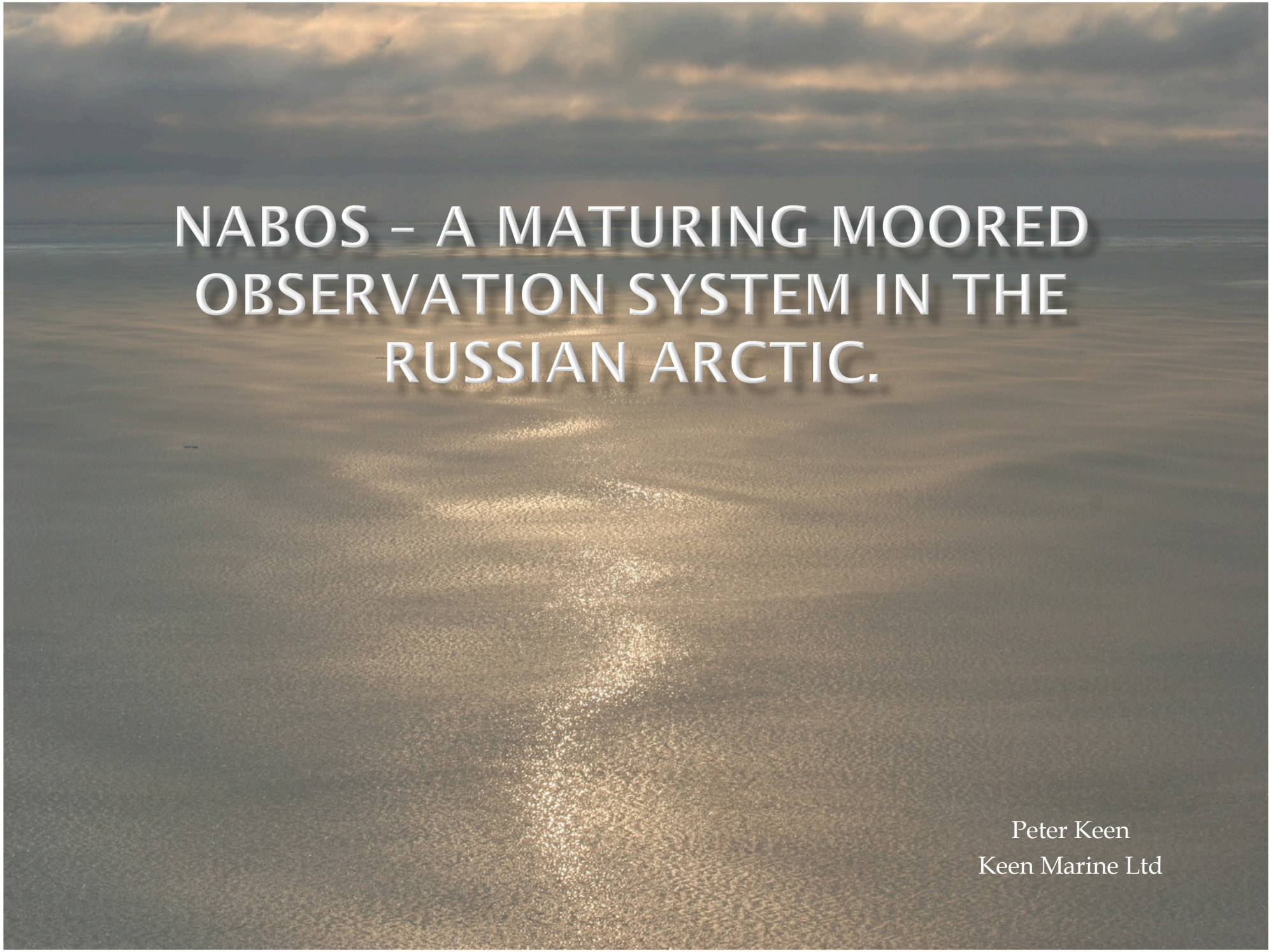


NABOS – A MATURING MOORED OBSERVATION SYSTEM IN THE RUSSIAN ARCTIC.

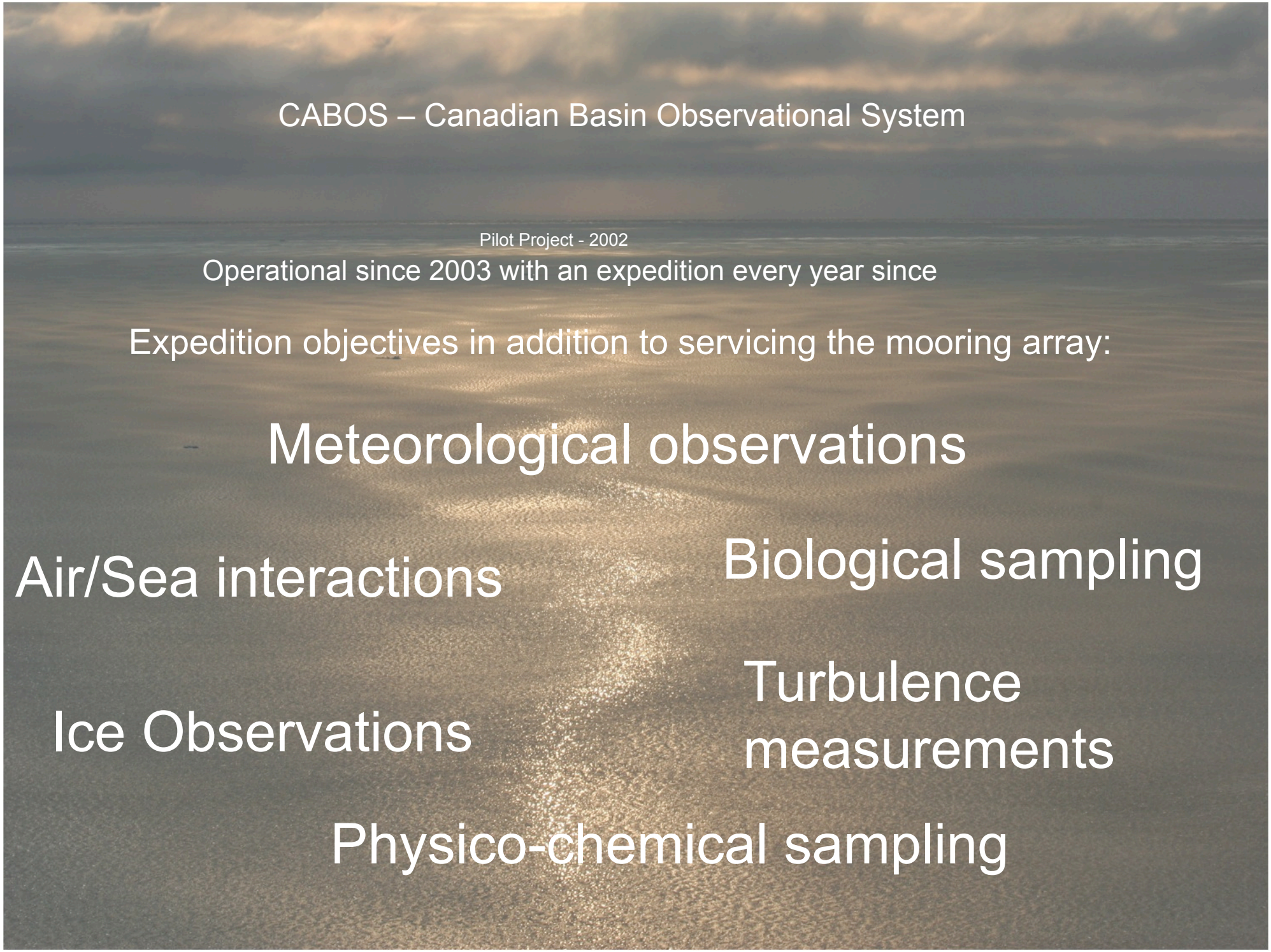
Peter Keen
Keen Marine Ltd

N Nansen
&
A Amundsen
B Basin
O Observational
S System

International Arctic Research Centre (IARC)

University of Alaska, Fairbanks (UAF)

Laval University, Quebeć, Canada
Polish Institute of Oceanography (IOPAS), Poland
Arctic and Antarctic Research Institute (AARI), St Petersburg, Russia
Institute of Atmospheric Physics, Moscow, Russia
The Norwegian Polar Institute and The Norwegian Meteorological Office, Norway
The Alfred Wegener Institute, Bremerhavn, Germany
National Oceanography Centre, Southampton, United Kingdom
Bangor University, Wales
Scottish Association for Marine Sciences, Scotland



CABOS – Canadian Basin Observational System

Pilot Project - 2002

Operational since 2003 with an expedition every year since

Expedition objectives in addition to servicing the mooring array:

Meteorological observations

Air/Sea interactions

Biological sampling

Ice Observations

Turbulence measurements

Physico-chemical sampling

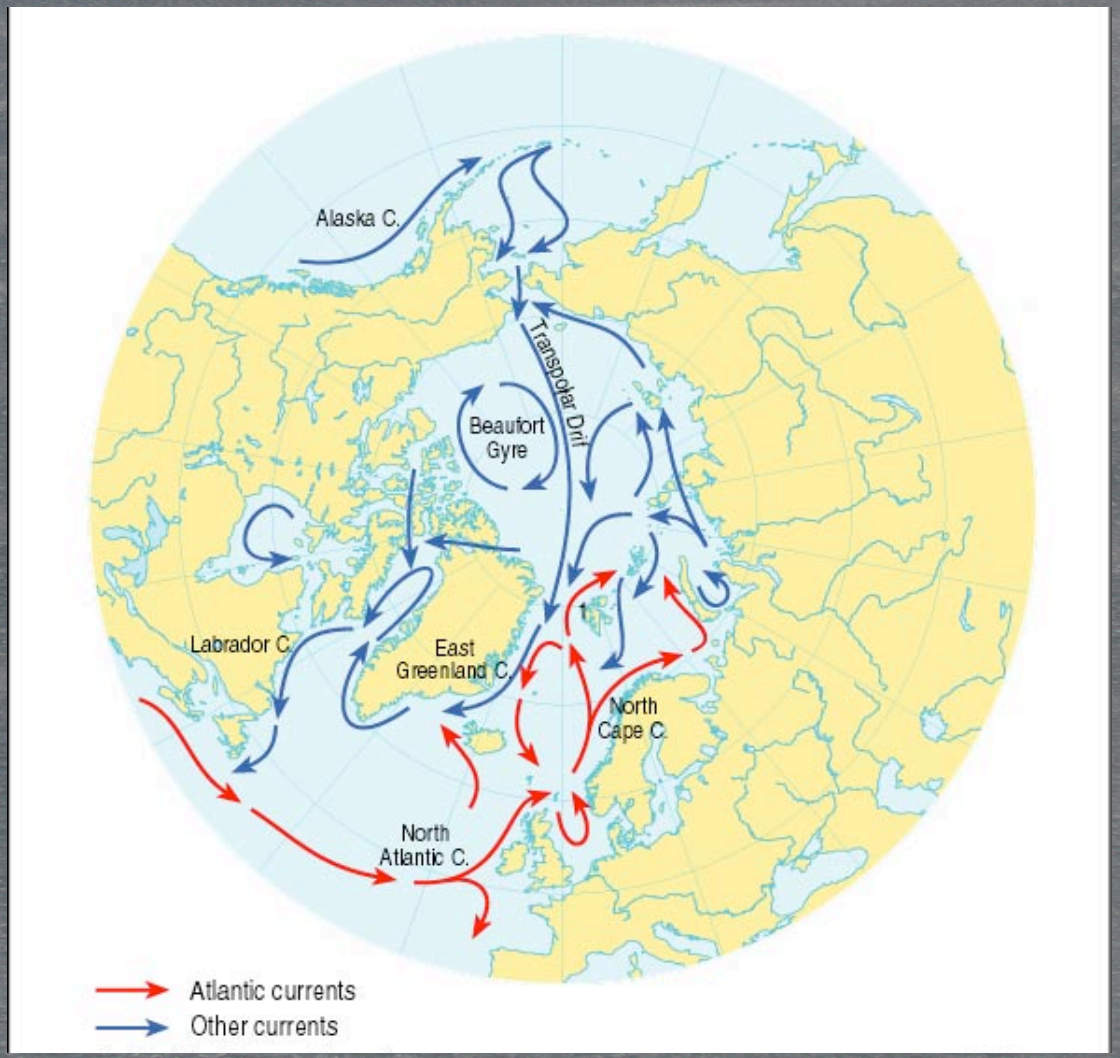
NABOS Objectives

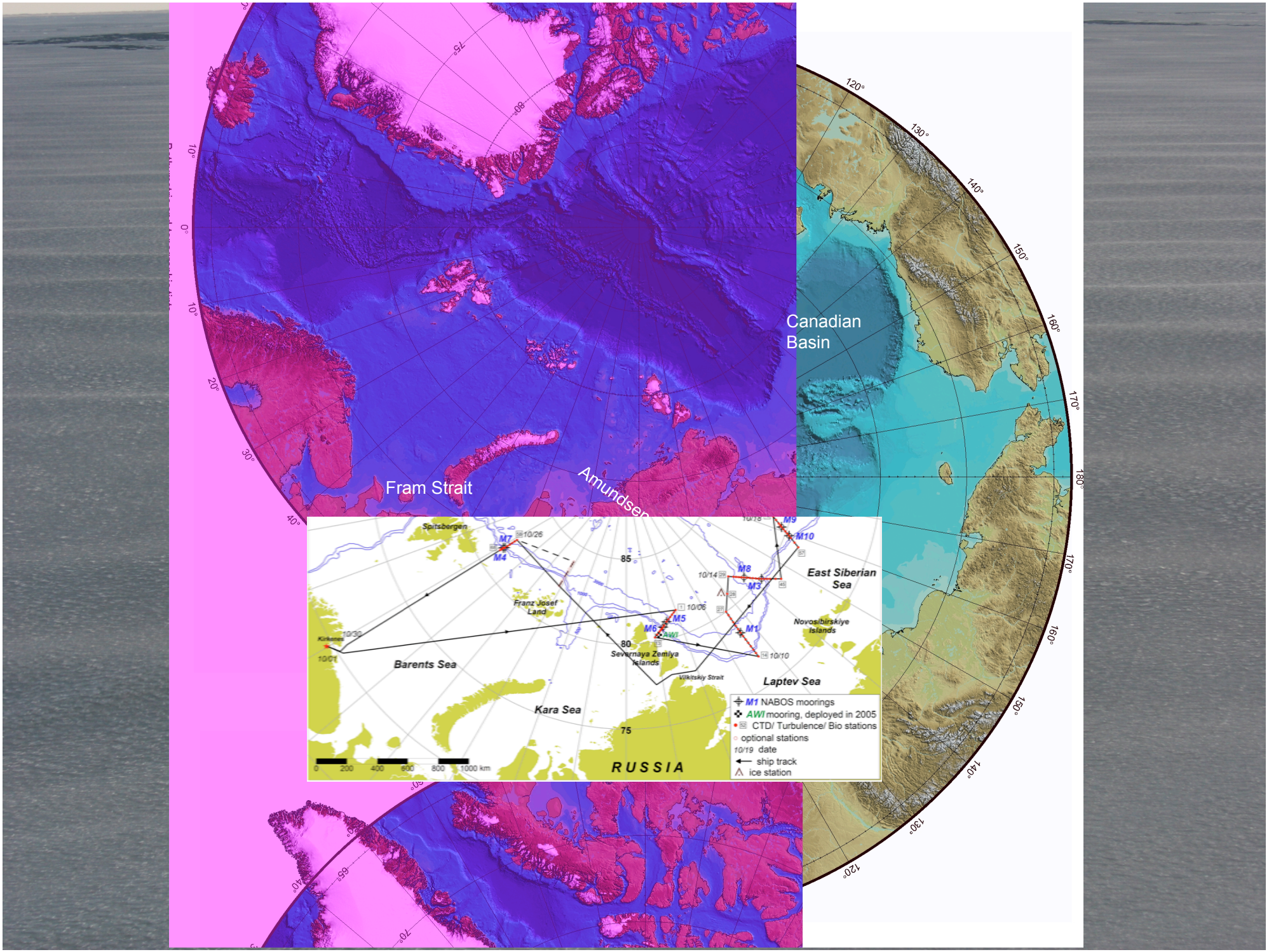
1. To quantify the structure and variability in circulation of the Eurasian and Canadian basins
2. To evaluate mechanisms by which the Atlantic Water (AW) is transformed on its way
3. To evaluate the impact of heat transport, from the AW, on ice
4. To investigate the strength and variability of the Fram strait and Barents sea branches of the AW
5. To estimate the rate of exchange between the arctic shelves and the arctic interior and clarify mechanisms for the formation of the halocline

CABOS

6. To quantify the storage and variability of heat and fresh water, particularly within the halocline of the Canadian basin
7. To quantify Pacific Water (PW) transport variability and water mass transformation mechanisms from the Chukchi Sea shelf toward the Eurasian basin

General model of Arctic Circulation

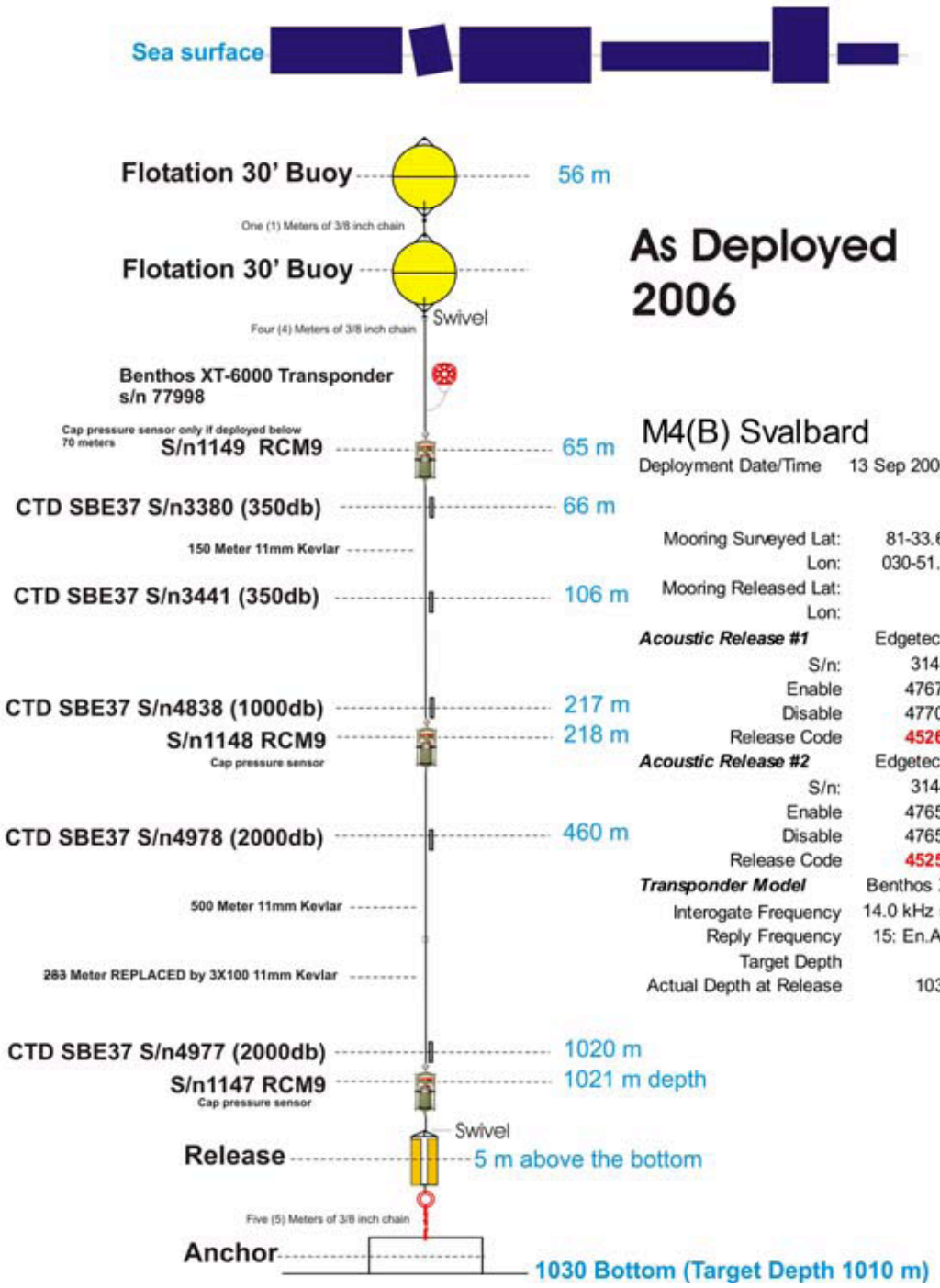



Canadian Basin
Fram Strait
Amundsen
Spitsbergen
M7
10/26
M4
85
M9
M10
10/18
10/14
M8
M3
East Siberian Sea
Franz Josef Land
10/06
M5
M6
AWI
M1
Novosibirskiye Islands
Kirkenes
10/30
10/01
80
Severnaya Zemlya Islands
10/10
Barents Sea
Vilkitskiy Strait
Laptev Sea
Kara Sea
75
RUSSIA
0 200 400 600 800 1000 km
M1 NABOS moorings
AWI mooring, deployed in 2005
CTD/ Turbulence/ Bio stations
optional stations
10/19 date
ship track
ice station

The Kapitan Dranitsyn

2008 Recoveries

Norwegian Mooring M4B, As Deployed 2006



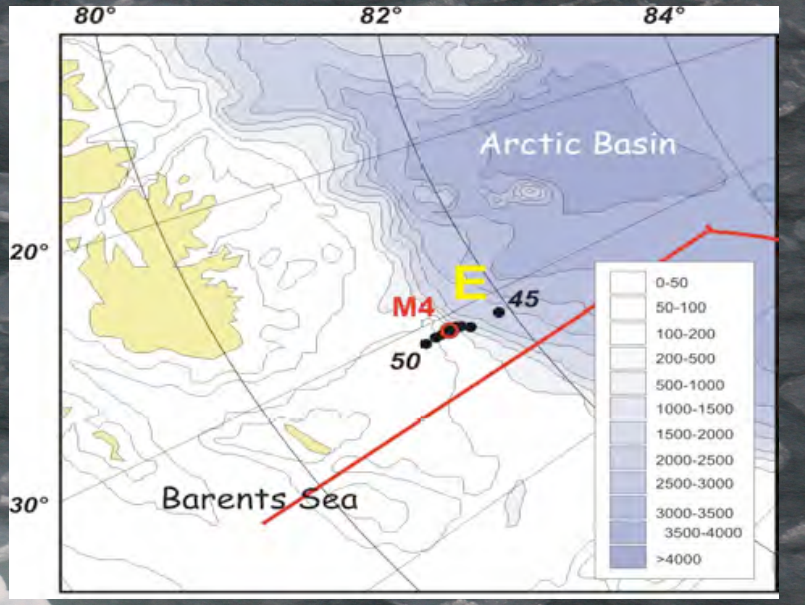
As Deployed 2006

M4(B) Svalbard

Deployment Date/Time 13 Sep 2006

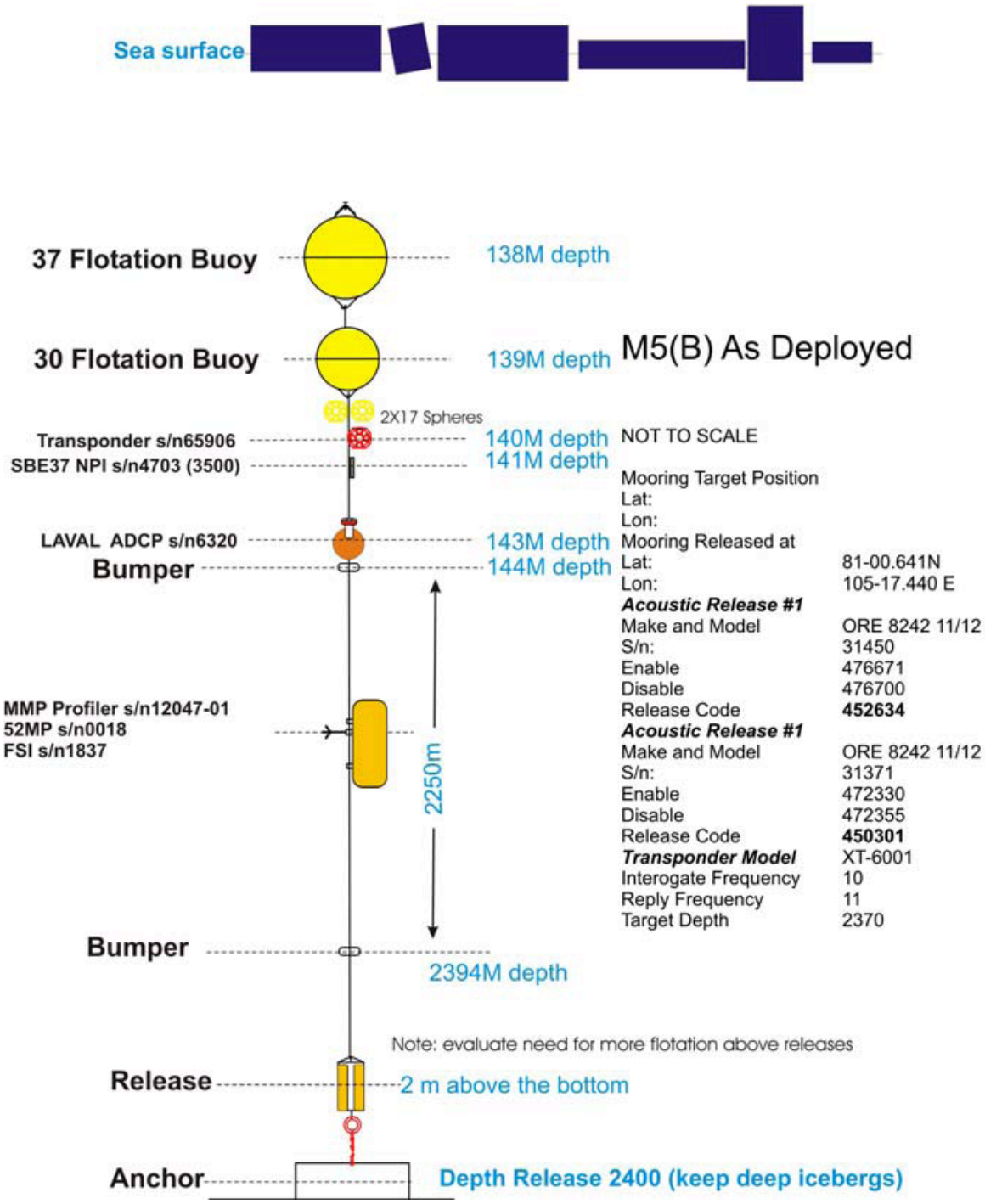
Mooring Surveyed Lat:	81-33.685 N
Lon:	030-51.127 E
Mooring Released Lat:	
Lon:	
Acoustic Release #1	Edgetech 8242
S/n:	31452
Enable	476765
Disable	477010
Release Code	452672
Acoustic Release #2	Edgetech 8242
S/n:	31447
Enable	476530
Disable	476555
Release Code	452556
Transponder Model	Benthos XT-6000
Interogate Frequency	14.0 kHz sn77998
Reply Frequency	15: En.A, Dis.B
Target Depth	
Actual Depth at Release	1030

- Northeast of Svalbard in 1000m of water



- Confirms the strong seasonal signal previously observed of winter temperature maximum and summer minimum
- Current direction very stable to the Northeast, relatively high flow rates (10 cm s^{-1}) with bursts up to 5 times that at times
- flows predominantly barotropic, low eddy activity

M5(B) As Deployed 2006

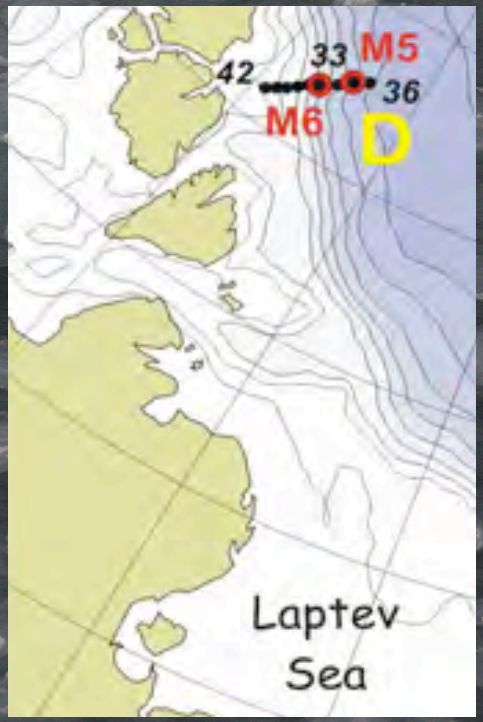


M5(B) As Deployed

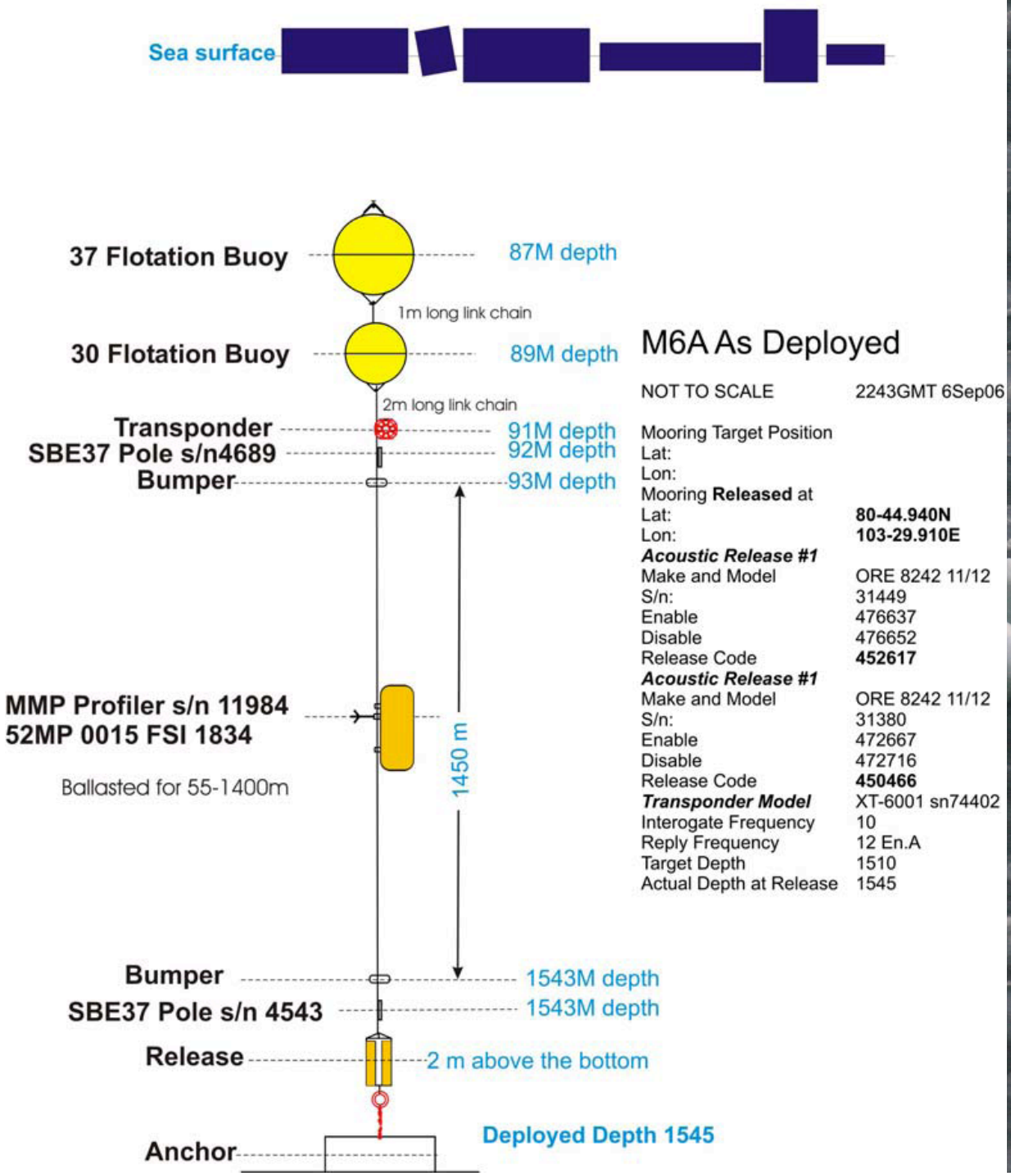
NOT TO SCALE

Mooring Target Position	
Lat:	
Lon:	
Mooring Released at	
Lat:	81-00.641N
Lon:	105-17.440 E
Acoustic Release #1	
Make and Model	ORE 8242 11/12
S/n:	31450
Enable	476671
Disable	476700
Release Code	**452634**
Acoustic Release #1	
Make and Model	ORE 8242 11/12
S/n:	31371
Enable	472330
Disable	472355
Release Code	**450301**
Transponder Model	XT-6001
Interogate Frequency	10
Reply Frequency	11
Target Depth	2370

- Northeast of Severnaya Zemlya in 2400m of water
- Records southeasterly flows consistent with the currents following the bathymetry
- Same seasonal temperature signal (winter high, summer low)
- Intrusions of super cold shelf waters on occasion

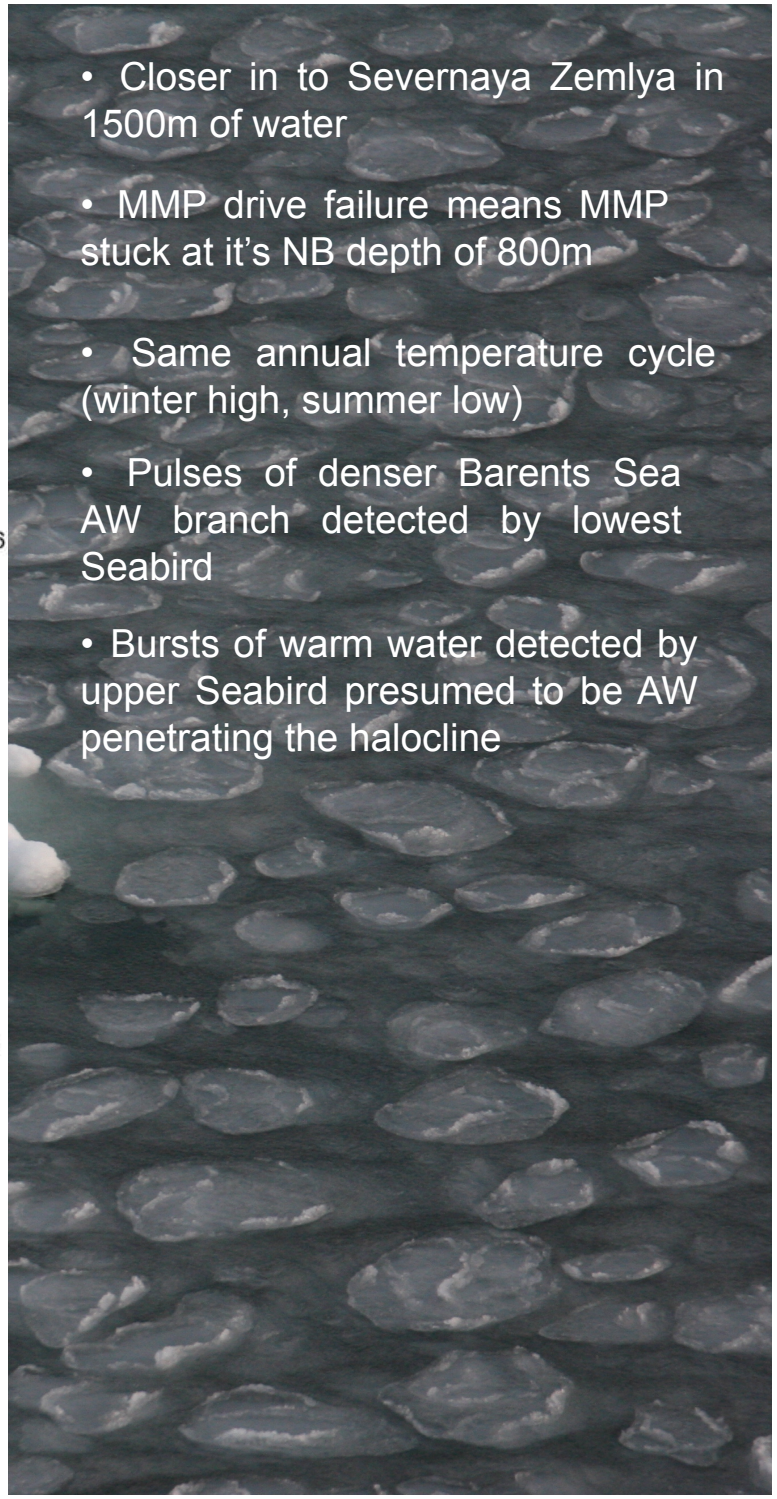


(Damocles-IOPAS) M6(A) As Deployed 2006



M6A As Deployed

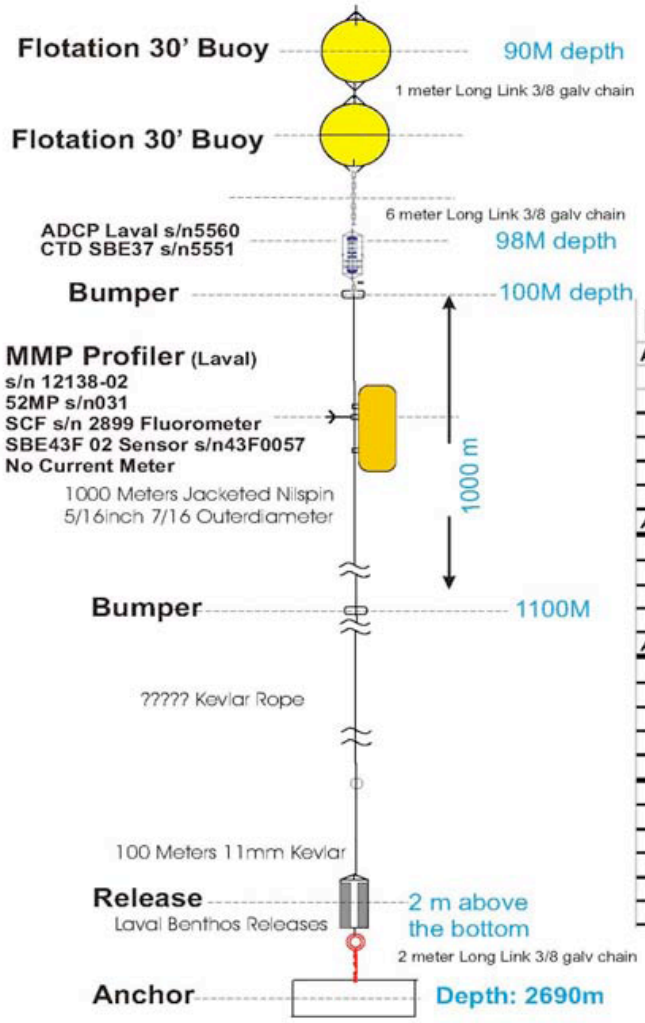
NOT TO SCALE	2243GMT 6Sep06
Mooring Target Position	
Lat:	
Lon:	
Mooring **Released** at	
Lat:	**80-44.940N**
Lon:	**103-29.910E**
Acoustic Release #1	
Make and Model	ORE 8242 11/12
S/n:	31449
Enable	476637
Disable	476652
Release Code	**452617**
Acoustic Release #1	
Make and Model	ORE 8242 11/12
S/n:	31380
Enable	472667
Disable	472716
Release Code	**450466**
Transponder Model	XT-6001 sn74402
Interogate Frequency	10
Reply Frequency	12 En.A
Target Depth	1510
Actual Depth at Release	1545



- Closer in to Severnaya Zemlya in 1500m of water
- MMP drive failure means MMP stuck at it's NB depth of 800m
- Same annual temperature cycle (winter high, summer low)
- Pulses of denser Barents Sea AW branch detected by lowest Seabird
- Bursts of warm water detected by upper Seabird presumed to be AW penetrating the halocline

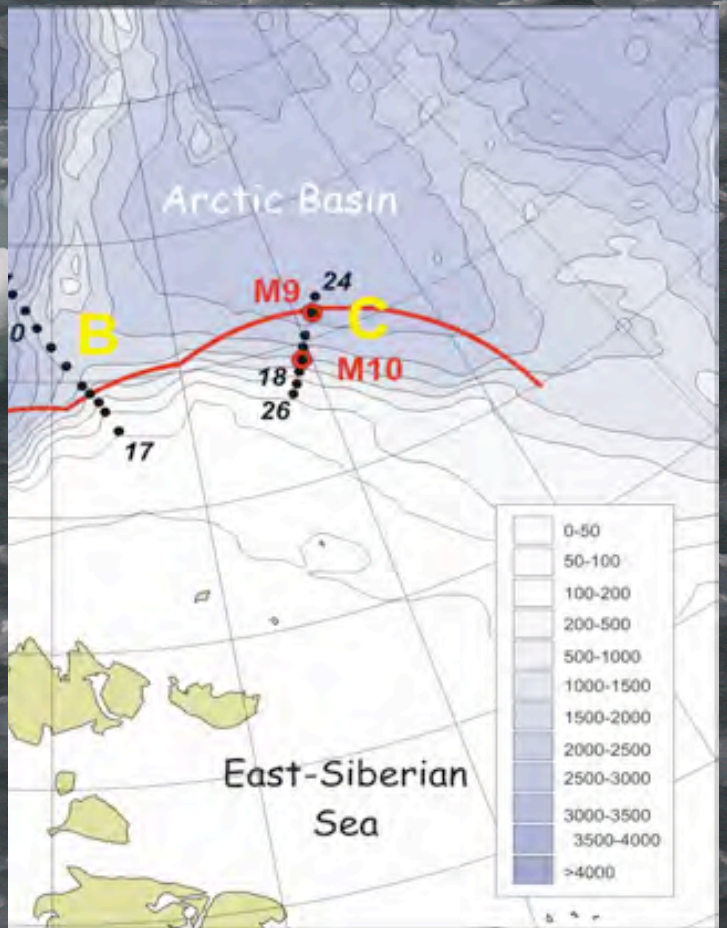
Mooring M9(A) As Deployed 2007
Laval University

M8A and M9A are essentially the same

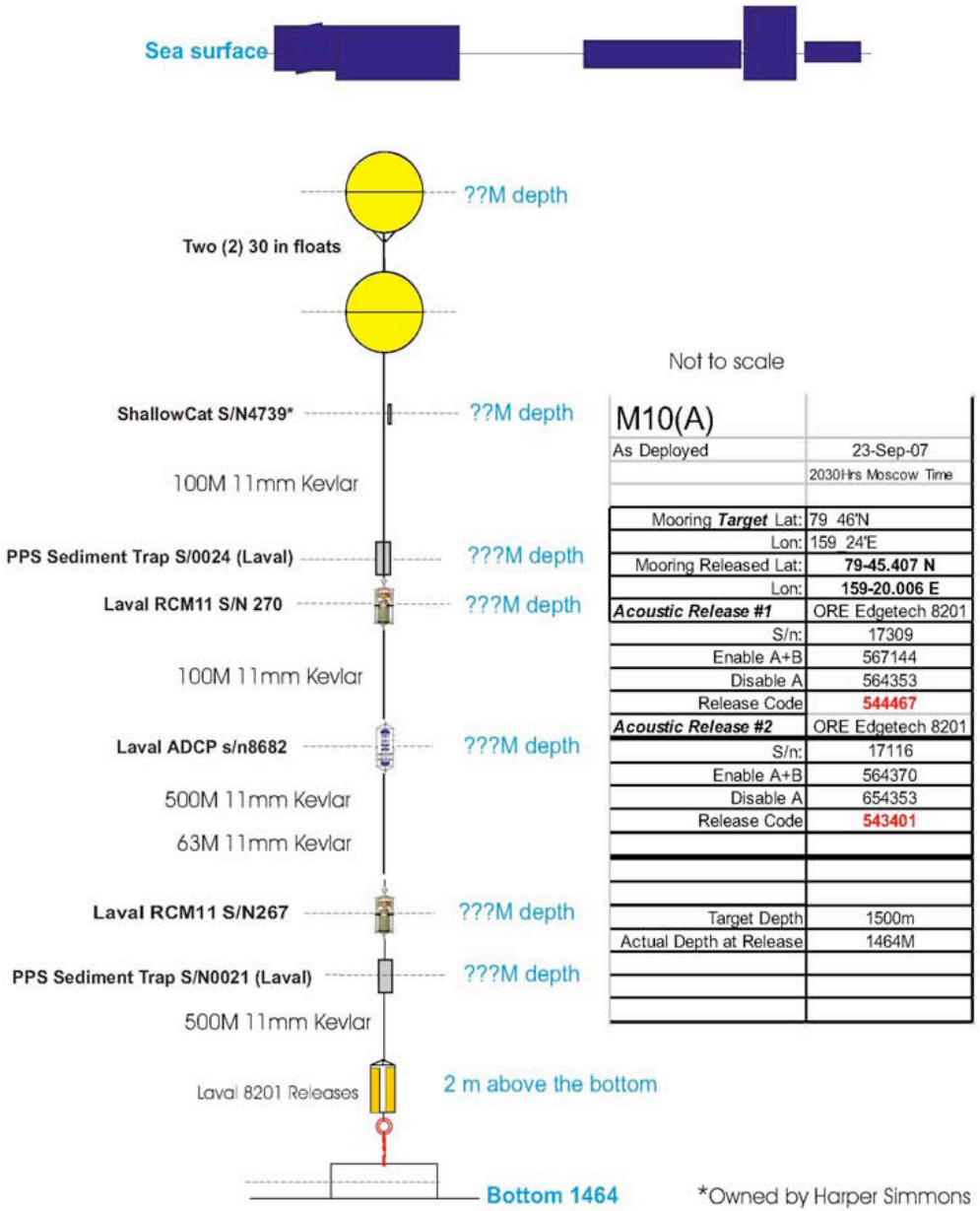


M9(A)	
As Deployed	September 24th 2007
	1430hrs Moscow Time
Target Lat:	???
Lon:	???
Anchor Surveyed at Lat:	**80-20.930 N**
Lon:	**161-15.837 E**
Acoustic Release #1	Benthos
S/n:	41441 RX11 TX12
Enable	C
Disable	Auto after 12hrs
Release Code	**B**
Acoustic Release #2	Benthos
S/n:	41442 RX**11.5** TX12
Enable	E
Disable	Auto after 12hrs
Release Code	**D**
Target Depth	2600
Actual Depth at Release	2690

- Off the east Siberian shelf in 2600 metres of water
- MMP totally failed on this rig
- No clear seasonal temperature and salinity cycle
- Strong southward transport in the pycnocline in the summer

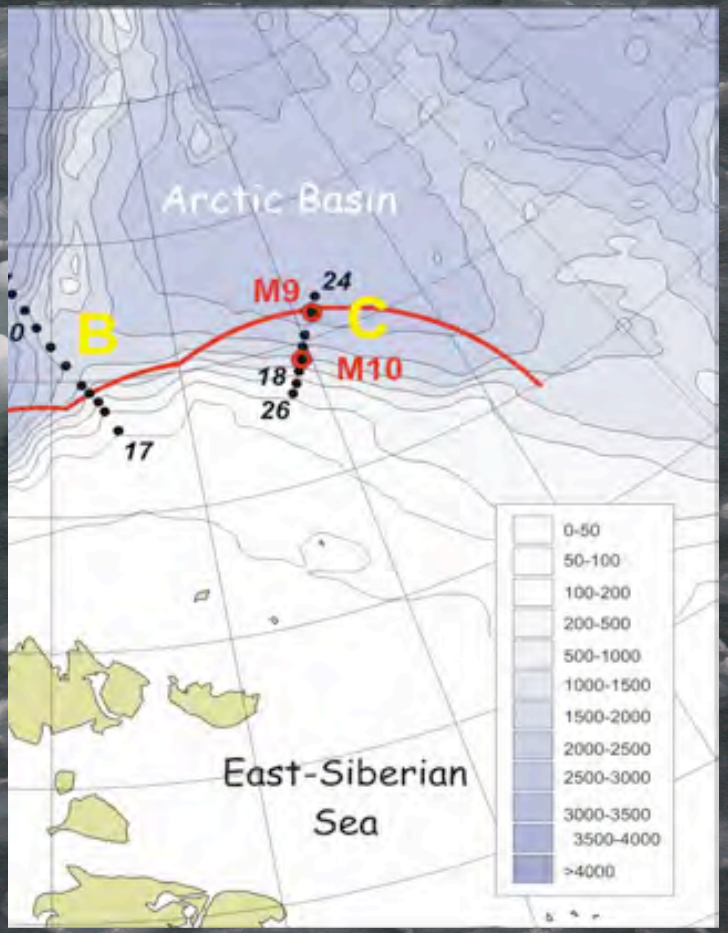


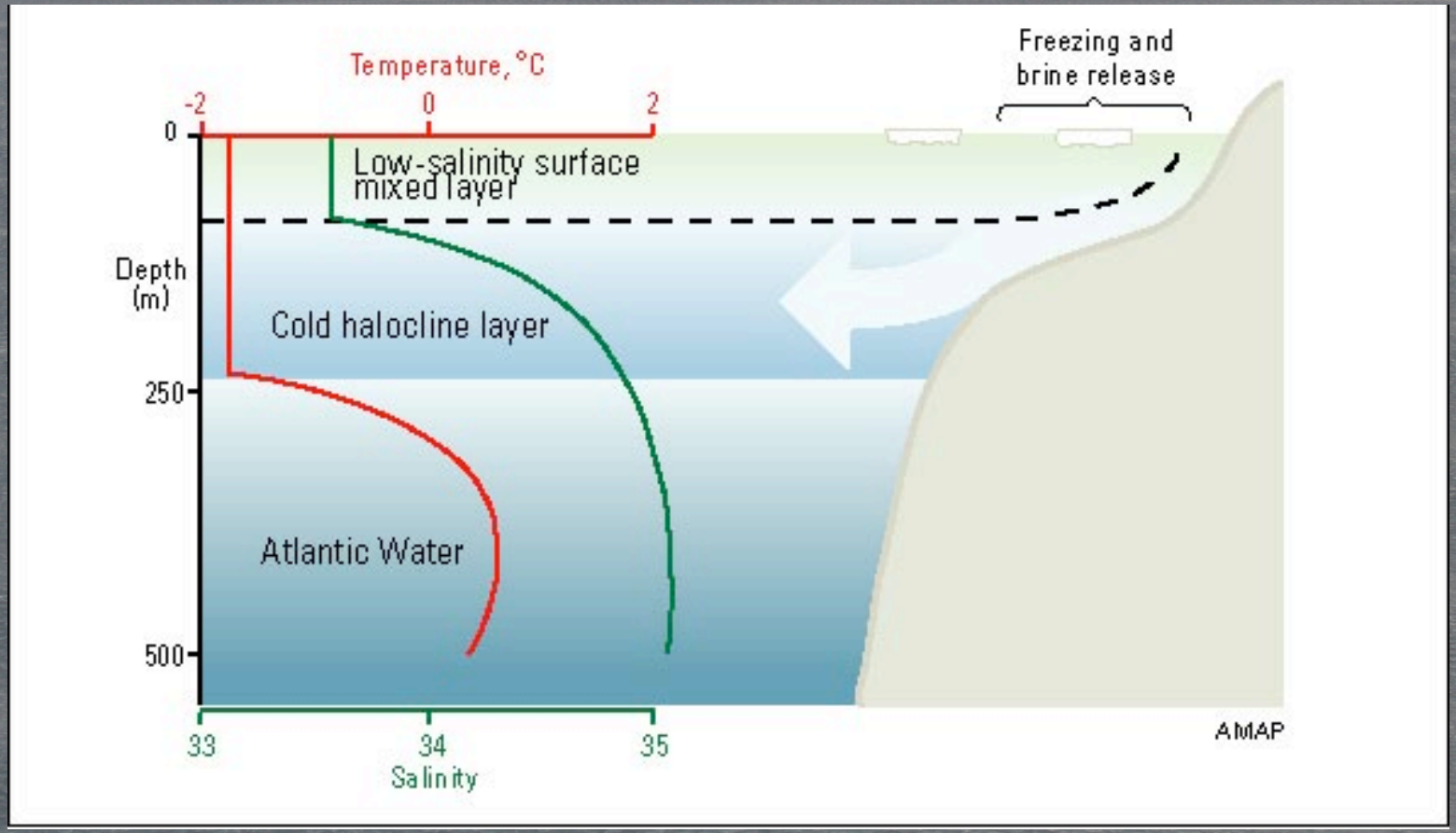
Mooring M10(A) As Deployed 2007

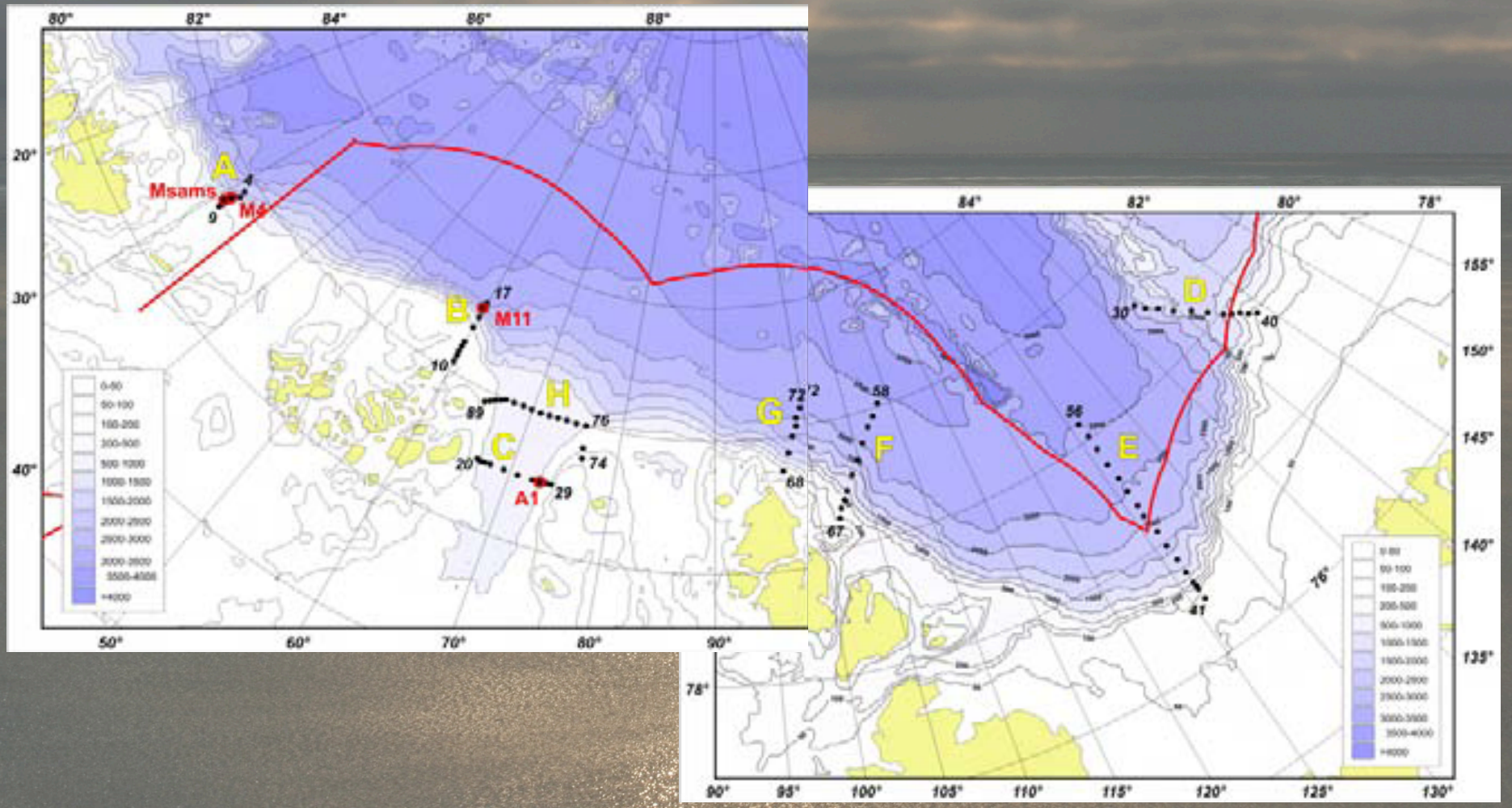


M10(A)	
As Deployed	23-Sep-07
	2030Hrs Moscow Time
Mooring *Target* Lat:	79 46'N
Lon:	159 24'E
Mooring Released Lat:	**79-45.407 N**
Lon:	**159-20.006 E**
Acoustic Release #1	ORE Edgetech 8201
S/n:	17309
Enable A+B	567144
Disable A	564353
Release Code	**544467**
Acoustic Release #2	ORE Edgetech 8201
S/n:	17116
Enable A+B	564370
Disable A	654353
Release Code	**543401**
Target Depth	1500m
Actual Depth at Release	1464M

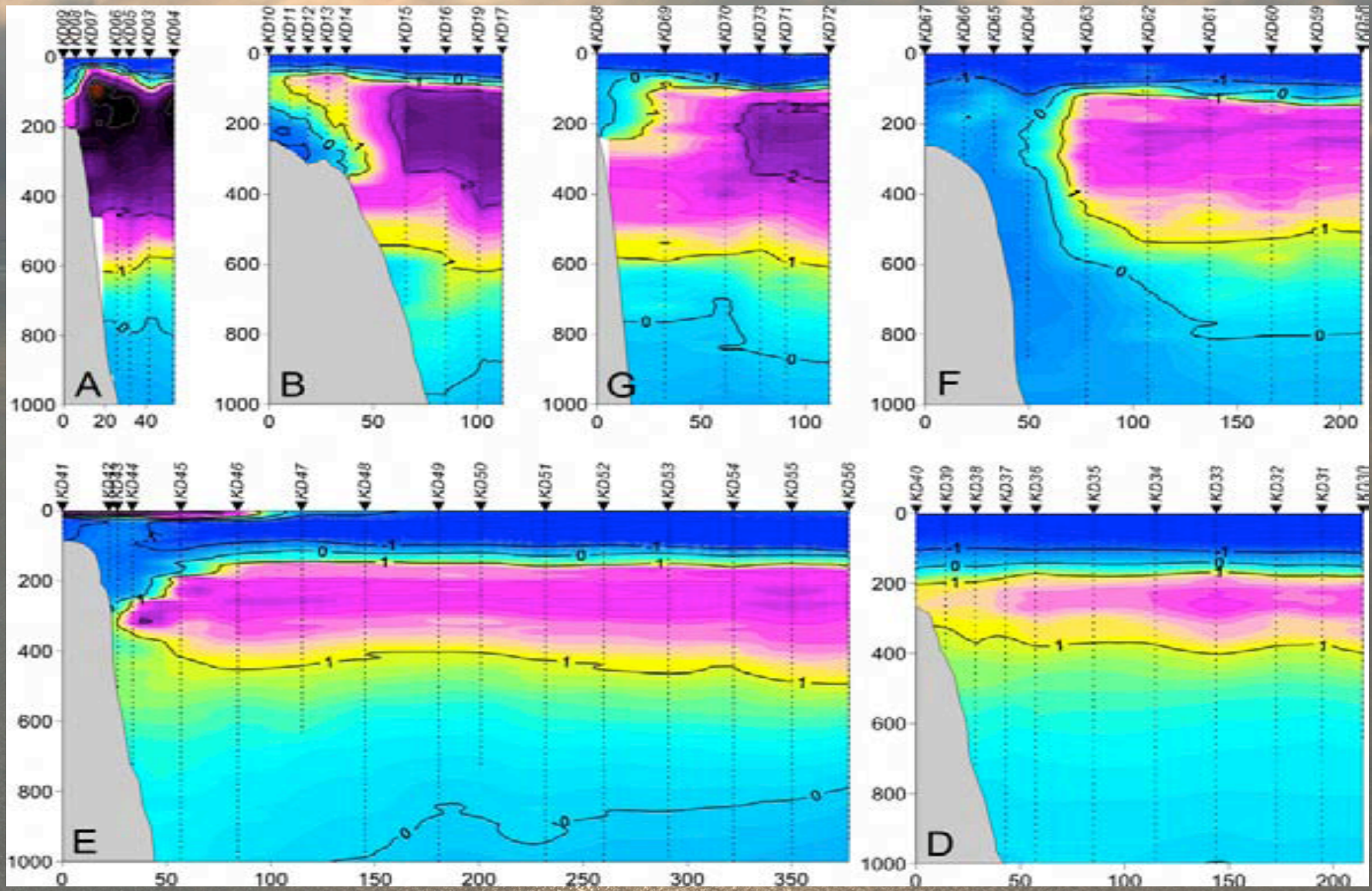
- Current measurements suggest along slope water transport – shallow to right.




Temperature, °C
-2
0
2
0
Low-salinity surface mixed layer
Freezing and brine release
Depth (m)
Cold halocline layer
250
Atlantic Water
500
33
34
35
Salinity
AMAP



CTD sections and mooring sites of the Barents Sea the Laptev and East-Siberian seas during the NABOS-09 cruise. Black circles represent CTD stations; red circles denote mooring positions. The red solid line represents the position of the Russian Exclusive Economic Zone. Yellow letters indicate the oceanographic cross-slope sections.



Vertical distribution of temperature (°C) at the sequential cross-slope sections along the Eurasian Arctic continental slope 2009 Expedition

Main Points up to here

There is a strong signal seasonally characterised by a winter temperature maximum and summer minimum

Temperature peaked in autumn 2006 and for the next 2 years a cooling trend has been observed at M4 in the order of ~ 1° C.

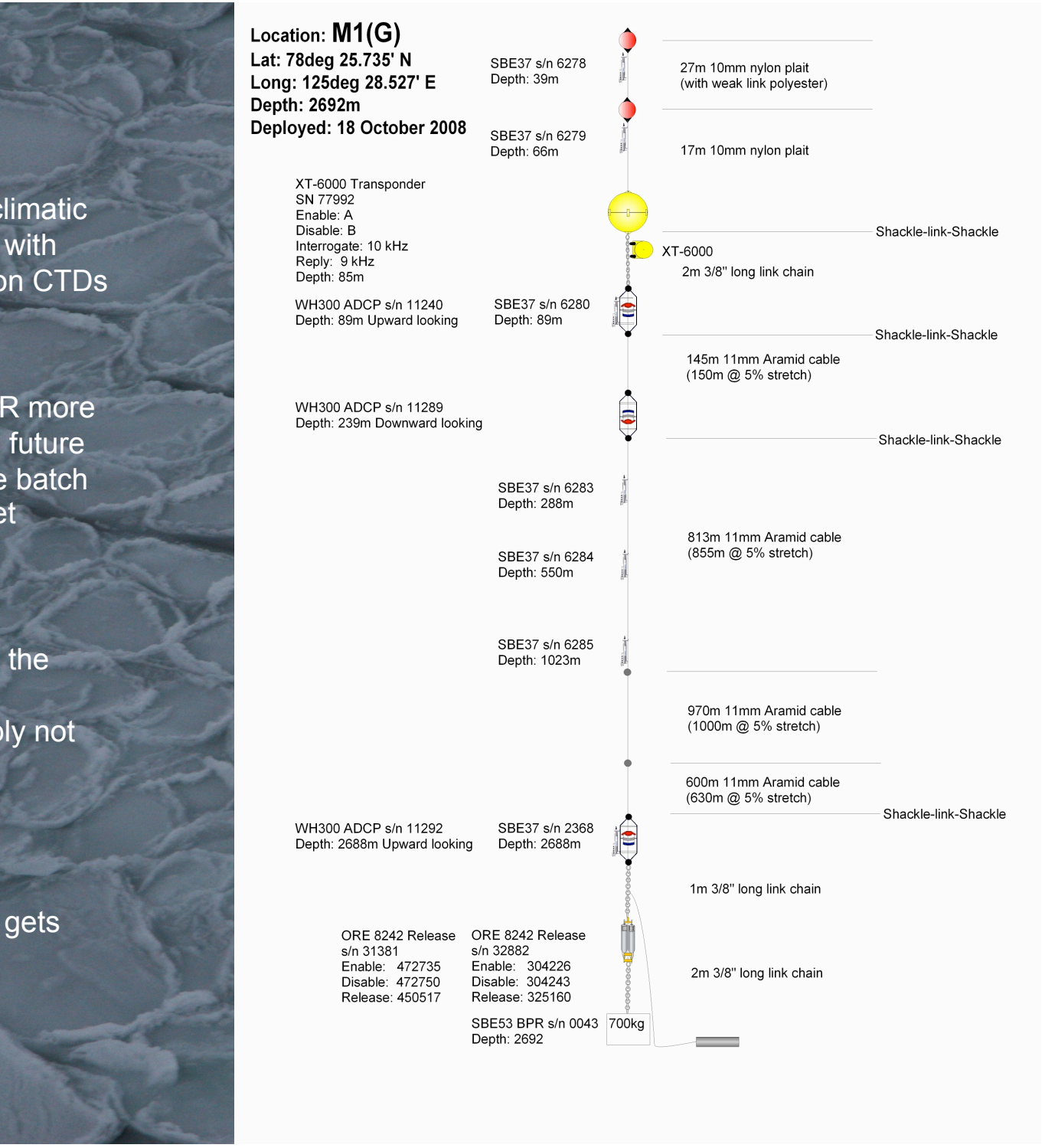
Other observations from the Fram strait indicate that a temperature minimum was reached in 2008 and the temperature here is cycling up again

AW in the Laptev Sea was colder in 2009 than it was a year before, showing the passing of a warm pulse first detected in 2006 as it entered the arctic, and now leaves, so the Nansen basin has entered a cooling phase

2008 Deployments

M1 (G)

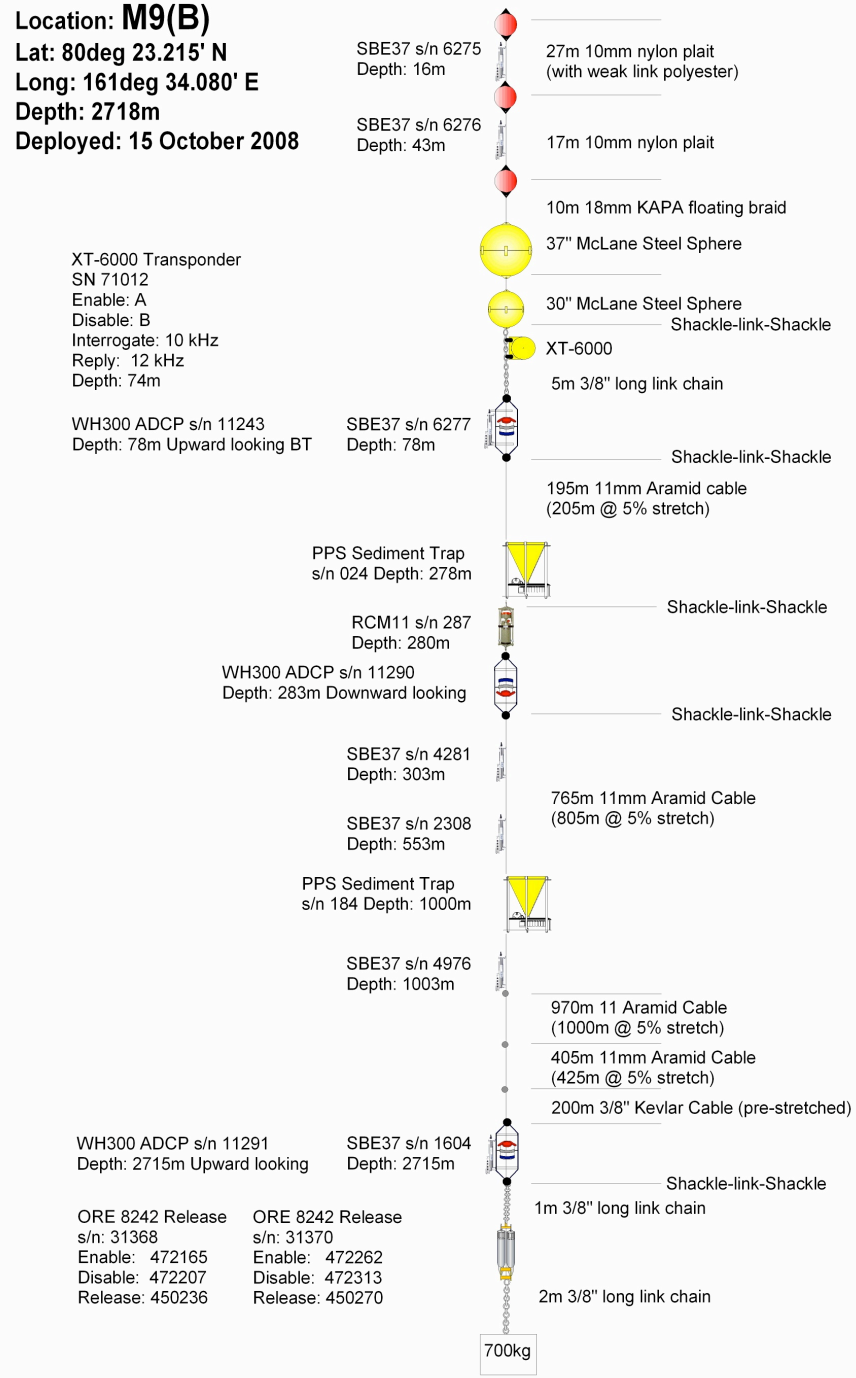
- Representing the mature climatic mooring design, dispensing with profilers and standardising on CTDs and ADCPs
- Introduces the SBE 53 BPR more of these will be deployed on future moorings. Unfortunately the batch bought by IARC did not meet stability trials except for one instrument
- Blessing in disguise giving the chance to provide a better deployment method, probably not on main mooring
- 'Flying' microcats with sacrificial link to protect the main structure if upper 40m gets tangled in an ice keel



M9 (B)

- Originally designed as two moorings, a NABOS climatic mooring aka M1(G) and a LAVAL sediment trap mooring
- Most complicated mooring in the NABOS array and at the limit for crane lift heights on inseparable elements
- Maintains the ‘flying’ microcat design as protection against ice-bergs
- Entertainingly deployed in the dark during a blizzard with an ambient temperature of -25° C
- Was originally planned to have a BPR but none available from those supplied

Location: M9(B)
Lat: 80deg 23.215' N
Long: 161deg 34.080' E
Depth: 2718m
Deployed: 15 October 2008



Good bits about the 2008 Expedition

Everything that got released was recovered

Most of what we set out to deploy made it into the water

M9 and M10 were combined to accommodate all science on a single mooring. While this is a lot of eggs in one basket this was a vital efficiency given the failing light and an extended work programme to visit the M4 and M7 sites north of Svalbard.

Bad bits about the 2008 Expedition

M1(F) responded to interrogation but failed to release on the first one of the pair. Ice conditions were not conducive to a second attempt to recover a week later and it was left in place for the 2009 season.

M3 and M8 disappeared completely

Due to ship availability issues the cruise did not start until October, consequently there was more ice to deal with and ever decreasing light available

The Kapitan Dranitsyn is very limited in its ability to manoeuvre or hold station

2009 Highlights

Confirmed that M1(G) is still alive

Redeployed M4 northeast of Svalbard

Deployed a mooring for SAMS near to M4

Deployed M11 at a position above Franz Josef land

Deployed a mooring for IFM-Geomar in the St Anna trough

Deployed two Ice Tethered Profilers at the eastern end of the cruise track for WHOI

Deployed 11 Surface Velocity Profilers in the eastern end of the cruise track

New Additions to the suite

Bottom Pressure recorders

Ice Tethered Profilers

Thanks are due to:
Igor Polyakov, Ian Beliveau, Sylvain Blondeau, Jack Greenburg,
Piotr Wieczonek,
Larry Hastings, Rob Rember, Ian Waddington, Rob Chadwell,
John Kemp, Jeff Pietro.