QUEEN'S UNIVERSITY BELFAST

THE INSTITUTE FOR GLOBAL FOOD SECURITY

Feed from the sea: A move towards sustainable ruminant livestock production using brown seaweed

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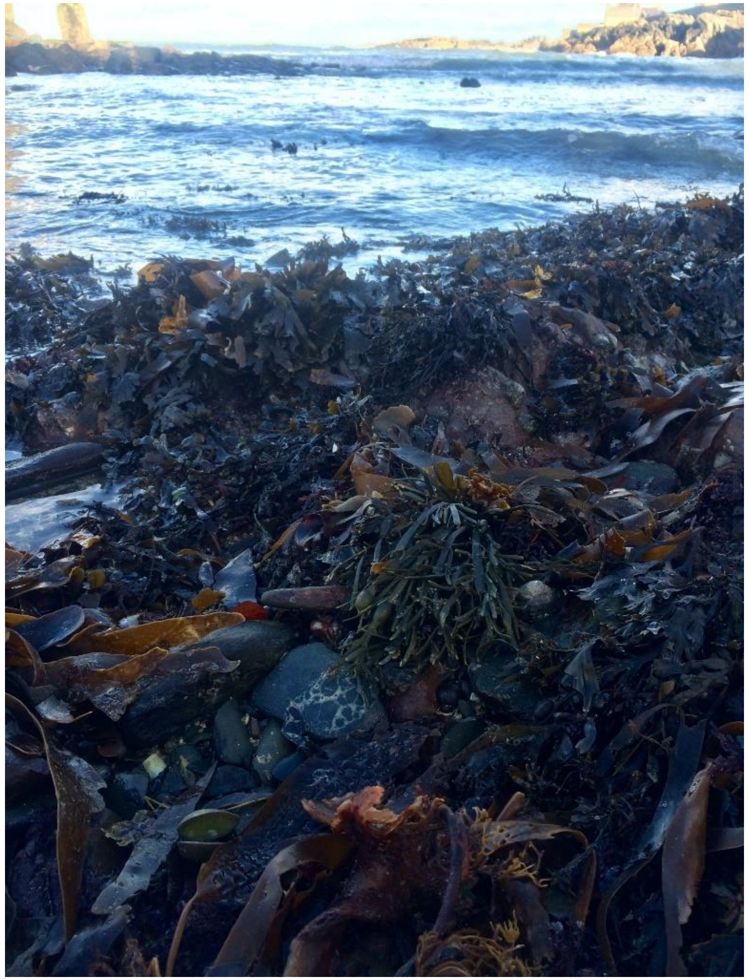


Project Aims

Nutritional value of brown seaweeds as alternative feeds for ruminant livestock

- Chemical composition
- Seasonal variation in nutritional profile
- Effect of seaweed on *in vitro* ruminal methane emissions

Ruminants, methane & seaweed

Methane from enteric fermentation is the second largest source (39%) of GHG associated with livestock production (Gerber et al., 2013)

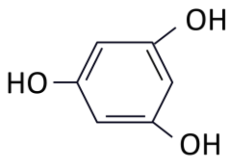
Rumen methane synthesis= **loss in dietary energy** (2-12%) (Johnson & Johnson, 1995)

Feeding low inclusions of **brown seaweed** shown to **reduce ruminal methane emissions** (Machado et al., 2014, Belanche et al., 2016a)

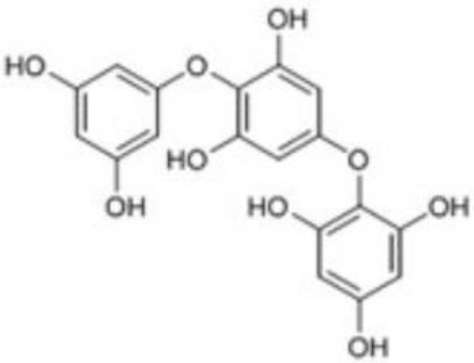
Low number of studies on **anti-methanogenic** properties and **nutritional value** of brown seaweed (Molina-Alcaide et al., 2017, Belanche et al., 2016b)

Possible pathways of methane inhibition by phlorotannins

Brown seaweed are rich in **polyphenols called phlorotannins**



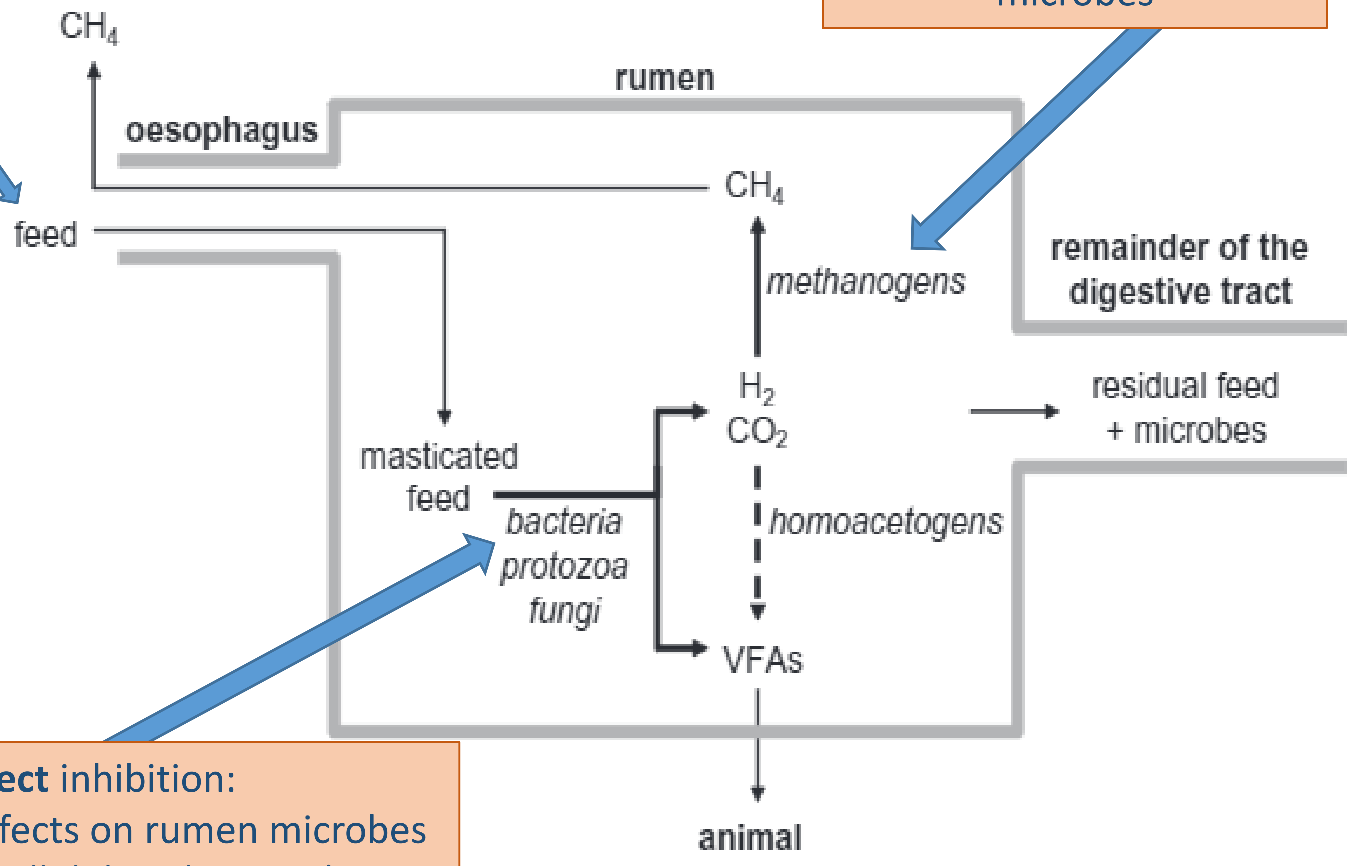
Basic phloroglucinol subunit



Form complex oligomers
E.g. Eckol
(Vissers et al., 2017)

Bind to proteins/carbohydrates in feed

Direct inhibition:
Antimicrobial effects on methane producing microbes



Indirect inhibition:
Antimicrobial effects on rumen microbes
(primarily cellulolytic bacteria)
(Wang et al., 2008)

Adapted from Buddle et al. (2011)

Effect of seaweed on *in vitro* ruminal methane emissions

Objective: A preliminary study into the effect of brown seaweed on polyphenol content and *in vitro* methane production

Material & Methods

Sample collections (Spring 2017)

- *Ascophyllum nodosum* (ASC)
- *Fucus vesiculosus* (FVS)
- *Saccharina latissimi* (SAC)
- *Laminaria digitata* (LAM)

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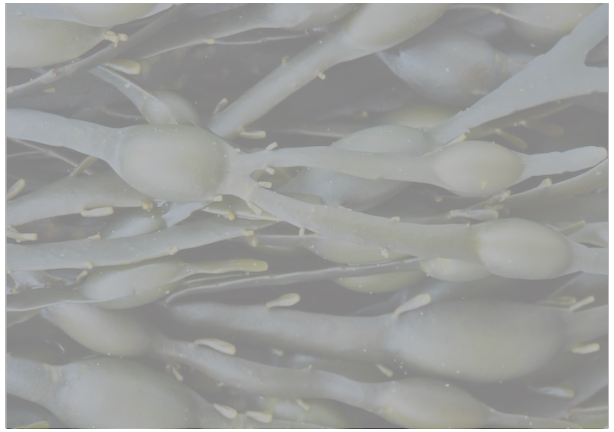

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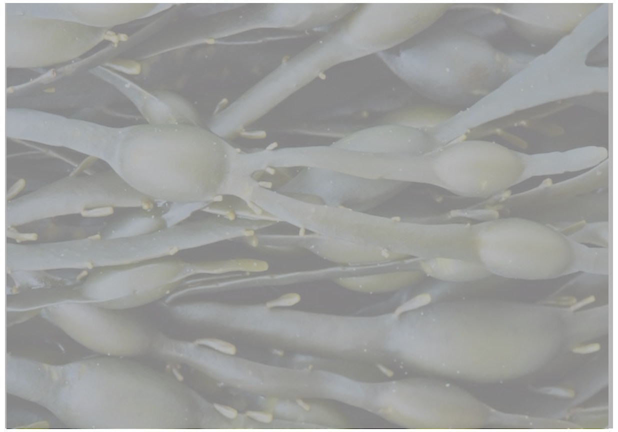

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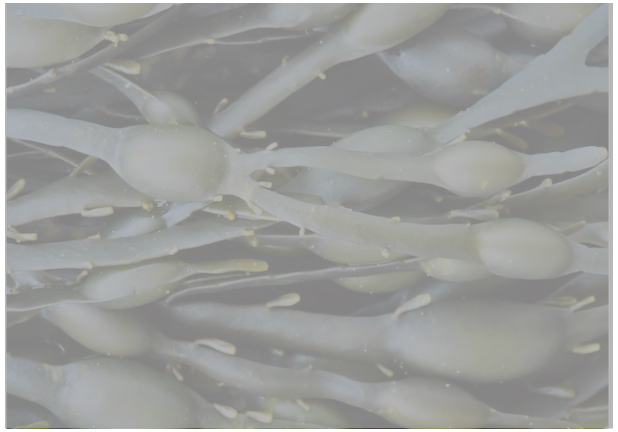
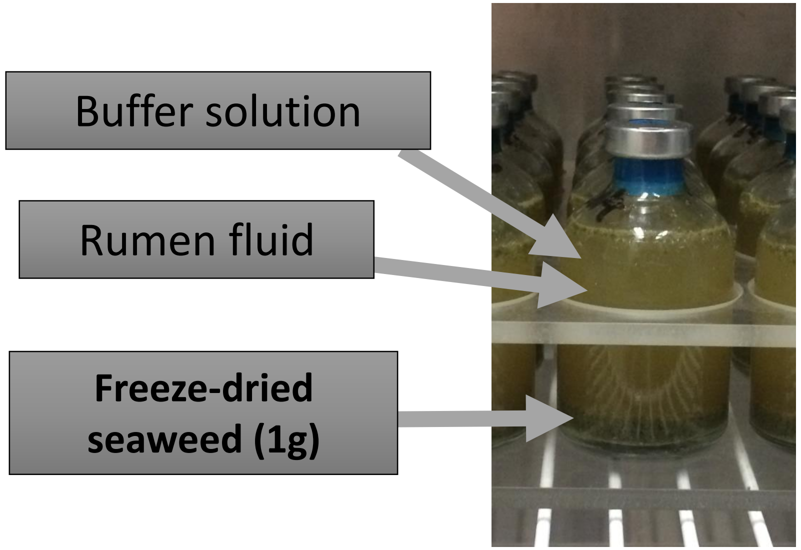


Material & Methods
In vitro gas production trial
(*Theodorou et al. 1994)*)

- 4x species: ASC, FVS, LAM, SAC
- Control: Lucerne (non-tannin containing feed)
- 100% inclusion
- Rumen fluid donors: Holstein-Friesian dry cows

Measurements :

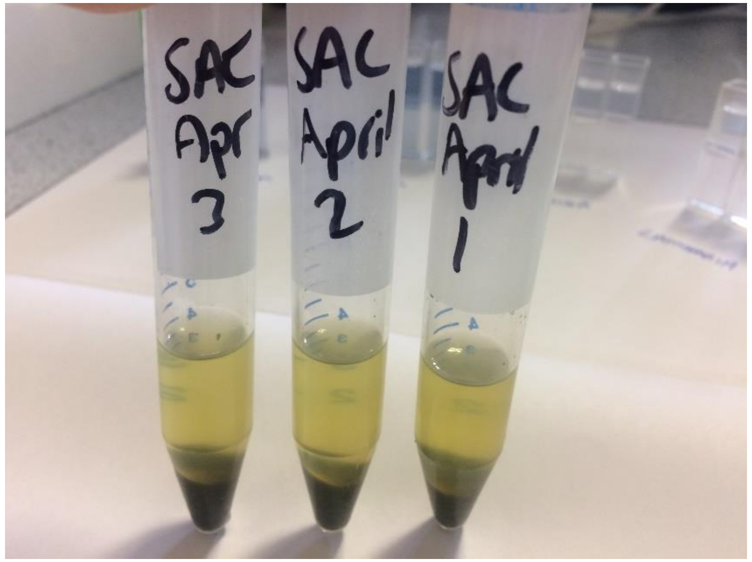
- Gas pressure (psi)
- Composition of fermentation gases (%CO_2, %CH_4)
- Calculated ml/g methane gas produced
- Time points: 3, 6, 12, 24, 36, 48, 72, 96, 120 hours



Method: Polyphenols

- Freeze-dried seaweed
- Obtain Crude extract using 30% Acetone solution
- Folin-Ciocalteu reagent & Na_2CO_3 added
- Stored in the dark for one hour
- Absorbance read at 725nm using a spectrophotometer

Results expressed as <u>phloroglucinol</u> equivalents



Total phenols were determined by the Folin-Ciocalteu, colourmetric method

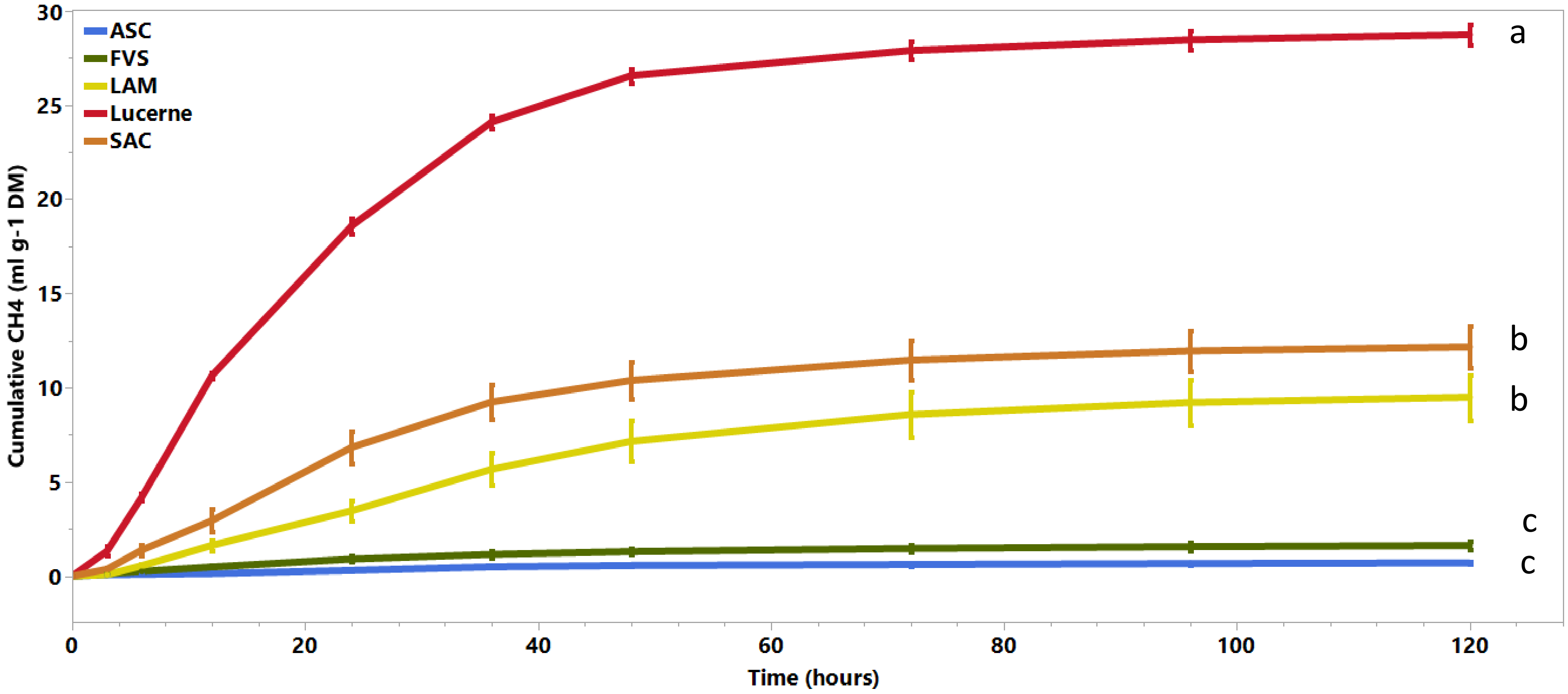
(Folin & Ciocalteau, 1927; Singleton & Rossi, 1965)

Results

Methane reduction (compared to Lucerne):

ASC -98%
FVS -95%
LAM -68%
SAC -60%

Effect of species on cumulative methane production over 120 hours (mean ± SD n=6)



Species *P<0.0001*
Different letters indicate significant differences in methane profiles (P<0.05)

Gas production kinetics

- Cumulative methane production data was fitted to Gompertez model using non linear modelling in JMP, according to Machado *et al.*, 2014:

$$y = Ae^{-Be^{-Ct}}$$

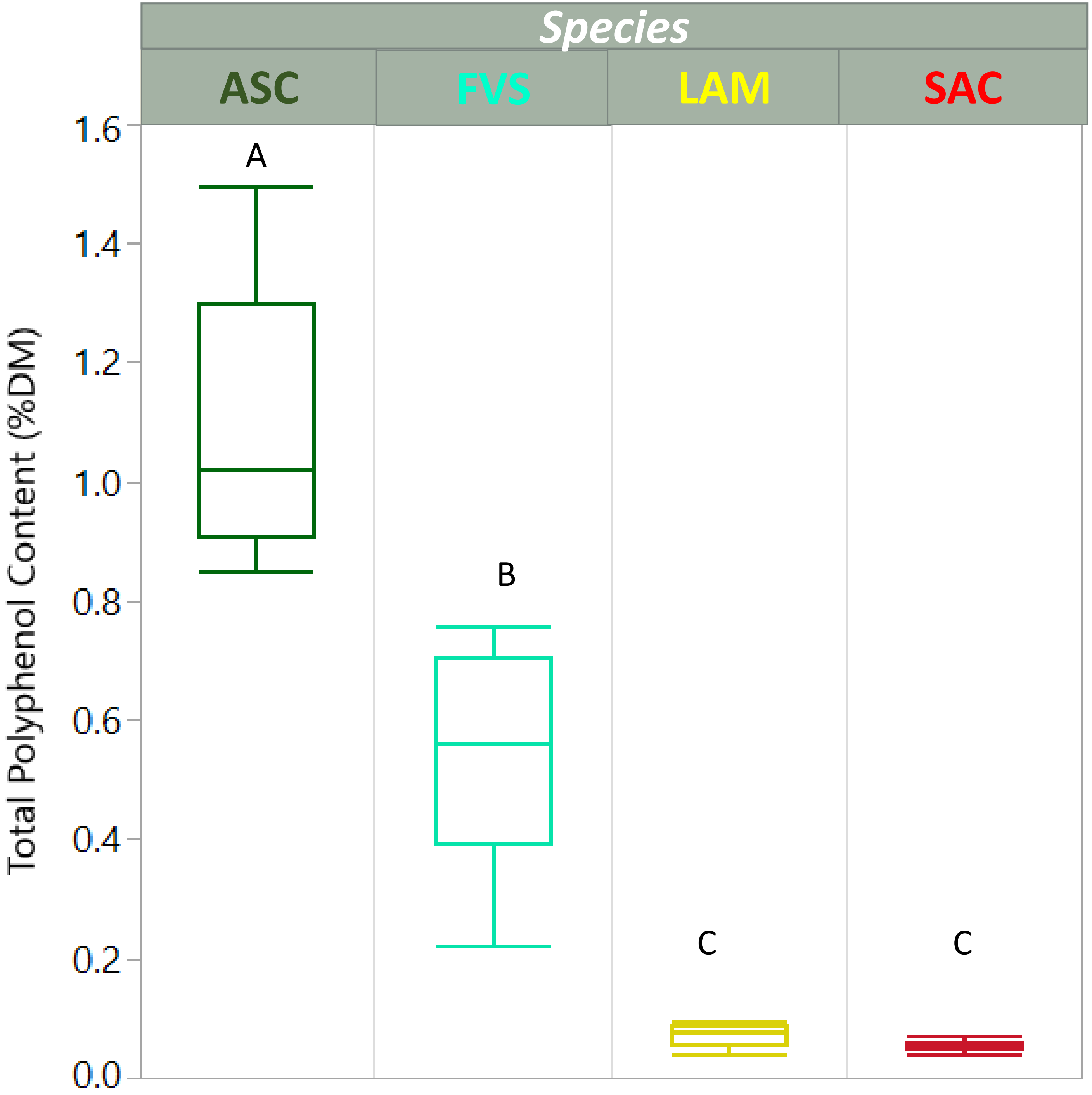
Where:
A= Max methane production (ml/g)
B= Lag period before exponential production (h)
C= Methane production rate (ml/h)

- Analysed data using Standard least squares in JMP

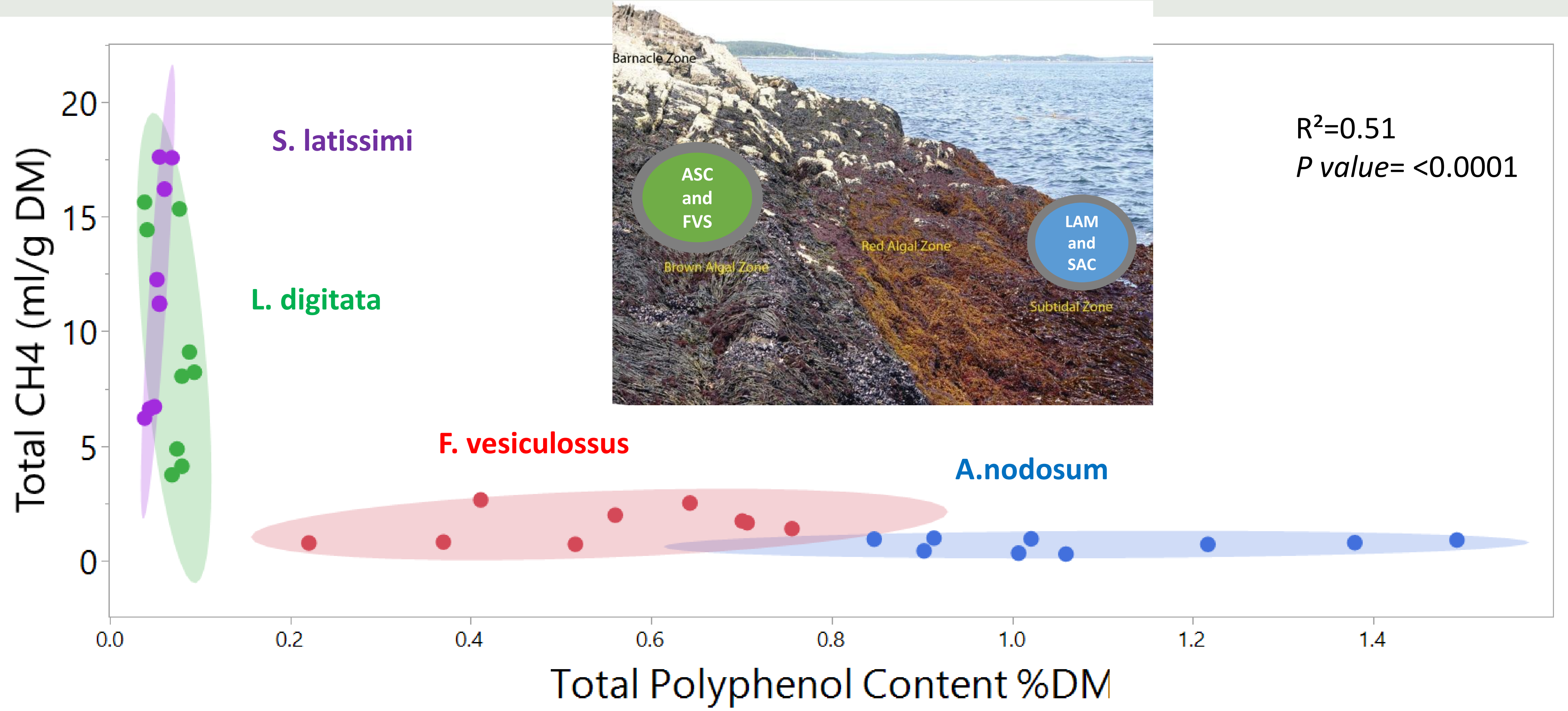
	Max. CH_4 production (ml/g) A	Lag period (h) B	CH_4 production rate (ml/h) C
		B	c
ASC	0.67 e	3.16 c	0.06 cd
FVS	1.55 d	2.77 d	0.06 c
LAM	9.37 c	3.79 a	0.06 d
SAC	11.84 b	3.52 ab	0.07 b
Lucerne	28.14 a	3.27 bc	0.09 a
SEM	0.045	0.088	0.001

Polyphenol analysis

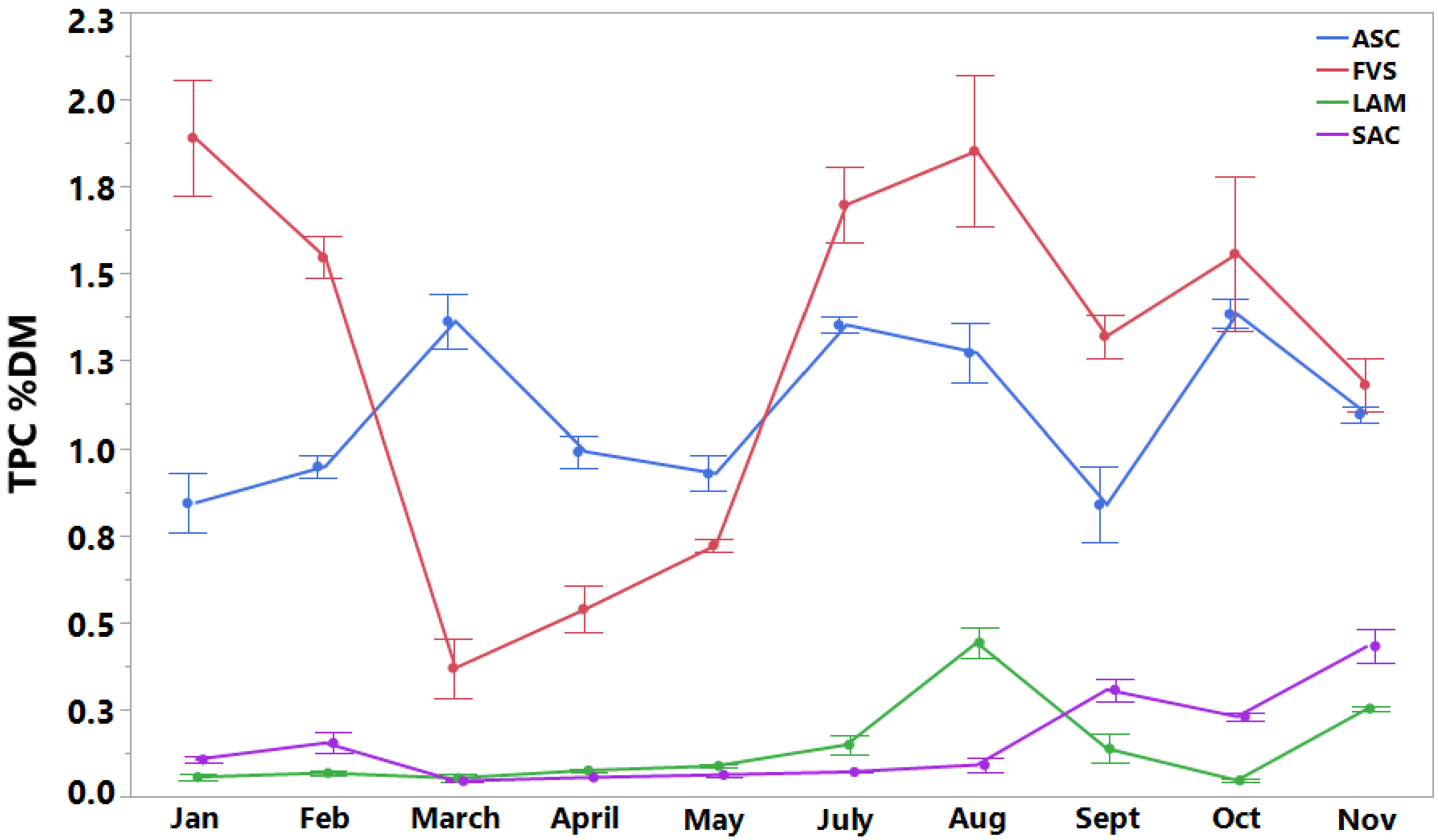
Species effect
P=0.0156



Total methane output was linked to total polyphenol content



High seasonal variation in polyphenol content could affect nutritional quality of seaweed



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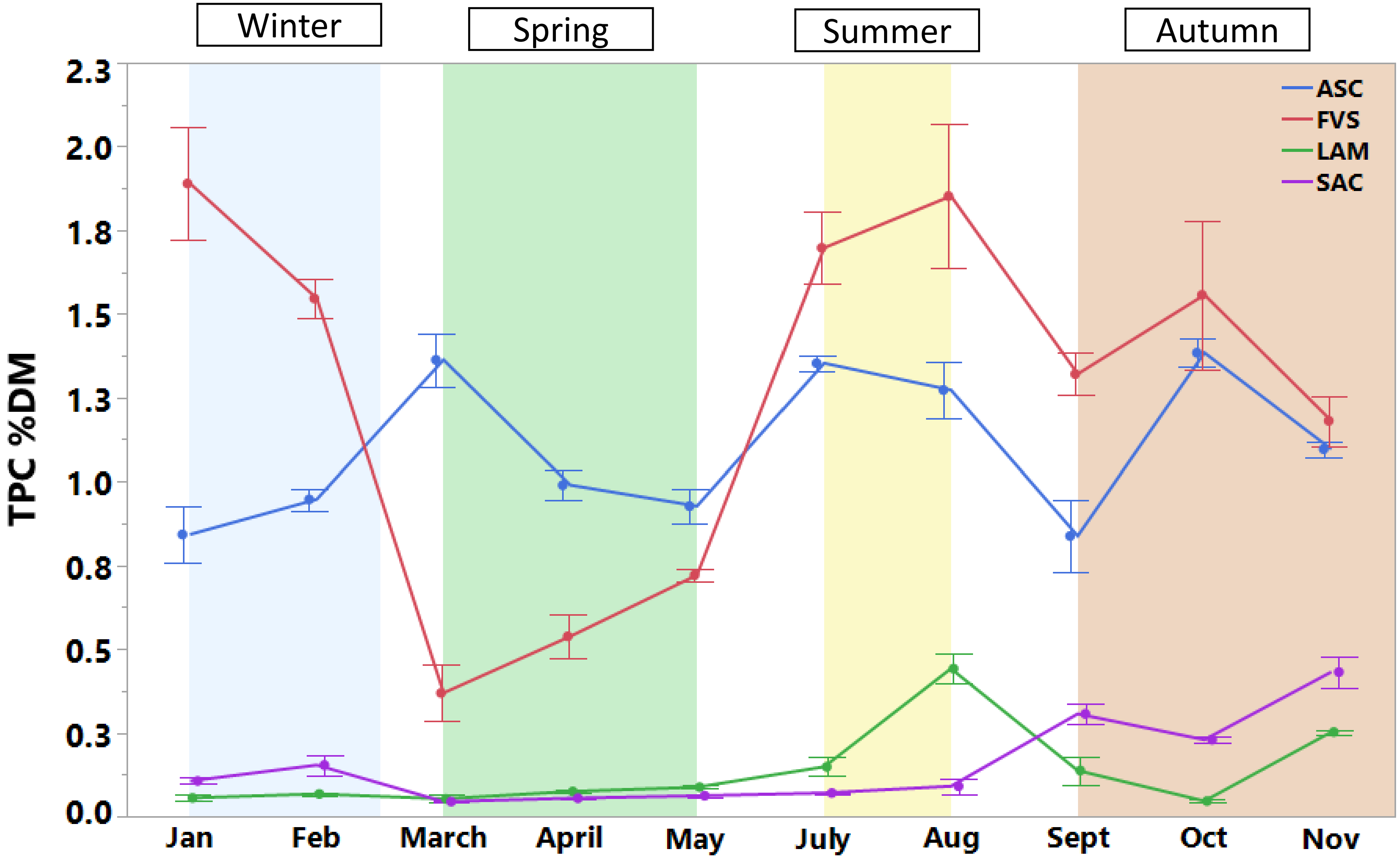

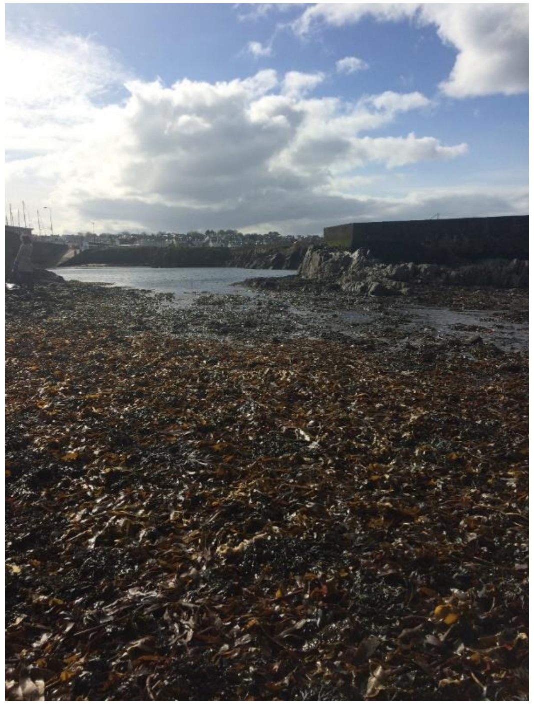

Conclusions

- *A. nodosum* and *F. vesiculosus* have potent anti-methanogenic effects

- Negative association between PT content and methane production

- Further work is planned to identify species-specific inclusion levels which mitigate methane **without adversely affecting feed digestion**

Thank you for listening!

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Department for the Economy

Protein content (N analyzed by Dumas method)

	ASC	FVS	LAM	SAC	Lucerne
Crude protein %DM	**7.5**	**10.3**	**14.2**	**13.4**	**18.7**

Nitrogen conversion factor of 5 for seaweeds (Angell et al., 2016) and 6.25 for Lucerne

But…polyphenols may not be the only mechanism of methane inhibition

Variable	By Variable	**Spearman ρ**	**Prob>|ρ|**	
Total CH4 (ml/g DM)	Ash%DM	0.507	0.0031	+++++
P	Total CH4 (ml/g DM)	0.8084	<.0001	++++++++
Cl	Total CH4 (ml/g DM)	0.8759	<.0001	+++++++++
Zn	Total CH4 (ml/g DM)	-0.6785	<.0001	-------
Sn	Total CH4 (ml/g DM)	0.4676	0.004	+++++

Minerals could play a role too

Chemical composition

	DM%	Ash %DM	Protein %DM	NDF %DM	ADF %DM	ADL %DM
ASC	25.73	21.86	7.54	35.94	15.84	8.65
FVS	17.42	23.06	10.27	29.23	15.13	7.87
LAM	14.96	28.53	14.21	34.39	14.55	4.72
SAC	14.42	30.06	13.43	33.49	13.16	3.57