HYDRA Marine Sciences

Performance of bio-degradable Plastic in the Marine Environment,

and considerations on their substitution potential

Dr. Miriam Weber & Christian Lott

Brussels, 07.06.2018

Biodegradation

complete conversion of the polymer to CO_2/methane, H_2O and biomass through the action of microorganisms

Biodegradability

intrinsic material property
(= generally degradable by microorganisms, under favourable conditions).

I.e., there are microorganisms that possess enzymes for the degradation of the specific polymer.

BUT: not necessarily equal under all conditions,
maybe under some conditions not at all!

The biodegradation performance of polymers under marine conditions: Knowledge (& Opinion)

Hardly any systematic field studies under natural conditions.

Few scientific results, a lot of (political) bias.

Many assumptions, many emotions.

→ need for science-based knowledge

Knowledge needed:

Is the material really bio-degradable in nature?

How long does it take?

Where should we use it and where should we not use it?

Method development and biodegradation tests of film (plastic foil):

Environmentally relevant, reliable field tests for 6 *coastal* scenarios:

beach, floating surface and midwater, seafloor shallow vertical/horizontal and deep






2 climate zones (Mediterranean Sea, tropical SE Asia)

METHODS

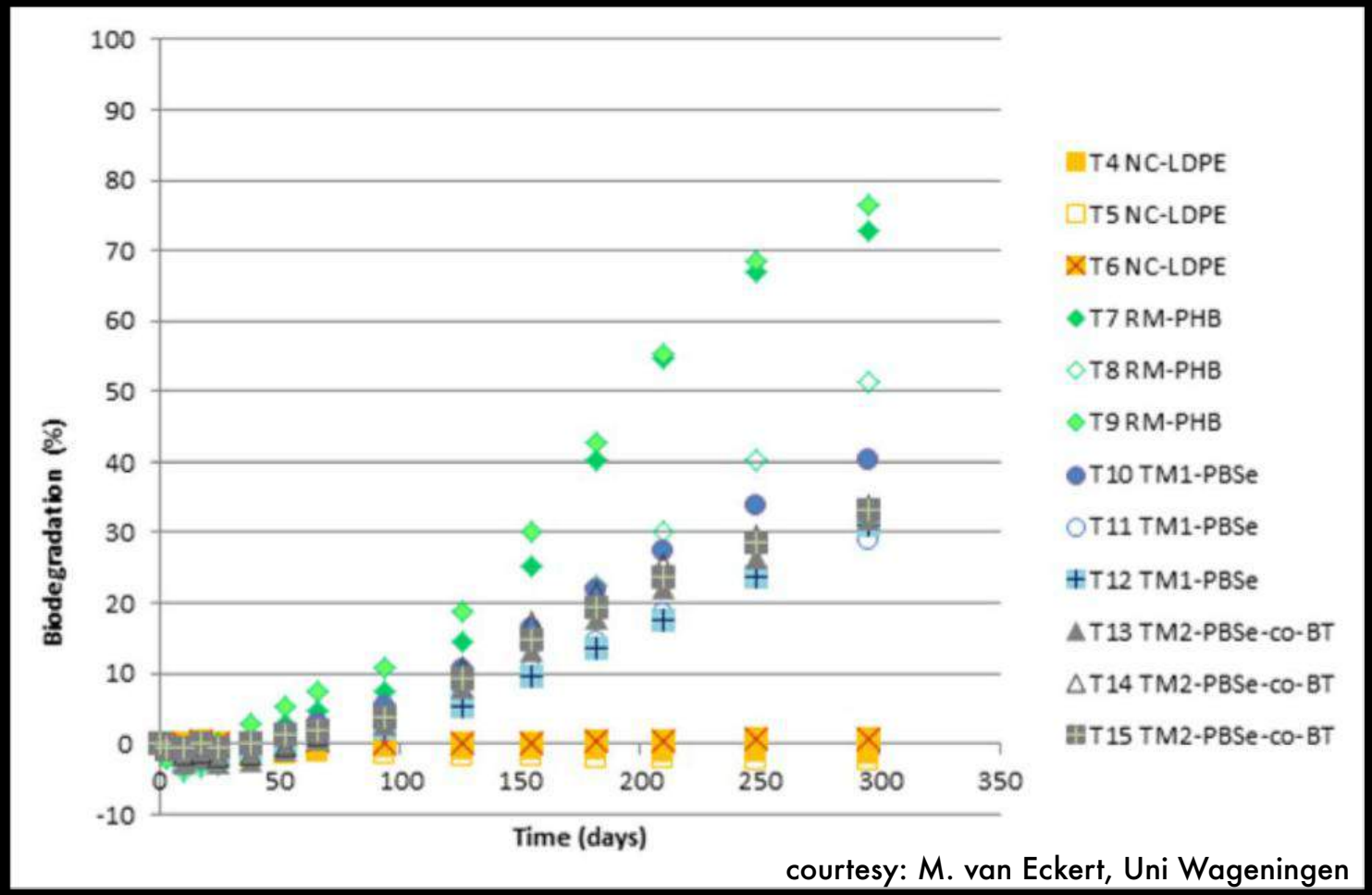
Test materials:

About 20 polymers and blends in field tests since 2009

Pure polymers like Cellophane, PHB, PHBH, PBSe, PBSeT, PLA

Also plastics products: commercially available or under development

RESULTS:
Before: Proof of bio-degradability under lab conditions



courtesy: M. van Eckert, Uni Wageningen

example scenario: plastic buried in beach sand (PHB 100µm)

RESULTS:

Bio-degradation under real natural field conditions measurable as disintegration

2.5 months

5 months

example scenario: plastic buried in beach sand (PHB 100µm)

Knowledge needed:

Is the material really bio-degradable in nature?

Field tests available

How long does it take?

Where should we use it and where should we not use it?

Knowledge needed:

Is the material really bio-degradable in nature? 

How long does it take?

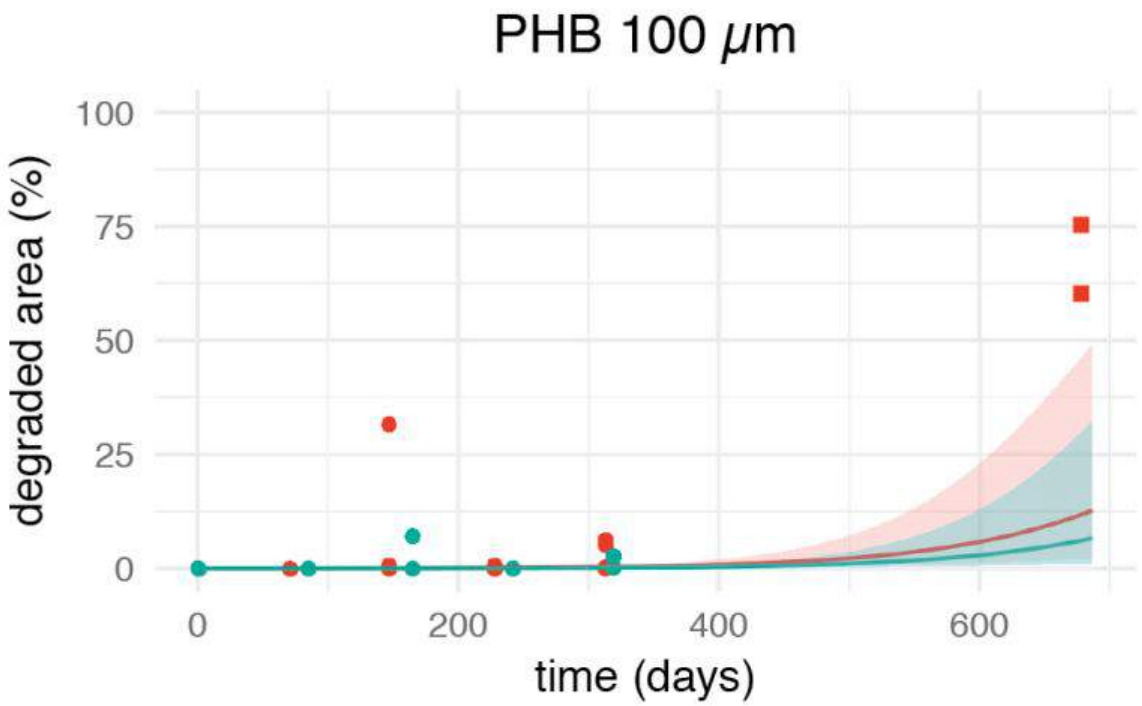
Where should we use it and where should we not use it?

RESULTS **modelled from measured data:**

half-life as a material property

PHB, 100 µm
polyhydroxybutyrate
from Open-Bio, Lott et al. (2016)

disintegration
half-life
mean 883-956 d
(568 - 3005 d)



RESULTS

disintegration depends on habitat and climate zone

PHB 100 µm

disintegration half-life

mean 883-956 d

(568 - 3005 d)

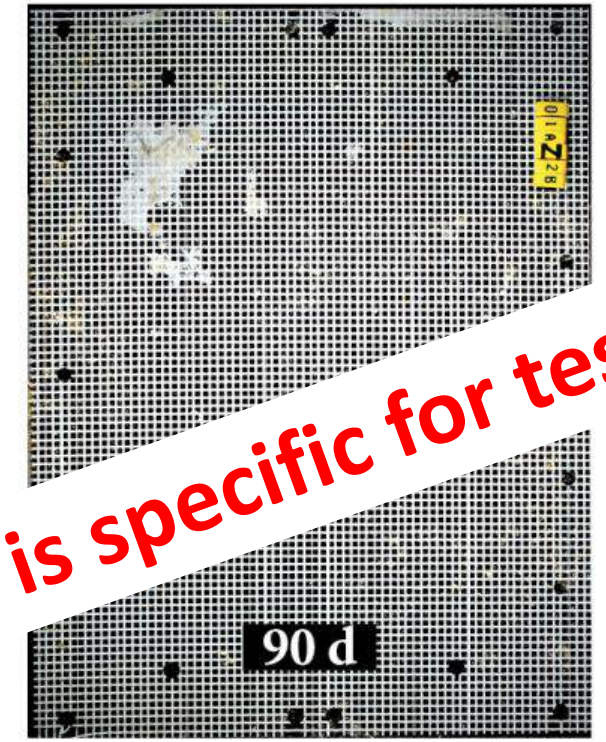
MEDITERRANEAN

disintegration

98.1 (±1.2) % after 90 d*

**experiment ongoing , no sufficient data for half-life yet*

SOUTH-EAST ASIA



Half-life is specific for test conditions

SUMMARY OF TEST RESULTS

All materials so far tested, that were proven bio-degradable in lab tests**,**
showed disintegration in field tests.

Disintegration depends on climate zone and habitat conditions,
like **matrix** (water, sand, mud), **temperature and nutrients**.

Half-life varies **from some weeks to several years**
(over all tested climate zones, habitats and test materials so far).

Disintegration of all tested bio-degradable plastic materials was **much faster than estimated for conventional plastic.**

SUMMARY OF TEST RESULTS

All materials so far tested, that were proven bio-degradable in lab tests**,**
showed disintegration in field tests.

Disintegration depends on climate zone and habitat conditions,
like **matrix** (water, sand, mud), **temperature and nutrients**.

Half-life varies **from some weeks to several years**
(over all tested climate zones, habitats and test materials so far).

Disintegration of all tested bio-degradable plastic materials was **much faster than estimated for conventional plastic.**

Knowledge needed:

Is the material really bio-degradable in nature?

How long does it take?

Half-life can be determined

Where should we use it and where should we not use it?

Knowledge needed:

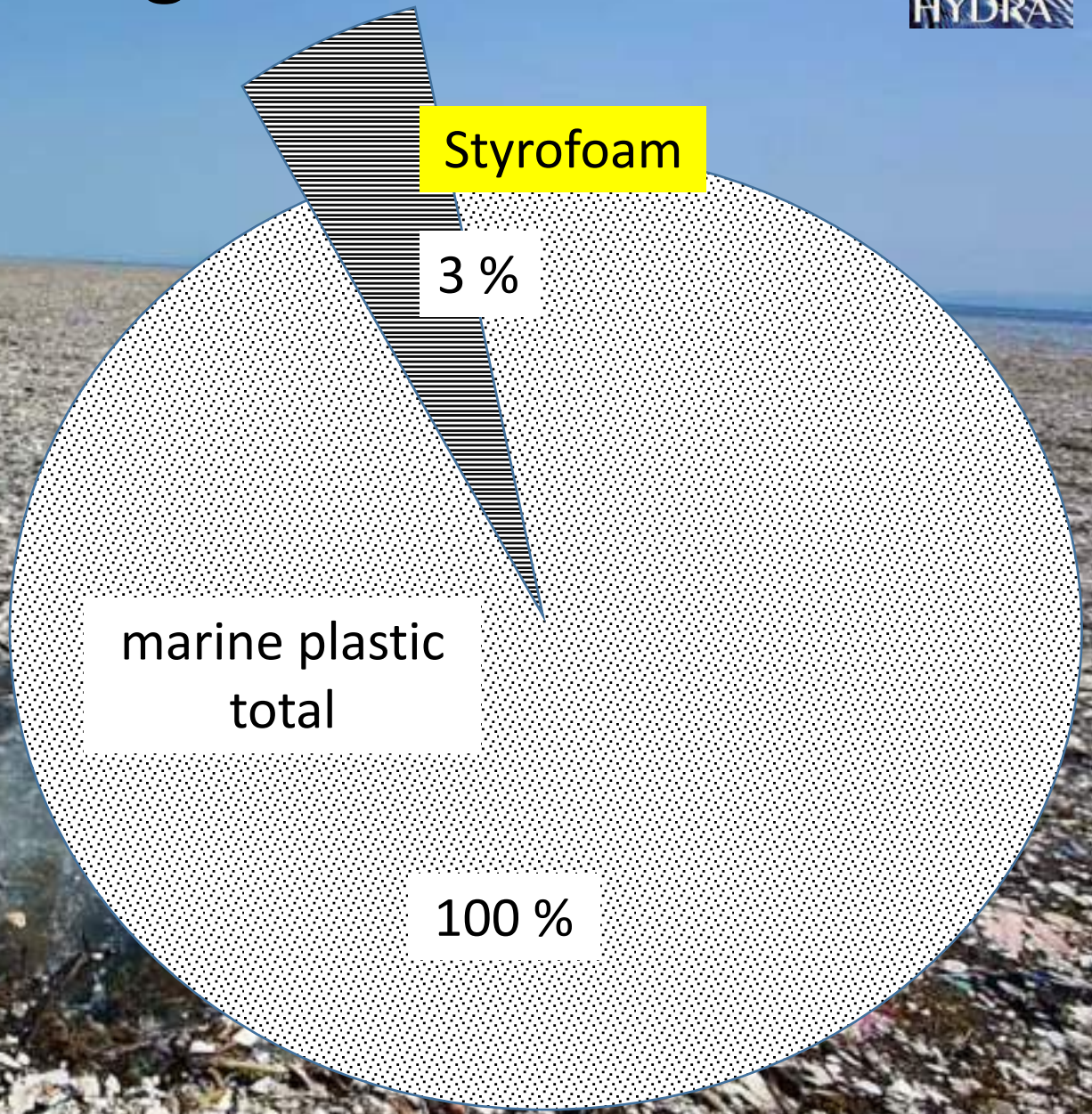
Is the material really bio-degradable in nature? 

How long does it take? 

Where should we use it and where should we not use it?

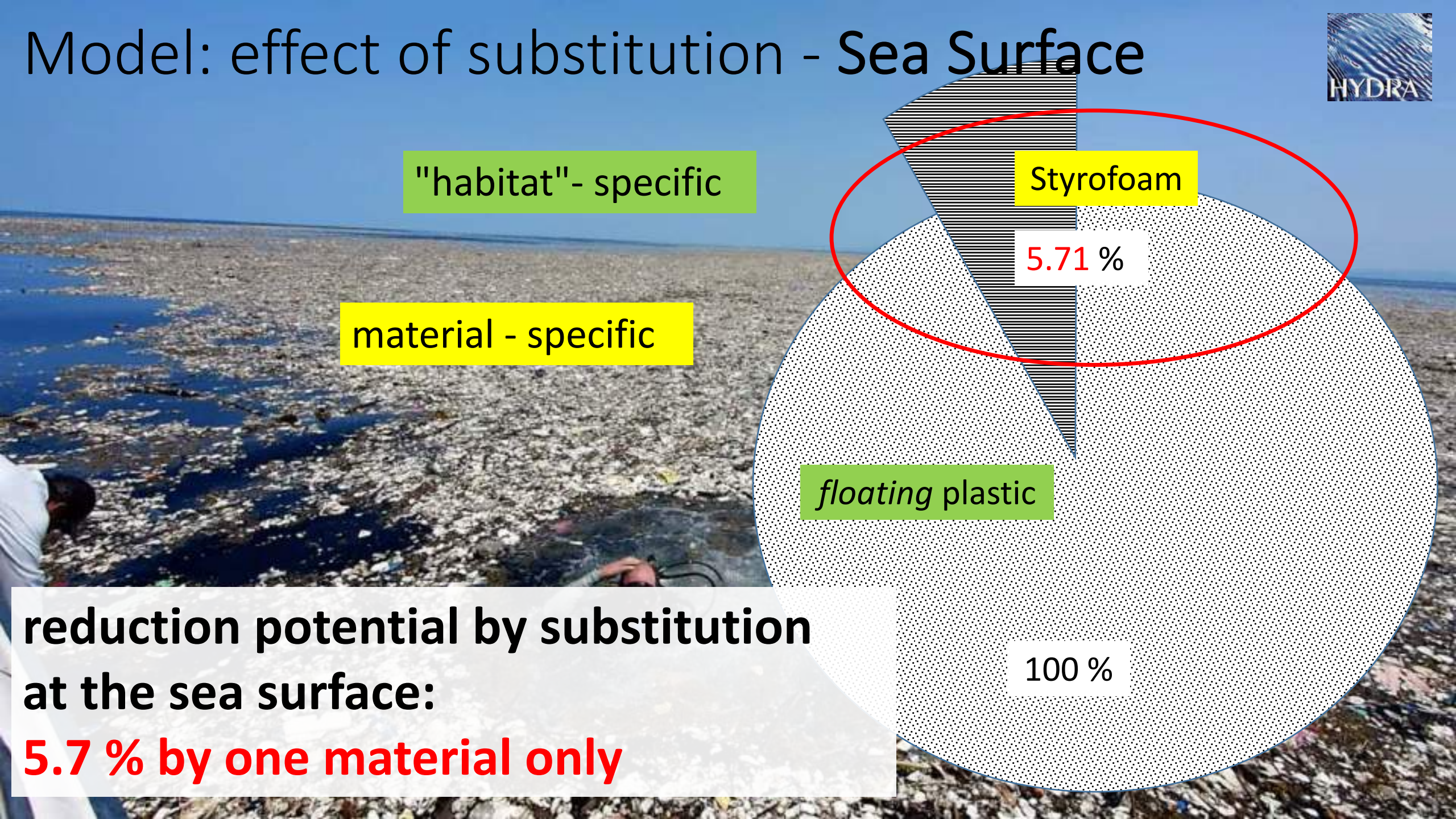
Model: effect of substitution - global marine

material - specific



Raw data from: AWI-LITTERBASE, litterbase.org, 2017

Model: effect of substitution - Sea Surface



reduction potential by substitution at the sea surface:

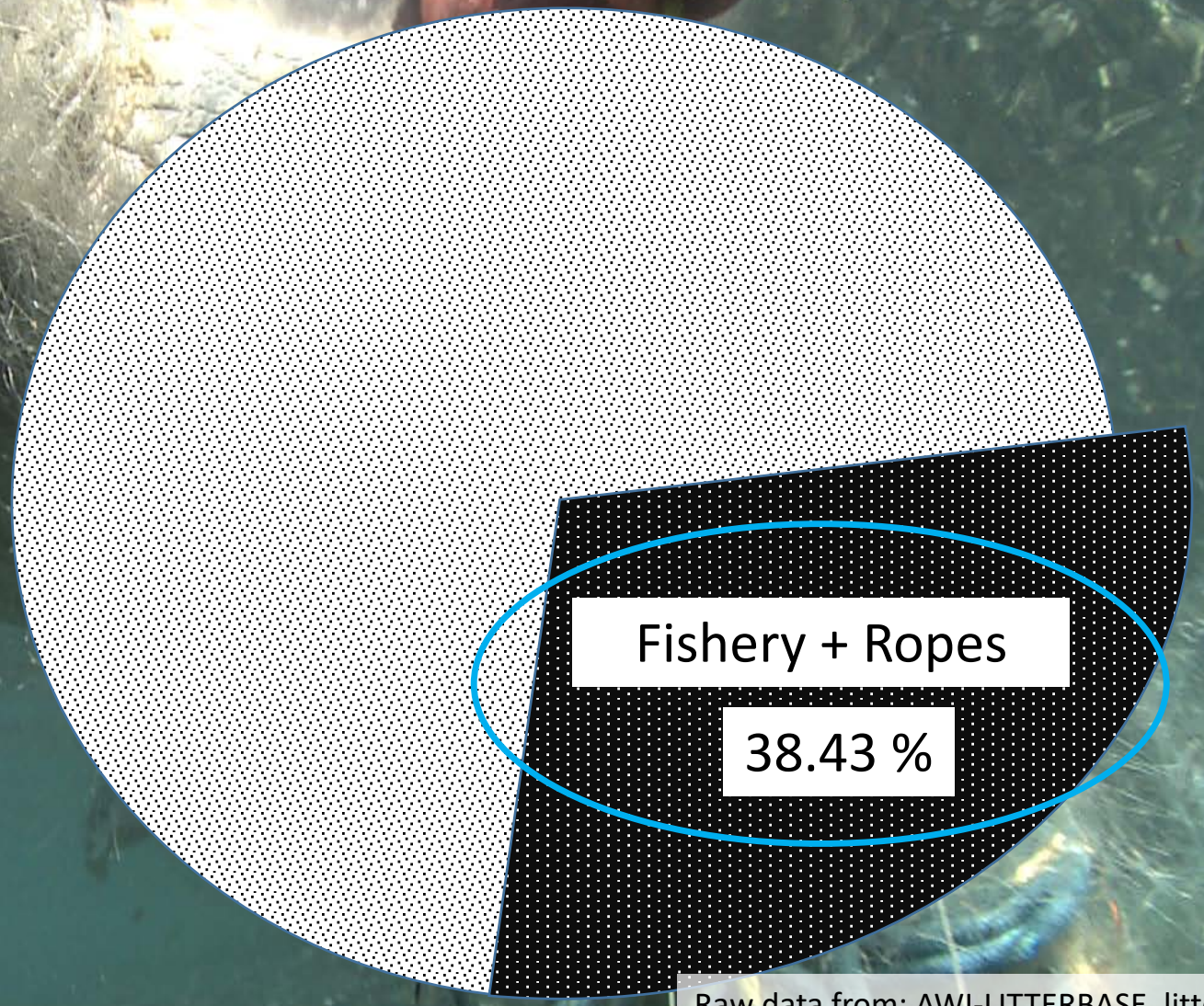
5.7 % by one material only

Model: effect of substitution - Seafloor

„habitat“ - specific

segment - specific

Derelict fishing gear at the seafloor:
38 % potential
in one segment



Raw data from: AWI-LITTERBASE, litterbase.org, 2017

Further Substitution Potential

local: item - specific

e.g. high share of
“mono-dose“ water cups

locally:
water cups in beached litter:
> 80 %

Further Substitution Potential

Intrinsic risk of loss

Fishing gear:

ropes, nets, traps, bait, fish boxes, etc.

Boating gear:

paint, ropes, floats, buoys, fenders, etc.

Products from coastal activities:

Mass events, Tourism (ships, resorts, beach activities etc.)

Cigarette filters, tableware, straws, drinking bottles, food packaging, toys, shoes, etc.

Further Substitution Potential

Intrinsic risk of loss

Fishing gear:

ropes, nets, traps, bait, fish boxes, etc.

Boating gear:

paint, ropes, floats, buoys, fenders, etc.

Products from coastal activities:

Mass events, Tourism (ships, resorts, beach activities etc.)

Cigarette filters, tableware, straws, drinking bottles, food packaging, toys, shoes, etc.

Further Substitution Potential

Intrinsic risk of loss

Fishing gear:

ropes, nets, traps, bait, fish boxes, etc.

Boating gear:

paint, ropes, floats, buoys, fenders, etc.

Products from coastal activities:

Mass events, Tourism (ships, resorts, beach activities etc.)

Cigarette filters, tableware, straws, drinking bottles, food packaging, toys, shoes, etc.

Chances and Risks

Bio-degradables cannot be the general solution to marine plastic pollution.
Plastic waste in the environment is pollution, also if bio-degradable!

Freshly introduced bio-degradable plastic **bears the same risks** as conventional plastic (e.g. ingestion, entangling, etc.). However, **it will not persist "forever" and accumulate further**.

In certain applications a big **impact on reducing accumulation of persistent plastic** in the environment is possible.

Certification by reliable agencies for claims for materials is **necessary**.

Chances and Risks

Bio-degradables cannot be the general solution to marine plastic pollution.
Plastic waste in the environment is pollution, also if bio-degradable!

Freshly introduced bio-degradable plastic **bears the same risks** as conventional plastic (e.g. ingestion, entangling, etc.). However, **it will not persist "forever" and accumulate further**.

In certain applications a big **impact on reducing accumulation of persistent plastic** in the environment is possible.

Certification by reliable agencies for claims for materials is **necessary**.

Chances and Risks

To **measure *biodegradation*** in the marine environment is **possible**.

To **determine marine *biodegradability* remains difficult**, and **requires boundary conditions**, as it is ”complicated by nature”:

- Which time is acceptable?
- Which habitats should be included/represent "marine”?

Knowledge needed:

Is the material really bio-degradable in nature? ✓

How long does it take? ✓

Where should we use it and where should we not use it?

???

questions remain

some can be answered by science

more have to be answered by society and politics

info@hydramarinesciences.com

www.hydramarinesciences.com
www.hydra-institute.com