

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE 10/13/97	3. REPORT TYPE AND DATES COVERED Final Report- 10/01/90-09/30/97
----------------------------------	----------------------------	---

4. TITLE AND SUBTITLE Upper Ocean Circulation	5. FUNDING NUMBERS N00014-91-J1016
--	---------------------------------------

6. AUTHOR(S) Dr. Peter Niiler

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) University of California, San Diego Scripps Institution of Oceanography 9500 Gilman Drive, Dept 0230 La Jolla, CA 92093-0230	8. PERFORMING ORGANIZATION REPORT NUMBER
---	--

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) Office of Naval Research 800 Noth Quincy Street Arlington, VA 22217-5660	10. SPONSORING/MONITORING AGENCY REPORT NUMBER
---	--

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT DISTRIBUTION STATEMENT A Approved for public release Distribution Unlimited	12b. DISTRIBUTION CODE
--	------------------------

13. ABSTRACT (Maximum 200 words)
(see attached)

19971017 129

DTIC QUALITY INSPECTED 2

14. SUBJECT TERMS	15. NUMBER OF PAGES 3
	16. PRICE CODE

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

Final Report: - N00014-91-J1016 (POR3929- Fund 23093A).
Project Period: 1 Oct. 1990 - 30 Sept. 1997
Title: "Upper Ocean Circulation"
Principal Investigator: Peter Niiler

Abstract: The "Upper Ocean Circulation" project was based on observations of circulation with drifters, bottom pressure gauges and current meters and the interpretation of these data on basis of conceptual and hydrodynamic models of the mixed layers, mesoscale and their interactions. The focus was in the north-eastern Pacific phenomena. The principal findings were: i) models demonstrate that mesoscale eddy circulation is significantly changed by the nonlinear interaction of the wind and eddy vorticity.; ii) the eastern Pacific mesoscale is observed to be more important to the dynamics of the propagation of near inertial motions than is the beta effect ; iii) a new data set of upper ocean circulation in the California Current was acquired with drifters and moorings. Wind driven motions, both barotropic and Ekman, account for significant part of the variance of circulation and sea level variability; iv) zonal shear on the scale of 1500km and amplitude of 12-15 cm/sec with respect to 1500m was measured in the subtropical Pacific. This phenomenon has yet no theoretical explanation; v) an eddy resolving, biologically active general circulation model has been configured for the California Current system.

Accomplishments: The California Current system and the eastern North Pacific was the laboratory in which the "Upper Ocean Circulation" project was conducted. The early focus was on the observations of the statistical nature of the California mesoscale and its interaction with the coastal zone (# 3,4,5,6,18,). This was followed with the description of the large scale fields, in which the eddies continue to play an important role (#2, 8, 11, 12, 13, 15, 17, 20, 22). Observations of the fate of near-inertial motions in the upper ocean again demonstrated the important effect of the ocean mesoscale (#14, 24). Modeling of the upper ocean wind-driven circulation with the mesoscale was the next topic (#10, 23). The continuous thread through all these investigations were the discoveries that the ubiquitous mesoscale, while in the eastern Pacific having energy several orders of magnitude smaller than in the western Pacific, played a crucial role in how the observations were interpreted and how the circulation evolved in the models. The details of the eddy interactions with the general circulation as well as the ocean adjustments to new forcing conditions formed the basis of the published research findings. Not yet published, are the results of integrations of California Current eddy resolving models.

The second important accomplishment was in the area of developing a calibrated upper ocean drifter (#16). For over a hundred years oceanographers have used drifting objects to infer ocean circulation, but before this project, no one had calibrated or understood quantitatively how well a particular object followed the water. The principal finding was that the drogue has to be five times larger than ocean engineers had speculated should be sufficient for accurate water following capability. This accomplishment was instrumental in the development of a global ocean circulation observing system, based on modern, low cost drifters. Secondly, a calibration of the TOPEX capability for measuring the geostrophic surface current was assessed by comparison with current meter data (#21). A 50-70 km average slope of sea level must be used to effect accurate calculations in the California Current system.

Dr. Pim- Van-Meurs obtained a Ph.D. under the sponsorship of this project. Dr. Jeff Paduan, Dr. John Lee, Dr. Mark Swenson and Dr. John Moisan were post-doctoral fellows.

Publications/Statistical Information:

1. Yan, X.-H., P.P. Niiler and R.H. Stewart: Construction and accuracy analysis of images of the daily-mean mixed-layer depth. *Int. Journal Remote Sensing*, 12(12) 2573-2584. (1991)
2. Niiler, P.P., D.K. Lee, W. Young and L.H. Hu: Expendable current profiler (XCP) section across the North Pacific at 25°N. *Deep-Sea Res.*, 38 (Suppl. 1) S45-S61. (1991)
3. Ramp, S.R., P.F. Jessen, K.H. Brink, P.P. Niiler, F.L. Daggett, and J.S. Best: The physical structure of cold filaments near Point Arena, California during June 1987. *Journal Geophysical Res.*, 96(C8) 14,859-14,883. (1991)
4. Brink, K.H., R.C. Beardsley, P.P. Niiler, M. Abbott, A. Huyer, S. Ramp, T. Stanton, and D. Stuart: Statistical Properties Of Near-Surface Flow in the California Coastal Transition Zone. *Journal Geophysical Res.*, 96(C8) 14,693-706. (1991)
5. Strub, P.T., P.M. Kosro, A. Huyer, and CTZ Collaborators including P.P. Niiler: The Nature of the Cold Filaments in the California Current System. *Journal Geophysical Res.*, 96(C8) 14,743-14,768. (1991)
6. Swenson, M.S., P.P. Niiler, K.H. Brink and M. Abbott: Drifter observations of a Cold Filament off Point Arena, California in July 1988. *Journal Geophysical Res.*, 97 (C3) 3593-3610. (1992)
7. Niiler, P.P., S. Piacsek, L. Neuberg, Hank Perkins and A. Warn-Varnas: Sea surface temperature variability of the Iceland-Faeroe front. *Journal Geophysical Res.* 97(C11) 17,777-785. (1992)
8. Niiler, P.P., J. Filloux, W.T. Liu, R.M. Samelson, J.D. Paduan, and C.A. Paulson: Wind-Forced Variability of the Deep Eastern North Pacific: Observations of Seafloor Pressure and Abyssal Currents. *Journal Geophysical Res.*, 98 (C12) 22,589-22, 602. (1993)
9. Paduan, J.D., and P.P. Niiler: Structure of velocity and temperature in the northeast Pacific as measured with Lagrangian drifters in fall 1987. *Journal of Physical Oceanography*, 23 (4) 585-600. (1993)
10. Lee, Dong-Kyu, P.P. Niiler, A Warn-Varnas, and S. Piacsek: Wind driven secondary circulation in ocean mesoscale. *Journal of Marine Res.*, 52(3)371-396. (1994)
11. Warn-Varnas, Alex, P.P. Niiler, M. Zahorodny, S. Piacsek and L. Neuberg. Sea surface temperature variability of the Iceland-Faeroe front: Correction. *Journal Geophysical Res.*, 99(C8) 16,409-16,411. (1994)
12. Chereskin, T. and P. Niiler: Circulation in the Ensenada Front-September 1988. *Deep-Sea Res.*, 41(C8) 1251-1287. (1994)
13. Yan, Xiao-Hai, Pearn.P. Niiler, Sudhir K. Nadiga, Robert H. Stewart and Dan R. Cayan: Seasonal heat storage in the North Pacific: 1976-1989. *Journal Geophysical Res.*, Vol. 100, No. C4, pp 6899-6926. (1995)

14. D'Asaro, E.A., C.C. Eriksen, M.D. Levine, P.P. Niiler, C.A. Paulson and P. Van Meurs: Upper ocean inertial currents forced by a strong storm. I : Data and comparisons with linear theory. *Journal of Physical Oceanography*; Vol. 25, No. 11 (Part II). (1995)
15. Niiler, P. and J. Paduan: Wind-driven motions in the northeast Pacific as measured by Lagrangian drifters. *Journal of Physical Oceanography*; Vol. 25, No. 11 (Part II). (1995) 1995)
16. Niiler, P.P., A.S. Sybrandy, K. Bi, P-M Poulain and D. Bitterman: Measurements of the water following capability of holey sock and TRISTAR drifters. *Deep-Sea Res. I*, 42 (11-12) pp 1951-1964. (1995)
17. Poulain, P-M., A. Warn-Varnas and P.P. Niiler: Near surface circulation of the Nordic seas as measured by Lagrangian drifters. *Journal Geophysical Research* 101 (C8) pp. 18237-18258. (1996)
18. Swenson, Mark S. and Pearn P. Niiler: Statistical analysis of the surface circulation of the California Current. *Journal of Geophysical Research* V. 101, No. C10 pp. 22631-22645. (1996)
19. Niiler, P.P. Modeling the statistical effects of internal waves on models of upper ocean vertical mixing. SIO Research Report # 97-11. (1997)
20. Hall, M.M., P.P. Niiler and W.J. Schmitz, Jr. : The three dimensional circulation in North Pacific along 152°W. (*In press, Deep-Sea Res., 1997.*)
21. Strub, P. Ted, Teresa K. Chereskin, Pearn P. Niiler, Corinne James and Murray D. Levine: Altimeter-derived variability of surface velocities in the California current system: Part 1- evaluation of TOPEX Altimeter Velocity Resolution. (Submitted to JGR, 10/17/96.)
22. Van Meurs, Pim and Pearn P. Niiler: The temporal variability of the large scale geostrophic surface velocity in the Northeast Pacific. (*To appear in Journal of Physical Oce. 11-97.*)
23. Lee, Dong-Kyu and Pearn P. Niiler: The inertial chimney: the near-inertial energy drainage from the ocean surface to the deep layer. (*Submitted to Journal of Geophysical Research, 1997.*)
24. Van Muers, Pim: The importance of spatial variabilities on the decay of near-inertial mixed layer currents: theory, observations and modeling. (*In press, Journal of Physical Oceanography, 1997.*)