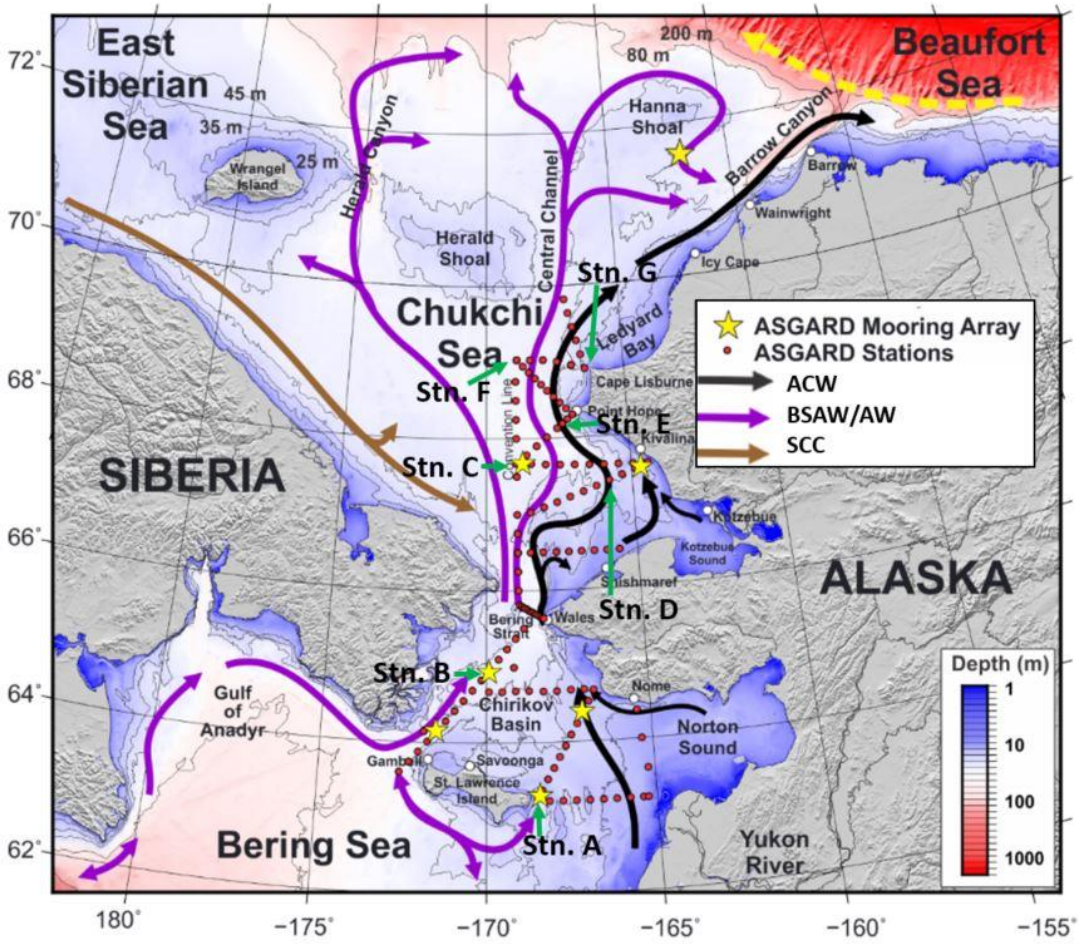
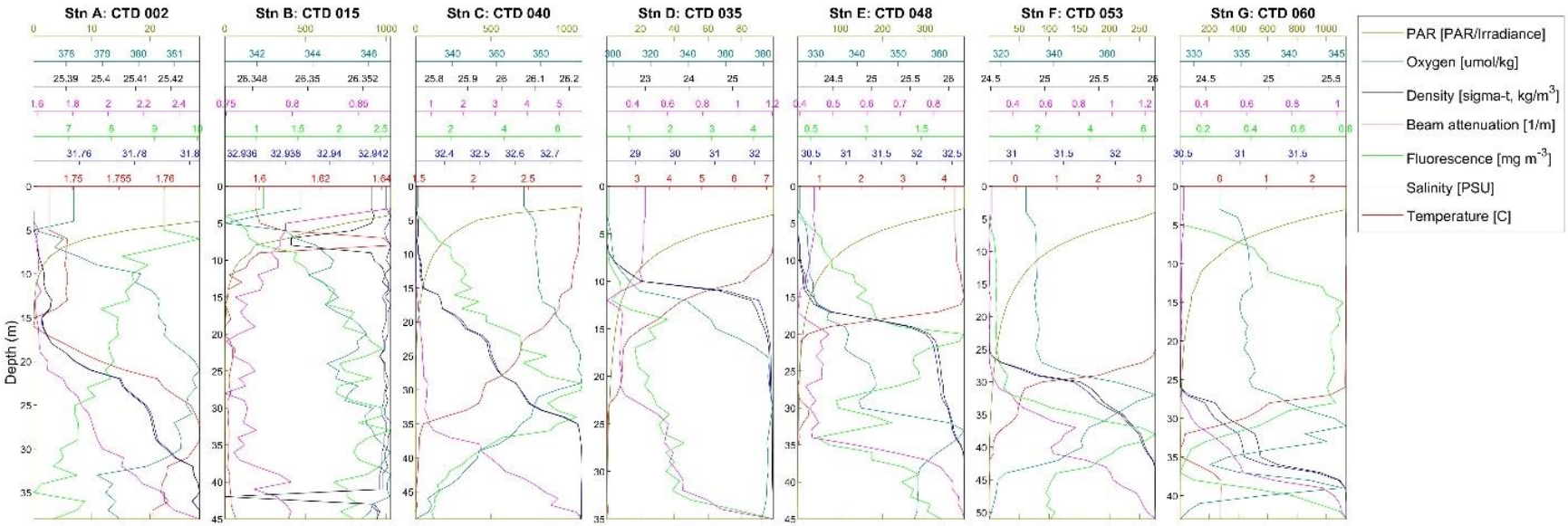
Supplementary Material

1 Supplementary Figures and Tables

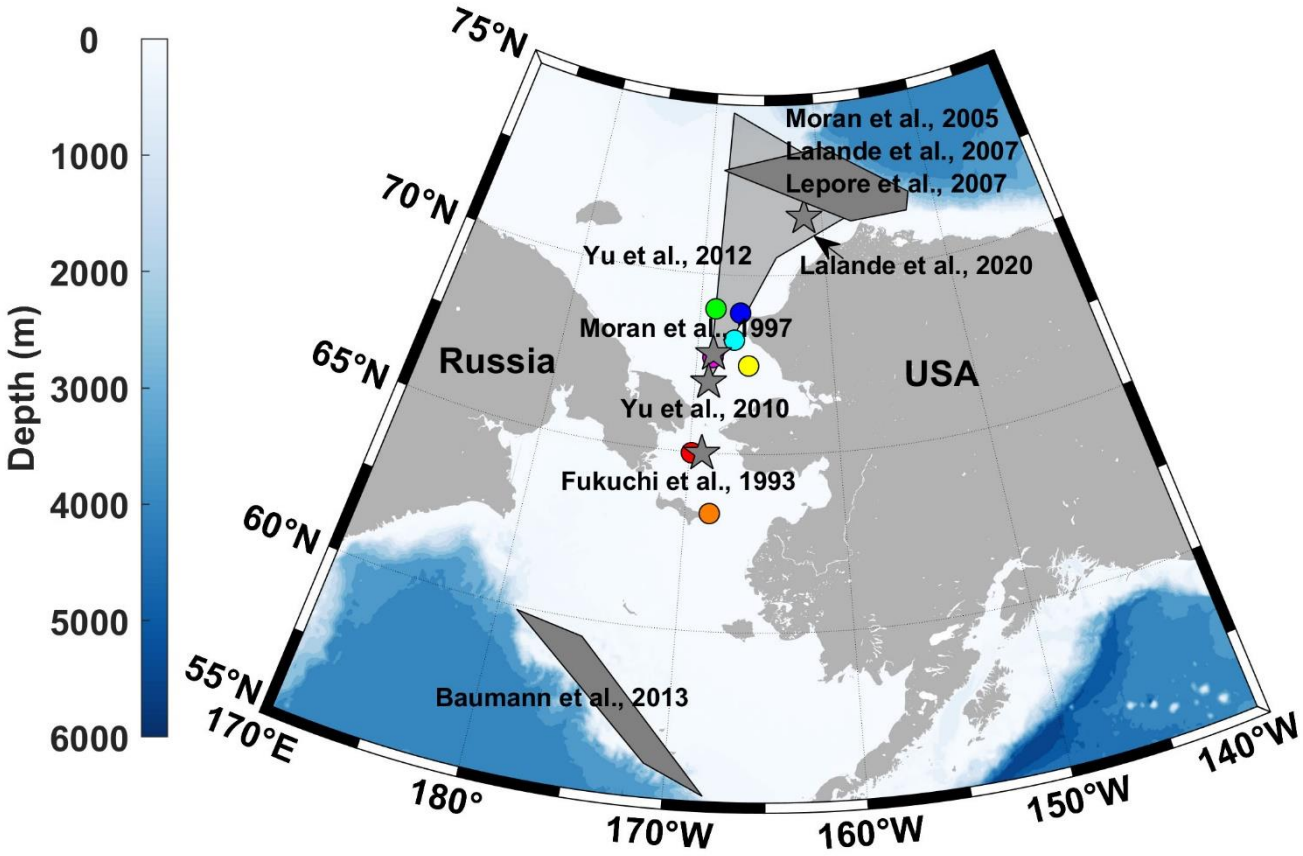
1.1 Supplementary Figures



Supplementary Figure 1. The ASGARD moorings (yellow stars) and stations (red circles) along with regional dominant currents on the Bering and Chukchi shelf; Alaska Coastal Water (ACW; black); Bering Shelf/Anadyr Water and Anadyr Water (BSAW/AW; purple) and Siberian Coastal Current (SCC; brown). Stations considered in this study are labeled and identified with green arrows.



Supplemental Figure 2. Water column profiles from each of the seven stations sampled showing PAR, Oxygen, Density, Beam attenuation (transmission), Fluorescence (proxy for chlorophyll), Salinity, and Temperature.



Supplemental Figure 3. Location of previous carbon flux studies on the Bering and Chukchi shelves and shelf breaks (grey stars and patches) along with stations from the present study (colored circles).

1.2 Supplementary Tables

Supplemental Table 1. Compilation of POC fluxes, primary productivity rates, and export ratios from other high latitude studies. POC flux values over 1000 mg C m^{-2} d^{-1} are shown in bold.

[a]Based on monthly averages

[b]Only these two methods are considered in this analysis not including POC flux using POC:234 TH ratio on GF/F filters from the water column or POC flux in collection-efficiency corrected sediment traps

[c]Study-wide average

[d]POC marine and POC terrestrial were determined with a mixing model and presented as separate values in Amiel and Cochran, 2008. In Supplementary Table 1, POC marine and POC terrestrial were added together to determine the Peak POC flux value of 2540 mg C m^{-2} d^{-1}.

[e]One station only

[f]Regional averages within study

[g]Samples above the euphotic zone were removed

[h]Calculated from MODIS satellite-derived chlorophyll-a concentrations and primary production calculated using the VGPM method

[i]Based on difference in flux between 600 and 750 m

[j]Only small particles (< 1 mm) considered

Location	Type of Sampling	Sampling Period	Sampling Depth Range (m)	Water Depth (m)	POC flux (mg C m^{-2} d^{-1})	PP rates (mg C m^{-2} d^{-1})	ER (flux / PP) (%)	Peak POC flux period	Peak POC flux depth (m)	Peak POC flux water depth (m)	Peak POC flux (mg C m^{-2} d^{-1})	Citation

Baffin Bay	Drifting sediment trap	June - October	50 - 150	163 - 560	200 - 554	414 - 1709[a]	32.4 - 58.0[a]	June	50	163 - 560	554	Caron et al., 2004
	Ice-tethered sediment traps	April - June	1	-	~40 - ~85	-	-	April - June	1	-	~85	Michel et al., 2002
	$^{234}Th/^{238}U$ disequilibrium (collected with pumps)	May - September	25 - 100	100 - 515	50 - 1074	-	-	July	50	259	**1074**	Amiel et al., 2002
	Drifting sediment trap	May - September	25 - 100	100 - 515	48 - 455	-	-	July	100	500	455	Amiel et al., 2002
	Moored sediment trap	May - September	201 - 406	100 - 515	4.8 - 63.7	-	-	July	259	259	63.7	Amiel et al., 2002
	Moored sediment trap	Year round sampling	198 - 259	365 - 569	3 - 110	-	-	July	258	365	110	Sampei et al, 2004
	Drifting sediment trap	April - July	50 - 100	~150	~50 - ~1080	-	-	June	50	~150	**~1080**	Michel et al., 2002
Baffin Bay, Beaufort Sea, Laptev Sea	Moored sediment trap	Year round sampling	175 - 200	307 - 1347	~1 - ~55	-	-	July	200	649	~55	Lalande et al., 2009
Baltic Sea	Drifting sediment trap[b]	Year round sampling	40	459	~50 - ~800	0 - 1500	14±2[c]	March	40	459	~800	Gustafsson et al., 2013
	$^{234}Th/^{238}U$ disequilibrium (collected with sediment trap)[b]	Year round sampling	40	459	~50 - ~1200	0 - 1500	21±3[c]	March	40	459	**~1200**	Gustafsson et al., 2013
Barents Sea	Drifting sediment trap	May	20	200 - 500	409 - 1090	-	-	May	20	300	**1090**	Andreassen and Wassmann, 1998
	Moored sediment trap	March, May, and July	30 - 200	168 - 350	30 - 1500	-	-	May	30	239	**1500**	Olli et al., 2002
	Drifting sediment trap	May and July	60 - 120	203 - 2052	67 - 456	-	-	May	60	343	456	Lalande et al., 2008
	$^{234}Th/^{238}U$ disequilibrium (collected with pumps)	May and July	60 - 120	203 - 2052	98.5 - 1506	-	-	July	120	229	**1506**	Lalande et al., 2008
	Moored sediment trap	May and July	30	150 - 2052	140 - 760	0 - 1500	-	July	30	-	760	Reigstad et al., 2008
	^{234}Th technique (collected with pumps)	June - July	100	~200 - ~500	22 - 940	120-757	9 - 130	June	100	~400	940	Le Moigne et al., 2015
	Drifting sediment trap	June - July	90 -200	~150 - ~250	88 - 265	-	-	June - July	150	~250	265	Coppola et al., 2002
	Moored sediment trap	March - July	610	~2000	10 - 290	-	-	June	610	~2000	290	Thomsen et al., 2001

	Drifting sediment trap and ice tethered sediment trap	July	60 - 100	75 - 3000	18 - 76	-	-	July	100	2500	76	Andreassen et al., 1996
Barents Sea and high Arctic	$^{234}Th/^{238}U$ disequilibrium (collected with ice-tethered sediment traps)	July - August	40	129 - 3917	24 - 384	100 - 500	16 - 75	July	40	129	384	Gustafsson and Andersson, 2012
Barents Sea, high Arctic, Kara Sea, and Laptev Sea	$^{234}Th/^{238}U$ disequilibrium (collected with pumps and Niskin bottles)	July - October	100	100 - >3000	0 - 66	-	-	July - October	100	~100	66	Cai et al., 2010
Beaufort and Chukchi Sea	$^{234}Th/^{238}U$ disequilibrium (collected with Niskin bottles)	July - September	40 - 50	46 - 3800	25.2 - 243.8	-	-	July - September	40	50	243.8	Yu et al., 2010
Beaufort Sea	Moored sediment trap	February - July	100	~300	~5 - ~75			July	100	~300	~75	Forest et al., 2011
	Drifting sediment trap	June - July	50 - 100	156 - 1142	37.5 - 76.7	178 - 926	4.1 - 41.2	June - July	100	220	76.7	Kellogg et al., 2011
	Moored Sediment Trap	Year round sampling	118 - 213	173 - 268	~5 - ~80	-	-	June-July	145	200	~80	O'Brien et al., 2006
	$^{234}Th/^{238}U$ disequilibrium (collected with pumps)	August - September	10 - 200	208 - 3300	8.4 - 89	-	-	August - September	50	208	89	Moran and Smith, 2000
	Drifting sediment trap	June - October	25 - 75	43 - 1280	14.8 - 258.4	-	5.2 - 97.2	July	50	280	258	Juul-Pedersen et al., 2010
	Ice-tethered sediment traps	February - June	1 - 25	~150 - ~550	11.2 - 521.7	-	-	June	1	~150 - ~550	521.7	Juul-Pedersen et al., 2008
	Moored sediment trap	October - August	200	300 - 500	1 - 16	-	-	May	200	300	16	Forest et al., 2007
	Moored sediment trap	Year round sampling	100 - 200	400	~1 - ~70	-	-	June	100	400	~70	Forest et al., 2010
	Moored sediment trap	October - July	112	309	~3 - ~70	-	-	July	112	309	~70	Sampei et al., 2012
	Moored sediment trap	Year round sampling	95 - 211	204 - 688	0.9 - 147.3	-	-	August	110	204	147.3	Forest et al., 2013
	Drifting sediment trap	August	40 - 200	227 - 625	6.6 - 15.2	-	-	August	85	625	15.2	Forest et al., 2013

	$^{234}Th/^{238}U$ disequilibrium (collected with pumps)	June - July and September - October	50 - 100	42.3 - 1200	175 - 2540	-	-	June	50	230	**2540**[d]	Amiel and Cochran, 2008
	$^{234}Th/^{238}U$ disequilibrium (collected with pumps and Niskin bottles)	-	5 - 60	22 - 3000	67.3 - 78.1	-	-	-	25	-	78.1	Baskaran et al., 2003
	Moored sediment trap	October - September	210	250	2 - 52	-	-	September	210	250	52	Forest et al., 2008
Beaufort Sea and Bering Sea	$^{234}Th/^{238}U$ disequilibrium (collected with Niskin bottles)	August	25	1000 - 2100	74.5 ± 14.4 - 187.4 ± 15.6	45.6[e]	26 - 70[f]	August	25	1000	187.4 ± 15.6	Chen et al., 2003
Beaufort Sea and Chukchi sea	$^{234}Th/^{238}U$ disequilibrium (collected with pumps and Niskin bottles)	August	50	25 - 3700	16.8 - 687	-	-	August	50	-	687	Trimble and Baskaran, 2005
Bering Sea	Drifting sediment trap	April-May and July	37 - 115	45 - 3450	24 - 853	62 - 853	3 - 133	April - May	20	73	853	Moran et al., 2012
	Drifting sediment trap	April - July	23 - 100	100 - 3500	47 - 1297[g]	135 - 1297	4 - 165	June - July	100	100-200	**1297**	Baumann et al., 2013
	Moored sediment trap	June - September	36	49	253 - 654	501[c]	-	July	36	49	654	Fukuchi et al., 1993
	Moored sediment trap	Year round sampling	3198	3788	2.4 - 22	-	-	-	3198	3788	22	Takahashi et al., 2002
Canadian Archipelago	Ice-tethered sediment traps	June - July	0.5 - 90	125 - 150	~10 - ~750	-	-	June	2.5	125	~750	Fortier et al., 2002
	Ice-tethered sediment traps	April - June	0.5 - 15	135	~10 - ~500	-	-	May	2.5	135	~500	Michel et al., 1996
Chukchi Sea	$^{234}Th/^{238}U$ disequilibrium (collected with pumps)	May - August	50 m	60 - 3071	0.4- 468	~106 - 431[f]	~15 - 37[f]	July - August	50	118	468	Moran et al., 2005
	$^{234}Th/^{238}U$ disequilibrium (collected with pumps)	May - August	50 m	39 - 3801	7.9 ± 6.4 - 825 ± 589	~106 - 1898[f]	6 - 38[f]	May - June	50	116	825	Lepore et al., 2007
	Drifting sediment trap	May - August	30 - 100	153 - 2061	3 - 796	0.28 - 3.85	0 - 185	July - August	30	326	796	Lalande et al., 2007
	Moored sediment trap	Year round sampling	37	45	72 - 1184	-	-	September	37	45	**1184**	Lalande et al., 2020

	$^{234}Th/^{238}U$ disequilibrium (collected with Niskin bottles)	July - September	30 - 60	35 - 100	21.6 - 951.2	-	-	July - September	30	40	951.1	Yu et al, 2012
Chukchi Sea and high Arctic	$^{234}Th/^{238}U$ disequilibrium (collected with pumps)	August - September	20 - 30	50 - >3000	3.6 - 456	12 - 2570	-	August - September	20 - 30	~50	456	Moran et al., 1997
Fram Strait	Moored sediment trap	Year round sampling	300	2500	~1 - ~45	~0- ~2400	-	July	300	2500	~45	Forest et al., 2010
	Moored sediment trap	Year round sampling	196 - 2364	2540	1 - 64	-	-	August	1296	2540	64	Lalande et al., 2016
	Moored sediment trap	Year round sampling	1087 - 1125	1618 - 1676	10 - 40.1	-	-	June	1125	1676	40.1	Hebbeln, 2000
	Moored sediment trap	Year round sampling	500	2241 - 3630	2.1 - 43	-	-	May	500	2499	43	Ramseier et al., 1999
	Moored sediment trap	Year round sampling	260 - 300	260 - 340	1.5 - 45	-	-	August	300	2584	45	Bauerfeind et al, 2009
	Moored sediment trap	Year round sampling	179 - 280	>2000	~1 - ~50	-	-	May	230	>2000	~50	Lalande et al., 2013
Greenland Sea	$^{234}Th/^{238}U$ disequilibrium (collected with pumps)	Year round sampling	0 - 50	100 - 500	156 - 841	240 - 961	41 - 88	July-August	50	~400	841	Cochran et al., 1995
	Moored sediment trap	Year round sampling	100 - 2000	-	2.9 - 90	-	-	Spring	100	-	90	von Bodungen et al., 1996
	Moored sediment trap	May - July	300	-	0.5 - 5			May	300	-	5	Pesant et al., 2002
High Arctic	$^{234}Th/^{238}U$ disequilibrium (collected with pumps)	August - September	15 - 250	1000+	0 - 120.1	1.2 - 60.1	5 - 100	August - September	100	1000+	120.1	Roca-Marti et al., 2016
	Ice-tethered sediment traps	April	20 - 70	~4000	4.4 - 10	-	-	April	20 - 70	~4000	10	Novigatsky and Lisitzin, 2018
	Moored sediment trap	Year round sampling	150 - 285	1355 - 4240	~1 - ~275	-	-	July	175	1350	~275	Lalande et al., 2019
	Ice-tethered sediment traps	July - September	2 - 25	100 - 4513	~5 - ~400	-	-	September	20 - 25	3570	~400	Lalande et al., 2014
Hudson Bay	Drifting sediment trap	September - October	50 - 150	86 - 342	50.0 - 76.8	70 - 435	19 - 69	September	50	342	76.8	Lapoussiere et al., 2013
	Moored sediment trap	Year round sampling	100	136	~5 - ~160	-	-	October	100	136	~160	Lalande and Fortier, 2011

Kara Sea	Moored sediment trap	Year round sampling	20 - 54	31 - 73	4.2 - 379.7	-	-	October	29	40	379.7	Gaye et al., 2007
Labrador Sea	$^{234}Th/^{238}U$ disequilibrium (collected with pumps)	July	0 - 250	-	37.2 - 996.9	509 - 1012.5	40 - 111	July	100	-	996.9	Moran et al., 2003
Laptev Sea	Moored sediment trap	Year round sampling	175	1350	~10 - ~300	-	-	July	175	1350	~300	Lalande et al., 2009
	Moored sediment trap	Year round sampling	150 and 1550	1712	0.33 - 21	-	-	August	150	1712	21	Fahl and Nöthig, 2007
North Atlantic	$^{234}Th/^{238}U$ disequilibrium (collected with pumps)	April - May and July - August	~80	-	~72 - ~144	1093 - 2449[h]	4.3 - 16[h]	April - May and July - August	~80	-	~144	Ceballos-Romero et al., 2016
	Neutrally buoyant drifting sediment trap	April - May and July - August	82 - 402	-	5.4 - 52	1093 - 2449[h]	4.3 - 16[h]	July - August	82	-	52	Ceballos-Romero et al., 2016
	$^{234}Th/^{238}U$ disequilibrium (collected with Niskin bottles)	May	100	> 750	360±120 - 620±200	-	-	May	100	>750	620 ± 200	Martin et al., 2011
	Neutrally buoyant drifting sediment trap	May	150 - 750	> 750	10.2±0.3 - 164±4.1	-	25±6 - 43±11[i]	May	600	>750	164±4.1	Martin et al., 2011
	Marine snow catcher	March- April	50 - 200	> 600	23 - 186[j]	38 - 359	-	March	50	>600	186	Giering et al., 2016
	$^{234}Th/^{238}U$ disequilibrium (collected with pumps)	April-May	35 - 75	>300	84 - 925	925-1093	8 - 78	May	75	>300	**1093**	Buesseler et al., 1992
North Sea	Drifting sediment trap	June - July	50	134 - 145	28.52 ± 2.66 - 325.24 ± 17.76	514-1330	11 - 55	June - July	50	134 - 145	325.24 ± 17.76	Van der Wal et al., 1995
	$^{234}Th/^{238}U$ disequilibrium (collected with Niskin bottles)	June	1 - 75	106 - 118	114 - 577	48 - 91	14 - 96	June	75	106 - 118	577	Foster and Shimmield 2002
White Sea	Moored sediment trap	June	55 - 270	320	85.2 - 136.1	-	-	June	270	320	136.1	Lukashin et al., 2003

Supplementary Table 2. Selection of particulate organic carbon flux values from high productivity and/or high flux regions

Location	Time of year Sampled	Type of Sampling	Depth Sampled (m)	POC Flux range (mg C m^{-2} d^{-1})	Citation
Arabian Sea	Year round sampling	$^{234}Th/^{238}U$ disequilibrium	100	12 - 312	Buesseler, 1998
BATS	March-October	$^{234}Th/^{238}U$ disequilibrium (collected with sediment trap)	0-100	1 - 6	Buesseler, 1998
California Coast	May	Moored sediment trap	450	10 - 120	Pilskaln et al., 1996
California Coast	May	$^{234}Th/^{238}U$ disequilibrium (collected with sediment trap)	100-150	72 - 151	Stukel et al., 2011
California Coast	Year round sampling	Moored sediment trap	540	20 - 200	Thunell, 1998
Equatorial Pacific	Spring/ Fall	$^{234}Th/^{238}U$ disequilibrium	0-100	1 - 8	Buesseler, 1998
Kerguelen Islands	October - November (Austral Spring)	$^{234}Th/^{238}U$ disequilibrium (collected with pumps)	100 - 200	22 - 142	Planchon et al., 2015
Mauritania/Cape Verde	March - April	Drifting sediment traps	100	20 - 100	Engel et al., 2017
Mauritania/Cape Verde	Year round sampling	Moored sediment trap	3580	1.29 - 11.42	Helmke et al., 2005
Namibian Upwelling	Year round sampling	Moored sediment trap	599 - 3921	1 - 47.7	Wefer and Fischer, 1993
North Pacific	Year round sampling	$^{234}Th/^{238}U$ disequilibrium (collected with sediment trap)	150	2.5 - 34.8	Benitez-Nelson et al., 2001
North Pacific	May and August	$^{234}Th/^{238}U$ disequilibrium (collected with niskin)	50 - 200	8.3 - 97	Buesseler and Boyd, 2009
North Pacific (Aloha)	June - July	$^{234}Th/^{238}U$ disequilibrium (collected with sediment trap)	150 - 300	4.3 - 14.5	Buesseler and Boyd, 2009
North Pacific (K2)	July-August	234Th/238U disequilibrium	50 - 500	9 - 133	Buesseler and Boyd, 2009
Peruvian upwelling	February (Austral Summer)	Drifting sediment trap	200	2 - 18	Haskell et al., 2013
Southern Ocean	December - January (Austral Summer)	$^{234}Th/^{238}U$ disequilibrium	50 - 150	69 - 488	Buesseler and Boyd, 2009

Weddell Sea/Polar front	November (Austral Spring)	$^{234}Th/^{238}U$ disequilibrium	0-100	4 - 29	Buesseler, 1998
Western Antarctic Penninsula	January (Austral)	Drifting sediment trap	150	92 - 104.4	Buesseler et al., 2010
Western Antarctic Penninsula	January (Austral Summer)	Moored sediment trap	170	2.4 - 4.0	Buesseler et al., 2010
Western Antarctic Penninsula	January (Austral Summer)	$^{234}Th/^{238}U$ disequilibrium (collected with pumps)	150	50 - 64	Buesseler et al., 2010

2 Supplementary References

Amiel, D., and Cochran, J. K. (2008). Terrestrial and marine POC fluxes derived from 234Th distributions and δ13C measurements on the Mackenzie Shelf. *J. Geophys. Res. Ocean.* 113, 1–19. doi:10.1029/2007JC004260.

Amiel, D., Cochran, J. K., and Hirschberg, D. J. (2002). 234Th/238U disequilibrium as an indicator of the seasonal export flux of particulate organic carbon in the North Water. *Deep-Sea Res. II* 49, 5191–5209. doi:10.1016/S0967-0645(02)00185-6.

Andreassen, I. J., and Wassmann, P. (1998). Vertical flux of phytoplankton and particulate biogenic matter in the marginal ice zone of the Barents Sea in May 1993. *Mar. Ecol. Prog. Ser.* 170, 1–14. doi:10.3354/meps170001.

Andreassen, I., Noting, E. M., and Wassmann, P. (1996). Vertical particle flux on the shelf off northern Spitsbergen, Norway. *Mar. Ecol. Prog. Ser.* 137, 215–228. doi:10.3354/meps137215.

Baskaran, M., Swarzenski, P. W., and Porcelli, D. (2003). Role of colloidal material in the removal of 234Th in the Canada basin of the Arctic Ocean. *Deep-Sea Res. I* 50, 1353–1373. doi:10.1016/S0967-0637(03)00140-7.

Bauerfeind, E., Nöthig, E. M., Beszczynska, A., Fahl, K., Kaleschke, L., Kreker, K., et al. (2009). Particle sedimentation patterns in the eastern Fram Strait during 2000-2005: Results from the Arctic long-term observatory HAUSGARTEN. *Deep-Sea Res. I* 56, 1471–1487. doi:10.1016/j.dsr.2009.04.011.

Baumann, M. S., Moran, S. B., Lomas, M. W., Kelly, R. P., and Bell, D. W. (2013). Seasonal decoupling of particulate organic carbon export and net primary production in relation to sea-ice at the shelf break of the eastern Bering Sea: Implications for off-shelf carbon export. *J. Geophys. Res. Ocean.* 118, 5504–5522. doi:10.1002/jgrc.20366.

Benitez-Nelson, C., Buesseler, K. O., Karl, D. M., and Andrews, J. (2001). A time-series study of particulate matter export in the North Pacific Subtropical Gyre based on234Th:238U disequilibrium. *Deep-Sea Res. I* 48, 2595–2611. doi:10.1016/S0967-0637(01)00032-2.

Buesseler, K. E. N., Michael, P., Livingston, H. D., and Cochrant, K. (1992). Carbon and nitrogen export during the JGOFS North Atlantic Bloom Experiment estimated from 234Th : 23U disequilibria. *Deep-Sea Res. I* 39, 1115-1137.

Buesseler, K. O. (1998). The decoupling of production and particulate export in the surface. *Global Biogeochem. Cycles* 2, 297–310. doi:10.1029/97GB03366.

Buesseler, K. O., and Boyd, P. W. (2009). Shedding light on processes that control particle export and flux attenuation in the twilight zone of the open ocean. *Limnol. Oceanogr.* 54, 1210–1232. doi:10.4319/lo.2009.54.4.1210.

Buesseler, K. O., McDonnell, A. M. P., Schofield, O. M. E., Steinberg, D. K., and Ducklow, H. W. (2010). High particle export over the continental shelf of the west Antarctic Peninsula. *Geophys. Res. Lett.* 37, 1–5. doi:10.1029/2010GL045448.

Cai, P., Rutgers Van Der Loeff, M., Stimac, I., Nöthig, E. M., Lepore, K., and Moran, S. B. (2010). Low export flux of particulate organic carbon in the central Arctic Ocean as revealed by 234Th:238U disequilibrium. *J. Geophys. Res. Ocean.* 115, C10037. doi:10.1029/2009JC005595.

Caron, G., Michel, C., and Gosselin, M. (2004). Seasonal contributions of phytoplankton and fecal pellets to the organic carbon sinking flux in the North Water (northern Baffin Bay). *Mar. Ecol. Prog. Ser.* 283, 1–13. doi:10.3354/meps283001.

Ceballos-Romero, E., Le Moigne, F. A. C., Henson, S., Marsay, C. M., Sanders, R. J., García-Tenorio, R., et al. (2016). Influence of bloom dynamics on Particle Export Efficiency in the North Atlantic: a comparative study of radioanalytical techniques and sediment traps. *Mar. Chem.* 186, 198–210. doi:10.1016/j.marchem.2016.10.001.

Chen, M., Huang, Y., Cai, P., and Guo, L. (2003). Particulate organic carbon export fluxes in the Canada Basin and Bering Sea as derived from 234Th/238U disequilibria. *Arctic* 56, 32–44. doi:10.14430/arctic600.

Cochran, J. K., Barnes, C., Achman, D., and Hirschberg, D. J. (1995). Thorium-234/uranium-238 disequilibrium as an indicator of scavenging rates and particulate organic carbon fluxes in the Northeast Water Polynya, Greenland. *J. Geophys. Res.* 100, 4399–4410. doi:10.1029/94JC01954.

Coppola, L., Roy-Barman, M., Wassmann, P., Mulsow, S., and Jeandel, C. (2002). Calibration of sediment traps and particulate organic carbon export using234Th in the Barents Sea. *Mar. Chem.* 80, 11–26. doi:10.1016/S0304-4203(02)00071-3.

Engel, A., Wagner, H., Le Moigne, F. A. C., and Wilson, S. T. (2017). Particle export fluxes to the oxygen minimum zone of the eastern tropical North Atlantic. *Biogeosciences* 14, 1825–1838. doi:10.5194/bg-14-1825-2017.

Fahl, K., and Nöthig, E. M. (2007). Lithogenic and biogenic particle fluxes on the Lomonosov Ridge (central Arctic Ocean) and their relevance for sediment accumulation: Vertical vs. lateral transport. *Deep-Sea Res. I* 54, 1256–1272. doi:10.1016/j.dsr.2007.04.014.

Forest, A., Babin, M., Stemmann, L., Picheral, M., Sampei, M., Fortier, L., et al. (2013). Ecosystem function and particle flux dynamics across the Mackenzie Shelf (Beaufort Sea, Arctic Ocean): An integrative analysis of spatial variability and biophysical forcings. *Biogeosciences* 10, 2833–2866. doi:10.5194/bg-10-2833-2013.

Forest, A., Bélanger, S., Sampei, M., Sasaki, H., Lalande, C., and Fortier, L. (2010a). Three-year assessment of particulate organic carbon fluxes in Amundsen Gulf (Beaufort Sea): Satellite observations and sediment trap measurements. *Deep-Sea Res. I* 57, 125–142. doi:10.1016/j.dsr.2009.10.002.

Forest, A., Sampei, M., Hattori, H., Makabe, R., Sasaki, H., Fukuchi, M., et al. (2007). Particulate organic carbon fluxes on the slope of the Mackenzie Shelf (Beaufort Sea): Physical and biological forcing of shelf-basin exchanges. *J. Mar. Syst.* 68, 39–54. doi:10.1016/j.jmarsys.2006.10.008.

Forest, A., Sampei, M., Makabe, R., Sasaki, H., Barber, D. G., Gratton, Y., et al. (2008). The annual cycle of particulate organic carbon export in Franklin Bay (Canadian Arctic): Environmental control and food web implications. *J. Geophys. Res. Ocean.* 113, 1–14. doi:10.1029/2007JC004262.

Forest, A., Tremblay, J. éric, Gratton, Y., Martin, J., Gagnon, J., Darnis, G., et al. (2011). Biogenic carbon flows through the planktonic food web of the Amundsen Gulf (Arctic Ocean): A synthesis of field measurements and inverse modeling analyses. *Prog. Oceanogr.* 91, 410–436. doi:10.1016/j.pocean.2011.05.002.

Forest, A., Wassmann, P., Slagstad, D., Bauerfeind, E., Nöthig, E. M., and Klages, M. (2010b). Relationships between primary production and vertical particle export at the Atlantic-Arctic boundary (Fram Strait, HAUSGARTEN). *Polar Biol.* 33, 1733–1746. doi:10.1007/s00300-010-0855-3.

Fortier, M., Fortier, L., Michel, C., and Legendre, L. (2002). Climatic and biological forcing of the vertical flux of biogenic particles under seasonal Arctic sea ice. *Mar. Ecol. Prog. Ser.* 225, 1–16. doi:10.3354/meps225001.

Foster, J. M., and Shimmield, G. B. (2002). 234Th as a tracer of particle flux and POC export in the northern North Sea during a coccolithophore bloom. *Deep-Sea Res. II* 49, 2965–2977. doi:10.1016/S0967-0645(02)00066-8.

Fukuchi, M., Sasaki, H., Hattori, H., Matsuda, O., Tanimura, A., Handa, N., et al. (1993). Temporal variability of particulate flux in the northern Bering Sea. *Cont. Shelf Res.* 13, 693–704. doi:10.1016/0278-4343(93)90100-C.

Gaye, B., Fahl, K., Kodina, L. A., Lahajnar, N., Nagel, B., Unger, D., et al. (2007). Particulate matter fluxes in the southern and central Kara Sea compared to sediments: Bulk fluxes, amino acids, stable carbon and nitrogen isotopes, sterols and fatty acids. *Cont. Shelf Res.* 27, 2570–2594. doi:10.1016/j.csr.2007.07.003.

Giering, S. L. C., Sanders, R., P., M. A., Lindeman, C., Moller, K. O., Daniels, C. J., et al. (2016). High export via small particles before the onset of the North Atlantic spring bloom. *J. Geophys. Res. Ocean.* 121, 6929–6945. doi:10.1002/2015JC011486.Received.

Gustafsson, Ö., and Andersson, P. S. (2012). 234Th-derived surface export fluxes of POC from the Northern Barents Sea and the Eurasian sector of the Central Arctic Ocean. *Deep-Sea Res. I* 68, 1–11. doi:10.1016/j.dsr.2012.05.014.

Gustafsson, Ö., Larsson, U., Andersson, P., Gelting, J., and Roos, P. (2013). An assessment of upper ocean carbon and nitrogen export fluxes on the boreal continental shelf: A 3-year study in the open Baltic Sea comparing sediment traps, 234 Th proxy, nutrient, and oxygen budgets. *Limnol. Oceanogr. Methods* 11, 495–510. doi:10.4319/lom.2013.11.495.

Haskell, W. Z., Berelson, W. M., Hammond, D. E., and Capone, D. G. (2013). Particle sinking dynamics and POC fluxes in the Eastern Tropical South Pacific based on 234Th budgets and sediment trap deployments. *Deep-Sea Res. I* 81, 1–13. doi:10.1016/j.dsr.2013.07.001.

Hebbeln, D. (2000). Flux of ice-rafted detritus from sea ice in the Fram Strait. *Deep-Sea Res. II* 47, 1773–1790. doi:10.1016/S0967-0645(00)00006-0.

Helmke, P., Romero, O., and Fischer, G. (2005). Northwest African upwelling and its effect on offshore organic carbon export to the deep sea. *Global Biogeochem. Cycles* 19, 1–16. doi:10.1029/2004GB002265.

Juul-Pedersen, T., Michel, C., and Gosselin, M. (2010). Sinking export of particulate organic material from the euphotic zone in the eastern Beaufort Sea. *Mar. Ecol. Prog. Ser.* 410, 55–70. doi:10.3354/meps08608.

Juul-Pedersen, T., Michel, C., Gosselin, M., and Seuthe, L. (2008). Seasonal changes in the sinking export of particulate material under first-year sea ice on the Mackenzie Shelf (western Canadian Arctic). *Mar. Ecol. Prog. Ser.* 353, 13–25. doi:10.3354/meps07165.

Kellogg, C. T. E., Carpenter, S. D., Renfro, A. A., Sallon, A., Michel, C., Cochran, J. K., et al. (2011). Evidence for microbial attenuation of particle flux in the Amundsen Gulf and Beaufort Sea: Elevated hydrolytic enzyme activity on sinking aggregates. *Polar Biol.* 34, 2007–2023. doi:10.1007/s00300-011-1015-0.

Lalande, C., Bauerfeind, E., Nöthig, E. M., and Beszczynska-Möller, A. (2013). Impact of a warm anomaly on export fluxes of biogenic matter in the eastern Fram Strait. *Prog. Oceanogr.* 109, 70–77. doi:10.1016/j.pocean.2012.09.006.

Lalande, C., Bélanger, S., and Fortier, L. (2009a). Impact of a decreasing sea ice cover on the vertical export of particulate organic carbon in the northern Laptev Sea, Siberian Arctic Ocean. *Geophys. Res. Lett.* 36. doi:10.1029/2009GL040570.

Lalande, C., Forest, A., Barber, D. G., Gratton, Y., and Fortier, L. (2009b). Variability in the annual cycle of vertical particulate organic carbon export on Arctic shelves: Contrasting the Laptev Sea, Northern Baffin Bay and the Beaufort Sea. *Cont. Shelf Res.* 29, 2157–2165. doi:10.1016/j.csr.2009.08.009.

Lalande, C., and Fortier, L. (2011). Downward particulate organic carbon export and jellyfish blooms in southeastern Hudson Bay. *J. Mar. Syst.* 88, 446–450. doi:10.1016/j.jmarsys.2010.12.005.

Lalande, C., Grebmeier, J. M., Hopcroft, R. R., and Danielson, S. L. (2020). Annual cycle of export fluxes of biogenic matter near Hanna Shoal in the northeast Chukchi Sea. *Deep-Sea Res. II* doi:10.1016/j.dsr2.2020.104730.

Lalande, C., Lepore, K., Cooper, L. W., Grebmeier, J. M., and Moran, S. B. (2007). Export fluxes of particulate organic carbon in the Chukchi Sea: A comparative study using 234Th/238U disequilibria and drifting sediment traps. *Mar. Chem.* 103, 185–196. doi:10.1016/j.marchem.2006.07.004.

Lalande, C., Moran, S. B., Wassmann, P., Grebmeier, J. M., and Cooper, L. W. (2008). 234Th-derived particulate organic carbon fluxes in the northern Barents Sea with comparison to drifting sediment trap fluxes. *J. Mar. Syst.* 73, 103–113. doi:10.1016/j.jmarsys.2007.09.004.

Lalande, C., Nothig, E.-M., Somavilla, R., Bauerfeind, E., Shevchenko, V. P., and Okolodkov, Y. (2014). Variability in under-ice export fluxes of biogenic matter in the Arctic Ocean. *Global Biogeochem. Cycles* 28, 571–583. doi:10.1002/2013GB004735.

Lalande, C., Nöthig, E. M., Bauerfeind, E., Hardge, K., Beszczynska-Möller, A., and Fahl, K. (2016). Lateral supply and downward export of particulate matter from upper waters to the seafloor in the deep eastern Fram Strait. *Deep-Sea Res. I* 114, 78–89. doi:10.1016/j.dsr.2016.04.014.

Lalande, C., Nöthig, E. M., and Fortier, L. (2019). Algal Export in the Arctic Ocean in Times of Global Warming. *Geophys. Res. Lett.* 46, 5959–5967. doi:10.1029/2019GL083167.

Lapoussière, A., Michel, C., Gosselin, M., Poulin, M., Martin, J., and Tremblay, J. É. (2013). Primary production and sinking export during fall in the Hudson Bay system, Canada. *Cont. Shelf Res.* 52, 62–72. doi:10.1016/j.csr.2012.10.013.

Le Moigne, F. A. C., Poulton, A. J., Henson, S. A., Daniels, C. J., Fragoso, G. M., Mitchell, E., et al. (2015). Carbon export efficiency and phytoplankton community composition in the Atlantic sector of the Arctic Ocean. *J. Geophys. Res. Ocean.* 120, 3896–3912. doi:10.1002/2015JC010700.

Lepore, K., Moran, S. B., Grebmeier, J. M., Cooper, L. W., Lalande, C., Maslowski, W., et al. (2007). Seasonal and interannual changes in particulate organic carbon export and deposition in the Chukchi Sea. *J. Geophys. Res. Ocean.* 112, 1–14. doi:10.1029/2006JC003555.

Lukashin, V. N., Kosobokova, K. N., Shevchenko, V. P., Shapiro, G. I., Pantyulin, A. N., Pertzova, N. M., et al. (2003). Results of multidisciplinary oceanographic studies in the White Sea in June 2000. *Mar. Geol.* 43, 224–239.

Martin, P., Lampitt, R. S., Jane Perry, M., Sanders, R., Lee, C., and D'Asaro, E. (2011). Export and mesopelagic particle flux during a North Atlantic spring diatom bloom. *Deep-Sea Res. I* 58, 338–349. doi:10.1016/j.dsr.2011.01.006.

Michel, C., Gosselin, M., and Nozais, C. (2002a). Preferential sinking export of biogenic silica during the spring and summer in the North Water Polynya (northern Baffin Bay): Temperature or biological control? *J. Geophys. Res. Ocean.* 107. doi:10.1029/2000jc000408.

Michel, C., Ingram, R. G., and Gosselin, M. (1996). Carbon budget of sea-ice algae in spring: Evidence of a significant transfer to zooplankton grazers. *J. Geophsical Res.* 101, 345–360. doi:10.1029/96JC00045.

Michel, C., Nielsen, T. G., Nozais, C., and Gosselin, M. (2002b). Significance of sedimentation and grazing by ice micro- and meiofauna for carbon cycling in annual sea ice (northern Baffin Bay). *Aquat. Microb. Ecol.* 30, 57–68. doi:10.3354/ame030057.

Moran, S. B., Ellis, K. M., and Smith, J. N. (1997). 234Th/238U disequilibrium in the central Arctic Ocean: Implications for particulate organic carbon export. *Deep-Sea Res. II* 44, 1593–1606. doi:10.1016/S0967-0645(97)00049-0.

Moran, S. B., Kelly, R. P., Hagstrom, K., Smith, J. N., Grebmeier, J. M., Cooper, L. W., et al. (2005). Seasonal changes in POC export flux in the Chukchi Sea and implications for water column-benthic coupling in Arctic shelves. *Deep-Sea Res. II* 52, 3427–3451. doi:10.1016/j.dsr2.2005.09.011.

Moran, S. B., Kelly, R. P., Iken, K., Mathis, J. T., Lomas, M. W., and Gradinger, R. (2012). Seasonal succession of net primary productivity, particulate organic carbon export, and autotrophic community composition in the eastern Bering Sea. *Deep-Sea Res. II* 65–70, 84–97. doi:10.1016/j.dsr2.2012.02.011.

Moran, S. B., and Smith, J. N. (2000). 234Th as a tracer of scavenging and particle export in the Beaufort Sea. *Cont. Shelf Res.* 20, 153–167. doi:10.1016/S0278-4343(99)00065-5.

Moran, S. B., Weinstein, S. E., Edmonds, H. N., Smith, J. N., Kelly, R. P., Pilson, M. E. Q., et al. (2003). Does 234Th/238U disequilibrium provide an accurate record of the export flux of particulate organic carbon from the upper ocean? *Limnol. Oceanogr.* 48, 1018–1029. doi:10.4319/lo.2003.48.3.1018.

Novigatsky, A. N., and Lisitzin, A. P. (2018). The North Pole Region: First Data on the Snow–Sea Ice–Ice Water Sedimentation System. *Dokl. Earth Sci.* 483, 1534–1538. doi:10.1134/S1028334X18120085.

O'Brien, M. C., Macdonald, R. W., Melling, H., and Iseki, K. (2006). Particle fluxes and geochemistry on the Canadian Beaufort Shelf: Implications for sediment transport and deposition. *Cont. Shelf Res.* 26, 41–81. doi:10.1016/j.csr.2005.09.007.

Olli, K., Wexels Riser, C., Wassmann, P., Ratkova, T., Arashkevich, E., and Pasternak, A. (2002). Seasonal variation in vertical flux of biogenic matter in the marginal ice zone and the central Barents Sea. *J. Mar. Syst.* 38, 189–204. doi:10.1016/S0924-7963(02)00177-X.

Pesant, S., Legendre, L., Gosselin, M., Bauerfeind, E., and Budéus, G. (2002). Wind-triggered events of phytoplankton downward flux in the Northeast Water Polynya. *J. Mar. Syst.* 31, 261–278. doi:10.1016/S0924-7963(01)00065-3.

Pilskaln, C. H., Berelson, W. M., Paduan, J. B., Chavez, F. P., and Anderson, R. Y. (1996). Carbon export and regeneration in the coastal upwelling system of Monterey Bay, central California. *J. Mar. Res.* 54, 1149–1178. doi:10.1357/0022240963213772.

Planchon, F., Ballas, D., Cavagna, A. J., Bowie, A. R., Davies, D., Trull, T., et al. (2015). Carbon export in the naturally iron-fertilized Kerguelen area of the Southern Ocean based on the 234Th approach. *Biogeosciences* 12, 3831–3848. doi:10.5194/bg-12-3831-2015.

Ramseier, R. O., Garrity, C., Bauerfeind, E., and Peinert, R. (1999). Sea-ice impact on long-term particle flux in the Greenland Sea's Is Odden-Nordbukta region, 1985-1996. *J. Geophsical Res.* 104, 5329–5343.

Reigstad, M., Wexels Riser, C., Wassmann, P., and Ratkova, T. (2008). Vertical export of particulate organic carbon: Attenuation, composition and loss rates in the northern Barents Sea. *Deep-Sea Res. II* 55, 2308–2319. doi:10.1016/j.dsr2.2008.05.007.

Roca-Marti, M., Puigcorbé, V., Rutgers Van Der Loeff, M., Katlein, C., Fernández-Méndez, M., Peeken, I., et al. (2016). Carbon export fluxes and export efficiency in the central Arctic during the record sea-ice minimum in 2012: a joint 234Th/238U and 210Po/210Pb study. *J. Geophys. Res. Ocean.* 121, 5030–5049. doi:10.1002/ 2016JC011816.

Sampei, M., Sasaki, H., Forest, A., and Fortier, L. (2012). A substantial export flux of particulate organic carbon linked to sinking dead copepods during winter 2007-2008 in the Amundsen Gulf (southeastern Beaufort sea, Arctic ocean). *Limnol. Oceanogr.* 57, 90–96. doi:10.4319/lo.2012.57.1.0090.

Sampei, M., Sasaki, H., Hattori, H., Fukuchi, M., and Hargrave, B. T. (2004). Fate of sinking particles, especially fecal pellets, within the epipelagic zone in the North Water (NOW) polynya of northern Baffin Bay. *Mar. Ecol. Prog. Ser.* 278, 17–25. doi:10.3354/meps278017.

Stukel, M. R., Landry, M. R., Benitez-Nelson, C. R., and Goericke, R. (2011). Trophic cycling and carbon export relationships in the California Current Ecosystem. *Limnol. Oceanogr.* 56, 1866–1878. doi:10.4319/lo.2011.56.5.1866.

Takahashi, K., Fujitani, N., and Yanada, M. (2002). Long term monitoring of particle fluxes in the Bering Sea and the central subarctic Pacific Ocean, 1990-2000. *Prog. Oceanogr.* 55, 95–112. doi:10.1016/S0079-6611(02)00072-1.

Thomsen, C., Blaume, F., Fohrmann, H., Peeken, I., and Zeller, U. (2001). Particle transport processes at slope environments - Event driven flux across the Barents Sea continental margin. *Mar. Geol.* 175, 237–250. doi:10.1016/S0025-3227(01)00143-8.

Thunell, R. C. (1998). Particle fluxes in a coastal upwelling zone: sediment trap results from Santa Barbara Basin, California. *Deep-Sea Res. II* 45, 1863–1884. doi:10.1016/s0967-0645(98)80020-9.

Trimble, S. M., and Baskaran, M. (2005). The role of suspended particulate matter in 234Th scavenging and 234Th-derived export fluxes of POC in the Canada Basin of the Arctic Ocean. *Mar. Chem.* 96, 1–19. doi:10.1016/j.marchem.2004.10.003.

Van Der Wal, P., Kempers, R. S., and Veldhuis, M. J. W. (1995). Production and downward flux of organic matter and calcite in a North Sea bloom of the coccolithophore Emiliania huxleyi. *Mar. Ecol. Prog. Ser.* 126, 247–265. doi:10.3354/meps126247.

von Bodungen, B., Antia, A., Bauerfeind, E., Haupt, O., Koeve, W., Machado, E., et al. (1995). Pelagic processes and vertical flux of particles: an overview of a long-term comparative study in the Norwegian Sea and Greenland Sea. *Geol. Rundschau* 84, 11–27. doi:10.1007/BF00192239.

Wefer, G., and Fischer, G. (1993). Seasonal patterns of vertical particle flux in equatorial and coastal upwelling areas of the eastern Atlantic. *Deep-Sea Res. I* 40, 1613–1645. doi:10.1016/0967-0637(93)90019-Y.

Yu, W., Chen, L., Cheng, J., He, J., Yin, M., and Zeng, Z. (2010). 234Th-derived particulate organic carbon export flux in the western Arctic Ocean. *Chinese J. Oceanol. Limnol.* 28, 1146–1151. doi:10.1007/s00343-010-9933-1.

Yu, W., He, J., Li, Y., Lin, W., and Chen, L. (2012). Particulate organic carbon export fluxes and validation of steady state model of 234Th export in the Chukchi Sea. *Deep-Sea Res. II* 81–84, 63–71. doi:10.1016/j.dsr2.2012.03.003.