Application for Port Call Clearance in Iceland and Norway and Consent to Conduct Marine Scientific Research in Areas Under National Jurisdiction of

Iceland, Norway, Denmark (Greenland, Faroe Islands), United Kingdom, Ireland

(name of coastal state)

Date: 11 October 2007

1. General Information

1.1 Cruise name and/or #:	Research Vessel *Knorr*

1.2 Sponsoring Institution:	
Name:	Woods Hole Oceanographic Institution
Address:	Woods Hole, MA 02543 USA
Name of Director:	Dr. James Luyten, Acting Director

1.3 Scientist in charge of the project (CV and passport photo appended):	
Name:	Mary Jane Perry
Address:	193 Clark's Cove Road, Walpole ME 04573, USA
Telephone:	207-563-3147 ext. 245
Fax:	207-563-3119
Email:	perrymj@maine.edu

Mary Jane Perry

Professor, School of Marine Sciences and Ira C. Darling Center, University of Maine

Affiliate Professor, School of Oceanography, University of Washington

Email: perrymj@maine.edu, Voice: (207) 563-3146 ext. 245, FAX: (207) 563-31196

Mailing address: Ira C. Darling Marine Center, 193 Clark's Cove Road, Walpole ME 04573-3307 USA

A. Professional Preparation:

Ph.D. –1974	Scripps Institution of Oceanography, University of California, San Diego
1974 – 1976	Lecturer, Washington University Medical School, St. Louis, Missouri

B. Appointments:

1999 – present	Professor of Oceanography, University of Maine, Orono, Maine
1999 – present	Affiliate Professor, University of Washington, Seattle, Washington
1980 – 1982	Assistant and Associate Program Officer positions at NSF
1976 – 1999	Progression of professorial ranks at University of Washington, Seattle
1976	Assistant Professor, University of Georgia, Athens, Georgia

C. Recent Publications:

Sackmann, B. M. J. Perry, C. C. Eriksen, and C. M. Lee. Using Seaglider to quantify variability in mid-day fluorescence quenching off the Washington coast. Submitted to *Limnology and Oceanography*, Special Issue on Autonomous Platforms.

Perry, M. J., B. S. Sackmann, C. C. Eriksen, C. M. Lee. Seaglider observations of subsurface chlorophyll maxima off the Washington coast, USA. Submitted to *Limnology and Oceanography*.

Boss, E., D. Swift, L. Taylor, P. Brickley, R. Zaneveld, S. Riser, and M.J. Perry. Submitted. Robotic in-situ and satellite based observations of pigment and particle distributions in the Western North Atlantic. Submitted to *Limnology and Oceanography*, Special Issue on Autonomous Platforms.

Paul,J., C. Scholin, G. Van Den Engh, and M.J. Perry. 2007. A Sea of Microbes: *In situ* instrumentation. *Oceanography* 20(3): 70-78.

Sackmann, B., and M. J. Perry. 2006. Ocean color observations of a surface water transport event: Implications for Pseudo-nitzschia on the Washington coast. *Harmful Algae* 5:608-619.

Sackmann, B., L. Mack, M. Logsdon, and M. J. Perry. 2004. Seasonal and inter-annual variability of SeaWiFS-derived chlorophyll a concentrations in waters off the Washington and Vancouver Island coasts, 1998-2001. *Deep-Sea Res.* II 51: 945-965.

Daly, K.L, R.H. Byrne, A.G. Dickson, S.M. Gallager, M.J. Perry, and M.K. Tivey. 2004. Chemical and Biological Sensors for Time-Series Research; Current Status and New Directions. *J. Mar. Tech. Soc.* 38:121-141.

Rudnick, D.L., R.E. Davis, C.C. Eriksen, D.M. Fratantoni, and M.J. Perry. 2004. Underwater gliders for ocean research. *J. Mar. Tech. Soc.* 38:73-84.

Eisner, L.B., M.S. Twardowski, T.J. Cowles, and M.J. Perry. 2003. Resolving phytoplankton photoprotective: Photosynthetic carotenoid ratios on fine scales using in situ spectral absorption measurements. *Limnology and Oceanography* 48: 632-646.

McManus, M.A., {others}... M.J. Perry, et al. 2003. Changes in Characteristics, Distribution and Persistence of Thin Layers Over a 48-Hour Period. *Mar. Ecol. Prog. Ser.* 261: 1-19.

Perry, M. J., and D. L. Rudnick. 2003. Observing the ocean with autonomous and Lagrangian platforms and sensors (ALPS): role of ALPS in sustained ocean observing systems. *Oceanography* 16: 31-36.

D. Synergistic Activities

2007 Co-organizer, Special Issue of Limnology and Oceanography on ALPS

2007–present, UNOLS Council

2005–present, Ocean Observatory Steering Committee (formerly ORION Executive Steering Committee)

2005–present, The Oceanography Society, Councilor for Biological Oceanography

2005–present, ACT (Alliance for Coastal Technology), Advisory Committee on Fluorometry

2004 Co-Chair of NSF Committee of Visitors' review of "Biocomplexity in the Environment"

2004 Member of Office of Naval Research Board of Visitors' review of Ocean Sciences

2004 Alliance for Coastal Technologies workshop on AUVs and gliders, invited speaker

2003 Co-Chair of workshop on "Autonomous and Langrangian Platforms and Sensors"

2002 Member of NSF Committee of Visitors' to review ship operations and facilities

2000–2002, Member of NSF Advisory Committee / Geosciences

2000–2002, Member of NSF Advisory Committee / Environmental Research & Education

Innovative Teaching: In 1980, optical and biological oceanography were distinct communities with different languages and cultures. In 1985 I developed an interdisciplinary, team-taught, intensive summer course in bio-optical oceanography that has been taught many times since; this course has played a significant role in bridging the chasm between communities and in creating a new one.

Research: My long-term goal is to understand the mechanisms responsible for controlling the abundance, distribution, and productivity of marine phytoplankton in the ocean. My current research focuses on the interpretation of optical data in a physiological context and on the incorporation of optical sensors into under-water, autonomous platforms for long-term ocean observations.

E. Collaborators & Other Affiliations.

(i) *Graduate and Post Doctoral Advisors*

Doctoral advisor: R. W. Eppley (retired)

Postdoctoral advisor: O. H. Lowry, deceased.

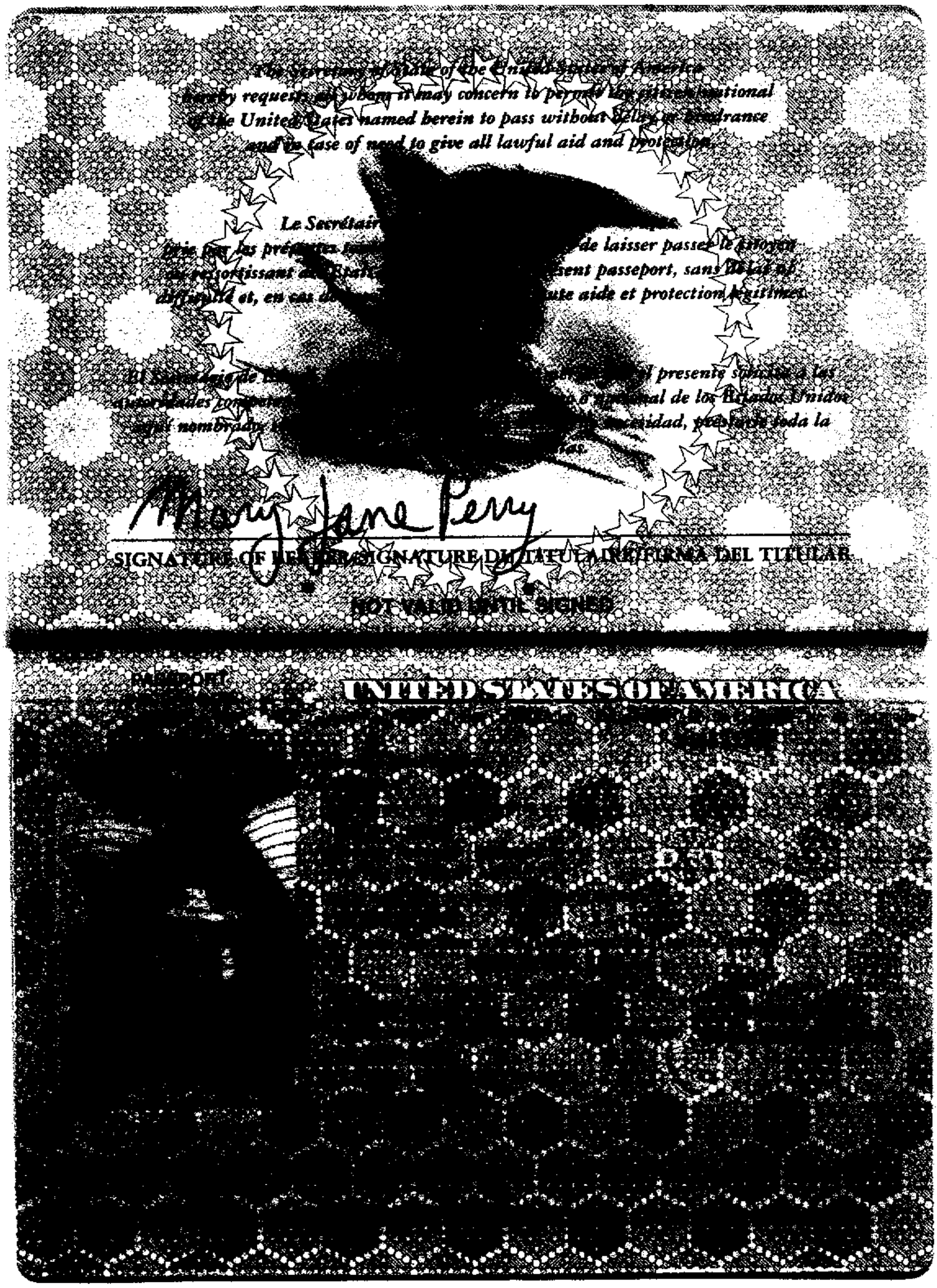
(ii) Students and Post-Doctoral Scholars supervised

Postgraduate scholars: Emmanuel Boss (UMaine), Paula Coble (USF), Rick Reynolds (Scripps)

Ph.D. students: Bess Ward (Princeton), Joan Cleveland (ONR), Monica Orellana (UW), David Martin (UW), Collin Roesler (Bigelow Labs), Mary Culver (NOAA), Brandon Sackmann MBARI)

M.S. students: J. Bolger, N. Navaluna, Boh-Yen Bang, J. Coleman, B. Thompson, C. Carter

Present graduate students: Andrea Drzewianowski and Witold Bagniewski


The Secretary of State of the United States of America
hereby requests all whom it may concern to permit the citizen/national
of the United States named herein to pass without delay or hindrance
and in case of need to give all lawful aid and protection.
Le Secrétaire
de laisser passer le citoyen
ent passeport, sans délai ni
difficulté et, en cas de
ute aide et protection légitimes.
El Secretario de
el presente solicita a las
autoridades
a nacional de los Estados Unidos
aquí nombrado
sidad, prestarle toda la
Mary Jane Perry
SIGNATURE OF BEARER/SIGNATURE DU TITULAIRE/FIRMA DEL TITULAR
NOT VALID UNTIL SIGNED
PASSPORT
UNITED STATES OF AMERICA

1.4 Scientist(s) from coastal state involved in the planning of the project:	
Name(s):	Dr. Kristinn Gudmundsson <kristinn@hafro.is>
Address:	Marine Research Institute, P.O.Box 1390, Skulagata 4, 121 Reykjavik, Iceland
Name(s):	Dr. Katherine Richardson <kr@adm.au.dk>
Address:	Det Naturvidenskabelige Fakultet, University of København, Øster Voldgade 3, 1350 København K, Denmark
Name(s):	Dr. Richard Lampitt <R.Lampitt@noc.soton.ac.uk>
Address:	National Oceanography Centre, Southampton Empress Dock, Southampton, SO14 3ZH, United Kingdom
Name(s):	Dr. Jan Kaiser <J.Kaiser@uea.ac.uk>
Address:	School of Environmental Sciences, University of East Anglia, Norwich, NR4 7TJ, United Kingdom
Name(s):	Ms. Nicole Bale <niba@pml.ac.uk>
Address:	Plymouth Marine Laboratory, Prospect Place, Plymouth, PL1 3DH, United Kingdom

1.5 Submitting officer:	
Name and address:	Elizabeth Caporelli, Marine Operations Coordinator Woods Hole Oceanographic Institution 38 Water Street, Mail Stop #37 Woods Hole, MA 02543 USA
Nationality:	USA
Telephone:	508-289-2277
Fax:	508-457-2185
Email:	ecaporelli@whoi.edu

2. Description of Project (Attach additional pages as necessary)

2.1 Nature and objectives of the project:
The overarching goal of this cruise is to study an important component of the oceanic carbon system – the North Atlantic Spring Bloom. Recent advances in autonomous platforms and novel sensors have enabled new approaches for studying oceanic carbon cycle research, with potentially broad impacts. This project addresses the North Atlantic Spring Bloom for its intrinsic merit but also as a testbed for developing strategies and knowledge needed to most effectively use these new autonomous methods in the future. Through the combination of autonomous platforms and ships, measurements will be made near 60°N, 20°W from late March 2008 (before the bloom) through early July (after the bloom). From late March through early July two Lagrangian floats will follow water parcels in the mixed layer, each with roving gliders to characterize its surroundings, and measure – in three dimensions over time – vertical and horizontal mixing rates and key carbon system components. Optical sensors will measure optical proxies for concentrations of phytoplankton, carbon and nitrate. Two-way communication via Iridium satellite will allow sampling strategies to evolve in response to observed conditions. The Lagrangian floats and underwater gliders will be deployed in March and retrieved in July from an Icelandic research vessel (Bjarni Saemundsson). In May R/V Knorr will sample in the vicinity of the floats and gliders and will deploy two additional types of autonomous profiling floats that will sample while the ship is in the vicinity of 60°N, 20°W.

The first key objective of the cruise is to collect water samples near the floats and gliders to verify the calibration of the autonomous sensors and to confirm the conversion factors to quantify phytoplankton carbon and nutrients. This objective may necessitate entry to coastal states waters, depending on the trajectory of the water masses the floats will follow. **The second key objective** is to determine the larger temporal and spatial scales surrounding the floats and gliders; this objective will be accomplished by CTD survey work and sampling underway with the ship's uncontaminated seawater system, and again may necessitate entry to coastal states waters. **The third key objective** is to bring together scientists from the United Sates, Iceland, Denmark, and the United Kingdom to study other phenomena associated with the bloom. Systematic comparison of these data with a bio-physical ecosystem model guided by adjoint analysis will be used to evaluate the appropriateness of such models for predicting both small-scale patchiness and net carbon uptake through the evolution of the bloom. These data sets will also be used by an educational program (COSEE–Ocean Systems) to develop a "story" on the role of the North Atlantic ocean ecosystem that will resonate with non scientists and be used in science curricula.

2.2 Relevant previous or future research cruises:
March and July 2008 cruises on Icelandic research vessel to same region, before and after the R/V Knorr cruise.

2.3 Previously published research data relating to the project:
This is a new project.

3. Methods and Means to be Used

3.1 Particulars of vessel:	
Name:	Research Vessel Knorr
Nationality (Flag state):	USA
Owner:	United States
Operator:	Woods Hole Oceanographic Institution
Overall length (meters):	85 meters
Maximum draught (meters):	5.1 meters
Displacement/Gross tonnage:	2,518 T
Propulsion:	Diesel Electric
Cruising & Maximum speed:	12 knots/15 knots
Call sign:	KCEJ
Method and capability of communication (including emergency frequencies):	INMARSAT Satellite Telephone Iridium Satellite telephone VHF Channel 13 and 16 Single Side Band 2182 kHz
Name of master:	Captain Kent Sheasley
Number of crew:	23
Number of scientists on board:	34

3.2 Aircraft or other craft to be used in the project:
Two profiling floats and three underwater gliders will already be in the water before the cruise; during the cruise, two other types of profiling floats will be deployed (Section 4, below).

3.3 Particulars of methods and scientific instruments

Types of samples and data	Methods to be used	Instruments to be used
Electronic samples	CTD package for profiles from ship	CTD (temperature, conductivity, depth); CDOM (chromphoric dissolved organic matter) and chlorophyll fluorometers; optical backscattering sensor; transmissometer
Electronic samples	Optical package for profiles from ship	Upwelling and downwelling spectral radiometers; absorption and attenuation meters
Electronic samples	Underway sampling of water from ship's uncontaminated seawater	Instruments same as above for CTD profiles; in addition, sensors for nitrate; variable fluorescence; pCO_2; argon and oxygen
Water samples	Collected from CTD/Rosette bottle profiles and from ship's uncontaminated seawater	Samples for chlorophyll a and HPLC pigments' nutrients; oxygen, argon and pCO_2; particulate and dissolved organic carbon, particulate organic nitrogen; particulate and dissolved spectral absorption coefficients; phytoplankton number and optical type by flow cytometry; phytoplankton isolates for culturing; phytoplankton samples for nitrogen metabolism genes; ^{14}C-rates of primary productivity; particulate-absorbed organic contaminates (also from air).
Settling particles	Floating sediment traps, to be deployed and retrieved during the May cruise.	APEX floats with sediment traps to collect particles

Aggregation of particles	Floating optical plankton counter, to be deployed and retrieved during the May cruise.	SOLO floats with an optical plankton counter to electronically measure aggregation of particles associate with phytoplankton bloom
Bathymetry	Bathymetric system	12.0 kHz and 3.5 kHz
Acoustic Doppler Current Profiles	ADCP	75 kHz and 150 kHz
Meteorological data	Meteorological Sensors	Meteorological Sensor Suite
Air samples for organic contaminants	Air filtration sample collection	Air Sampling Sensors

3.4 Indicate whether harmful substances will be used:
No harmful substances will be discharged from the ship. Solvents such as acetone and weak acid solutions will be used in small quantities on the ship. ^{14}C-bicarbonate will be used to measure phytoplankton primary productivity.

3.5 Indicate whether drilling will be carried out:
No.

3.6 Indicate whether explosives will be used:
No.

4. Installations and Equipment

Details of installations and equipment (dates of laying, servicing, recovery; exact locations and depth):

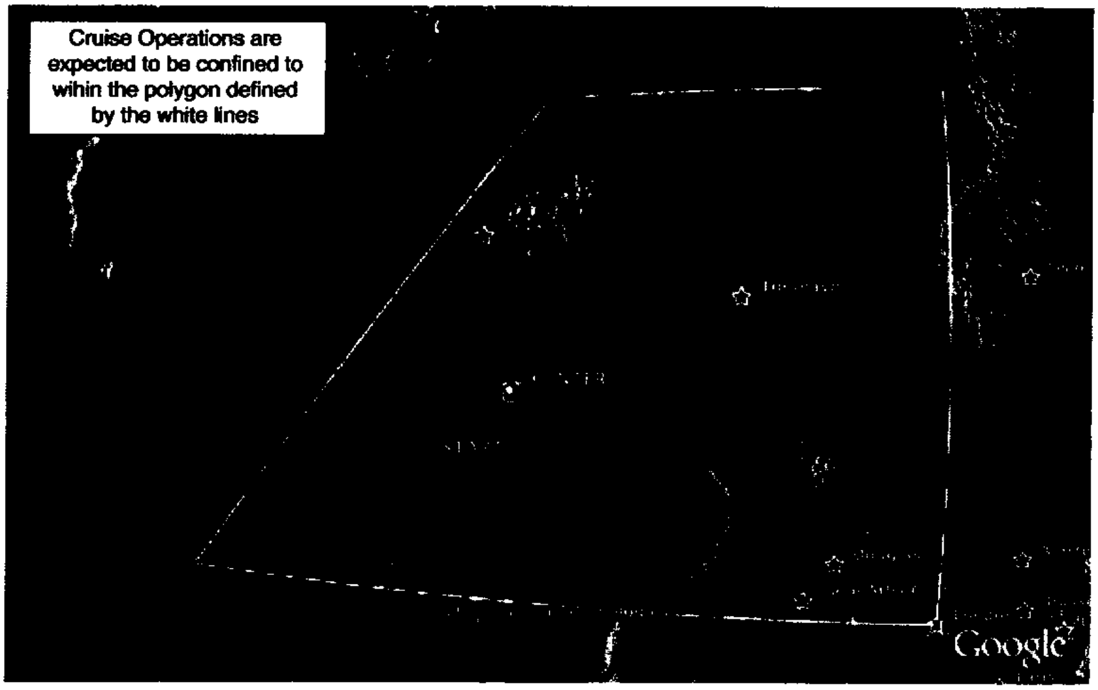
Two types of floats will be deployed from the R/V Knorr in May 2008 and retrieved before the end of the May cruise:

1) floating sediment traps: up to five floating sediments, each of which will be programmed to seek an independent depth between approximately 200 and 1,000 m. Each deployment will last 2-4 days, after which the traps will be retrieved. The intention is do to up to a maximum of four separate deployments. The exact location will depend on the existing oceanographic conditions, including where the highest concentrations of phytoplankton are located.
2) floating optical plankton counter that will be deployed once during the cruise to profile multiple times within the upper 200 m. The trap will be retrieved at the end of the cruise. The exact location will depend on the existing oceanographic conditions, including where the highest concentrations of phytoplankton are located.

5. Geographical Areas

5.1 Indicate geographical areas in which the project is to be conducted (with reference in latitude and longitude):
Within the following coordinates: 68°N 17.5°W, 54°N 35°W, 51.5°N 0°W, 66.5°N 11°E

5.2 Attach chart(s) at an appropriate scale (1 page, high-resolution) showing the geographical areas of the intended work and, as far as practicable, the positions of intended stations, the tracks of survey lines, and the locations of installations and equipment.



6. Dates

6.1 Expected dates of first entry into and final departure from the research area of the research vessel:
First entry on 26 April with final departure by 31May 2008.

6.2 Indicate if multiple entry is expected:
Multiple entry is not expected. However, if the floats and gliders being tracked drift in unintended trajectories, multiple entries may be necessary to sample near the floats and gliders, and to retrieve floats.

7. Port Calls

7.1 Dates and names of intended ports of call:
Reykjavik, Iceland: Estimated Arrival 3 May 2008 Reykjavik, Iceland: Estimated Departure 24 May 2008

7.2 Any special logistical requirements at ports of call:
No.

7.3 Name/Address/Telephone of shipping agent (if available):
Reykjavik, Iceland: EIMSKIP Port Agency Services Korngarour 2 104 Reykjavik ICELAND Contact: Berry Timmermans Phone: 354 525 7273 Fax: 354 525 7279 Cell: 354 825 7273 Email: byt@eimskip.is

8. Participation:

8.1 Extent to which coastal state will be enabled to participate or to be represented in the research project:
Scientists from Iceland, Denmark, and the U.K. will participate on the cruise.

8.2 Proposed dates and ports for embarkation/disembarkation:
Estimated embarkation on 3 May from Reykjavik, Iceland and estimated disembarkation in Reykjavik, Iceland on 24 May 2008.

9. Access to data, samples and research results

9.1 Expected dates of submission to coastal state of preliminary reports, which should include the expected dates of submission of the final results:
No more than 30 days from the end date of the cruise.

9.2 Proposed means for access by coastal state to data and samples:
Participants from the coastal states will have access to the data collected on the cruise, results of analysis of water samples, and will participate in data analysis and reporting.

9.3 Proposed means to provide coastal state with assessment of data, samples and research results or provide assistance in their assessment or interpretation:
Participants from the coastal states will have access to the data and will participate in data analysis, reporting, and manuscript preparation for publication in scientific journals.

9.4 Proposed means of making results internationally available:
The results of this cruise will lead to collaborative scientific papers with scientists from coastal states; these papers will be published in internationally recognized scientific journals. Results from the cruise will be incorporated in educational learning modules that will available on the web.

Application for Port Call Clearance in Iceland and Norway
and Consent to
Conduct Marine Scientific Research
in Areas Under National Jurisdiction of

ICELAND, CANADA, NORWAY, GREENLAND/DENMARK, FRANCE (St. Pierre & Miquelon Islands)
(name of coastal state)

Date: 14 August 2007

1. General Information

1.1 Cruise name and/or #:	Research Vessel *Knorr* ICEALOT: International Chemistry Experiment in the Arctic Lower Troposphere (http://saga.pmel.noaa.gov/Field/icealot/)

1.2 Sponsoring Institution:	
Name:	Woods Hole Oceanographic Institution
Address:	Woods Hole, MA 02543 USA
Name of Director:	Dr. James Luyten, Acting Director

1.3 Scientists in charge of the project (include CV and passport photo):	
Name:	Timothy S. Bates and Patricia K. Quinn
Address:	NOAA/PMEL Seattle, WA 98115
Telephone:	206-526-6248, 206-526-6892
Fax:	206-526-6744
Email:	Tim.bates@noaa.gov, patricia.k.quinn@noaa.gov

Biographical Sketch: Timothy S. Bates

Professional Preparation:

B.A.	Wittenberg University	Chemistry	1975
M.S.	University of Washington	Oceanography	1978
Ph.D.	University of Washington	Environmental Chemistry	1988

Appointments:

NOAA/Pacific Marine Environmental Laboratory
- Research Chemist 1984- present
- Chemist 1978-1984

University of Washington
- Affiliate Associate Professor, Department of Atmospheric Sciences 1994-present
- Affiliate Assistant Professor, Department of Atmospheric Sciences 1990-1994
- Senior Fellow, JISAO 1995-present
- Fellow, JISAO 1991-1995

Selected Publications: (pdf versions available at http://saga.pmel.noaa.gov/public.html)

Bates, T.S., T.L. Anderson, T. Baynard, T. Bond, O. Boucher, G. Carmichael, A. Clarke, C. Erlick, H. Guo, L. Horowitz, S. Howell, S. Kulkarni, H. Maring, A. McComiskey, A. Middlebrook, K. Noone, C.D. O'Dowd, J. Ogren, J. Penner, P.K. Quinn, A.R.

Ravishankara, D.L. Savoie, S.E. Schwartz, Y. Shinozuka, Y. Tang, R.J. Weber, and Y. Wu (2006), Aerosol direct radiative effects over the northwest Atlantic, northwest Pacific, and North Indian Oceans: Estimates based on in-situ chemical and optical measurements and chemical transport modeling. *Atmos. Chem. Phys.*, 6, 1657-1732, SRef-ID: 1680-7324/acp/2006-6-1657.

Bates, T.S., P.K. Quinn, D.J. Coffman, J.E. Johnson, and A.M. Middlebrook (2005), Dominance of organic aerosols in the marine boundary layer over the Gulf of Maine during NEAQS 2002 and their role in aerosol light scattering. *J. Geophys. Res.*, 110, D18, D18202, doi:10.1029/2005JD005797.

Bates, T.S., P.K.Quinn, D.J. Coffman, D.S. Covert, T.L.Miller, J.E. Johnson, G.R. Carmichael, S.A. Guazzotti, D.A. Sodeman, K.A. Prather, M. Rivera, L.M. Russell, and J.T. Merrill (2004). Marine boundary layer dust and pollution transport associated with the passage of a frontal system over eastern Asia, *J. Geophys. Res.*, 109, D19, doi:10.1029/2003JD004094.

Bates, T.S., D.J. Coffman, D.S. Covert, and P.K. Quinn (2002). Regional marine boundary layer aerosol size distributions in the Indian, Atlantic and Pacific Oceans: A comparison of INDOEX measurements with ACE-1, ACE-2, and Aerosols99. *J. Geophys. Res.*, 107(D19), 10.1029/2001JD001174.

Bates, T.S., P.K. Quinn, D.J. Coffman, J.E. Johnson, T.L. Miller, D.S. Covert, A. Wiedensohler, S. Leinert, A. Nowak and C. Neusüß (2001), Regional Physical and Chemical Properties of the Marine Boundary Layer Aerosol across the Atlantic during Aerosols99: An overview, *J. Geophys. Res.*, 106, 20,767–20,782.

Huebert, B.J., B.W. Blomquist, J.E. Hare, C.W. Fairall, J.E. Johnson, and T.S. Bates (2004), Measurement of the sea-air DMS flux and transfer velocity using eddy correlation, *Geophys. Res. Lett.*, 31, L23113, doi:10.1029/2004GL021567.

Synergistic Activities:

Associate Editor, *Journal of Geophysical Research, Atmospheres*	1992-present
Co-chair IGAC SSC (with Sandro Fuzzi and Shaw Liu)	2003-2005

[redacted]

Timothy S. Bates

Biographical Sketch: Patricia K. Quinn

Professional Preparation:

B.A.	Reed College	Chemistry	1982
Ph.D.	University of Washington	Chemistry	1988

Appointments:

CIRES, University of Colorado	
Research Associate	1989 - 1990
JISAO, University of Washington	
Oceanographer III	1990 - 1993
NOAA/Pacific Marine Environmental Laboratory	
Research Chemist	1993 - present
University of Washington	
Affiliate Assistant Professor, Department of Chemistry	1996 - 1998
Affiliate Associate Professor, Department of Chemistry	1998 - present
Fellow, JISAO	1996 – 1999
Senior Fellow, JISAO	1999 - present

Selected Publications: (pdf versions available at http://saga.pmel.noaa.gov/public.html)

Quinn, P.K., T.S. Bates, D. Coffman, T.B. Onasch, D. Worsnop, T. Baynard, J.A. de Gouw, P.D. Goldan, W.C. Kuster, E. Williams, J. M. Roberts, B. Lerner, A. Stohl, A. Pettersson, and E.R. Lovejoy, Impacts of sources and aging on submicrometer aerosol properties in the marine boundary layer across the Gulf of Maine, *J. Geophys. Res.*, 111, D23S36, doi:10.1029/2006JD007582, 2006.

Quinn, P. K., T.S. Bates, T. Baynard, A.D. Clarke, T.B. Onasch, W. Wang, M.J. Rood, E. Andrews, J. Allan, C.M. Carrico, D. Coffman, and D. Worsnop, Impact of particulate organic matter on the relative humidity dependence of light scattering: A simplified parameterization, *Geophys. Res. Lett.*, *32*, L22809, doi:101029/2005GL024322, 2005.

Quinn, P.K. and T.S. Bates, Regional Aerosol Properties: Comparisons from ACE 1, ACE 2, Aerosols99, INDOEX, ACE Asia, TARFOX, and NEAQS, *J. Geophys. Res., 110*, D14202, doi:10.1029/2004JD004755, 2005.

Quinn, P.K. and T.S. Bates, North American, Asian, and Indian haze: Similar regional impacts on climate?, *Geophys. Res. Lett.*, 30 (11), 1555, doi:10.1029/2003GL016934, 2003.

Quinn, P.K., D.S. Covert, T.S. Bates, V.N. Kapustin, D.C. Ramsey-Bell, and L.M. McInnes, Dimethylsulfide/cloud condensation nuclei/climate system: Relevant size-resolved measurements of the chemical and physical properties of atmospheric aerosol particles, *J. Geophys. Res., 98*, 10411 - 10427, 1993.

Quinn, P.K., G. Shaw, E. Andrews, E.G. Dutton, T. Ruoho-Airola, S.L. Gong, Arctic Haze: Current trends and knowledge gaps, *Tellus, 59B*, 99 – 114, 2007.

Witek, M.L., P.J. Flatau, P.K. Quinn, and D. Westphal, Global sea salt modeling: Results and validation against multi-campaign shipboard measurements, *J. Geophys. Res., 112*, D08215, doi:10.1029/2006JD007779, 2007.

Synergistic Activities:

Associate Editor, *Journal of Geophysical Research, Atmospheres*	1997-present
Secretary, Atmospheric Sciences Section of AGU	1996 – 1998
Council Delegate, AAAS	2002 – 2005
Chair, Editor Search Committee for JGR-Atmosphere	2006 – 2008

Patricia K. Quinn

1.4 Scientist(s) from coastal state involved in the planning of the project:	
Name(s):	Andreas Stohl
Address:	Norwegian Institute for Air Research (NILU) P.O. Box 100, Kjeller, NO-2027

1.5 Submitting officer:	
Name and address:	Elizabeth Caporelli, Marine Operations Coordinator Woods Hole Oceanographic Institution 38 Water Street, Mail Stop #37 Woods Hole, MA 02543 USA
Nationality:	USA
Telephone:	508-289-2277
Fax:	508-457-2185
Email:	ecaporelli@whoi.edu

2. Description of Project (Attach additional pages as necessary)

2.1 Nature and objectives of the project:

A springtime study of aerosol properties and atmospheric chemistry over the ice-free region of the Arctic. This project is part of the International Polar Year activity POLARCAT (http://www.polarcat.no/polarcat)

ICEALOT
International Chemistry Experiment in the Arctic LOwer Troposphere

Overview

As part of POLARCAT, NOAA will undertake a research cruise in an ice-free region of the Arctic during March and April of 2008. The study area will include the Greenland, Norwegian, and Barents Seas. Scientific issues to be addressed include springtime sources and transport of pollutants to the Arctic, evolution of aerosols and gases into and within the Arctic, and climate impacts of haze and ozone in the Arctic.

Background

In the late 1950s, pilots flying over the Canadian and Alaskan Artic observed a haze of unknown origin that significantly decreased visibility. This "Arctic Haze" is a phenomenon that recurs every winter and spring and is now understood to be due to long range transport of anthropogenic aerosols primarily from Europe and Western Asia. The haze is composed of a varying mixture of sulfate, nitrate, particulate organic matter

(POM), dust, and black carbon. Long-term measurements at ground sites within the Arctic (Barrow and Alert), reveal a decreasing trend in concentrations of aerosol black carbon during March and April throughout the 1990s. Since the beginning of the 21st century, however, concentrations have increased not only during the Arctic Haze months but also during the summer. Aerosol light scattering follows a similar trend with levels decreasing through the 1990s and increasing since 2000. In addition, concentrations of nitrate have increased at Alert from the early 1980s to present. In contrast, levels of sulfate have decreased from the 1990s to present. The lack of long term measurements of POM in the Arctic makes it difficult to assess trends in POM. Reasons for the changing trends, especially the decoupling of sulfate from nitrate and black carbon, are uncertain as are the impacts on the climate of the region.

Just as anthropogenic aerosol is transported to the Arctic during the spring, so are gas phase compounds that impact the oxidative capacity of the atmosphere and Arctic climate. The peak in average surface level arctic ozone concentrations occurs coincidentally with the artic haze during springtime due to the presence of reactive nitrogen and other ozone precursors. There are uncertainties surrounding the partitioning of reactive nitrogen as it is transported into the Arctic and the mechanism for the conversion and cycling between NO_x (=NO + NO_2) and NO_y (= the sum of all reactive nitrogen). The uncertainty in reactive nitrogen chemistry leads to uncertainty in the rate of photochemical ozone production in relation to processes such as long range transport and stratosphere-troposphere exchange during the arctic spring ozone maximum. For example, photochemical HO_x production, a key component of ozone photochemistry, has a potentially large but still uncertain contribution from long wavelength photolysis of HO_x and NO_x reservoir compounds at the high solar zenith angles that occur during the spring in the Arctic. Furthermore, the production and photochemical cycling of halogen species has a profound effect on the local O_3 in the lower arctic troposphere, leading to intense ozone destruction events (ODEs). There are considerable uncertainties in this chemistry, including the processes that are responsible for its initiation, the magnitude and extent of halogen radical processing in this environment, the interplay between chlorine and bromine, and the broader implications of this chemistry, especially with respect to hydrocarbon processing.

Changes in surface air temperature and ice extent over the past decade suggest that anthropogenically-induced climate change is occurring in the Arctic. However, the impact of short lived pollutants such as aerosols and tropospheric ozone versus long lived greenhouse gases on Arctic climate is, as of yet, unknown. A better understanding of the climatic effects of the short lived pollutants is required to guide mitigation strategies and, in particular, to determine to what extent reducing concentrations of aerosols and tropospheric ozone in the source regions will reduce the rate of warming in the Arctic.

NOAA will undertake a research cruise in the eastern Arctic in March and April of 2008 to address scientific questions related to the sources, transport, and climatic impacts of anthropogenic aerosol and gas phase species. This experiment, which will be part of POLARCAT (an IPY activity), will take place in the Greenland, Norwegian, and Barents Seas. One unique aspect of the project is the focus on the ice free region of the Arctic at a time when the fraction of Arctic ice coverage is decreasing. In addition, measurements made of aerosol and gas phase species associated with ship emissions will serve as a "baseline" before the possibility of an increase in ship traffic as a result of the decrease in ice coverage is realized along the Northern Sea Route and

Northwest Passage. Specific scientific questions to be addressed are listed below.

Scientific Questions

Q1. Springtime sources and transport of pollutants to the Arctic

Measurements of aerosol properties coupled with chemical transport models are required to understand the apparently changing trends in certain components of Arctic Haze. Measurements of aerosol composition will be made and these data will be used in conjunction with chemical transport models to determine:

- What is the composition of the aerosol during March and April over the ice-free regions of the Arctic?
- What are the sources of the aerosol to this region during March and April?
    - How significant is local production of aerosols (e.g., oceanic emissions of particles and trace gases, emissions from ships, local point sources in the Arctic)? What are the dominant oxidation pathways in the production of aerosols from these sources?
    - How significant is the North Atlantic as a marine boundary layer transport pathway for mid-latitude pollutants into this region of the Arctic?
    - How significant is the exchange of aerosols between the MBL and free troposphere?

Q2. Evolution of aerosols and gases into and within the Arctic

The impact of aerosols on climate is determined by the size and composition of the particles which, in turn, is affected by processing during transport and the spring progression. Measurements will be made to determine:

- How do aerosol precursor gases and the chemical, physical, optical and cloud nucleating properties of the aerosol evolve along the North Atlantic transport route?
- How do aerosol precursor gases and the chemical, physical, optical and cloud nucleating properties of the aerosol evolve as the spring progresses?

Previous aircraft and surface measurements in the Arctic have provided evidence for reactive nitrogen transport into the Arctic during spring. Although most of the measured NO_y is in the form of PAN, modeling studies suggest that N_2O_5 hydrolysis is responsible for much of the conversion of NO_x to NO_y during transport. Measurements will be made to determine:

- What is the partitioning of reactive nitrogen in the springtime Arctic?
- What is the rate of N_2O_5 hydrolysis in the Arctic, and how does it impact NO_y?
- What are the lifetimes of and loss processes for NO_3 in the Arctic?

The lower tropospheric ozone maximum that occurs in the Arctic spring has contributions from long range transport, stratosphere-troposphere exchange, and *in-situ* production. Modeling of aircraft data from 2000 showed an unexpectedly large contribution from the latter. Additional uncertainties surrounding the Arctic springtime ozone budget include the importance of HO_x in the photochemical production of ozone and ozone depletion events linked to halogen activation in the Arctic spring. Measurements will be made to determine:

- What are the *in-situ* ozone production rates during the spring in the Arctic?
- What is the role of HO_x chemistry at high solar zenith angles?
- Are ozone depletion events due to halogen activation significant in the ice-free regions of the Arctic?
- What mechanism activates halogens to initiate arctic ozone depletion events?

- What is the role of reactive nitrogen uptake by sea salt?

Q3. Climate impacts of aerosols and ozone in the Arctic

The contribution of aerosols to anthropogenically-induced climate change in the Arctic is uncertain yet may be significant through direct interaction with solar and longwave radiation, aerosol – cloud interactions, and feedback processes. Measurements will be made to determine:

- What is the impact of anthropogenic aerosol on the clear-sky radiation balance of the ice-free regions of the Arctic during March and April?
- How do anthropogenic aerosols affect the radiative properties of clouds in this region?
  - What are the cloud nucleating properties of the aerosol?
  - What is the impact of anthropogenic aerosol on cloud drop effective radius and reflectivity?
  - What is the impact of anthropogenic aerosol on longwave downwelling radiation, atmospheric heating rates, and surface warming?

During the winter and early spring, tropospheric ozone is sufficiently long-lived to be transported from lower latitude source regions to the Arctic. Since ozone absorbs both infrared and shortwave radiation, it can induce large warming over highly reflective surfaces which may, in turn, contribute to snow/ice melting.

- Given the observed surface concentrations and vertical profiles of tropospheric ozone, what is the radiative impact in the springtime western Arctic?
- How does radiative forcing by tropospheric ozone vary as a function of ozone production and depletion in the ice-free western Arctic?

2.2 Relevant previous or future research cruises:

- IGAC-Aerosol Characterization Experiment, ACE-1, Tasmania, November-December 1995
- IGAC-Aerosol Characterization Experiment, ACE-2, Tenerife-Sagres, June-July 1997
- IGAC-Aerosol Characterization Experiment, ACE-Asia, 2000-2001
- NEAQS-ITCT 2004, New England Air Quality Study – Intercontinental Transport and Chemical Transformation Experiment
- GoMACCS 2006, Gulf of Mexico Atmospheric Chemistry and Climate Study

Further details of these experiments can be found at http://saga.pmel.noaa.gov/ProgramsField.php

2.3 Previously published research data relating to the project:

http://saga.pmel.noaa.gov/public.html

3. Methods and Means to be Used

3.1 Particulars of vessel:	
Name:	Research Vessel Knorr
Nationality (Flag state):	USA
Owner:	United States
Operator:	Woods Hole Oceanographic Institution
Overall length (meters):	85 meters
Maximum draught (meters):	5.1 meters
Displacement/Gross tonnage:	2,518 T
Propulsion:	Diesel Electric
Cruising & Maximum speed:	12 knots/15 knots
Call sign:	KCEJ
Method and capability of communication (including emergency frequencies):	INMARSAT Satellite Telephone Iridium Satellite telephone VHF Channel 13 and 16 Single Side Band 2182 kHz
Name of master:	Captain Kent Sheasley
Number of crew:	23
Number of scientists on board:	34

3.2 Aircraft or other craft to be used in the project:
none

3.3 Particulars of methods and scientific instruments

Types of samples and data	Methods to be used	Instruments to be used
Atmospheric sampling of gases and aerosols	See attached list below	
Surface seawater sampling of plankton, ocean chemistry	See attached list below	

Proposed measurements aboard R/V Knorr during ICEALOT

Parameter	Method	Laboratory	PI
Aerosol ionic composition	PILS-IC	PMEL	Quinn
Aerosol WSOC	PILS-TOC	PMEL	Quinn/Bates
Aerosol size and composition	Quad- AMS	PMEL	Bates
Single particle (180-3000nm Dp) aerosol size, composition (mixing state), and light scattering	ATOFMS	UCSD	Prather
Aerosol functional groups	FTIR	SIO	Russell

Size resolved aerosol composition and mass,2 stage (sub/super micron) & 7 stage at 60% RH	Impactors (IC, XRF and thermal optical OC/EC, total gravimetric weight)	PMEL	Quinn/Bates
Total iodine, iodide, reducible iodine	Neutron activation, IC	UNH	Pszenny
Total and sub-micron aerosol scattering & backscattering (450, 550 and 700 nm) at 60% RH	TSI 3563 nephelometers (2)	PMEL	Quinn
Total and sub-micron aerosol absorption (450, 550, 700 nm) dry	Radiance Research PSAPs (2)	PMEL	Quinn
Aerosol light scattering hygroscopic growth	Twin TSI 3563 nephelometers	UW	Covert
Total and Sub-micron aerosol extinction, aerosol extinction hygroscopic growth	Cavity ring-down spect.	ESRL	Ravishankara
Sub-micron aerosol absorption	Photo acoustic	ESRL	Ravishankara
Aerosol number	CNC (TSI 3010, 3025)	UW/PMEL	Covert/Bates
Aerosol size distribution	DMA and APS	UW/PMEL	Covert/Bates
Non-volatile aerosol size distribution	SMPS (2) one with heated inlet	UW/PMEL	Covert/Bates
CCN	DMT	PMEL	Quinn
Cloud liquid water path	Microwave radiometer	ESRL	Fairall
Cloud droplet effective radius	Cloud radar	ESRL	Fairall
Radiative fluxes	Spectral radiometer	CU	Pilewski
Aerosol optical depth	Microtops	PMEL	Quinn
Aerosol vertical profiles	Micropulse lidar	UNH	Talbot
Photolysis rates (JNO2, JNO3, JO-1D)	Filter radiometer	ESRL	Lerner
Ozone	UV absorbance	ESRL	Williams
Ozone	UV absorbance	PMEL	Johnson
Ozone	NO chemiluminescence	ESRL	Williams
Carbon monoxide	UV fluorescence (AeroLaser)	ESRL	Lerner
Carbon dioxide	Non-dispersive IR	ESRL	Lerner
Water vapor	Non-dispersive IR	ESRL	Lerner
Sulfur dioxide	Pulsed fluorescence	ESRL	Lerner
Sulfur dioxide	Pulsed fluorescence	PMEL	Bates
Nitric oxide	Chemiluminescence	ESRL	Lerner
Nitrogen dioxide	Photolysis cell	ESRL	Lerner
Total nitrogen oxides	Au tube reduction	ESRL	Williams
PANs	GC/ECD	ESRL	Roberts
Alkyl nitrates, hydrocarbons	GC/MS	ESRL	Kuster
NO3/N2O5	Cavity ring-down spect.	ESRL	Brown
Acyl peroxy nitrates, ClNO2	CIMS	UW	Thornton

Total gas phase inorganic iodine	Neutron activation	UNH	Pszenny
Particulate and gaseous persistent organic pollutants	GCMS	URI	Lohmann
Radon	Radon gas decay	PMEL	Johnson
Seawater and atmospheric pCO2	Non-dispersive IR	AOML	Wanninkhof
Seawater DMS	S chemiluminesence	PMEL	Bates/Johnson
Surface seawater primary production and respiration, O2, POC, PON, PIC, TOC, Chlorophyll a, nutrients, plankton cell biomass	O2 incubations, flow cytometry, and std techniques	Bigelow	Matrai
Temp/RH profiles	Sondes	ESRL	White
Turbulent fluxes	Bow-mounted EC flux package	ESRL	Fairall
High resolution turbulence	Mini-sodar	ESRL	Fairall
Meteorological forecasting	Flexpart	NILU	Burkhart
Data and systems management	PCs; Ship's LAN; e-mail; ftp	PMEL	Johnson
Data and systems management	Macs; PCs; e-mail; ftp	ESRL	Murphy
Ship naviagation, SST, salinity, meteorological data		PMEL	Johnson

3.4 Indicate whether harmful substances will be used:
none

3.5 Indicate whether drilling will be carried out:
none

3.6 Indicate whether explosives will be used:
none

4. Installations and Equipment

Details of installations and equipment (dates of laying, servicing, recovery; exact locations and depth):
none

5. Geographical Areas

5.1 Indicate geographical areas in which the project is to be conducted (with reference in latitude and longitude):
42°N to 76°N, 67°W to 30°E – Gulf of Maine, N. Atlantic, Norwegian Sea, Greenland Sea, Barents Sea

5.2 Attach chart(s) at an appropriate scale (1 page, high-resolution) showing the geographical areas of the intended work and, as far as practicable, the positions of intended stations, the tracks of survey lines, and the locations of installations and equipment.

6. <u>Dates</u>

6.1 Expected dates of first entry into and final departure from the research area of the research vessel:
17 March 2008 to 28 April 2008

6.2 Indicate if multiple entry is expected:
Yes

7. Port Calls

7.1 Dates and names of intended ports of call in
Depart Woods Hole, MA: 17 March 2008 Arrive Tromso, Norway: 11 April 2008 Depart Tromso, Norway: 15 April 2008 Arrive Reykjavik, Iceland: 28 April 2008

7.2 Any special logistical requirements at ports of call:
Refill liquid nitrogen dewars

7.3 Name/Address/Telephone of shipping agent (if available):
TROMSO, NORWAY AGENT: TO BE DETERMINED **REYKJAVIK, ICELAND AGENT:** EIMSKIP Port Agency Services Korngarour 2 104 Reykjavik ICELAND Contact: Berry Timmermans Phone: 354 525 7273 Fax: 354 525 7279 Cell: 354 825 7273 Email: byt@eimskip.is

8. Participation:

8.1 Extent to which coastal state will be enabled to participate or to be represented in the research project:
Accommodations will be made for observers from the coastal state.

8.2 Proposed dates and ports for embarkation/disembarkation:
Embark Woods Hole, MA: 17 March 2008 Disembark Tromso, Norway: 11 April 2008 Embark Tromso, Norway: 15 April 2008 Disembark Iceland: 28 April 2008

9. Access to data, samples and research results

9.1 Expected dates of submission to coastal state of preliminary reports, which should include the expected dates of submission of the final results:
No more than 30 days from the end date of the cruise.

9.2 Proposed means for access by coastal state to data and samples:
All data will be available at http://saga.pmel.noaa.gov/DataServers.php

9.3 Proposed means to provide coastal state with assessment of data, samples and research results or provide assistance in their assessment or interpretation:
All data will be available at http://saga.pmel.noaa.gov/DataServers.php

9.4 Proposed means of making results internationally available:
International conferences, journal articles, IPY workshops, website