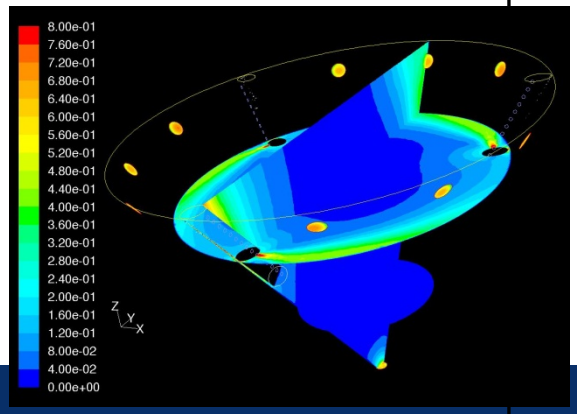




Nine upper Oulets



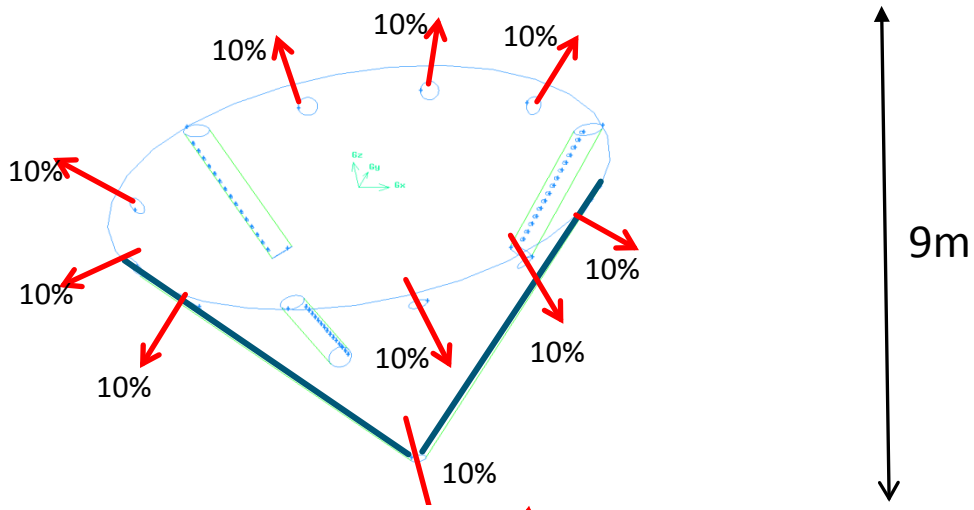




Design of simulated configuration : Conic and ellipsoid shapes

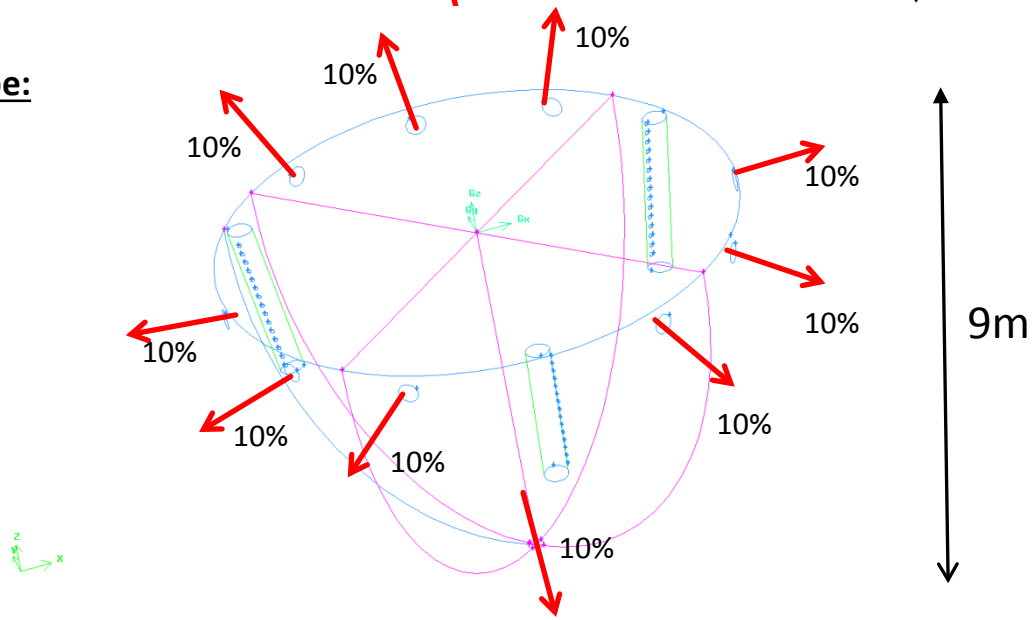
Case Conic shape :

Nine upper Oulets



Case Ellipsoid Shape:

Nine upper Oulets :



Design of simulated configuration : Conic and ellipsoid shapes

Surfaces visualization for Velocity field

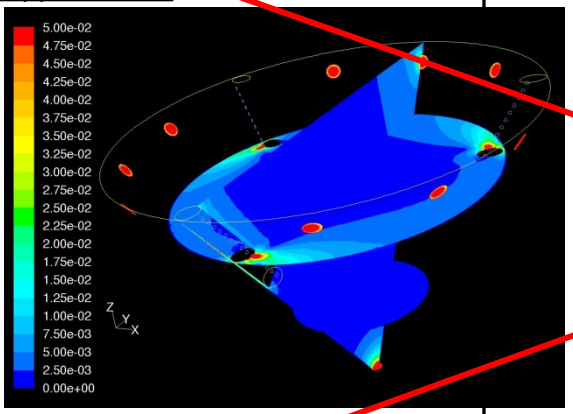
5 m3/min

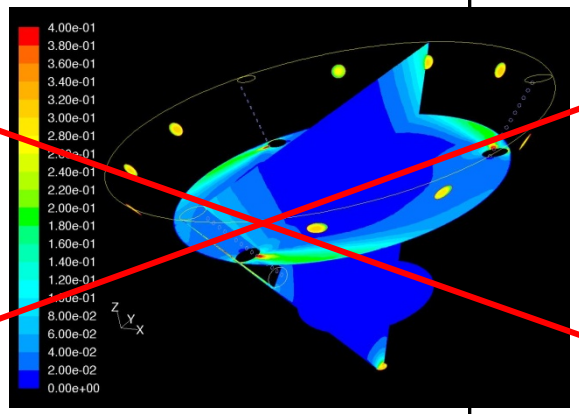
20 m3/min

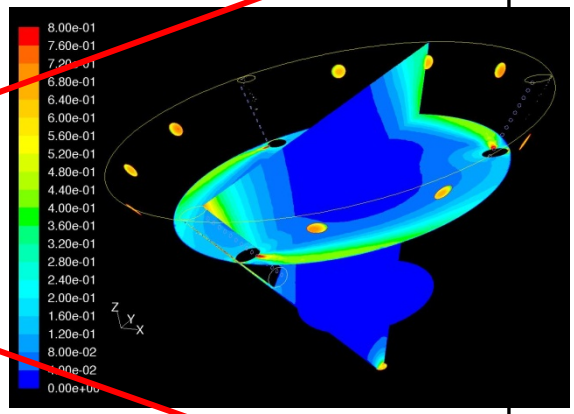
40 m3/min

Case Conic shape :

Nine upper Oulets

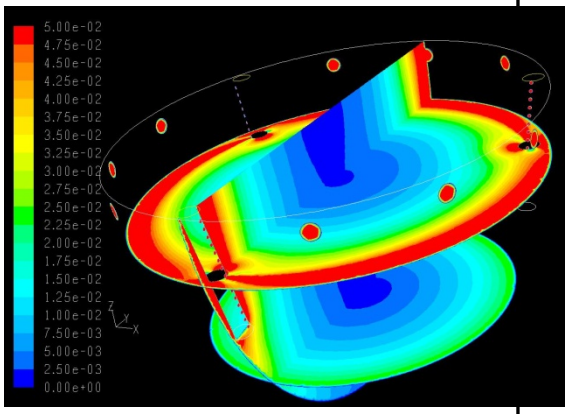


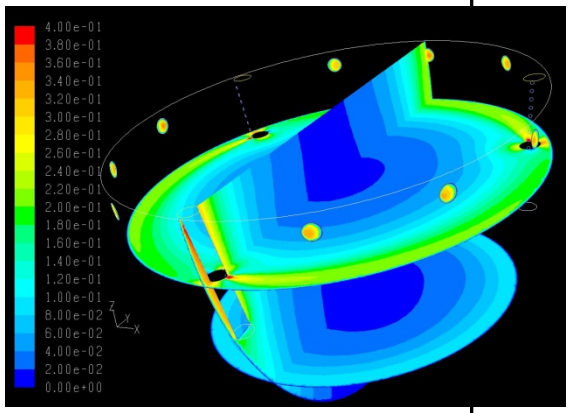


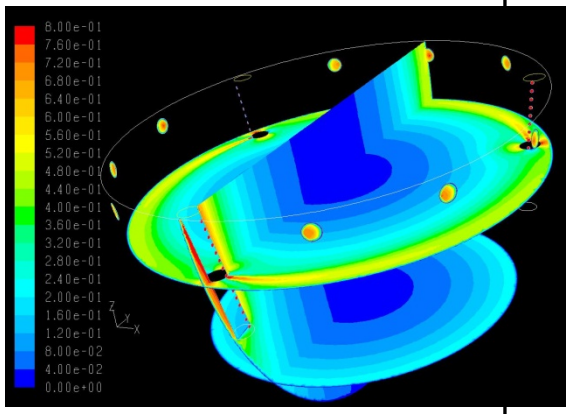


Case Ellipsoid Shape:

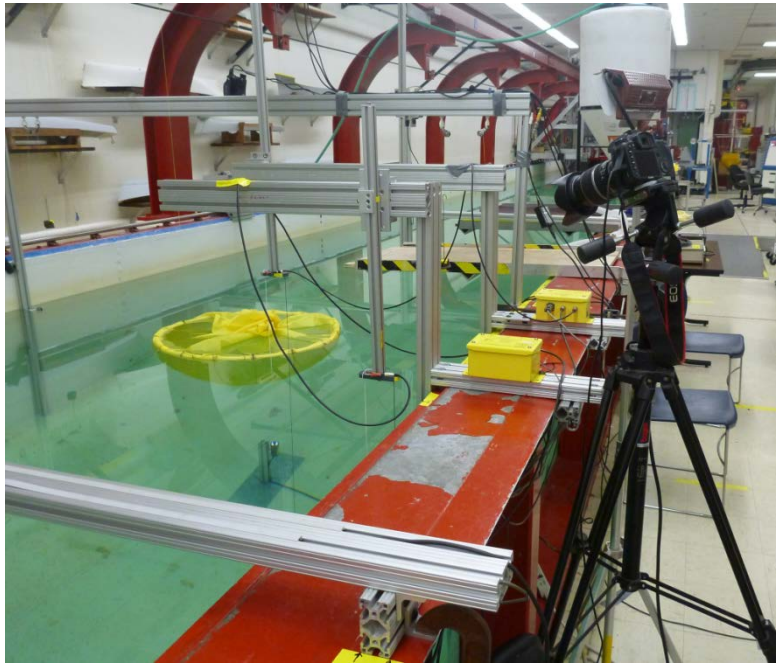
Nine upper Oulets :

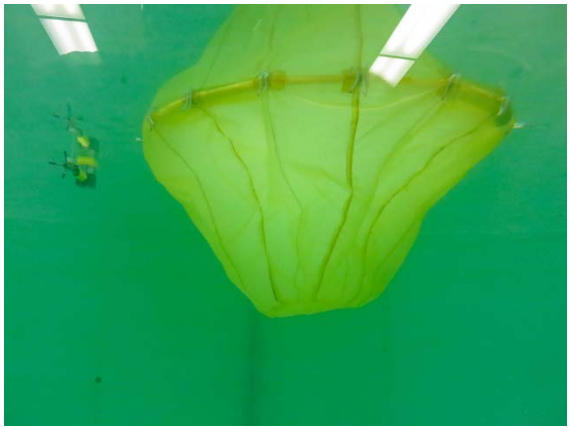


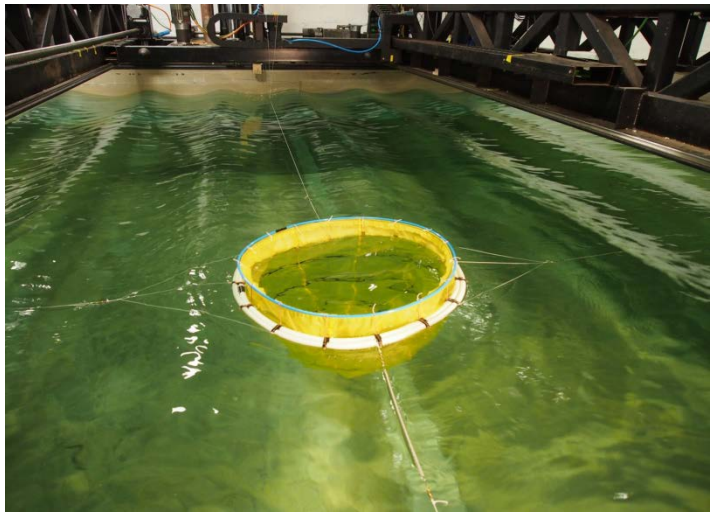




Laboratory scale design and testing

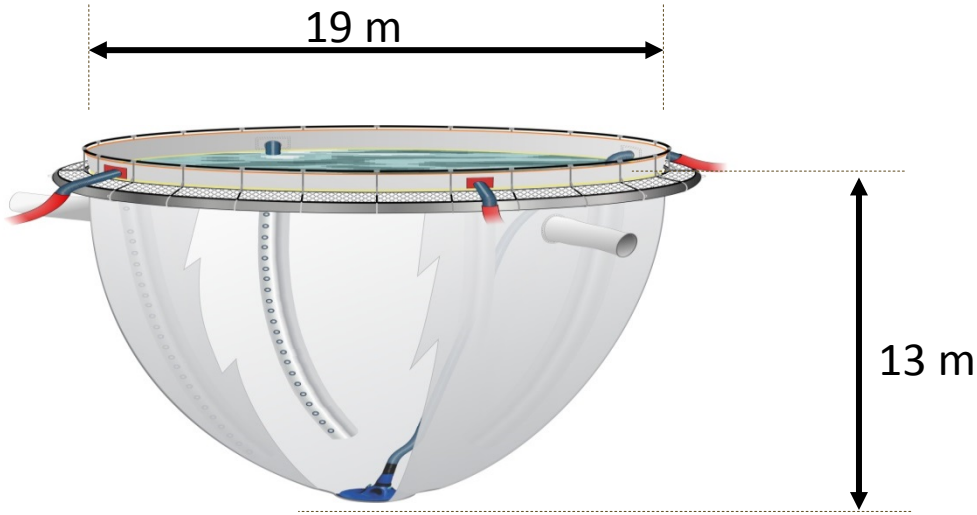




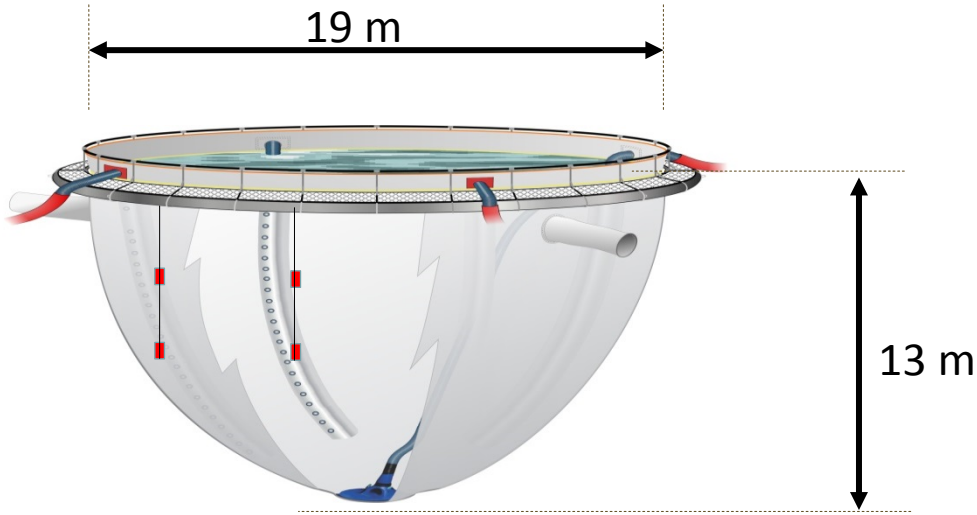


Full scale design and testing

4 Inlets pipes
4 Outlets pipes at the top + 1 outlet at the bottom
Inlets Flowrate : 9 x 4 =36 m3
Upper Outlets Flowrate : 8,3 x 4 = 33,2 m3
Bottom Outlet Flowrate : 2,8 m3



Full scale design and testing

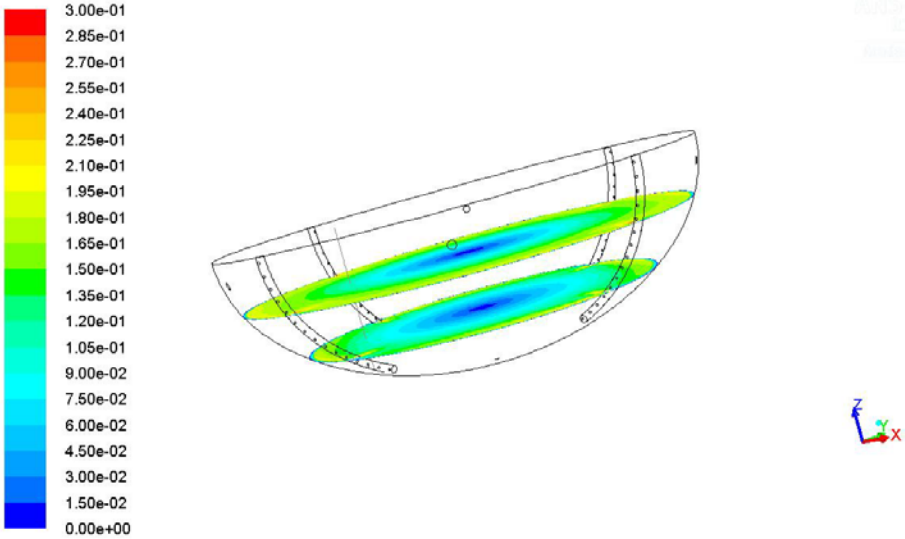


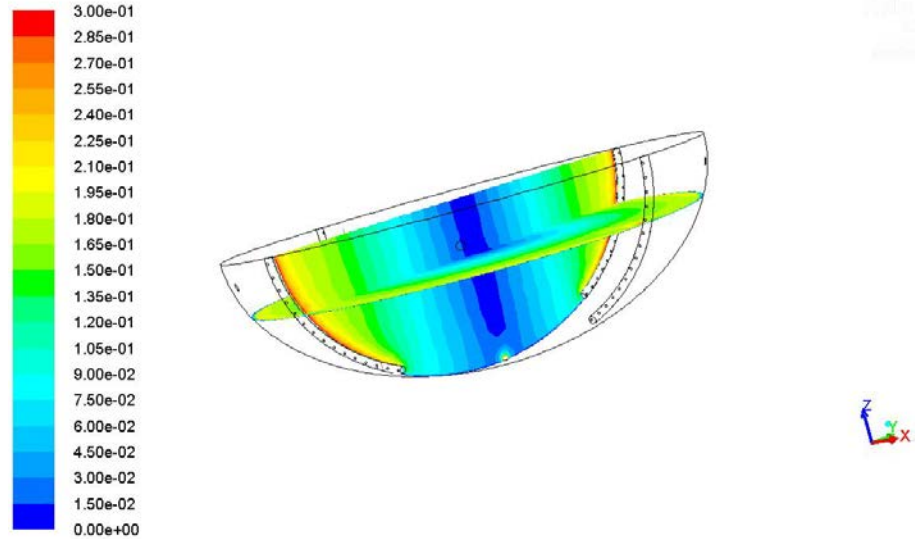
Measurement technics :

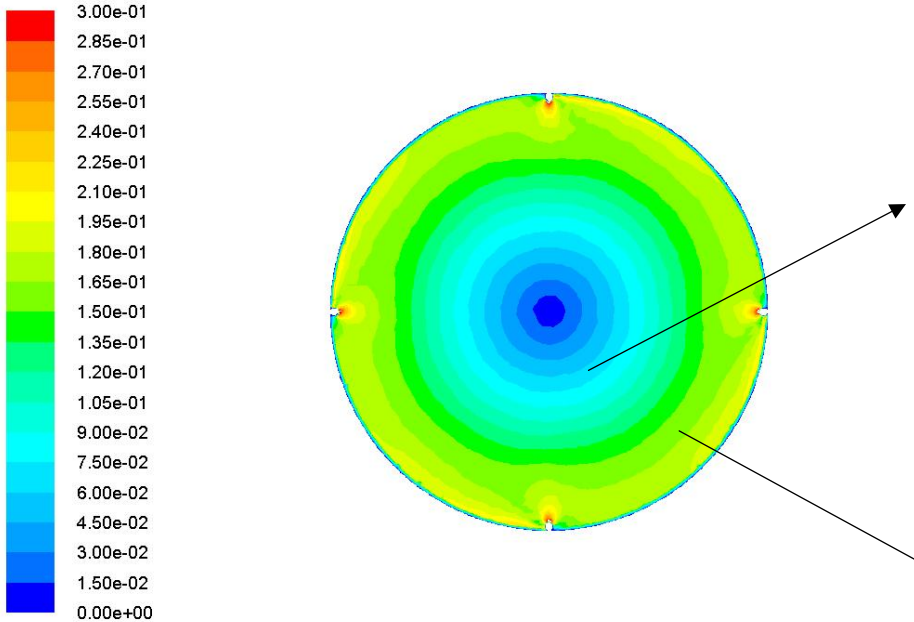
ADV : 3D Acoustic Doppler velocimetry sensors
DO sensors
T sensors

Full scale design and testing : Simulation

Surfaces visualization for Velocity field



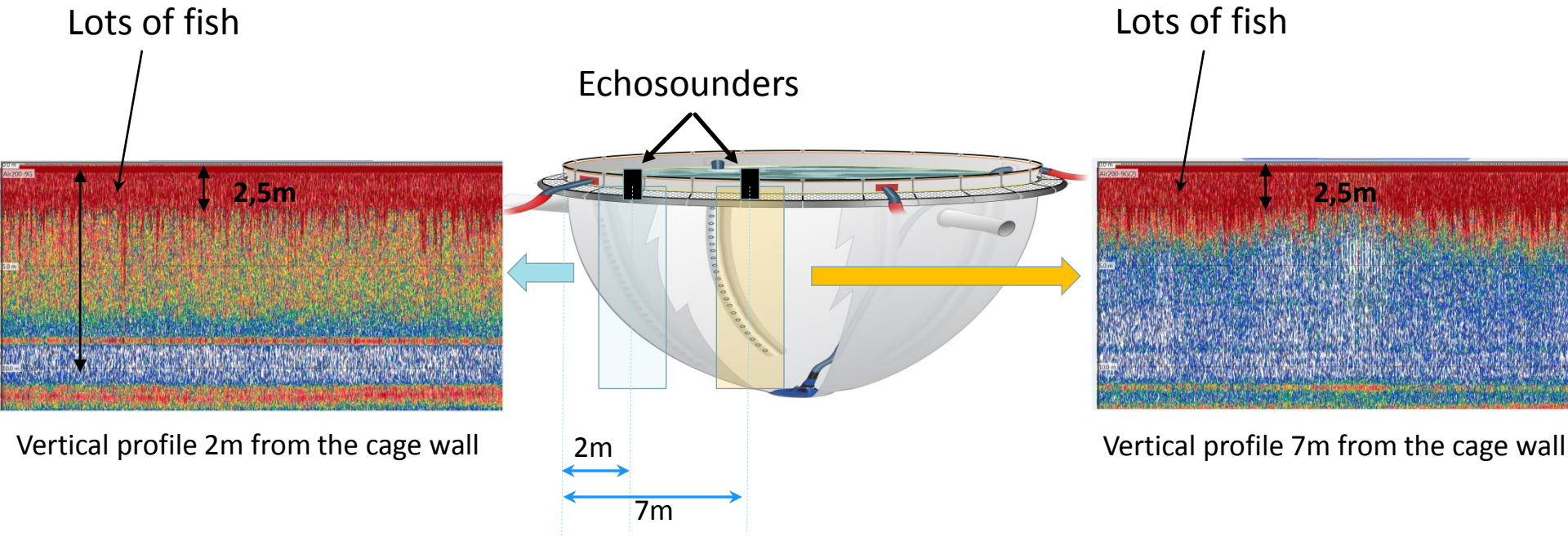




Measured : 7,5 cm/s-8 cm/s
Simulated : 7 cm/s

Measured : 17 cm/s-18 cm/s
Simulated : 16,5 cm/s

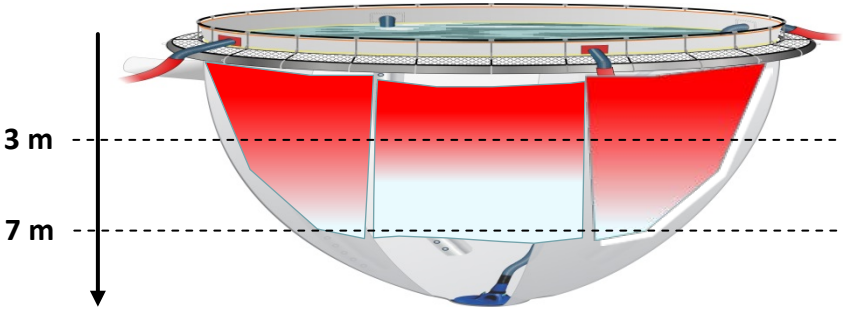
Fish population versus depth and location



Vertical profile 2m from the cage wall

Vertical profile 7m from the cage wall

Fish population with under water camera



(II.) Closed Harvesting Pen – short update

Trond W. Rosten[1)]*, Zsolt Volent[1)], Ulf Erikson[1)], Stian Aspaas[1)], [2)]Asbjørn Husby, [3)]Roger Sørgaard, [4)]Nils Almvik, [5)] Magnus Stendal

[1)]Sintef Fisheries and Aquaculture

[2)] Xylem Water Solutions

[3)] Kråkøy Slakteri

[4)] Storvik Aqua

[5)] Botngaard

Partners

SINTEF

Kråkøy Slakteri AS

xylem
Let's Solve Water

botngaard

STORVIK

aquastructures

PROSJEKTUTVIKLING
MIDT-NORGE AS

Introduction

- Project owner : Kråkøy slakteri AS , specialised salmon harvesting and packing company at the coast of Mid- Norway since mid 80'thies
- 55 employees produces 15-16 000 MT Salmon pr year
- Biggest employer in the local community
- Closed in 5 months due to Pancreas Disease in area in Mai 2013
- *Pre -Harvesting system (waiting cages)*
  - *4 open cage systems with* 2592 m^3 each
  - 1 closed containment system
  - E:\Krakoy.mp4- _join_29049.mp4

System info

- Flexible bag, volume 7 000m3, (93 % PA (polyamid) og 7 % HPPF weight 205 g/m^2)
- Rupture strength: 3000-3200 N/5cm
- Tear resistance : 250-300 N
- Permeability: 0,047 l/min/m^2 (+10 cm water pressure)
- Make up water TOTAL 60 m^3 SW /min
  - Inlet side : two propeller pumps seawater from -5meter
  - Outlet side : two propeller pumps
- Control system to avoid overfilling and sinking
- Outlet filter 200 µm, backflushes every 20 min, and backflush treated with chlorine before discharge to sea
- Disinfection outlet water : 3-3,5 log reduction (>99,9 % reduction) with UVT > 90 % with 1 cm light, RED 150 J/m^2)
- Volume divided in two with net (2x 1728 m^3), that can be used for crowding fish
- Oxygen supply from LOX tank, distributed by diffusor hoses (300 -400 kg /day)
- Electric consumption 1100 – 1200 Kwh/day
- Operational time 1 – 48h before slaughter

Test 10. Sept 2015 – Focus fish quality /welfare

Test

- Temperature 15 ^{o}C
- Fish : Atlantic salmon (4,1 ± 0,9 kg, 67 ± 5 cm og CF = 1,4). Feed restricted for 6 days before transport. Total nb (n=12 358 or 51 MT) transported 3h in closed containment wellboat (2* 450 m^3 hauls) at fish density 56 kg/m^3.
- 50 % unloaded to open cage (volume 2592 m^3 , fish density 9,8 kg/m^3)
- 50 % unloaded to closed cage (volum 1728 m^3, fish density 14,7 kg/m^3)
- Compared fish before pumping to stunner
- Fish samplet one by one and killed by blow to the head with in 10s followed by bloodtest, core temperature, initial muscle PH, contraction measurements
- Stored on ice for evaluation of rigor mortis and filet flesh quality

Samples

- Rigor mortis (1 no – 5 very strong)
- White muscle pH and muscle contraction (9 V DC i 1-2 sek with Twitch Tester Quality Assessment Tool, AQUI-S Ltd, New Zealand)
- DO, CO_2, pH og temperature
- Water samples – Total bacteria count + Vibrio, water chemistry-,
- Total ammonium (TAN), total organic karbon (TOC), color og turbidity
- Blood; pH (WTW SenTix 41 elektrode), glucose (Ascensia Contour meter), lactate (Lactate Scout+ meter).
- epoc® Blood Analysis System :
  - pH, glukose, laktat, pCO_2, natrium (Na^+), kalium (K^+), kalsium (Ca^{2+}) og hematocrite using. (Epocal Inc., Ottawa, Canada)
- Cortisol (RIA)
- Plasma Chloride (titration)

Water Quality

OPEN

DO (% SAT)	: 96
pH	: 8,21
TAN (µg/l)	: 4,2
NH3 (µg/l)	: 0,2
TOC (mg/l)	: 17,7
Colour (mg Pt/l)	: < 2
Turbiditet (FNU)	: 0,22
CO2 (mg/l)	: na

CLOSED

DO (% SAT)	: 104
pH	: 8,17
TAN (µg/l)	: 19
NH3 (µg/l)	: 0,7
TOC (mg/l)	: 16,7
Colour (mg Pt/l)	: 2
Turbiditet (FNU)	: 0,12
CO2 (mg/l)	: 1,2

Bacteria

OPEN

TBC (cfu*10^3 /l) : 65

Vibrio (cfu *10^3 /l) : 40

CLOSED

TBC (cfu*10^3 /l) : 92

Vibrio (cfu *10^3 /l) : 85

Blood – stress indicators

OPEN	
pH	: 7,44 ± 0,02
Glucose (mmol/l)	: 3,7 ± 0,2
Lactate (mmol/l)	: 3,7 ± 0,6
Cortisol (nmol/l)	: 479 ± 53
pCO2 (mmHg)	: 0,99 ± 0,05
Cl^-(mmol/l)	: 143,7 ± 2,1
Na^+	: 167 ± 2,0

CLOSED	
pH	: 7,43 ± 0,02
Glucose (mmol/l)	: 4,0 ± 0,2
Lactate (mmol/l)	: 3,5 ± 1,3
Cortisol (nmol/l)	: 543 ± 118
pCO2 (mmHg)	: 1,05 ± 0,05
Cl^- (mmol/l)	: 142,4 ± 1,6
Na^+	: 168 ± 1,0

Fish Quality (Time to start rigor mortis (h))

OPEN	*CLOSED*
6 -7,5	3,5 -5,0

Fish Filets Quality (colour, firmness, gaping)

OPEN		***CLOSED***	
Normal (%)	: 83	Normal (%)	: 87
Compromised (%)	: 17	Compromised (%)	: 13

Conclusion

- A closed containment flexible bag system for harvesting salmon is developed and operating pt.
- Have been tested with more than 4000 MT Atlantic salmon this autumn with good results
- Good water quality obtained by using makeup water and oxygen supply as main instruments for controlling CO2 and Ammonia
- Results indicate
  - No difference in fish stress level between OPEN and CC harvesting pen
  - No difference in fish quality between OPEN and CC harvesting pen
- Still to be tested
  - Maximum load
  - UV efficiency
  - Optimal and safest operation under all weather conditions
- A Proxy for floating flexible bag closed containment post-smolt system?

Thank you for your attention