Ship-of-opportunity observations of mesoscale eddies

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CONTINUOUS PLANKTON RECORDER SURVEY SAHFOS

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The Continuous Plankton Recorder survey

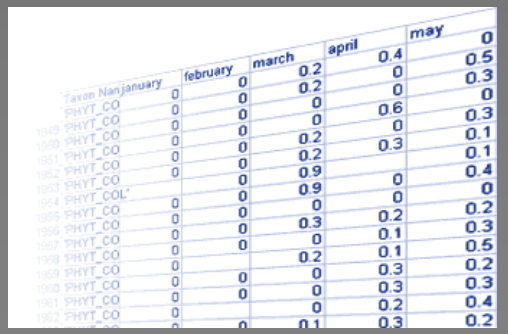
Ships…

…tow CPRs at 7m that collect plankton on lengths of mesh..

…that are cut into 18 km samples…

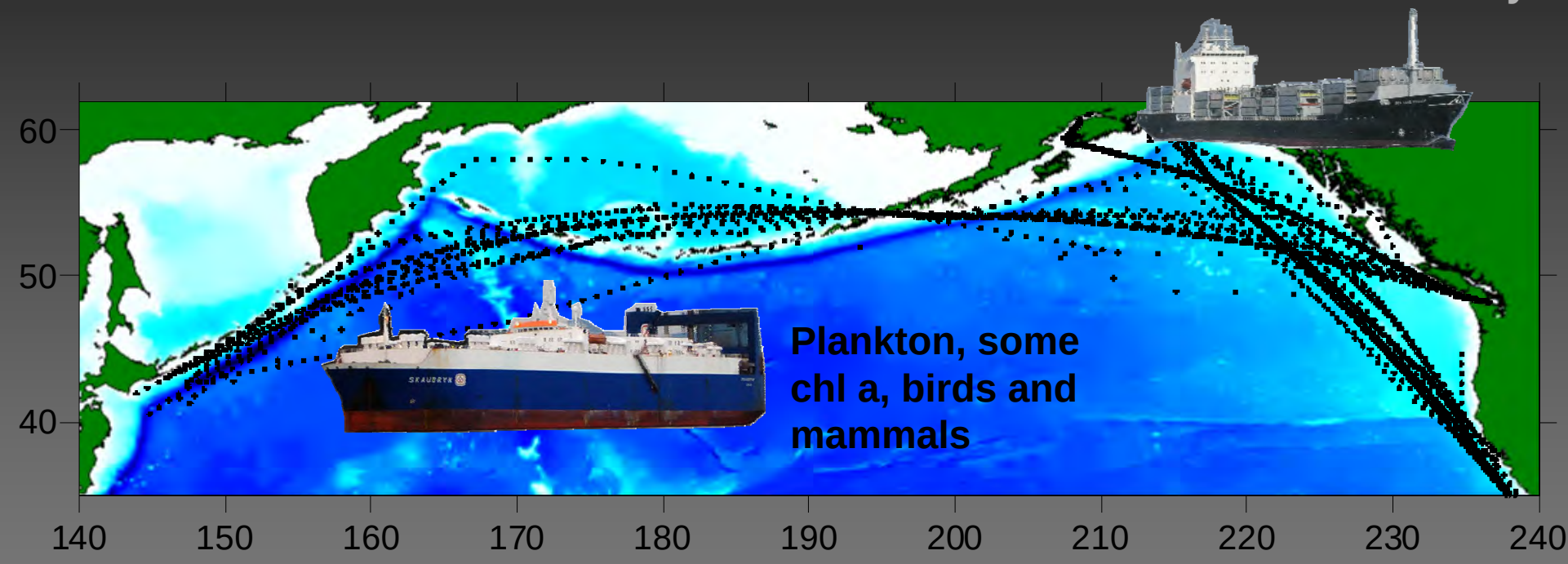
..that are analysed by taxonomists…

..who generate data…



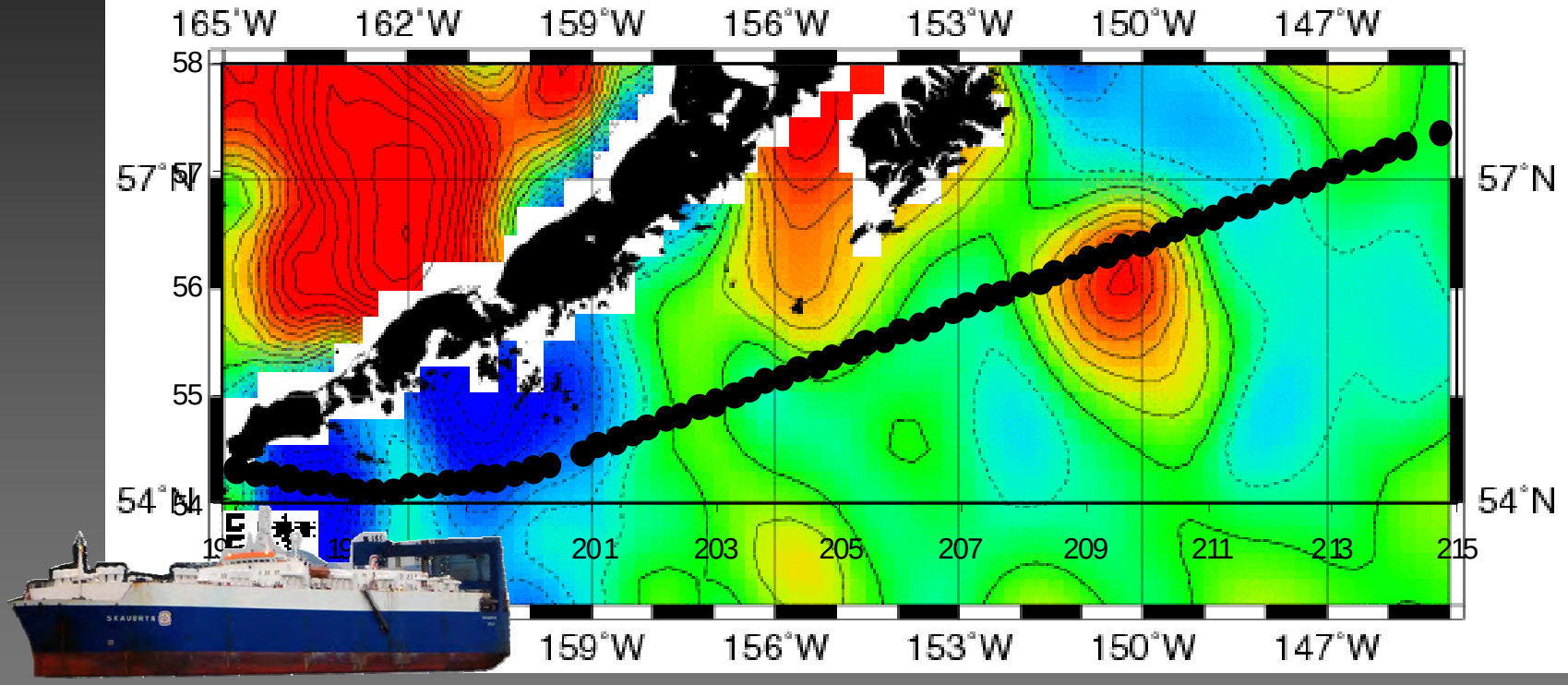
Taxon Name	january	february	march	april	may
PHYT_CO	0	0	0.2	0.4	0
PHYT_CO	0	0	0.2	0	0.5
PHYT_CO	0	0	0	0	0.3
PHYT_CO	0	0	0	0.6	0
PHYT_CO	0	0	0.2	0	0.3
PHYT_CO	0	0	0.2	0.3	0.1
PHYT_CO	0	0	0.9		0.1
PHYT_COL*		0	0.9	0	0.4
PHYT_CO	0	0	0	0	0
PHYT_CO	0	0	0.3	0.2	0.2
PHYT_CO	0	0	0	0.1	0.3
PHYT_CO	0		0.2	0.1	0.5
PHYT_CO	0	0	0	0.3	0.2
PHYT_CO	0	0	0	0.3	0.3
PHYT_CO	0		0	0.2	0.4
PHYT_CO	0	0	0.1	0.3	0.2

There are 2 transects in the North Pacific, operating since 2000

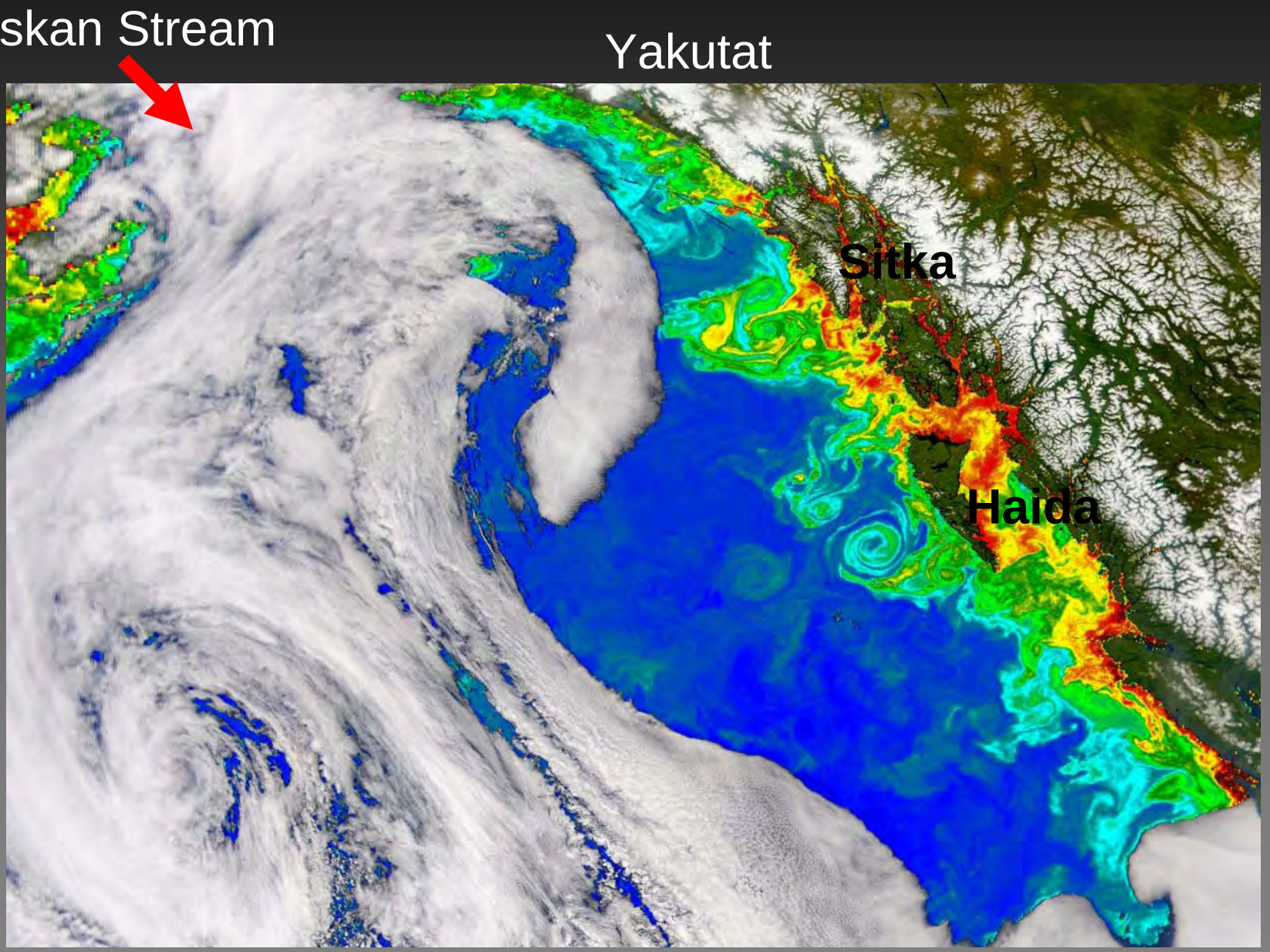


Although we cannot direct the ships, by overlaying the ship tracks on altimetry images afterwards we can see when ships passed through eddies

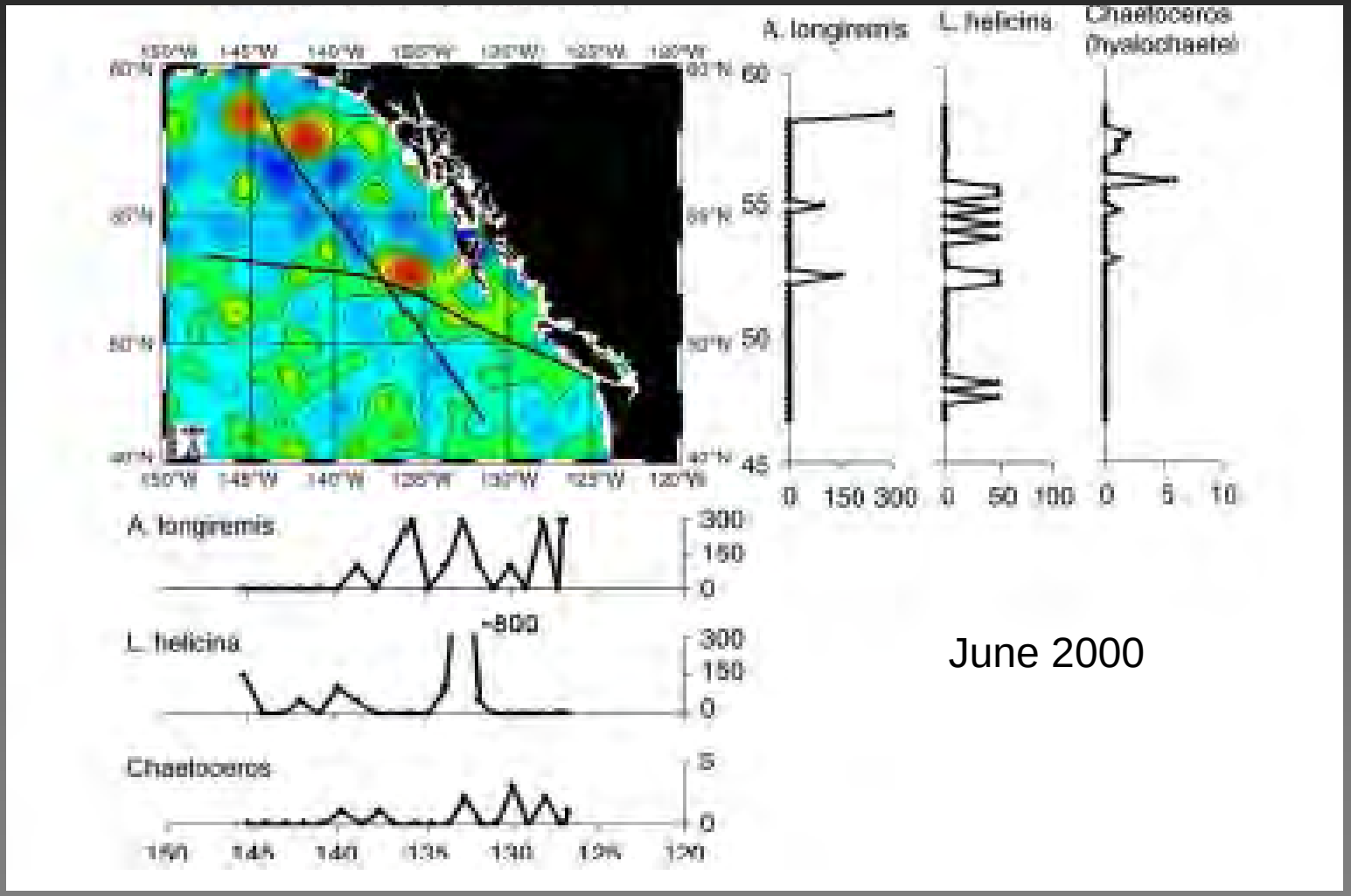
Real-Time Mesoscale Altimetry - Mar 24, 2007



Formation regions in GoA



Previously shown that coastal-origin taxa are found in CPR samples collected within/near Haida and Sitka eddies and some oceanic taxa were elevated



Batten and Crawford 2005, DSR II, 52

Focusing on the Gulf of Alaska we first catalogued the eddies:

- 35 eddy ‘events’ 2000 to 2008
- 4 formation regions:
  - 7 Alaska Stream
  - 3 Haida
  - 5 Sitka
  - 2 Yakutat
- Some eddies sampled multiple times

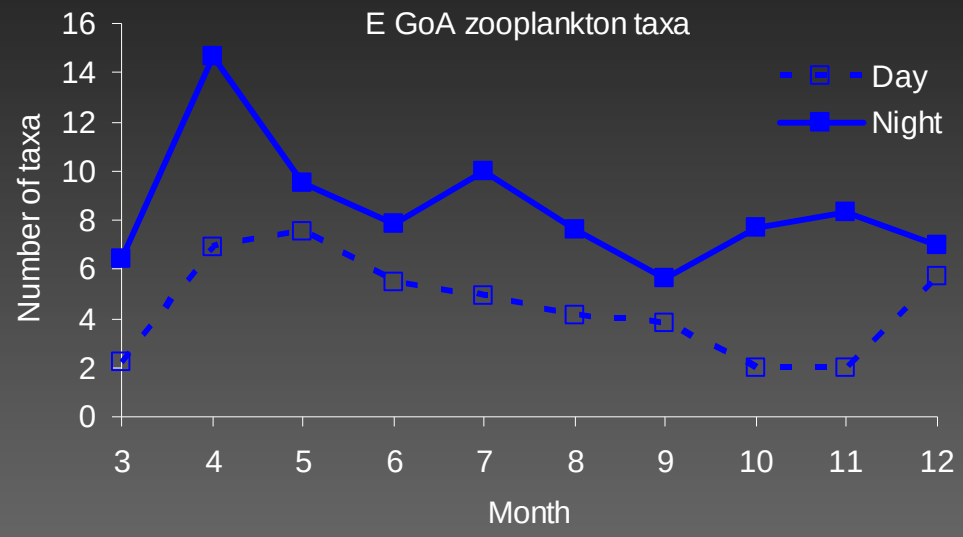
Eddy name	Formation region	Month	Year	Location where sampled	Intensity (cm)	Age (mo)	(Size km2)
AS1	Alaska Stream	12	2002	W GoA	25	1.5	12215
AS2	Alaska Stream	4	2003	W GoA	35	15	41299
AS3	Alaska Stream	6	2005	W GoA	10	2	19234
AS3	Alaska Stream	9	2005	W GoA	25	5	45374
AS4	Alaska Stream	3	2007	W GoA	30	3.5	38979
AS5	Alaska Stream	4	2007	NC GoA	10	3	19506
AS5	Alaska Stream	6	2007	NC GoA	10	5	18913
AS6	Alaska Stream	6	2007	W GoA	15	2	34480
AS7	Alaska Stream	5	2008	W GoA	30	3	85936
Haida1	Haida	3	2000	E GoA	15	4	37856
Haida1	Haida	6	2000	E GoA	20	6	26467
Haida1	Haida	7	2000	E GoA	15	7	30847
Haida2	Haida	4	2002	E GoA	10	2	19378
Haida2	Haida	6	2002	E GoA	10	4	9553
Haida2	Haida	6	2002	E GoA	10	4.5	30409
Haida2	Haida	7	2002	E GoA	10	5.5	13615
Haida3	Haida	6	2002	NE GoA	15	4	24607
Haida3	Haida	10	2004	E GoA	15	8	16195
Sitka1	Sitka	6	2000	NE GoA	20	4	29428
Sitka1	Sitka	7	2000	NE GoA	10	5	25030
Sitka1	Sitka	8	2000	NE GoA	10	6	16716
Sitka2	Sitka	12	2002	W GoA	20	23	25574
Sitka3	Sitka	6	2003	NE GoA	15	4	40197
Sitka3	Sitka	8	2003	NE GoA	15	5	68637
Sitka3	Sitka	9	2003	NE GoA	15	6	54030
Sitka4	Sitka	3	2006	NC GoA	15	11	47297
Sitka4	Sitka	4	2006	NC GoA	10	12	51440
Sitka5	Sitka	9	2007	NC GoA	10	9	26365
Yakutat1	Yakutat	3	2003	NE GoA	15	2	14544
Yakutat1	Yakutat	5	2003	NE GoA	15	4	27065
Yakutat1	Yakutat	4	2005	W GoA	25	26	39134
Yakutat1	Yakutat	6	2005	W GoA	25	28	32503
Yakutat1	Yakutat	9	2005	W Goa	20	31	34787
Yakutat2	Yakutat	4	2004	NC GoA	10	3	12506
Yakutat2	Yakutat	6	2004	NC GoA	20	5	48329

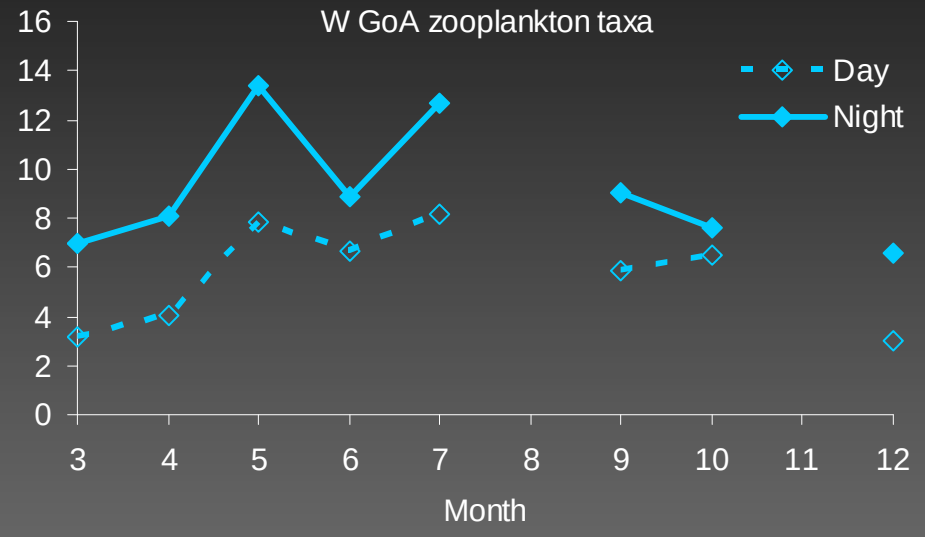
Biological variables in eddy samples:

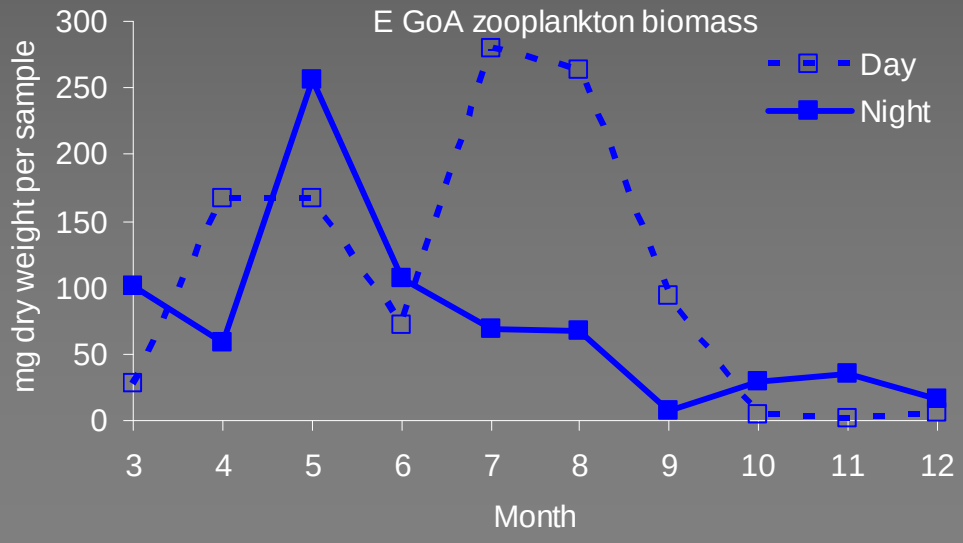
- Number of zooplankton taxa
- Number of phytoplankton taxa
- Zooplankton biomass and/or abundance
- Some chlorophyll (fluorescence) data (6 eddies)
- Some marine mammal and seabird observations (5 eddies)

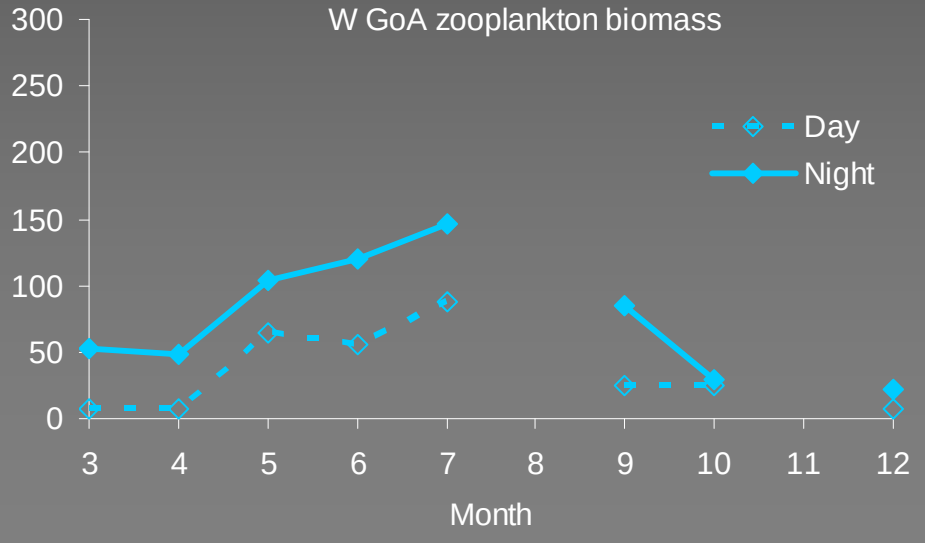
However, plankton especially, vary by day/night, season, and location

Non-eddy sample means for eastern and western GoA:



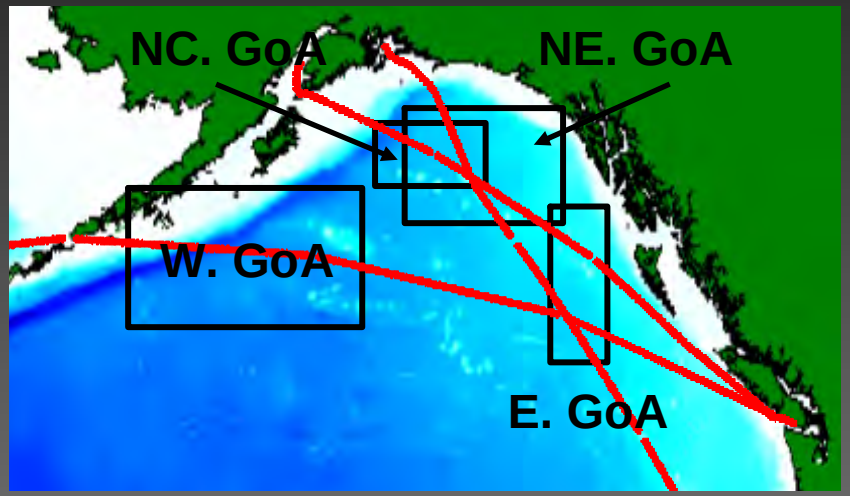






We calculated a mean specific to:

- Region where eddies were sampled



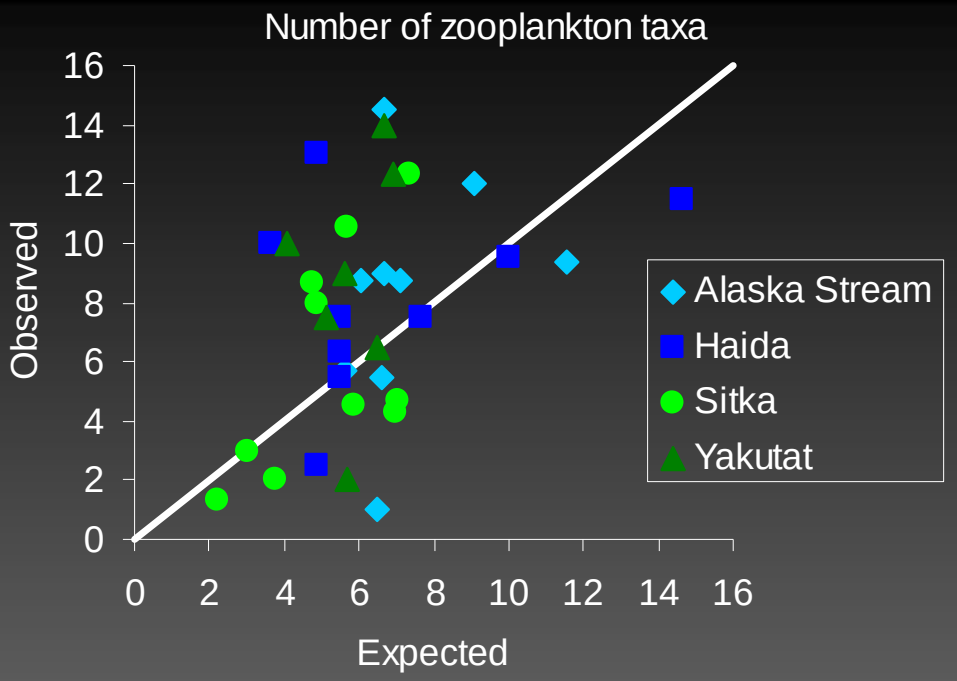
- Day or night (before or after local sunrise and sunset)

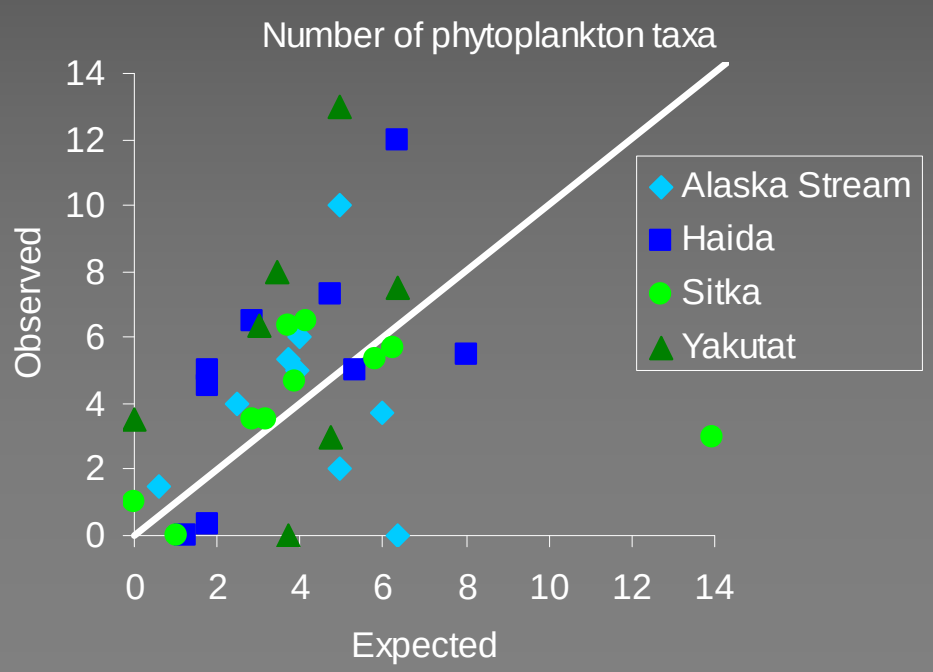
- Month

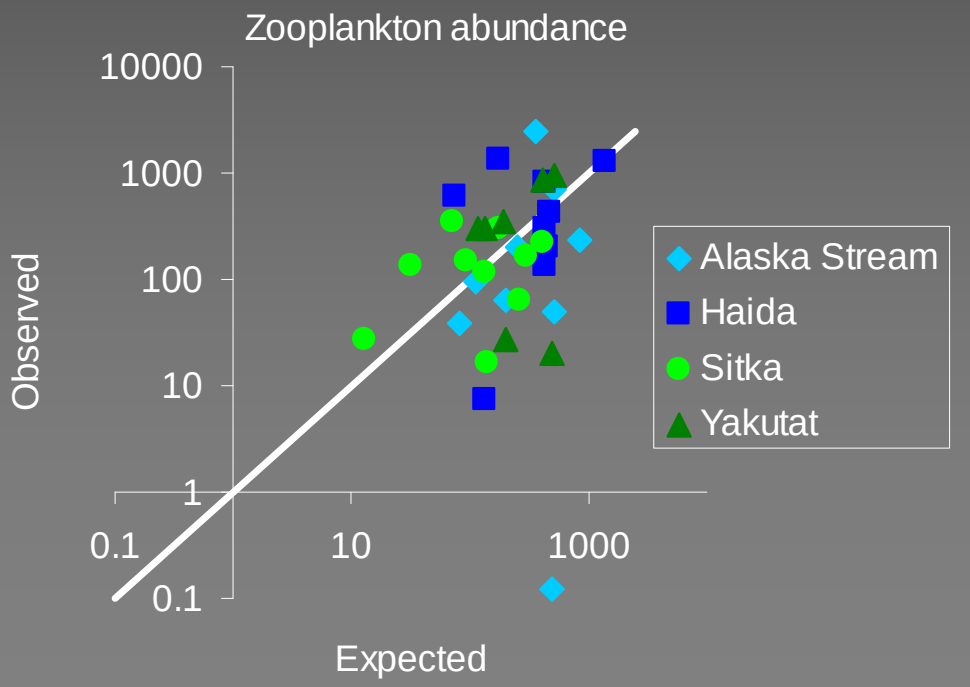
Then compared the mean within-eddy values to these ‘expected’ values

Plotting observed eddy values against expected non-eddy values

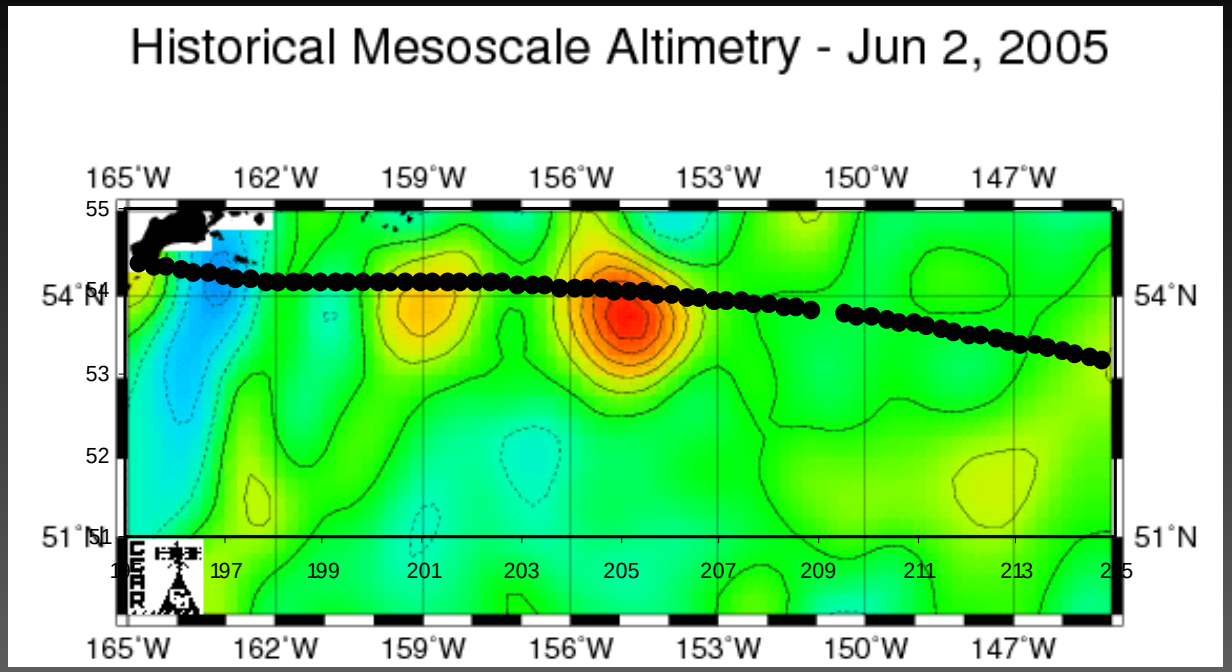
Most of the Yakutat eddy events showed increased diversity and increased abundance

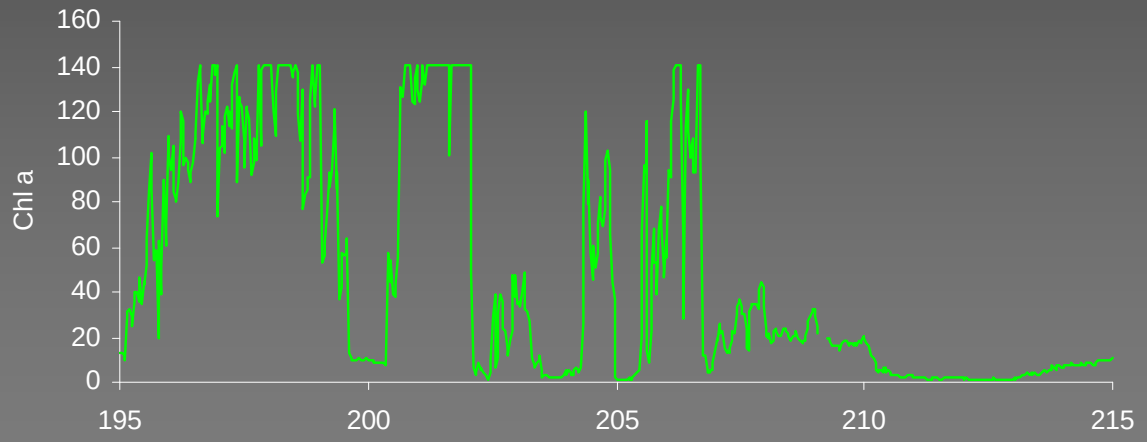






Because of the issues with determining chlorophyll from fluorescence we had to compare each CTD record with altimetry

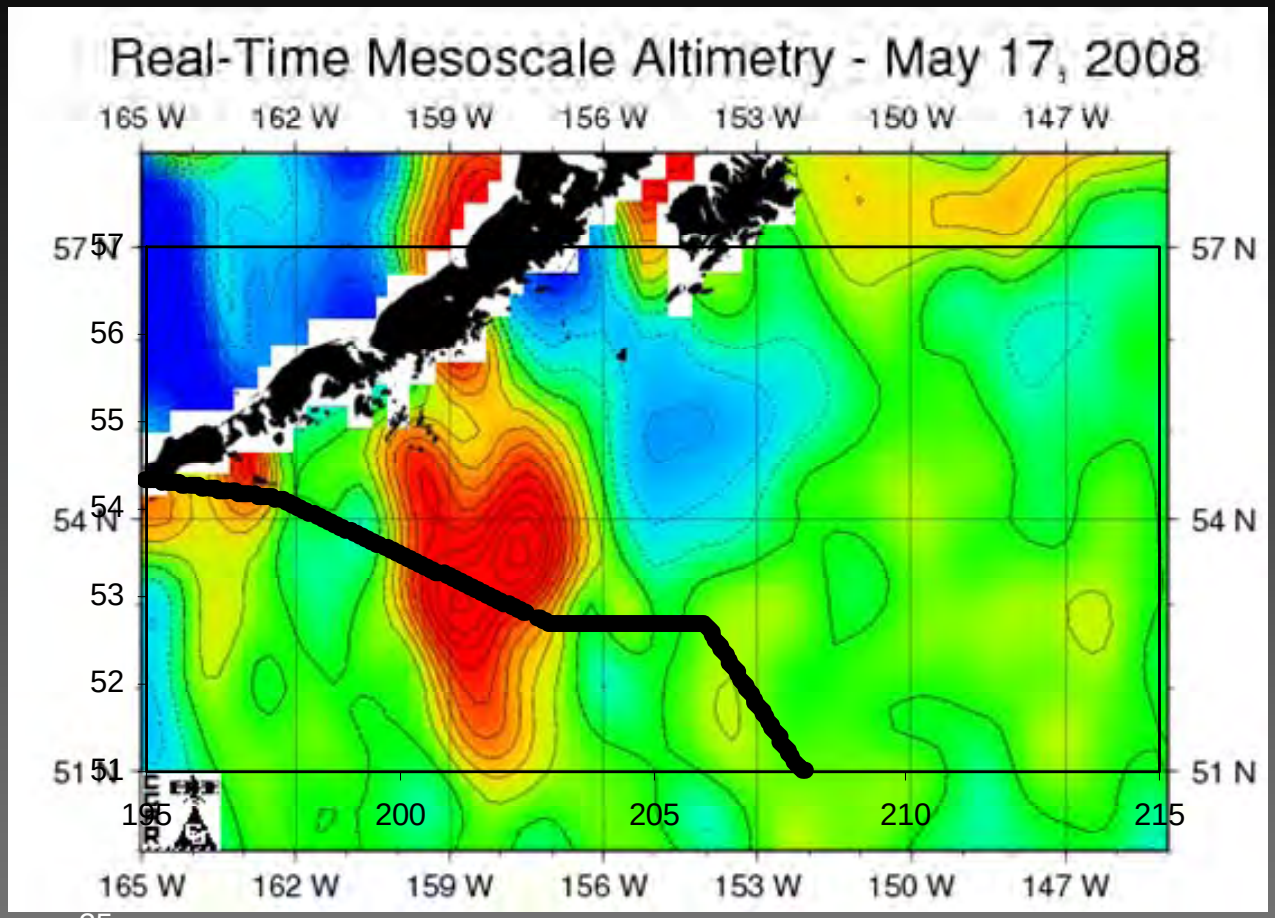


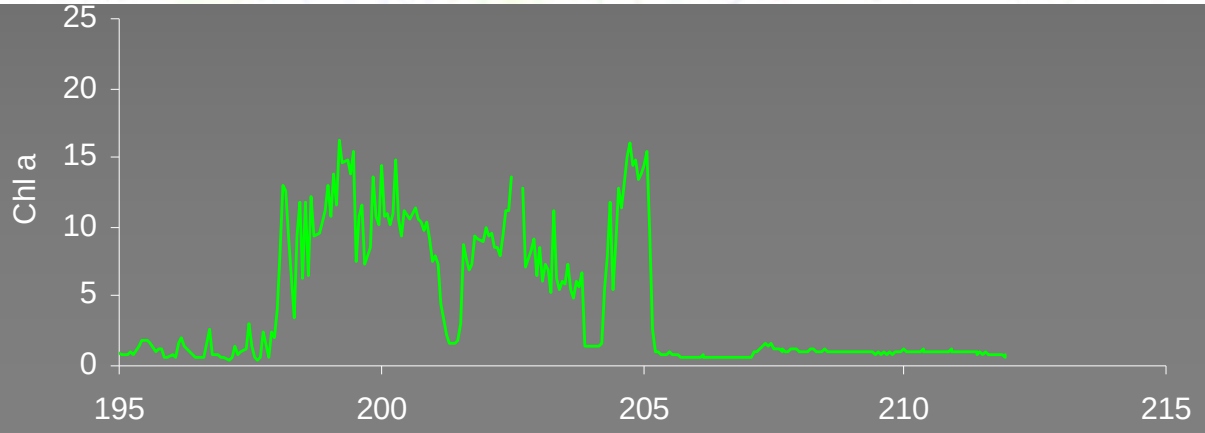


(note that CPR only catches large phyto cells, not those that contribute most to chlorophyll so phyto biomass data must come from CTD)

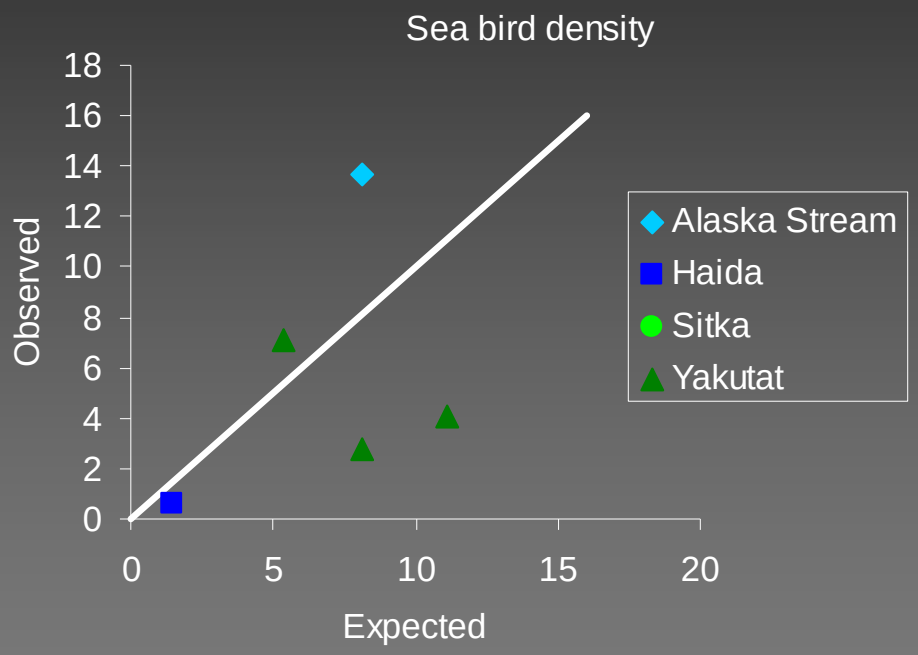
Some evidence of high chl a at edges and depressed in centre

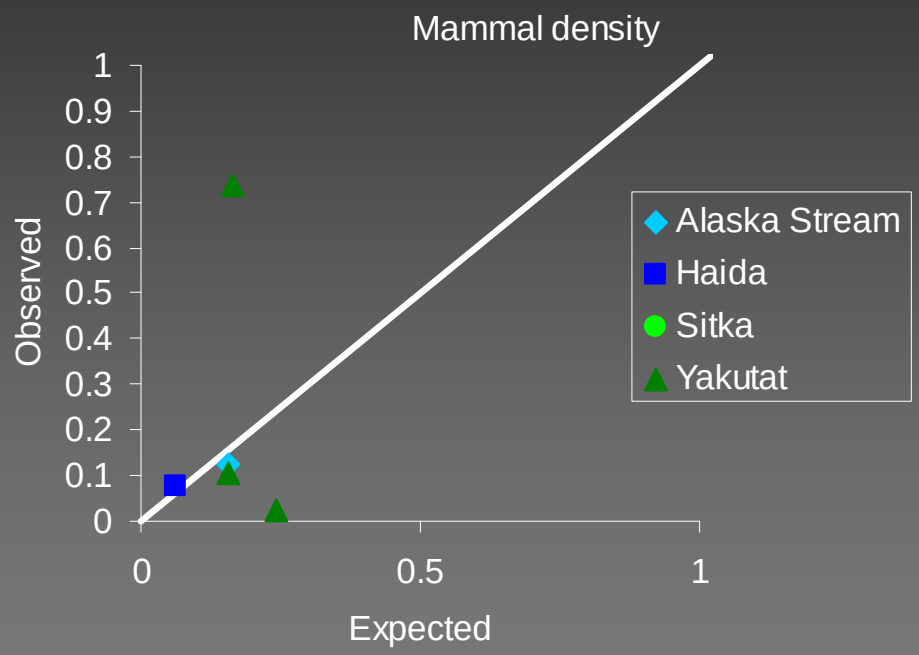
However, other 3 eddies sampled by CTD show no chl a signal





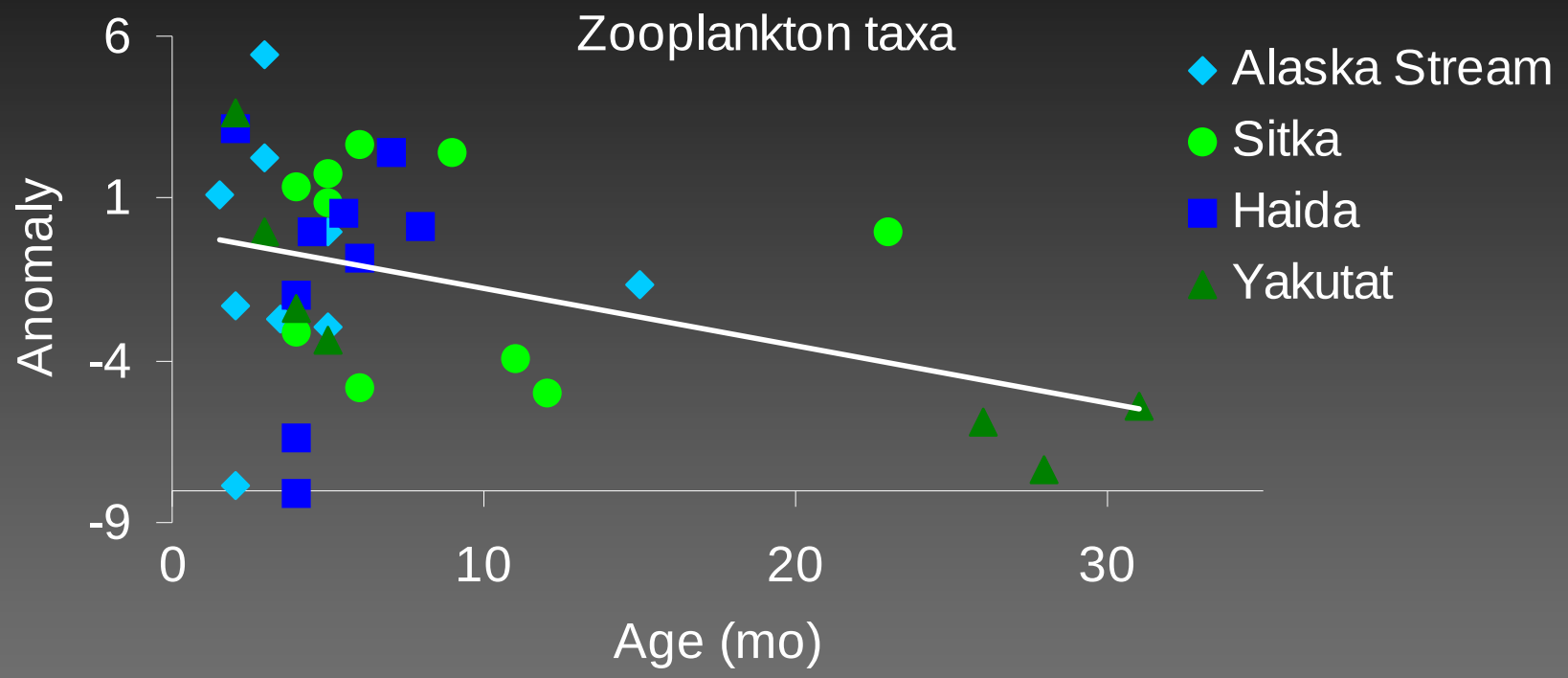
Few upper trophic level observations





But no evidence that these eddies were ‘hot spots’

Relationship between biology and eddy age:



	Zooplankton taxa	zooplankton abundance	Phytoplankton taxa
All	**-0.38** *	-0.15	-0.26
Alaska Stream	-0.05	-0.11	0.22
Haida	0.21	0.31	-0.05
Sitka	-0.14	0.11	0.13
Yakutat	**-0.82** *	**-0.73** *	**-0.72** *

Summary

- Ships of opportunity are not an ideal platform but they offer an inexpensive way to sample the biology of eddies

- Eddies that originate off Yakutat have noticeably enhanced biological variables

- For other formation regions there are no generalities and we need to study case by case

- Suggestions on other/better ways to analyse the data are welcome.