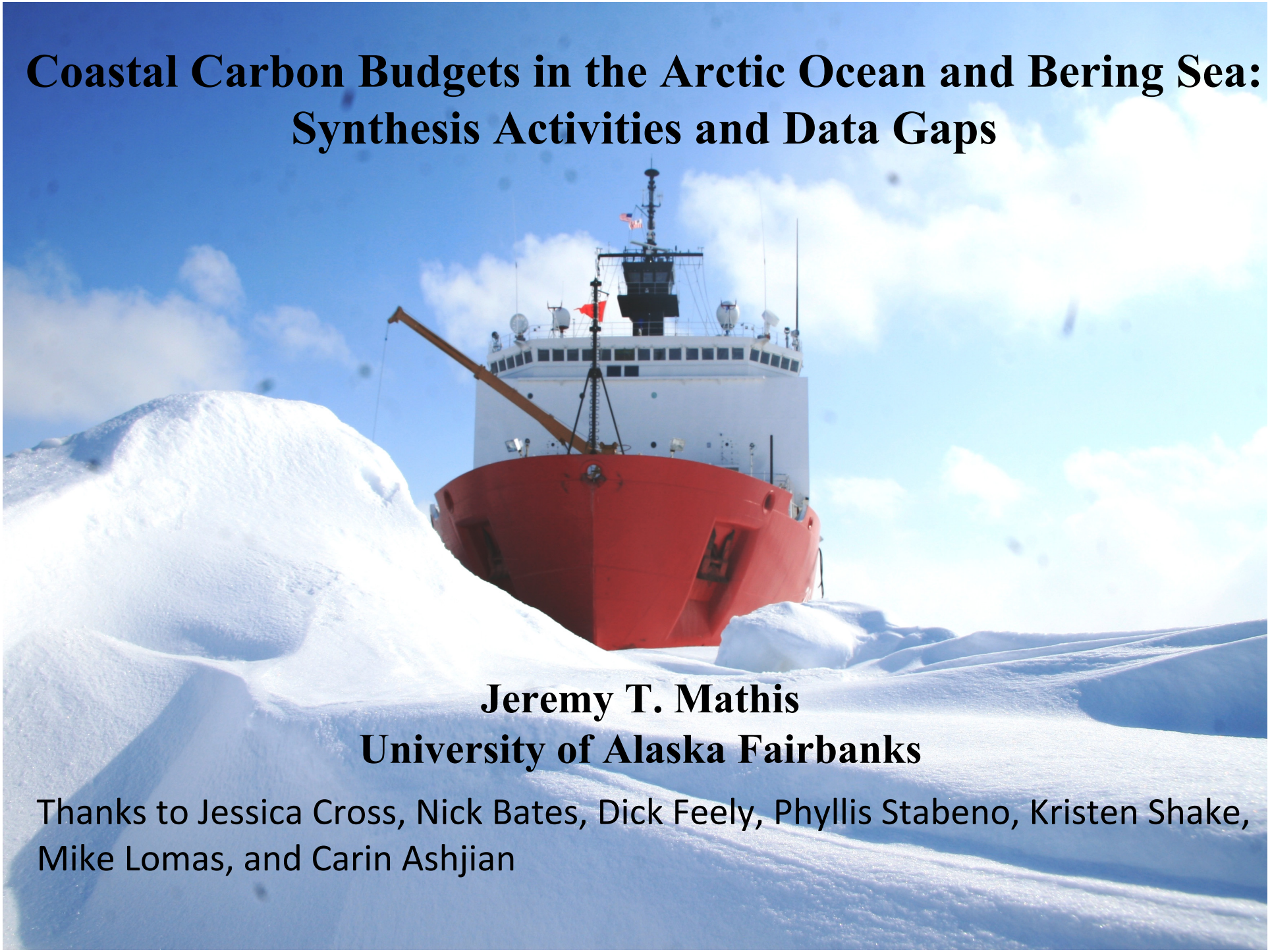
Coastal Carbon Budgets in the Arctic Ocean and Bering Sea: Synthesis Activities and Data Gaps



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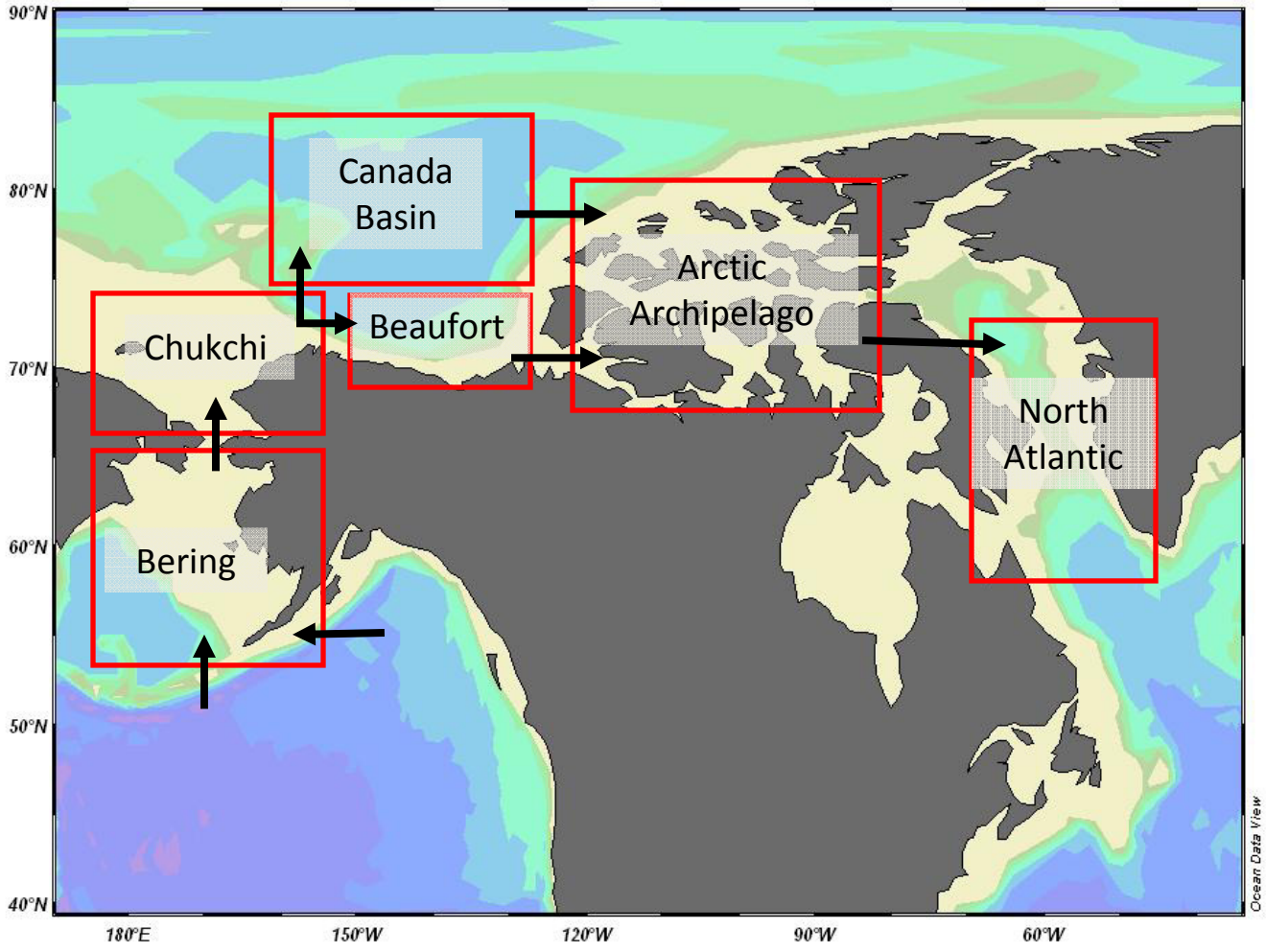
University of Alaska Fairbanks

Thanks to Jessica Cross, Nick Bates, Dick Feely, Phyllis Stabeno, Kristen Shake, Mike Lomas, and Carin Ashjian

98 % of Alaskans are in favor of global warming!

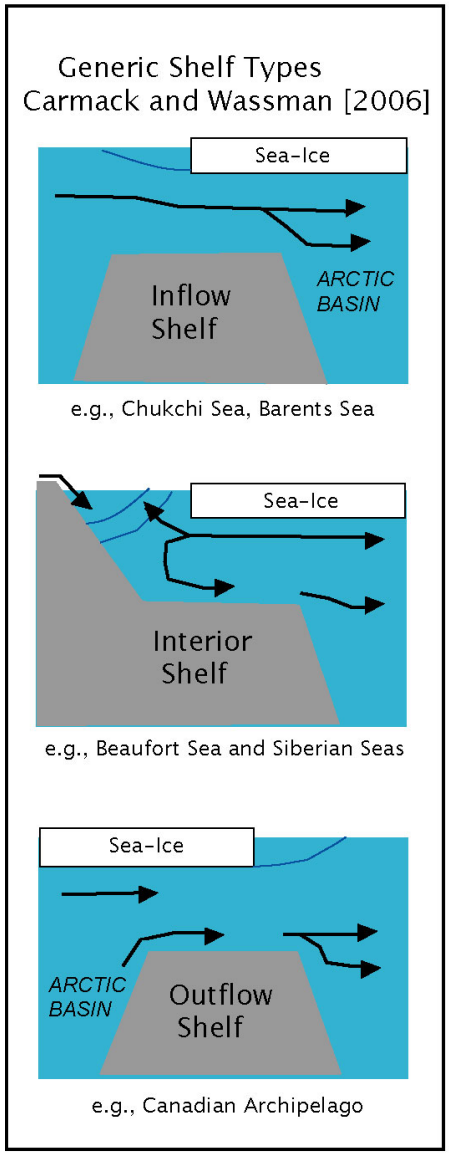
NACP: Coastal Synthesis - Arctic (including Bering, Chukchi and Beaufort Seas)

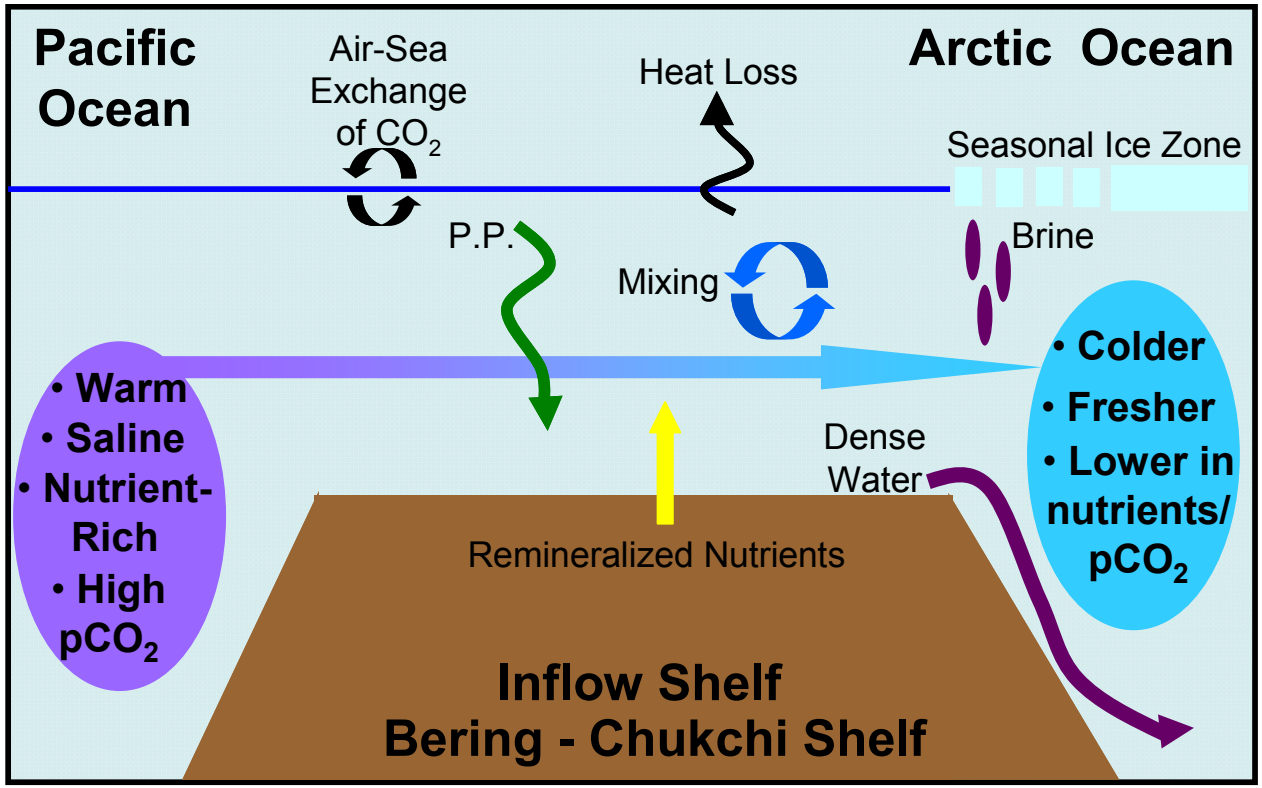


What doe we know in each zone?

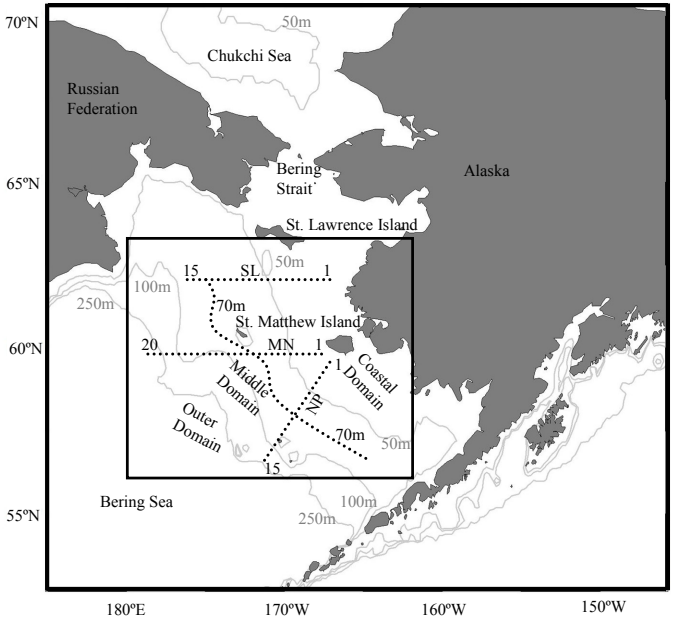
1. CO_2 Fluxes
2. PP and Export
3. Terrestrial Inputs
4. Ocean Acidification
5. Synthesis Activities

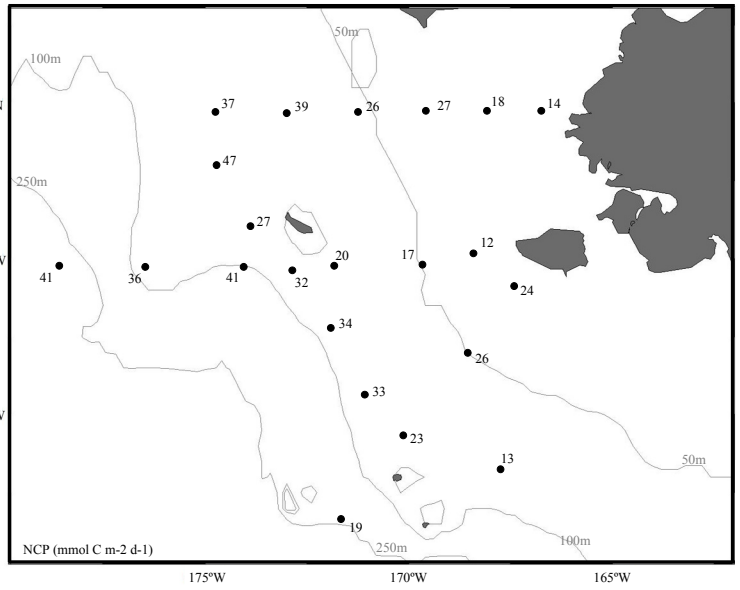
Carbon Biogeochemistry of Arctic Shelves

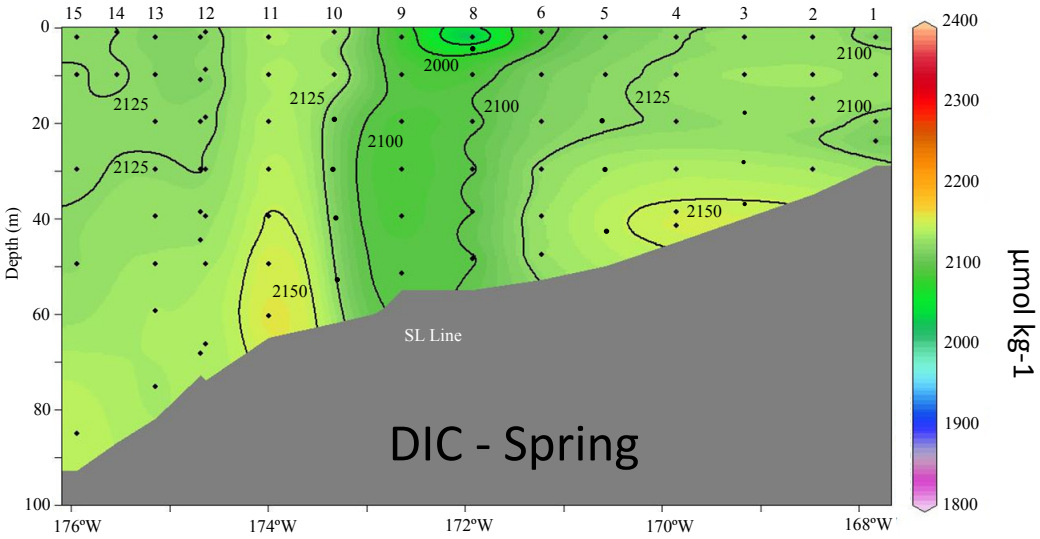


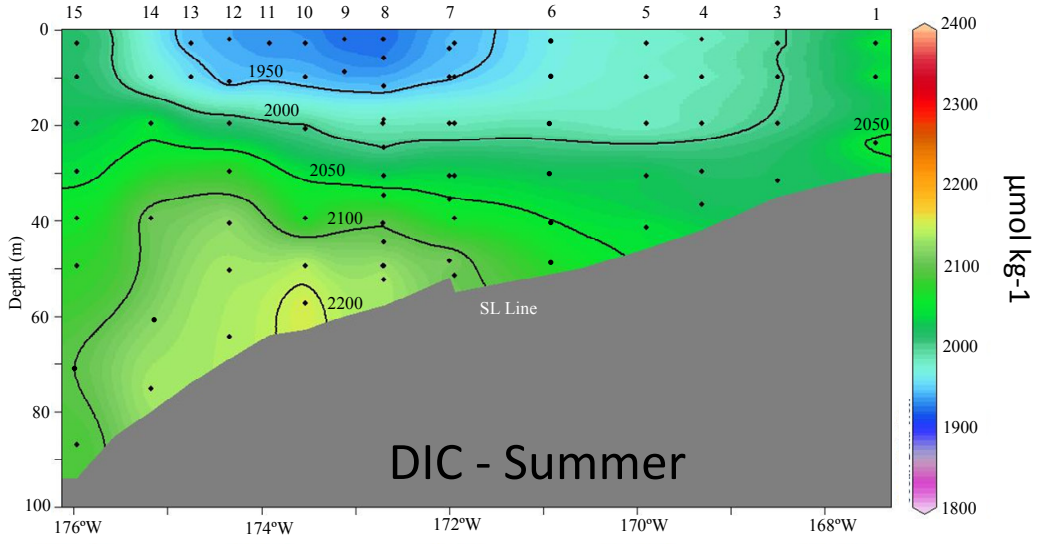


Bering Ecosystem Study (BEST) Results from 2008



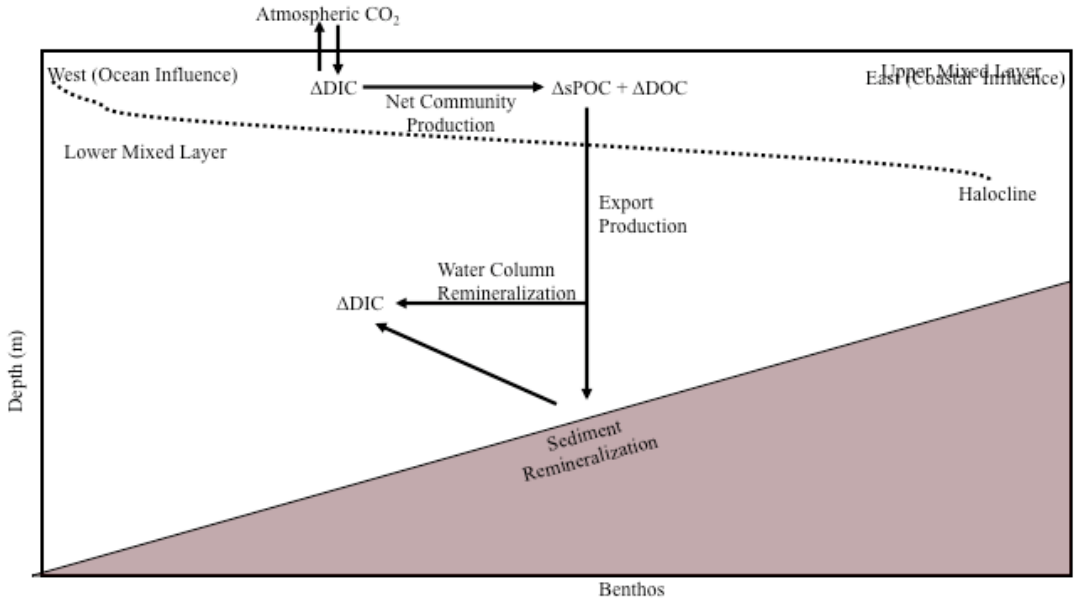






Mathis et al., In Review

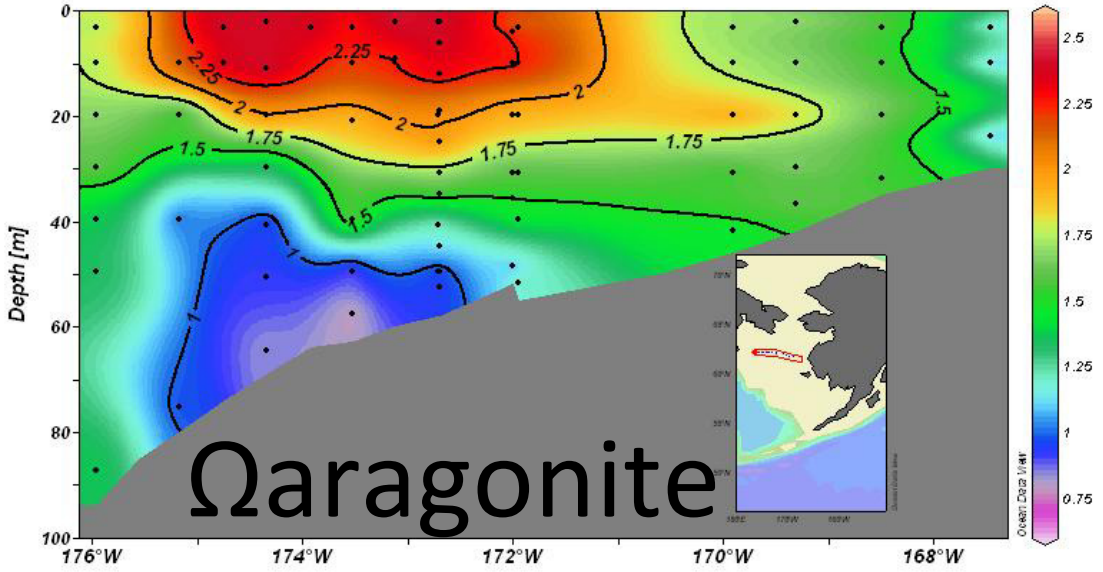
Coupling Export Production to the Suppression of Carbon Mineral Saturation States



High rates of export production lead to enhanced remineralization in the bottom waters over the Bering Sea shelf. This leads to a suppression in saturation states coupled to surface productivity.

If anthropogenic CO2 is removed from the water column, then these undersaturated conditions are no longer present….

This is likely a recent, anthropogenic effect.



Mathis et al., In Prep.

Carbon Budgets for the Chukchi Sea

Export Production = ΔnDIC – ΔDOC - Δ suspended POC

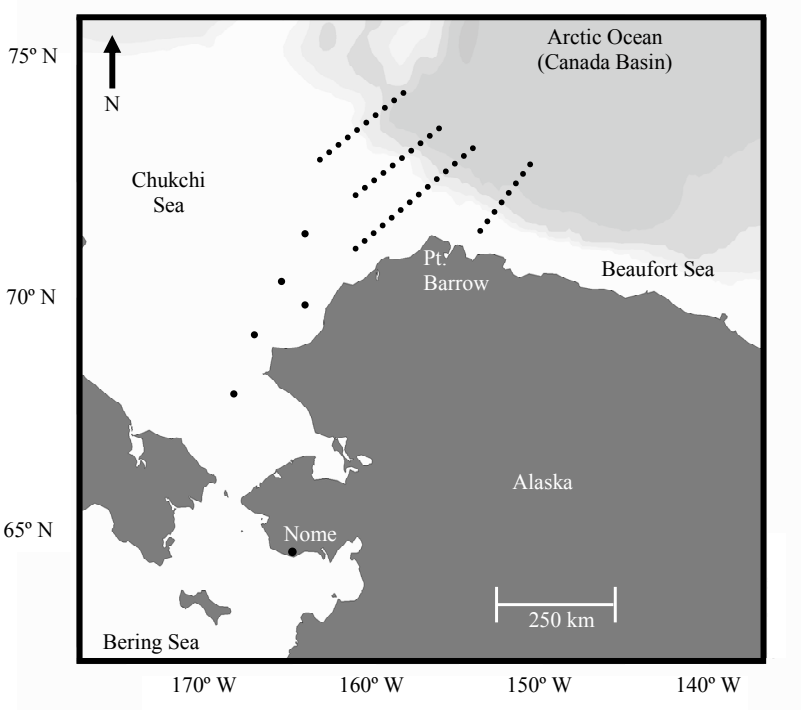
- Δ values in μmol kg^{-1}
- (%) is the amount of ΔDIC converted

Location	ΔnDIC	ΔDOC	Δsuspended POC	Export Prod. (mmol C m^{-2} d^{-1})*
Central				
Shelf	230	22 (9%)	40 (17%)	104 (74%)
Slope	41	4 (10%)	7 (17%)	15 (73%)
Basin	2	0	0.3 (15%)	0.5 (85%)
Western				
Shelf	86	9 (10%)	14 (16%)	32.5 (74%)
Slope	22	2.5 (11%)	3 (14%)	8 (75%)
Basin	3	0	0.5 (15%)	1.3 (85%)
Eastern				
Shelf	94	11 (12%)	16 (17%)	40 (71%)
Slope	58	6 (10%)	8 (14%)	23 (76%)
Basin	11	0.8 (7%)	1.8 (16%)	3.7 (77%)

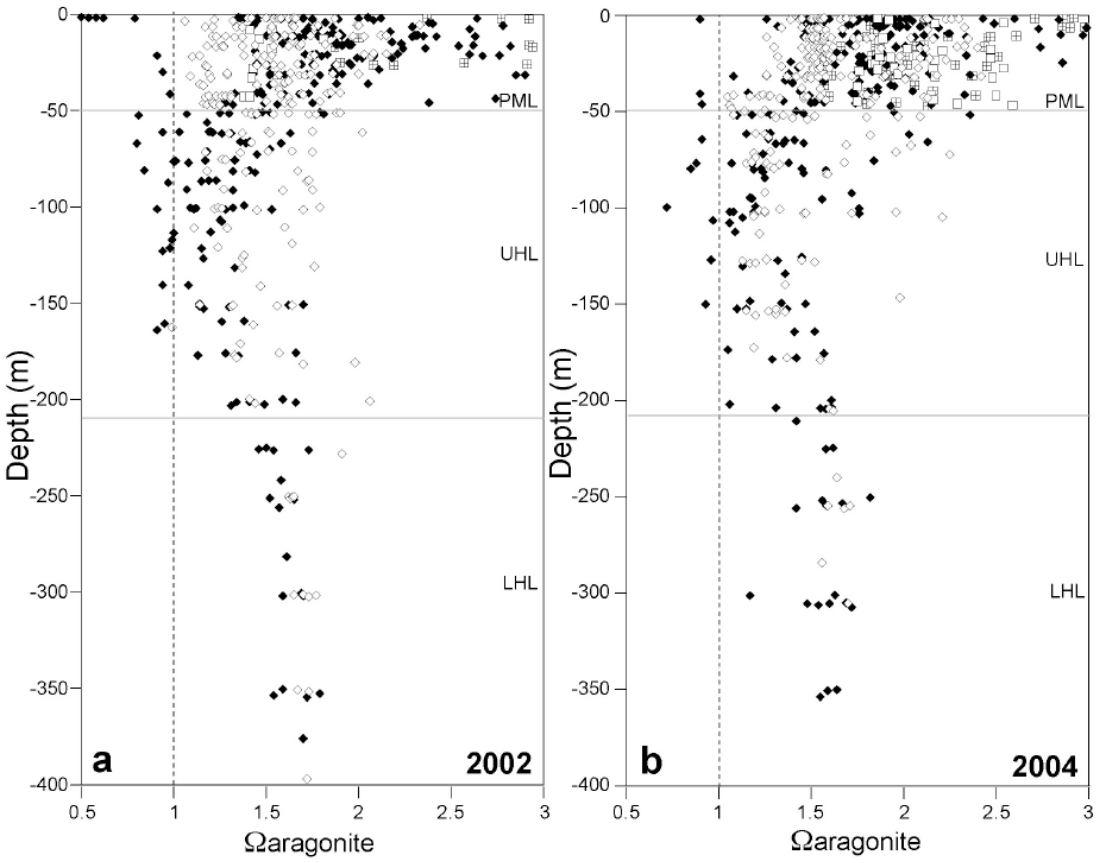
* The export production values are consistent with observations taken from sediment traps.

Mathis et al., 2007b

Coupling Export Production to the Suppression of Carbon Mineral Saturation



Aragonite under saturation was present over the Chukchi Shelf in 2002 and 2004

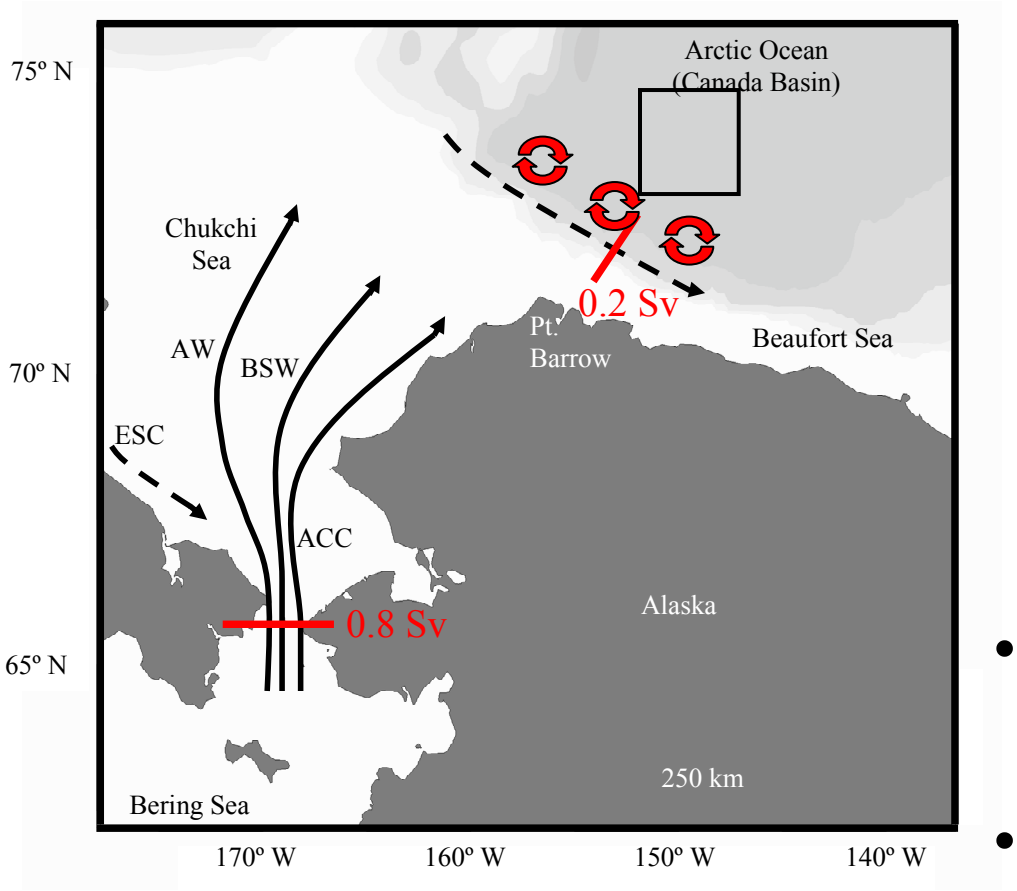


Warming in these regions, along with longer growing seasons (diminishing sea) will likely lead to increased export production……

This could lead to enhanced suppression of saturation states.

Bates et al., 2009, In Press - JGR

Transport Processes and Impacts: Eddies in the Western Arctic



Eddy Characteristics

- Center at ~150m depth
- Cold core, anti-cyclonic
- Strong remineralization signal (i.e. high nutrients, low DO, particle rich)
- Excess carbon (+4µM POC and +10 µM DOC; +25 µM DIC)

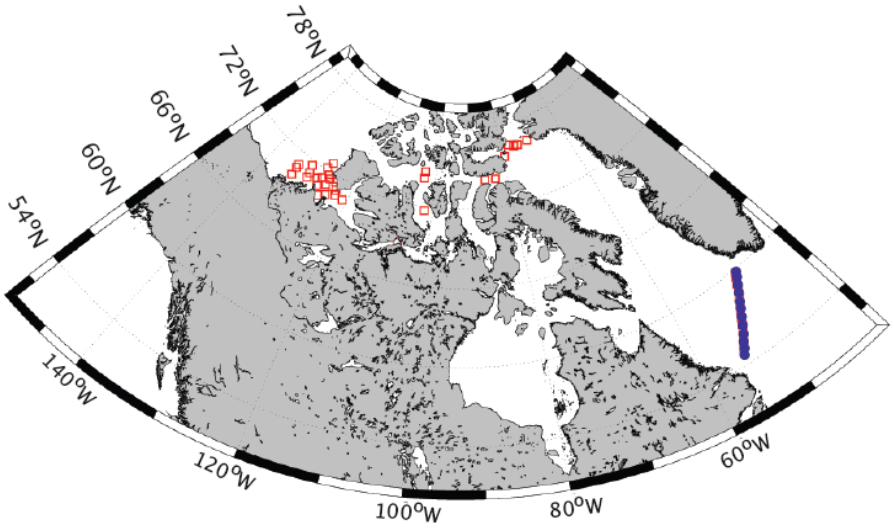
Eddy Impacts

- Transport ~ 3.02 Tg – Organic C yr^{-1}
  - Represents half of observed AOU
- Transport ~ 1.54 Tg – DIC yr^{-1}
  - Storage of Ant. CO_2

Mathis et al., 2007a
Mathis et al., In Review – GBC

1 Tg = 10^{12} g

Carbon Cycling in the Arctic Archipelago

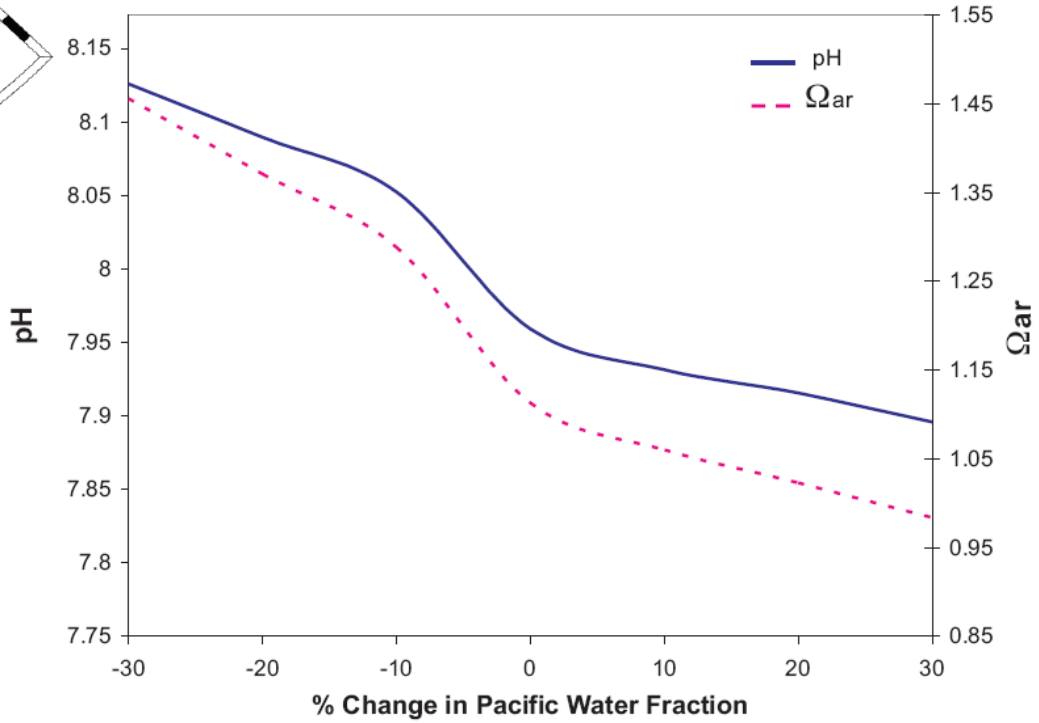


Sv X10^{14} g C yr^{-1}

Depth	Volume Transport	DIC	Carbon Transport
0-30	0.030	1957	0.23
30-150	0.120	1979	0.90
150-200	0.050	2168	0.41
200-300	0.100	2206	0.83
Total	0.3	2084	2.37
0-30	0.066	1957	0.49
30-150	0.264	2102	2.10
150-200	0.110	2175	0.91
200-300	0.220	2202	1.83
300-500	0.440	2185	3.64
Total	1.1	2154	8.97
Both	1.4	2140	11.34

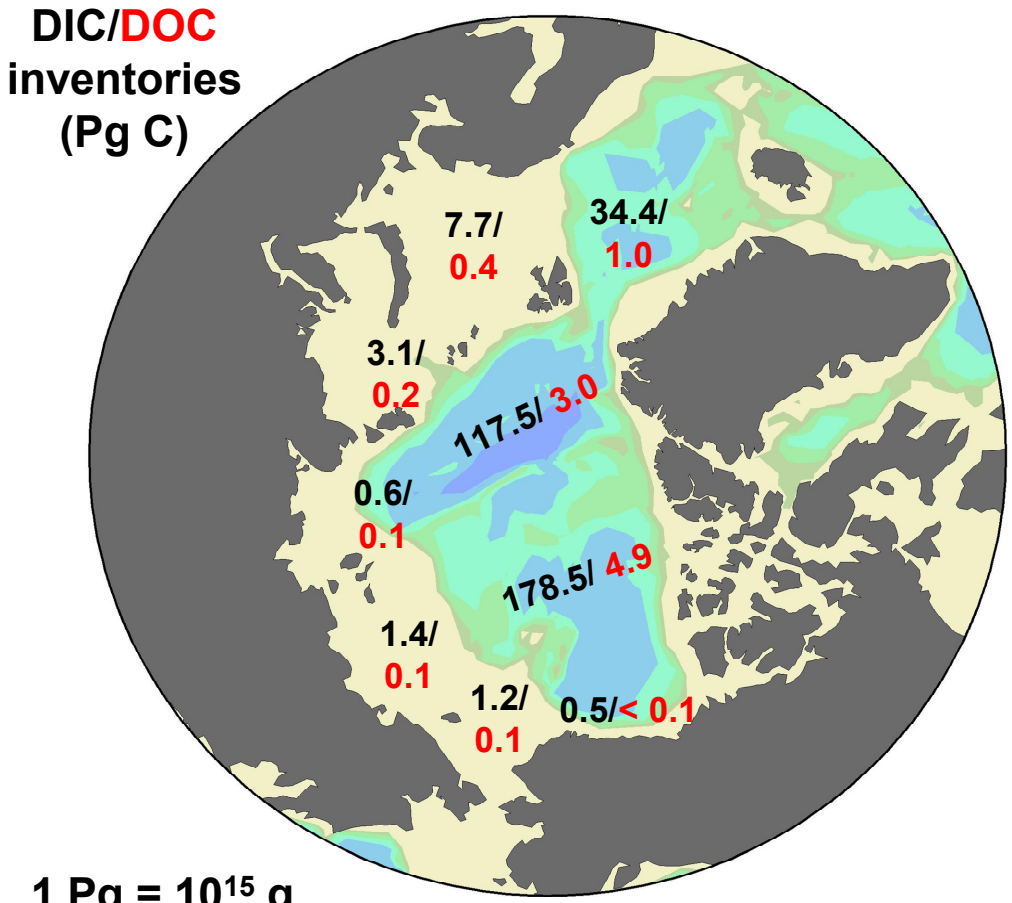
Jones Sound

Lancaster Sound



Shadwick et al., submitted – Biogeosciences

Inventories of Dissolved Carbon in the Arctic Ocean and CO_2 Fluxes



Mathis et al., In Review - JGR

Air-Sea Fluxes of CO_2

Annual CO2 Flux (Tg C yr^{-1})	
Chukchi	-11 to -53
Beaufort	-2 to -3
Arctic Archipelago	-16 to -24
Central Basin	-1 to -19
Arctic Ocean	-24 to -130

Bates and Mathis, 2009. Biogeosciences Discuss.

PARTNERS Program:

Pan-Arctic River Transport of Nutrients, Organic Matter, and Suspended Particles

http://ecosystems.mbl.edu/partners/

The Arctic receives ~10% of the total river runoff, while containing only ~1% of the total ocean volume. There is also rapid coastal erosion taking place.

Terrigenous POC Supply (10^9 moles yr^{-1})

	Rivers	Coastal Erosion
Chukchi	11	67
Beaufort	175	8
Arctic Archipelago	22	40
Central Basin	100	91
Total Arctic	460	560

Based on Stein and Macdonald (2004), adapted from Macdonald et al., (2009)

Synthesis Activities: Primary Production in the Arctic

	Total Primary Production		New Primary Production	
	g C m^{-2} yr^{-1}	10^9 moles yr^{-1}	g C m^{-2} yr^{-1}	10^9 moles yr^{-1}
Chukchi	20 - 400	4,900	5 – 160	2,600
Beaufort	30 – 70	670	7 - 17	180
Arctic Archipelago	60	6,000	40	4,200
Central Basin	5 - 30	7,500	<1	370
Total Arctic		31,800		11,300

Hill and Cota, (2005), McLaughlin et al., (2006), Sakshaug, (2004), Carmack, (2004), Harrison and Cota, (1990), Walsh et al., (2005), Koike et al., (2001), Mathis et al.,(2007), Bates et al, (2006), MacDonald et al., (2009)

NACP: Coastal Synthesis - Arctic (including Bering, Chukchi and Beaufort Seas)

If you are working on atmospheric, terrestrial, marine, or benthic processes in these regions, please consider joining the synthesis efforts.

arctic-coastal@mail.nacarbon.org

http://www.nacarbon.org/nacp/index.html

ART Initiation Workshop 7-9 November 2009 University of Alaska Fairbanks (IARC)

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A Core Element of the U.S. Climate Change Science Program

North American Carbon Program

Continental carbon budgets, dynamics, processes, and management

Conclusions and Data Gaps

- Each one of the four shelf systems in the Bering Sea-Arctic coastal zone is influenced by different biogeochemical and physical processes and preconditions north Pacific water as it makes its way to the Atlantic.

- The Bering and Chukchi Seas have intermediate to high PP, high terrestrial inputs of carbon, and enhanced ocean acidification coupled to the biology.

- The Beaufort Sea has low PP and high terrestrial inputs. Ocean acidification is not well understood.

- The Arctic Archipelago has intermediate PP and terrestrial inputs and is the gateway for modified Pacific water flowing into the north Atlantic.

- We need additional data in the Beaufort Sea particularly, but also time-series data to fill in the gaps between October and May.