

Fishfarmingexpert

A peek into the future?

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Passing the screen test



The Smoltscreen enclosure and the control pen to the right. All photos: Salar Pursuits

A trial in Ireland has demonstrated that a fine-mesh bag installed inside a salmon pen can exclude lice and micro jellyfish but let water pass through

Scottish R&D company Salar Pursuits is seeking a farming partner for commercial trials of its porous semi-closed containment system following a successful proof-of-concept trial.

The company is run by co-founders Andrew and Colette Bett. Andrew drew on decades of experience in the paper packaging industry, which included fibre-based filtration media, and knowledge of copepods gained from degree-level zoology studies, to develop the system, called the Smoltscreen™.

As someone used to filtering items far smaller than a louse nauplius, the solution to salmon farming's lice problem seemed obvious and affordable to Andrew Bett: a retrofit, porous enclosure made from a material he knew was commercially available.

Following tests on a laboratory-scale enclosure by the University of Stirling, Salar Pursuits took the next step to commercialisation with an in-sea trial in Ireland of a small Smoltscreen™ pen containing smolts.

Here, Andrew Bett explains in detail how the trial was conducted and what has been learned from the results.

On 6 March 2023 Salar Pursuits completed a proof-of-concept trial on its patented porous semi-closed contained salmon aquaculture system, trademark Smoltscreen™ with the Marine Institute of Ireland (MI) at its trial aquaculture site in Cashel Bay, Galway. The trial ran from 15 November 2022 to 6 March 2023 in a sentinel pen, incorporating the retrofitted fine mesh (150-micron nylon woven) enclosure with a volume of 49

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cubic metres, alongside a sentinel control pen with standard 18 mm knotless nylon netting with a volume of 64m³.

On 15 November last year, 400 organic salmon smolts were stocked into the SmoltScreen and 400 into the control pen at an average weight of 72 grams. At the fourth and final MI fish sampling on 23 February 2023 the average weight of the SmoltScreen smolts was 149g (60-290g).

At the fourth and final MI fish sampling on 23 February 2023 the average weight of the SmoltScreen smolts was 149g (60-290g) and the average for the control pen was 151g (59-310g). In the 3.5-month trial, three smolts died in the control pen and there were no mortalities in the SmoltScreen pen. At the final MI fish sampling on 23 February the total weight of stock was estimated at 59.6 kg, based on the average sampled weight of 149g/smolt, giving a stock density of 1.22 kg/m³. At the same time, the stock in the control pen was 59.8 kg with a density of 1.07 kg/m³.

The SmoltScreen was supplied with oxygenating water from a stainless-steel submersible pump suspended 10 metres beneath the feed barge. The water was filtered through a 150-micron titanium basket strainer and delivered to the SmoltScreen through a 4" (10cm) pipe. The flow rate averaged 112 litres per minute, providing circa 1.5-2 litres/minute/kg of stocked fish, maintaining dissolved oxygen (DO) of between 71-88% during the period to 6 December. The incoming flow of water into the enclosure was flowing out through the nylon mesh enclosure, and the pressure equilibrium inside and outside the enclosure was well maintained.

The SmoltScreen was cleaned weekly with a hand controlled two-disc power washer. This worked perfectly from 15 November until 6 December, when problems with blocking nozzles began to occur and the cleaning of the mesh enclosure became less thorough. It was decided to suspend a second stainless steel submersible pump into the centre of the SmoltScreen to maintain the water exchange, with DO not below 70%, until new nozzles could be shipped to Cashel to repair the cleaner. With a water exchange of between 112 and 120 litres per minute maintaining

Date: 6 April 2023

Site: Lehanagh pool

Case background: SmoltScreen trialled on Lehanagh pool site, one control pen available

SmoltScreen™ porous semi-close contained system, developed and patented by Salar Pursuits Ltd., was trialled at Lehanagh Pool site (Marine Institute) for 3.5 months, from early November 2022 to late February 2023. Body weights, lengths, gill scores and sea lice counts were regularly assessed by the Marine Institute staff members for the duration of the trial. PHARMAQ Analytiq examined both the SmoltScreen™ and control cage on the 28th of February to obtain information on:

- Operational Welfare Indicator scores (including body condition, gill scores -AGD and total-, skin, eyes, fins, head/snout) and sea lice counts: ~20 fish/group
- Gill tissue: 6 fish/group
- Gill mucus swabs: 6 fish/group

For maximum effect, these results should be considered together with data collected by other parties.

Fish health and welfare assessment

Operational Welfare Indicators

Operational Welfare Indicators were scored according to the following description:

OWI	Score 0	Score 1	Score 2
Body condition	Fish in good condition	Thin condition	Emaciated condition
AGD	No AGD lesions	Minor AGD lesions	Severe AGD lesions
TGS	No other gill lesions	Mild or isolated gill lesions	Severe or multifocal gill lesions
Skin	No skin lesions present	Minor skin lesions	Severe skin lesions
Eyes	No damage, cataracts or exophthalmia	Damage, cataracts or exophthalmia affecting one eye	Damage, cataracts or exophthalmia affecting both eyes
Fins (dorsal, caudal and pectoral fins)	No fin splitting, erosion or damage	Minor splitting, erosion or damage	Severe splitting, erosion or damage
Head/snout	No lesions	Mild erosion	Severe erosion

Table 1. Score description for Operational Welfare Indicators used.

Gill histology scoring

The second gill arch of 6 fish/group (Control vs. SmoltScreen) was collected and preserved in 10% neutral buffered formalin for histology scoring. Slides were scored using a histopathological scoring system, described by Mitchell et al., 2012 (Appendix 4), to obtain a semi-quantitative measure of gill pathology. The index criteria used for gill histopathology were lamellar hyperplasia, lamellar fusion and cellular anomalies (including necrosis or sloughing); a score from 0 to 3 (0: None, not significant or very minor, 1: Mild, 2: Moderate, 3: Severe) was assigned to each parameter. Ancillary criteria such as vascular disturbance (thrombi, telangiectasis, congestion) was scored for absence/presence (0/1) if more than 10% of the tissue was affected.

Gill mucus swabs were also collected from 6 fish/group. They are stored in RNAlater and frozen for pathogen screening if needed.

Sea lice



The first sampling of the smolts in the Smoltscreen and control pens.



A hand controlled two-disc power washer was used to clean the Smoltscreen weekly.



A smolt taken from the Smoltscreen pen during final sampling in February.

the pressure difference and the DO at between 77-89% thereafter, the flow conditions remained optimised until the cleaner could be finally repaired on 20 February, and the water flow was fully restored through the mesh.

During the period of compromised flow through the mesh, the problem of a small number of precocious males occurred and appeared in the MI fish sampling of 23 February. Dr Carolina Gutierrez of PHARMAQ Analytiq Ireland, advised what might have been responsible in this respect:

“As you mentioned, sexual maturation is a complex issue as many different factors can play part, being the most common ones - water temperature (especially, fluctuations) and photoperiod.

“So, yes, it is possible that such fluctuation (in water flow) for 3 months could have triggered early maturation. Also, if the exchange rates were low on that system, there may be potential accumulation of different metabolites that could also trigger early maturation in combination with water temperatures (and could also



A sample of Smoltscreen material is examined by Salar Pursuits co-founder Andrew Bett, left, and Plany chief executive Kjell-Age Saure.

explain why the fish were swimming deeper in that system).”

An important learning from this incident was that the SmoltScreen operated well when it was cleaned weekly and this is the benchmark for maintaining optimum conditions for the salmon, using the latest trackless power washing net cleaners, such as the range offered by AKVA Scotland.

On 28 February, PHARMAQ Analytiq Ireland sampled 26 smolts from the control pen and 23 smolts from the SmoltScreen for fish health and welfare examination and to conduct 12 gill histology tests, 6 from the control and 6 from the SmoltScreen, with the results in the following report:

The proof-of-concept trial with the Marine Institute of Ireland was to prove that a volume of sea water could be maintained over a period with the appropriate level of oxygen content for the optimum health of the salmon and with the 100% exclusion of sea lice and micro jellyfish. Salar Pursuits was offered the availability of a sentinel pen at the Marine Institute during a known period of low challenge in respect of sea lice and also of other zooplankton and micro jellyfish – from November to February. However, as long as there was even a small challenge, and smolts were found with sea lice in the control pen (as occurred on four occasions) and none were found in the SmoltScreen, it would prove that sea lice nauplius larvae cannot enter through a 150-micron nylon woven mesh. During the period when juvenile sea lice *Caligus elongatus* were found on smolts in the control pen (and on 16 January, one incident of *Lepeophtheirus salmonis* juvenile lice found on sampled smolts from the 50 metre open net pen in which the two sentinel pens were deployed), 117 smolts sampled from the SmoltScreen were checked for sea lice on four occasions, and no sea lice were found. Although it was also a low period of jellyfish challenge in Cashel Bay, the gill histology conducted by PHARMAQ Analytiq Ireland did find one micro jellyfish in the gills of one smolt from the control pen, and once again not in the SmoltScreen. Micro jellyfish are no smaller than 300 microns and therefore a 150-micron nylon mesh would be

Results

Average scores per group (mean and range)

Operational Welfare Indicators

Fish were in good overall external condition and no indications of systemic diseases of concern were seen in either group. AGD like pathology was present in both groups, presence of amoeba was confirmed on wet mounts. Precocious males were present in the SmoltScreen sample. Mild fin splitting was present in both groups. See Appendix 1 for more details. Average scores of Operational Welfare Indicators and sea lice counts per group, presented as mean (range), were as follows:

	Body Condition	AGD	TGS	Skin	Eyes	Fins	Head/snout	Sea lice counts
Control	0.04 (0-1)	0.08 (0-1)	0.26 (0-1)	0.04 (0-1)	0 (0)	0.26 (0-1)	0 (0)	0.04
SmoltScreen	0.21 (0-1)	0.04 (0-1)	0.29 (0-1)	0 (0)	0 (0)	0.33 (0-1)	0.04 (0-1)	0

Gill histopathology scoring

Gills were in good overall condition. See Appendix 2 for detailed findings. Average scores for gill histology lesions and total, presented as mean (range), were as follows:

	Lamellar hyperplasia	Lamellar fusion	Cellular anomalies	Vascular disturbances	Total gill score
Control	1.00	0	0.67	0	1.67
SmoltScreen	0.83	0	0.67	0	1.5

Interpretation of findings

Salmon smolts from both groups were overall in very good condition and no significant mortalities or indications of disease were reported by site staff. Behavioural differences were evident, it was more difficult to catch fish from the SmoltScreen cage than from the control cage, as they were schooling deeper. Impact on random sampling procedure is uncertain.

Minor gill pathology, described as minor lamellar hyperplasia and mild focal sloughing, was observed in fish from both groups. These are non-specific changes commonly seen following waterborne irritation for example, but prevalence and severity is in the expected range for fish reared in sea water cages.

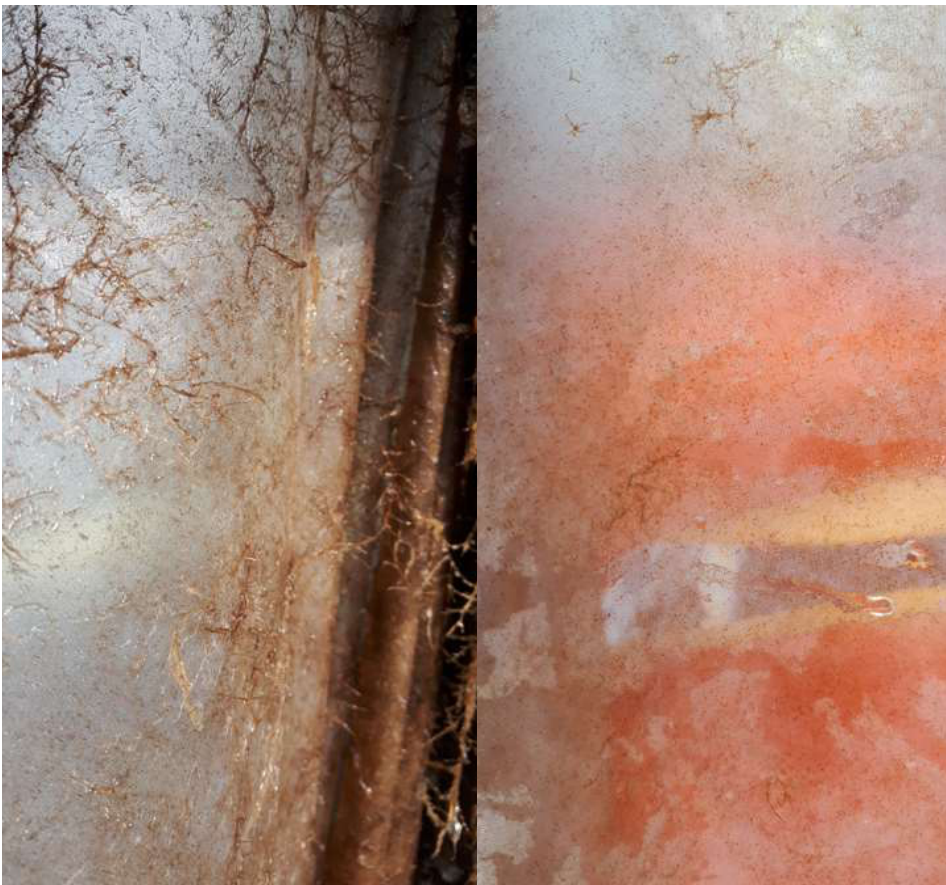
Operational welfare indicators and histopathology scoring indicate minor differences between fish held in the SmoltScreen system and the control system, but the extent of these is not considered significant and they do not demonstrate significant variation between the systems.

Presence of zooplankton in one control fish on gill histopathology, but not in trialled fish, may indicate a difference in water quality within the system, but a suitable water sampling protocol and results would be needed to confirm. There was a very low sea lice challenge during the trial in the site, complicating

Sea lice



A waste collector designed and supplied by Clew Bay Engineering, Ireland.



A 1.8 x 10 metre panel of Smoltscreen 150-micron nylon mesh used in a fouling test, shown being put into the water (top left); after two weeks (top right); after nine weeks (bottom left); and after being cleaned with a power washer (bottom right).

expected to protect salmon from micro jellyfish infestations.

The next step, as recommended by Dr Carolina Gutierrez in her PHARMAQ Analytiq Ireland report, will be to conduct a commercial trial in a 50, 80 or 120-metre pen, with all elements - pumps (high efficiency variable control 35-100k l/min column pumps), filters and waste removal - scaled up to meet water quality requirements for commercial stocking density.

After successful prototype trials with Stirling University's Marine Environment Research Laboratories at Machrihanish in October 2020, Salar Pursuits approached Plany AS, Gursken, Norway to conduct a proof of manufacture trial in June 2022.

Plany AS proved that an enclosure of any size or shape could be sewn together from panels of 150-micron nylon mesh, with polyester webbing joins. In November 2022, Salar Pursuits signed an exclusive patent-licensed manufacturing agreement with Plany AS. As agent for Plany AS in Scotland and in

Ireland, Morenot is providing technical advice to Salar Pursuits in areas relating to salmon farming. John Age Ronning of AquaSolutions AS is acting as agent for Salar Pursuits for all potential customers in Norway.

In respect of pumps, Salar Pursuits is working with Polypump, the UK distributor for Xylem, and in respect of basket strainers, Salar is working with IPS Flow Systems, the UK distributor for Hayward.

Concerning the collection of fish waste/bio-resource for biofuel and fertiliser, Salar is working with I&C Processing and Blue Ocean Technology AS. The waste collector to collect fish waste from the base of the Smoltscreen was designed and supplied by John Moran, Clew Bay Engineering, Newport, Ireland.

Before the Marine Institute of Ireland would consider allowing Salar Pursuits to conduct a proof-of-concept trial in Cashel Bay, Connemara, it was necessary to run a fouling test on a 1.8 x 10 m panel of Smoltscreen 150-micron nylon mesh. This, weighted at the base, was deployed into a stocked pen at Cashel Bay in mid-March 22.

Two weeks later the panel was lifted out of the water and photographed – showing almost no growth of algae on the mesh.

Seven weeks later, on 23 May the panel was lifted out and photographed, showing the growth of fine filamentous algae, but no mussel spat or heavy fouling.

Finally, the mesh was lifted out and power-washed in mid-July – demonstrating that



The Smoltscreen trial enclosure photographed at the Plany factory.

the assessment of SmoltScreen efficacy. Lice score was higher in the control group, but lice burden was considered too small for this to be significant. Repeating the trial in a period with higher lice challenge, or a sampling protocol designed to demonstrate variation at very low lice prevalence would be necessary to confirm results.

AGD (Neoparamoeba perurans infection) was present, but generally appeared low in the trial period, complicating the comparison. Processing of gill swabs for putative pathogens of concern can be considered to further assess effects of the system on gill health. Trials at higher risk periods would experience a higher level of challenge and would help prove system efficacy. Gill swabs could be considered for comparing amoeba burden in addition to gill scores.

Results cannot demonstrate efficacy of the system in disease prevention but indicate that the SmoltScreen system was suitable for maintaining salmon health and welfare in the set up trialled.

Dr. Carolina Gutierrez Rabadan

Gill histology scoring (raw data)

SMOLTSCREEN PROJECT								
Fish ID	Group	GILL HISTOLOGY SCORING					Total Score	Comments
		Lamellar hyperplasia	Lamellar fusion	Cellular anomalies	Vascular disturbances			
1	Control	1	0	1	0	2	None	
2	Control	1	0	1	0	2	Both mild focal hyperplasia and sloughing	
3	Control	1	0	1	0	2	Small jellyfish on slide and mild hyperplasia	
4	Control	1	0	0	0	1	Mild hyperplasia	
5	Control	1	0	0	0	1		
6	Control	1	0	1	0	2		
7	SmoltScreen	0	0	0	0	0	Very good gills	
8	SmoltScreen	1	0	1	0	2	Mild focal sloughing and hyperplasia	
9	SmoltScreen	1	0	1	0	2		
10	SmoltScreen	1	0	0	0	1		
11	SmoltScreen	1	0	1	0	2	Mild focal sloughing and hyperplasia	
12	SmoltScreen	1	0	1	0	2	Mild focal sloughing and hyperplasia	



Image 1. Zooplankton observed in one of the control fish.

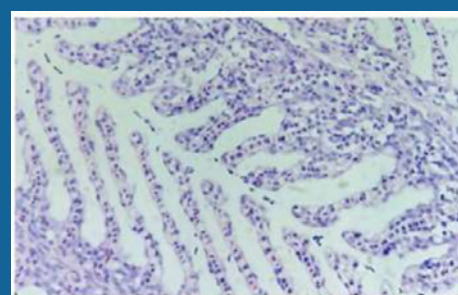


Image 2. Lamellar hyperplasia (Control fish).

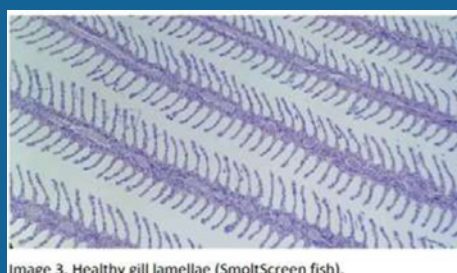


Image 3. Healthy gill lamellae (SmoltScreen fish).

References

Mitchell, S.O., Baxter, E.J., Holland, C. and Rodger, H.D., 2012. Development of a novel histopathological gill scoring protocol for assessment of gill health during a longitudinal study in marinefarmed Atlantic salmon (*Salmo salar*). *Aquaculture International*, 20, pp.813-825.

although now covered by filamentous algal growth, the algae could be easily cleaned off with a standard power washer.

The Marine Institute declared that the material was 'performing well', and the proof-of-concept Smoltscreen trial was allowed to be conducted in a sentinel pen on the Cashel Bay farm from 22 November.

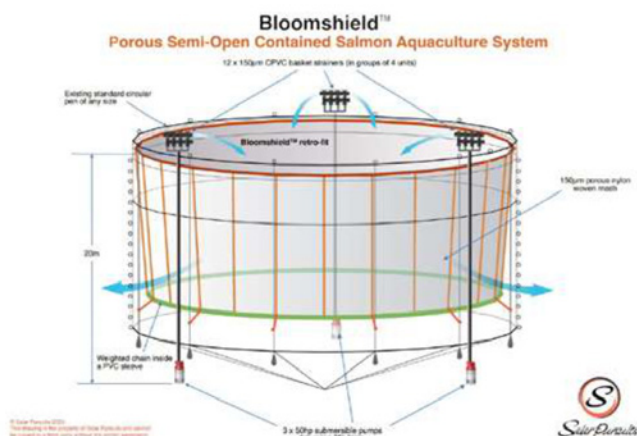
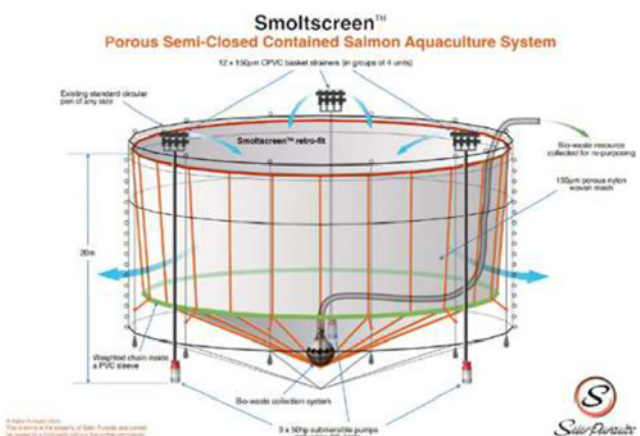
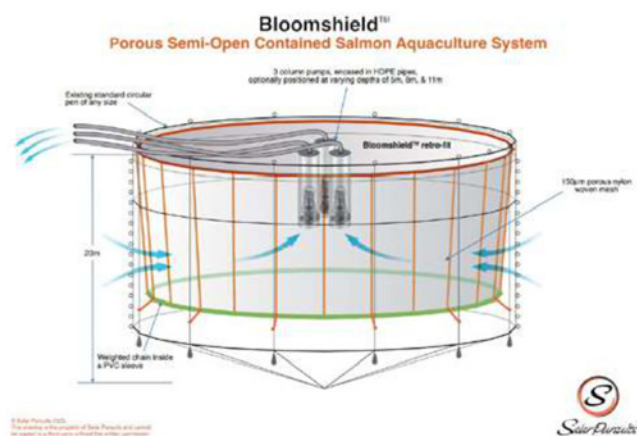
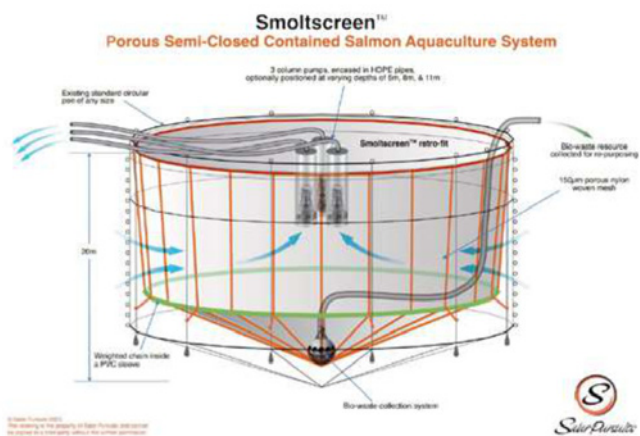
The Smoltscreen was accordingly designed by Salar Pursuits and manufactured to a very high standard by Plany AS, with all polyester joins double sewn. The 150-micron nylon mesh, supplied by Decotex Inc., US, is under a 10% production tolerance of all parameters, including pore size, and this was also undergoing a proof-of-manufacture challenge in the trial.

The Hayward basket strainer was supplied by IPS UK, with a perfectly constructed 150-micron fine titanium mesh and

designed for a maximum flow of 250 litres/minute.

Polypump UK supplied the submersible stainless-steel pumps, designed for up to 240 litres/minute, controlled by a ball valve before the basket strainer. One submersible pump was suspended 10 metres below the feed barge (to reduce the intake of algae) and the second was suspended inside the Smoltscreen enclosure. The pumps worked faultlessly, non-stop 24/7 for 15 weeks, powered by a hybrid battery, solar power, and diesel generator source on the barge.

Salar Pursuits believes that fine mesh enclosures and curtains with optional combinations of column pumps or submersible pumps with basket strainers are potential climate resilient solutions for cost efficient and sustainable salmon and sea trout aquaculture. Salar Pursuits is now offering its patented Smoltscreen™



Designs for Salar Pursuits' Smoltscreen and Bloomshield retrofit semi-closed systems offering the option of pumps suspended beneath the pen or within the pen.



The equipment used in the trial prior to it being taken to Ireland.

porous semi-closed contained, and patented Bloomshield™ semi-open contained systems for commercial trials.

Salar Pursuits wishes to thank the Marine Institute of Ireland and Clear Seas Aqua (Ireland) Ltd for managing a successful proof-of-concept trial in Cashel Bay. Salar Pursuits also thanks Marine Scotland for 50% funding of the trial through Marine Fund Scotland.

Find out more about the Smoltscreen at www.salarpursuits.co.uk. Enquiries about the Smoltscreen or Bloomshield enclosures may also be made directly with Plany AS on stand A-110 at Aqua Nor.



One of the two pumps used in the trial. Both worked perfectly.

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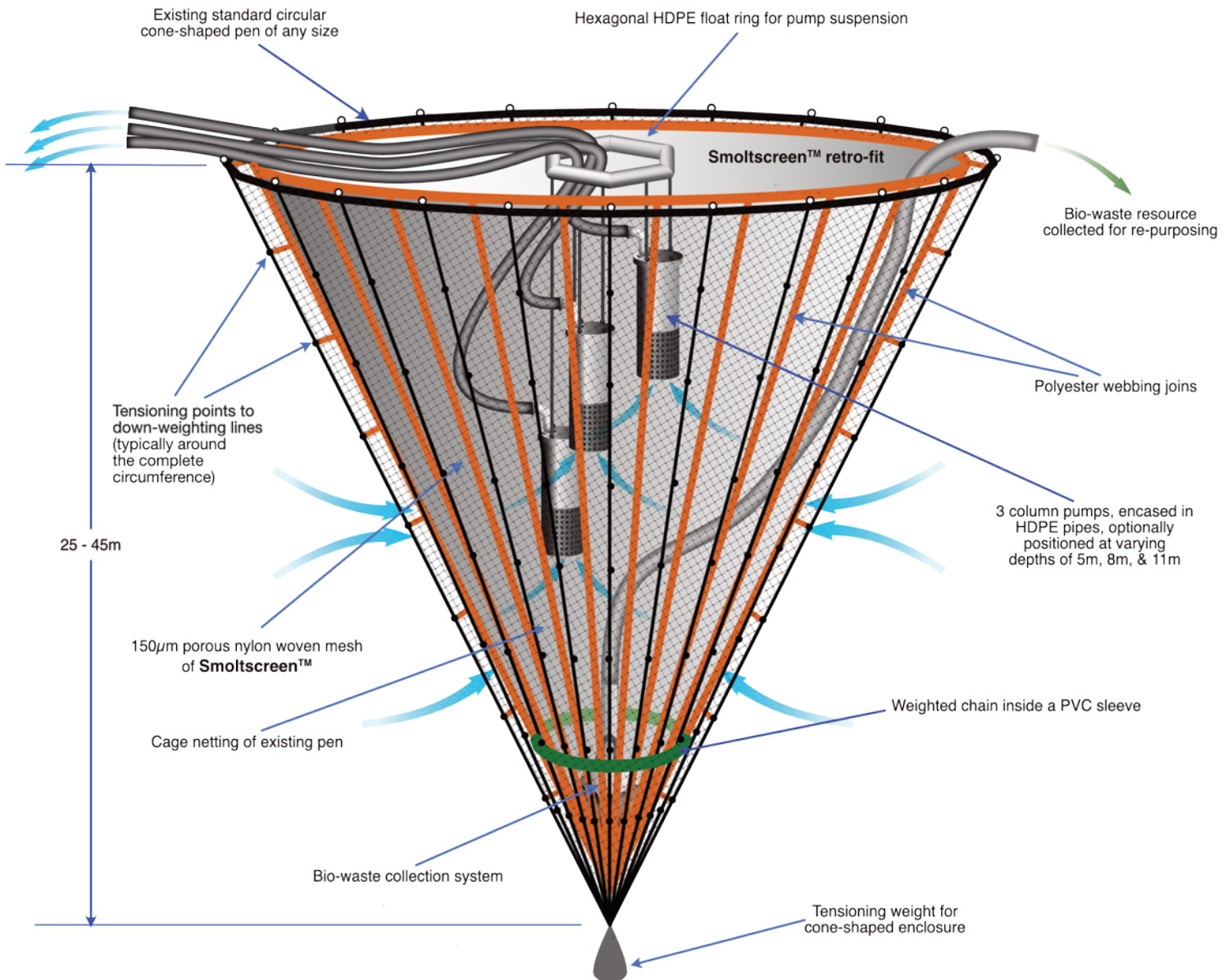
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Smoltscreen™

Porous Semi-Open Salmon Aquaculture System

Cone shaped enclosure 70 - 160 Meter





Smoltscreen™ salmon farming will be lice-free, stress-free and natural.

- Lice treatment eliminated.
- Cleaner-fish avoided.
- Co2 emissions reduced.
- Fish handling reduced.
- Fish health & welfare increased.
- Growth rates increased
- Projected to reduce production costs by €20 cents/kg.



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