

MOSS LANDING MARINE LABORATORIES

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23 September 1991

Monique Dillon
Resident Representative
Office of Naval Research
Charles S. Draper Laboratory, Inc.
555 Technology square, MS54
Cambridge, MA 02139-3539

Dear Ms. Dillon,

Please find enclosed the Final Technical Report and Report of Inventions (Form 882) for our ONR contract N00014-87-K-0536, "Upper Ocean Mixing: The Use of Algal Pigments as Biological Tracers for Turbulent Diffusion", Principal Investigator: Nicholas A. Welschmeyer. Thank you, in advance, for your patience in awaiting the arrival of this report.

Some notes are probably warranted to recount the history of this contract, to clear any confusion. The contract originated as an ONR Young Investigator Program award while I was at Harvard University (N00014-87-K-0536). In 1990 I took a new position at San Jose State University (Moss Landing Marine Laboratories). The existing contract was transferred to San Jose State University Foundation and issued a new contract number, N00014-89-J-1615. However, there was no change in scope for the project. The Final Technical Report, enclosed herein, covers work accomplished throughout the whole project, referenced by the two contract numbers above; I hope this is satisfactory.

If there are any questions, please do not hesitate to call. Thank you again for your attention to these matters.

Sincerely,

N. Welschmeyer
Nicholas Welschmeyer
Professor, Oceanography

cc:

Paul Biddle, ONR Resident Representative, Stanford Univ.
Diane Kruse, San Jose State University Foundation
Merrily Sterns, Office for Sponsored Research, Harvard Univ.
Bernard Zahuranec, ONR, Code 1122B, Arlington VA
✓ Defense Technical Information Center
Director, Naval Research Laboratory

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Upper Ocean Mixing: The Use of Algal Pigments as Biological Tracers for Turbulent Diffusion

N00014-87-K-0536

DTIC QUALITY INSPECTION

Final Technical Report

Office of Naval Research

Principal Investigator: Nicholas A. Welschmeyer

Moss Landing Marine Laboratories
P.O. Box 450
Moss Landing, CA 95039

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ABSTRACT

The goal of the proposed research was to develop an in situ method for determining upper-ocean mixing rates using algal pigments as natural biological tracers. The work focused specifically on *xanthophyll-cycling*, a well known series of reversible, light-sensitive pigment transformations that occur in all higher land plants and many marine phytoplankton species. Laboratory work was initiated to define the rate constants for xanthophyll-cycling in microalgal cultures, and to develop a quantitative understanding of the influence of light intensity on the xanthophyll-cycling process. Field work was completed which verified that xanthophyll-cycling processes measured in natural phytoplankton populations indeed reproduced our laboratory observations.

A Monte-Carlo computer model was developed in order to study the influence of xanthophyll-cycling on algal pigmentation under known conditions of simulated mixing. The collective results from physiological experimentation and simulation modeling were used to develop a field method for calculating ocean mixing rates (Welschmeyer and Hoepffner, 1991; Welschmeyer 1991). The work has now identified previously unrecognized relationships between xanthophyll-cycling and cellular fluorescence, which are of potential importance in exploiting single-cell characteristics as novel tracers of ocean mixing. This new work is continuing in our laboratory.

PUBLICATIONS AND MANUSCRIPTS RESULTING FROM CONTRACT N00014-87-K-0536

PUBLICATIONS:

- Chisholm, S.W., R.J. Olson, E.R. Zettler, R. Goericke, J.B. Waterbury, and N.A. Welschmeyer. 1988. A novel, free-living Prochlorophyte abundant in the oceanic euphotic zone. *Nature* 334: 340-343.
- Kana, T.M., P.M. Glibert, R. Goericke, and N.A. Welschmeyer. 1988. Zeaxanthin and B-carotene in *Synechococcus* WH7803 respond differently to irradiance. *Limnology and Oceanography* 33: 1623-1627.
- Wright, S.W., S.W. Jeffrey, R.F.C. Mantoura, C.A. Llewellyn, N.A. Welschmeyer, T. Bjornland, D. Repeta. 1991. An improved HPLC method for the analysis of chlorophylls and carotenoids from marine phytoplankton. *Marine Ecology Progress Series* (in press).
- Welschmeyer, N.A. and N. Hoepffner. 1990. Xanthophyll cycling I: Dynamics of rapid, light-induced pigment changes in phytoplankton. *Limnology and Oceanography* (in press).

MANUSCRIPTS

- DiTullio, G.R. and N.A. Welschmeyer. 1991. Effects of growth irradiance and nitrogen limitation on xanthophyll cycling and fluorescence quenching. *Journal of Phycology* (to be submitted).
- Goericke, R. and N.A. Welschmeyer. 1991. Pigment turnover in the diatom *Thalassiosira weissflogii* I: Kinetics of chlorophyll a 14-C labeling. *Plant Physiology* (in revision).
- Goericke, R. and N.A. Welschmeyer. 1991. Pigment turnover in the diatom *Thalassiosira weissflogii* II: Kinetics of 14-C labeling in carotenoids. *Plant Physiology* (in revision).
- Goericke, R. and N.A. Welschmeyer. 1991. A seasonal study of the abundance and growth rates of marine Prochlorophytes in the Sargasso Sea. *Nature* (submitted).
- Goericke, R. and N.A. Welschmeyer. 1991. The chlorophyll-labeling method: Measuring specific rates of chlorophyll *a* synthesis in cultures and in the open ocean. *Limnology and Oceanography* (submitted).
- Welschmeyer, N.A. 1990. Xanthophyll cycling II: A biological tracer for upper-ocean mixing. *Limnology and Oceanography* (in revision).

PH.D. DEGREE:

- Goericke, R. 1990. Pigments as ecological tracers for the study of the abundance and growth of marine phytoplankton. Ph.D. Thesis, Harvard University, 418p.

REPORT OF INVENTIONS AND SUBCONTRACTS

(Pursuant to "Patent Rights" Contract Clause) (See Instructions on Reverse Side.)

Form Approved
OMB No. 0704-0297
Expires Jun 30, 1992

Public reporting burden for this collection of information is estimated to average 5 minutes 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 (0704-0297), Washington, DC 20503.

1a. NAME OF CONTRACTOR/SUBCONTRACTOR SJSU University Foundation		c. CONTRACT NUMBER N00014-87-K-0536		3. TYPE OF REPORT (X one) a. INTERIM ☒ b. FINAL	
b. ADDRESS (Include ZIP Code) P.O. Box 760 San Jose, CA 95106		d. AWARD DATE (YYMMDD) 87/07/01		4. REPORTING PERIOD (YYMMDD) a. FROM 87/07/01 b. TO 90/12/31	
2a. NAME OF GOVERNMENT PRIME CONTRACTOR ONR		b. ADDRESS (Include ZIP Code) 800 N. Quincy St. Arlington, VA 2217-5000			

SECTION I - SUBJECT INVENTIONS

5. "SUBJECT INVENTIONS" REQUIRED TO BE REPORTED BY CONTRACTOR/SUBCONTRACTOR (If "None," so state)

a. NAMES OF INVENTOR(S) (Last, First, MI)	b. TITLE OF INVENTION(S)	c. DISCLOSURE NO., PATENT APPLICATION SERIAL NO. OR PATENT NO.	d. ELECTION TO FILE PATENT APPLICATIONS				e. CONFIRMATORY INSTRUMENT OR ASSIGNMENT FORWARDED TO CONTRACTING OFFICER
			(1) United States		(2) Foreign		
			(a) Yes	(b) No	(a) Yes	(b) No	
Welschmeyer, N.A.	None to report						

g. ELECTED FOREIGN COUNTRIES IN WHICH A PATENT APPLICATION WILL BE FILED

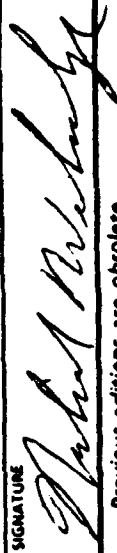
1. EMPLOYER OF INVENTOR(S) NOT EMPLOYED BY CONTRACTOR/SUBCONTRACTOR		(1) Title of Invention		(2) Foreign Countries of Patent Application	
(1)(a) Name of Inventor (Last, First, MI)	(2)(a) Name of Inventor (Last, First, MI)				
(b) Name of Employer	(b) Name of Employer				
(c) Address of Employer (Include ZIP Code)	(c) Address of Employer (Include ZIP Code)				

SECTION II - SUBCONTRACTS (Containing a "Patent Rights" clause)

6. SUBCONTRACTS AWARDED BY CONTRACTOR/SUBCONTRACTOR (If "None," so state)

a. NAME OF SUBCONTRACTOR(S)	b. ADDRESS (Include ZIP Code)	c. SUBCONTRACT NO.(S)	d. DEAR "PATENT RIGHTS"		e. DESCRIPTION OF WORK TO BE PERFORMED UNDER SUBCONTRACT(S)	f. SUBCONTRACT DATES (YYMMDD)	
			(1) Clause Number	(2) Date (YYMM)		(1) Award	(2) Estimated Completion
None							

SECTION III - CERTIFICATION

7. CERTIFICATION OF REPORT BY CONTRACTOR/SUBCONTRACTOR		(Not required if ☐ Small business or ☐ Non-Profit organization.) (X appropriate box)	
a. NAME OF AUTHORIZED CONTRACTOR/SUBCONTRACTOR OFFICIAL (Last, First, MI) Nicholas A. Welschmeyer		c. I certify that the reporting party has procedures for prompt identification and timely disclosure of "Subject Inventions," that such procedures have been followed and that all "Subject Inventions" have been reported.	
b. TITLE Professor	d. SIGNATURE 	e. DATE SIGNED 9/23/91	