Fish International, Bremen
Feb. 26th 2018 Scope quaculture Workshop
„Shrimpszucht“

Stefan Bruns, Polyplan GmbH (D) &
Eric de Muylder, CreveTec bvba (BE):

Indoor shrimp aquaculture in Europe: feasibility, designs and experiences

- Part 1 and 3 (R&D) -

by Stefan Bruns and Christina Peppler

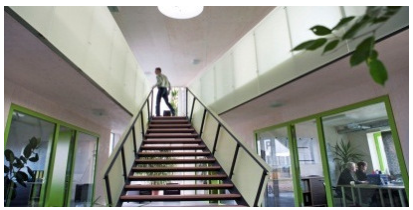
POLYPLAN Company profile (Div. environmental engineering)

Lakes and urban waters – Planning, Restoration, Monitoring

Public pools – Planning, construction, support service

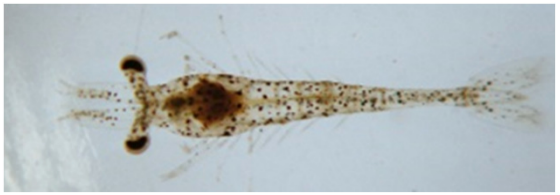
Development of systems for water treatment

Aquaculture - Indoor-Shrimpfarming



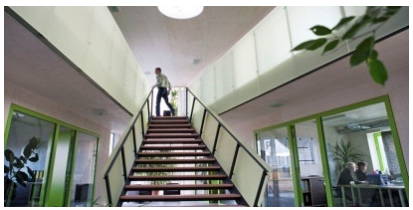
POLYPLAN

Aquaculture



Planning, support service, training and R&D

Development of RAS- and BFT-systems for indoor shrimp production



Polyplan Aquaculture Network



Mariculture Network: „Marella™“

Biology and R&D	**:**	**Polyplan GmbH** **University of Vet. Medicine Hannover Foundation** **BFT-system: CreveTec, Belgium** **RAS-system: Aquakultur Kahle**
Project development	**:**	**Polyplan GmbH** **for BFT: in cooperation with CreveTec**
Technical planning	**:**	**Polyplan GmbH**
Construction	**:**	**Polycon GmbH**
Product marketing	**:**	**„Marella Cooperative“ (in foundation)**

POLYPLAN

Polyplan experiences: Aquaculture Projects

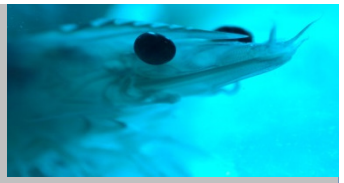
Realized and *pending* projects

RAS: Affinghausen, Garnelenhof Schäfer:	**10 t/a**
RAS: Strande, Förde Garnele (re-construction):	**3 t/a**
RAS: Zuben (CH), Mayer Shrimp:	**2 t/a**
BFT: Kassel, Damm Aquakultur:	**11 t/a**
BFT: Rottenmann (A), FDSG Bio Produktion:	**22 t/a**

Planned projects:

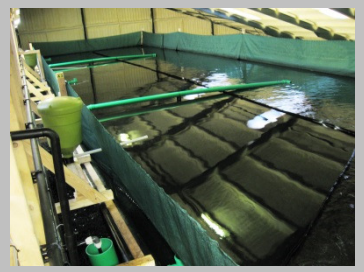
RAS: Visbeck (planning phase 1-3):	**42 t/a**
RAS: Bottrop (planning phase 1-4):	**18 t/a**
RAS: Sofia/ Ru (planning phase 1-7):	**18 t/a**
RAS: Altenstadt (planning phase 1-6):	**20 t/a**

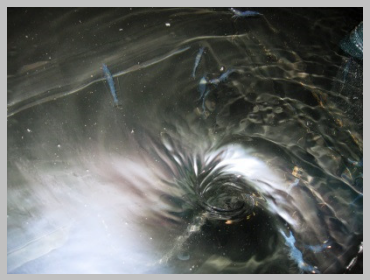
Experiences: RAS Indoor shrimp farming



2009: start of „Garnelenhof Schaefer“ (GER), 1st RAS by Polyplan

- 10 t shrimps /year in max- 500 m³, harmonized harvest schedule
- excess heat deliverd by biogas plant
- „Stacked“ raceway concept by Texas A&M, later patent no. **EP 2 429 282 B1**
- <1% water exchange/ day, at constantly low ammonia and nitrite levels
- no discharge of saltwater into municipal wastewater system
- but: vertical transfer of shrimp → risk of injuries





POLYPLAN

RAS „Garnelenhof Schäfer“

Outcome:

More than 3 years of R&D and support service -

Shortly later:

breakdown of biogas reactor

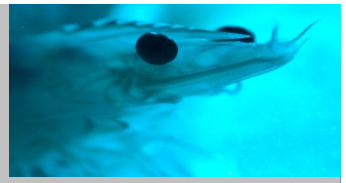
→ heat supply problems

→ economical problems

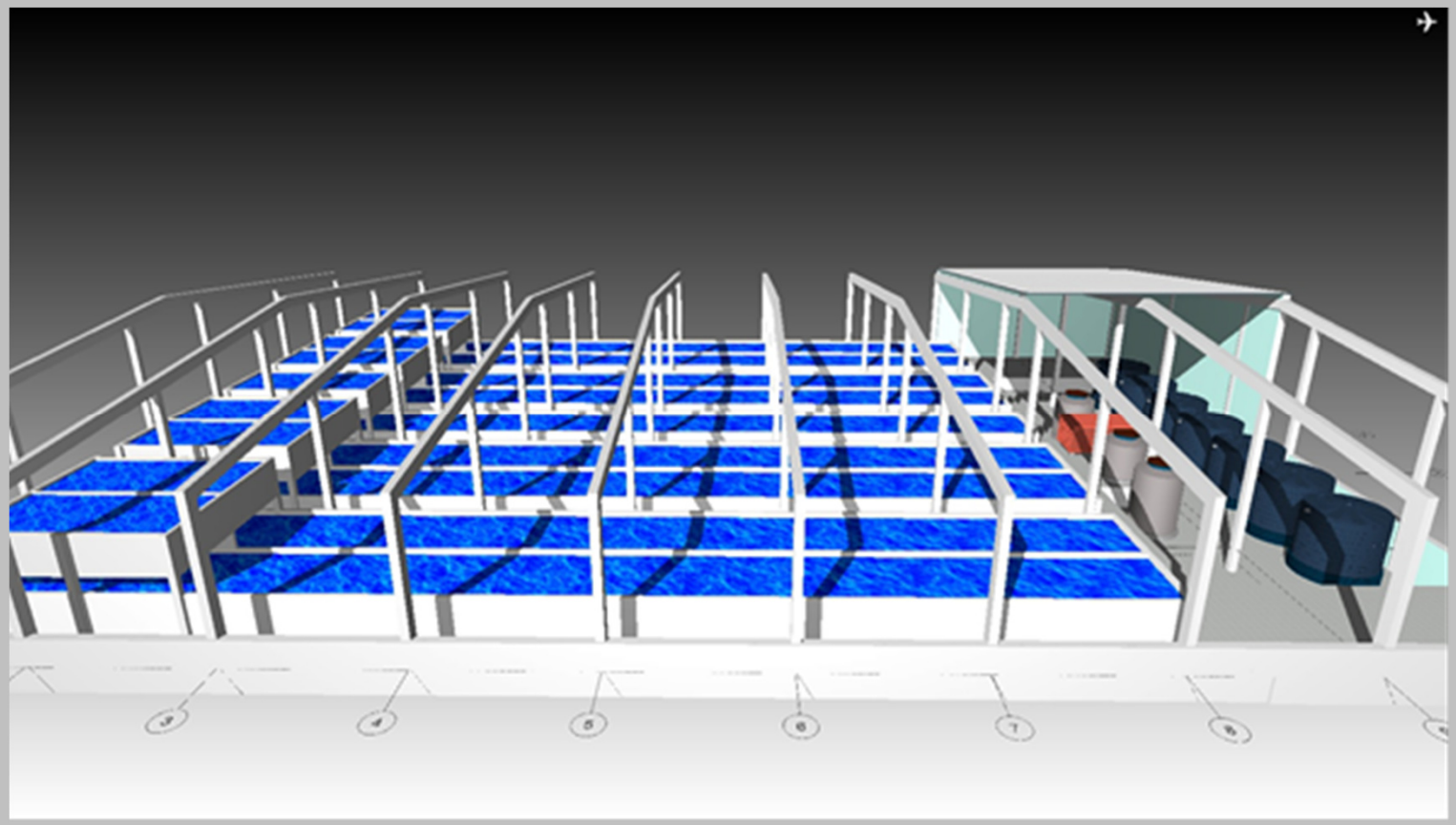
→ insolvency by end of 2013

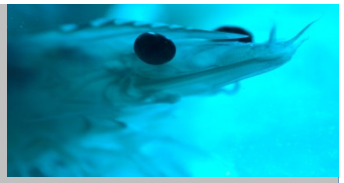
Gangway between raceways

2011: new RAS concept: one to two floor design „α-Maris“



3800 m²/ 20t yearly production, investment: approx. 2.500.000 €



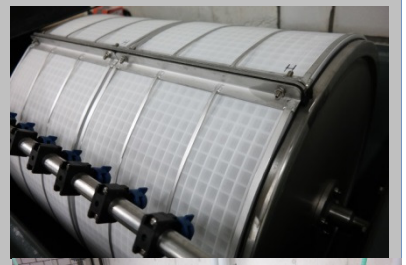


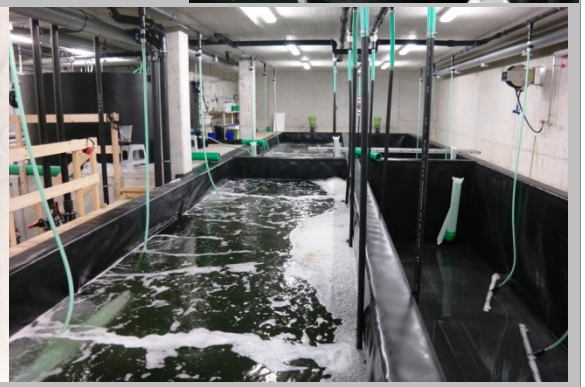
2015: start of 2nd RAS „Mayer Shrimp“

Features:

- 1,2 t in 4 grow-out tanks on 1-floor, ca. 130 m³
- Water treatment: moving bed bioreactor, drumfilter and protein skimmer
- 1st farm in Polyplan DBU-funded online database „DELTA“ (Database for European, land- and technique based Aquaculture) for exchanging data in real-time
- Thanks to Mr . Mayer‘s idea:

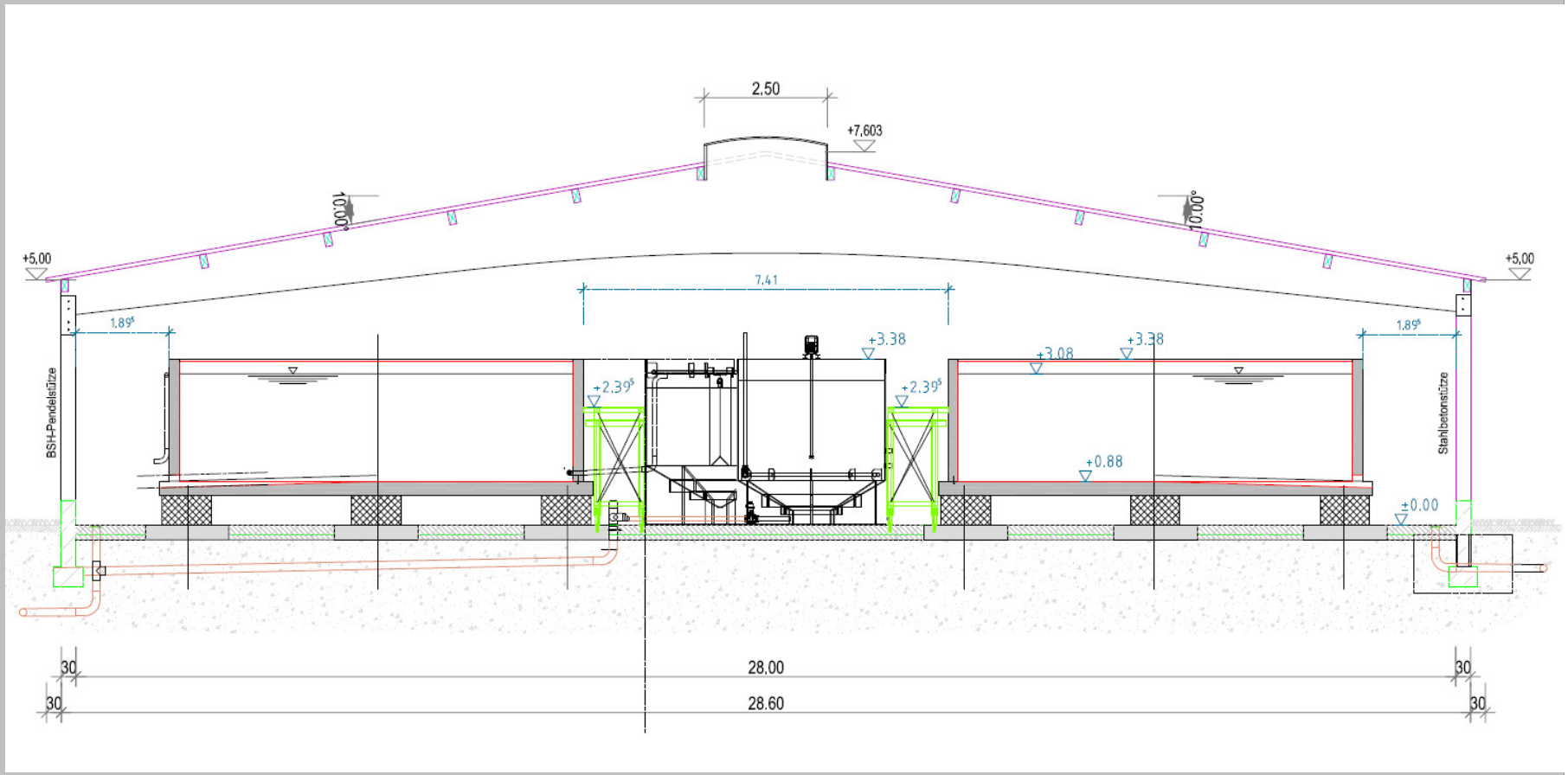
  „0“ area footprint by building appartments on top

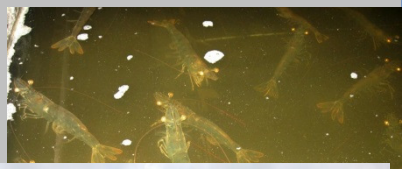




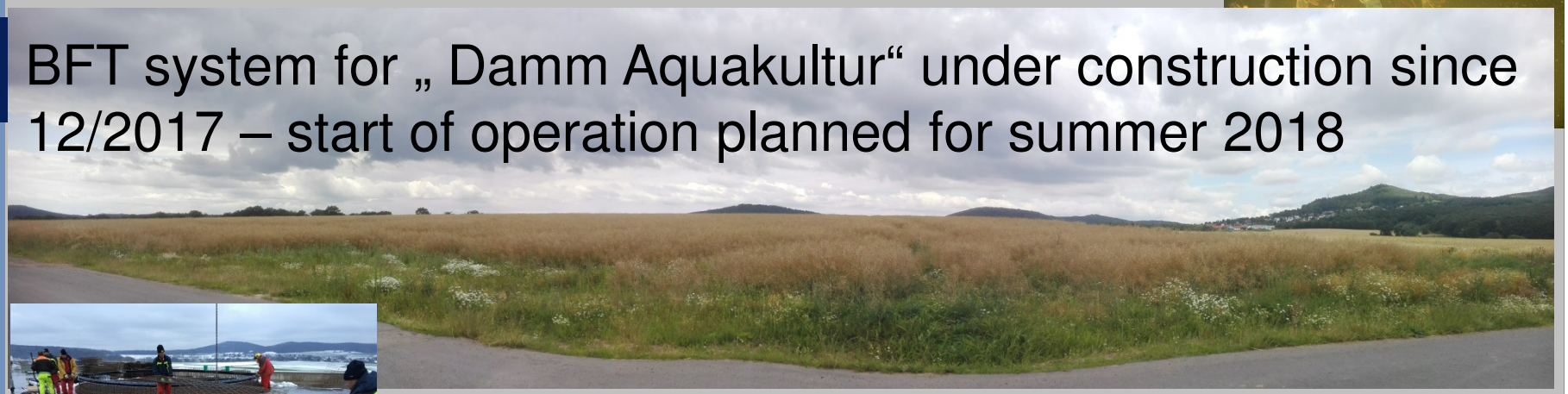
Polyplan & CreveTec cooperation in BFT systems

BFT system for „ Damm Aquakultur“ under construction since 12/2017





BFT system for „ Damm Aquakultur“ under construction since 12/2017 – start of operation planned for summer 2018



Perspectives for indoor aquaculture production in Europe

1. High-value products
2. In very high qualities
3. In environmentally friendly production
4. With low demand of proteins (protein balance)
5. With grow out time less than 1 year
6. In small production units for local markets

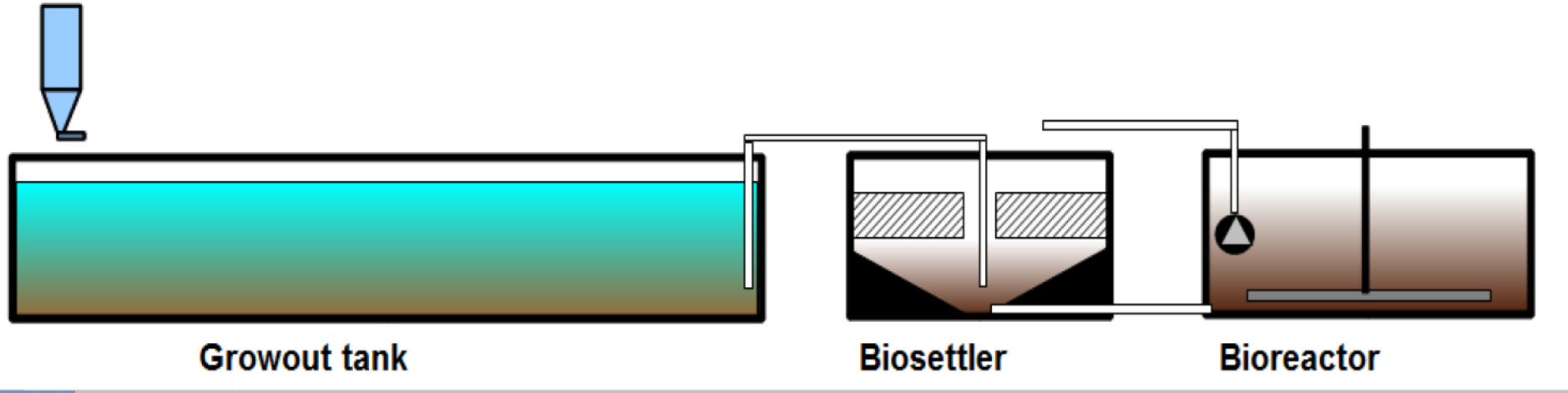
Criteria for a sustainable aquaculture production

- Low consumption of resources (water and feed, low in fish meal)
- Water treatment system allowing least possible wastewater disposal
- Simple, sound and energy saving technique
- Options for polyculture implementation (enhancing Nitrogen efficiency)

POLYPLAN

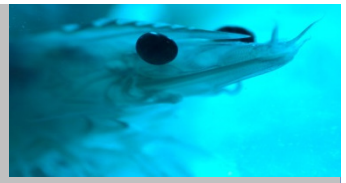
Biofloc versus RAS: technical aspects

The concept and design „β-MARIS“ is based on the CreveTope-Biofloc technology, developed by our cooperation partner Eric de Muylder, company „Crevetec“, Belgium

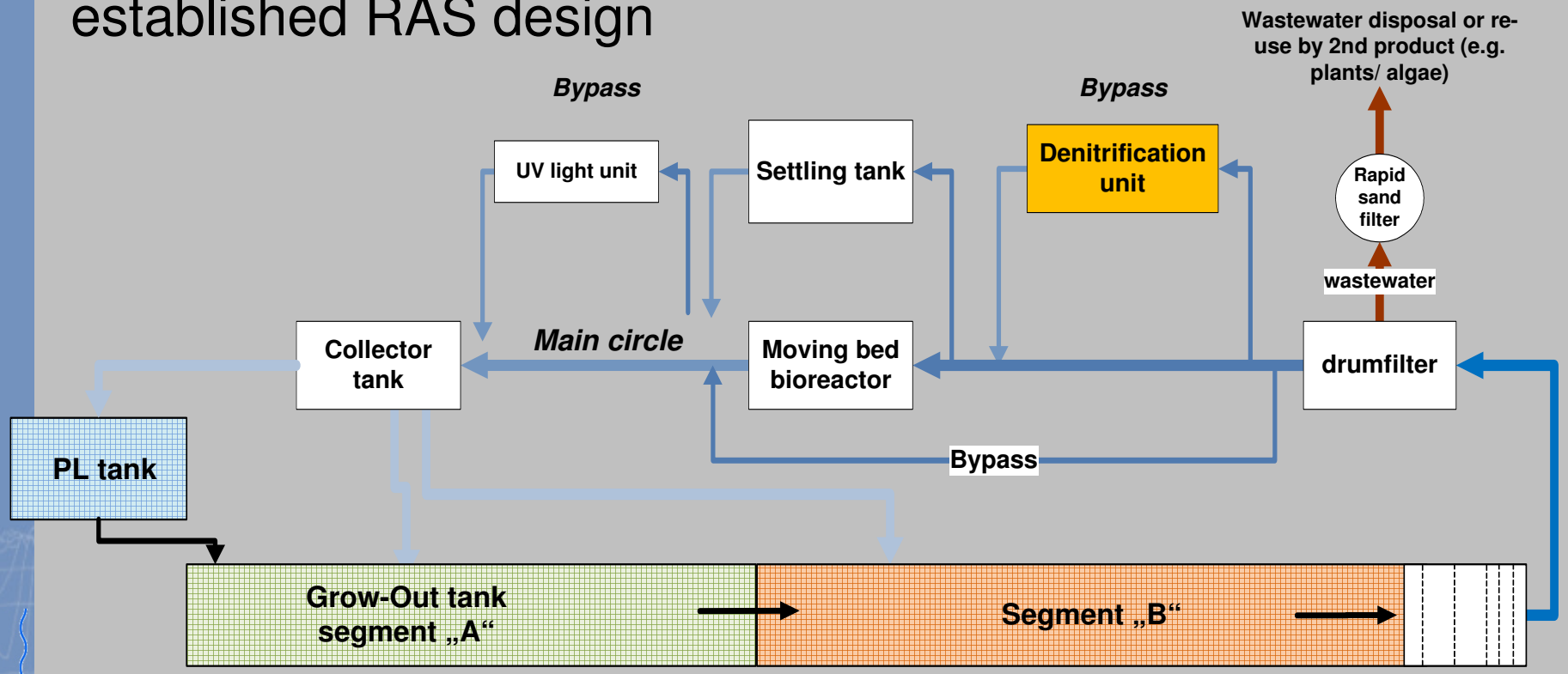


Three main units:

1. Husbandry with Grow-Out and (separate) PL-Nursery in round tanks of high volume
2. Sedimentation
3. Bioreactor, functioning as a denitrification unit



The concept and design „α-MARIS“ is complying with the established RAS design



Main difference to BFT design:

- requires daily water renewal, in minimum ca. 1%/day
- Raceways rectangular shaped
- Drumfilter for clearer water
- Bioreactor plus denitrification unit

Biofloc versus RAS (*R*ecirculating *A*quaculture *S*ystem)

System	Positive aspects	Negative aspects
α-Maris (RAS)	Flexible, thanks to high volume flows → **Fish production feasible**	Higher energy demand by higher pump power
	Higher level of automatization → **easing operation**	Higher technical maintenance effort, higher investment for equipment
	Less complex system, more safety by option to exchange water → **less effort for monitoring and training**	Need for wastewater disposal, higher operational costs (salt + water), determining choice of location
β-Maris (Biofloc)	**Almost „0“ water exchange** → lower costs (salt + water), free choice of location, reduced environmental impact	higher effort for monitoring (e.g. ion balances) and training/ higher level of education required for control of complex biology
	Lower volume flow, less pump power required → **reduced consumption of electrical power**	Lower flexibiity regarding product of aquaculture: fish is no option
	Better food conversion, enhanced immune system by consumption of bioflocs → reduced feed costs, higher vitality, growth and survival of shrimp	

POLYPLAN

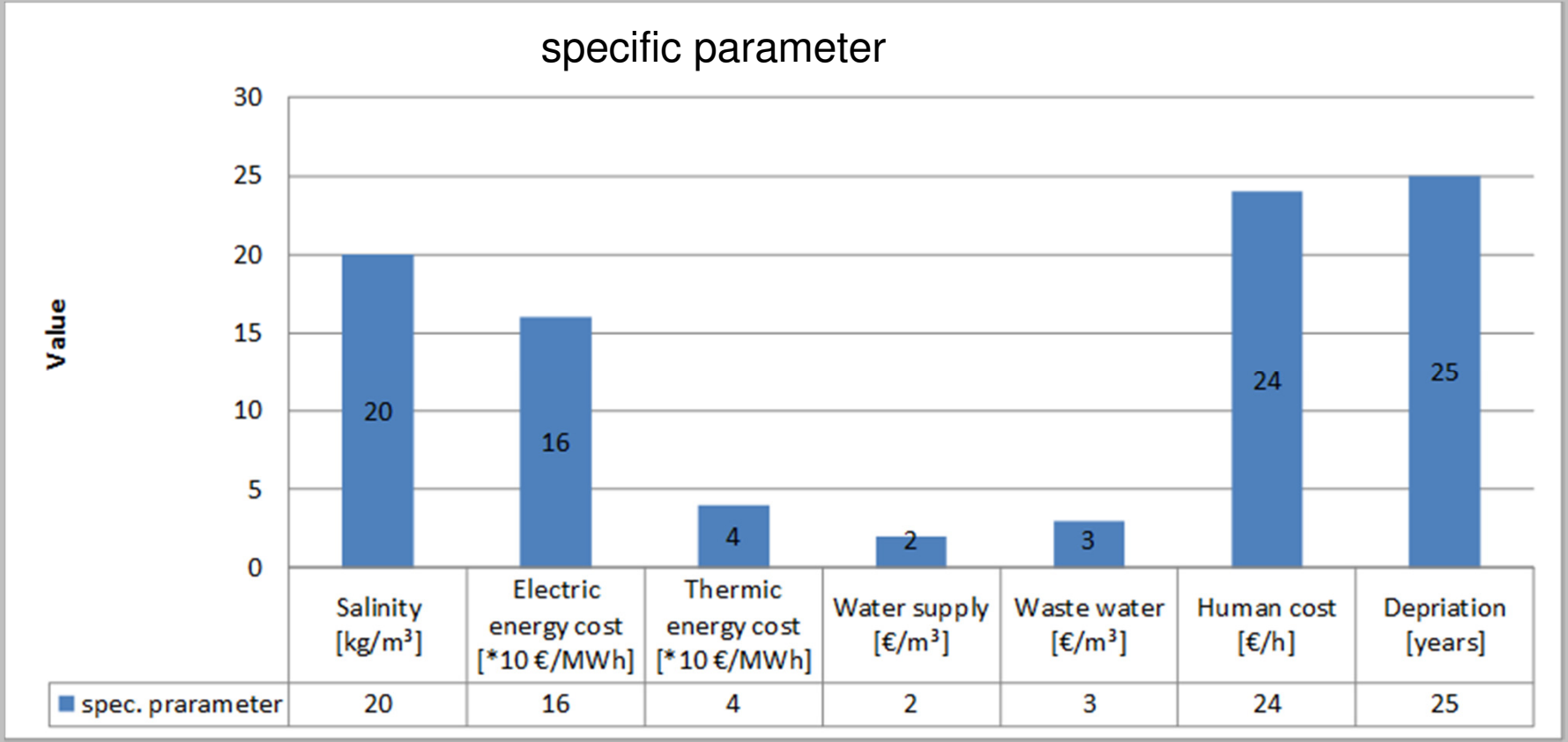
Biofloc versus RAS: financial aspects

versus

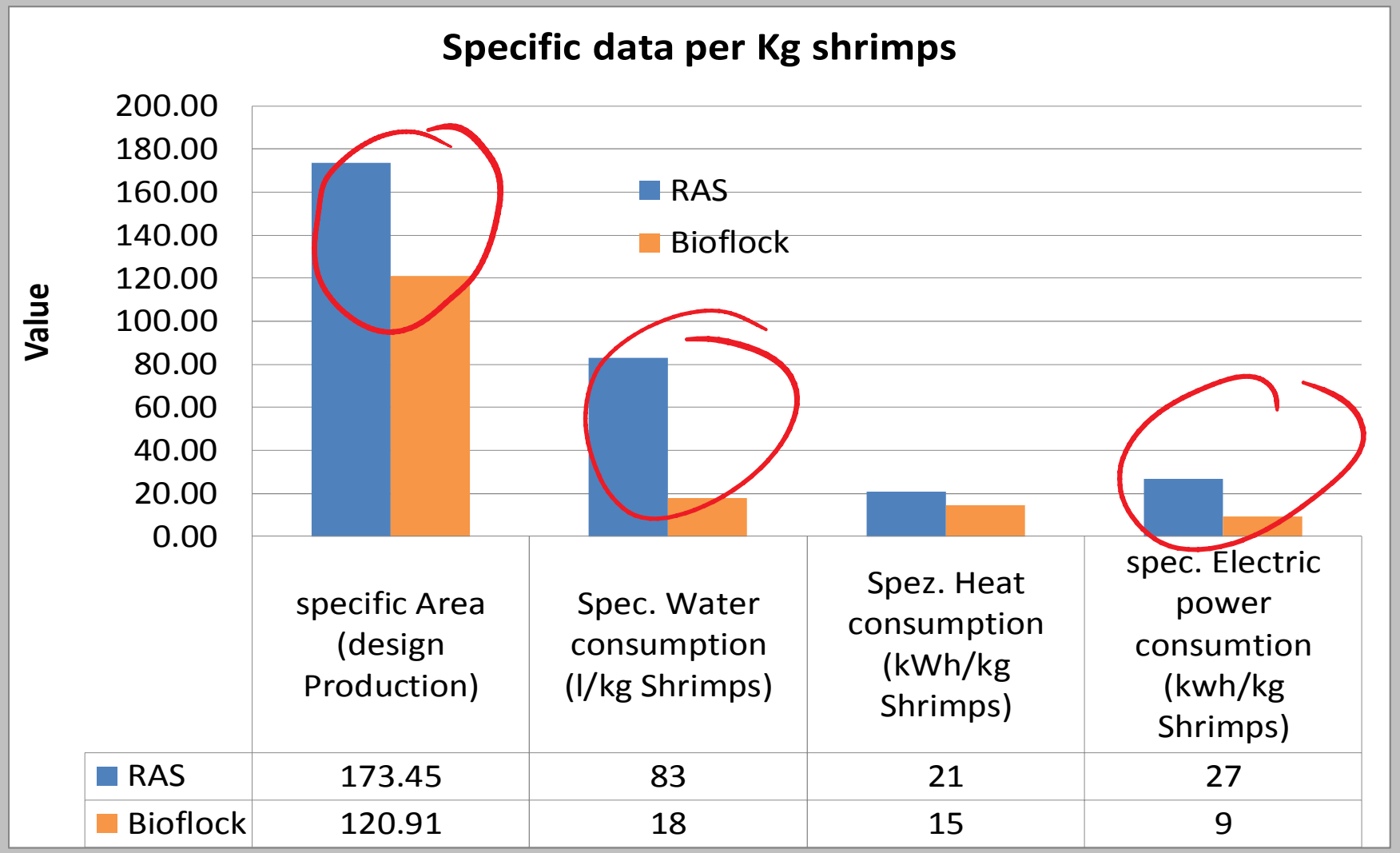
POLYPLAN

Biofloc versus RAS: financial aspects

Costs

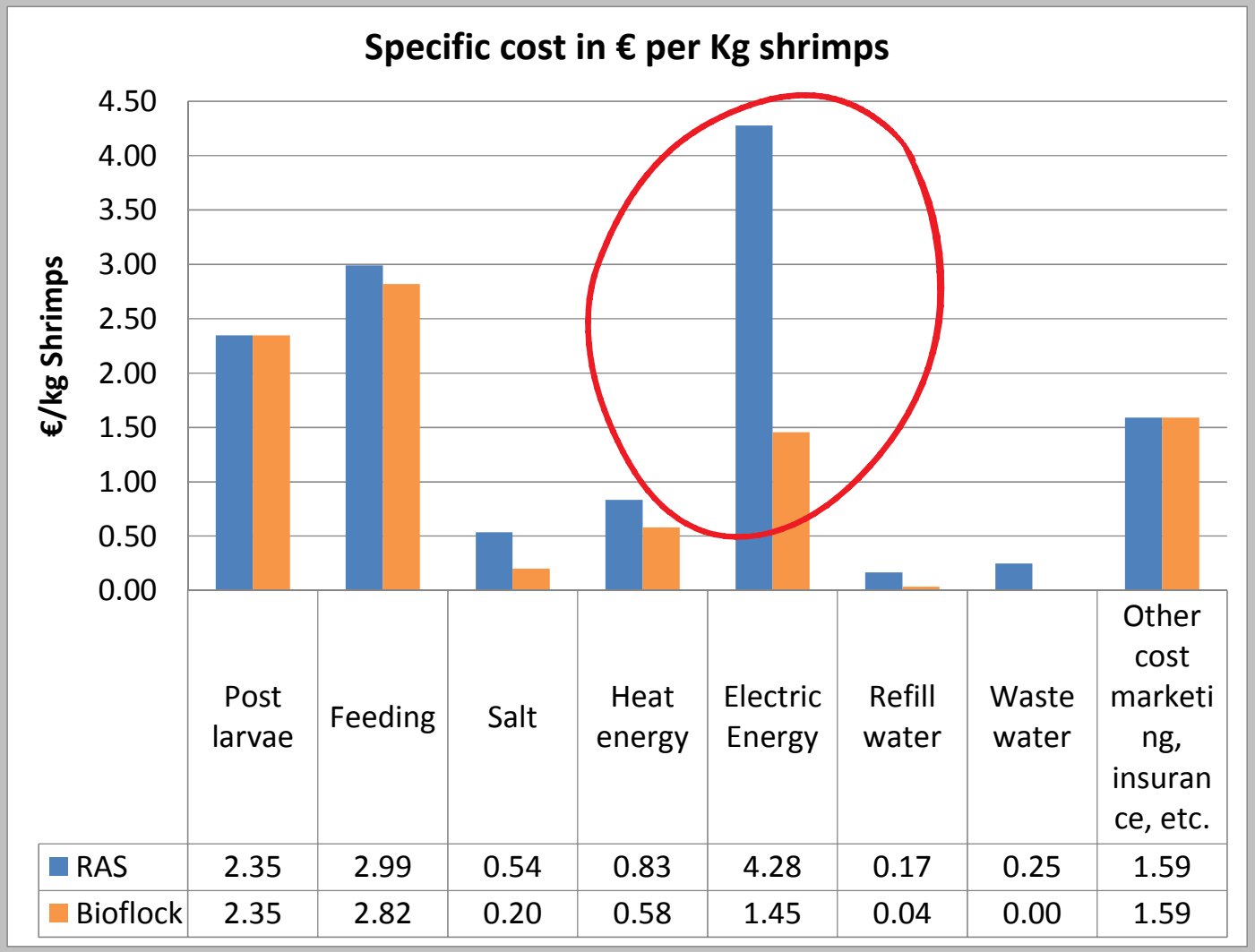


Consumptions



	specific Area (design Production)	Spec. Water consumption (l/kg Shrimps)	Spez. Heat consumption (kWh/kg Shrimps)	spec. Electric power consumtion (kwh/kg Shrimps)
RAS	173.45	83	21	27
Bioflock	120.91	18	15	9

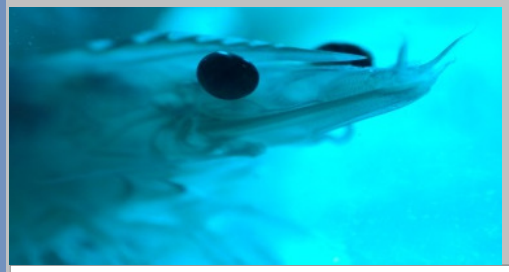
Production costs



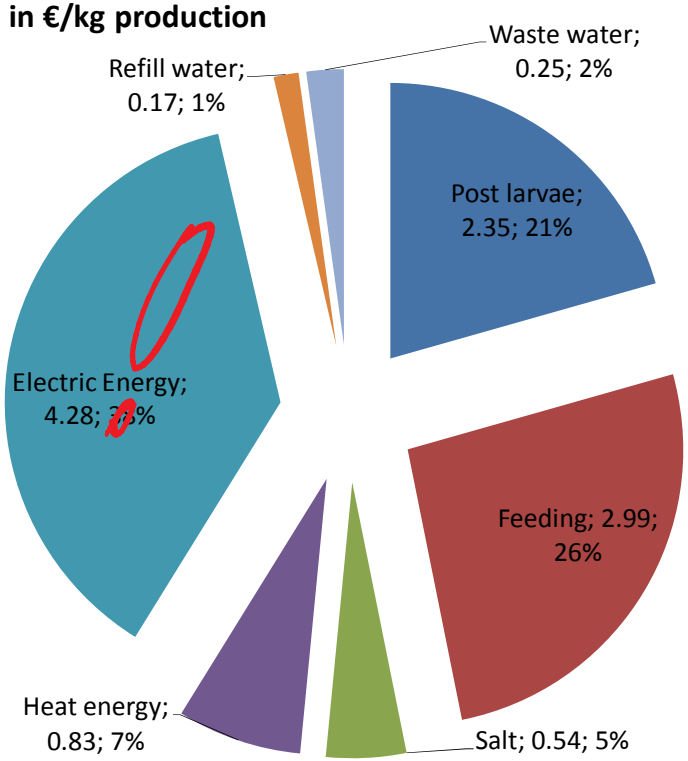
	Post larvae	Feeding	Salt	Heat energy	Electric Energy	Refill water	Waste water	Other cost marketing, insurance, etc.
RAS	2.35	2.99	0.54	0.83	4.28	0.17	0.25	1.59
Bioflock	2.35	2.82	0.20	0.58	1.45	0.04	0.00	1.59

Biofloc versus RAS: financial aspects

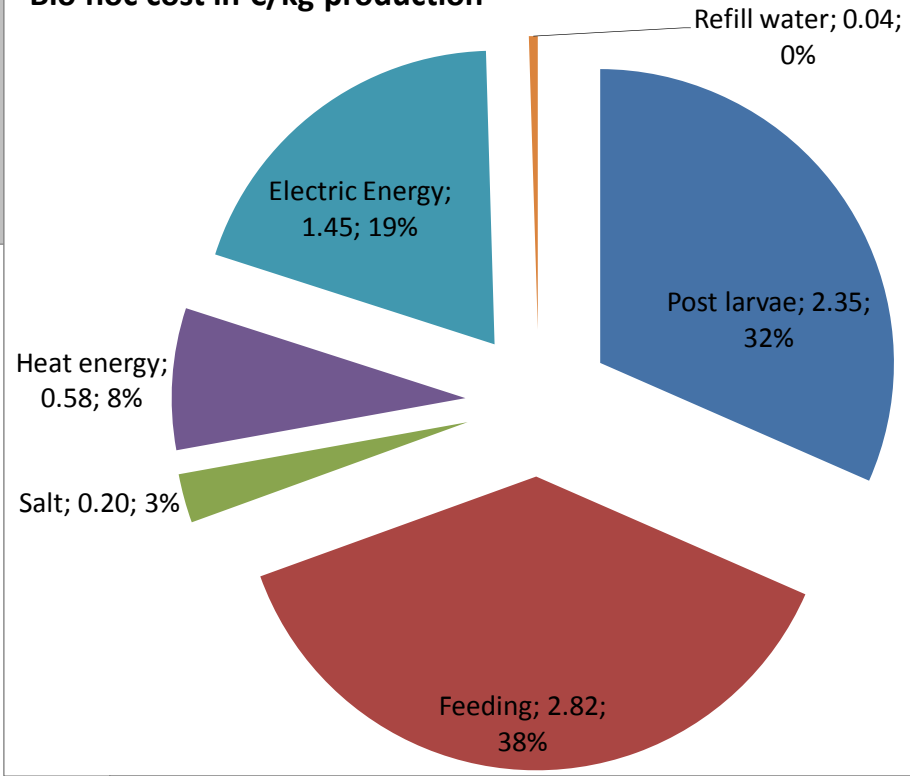
Relation of production costs



RAS: Cost in €/kg production

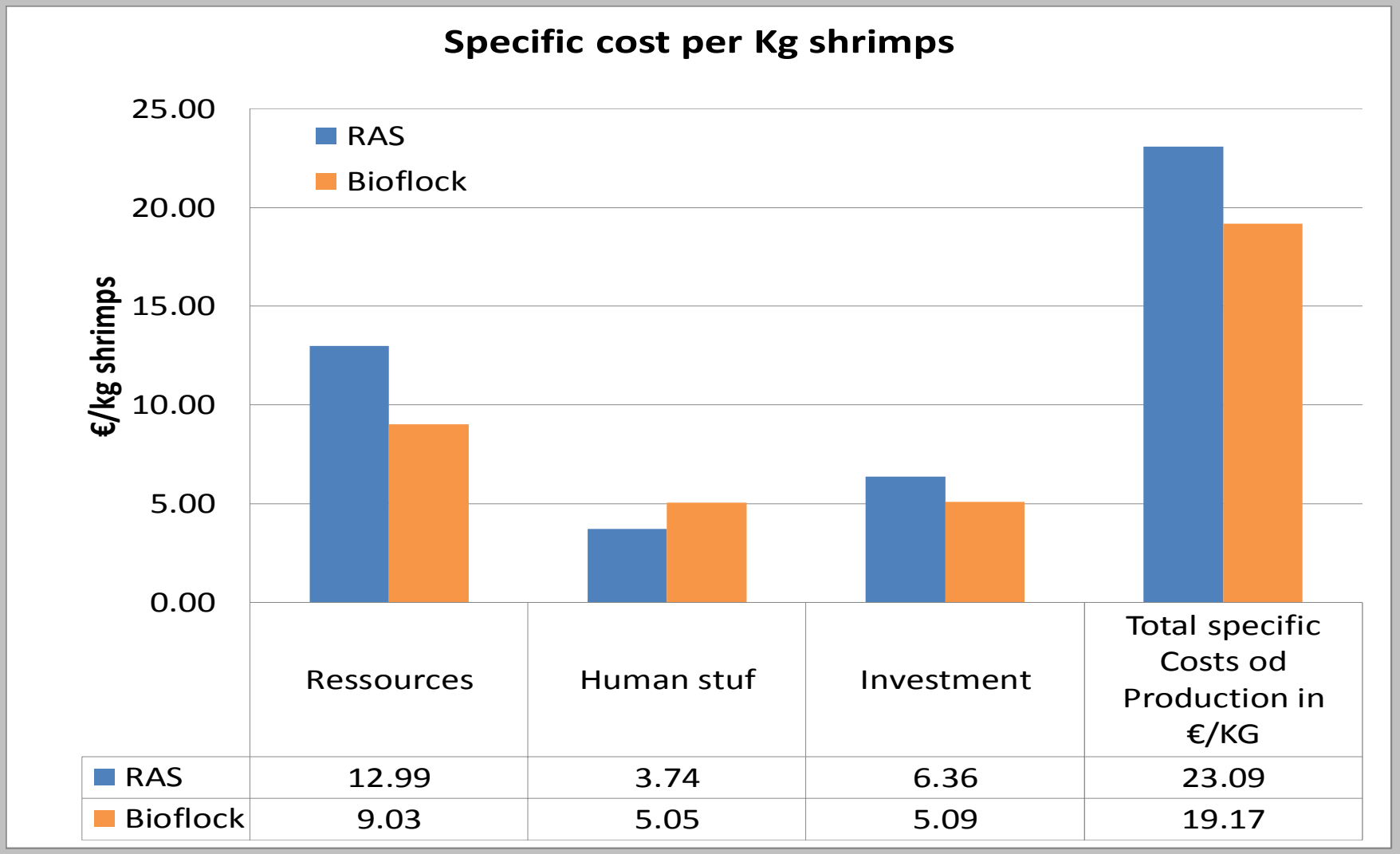


Bio floc cost in €/kg production



POLYPLAN

Production cost per kg shrimps (30g/pcs)



	Ressources	Human stuf	Investment	Total specific Costs od Production in €/KG
RAS	12.99	3.74	6.36	23.09
Bioflock	9.03	5.05	5.09	19.17

Ecological and economical comparison between RAS and Biofloc (22 to yearly production) - Results

Biofloc system has a better ecological finger print:

Electric consumption is 1/3 of the RAS System

Water consumption ¼ of the RAS System

The production cost of 1 kg shrimps in a Biofloc system is approx. 20% lower than in the RAS system

This difference is mostly due to the higher energy consumption of the RAS production

POLYPLAN

Resulting focuses for improvements

Quality of post larvae: improve the survival rate

Quality of end product: options for regulation

Direct marketing solutions

Cooperation among operator – marketing – designer

Biofloc versus RAS: outlook

Resulting focuses for improvements

Biofloc system

- Automatization for saving human resources
- Solutions for re-use of sludge

RAS system:

- Reducing the energy demands (high efficiency pumps etc.)
- Reducing the filtration rate by e.g. using ultra membrane technology in a bypass circulation
- Reducing water levels and work with more shallow basins in more floors to reduce the specific investment costs

POLYPLAN

Polyplan GmbH
Überseetor 14
28217 Bremen

Stefan Bruns
Tel.: 0421-17876-10
info@polyplan-gmbh.de
www.polyplan-gmbh.de

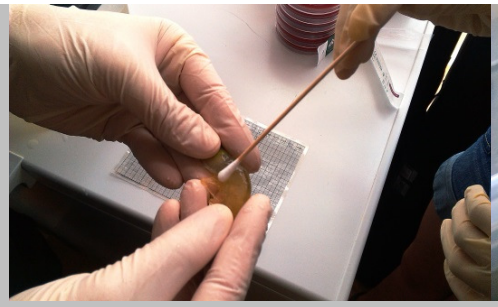
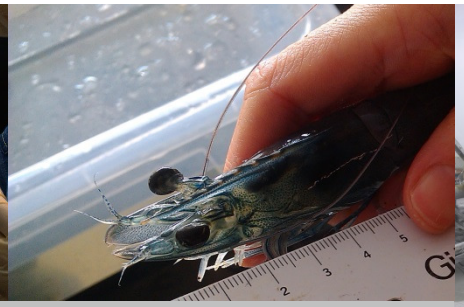
Fish International, Bremen
Feb. 26th 2018 Scope quaculture Workshop „Shrimpszucht“

Stefan Bruns, Polyplan GmbH (D) &
Eric de Muylder, CreveTec bvba (BE):
Indoor shrimp aquaculture in Europe: feasibility, designs and experiences

- Part 3 on R&D - by Christina Peppler

POLYPLAN

Polyplan Aquaculture Network


Recent cooperation partners in R&D:

Research institutes:

- **Hochschule Bremerhaven (Applied University Bremerhaven - Molecular Genetics and Biotechnology) -** https://www.hs-bremerhaven.de/start
- **ttz Bremerhaven (technology transfer center) -** http://www.ttz-bremerhaven.de/en/
- **University of Vet. Medicine Hannover Foundation -** https://www.tiho-hannover.de/

Companies:

- **Ratz Aqua & Polymer Technik GmbH & Co. KG -** http://www.ratz-aqua-polymertechnik.de/
- **LagoTec GmbH -** http://www.lagotec.de/
- **KOWITEC Ingenieurgesellschaft für Wassertechnik mbH -** http://kowitec.de/?babel=en&pg=

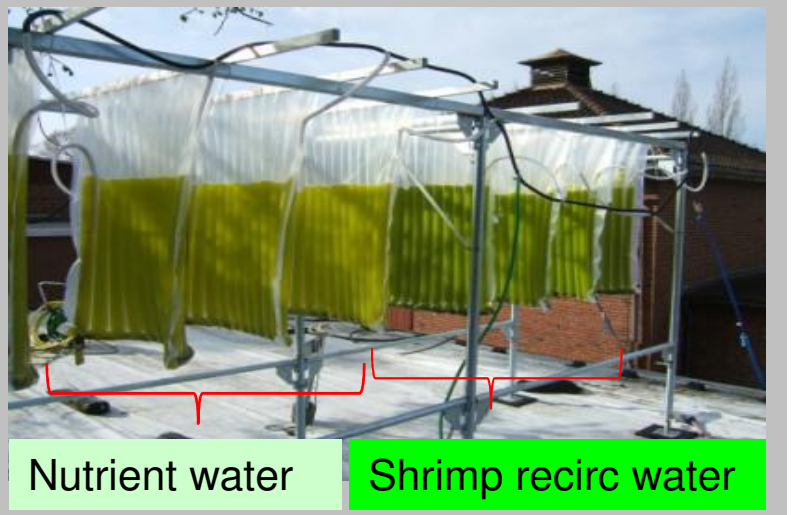
POLYPLAN

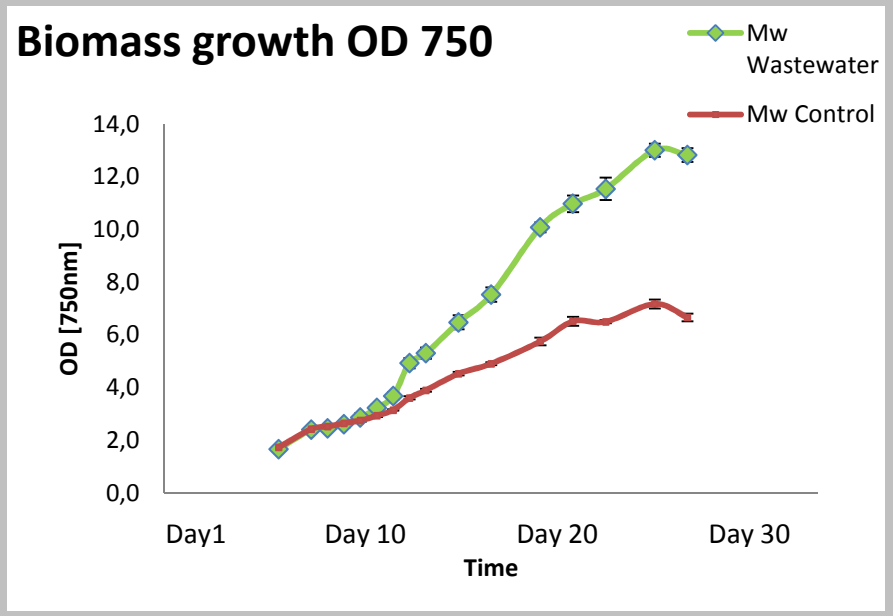
Gefördert durch:
Bundesministerium für Wirtschaft und Energie
aufgrund eines Beschlusses des Deutschen Bundestages

„SaBinA Shrimps“ – Inland Saltwater RAS using waste heat for producing shrimp (*funded by BMWI Germany, code: KU2197801FO9)*

Algae: different species consumable by shrimp (Diatomeen, Tetraselmis) – still: algae culture is labour~ and cost intensive, with high hygienic requirements

→ **Application mostly restricted to hatcheries**





Trial with company Phytolutions GmbH (Bremen):
Tetraselmis growth in nutrient water versus in water of shrimp recirc system („Garnelenhof Schäfer“). Results: algae growth enhanced in „shrimp recirc water“

R&D projects

Gefördert durch:
Bundesministerium für Wirtschaft und Energie
aufgrund eines Beschlusses des Deutschen Bundestages

„INNO-PROBE“- development of an innovative sample-taking tool for specified test pieces exposed in pipelines for assessing their inner surface during operation, and for analysis of sedimented matter, corrosion and microbiological contaminats in biofilms -

(funded by BMWI Germany; code: KF2763703SAS3; period: 1.6.2014 bis 30.5.2016

Partners and their main tasks:

- Hochschule Bremerhaven (test pieces and new analytical procedures)
- LagoTec (test piece surfaces & new device, based on patent DE102011014842A1)
- KowiTec (test pieces for and verification in paper industry & power plants)
- Polyplan (test pieces for and verification in RAS, lab scale + commercial, & in public pools)

Outcome: new instrument named „DepoTrap“

- the new tool and test pieces were successfully applied in all fields, with reproducable results for all tested parameters
- offers a new quality control of pipelines susceptible to biofilm formation and allows to predict potential pathogens
- *More information at:*

http://www.lagotec.de/depotrap.html

POLYPLAN

R&D projects

„KoMARe“ – about the control of microbiology in RAS for safeguarding a stunainable production of shrimp

- *Funded by The DBU (Deutsche Bundesstiftung Umwelt/ German Federal Environmental Foundation*), code: Az 30575-23

Period: 26.07.2013 - 25.01.2016

In cooperation with University of Veterinary Medicine Hannover, Foundation (Stiftung tierärztliche Hochschule Hannover)

gefördert durch

DBU

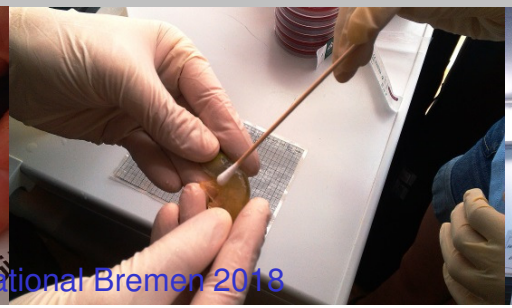
Deutsche Bundesstiftung Umwelt

www.dbu.de

Outcome:

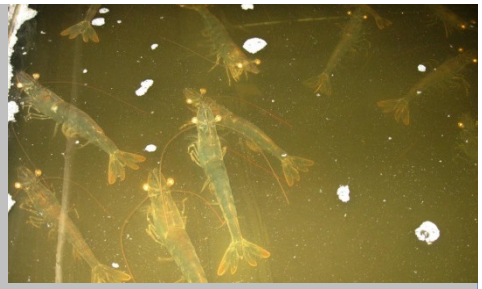
1. In 5 laboratory trials hygienization by UV light or Ozone did not constantly result in better chemical and microbiological water quality compared to a **stable aquatic environment** – a more important tool for the targetted control of the microbiology
2. New online database implemented in a commercial RAS for data input, -transfer and –evaluation, titled: **„DeltA“** Database for European, land- and technology based aquaculture systems

– easing communication of operator and support service



POLYPLAN

R&D: new project with TiHo



Development of a sustainable, nitrogen efficient and animal welfare addressing indoor shrimp production based on Biofloc technology (BFT)

Main objectives:

a. To reduce the use of resources and verify key figures (feed, water, salt, energy)

b. To gain deeper understanding of the complex interactions of biofloc quality and composition (microorganisms and meiofauna), water quality, and shrimp performance – for defining control options

c. To support animal welfare in shrimp farming, by reducing stress during culture and at harvest

d. To develop and implement operational and technical solutions for achieving these goals

e. To adapt and implement our database DeltA for use in BFT farms, assisting in the relevant data evaluations

POLYPLAN

R&D: future subjects - by different authors

- Documentation of **resource efficiency** of different production methods on farm level for a sound basis for marketing sustainably produced shrimp (Boyd et al. 2015)
- **Variable physical properties (size) and nutritional composition of bioflocs** in different culture phases and from different commercial BFT farms for further reducing feed input (Avnimelech 2015; Ekasari et al. 2014)
- Proper and longterm functioning of the **water treatment** in BFT systems at longer periods of „0“ water renewal (da Silva 2013); e.g. accumulation and depletion of selected ions (Samocha et al. 2017)
- Better knowledge of the **ecology in BFT systems** for managing the microbial community of these systems (Bentzon-Tilla et al. 2016, Avnimelech 2015), for optimizing their essential functions in support of water quality, shrimp vitality and health (Cardona et al. 2016)
- The **mode of action of bioflocs** regarding positive effects on growth and animal health, e.g. by detailing the amino acid and fatty acid composition (Daniel and Nageswari 2017), or by specifying the accumulation of the microbial storage product PHB[1] in bioflocs (Avnimelech 2015)
- Supplementation of **probiotics in BFT** (positive findings in field trials in India; Daniel and Nageswari 2017)

POLYPLAN

[1] poly-b-hydroxybutyrate

R&D: future subjects – by Samocha et al. (2017)

Development needs in disease prevention and minimization

- prebiotics and probiotics designed to control specific bacterial and fungal diseases
- fast-growth breeding lines of shrimp, performing well under crowded conditions and being resistant to pathogenic *Vibrio* and other bacteria

Questions related to waste disposal (cost and potential environmental issue)

- Refined techniques for treating and safely reusing waste, to improve system sustainability and biosecurity
- Alternative uses for solid waste, such as soil amendments and feed additives
- More efficient feeds and feeding strategies optimizing growth and reducing solids production will limit waste disposal needs

General shrimp performance

- Establish transfer and harvest protocols to minimize shrimp stress and losses
- Develop reliable and cost effective methods to estimate the shrimp population in culture tanks

POLYPLAN

Another project: „BioGaLa“ on a constant Artemia culture for constant Naupliie harvest in hatcheries

Another trial: feeding algae (Tetraselmis) to shrimp PL

R&D projects

Gefördert durch:

Bundesministerium für Wirtschaft und Energie

aufgrund eines Beschlusses des Deutschen Bundestages

„BioGaLa“: development of a procedure for feeding shrimp larvae based on a continuous culture of live feed, complying with the EU organic standards (shrimp species: *Litopenaues vannamei*) – (*funded by BMWI Germany; code 16KN019926; 1.5.2014 – 31.10.2016)*

Partners: ttz Bremerhaven (new MBR technology) and Ratz Aquakultur & Polymer Technik (new culture technology), Polyplan (new culture operation & protocols)

Obstacles and outcome:

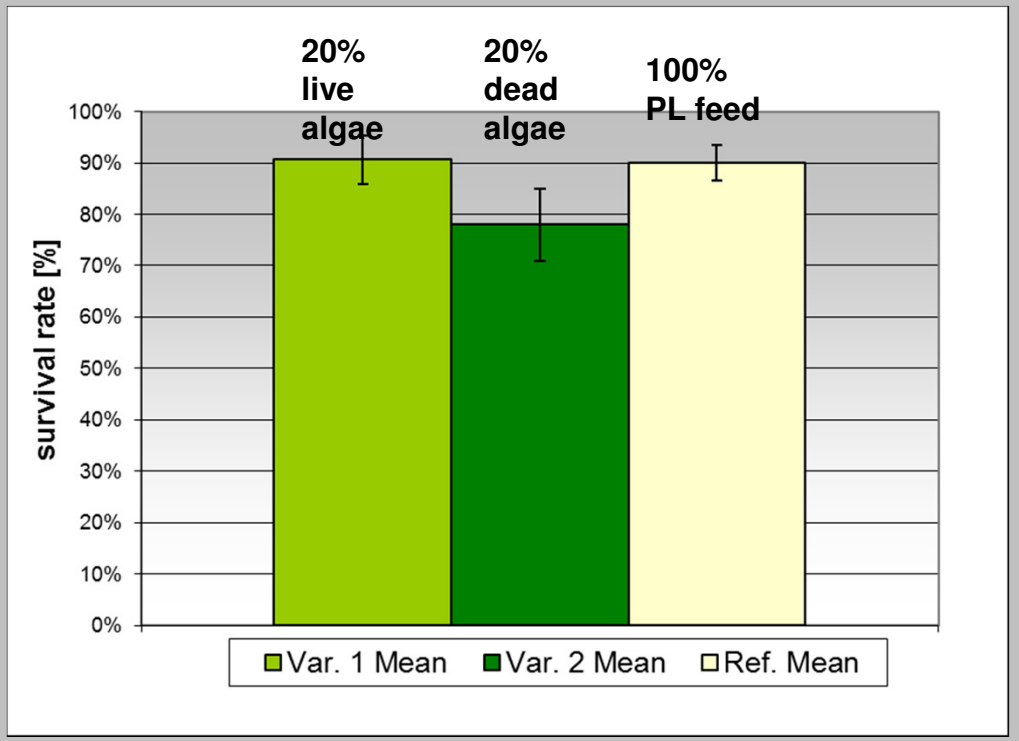
- During the project EU organic standard was adapted, now accepting commercial feed for organic shrimp larvae
- Artemia culture: *A. franziskana* more robust than *A. parthenogenetica*
- Successful reproduction of A. franziskana in natural seawater at improved survival rates, but not reaching a commercially viable rate – confirming assumed risks
- Positive outcome: a system was developed, using the new saltwater tolerant MBR, allowing a stable culture of Artemia at low effort – eventually attractive for aquaristics

Gefördert durch:
Bundesministerium für Wirtschaft und Energie
aufgrund eines Beschlusses des Deutschen Bundestages

„SaBinA Shrimps“ – Inland Saltwater RAS using waste heat for producing shrimp“(*funded by BMWI Germany)*

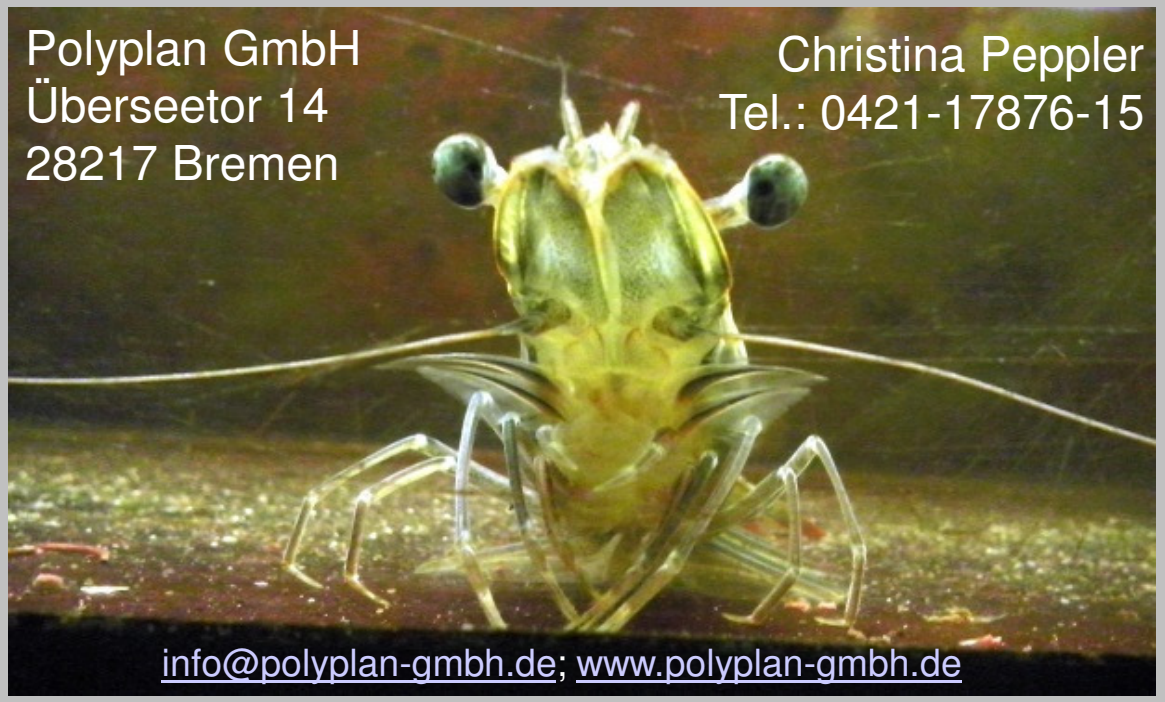
28-d feeding trial on post larvae (PL18) with protein balanced 20% substitution of PL feed by Tetraselmis[1] (as fluid – as alge paste) versus 100% commercial feed

Results: no significant difference in survival and growth – but feeding algae can have longterm positive effects on immune system and performance



[1]purchased at Phytolutions GmbH

Thanks For Your Attention!



R&D: future subjects - Literature

Avnimelech, Y. (2015) ”Biofloc technology – A practical Guidebook” 3rd Edition. The World Aquaculture Society, Baton Rouge, Louisiana, United States. (259 S.)

Bentzon-Tilia, M.; Sonnenschein, E.C., Gram, L. (2016) ”Monitoring and managing microbes in aquaculture – Towards a sustainable industry”, Microb Biotechnol. 2016 Sep; 9(5): 576–584 (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4993175/)

Boyd, C.E.; McNevin, A.A.; Clay, J. (2015) “Resource Efficiency In Aquaculture: Examining The Known And Unknown”, Journal of the World Aquaculture Society (WAS) June 2015: S. 25-30

Cardona, E.; Gueguen, Y.; Magré, K.; Lorgeoux, B.; Piquemal, D.; Pierrat, F.; Noguier, F.; Saulnier, D. (2016): “Bacterial community characterization of water and intestine of the shrimp Litopenaeus stylirostris in a biofloc system”, BMC Microbiology (9 pages), DOI 10.1186/s12866-016-0770-z

Da Silva , K.R.; Wasielesky Jr., W.; Abreu, P.C. (2013) :” Nitrogen and Phosphorus Dynamics in the Biofloc Production of the Pacific White Shrimp, Litopenaeus vannamei” Journal of the World Aquaculture Society, Vol. 44, No. 1 Feb. 2013; 30-41

Daniel, N. and Nageswari, P. (2017): “Exogenous probiotics on biofloc based aquaculture: a review: Current agriculture Research Journal, Vol. 581), 88-107

Ekasari, J.; Deasy, A.; Waluyo, S. H.; Bachtiar, T.; Surawidjaja, E.H.; Bossier, P.; De Schryver, P. (2014): “ The size of the biofloc determines the nutritional composition and the nitrogen recovery by aquaticulture animals”. Aquaculture 426-427 (2014b) 104-11

Samocha, T.M.; Prangnell, D.I.; Hanson, T.R.; Treece, G.D.; Morris, T.C.; Castro, L.F.; Staresinic, N. (2017): “Design and Operation of Super Intensive, Biofloc-Dominated Systems for Indoor Production of the Pacific White Shrimp, Litopenaeus vannamei – The Texas A&M AgriLife Research Experience”.The World Aquaculture Society, Baton Rouge, Louisiana USA.