Results from the FHF project ALLEGRO: Efficacy testing of novel antifouling coatings for nets and sensors in aquaculture

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Aim of the ALLEGRO project

To document the efficacy of alternative methods for biofouling control on nets and hard surfaces.

Consequences of biofouling in aquaculture

Nets

- Distraction of the cleaner fish
- Reduced water exchange
- Increased drag
- Reservoir for pathogens

Sensor equipment

- Prevention of the measurement
- False measurement
- Damage to the equipment

Current AF strategies

Nets

Copper coating & cleaning

- Expensive
- Environmentally hazardous
- Time consuming = expensive
- Impact on fish health
- Abrasion of the coating

Aims for <u>Novel AF</u>

- More environmentally friendly → Less / no copper
- Similar / better efficacy than a copper-based coating

Sensor equipment

Copper tape & exchange

- Limited functionality
- Cumbersome application & exchange

Aims for <u>Novel AF</u>

- Easier to use than copper tape
- Similar / better efficacy than copper

Tested products for nets

ID	Colour	Active ingredients	Producer
Low 1	Gold	Low copper content (0.6 % CuO + copper pyrithione)	Brynsløkken AS, NO
Low 2	Green	Low copper content (< 5 % CuO + zinc/zinc pyrithione)	NetKem AS, NO
Alt 1	Olive	Alternative biocide (2 % Econea + zinc pyrithione)	Brynsløkken AS, NO
Alt 2	Blue	Alternative biocide (2.9 % Econea)	NetKem AS, NO
Alt 3	Yellow	Alternative biocide (boron compound) (= 'Nitto Boron Paint')	Nitto Seimo, Japan
Free	Black	Biocide-free, based on alternative substance	NetKem AS, NO
Cu Ctrl	Red	Commercial copper coating (CuO = 22 %) (= 'Netwax NI 4')	NetKem AS, NO
Blank	White	Uncoated net	Egersund Net AS, NO

→ Samples were immersed at a salmon farm in Mid-Norway

Spring trial: March – October = → 6 months

Autumn trial: July – October = → 3 months

12 replicates (20 x 20 cm) per coating, distributed over 4 frames

Nets: Data analyses

Monthly photographs

% cover, ID of taxa

Prevalence of biofouling

→ How many samples of one treatment are fouled?

Fouling Resistance (FR)

→ How much of the **NET** is **FREE** of biofouling?

Species composition

→ Which taxa can grow on this coating?

In addition, an analysis of Percentage Net-aperture Occlusion (PNO) was conducted.
Results correlate very well with FR and are therefore not shown.
Wet weight measurements were too strongly affected by varying water retention of the samples and were not included.

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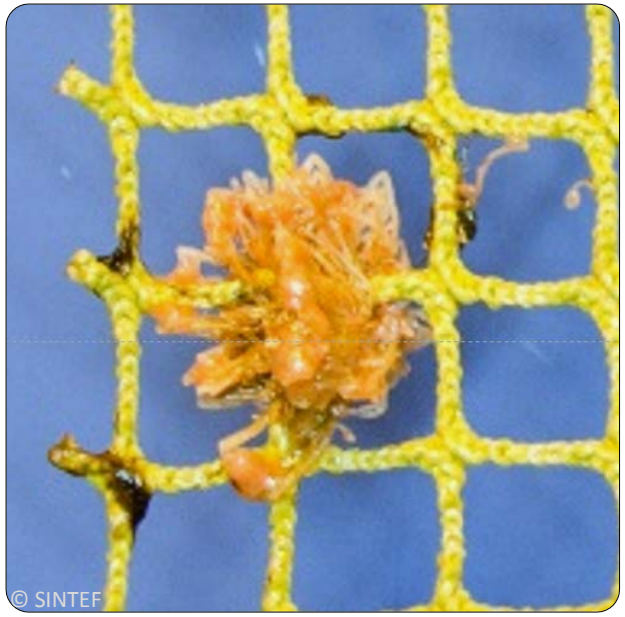
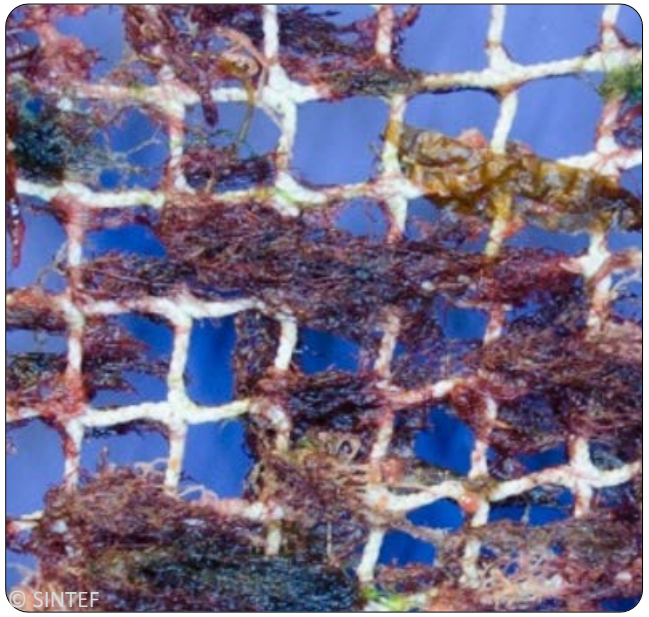
Nets: Key biofouling taxa

- 21 taxonomic groups were identified

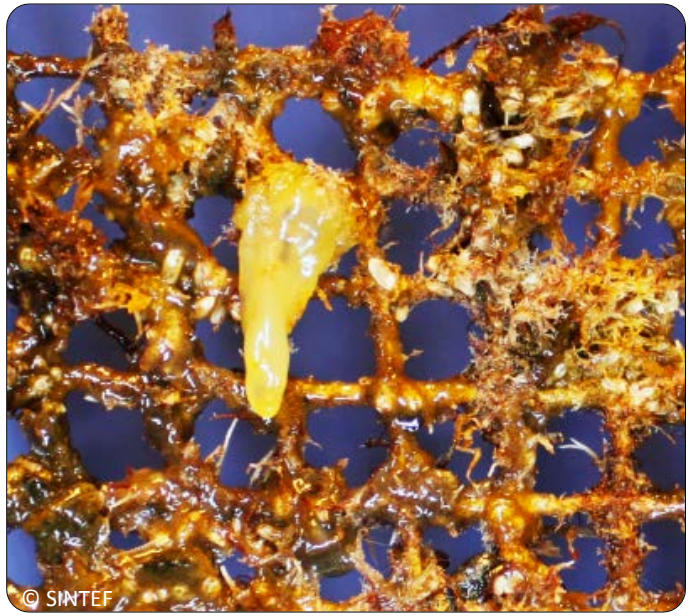
Most abundant:



Hydroids



Algae



Ascidians

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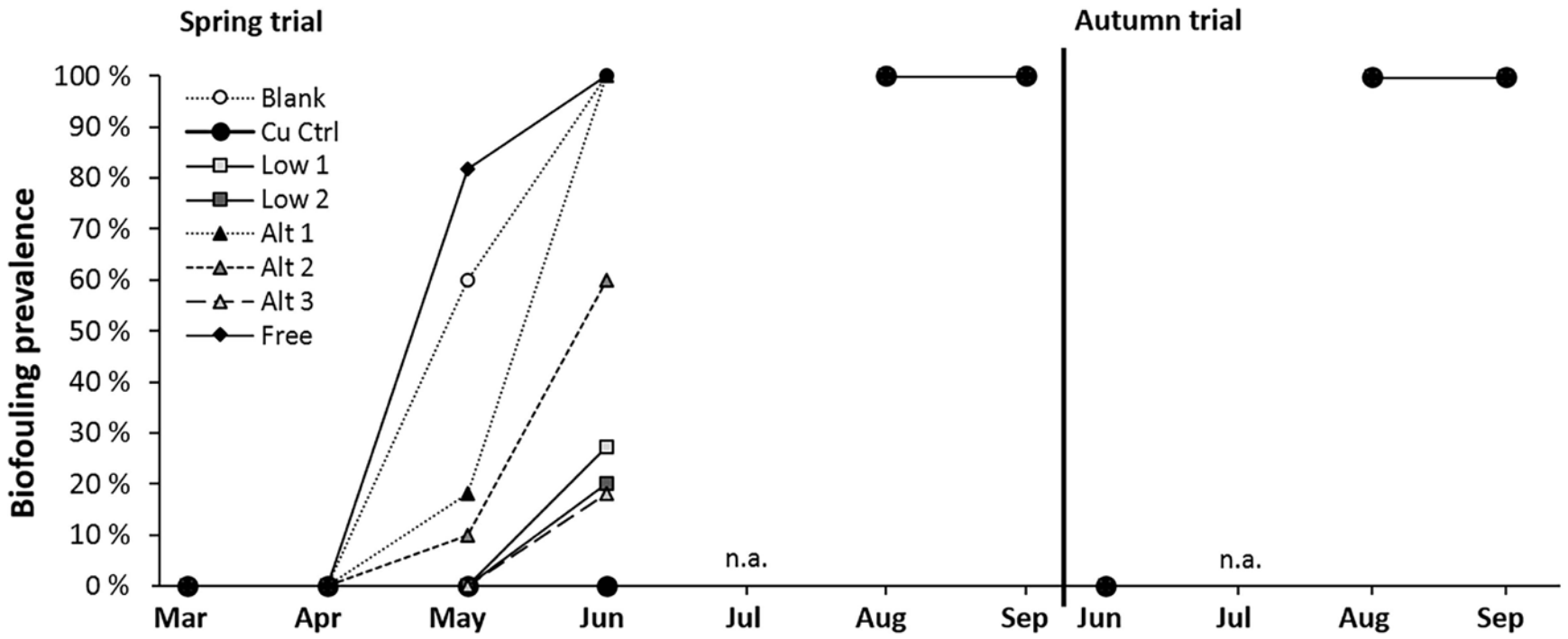
Nets: Biofouling prevalence



Order of appearance of BF:

Spring

- Free, Blank
- Alt 1, Alt 2 (Econea)
- Low 1, Alt 3 (Boron)
- Cu Ctrl

Autumn

All were fouled after 2 months at sea

- The commercial copper coating protected the longest from BF

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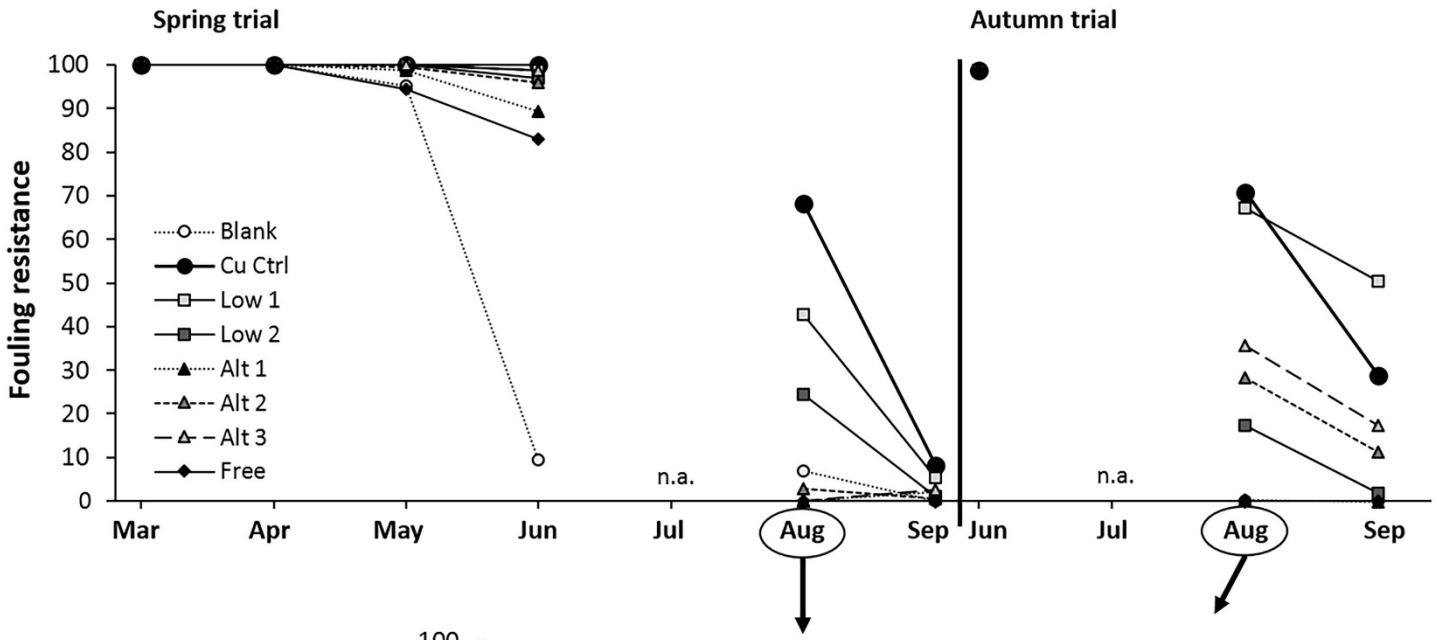
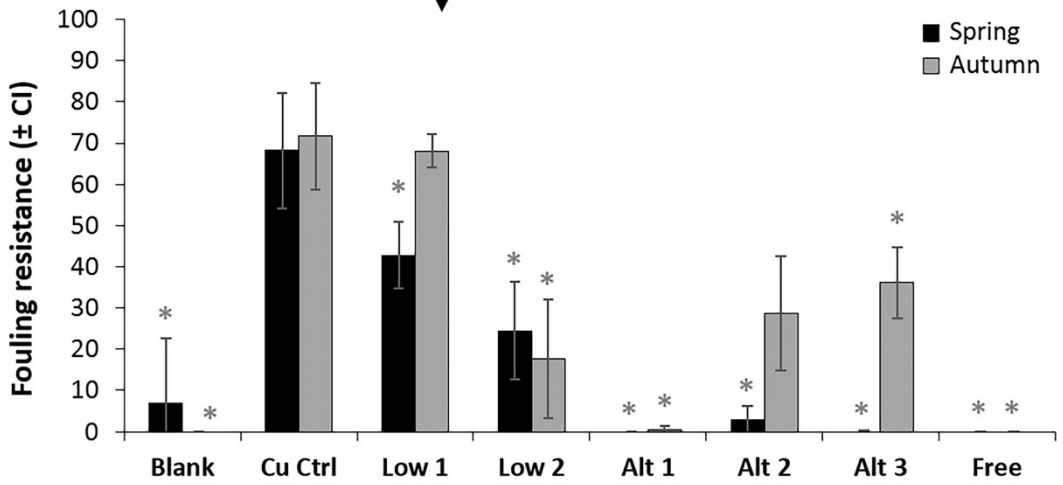
Nets: Fouling resistance



Detailed analysis of the August data:

Significant differences from the Cu Ctrl are indicated by an asterisk.



Spring:

- None of the coatings performs as well as the Cu Ctrl

Autumn:

- The Low 1 performed as well as the control
  (The Alt 1 coating did not differ from the control, but did also not differ from the blank)

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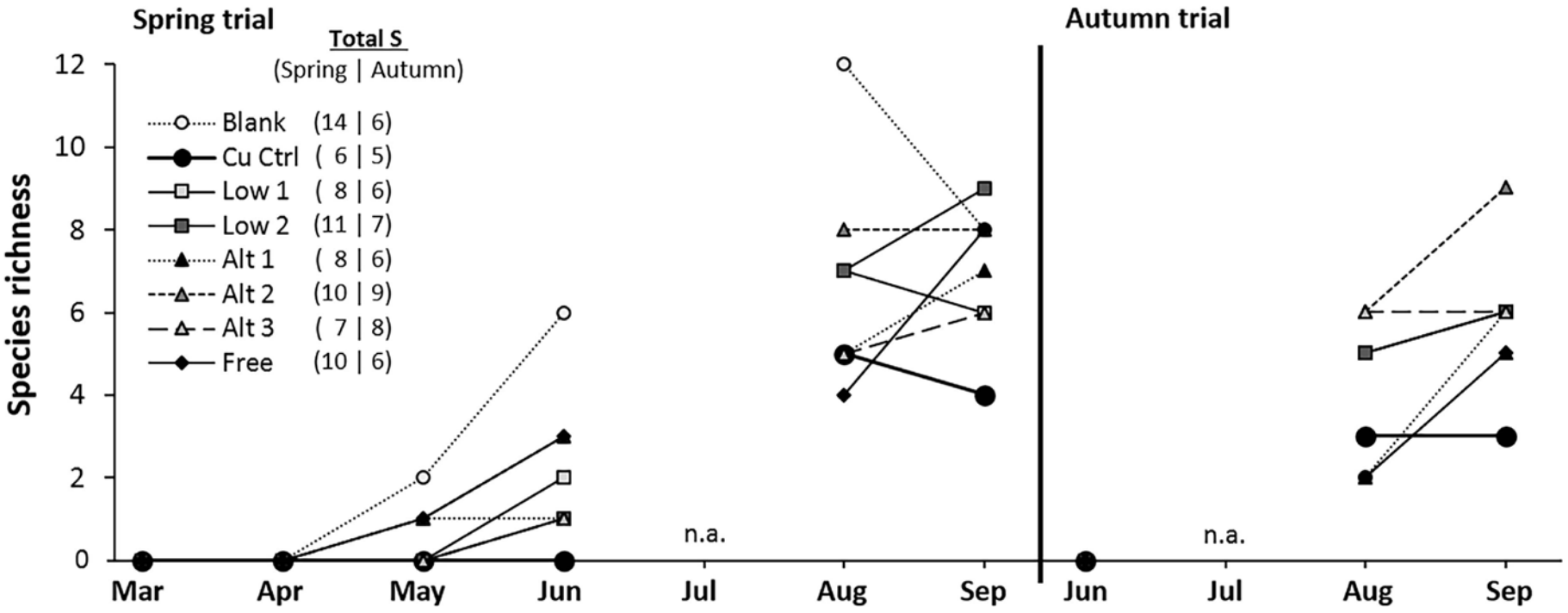
Nets: Species richness



Total S = sum of all taxa found throughout the trial

- Cu Ctrl had the lowest total species richness in both trials
  (i.e. only very few species were able to settle on the commercial copper coating)

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Nets: Summary

- Commercial copper is superior
- Low copper in combination with copper pyrithione (Low 1) is better than the other tested coatings
- Biocides are better than the biocide free coating
- The biocide free coating is better than using no coating

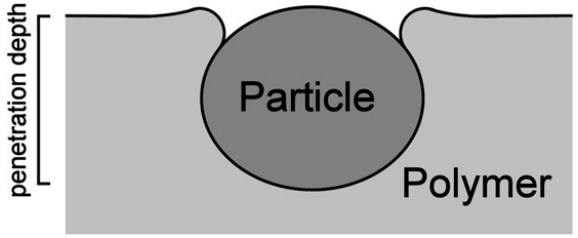
However,

- ALL coatings fail eventually
- Higher BF pressure in autumn lead to more rapid coating failure

Tested products for sensor surfaces

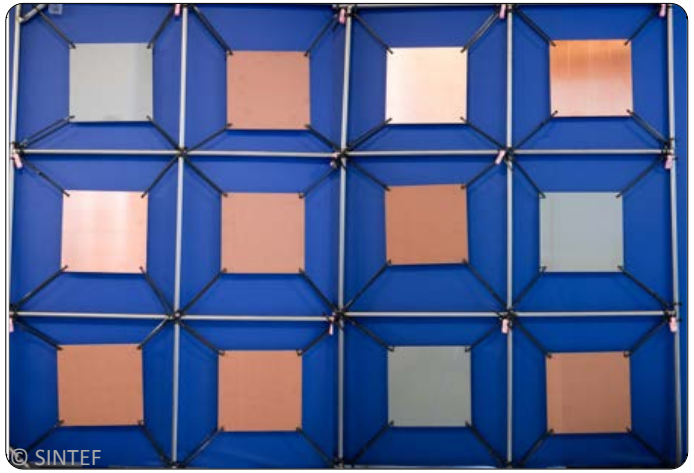
ID	Active ingredients	Producer
High	PU film embedded with copper particles (586 g Cu m-2)	CSIRO, Australia
Low	PU film embedded with copper particles (306 g Cu m-2)	CSIRO, Australia
Blank	Control, untreated PU film	CSIRO, Australia
Tape	Commercial copper shim tape (367 g Cu m-2)	McMaster-Carr Supply Co, USA

Adhesive PU film with embedded Cu particles (Cold-spray coated)



King et al. 2013

Copper shim tape



12 replicates (20 x 20 cm panels) per coating distributed over 4 frames

→ Samples were immersed at a salmon farm in Mid-Norway

March 2017 – January 2018 = → 10 months

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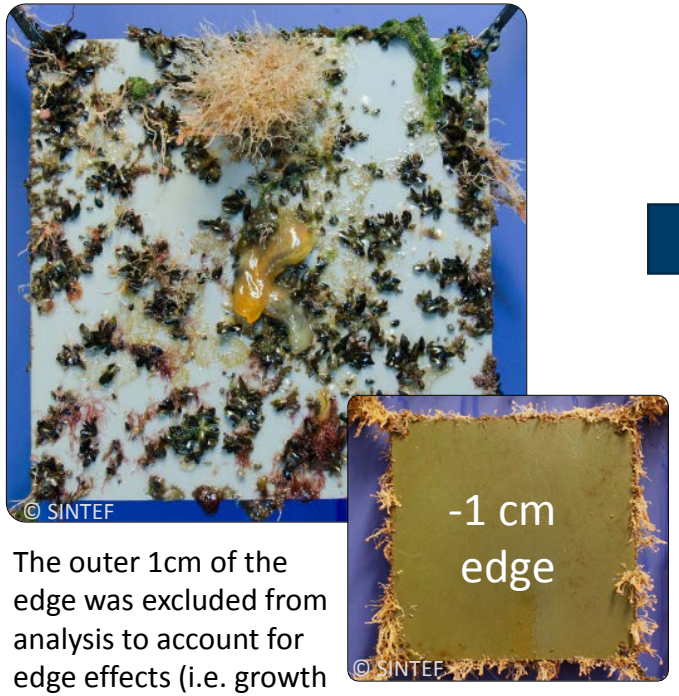
Sensor surface: Data analyses

Monthly photographs



The outer 1cm of the edge was excluded from analysis to account for edge effects (i.e. growth from the unprotected sample backside)

% cover, ID of taxa

Prevalence of biofouling

→ How many samples are fouled?

Fouling Resistance (FR)

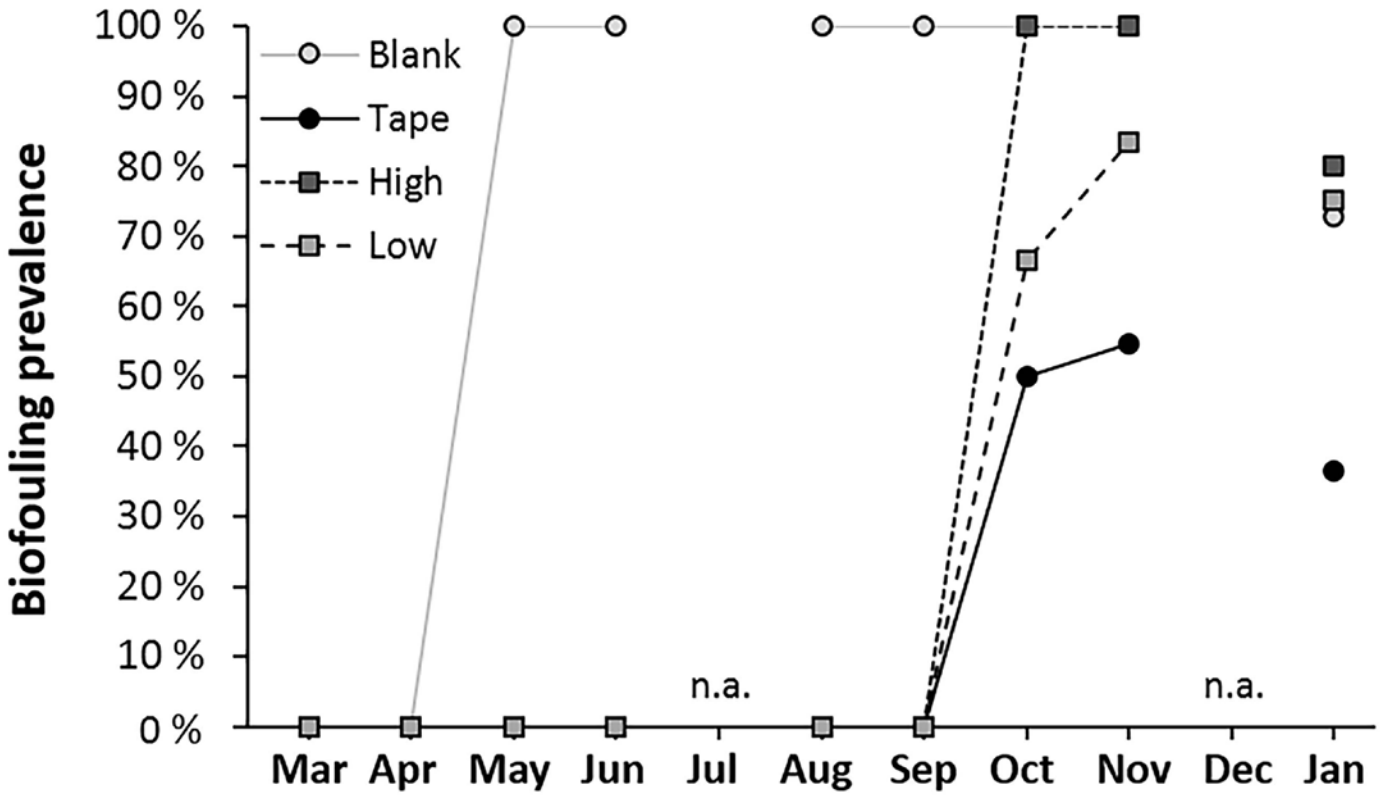
→ How much of the **NET** is **FREE** of biofouling?

Species composition

→ Which taxa can grow on this coating?

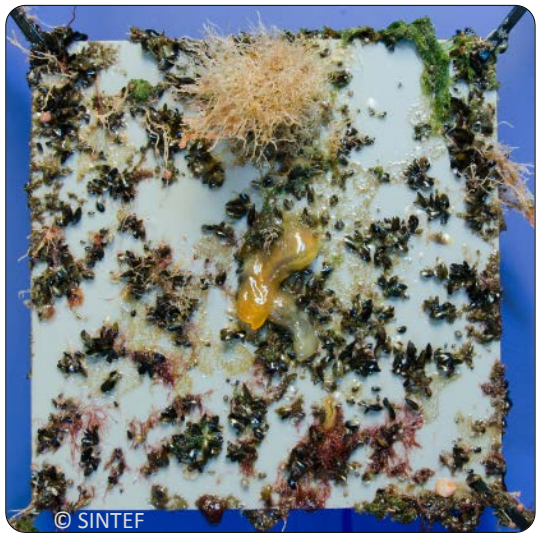
Wet weight measurements were too strongly affected by varying water retention of the samples and were not included.

Sensor surface: biofouling prevalence



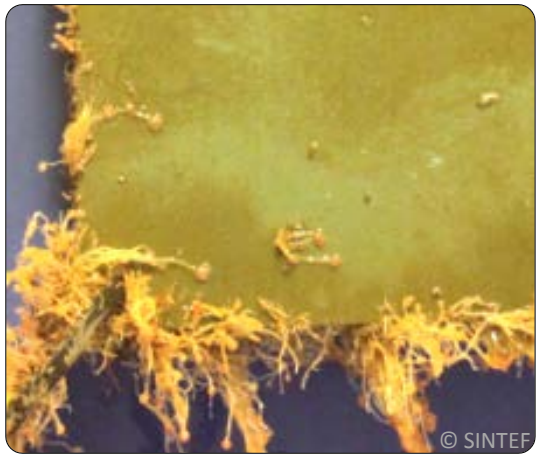
- Blank surface attracted BF after 2 months in the water
- Cu Tape had the lowest prevalence of BF, followed by low Cu films and high Cu films.

Blank



→ 20 taxa

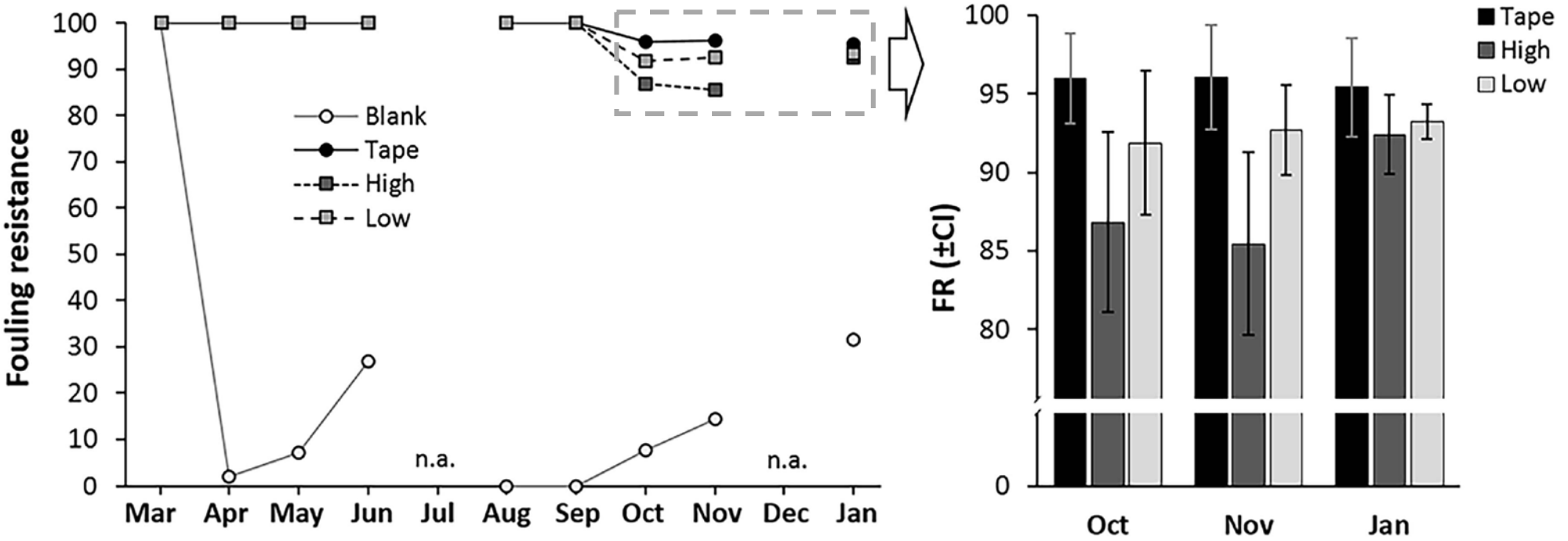
Cu tape and films



→ Max. 3 taxa

(Algae, hydroids, amphipods)

Sensor surface: Fouling resistance



- No difference in fouling resistance between commercial copper tape and Cu films
- No difference between high and low Cu concentration films

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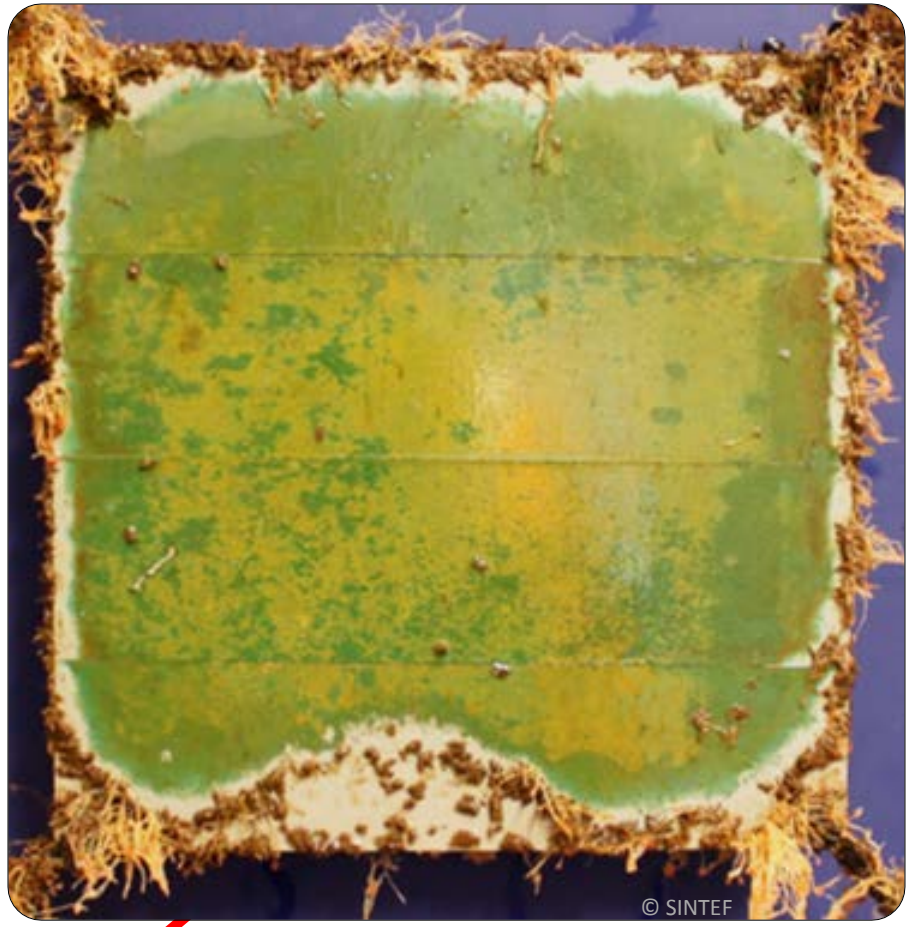
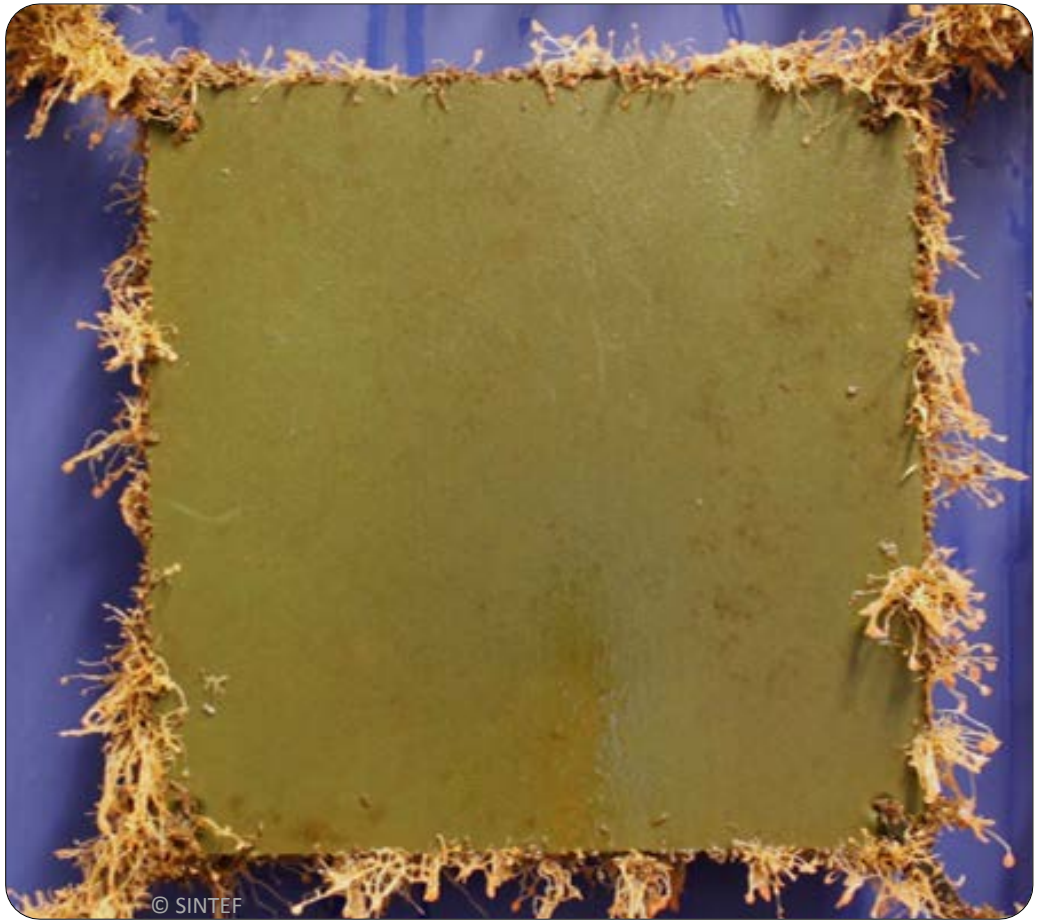
Sensor surface: Patchy copper leaching



PVC panel visible through adhesive

→ Loss of AF protection

Average unprotected area of tape panels = 16 %



No patchy leaching visible

→ Increased durability?

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Sensor surface: Summary

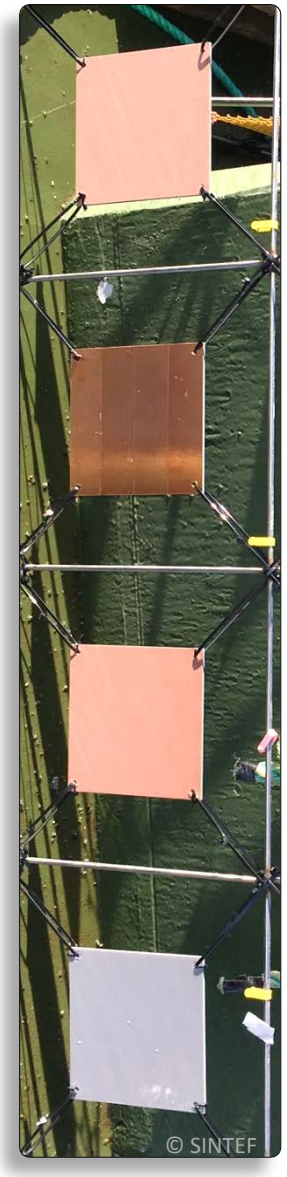
- Differences in biofouling prevalence did not translate to fouling resistance:

  The Cu films with high and low concentration performed equally well as the Cu Tape

  → BUT: Strong leaching and associated BF growth along the edges of the Cu Tape panels indicates reduced durability

- No difference in fouling resistance between films with high vs. low Cu concentration

  → Particles in the high Cu film embedded too deep (= unavailable)?



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Outlook

- None of the tested net or sensor coatings could prevent biofouling in the long-term
- There is clearly a need for more research into alternative methods against biofouling
- Potential impacts on environment and non-target organisms should be considered when choosing novel substances

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Technology for a better society