

A Workshop to consider the Southern Ocean slope front role in governing exchange across the shelf and deep ocean regimes.

27-29 September 1999

Lamont-Doherty Earth Observatory
Palisades NY

Introduction:

During the last few decades we have advanced our knowledge of the dominant processes of the southern ocean shelf regime and adjacent deep ocean regime, but what has lagged, mostly because of difficult scientific and logistic problems, is the interface across which these two distinct regimes interact: the continental slope regime. The slope regime is often characterized by strong thermohaline gradients (the Slope Front) and irregular topography with incised canyons.

As the shelf/deep regime interaction is related to major ventilation of the global ocean, it is important that it be properly represented within global climate models.

An important climate related question remains unresolved:

What is the role of the Southern Ocean slope front and slope canyons in the exchange of mass, heat, and freshwater between the shelf and oceanic regimes, in particular those leading to deep reaching plumes?

An iAnZone Slope Front workshop was held on 27-29 September 1999 to discuss what we know about shelf/deep regime exchange and to structure an observational and modeling research plan which would help develop a quantitative understanding of the cross slope exchange processes.

The workshop participants, representing US, Italy, UK, Germany, Russia and Japan, are listed in Table I. Written reports from Australia and Norway were also available. The meeting agenda is attached as Appendix A.

The meeting began with science presentations, with a focus on water mass exchange between the shelf and deep water regimes; slope front structure and variability and its role in shelf/deep water exchange; descending dense waters on the slope and within canyons, and the relationships to atmospheric and sea ice conditions. The presentations can discuss observational and modeling information at any site along the Antarctic margins. However, as the Ross Sea remains the most likely site of observational research, emphasis on the Ross Sea or on the relevance of results to the Ross Sea region, was encouraged.

The science presentations and national reports were followed by a discussion and further development of the June 30, 1999 Summary Statement (strawman plan), prepared by the US iAnZone group.

Results:

The group agrees with summary statement that from both logistics and scientific considerations that the Ross Sea offers the most promising site to study cross slope exchange. The slope regime in the Ross Sea is generally ice free in the summer months, enabling use of mooring and Lagrangian technology, and a greater chance of sampling of the thermohaline and tracer fields at the proper scales. Dense shelf water abounds, including Ice Shelf Water. Its bathymetry is better surveyed than other segments of the continental margins. It is close to the logical bases of McMurdo and Christchurch. The alternative site within the Weddell Sea, is considered too logistically difficult and remote to allow implementation of a properly designed experiment. While the Ross Sea is clearly the region of choice, where in the Ross Sea is still an open question: western, central or eastern dense water escape routes. Each has positives and negatives.

It is recommended that US and Italian programs be closely coordinated to further develop the experimental approach. Coordination will enable more than one site within the Ross Sea to be studied. Coordination with the Australian program along the Adelie coast to the west (which probably represents the downstream condition) will also be explored.

The workshop participants more sharply focussed the initial Summary Statement towards addressing the nature of the descending plumes of dense shelf water over the continental slope regime, and their relationship to topography and Slope Front structure and variability.

Draft statement of the research program:

Title: Cross-slope fluxes of Antarctic Shelf Water along the Antarctic continental slope.

Goal: Determine the principal physical processes that cause the injection of dense shelf water into the intermediate and deep layers of the deep water surrounding the Antarctic continent.

Hypothesis: The property characteristics and rate of transport of dense shelf water across the shelf break is determined by the following processes:

1. Topographic effects (role of canyons, isobath divergence/convergence, proximity to end of western boundary);
2. Cross-slope advection by tides, other “high frequency” forcing (weather-band wind stress, frontal instabilities), and benthic Ekman dynamics associated with the along-isobath mean barotropic circulation;
3. Nonlinear equation of state effects (thermobaricity, cabbeling);
4. Shelf water mass properties and spatial variability of cross-slope surface and benthic layer fluxes.

Methodology: Obtain measurements and develop models that describe the structure of cross-slope flow of shelf water at a specific “characteristic” site, use the data to improve the models’

local predictive skill, then use the upgraded models to extrapolate our estimate of cross-slope benthic flow to the major regions of AABW production in the Antarctic.

The processes described in “Hypothesis” require a coordinated program involving mesoscale and process modeling, and observations capable of resolving the small scales of variability that are expected from our present knowledge of the small space and time scales of the dominant processes near the shelf break. We expect the cross-slope transport of shelf water mass properties to be highly variable, almost certainly actually intermittent, in both time and space.

The elements of the required program must include:

1. Bathymetric surveys of the chosen principal region of study, with resolution of better than 2 km (preferably Seabeam);
2. Hydrographic (CTD/LADCP) surveys at spacing finer than the Rossby radius (<5 km spacing), concentrating on the benthic plume and Slope Front, and including tracer chemistry for water age (CFCs, O₂) and ice shelf water concentration (stable isotopes). Several sufficiently rapid transects across the plume to limit aliasing of the transect, using XCTD and hull ADCP;
3. Moorings to augment the hydrographic surveys, provide the spatial and temporal scales of variability of the ambient flow, and allow extrapolation of hydrographic data to one annual cycle;
4. Lagrangian methods (floats, profilers and injection of tracers) may be used to conduct measurements in and near the plume that would allow us to develop at least a qualitative understanding of the dominant processes responsible for mixing of the sinking plume with ambient waters.
5. Analytical and numerical process modeling, plume flow over rough/variable topography, role of nonlinear equation of state);
6. Mesoscale modeling to help map the small-domain measurement program to the circum-Antarctic level *via* improved parameterizations tied to the process models.

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Prepared by Arnold L. Gordon (chairman), Glen Gawarkiewicz, Alex Orsi and Laurie Padman...21 October 1999

APPENDIX A.

Slope Front Workshop 27-29 September 1999 DRAFT Agenda (16 September, 1999)

Monday, 27 September [9 AM to 5 PM]

I Introduction:

Gordon, Arnold: workshop objectives
 Review of Summary Statement

II Science Talks: Presentations up to 20 minutes long, followed by discussion of up to 10 minutes. Presentations should focus on: water mass exchange between the shelf and deep water regimes; slope front structure and variability and its role in shelf/deep water exchange; and descending dense waters on the slope and within canyons. The presentations can discuss observational and modeling information at any site along the Antarctic margins. However, emphasis on the Ross Sea or on the relevance of results to the Ross Sea region, would be most helpful.

Observations:

Orsi, Alex: Observations

Whitworth, Tom: Observations

Jacobs, Stan: Observations

Bergamasco, Andrea: "Results of the CLIMA-PNRA Cruises in the Ross Sea.

Padman, Laurie: "Hydrography over the continental shelf and slope of the southwestern Weddell Sea during the 1997/98 austral summer"

Comiso, Joey: "Variability of the Sea Ice Cover"

Models:

Gawarkiewicz, Glen: Modeling of exchange across the continental slope

Akitomo, Kazunori: "Model study of descending current and dense water transport along continental slope"

Nof, Doran: "The export of upper water from the Southern Ocean and the associated

upwelling”

Hellmer, Hartmut: Weddell Margins

Padman, Laurie: “High-frequency (tides and shelf waves) variability at the Weddell Sea shelf/slope front”.

Robertson, Robin: “Effects of the critical latitude & fronts on internal tides in the southern Weddell Sea”

Muench, Robin: “Turbulence and mixing related issues”

Monday, evening: Lamont’s 50th anniversary party will be held in Casa Italiana (affiliated with Columbia University; Amsterdam St and 118th st NYC) from 6 to 9 PM. Workshop participant’s can attend, if they wish.

Tuesday, 28 September [9 AM to 5 PM]

III Review of related projects already underway or planned:

Zambianchi, Enrico: Italian Ross Sea Program Plans

Jacobs Stan: NBP cruise Feb-Mar 2000

Jenkins, Adrian: BAS

Akitomo: JARE

Hellmer: AWI

Klepikov: Russia

IV Revisit the Summary Statement (June 30, 1999 version was distributed earlier):

A group discussion, chaired by the Steering Committee (Gordon, Orsi, Padman, Gawarkiewicz); objective: to consider and revise as necessary the document.

Wednesday, 29 September [9 AM to 5 PM]

V What’s Needed? Discussion of how we might address the objectives expressed in the (revised) Summary Statement to advance understanding of the southern ocean shelf/deep

water exchange; slope front, and descending dense waters through observational & modeling research. All are invited to participate but those named are encouraged to prepare and lead the discussion.

Models: what are outstanding questions, what obs are needed? Gawarkiewicz (lead discussion), Hellmer, Akitomo, Nof, Robertson...

Sea Ice: Ackley, Comiso, Martinson...

Moorings (current meters, ADCP, other): Whitworth, Orsi...,

Drifters: Hellmer, Martinson...

Floats: Hebert, Prater, Visbeck...

CTD/LADCP: Gordon, Jacobs, Visbeck

Tracers: Smethie, Schlosser...

Purposeful Tracers: Ledwell, Schlosser

VI Conclusion & what next? Gordon...

TABLE 1. LIST OF PARTICIPANTS

Stephen Ackley
U.S. Army Cold Regions Research and Eng.
72 Lyme Road
Hanover, New Hampshire 03755
Ph: 603-646-4258E
E-Mail: sackley@pol.net

Kazunori Akitomo,
Associate Professor
Graduate School of Science
Kyoto University
Dept. of Geophysics
Kyoto 606-01, Japan
Ph: 011-81-75-753-3923
Fax: 011-81-75-753-3928
E-Mail: akitomo@kugi.kyoto-u.ac.jp

Andrea Bergamasco
Istituto Dinamica Grandi Masse del CNR
S. Polo 1364
30125 Venice, Italy
Ph: 011-39-041-5216836
Fax: 011-39-041-2602340
E-Mail: andreab@isdgm.ve.cnr.it

Olaf Boebel
Graduate School of Oceanography
University of Rhode Island
221 Watkins Building
Narragansett, Rhode Island 02882
Ph: 401-874-6518
Fax: 401-874-6728
E-Mail: ofoebel@gso.uri.edu

David C. Chapman
Woods Hole Oceanographic Institution
Clark 316B, MS#21
Woods Hole, MA 02543
Ph: 508-289-2792
Fax: 508-457-2181
E-Mail: dchapman@whoi.edu

Joey Comiso
Goddard Space Flight Center/NASA
Laboratory for Oceans, Code 971
Greenbelt, Maryland 20771
Ph: 301-614-5708
Fax: 301-614-5644
E-Mail: comiso@gsfc.nasa.gov

Glen Gawarkiewicz
Woods Hole Oceanographic Institution
MS#21 360 Woods Hole Road
Woods Hole, MA 02543
Ph: 508-289-2913
Fax: 508-457-2181
E-Mail: ggawarkiewicz@whoi.edu

Arnold L. Gordon
Lamont-Doherty Earth Observatory
Dept. of Physical Oceanography
Route 9W
Palisades, NY 10964
Ph: 914-365-8325
Fax: 914-365-8157
E-Mail: agordon@ldeo.columbia.edu

David Hebert
University of Rhode Island
Graduate School of Oceanography
Narragansett, RI 02882
Ph: 401-874-6610
Fax: 401-874-6728
E-Mail: hebert@gso.uri.edu

Hartmut Hellmer, Alfred-Wegener-Institut
für Polar- und Meeresforschung
Postfach 12 01 61
Columbusstrasse
D-27515 Bremerhaven, Germany
Ph: 011-49-471-4831-277
Fax: 011-49-471-4831-149
E-Mail: hellmer@awi-bremerhaven.de

Bruce A. Huber
Lamont-Doherty Earth Observatory
Palisades, New York 10964
Ph: 914-365-8329
Fax: 914-365-8157
E-Mail: bhuber@ldeo.columbia.edu

Stanley Jacobs
Lamont-Doherty Earth Observatory
Palisades, New York 10964
Ph: 914-365-8326
Fax: 914-365-8157
E-Mail: sjacobs@ldeo.columbia.edu

Adrian Jenkins
British Antarctic Survey
High Cross Madingley Road
Cambridge CB3 0ET, United Kingdom
Ph: 011-44-1223-251493
Fax: 011-44-1223-362616

E-Mail: ajen@pcmail.nerc-bas.ac.uk

Alexander Klepikov
Arctic and Antarctic Research Institute
Bering Str., 38
199397 St. Perersburg, Russia
Ph: 011-7-812-352-0226
Fax: 011-7-812-352-2688
E-Mail: klep@aari.nw.ru

James Ledwell
Woods Hole Oceanographic Institution
Woods Hole, MA 02543
E-Mail: ledwell@tracer.whoi.edu

Bernhard Lettau
National Science Foundation
Division of Polar Programs
4201 Wilson Boulevard
Arlington, Virginia 22230
Ph: 703-306-1045/7352
Fax: 703-306-0139
E-Mail: blettau@nsf.gov

Robin Muench
Earth & Space Research
1910 Fairview East, #102
Seattle, Washington 98102-3620
Ph: 206-726-0522
Fax: 206-726-0524
E-Mail: rmuench@esr.org

Doron Nof
The Florida State university
Dept. of Oceanography and Geophysical Fluid Dynamics Institute
Tallahassee, FL 32306-3048
Ph: 904-644-2736
Fax: 904-644-2581
E-Mail: nof@ocean.fsu.edu

Alex Orsi
Texas A & M University
Dept. of Oceanography
College Station, Texas 77843-3146
Ph: 409-845-4014
Fax: 409-847-7789
E-Mail: alex@bonito.tamu.edu

Laurie Padman
Earth and Space Research
522 NW 30th Street
Corvallis, Oregon 97330-5143
Ph: 541-753-6695
Fax: 541-753-1999
E-Mail: padman@esr.org

Mark Prater
University of Rhode Island
Graduate School of Oceanography
Narragansett, RI 02882
Ph: 401-874-6512
Fax: 401-874-6728
E-Mail: mark@seip.gso.uri.edu

Paola Rivarò
Dip. Chimica e Chimica Industriale
Sezione chimica Analitica Ambientale
Univerista' degli Studi di Genova
Via Dodecaneso
3106146 Genova, Italy
Ph: 011-39-010-3536178
Fax: 011-010-3536190
E-Mail: rivarò@chimica.unige.it

Robin Robertson
Lamont-Doherty Earth Observatory
Dept. of Physical Oceanography
Route 9W
Palisades, NY 10964
Ph: 914-365-8576
Fax: 914-365-8157
E-Mail: rroberts@ldeo.columbia.edu

Peter Schlosser
Lamont-Doherty Earth Observatory
Palisades, New York 10964
Ph: 914-365-8707
Fax: 914-365-8155
E-Mail: peters@ldeo.columbia.e

William Smethie
Lamont-Doherty Earth Observatory
Palisades, New York 10964
Ph: 914-365-8566
Fax: 914-365-8155
E-Mail: bsmeth@lamont.ldeo.columbia.edu

Gian Carlo Spezie
Istituto Universitario Navale
Facoltà De Scienze Nautiche
Cattedra Di Oceanografia
Via Amm. I. Acton 38
I-80133 Napoli, Italy
Ph: 011-39-08-5475586
Fax: 011-39-08-5513157
E-Mail: spezie@naval.uninav.it

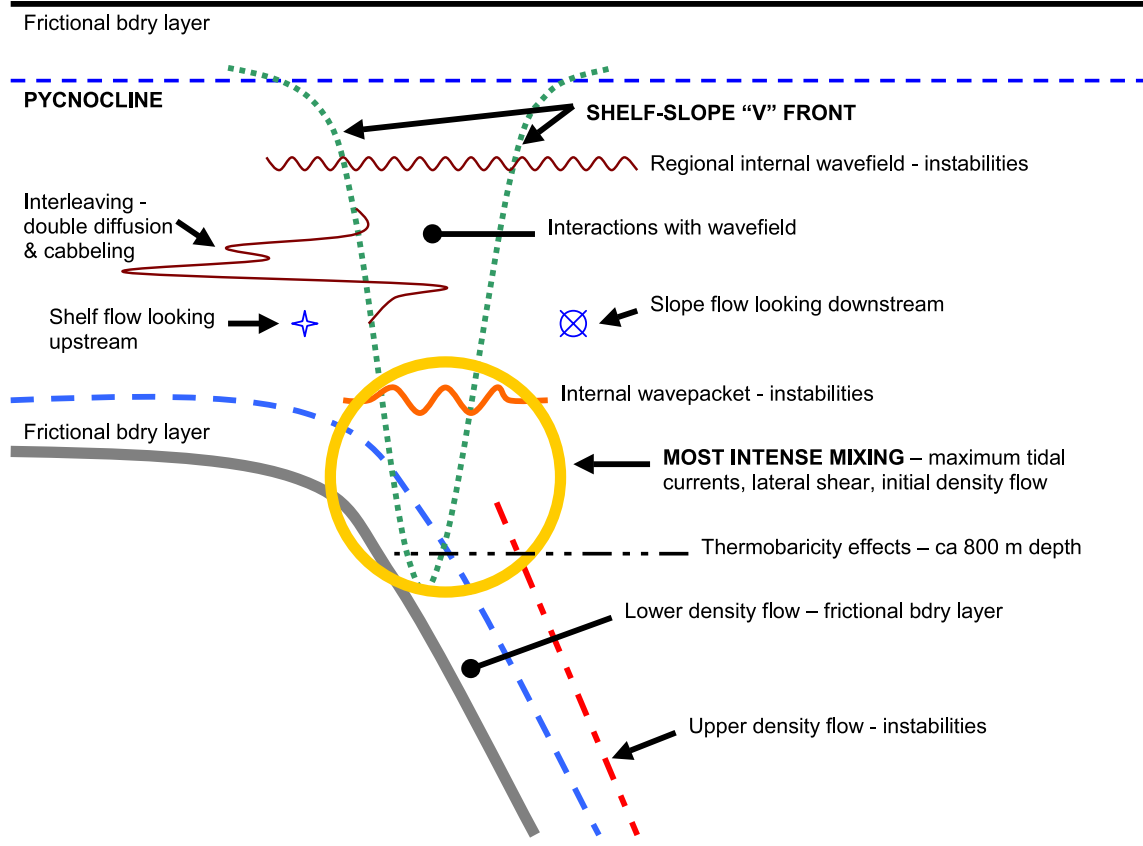
Martin Visbeck
Lamont-Doherty Earth Observatory
Dept. of Physical Oceanography
Route 9W

Palisades, NY 10964
Ph: 914-365-8531
Fax: 914-365-8157
E-Mail: visbeck@ldeo.columbia.edu

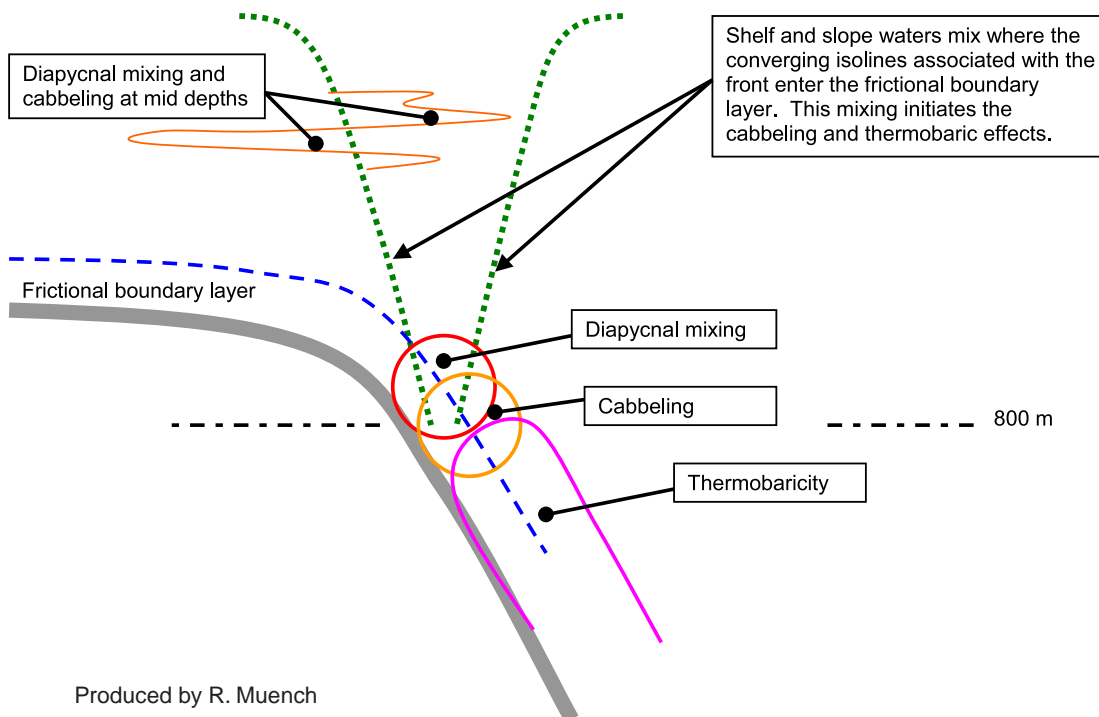
Thomas Whitworth III
Texas A & M University
Department of Oceanography
College Station, TEXAS 77843
Ph: 409-845-5872
Fax: 409-845-6331
E-Mail: twhitworth@tamu.edu

Enrico Zambianchi
Istituto di meteorologia e Oceanogr.
Istituto Universitario Savale
Corso Umberto I 174
80138 Napoli, Italy
Ph: 011-39-81-5475731
Fax: 011-39-08-15513679
E-Mail: enrico@NAV1.uninav.it

Shelf-Slope Front Mixing Processes Conceptualized



R. Muench 9/99



Produced by R. Muench