MARELITT Baltic

Towards a pathway for the recycling of fishing gear

Dr. Andrea Stolte, WWF Germany

Circular Oceans 2018

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Budget and partners

The projects total budget is EUR 3,8 MM

Lead partner: Municipality of Simrishamn, Sweden

- Keep the Estonian Sea Tidy
- WWF Poland Foundation
- WWF Germany
- Keep Sweden Tidy
- Maritime University of Szczecin
- Kolobrzeg Fish Producers Group
- Institute of Logistics and Warehousing
- Estonian Divers Association

Photo credits: Andreas Frössberg

Key questions

Why are fishing gears lost?
How can we minimise the reasons for gear loss?
Where can we find the lost fishing gear?
How can we retrieve lost gears?
How can we reuse or recycle them?
What are the costs?
Who is responsible for retrieval?

Photo credits: Andrea Stolte, WWF Germany

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Project aims

Increase institutional capacity in the Baltic Sea region to solve the ghost fishing problem.

Search & Retrieval of derelict fishing gear (DFG)

- Develop cost-efficient, safe and environmentally friendly derelict fishing gear cleaning methods.
- Produce a handbook on derelict fishing gear retrieval methodologies consisting of the evaluation of dragging operations and documentation of lessons learned.
- Establish a baseline for future cleaning measures and a map of the host areas in the Baltic Sea and a plan for post-project operation.

Project aims

Increase institutional capacity in the Baltic sea region to solve the ghost fishing problem.

Mitigation measures to avoid future gear loss

– Increase responsible fishery schemes while developing a code of conduct for the fishing industry.

Recycling of lost fishing gear

– **Improve reception facilities in harbours**

– **Develop pathways for environmentally sound waste management**

What are the problems with (lost) fishing gear recycling?

Why are even discarded nets not regularly recycled, and why should they be?

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What are the problems with (lost) fishing gear recycling?

The situation today:

- Fishermen currently discard end-of-life fishing nets in household trash
- Retrieved fishing nets are incinerated, landfilled, but might be hazardous trash
- Some fisheries associations collect end-of-life nets in collaboration with the local waste management companies, fees are payed by associations
- A regular scheme to sort and, if possible, recycle fishing gear is not in place

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Recycling: Ecological & economic solutions

Materials used in fishing nets:

Probe | Sample	**PE** (ca. 120 °C)	**PP** (ca. 160 °C)	**PA6** (ca. 220 °C)	**PET** (ca. 260 °C)
Sassnitz Taue	-	x	**X**	x
Polen Taue	x	-	x	**X**
Sassnitz Netze	x	x	**X**	x
Polen Netze	x	x	**X**	x
Ahlbeck Netze	x	x	**X**	x

Anmerkung | Annotation: - = nicht vorhanden | not present; x = vorhanden | present; **X** = Hauptanteil | main fraction

Recycling: Ecological & economic solutions

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Recyling of mixed materials is always a challenge!

Recycling: Ecological & economic solutions

© WWF / Vaude

Materials used in fishing nets:

Nylon (Polyamide PA6), Polyethylen, Polypropylen

PET (ropes)

- high-calorie polymers
- high-value recyclates if materials are pure
- if cleaning and sorting are efficient, recycling is efficient

It is a waste not to recycle fishing nets!

Physical properties are comparable to available recyclates

Photo Credits: MAKSC Gmbh

<u>Mechanical parameters are partially comparable:</u>

Material strength and flexibility were tested:

- Tensile strength and elasticity were in the same range as recyclates available on the market.
- Breaking elongation is very low, probably caused by impurities contained in DFG

Mechanical properties could be improved and applications could be found where DFG granulates can be used.

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Photo Credits: MAKSC Gmbh

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But…

DFG is not only mixed, it’s also contaminated

Cleaned, washed and sorted material can contain:

- High fraction of lead

  Threshold for packaging: 100ppm
- Even higher fraction of chlorine

  Also above REACH thresholds

Substanzgruppe Substance group	**Substanz** | Substance	Sassnitz Taue [ppm]	Polen Taue [ppm]	Sassnitz Netze [ppm]	Polen Netze [ppm]	Ahlbeck Netze [ppm]
Schwermetalle | Heavy metals	Antimon | Antimony	< 10	42,9	< 10	12,4	28,2
	Blei | Lead	10,1	189	25,7	335	358
	Cadmium | Cadmium	0,72	< 0,10	7,20	0,13	0,30
	Chrom, gesamt | Chrome, complete	< 10	< 10	< 10	62,7	< 10
	Quecksilber | Mercury	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1
Halogene | Halogens	Fluor | Flourine	< 50	< 50	< 50	< 50	< 50
	Chlor | Chlorine	973	221	1421	493	1011
	Brom | Bromine	< 193,5	< 127,7	< 159,7	< 39,2	< 96,8

Problems faced in fishing gear recycling

Retrieved fishing gear from the sea faces numerous problems:

- Contamination with lead, metal fragments, sediments, ...
- Entanglement means materials cannot easily be separated
- Organic matter including dead fish is smelly & needs to be removed
- Proper material recycling requires polymer types to be separated

Material quality cannot be ensured!
These are the reasons why (lost) fishing gear is not regularly recycled today.

A variety of techniques were tested to evaluate ecologically & economically viable recycling methods for retrieved fishing gear.

Photo credits: Andrea Stolte, WWF Germany

Recycling trials in Marelitt Baltic:
Developing a recycling pathway for fishing gear

1. Harbour reception facilities (KEST, M. Press)
2. Pre-processing in harbours & analysis
   – cutting, sorting, cleaning in harbours
   – chemical & physical analysis: recycling?
3. Processing of nets for recycling
   – sorting + cutting, shredding, washing
4. Recycling trials
   – thermal processing (”hydrolysis”, pyrolysis)
   – material recycling

Photo credits: Andrea Stolte, WWF Germany

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DFG Treatment Scheme

Best-practice recommendations for the treatment of Derelict Fishing Gear

DFG recycling is challenging

1. **Choice: Raw plastic material from ghostnets**
   ✓Pellets to re-enter production cycle
   ✓Nylon-threads

2. **Choice: Thermal energy conversion (Pyrolysis, Steam reforming)**
   ✓Engine fuel or energy gas from polymers
   ✓extraction of metals

3. **Choice: Energy generation through incineration**

Photo credits: bureo

Photo credits: Johann Hee, Thomas Horst, TEER / RWTH Aachen

Recycling starts at the harbour

Fishing gear needs to be properly prepared:

- Removal of large metal items
- Removal of sink lines with lead
- Cutting into fragments that can be handled in big bags
- Pre-cleaning with pressurised air or water to remove sand

Photo credits: Andrea Stolte, WWF Germany

Prerequisites for DFG retrieval & recycling:

1. Landing of retrieved fishing gear needs harbour infrastructure

2. Derelict fishing gear is only fit for recycling when handling is possible

Processing steps of nets for recycling

Step 1: Manual sorting

- Removal of large metal items
- Removal of dead fish, mussels, ...
- Separation of ropes, trawls and gillnets





Photo credits: Andrea Stolte/WWF Germany, Falk Schneider

Processing steps of nets for recycling

Results of manual sorting

Photo credits: Andrea Stolte, WWF Germany

Processing steps of nets for recycling

Step 2: Shredding

Vecoplan shredder with 20mm sieve

→ very good results with all material types

→ magnetic separator: efficient removal of fishing hooks & small iron pieces *(lead is not removed!)*

→ problem: if material was only coarsely sorted: large metal fragments damaged counter-knive triangles

→ substantial wear on machine leads to high cost

Photo credits: Falk Schneider

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Manual pre-processing is required to remove larger metal items, rocks, and other damaging contaminants.

Retrieved mixed nets after shredding

Photo credits: Andrea Stolte, WWF Germany

Processing steps of nets for recycling

Step 3: Density separation

Aim 1: Remove lead fragments, sediments, (PVC)

Aim 2: Separate PA6 from low-density polyolefins PE, PP

Stage 1: Saturated saline solution (de-icing salt)

→ all polymers except PVC float

Stage 2: Tap water

→ PA6, PET sink PE, PP float

Result: Principle works, but would need automisation.

Photo credits: Andrea Stolte, WWF Germany

Processing steps of nets for recycling

Step 3: Density separation

Problem:

- Fluffiness of fibres prohibits clean separation
- Lead fragments, sediments, organic particles get trapped in “fluffy furballs”!

Photo credits: Andrea Stolte, WWF Germany

Processing steps of nets for recycling

Step 4: Friction Washer

- 2 discs rotation against each other
- Transport of material outwards in grooves
- Friction causes dirt particles to be removed

→ Worked well for fibres, best for monofilament

→ Fine-grained sediments & smallest lead fragments could not be removed

before & after washing

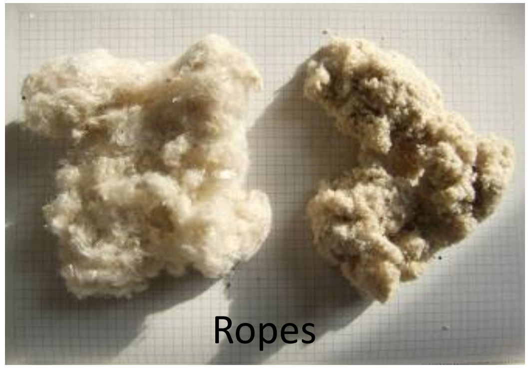

Photo credits: Andrea Stolte, WWF Germany

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Processing steps of nets for recycling

Step 4: Friction Washer

Problems:

- Fluffiness of fibres traps fine sediments
- Polyamide fluffs up into “wool tuffs”
- If a pump is involved, the filter can get blocked
- A drying stage is needed for subsequent extrusion

Environmental concern:

- Washing liquid contains polymer emulsion

→ Nanoplastics might enter the waste water

→ Needs closed circle with waste-water treatment and residue as hazardous waste

Vecoplan friction washer

Waste water treatment

Photo credits: Andrea Stolte, WWF Germany

Recycling trials: Thermal processing

Two methods were investigated:

- Pyrolysis
- Steam reforming ("hydrolysis")

EXOY steam reforming reactor

Photo credits: Andrea Stolte, WWF Germany

Pyrolysis

Low-temperature coking

- 400-800°C max

→ Evaporation & recondensation of polymers

Outputs

→ Carbon-rich liquid can be used as engine fuel (“pyrolysis oil”)

→ Only 2-5% of fuel output was generated

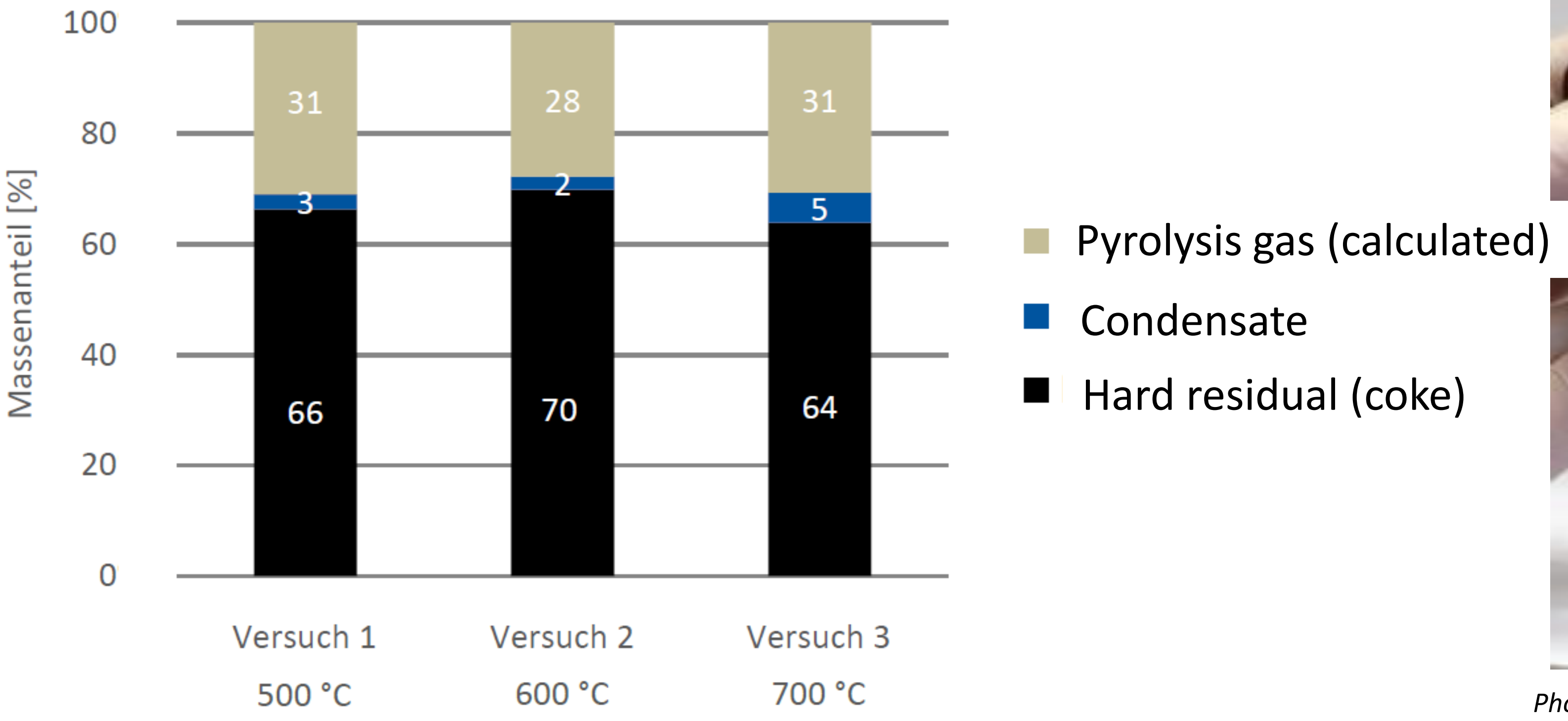
→ Ash residual (“coke”) contains sediments, lead, metals, ...

→ Discussed for use in marine litter collection ships

e.g., US navy household-waste processing at sea

Photo credits: Johann Hee, Thomas Horst, RWTH Aachen

Pyrolysis



Johann Hee, Thomas Horst, TEER RWTH Aachen

Photo credits: Johann Hee, Thomas Horst, TEER RWTH Aachen

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Pyrolysis

Problems

- Energy return in the form of “fuel” is low
- Polymer-disintegration is not complete
- PA especially leads to toxic emissions (hydrocyanic acid)
  → hazard for workers & environment
- Removal of toxins requires costly filtering or chemical treatment techniques

Making pyrolysis safe for DFG processing requires extensive technical measures, but if feasible, could result in fuel for ships.

Pyrolysis ↓ 700°C

Photo credits: Johann Hee, Thomas Horst, TEER RWTH Aachen

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Steam reforming

High-temperature polymer evaporation (“hydrolysis”)

- 1000-1300°C
- 1100°C trial at EXOY/CleanCarbonConversion, Switzerland
  - → Gillnet-dominated sample with large lead content
  - → Hazardous waste!

Aims:

- Extract energy contained in polymers
- Lead is a high-value metal (scrap lead 2000 €/tonne)

Task: How to extract the lead and energy content from the heavily mixed material when manual sorting is not feasible?

Gillnet mixed sample

Photo credits: Andrea Stolte, WWF Germany

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Steam reforming

High-temperature polymer evaporation outputs

- Energy-gas with high hydrogen content (48%)
  → can be used to extract hydrogen for fuel cells
- Hard substance residue: residual sediments, metals, lead
  → Lead can be recycled
- Small amount of non-hazardous slag

Toxic lead & metals are extracted, organic toxins are disintegrated.
Energy content in polymers can be harnessed.

Lead melts & recondenses

Lead & iron dust residue

Photo credits: Peter Jeney, EXOY

Steam reforming is promising!

- Steam reforming is a solution to process gillnet-dominated DFG!
- Energy gas is just sufficient to re-generate the energy consumed to reach the high temperatures & needs to be used to fuel the reactor

Material recycling

Problems:

- Mixed polymers & other wastes are difficult to disentangle
- Sediments cause extensive wear on machines
- Continuous material quality & quantity cannot be guaranteed
  - → Material recycling is costly & technically challenging
  - → Toxic contamination has to be excluded

Photo credits: Andrea Stolte, WWF Germany

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Material recycling

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Trials:

- Gillnets as the toughest recycling material

➡ Contamination with lead & sediments: recycling non-economic

- Ropes as the most uniform recycling material for granulation

➡ Recycling is feasible with approx 50% prestine polymer matrix

Photo credits: Andrea Stolte, WWF Germany

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Is it worth all the effort?

➡ Life-Cycle Analysis tests ecological & economical viability of a Circular Economy for Derelict Fishing Gear

➡ **PhD thesis by Falk Schneider, University of Bath, UK**
Publication planned Autumn 2018

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For details see the MARELITT Baltic recycling feasibility study
https://marelittbaltic.eu
Publication date June 2018

Thank you very much for your attention!

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