Bioturbation and organic carbon mineralization pathways in Bering Sea shelf sediments

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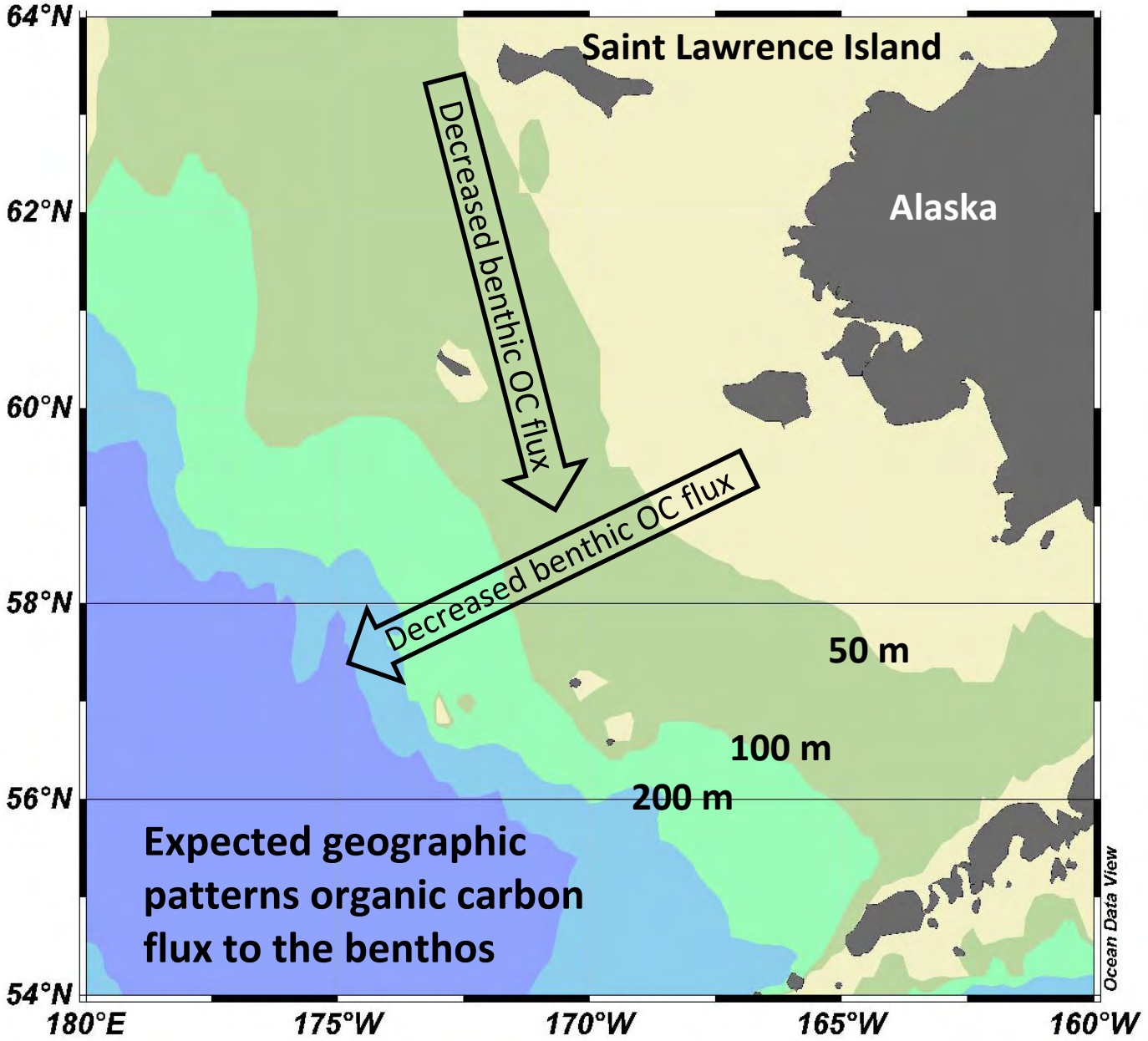
64°N
62°N
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58°N
56°N
54°N
180°E
175°W
170°W
165°W
160°W
Saint Lawrence Island
Alaska
Decreased benthic OC flux
Decreased benthic OC flux
50 m
100 m
200 m
Expected geographic patterns organic carbon flux to the benthos
Ocean Data View

Hypothesis:

Organic matter oxidation pathways vary with latitude, water depth, and among Bering Shelf "domains"

Rate of organic matter mineralization decreases from:
Northern shelf →Middle shelf → Outer shelf → Off shelf

Ratio of anaerobic to aerobic respiration decreases from:
Northern shelf →Middle shelf → Outer shelf → Off shelf

Sedimentary organic-matter mineralization pathways

Aerobic metabolism:

$$OM + 138\ O_2 \rightarrow 106\ CO_2 + 16\ HNO_3 + H_3PO_4 + 122\ H_2O$$

Anaerobic metabolism:

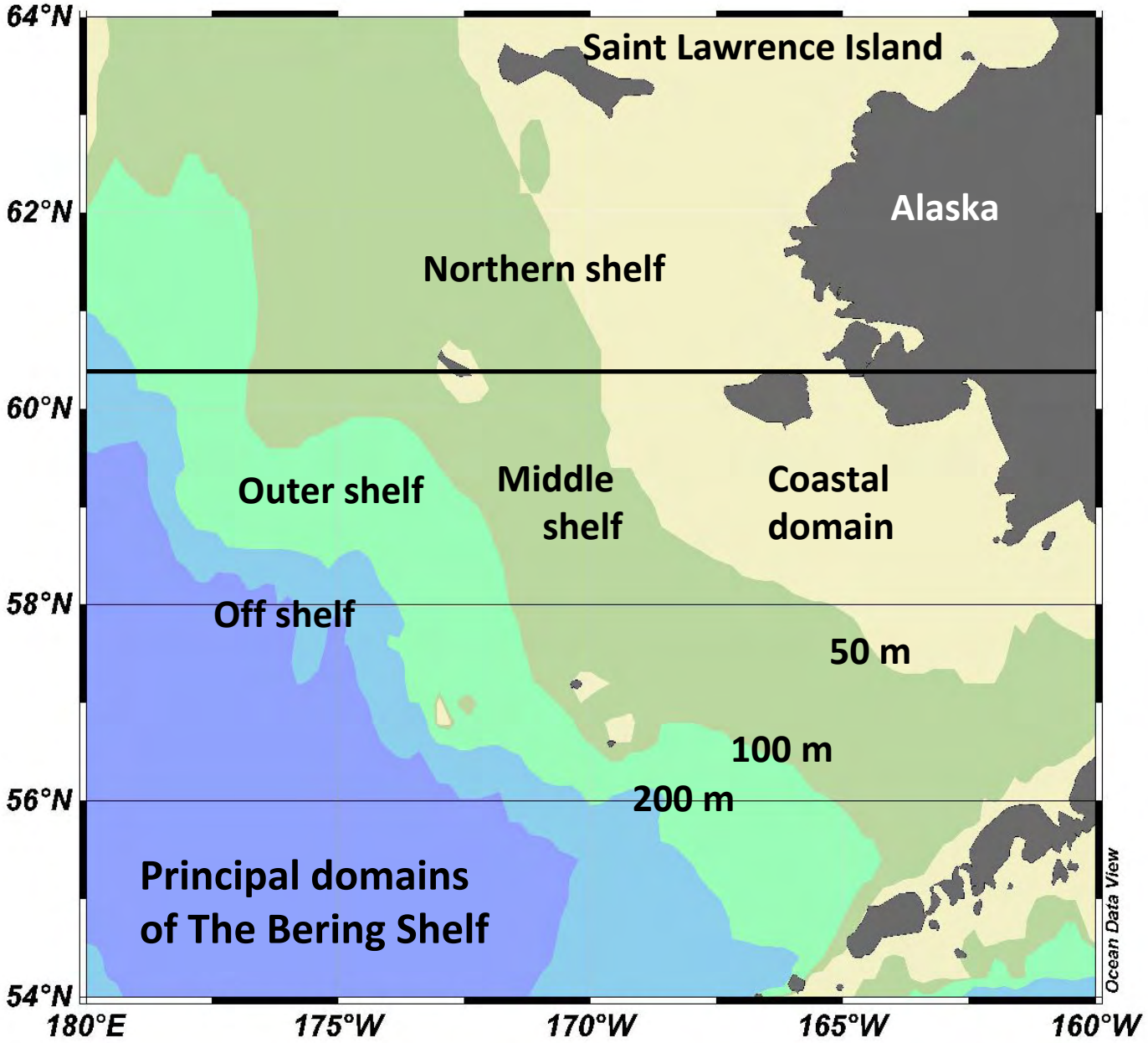
$$OM + 94.4\ HNO_3 \rightarrow 106\ CO_2 + 55.2\ N_2 + H_3PO_4 + 177.2\ H_2O$$

$$OM + 236\ MnO_2 + 4H^+ \rightarrow 236\ Mn^{2+} + 106\ CO_2 + 8\ N_2 + H_3PO_4 + 366\ H_2O$$

$$OM + 424\ FeOOH + 848\ H^+ \rightarrow 424\ Fe^{2+} + 106\ CO_2 + 16\ NH_3 + H_3PO_4 + 742\ H_2O$$

$$OM + 53\ SO_4^{2-} \rightarrow 106 CO_2 + 16 NH_3 + 53\ S^{2-} + H_3PO_4 + 106\ H_2O$$

from Froelich et al. (1979)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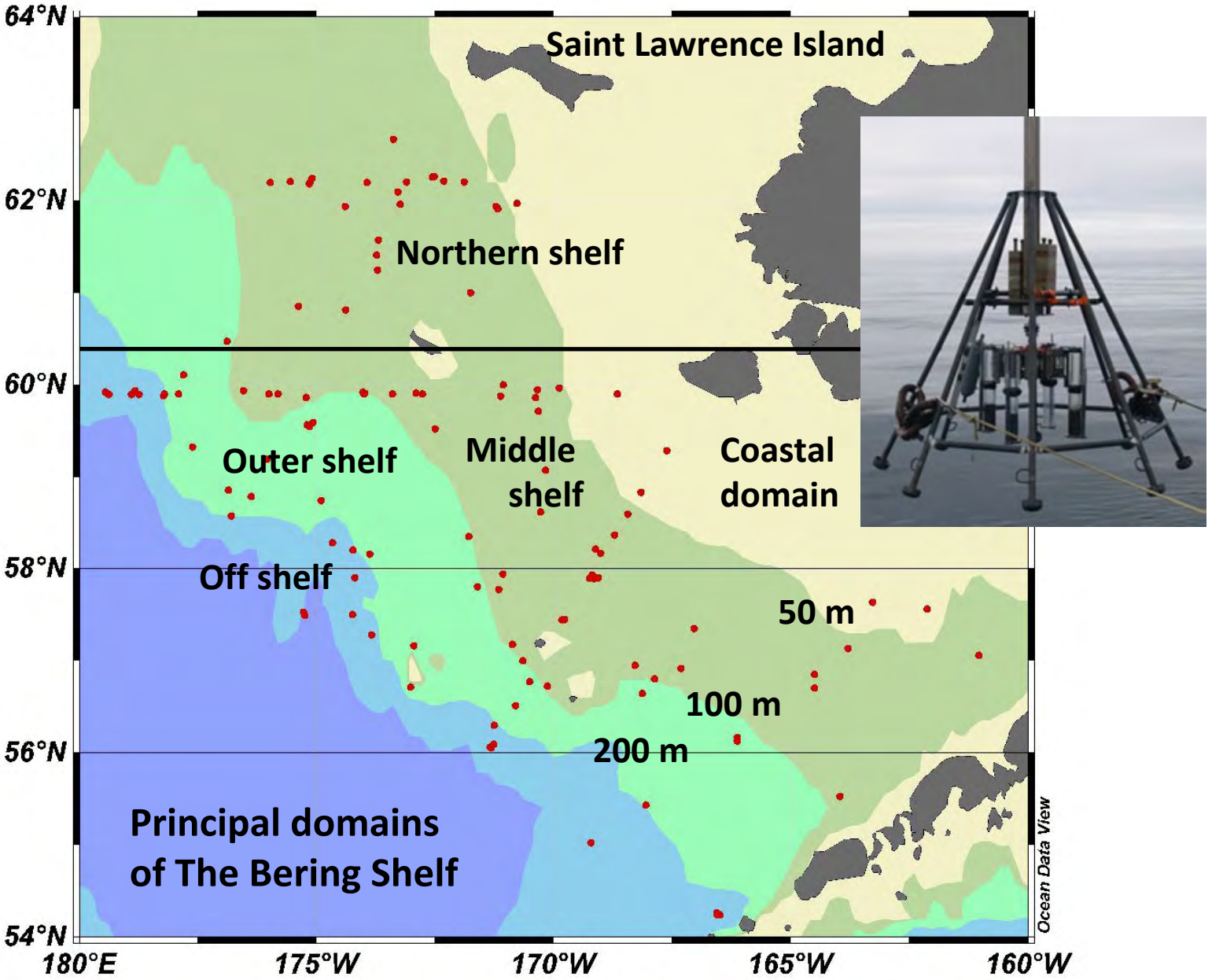
Saint Lawrence Island
Alaska
Northern shelf
Outer shelf
Middle shelf
Coastal domain
Off shelf
50 m
100 m
200 m
Principal domains of The Bering Shelf
Ocean Data View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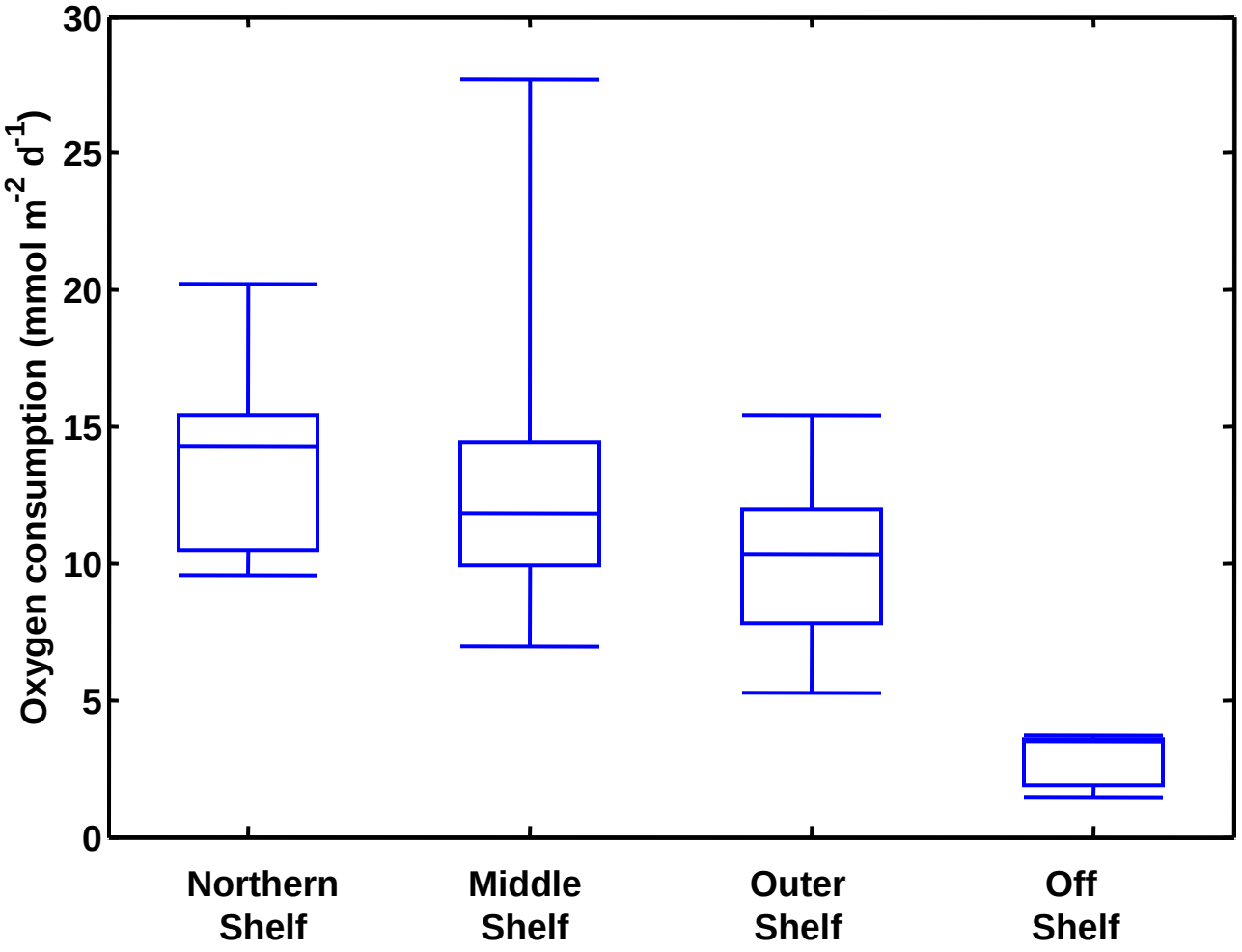
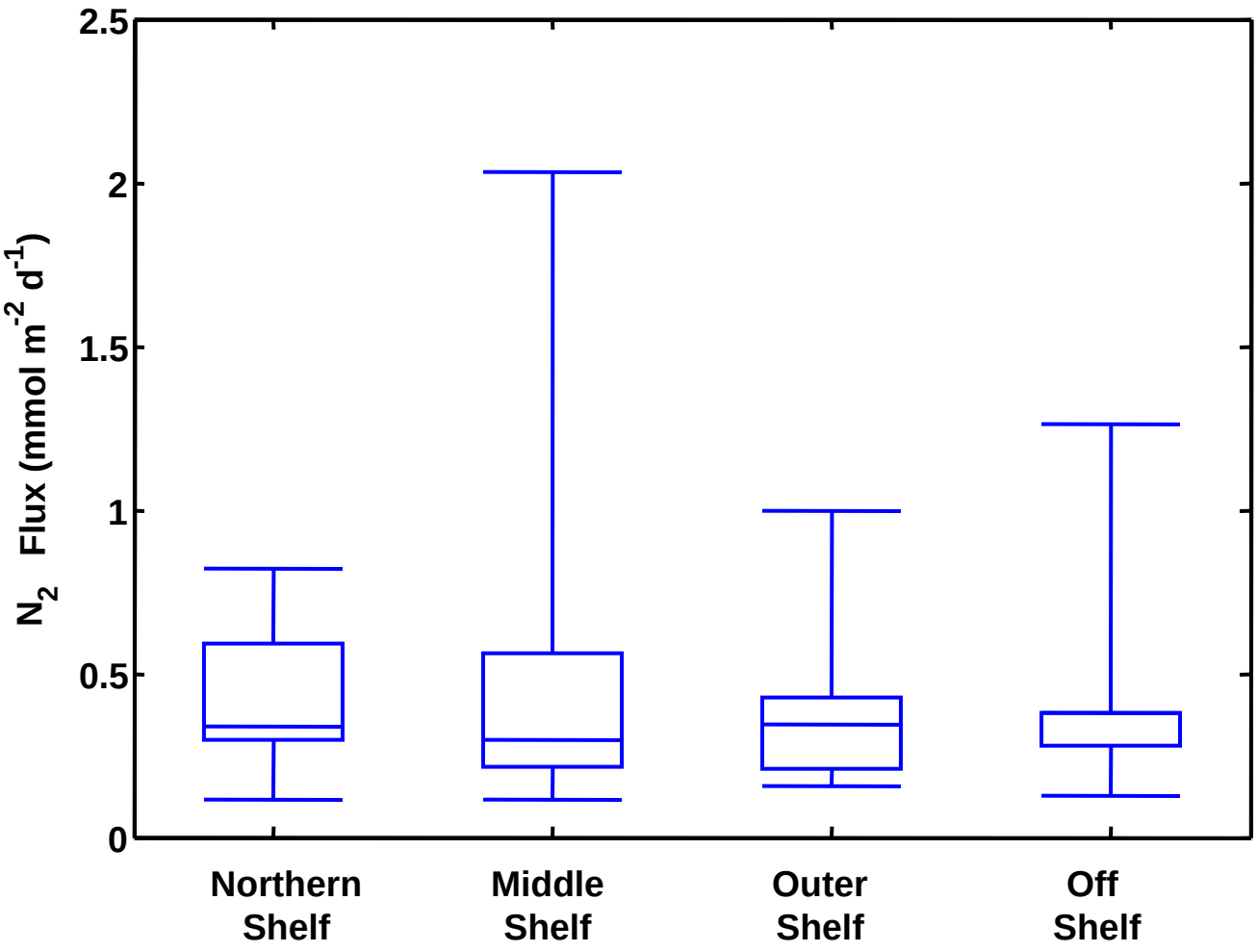
Relevant measurements

- O_2 consumption in flux core incubations analyzed by Optode and MIMS (O_2/Ar)
- N_2 production in flux cores by MIMS (NO_3^- reduction + ANAMMOX)
- Mn- and Fe-oxide reduction from concentration profiles + bioturbation rates
- SO_4^- reduction by $^{35}SO_4^-$ incubation
- Quantitative samples of benthic infauna

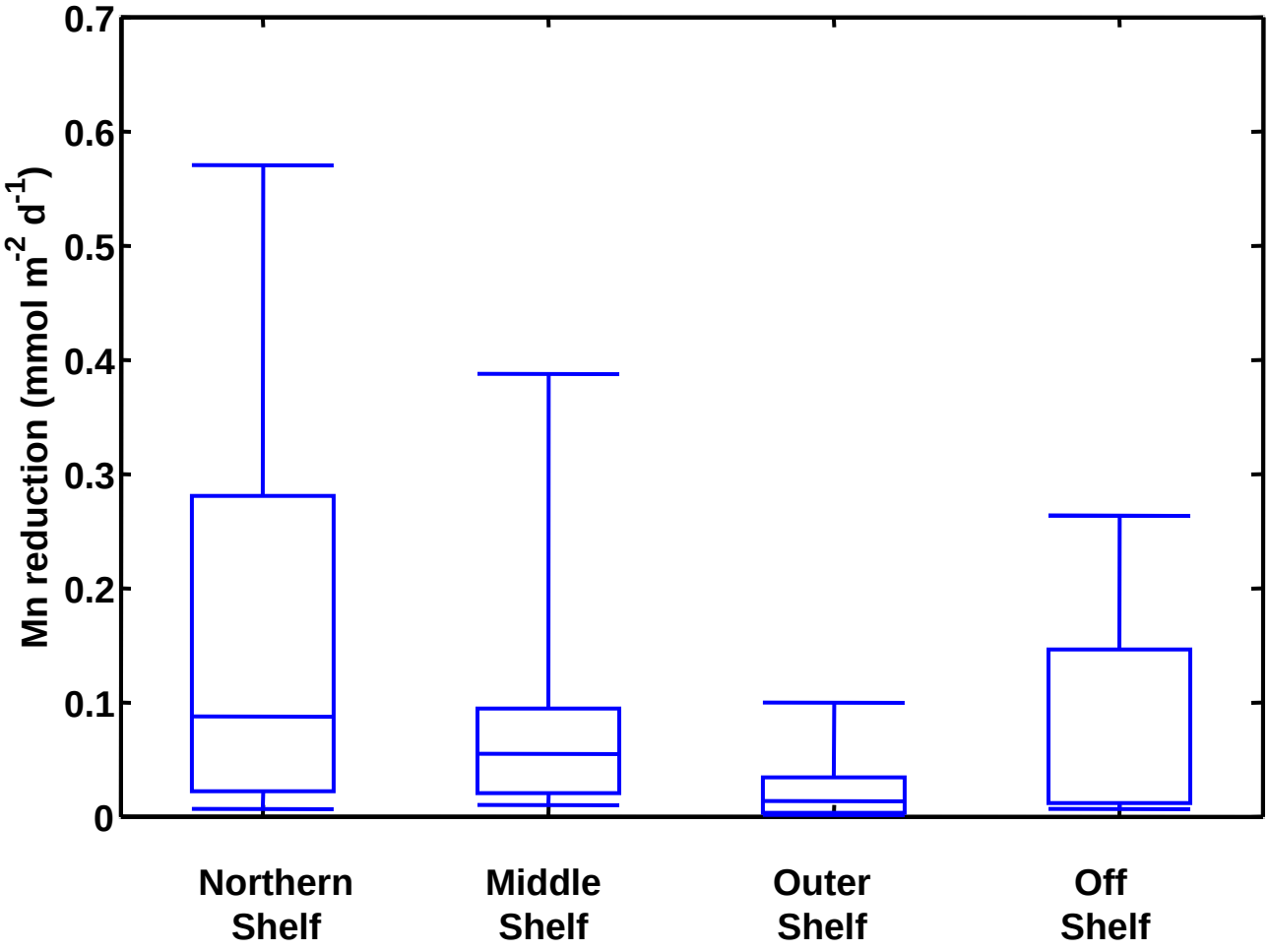
Variation in sedimentary oxygen consumption among regions



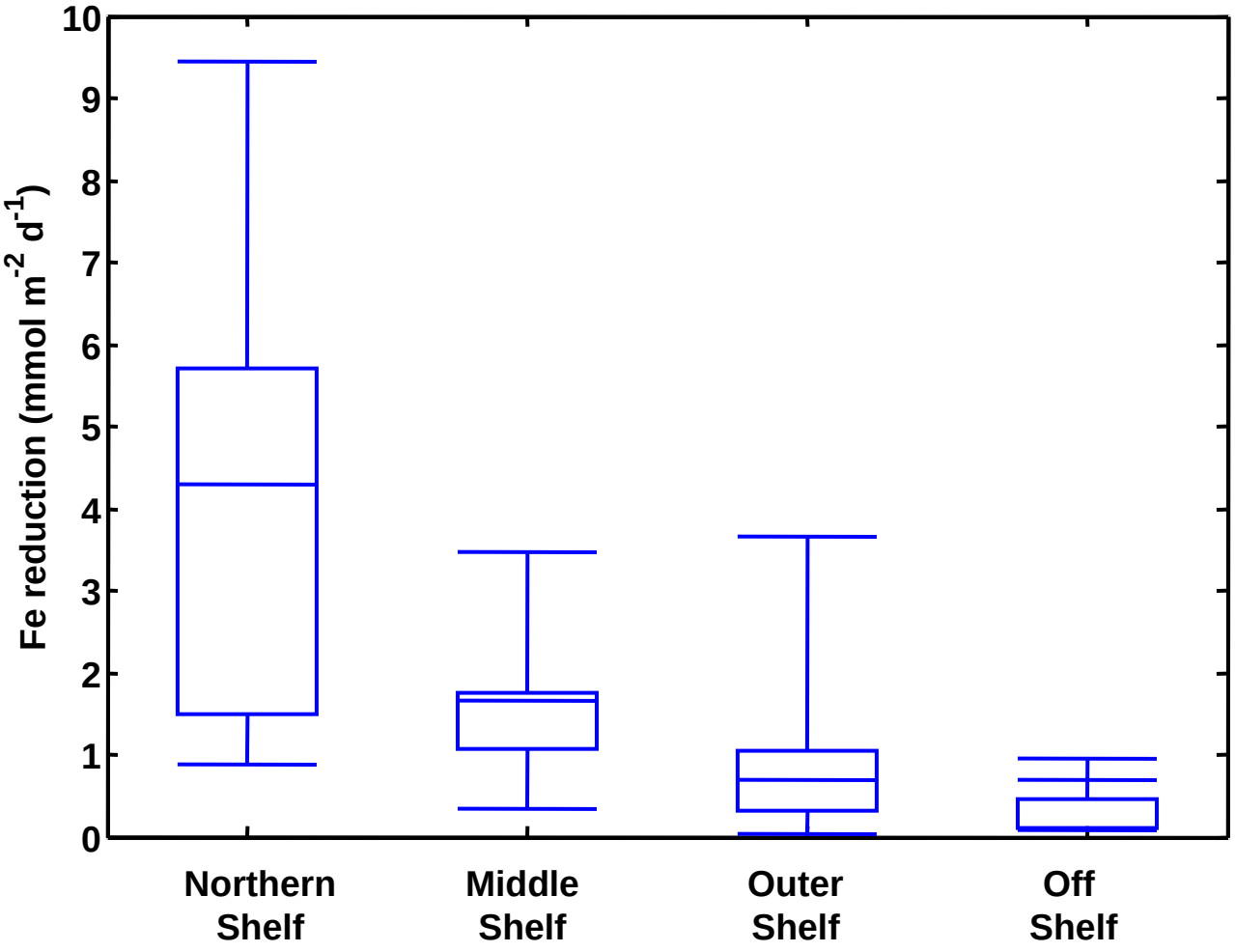
Variation in sedimentary denitrification among regions



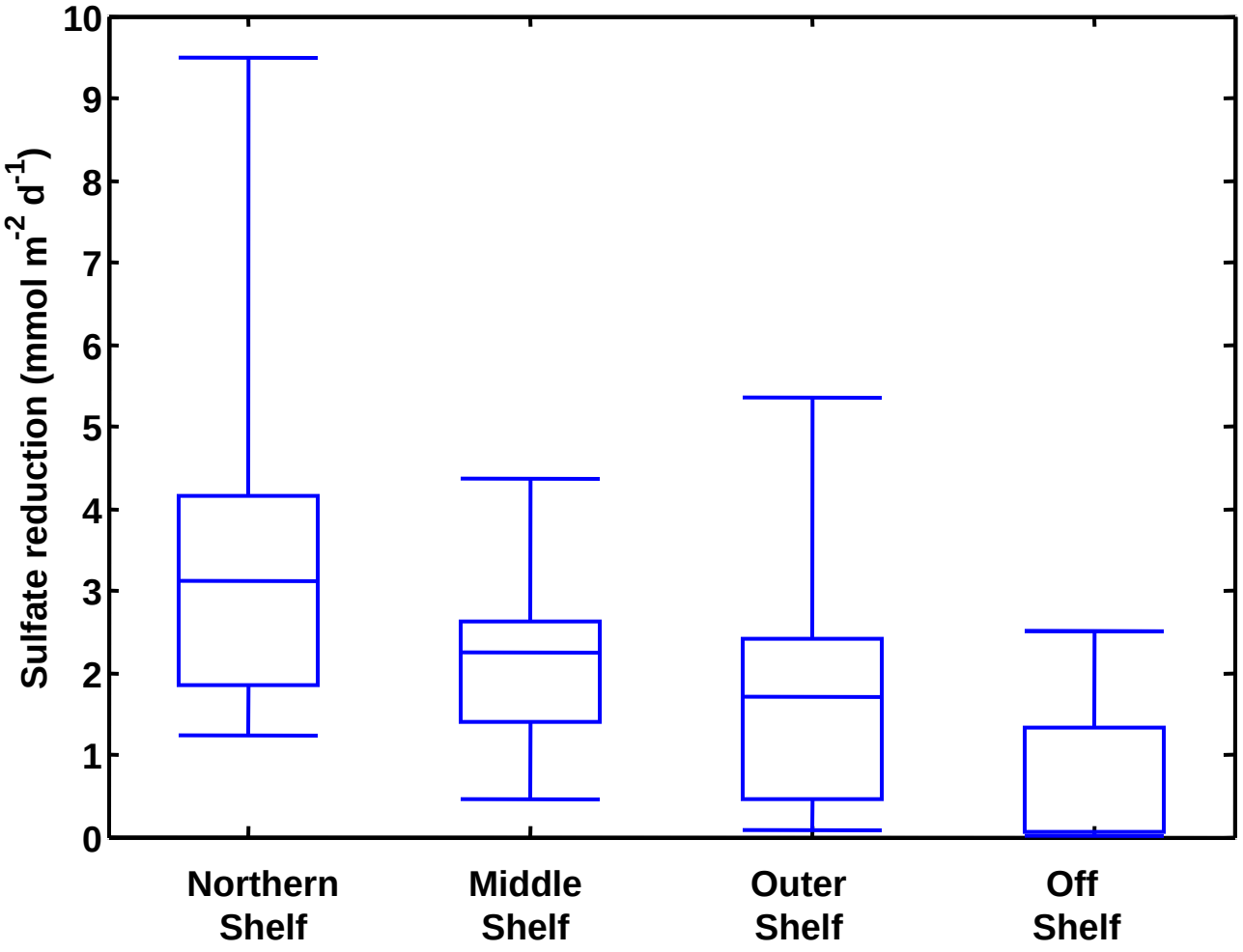
Variation in sedimentary manganese reduction among regions



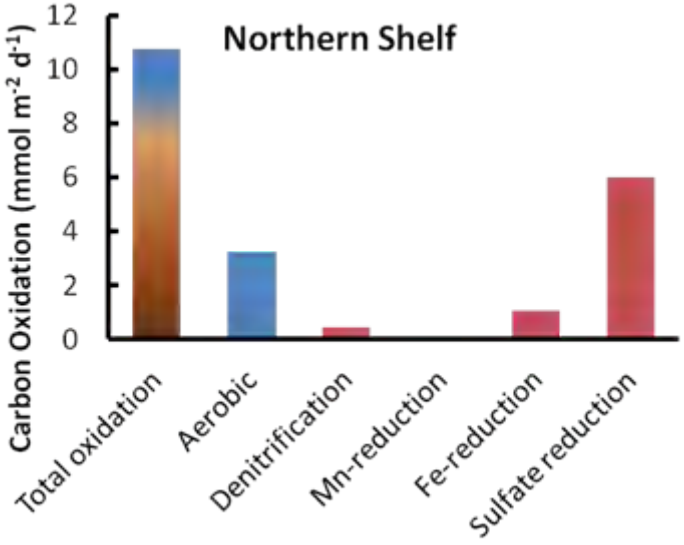
Variation in sedimentary iron reduction among regions

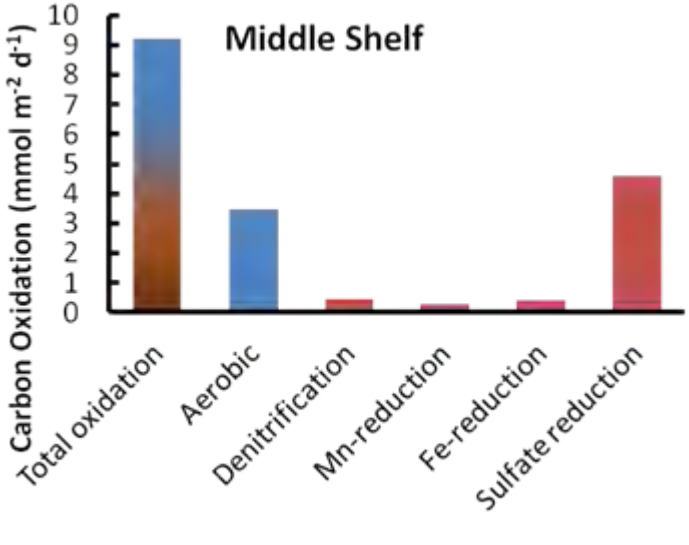


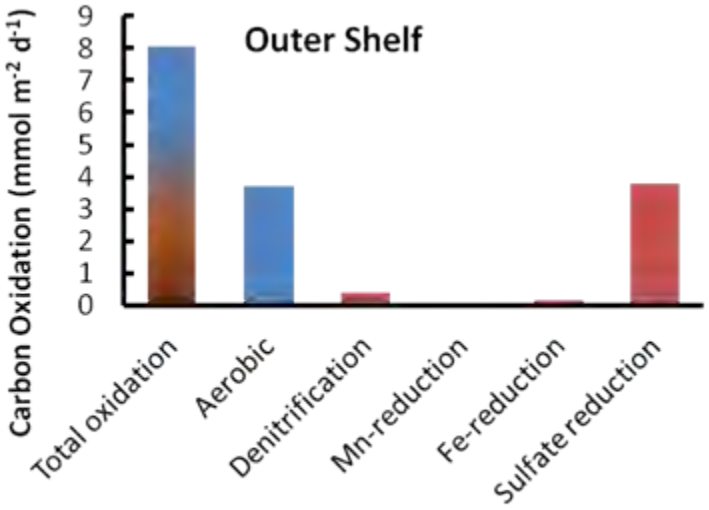
Variation in sedimentary sulfate reduction among regions

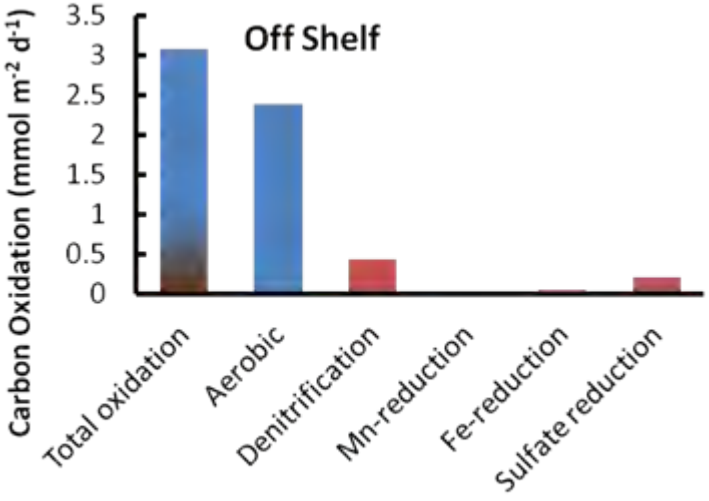


Rates and approximate pathways of organic-carbon mineralization

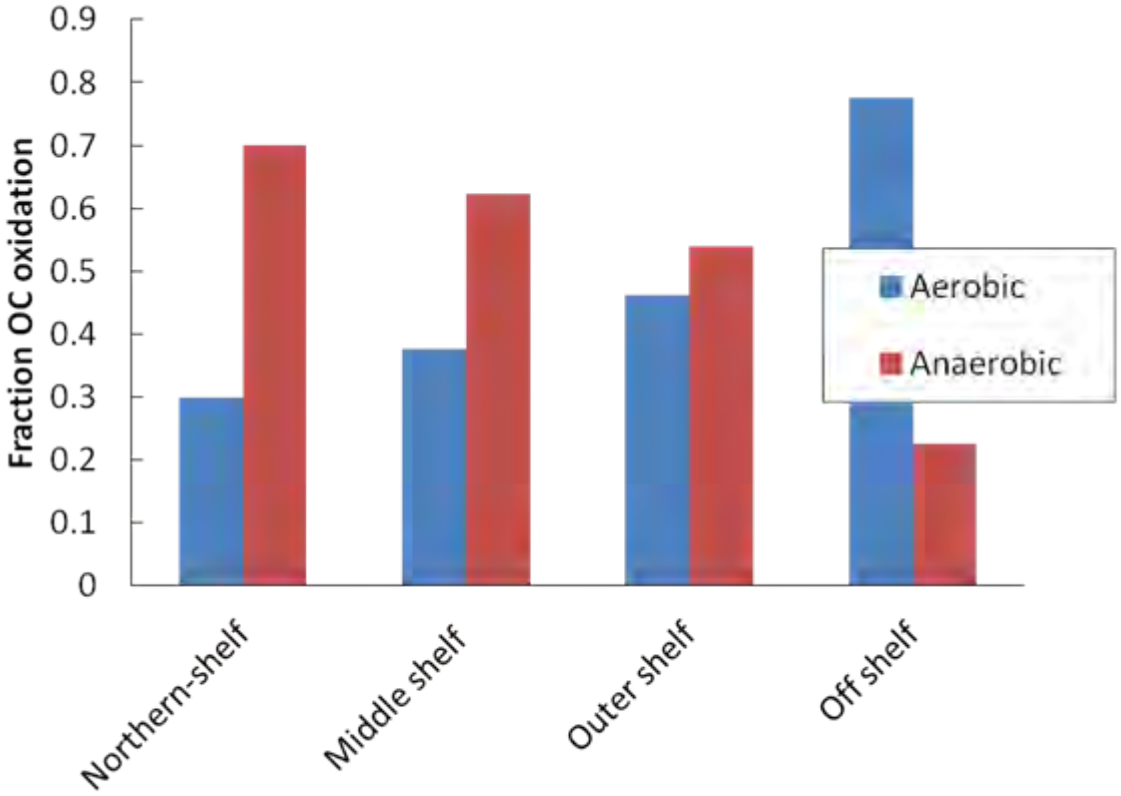






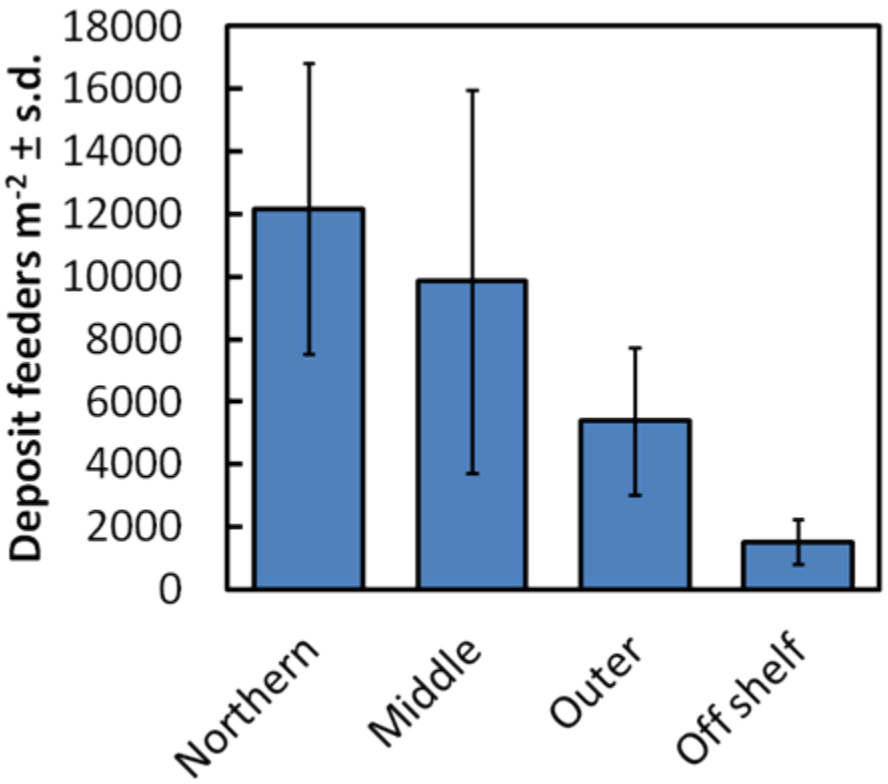


Regional variation in aerobic versus anaerobic respiration

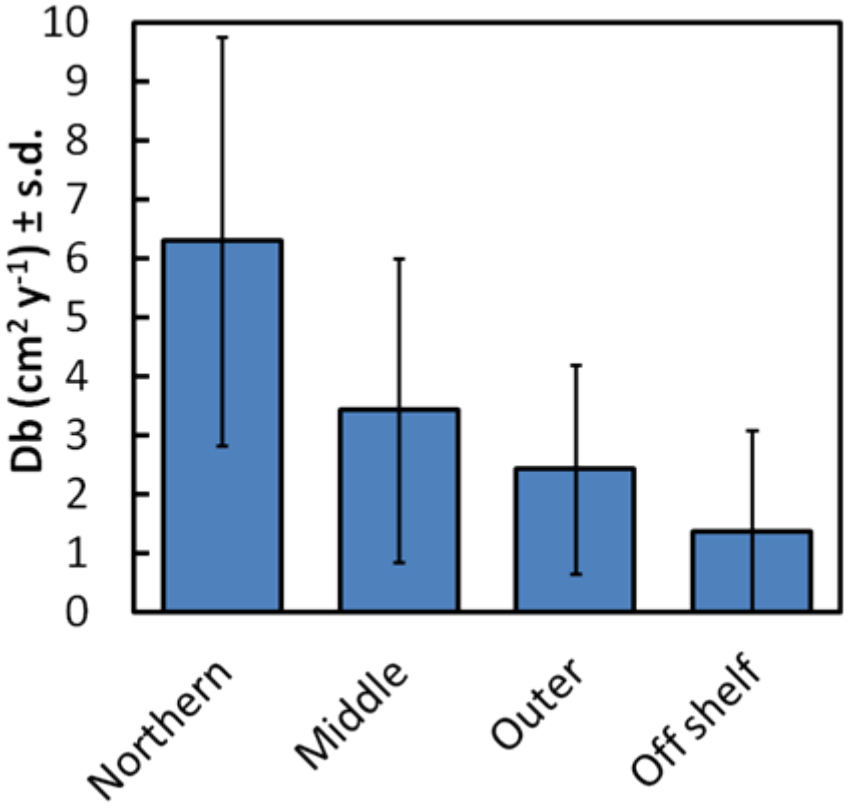


Variation in deposit feeder abundance and bioturbation rate

Mean abundance of deposit feeders



Mean bioturbation rate from $^{234}Th_{xs}$



Summary

- Organic-matter mineralization varies regionally across the Bering Shelf
- Highest rates of total OM mineralization are found in the northern shelf domain
- Regional variation in OM degradation pathways is consistent with the expectation of higher OM export in northern-shelf domain along with higher rates of bioturbation in this region
- The ratio of aerobic:anaerobic respiration decreases from Northern→Middle→Outer → Off-shelf domains