# REPORT DOCUMENTATION PAGE

*Form Approved*
*OMB No. 0704-0188*



| 1. AGENCY USE ONLY (*Leave blank*) | 2. REPORT DATE | 3. REPORT TYPE AND DATES COVERED |
|---|---|---|
| | 6/1/99 | Final Report 6/1/93 - 12/31/98 |

**4. TITLE AND SUBTITLE**

**Studies in Vortex Dynamics**

**5. FUNDING NUMBERS**

**ONR N00014-93-1-0788**

**6. AUTHOR(S)**

**Daniel Rudnick and George Carnevale**

**7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)**

**University of California, San Diego**
**Scripps Institution of Oceanography**
**Physical Oceanography Research Division**
**9500 Gilman Drive**
**La Jolla, CA 92093-0230**

**8. PERFORMING ORGANIZATION REPORT NUMBER**

**UCSD 93-1202**

**9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)**

**10. SPONSORING/MONITORING AGENCY REPORT NUMBER**

**11. SUPPLEMENTARY NOTES**

**12a. DISTRIBUTION/AVAILABILITY STATEMENT**

**available to public**

**12b. DISTRIBUTION CODE**

**13. ABSTRACT** (*Maximum 200 words*)

**Please see attached final report**



| 14. SUBJECT TERMS | 15. NUMBER OF PAGES |
|---|---|
| | 2 |
| | 16. PRICE CODE |

| 17. SECURITY CLASSIFICATION OF REPORT | 18. SECURITY CLASSIFICATION OF THIS PAGE | 19. SECURITY CLASSFICATION OF ABSTRACT | 20. LIMITATION OF ABSTRACT |
|---|---|---|---|
| | | | |

Final Report: **ONR N00014-93-1-0788**
Project Title: **Studies in Vortex Dynamics**
Project Period: 6/1/93 – 12/31/98

Principal Investigators: Daniel Rudnick
drudnick@ucsd.edu
George Carnevale
gcarnevale@ucsd.edu
Institution: University of California, San Diego
Scripps Institution of Oceanography
9500 Gilman Drive
La Jolla, CA 92093-0230

This AASERT provided support for graduate student Kara Lavender who has just completed her fourth year of graduate study in physical oceanography. Ms. Lavender has been steadily working on the thesis project she proposed in her qualifying exam one year ago. The thesis proposal focuses on the general circulation and the process of open-ocean deep convection in the Labrador Sea. The research involves the analysis of data from roughly 200 PALACE floats which were released in the Labrador Sea as part of the ONR Deep Convection Experiment. The finished project will include: an examination of the large-scale circulation of the Labrador Sea by mapping the property and horizontal velocity fields, a study of the formation of convective regions using hydrographic profile data as well as vertical velocity data, and an investigation of the small-scale dynamics of the deep convection process using temperature and vertical velocity time series data.

Ms. Lavender has worked with the PALACE data, processing and performing quality control on the data, as well as developing analysis methods to address the above-mentioned thesis topics. She has created updated and improved maps of the horizontal velocity field and has examined the depth-dependence and seasonality of this field. She has also used the velocity data to compute a map of the residence time of water in the basin to aid in the analysis of the export of newly convected Labrador Sea Water (LSW). An immediate goal is to write up these results, which include a previously unreported circulation path in the Labrador Sea with implications for the export of LSW, for publication.

To investigate the formation of convective patches in the Labrador Sea, Ms. Lavender has used the hydrographic profile data in analyses of the heat budget of the water column and the seasonal evolution of the mixed layer, stratification, and finestructure throughout the basin. In order to investigate the dynamical aspects of deep convection she has examined the statistics of the vertical velocity field in conjunction with the temperature field. These results illustrated the possibility of a bias in the float measurements, and work is planned for a comparative study using numerical model results with an investigator at another institution. Ms. Lavender also hopes to write up the results from the study of the properties and statistics of convective regions so that she may focus on the full mapping of the large-scale properties of the basin.

Ms. Lavender made a presentation at the Ocean Sciences meeting in February 1998 (see Appendix) In addition she attended a workshop in 1998 for the ONR Deep Convection Experiment, where she made two presentations of her work and was able to participate in an exchange of ideas with other scientists in the field. She hopes to publish her results in a timely manner and to finish her thesis in the next 1-1.5 years.

Appendix. Abstract of presenation at the Ocean Sciences meeting, February 1998.

PALACE Floats Describe the General Circulation and Convection in the Labrador Sea

A total of 66 Profiling Autonomous Lagrangian Circulation Explorer (PALACE) neutrally buoyant floats were deployed in the Labrador Sea between November 1994 and May 1997. PALACEs track flow at either 600 m or 1500 m and ascend to the surface every 5 to 20 days to communicate with ARGOS satellites. During ascent or descent, most PALACEs measure both temperature and salinity of the water column to 1500 m. Float trajectories describe a general circulation in the Labrador Sea consisting of strong, deep peripheral flows, namely the West Greenland and Labrador Currents, a previously unreported recurrent retroflection of the West Greenland
Current, and a chaotic interior flow. Trajectories also indicate possible pathways of convectively formed Labrador Sea Water.

The temperature and salinity profiles describe the preconditioning of water before convection, the convection itself, and the seasonal restratification following convection. PALACEs with vertical current meters measure O(5 cm/s) vertical velocities which are poorly correlated with temperature fluctuations. This, along with strong fine-structure, indicates that lateral processes are important in convection.