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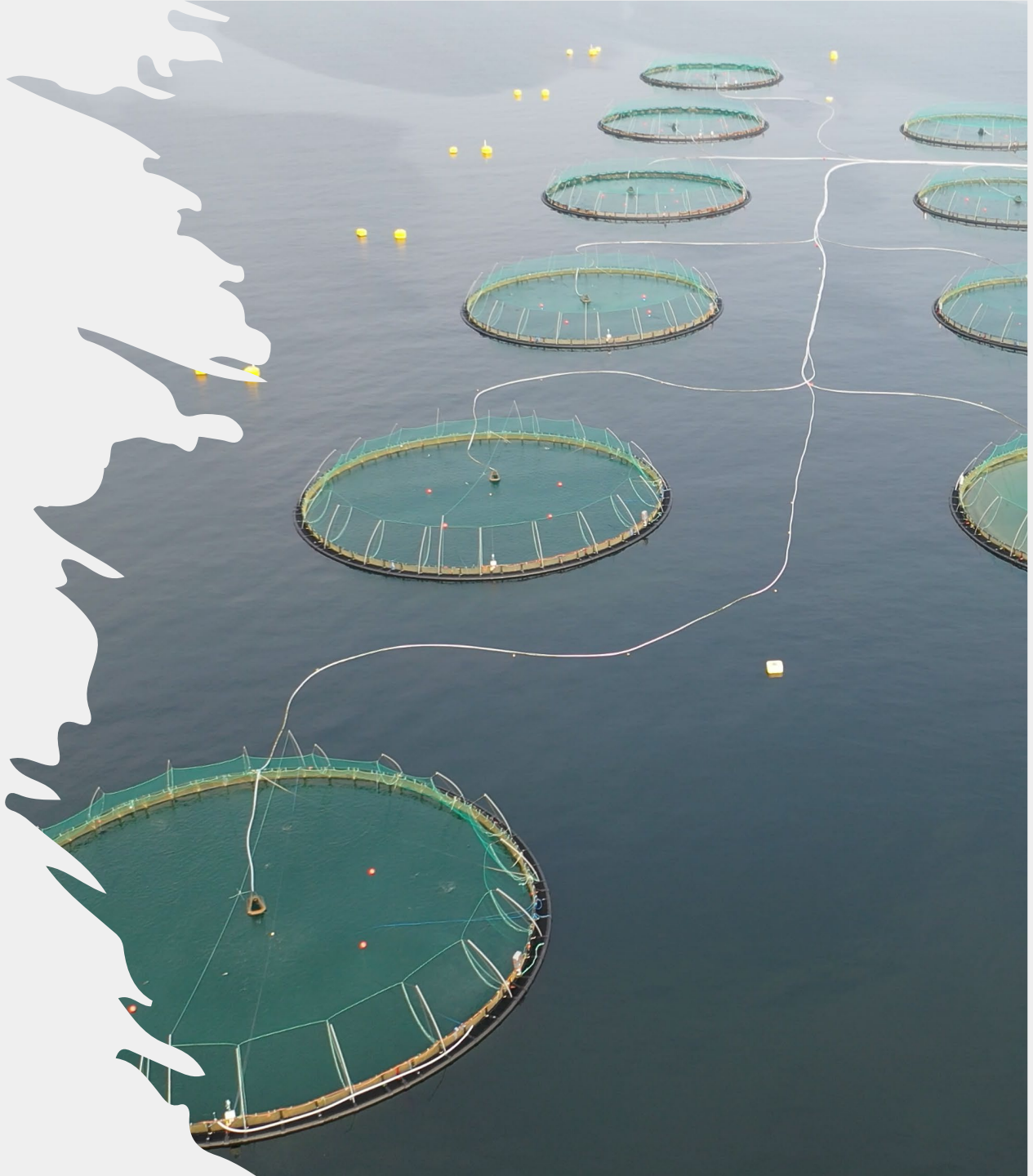
Applying Multi-Criteria Decision Analysis (MCDA) to Evaluate Sustainable Biofouling Alternatives in Norwegian Sea-Based Aquaculture

Marina Hauser, Bellona Foundation



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Circular and environmental impacts of aquaculture nets

2023-2024

Financing:

SINTEF

NTNU
Norwegian University of Science and Technology

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SCALE AQ

oceanize

NOVA SEA

AKVA GROUP

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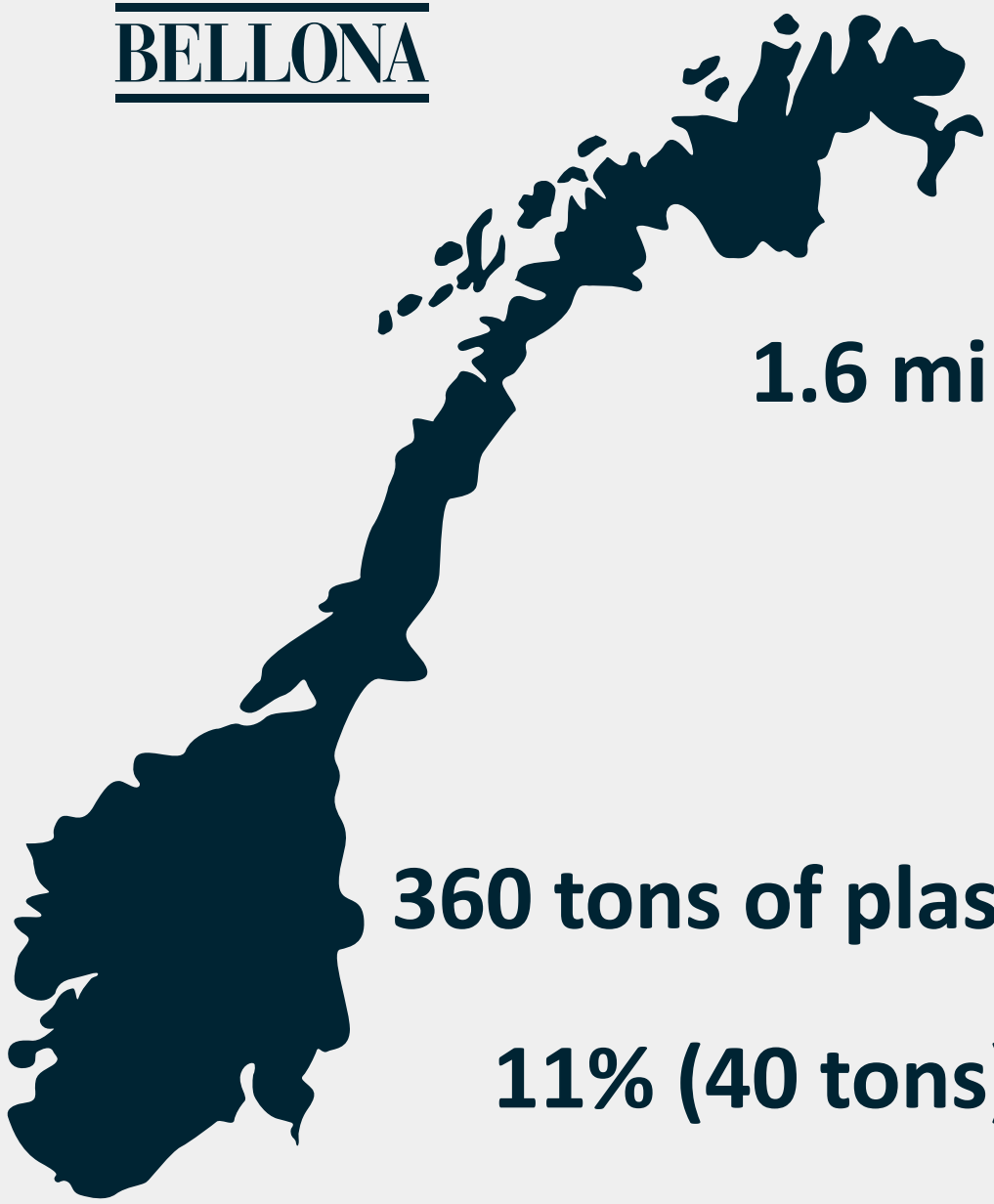

In 2023

1.6 million tons of farmed fish slaughtered

94% salmon

Around 1000 fish farms

360 tons of plastic equipment in the sea per fish farm

11% (40 tons) of this is are plastic nets

Kilde: Fiskeridirektoratet, Grieg Seafood

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Foto: Bloecher & Floerl, 2021

Biofouling leads to:

- Reduced water flow
- Lower oxygen levels
- Decreased feed intake
- Increased fish stress
- Higher fish mortality
- Structural destabilization during storms

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Prevent biofouling

Inorganic biocide-based coating (copper)

- Most common in Norway
- 300 tons of copper in 2023
- High copper concentrations in sediments

Organic biocide-based coating (tralopyril)

- Approved in 2017
- 116 tons of tralopyril in 2023
- PFAS
- Limited knowledge of toxicity

Biocide-free coating (wax-based)

- Water-repellent surfaces
- Less toxic
- May require more frequent cleaning

No coating (HDPE nets)

- Smooth surfaces
- No release of pollutants
- Requires frequent cleaning

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Multi-Criteria Decision Analysis (MCDA)

Evaluate different alternatives based on multiple, often conflicting, criteria

Alternatives **Criterias** **Weighting** **Performance** **Ranking**

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Alternatives | Criterias | Weighting | Performance | Ranking

Env. sustainability	Economic sustainability	Social sustainability	Technical aspects
E1. Risk to marine ecosystem	C1. Cost of net coating used	S1. Labor safety	T1. Effectivity against biofouling
E2. Water footprint	C2. Cost of operations and maintenance	S2. Acceptance of the coating	T2. Lifespan of coating
		S3. Availability regulatory frameworks	T3. Availability of coating
		S4. Risk to human health	T4. Ease of handling
			T5. Potential for EOL management

Criteria weighting

Main criteria	Weighting
Environmental sustainability	30%
Economic sustainability	29%
Social sustainability	9%
Technical aspects	32%

Undercriteria	Unit	Inorganic biocide-based coating (copper)	Organic biocide-based coating (tralopyril)	Biocide-free coating (wax-based)	No coating (HDPE nets)
E1. Risk to marine ecosystem	RQ	1.01	0.09	0	0
E2. Water footprint	Ranking	0.25	0.5	0.75	1
C1. Cost of net coating used	NOK	140 000	120 000	38 000	0
C2. Cost of operations and maintenance	Million NOK	0.25	0.25	0.45	0.54
S1. Labor safety	Ranking	2	1.75	3.13	3.43
S2. Acceptance of the coating	Ranking	2.15	2.42	3.54	3
S3. Availability regulatory frameworks	Ranking	1	0.5	0.25	1
S4. Risk to human health	Exposure/ AEL	14	1.7	0	0
T1. Effectivity against biofouling	Ranking	3.71	3.29	2	1
T2. Lifespan of coating	Ranking	2.71	2.5	2.71	4
T3. Availability of coating	Ranking	3.5	2.67	2.4	4
T4. Ease of handling	Ranking	3.43	2.29	2.71	1.67
T5. Potential for EOL management	Ranking	0.25	0.25	0.25	0.75

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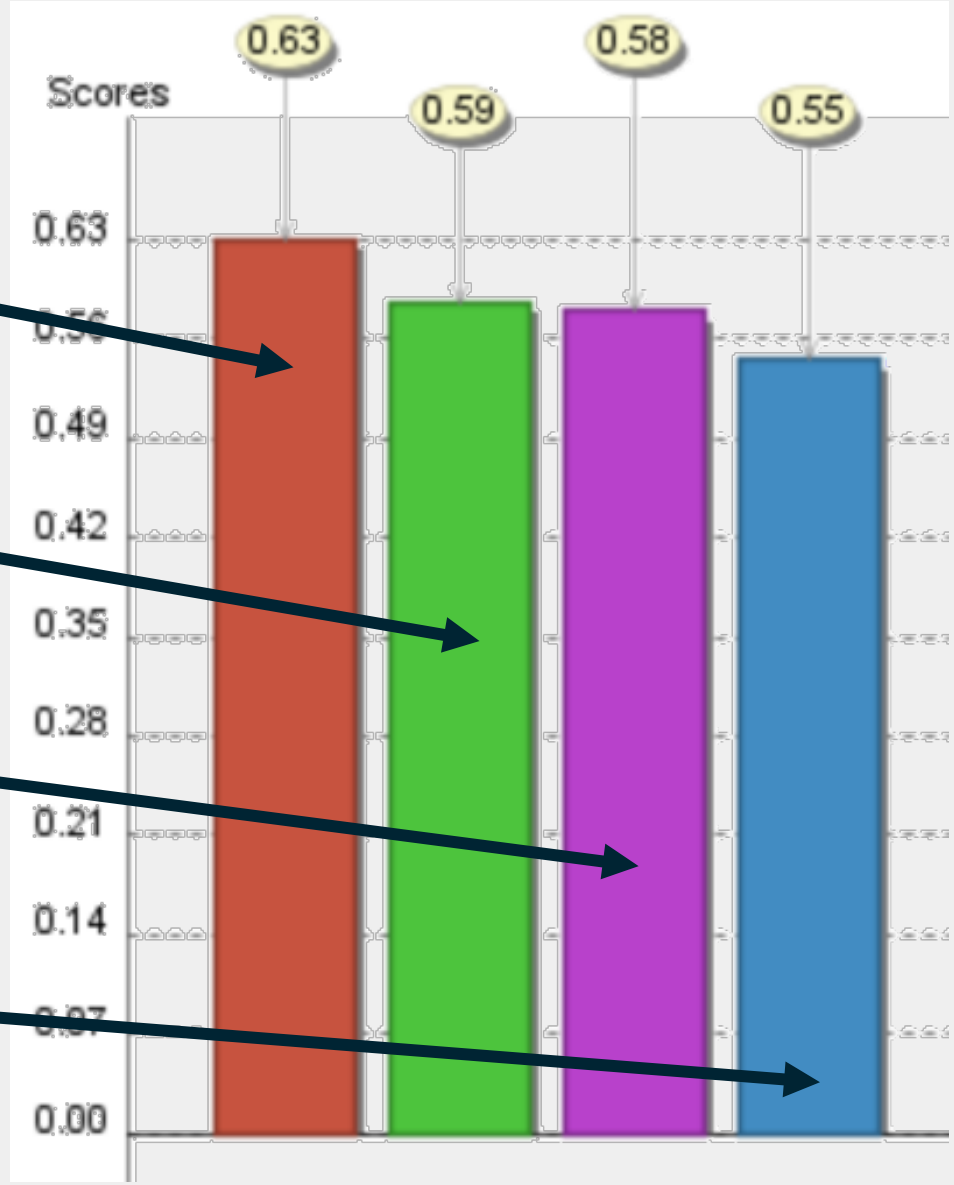
Alternatives Criterias Weighting Performance Ranking

Organic biocide-based coating (tralopyril)

No coating (HDPE nets)

Biocide-free coating (wax-based)

Inorganic biocide-based coating (copper)



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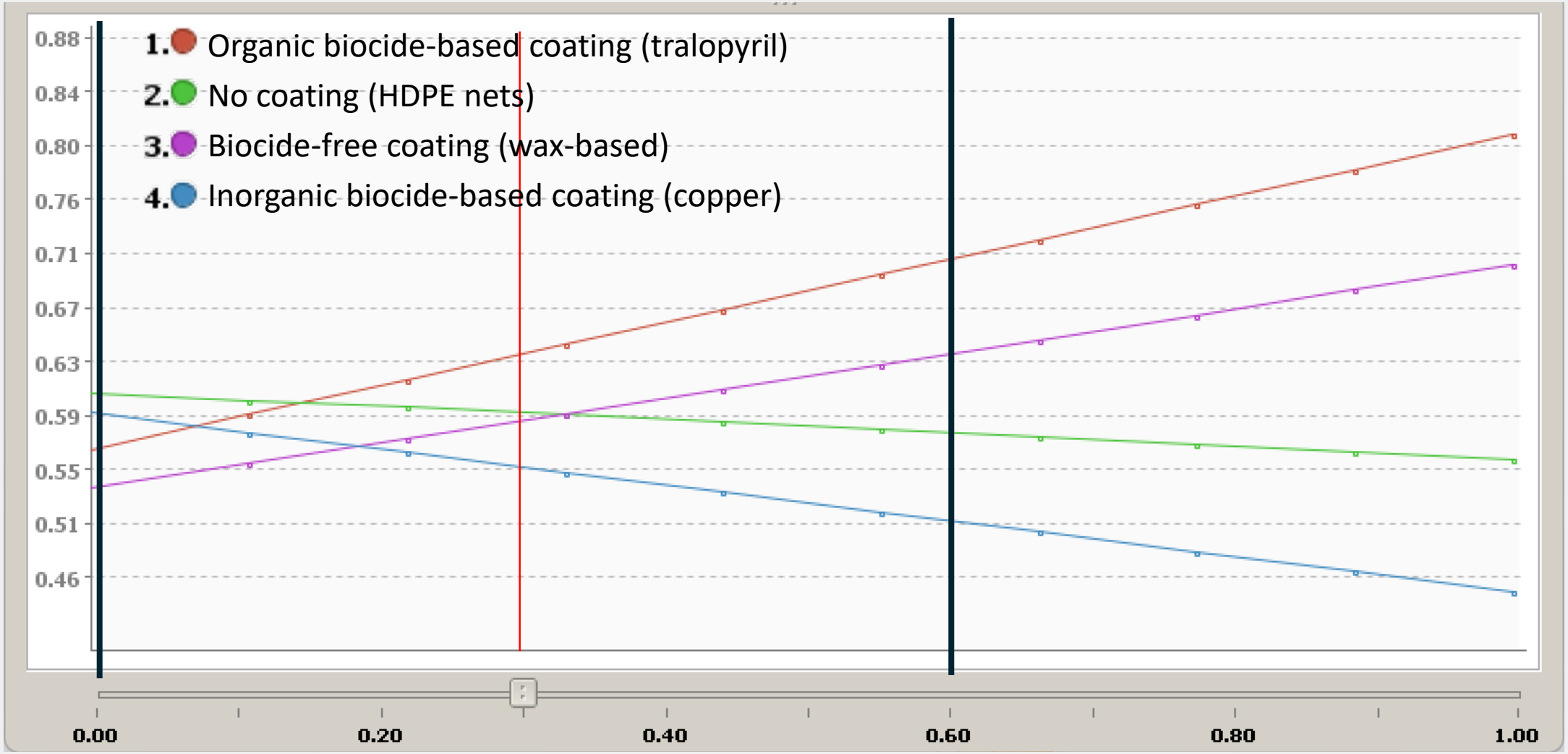
Environmental sustainability



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Limitations

Exclusion of certain sub-criteria due to insufficient data

- E3. Risk to farmed species
- E4. Risk from end-of-life products
- C3. Secondary value from recycling

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Decision-making tool for aquaculture companies and policy makers

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Thank you!

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Marina Hauser
LCA Advisor
marina@bellona.no