Interannual variation of DIC in the Oyashio region along the A-line transect

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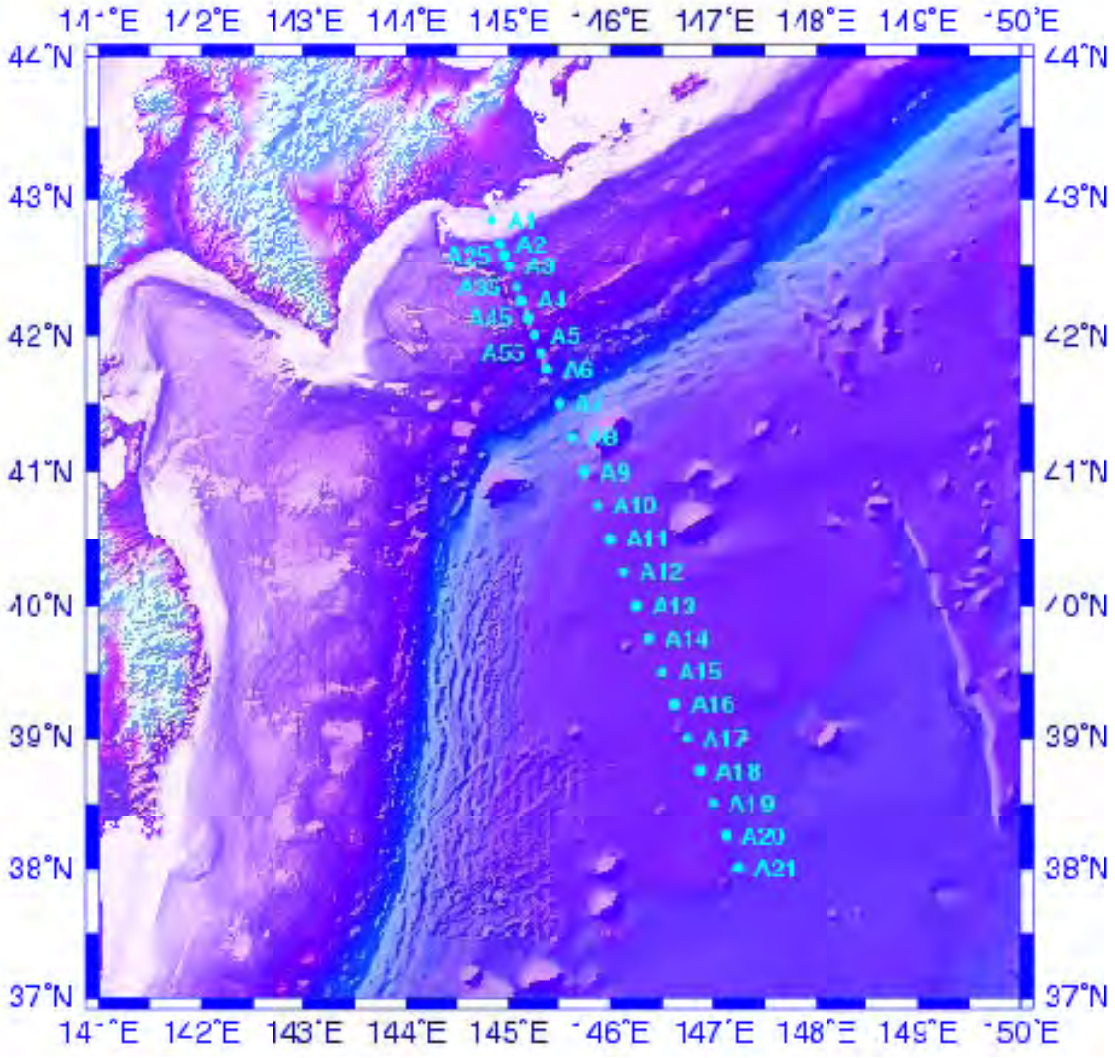
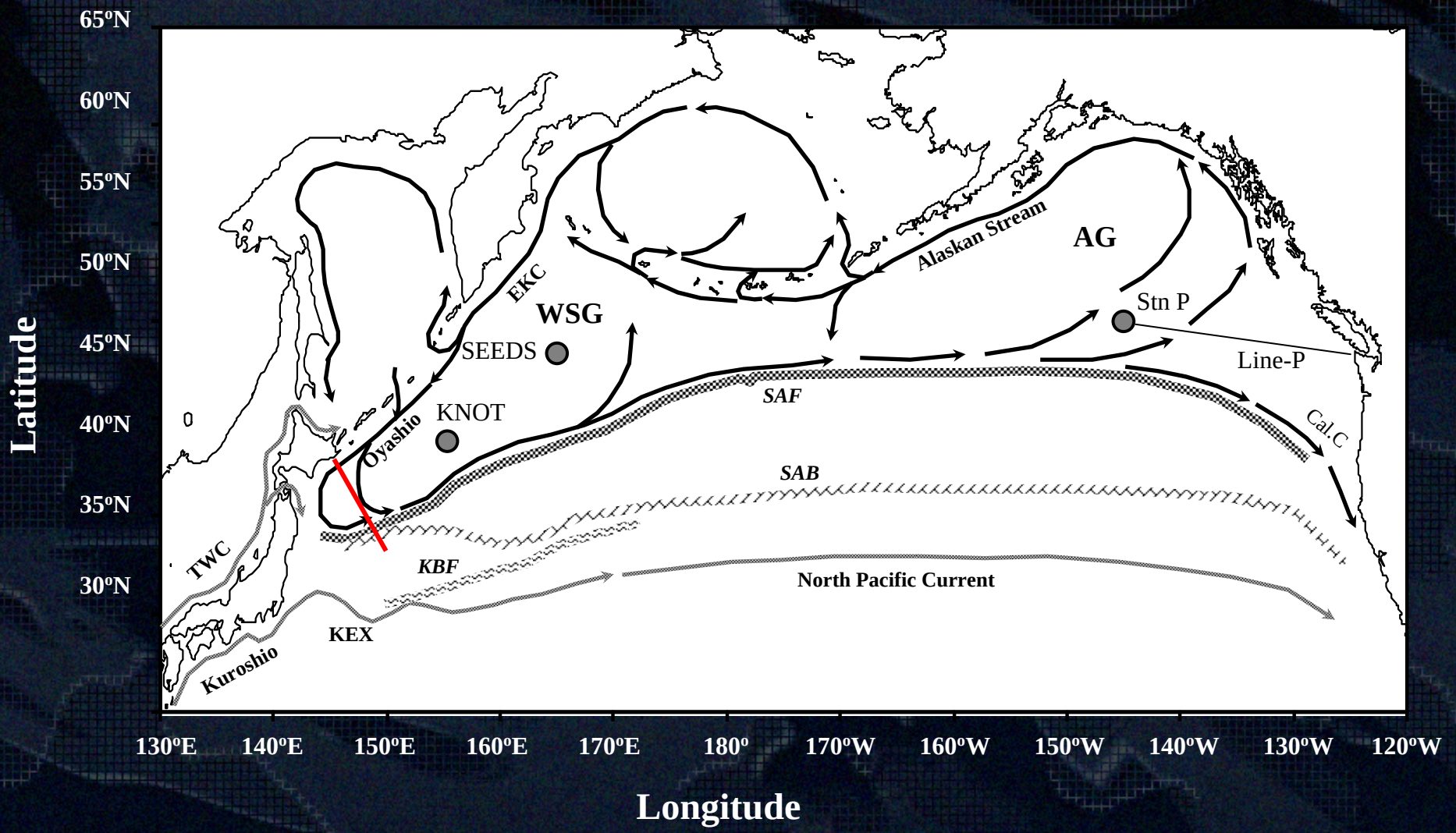
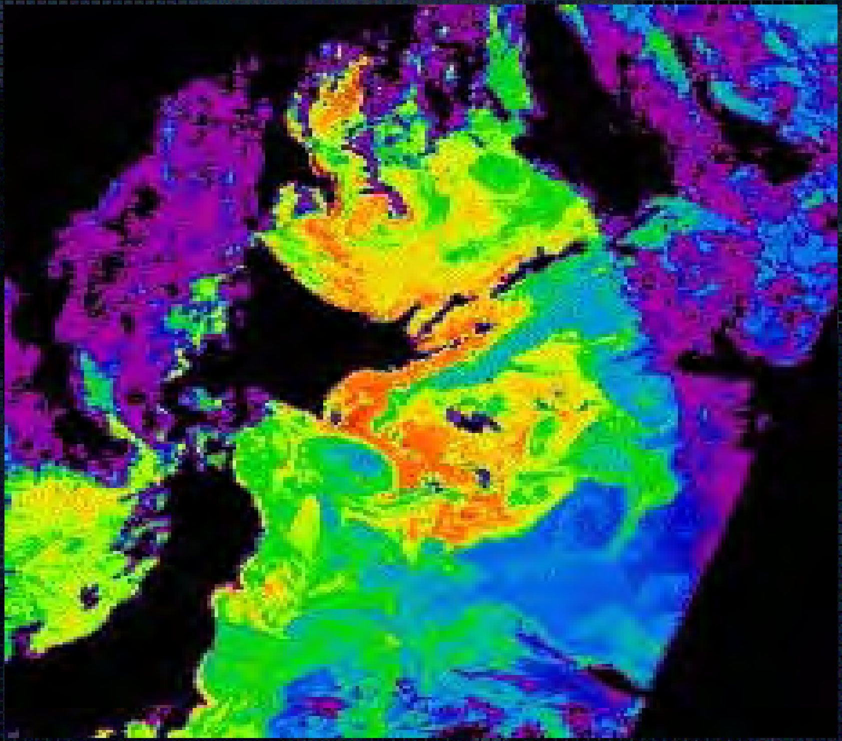
HNF/TNFRI A-line monitoring team



Oyashio Region



Spring Bloom



Outline of A-line

Cuise Outline

5-8 cruises a year
75 cruises 1990～
2-12 persons/cruise
Open for other Inst.&Univ.

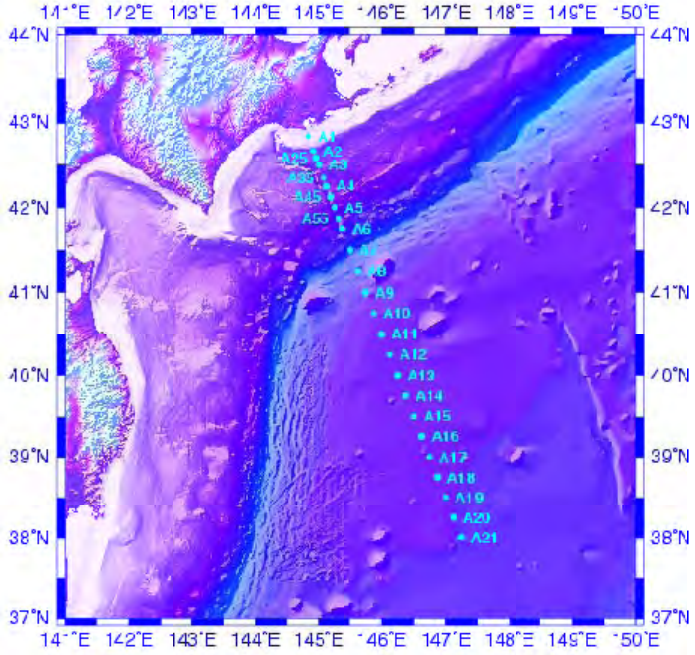
Tankai-maru 168 t
Hokko-maru 466 t (now 999t)

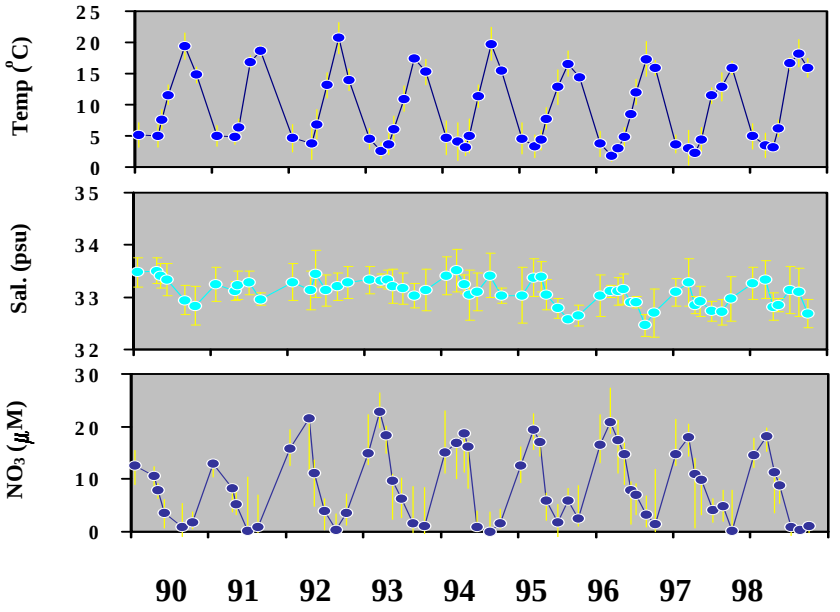
Core Parameters

T,S
DO (2001-)
NO_3, NO_2, PO_4, $Si(OH)_4$
DIC,Talk (1996-1998, 2001 -)
Chl (fluorometry)
Zoopl. DW, C, N (SML)
FCM (2004 -)
Diatom composition (2004 -)
Copepods Composition (with ODATE)

Optional Parameters

NH_4
Fe
BioSi
POC/PON
DOC/DON
Chl. size fraction
HPLC
Phytopl. light abs.
Microphytopl. sp. comp.
Bongo net/VMPS
Current meter
1er production
Sediment trap
^{13}C, ^{18}O

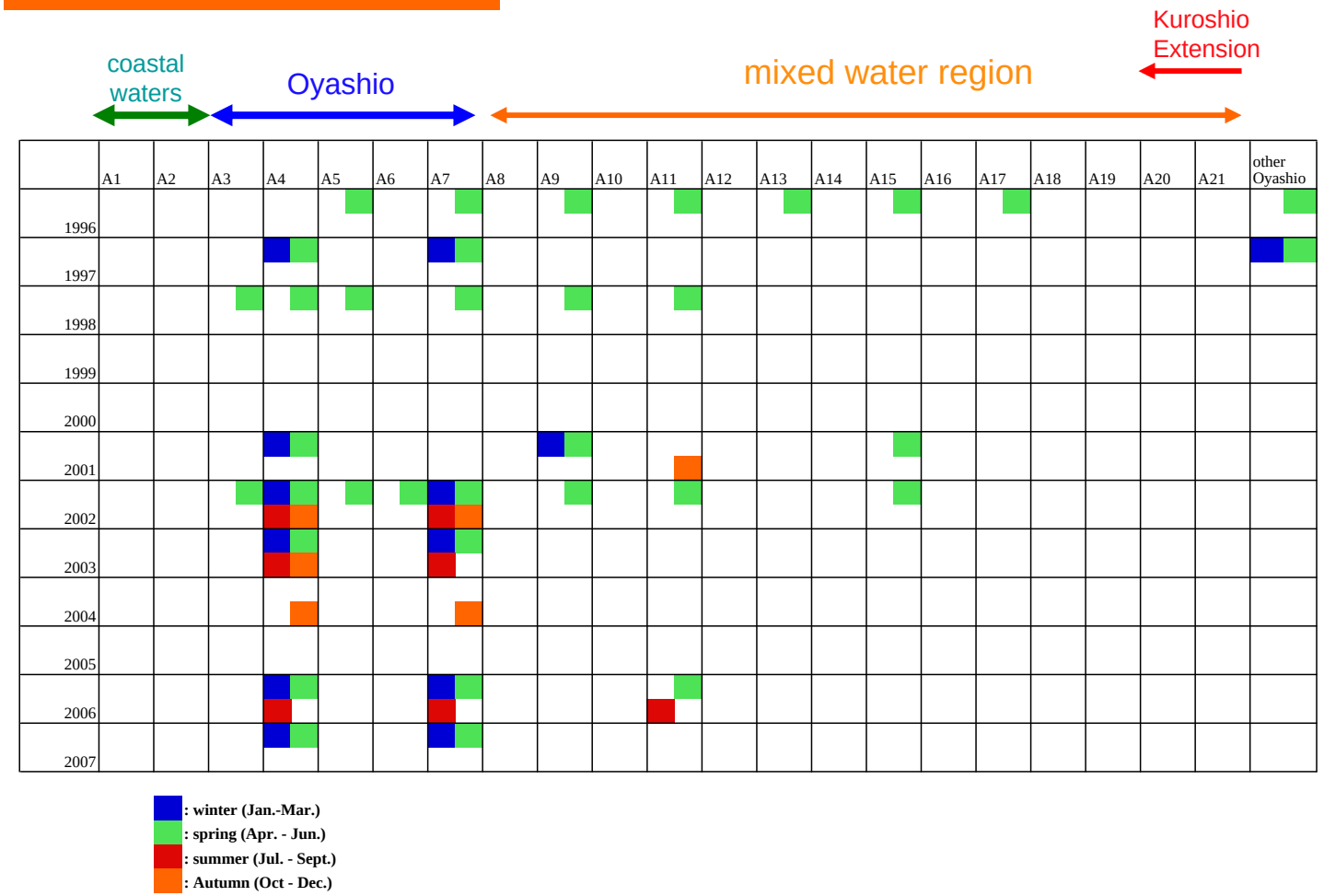




Carbon monitoring along the A-line

- intermittently from 1996, 1-5 cruise/y (with emphasis on winter & spring)
- A4, A7 + other stations (temporally)
- DIC regularly, but Talk temporally

A-line carbon sampling history

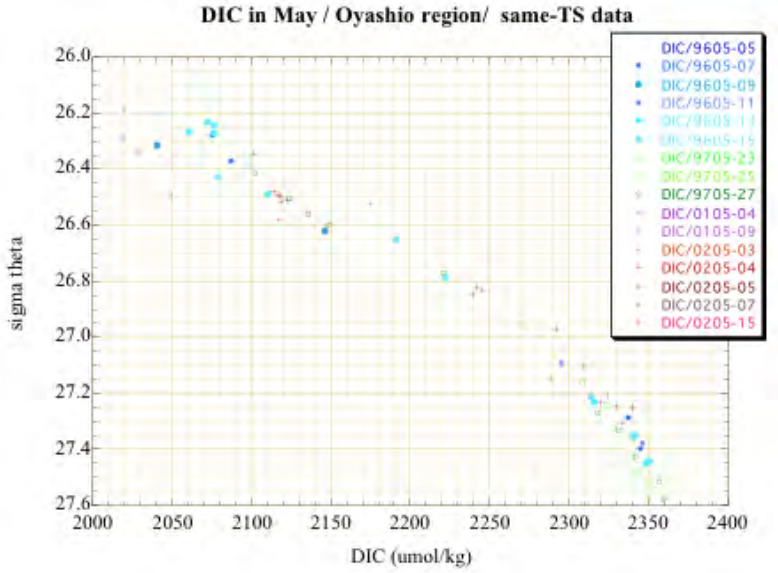


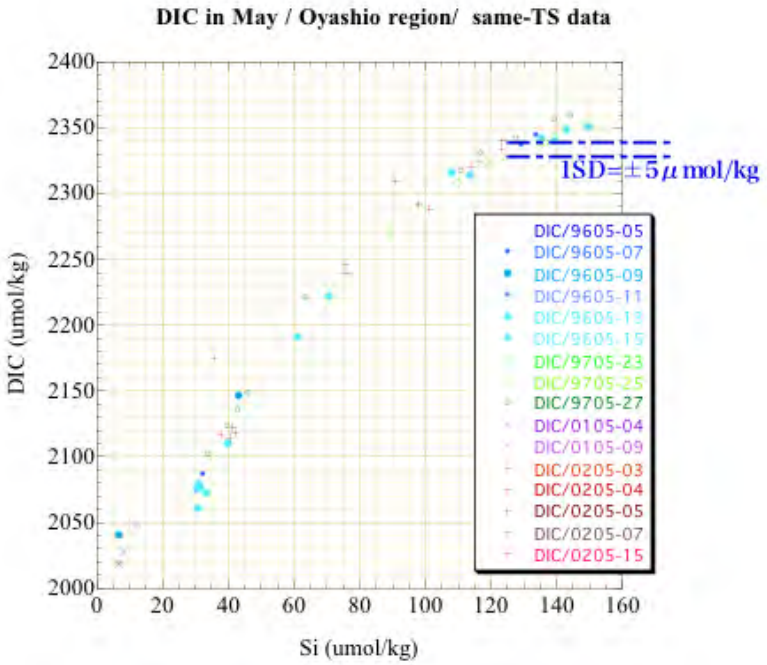
Standardization & Traceability

measurement lab. & Std. for A-line DIC

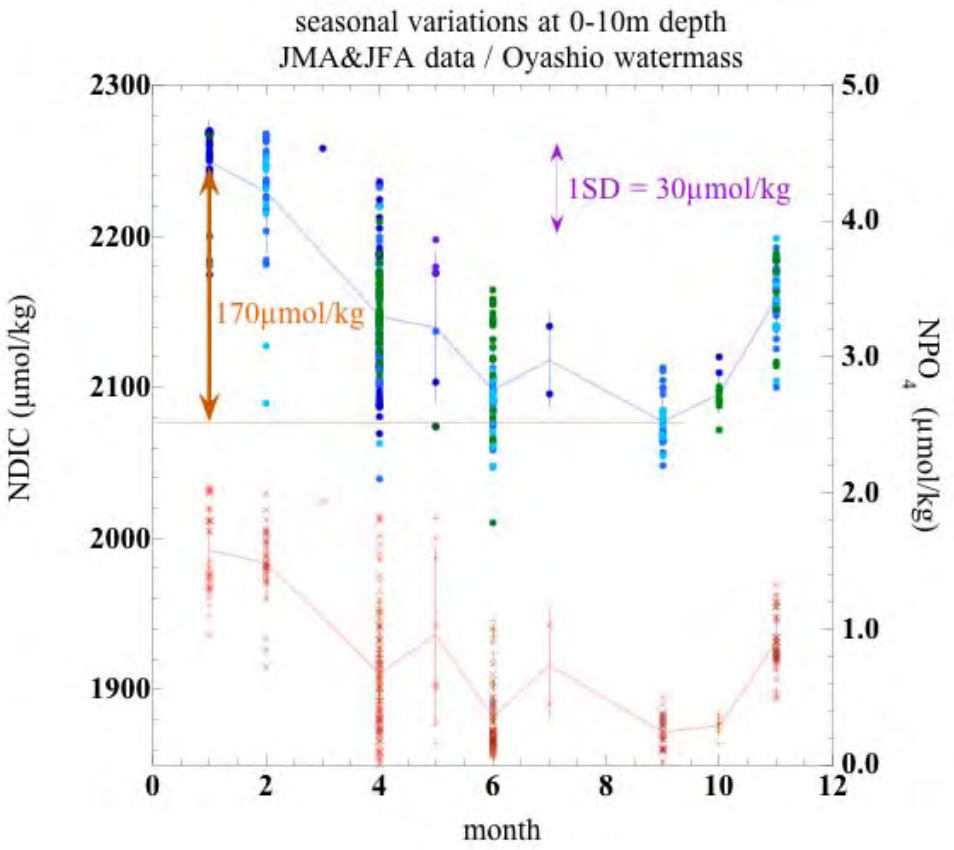
year	measured at	Std. manufactured at
1996	HU	HU
1997	NRIFS	NRIFS
1998	NRIFS	NRIFS
1999	----	----
2000	----	----
2001	MRI	MRI
2002	MRI/HU	MRI/HU
2003	HNF	HU
2004	HNF	HU
2005	----	----
2006	HNF	HNF/KANSO
2007	HNF	HNF/KANSO

Self-Check DIC precision: ± 5μmol/kg

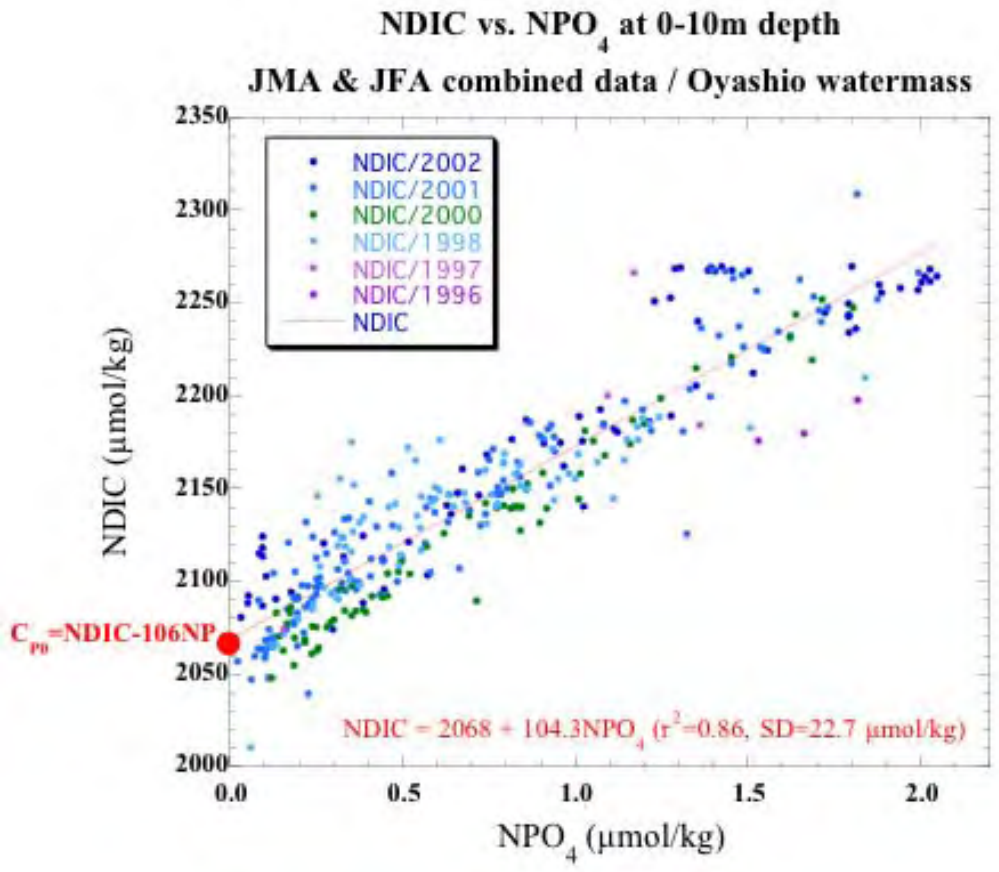


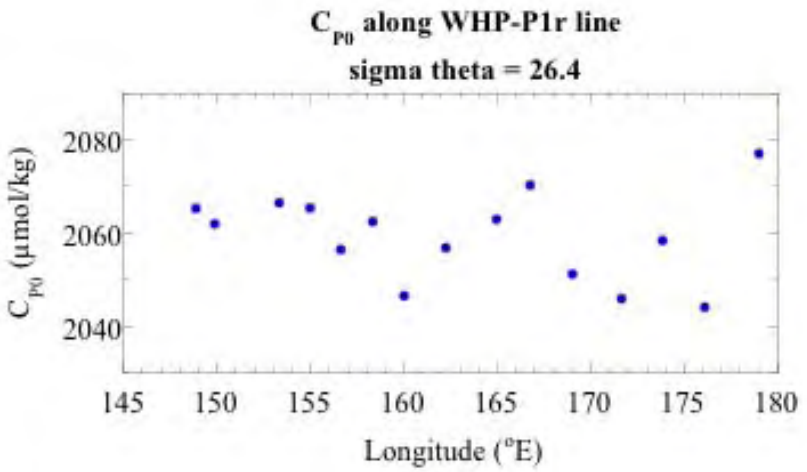


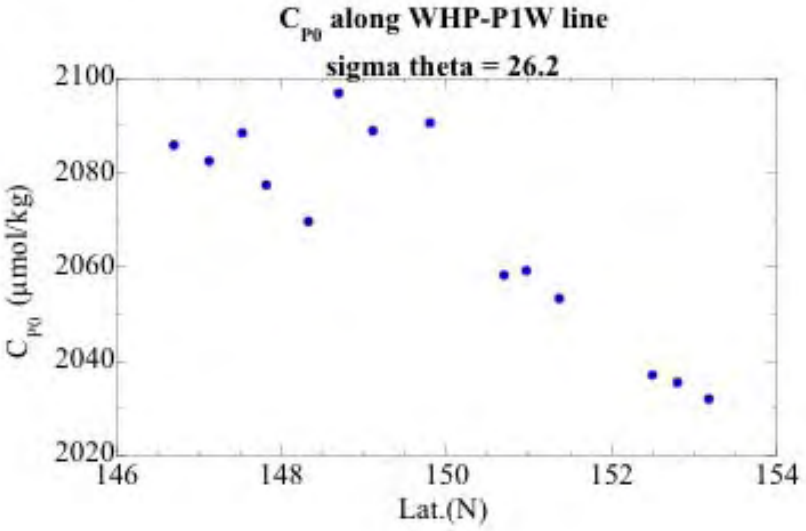
climatology of Oy DIC



area	annual ΔDIC [μmol/kg]	reference
A-line	170	Ono et al. [2005]
WSAG	160	Wong et al. [2002]
Araskan Gyre	80	Wong et al. [2002]

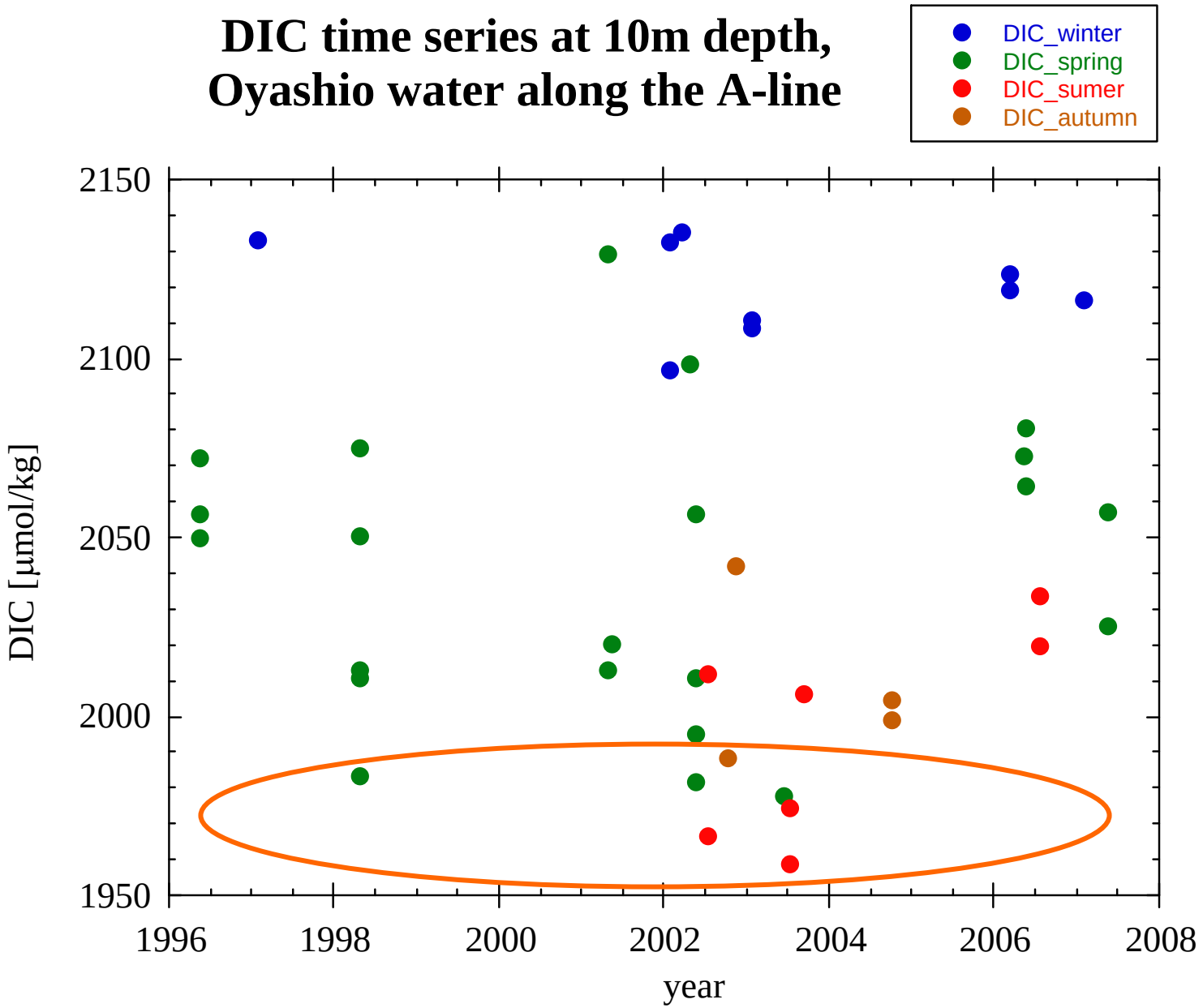






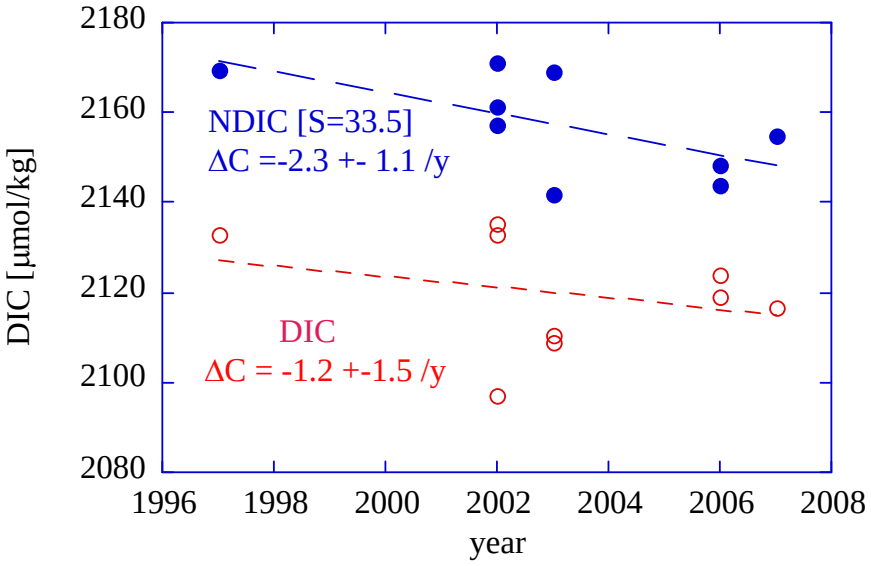
*constant C_{P0} throughout a year indicates 1-D surface - subsurface annual DIC circulation

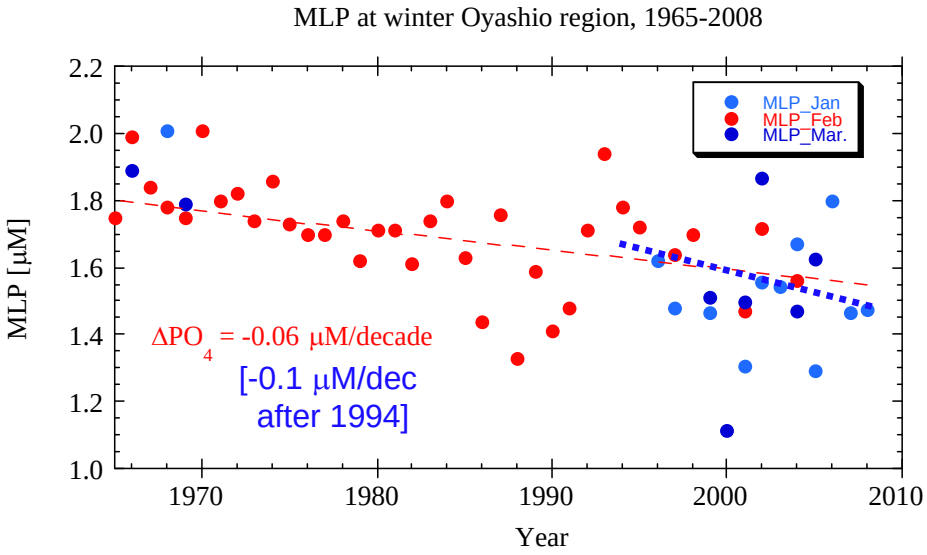
interannual variation



interannual variation

winter Oyashio DIC at 10m depth





[Ono, PICES NPESR-II]

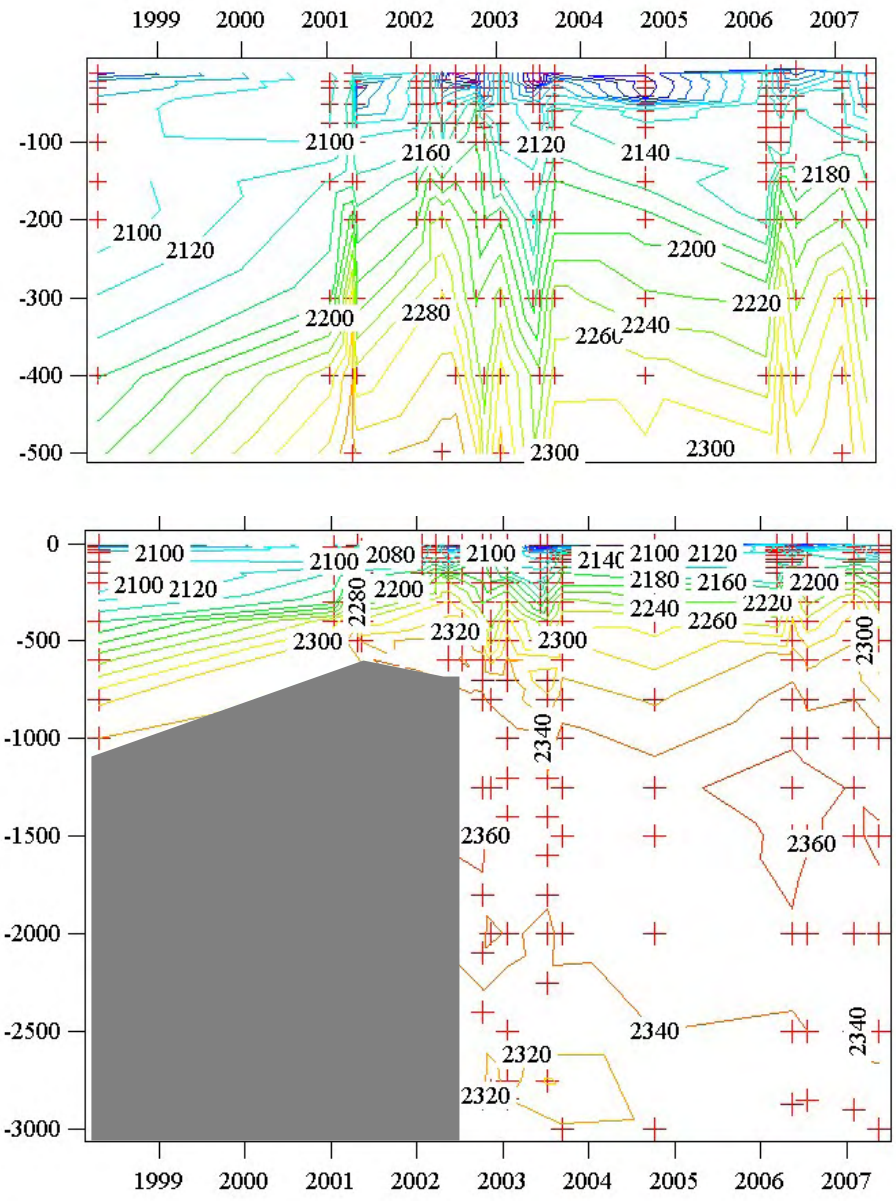
<theoretically>

- -0.1 μM/decade of PO_4 decrease corresponds to ~1.0 μmol/kg/y of DIC decrease for 1996-2007 period when $\Delta DIC/\Delta PO_4$ = 104.3 (see prep. slide)

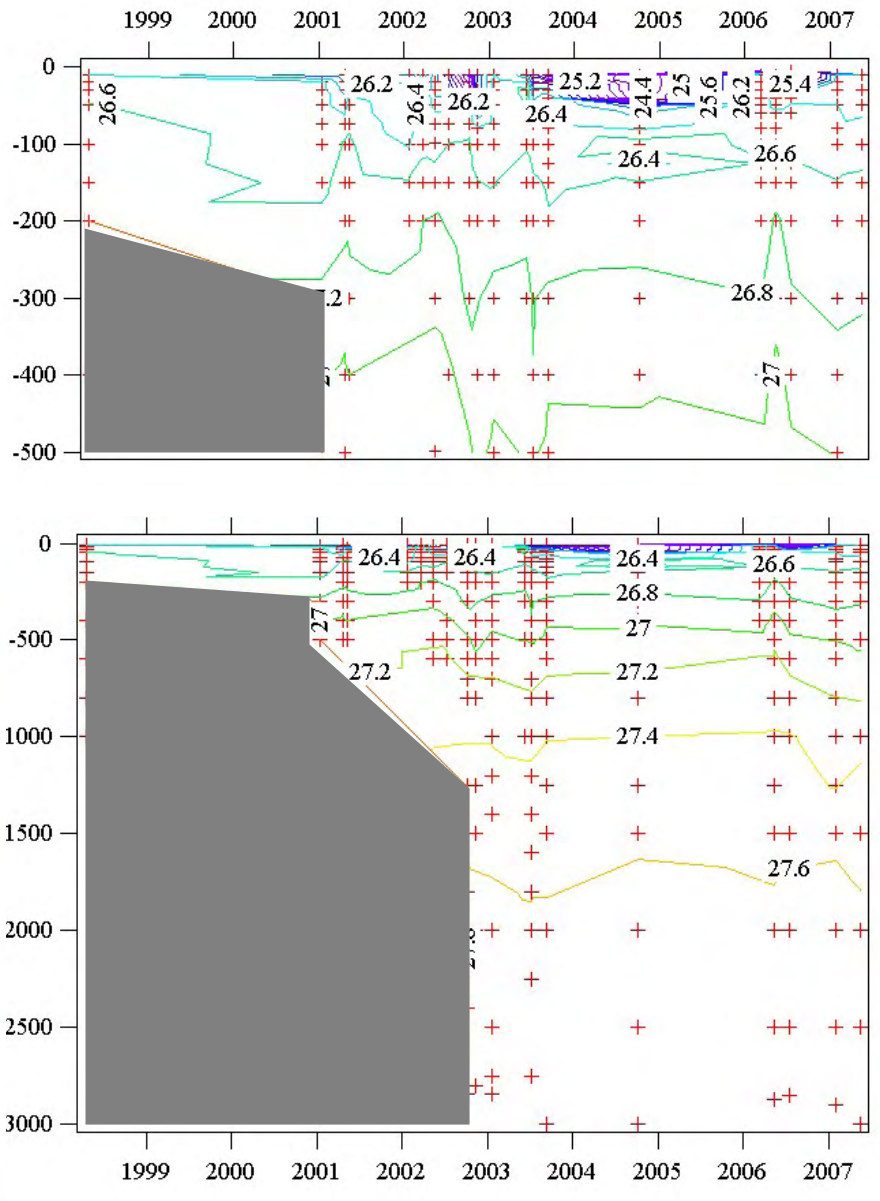
- on the other hand, 12-y atmospheric CO_2 should have cause + 8-9 μmol/kg DIC increase in the Oyashio surface.

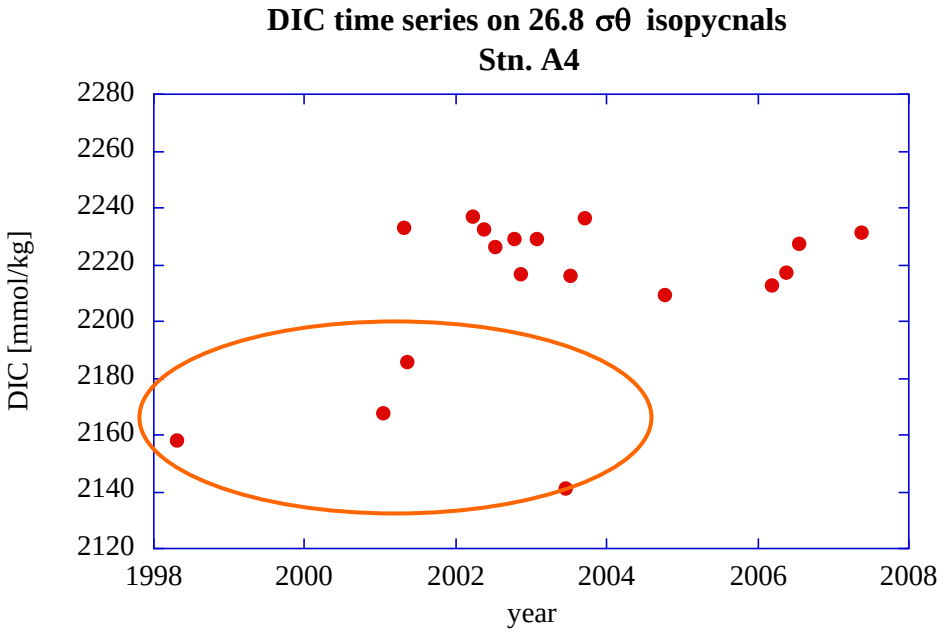
interannual variation

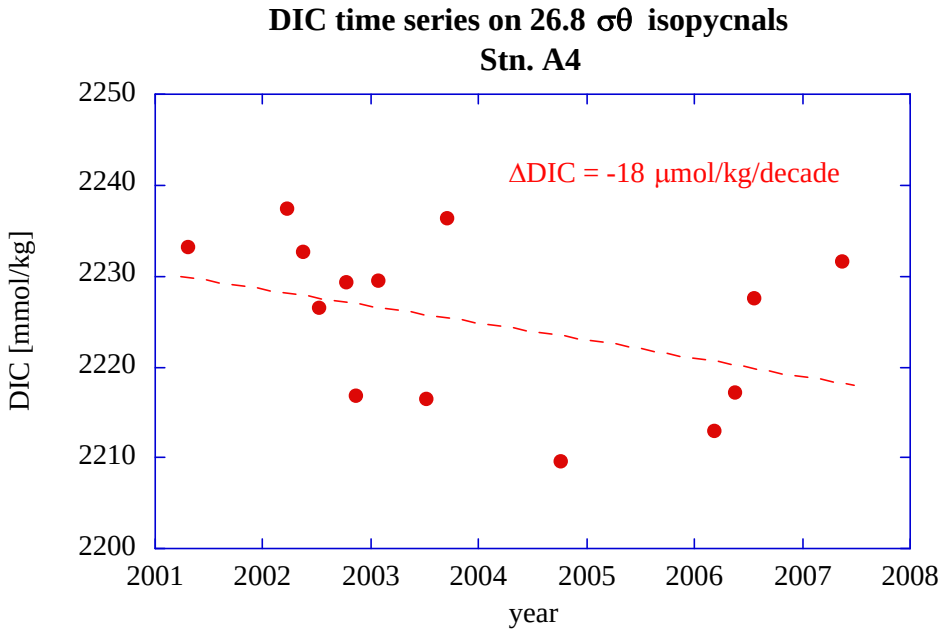
water column DIC at A4

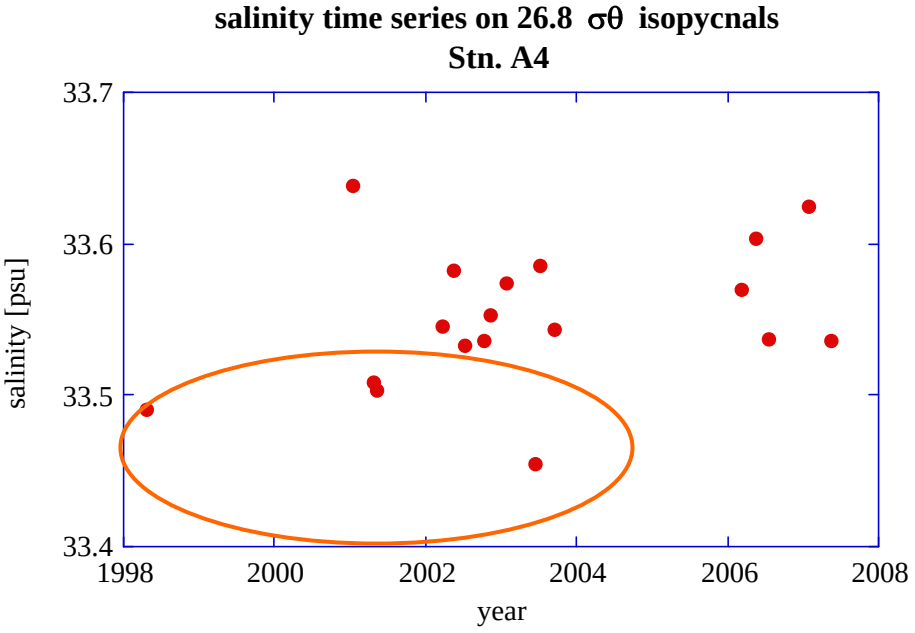


σθ



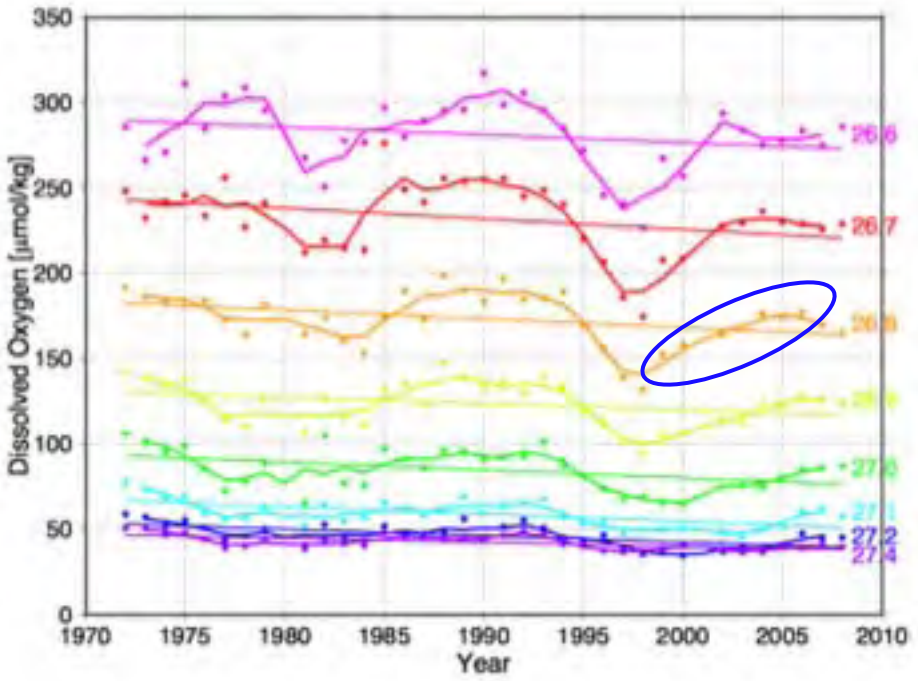






Dissolved oxygen time series on the isopycnals in Oy region [Midorikawa et al., PICES-NPESR II]

Dissolved oxygen time series
on the isopycnals in Oy region
[Midorikawa et al., PICES-NPESR II]



~20 μmol/kg increase
of DO

Summary

Time series observation of DIC along the A-line from 1996 achieves:

- 47 observation in Oyashio region, 12 in Mixed water Region
- overall precision..... ±5 μmol/kg (1SD)

Seasonal variation climatology:

- annual DIC amplitude.....170 μmol/kg , same as KNOT but twice as larger as Stn. P
- 1D surface-subsurface circulation in the 1-y time frame

Annual variation:

- large y-to-y amplitude due to water mass variation (even subsurface)
- relatively constant summer surface DIC through 1996-2007
- weak signal of winter surface DIC decrease (corresponding to PO_4)
- similar DIC decrease signal on 26.8 isopycnals (corresponding to 2001-2007 DO)

Seasonal maximum and minimum values in Oyashio mixed layer, A-line *(http://hnf.fra.affrc.go.jp/a-line/find/index_e.html)*

	Max.	Min.	Δ	Max (KNOT)	Min (KNOT)	Δ (KNOT)	Max (OSP)	Min (OSP)	Δ (OSP)
Temp. (°C)	18.2±1.6	3.3±1.1	15.1±1.4	15.0±0.7[a]	2.0[a*]	13.0±0.7[a*]	~13.0[b]	~5.5[b]	7.5[b]
NO_3 (μM)	18.3±3.5	0.72±0.62	17.6±3.4	19.6[a*]	4.9±0.5[a]	14.7±0.5[a*]	15.8±2.3[b]	8.9[b]	6.9[b]
$Si(OH)_4$ (μM)	30.7±5.5	3.5±1.9	27.2±5.5	33.4[a*]	6.0±1.9[a]	27.4±1.9[a*]	24.0±3.4[b]	12.9[b]	11.1[b]
Chl. (mg m^{-3})	5.6±3.6	0.24±0.09	5.3±3.6	2.8±1.4[a]	0.61[a*]	2.2±1.4[a*]	~0.5[c]	~0.2[c]	0.3[c]
Net Zooplankton (mmol N m^{-3})	1.4±1.2	0.08±0.05	1.3±1.2	--	--	--	--	--	0.16[d]

a: figures calculated from the data appeared in the KNOT home page (http://www.mirc.jha.jp/CREST/KNOT/index.html),
b: figures cited from Whitney and Freeland (1999), DSR-II 11-12, 2351-2370.
c: figures cited from Boyd and Harrison (1999), DSR-II 11-12, 2405-2432.
d: figures cited from Saito et al. (2002), DSR-II 11-12, 5463-5486.
*Note that the data obtained during winter at KNOT is so limited that nutrient maximum, temp. minimum, and Chla minimum may be underestimated.