ARC Training Centre for Bioplastics and Biocomposites

38APS
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The effect of additives on the biodegradation of polyhydroxyalkanoate (PHA) in marine field trials

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Bioplastics

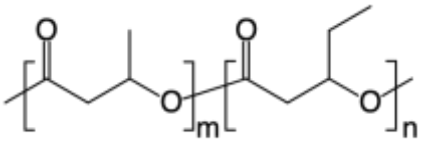
are already part of
our **everyday life.**

‘Bioplastics’ covers a suite of very different materials

Bioplastics (and additives)

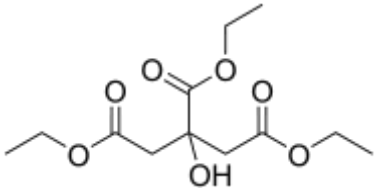
Poly(3-hydroxybutyrate-co-3-hydroxyvalerate) (PHBV):

- 1 mol% 3HV content



Non-toxic plasticiser:
Triethyl citrate

- ester of citric acid



Filler:
Radiata pine

- wood flour milled to 75 µm
- cellulose, hemicellulose, lignin

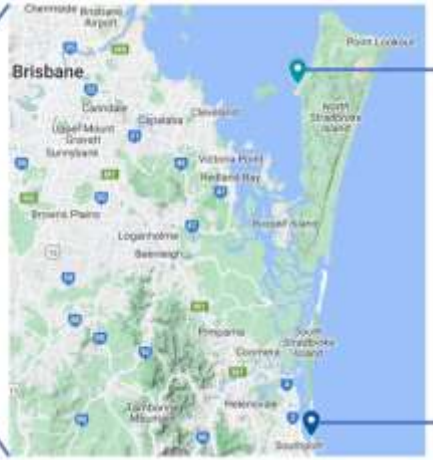
Polyhydroxyalkanoate (PHA)
+
bioderived, biodegradable additives

What happens if the end of life of bioplastic products is in the marine environment?

How do additives effect bioplastic degradation and lifetimes in the marine environment?

Field trial methodology

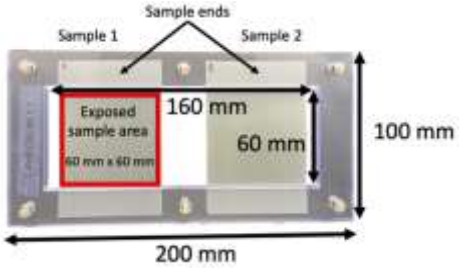
35-week exposure in 2 sub-tropical marine sites of melt extruded PHBV

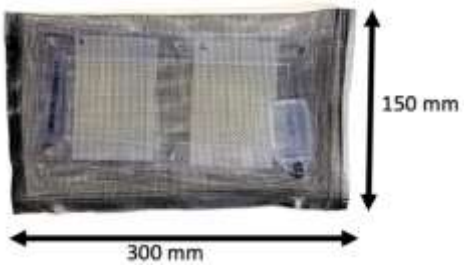


Seabed in Open Sea

Seabed in Mesocosm / continuous flow seawater

Sample Code	Component content (wt%)	Thickness (µm)	Number of sheets used in field trial
PHBV(150)	100	150	40
PHBV/TEC(150)	80/20	150	40
PHBV(250)	100	250	40
PHBV/WF(250)	80/20	250	40

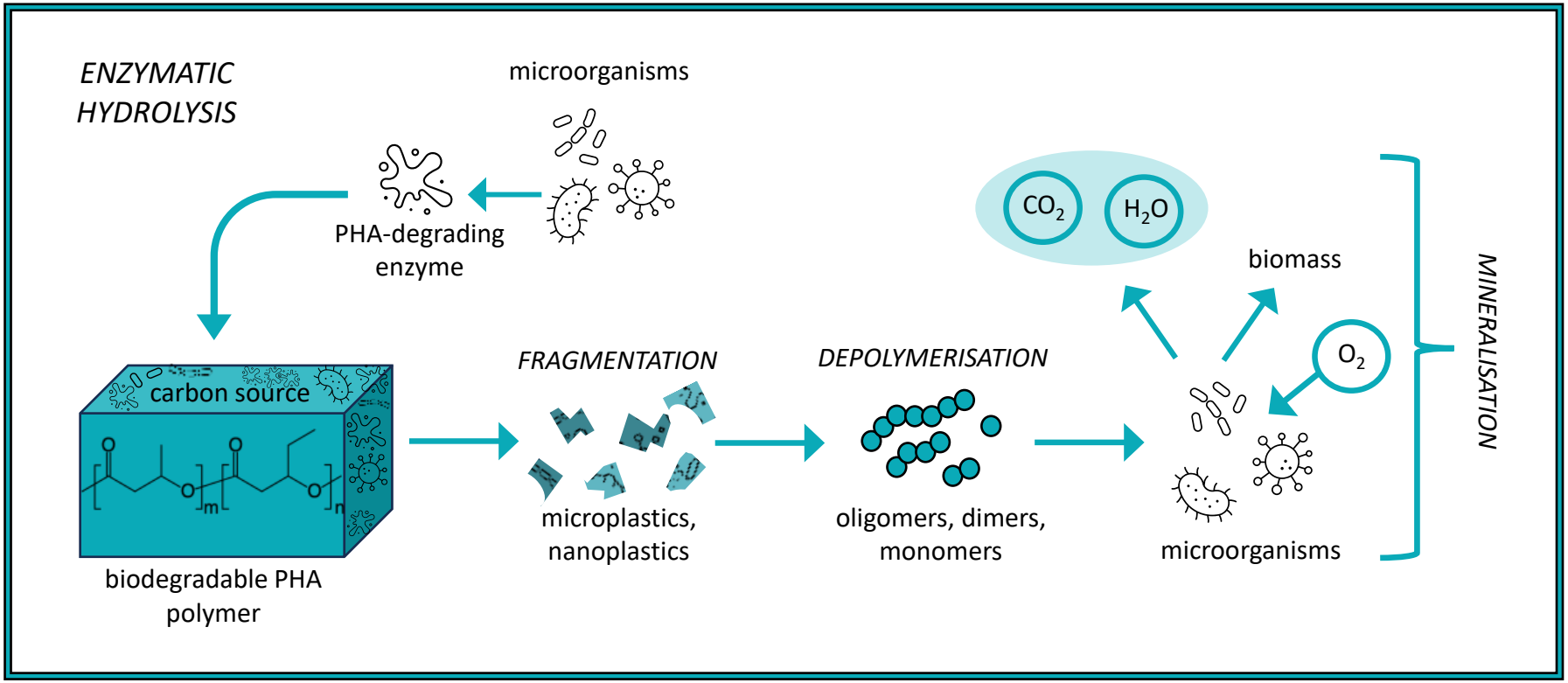




Sample set retrieval:
3-5 weeks

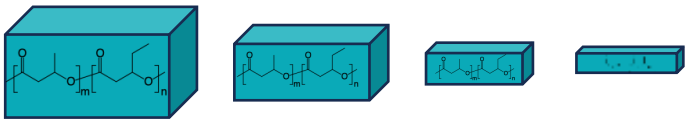
Lifetimes: mass loss
Mechanisms: molecular weight, mechanical properties, surface changes

Biodegradation process of PHA in the natural environment



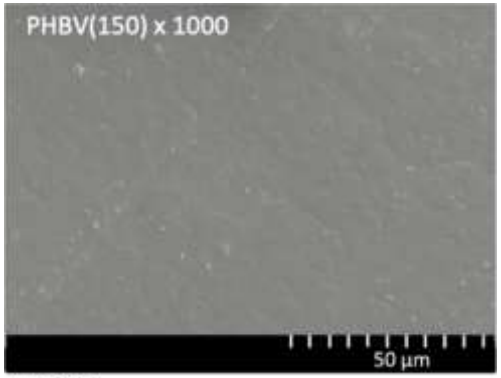
Surface erosion mechanism

- Mass and thickness decreases
- Molecular weight is maintained
- Mechanical properties maintained

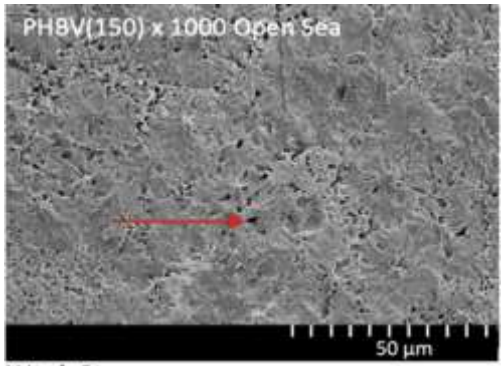


The effect of TEC plasticiser on the biodegradation of PHBV

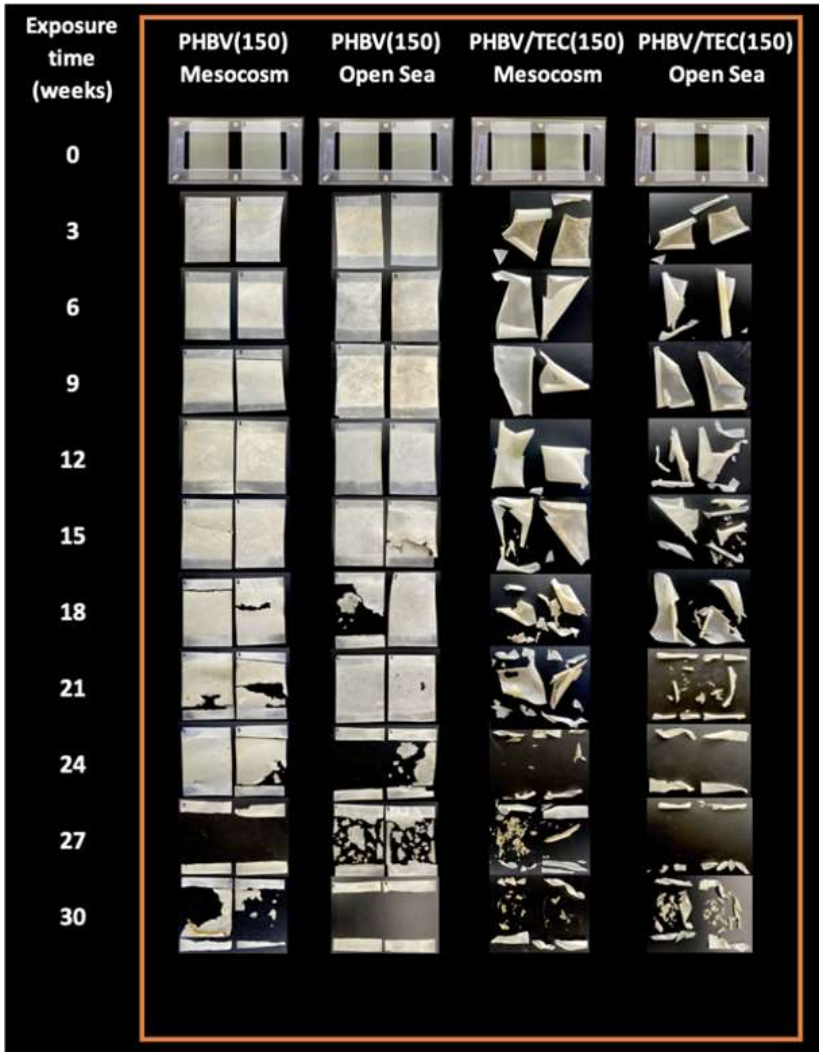
Scanning Electron Microscopy (SEM)

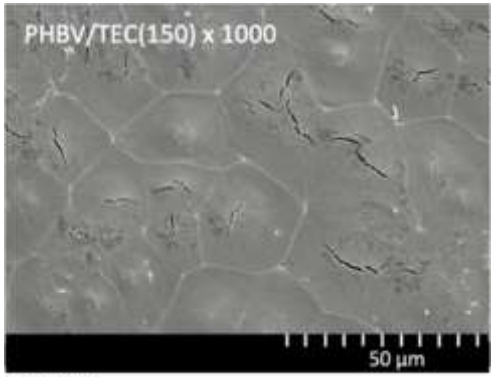


Week 0

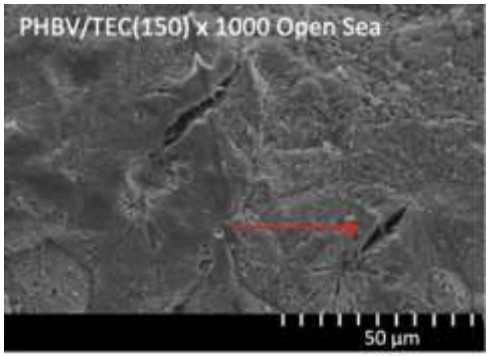


Week 6





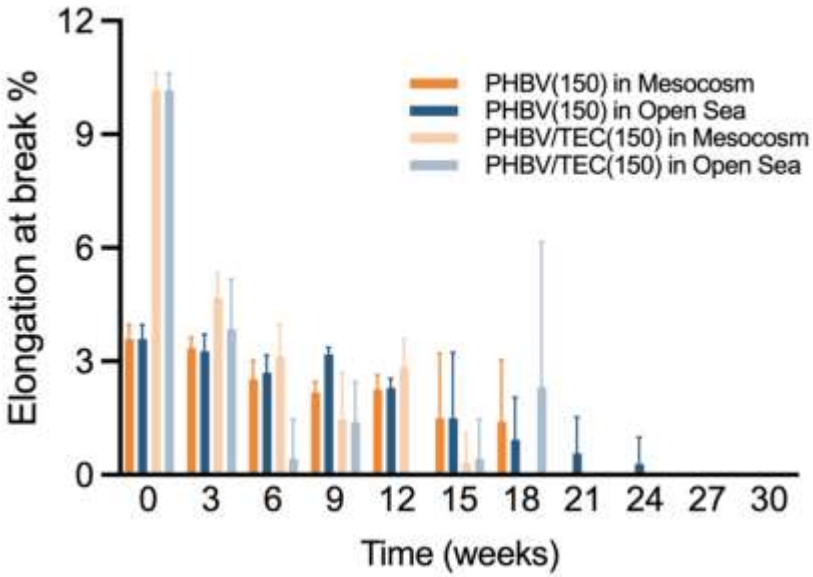
Week 0



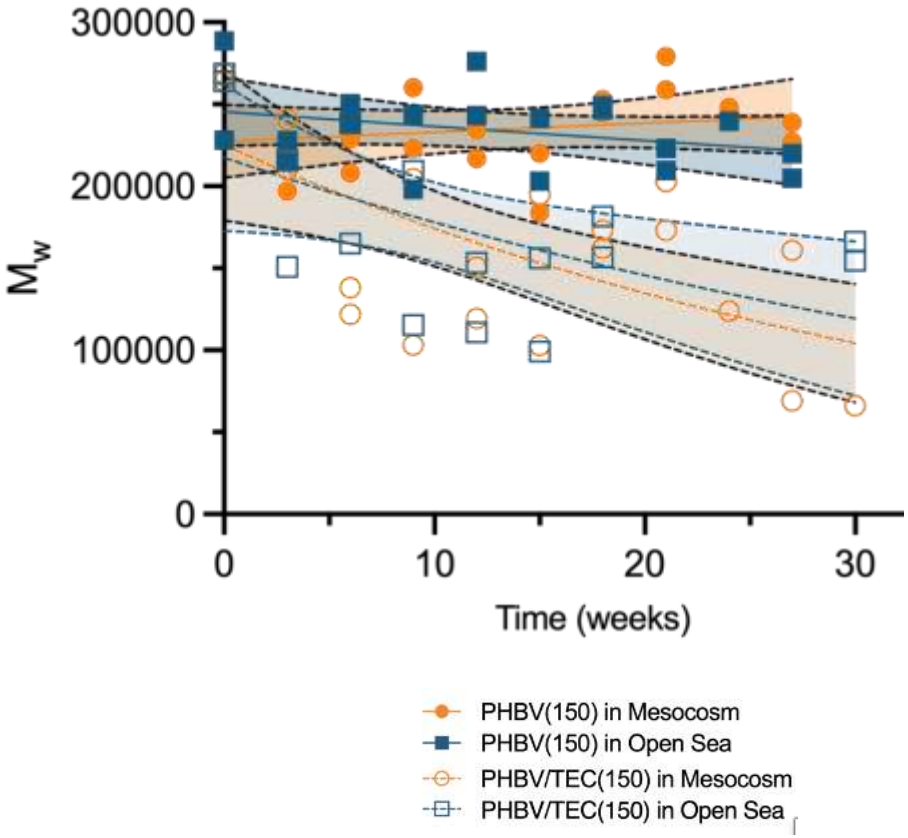
Week 6

The effect of TEC plasticiser on the biodegradation of PHBV

Mechanical property changes



Molecular weight differences

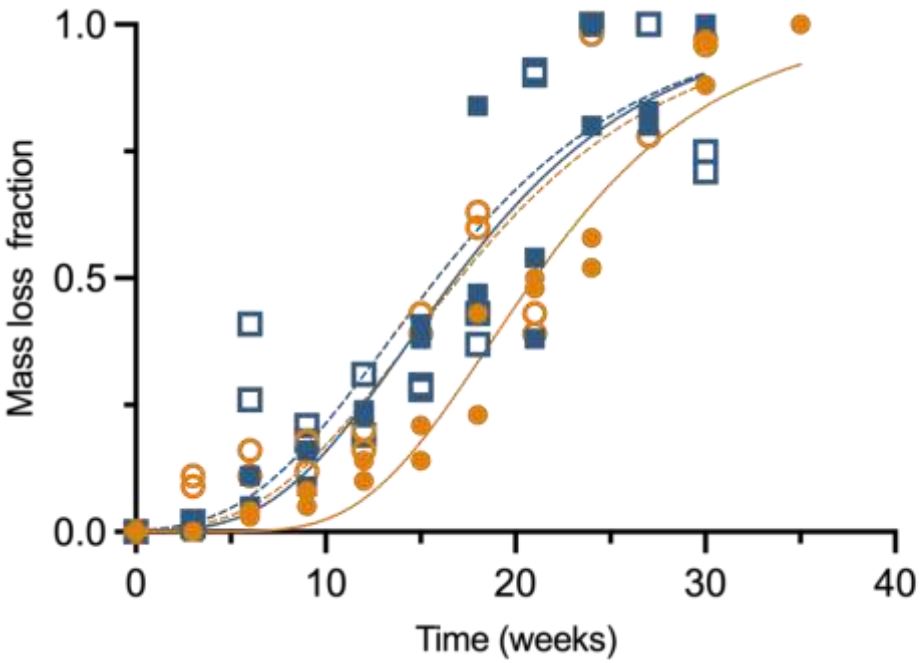


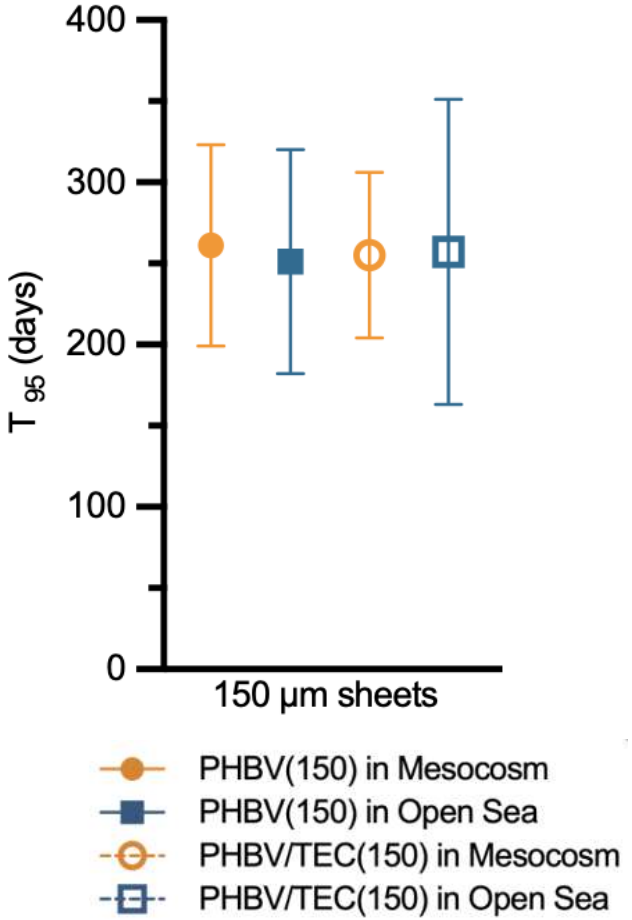
Week 6: <5% initial mass of TEC detected by ^{1}H NMR

The effect of TEC plasticiser on the lifetime of PHBV sheets

Gompertz modelling:

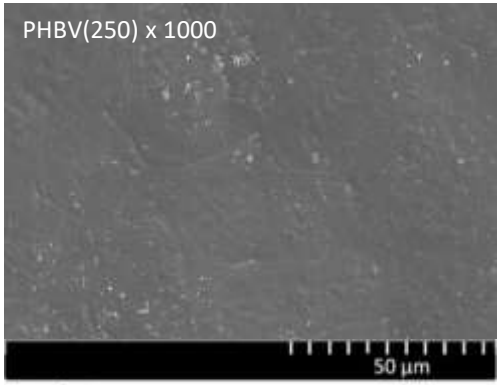
- biodegradation rate
- lag time
- time to 95% mass loss



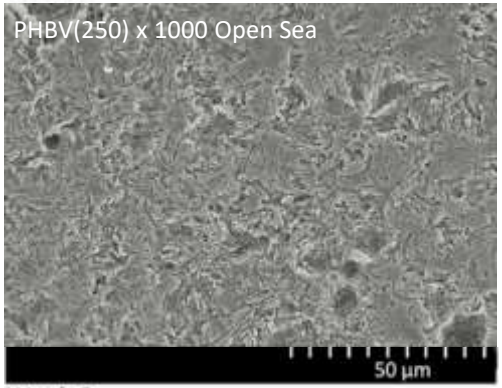


The effect of WF filler on the biodegradation of PHBV

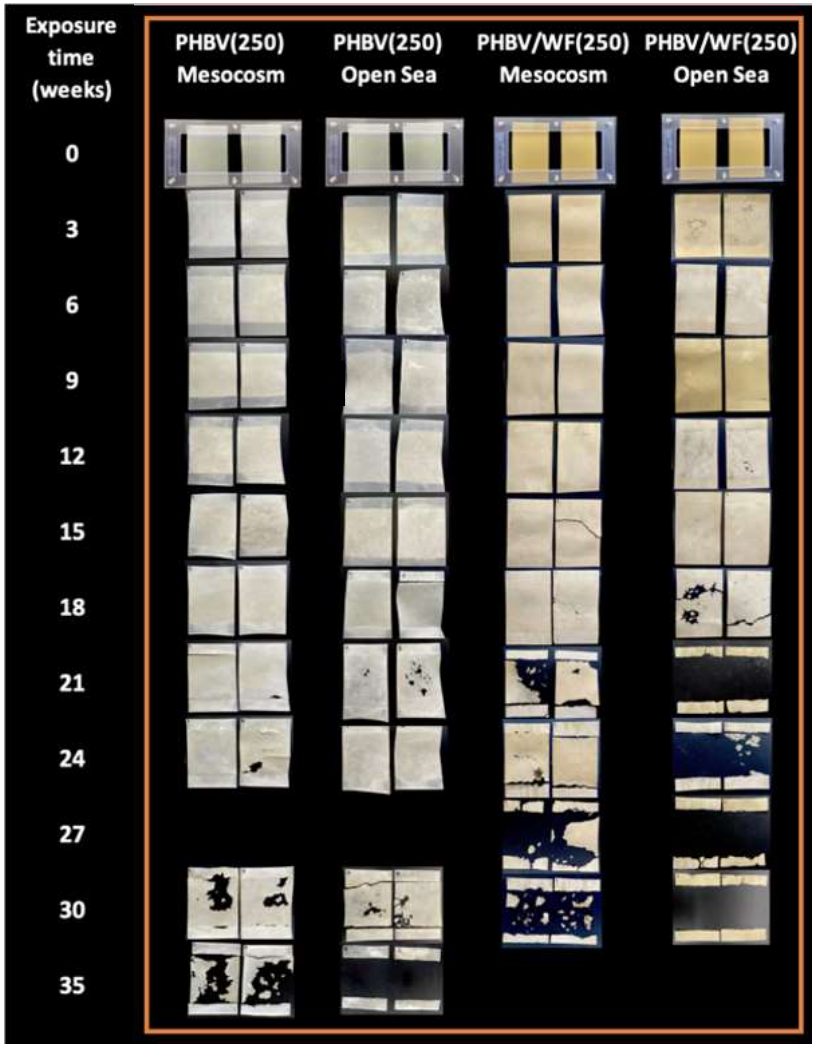
Scanning Electron Microscopy (SEM)

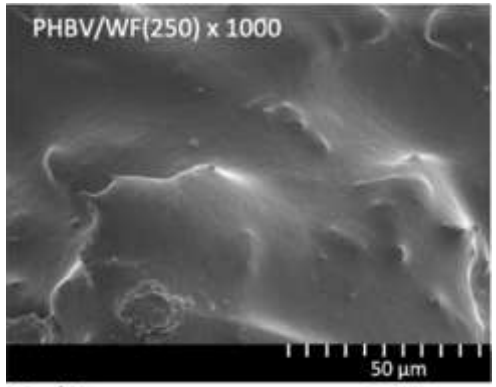


Week 0

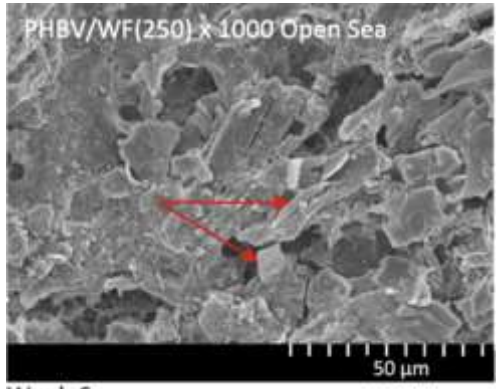


Week 6





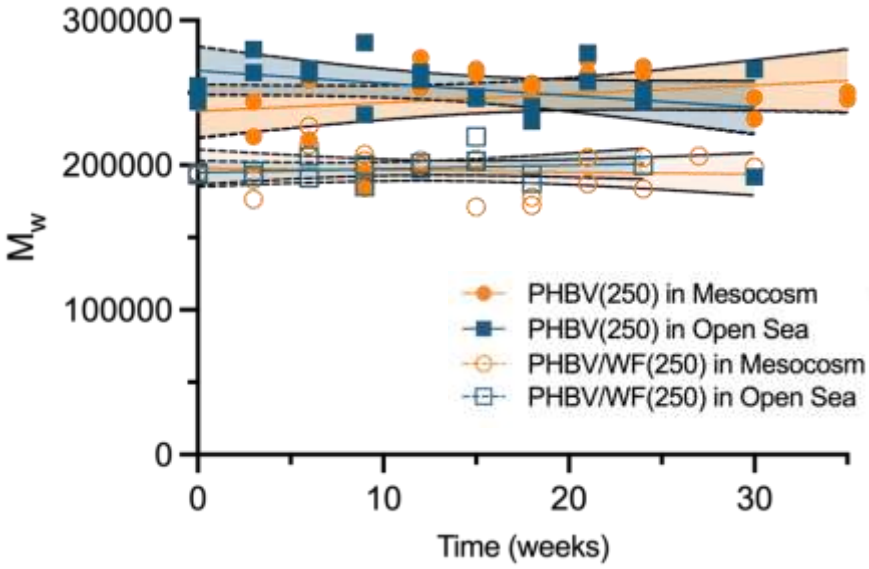
Week 0



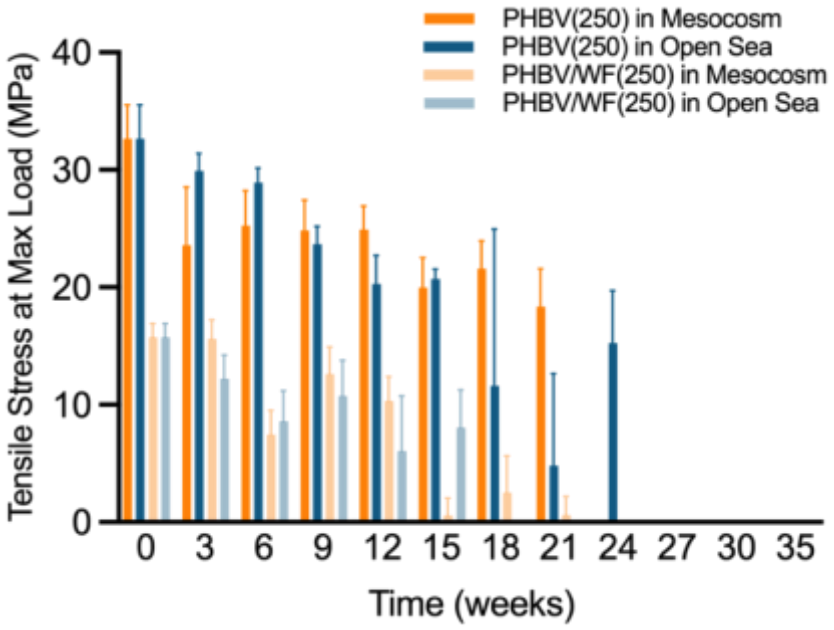
Week 6

The effect of WF filler on the biodegradation of PHBV

Molecular weight maintained



Mechanical property changes



The effect of WF filler on the lifetime of PHBV sheets

Gompertz modelling:

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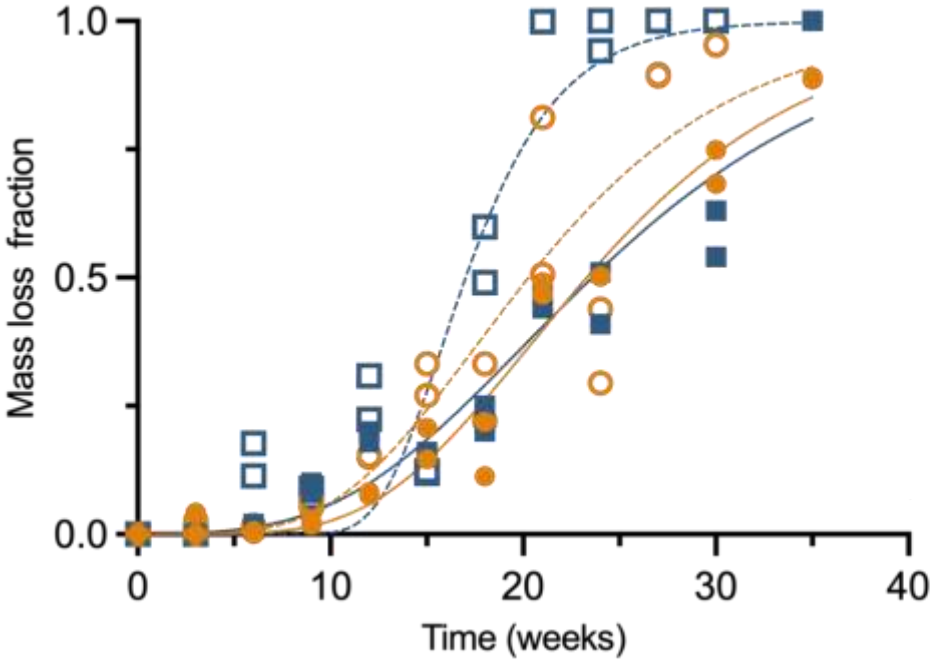
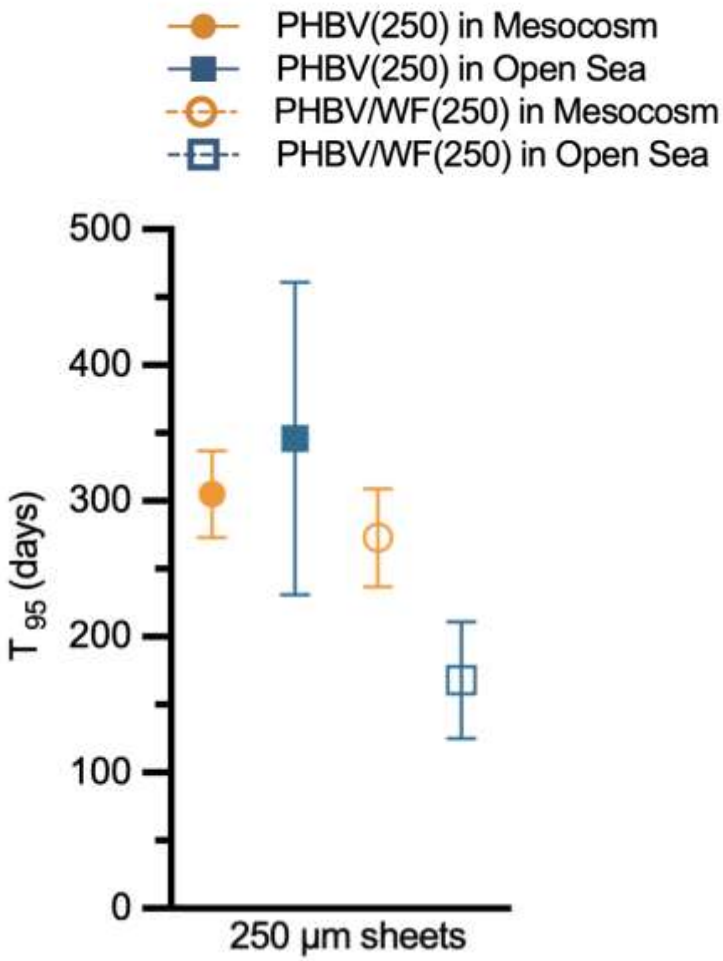
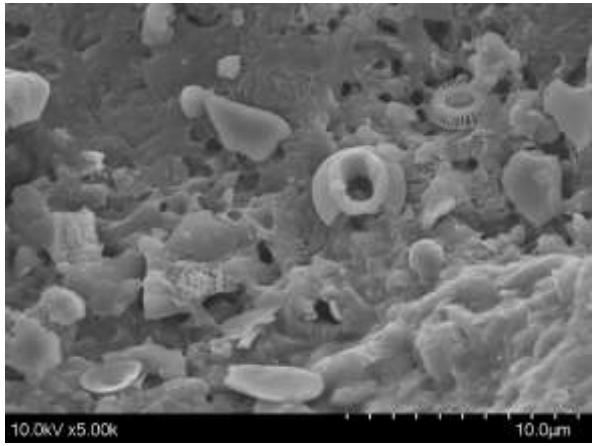




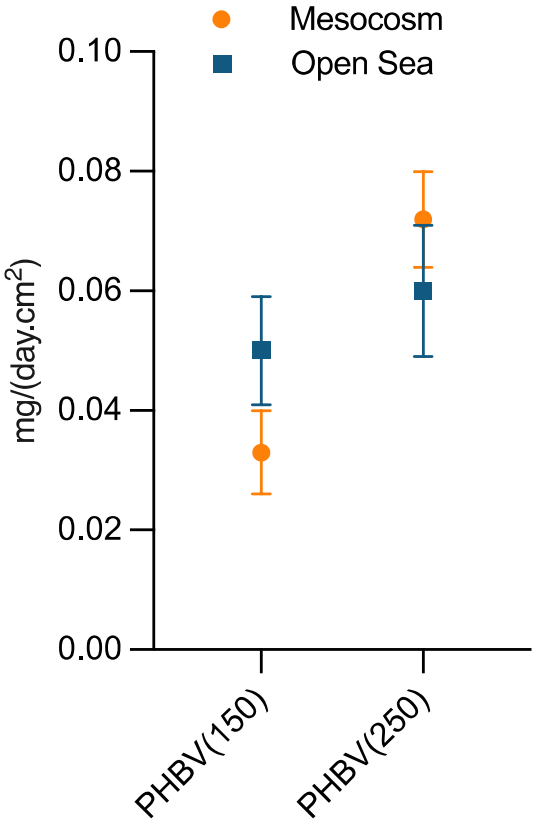
Conclusions

Rapid biodegradation for all PHBV samples

	T_{95}
PHBV(150) Mesocosm PHBV(150) Open Sea PHBV/TEC(150) Mesocosm PHBV/TEC(150) Open Sea	**250 - 260 days**
PHBV/(250) Mesocosm PHBV/(250) Open Sea	**300 - 350 days**
PHBV/WF(250) Mesocosm	**270 days**
PHBV/WF(250) Open Sea	**170 days**

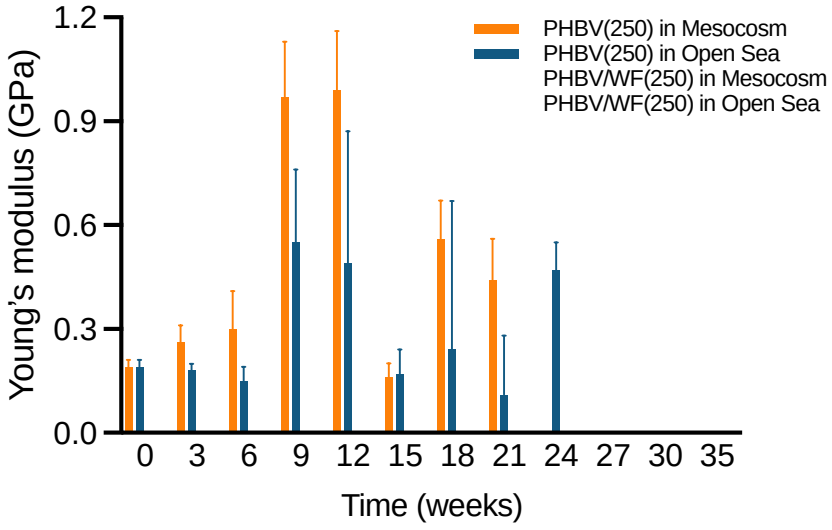


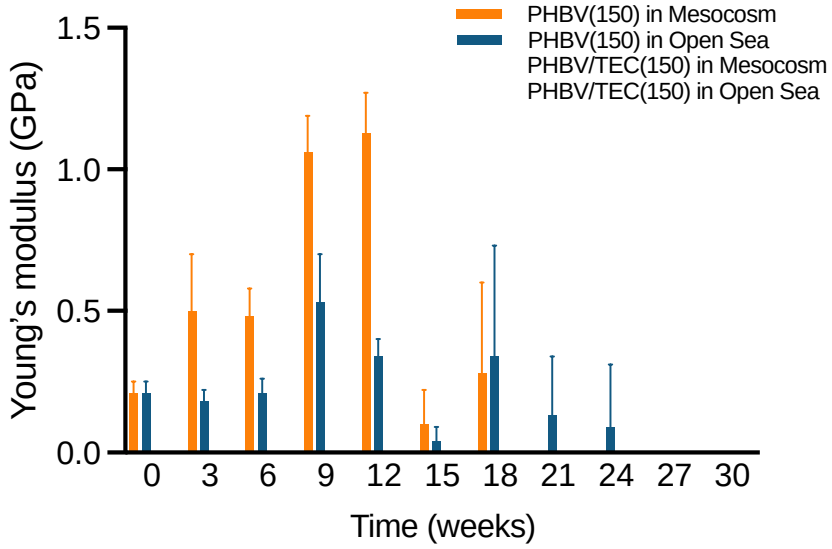
Mesocosm – PHBV/WF(250) Week 6
Diatoms in the biofilm (magnification x 5000)



Specific rates of mass loss

Conclusions





Young's modulus increase

Acknowledgements

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- **Prof. Bronwyn Laycock**
- **A/Prof. Steven Pratt**
- **Prof. Paul Lant**

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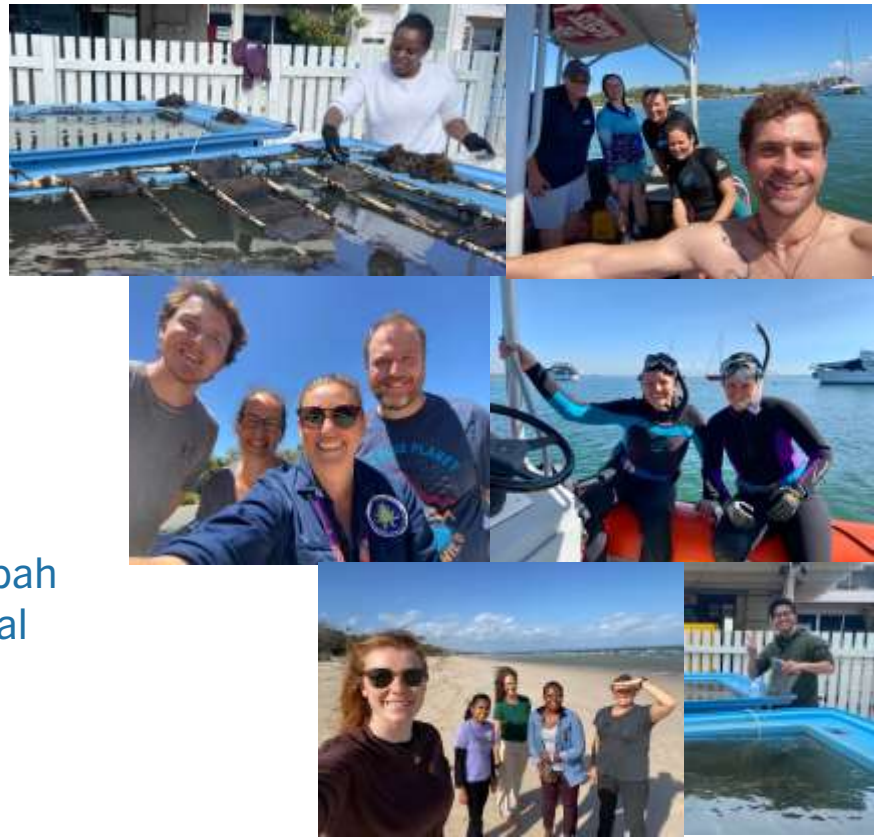
- Moreton Bay Research Station, Minjerribah
- Quandamooka Yoolooburrabee Aboriginal Corporation (QYAC)

23 Volunteers supporting the sample collection



Read, Tracey and Chan, Clement Matthew and Chaléat, Céline and Laycock, Bronwyn and Pratt, Steven and Lant, Paul,
The Effect of Additives on the Biodegradation of Polyhydroxyalkanoate (PHA) in Marine Field Trials
Available at SSRN: https://ssrn.com/abstract=4681392 or http://dx.doi.org/10.2139/ssrn.4681392

Thank you

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State your aim/purpose.
Contextualise your research.
Present methods and findings clearly and attractively.
End your talk with a powerful 'take-home' message.
Deal with questions effectively.

Introduction
The 18-month Field Trial
Methodology
Results
Outcomes

https://docs.european-bioplastics.org/publications/market_data/2022/Report_Bioplastics_Market_Data_2022_short_version.pdf