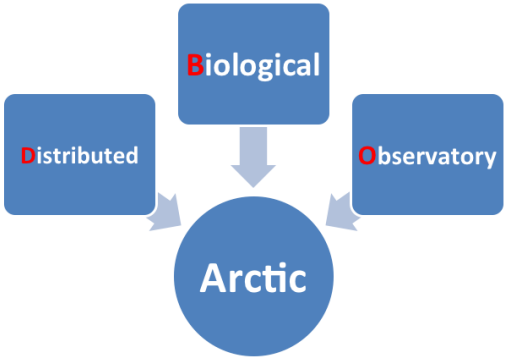


Linking Biology to Physics in an Arctic Ocean Observing System: Workshop Outcomes and Way Forward

Development of a Distributed Biological Observatory (DBO) in the Pacific Arctic and potential for pan-Arctic system studies

Jackie Grebmeier on behalf of the workshop participants
Pacific Arctic Group and the IASC AOSB:Marine Working Group
IOS/DFO, Sidney, BC Canada
15-16 November 2011

The Goal of the Workshop

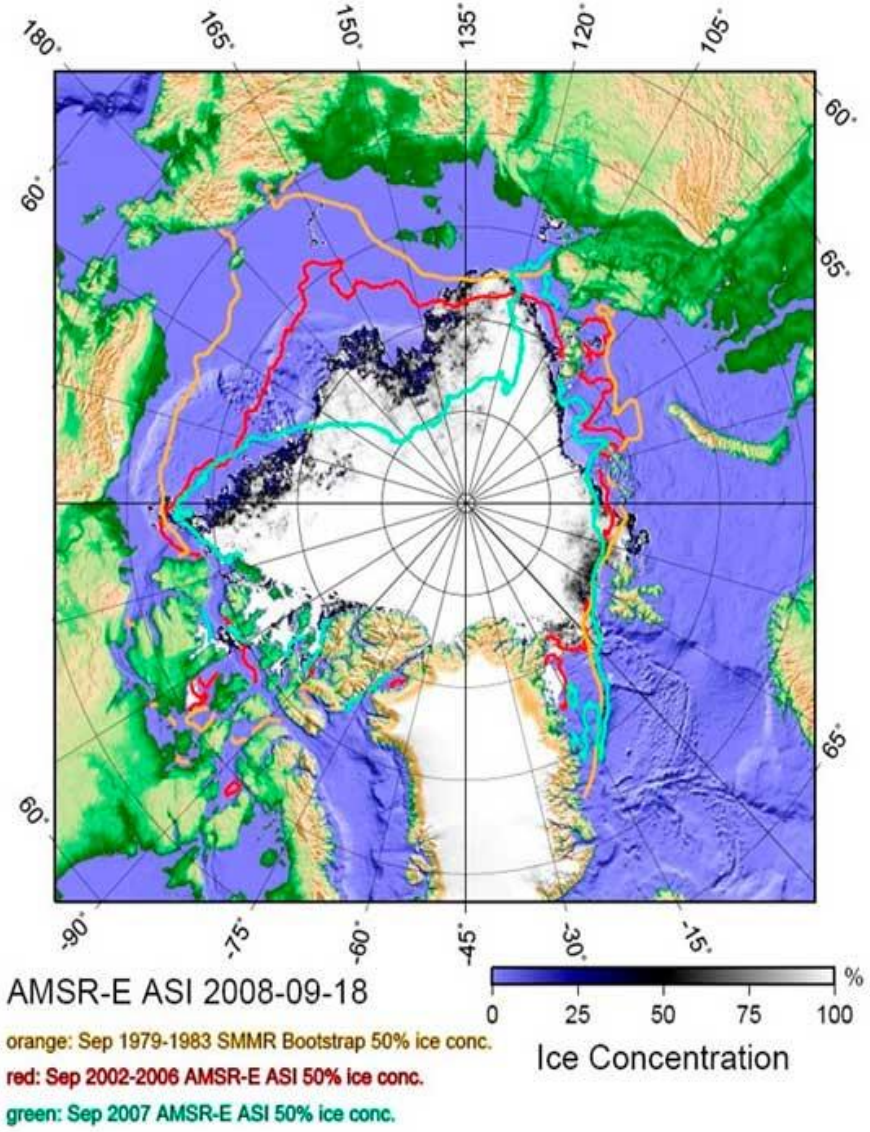
The workshop is organized by the Pacific Arctic Group and the AOSB/Marine Working Group of IASC. During the workshop we will:

- review the data collected during the 2010 and 2011 DBO pilot project and analyses
- discuss the potential expansion of the program to a pan-Arctic biological observation network
- data management issues
- plans for DBO occupation in 2012 onwards

[http://www.arctic.noaa.gov/dbo/]

Arctic Sea Ice = 'New State'

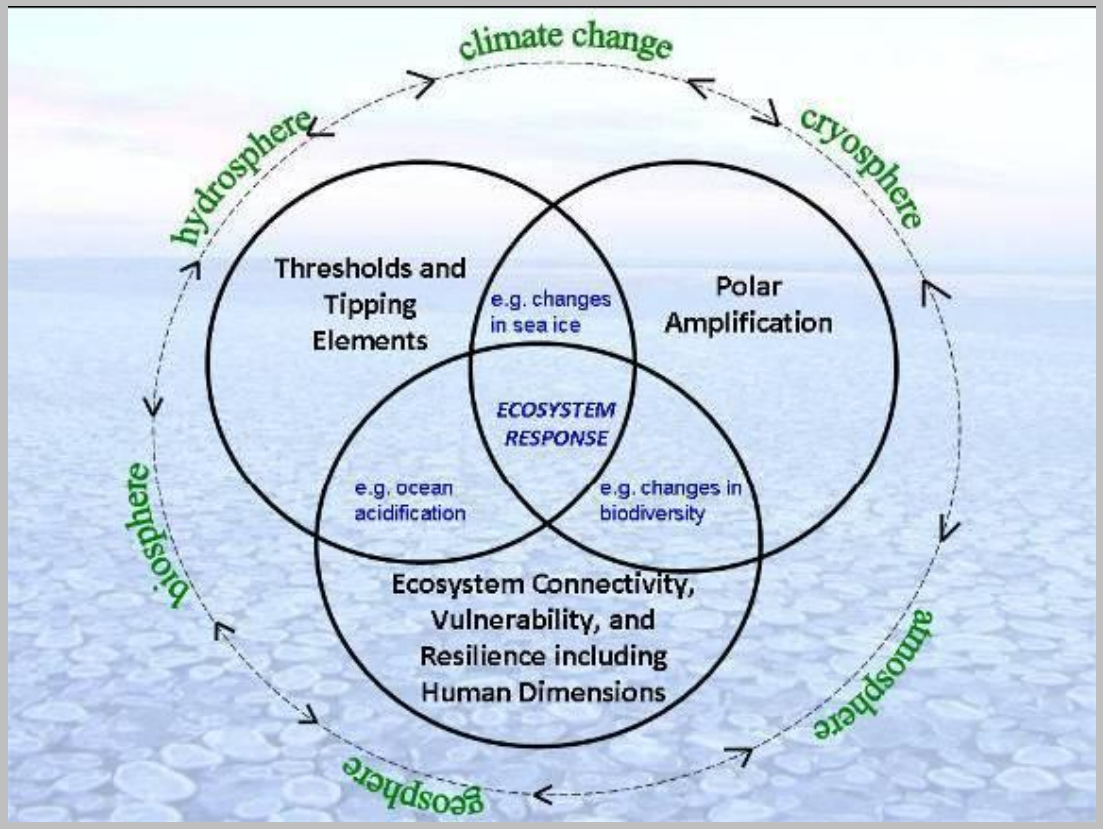
- 2007 sea ice retreat called 'catastrophic' (Shimada 2007)
- Nearly ice-free September now predicted for 2037 (Wang & Overland 2009)
- Biggest change is loss of multi-year ice + delay in fall freeze-up



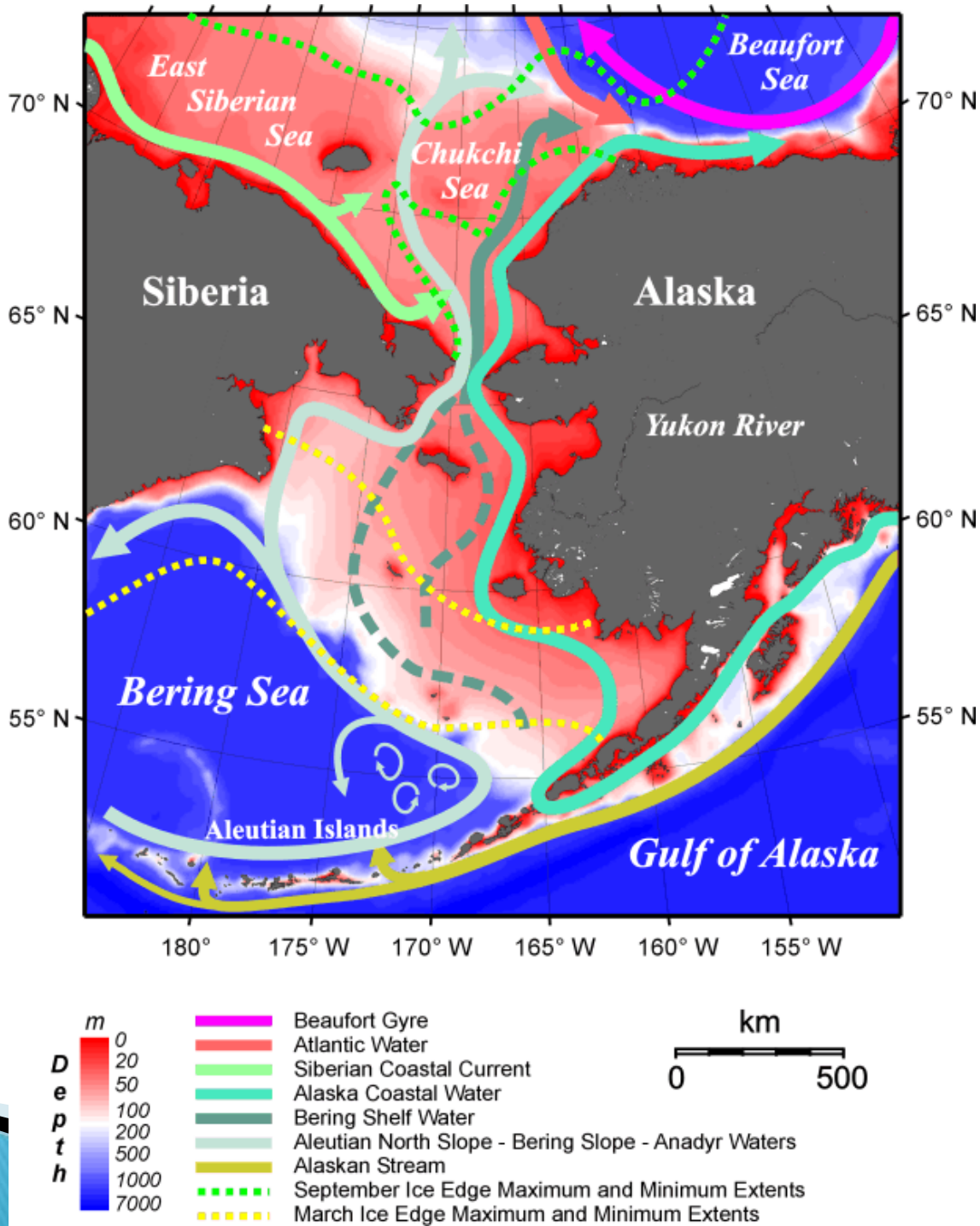
Frontiers in Understanding Climate Change and Polar Ecosystems: Report of a Workshop, U.S. Polar Research Board, National Academies

(published May 2011; free pdf download)

Committee: Jacqueline M. Grebmeier and John C. Priscu (co-chair), Rosanne d'Arrigo, Hugh W. Ducklow, Craig Fleener, Karen E. Frey, and Cheryl Rosa

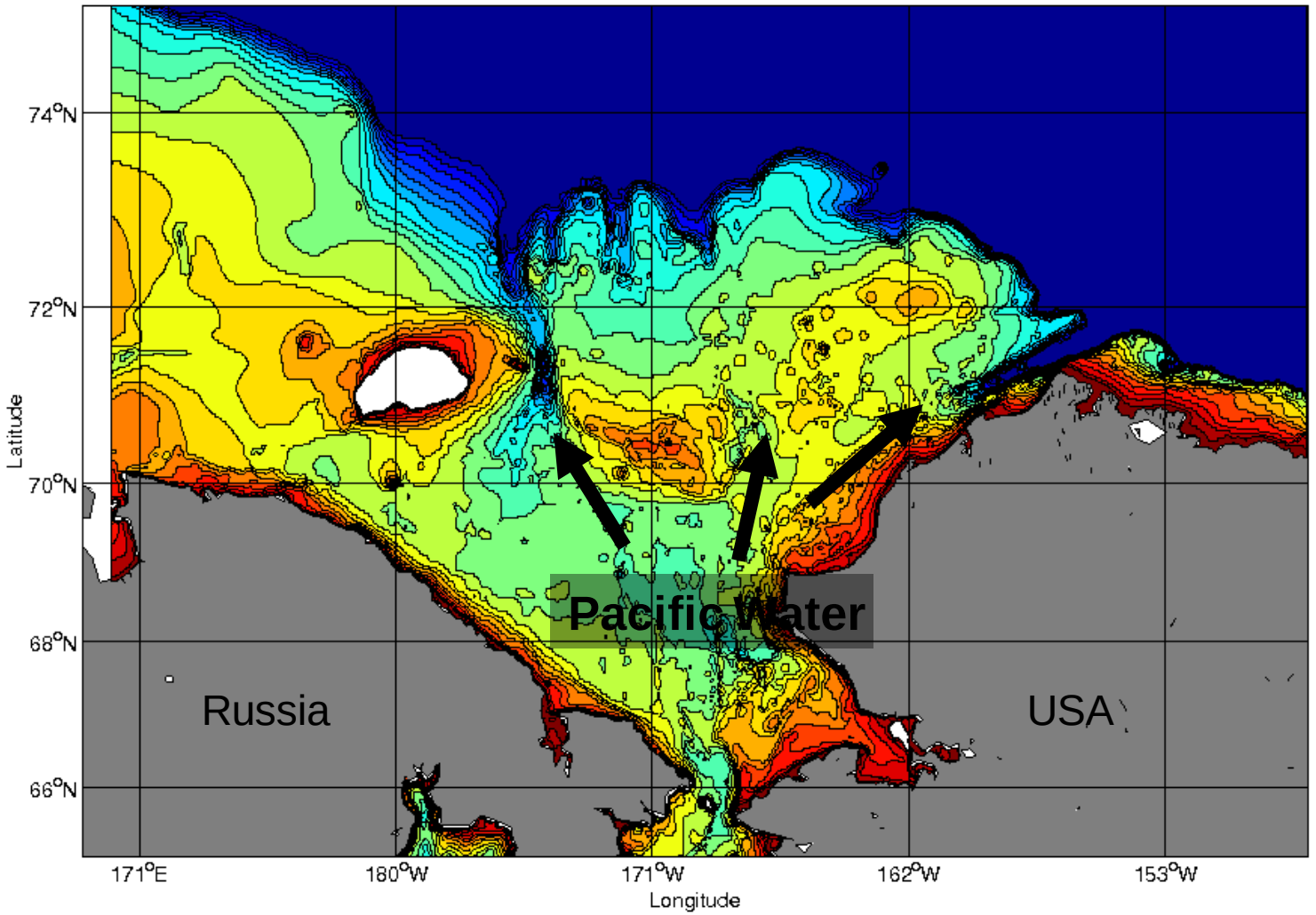


It highlights the need for biologically-oriented, time-series, long-term observations in the polar marine environment to track ecosystem response to climate forcing



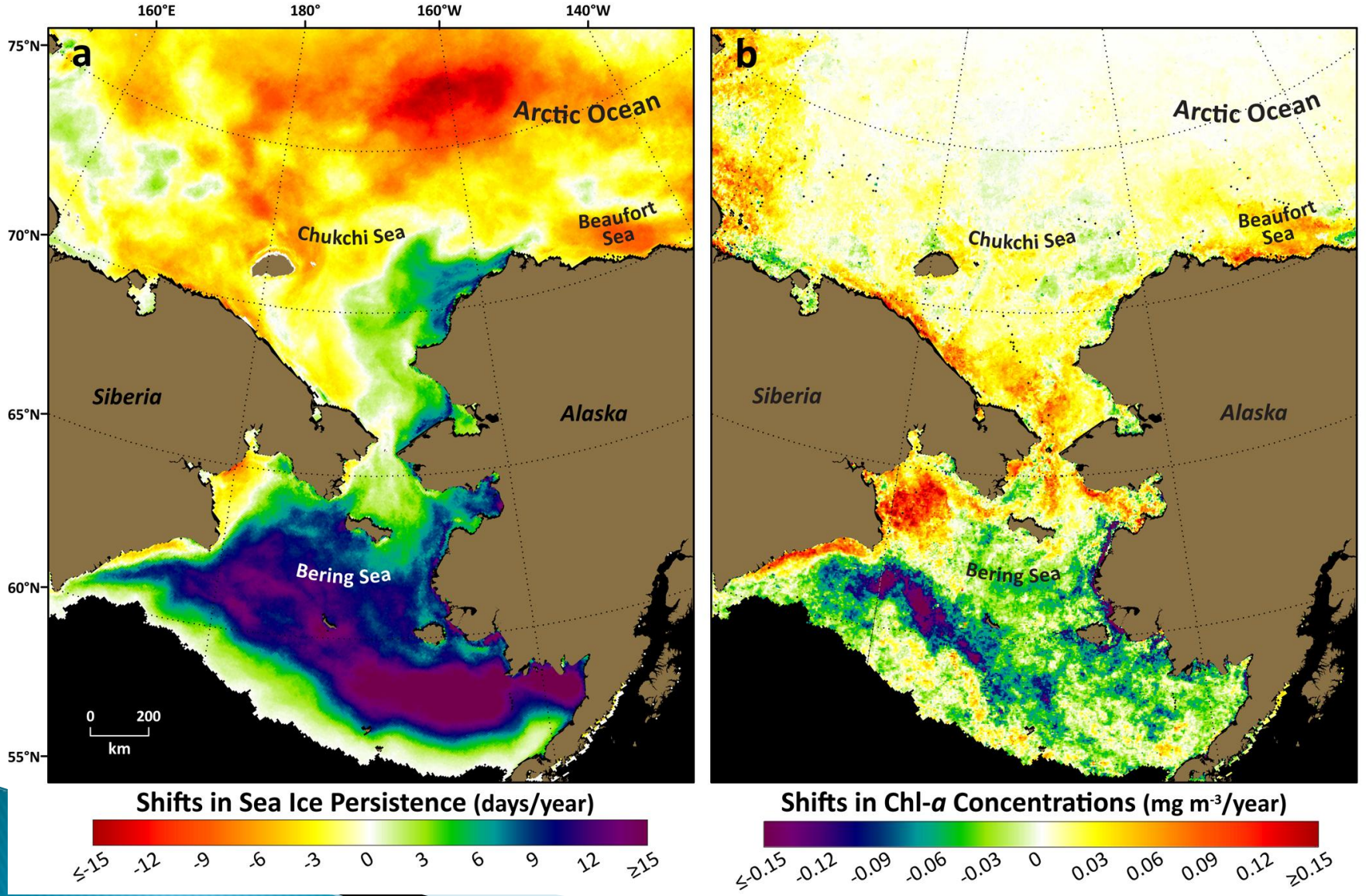
[courtesy Tom Weingartner and Seth Danielson]

Pathways: Pacific water into the Arctic



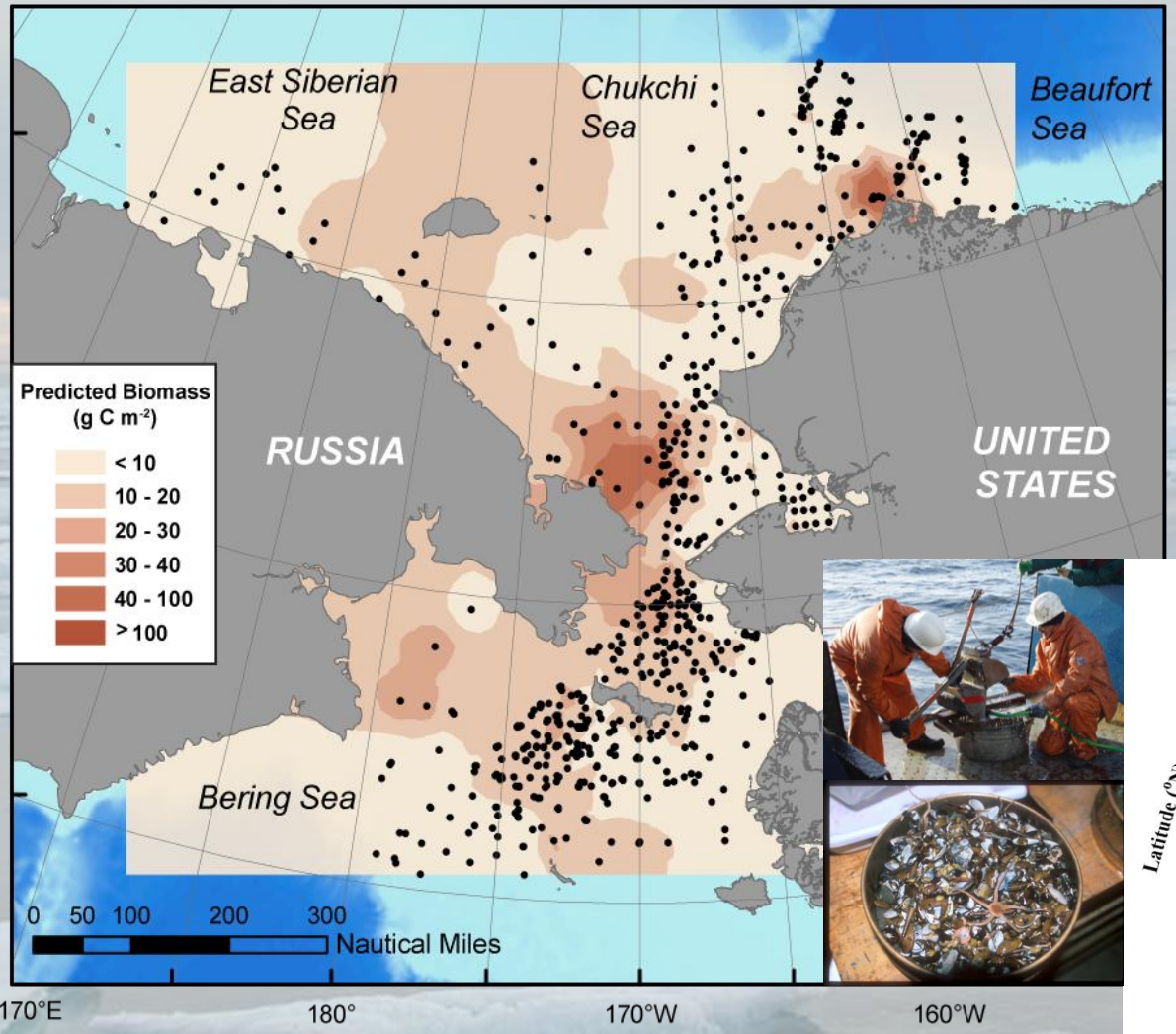
[courtesy R. Pickart]

Shifts in sea ice persistence and Chl-a concentration from 2003-2009



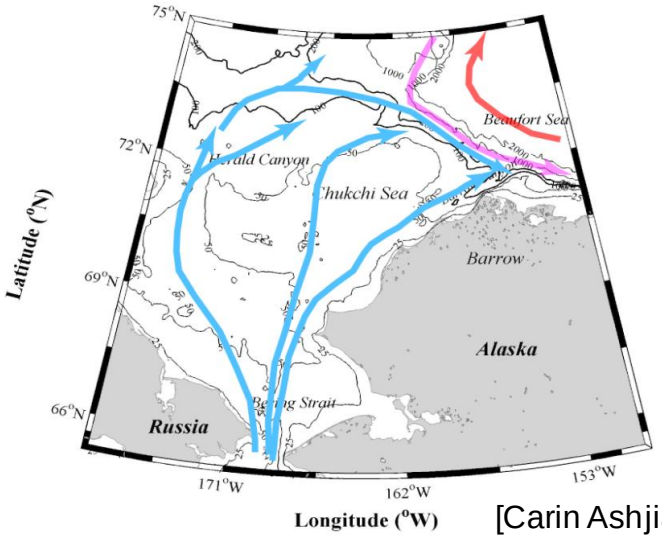
Based on SSM/I Sea Ice Concentrations and the GlobColour (SeaWiFS, MODIS, MERIS) satellite time series, courtesy Karen Frey

Rich benthic communities on the western side of the Bering/Chukchi Sea system 1970-2010



[updated from Grebmeier et al. 2006]

- **"foot prints"** of high benthic biomass reflect pelagic-benthic coupling and export of carbon to sediments
- infaunal dominated by amphipods, bivalves, polychaetes, and sipunculids



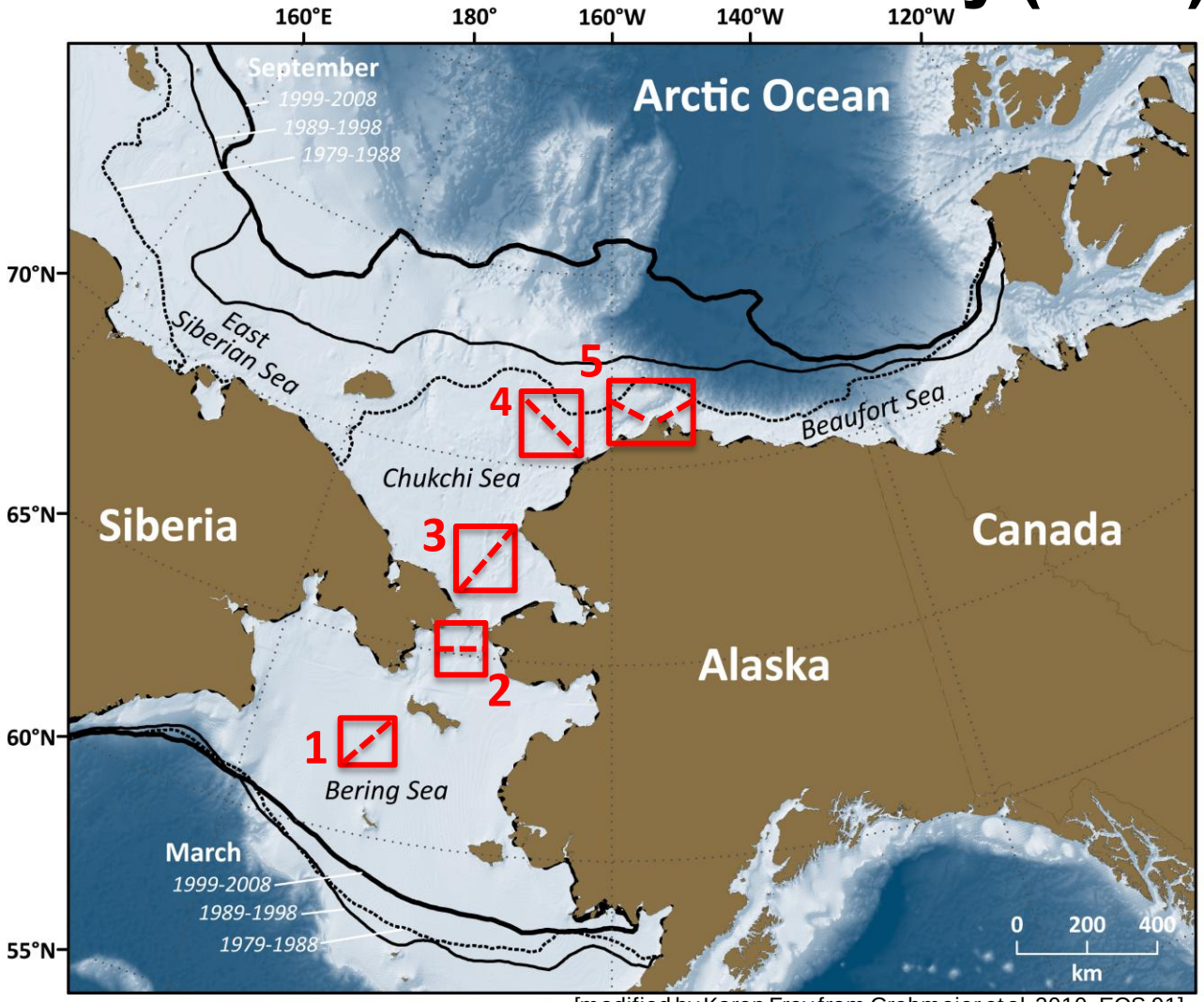
[Carin Ashjian]

Observed Changes in the PAR

a few examples

- Pacific zooplankton in Beaufort Sea
- Commercially fished 'Bering species' & snow crab in the western Beaufort Sea
- Seabird declines with drop in clam biomass [eiders] & access to ice-associated cod [guillemots]
- Gray whale feeding-focus shift from N. Bering to Chukchi
- Walrus hauling out on land in unprecedented numbers
- Polar bears reported drowned at sea, scavenging & denning on land

Linking Physics to Biology: the Distributed Biological Observatory (DBO)



[modified by Karen Frey from Grebmeier et al. 2010, EOS 91]

- DBO sites (red boxes) are regional "hotspot" transect lines and stations located along a latitudinal gradient
- DBO sites are considered to exhibit high productivity, biodiversity, and overall rates of change
- DBO sites will serve as a change detection array for the identification and consistent monitoring of biophysical responses
- Sites occuppied by national and international entities with shared data plan

Distributed Biological Observatory: Linking Physics to Biology

Core standardized ship-based sampling:

- CTD
- Chlorophyll
- Nutrients
- Ice algae/Phytoplankton (size, biomass and composition)
- Zooplankton (size, biomass and composition)
- Benthos (size, biomass and composition)
- Seabird (standard transects, no additional shiptime)
- Marine mammal observations (no additional ship time)

"Change detection array" – same measurements every year, process information in near real time <6 mos; detect regime shifts in rapid changes

Second tier ship-based sampling:

- Fishery acoustics (less effort than standardized bottom trawling)
- Bottom trawling (every 3-5 years)

DBO occupations by national and international science programs

Endorsements

- Marine Working Group of the International Arctic Science Committee (IASC) has endorsed the DBO (2010), is supporting similar activities in the Atlantic sector of the Arctic, and co-sponsored the DBO workshops in Seoul, Korea March 2011 and Sidney, BC, Canada in November 2011
- the IASC-SCAR bipolar action group for the Arctic and Antarctic recently identified the DBO concept of latitudinal transects and stations as a possible mode for biological observations in the Antarctic
- In the USA DBO identified in US Polar Research Board report
- several U.S. agencies have endorsed the DBO concept in the Arctic research planning documents, including: (1) the 2010 NOAA Arctic Strategic Plan, (2) aspects in the BOEMRE Alaska Region planning efforts in the Chukchi Sea (COMIDA-Hanna Shoal), (3) statements in the recent USGS Science "Needs to Inform Decisions on Outer Continental Shelf Energy Development in the Chukchi and Beaufort Seas Alaska" document, and (4) discussions Shell-ConocoPhillips-StatOil environmental program. Perhaps most importantly, the DBO is specifically included in the draft US National Ocean Policy Strategic Plan.

[http://www.arctic.noaa.gov/dbo/]

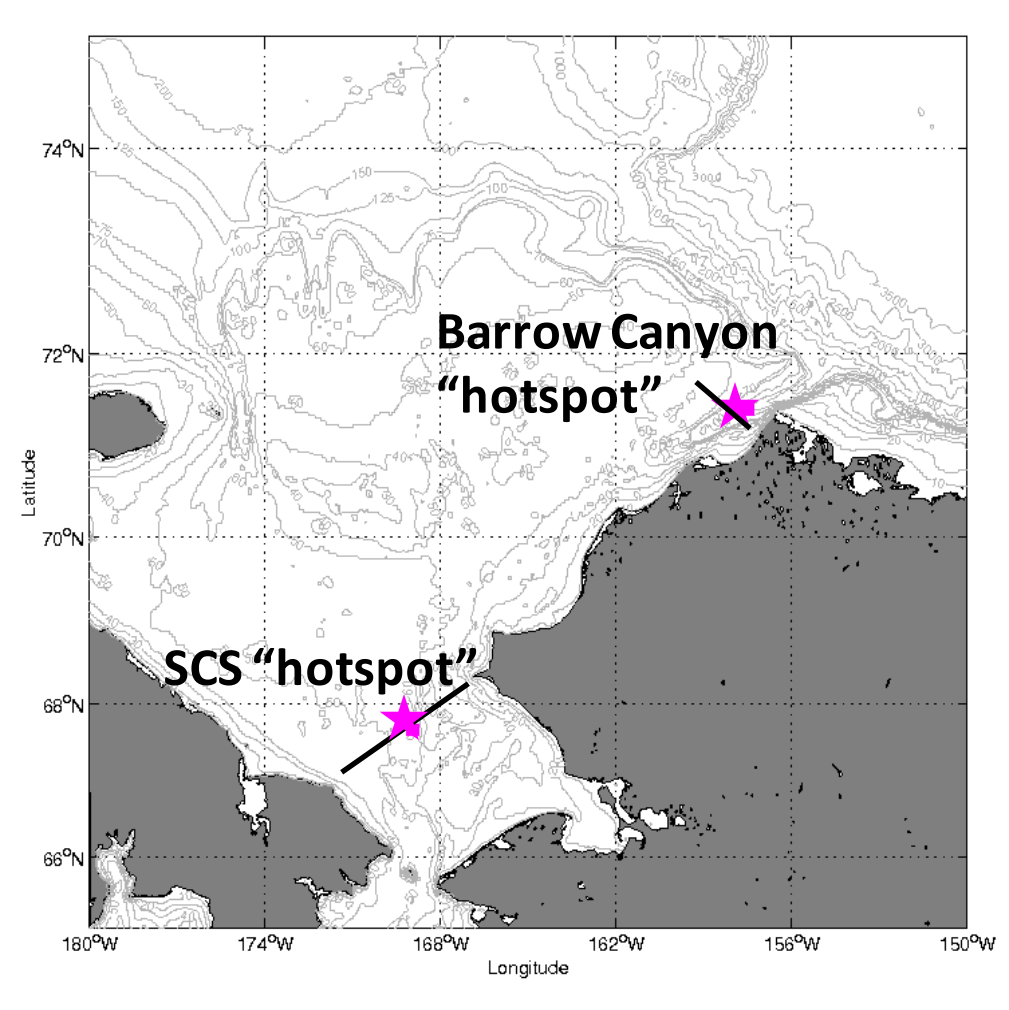
ASSW 2010= IASC/AOSB Endorsement [April 2010]Arctic Ocean Sciences Board: Marine Working Group

- ACTION: The Board supports the DBO pilot program in the Pacific Arctic Sector, and will…
- Co-sponsor a workshop w/ PAG to identify ways to expand the program to a pan-Arctic DBO
- AOSB Steering Group will consult with ICES to determine their interest in the DBO concept.

Introduction: The DBO 2010 and 2011 Pilot Program and Beyond

- 2008 Discussions within PAG for observations and synthesis activities
- May 2009: NOAA Biology workshop, Seattle, WA; also NSF/NOAA Bering Strait workshop, both in May
- Feb. 2010: Open session on the Distributed Biological Observatory (DBO) planning effort, Feb. 2010, Ocean Science Meeting, ~40 participants
- April 2010: DBO discussion at ASSW, Nuuk, Greenland:,AOSB:MWG
- May 2010: Feature article in EOS on NOAA Biology workshop and DBO
- June-October 2010 DBO field pilot project: multiple DBO occupations
- Dec. 2010: Update on DBO 2010 pilot project at PAG meeting in Tokyo, Japan
- Jan 2011: DBO poster at the Alaska Marine Science Symposium Anchorage, AK
- Jan 2011: DBO workshop at the AMSS, ~50 participants
- Jan 2011: Presentation to AOSB/MWG in Potsdam, Germany
- Continued interest by multiple US agencies in DBO planning effort, listed in NOAA strategic plans, discussions with US NSF SEARCH, USGS, BOEM, NOAA
- Mar 2011: DBO workshop at ASSW, Seoul, Korea, status & 2011 plans, ~90 people
- Mar 2011: PAG meeting discuss 2011 DBO plans, future direction
- June-October 2011 DBO field pilot project: multiple DBO occupations
- Nov 2011: DBO Workshop in Sidney, BC and PAG meeting, ~35 people
- Dec 2011: Open DBO information session at AGU
- Feb 2012: Open DBO information session at Oceans meeting in Salt Lake City
- April 2012: DBO updates and discussion PAG and IASC AOSB/MWG Montreal IPY

DBO 2010 and 2011 "Pilot" Season: International cruises to Pacific Arctic (**both years)



http://pag.arcticportal.org

Vessel	Country	PI
Moana Wave	USA	Grebmeier
Healy (**)	USA	Arrigo
Xue Long	China	He
Mirai *Laurier (**)*	Japan Canada	Itoh Vagle
Khromov (**)	Russia and USA	Woodgate
Alaskan Enterprise	USA	Napp
Annika Marie (**)	USA	Ashjian
Healy (**)	USA	Pickart

2010 DBO International Pilot Project

DBO 2010 Data Parameter Matrix (SE Chukchi Sea-SECS) and Barrow Canyon (BC)

Cruise (DBO PI Lead)	Period (DBO lines)	CTD*	Chl-extracts	Nutrients	Algae-Ice/Phyto-plankton: size, biomass, composition	Zooplankton: size, biomass, composition	Benthos: size, biomass, composition	Seabird surveys	Marine Mammal surveys
Healy 1001 (Pickart)	June-July (both)	x	x	x	x			x	
Sir Wilfrid Laurier (Vagle)	July (both)	x	x-SECS only	x		x**	x**	x	
Moana Wave** (Grebmeier)	July-Aug (both**)	x	x	x	x	x	x	x	x
Xuelong (He)	July-Aug	x	x	x	x	x	x***		
Annika Marie (Ashjian)	August (BC)	x	x	x	x	x		x	x
Alaskan Enterprise (Napp/CHAOZ)	Aug-Sept (BC)	x							x
Khromov (Woodgate) (RUSALCA CS line)	Aug (SECS)	x	x	x	x	x			x
Healy 1003 (Pickart)	Sept (BC)	x		x				x	x
Mirai (Itoh)	Oct (BC; one stn SECS)	x	x	x		x (1 stn)			
Sum data sets		**9**	**7**	**8**	**5**	**6**	**3**	**5**	**5**

*=T, S, plus some cruises transmissivity, fluorescence (chlorophyll), CDOM, dissolved oxygen, pH

**=all water column, plankton and benthic data at "hotspot" sites both areas, plus nearshore stn SECS line; seabird/marine mammal

***=3 stations per transect

2011 DBO International Pilot Project-UPDATE

DBO 2011 Data Parameter Matrix (SChukchi Sea-SCS) and Barrow Canyon (BC)

Cruise (DBO PI Lead)	Period (DBO lines)	CTD*	Chlorophyll-extractions	Nutrients	Algae-Ice/Phyto-plankton: size, biomass, composition	Zooplankton: size, biomass, composition	Benthos: size, biomass, composition	Seabird surveys	Marine Mammal surveys
Healy 1101 (Pickart and Arrigo)	June 15-July 25 (both)	x	x	x	x				
Sir Wilfrid Laurier (Vagle and Grebmeier)	July 6-21 (both)	x	x	x	x	x	x	x	x
Khromov (Woodgate)	July 9-25 (SECS)=RUS ALCA CS line	x	x	x	x	x			x
Annika Marie (Ashjian)	August (BC)	x	x	x		x			x
Alaskan Enterprise (Napp/CHAOZ)	Aug-Sept (BC)	x				x			x
Healy 1103 (Pickart)	Sept (BC)	x		x				x	
Healy 1104 (Ashjian)	Nov (BC)	x				x			x
Sum data sets		**7**	**4**	**5**	**3**	**5**	**1**	**2**	**5**

*=T, S, plus some cruises transmissivity, fluorescence (chlorophyll), CDOM, dissolved oxygen, pH

Tuesday, Nov. 15

0830-0900

- **Welcome and Introductions** *(Jackie Grebmeier)*

  - Jackie Grebmeier, Chair DBO/PAG Science Steering Committee
  - Bill Willams, IOS/DFO
  - Robet Fudge, Director NCAARE (National Center of Arctic Aquatic Research Excellence); introduce Sally Wong (NCAARE)
  - Welcome on behalf John Calder and Kathy Crane; introduce Gillian Lichota (NOAA)
  - Sara Bowden, AOSB/MWG IASC

  - Introduction of participants and annoucements

  - Brief DBO Overview: What and why a DBO?

0900-1000

- **Data analysis and integration: individual field results from the DBO 2010 and 2011 effort; presentations by DBO field participants and collaborators (10 min talks)**

  - Satellite derived trends across the DBO

    - "Satellite derived trends across the DBO" (*Karen Frey)*

    - "Inter-annual variation of primary productivity in the Bering and Chukchi Seas from satellites using an absorption-based model" (*Toru Hirawake*)

  - Seasonal variation of water masses

    - "Biogeochemical and physical oceanographic sampling along DBO lines from CCGS Sir Wilfrid Laurier 2010 & 2011" (*Svein Vagle*)

    - "Bering Strait - up to RUSALCA 2011" (*Rebecca Woodgate*)

    - "Physical and biogeochemical results: Pilot DBO" (*Jackie Grebmeier and Bob Pickart*)

  - Phytoplankton collections

1000-1030 Break

1030-1200

- **Continued DBO data analysis and integration (10 min talks)**
  - Zooplankton collections
    - "Zooplankton collections within the DBO effort" (*John Nelson*)
    - "RUSALCA and industry zooplankton study efforts" (*Russ Hopcroft*)
  - Benthic collections
    - "Benthic time series collections within the DBO effort" (*Jackie Grebmeier)*
    - "Benthic species diversity and dynamics along the DBO sites" (*Monika Kedra*)
  - Marine mammal, seabird and fish observations
    - "Fish, seabird and marine mammal observations during the 2010-2011 pilot DBO" (*Sue Moore*)
  - Other data sets from DBO participants?
- Open discussion period

1200-1330 Lunch Break-IOS cafetria

1330-1430

- DBO Plans for 2012 onwards
  - "New Japanese project on sea ice reduction/variability and its impact to Arctic marine ecosystem" (*Takashi Kikuchi/JAMSTEC*)
  - "Planned US and international DBO efforts" (*Jackie Grebmeier*)
  - Other country plans related to DBO?
- Open discussion period for collaborations and publication planning

1430-1500 Coffee Break

1500-1545

- International data collection, use and archiving topics
  - "A-CADIS (Advanced-Cooperative Arctic Data and Information Service") data archiving of DBO field data" (*Jim Moore*)
  - Open discussion national and international data use issues, need for data plan, common data portal
  - ACTION: Formation of DBO data working group

1545-1715

- **Program expansion, outreach and interfaces for pan-Arctic DBO (10 min talks)**
  - "Arctic Resilience Report/Arctic Council effort" (*Eddy Carmack*)

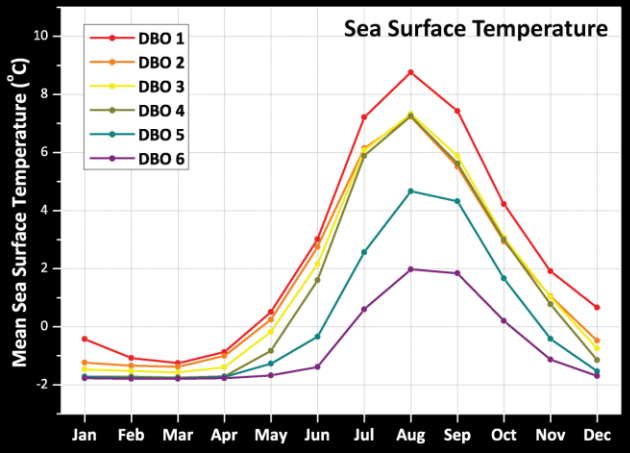
- "Twenty year observation series from Norwegian and Greenland Seas, and Fram Strait" (*Monika Kedra*)
- "Time series for an East Siberian Sea DBO?" (*Igor Semiletov*)
- "DBO Extensions: Canada Basin (JOIS) and Cape Bathurst 'hotspot' and beyond" (Bill Williams)
- "Hausgarten and Svalbard Observatory" (*Michael Klages*) and "Future DBO collaboration in the Eusasian Arctic" (*Marit Reigstad*) (*both presented by Jackie Grebmeier*)
- "The DBO within the CBMP (Circumpolar Marine Biodiversity Monitoring Plan" and SAON (Sustaining Arctic Observing Network) (*John Calder and Kathy Crane, presented by Jackie Grebmeier*)
- DBO as a NSF Research Coordination Network? (*Jackie Grebmeier*)

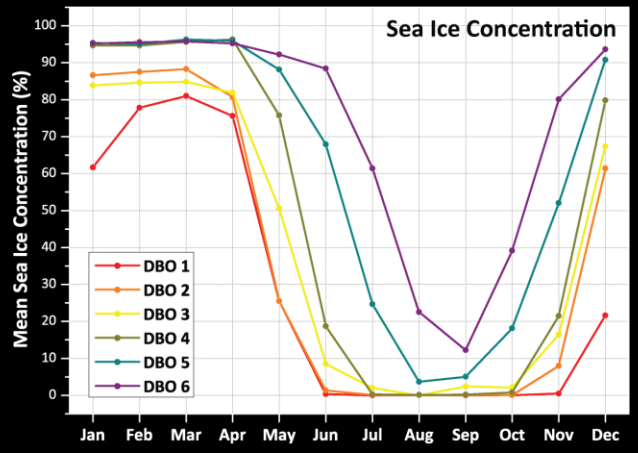
- **Concluding remarks and end Day 1 DBO workshop**

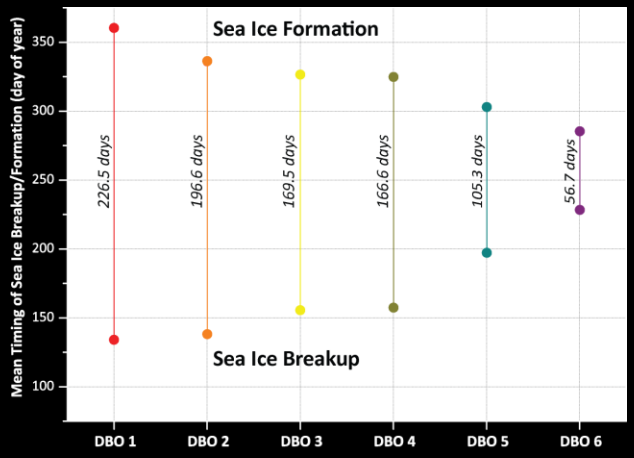
1900 Group dinner at Sabhai Thai restaurant in Sidney, BC (2493 Beacon Ave, 2 blocks on the main street from the meeting hotel) for DBO workshop participants; hosted by IASC AOSB/Marine Working Group

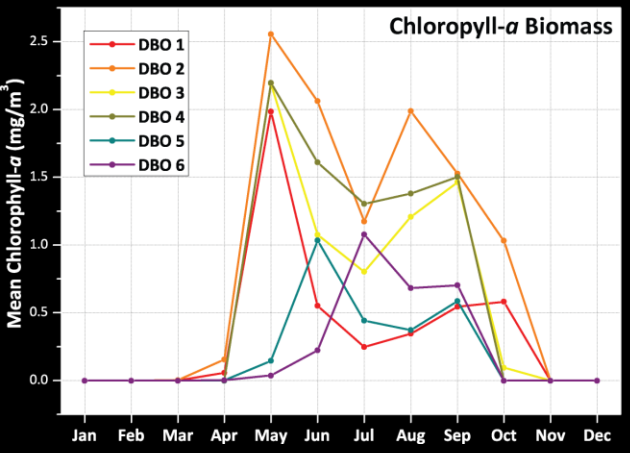
A Climatology of the DBO Sites

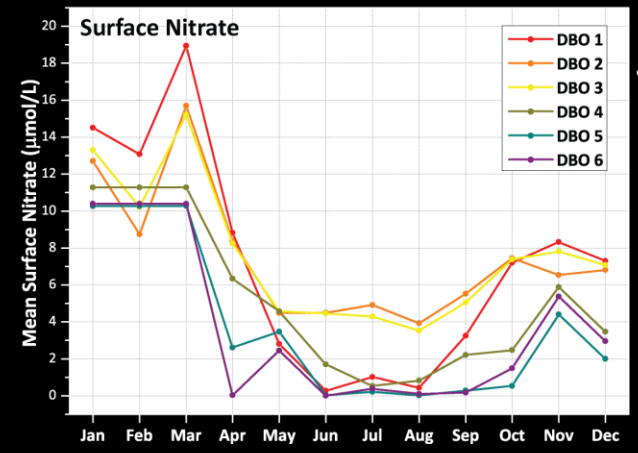
Sea Surface Temperature (AVHRR)
Sea Ice Concentration (SMMR/SSMI)
Sea Ice Breakup/Formation Timing (SMMR/SSMI)
Chlorophyll-*a* Biomass (Globcolour)
Surface Nitrate (World Ocean Atlas)
Solar Insolation (NASA)

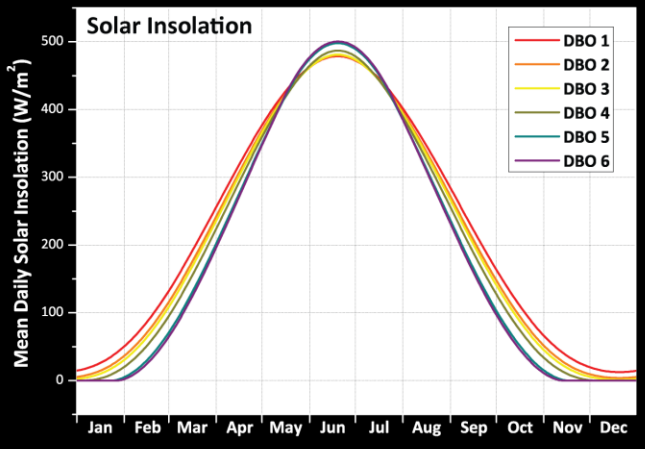








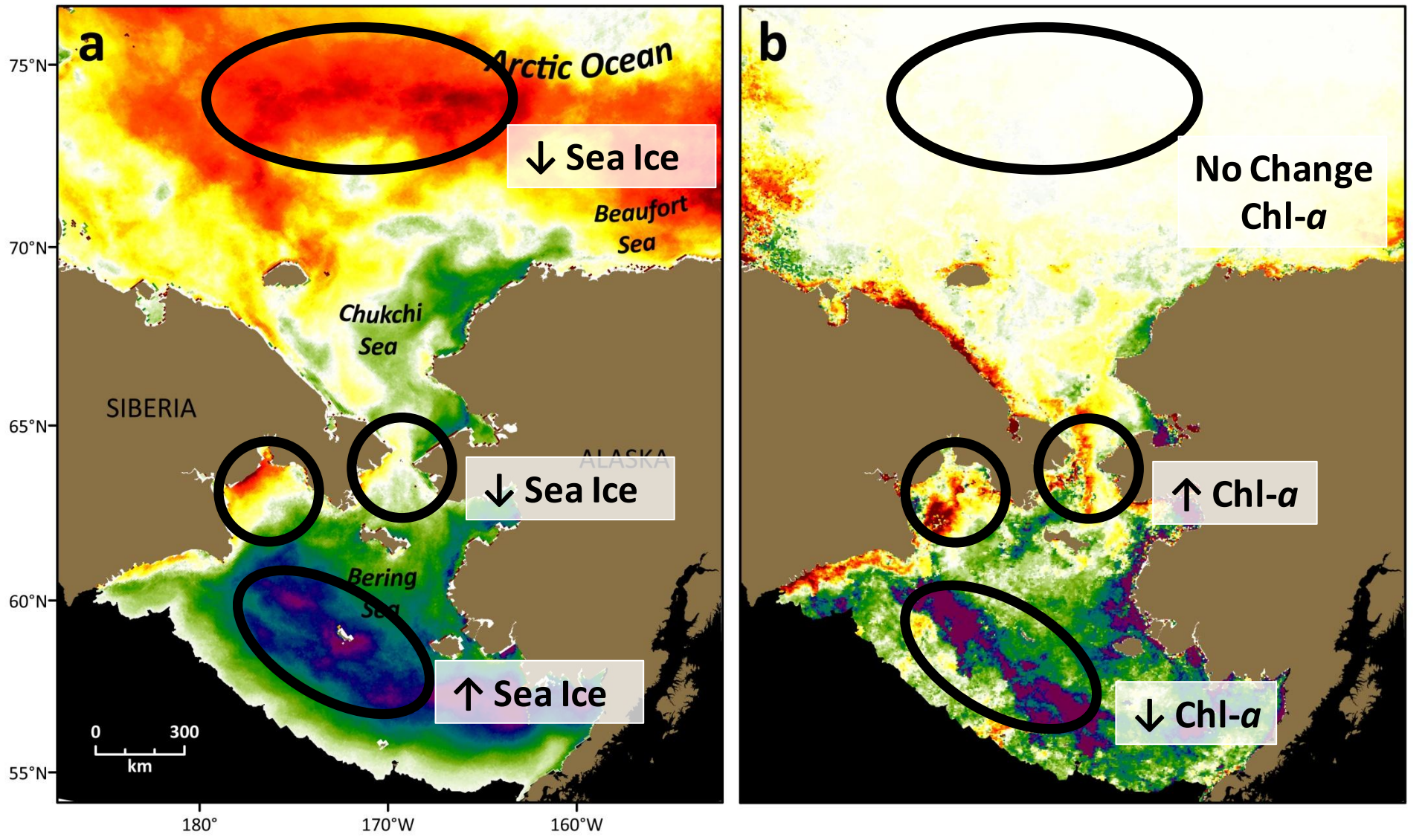




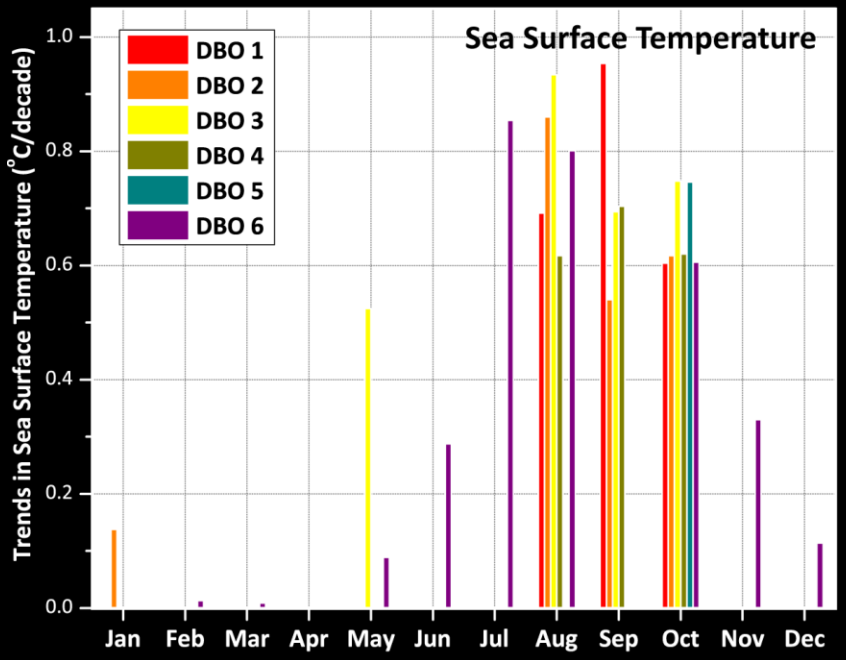
[Karen Frey]

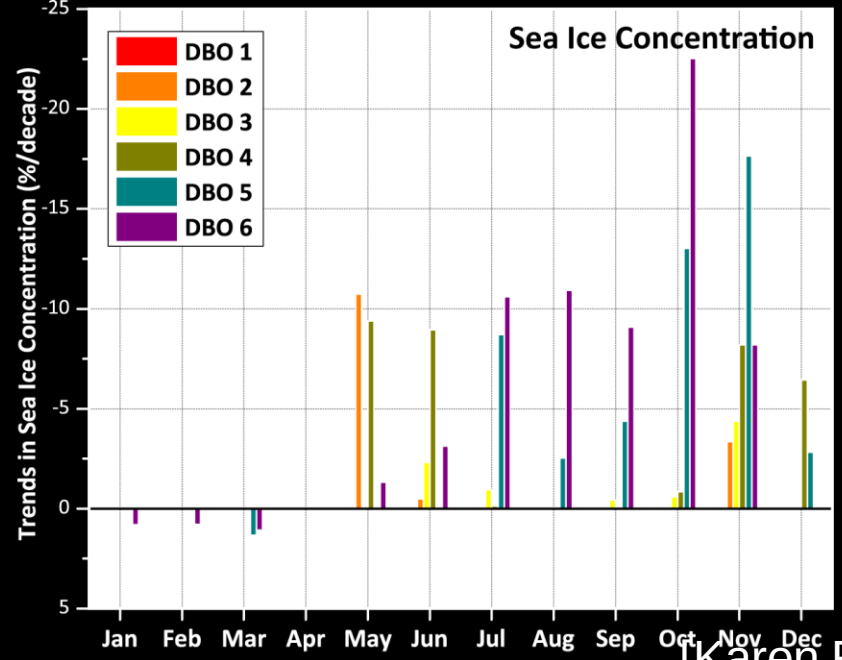
Recent Shifts in Sea Ice Persistence vs. Chlorophyll-*a* Biomass

(2003-2009, AMSR-E/MODIS era) [Karen Frey]

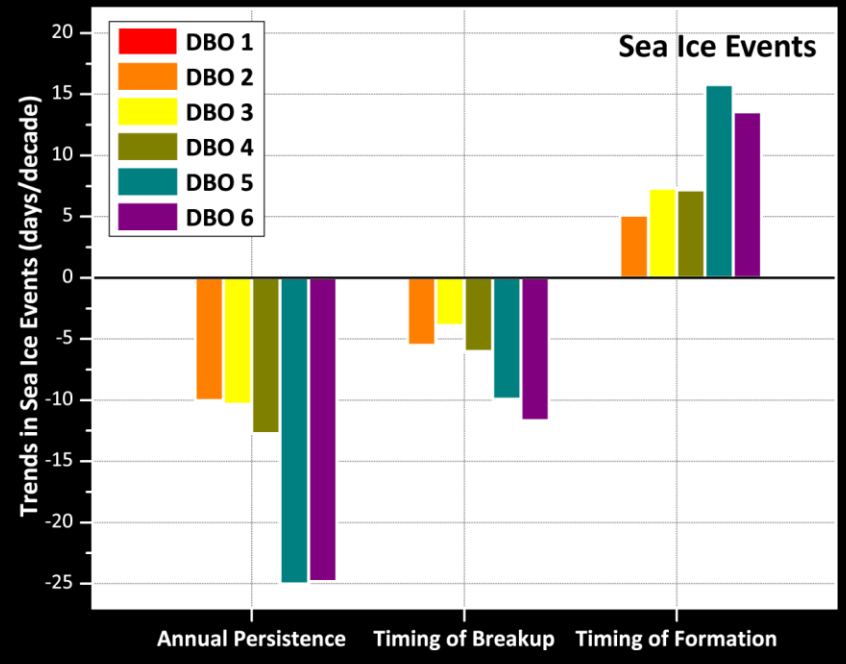


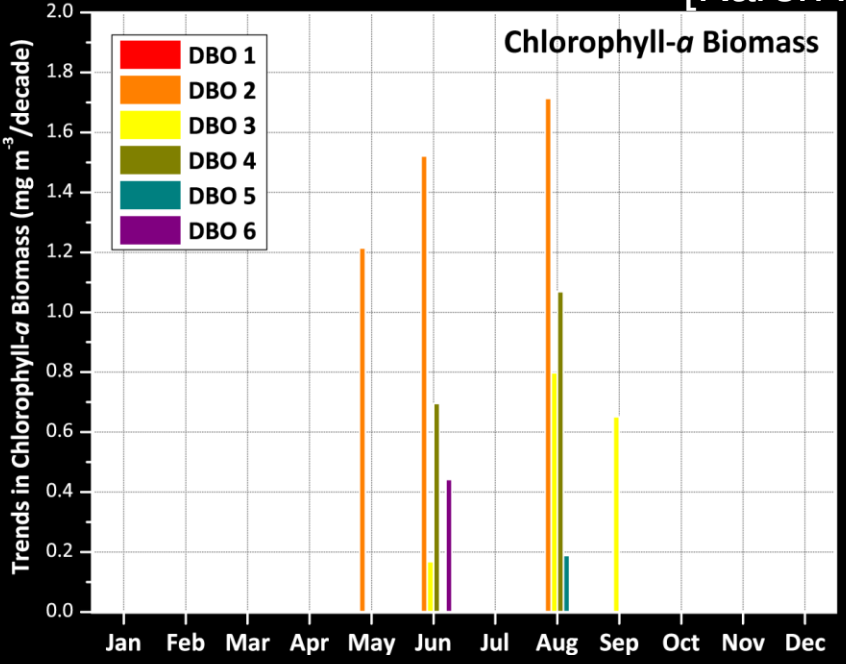
Trends in SST, Sea Ice Cover, Chl-*a* Biomass (Mann-Kendall, $p<0.1$)



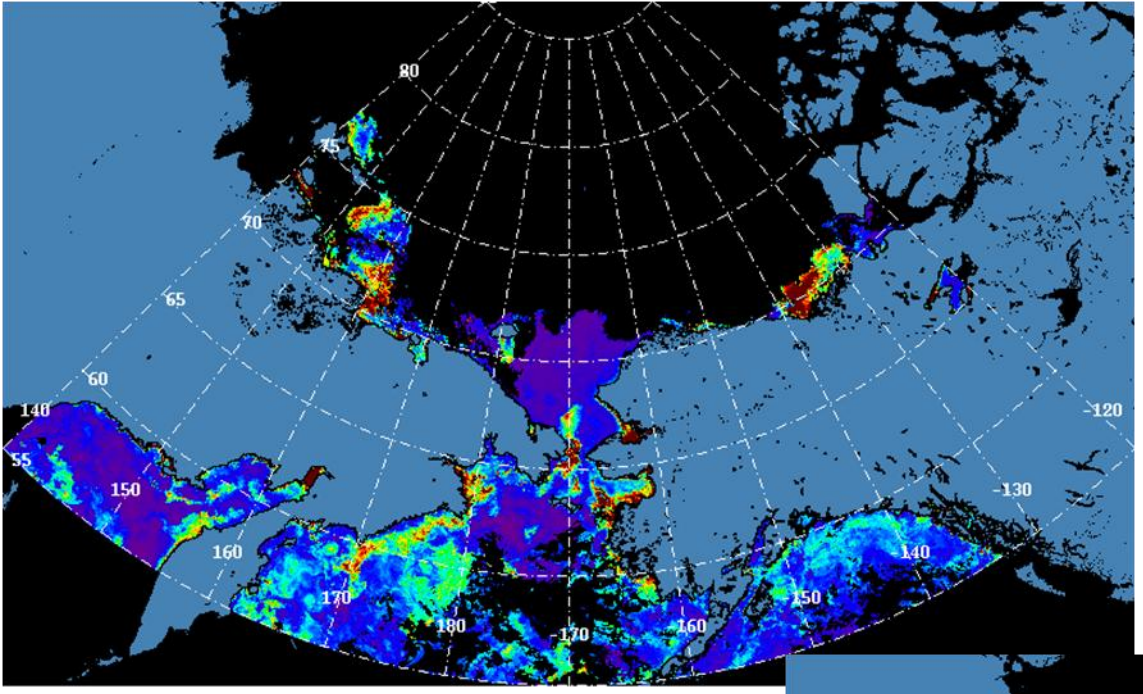


[Karen Frey]



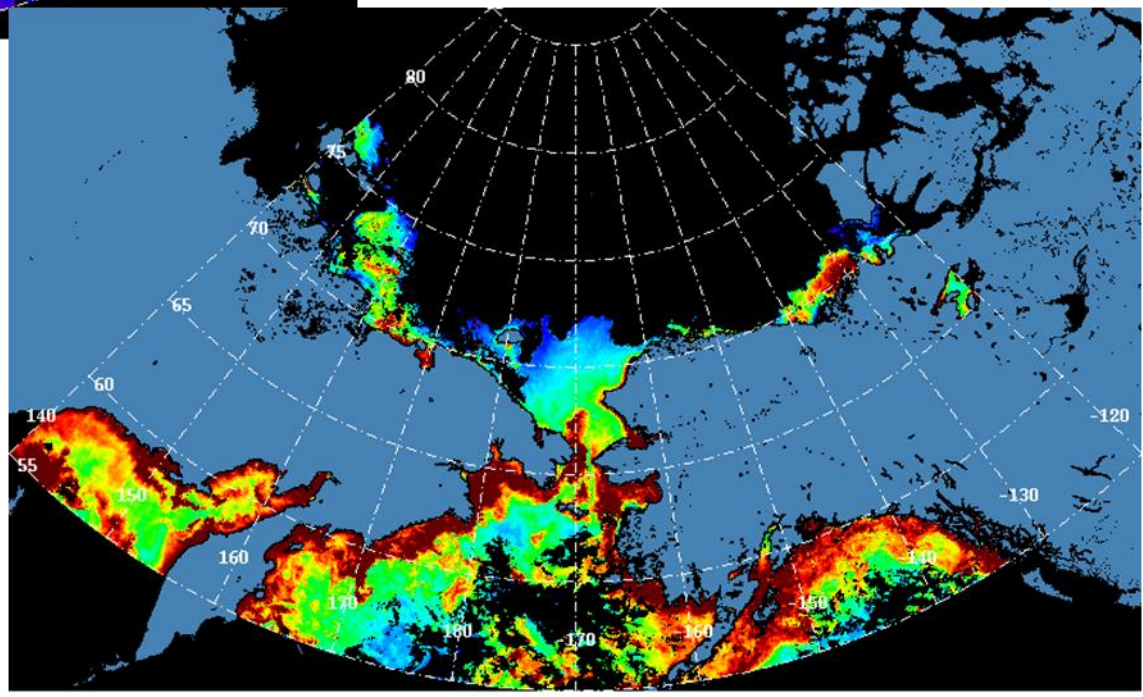


Column integrate daily primary productivity in July 2002 (mg C m^{-2} d^{-1})



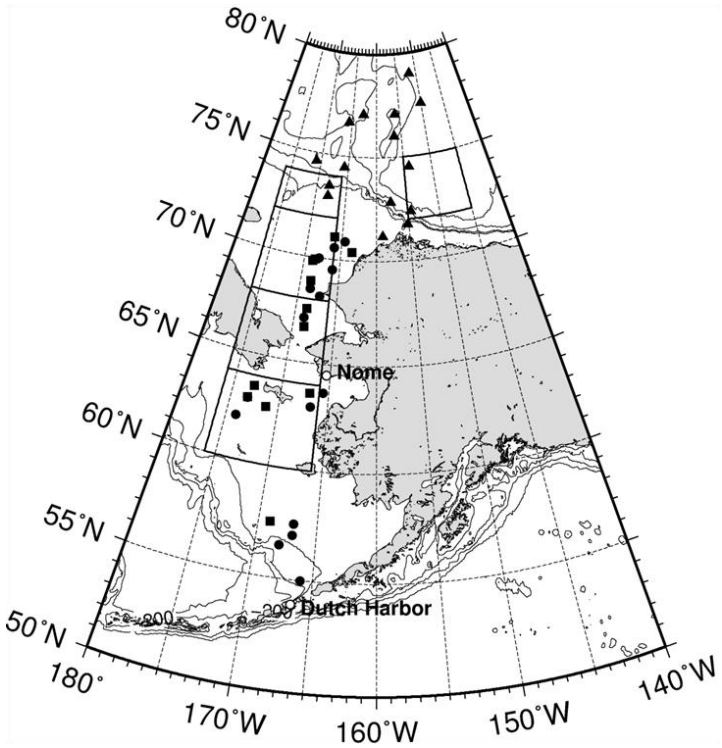
Absorption-based

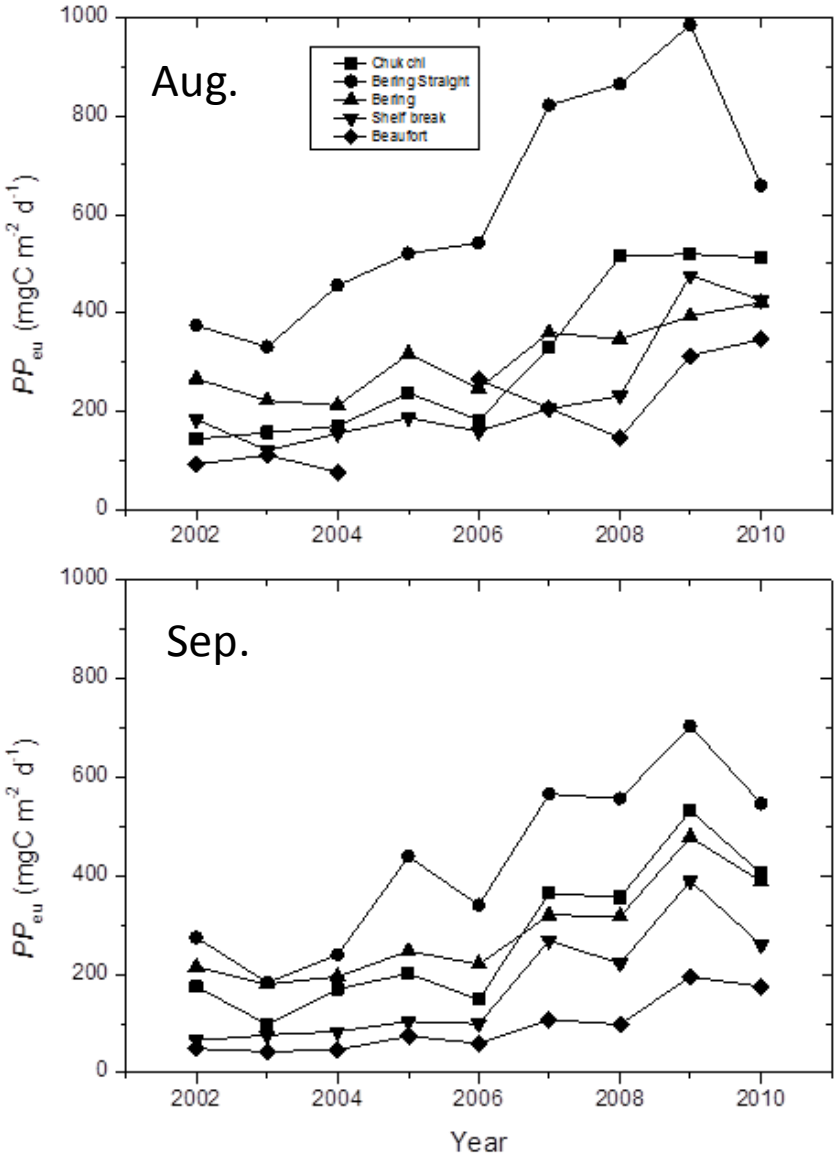
VGPM



[Toru Hirawake]

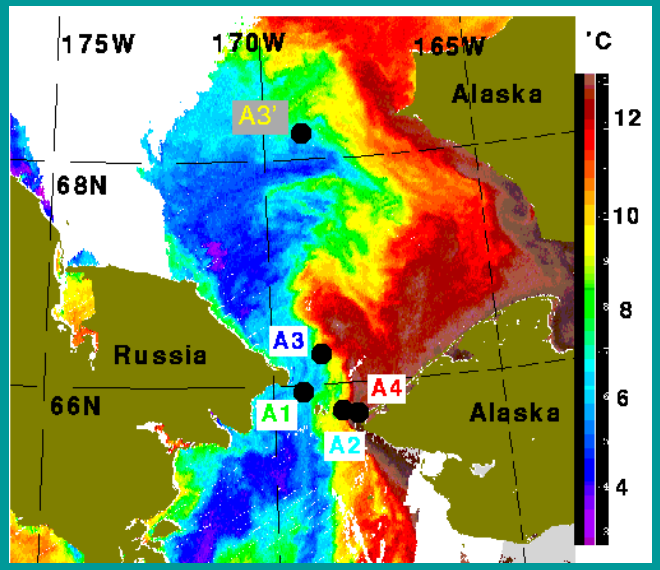
Inter-annual variation in PP

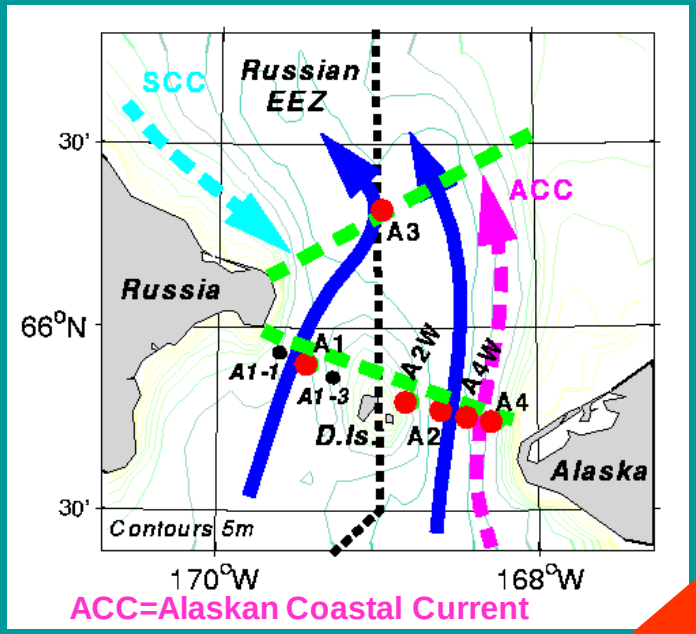




[Toru Hirawake]

Bering Strait Moorings





ACC=Alaskan Coastal Current

Since 1990

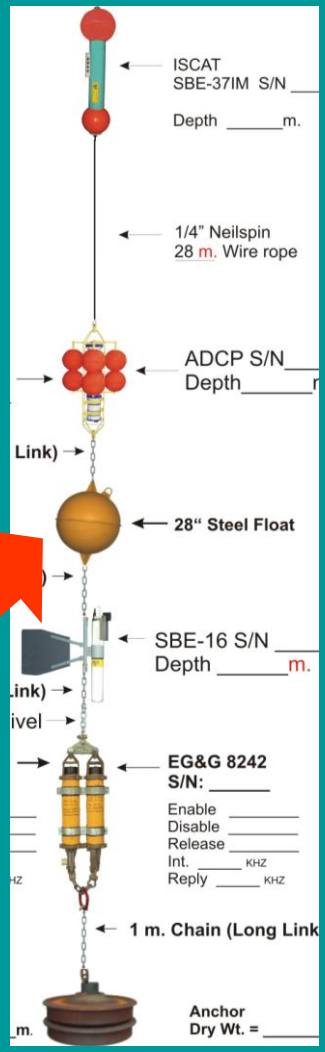
1-4 near–bottom moorings

Since 2007

(International Polar Year)

8 moorings with upper and lower sensors

Your instrument here!!!!



Now also with

- Whale Recorders – Kate Stafford and Carter Esch

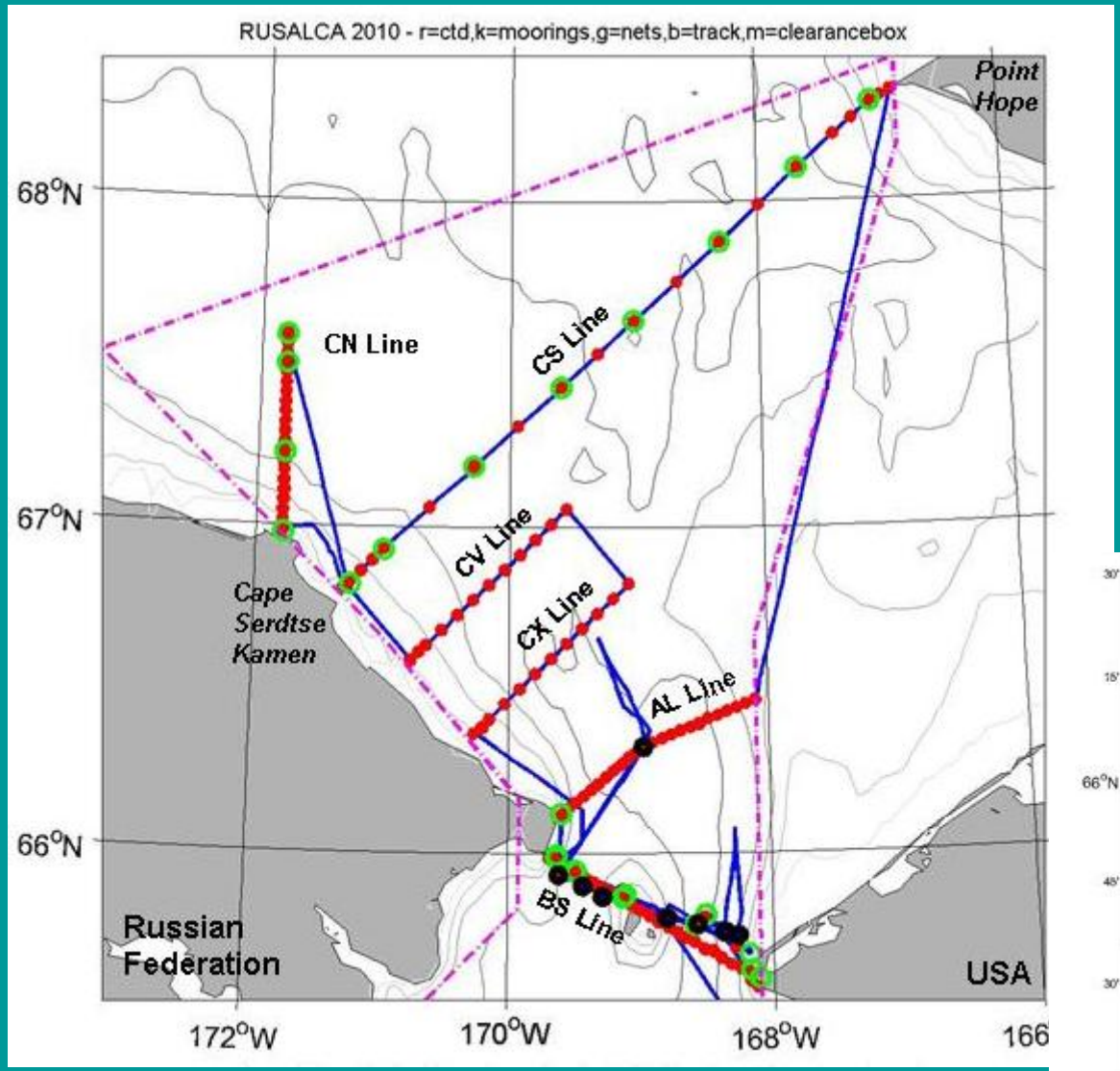
- pH and pCO2 sensors – Fred Prahl, OSU

Annual CTD sections

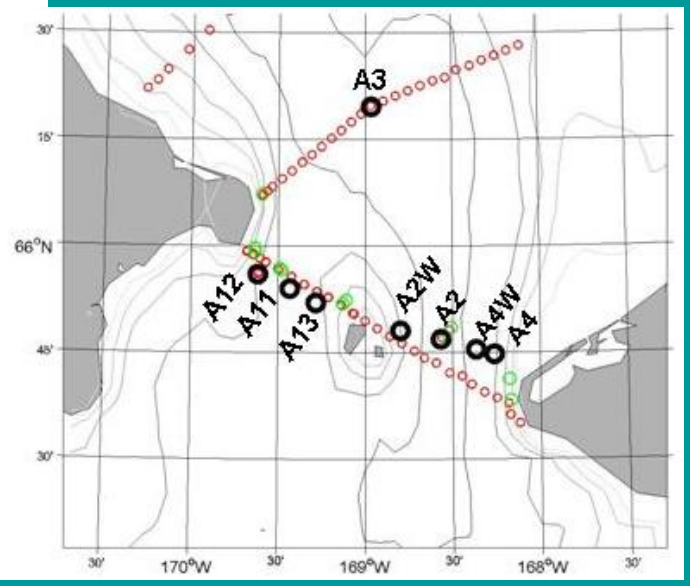
[Rebecca Woodgate]

RUSALCA 2010 Khromov Cruise

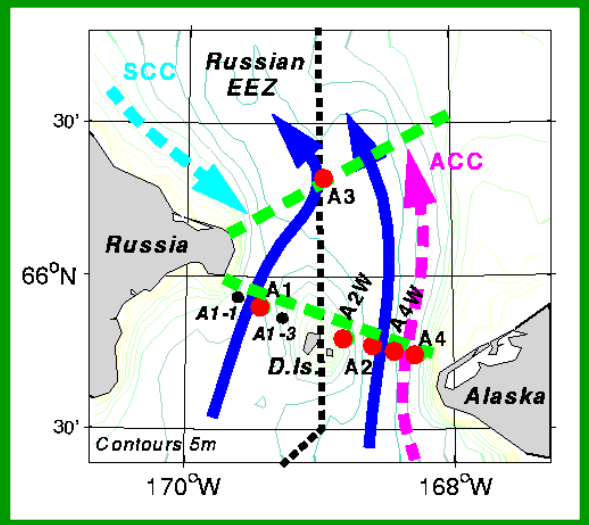
31st July – 11th Aug 2010
Nome to Nome



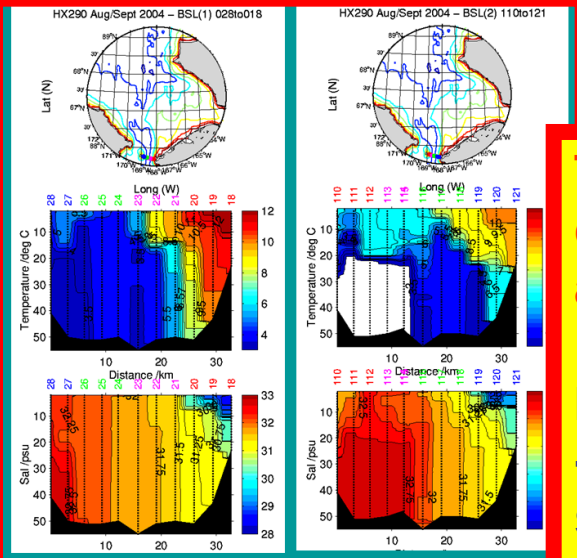
Mauve = clearance box
Blue = ship track
Black dots = moorings
Red dots = CTDS
Green dots = nets
+ 4 Primary productivity stations



[Rebecca Woodgate]



High resolution mooring array in the strait + CTD until 2013
– RUSALCA-NOAA & NSF

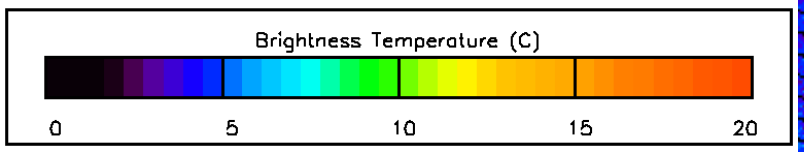


Time and space scales of change are FAST (hours) and SMALL (kms or less)

NEED TO WORRY ABOUT
- lack of synopticity of sections
- how representative a snap shot section is of what we really want to know
- what DO we really want to know?

WAYS FORWARD
- Comparing section data with Mooring data
- Comparing section data with satellite data

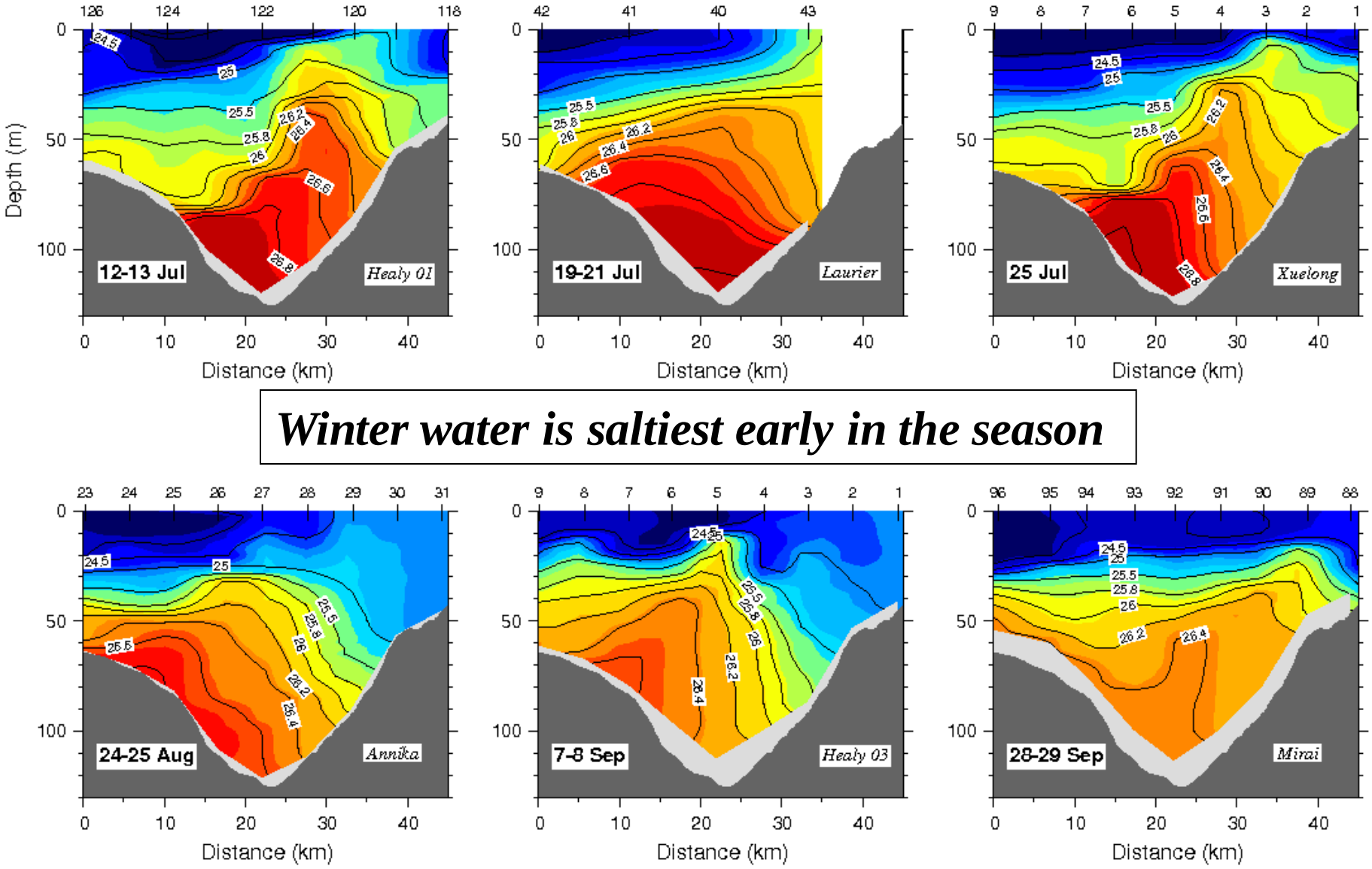
Land Sat – CH6H – Jul18th 2003, from R Lindsay



[Rebecca Woodgate]

psc.apl.washington.edu/BeringStrait.html

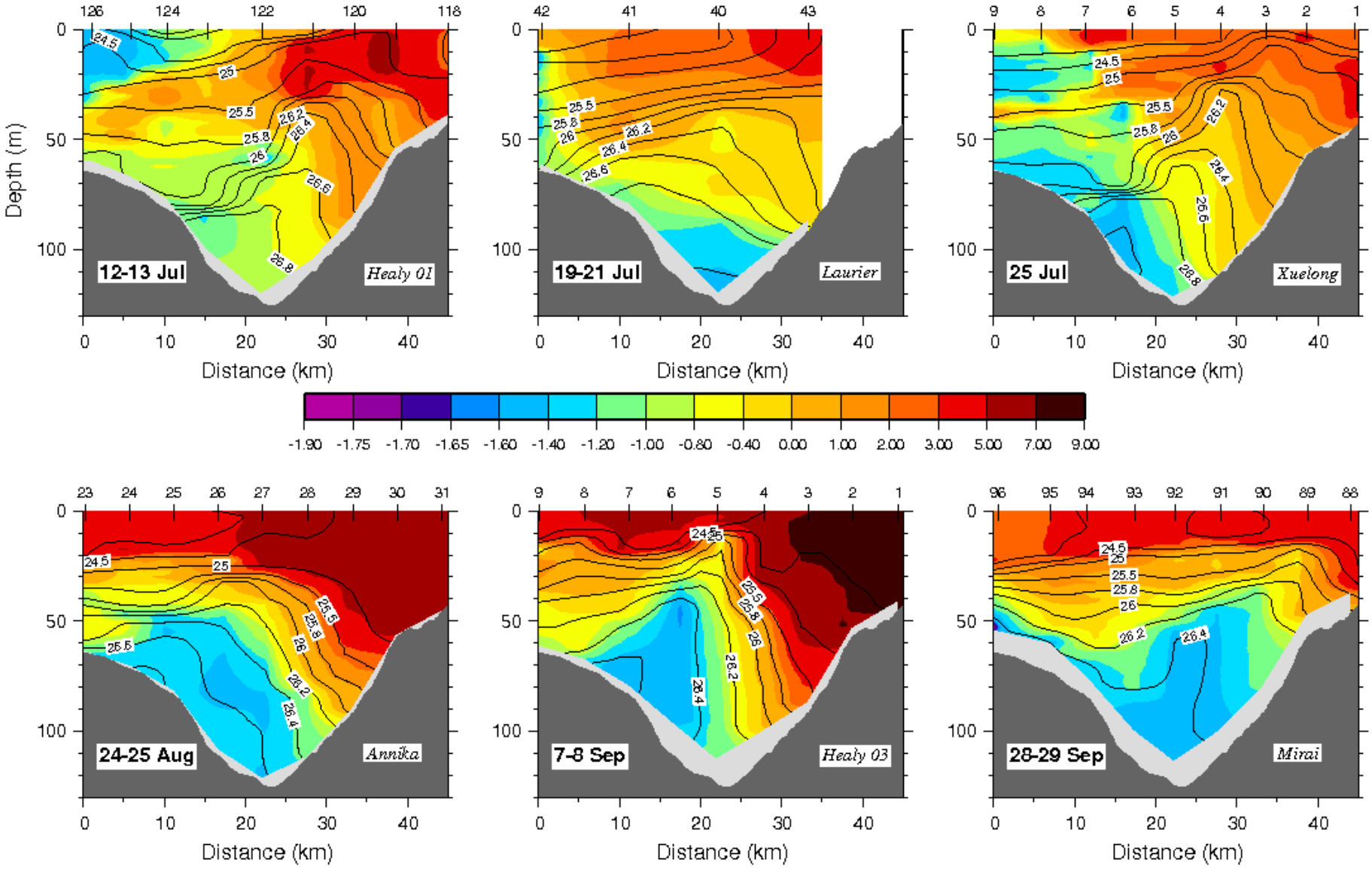
2010: Pickart, Vagle, He, Ashjian, Pickart, Itoh



Winter water is saltiest early in the season

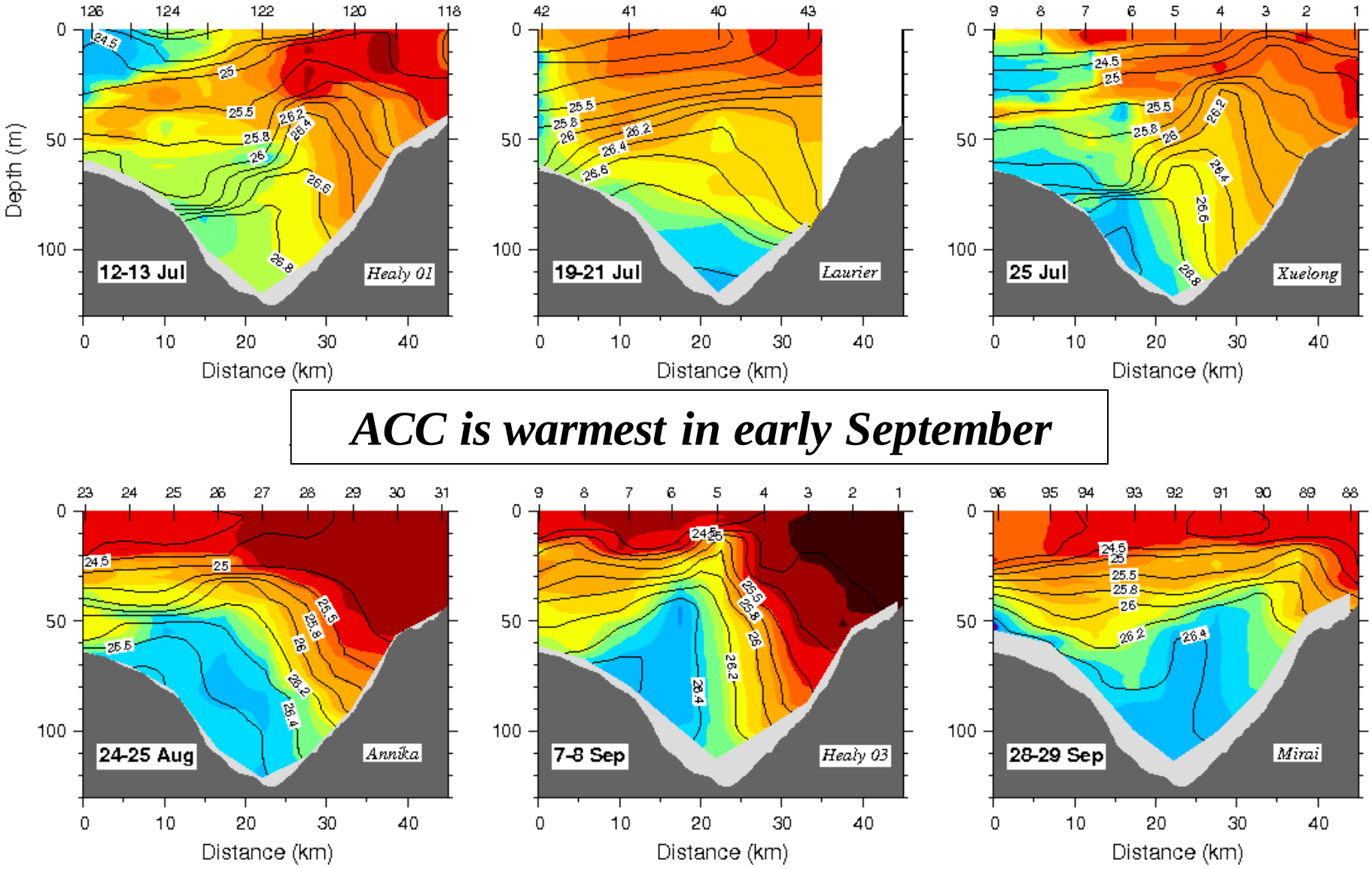
Individual Sections: *Salinity*

2010: Pickart, Vagle, He, Ashjian, Pickart, Itoh



Individual Sections: *Potential Temperature (°C)*

2010: Pickart, Vagle, He, Ashjian, Pickart, Itoh

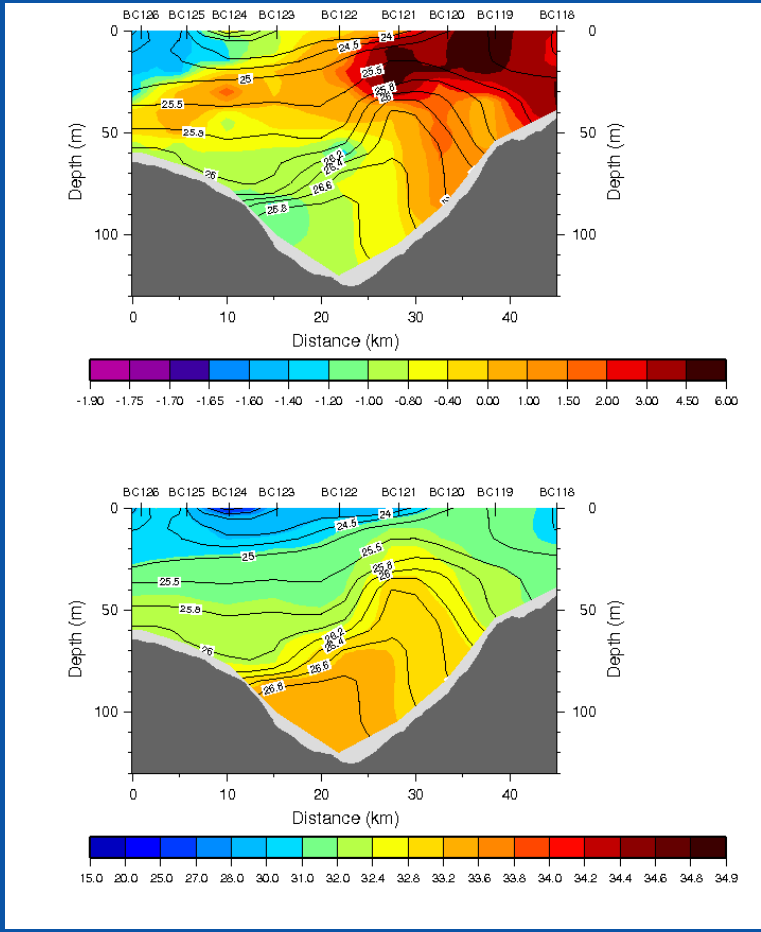


ACC is warmest in early September

Individual Sections: *Potential Temperature (°C)*

Comparison between July 2010 and July 2011

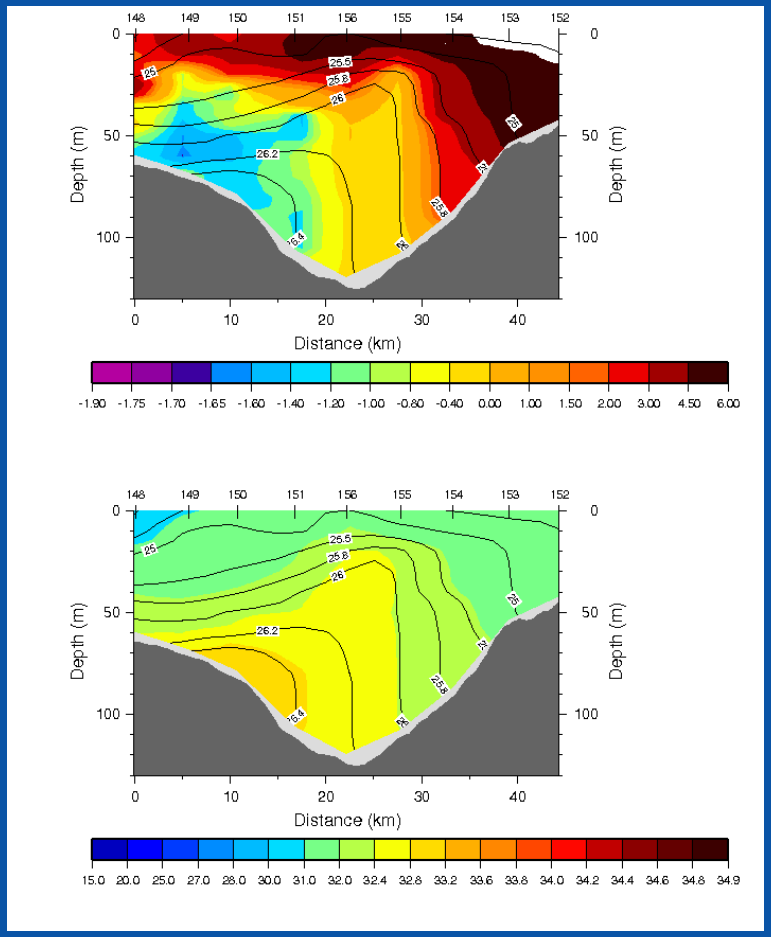
2010



Temp (°C)

Salinity

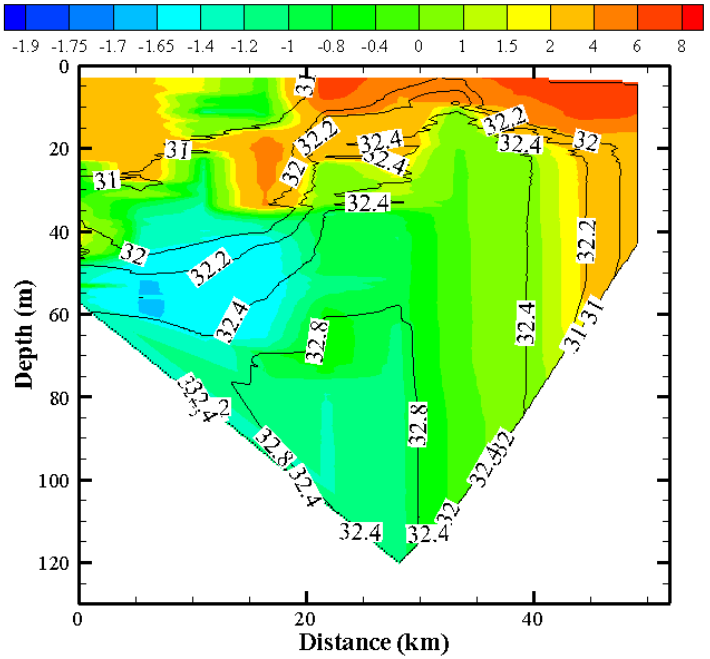
2011

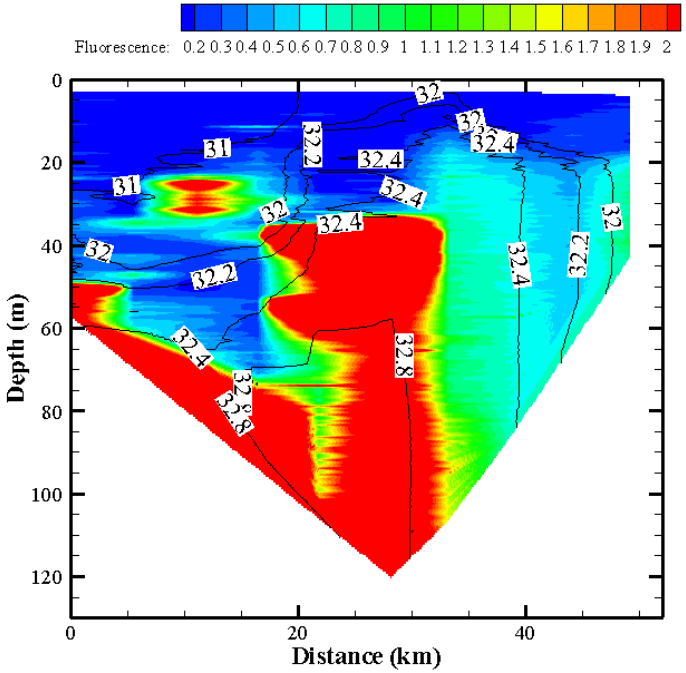


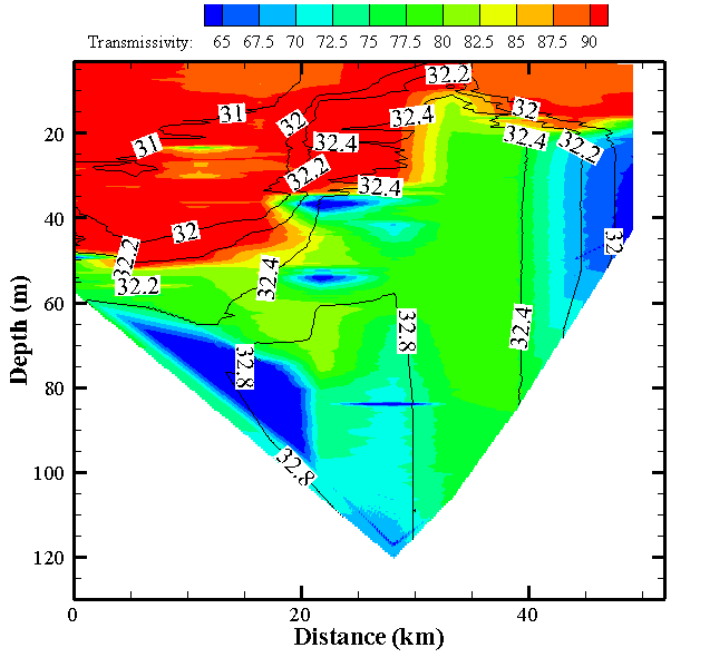
In early 2011 the ACC was warmer and the subsurface winter-remnant water was colder. However, the winter water was pronouncedly less dense. *Why ??*

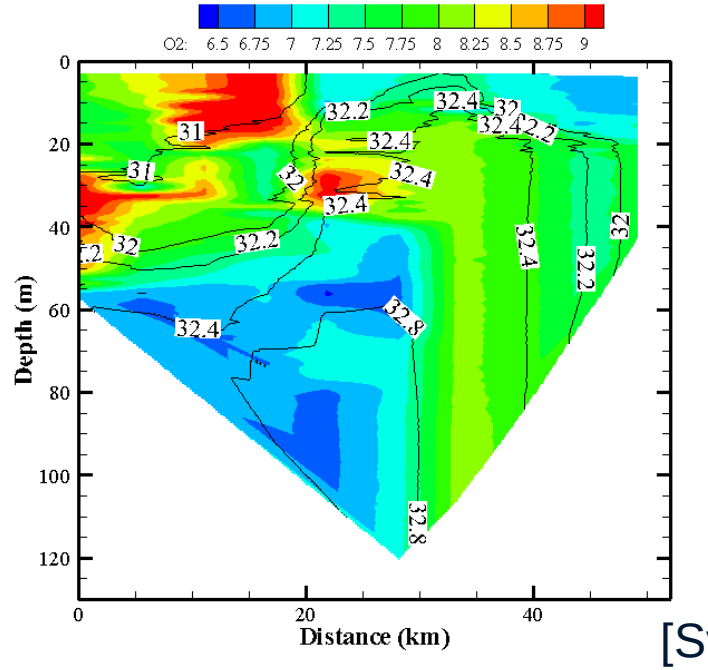
[Bob Pickart]

Barrow Canyon Transect SWL 2011-18, July 20-21





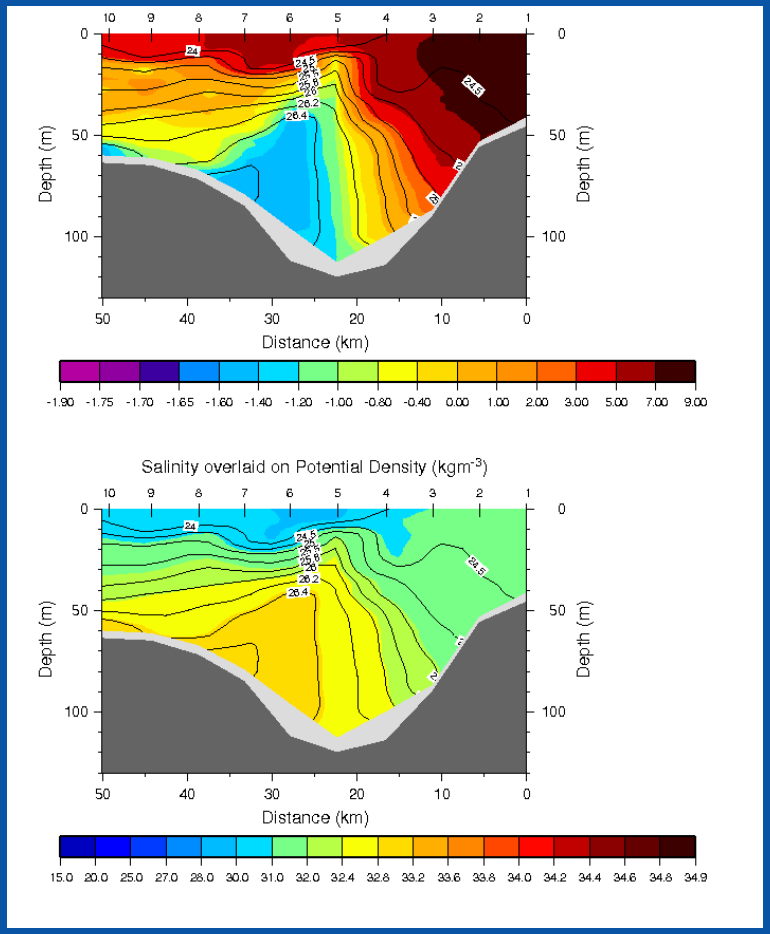




[Svein Vagle]

Comparison between Sept 2010 and Oct 2011

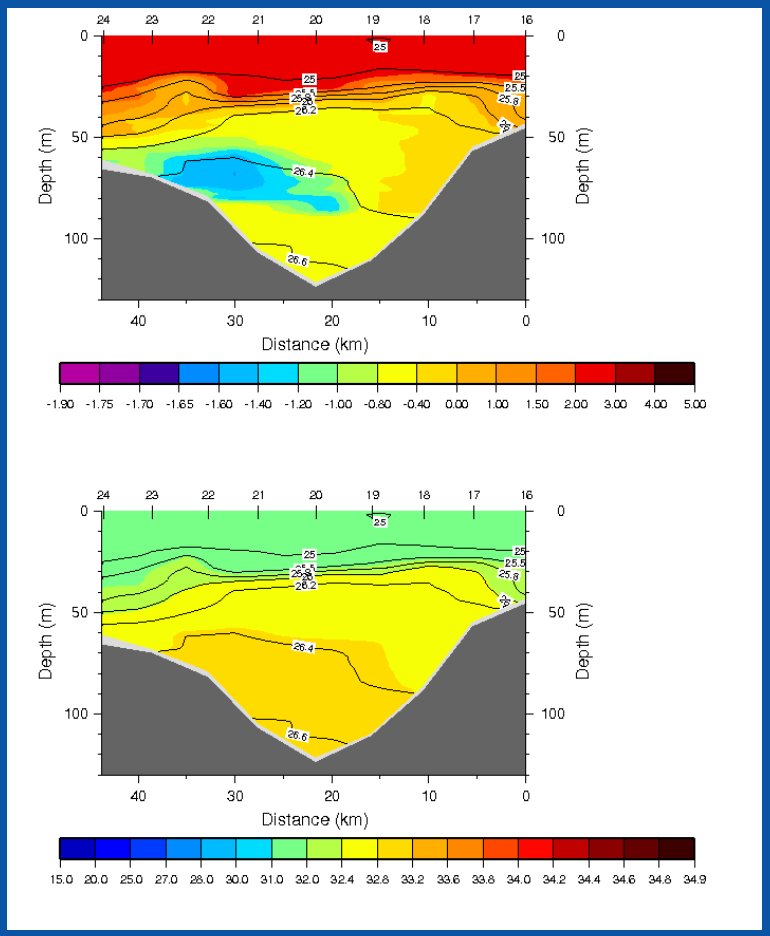
8 Sep 2010



Temp (°C)

Salinity

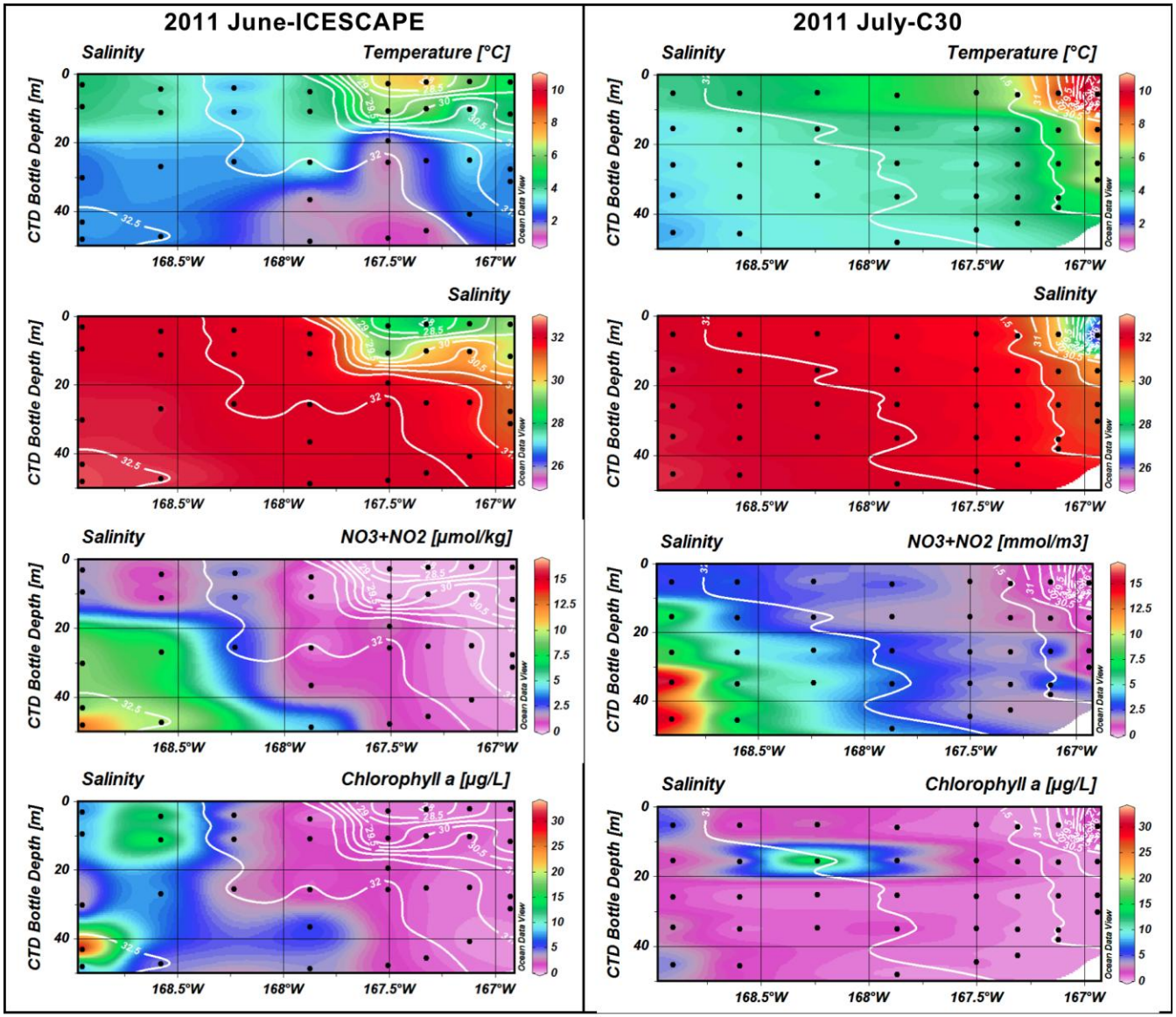
7 Oct 2011



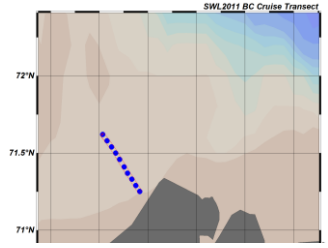
The ACC is absent in the 2011 crossing. Is this a seasonal difference or an inter-annual change (or both)? ***We need more data to sort out such issues!***

[Bob Pickart]

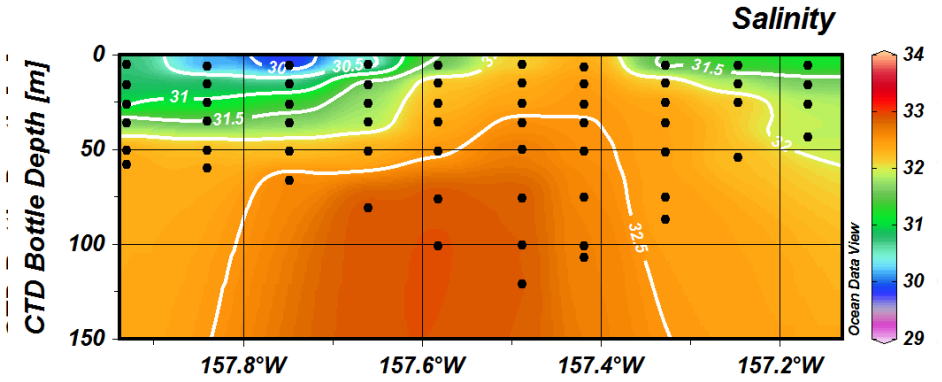
T, S, nutrient and chlorophyll profiles collected in 2011 on the DBO-SCS line

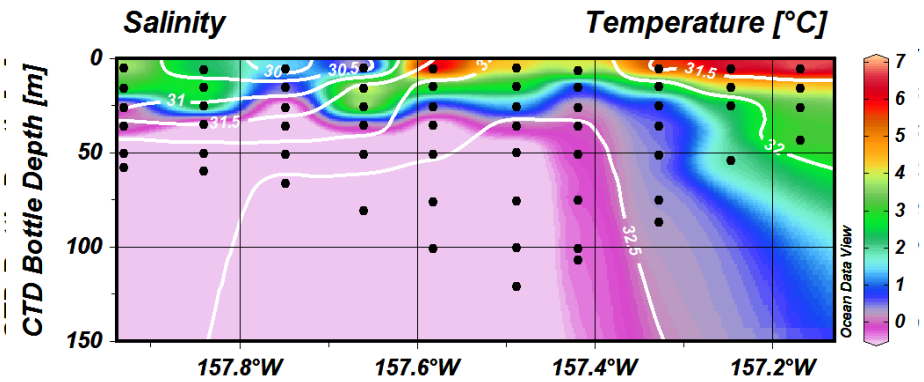


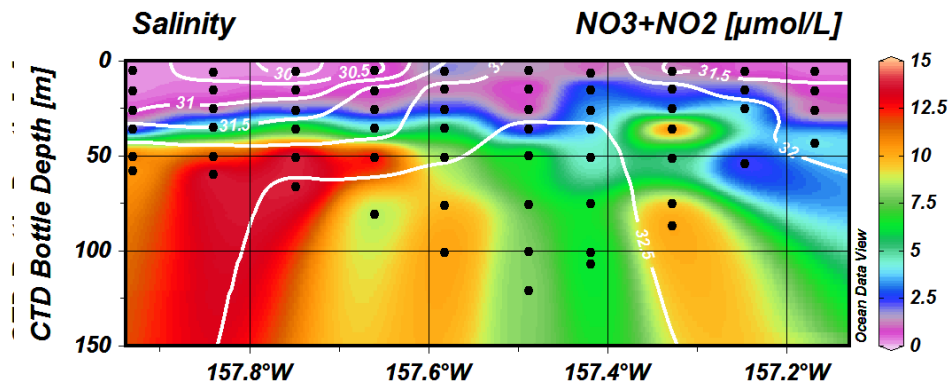
data courtesy ICESCAPE program (Kevin Arrigo) and the C30 program (Jackie Grebmeier/Lee Cooper)

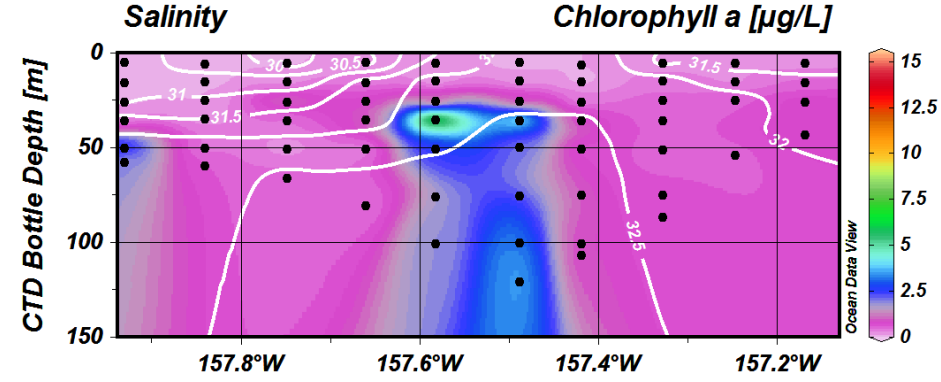


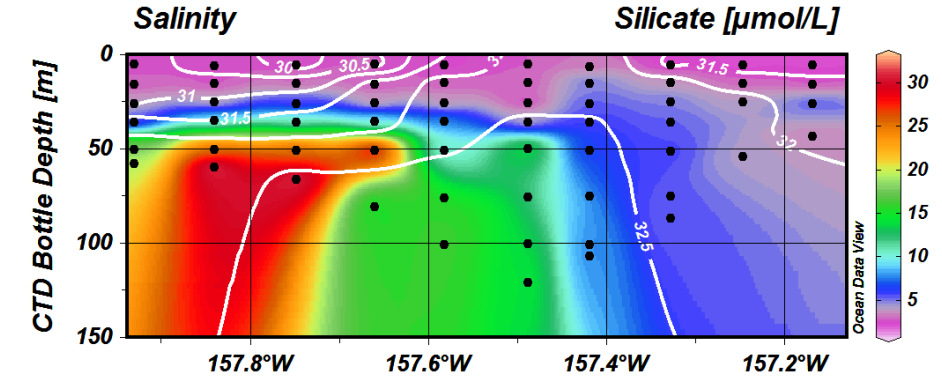
SWL2011 Barrow Canyon: Grebmeier/Cooper

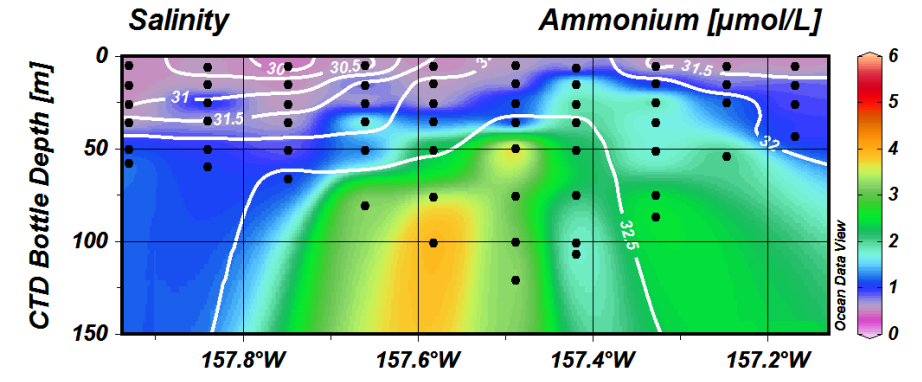


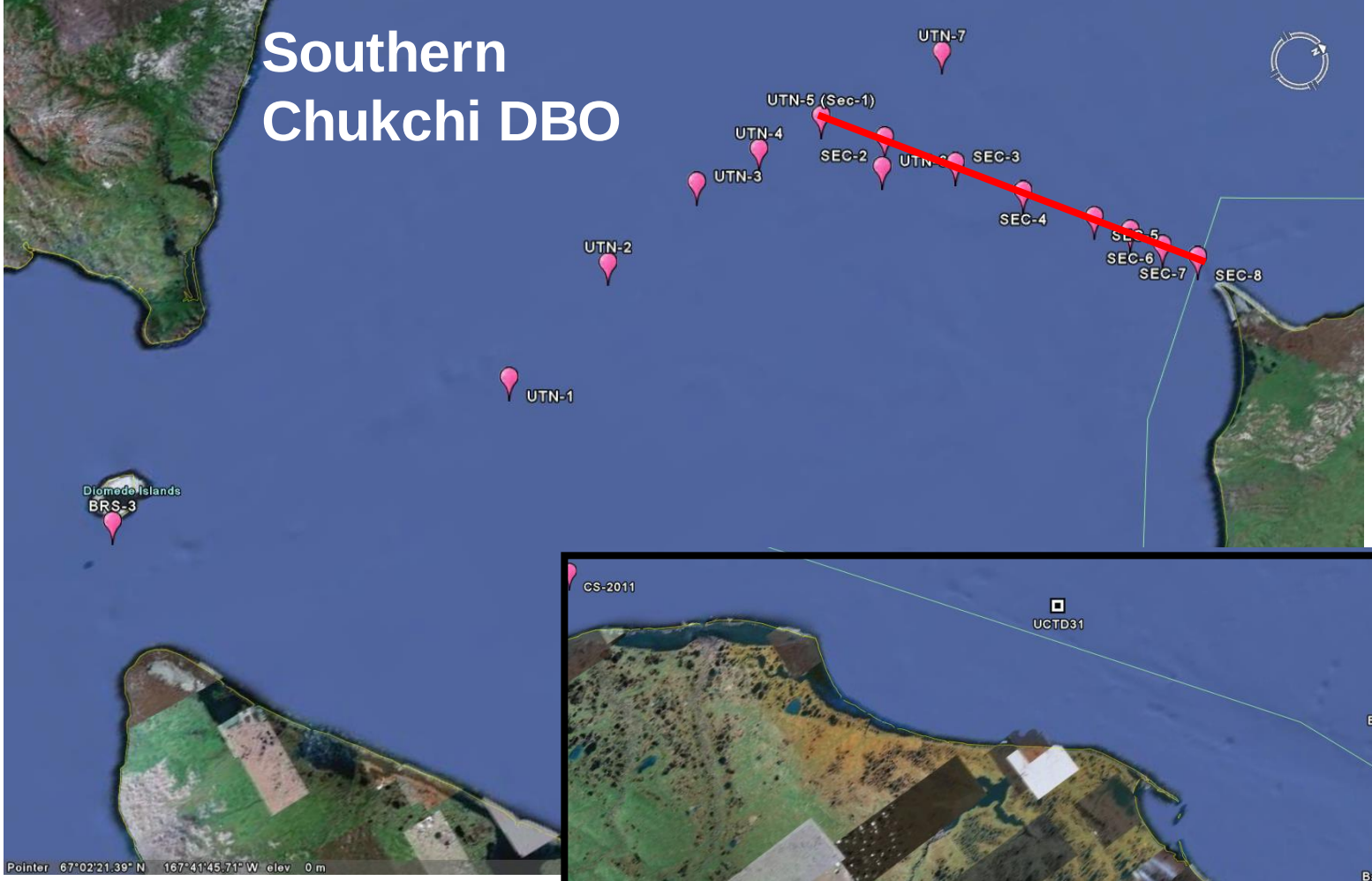








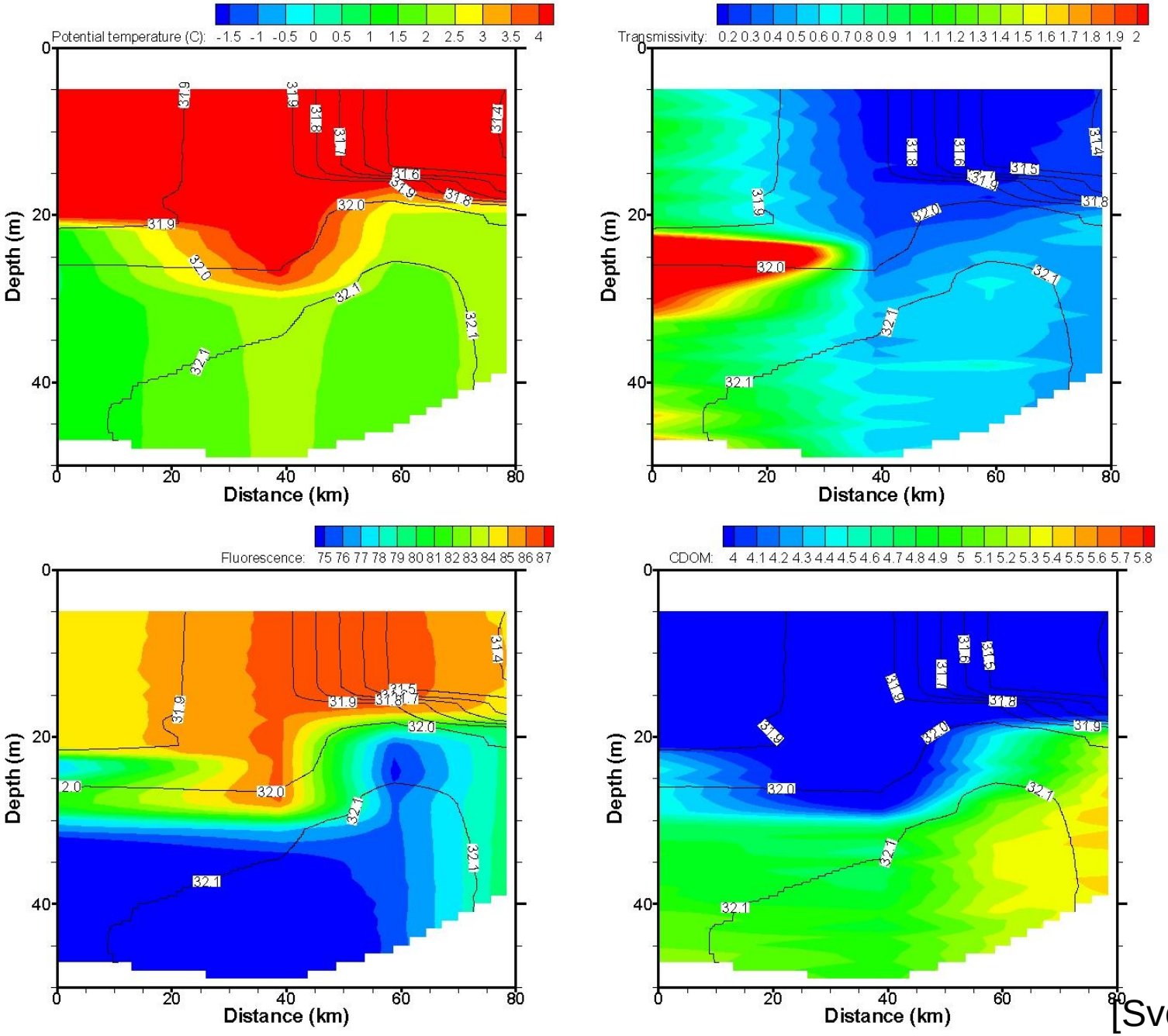



Southern
Chukchi DBO
UTN-7
UTN-5 (Sec-1)
UTN-4
SEC-2
SEC-3
UTN-3
SEC-4
UTN-2
SEC-6
SEC-7
SEC-8
UTN-1
Diomede Islands
BRS-3
Pointer 67°02'21.39" N 167°41'45.71" W elev 0 m


CS-2011
UCTD31
BarC-10
BarC-9
BarC-8
BarC-7
BarC-6
BarC-5
BarC-4
BarC-3
BarC-2
BarC-1
Barrow Canyon
DBO
Carlock Island
Image IBCAO
© 2011 Google
© 2011 Europa Technologies
Image © 2011 TerraMetrics
©2007 Google™

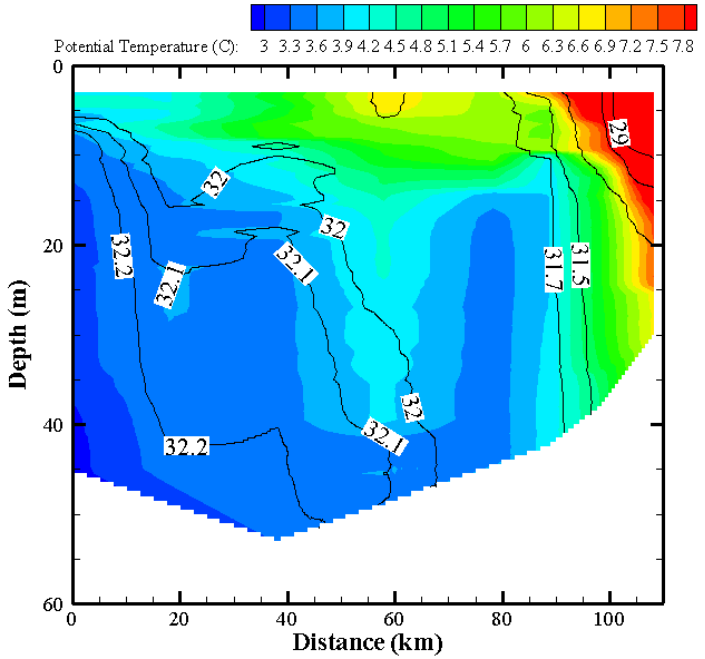
[Svein Vagle]

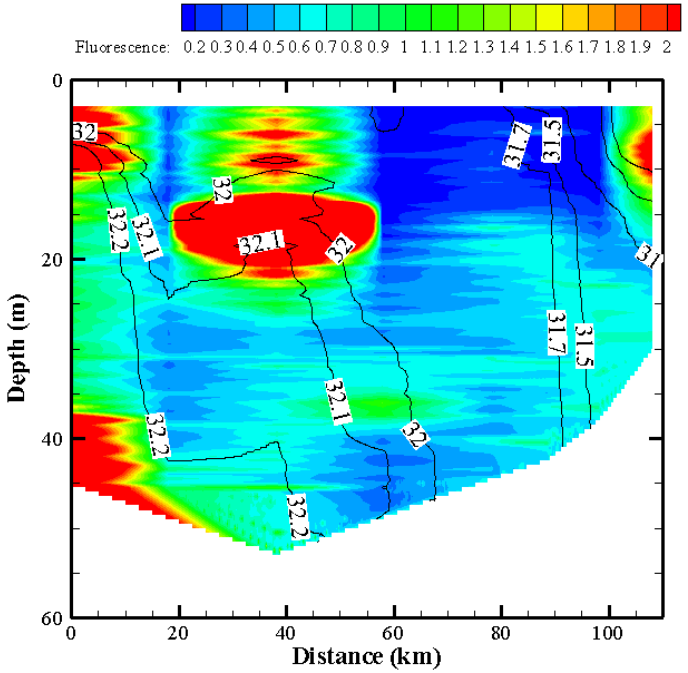
Southern Chukchi Sea (SCS) Transect SWL 2010-05

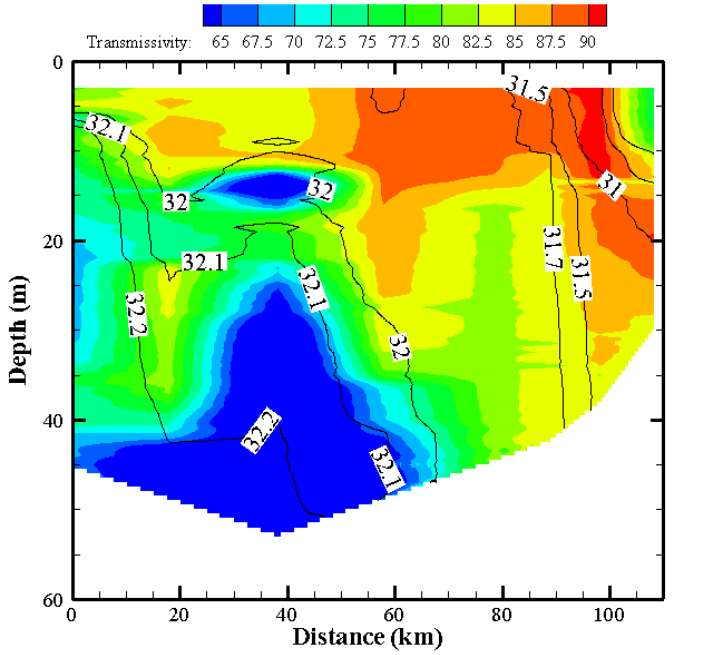


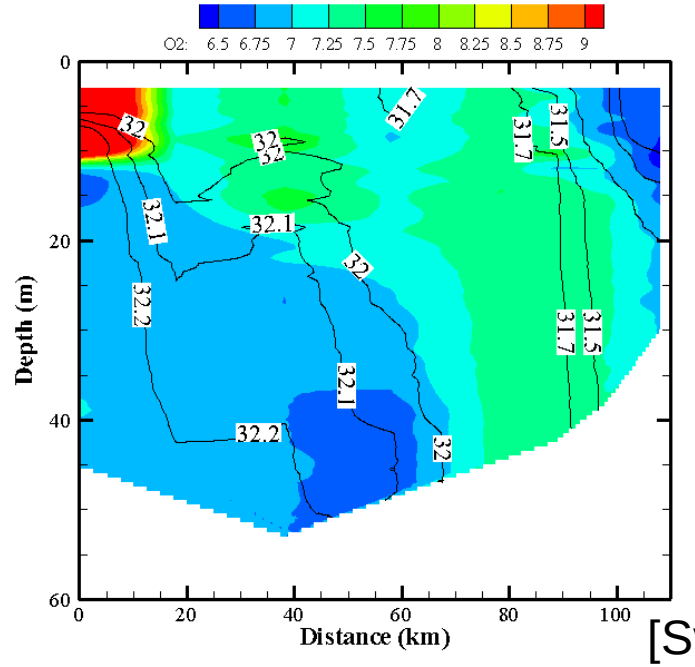
[Svein Vagle]

SE Chukchi Sea Transect SWL 2011-18, July 18



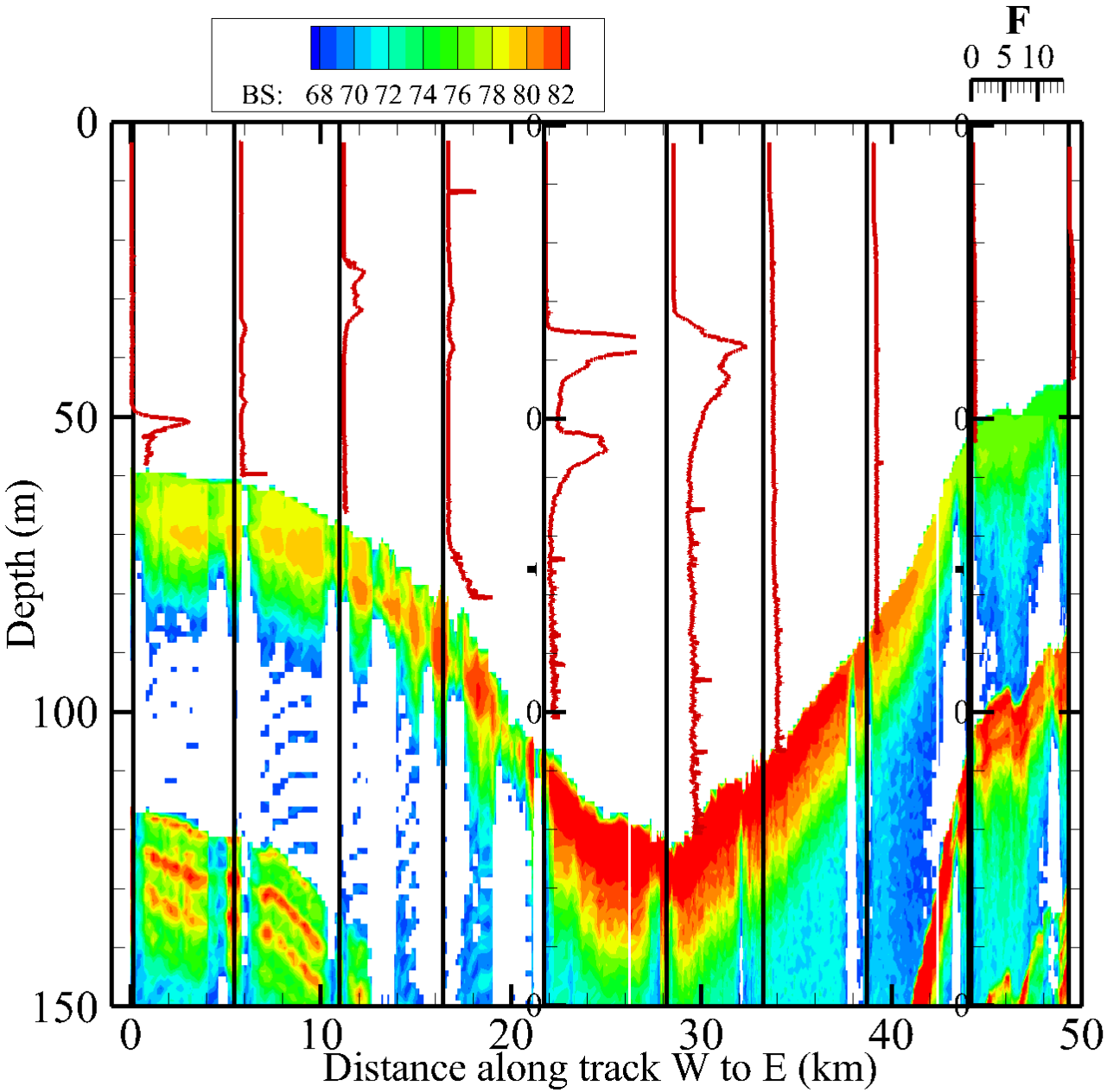






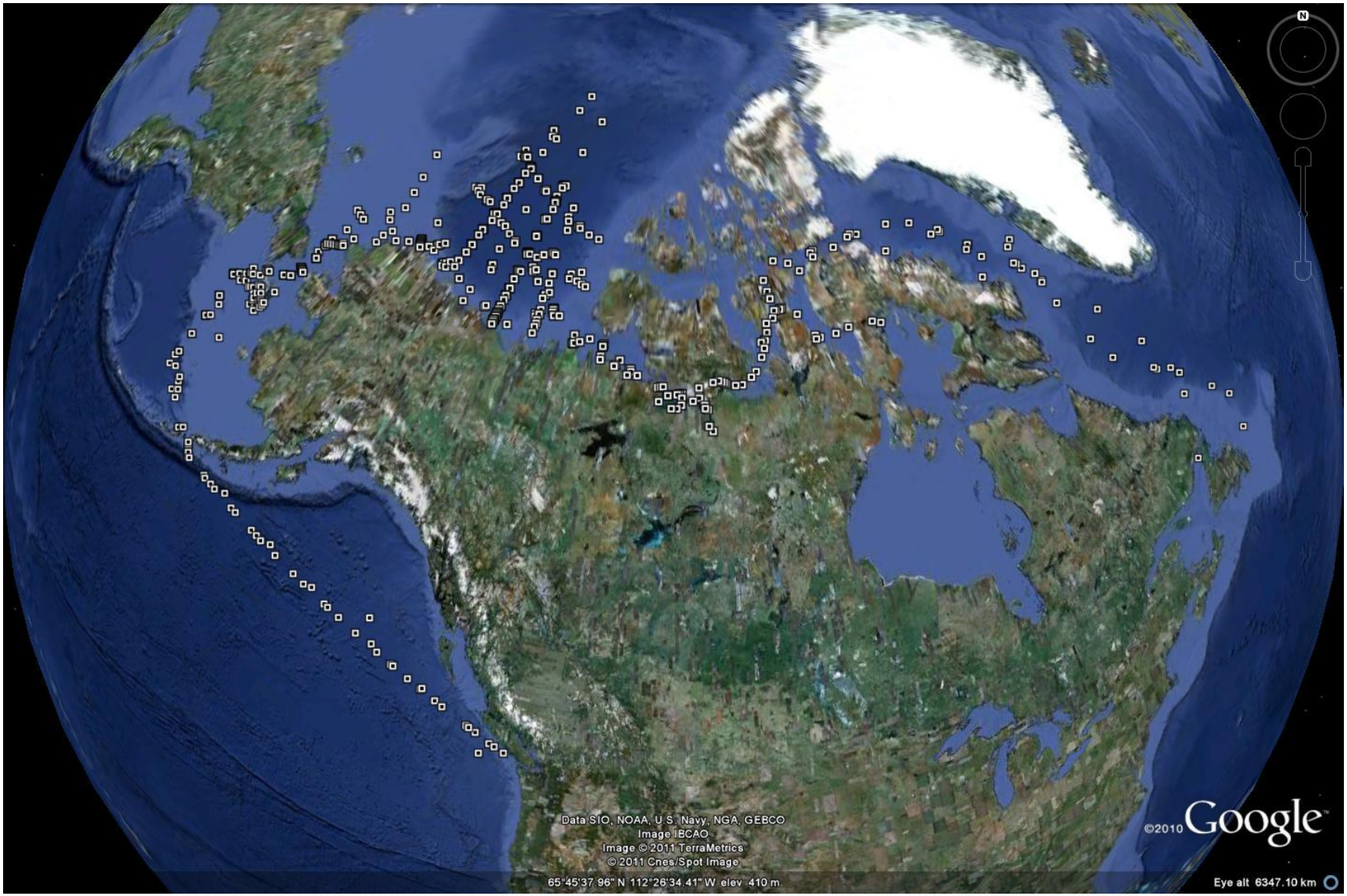
[Svein Vagle]

CTD fluorescence, Barrow Canyon, DBO, 2011



[Svein Vagle]

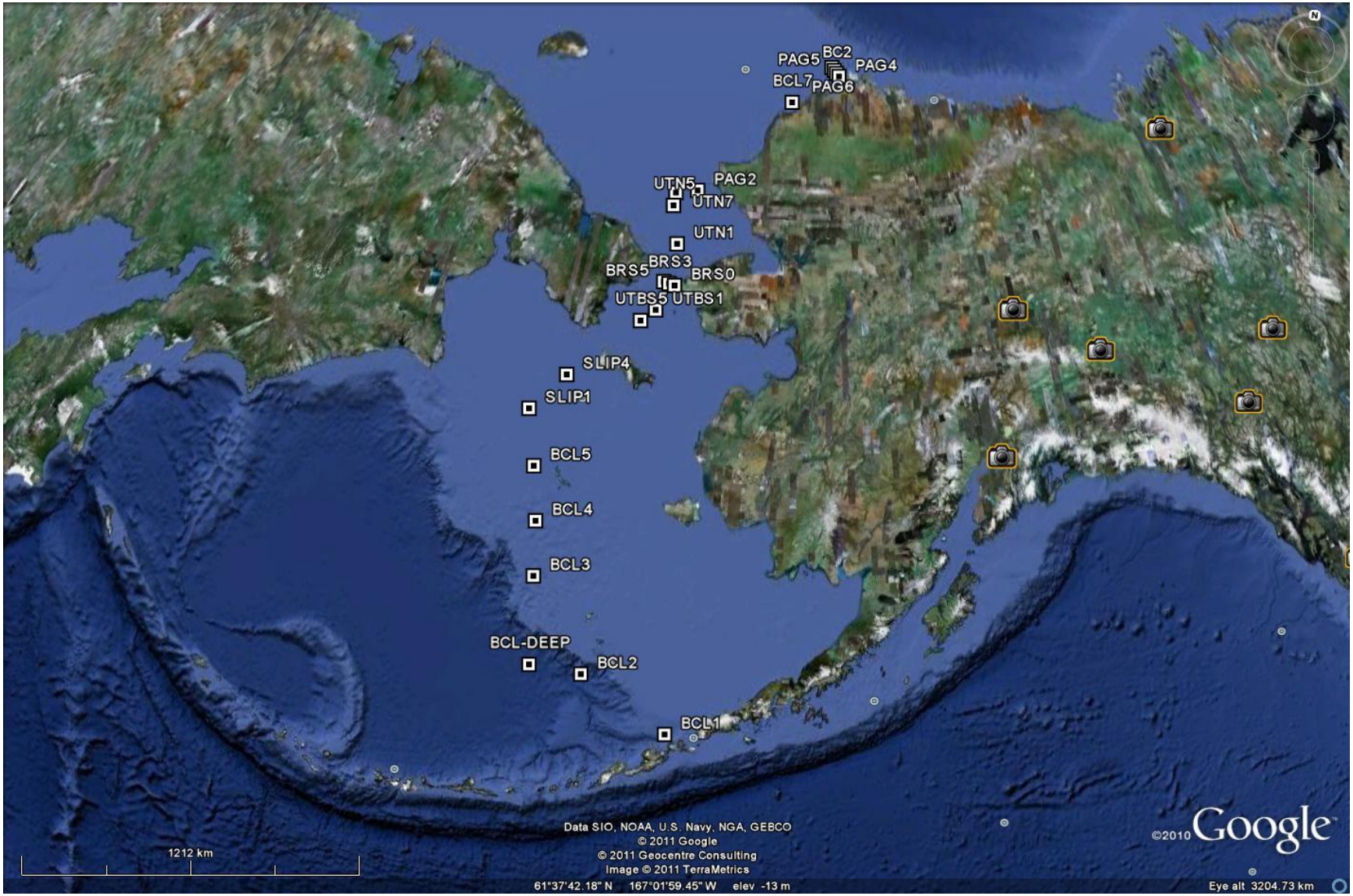
Zooplankton sampling in region since 2000.



This data is available as context for DBO

[John Nelson]

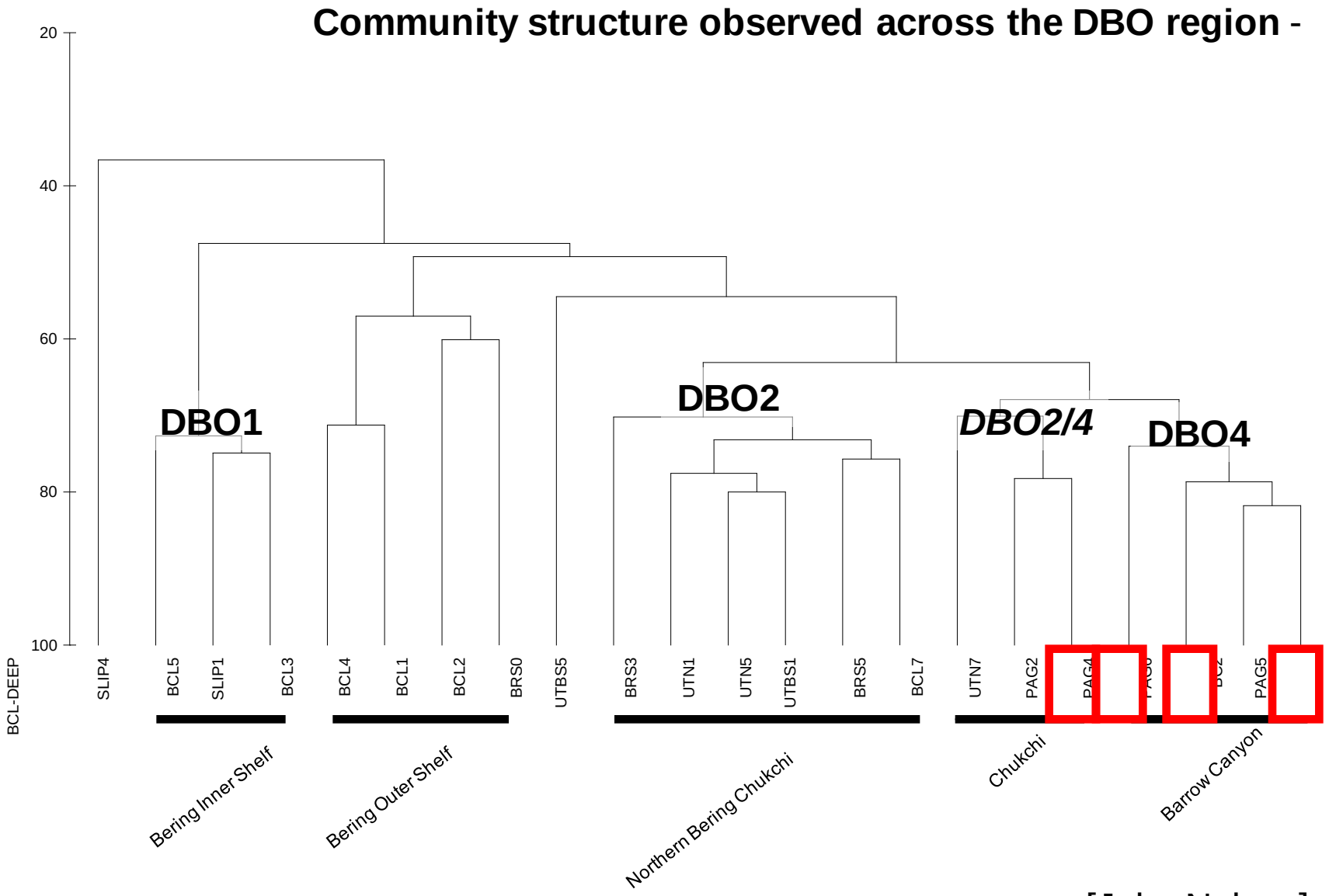
2010 Integrated Canada's Three Oceans and DBO Zooplankton Sampling



[John Nelson]

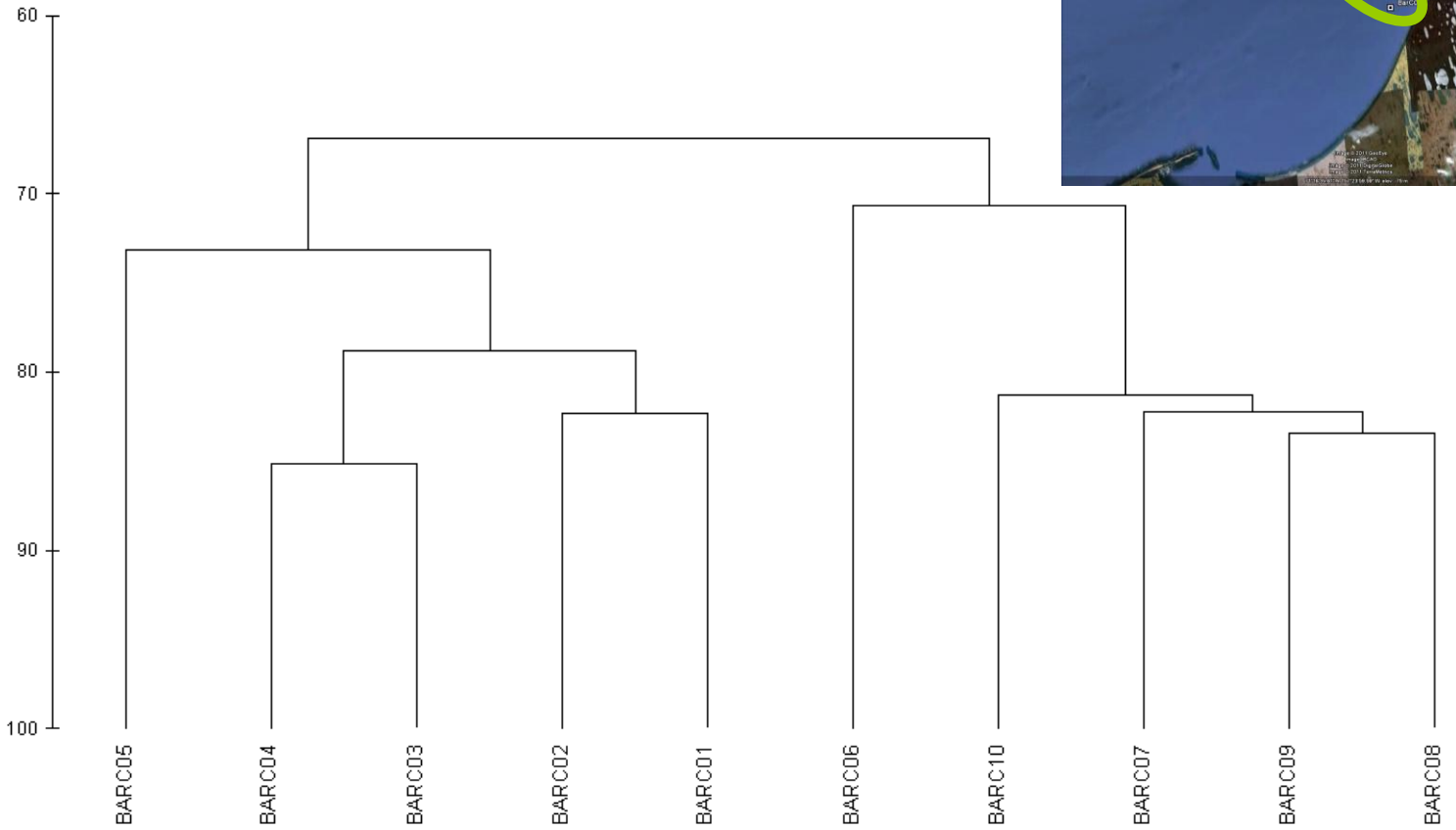
2010 Integrated C3O and DBO Zooplankton Analysis

– 4th root transformed Bray-Curtis similarity based on abundance



[John Nelson]

2011 DBO- results



Neocalanus

C. hyperboreus

– 4th root transformed Bray-Curtis similarity based on abundance

[John Nelson]

Summary

Biogeographic Structure definable and serves as an underpinning of DBO pelagic ecosystem structure.

Baseline biogeographic structure can be used to monitor both community composition changes and range shifts.

<u>To do: Science</u>
Assess change > abundance, biomass, community composition, etc.

Define how biogeographic structure corresponds to physics and geochemistry.

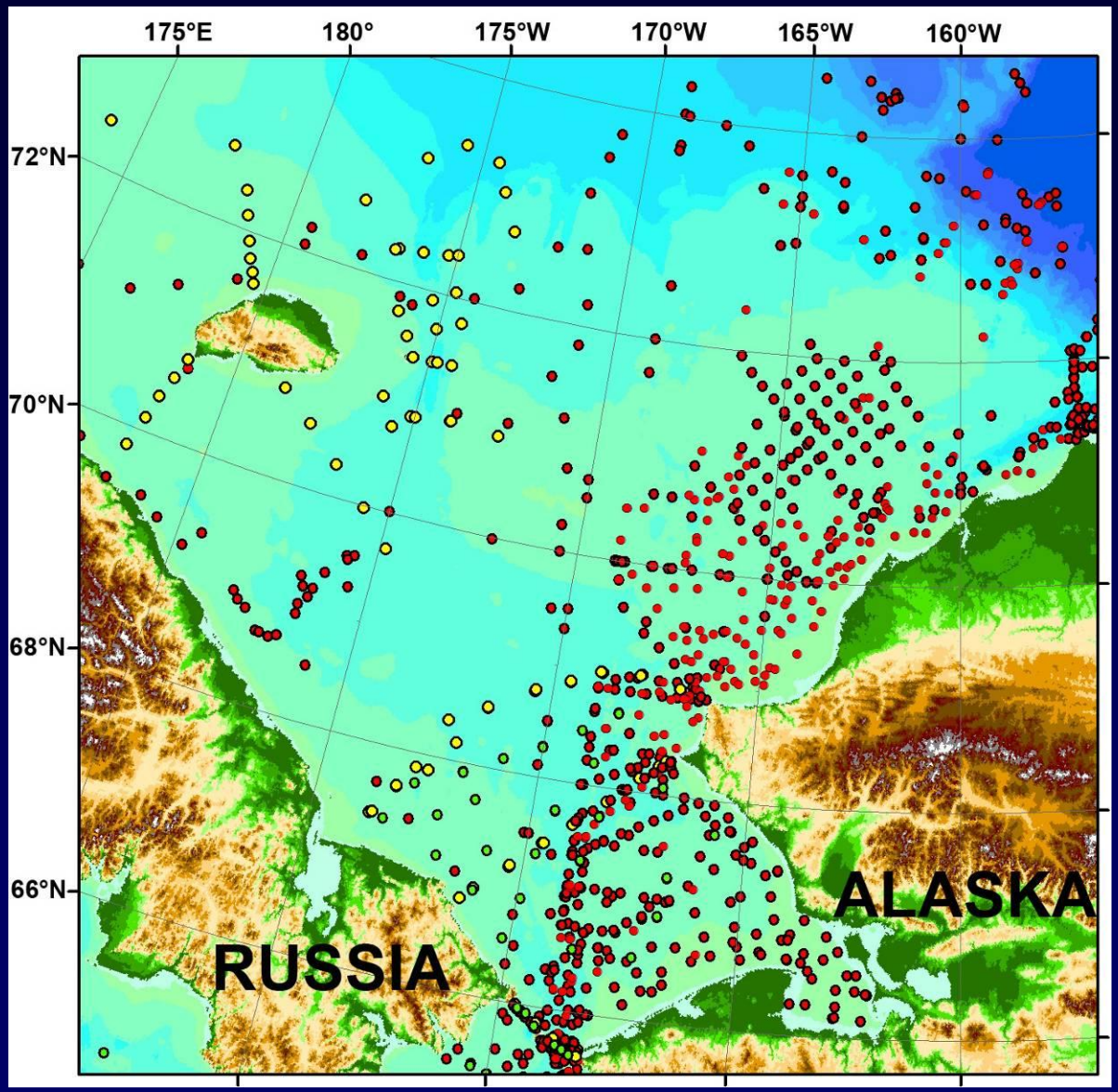
<u>To do: Logistics</u>
Develop data sharing and analysis protocols.

Agree on list of indicators-indices

Sampling (cruise) coordination.

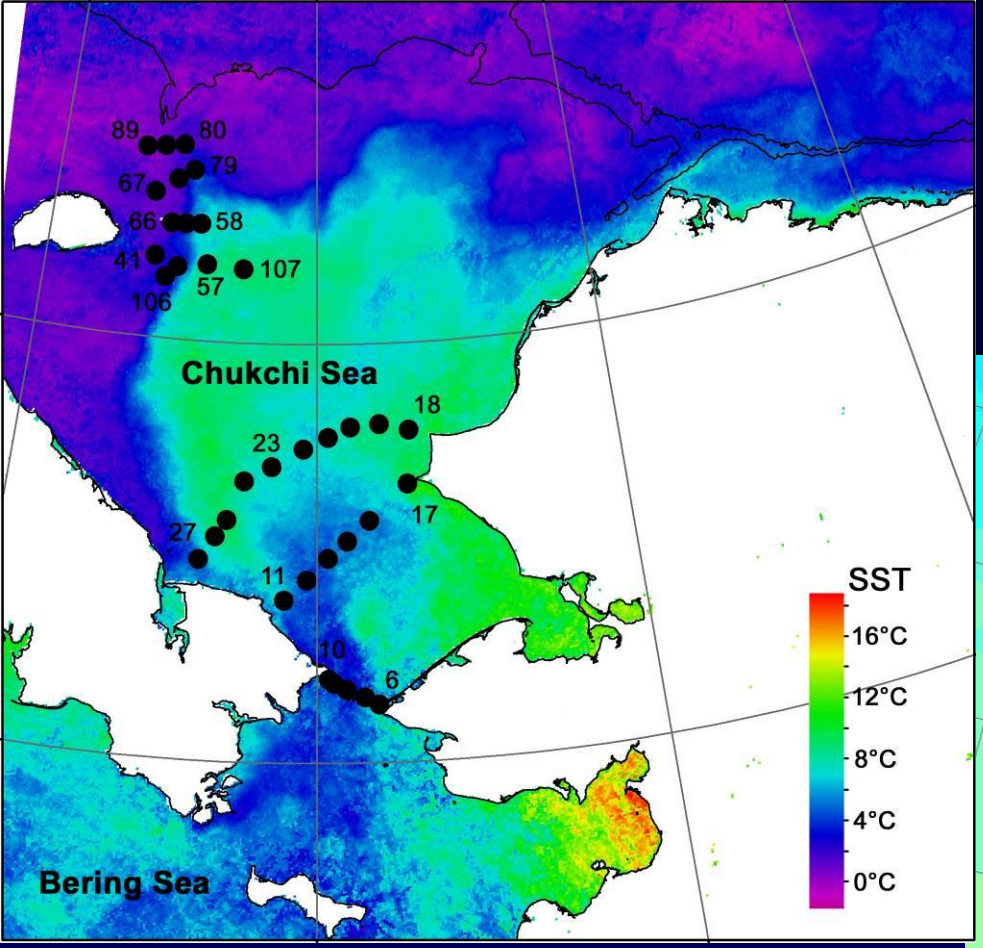
[John Nelson]

Zooplankton observations 1900-2010



- Sampling intensity has increased in the Alaskan Arctic
- Data in Russian waters is either many decades old or comes from joint efforts such as RUSALCA (yellow) or its predecessor BERPAC (green)
- The Chukchi Sea is oceanographically complex, we cannot understand changes in it without sampling the entire domain

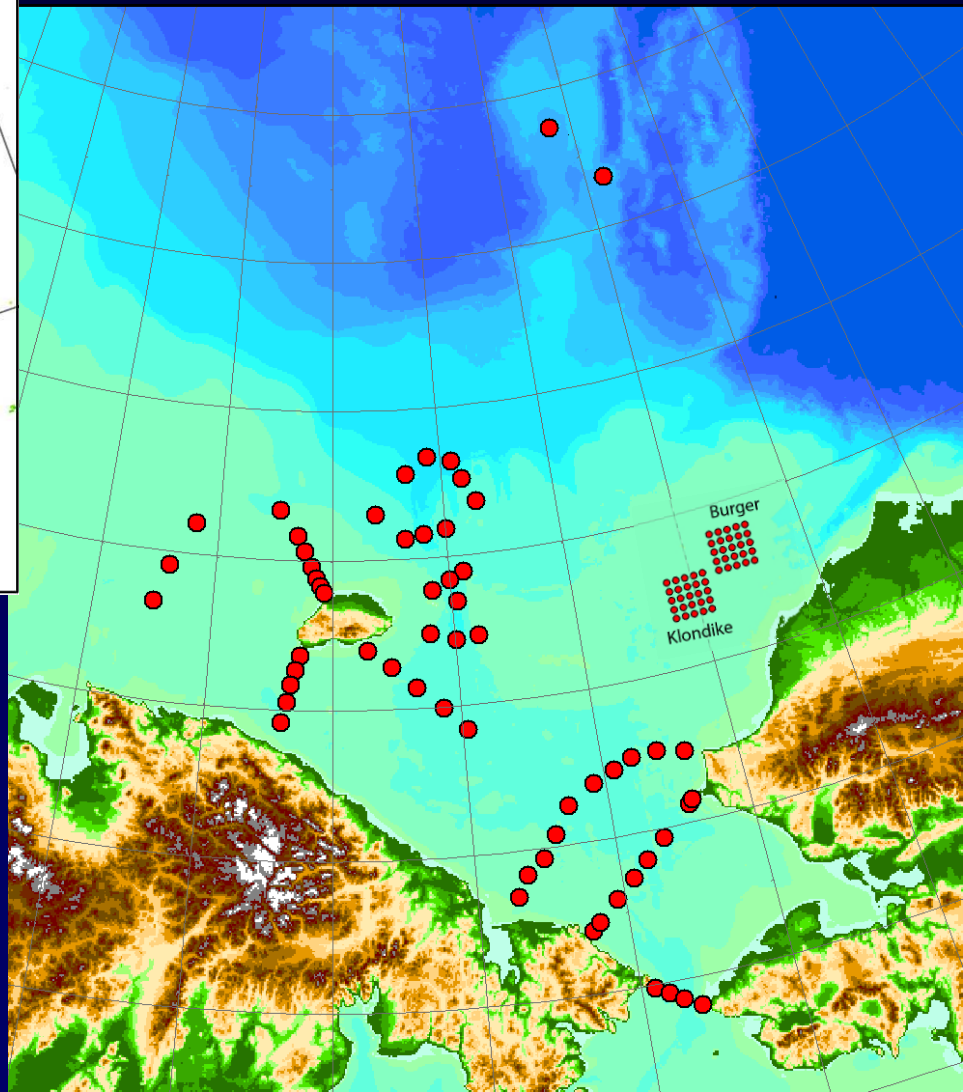
[Russ Hopcroft]



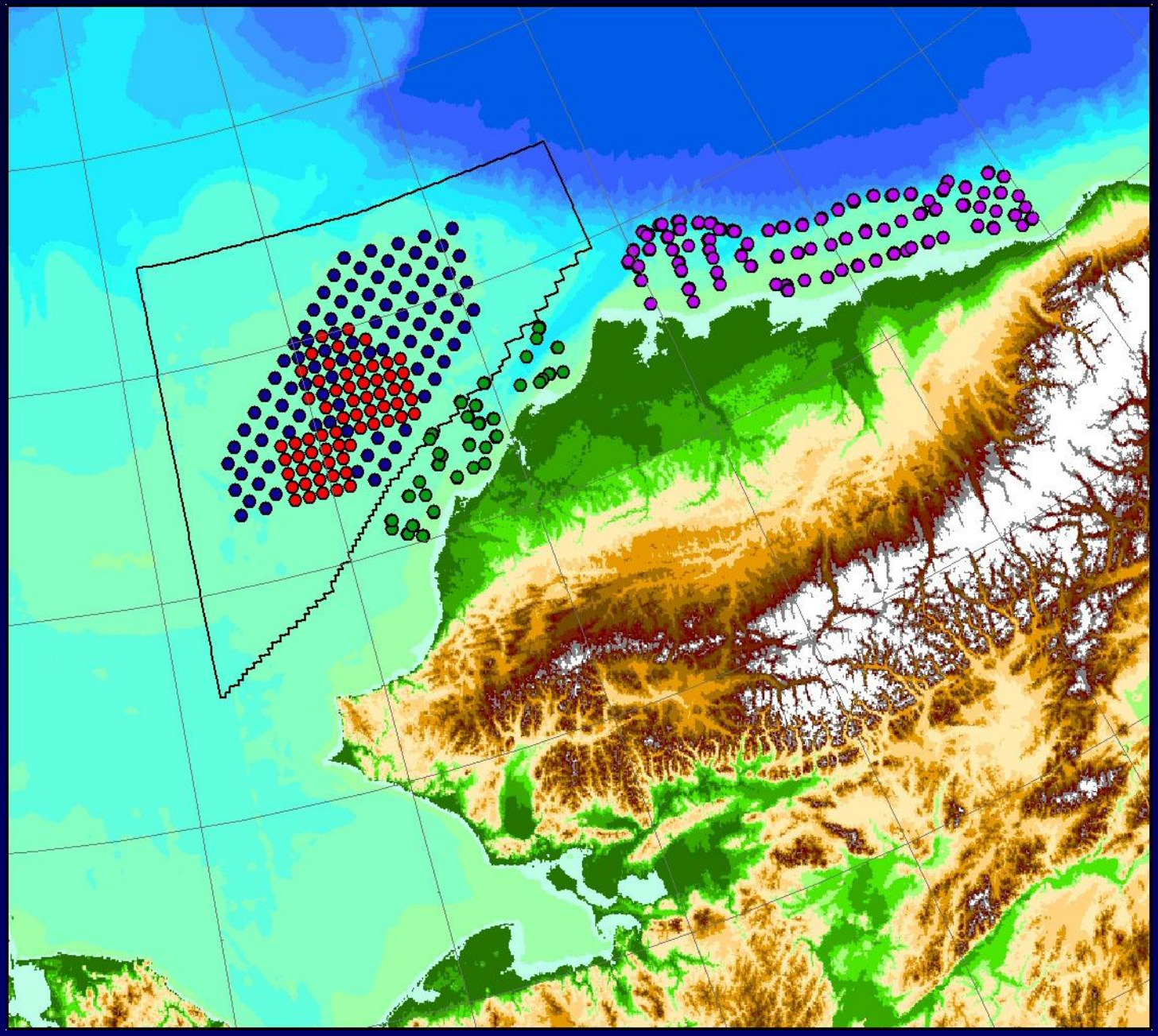
2004

2009

Samples scanned live for jellies & ctenophores



[Russ Hopcroft]



2011

CSEAP

Shell

Conoco-Phillips

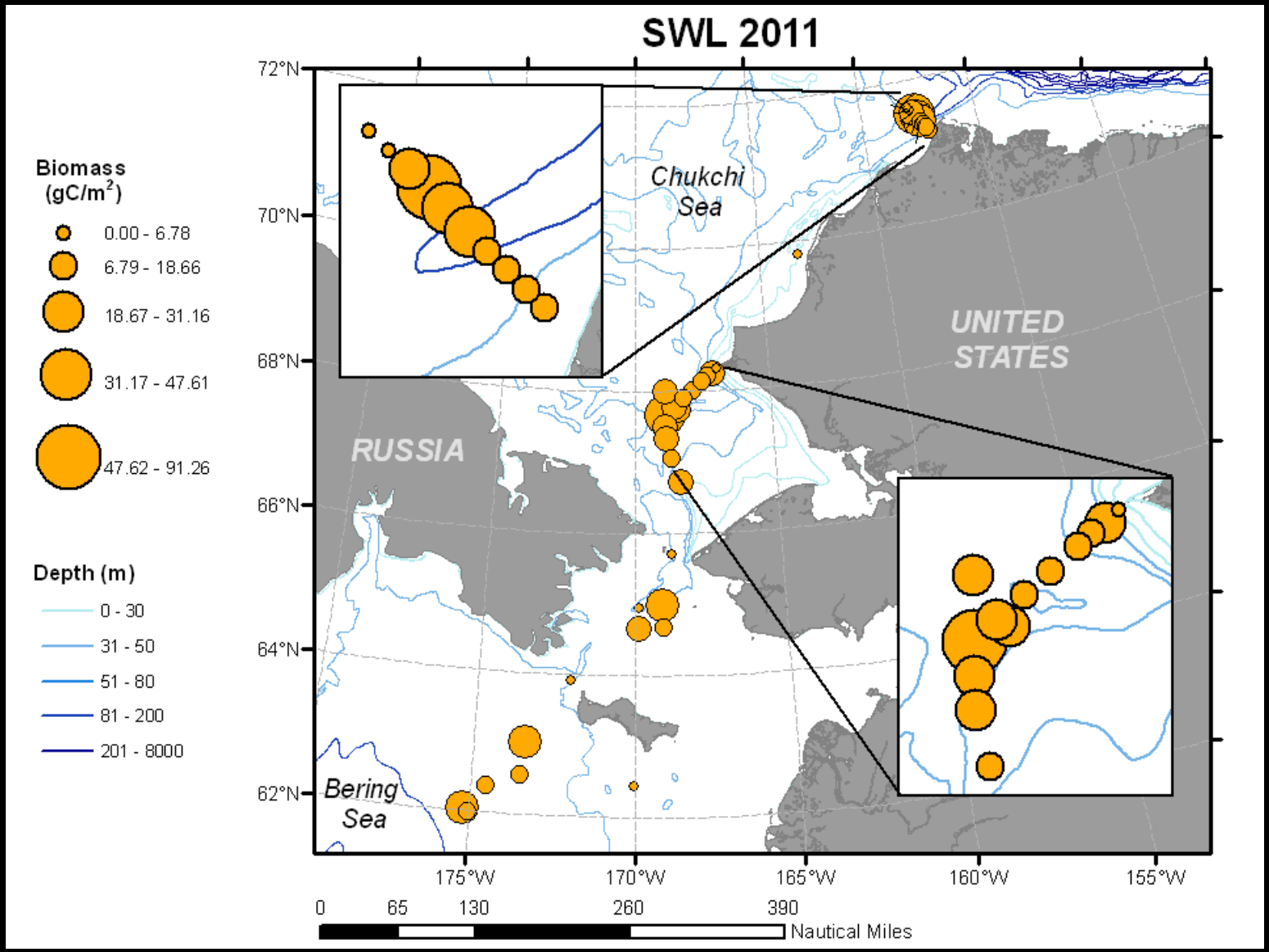
Statoil

AKMAP

BeauFISH

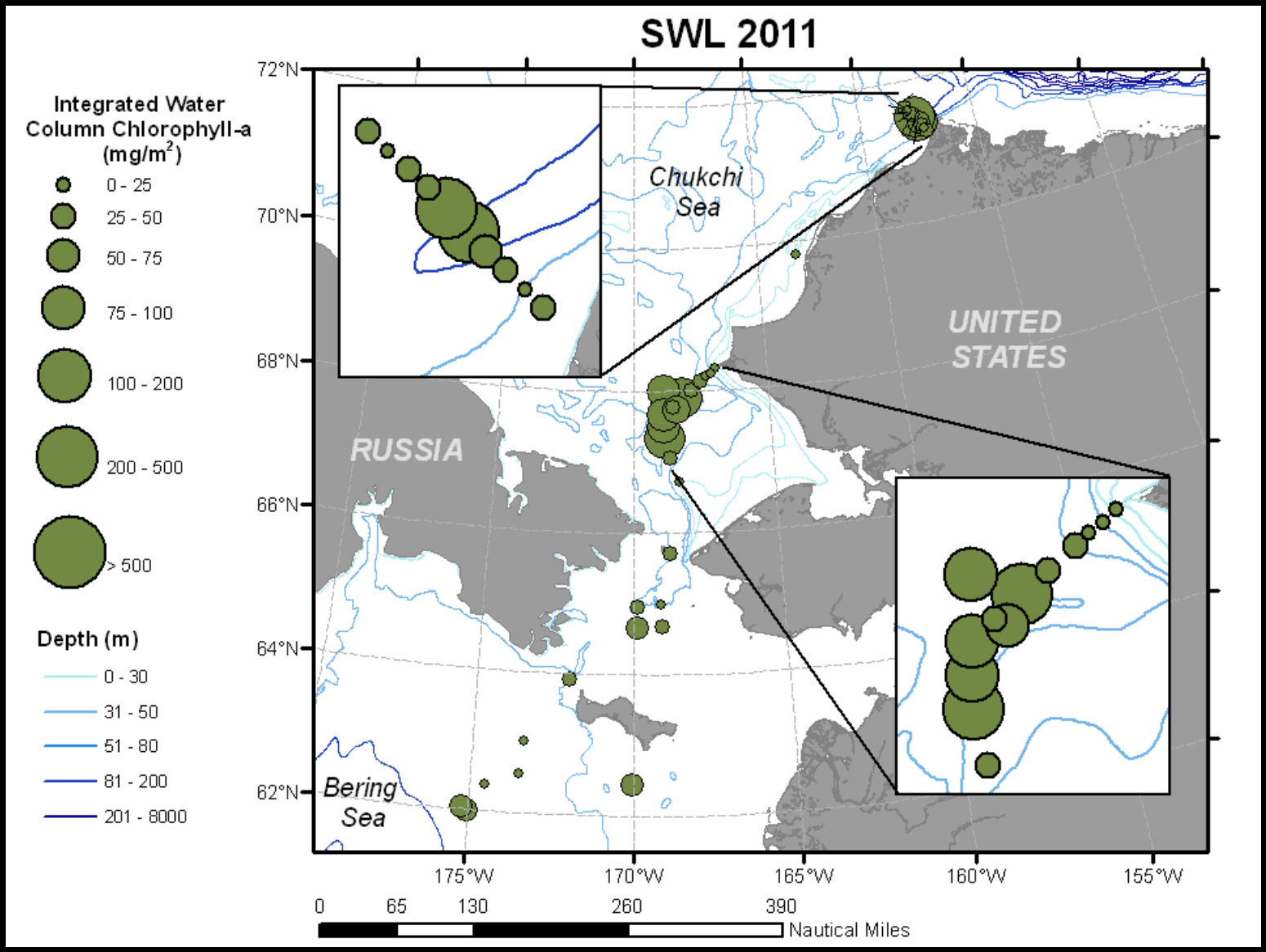
[Russ Hopcroft]

SWL 2011 Benthic Biomass (gC/m2)-Grebmeier



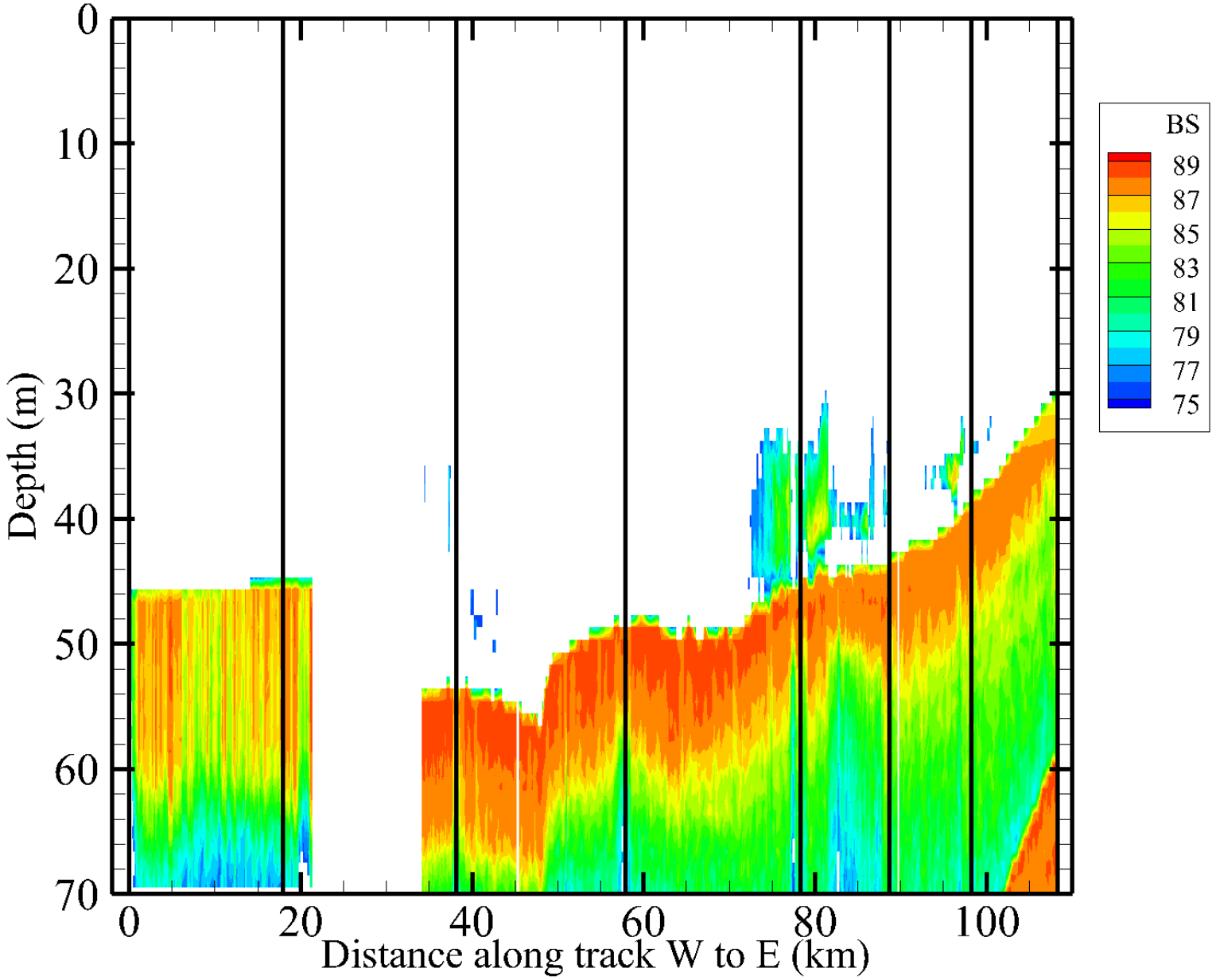
[Jackie Grebmeier]

2011 Integrated Chl (mg/m2)-Grebmeier

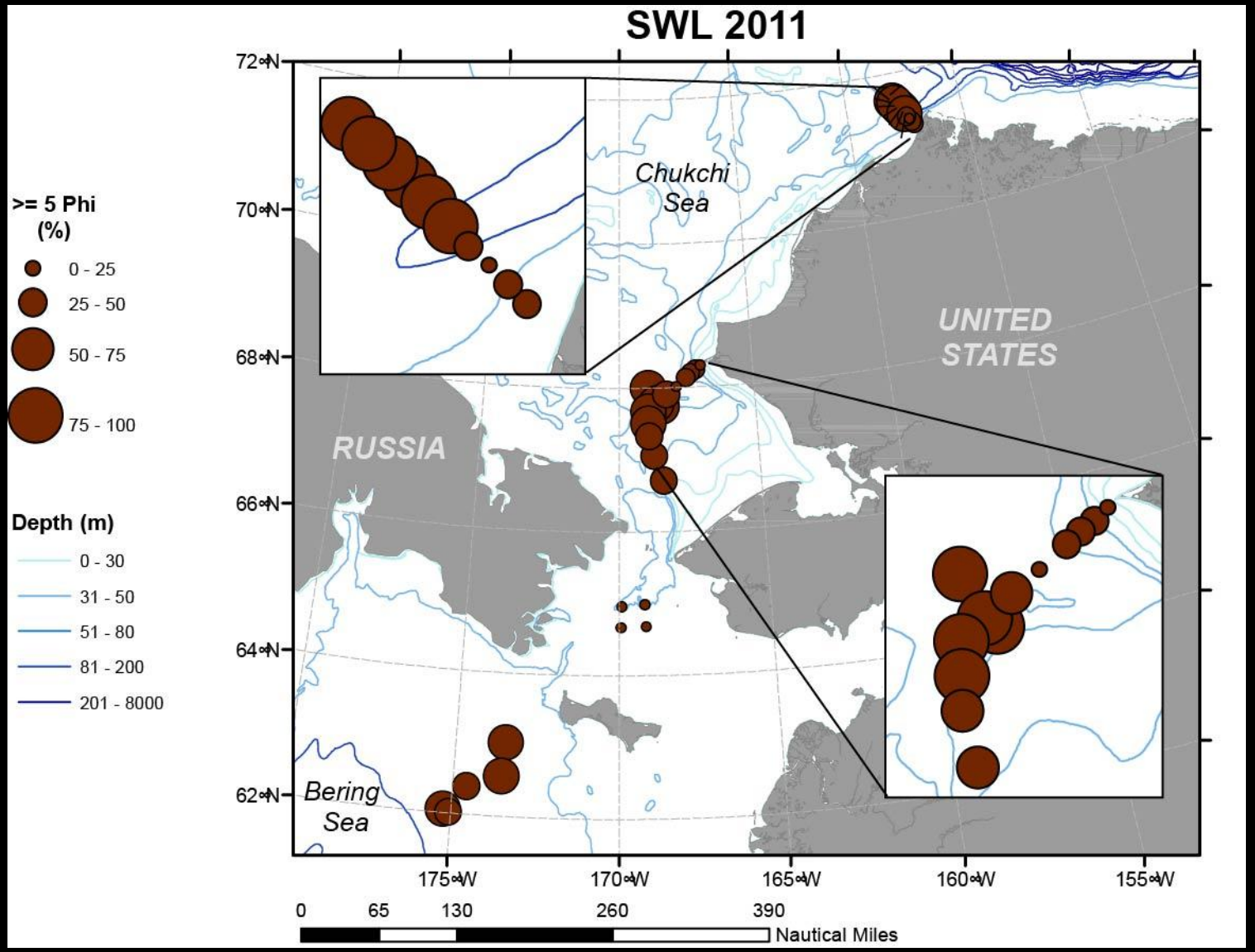


[Jackie Grebmeier]

12kHz bottom backscatter, Southern Chukchi, DBO, 2011

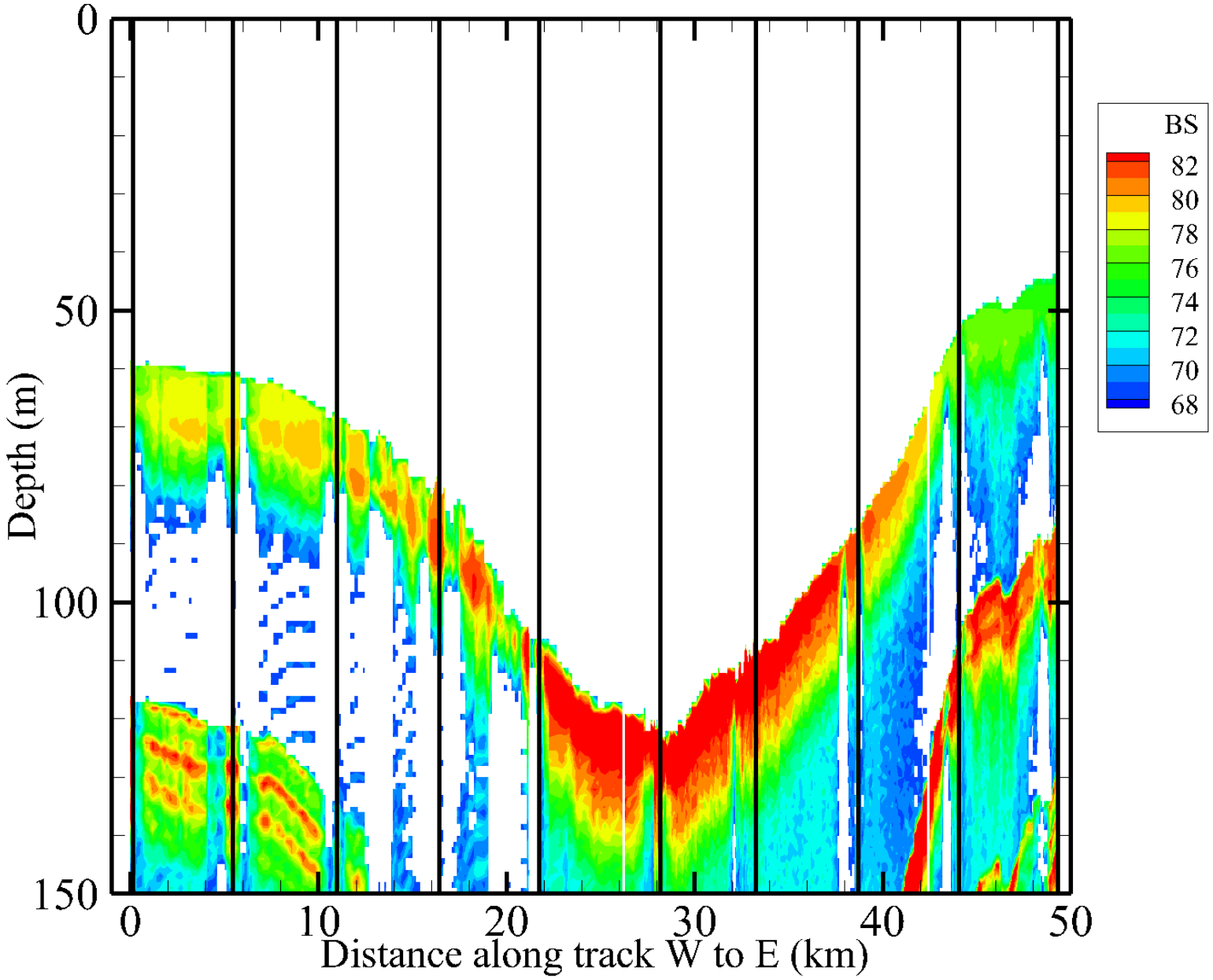


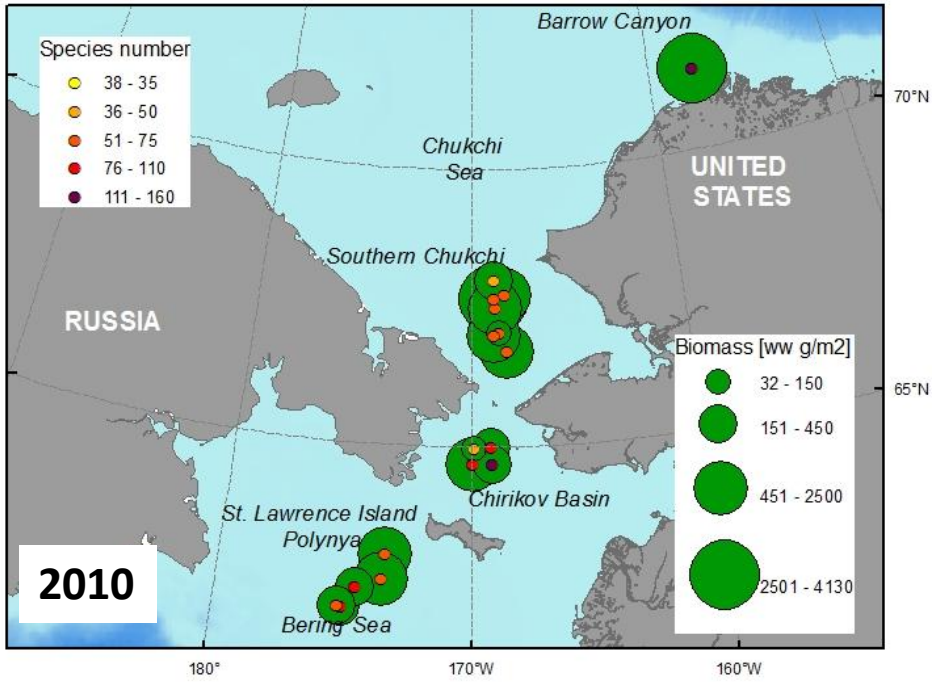
2011 silt and clay (%)-Grebmeier

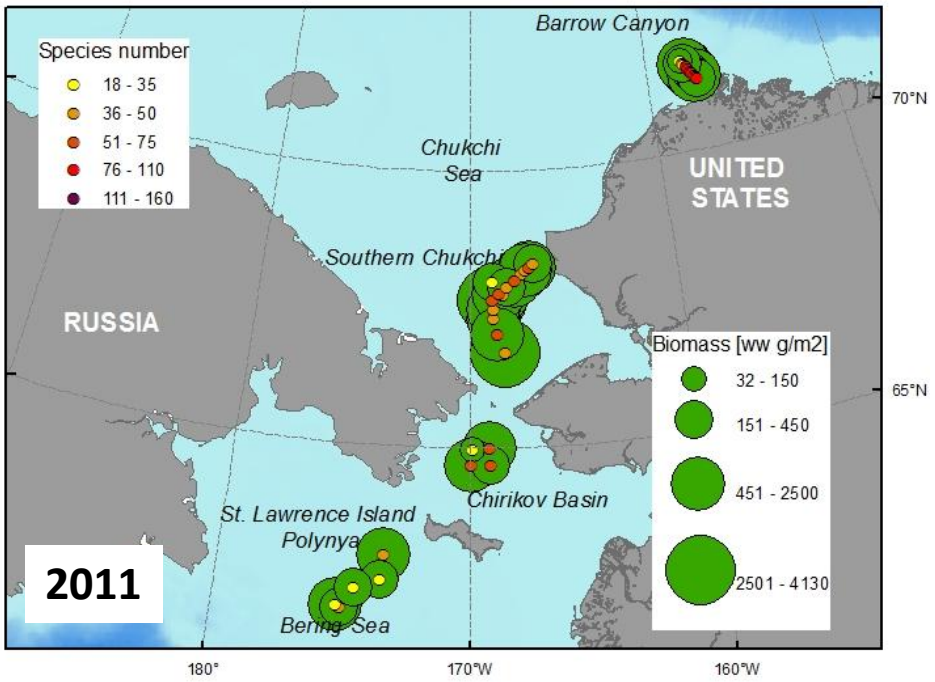


[Jackie Grebmeier]

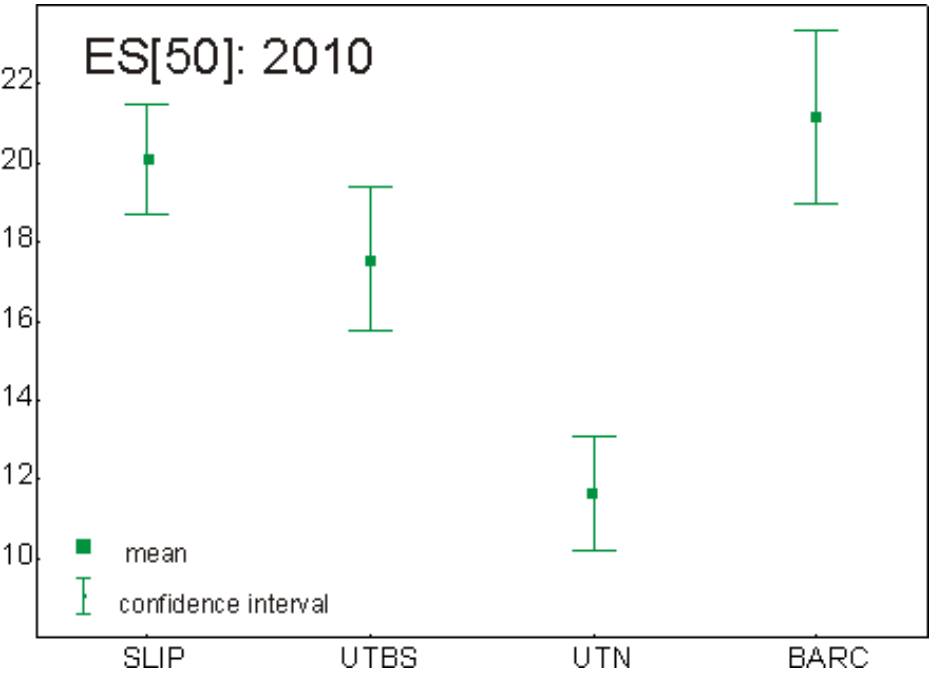
12kHz bottom backscatter, Barrow Canyon, DBO, 2011

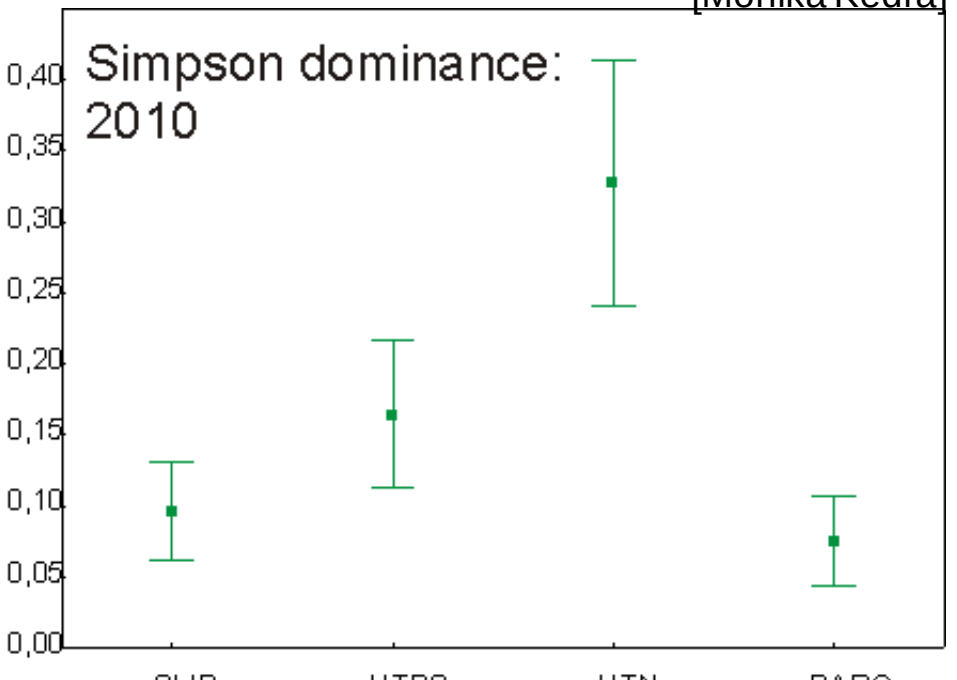






[Monika Kedra]

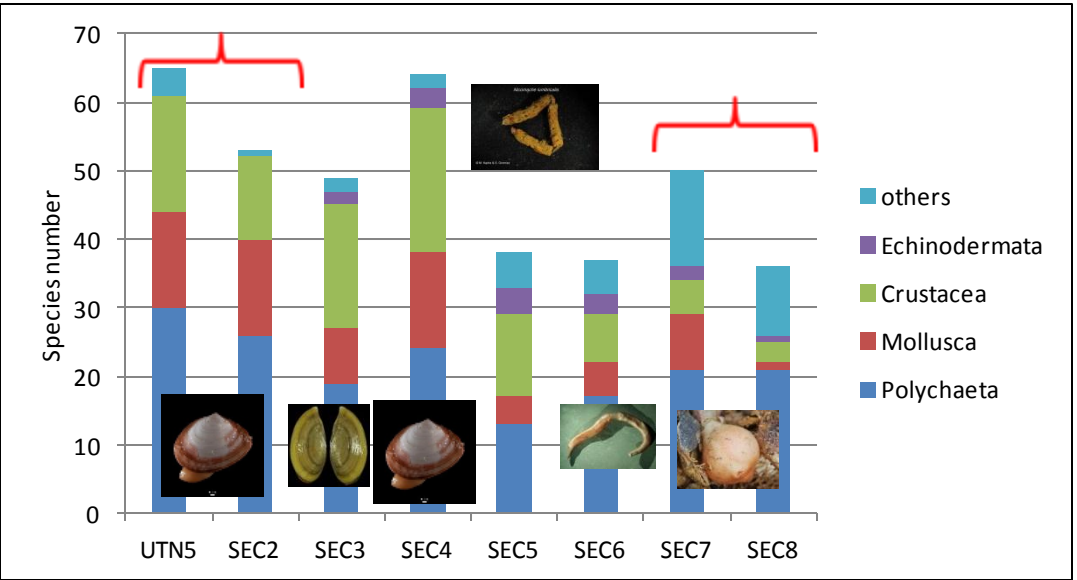


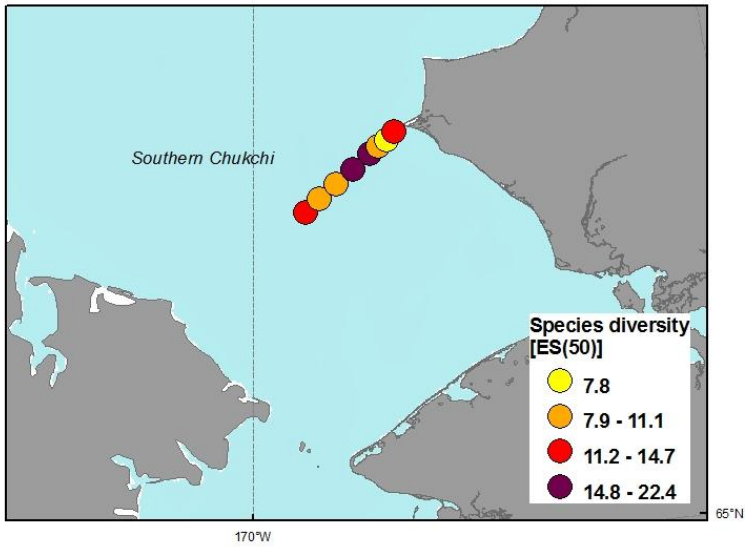


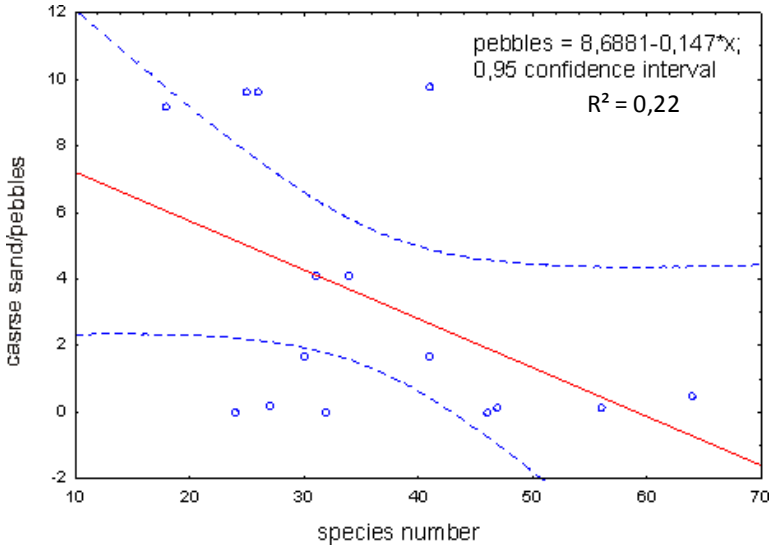
DBO site #3;
South Eastern Chukchi Sea; SEC transect

180 taxa; inc 85 polychaeta and 38 crustacea
biomass : 5.1 – 30.8 (101.46 – UTN5) gCm^2
abundance: 580 – 9165 (10740 – UTN5) m^2
Simpson dominance: 0.07 – 0.62
Shannon index: 0.7 – 3.26
Decrease in abundance towards the shore (exp SEC7)

Surface deposit feeders at first 4 station of the transect: *Pontoporeia femorata* and *Protomedeia spp*
Towards the shore suspension feeders: *Hiatella arctica* and ascidians





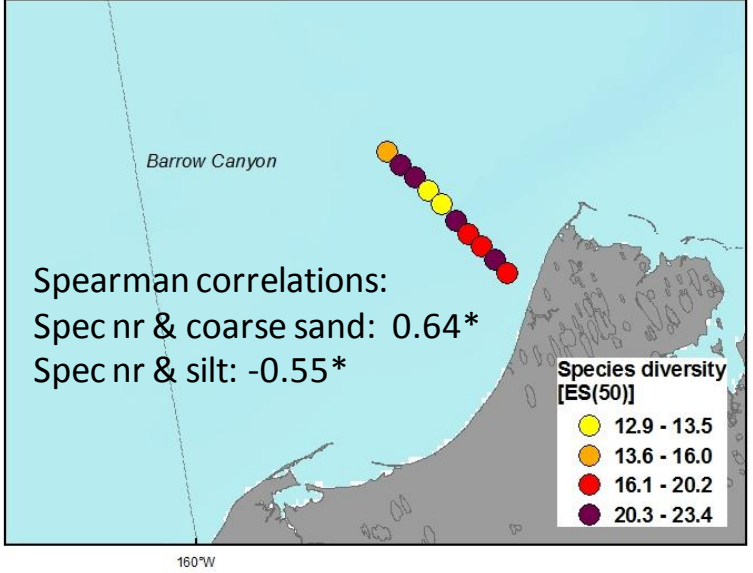


Spearman correlations:
Diversity & sed chl a: -0.69*
Diversity & coarse sand/pebbles: 0.57*
Diversity & silt: -0.67*
Diversity & TOC: -0.69*
Diversity & TON: -0.76

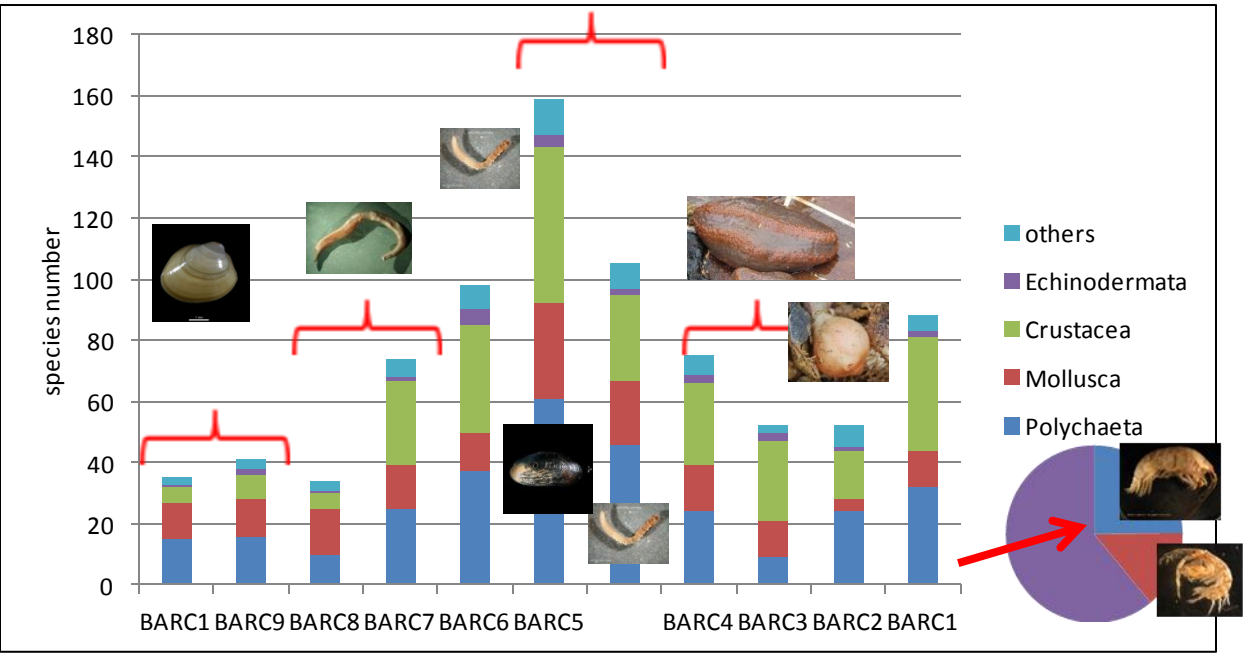
[Monika Kedra]

DBO site #5;
Barrow Canyon

312 taxa; inc 120 polychaetes and 103 crustaceans
biomass : 1.4 – 66.37 gCm^2
abundance: 2970 – 48390 m^2
Simpson dominance: 0.06 – 0.38
Shannon index: 1.95 – 3.19



Towards the shore:
Surface deposit feeders (*Ennucula tenuis*), subsurface deposit feeders (*Maldane sarsi*) and suspension feeders (*Brachydistylis resima* and *Mytilus* spp.,), ascidians: stronger current indicators



Qualitative: Barc 5 – drop in species number, diversity and biomass but not abundance; possible switch from mytilidae to terebelidae and maldanidae

[Monika Kedra]

FISH, SEABIRD & MARINE MAMMALS = Higher Trophic (HT) Species
SURVEYS, OBSERVATIONS AND LINKAGES TO RELATED PROJECTS

Higher-Trophic (HT) species reflect ecosystem 'hotspots' & organization

People *CARE* about HT species – they provide a link for education & outreach

Surveys during DBO Pilot Study

FISH: no effort on DBO cruises

*Related Projects = BASIS surveys in DBO Regions 1 &2 + shore-cast sampling Region 5

Data archived @ NOAA/Alaska Fisheries Science Ctr

+ Industry sampling in Region 4?

SEABIRDS: standard 300m survey protocol

2010 = 5 of 9 DBO cruises

2011 = 3 of 9 DBO cruises

Data archived = North Pacific Pelagic Seabird Database

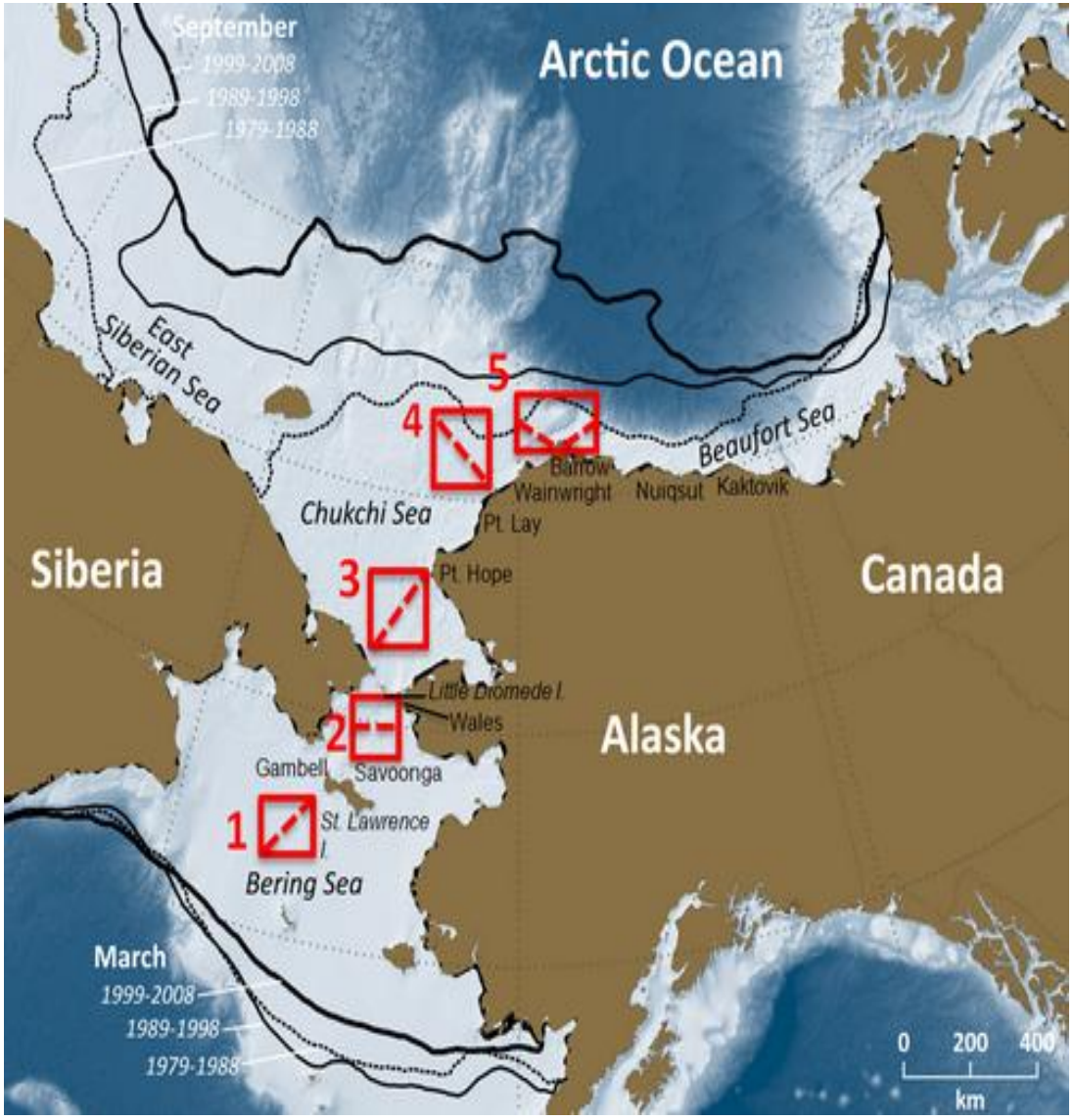
MARINE MAMMALS: watches & standard 'Big Eye' survey protocol

2010 = 5 of 9 DBO cruises

2011 = 4 of 9 DBO cruises

*Related acoustic sampling = Regions **1** (M8), Bering Strait (RUSALCA), **4** (CHAOZ) & **5** (BOWFEST)

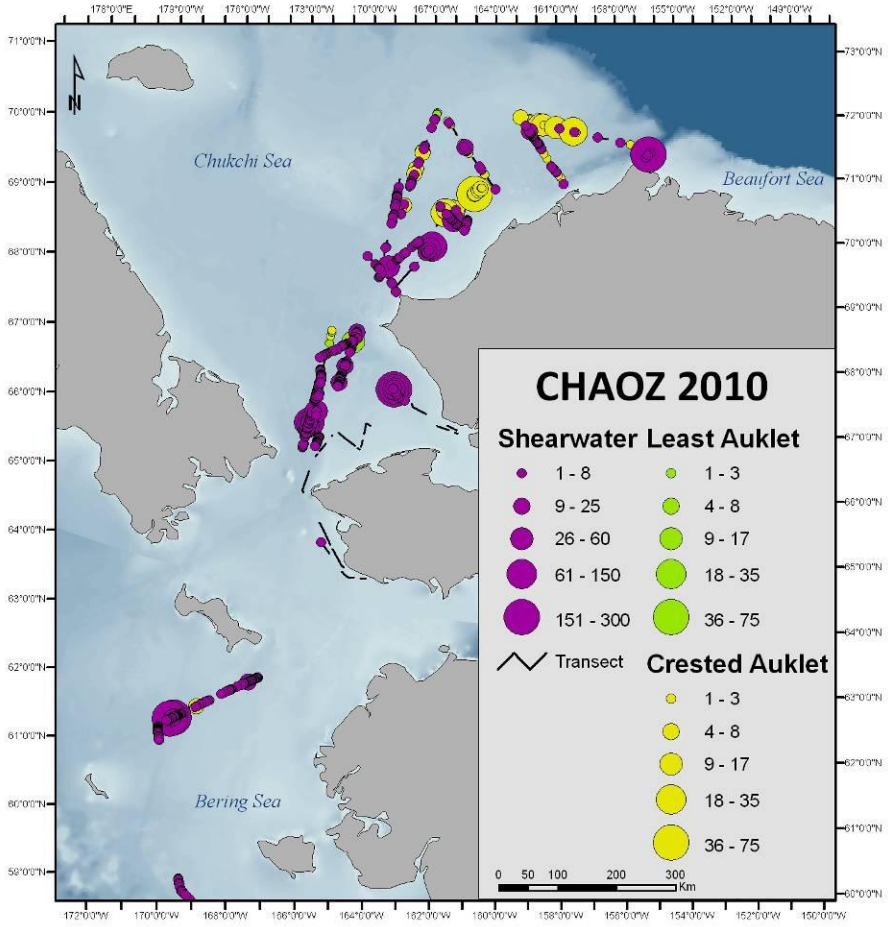
Data archived by projects; standard visual survey data (CHAOZ) & acoustic data @ NOAA/NMML & UW



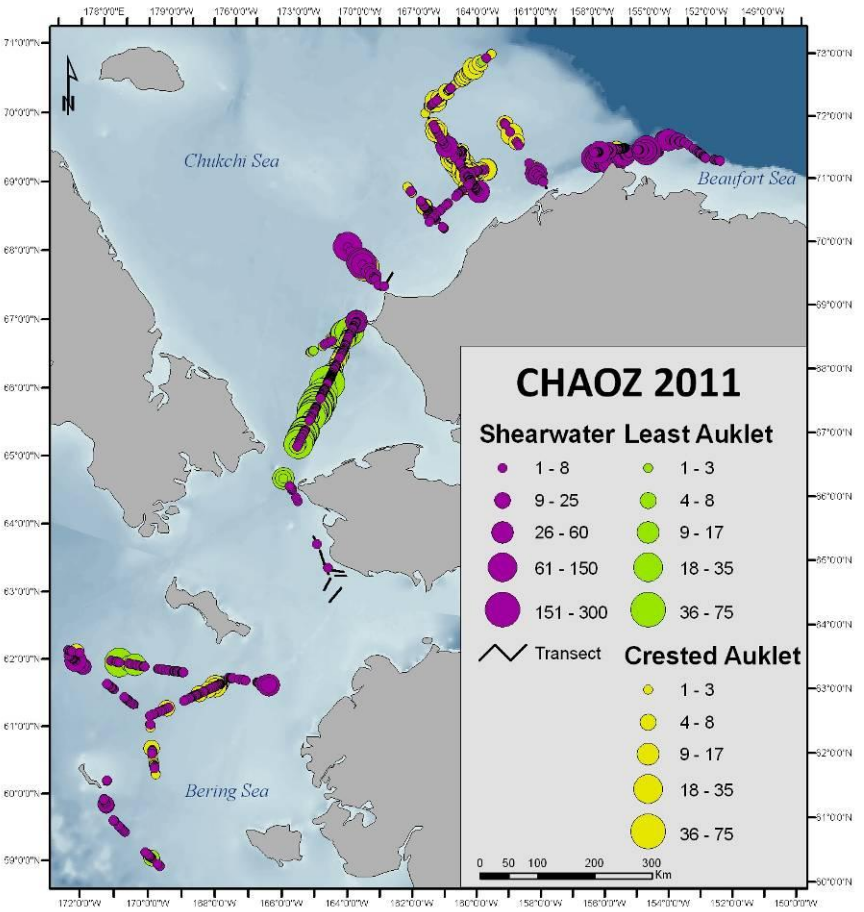
[Sue Moore]

Seabird Sightings from CHAOZ Cruises (USFWS Survey Protocol)

2010 – DBO Region 3 – 'hotspot'



2011: DBO Region 1& 3 – 'hotspot'

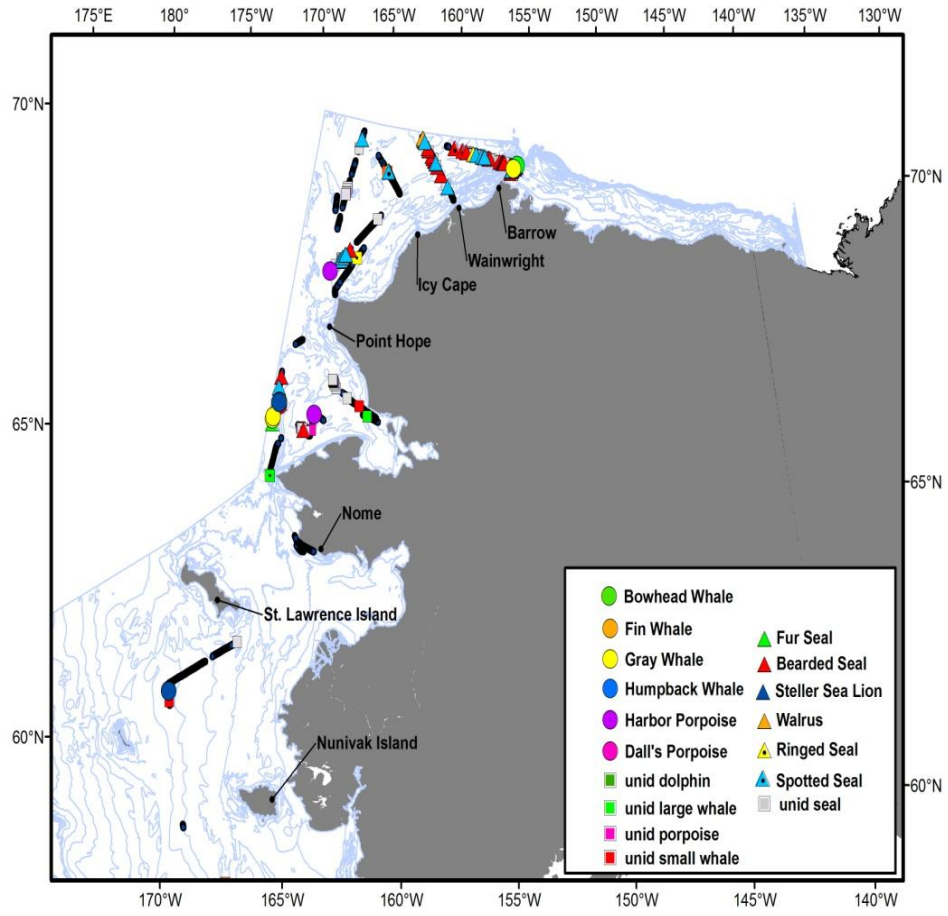


CHAOZ = **CH**ukchi **A**coustic **O**ceanographic and **Z**ooplankton study [Sue Moore]

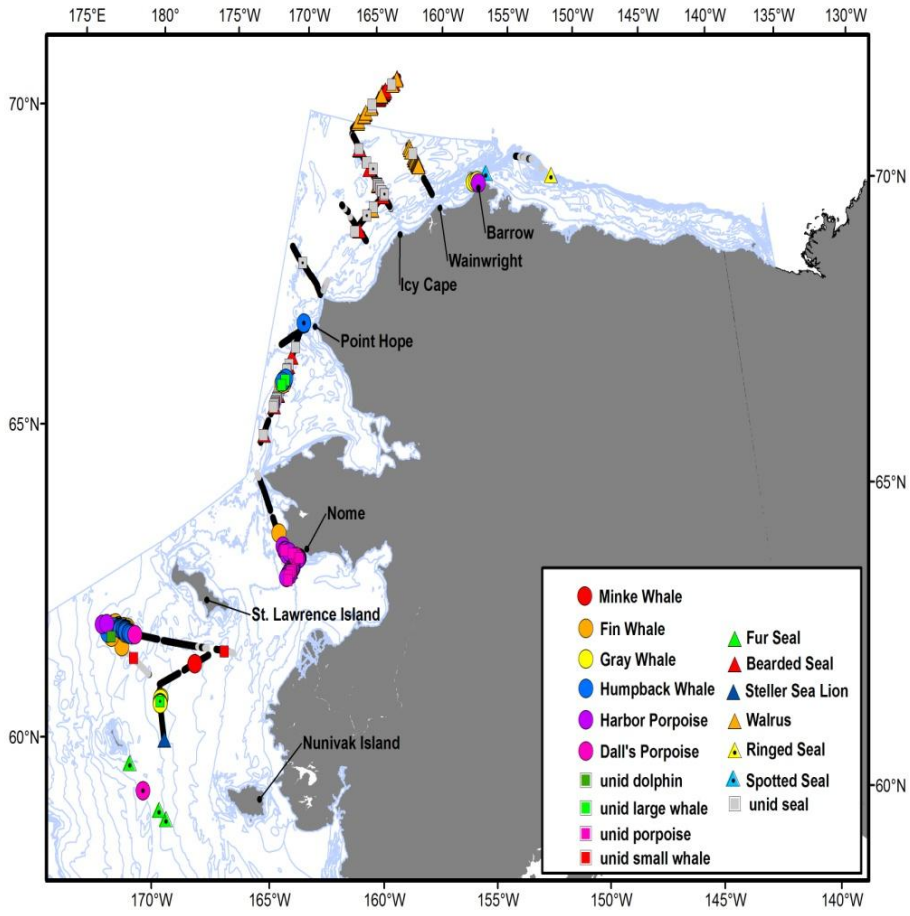
Marine Mammal Sightings (CHAOZ)

Standard Survey Protocol

2010 – DBO Region 3 – 'hotspot'



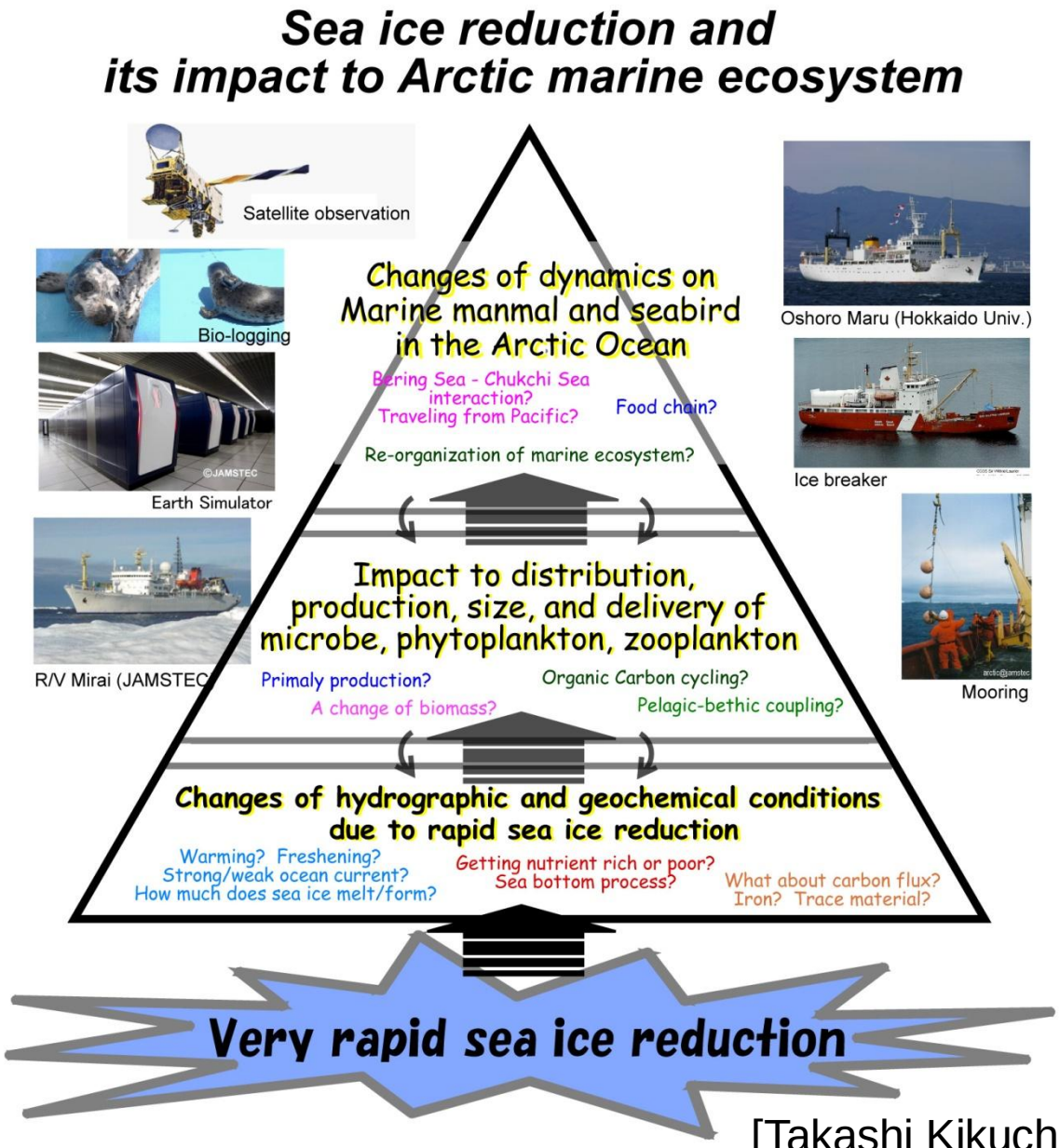
2011: DBO Region 1 – 'hotspot'



[Sue Moore]

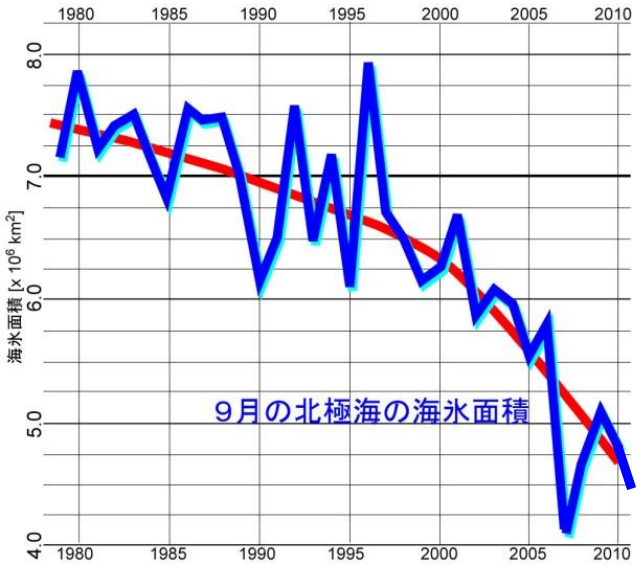
New Japanese project (2011-2015):

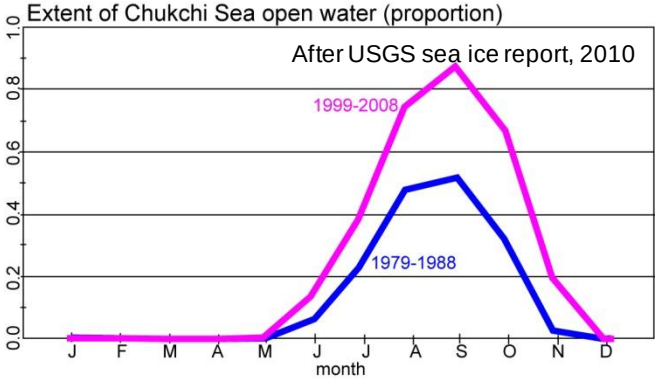
Sea ice reduction and its impact to Arctic marine ecosystem



[Takashi Kikuchi]

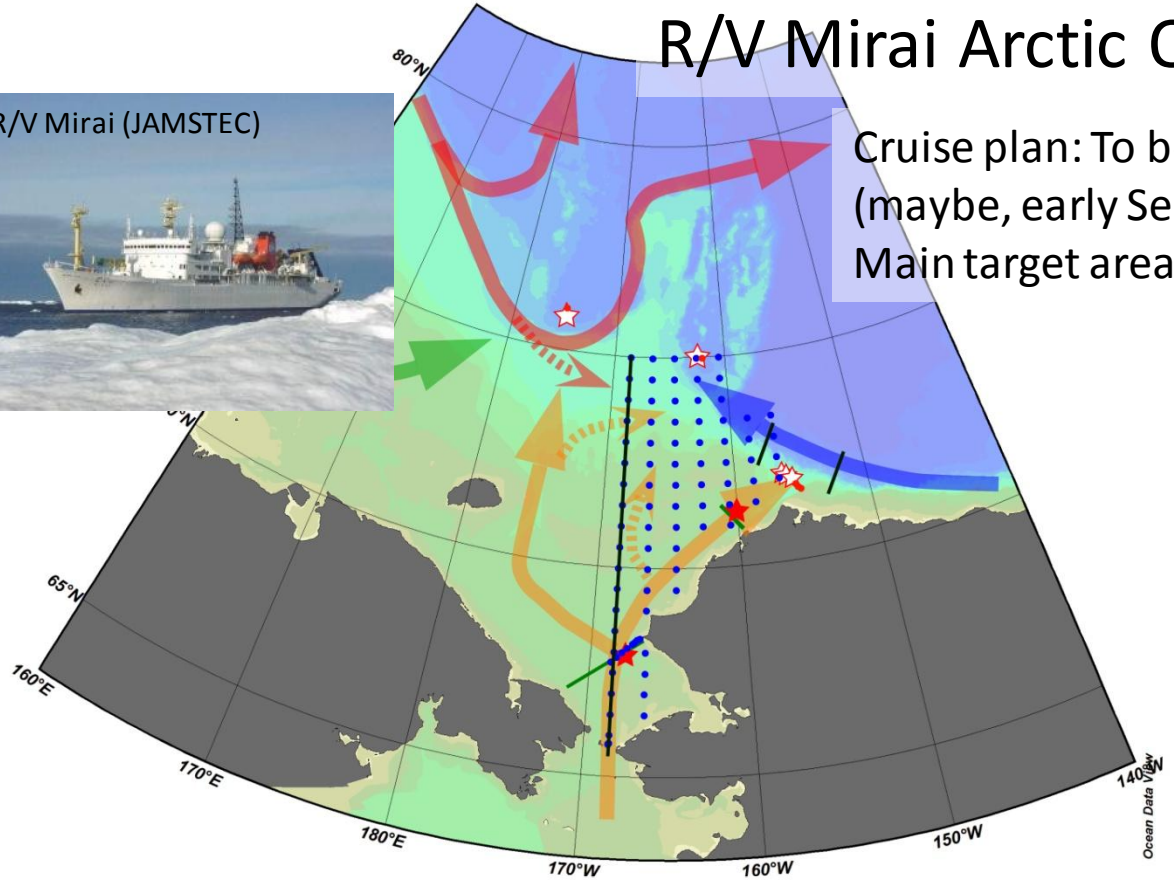
Based on our previous experiments and publications of ours, we planed to initiate multidisciplinary project mainly focused on “sea ice reduction and its impact to Arctic Marine ecosystem”.



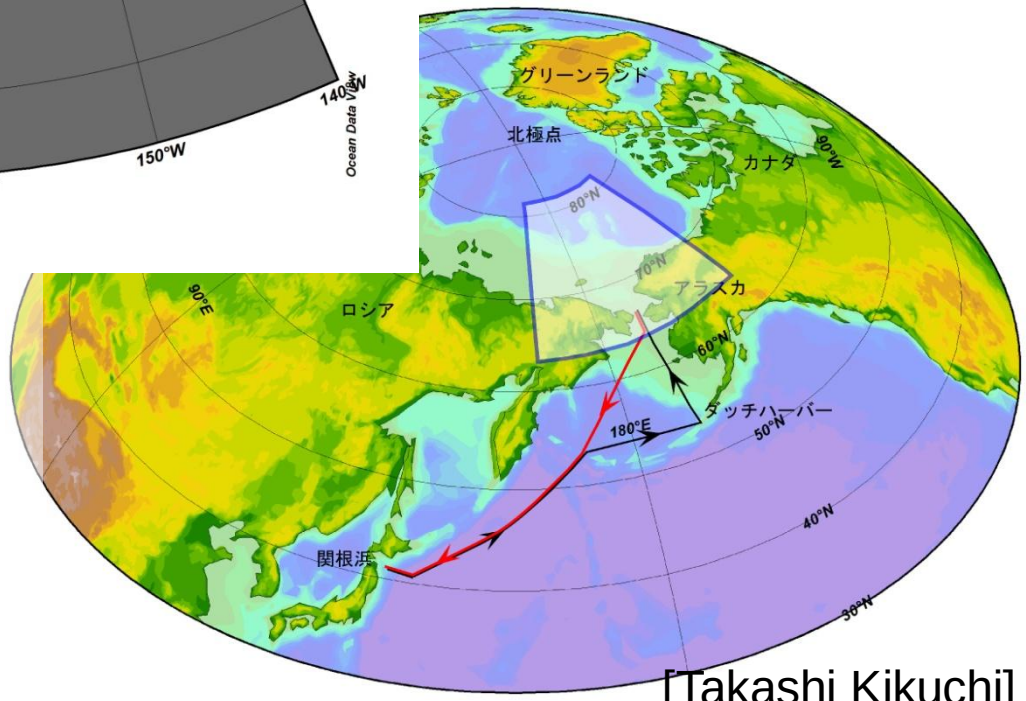


R/V Mirai Arctic Ocean cruise in 2012

Cruise plan: To be determined
(maybe, early September to late October, 2012)
Main target area: Chukchi shelf and shelf slope



CTD/LADCP/water sampling & XCTD
Mooring recovery/deployment
Plankton net sampling
Bio-geochemical measurements
Multiple corer sampling
General meteorological monitoring
Surface water sampling/monitoring
Shipboard ADCP monitoring and so on. . .



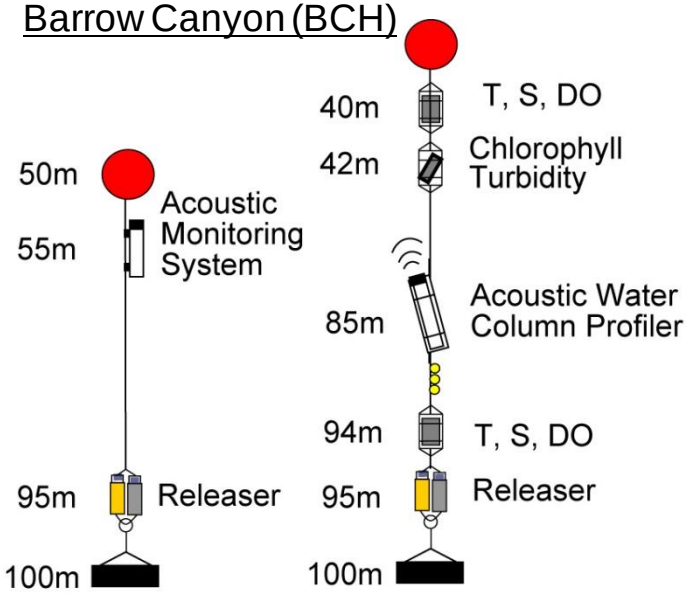
[Takashi Kikuchi]

New Japanese project (2011-2015):

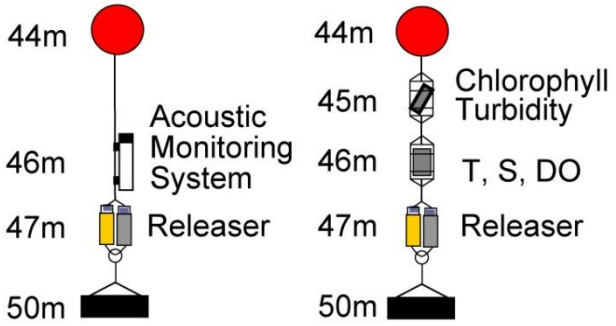
Sea ice reduction and its impact to Arctic marine ecosystem

Mooring observation

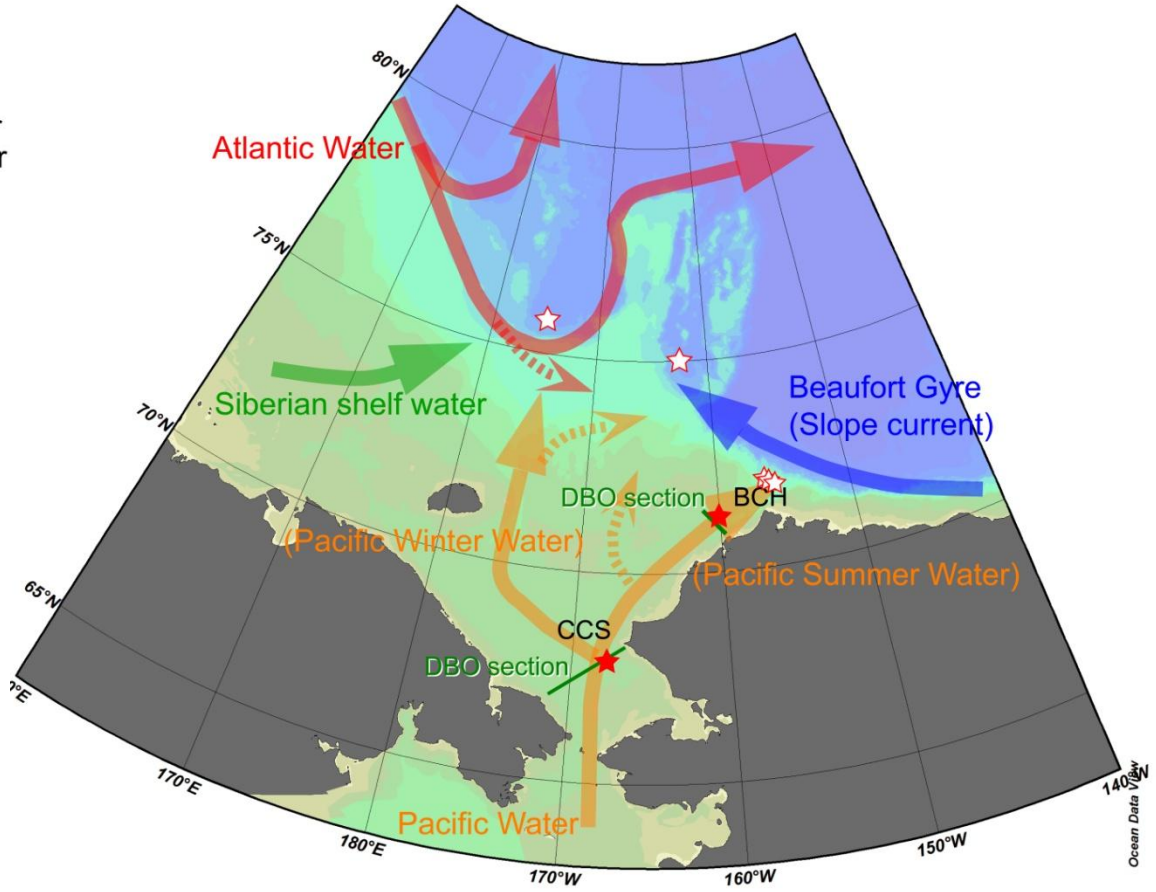
Barrow Canyon (BCH)



Chukchi continental shelf (CCS)



Not only physical but also chemical and biological sensors are equipped on the moorings. First (short-term) mooring will be deployed by CCGS Laurier cruise in July 2012. Year-round mooring observation will start from September 2012 (R/V Mirai cruise).



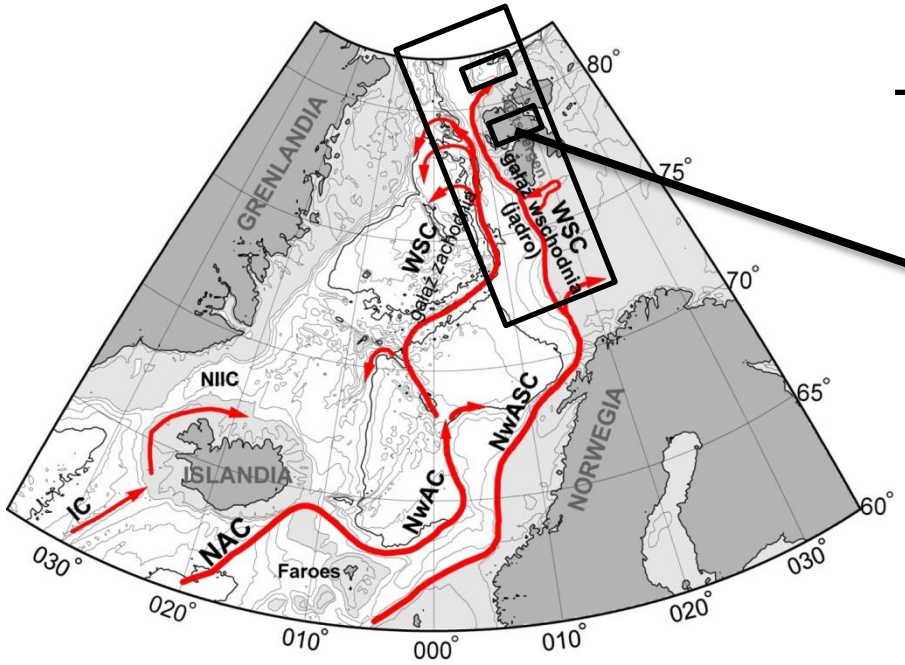
[Takashi Kikuchi]

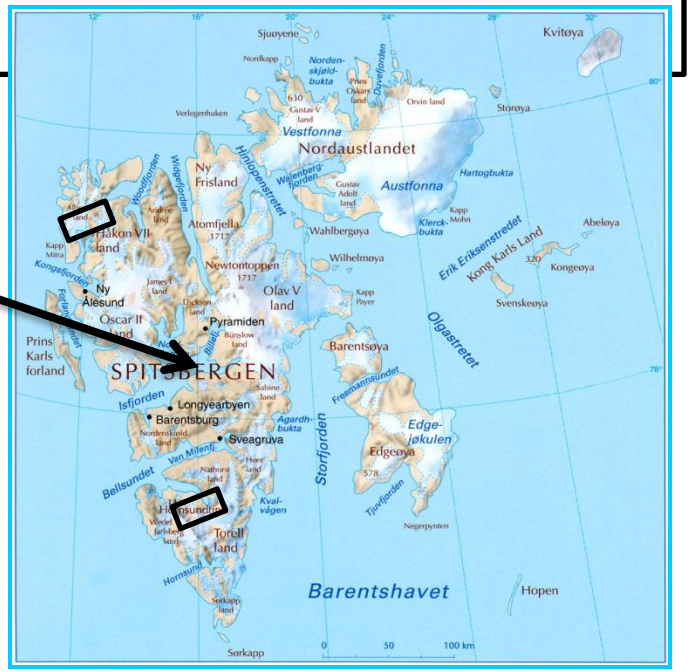
DBO to the pan-Arctic

- Arctic Resilience Report (Arctic Counil)-discussed issues of tipping elements, science to society, understanding the system by downscaling to evaluate the connectivity of components (Eddy Carmack)

Main monitoring activities

- North-eastern part of the Nordic Seas: Atlantic Water pathways and transports plus chemical and biological measurements (plankton)
- Long term transects in Kongsfjorden (since 1996) and Hornsund (since 2001): physical parameters, benthos, plankton

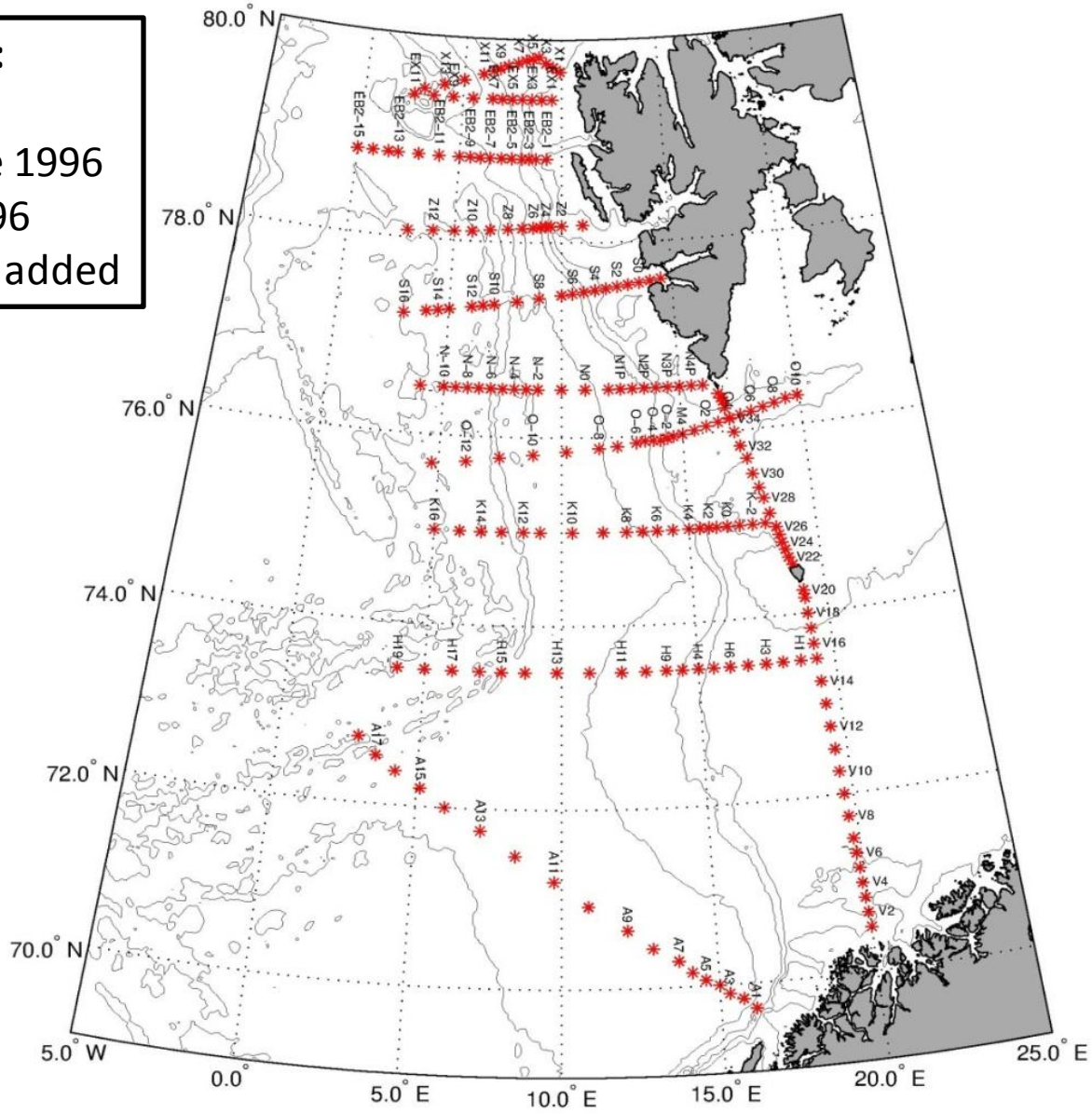




[Monika Kedra]

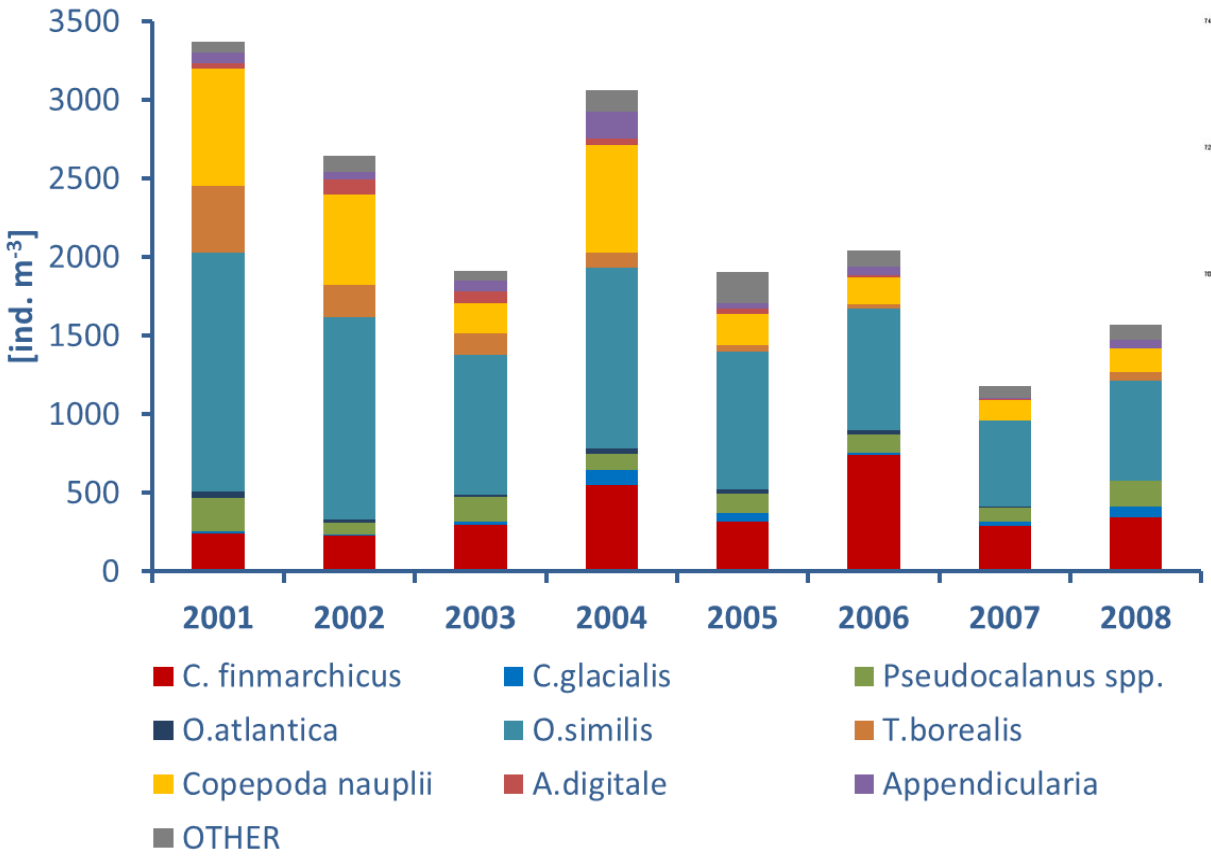
Nordic Seas monitoring activities:

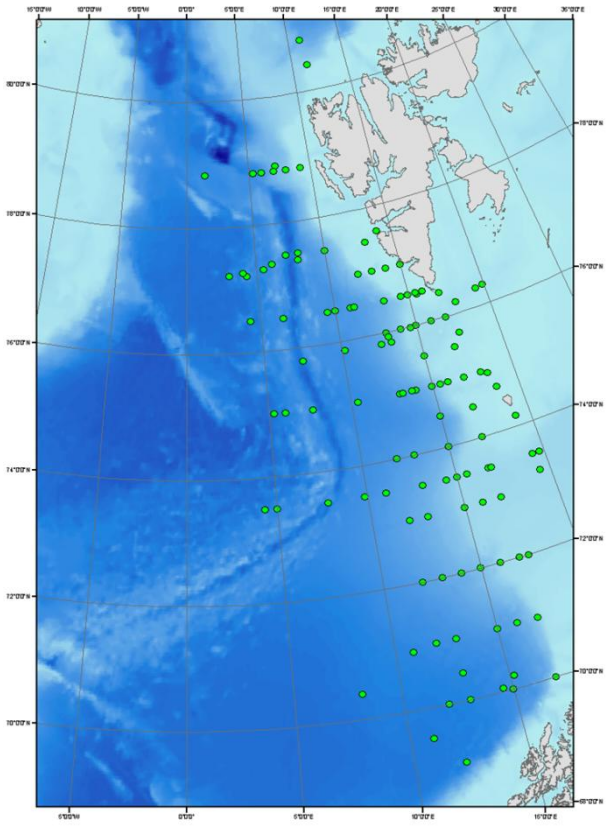
Hydrography measurements since 1996
Plankton measurements since 1996
Recently chemical measurements added



[Monika Kedra]

Time series of mesozooplankton observations from the area of the West Spitsbergen Current



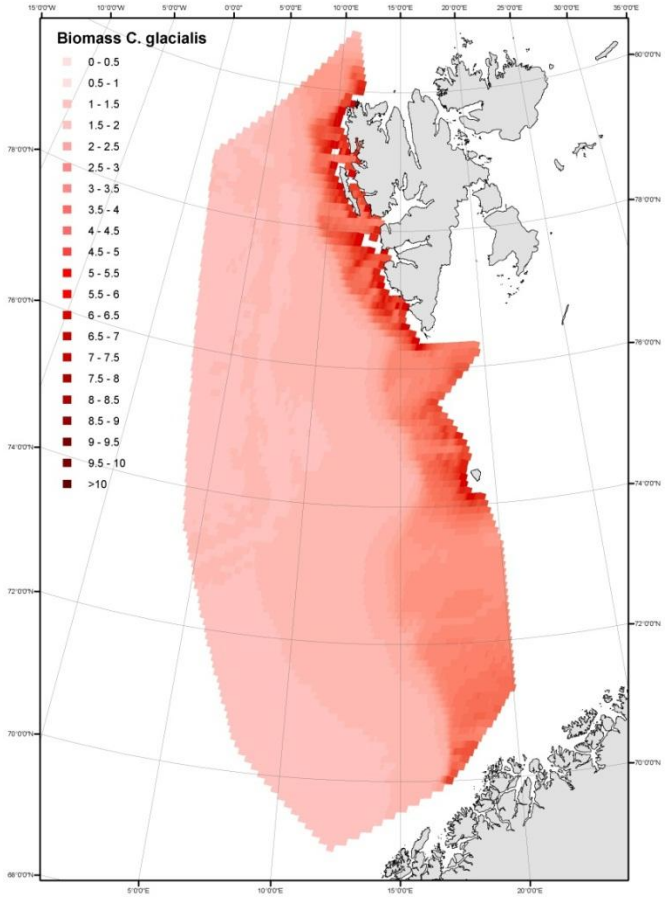


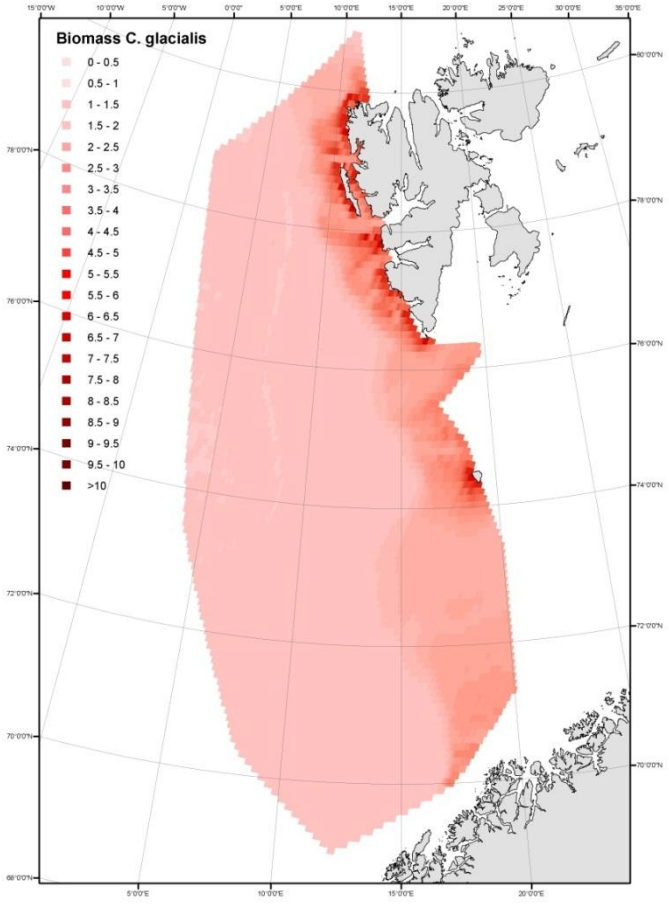
Oithona similis

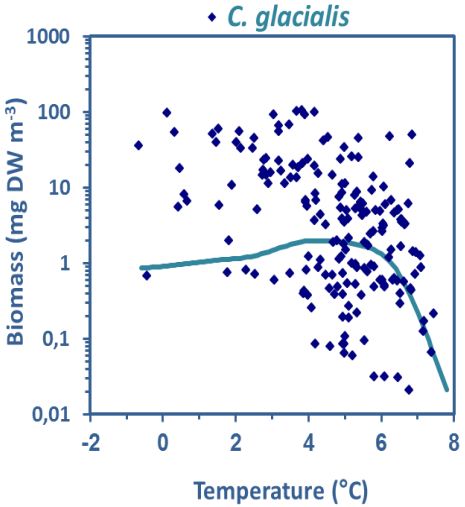
Calanus finmarchicus

S. Kwasniewski

Calanus glacialis – present and future modeled distribution with 2 C temperature increase

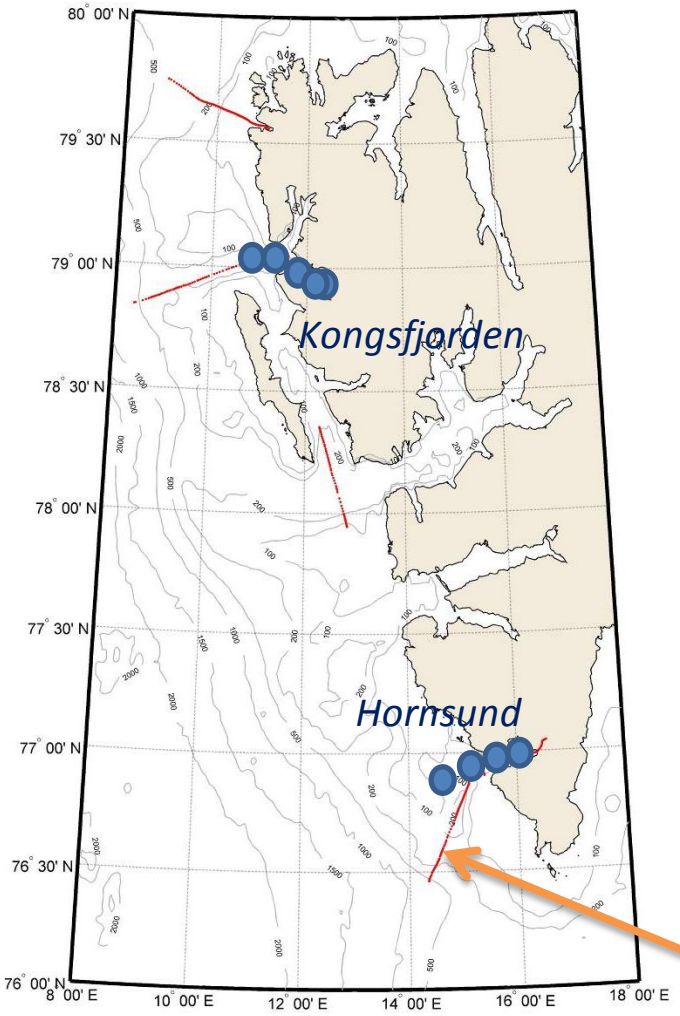


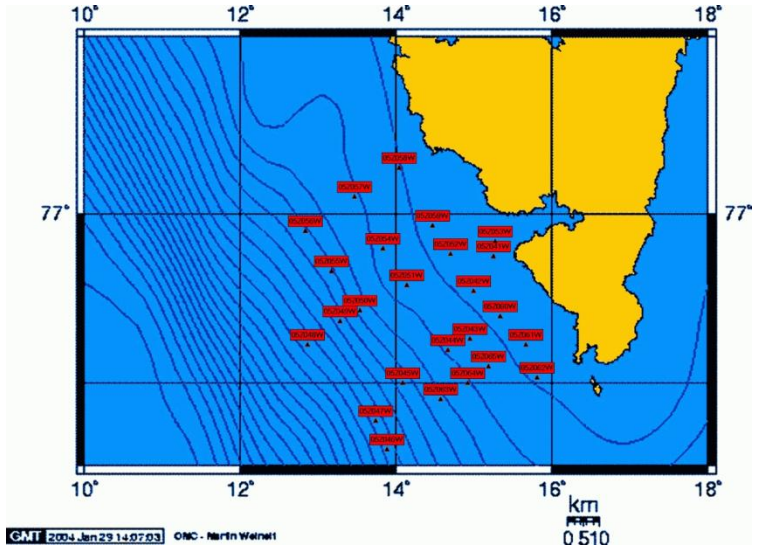


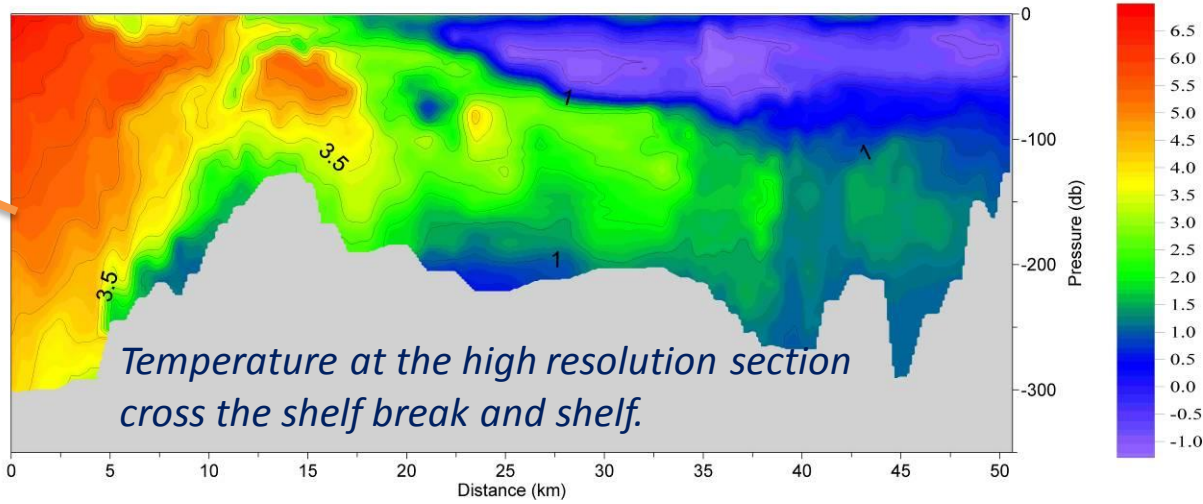


S. Kwasniewski; Arctic Tipping Points EU 7FP project

The West Spitsbergen shelf – fjords exchange; fjords hydrography; plankton and benthos monitoring; little auk feeding grounds



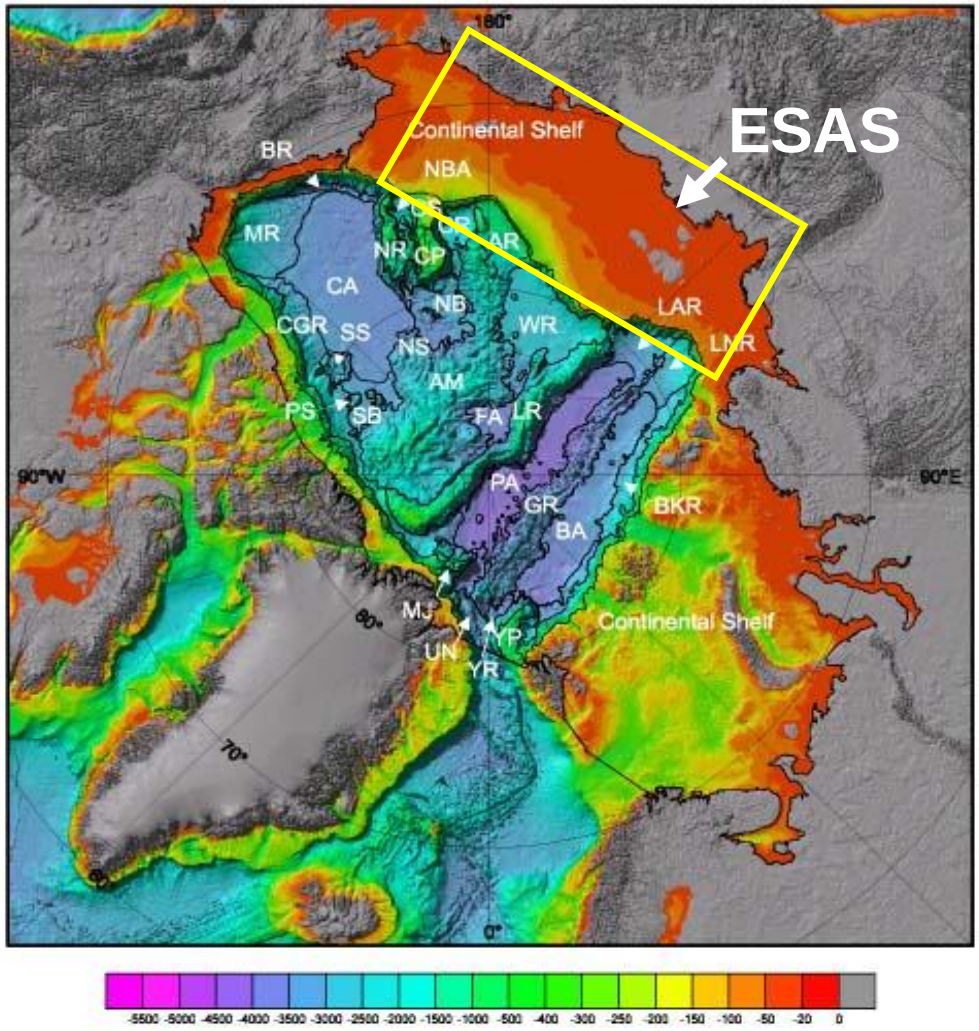




The towed CTD probe standard sections

[Monika Kedra]

ESAS is an unique natural laboratory comprising most of the accessible Arctic Shelf



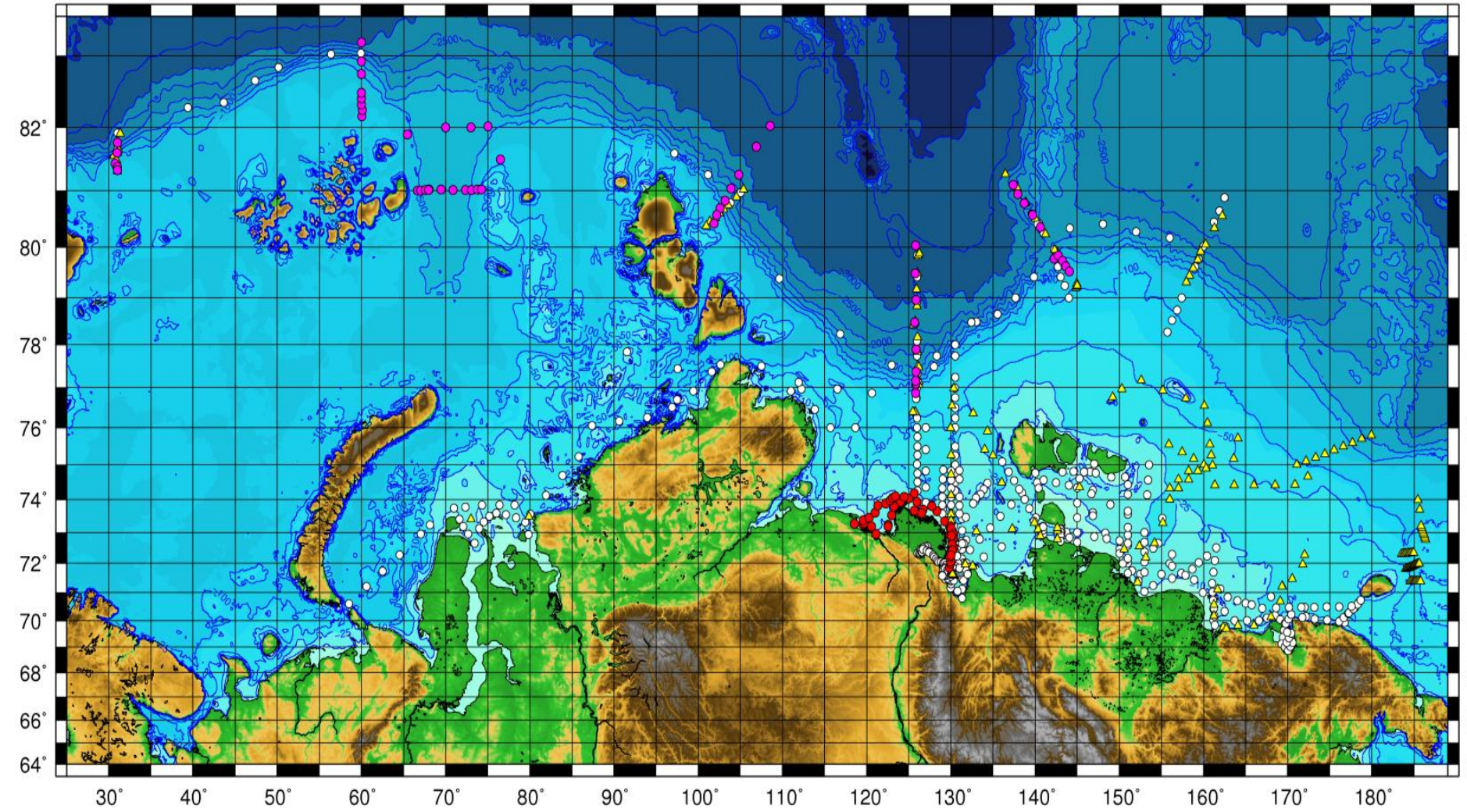
- The total area is **2.1×10^6 km^2** area **(~25%** of the Arctic Shelf, **~8%** of the World Ocean's continental shelf;

- **~75%** is shallower than **50 m** (*mean depth of the continental shelf is **130 m**)*; this provides very short conduit for GHGs to escape to the atmosphere;

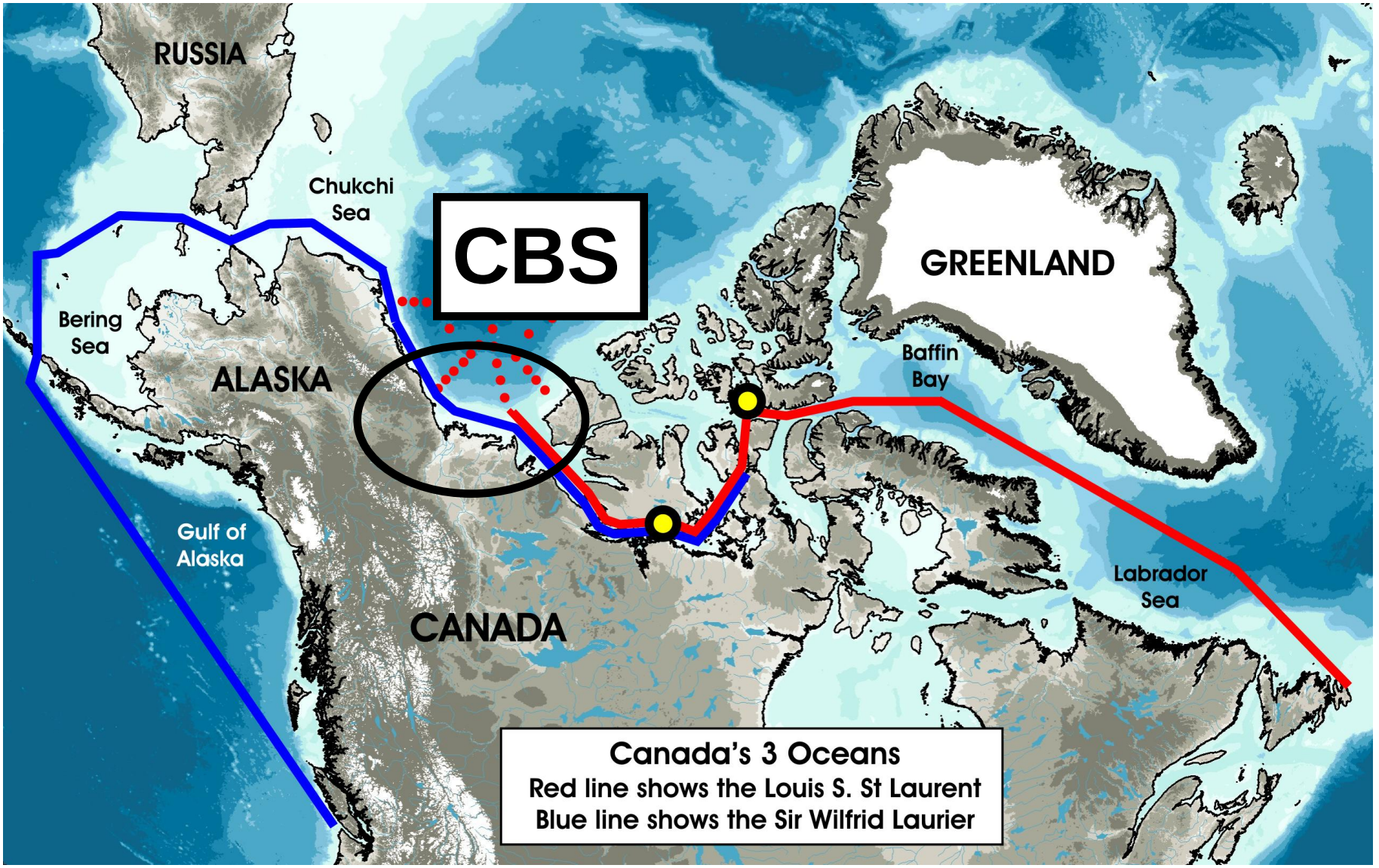
- shallowness determines alteration of dry position (cold epochs)/ submerged position (warm epochs), which occurs due to lea level fluctuation

[Igor Semiletov]

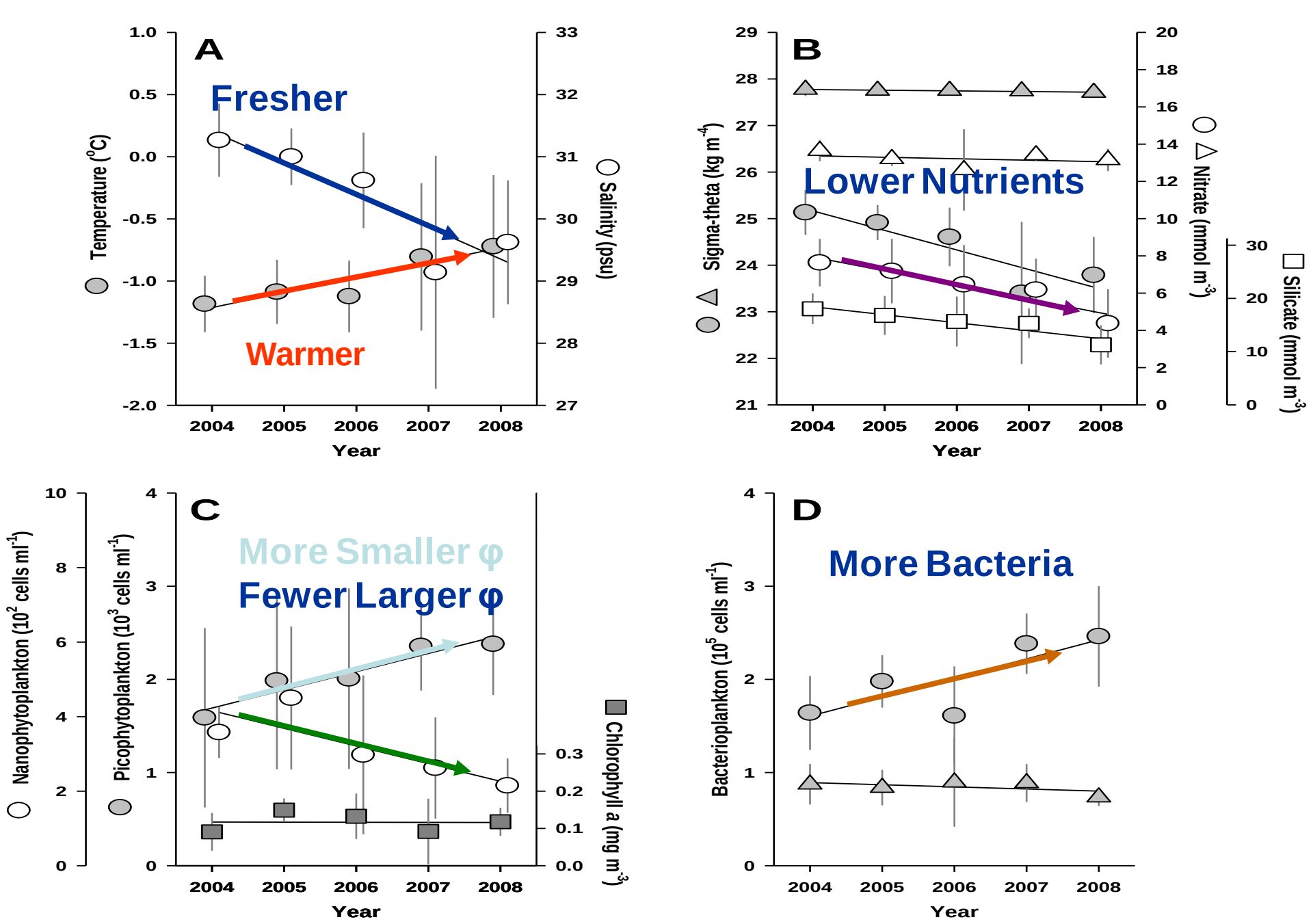
Location of oceanographic stations accomplished with NOAA-support in (2003-2010)



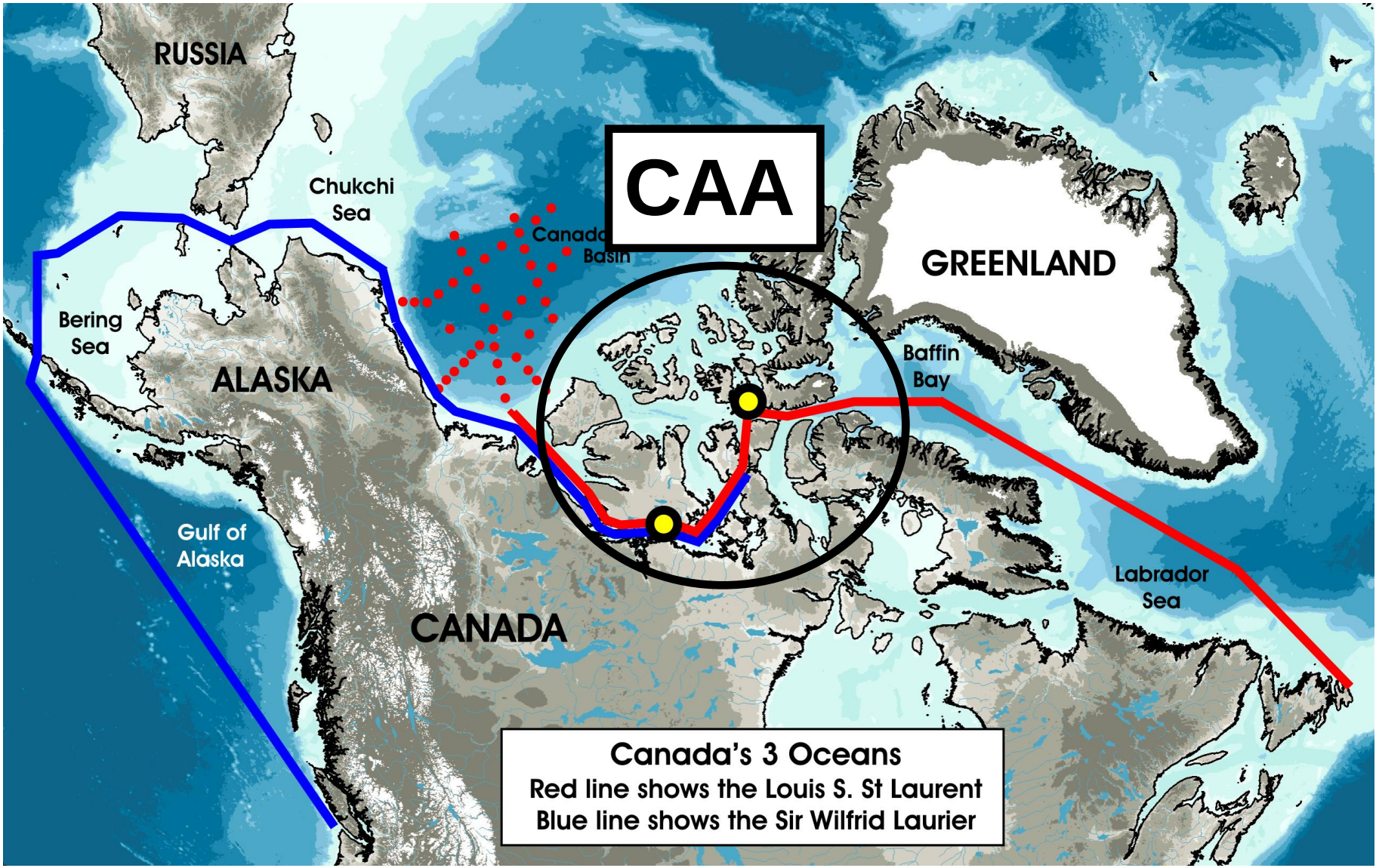
[Igor Semiletov]



[Bill Williams]

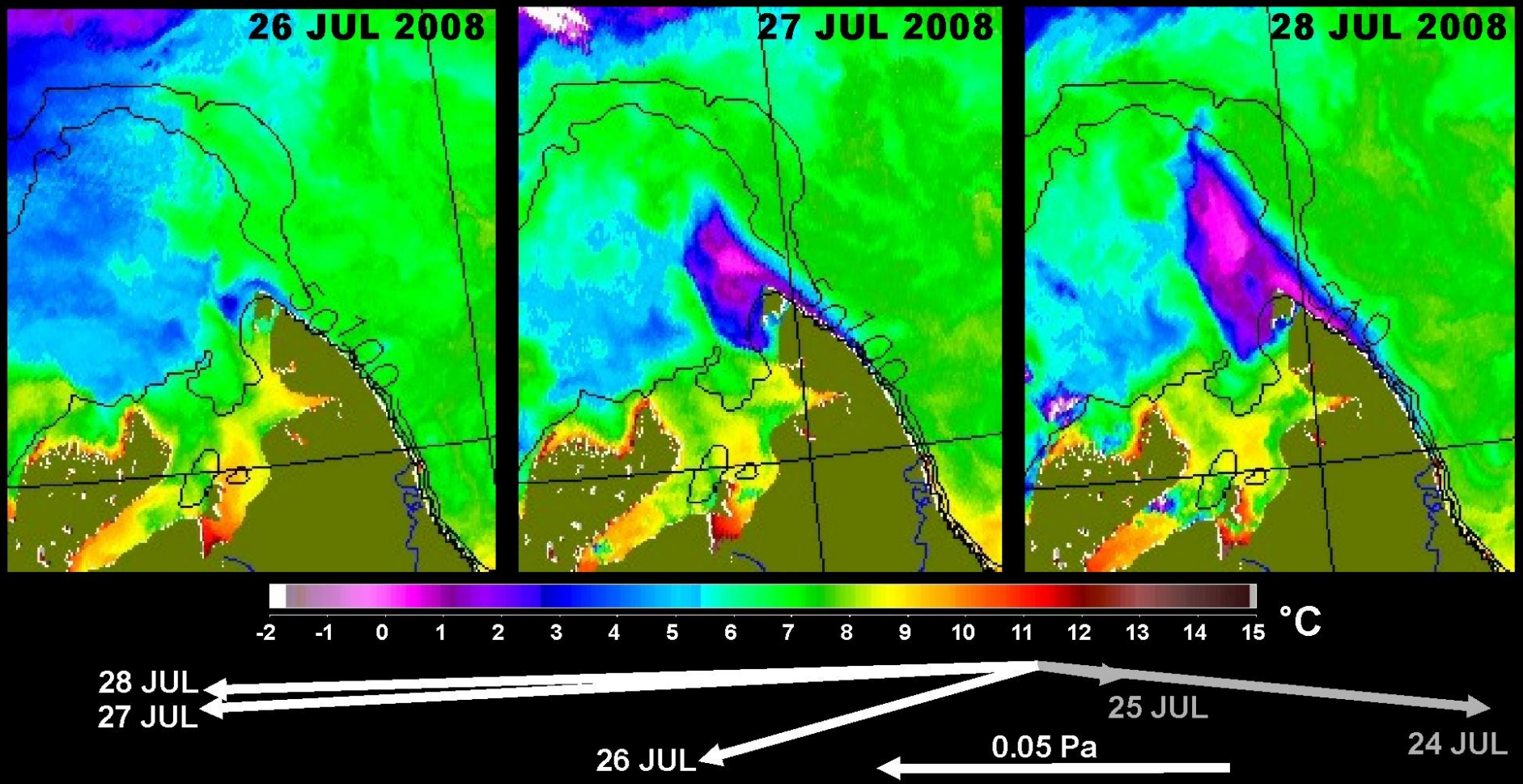


Li, McLaughlin, Lovejoy, Carmack, *Science* (2009)



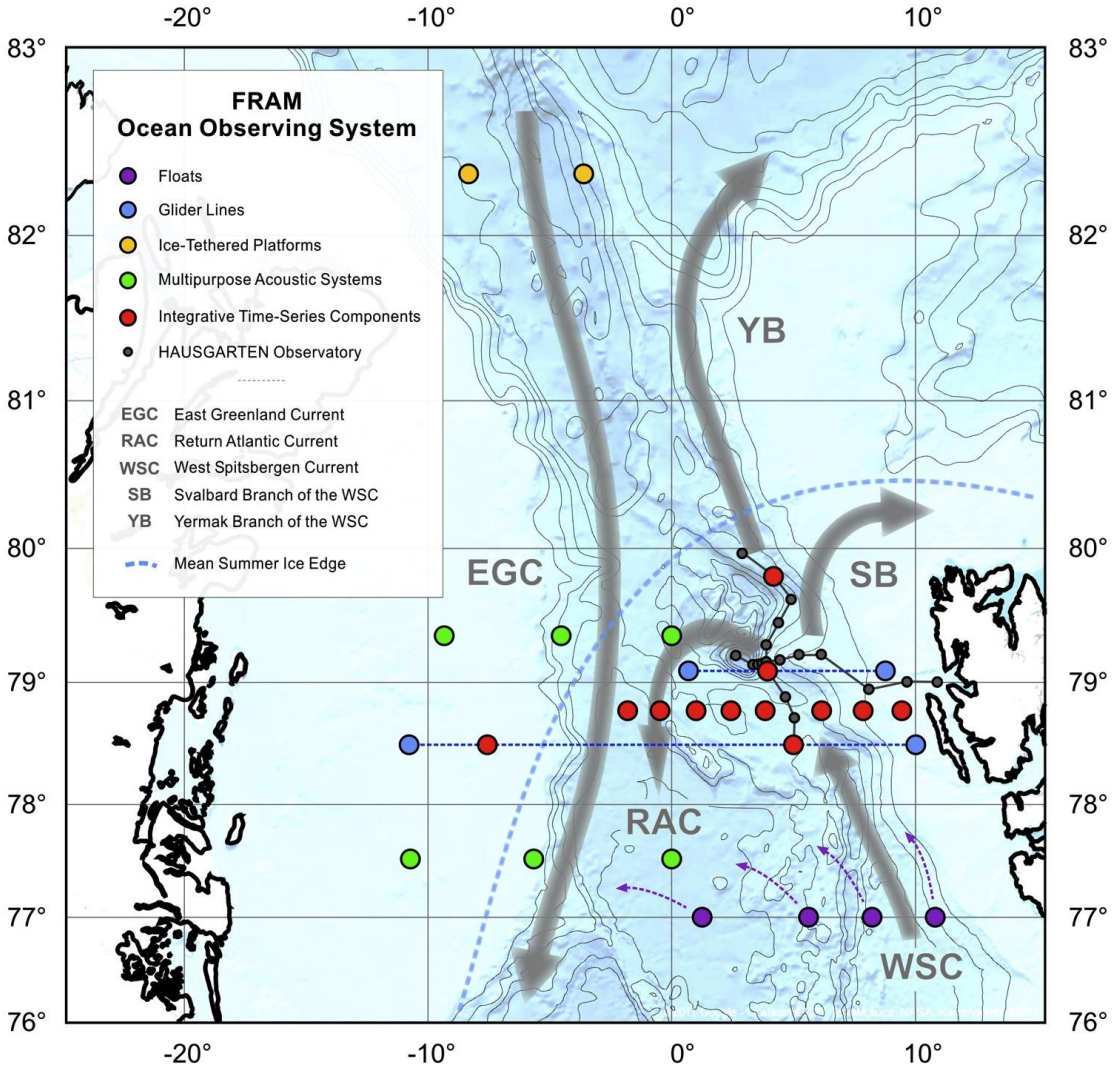
[Bill Williams]

Development of upwelling at Cape Bathurst as the wind turns to blow from the east. The upwelled water is cold and nutrient-rich.



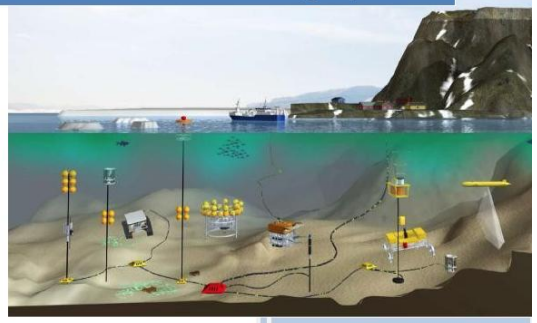
[Bill Williams]

Deep-Sea Observatory HAUSGARTEN



FRAM

Frontiers In Arctic Marine Monitoring
An Ocean Observing System



HELMHOLTZ ASSOCIATION

AWI Alfred-Wegener-Institut für Polar- und Meeresforschung in der Helmholtz-Gemeinschaft

HELMHOLTZ GEMEINSCHAFT

Core Measurements

- Pelagic Zone*

  particle flux (biogenic, lithogenic), currents (speed, direction), oxygen concentrations

- Near-Bottom Zone

  currents and oxygen concentrations in high-resolution, nutrients, bacterial densities

- Sediment-Water-Interface

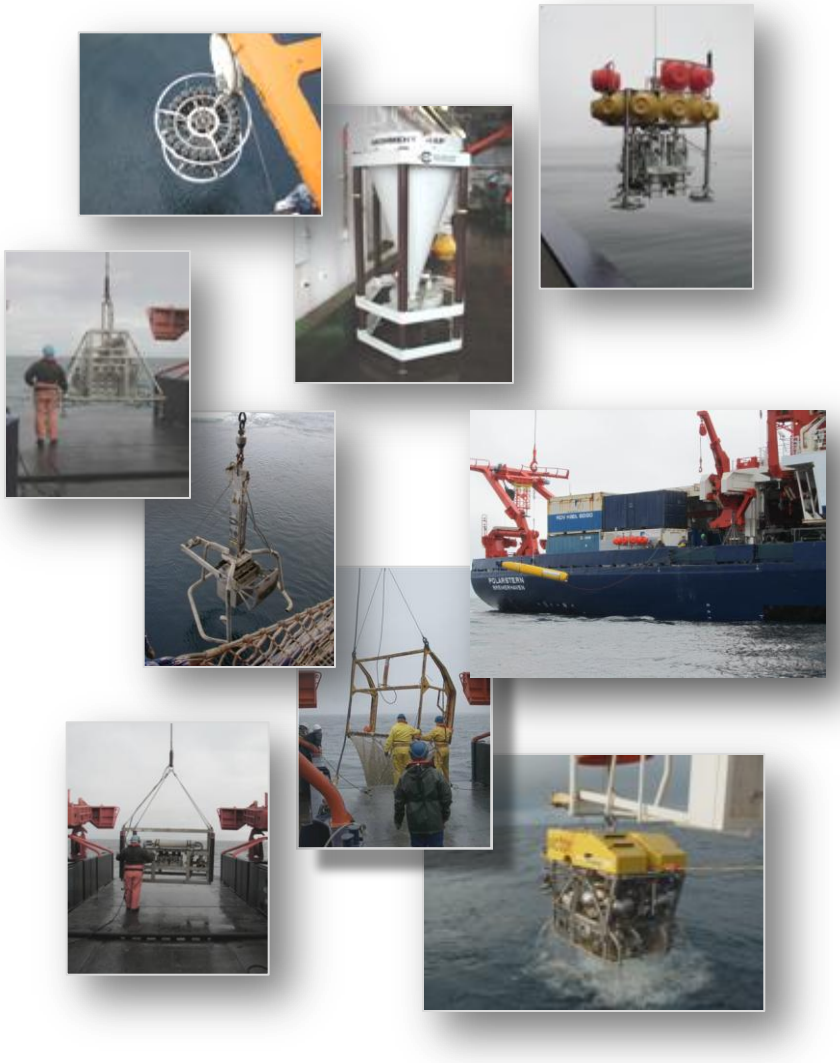
  carbon remineralisation (oxygen microelectrodes, sediment community oxygen consumption)

- Sediments

  granulometry, porosity, organic carbon, carbonates, opal, C/N ratios, biomarker (e.g. alkenone, n-alkanes), organic matter input (phytodetrital pigments)

- Benthos

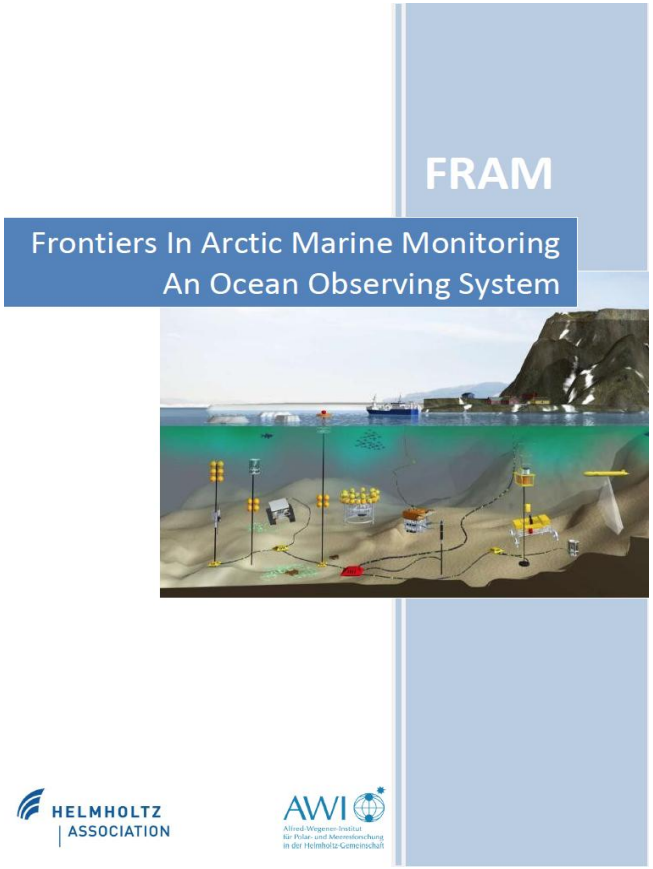
  bacteria, meiofauna, macrofauna, megafauna including fish (densities, biomass, dispersion, biodiversity)



* new working on “Phytoplankton Ecology and Biogeochemistry in the Changing Arctic Ocean” (PEBCAO)

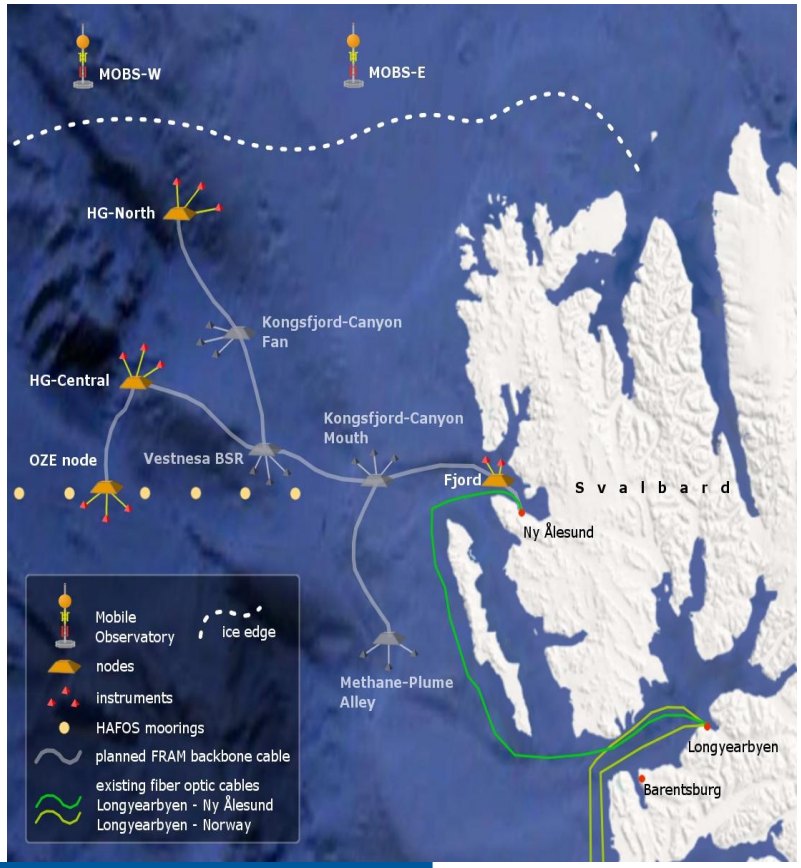
Future Perspectives:

FRAM - Observatory infrastructure proposal submitted by AWI to the Helmholtz Association has been recently evaluated



FRAM Cabled Observatory

- consortium of national and international partners
- on-line / real-time data from the deep Arctic Ocean
- unlimited energy supply for scientific instruments



HELMHOLTZ GEMEINSCHAFT

Main monitoring activities at present:

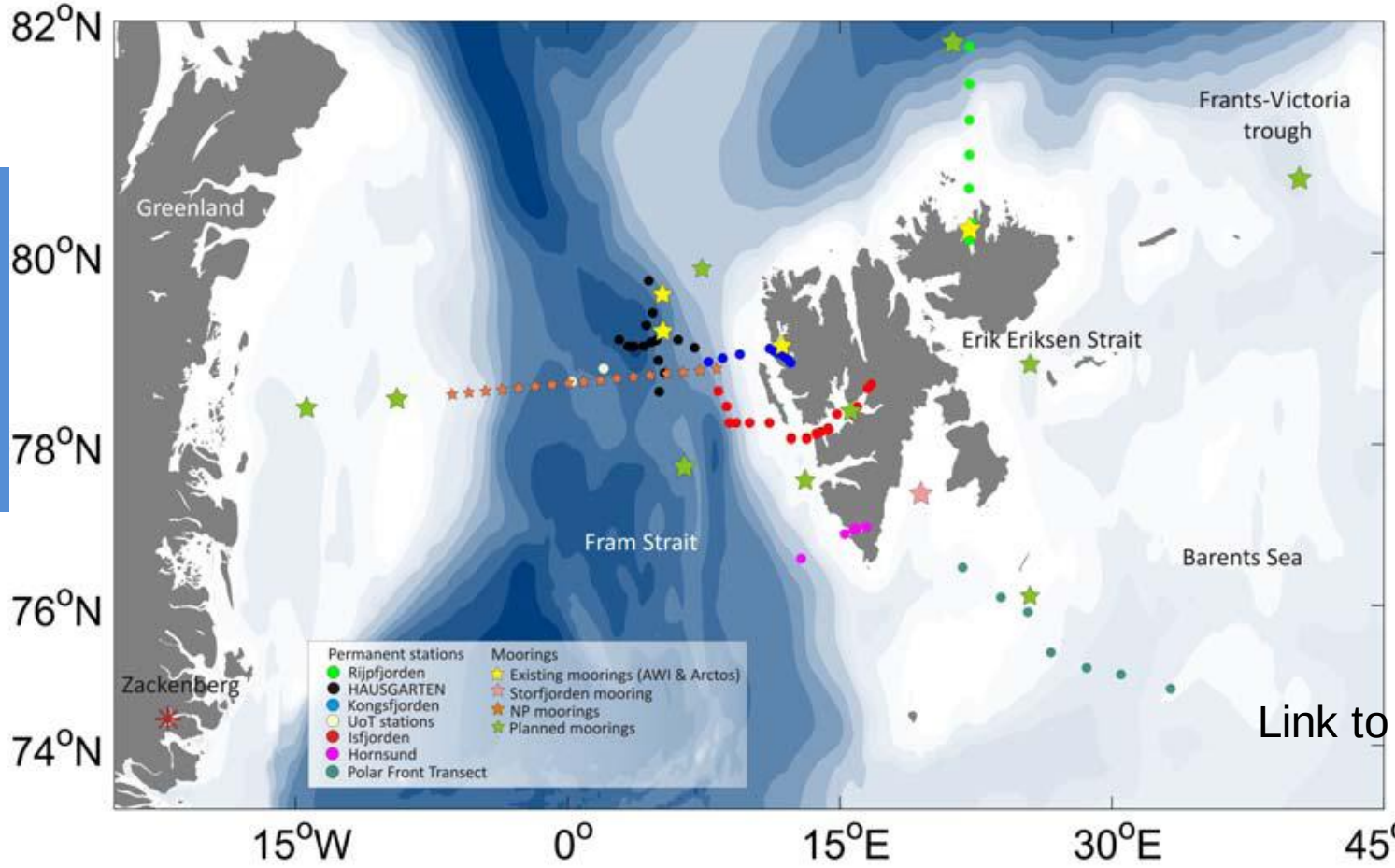
- **Norwegian Polar Institute (NP):** Arctic Ecosystem Monitoring Program (AEM/MOSJ)
  - Long term transect (Kongsfjord since 1995)
  - Database of all phyto- and zooplankton data (cooperation with Poland)
  - Established cross shelf sampling transect north of Spitsbergen
- **Institute of Marine Research (IMR)**
  - Extensive ecosystem surveys for fisheries, plankton and physics in the Barents Sea in cooperation with Russia
- **UNIS (Svalbard University Studies)**
  - Annual cruises as student courses around Spitsbergen, including mooring surveys (3 moorings in fjord systems)
- **University of Tromsø**
  - Benthos hard bottom
  - Project related process and community studies on pelagic-benthic coupling in Barents Sea, Fram Strait and Spitsbergen area

Marit Reigstad

Example: Observations around Svalbard

- Community Time Series (Polar Front, KongHau, Rijpfjord)

CTD
PhPl
ZooPl
Nutr
Soft b.
Hard b.



Link to SIOS

[Marit Reigstad]

Initiatives that could take a coordinating role

- SIOS – Svalbard integrating observatory network. But requires that ship-based sampling is included – not only observatories (operational phase planned end 2013)

- CoE application Centre for Arctic Marine Productivity (CAMP) from ARCTOS: have idea to identify potential stations north of Svalbard-Fram Strait

- FRAM centre (Tromsø): establish mooring array north of Spitsbergen, one mooring with biological sensors (shelfbreak) from summer 2012 – will make a test DBO station

- Konghau/ Hausgarten transect (AWI/NP/UiT/SIOS) could identify Fram Strait station as DBO

Characteristics of Circumpolar Biodiversity Monitoring Program (CBMP)

- Formal activity established under Arctic Council, Conservation of Arctic Flora and Fauna WG
- Has marine, terrestrial, fresh water and coastal components that conduct sustained observations and analysis
- National commitments to sustain observations at key sites selected by each country
- Open only to Arctic Council states through 2015 and then to AC observer states

Characteristics of Sustaining Arctic Observing Networks (SAON)

- Independent activity sponsored by Arctic Council and International Arctic Science Committee
- Does not engage in conducting observations
- Promotes networking among observation sites operated by different countries
- Focuses on improving standards, data quality, and data sharing, and improving technology
- Encourages creation of integrated data bases that can be shared for analysis
- Has emphasis on linking formal science with traditional knowledge of indigenous people
- Open to Arctic and non-Arctic countries on an equal basis
- International SAON Board oversees work done on a task basis by self-funded participants (Initial meeting Jan. 24-25, 2012 in Tromso)

Preliminary results and benefits of DBO data array

- DBO concept can work: 6 cruises by 4 nations in 2010 and 2011
- Repeat hydography is successfully capturing seasonal variation of the Pacific Water, with goal to sort out seasonal vs. interannual variation
- Immediate data sharing advantageous for real-time evaluation of system
- Information can help interpretation of individual studies by providing a temporal context
- High resolution measurements, both vertically and horizontally
- Provides essential Information of 0-30m region not captured by moorings
- Lower trophic taxa data (phytoplankton, zooplankton and benthos) shared amongst DBO participants can provide seasonal biological information
- DBO can be used to look at temporal variation in biological parameters, latitudinal variation (time and space scales)
- Evaluation of data between labs possible
- Averaged volume transport through the Barrow Canyon be evaluated with seasonal ADCP measurements
- Seasonal variation of heat content and heat flux is large in Barrow Canyon
- Fresh water flux primarily from July to September
- Moorings: important for seasonal variation (including winter), but need more biochemical sensors on moorings for DBO array
- Satellites needed for overview of surface temperature, sea ice and chlorophyll/productivity over large regions of interest in the Pacific sector

Challenges

- Requires coordination and commitment
- Need for spatial resolution of water sample variables (ideally more nutrients than just nitrate)
- Recognition that different sampling scales are needed for physics, hydrography, plankton and benthic sampling
- Data quality and processing time are issues
- Need data policy for sharing and access, agreement on timing use by DBO partners and open to community use
- Need more post-cruise analysis sorting time for biological data
- Standardization of gear and analytical capability
- Collection of standard parameters sites on a regular basis
- Need for dedicated national funding for incremental shiptime, data processing and analysis

Future of DBO-Ways Forward

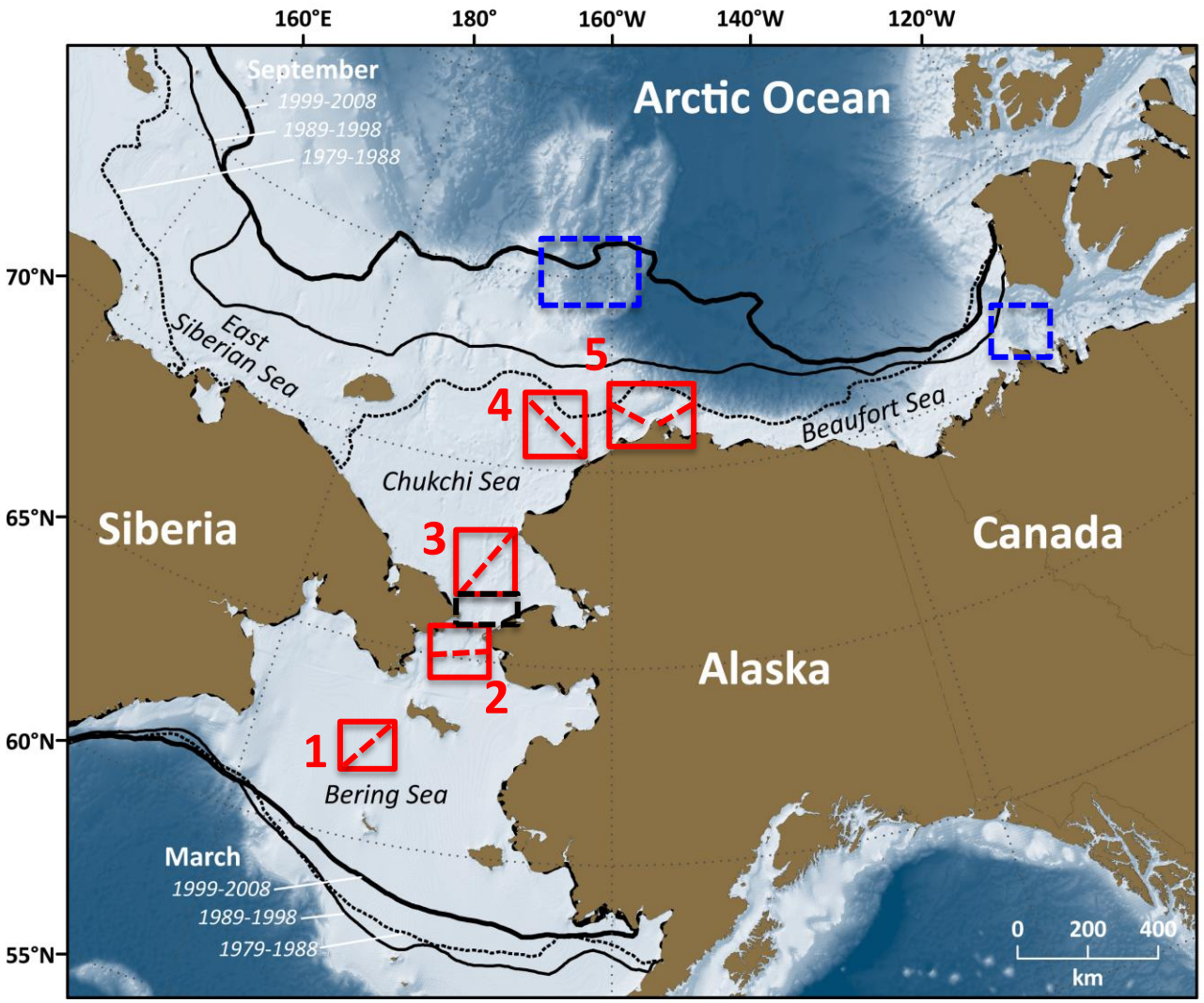
- 2012 Field plans DBO sites: Canada (C30), ?China, Japan, Korea?, Japan (JAMSTEC/NIPR, others), Russia (RUSALCA), USA (collab w/C30, AON projects, ? Oil & gas industry-discuss further within PAG meeting as part national reports
- Need work on joint publications: discuss and determine publication policy
- ACTION: Data issues-agreed respond to DBO data questionnaire on type DBO data collections, units, format, national archive link as step in process to develop data access & release policy for international DBO data sets
- ACTION: Submission 2 pg. DBO data management task for international network for SAON

Future of DBO-Ways Forward (cont.)

- ACTION: Submission 2 pg. DBO project statement as SAON project
- ACTION: Submission NSF RCN (Research Coordination Network)
- ACTION: Need updated name for international members to a DBO Steering Group
- ACTION: will activate subgroups for further data discussions(biological and physical)-please email me if interested in participating or send contact name
- Upcoming community updates on DBO
  - 2011 DBO ARCUS open community information session, AGU, Thurs. Dec. 8 8:30-9:30
  - 2012 DBO Oceans meeting, Salt Lake City
  - 2012 DBO updates/discussion during PAG meeting ASSW Montreal

- Other comments from DBO workshop participants?

DBO current and potential sites



- DBO sites (numbered red boxes) are regional "hotspot" transect lines and stations
- Potential future sites (blue dashed boxes) are regions of changing physical processes, biochemical and atmospheric "hotspot" sites, some tied to biological indicators of change
- Black box: ongoing Bering Strait study

Questions and comments?

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