

Oppsummering av Ctrl[^]AQUA[^] SFI

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Mål for CtrlAQUA SFI

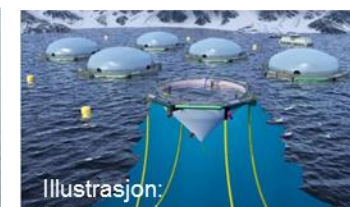
CtrlAQUA skal utvikle teknologiske og biologiske innovasjoner som vil gjøre lukkede anlegg til en pålitelig og økonomisk levedyktig teknologi.

Hovedfokus er innovasjoner for de strategiske periodene i laksens produksjonssyklus, slik som postsmoltfasen

RAS on land



S-CCS in sea



21 CtrlAQUA SFI partners!

Host institution:

- Nofima



R&D-partners:

- Norce
- University of Bergen
- Norwegian University of Science and Technology
- The Freshwater Institute, WV, U.S.
- University of Gothenburg, Sverige
- University of South-East Norway



User partners:

Suppliers of Technology:

- Pure Salmon Kaldnes
- Create View
- Aquafarm Equipment
- FishGLOBE
- Fiizk
- Atlantium



Farmers:

- Mowi
- Cermaq
- Grieg SeaFood
- Lerøy SeaFood Group
- Bremnes Seashore
- Nekton



Biotechnology companies:

- Pharmaq
- Pharmaq Analytiq



- Delvis finansiert av NFR)
- 8 år (2015 – 2023)



CtrlAQUA skulle bidra med kunnskap for å.....

Sikre at postsmolt blir robust og får god helse og velferd

- Vannkvalitet (H_2S , VK parametere, hastighet....)
- Hindre kjønnsmodning
- God karhydraulik
- Dokumentere velferd i SCCS

Forebygge fiskehelse

- Barriærefunksjoner
- Hindre nefrokalsinose
- SCCS og fare for smitte
- Biosikkerhet (desinfisering, behandling av inntaksvann)

Videreutvikle teknologi og sikre miljø

- Optimale teknologiske løsninger
- Teknologi på fisken sine premisser
- Vannbehandling
- Biofilter
- Energioptimalisering

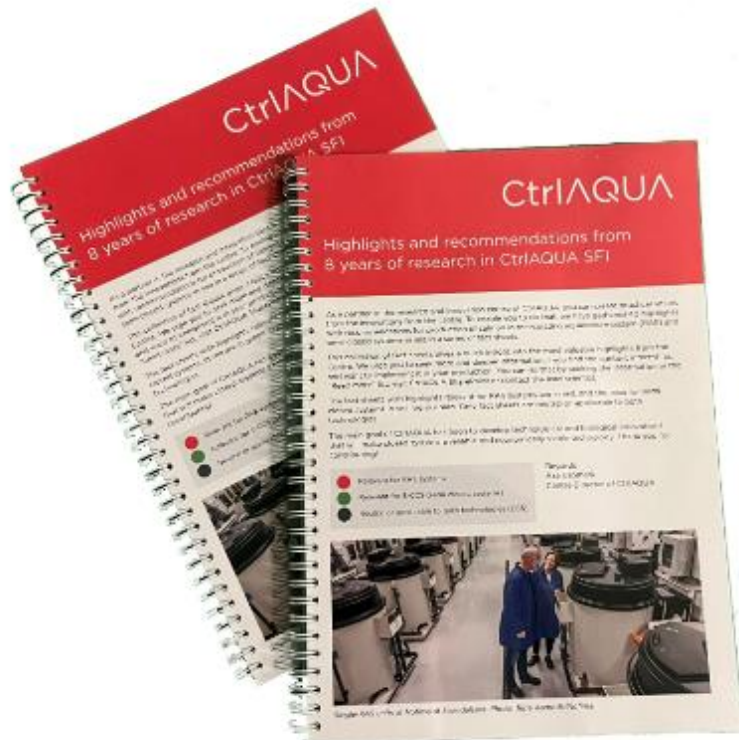
Oppsummering av CtrlAQUA på 15 minutter!?

Ca 13 CtrlAQUA prosjekter per
10 assosierte prosjekter
15 PhD studenter
55 MSc studenter



- Innovasjoner
- Faktaark
- Hvilke erfaringer sitter vi igjen med

Faktaark – oppsummering av sentrale resultater



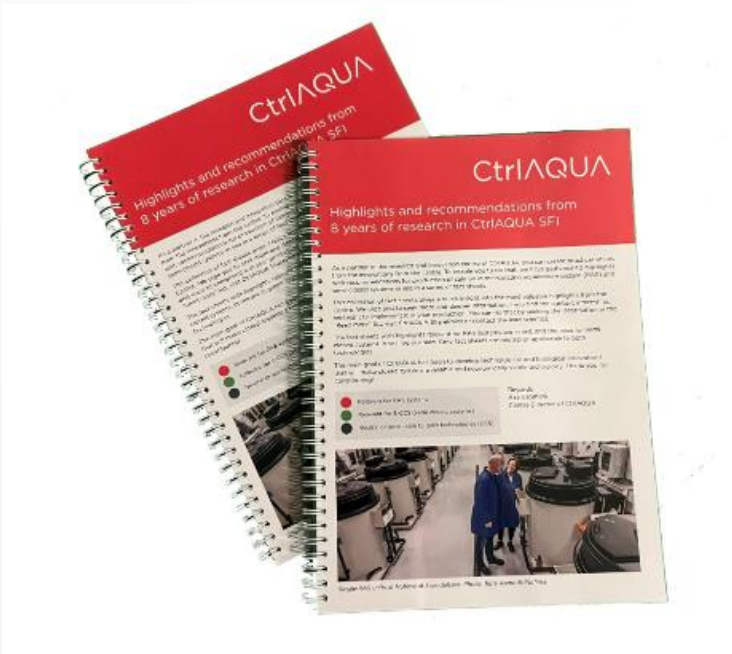
- 43 faktaark - høydepunkter fra 8 års forskning på lukkede oppdrettssystemer
- Samarbeid med industripartnerne
- Klare til implementering

Faktaark – oppsummering av sentrale resultater

Oppbyggingen er gjort sammen med næringsaktørene

Hvert faktaark

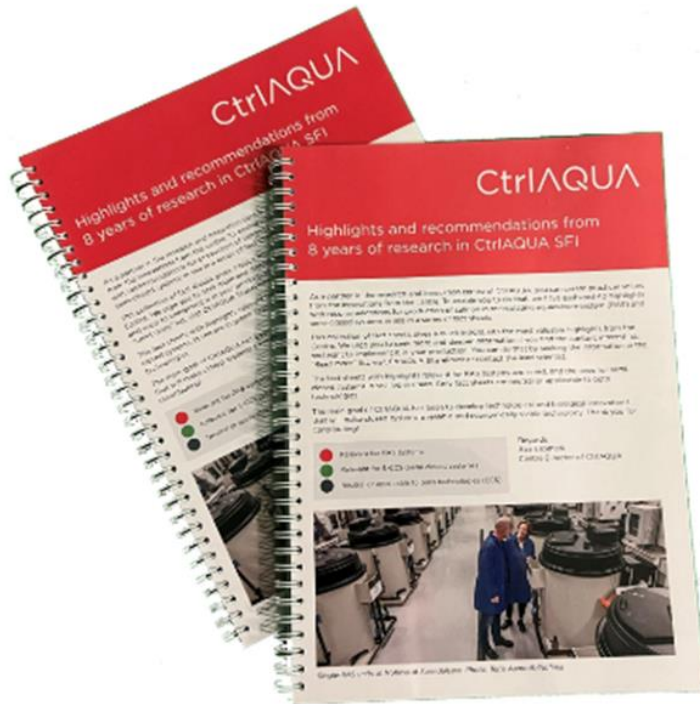
- Kort beskrivelse av resultat
- Anbefalinger
- Kontaktperson
- Anbefalt videre lesing for mer informasjon
- Delt inn etter relevans
 - Rød: RAS
 - Grønn: S-CCS
 - Grå: nøytral eller relevant for både RAS og S-CCS



Faktaark – tilgang

www.ctrlaqua.no

www.nofima.no



23 faktaark

Relevant for RAS-system

10 faktaark

Relevant for semi-lukkede systemer i sjø

10 faktaark

Nøytral eller anvendelig for begge teknologier

Faktaark – eksempel RAS

PROJECT: BENCHMARK
SYSTEM: RAS

PARTNERS: Nofima, NORCE, University of Bergen,
Pharmaq Analytic, Pharmaq, Bremnes
Seashore, Grieg Seafood, Cermaq
Norway, Mowi

CONTACT: Trine Ytrestøl (trine.ytrestol@nofima.no)

CtrlAQUA

The effect of timing and length of a winter signal in RAS and size at transfer on post-smolt performance in seawater

RESEARCH QUESTION:

In Benchmark 1, the best performing group was the 100 g smolt transferred in August, the optimum smolt window, 360 daydegrees after the end of the winter signal. The question was whether delaying and prolonging the winter signal in RAS could improve seawater performance of Atlantic salmon transferred to seawater at a larger size.

DURATION: 2021-2023

FISH SIZE TESTED: 50-3600 g

SALINITY TESTED: Fresh water and brackish water (12 ppt and 0 ppt)

HIGHLIGHTS:

- 24 h light improved growth in RAS whereas no positive effect of using brackish water was found.
- 24 h light in RAS led to reduced growth rate in seawater.
- Salinity in RAS did not affect growth in seawater.
- Fish transferred in September that were produced with early winter had the highest TGC (thermal growth coefficient) in seawater (3.3) and were largest at slaughter. Fish on 24 h light in RAS were slightly bigger at slaughter (3681 g) than fish given an early winter signal (3571 g).
- Mean bodyweight at slaughter for fish transferred in October and January were 3054 and 3058 g and TGCs were 3.0 and 2.4 respectively.

- Photoperiod and salinity in RAS did not significantly affect survival in seawater.
- The fish were infected with *Moritella viscosa* and *Tenacibaculum* which caused mortality due to winter ulcers from February until April.
- Fish transferred in September was affected by winter ulcers and mortality until the end of April was 5% for the group. Fish transferred in October and January suffered mortalities of around 30% until late April.
- The fish was diagnosed with HSM in July and delousing in July and September resulted in 15-20% mortality that related to size at transfer to sea.
- A 6-week winter signal in RAS and transfer at 850 g increased male maturation in seawater.

Protocol in RAS	Transfer time	Weight at transfer (g)	Final weight (g)	TGC in seawater	Maturation (% of dead males)
NW-BW	13 th of Sept	185	3699 ****	3,2 ****	0 ****
NW-FW	13 th of Sept	190	3663 ****	3,2 ****	0 ****
EW-FW	13 th of Sept	151	3600 ****	3,3 ****	0 ****
EW-BW	13 th of Sept	146	3546 ****	3,3 ****	0 ****
LW-BW	24 th of Jan	901	3231 ***	2,4 *	7 ***
LW-FW	29 th of Oct	341	3212 ***	3,3 ****	5 ****
EW-FW	24 th of Jan	840	3110 **	2,4 *	23 *
NW-FW	29 th of Oct	361	3108 **	2,9 ***	2 ****
LW-FW	24 th of Jan	900	3102 **	2,3 *	26 *
LW-BW	29 th of Oct	319	3091 **	3,0 ***	2 ****
LLW-BW	24 th of Jan	725	3052 **	2,6 **	2 ****
EW-BW	24 th of Jan	892	3037 **	2,3 *	21 *
NW-BW	24 th of Jan	937	3000 *	2,2 *	3 ****
NW-BW	29 th of Oct	351	2990 *	2,8 ***	7 ***
NW-FW	24 th of Jan	920	2982 *	2,2 *	8 ***
EW-BW	29 th of Oct	270	2963 *	3,1 ****	0 ****
EW-FW	29 th of Oct	280	2963 *	3,0 ***	8 ***
LLW-FW	24 th of Jan	730	2954 *	2,5 **	11 **

NW = No winter
EW = Early winter
LW = Late winter
LLW = Late long winter

	weight	TGC	maturation
****	3400-	3.1-3.3	0-5%
***	3200-3300	2.8-3.0	5-10%
**	3100-3000	2.5-2.7	10-15%
*	2900-3000	2.2-2.4	15-26%

RECOMMENDATION:

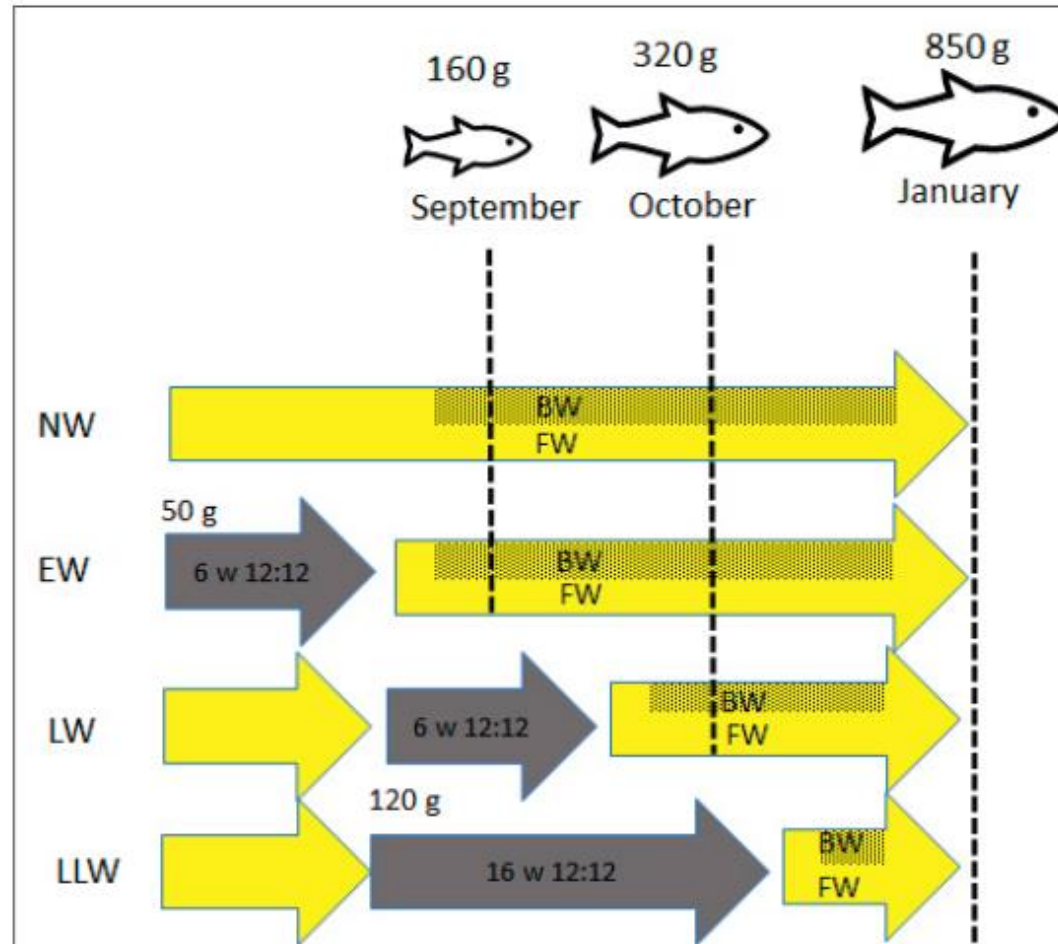
- These are preliminary data as not all results are processed.
- It is recommended to transfer fish at a smaller size earlier in the fall if there is

The factsheet is ready for implementation, but with the note that the testing has not been done for all industrial relevant conditions.

should be used with caution if the smolts

Growth and maturation in seawater for the different protocols, ranged by final weight in November 2022.

Faktaark – eksempel RAS



Photoperiods in RAS and mean bodyweight at transfer to seawater pens at Gifas. The fish were exposed to 4 photoperiods in RAS, continuous 24 h light (NW), an early winter signal (EW, 6 weeks 12 h L:D from 50 g), a late 6-weeks winter signal (LW, from 120 g) or a long winter signal (LLW, 16 weeks from 120 g). All photoperiod treatments were replicated in freshwater (FW) and in brackish water RAS (12 ppt) until seawater transfer at in September, October and January. Seawater survival and growth performance was compared in the different treatments until slaughter in November 2022.

Faktaark – eksempel S-CCS

PROJECT: MICROPARASITES
SYSTEM: Semi-closed system in sea
PARTNERS: University of Bergen, Mowi, Cermaq Norway, Lerøy Seafood Group
CONTACT: Are Nylund (are.nylund@uib.no)

Microparasites in semi-closed system

A major step towards successful production of salmon in a containment system (CCS, S-CCS) is knowledge of the diversity, prevalence and load of microparasites (bacteria, fungi) in comparison with existing knowledge from the culture system (e.g. S-CCS with water in cages). Microparasites not found in open production

HYPOTHESIS:

Use of S-CCS will not affect the diversity of microparasites in production systems at the sea.

DURATION: 2015 – 2024

FISH SIZE TESTED: The salmon collected from smolt production in S-CCS and open control cages.

SALINITY TESTED: Salt water

HIGHLIGHTS:

1. S-CCS reduce the impact of lice (*Lepeophtheirus*) on the water intake in comparison to open production areas. In S-CCS cages and further, the water intake could possibly be obtained by the water in-take to deeper waters 20 meters or by treatment of the intake water.
2. A range of microparasites (mostly viruses) can be introduced from smolt production sites into the S-CCS. This can be avoided with a stronger focus on production of smolt that are negative for viruses like HPRV, ISAV and PRV1.
3. S-CCS does not protect against infection with microparasites (viruses, bacterial,

Ctrl



RECOMMENDATION:

1. Reduction of lice could possibly be obtained by lowering the water in-take to below 20 meters or by treatment of the intake water.

The factsheet is ready for commercial implementation

followed in this project are early prototypes that need to be located in fjords and close to land. The future S-CCS will probably have to be more robust technologies compared to those tested in open production. The future S-CCS will probably have to be more robust technologies compared to those tested in open production.

MEET SCIENTISTS IN CTRLAQUA WORKING ON KEY QUESTIONS

Do semi-closed facilities in the sea protect farmed salmon against pathogens? Which production protocols in RAS provide the best health and growth of post-smolt for grow-out up in sea? These questions are answered in three articles where researchers provide knowledge that hopefully authorities, fish farmers and suppliers will find useful to support their decisions in the production of safe and healthy farmed salmon. Read the articles here, at page 20-21 and 38-41.

Article by Reidun Lilleholt Kraugerud

Two pieces of fish health advice

Are Nylund, professor at the University of Bergen



CtrlAQUA Annual Report 2021

as Borka Kloster-Jensen (2015) development of a genotyping tool for the monid Gill Poxvirus (SGPV) in farmed wild salmon (*Salmo salar*) in Norway. Master thesis, University of

Mjølnerød EB, Srivastava A, Moore Plarre H, Nylund A (2022). Identification of housekeeping genes of *Candidatus* Branchiomonas isticola associated with epitheliocystis in Atlantic salmon (*Salmo salar* L.). Archives of Microbiology 204:365. <https://doi.org/10.1007/s00203-022-02966-y>. Siri Marie Lillebostad (2022). Phylogenetic and histological analysis of *Candidatus* Branchiomonas isticola associated with

Faktaark – eksempel nøytral, eller både RAS og S-CCS

PROJECT: BARRIER
PARTNERS: Nofima, CreateView
CONTACT: Christian Karlsen
(christian.karlsen@nofima.no)

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Wound types and regeneration

A major step towards successful production of Atlantic salmon in closed and semi-closed containment system (CCS, S-CCS) is knowledge about how these systems affect the diversity, prevalence and load of microparasites (viruses, bacteria, protozoan parasites, and fungi) in comparison with existing knowledge from open production systems. Will change in the culture system (e.g. S-CCS with water intake at large depths) lead to introduction of new microparasites not found in open production systems?

HYPOTHESIS:

The healing progression of physical or mechanical induced wounds depends on the wound's severity and type.

DURATION: 2021 - 2022

FISH SIZE TESTED: 400-600 g

SALINITY TESTED: Salt water

WATER TEMPERATURE: 10 °C

HIGHLIGHTS:

Wound healing progression after 5 weeks.

Healing progression between wound types is shown in Figure 1.

- Scale loss initiates re-epithelialization with rapid migrating skin keratocyte cells that cover and seal the surface after hours restoring the barrier function. The blood osmotic balance is restored after less than 2 days when fish suffer a skin area scale loss of -10%, as shown in Figure 1. Healing of the tissue takes longer time. By week 5 at 10 °C, appearance is similar to the control with developed scales and structured epithelial layer with a high number of mucosal cells.
- Superficial wounds (scales are scraped off, also removing the outer skin structures completely, while leaving the dermis

intact) have a longer recovery time. After 5 weeks, a gel like substrate is still filling the wound. Epidermis is sealed with a thick layer of keratocytes. Skin tissue layers are regenerating, display pigmentation, and starts developing scales. The epidermal surface has a high number of mucosal cells.

- Deep wounds (induced by punch biopsy tool) are after 5 weeks noticeable with dark coloration at the wound edges on the dorsal side. Ventral wounds appear more contracted. Restructuring of the tissue is on-going but the thickness of the epidermal layer is dominating. The epidermal layer has a high number of mucosal cells.

RECOMMENDATION:

- Knowing the healing progression of different wound types when injuries occur is valuable. This can be used to estimate a time frame for healing, if the tissue recovers and restore, or if activities such as e.g., handling or necessary treatments may increase the risk of recurrence and add to further damage.
- Wound healing progression depends on the severity of damage (Figure 1). After 5

weeks at 10 °C, scale loss area was in the final remodelling stage, superficial wounds were closed but only starting to develop scales, and deep wounds were still in inflammation with active tissue formation.

- It is expected that at higher temperatures healing progression is faster, while lower temperatures lengthen the healing time.

The factsheet is ready for implementation, but with the note that the testing has not been done for all industrial relevant conditions.

READ MORE:

- Deliverable D3.1/BARRIER/2022

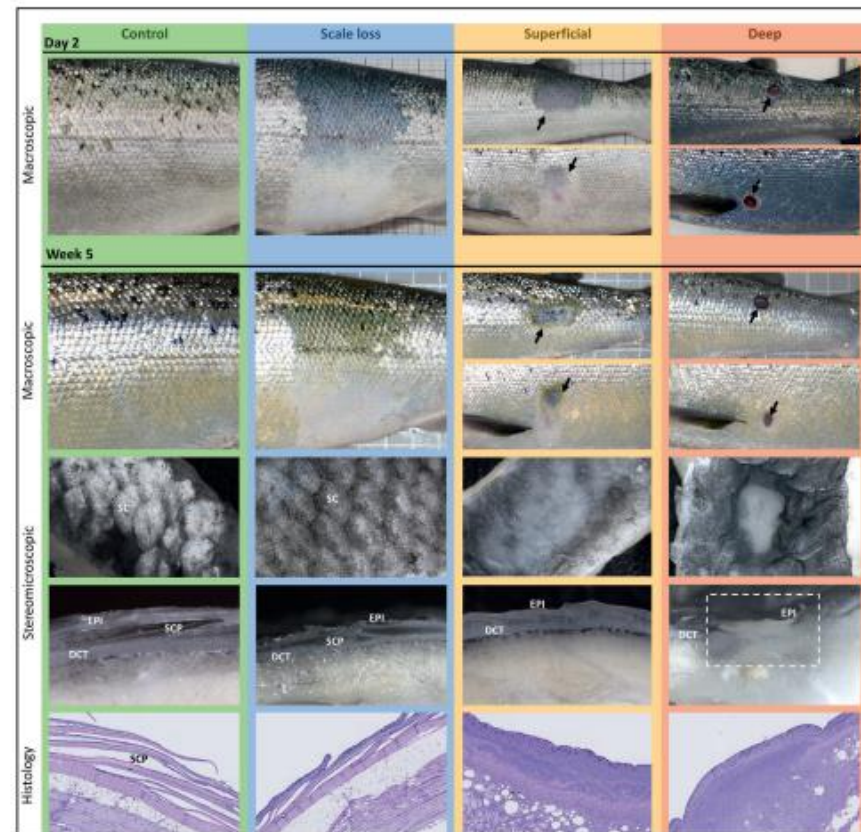


Figure 1. Wound healing progression, in salt water at 10 °C, between wound types shown by visual appearance, close up of the surface, by vertical sagittal cut followed by histological sections of the different wound types. The general wound healing cascade includes re-epithelialization, inflammation, granulation tissue formation and tissue remodeling.

Hvilke erfaringer sitter vi igjen med....bortsett fra at vi har skapt mye ny kunnskap

Konsortium

- Engasjerte pga relevant tematikk
- Mye deling av erfaring og kunnskap

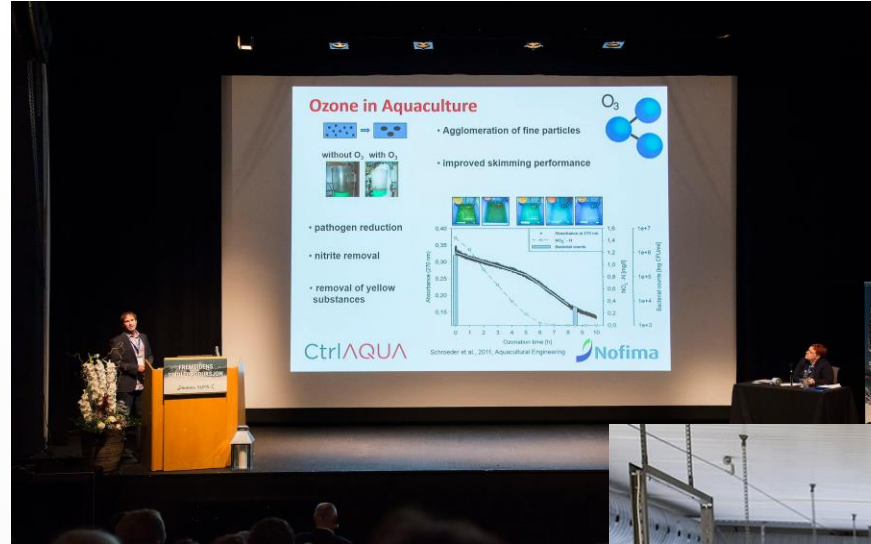
8 år

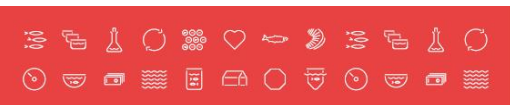
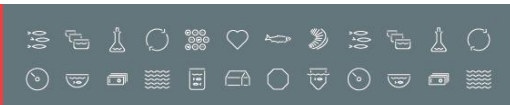
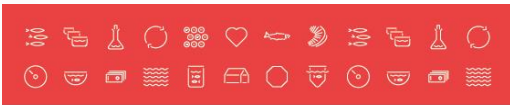
- Nødvendig for å få signifikant løft av tema
- Kontinuitet skaper resultater og engasjement
- SFI`er er fleksible og tar hensyn til at verden endrer seg på 8 år
- God mulighet til å bygge kompetanse med rekruttering



CtrlAQUA på Fremtidens smoltproduksjon

CtrlAQUA





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containment Aquaculture

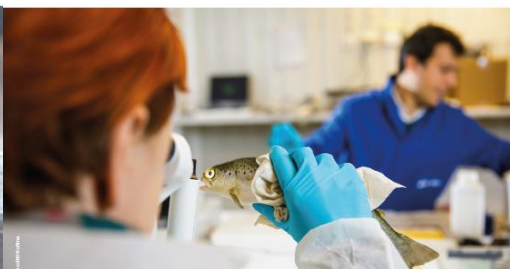


Centre for Closed-containment Aquaculture **sfi** = Centre for Research-based Innovation
The Research Council of Norway



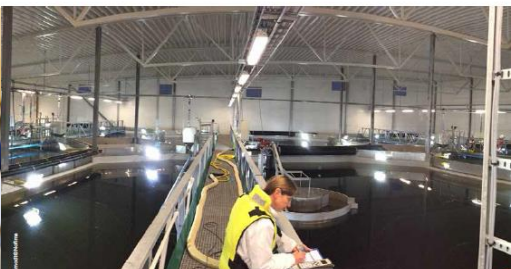
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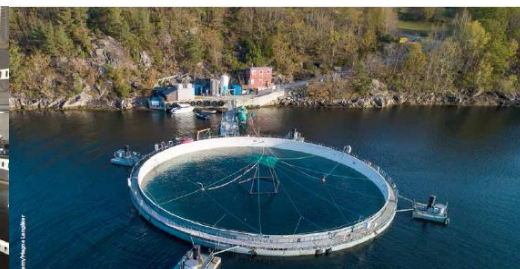
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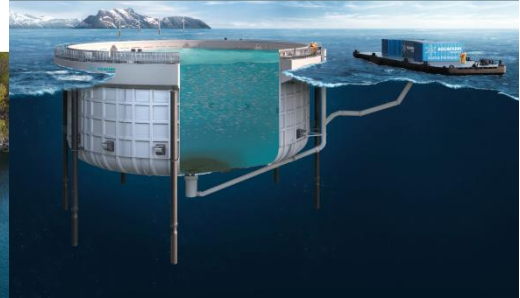
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FINAL REPORT



Norwegian Centre
for Research-based
Innovation

Takk for oppmerksomheten!!

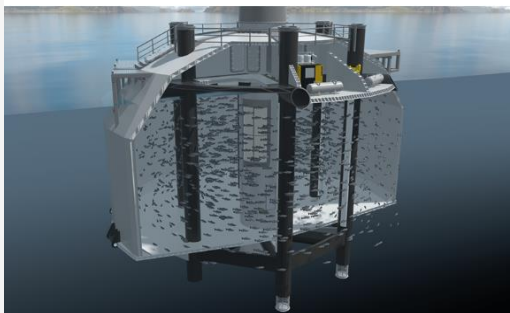
sfi = Senter for
forskningsdrevet
innovasjon
Norges forskningsråd

CtrlAQUA

Highlights and recommendations from
8 years of research in CtrlAQUA SFI

CtrlAQUA

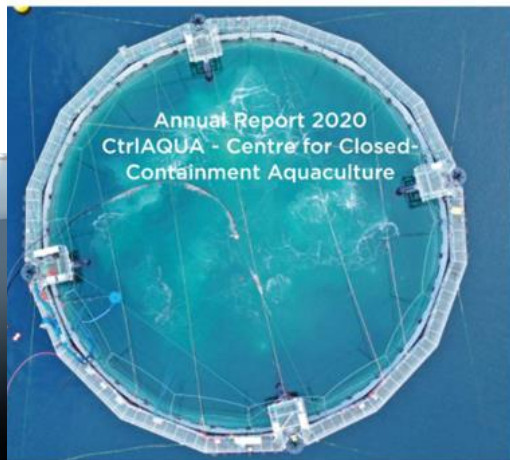
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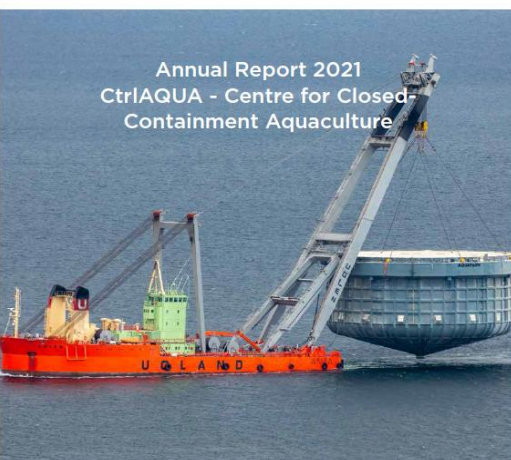
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Norwegian Centre
for Research-based
Innovation

As a partner in the research and innovation centre of CtrlAQUA, you can create practical values from the innovations from the centre. To enable you to do that, we have gathered 40 highlights with recommendations for production of salmon in recirculating aquaculture system (RAS) and semi-closed systems in sea in a series of fact sheets.

This collection of fact sheets gives a quick insight into the most valuable highlights from the Centre. We urge you to seek more and deeper information if you find the content interesting, and want to implement it in your production. You can do that by seeking the information in the "Read more" list, visit CtrlAQUA SharePoint or contact the lead scientist.

The fact sheets with highlights relevant for RAS systems are in red, and the ones for semi-closed systems in sea are in green. Grey fact sheets are neutral or applicable to both technologies.

The main goal of CtrlAQUA has been to develop technological and biological innovations that will make closed systems a reliable and economically viable technology. Thank you for contributing!

- Relevant for RAS systems
- Relevant for S-CCS (semi-closed systems)
- Neutral or applicable to both technologies (CCS)

Regards,
Åsa Espmark
Centre Director of CtrlAQUA



Single-RAS units at Norima at Sunndalsøra. Photo: Torje Aamodt/Norima.