AKVATISKE UTNYTTELSER

Digitalt arbeidsmøte om utnyttelse av utslipp fra oppdrett

12.05.2020 Kl. 09.30 – 9.45

Andreas Hagemann, Seniorforsker SINTEF Ocean

Næringsverdi Slam

- Varierende kvalitet og kvantitet avhengig av:
  - Tid på året (biomasse i anlegget, fôrtype og utfôringsmengde)
  - Art (laks, ørret, røye) og størrelse (settefisk, post-smolt)
  - Slamhåndteringsteknologi (TS fra 10 – >90 %)

Slam fra ulike anlegg	
Aske (% av TS)	15 – 22
Protein (% av TS)	13 – 25
N (% av TS)	3 – 12
C (% av TS)	29 – 41
Lipid (% av TS)	8 – 20
Fettsyrer (% av TS)	2 – 5
Fosfor (% av TS)	2 – 3

* Verdier hentet fra Blytt et al, 2011; Rosten et al, 2013; Forbord et al, 2016; Hilmarsen et al, 2018; Wang et al, 2019a, Wang et al, 2019b)

Blytt, Line Diana, Trond Knapp Haraldsen, Herman Helness, Bjarne Paulsrud, and Yngve Ulgenes. "Håndtering av slam fra rensing av avløp i settefiskanlegg." *Sintef Byggforsk Rapport SBF2011F0081* (2011).
Forbord, Silje, Standal, Inger Beate, Reitan, Kjell Inge "Avfall fra sjøbasert lakseoppdrett som en ressurs" *SINTEF Fiskeri og havbruk rapport* (2016);
Hilmarsen, Øyvind, Even Ambros Holte, Hanne Brendeløkken, Randulf Høyli, and Erik Skontorp Hognes. "OC2018 A-033-Konsekvensanalyse av landbasert oppdrett av laks–matfisk og post-smolt." (2018).
Rosten, T.W., Azrague, K., Toldnes, B., (2013). Primærrensing og aktuelle løsninger for slambehandling i norske settefiskanlegg. SINTEF A24445. pp 1-123
Wang, Haiqing, Inka Seekamp, Arne Malzahn, Andreas Hagemann, Ana Karina Carvajal, Rasa Slizyte, Inger Beate Standal, Aleksander Handå, and Kjell Inge Reitan. "Growth and nutritional composition of the polychaete Hediste diversicolor (OF Müller, 1776) cultivated on waste from land-based salmon smolt aquaculture." *Aquaculture* 502 (2019): 232-241.
Wang, Haiqing, Andreas Hagemann, Kjell Inge Reitan, Jørgen Ejlertsson, Håvard Wollan, Aleksander Handå, and Arne M. Malzahn. "Potential of the polychaete Hediste diversicolor fed on aquaculture and biogas side streams as an aquaculture food source." *Aquaculture Environment Interactions* 11 (2019): 551-562.

Slamutnyttelse - Dagens løsninger

- Gjødsel i landbruket
  - Kan redusere behov for fosfor i mineralgjødsel
  - Grenseverdier for tungmetaller setter begrensningene for bruk
  - Tap av næringsstoffer (lipider, protein)
- Biogass
  - Næringsstoffer kan gjenvinnes fra biorest
- Forbrenning
  - Slam har god brennverdi, men er energikrevende å tørke
  - Tap av viktige næringsstoffer
- ***Bioproduksjon***
  - ***Viktige næringsstoffer gjenvinnes***
  - ***Rest etter bioproduksjon kan fortsatt inngå i andre løsninger***

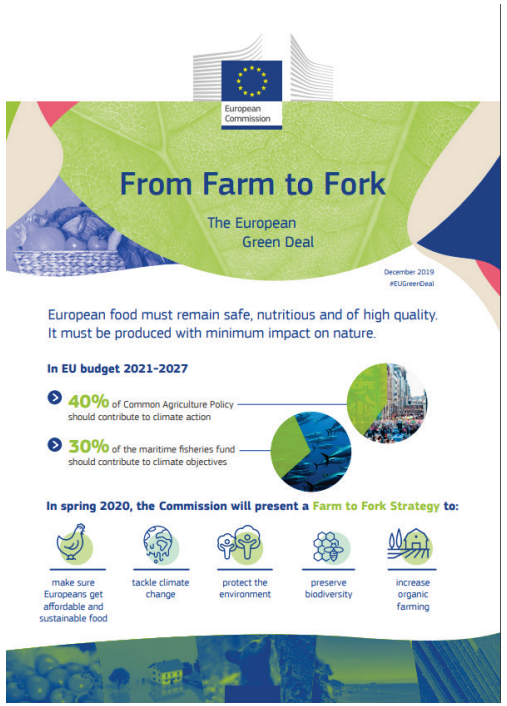
Figur fra: Aspaas, S., Hagemann, A. og Rosten, T.W. 2016 - Identifisering av aktuelle løsninger for håndtering og anvendelse av avløpsslam fra settefiskanlegg i Nordland

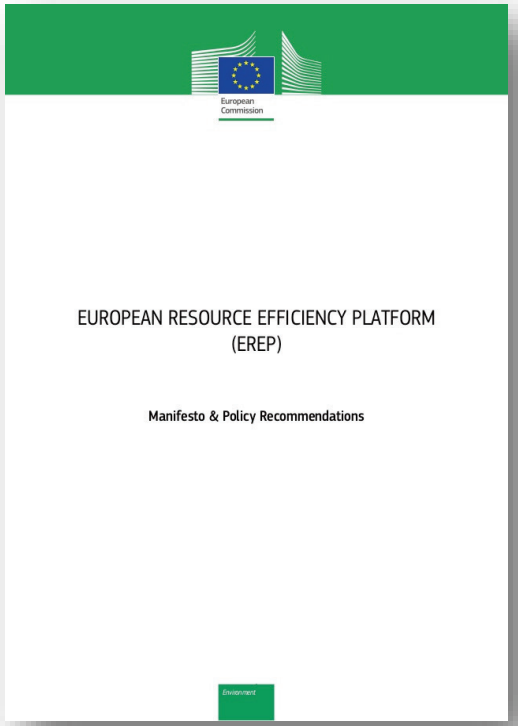
SINTEF

Sirkulær bioøkonomi

"In a world with growing pressures on resources and the environment, the EU has no choice but to go for the transition to a resource-efficient and ultimately regenerative circular economy" (EREP, 2014)

- **Bioproduksjon**
  - Resirkulering og gjenbruk av organiske og uorganiske forbindelser i industrielle sidestrømmer
  - Baseres ofte på naturlige prosesser tilpasset industrielle forhold
- **Suksesskriterier**
  - Biologi
  - Produksjonsteknologi
  - Høsting
  - Prosessering
  - Produkt & Marked
  - Regelverk





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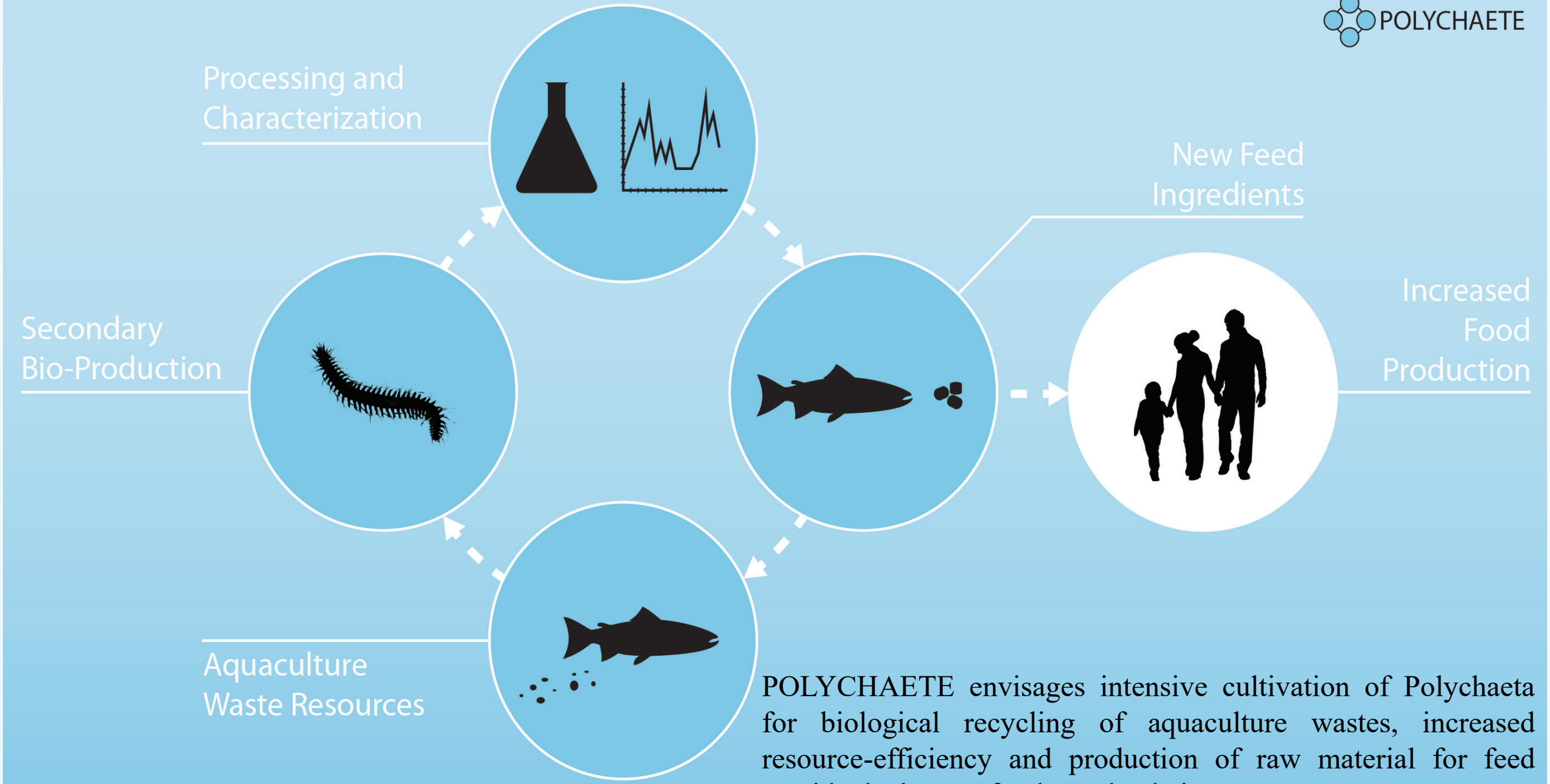
POLYCHAETE

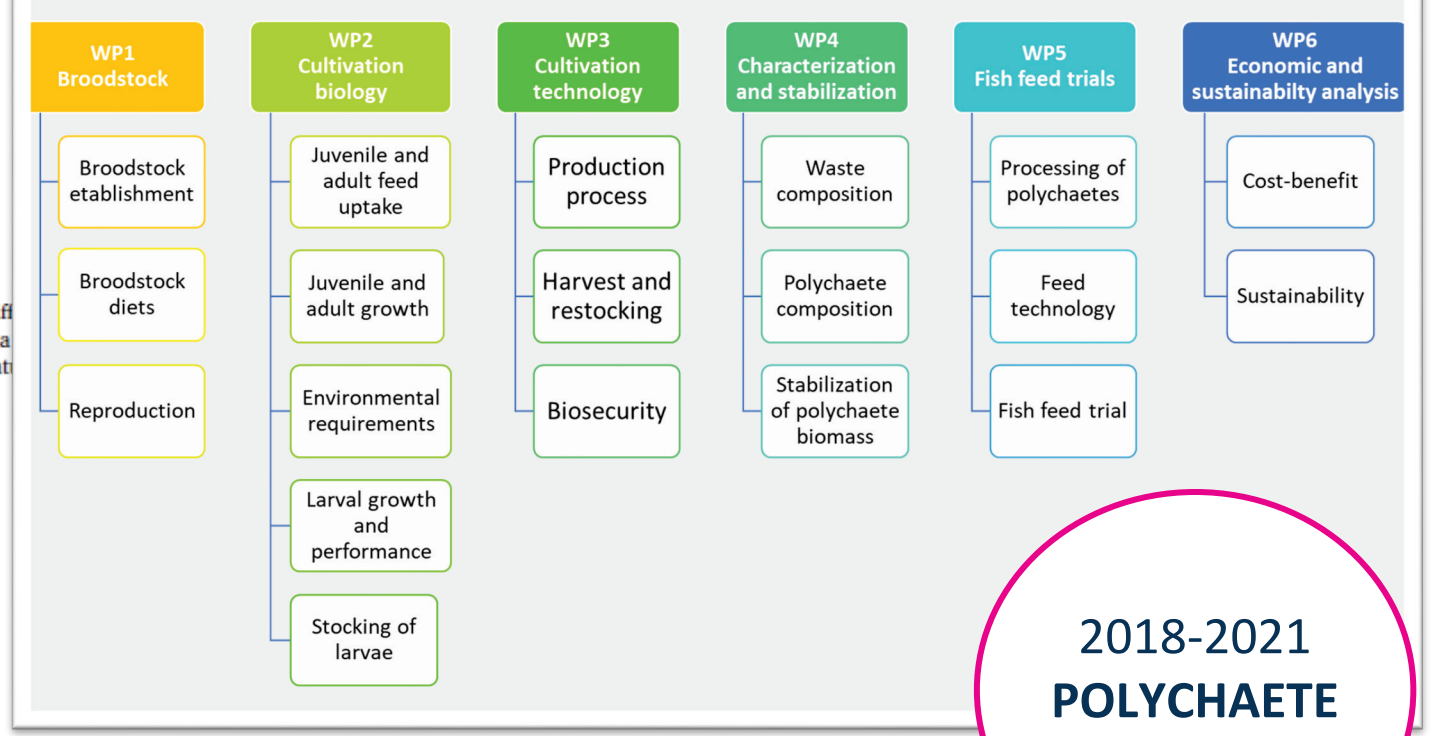


POLYCHAETE envisages intensive cultivation of Polychaeta for biological recycling of aquaculture wastes, increased resource-efficiency and production of raw material for feed outside the human food supply chain.

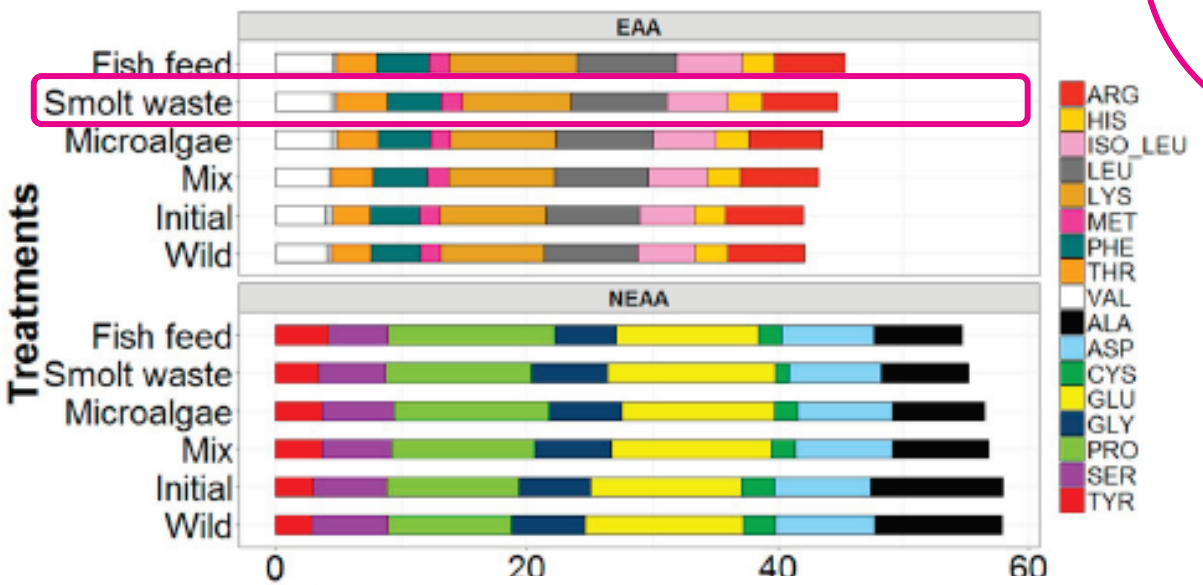
POLYCHAETE

Table 4
Fatty acid content (mg FA g DW^{-1}, means ± SD) and fatty acid composition (% of total FA) of *H. diversicolor* under diff
microalgae, mixed diet (n = 5 replicates); and Wild (n = 2 replicates), Initial (n = 3 replicates). Superscripts from a
descending concentration ($p < 0.05$). SFA = saturated fatty acids, MUFA = monounsaturated FA and PUFA = polyunsat
within rows in table indicate significant ($p < 0.05$) differences in descending order.

	Feeding treatments		Initial
	Fish feed	Smolt waste	
Total lipid (mg g DW^{-1})	157.4 ± 10.4^{a}	123.6 ± 12.8^{bc}	113.7 ± 0.8^{c}
Total FA (mg g DW^{-1})	73.7 ± 6.2^{a}	56.9 ± 7.8^{b}	41.16 ± 0.4^{c}
% of total FA			
C14:0	2.41 ± 0.48^{b}	1.67 ± 0.56^{bc}	1.21 ± 0.04^{c}
C15:0	0.49 ± 0.07^{c}	0.60 ± 0.08^{bc}	0.62 ± 0.03^{bc}
C16:0	20.06 ± 0.99^{bc}	20.8 ± 1.01^{b}	18.57 ± 0.34^{c}
C17:0	0.70 ± 0.14^{b}	0.88 ± 0.14^{ab}	1.03 ± 0.02^{a}
C18:0	4.12 ± 0.61^{c}	5.00 ± 0.72^{abc}	5.72 ± 0.09^{ab}
ΣSFA	27.78 ± 1.29^{bc}	29.47 ± 1.00^{b}	26.97 ± 0.34^{c}
C16:1 *n*-7	5.29 ± 0.73^{ab}	4.06 ± 1.02^{b}	4.40 ± 0.29^{ab}
C18:1 *n*-9	11.51 ± 0.34^{a}	10.46 ± 0.81^{ab}	8.83 ± 0.44^{c}
C18:1 *n*-7	5.34 ± 0.42^{ab}	5.64 ± 0.17^{a}	5.43 ± 0.14^{ab}
C20:1 *n*-9	2.63 ± 0.58^{b}	4.11 ± 0.94^{a}	3.45 ± 0.18^{ab}
C22:1 *n*-9	0.26 ± 0.10	0.78 ± 1.02	0.47 ± 0.81
C24:1	0.30 ± 0.12	0.38 ± 0.10	–
ΣMUFA	25.33 ± 0.76^{a}	25.43 ± 0.73^{a}	22.56 ± 0.14^{b}
C18:2 *n*-6	6.92 ± 0.25^{a}	6.47 ± 0.29^{ab}	5.79 ± 0.68^{bc}
C18:3 *n*-3	1.96 ± 0.09^{c}	2.06 ± 0.22^{c}	3.35 ± 0.11^{a}
C18:4 *n*-3	0.75 ± 0.18^{b}	0.39 ± 0.30^{b}	0.53 ± 0.04^{b}
C20:2 *n*-6	4.86 ± 0.44	4.86 ± 0.44	4.73 ± 0.24
C20:4 *n*-6	2.19 ± 0.53^{c}	3.26 ± 0.63^{abc}	3.74 ± 0.21^{ab}
C20:3 *n*-3	0.50 ± 0.06^{c}	0.57 ± 0.10^{bc}	0.81 ± 0.03^{a}
C20:5*n*-3 (EPA)	19.04 ± 0.87^{d}	19.13 ± 0.58^{d}	26.09 ± 0.41^{a}
C22:5 *n*-3	2.89 ± 0.10^{c}	2.94 ± 0.22^{bc}	3.77 ± 0.13^{a}
C22:6*n*-3 (DHA)	7.80 ± 1.09^{a}	5.43 ± 1.21^{b}	1.47 ± 0.06^{c}
ΣPUFA	46.89 ± 1.64^{b}	45.11 ± 1.18^{b}	50.47 ± 0.47^{a}
Σ *n*-3	32.93 ± 2.07^{ab}	30.52 ± 1.85^{b}	36.12 ± 0.09^{a}
Σ *n*-6	13.96 ± 0.57^{a}	14.59 ± 0.79^{a}	14.35 ± 0.56^{a}
n-3/*n*-6	2.37 ± 0.23^{b}	2.10 ± 0.25^{b}	2.52 ± 0.11^{b}
DHA/EPA	0.41 ± 0.04^{a}	0.28 ± 0.05^{b}	0.06 ± 0.0^{c}



2018-2021
POLYCHAETE
10 MNOK
The Research Council of Norway



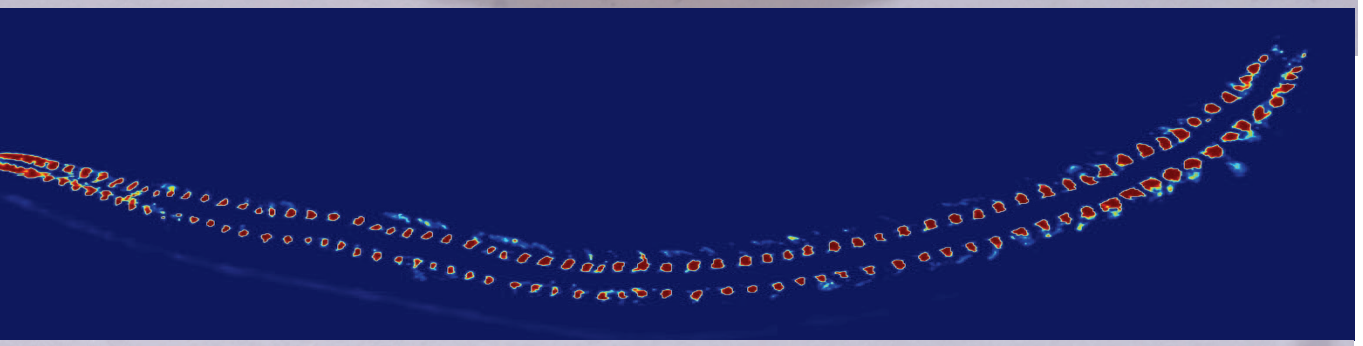
Aminosyresammensetning i *H. diversicolor*

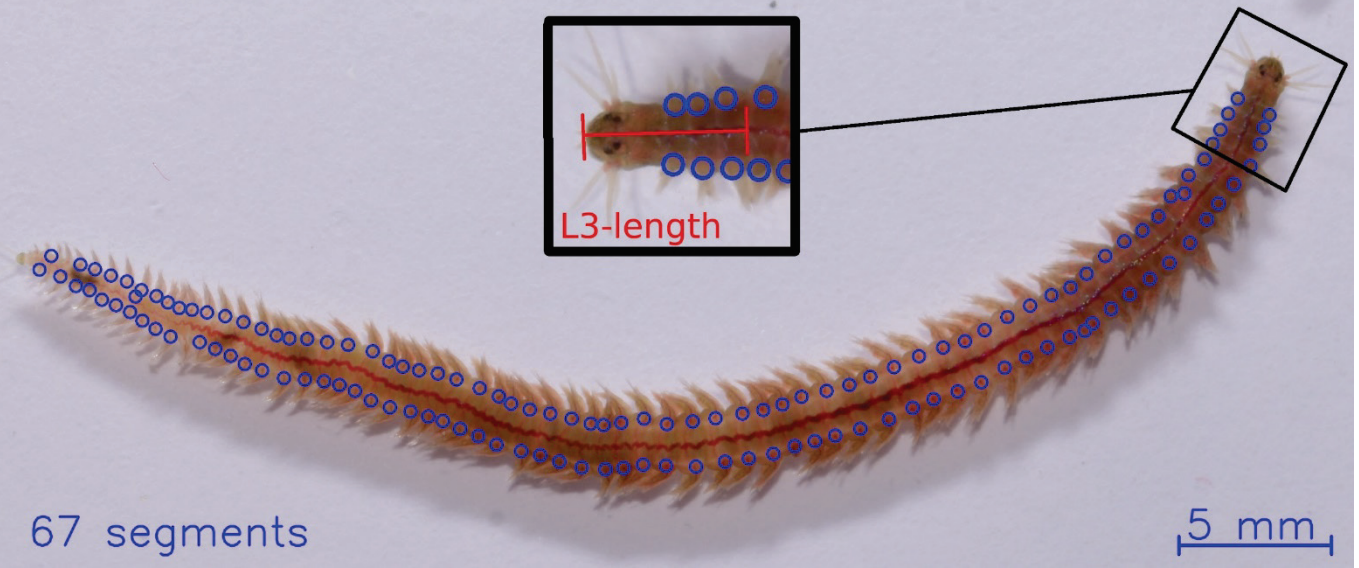
SINTEF

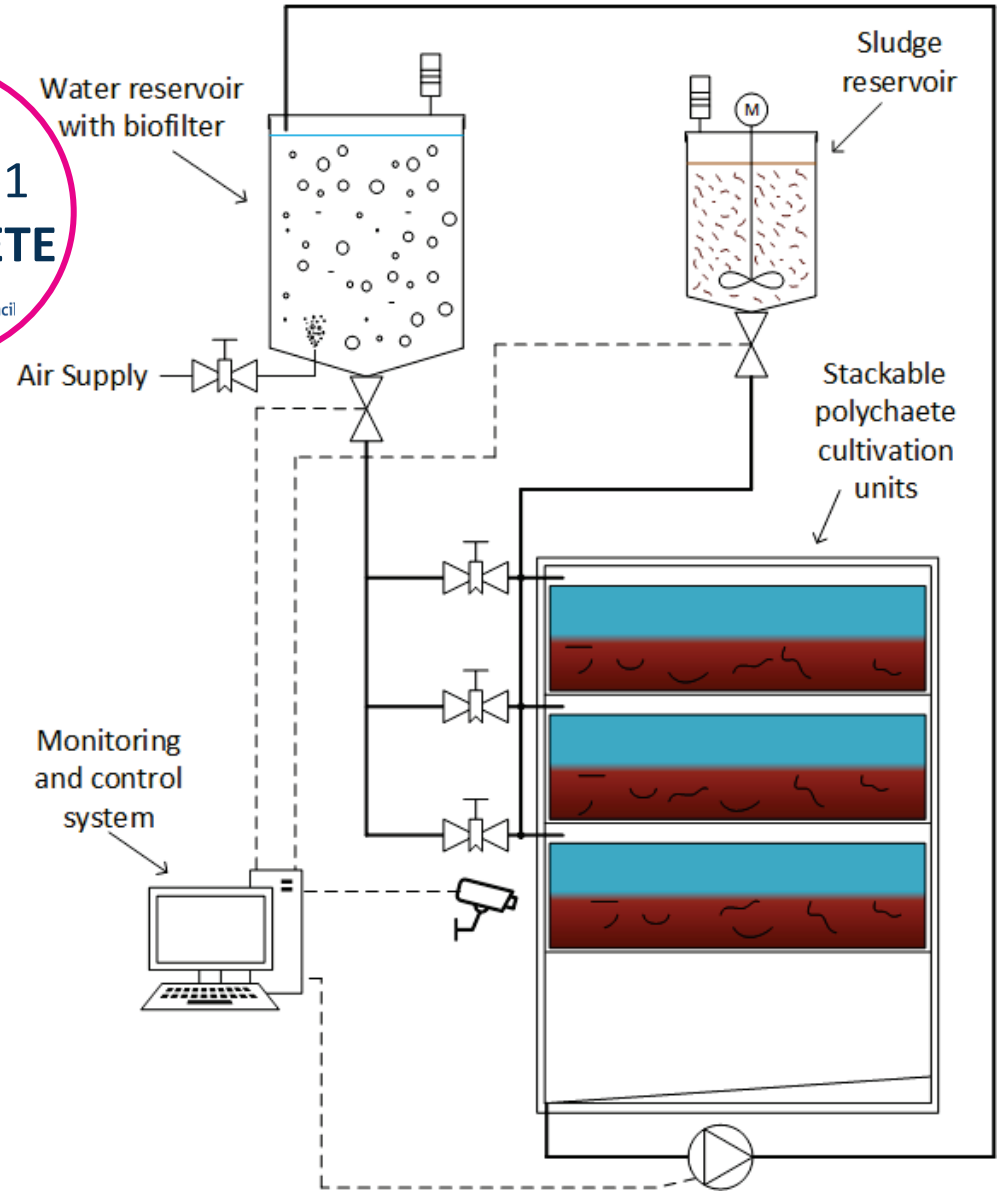
Wang, H., Seekamp, I., Malzahn, A., Hagemann, A., Carvajal, A. K., Slizyte, R., ... & Reitan, K. I. (2019). Growth and nutritional composition of the polychae
Hediste diversicolor (OF Müller, 1776) cultivated on waste from land-based salmon smolt aquaculture. *Aquaculture*, *502*, 232-241.

Machine vision and automation for monitoring and upscaling

2018-2021
POLYCHAETE
The Research Council of Norway







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Protein- og fettsyreinnhold i forskjellige fôrråstoff

2018-2021
POLYCHAETE
10 MNOK
The Research Council of Norway

	Fishmeal LT 70	Wheat gluten	Soy protein concentrate	Soybean meal	Insect meal	*H. diversicolor*
Protein	69-72	79-82	60-63	45-47	52,6	53-56

Fatty acids	Anchovy	Mackerel	Cod liver	Squid	Krill	Plant oil	Insects	*H. diversicolor*
20:5 n-3	12	13	9	11	22	-	0,2	14-19
22:5 n-3	2	2	2	1	1	-	0,2	3-6
22:6 n-3	12	8	9	12	13	-	<0,1	1-5
MUFA	30	37	49	35	22	7-77		26-33
PUFA	34	37	28	37	46	0-75		43-46
n-3FA	30	26	24	31	43	0-56	1-2	28-29
n-6FA	2	5	3	3	3	0-73	11	12-15

% of total lipid, *Tacon et al. (2009)*, insects from other source and polychaetes in POLYCHAETE

Wang et al., 2019 Growth and nutritional composition of the polychaete Hediste diversicolor (OF Müller, 1776) cultivated on waste from land-based salmon smolt aquaculture. *Aquaculture*, *502*, 232-241.; Wang et al., 2018 "Potential of the polychaete Hediste diversicolor fed on aquaculture and biogas side streams as an aquaculture food source." *Aquaculture Environment Interactions* *11* (2019): 551-562.

SINTEF

Produksjonsestimat for børstemark dyrket på slam

Eksempel -
1000 kg (TS) slam fra settefiskanlegg inneholder

- 61 kg Nitrogen (6,1%)
- 11 kg Fosfor (1,1%)
- 388 kg Organisk karbon (38,8%)

150 kg børstemarkbiomasse TV (0,15 g børstemark/g slam)

17-23 kg lipider (12-16 %)

- 5,8 kg FA (4 %)
- 4,3 kg PUFA (3%)

76-81 kg proteiner
(53-56%)

21-29 kg karbohydrater
(15-20 %)

Avfall
~50 kg Nitrogen

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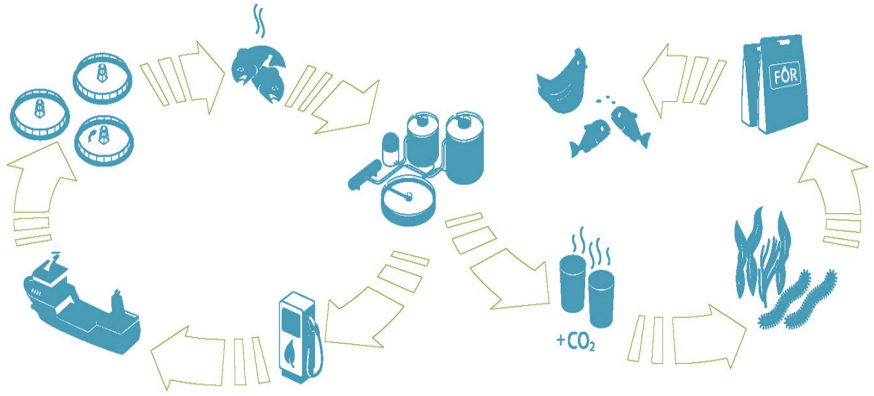
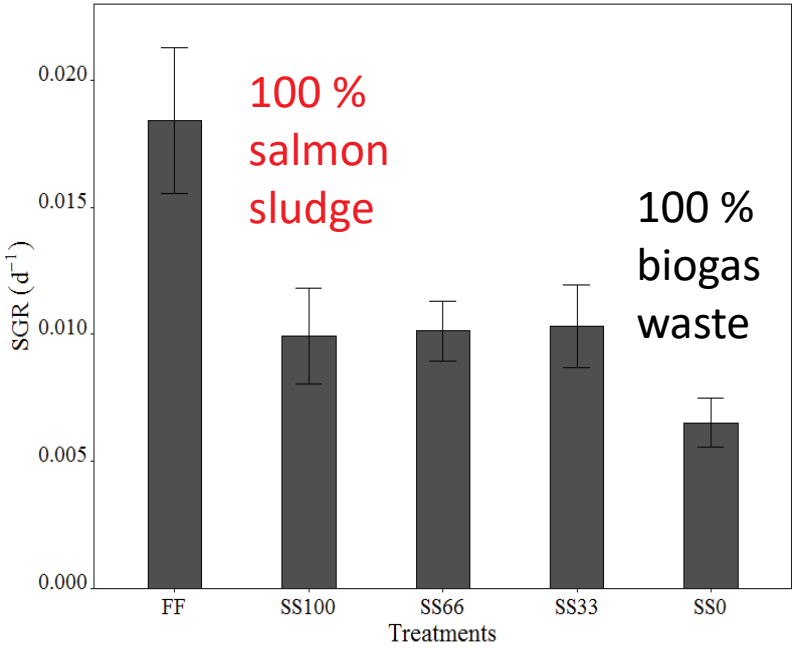
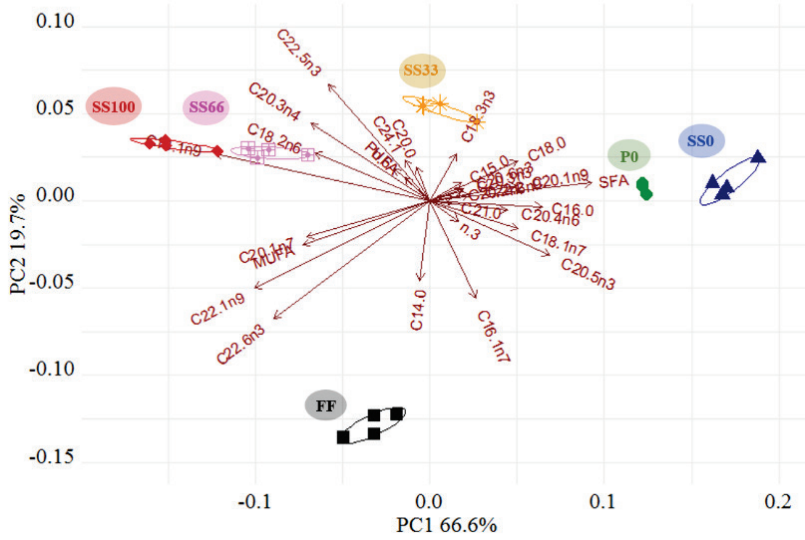
COMPLETE

Energy efficient biogas production by recirculation of nutrients and complete utilization of resources

2016-2018
COMPLETE
25 MNOK
The Research Council of Norway
BIOKRAFT







BIOKRAFT
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NTNU
Scandinavianbiogas
NIBIO NORWEGIAN INSTITUTE OF BIOECONOMY RESEARCH
The Research Council of Norway

Wang, Haiqing, Andreas Hagemann, Kjell Inge Reitan, Jørgen Ejlertsson, Håvard Wollan, Aleksander Handå, and Arne M. Malzahn. "Potential of the polychaete Hediste diversicolor fed on aquaculture and biogas side streams as an aquaculture food source." *Aquaculture Environment Interactions 11* (2019): 551-562.

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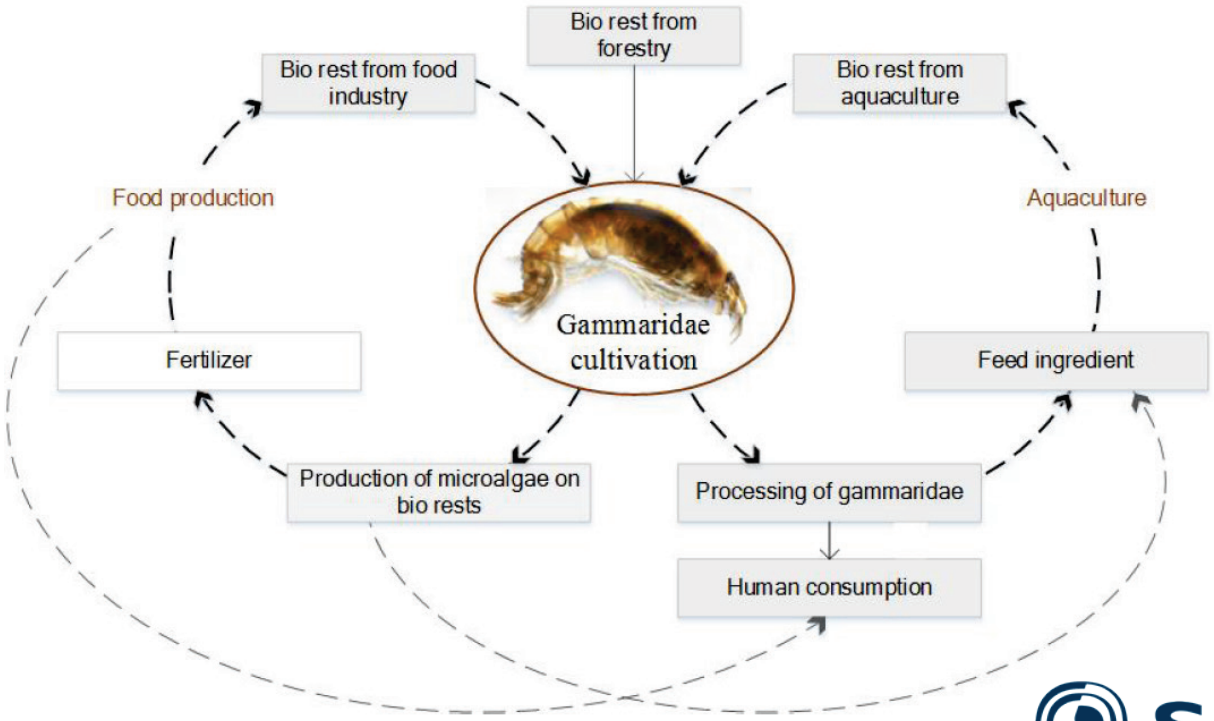
BIOCYCLES

NFR 2019 - 2022



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PFI PART OF RI.SE

Forskningsrådet

NIBIO NORSK INSTITUTT FOR BIOØKONOMI

CSIC CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS

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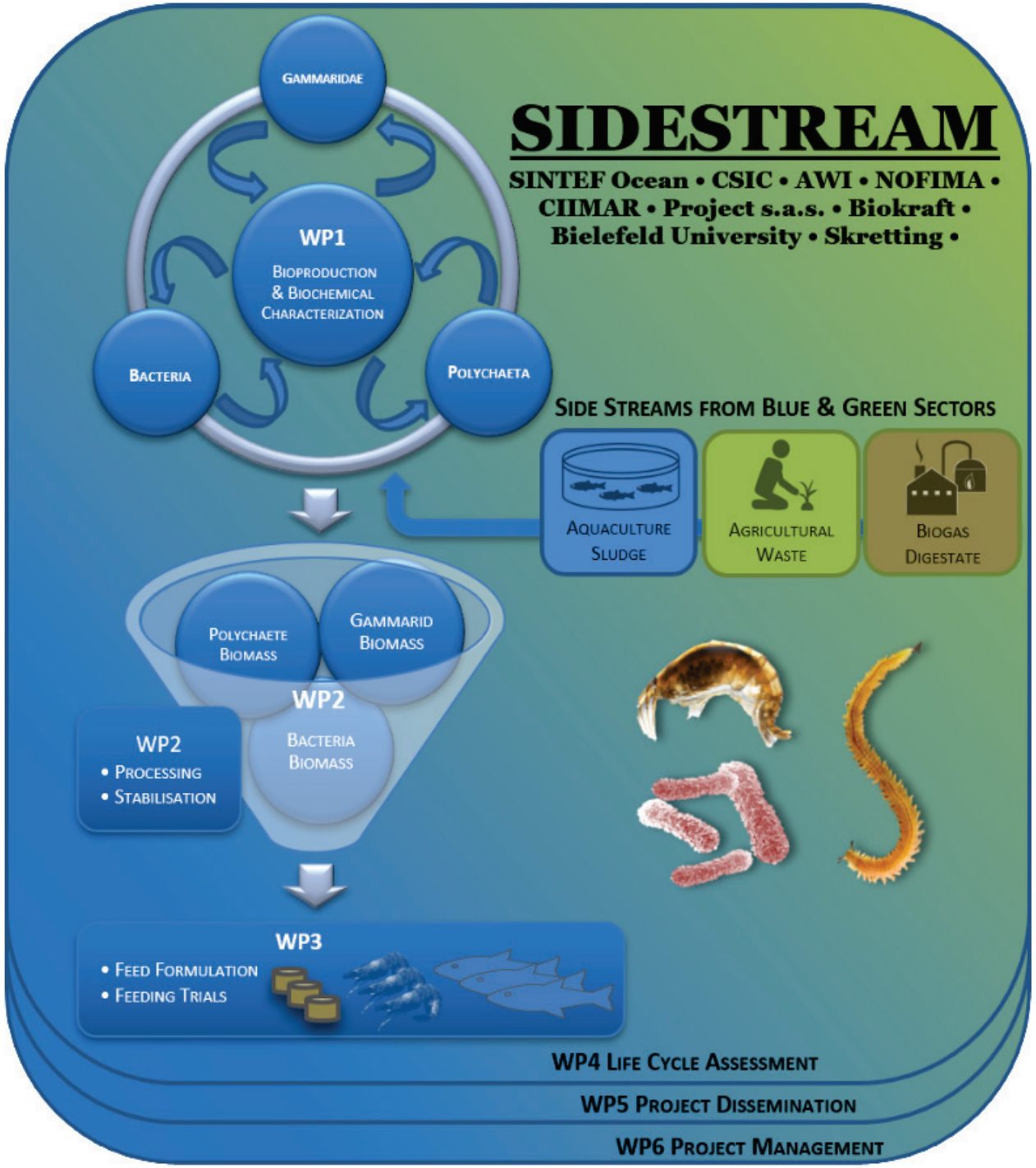


Blue BIO COFUND

New Blue
on the Bl

NOVEMBER 27, 2019

2020-2023
SIDESTREAM
20 MNOK

BLUEBIO COFUND FUNDS NINETEEN PROJECTS FOR 25 MILLION EUROS IN ITS FIRST JOINT CALL

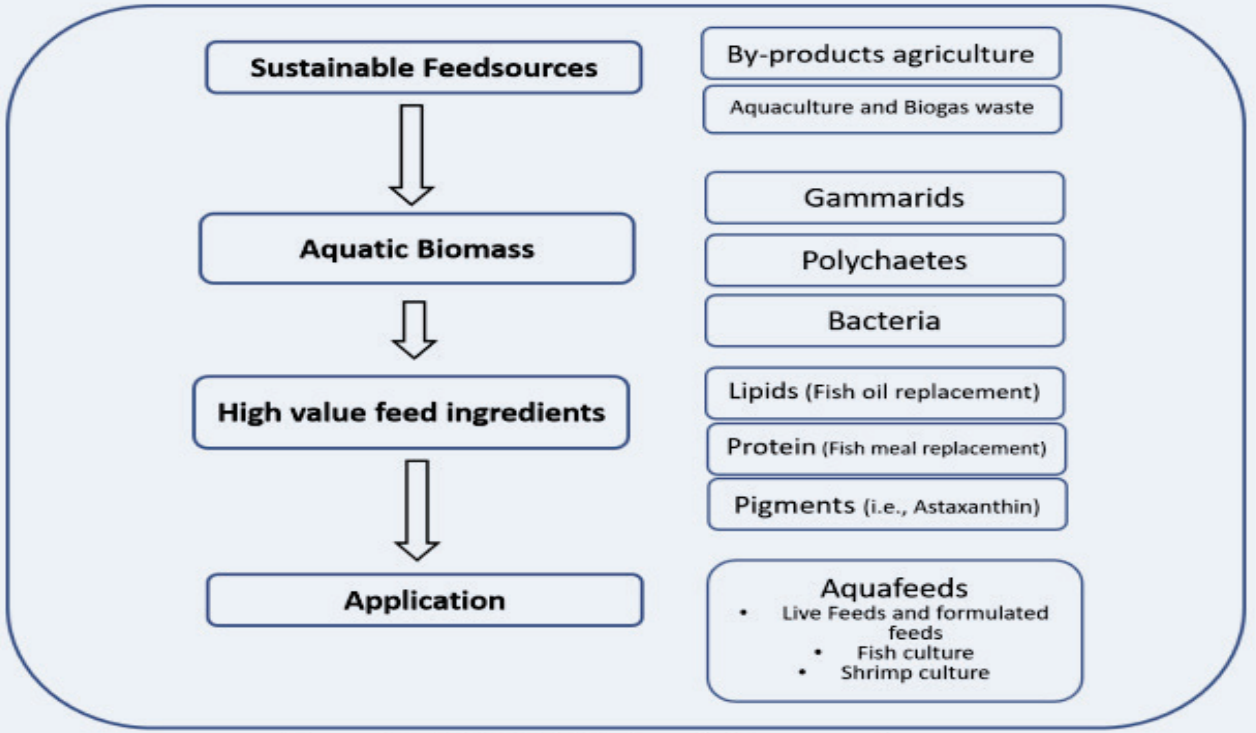
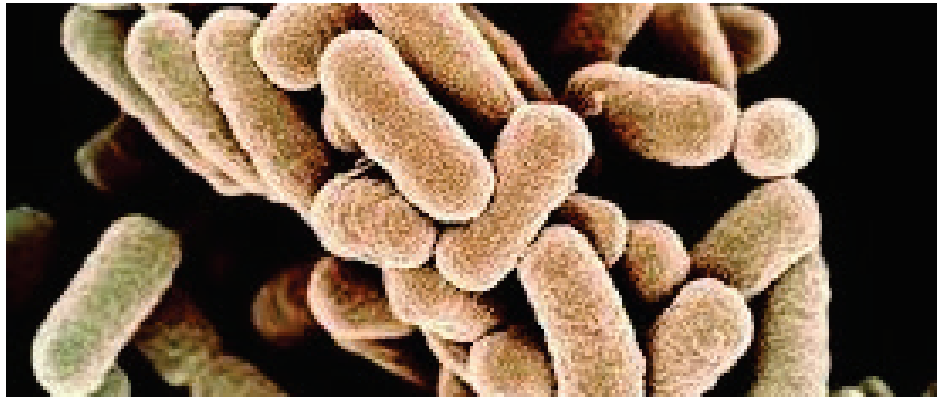
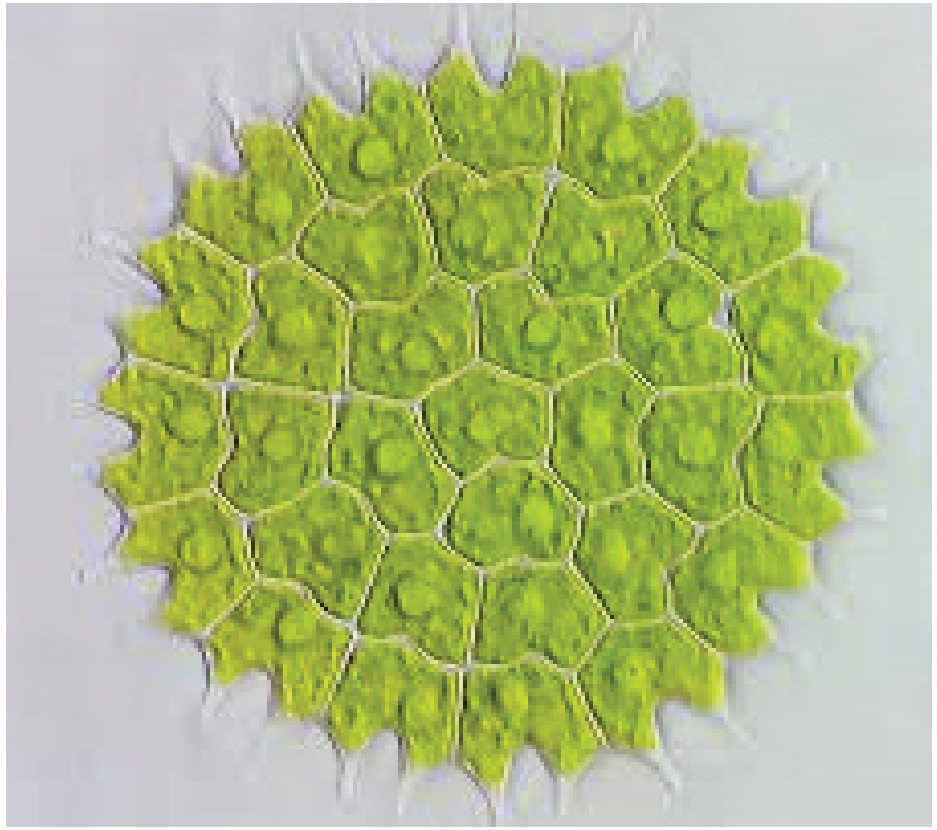
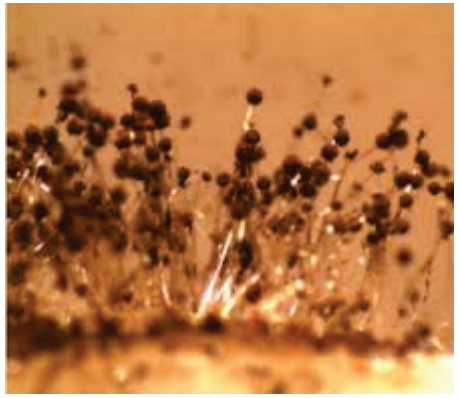


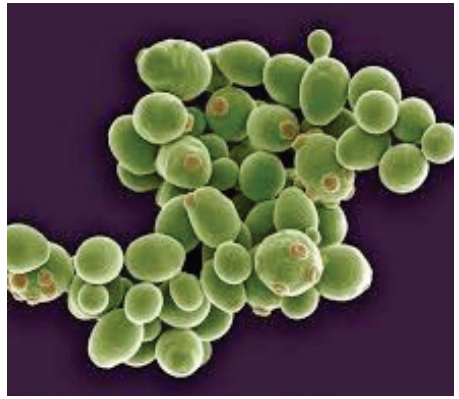
Figure 2: SIDESTREAM value chain approach

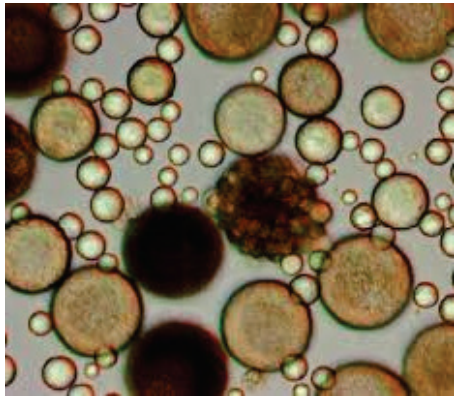
Encelleprotein
(SCP - Single Cell Protein)











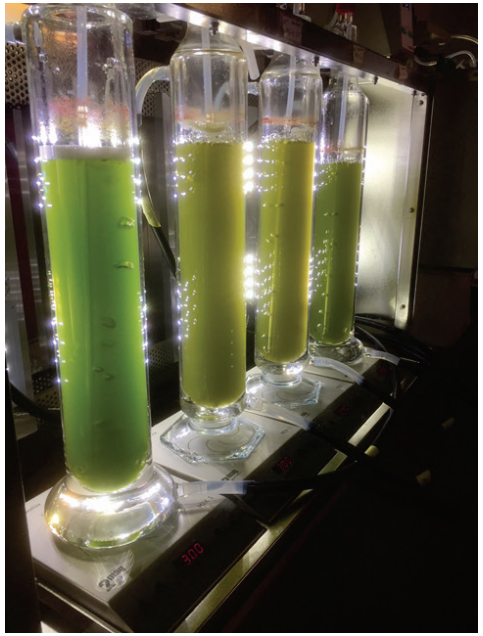
Encelleproteiner kommer fra flere ulike mikroorganismer med ulike egenskaper:

- Gjær/Mycoprotein
- Muggsopper
- Bakterier
- Mikroalger
- Thraustochytrider
- Cyanobakterier

SINTEF

Slam som råstoff i SCP-produksjon?

- God kilde til N, P, C:
  - Fast fraksjon rik på P
  - Løst fraksjon rik på N (både NH_4 og NO_3 er relevant)
- To ulike hovedprinsipp for produksjon:
  - Lysenergi og uorganisk karbon/CO2



  - Fermentering med organisk karbonkilde, uavhengig av lys

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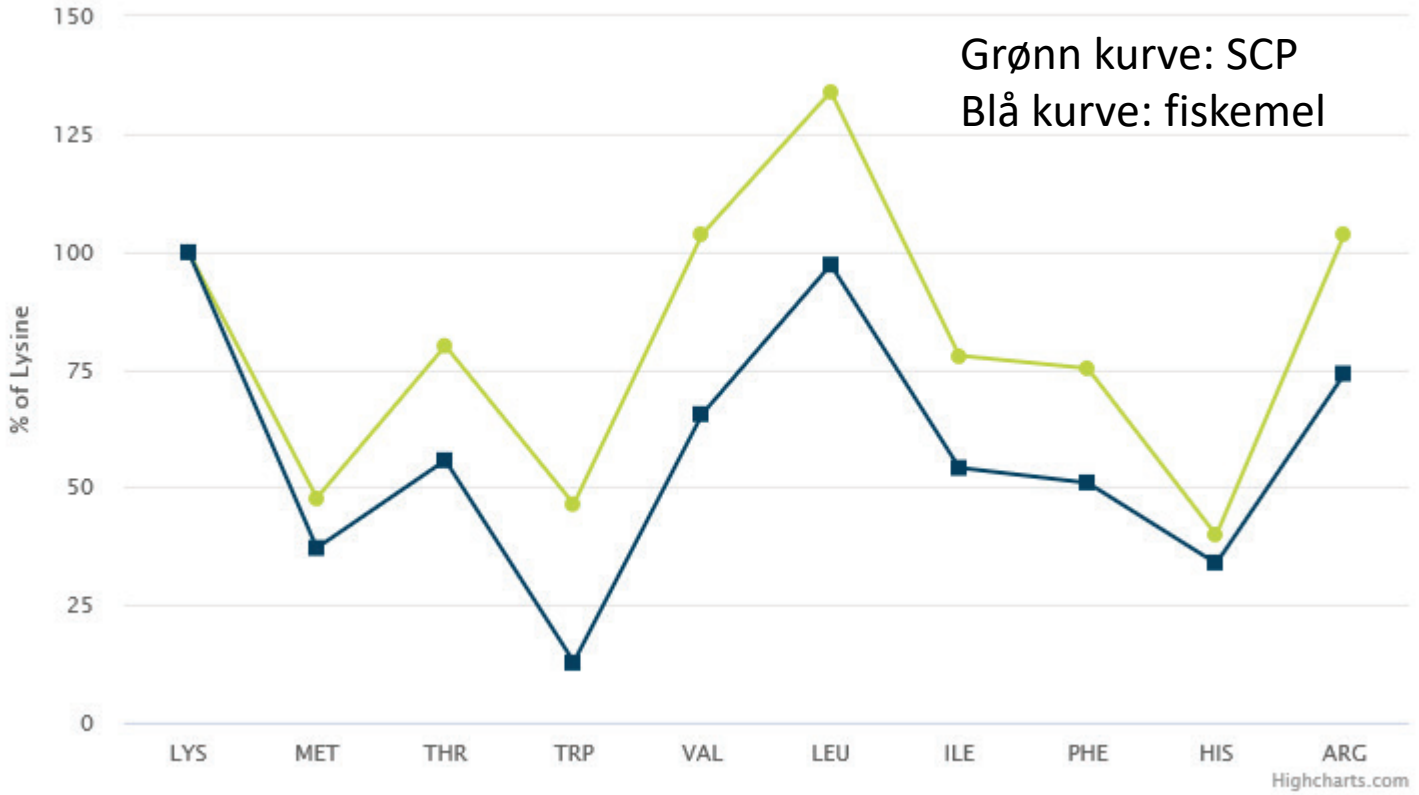
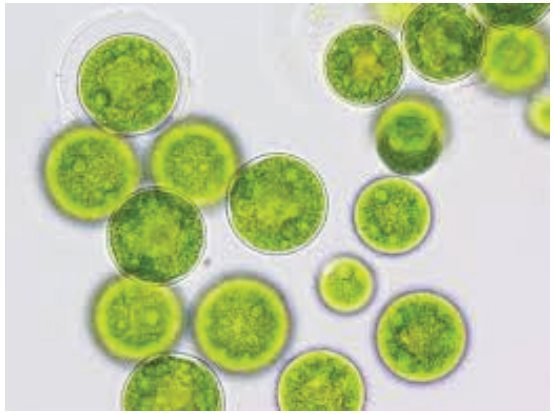
Gunstig aminosyreprofil:





https://www.unibio.dk/end-product/amino-acid-profile/

SINTEF

Oppdrett av vanlig strandsnegl (RFF-Midt # 299075)

2019 - 2022

Undersøke muligheter for helårlig intensiv oppdrett av strandsnegl

- Statsnail AS selger >40 tonn strandsnegl $år^{-1}$
- Havsalat (*Ulva lactuca)* kan produseres på avløpsvann fra marin RAS og brukes som fôr til strandsnegl

REGIONALE FORSKNINGSFOND MIDT-NORGE

StatsnailAS

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Nofitech

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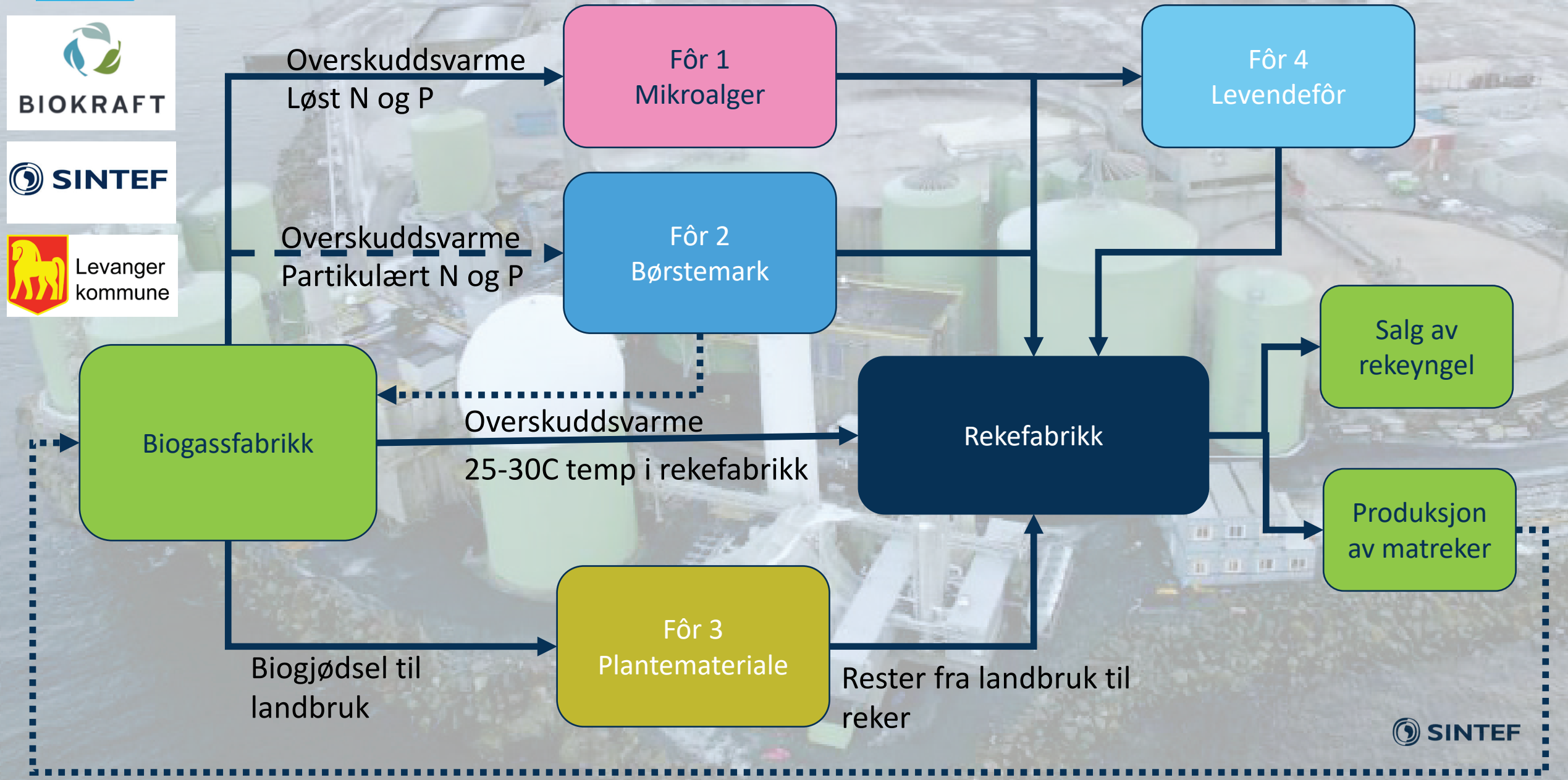
SIRKULÆR BIOPRODUKSJON AV TROPISKE REKER PÅ SKOGN



SINTEF PLANKTONLAB NTNU

The Research Council of Norway

2016-2026
NCPT
20 MNOK

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Norwegian Center for Plankton Technology