Type II Aerobic Methane Oxidizing Bacteria (AMOB) Drive Methane Oxidation in Pulsed Wetlands as Indicated by ^{13}C-Phospholipid Fatty Acid Composition

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INTRODUCTION

- The magnitude of climate change predicted for the United States over the next 100 years will cause significant impacts on temperature and precipitation patterns
- Wetlands are a major source (~25 %) of methane globally[1]
- Aerobic Methane Oxidizing Bacteria (AMOB) have the unique ability to utilize CH_4 as the sole source of carbon and energy by the Methane Mono Oxygenase (MMO) mediated reaction
- A variety of environmental determinants have been implicated in the dominance of AMOB type. Generally, type I AMOB outcompete type II AMOB in low CH_4 (~2ppmv), high oxygen environments, while type II AMOB are favored in high CH_4 (≥40ppmv) environments[2]
- AMOB are active at the oxic sediment - water interface ("pulsing fringe", Fig. 2)
- AMOB consume ~30 Tg-CH_4-yr^{-1}, and potentially can offset CH_4 losses to the atmosphere[1]
- Very little is known about the effects of pulsing hydrology and season on the AMOB ecology
- Therefore, the Objectives of this Study were:

❑ Experiment 1: Determine the effects of Season and Landscape position on Potential Methane Oxidation (PMO) in the two wetlands

❑ Experiment 2: Determine the effects of Season and Landscape position on the Aerobic Methane Oxidizing Bacteria (AMOB) as reflected by their biomarker Phospholipid Fatty Acid (PLFA) Compositions

WETLAND HYDROLOGY EXPERIMENT

Effect of Pulsing on Methane Emission in the Olentangy River Wetlands[4] (Altor and Mitsch, 2006)

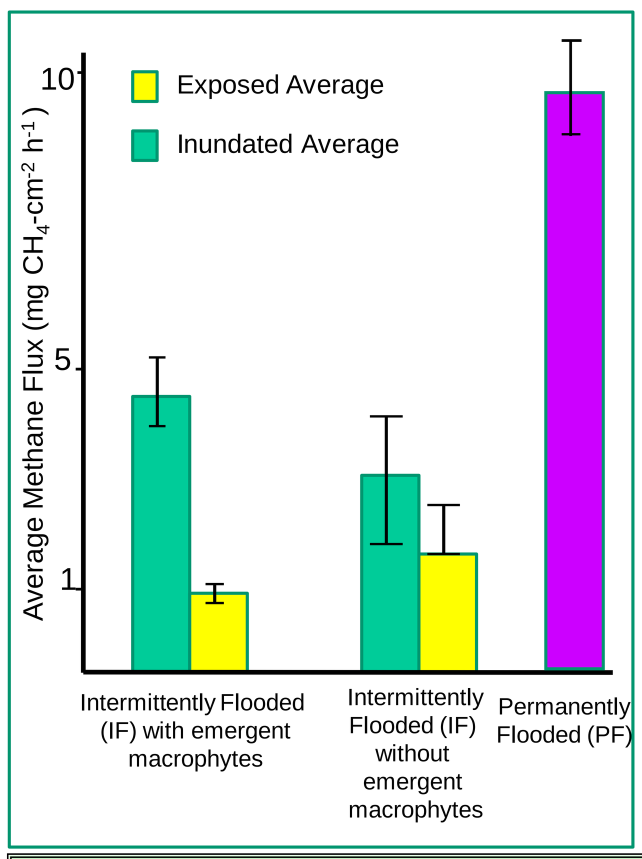
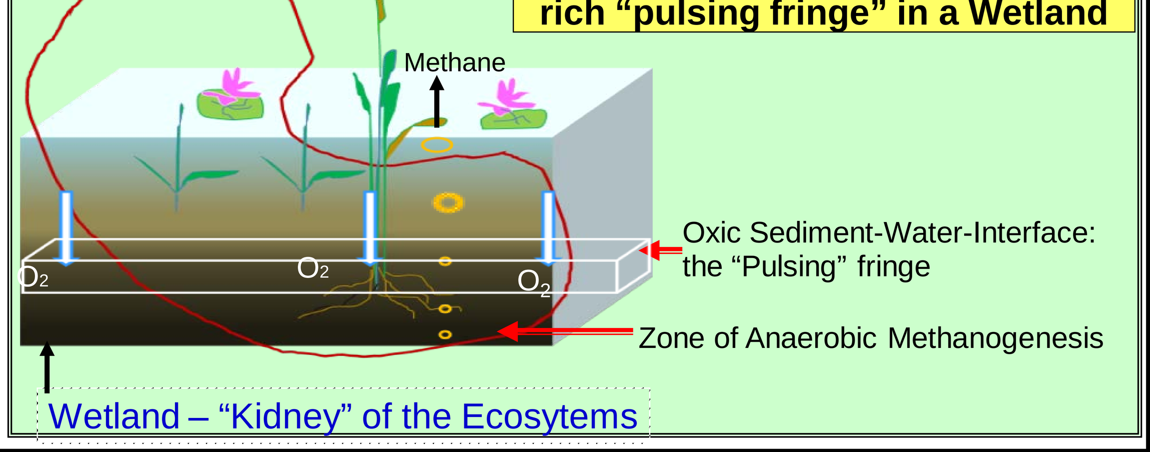


Fig.1

- Effect of pulsing on Methane emission in the two 1-ha experimental Olentangy River Wetlands
- Methane fluxes in IF zones of the wetlands were 30% of those in the PF wetland areas (Fig. 1)

Fig. 2. Illustration of the Oxygen rich "pulsing fringe" in a Wetland



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EXPERIMENTAL SITE

THE OLENTANGY RIVER "Kidney" WETLANDS, Ohio, U.S.A.
Soil Sampling Locations (Fig. 3) and Factors:

Factor	Number	Name
Landscape	2	ORW1,ORW2
Hydrology	3	Permanently Flooded (PF) Intermittently Flooded (IF) Upland (UP)
Flow zones	2	Inflow (I), Outflow (O)
Soil Depth	2	0-8 cm 816 cm
Season	4	Fall, Winter, Spring, Summer

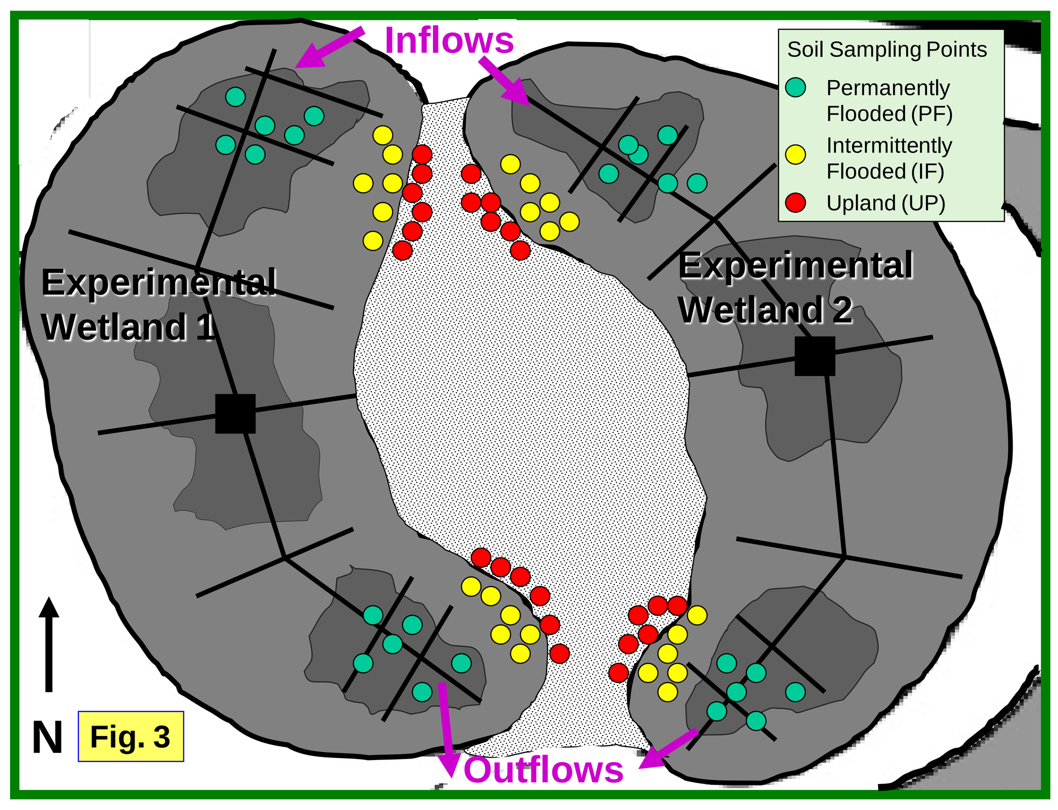
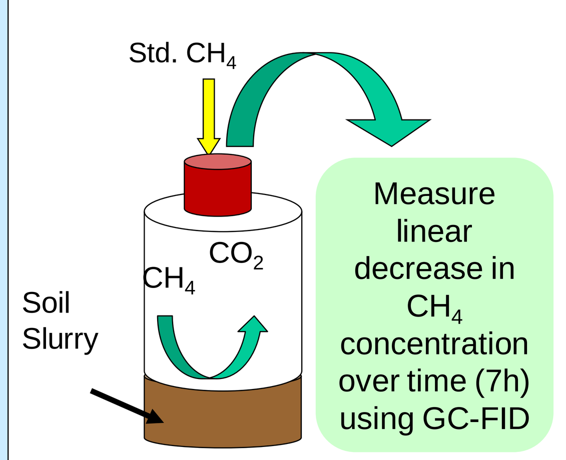


Fig. 3

METHODS

- Soil samples injected with known concentration of 99.99% pure CH_4 gas

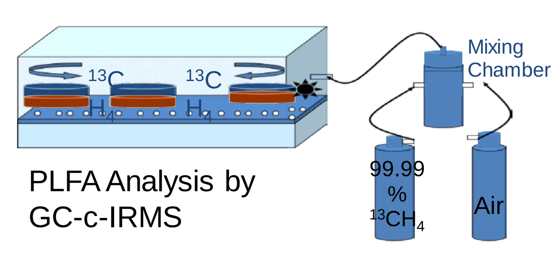


- PMO reported in nmol-CH_4.gdwt.$^{-1}$Soil.h^{-1}

Method 1: Potential Methane Oxidation (PMO), Crossman et al. (2004)

Soils Incubated under two different concentrations of $^{13}CH_4$: 2ppmv and 60ppmv

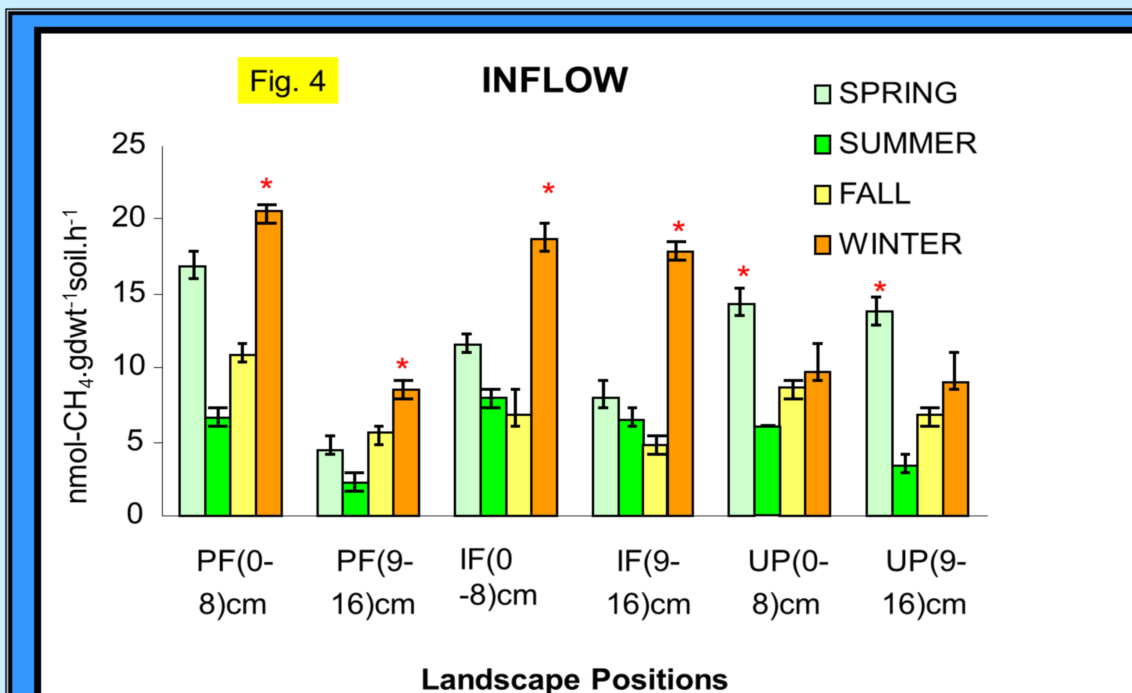
i. "Type I AMOB": [CH_4] <1.8 ppm
ii. "Type II AMOB": [CH_4] > 40 ppm

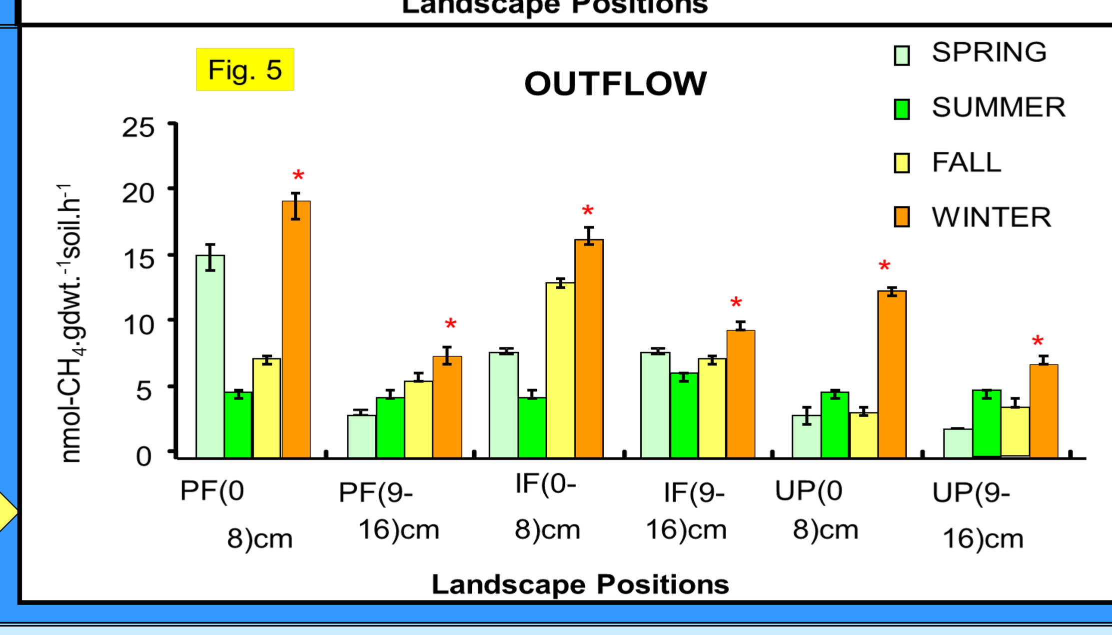


Fingerprint AMOB PLFAs:
Type I AMOB: 16:1ω5c, 16:1ω7c
Type II AMOB: 18:1ω7c, 18:1ω9c
18:1ω8c

Method 2: $^{13}CH_4$ Incubation Pulse-Chase Experimental Setup: Stable Isotope Probing of PLFA using GC-c-IRMS, Maxfield et al., 2006

RESULTS: Potential Methane Oxidation





Figs. 4 & 5: Seasonal average PMO across landscape positions:
- PMO in Winter significantly higher than in Summer (p< 0.01)
- PMO statistically higher at 0-8 cm depth of soil in the PF and IF sites (p< 0.05)

RESULTS: ^{13}C-Phospholipid Fatty Acids

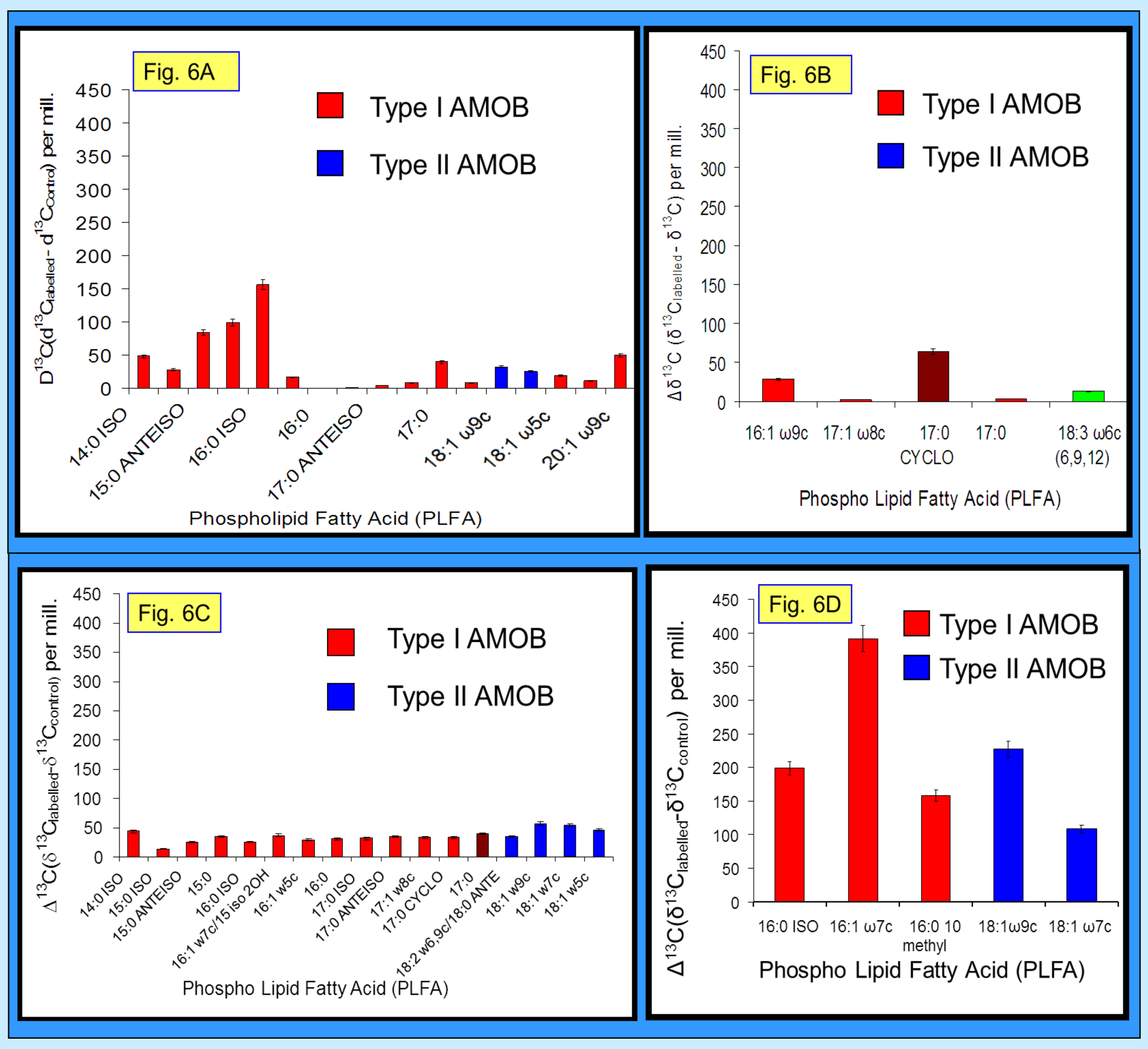


Fig. 6. Compound-specific carbon isotope values of PLFAs incorporating ^{13}C following incubation of Winter soil samples under Ypppmv $^{13}CH_4$:

A: 0-8cm, PF Site, 2ppmv
B: 0-8cm, IF Site, 2ppmv
C: 0-8cm, PF Site, 60ppmv
D: 0-8cm, IFSite, 60ppmv

SUMMARY: AMOB PLFA Conc. & PMO

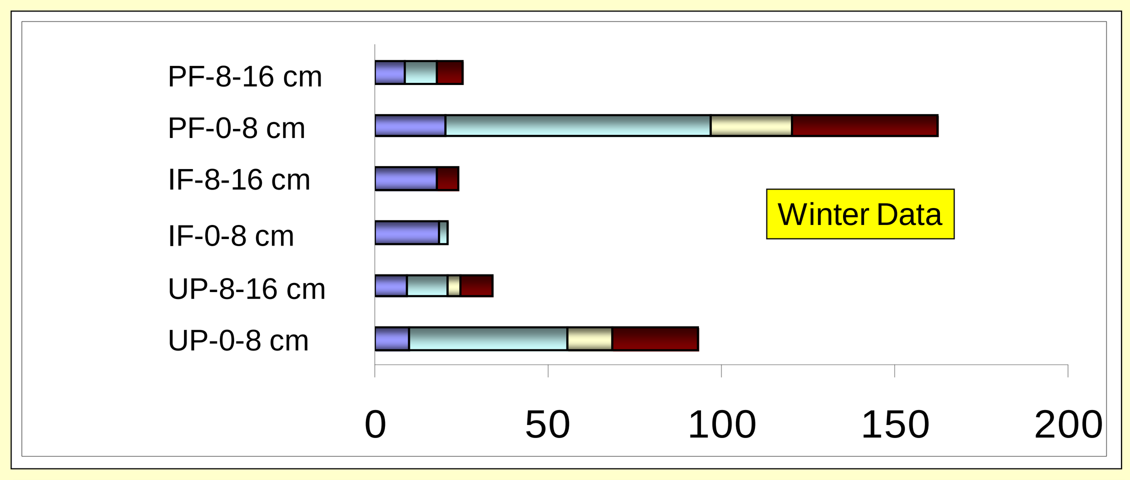
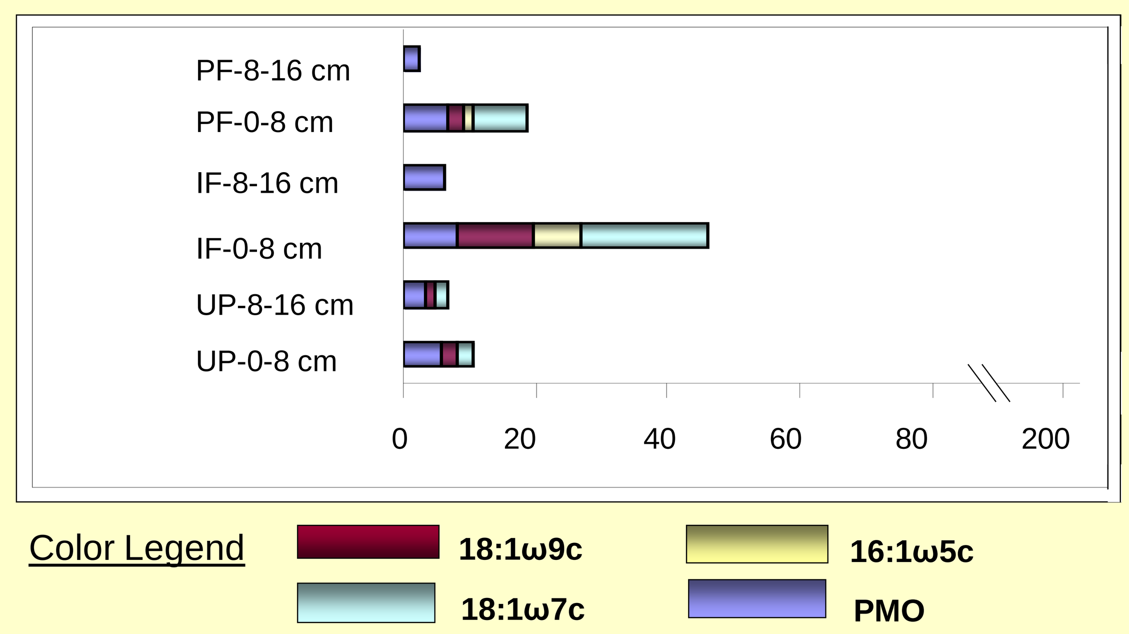


Fig. 7. Mean AMOB PLFA concentration (nmolgdwt.$^{-1}$soil) and PMO at different Landscape positions in Winter and Summer



CONCLUSIONS

- The concentration profiles of AMOB signature PLFAs, as detected by Stable Isotope Probing (SIP) completely corroborates with the Potential Methane Oxidation (PMO) values at all study sites
- The highest PMO values in the Permanently Flooded site can be entirely attributed to the AMOB, as reflected by the relative abundance of the signature PLFAs
- Type I AMOB are dominant under the oxygen rich conditions in contrast to the Type II that are abundant under submerged conditions
- The three hydrologically distinct landscape positions each present characteristic microbial community structure, as evident in this study

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