Increased fluxes of shelf-derived materials to the central Arctic Ocean

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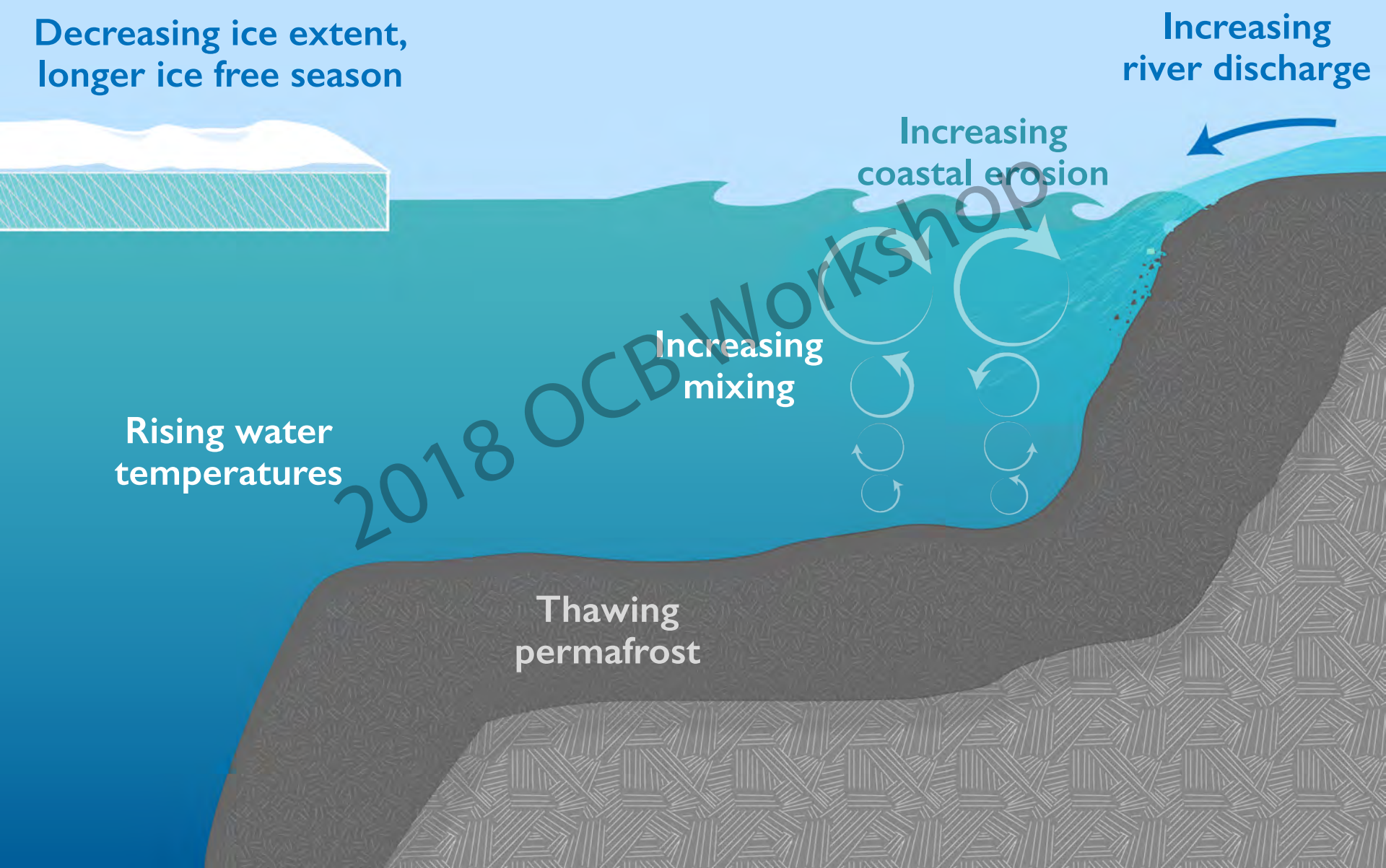
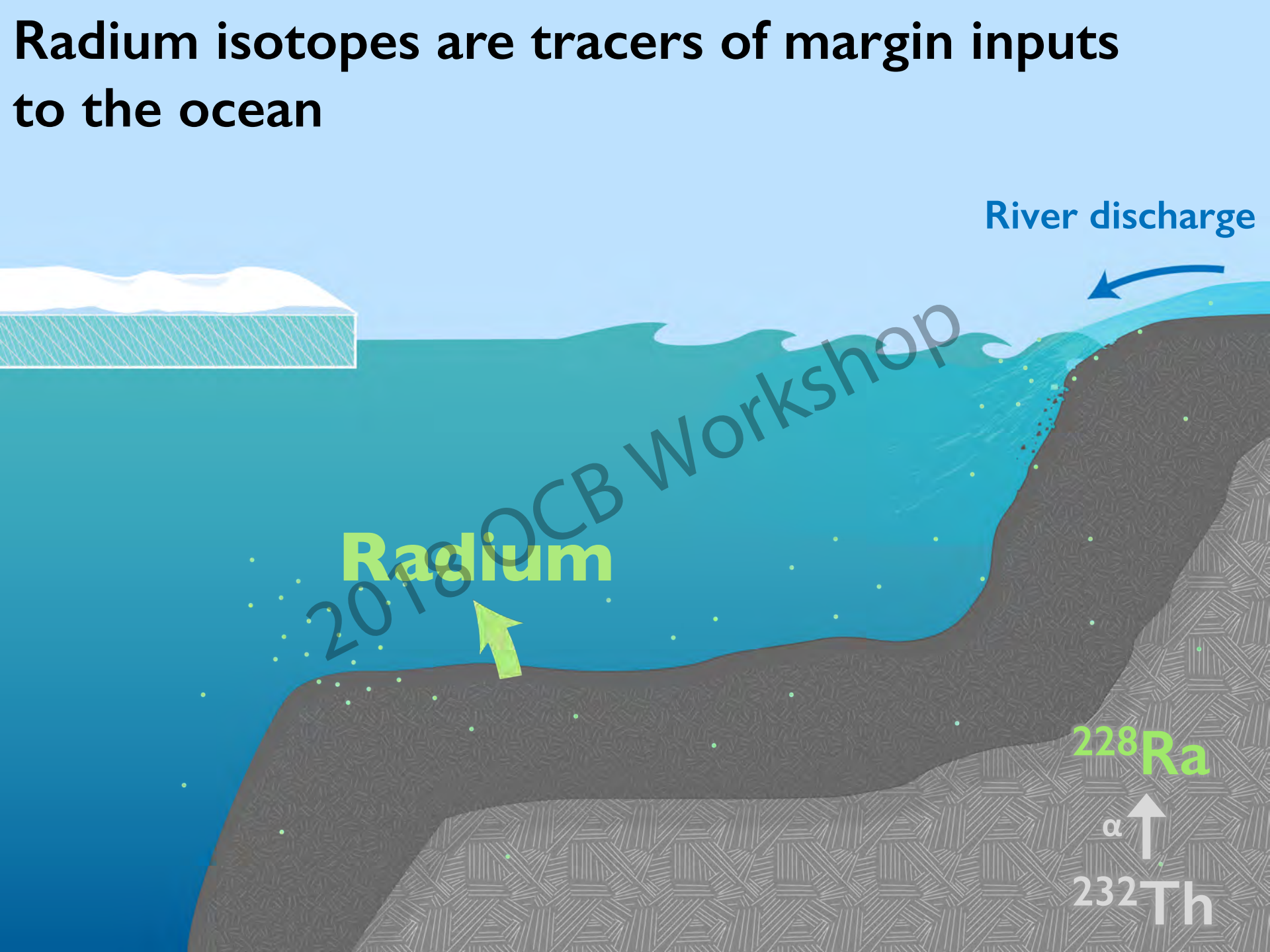
Photos by Cory Mendenhall, USCG
Graphics by Natalie Renier, WHOI

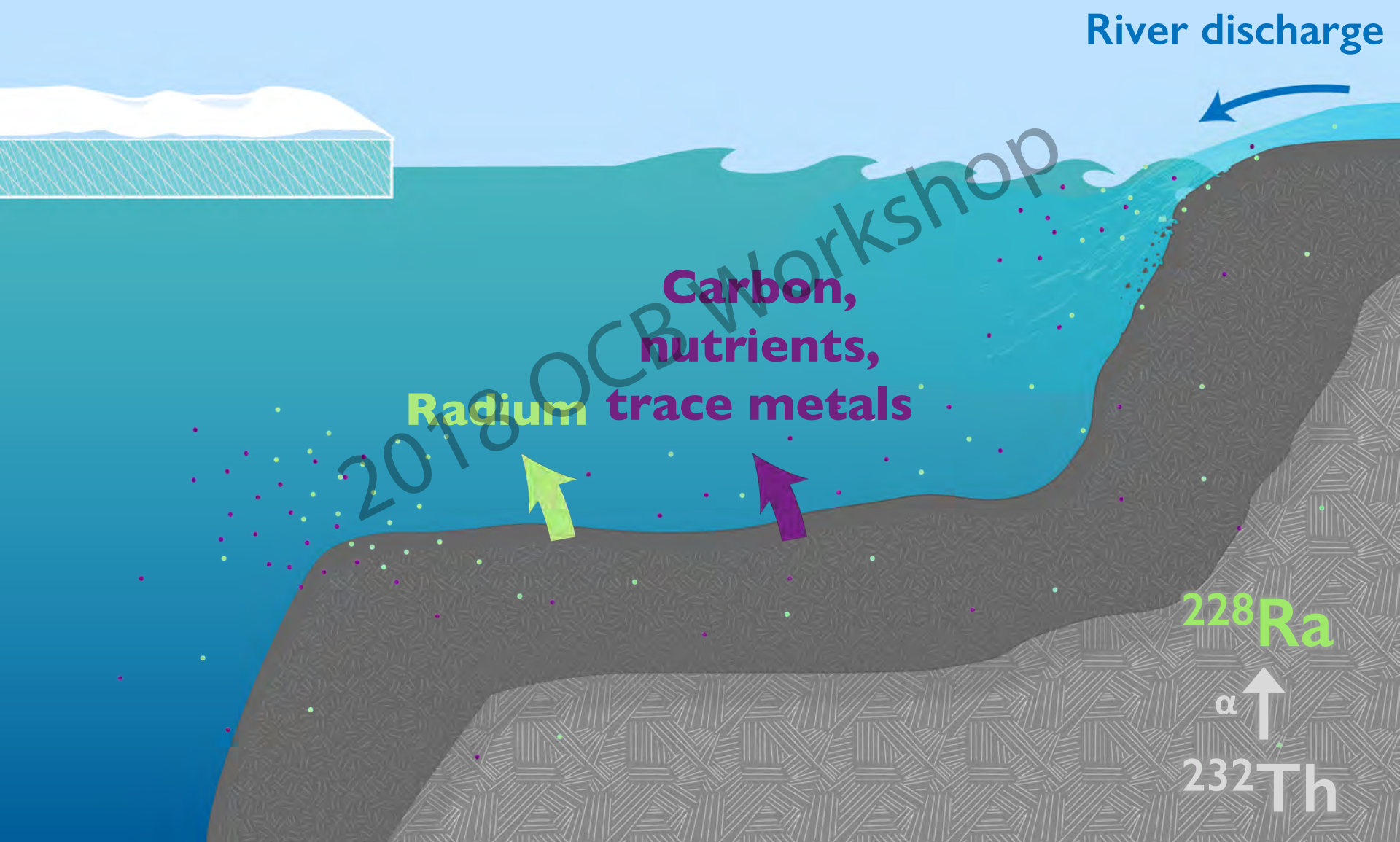
Rising temperatures are causing changes over Arctic shelves

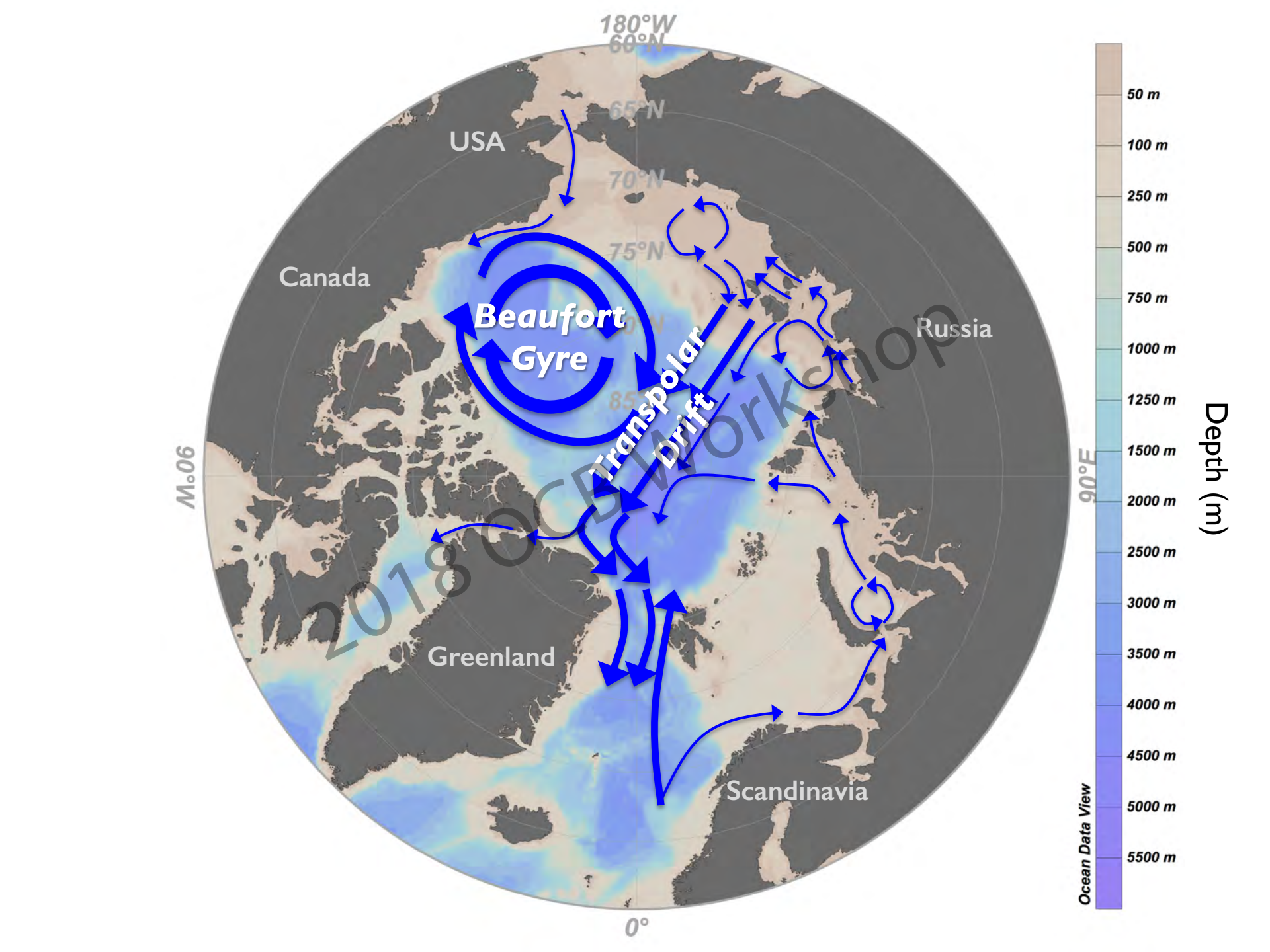


Radium isotopes are tracers of margin inputs to the ocean



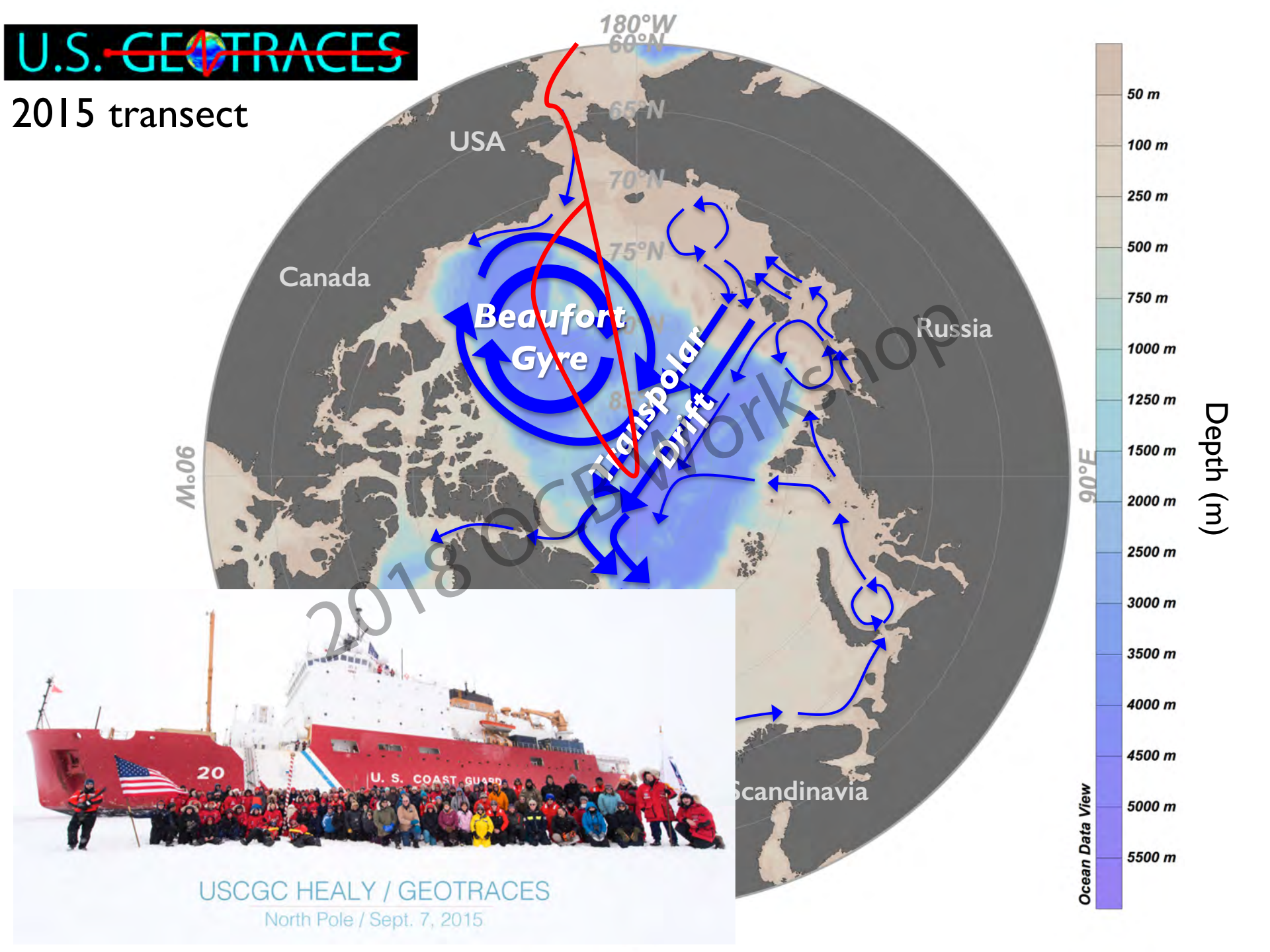
Radium isotopes can trace inputs of other shelf-derived materials

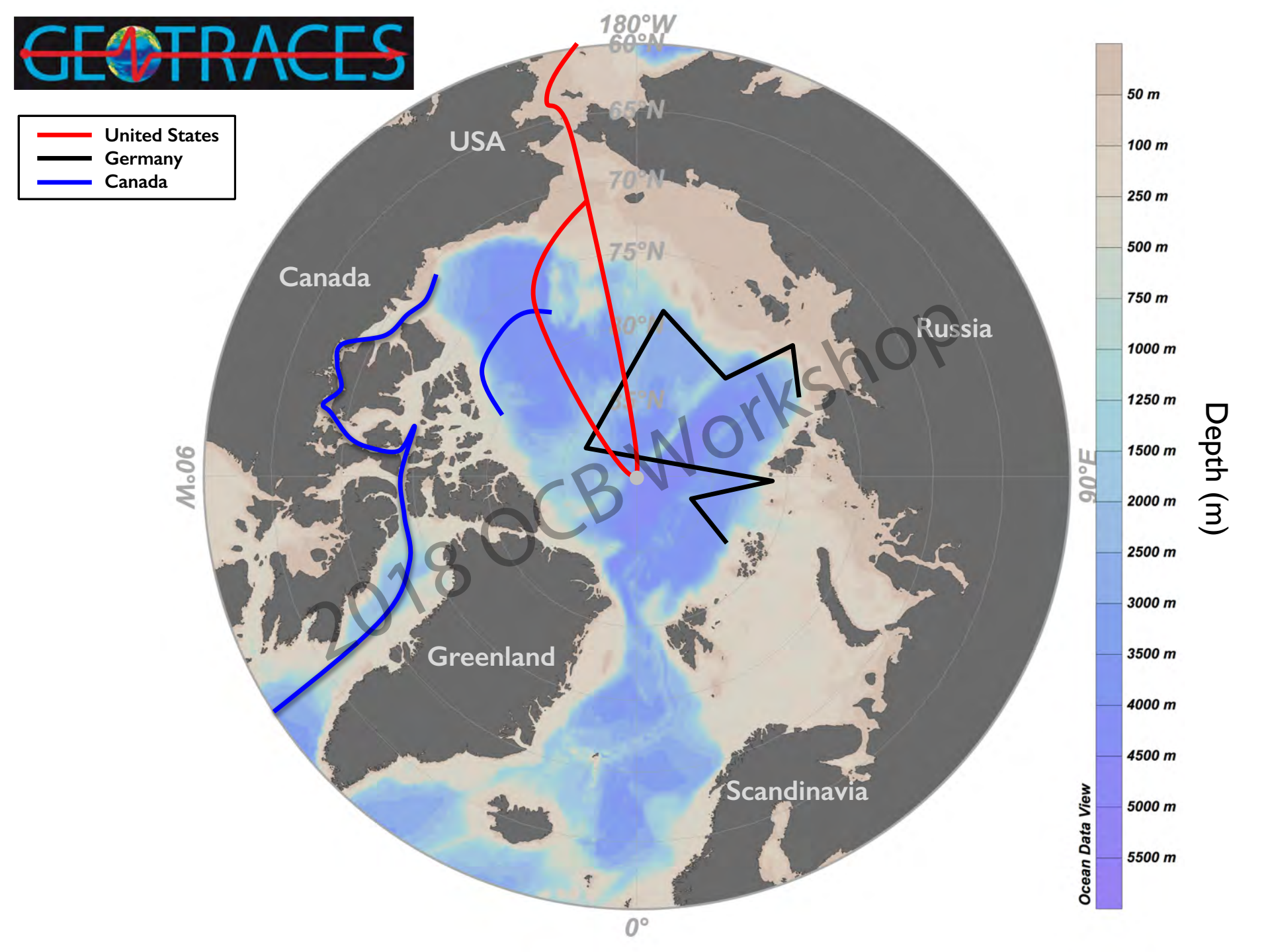



180°W
60°N
65°N
70°N
75°N
85°N
90°W
90°E
0°
USA
Canada
Russia
Greenland
Scandinavia
Beaufort Gyre
Transpolar Drift
2018 OCB Workshop
50 m
100 m
250 m
500 m
750 m
1000 m
1250 m
1500 m
2000 m
2500 m
3000 m
3500 m
4000 m
4500 m
5000 m
5500 m
Depth (m)
Ocean Data View

U.S. GEOTRACES

2015 transect




GEOTRACES
United States
Germany
Canada
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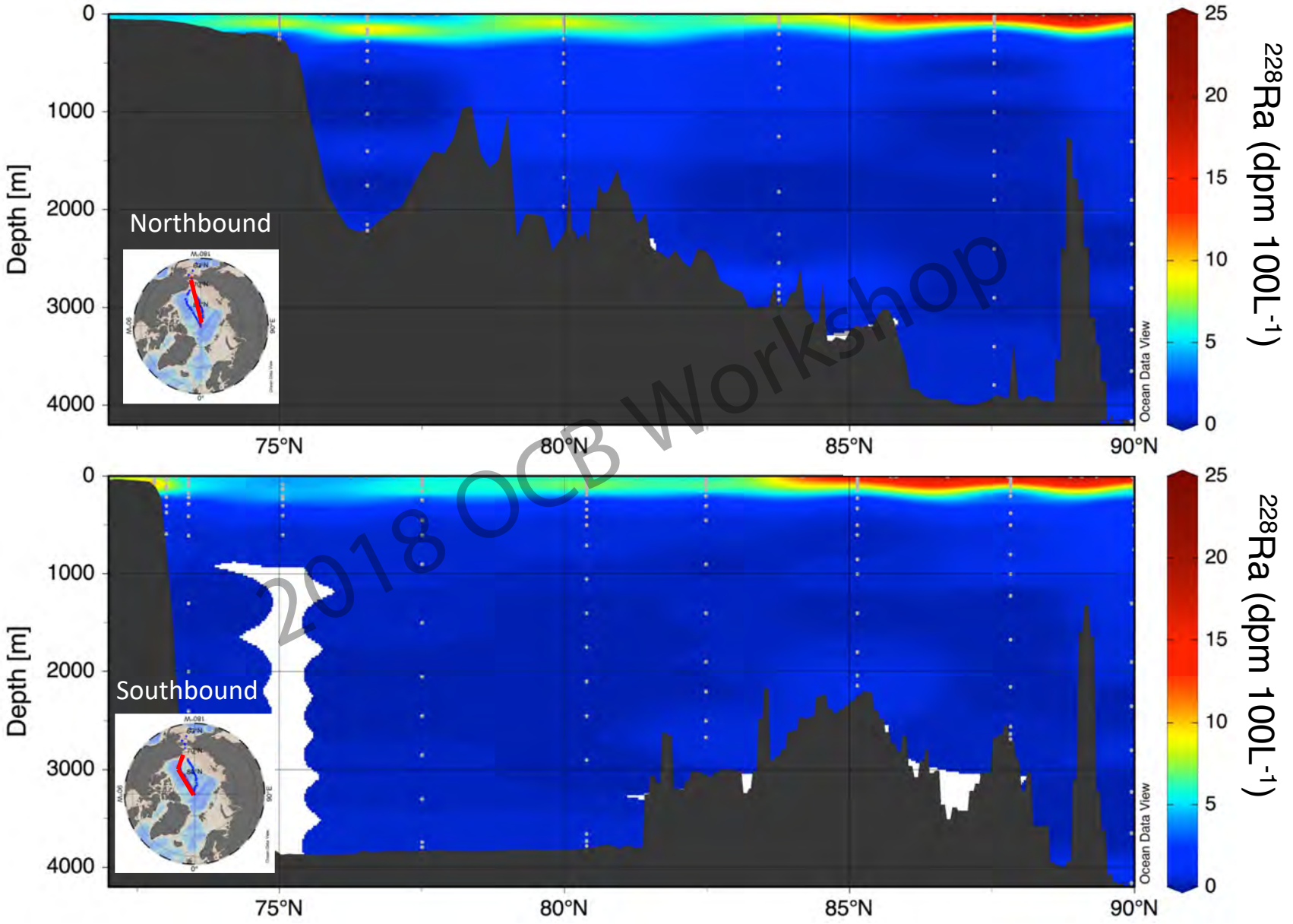
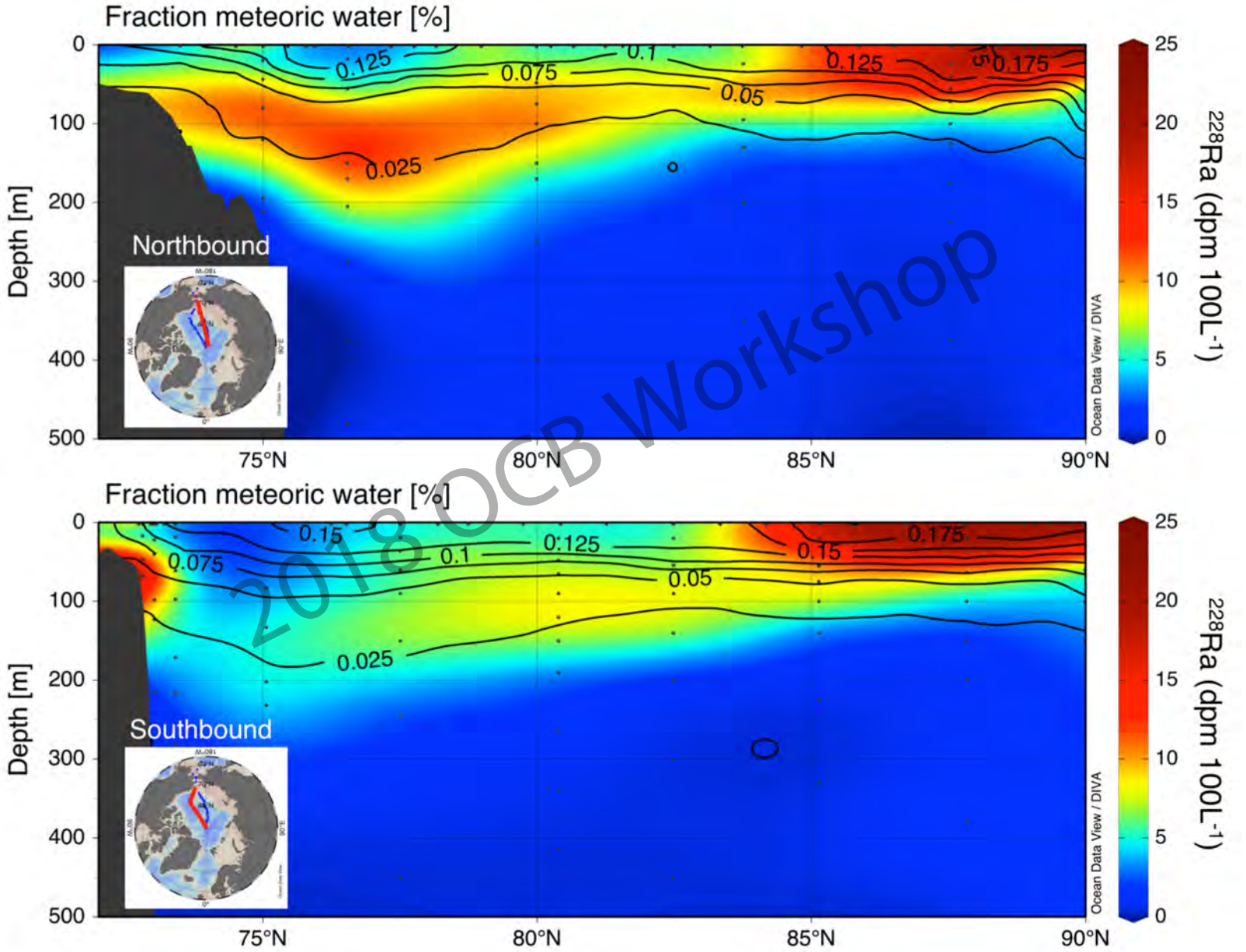
High ^{228}Ra activities in surface waters, particularly above 85°N



Bering Strait **North Pole**

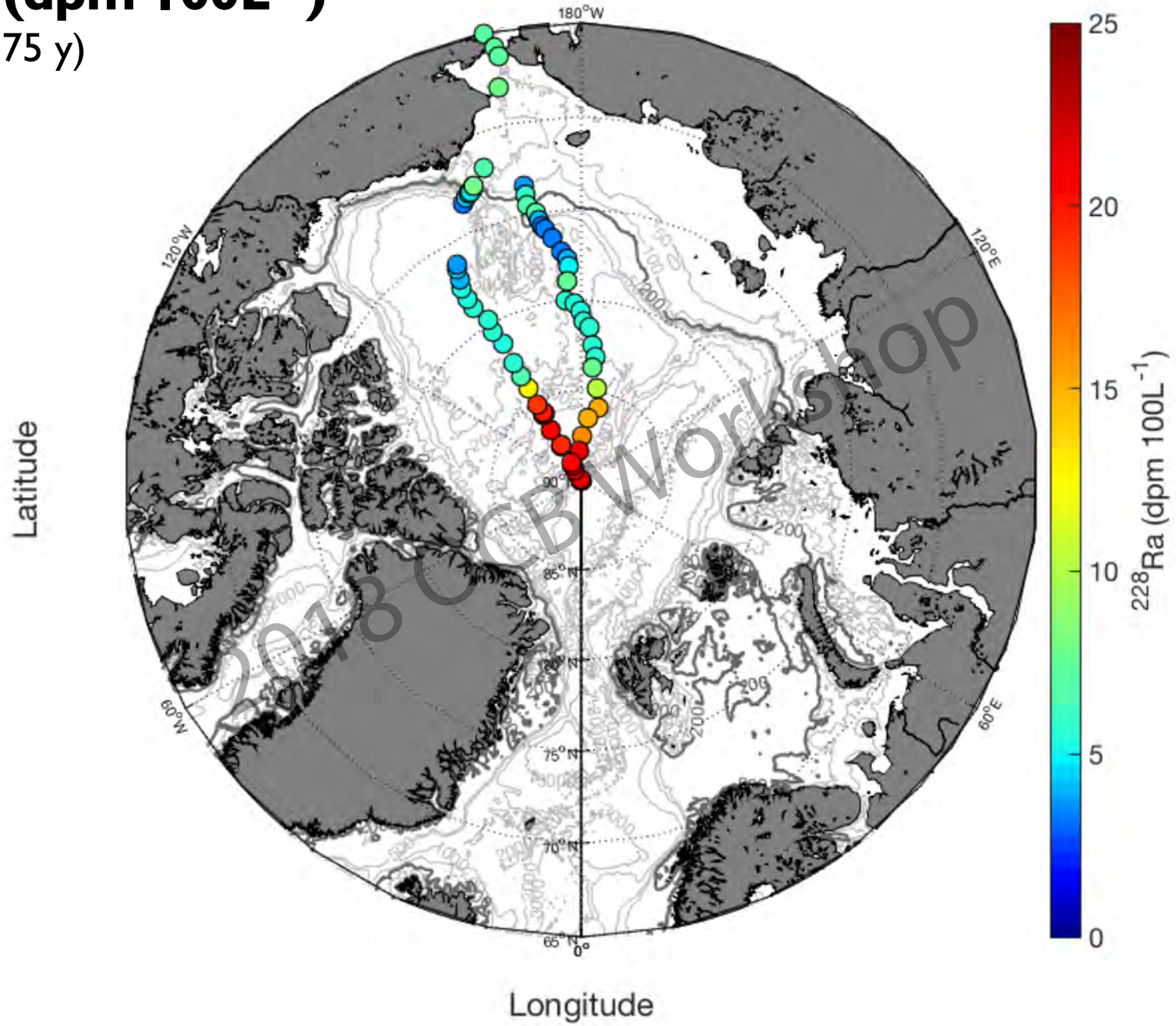
High ^{228}Ra activities are correlated with high meteoric water fractions, evidence of shelf influence



(Meteoric water fraction determined by P. Schlosser, R. Newton, T. Koffman, and A. Pasqualini)

^{228}Ra (dpm 100L^{-1})

($t_{1/2}$ = 5.75 y)



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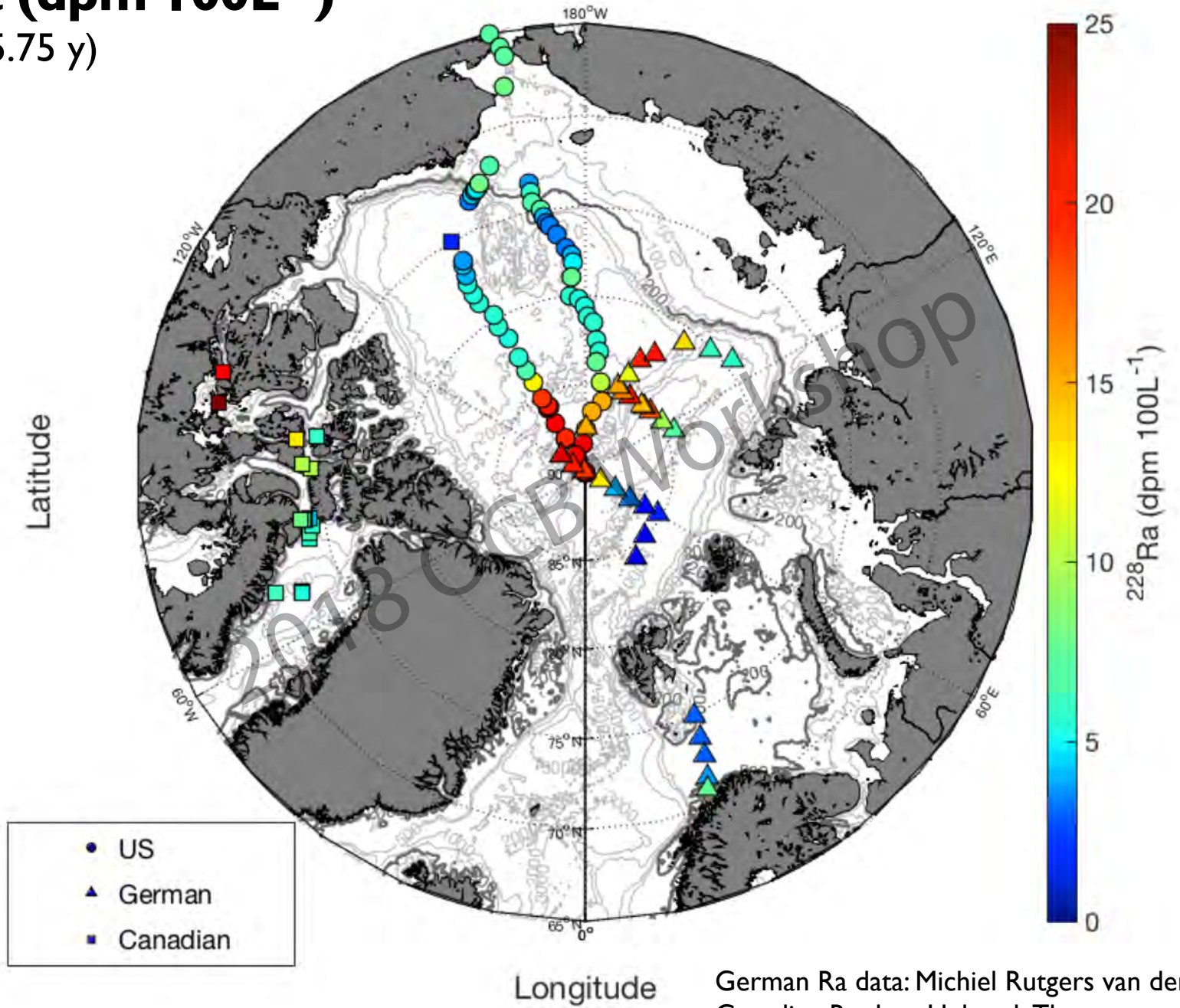

German Ra data: Michiel Rutgers van der Loeff
Canadian Ra data: Helmuth Thomas

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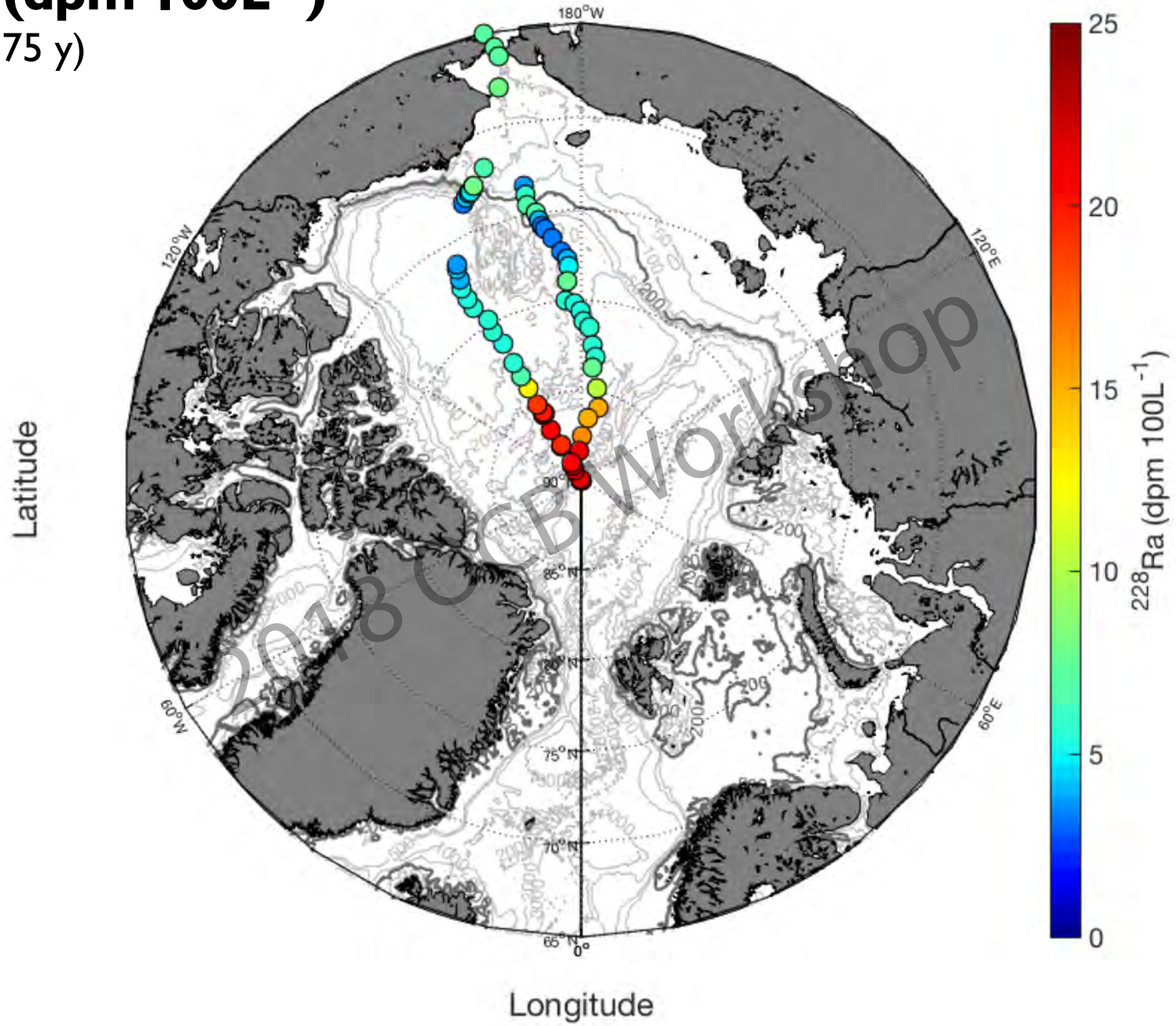
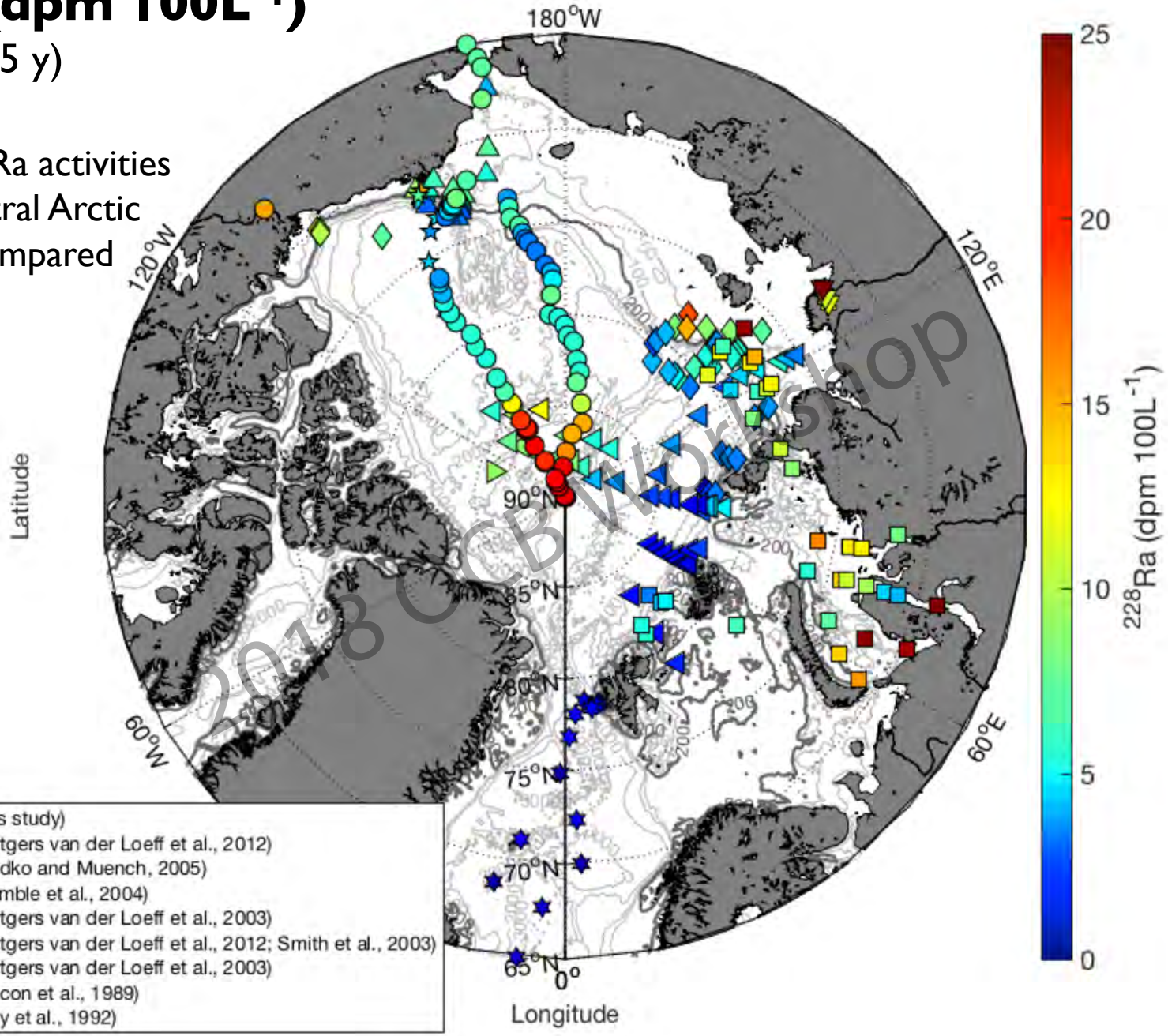


^{228}Ra (dpm 100L^{-1})

($t_{1/2}$ = 5.75 y)

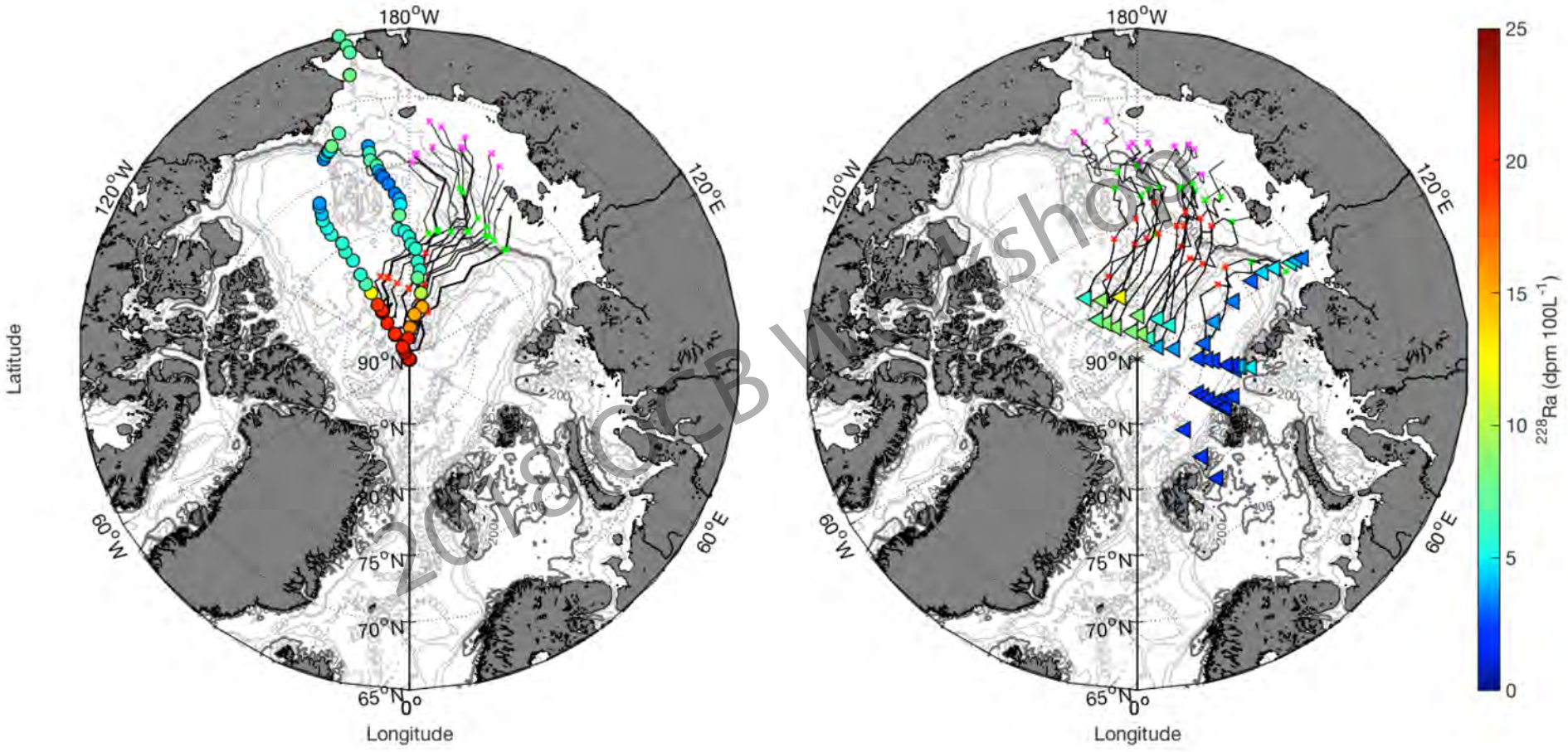
Higher ^{228}Ra activities in the central Arctic in 2015 compared to 2007



Ice back-trajectories show that water was transported from the East Siberian Arctic Shelf to the central Arctic via the Transpolar Drift

2015 *(this study)*:

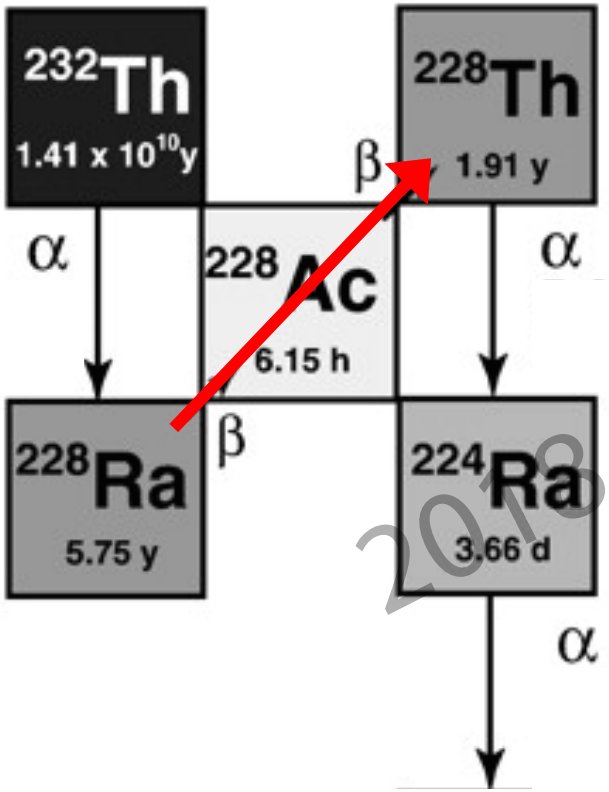
2007 *(Rutgers van der Loeff et al 2012)*:



Different origins cannot explain the higher activities in 2015

(Ice back-trajectories modeled by I. Rigor, International Arctic Buoy Program)

$^{228}Th/^{228}Ra$ ratio can be used to determine the time elapsed since water left the shelf

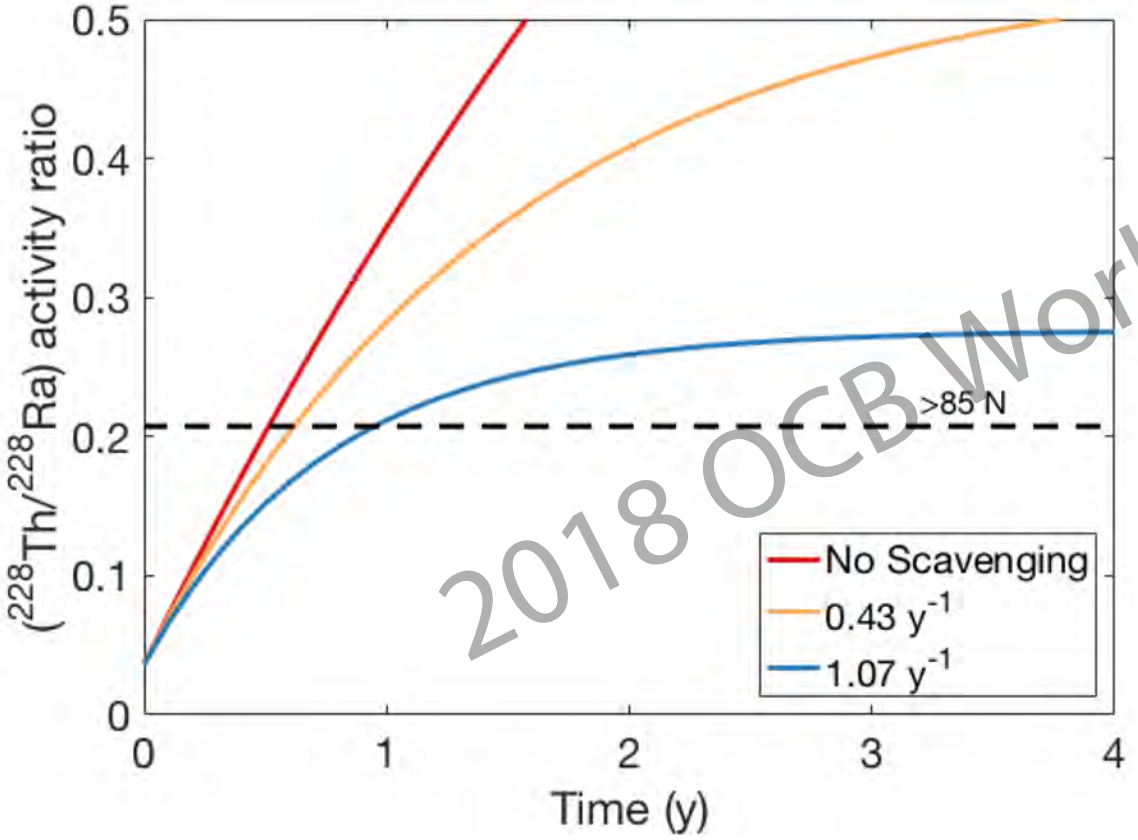


Biological productivity removes ^{228}Th from dissolved phase over the shelf

Once water moves into the open ocean, ^{228}Th ($t_{1/2}$ = 1.91 y) grows into equilibrium with its parent ^{228}Ra

Higher $^{228}Th/^{228}Ra$ ratios = older water

$^{228}Th/^{228}Ra$ ratio can be used to determine the time elapsed since water left the shelf



Water age from $^{228}Th/^{228}Ra$:

6 – 12 months in 2015

1 – ≥3 years in 2007*

Water age from ice trajectories:

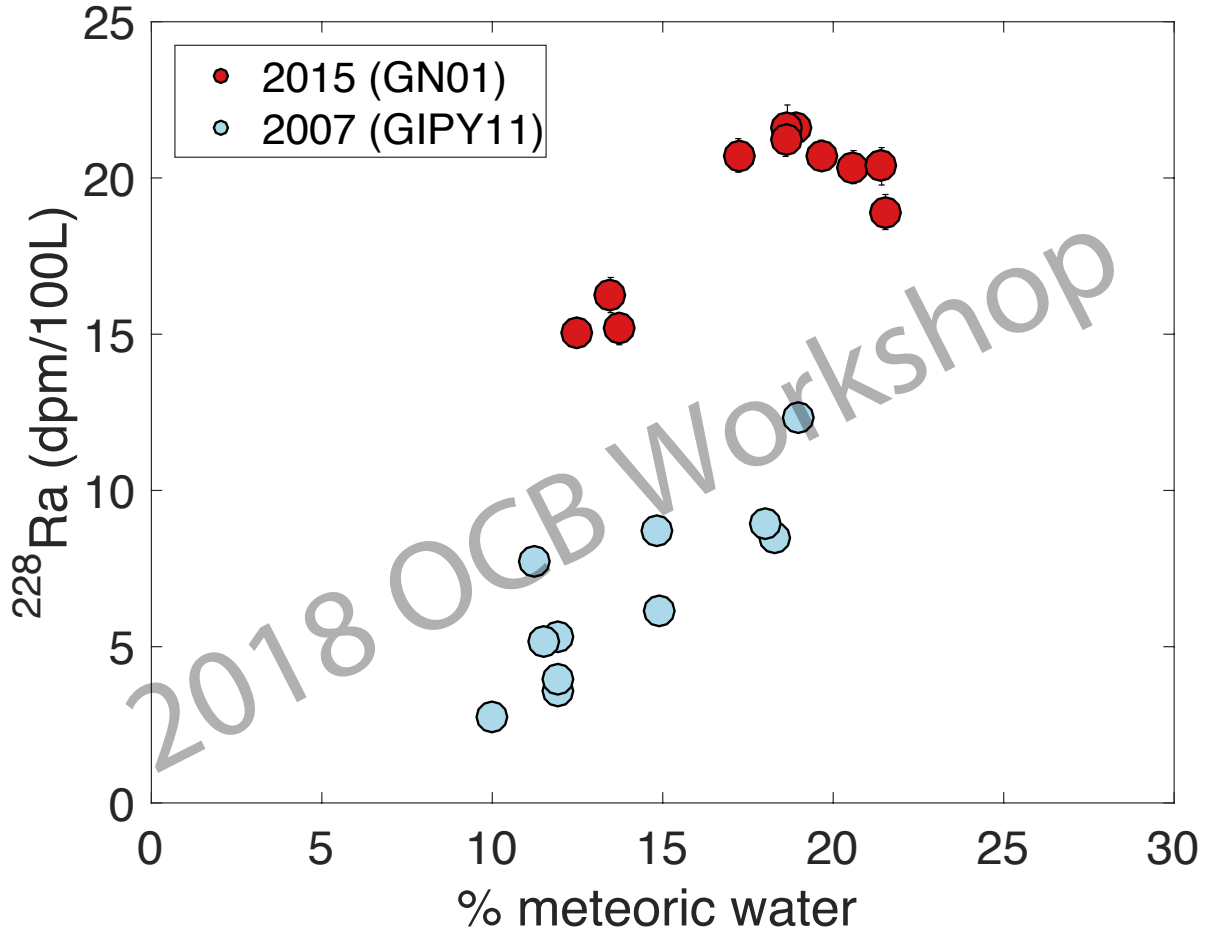
8 – 18 months in 2015

4 – 16 months in 2007

Differences in the water transport times cannot explain the higher ^{228}Ra activities observed in 2015

*2007 estimate from *Rutgers van der Loeff et al., 2012*

At the same fraction of meteoric water, ^{228}Ra activities are ~2x as high in 2015 compared to 2007

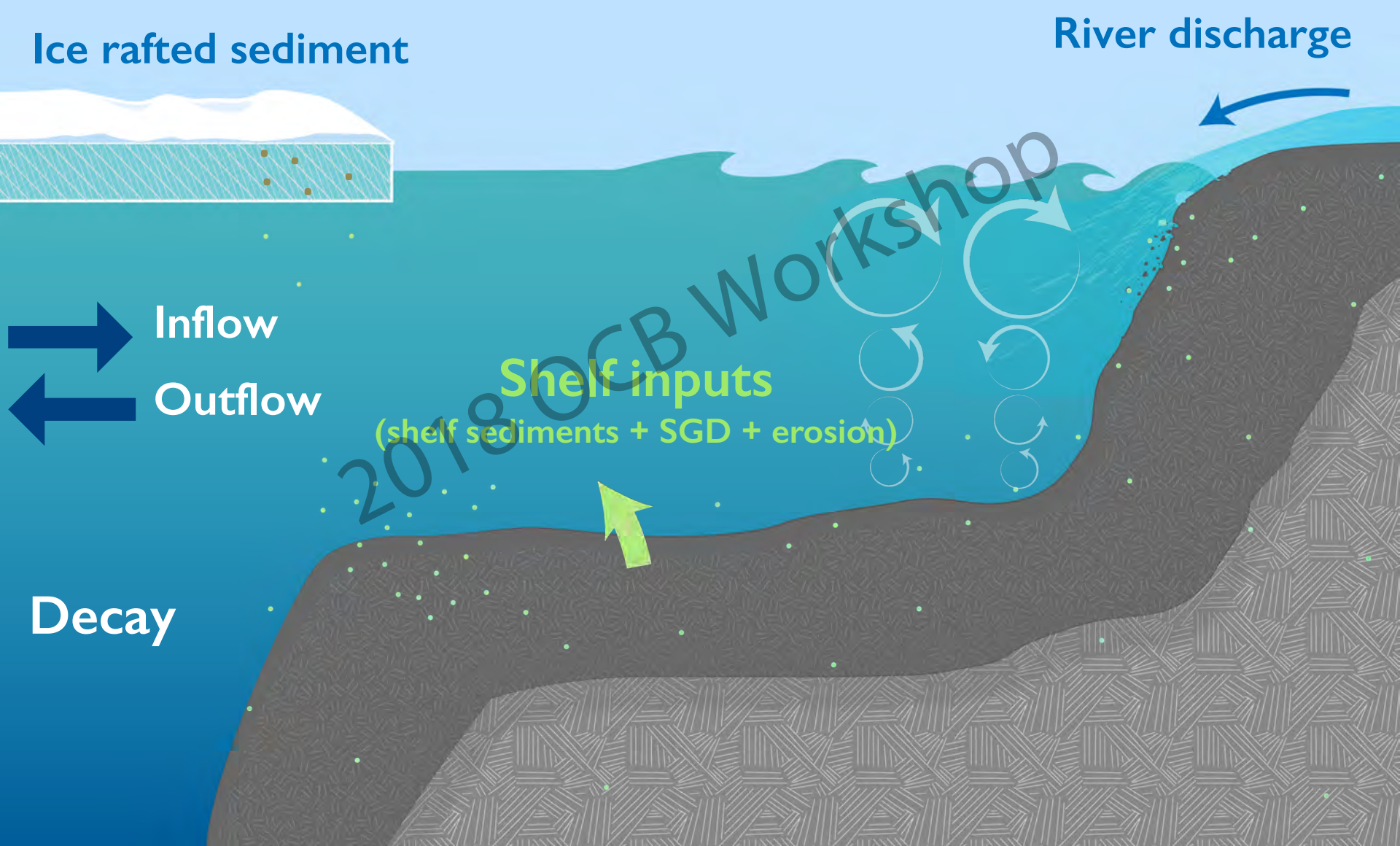


Increased river discharge cannot explain the higher ^{228}Ra activities observed in 2015

(2015 meteoric water fraction determined by P. Schlosser, R. Newton, T. Koffman, and A. Pasqualini;
2007 Ra data from *Rutgers van der Loeff et al., 2012*; 2007 meteoric water fraction determined by *Bauch et al. 2011*)

^{228}Ra mass balance:

Rivers + Ice melt + Shelf inputs + Advection = Decay + Advection



^{228}Ra mass balance:

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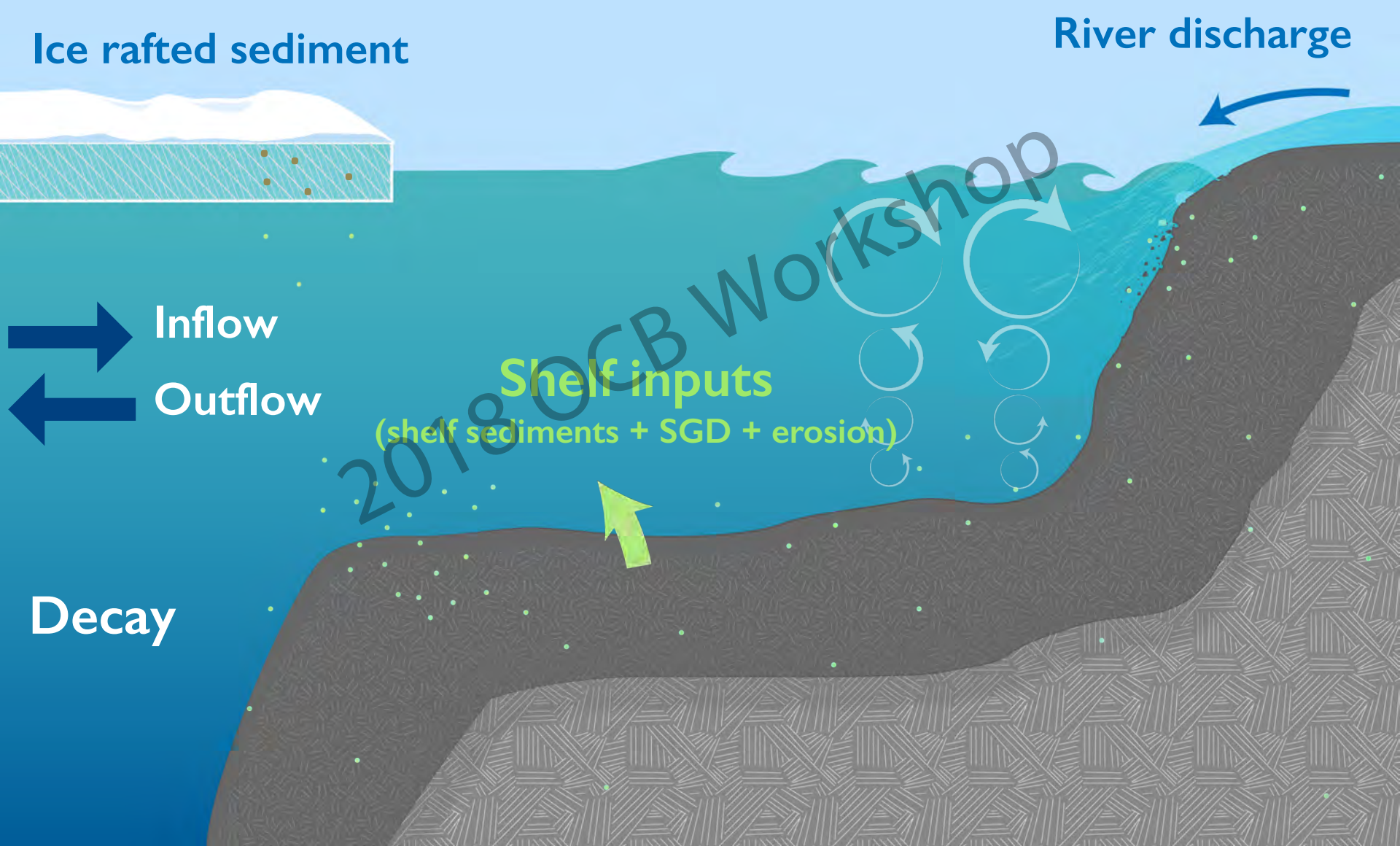
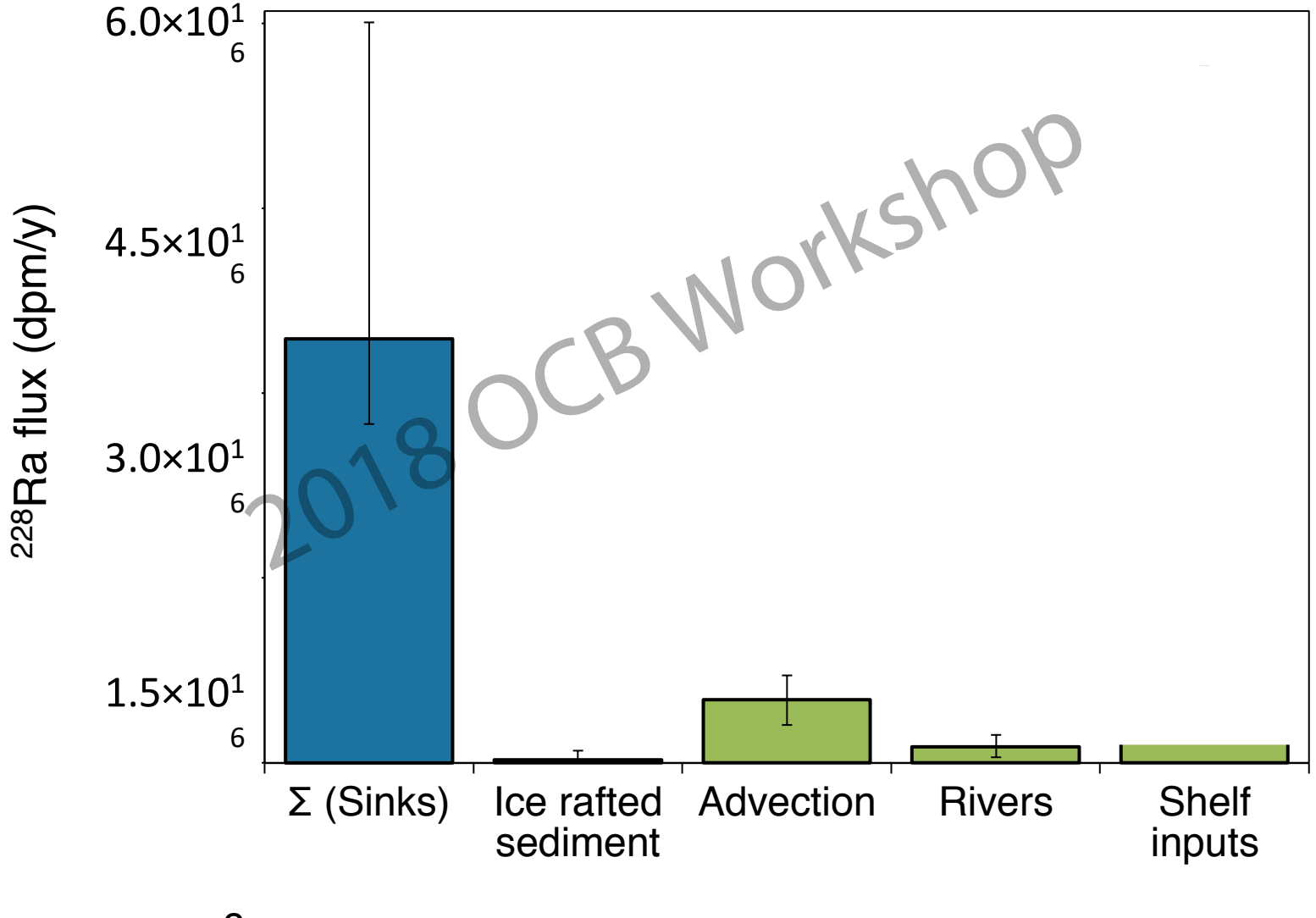
✓ ✓ ✓ ✓ ✓



^{228}Ra mass balance:

Rivers + Ice melt + Shelf inputs + Advection = Decay + Advection

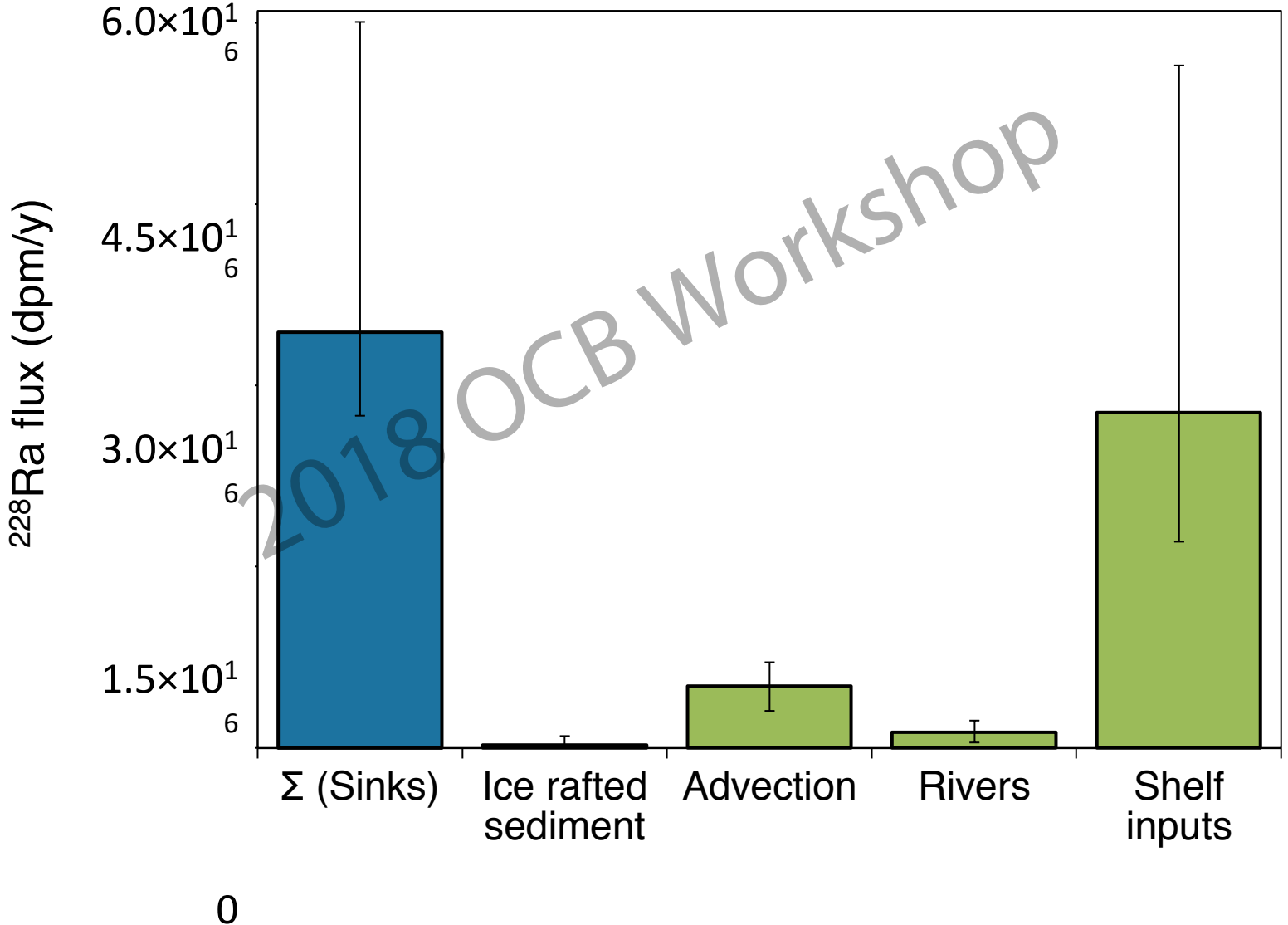
3% 1% 12%



^{228}Ra mass balance:

Rivers + Ice melt + Shelf inputs + Advection = Decay + Advection

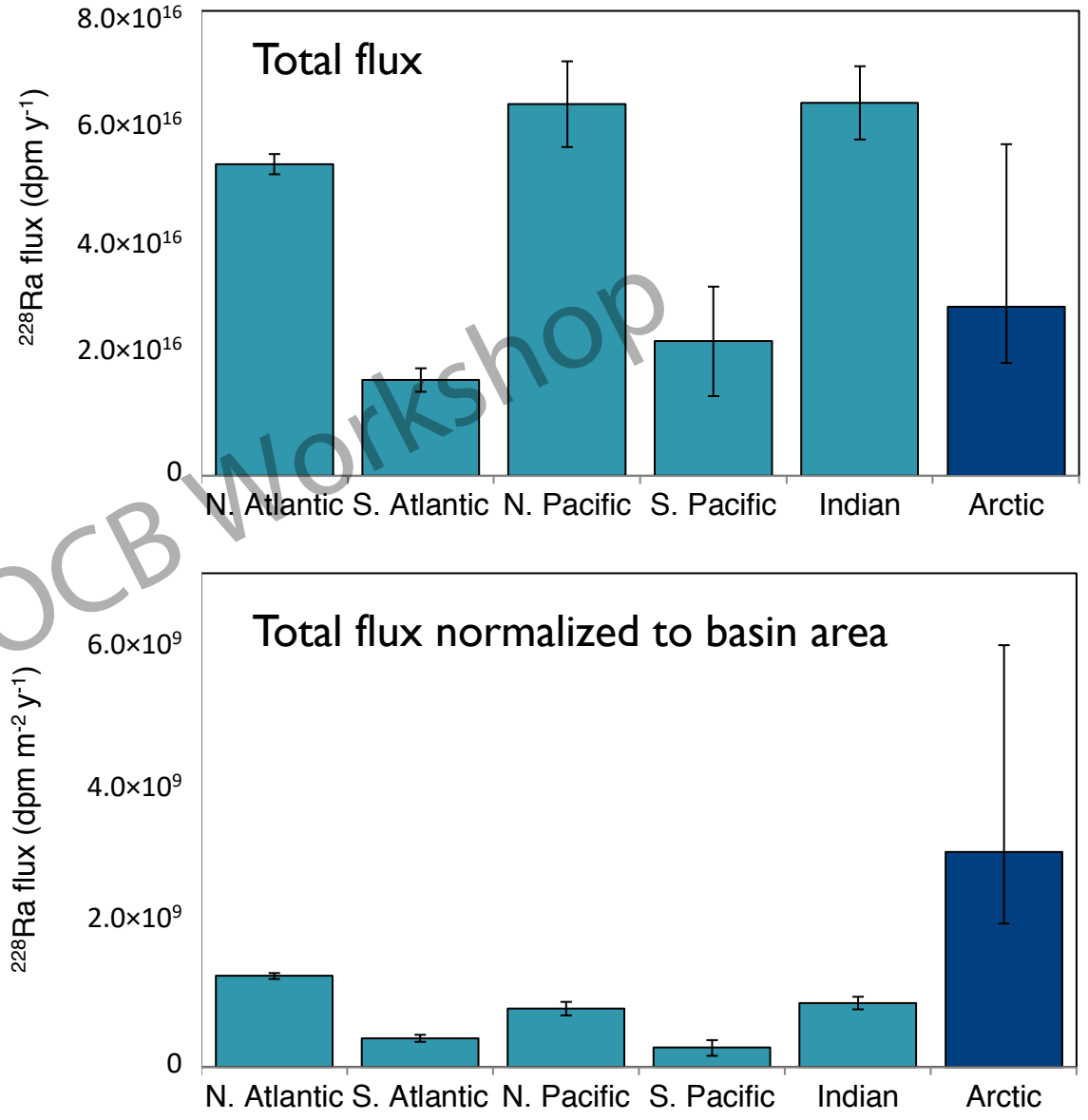
Shelf inputs = Decay ± Advection – Rivers – Ice melt



Shelf inputs have a disproportionately large impact on the Arctic basin

Shelf flux of ^{228}Ra in the Arctic is similar to the flux in other basins…

…but when normalized to basin size it is clear that the shelf has a disproportionately large influence on the Arctic



(^{228}Ra fluxes from other basins are from Kwon et al., 2014)

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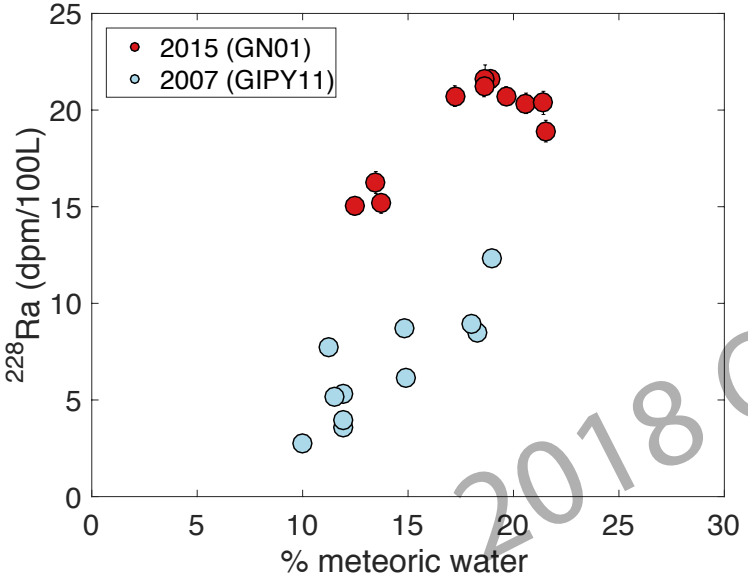

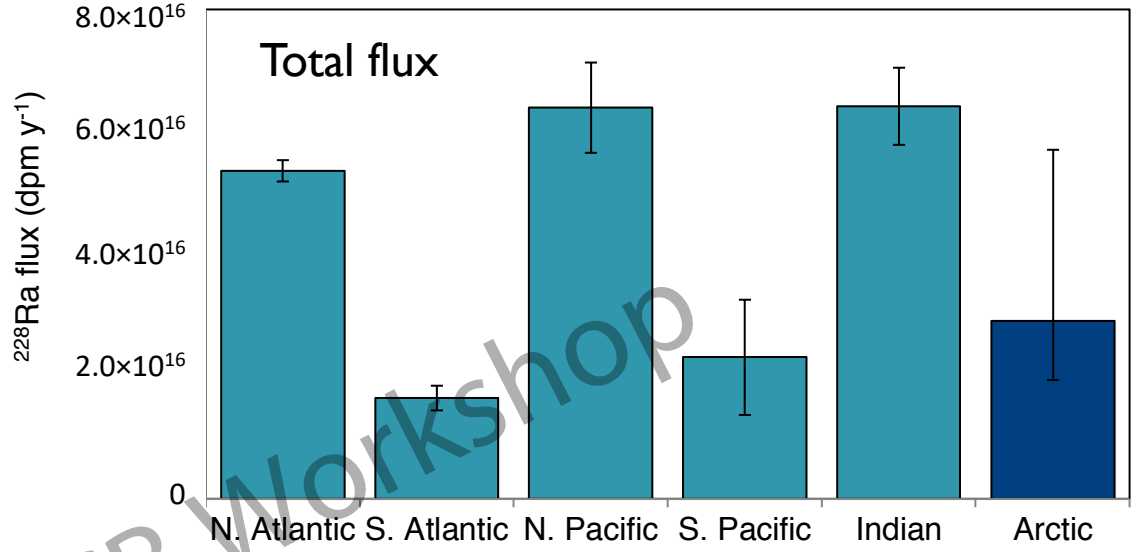

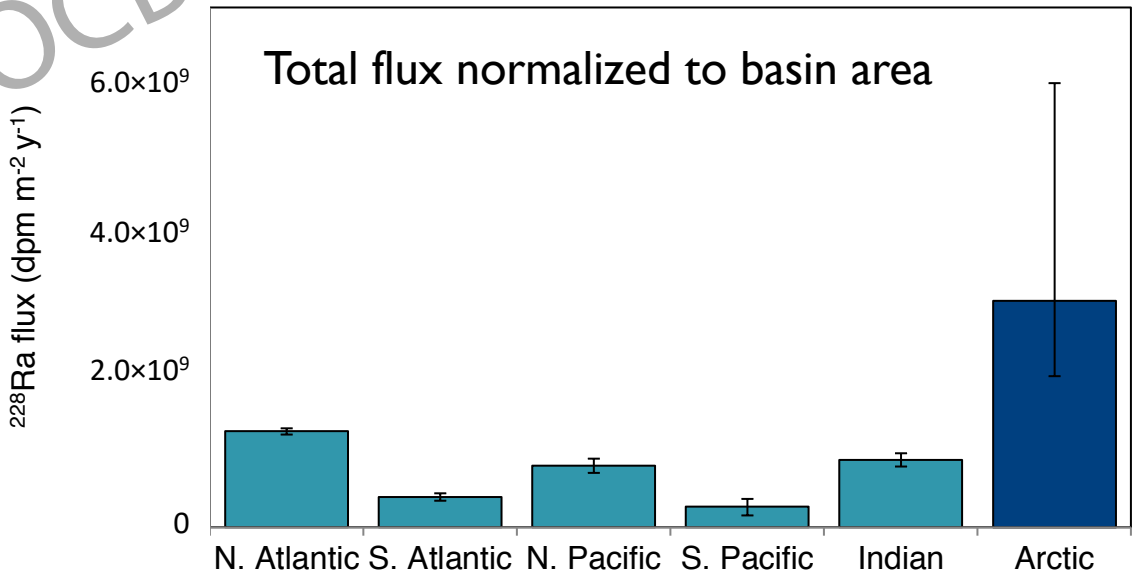

(^{228}Ra fluxes from other basins are from Kwon et al., 2014)

Solute fluxes from Arctic shelves are being affected by climate change

Increased ^{228}Ra activities over the shelf could be driven by:

- Increased coastal erosion
- Permafrost thaw
- Increased wind-driven mixing

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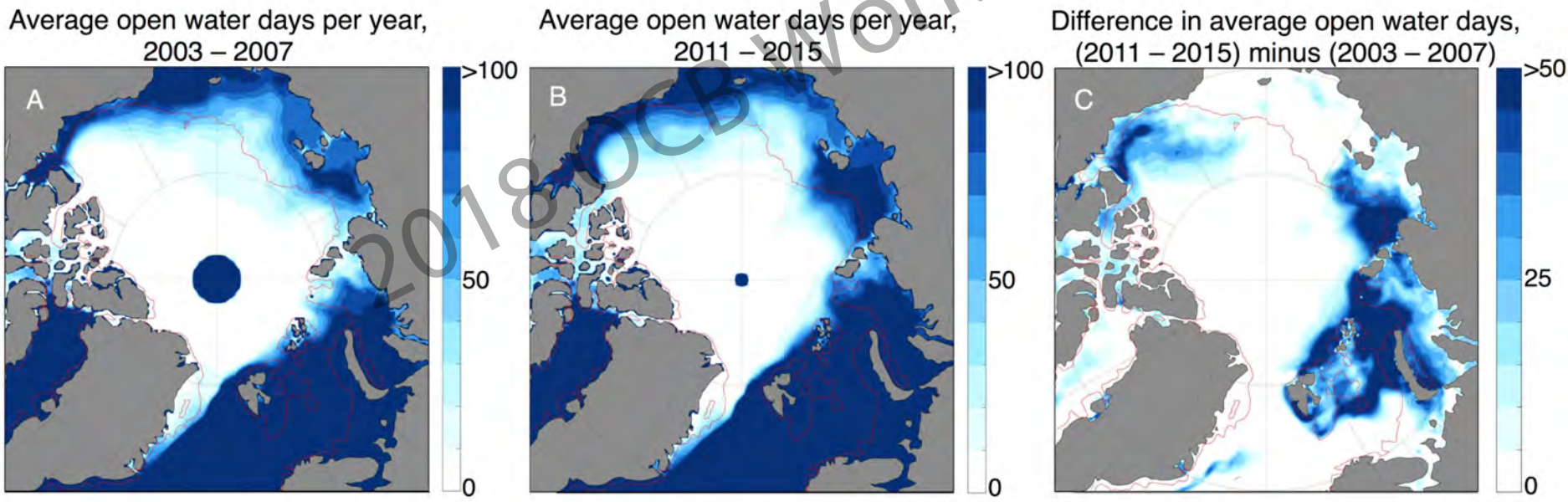
Increased ^{228}Ra activities over the shelf could be driven by:

- ~~Increased coastal erosion~~
- ~~Permafrost thaw~~
- **Increased wind-driven mixing**

A higher number of open water days preceded sampling in 2015 compared to 2007

The loss of sea ice over Arctic shelves allows for more wind-driven mixing, resulting in more solutes mixed into the overlying water column.

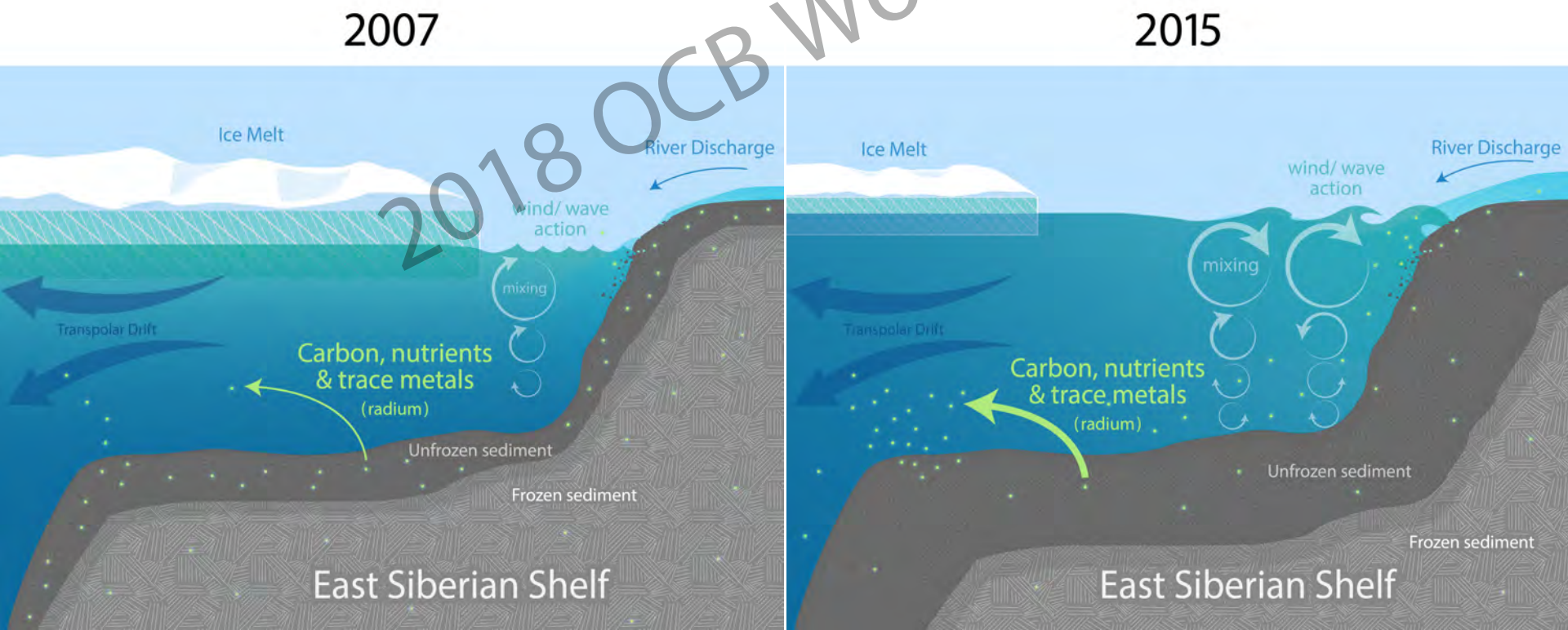
Changes are most pronounced over the Eastern Arctic shelves, where the Transpolar Drift originates.



Increased ^{228}Ra inputs imply increased fluxes of other shelf-derived materials

Changing shelf inputs will affect nutrient and trace metal concentrations in surface waters, with implications for primary productivity.

As decreasing ice concentrations reduce light limitations in the central Arctic, changing nutrient & trace metal fluxes are important to consider.



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- Cory Mendenhall (US Coast Guard) for the photos

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