COVER SHEET FOR PROPOSAL TO THE NATIONAL SCIENCE FOUNDATION

PROGRAM ANNOUNCEMENT/SOLICITATION NO./DUE DATE **PD 98-1650** **08/15/16**	☐ Special Exception to Deadline Date Policy	FOR NSF USE ONLY NSF PROPOSAL NUMBER **1657803**
FOR CONSIDERATION BY NSF ORGANIZATION UNIT(S) (Indicate the most specific unit known, i.e. program, division, etc.) **OCE - BIOLOGICAL OCEANOGRAPHY, OCE - PHYSICAL OCEANOGRAPHY, (continued)**		

DATE RECEIVED	NUMBER OF COPIES	DIVISION ASSIGNED	FUND CODE	DUNS# (Data Universal Numbering System)	FILE LOCATION
08/12/2016	2	06040000 OCE	1650	001766682	08/12/2016 10:17am

EMPLOYER IDENTIFICATION NUMBER (EIN) OR TAXPAYER IDENTIFICATION NUMBER (TIN)	SHOW PREVIOUS AWARD NO. IF THIS IS	IS THIS PROPOSAL BEING SUBMITTED TO ANOTHER FEDERAL AGENCY?
042105850	☐ A RENEWAL ☐ AN ACCOMPLISHMENT-BASED RENEWAL	YES ☐ NO ☒ IF YES, LIST ACRONYM(S)

NAME OF ORGANIZATION TO WHICH AWARD SHOULD BE MADE **Woods Hole Oceanographic Institution**	ADDRESS OF AWARDEE ORGANIZATION, INCLUDING 9 DIGIT ZIP CODE **FENNO HOUSE MS#39** **WOODS HOLE, MA 025431041** **US**
AWARDEE ORGANIZATION CODE (IF KNOWN) **0022301000**	
NAME OF PRIMARY PLACE OF PERF **Woods Hole Oceanographic Institution**	ADDRESS OF PRIMARY PLACE OF PERF, INCLUDING 9 DIGIT ZIP CODE **Woods Hole Oceanographic Institution** **MA ,025431041 ,US.**

IS AWARDEE ORGANIZATION (Check All That Apply) (See GPG II.C For Definitions)	☐ SMALL BUSINESS ☐ FOR-PROFIT ORGANIZATION	☐ MINORITY BUSINESS ☐ WOMAN-OWNED BUSINESS	☐ IF THIS IS A PRELIMINARY PROPOSAL THEN CHECK HERE

TITLE OF PROPOSED PROJECT **Collaborative Research: Shelfbreak Frontal Dynamics: Mechanisms of Upwelling, Net Community Production, and Ecological Implications**

REQUESTED AMOUNT	PROPOSED DURATION (1-60 MONTHS)	REQUESTED STARTING DATE	SHOW RELATED PRELIMINARY PROPOSAL NO. IF APPLICABLE
$ **1,993,156**	**36** months	**10/01/17**	

THIS PROPOSAL INCLUDES ANY OF THE ITEMS LISTED BELOW

- ☐ BEGINNING INVESTIGATOR (GPG I.G.2)
- ☐ DISCLOSURE OF LOBBYING ACTIVITIES (GPG II.C.1.e)
- ☐ PROPRIETARY & PRIVILEGED INFORMATION (GPG I.D, II.C.1.d)
- ☐ HISTORIC PLACES (GPG II.C.2.j)
- ☐ VERTEBRATE ANIMALS (GPG II.D.6) IACUC App. Date ________
  PHS Animal Welfare Assurance Number ________
- ☒ FUNDING MECHANISM **Research - other than RAPID or EAGER**
- ☐ HUMAN SUBJECTS (GPG II.D.7) Human Subjects Assurance Number ________
  Exemption Subsection ______ or IRB App. Date ________
- ☐ INTERNATIONAL ACTIVITIES: COUNTRY/COUNTRIES INVOLVED (GPG II.C.2.j)
- ☒ COLLABORATIVE STATUS
  A collaborative proposal from multiple organizations (GPG II.D.4.b)

PI/PD DEPARTMENT **Applied Ocean Physics & Engineering**	PI/PD POSTAL ADDRESS **MS 11** **Woods Hole, MA 02543** **United States**
PI/PD FAX NUMBER **508-457-2194**	

NAMES (TYPED)	High Degree	Yr of Degree	Telephone Number	Email Address
PI/PD NAME **Dennis J McGillicuddy**	PhD	1993	508-289-2683	dmcgillicuddy@whoi.edu
CO-PI/PD **Heidi M Sosik**	PhD	1993	508-289-2311	hsosik@whoi.edu
CO-PI/PD **Weifeng Zhang**	PhD	2009	508-289-2521	wzhang@whoi.edu
CO-PI/PD				
CO-PI/PD				

CERTIFICATION PAGE

Certification for Authorized Organizational Representative (or Equivalent) or Individual Applicant

By electronically signing and submitting this proposal, the Authorized Organizational Representative (AOR) or Individual Applicant is: (1) certifying that statements made herein are true and complete to the best of his/her knowledge; and (2) agreeing to accept the obligation to comply with NSF award terms and conditions if an award is made as a result of this application. Further, the applicant is hereby providing certifications regarding conflict of interest (when applicable), drug-free workplace, debarment and suspension, lobbying activities (see below), nondiscrimination, flood hazard insurance (when applicable), responsible conduct of research, organizational support, Federal tax obligations, unpaid Federal tax liability, and criminal convictions as set forth in the NSF Proposal & Award Policies & Procedures Guide,Part I: the Grant Proposal Guide (GPG). Willful provision of false information in this application and its supporting documents or in reports required under an ensuing award is a criminal offense (U.S. Code, Title 18, Section 1001).

Certification Regarding Conflict of Interest

The AOR is required to complete certifications stating that the organization has implemented and is enforcing a written policy on conflicts of interest (COI), consistent with the provisions of AAG Chapter IV.A.; that, to the best of his/her knowledge, all financial disclosures required by the conflict of interest policy were made; and that conflicts of interest, if any, were, or prior to the organization's expenditure of any funds under the award, will be, satisfactorily managed, reduced or eliminated in accordance with the organization's conflict of interest policy. Conflicts that cannot be satisfactorily managed, reduced or eliminated and research that proceeds without the imposition of conditions or restrictions when a conflict of interest exists, must be disclosed to NSF via use of the Notifications and Requests Module in FastLane.

Drug Free Work Place Certification

By electronically signing the Certification Pages, the Authorized Organizational Representative (or equivalent), is providing the Drug Free Work Place Certification contained in Exhibit II-3 of the Grant Proposal Guide.

Debarment and Suspension Certification

(If answer "yes", please provide explanation.)

Is the organization or its principals presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from covered transactions by any Federal department or agency? Yes ☐ No ☒

By electronically signing the Certification Pages, the Authorized Organizational Representative (or equivalent) or Individual Applicant is providing the Debarment and Suspension Certification contained in Exhibit II-4 of the Grant Proposal Guide.

Certification Regarding Lobbying

This certification is required for an award of a Federal contract, grant, or cooperative agreement exceeding $100,000 and for an award of a Federal loan or a commitment providing for the United States to insure or guarantee a loan exceeding $150,000.

Certification for Contracts, Grants, Loans and Cooperative Agreements

The undersigned certifies, to the best of his or her knowledge and belief, that:
(1) No Federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any Federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.
(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, ''Disclosure of Lobbying Activities,'' in accordance with its instructions.
(3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements and that all subrecipients shall certify and disclose accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by section 1352, Title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

Certification Regarding Nondiscrimination

By electronically signing the Certification Pages, the Authorized Organizational Representative (or equivalent) is providing the Certification Regarding Nondiscrimination contained in Exhibit II-6 of the Grant Proposal Guide.

Certification Regarding Flood Hazard Insurance

Two sections of the National Flood Insurance Act of 1968 (42 USC §4012a and §4106) bar Federal agencies from giving financial assistance for acquisition or construction purposes in any area identified by the Federal Emergency Management Agency (FEMA) as having special flood hazards unless the:
(1) community in which that area is located participates in the national flood insurance program; and
(2) building (and any related equipment) is covered by adequate flood insurance.

By electronically signing the Certification Pages, the Authorized Organizational Representative (or equivalent) or Individual Applicant located in FEMA-designated special flood hazard areas is certifying that adequate flood insurance has been or will be obtained in the following situations:
(1) for NSF grants for the construction of a building or facility, regardless of the dollar amount of the grant; and
(2) for other NSF grants when more than $25,000 has been budgeted in the proposal for repair, alteration or improvement (construction) of a building or facility.

Certification Regarding Responsible Conduct of Research (RCR)
(This certification is not applicable to proposals for conferences, symposia, and workshops.)

By electronically signing the Certification Pages, the Authorized Organizational Representative is certifying that, in accordance with the NSF Proposal & Award Policies & Procedures Guide, Part II, Award & Administration Guide (AAG) Chapter IV.B., the institution has a plan in place to provide appropriate training and oversight in the responsible and ethical conduct of research to undergraduates, graduate students and postdoctoral researchers who will be supported by NSF to conduct research.
The AOR shall require that the language of this certification be included in any award documents for all subawards at all tiers.

CERTIFICATION PAGE - CONTINUED

Certification Regarding Organizational Support

By electronically signing the Certification Pages, the Authorized Organizational Representative (or equivalent) is certifying that there is organizational support for the proposal as required by Section 526 of the America COMPETES Reauthorization Act of 2010. This support extends to the portion of the proposal developed to satisfy the Broader Impacts Review Criterion as well as the Intellectual Merit Review Criterion, and any additional review criteria specified in the solicitation. Organizational support will be made available, as described in the proposal, in order to address the broader impacts and intellectual merit activities to be undertaken.

Certification Regarding Federal Tax Obligations

When the proposal exceeds $5,000,000, the Authorized Organizational Representative (or equivalent) is required to complete the following certification regarding Federal tax obligations.
By electronically signing the Certification pages, the Authorized Organizational Representative is certifying that, to the best of their knowledge and belief, the proposing organization:
(1) has filed all Federal tax returns required during the three years preceding this certification;
(2) has not been convicted of a criminal offense under the Internal Revenue Code of 1986; and
(3) has not, more than 90 days prior to this certification, been notified of any unpaid Federal tax assessment for which the liability remains unsatisfied, unless the assessment is the subject of an installment agreement or offer in compromise that has been approved by the Internal Revenue Service and is not in default, or the assessment is the subject of a non-frivolous administrative or judicial proceeding.

Certification Regarding Unpaid Federal Tax Liability

When the proposing organization is a corporation, the Authorized Organizational Representative (or equivalent) is required to complete the following certification regarding Federal Tax Liability:

By electronically signing the Certification Pages, the Authorized Organizational Representative (or equivalent) is certifying that the corporation has no unpaid Federal tax liability that has been assessed, for which all judicial and administrative remedies have been exhausted or lapsed, and that is not being paid in a timely manner pursuant to an agreement with the authority responsible for collecting the tax liability.

Certification Regarding Criminal Convictions

When the proposing organization is a corporation, the Authorized Organizational Representative (or equivalent) is required to complete the following certification regarding Criminal Convictions:

By electronically signing the Certification Pages, the Authorized Organizational Representative (or equivalent) is certifying that the corporation has not been convicted of a felony criminal violation under any Federal law within the 24 months preceding the date on which the certification is signed.

Certification Dual Use Research of Concern

By electronically signing the certification pages, the Authorized Organizational Representative is certifying that the organization will be or is in compliance with all aspects of the United States Government Policy for Institutional Oversight of Life Sciences Dual Use Research of Concern.

AUTHORIZED ORGANIZATIONAL REPRESENTATIVE	SIGNATURE	DATE
NAME **David A Stephens**	**Electronic Signature**	**Aug 12 2016 9:03AM**

TELEPHONE NUMBER	EMAIL ADDRESS	FAX NUMBER
508-289-3542	**dstephens@whoi.edu**	**508-457-2189**

COVER SHEET FOR PROPOSAL TO THE NATIONAL SCIENCE FOUNDATION

FOR CONSIDERATION BY NSF ORGANIZATION UNIT(S) - continued from page 1
(Indicate the most specific unit known, i.e. program, division, etc.)

OCE - CHEMICAL OCEANOGRAPHY

Not for distribution

COVER SHEET FOR PROPOSAL TO THE NATIONAL SCIENCE FOUNDATION

PROGRAM ANNOUNCEMENT/SOLICITATION NO./DUE DATE: **PD 98-1650** **08/15/16**	☐ Special Exception to Deadline Date Policy
FOR CONSIDERATION BY NSF ORGANIZATION UNIT(S) (Indicate the most specific unit known, i.e. program, division, etc.): **OCE - BIOLOGICAL OCEANOGRAPHY, OCE - PHYSICAL OCEANOGRAPHY, (continued)**	

FOR NSF USE ONLY

NSF PROPOSAL NUMBER

DATE RECEIVED	NUMBER OF COPIES	DIVISION ASSIGNED	FUND CODE	DUNS# (Data Universal Numbering System)	FILE LOCATION
				169516213	

EMPLOYER IDENTIFICATION NUMBER (EIN) OR TAXPAYER IDENTIFICATION NUMBER (TIN)	SHOW PREVIOUS AWARD NO. IF THIS IS	IS THIS PROPOSAL BEING SUBMITTED TO ANOTHER FEDERAL AGENCY?
546001802	☐ A RENEWAL ☐ AN ACCOMPLISHMENT-BASED RENEWAL	YES ☐ NO ☒ IF YES, LIST ACRONYM(S)

NAME OF ORGANIZATION TO WHICH AWARD SHOULD BE MADE: **College of William & Mary Virginia Institute of Marine Science**

ADDRESS OF AWARDEE ORGANIZATION, INCLUDING 9 DIGIT ZIP CODE:
College of William & Mary Virginia Institute of Marine Science
P.O. Box 1346
Gloucester Point, VA. 230621346

AWARDEE ORGANIZATION CODE (IF KNOWN): **0002824000**

NAME OF PRIMARY PLACE OF PERF: **Virginia Institute of Marine Science**

ADDRESS OF PRIMARY PLACE OF PERF, INCLUDING 9 DIGIT ZIP CODE:
Virginia Institute of Marine Science
VA ,230621346 ,US.

IS AWARDEE ORGANIZATION (Check All That Apply) (See GPG II.C For Definitions): ☐ SMALL BUSINESS ☐ MINORITY BUSINESS ☐ FOR-PROFIT ORGANIZATION ☐ WOMAN-OWNED BUSINESS

☐ IF THIS IS A PRELIMINARY PROPOSAL THEN CHECK HERE

TITLE OF PROPOSED PROJECT: **Collaborative Research: Shelfbreak frontal dynamics: mechanisms of upwelling, net community production, and ecological implications**

REQUESTED AMOUNT	PROPOSED DURATION (1-60 MONTHS)	REQUESTED STARTING DATE	SHOW RELATED PRELIMINARY PROPOSAL NO. IF APPLICABLE
$ **420,394**	**36** months	**10/01/17**	

THIS PROPOSAL INCLUDES ANY OF THE ITEMS LISTED BELOW

- ☐ BEGINNING INVESTIGATOR (GPG I.G.2)
- ☐ DISCLOSURE OF LOBBYING ACTIVITIES (GPG II.C.1.e)
- ☐ PROPRIETARY & PRIVILEGED INFORMATION (GPG I.D, II.C.1.d)
- ☐ HISTORIC PLACES (GPG II.C.2.j)
- ☐ VERTEBRATE ANIMALS (GPG II.D.6) IACUC App. Date ________
  PHS Animal Welfare Assurance Number ________
- ☒ FUNDING MECHANISM **Research - other than RAPID or EAGER**
- ☐ HUMAN SUBJECTS (GPG II.D.7) Human Subjects Assurance Number ________
  Exemption Subsection ________ or IRB App. Date ________
- ☐ INTERNATIONAL ACTIVITIES: COUNTRY/COUNTRIES INVOLVED (GPG II.C.2.j) ________
- ☒ COLLABORATIVE STATUS **A collaborative proposal from multiple organizations (GPG II.D.4.b)**

PI/PD DEPARTMENT: **Department of Biological Sciences**

PI/PD FAX NUMBER: **804-684-7399**

PI/PD POSTAL ADDRESS:
Virginia Institute of Marine Science
College of William and Mary
Gloucester Point, VA 230621346
United States

NAMES (TYPED)	High Degree	Yr of Degree	Telephone Number	Email Address
PI/PD NAME **Walker O Smith**	**PhD**	**1976**	**804-684-7709**	**wos@vims.edu**
CO-PI/PD				
CO-PI/PD				
CO-PI/PD				
CO-PI/PD				

CERTIFICATION PAGE

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By electronically signing the Certification Pages, the Authorized Organizational Representative (or equivalent), is providing the Drug Free Work Place Certification contained in Exhibit II-3 of the Grant Proposal Guide.

Debarment and Suspension Certification

(If answer "yes", please provide explanation.)

Is the organization or its principals presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from covered transactions by any Federal department or agency? Yes ☐ No ☒

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The undersigned certifies, to the best of his or her knowledge and belief, that:
(1) No Federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any Federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.
(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, ''Disclosure of Lobbying Activities,'' in accordance with its instructions.
(3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements and that all subrecipients shall certify and disclose accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by section 1352, Title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

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Certification Regarding Flood Hazard Insurance

Two sections of the National Flood Insurance Act of 1968 (42 USC §4012a and §4106) bar Federal agencies from giving financial assistance for acquisition or construction purposes in any area identified by the Federal Emergency Management Agency (FEMA) as having special flood hazards unless the:
(1) community in which that area is located participates in the national flood insurance program; and
(2) building (and any related equipment) is covered by adequate flood insurance.

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CERTIFICATION PAGE - CONTINUED

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When the proposal exceeds $5,000,000, the Authorized Organizational Representative (or equivalent) is required to complete the following certification regarding Federal tax obligations.
By electronically signing the Certification pages, the Authorized Organizational Representative is certifying that, to the best of their knowledge and belief, the proposing organization:
(1) has filed all Federal tax returns required during the three years preceding this certification;
(2) has not been convicted of a criminal offense under the Internal Revenue Code of 1986; and
(3) has not, more than 90 days prior to this certification, been notified of any unpaid Federal tax assessment for which the liability remains unsatisfied, unless the assessment is the subject of an installment agreement or offer in compromise that has been approved by the Internal Revenue Service and is not in default, or the assessment is the subject of a non-frivolous administrative or judicial proceeding.

Certification Regarding Unpaid Federal Tax Liability

When the proposing organization is a corporation, the Authorized Organizational Representative (or equivalent) is required to complete the following certification regarding Federal Tax Liability:

By electronically signing the Certification Pages, the Authorized Organizational Representative (or equivalent) is certifying that the corporation has no unpaid Federal tax liability that has been assessed, for which all judicial and administrative remedies have been exhausted or lapsed, and that is not being paid in a timely manner pursuant to an agreement with the authority responsible for collecting the tax liability.

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Certification Dual Use Research of Concern

By electronically signing the certification pages, the Authorized Organizational Representative is certifying that the organization will be or is in compliance with all aspects of the United States Government Policy for Institutional Oversight of Life Sciences Dual Use Research of Concern.

AUTHORIZED ORGANIZATIONAL REPRESENTATIVE	SIGNATURE	DATE
NAME		

TELEPHONE NUMBER	EMAIL ADDRESS	FAX NUMBER

COVER SHEET FOR PROPOSAL TO THE NATIONAL SCIENCE FOUNDATION

FOR CONSIDERATION BY NSF ORGANIZATION UNIT(S) - continued from page 1
(Indicate the most specific unit known, i.e. program, division, etc.)

OCE - CHEMICAL OCEANOGRAPHY

Not for distribution

COVER SHEET FOR PROPOSAL TO THE NATIONAL SCIENCE FOUNDATION

PROGRAM ANNOUNCEMENT/SOLICITATION NO./DUE DATE	☐ Special Exception to Deadline Date Policy	FOR NSF USE ONLY
PD 98-1650 — 08/15/16		NSF PROPOSAL NUMBER
FOR CONSIDERATION BY NSF ORGANIZATION UNIT(S) (Indicate the most specific unit known, i.e. program, division, etc.) OCE - BIOLOGICAL OCEANOGRAPHY, OCE - PHYSICAL OCEANOGRAPHY, (continued)		1657489

DATE RECEIVED	NUMBER OF COPIES	DIVISION ASSIGNED	FUND CODE	DUNS# (Data Universal Numbering System)	FILE LOCATION
08/10/2016	2	06040000 OCE	1650	076572965	08/12/2016 10:17am

EMPLOYER IDENTIFICATION NUMBER (EIN) OR TAXPAYER IDENTIFICATION NUMBER (TIN)	SHOW PREVIOUS AWARD NO. IF THIS IS ☐ A RENEWAL ☐ AN ACCOMPLISHMENT-BASED RENEWAL	IS THIS PROPOSAL BEING SUBMITTED TO ANOTHER FEDERAL AGENCY? YES ☐ NO ☒ IF YES, LIST ACRONYM(S)
042103637		

NAME OF ORGANIZATION TO WHICH AWARD SHOULD BE MADE	ADDRESS OF AWARDEE ORGANIZATION, INCLUDING 9 DIGIT ZIP CODE
Wellesley College	Wellesley College 106 Central Street Wellesley, MA. 024818204
AWARDEE ORGANIZATION CODE (IF KNOWN): 0022244000	
NAME OF PRIMARY PLACE OF PERF	ADDRESS OF PRIMARY PLACE OF PERF, INCLUDING 9 DIGIT ZIP CODE
Wellesley College	Wellesley College 106 Central St. Wellesley ,MA ,024818204 ,US.

IS AWARDEE ORGANIZATION (Check All That Apply) (See GPG II.C For Definitions) ☐ SMALL BUSINESS ☐ FOR-PROFIT ORGANIZATION ☐ MINORITY BUSINESS ☐ WOMAN-OWNED BUSINESS ☐ IF THIS IS A PRELIMINARY PROPOSAL THEN CHECK HERE

TITLE OF PROPOSED PROJECT **Collaborative Research: Shelfbreak frontal dynamics: mechanisms of upwelling, net community production, and ecological implications**

REQUESTED AMOUNT	PROPOSED DURATION (1-60 MONTHS)	REQUESTED STARTING DATE	SHOW RELATED PRELIMINARY PROPOSAL NO. IF APPLICABLE
$ 103,583	36 months	10/01/17	

THIS PROPOSAL INCLUDES ANY OF THE ITEMS LISTED BELOW

- ☐ BEGINNING INVESTIGATOR (GPG I.G.2)
- ☐ DISCLOSURE OF LOBBYING ACTIVITIES (GPG II.C.1.e)
- ☐ PROPRIETARY & PRIVILEGED INFORMATION (GPG I.D, II.C.1.d)
- ☐ HISTORIC PLACES (GPG II.C.2.j)
- ☐ VERTEBRATE ANIMALS (GPG II.D.6) IACUC App. Date ________ PHS Animal Welfare Assurance Number ________
- ☒ FUNDING MECHANISM **Research - other than RAPID or EAGER**
- ☐ HUMAN SUBJECTS (GPG II.D.7) Human Subjects Assurance Number ________ Exemption Subsection ________ or IRB App. Date ________
- ☐ INTERNATIONAL ACTIVITIES: COUNTRY/COUNTRIES INVOLVED (GPG II.C.2.j) ________
- ☒ COLLABORATIVE STATUS **A collaborative proposal from multiple organizations (GPG II.D.4.b)**

PI/PD DEPARTMENT	PI/PD POSTAL ADDRESS
Chemistry	106 Central St Wellesley, MA 02681 United States
PI/PD FAX NUMBER: 781-283-3642	

NAMES (TYPED)	High Degree	Yr of Degree	Telephone Number	Email Address
PI/PD NAME Rachel Stanley	PhD	2007	781-283-3122	rachel.stanley@wellesley.edu
CO-PI/PD				
CO-PI/PD				
CO-PI/PD				
CO-PI/PD				

CERTIFICATION PAGE

Certification for Authorized Organizational Representative (or Equivalent) or Individual Applicant

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The AOR is required to complete certifications stating that the organization has implemented and is enforcing a written policy on conflicts of interest (COI), consistent with the provisions of AAG Chapter IV.A.; that, to the best of his/her knowledge, all financial disclosures required by the conflict of interest policy were made; and that conflicts of interest, if any, were, or prior to the organization's expenditure of any funds under the award, will be, satisfactorily managed, reduced or eliminated in accordance with the organization's conflict of interest policy. Conflicts that cannot be satisfactorily managed, reduced or eliminated and research that proceeds without the imposition of conditions or restrictions when a conflict of interest exists, must be disclosed to NSF via use of the Notifications and Requests Module in FastLane.

Drug Free Work Place Certification

By electronically signing the Certification Pages, the Authorized Organizational Representative (or equivalent), is providing the Drug Free Work Place Certification contained in Exhibit II-3 of the Grant Proposal Guide.

Debarment and Suspension Certification

(If answer "yes", please provide explanation.)

Is the organization or its principals presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from covered transactions by any Federal department or agency? Yes ☐ No ☒

By electronically signing the Certification Pages, the Authorized Organizational Representative (or equivalent) or Individual Applicant is providing the Debarment and Suspension Certification contained in Exhibit II-4 of the Grant Proposal Guide.

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This certification is required for an award of a Federal contract, grant, or cooperative agreement exceeding $100,000 and for an award of a Federal loan or a commitment providing for the United States to insure or guarantee a loan exceeding $150,000.

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The undersigned certifies, to the best of his or her knowledge and belief, that:
(1) No Federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any Federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.
(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, ''Disclosure of Lobbying Activities,'' in accordance with its instructions.
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This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by section 1352, Title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

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By electronically signing the Certification Pages, the Authorized Organizational Representative (or equivalent) is providing the Certification Regarding Nondiscrimination contained in Exhibit II-6 of the Grant Proposal Guide.

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Two sections of the National Flood Insurance Act of 1968 (42 USC §4012a and §4106) bar Federal agencies from giving financial assistance for acquisition or construction purposes in any area identified by the Federal Emergency Management Agency (FEMA) as having special flood hazards unless the:
(1) community in which that area is located participates in the national flood insurance program; and
(2) building (and any related equipment) is covered by adequate flood insurance.

By electronically signing the Certification Pages, the Authorized Organizational Representative (or equivalent) or Individual Applicant located in FEMA-designated special flood hazard areas is certifying that adequate flood insurance has been or will be obtained in the following situations:
(1) for NSF grants for the construction of a building or facility, regardless of the dollar amount of the grant; and
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The AOR shall require that the language of this certification be included in any award documents for all subawards at all tiers.

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(1) has filed all Federal tax returns required during the three years preceding this certification;
(2) has not been convicted of a criminal offense under the Internal Revenue Code of 1986; and
(3) has not, more than 90 days prior to this certification, been notified of any unpaid Federal tax assessment for which the liability remains unsatisfied, unless the assessment is the subject of an installment agreement or offer in compromise that has been approved by the Internal Revenue Service and is not in default, or the assessment is the subject of a non-frivolous administrative or judicial proceeding.

Certification Regarding Unpaid Federal Tax Liability

When the proposing organization is a corporation, the Authorized Organizational Representative (or equivalent) is required to complete the following certification regarding Federal Tax Liability:

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Certification Dual Use Research of Concern

By electronically signing the certification pages, the Authorized Organizational Representative is certifying that the organization will be or is in compliance with all aspects of the United States Government Policy for Institutional Oversight of Life Sciences Dual Use Research of Concern.

AUTHORIZED ORGANIZATIONAL REPRESENTATIVE	SIGNATURE	DATE
NAME Elizabeth J Demski	Electronic Signature	Aug 10 2016 4:34PM

TELEPHONE NUMBER	EMAIL ADDRESS	FAX NUMBER
781-283-2079	edemski@wellesley.edu	

COVER SHEET FOR PROPOSAL TO THE NATIONAL SCIENCE FOUNDATION

FOR CONSIDERATION BY NSF ORGANIZATION UNIT(S) - continued from page 1
(Indicate the most specific unit known, i.e. program, division, etc.)

OCE - CHEMICAL OCEANOGRAPHY

COVER SHEET FOR PROPOSAL TO THE NATIONAL SCIENCE FOUNDATION

PROGRAM ANNOUNCEMENT/SOLICITATION NO./DUE DATE: **PD 98-1650** **08/15/16**

☐ Special Exception to Deadline Date Policy

FOR NSF USE ONLY — NSF PROPOSAL NUMBER

FOR CONSIDERATION BY NSF ORGANIZATION UNIT(S) (Indicate the most specific unit known, i.e. program, division, etc.)

OCE - BIOLOGICAL OCEANOGRAPHY, OCE - PHYSICAL OCEANOGRAPHY, (continued)

DATE RECEIVED	NUMBER OF COPIES	DIVISION ASSIGNED	FUND CODE	DUNS# (Data Universal Numbering System)	FILE LOCATION
				799477427	

EMPLOYER IDENTIFICATION NUMBER (EIN) OR TAXPAYER IDENTIFICATION NUMBER (TIN): **043167352**

SHOW PREVIOUS AWARD NO. IF THIS IS
☐ A RENEWAL
☐ AN ACCOMPLISHMENT-BASED RENEWAL

IS THIS PROPOSAL BEING SUBMITTED TO ANOTHER FEDERAL AGENCY? YES ☐ NO ☒ IF YES, LIST ACRONYM(S)

NAME OF ORGANIZATION TO WHICH AWARD SHOULD BE MADE: **University of Massachusetts, Dartmouth**

ADDRESS OF AWARDEE ORGANIZATION, INCLUDING 9 DIGIT ZIP CODE:
University of Massachusetts, Dartmouth
285 Old Westport Road
North Dartmouth, MA. 027472300

AWARDEE ORGANIZATION CODE (IF KNOWN): **0022103000**

NAME OF PRIMARY PLACE OF PERF: **University of Massachusetts Dartmouth SMAST**

ADDRESS OF PRIMARY PLACE OF PERF, INCLUDING 9 DIGIT ZIP CODE:
University of Massachusetts Dartmouth SMAST
706 South Rodney French Blvd
New Bedford ,MA ,027441221 ,US.

IS AWARDEE ORGANIZATION (Check All That Apply) (See GPG II.C For Definitions)
☐ SMALL BUSINESS ☐ MINORITY BUSINESS
☐ FOR-PROFIT ORGANIZATION ☐ WOMAN-OWNED BUSINESS

☐ IF THIS IS A PRELIMINARY PROPOSAL THEN CHECK HERE

TITLE OF PROPOSED PROJECT: **Collaborative Research: Shelfbreak frontal dynamics: mechanisms of upwelling, net community production, and ecological implications**

REQUESTED AMOUNT	PROPOSED DURATION (1-60 MONTHS)	REQUESTED STARTING DATE	SHOW RELATED PRELIMINARY PROPOSAL NO. IF APPLICABLE
$ **461,615**	**36** months	**10/01/17**	

THIS PROPOSAL INCLUDES ANY OF THE ITEMS LISTED BELOW
☒ BEGINNING INVESTIGATOR (GPG I.G.2)
☐ DISCLOSURE OF LOBBYING ACTIVITIES (GPG II.C.1.e)
☐ PROPRIETARY & PRIVILEGED INFORMATION (GPG I.D, II.C.1.d)
☐ HISTORIC PLACES (GPG II.C.2.j)
☐ VERTEBRATE ANIMALS (GPG II.D.6) IACUC App. Date ________
PHS Animal Welfare Assurance Number ________
☒ FUNDING MECHANISM **Research - other than RAPID or EAGER**
☐ HUMAN SUBJECTS (GPG II.D.7) Human Subjects Assurance Number ________
Exemption Subsection ________ or IRB App. Date ________
☐ INTERNATIONAL ACTIVITIES: COUNTRY/COUNTRIES INVOLVED (GPG II.C.2.j)
☒ COLLABORATIVE STATUS
A collaborative proposal from multiple organizations (GPG II.D.4.b)

PI/PD DEPARTMENT: **Biology/Fisheries Oceanography**

PI/PD POSTAL ADDRESS:
285 Old Westport Road

North Dartmouth, MA 02747
United States

PI/PD FAX NUMBER: **508-999-8196**

NAMES (TYPED)	High Degree	Yr of Degree	Telephone Number	Email Address
PI/PD NAME **Jefferson T Turner**	**PhD**	**1977**	**508-999-8229**	**jturner@umassd.edu**
CO-PI/PD **Christian M Petitpas**	**DPhil**	**2015**	**508-999-8953**	**cjadlowic@umassd.edu**
CO-PI/PD				
CO-PI/PD				
CO-PI/PD				

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AUTHORIZED ORGANIZATIONAL REPRESENTATIVE	SIGNATURE	DATE
NAME		

TELEPHONE NUMBER	EMAIL ADDRESS	FAX NUMBER

COVER SHEET FOR PROPOSAL TO THE NATIONAL SCIENCE FOUNDATION

FOR CONSIDERATION BY NSF ORGANIZATION UNIT(S) - continued from page 1
(Indicate the most specific unit known, i.e. program, division, etc.)

OCE - CHEMICAL OCEANOGRAPHY

PROJECT SUMMARY

Overview:

The continental shelfbreak of the Middle Atlantic Bight supports a productive and diverse ecosystem. Current paradigms suggest that this productivity is driven by several upwelling mechanisms at the shelfbreak front. This upwelling supplies nutrients that stimulate primary production by phytoplankton, which in turn leads to enhanced production at higher trophic levels. Although local enhancement of phytoplankton biomass has been observed in some synoptic measurements, such a feature is curiously absent from time-averaged measurements, both remotely sensed and in situ. Why would there not be a mean enhancement in phytoplankton biomass as a result of the upwelling? One hypothesis is that grazing by zooplankton prevents accumulation of biomass on seasonal and longer time scales, transferring the excess production to higher trophic levels and thereby contributing to the overall productivity of the ecosystem. However, another possibility is that the net impact of these highly intermittent processes is not adequately represented in long-term means of the observations, because of the relatively low resolution of the in situ data and the fact that the frontal enhancement can take place below the depth observable by satellite.

A unique opportunity to test these hypotheses has arisen with deployment of the Ocean Observatories Initiative (OOI) Pioneer Array south of New England. The combination of moored instrumentation and mobile assets (gliders, AUVs) will facilitate observations of the frontal system with unprecedented spatial and temporal resolution. This will provide an ideal four-dimensional (space-time) context in which to conduct a detailed study of frontal dynamics and plankton communities needed to test the aforementioned hypotheses.

We propose a set of three cruises to obtain cross-shelf sections of physical, chemical, and biological properties within the Pioneer Array. Nutrient distributions will be assayed together with hydrography to detect the signature of frontal upwelling and associated nutrient supply. We expect that enhanced nutrient supply will lead to changes in the phytoplankton assemblage, which will be quantified with conventional flow cytometry, imaging flow cytometry (Imaging FlowCytobot, IFCB), in situ optical imaging (Video Plankton Recorder, VPR), traditional microscopic methods, and HPLC pigments. Zooplankton will be measured in size classes ranging from micro- to mesozooplankton with the IFCB and VPR, respectively, and also with microscopic analysis. Biological responses to upwelling will be assessed by measuring rates of primary productivity, zooplankton grazing, and net community production. These observations will be synthesized in the context of a coupled physical-biological model to test the two hypotheses that can potentially explain prior observations: (1) grazer-mediated control and (2) undersampling. Hindcast simulations will also be used to diagnose the relative importance of the various mechanisms of upwelling.

Intellectual Merit :

The intellectual merit of this effort stems from our interdisciplinary approach, advanced observational techniques, and integrated analysis in the context of a state-of-the-art coupled model. The proposed research will address longstanding questions regarding hydrodynamics and productivity of an important ecosystem, leading to improved understanding of physical-biological interactions in a complex continental shelf regime. Given the importance of frontal systems in the global coastal ocean, we expect that knowledge gained will have broad applicability beyond the specific region being studied here.

Broader Impacts :

Broader impacts include (1) promoting teaching, training and learning via participation of graduate and undergraduate students in the proposed research , (2) broad dissemination by means of outreach in public fora, printed media, and a video documentary of the field work, and (3) improving societal well-being and increased economic competitiveness by providing the knowledge needed for science-based stewardship of coastal ecosystems, with particular emphasis on connecting with the fishing industry through the Commercial Fisheries Research Foundation.

This collaborative proposal involved partners from WHOI ($1,993,156), UMass Dartmouth ($461,615), VIMS ($420,394), and Wellesley ($103,583) for a total of $2,978,748.

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	Total No. of Pages	Page No.* (Optional)*
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Project Summary (not to exceed 1 page)	1	
Table of Contents	1	
Project Description (Including Results from Prior NSF Support) (not to exceed 15 pages) **(Exceed only if allowed by a specific program announcement/solicitation or if approved in advance by the appropriate NSF Assistant Director or designee)**	15	
References Cited	15	
Biographical Sketches (Not to exceed 2 pages each)	6	
Budget (Plus up to 3 pages of budget justification)	10	
Current and Pending Support	8	
Facilities, Equipment and Other Resources	2	
Special Information/Supplementary Documents (Data Management Plan, Mentoring Plan and Other Supplementary Documents)	10	
Appendix (List below.) **(Include only if allowed by a specific program announcement/ solicitation or if approved in advance by the appropriate NSF Assistant Director or designee)**		

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Preamble: This revision of a prior proposal addresses reviewer concerns by (1) strengthening the rationale for the project, introducing a new hypothesis to explain the lack of enhancement of seasonal mean chlorophyll at the shelfbreak front, (2) addition of triple oxygen isotope and oxygen/argon measurements, providing additional constraints on gross primary production and net community production, as well as expanding the space and time scales to which our suite of observations apply, (3) augmenting our plans for extrapolating discrete rate measurements to larger space and time scales, and (4) clarifying our sampling strategy. Lastly, we have attempted to emphasize the novelty of the proposed research by highlighting the unique opportunity to use advanced observational infrastructure to assess quantitatively the relative importance of bottom-up and top-down controls on plankton populations in a highly dynamic frontal system—and that understanding gained from this study will be applicable to many other regions of the global coastal ocean where frontal phenomena are pervasive.

1. Introduction

The Middle Atlantic Bight (MAB) shelfbreak is a region of high biological productivity (Marra et al. 1990, O'Reilly et al. 1987, Ryan et al. 1999b). Large horizontal and vertical gradients in water properties and persistent upwelling are associated with the shelfbreak front, a feature susceptible to nonlinear instabilities and strong interactions with Gulf Stream warm-core rings that impinge on the continental slope (Barth et al. 2004, Houghton et al. 1994, Linder et al. 2004, Lozier et al. 2002, Ryan et al. 2001). Long-term studies suggest both persistence of the shelfbreak jet, as well as upstream advective influences from the Scotian shelf (Bisagni et al. 2006, Flagg et al. 2006). As a result, this region has significant along- and cross-shelf fluxes of heat, freshwater, nutrients, and carbon that control the water mass characteristics and the ecosystem, both at the shelfbreak and in the neighboring shelf and slope (Falkowski et al. 1988, Greer et al. 2015, Houghton & Marra 1983, Malone et al. 1983, Marra et al. 1982, Ryan et al. 1999a,b, Vaillancourt et al. 2005, Walsh et al. 1988). Both satellite and *in situ* observations reveal synoptic enhancement of phytoplankton biomass at the front, although such enhancements are not always present (Hales et al. 2009).

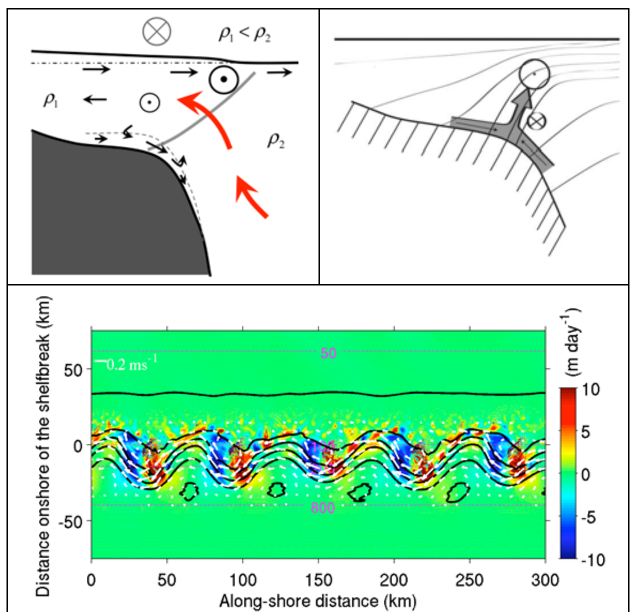

Fig. 1. Three upwelling mechanisms at the shelfbreak. Upper left: mean upward motion (red arrows) driven by divergence in the onshore interior flow (Zhang et al. 2011). Upper right: along-isopycnal upwelling associated with convergence in the bottom boundary layer (Linder et al. 2004). Bottom: vertical motion associated with frontal meandering in an idealized simulation (Zhang & Gawarkiewicz 2015b). Colors, white arrows, and black lines indicate vertical velocity, horizontal velocity, and isopycnal contours (interval of 0.1 kg m^{-3}) at 40 m; magenta lines are isobaths.

Despite numerous studies, both observational (Biscaye et al. 1994, Flagg et al. 2006, Houghton et al. 2009) and numerical (Chapman & Lentz 1994, Chen & He 2010, Gawarkiewicz & Chapman 1992), our understanding of the processes that control the circulation and ecosystem dynamics of the shelfbreak front is still inadequate. The primary reason is that shelfbreak frontal processes are inherently nonlinear and exhibit variations over a broad range of spatial and temporal scales. To grapple with this complexity, Linder and Gawarkiewicz (1998) combined historical temperature and salinity observations and generated a seasonal two-dimensional (2D) cross-shelfbreak climatology for subregions of the MAB. Similarly, Fleming and Wilkin (2010) generated a monthly 3D climatology of temperature and salinity for the entire MAB. These climatologies provide a description of the mean state that serves as a baseline for studying temporal and spatial variability of the frontal dynamics.

Associated with the shelfbreak front are strong vertical motions, which may significantly influence the shelfbreak ecosystem. Specifically, upward motion could deliver nutrients into the euphotic zone and stimulate local primary productivity during periods when nutrients are depleted. There are multiple mechanisms of shelfbreak upwelling (Fig. 1). Although the processes regulating this vertical motion are complex, simple models can be useful for understanding key aspects, such as frontogenesis (Benthuysen & Thomas 2013) and buoyancy shutdown (Benthuysen et al. 2015). Based on the fact that density is approximately uniform in the along-shelf direction (Lentz 2010), Zhang et al. (2011) employed a 2D (cross-shelf and vertical) model and the 3D temperature and salinity climatology (Fleming & Wilkin 2010) to examine the annual and seasonal mean circulation around the New England shelfbreak. Analysis of the solutions facilitated distillation of a simple schematic of the mean flows and secondary circulation at the front (Fig. 1, upper left). To summarize, sloping isopycnals cause a geostrophically balanced alongshore flow in the interior that is augmented by a cross-shelf tilt in sea level. Flows are directed offshore in the surface and bottom boundary layers, because of an eastward along-shelf component of the mean wind stress in the former and bottom Ekman layer dynamics in the latter. An along-shelf pressure gradient drives onshore flow in the interior, leading to upwelling at the shelfbreak as a result of continuity. The associated mean vertical velocity varies seasonally from tens of cm d^{-1} in summer to a few m d^{-1} in winter (Zhang et al. 2011).

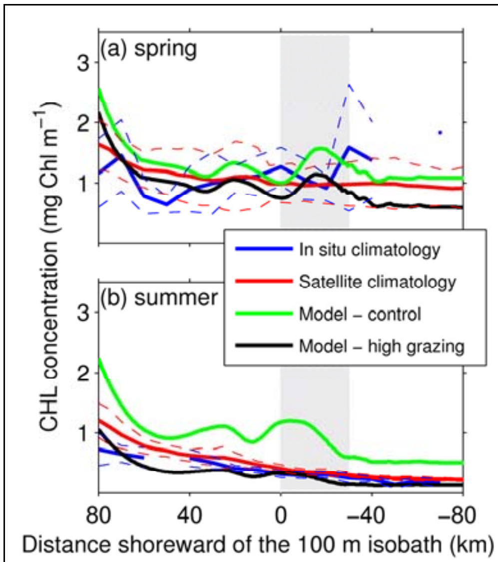

Fig. 2. Observed and simulated cross-shelf distributions of chlorophyll (Zhang et al. 2013). Dashed lines are the 95% confidence intervals for the means. Gray shading indicates the envelope of the front.

This mechanism differs from the upwelling associated with the convergence in the bottom boundary layer (Fig. 1, upper right; Chapman & Lentz 1994, Linder et al. 2004, Pickart 2000). Observations at the shelfbreak (Barth et al. 1998, Houghton & Visbeck 1998) have shown convergence of the cross-shelf bottom flows near the foot of the shelfbreak front, leading to abrupt detachment of the bottom boundary layer and then upwelling into the interior with vertical velocity up to 9 m d^{-1}. Yet another mechanism of upwelling derives from instability-driven meandering of the shelfbreak front (Fig. 1, bottom; Zhang & Gawarkiewicz 2015b). As demonstrated by studies in the open ocean (Lévy et al. 2001, Mahadevan & Archer 2000, Woods 1988), frontal instability can induce strong vertical motion (several to tens of m d^{-1}) through mesoscale and submesoscale vorticity dynamics. Lastly, we note that surface Ekman transport divergence can cause upwelling at the shelfbreak front (Csanady 1984), although the associated vertical velocity is only 10^{-5} m d^{-1} for typical conditions at the New England shelfbreak (Zhang et al. 2011).

All of these upwelling mechanisms would deliver nutrients to the euphotic zone, thereby increasing productivity. However, because the associated spatial and temporal scales are dramatically different, the overall strength of these different types of upwelling and the relative importance of the vertical nutrient fluxes associated with each are not well constrained. Curiously, there does not appear to be a significant enhancement in the seasonal mean cross-shelf distribution of chlorophyll in either satellite-based or *in situ* data sets (Fig. 2), despite the variety of upwelling processes thought to be active at the front. **Why would there *not* be an enhancement of mean chlorophyll associated with the mean upwelling?** Zhang et al. (2013) investigated this in a simple nutrient-phytoplankton-zooplankton-detritus model coupled to the aforementioned 2D circulation model. Whereas a control run exhibits chlorophyll enhancement at the front during the spring and summer as a result of upwelling, enhanced top-down control by zooplankton in a “high grazing” case can prevent accumulation of phytoplankton biomass (Fig. 2, Cf. green and black lines). We regard this latter model solution as a hypothesis in need of testing in the field. Alternatively, physical transport could also play a role in diminishing enhancement of phytoplankton biomass at the front. However, physical processes such as advection or diffusion are not likely to be the primary cause of the absent frontal biomass enhancement, as the same processes would also suppress the frontal density gradient. In any case, our models (section 4) will include explicit representation of those effects. To summarize, our hypotheses are:

H_1: Upwelling at the shelfbreak front results from a combination of (1) onshore interior flow driven by an along-shelf pressure gradient, (2) convergence in the bottom boundary layer, (3) vortex stretching driven by frontal meandering and associated mesoscale/submesoscale dynamics, and (4) Ekman divergence in the surface boundary layer.

H_2: These upwelling processes result in local enhancement of nutrient fluxes into the euphotic zone.

H_3: Enhanced nutrient availability stimulates increased primary productivity in the front and leads to changes in the phytoplankton species assemblage.

H_{4a}: Autotrophic biomass does not accumulate in areas of frontal upwelling because of zooplankton grazing; this grazer-mediated control is reflected in both zooplankton biomass and species composition.

H_{4b}: Autotrophic biomass does accumulate in areas of frontal upwelling, but the spatial and temporal intermittency of these events causes their net impact to be smoothed out in long-term means of historical observations of nutrients and chlorophyll.

The hypothesis of top-down control (H_{4a}) has been examined in detail in other regions such as the subarctic Pacific (Banse 1990, Frost 1993), with recent foci by the GLOBEC program in the northeast Pacific (Batchelder et al. 2005) and BEST programs (Lomas & Stabeno 2014), the latter of which highlighted trophic dynamics of the "green belt" (Springer et al. 1996) at the Bering Sea shelf edge. We note this is a particularly challenging hypothesis to test at the MAB shelfbreak front, owing to the highly dynamic nature of the frontal system and the small spatial scales (km) and short temporal scales (days) of the attendant processes. A competing hypothesis to explain the lack of enhancement of the mean chlorophyll at the front is undersampling in prior *in situ* observations (H_{4b}). As for undersampling by remote sensing, this could potentially be explained by the fact that frontal chlorophyll enhancement takes place subsurface (Marra et al. 1990), too deep to be detected in satellite ocean color.

We will adopt a coupled observational and modeling strategy to test our set of five linked hypotheses. We propose a set of three cruises to be carried out in the vicinity of the Ocean Observatories Initiative (OOI) Pioneer Array. Real-time data streams from the Pioneer Array as well as satellite remote sensing will be used to guide adaptive sampling of physical, biological, and chemical properties. The resultant data sets will yield direct observational tests of H_2, H_3, and some aspects of H_{4a}. Testing of H_1 and the unobserved aspects of H_{4a} will be carried out with a data assimilative coupled physical-biological model. Evaluation of H_{4b} will be facilitated by long-term averages of the Pioneer data, as well as model-based assessment. We expect what is learned to be broadly applicable to other frontal regimes, for which there are many throughout the global coastal ocean (Robinson & Brink 1998).

2. Context for the proposed research: the OOI Pioneer Array

The wide range of space and time scales relevant to the processes of interest necessitates a multi-scale approach, and the OOI Pioneer Array provides the required infrastructure. Key data streams for this research come from gliders (Rudnick et al. 2004, Sherman et al. 2001) and the moored array. A set of glider tracks (Fig. 3) obtained from the OOI data portal (OOI 2016) illustrates how these data would be used in our study.

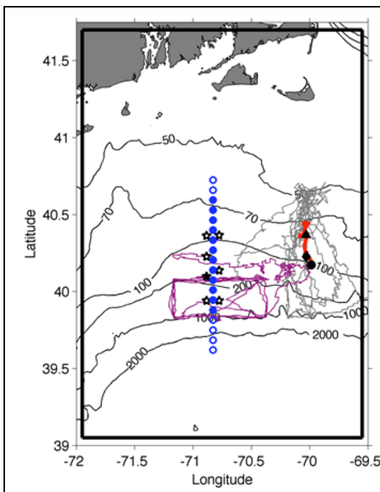

Fig. 3. Tracks of Pioneer Array gliders (grey, magenta lines), 17 Apr – 30 Jun 2014. Red line is a cross-shelf transect on 25-26 Apr (Fig. 4); the black triangle, diamond, and circle indicate the positions of the foot, jet and surface expression of the front, respectively. Mooring locations are shown as stars, with the central offshore mooring (Fig. 5) filled in black. Proposed shipboard transects indicated with blue circles. The solid black boundary depicts the NESEC model domain (section 4).

Along-track temperature and salinity distributions (Fig. 4) will be used to identify the foot of the front (where the pycnocline intersects the bottom), the location of the shelfbreak jet (where the density gradient at 40 m is maximal), and the near-surface expression of the front. Similar diagnostics can be derived from the moored array (stars in Fig. 3). Time series of temperature, salinity, and chlorophyll from the central offshore mooring (Fig. 5) highlight the energetic high-frequency variability characteristic of the region. Nevertheless, clear low-frequency trends of particular interest are visible: shoaling of the front from April 17 to April 23, followed by meandering of the front with a period of 3-4 days (dashed lines in Fig. 5).

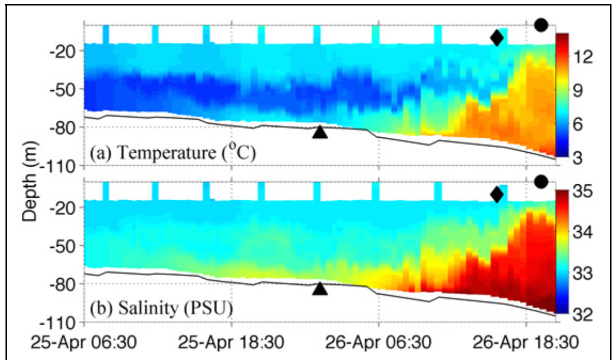

Fig. 4. Temperature and salinity from a glider as it transited in the offshore direction (Fig. 3, red track). Shoaling of isothermal and isohaline surfaces on 26 April is associated with the shelfbreak front. Approximate positions of the foot, jet, and surface expression of the front are indicated by the triangle, diamond and circle, respectively. The subsurface temperature minimum onshore of the front is likely part of the cold pool (Houghton et al. 1982).

Data from the gliders and moorings will be used in two ways. First, real-time data streams will be used to estimate the location of the front and orient our shipboard transects (section 3). For example, the glider and mooring data from April 2014 (Figs. 4,5) suggest the front is well shoreward of its mean position, likely due to the influence of an adjacent warm-core ring (not shown). Therefore, the twelve-station ship transect we propose (section 3) is near the northernmost extent of the expected envelope (Fig. 3). The second use of the glider and mooring data will be for numerical modeling (section 4). In short, the physical oceanographic data will be assimilated into hydrodynamic hindcasts, whereas the biological data will be used to evaluate the coupled plankton model.

Within the Pioneer Array, a combination of discrete-depth and profiling sensors will provide temperature, conductivity, and velocity throughout the water column. Additional instrumentation will include oxygen, nutrient, and bio-optical sensors (fluorometers, radiometers, and backscattering, attenuation and absorption meters). The optical sensors will be important for providing indices of concentration and characteristics of phytoplankton (e.g., chlorophyll, particulate carbon concentration) and particle size distribution (Sosik 2008). The combination of moored and profiling nutrient and irradiance sensors, plus local surface forcing and extensive subsurface hydrographic data, will provide unprecedented detail on the various impacts of physical forcing on light and nutrient availability that affect the growth and distribution of different types of phytoplankton.

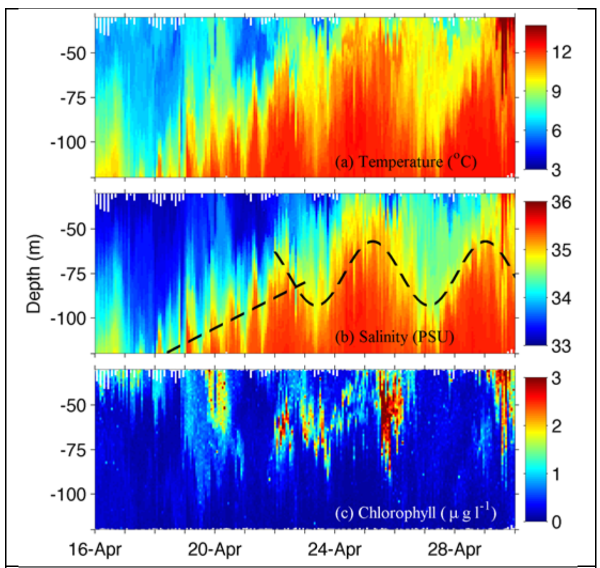

Fig. 5. Temperature, salinity, and chlorophyll at the central-offshore mooring (Fig. 3). Dashed lines in (b) indicate 1) gradual shoaling of isopycnals during 17-22 April caused by onshore migration of the front, and 2) vertical oscillation of isopycnals with a period of 3-4 days over 23-30 Apr caused by frontal meanders. Higher frequency changes are likely internal waves or inertial oscillations.

We note that selected surface buoys house meteorological sensors for air temperature, specific humidity, sea surface temperature and conductivity, wind speed and direction, barometric pressure, short- and longwave radiation, and precipitation. These measurements will be used to compute air-sea fluxes of heat, moisture and momentum with bulk aerodynamic formulas to provide realistic forcing estimates for evaluating adjustments to the surface forcing by the data assimilation procedure (section

4.1). These computations will also be of value in constraining air-sea gas fluxes (section 3.6).

3. Seagoing process studies

We propose three cruises of 14 days each: spring 2018, summer 2018, and spring 2019. The two cruises in year one will provide contrast between the springtime period when ephemeral enhancement of phytoplankton biomass is most visible from satellite data (Ryan et al. 1999a) and more stratified conditions when the response may be muted (Hales et al. 2009), especially in the near-surface region. The final cruise in spring 2019 will provide additional sampling at a time when we expect the signal to be maximal; comparisons with spring 2018 will permit an assessment of between-year variability. This latter aspect is particularly important in light of the potential for warm-core Gulf Stream rings to perturb the system (Chen et al. 2014, Flierl & Wroblewski 1985, Joyce et al. 1992, Zhang & Gawarkiewicz 2015a).

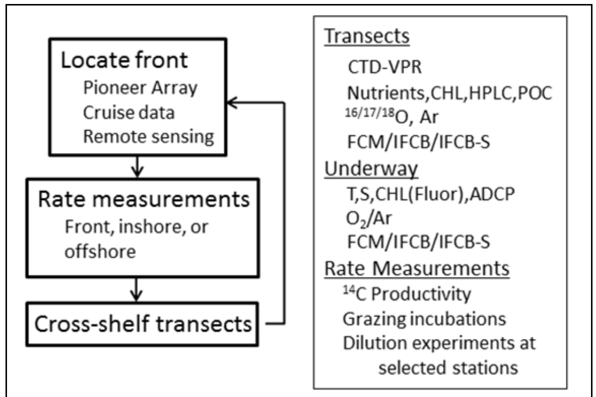

Fig. 6. Daily sampling cycle (left) and summary of measurements (right).

Our observational plan consists of cross-frontal transects and rate measurements, conducted in a daily cycle of activity (Fig. 6). Each day will begin with determining the precise location of the front from a combination of data from the Pioneer Array, cruise observations, and remote sensing images. Rate measurements will start at dawn each day, strategically located in one of the three key regimes: inshore, offshore, and at the front. Twelve repetitions of the observational cycle (see below) will permit four replicates in each of the three regimes, facilitating estimates of the mean and variance for each.

Fourteen-day cruises will allow for 12 science days, assuming one-day transits to and from the sampling area. Our plan is to conduct 12 cross-frontal transects, each taking ca. 24 h (Fig. 3). Each transect will be composed of 12 stations spaced 7 km apart. Our rationale for 12 sections stems from the fact that meandering of the shelfbreak front is a major source of variability of the hydrographic and biological states. Based on repeated surveys, Gawarkiewicz et al. (2004) reported that 1) spatial decorrelation scales for temperature, salinity, and velocity in the upper 60 m were 8-15 km, with temporal decorrelation scales of ~1 day; 2) frontal variability was dominated by passage of a westward propagating meander with wavelength of 40 km and period of 4 days (propagation speed ~0.11 m s^{-1}). Analysis of recent subsurface measurements in the same region gave similar horizontal scales of frontal variability (Todd et al. 2013, Zhang & Gawarkiewicz 2015b). Each of our 24-hour cross-shelf transects will provide one statistically independent snapshot of the cross-shelf distribution of physical and biological properties, and the 12 transects in each cruise will cover ~3 cycles of the dominant frontal meander scale.

To achieve our goals for the cross-shelf transects, we must combine physical measurements with concurrent biological observations. We will make detailed surveys that provide biomass, rates of net community and gross primary production, and high resolution observations of taxonomic composition and size structure of the plankton. We will use state-of-the-art observational approaches that allow these biological characteristics to be observed rapidly enough for the proposed cross-shelf station transects. The surveys will be complemented by strategically-located rate measurements of primary production and zooplankton grazing. Because these multiple approaches will provide information across multiple trophic levels, we will be able to investigate physical forcing, bottom-up processes, and grazer-mediated controls as they interact to influence plankton community structure and associated food web dynamics.

3.1 Physical oceanographic measurements

High-resolution transects are essential for understanding the spatial and temporal structure of cross-shelf gradients within the shelfbreak front. A shipboard ADCP will provide continuous measurements of horizontal velocity throughout the water column. We will also measure vertical profiles of temperature and salinity at all cross-shelf CTD stations concurrent with biological sampling. These observations will provide high-resolution quasi-synoptic views of the cross-shelf distribution of frontal gradients, including the position and strength of the shelfbreak front and jet. These will be used to identify key dynamical parameters of the front (e.g., cross-shelf convergence/divergence, upwelling/downwelling, bottom boundary layer detachment, surface and subsurface onshore intrusions) at the times and locations of the biological measurements. These measurements are essential for understanding physical-biological interactions at the shelfbreak front, and will provide crucial subsurface constraints for the data assimilative model in hindcasting our cruise periods (see section 4).

3.2 Nutrients

Samples will be drawn from Niskin bottles at 12 discrete depths. To reduce the analysis load, we will sample either every other station or every other transect, such that the number of samples generated per cruise is 864 (12 transects · 12 stations · 12 depths / 2). Samples will be syringe-filtered and frozen, and later processed at the WHOI Nutrient Analytical Facility with standard AutoAnalyzer techniques.

3.3 Flow cytometry for phytoplankton and microzooplankton

Conventional flow cytometry – Pico- and small nano-phytoplankton will be enumerated and sized with conventional laser-based flow cytometric (FCM) analysis using a BD Accuri C6 flow cytometer (BD Biosciences). We will conduct analyses on discrete samples collected from depth profiles, as well as on a continuous stream from the ship's seawater intake to provide higher resolution for surface waters along-track. At least 200 µL samples will be analyzed. Due to small sample volumes and dynamic range limits, these FCM measurements will be practical for analysis of ~1-20 µm cells. The measurements will include individual cell-based assessments of chlorophyll and phycoerythrin fluorescence, permitting picocyanobacteria and cryptophytes to be unambiguously distinguished from a mixture of other pico- and nano-sized eukaryotic phytoplankton (e.g., Olson et al. 1993, Sosik et al. 2010). Individual cell light scattering will be converted into cell volume estimates on the basis of calibration with independently sized cell cultures following approaches we have previously developed (DuRand et al. 2002, Laney & Sosik 2014, Olson et al. 2003). When integrated with measurements of larger phytoplankton (described next), this approach will allow us to assess quantitatively how phytoplankton size spectra change across the shelfbreak front.

Imaging FlowCytobot – Imaging-in-flow cytometry will be used to extend the FCM-based observations into the microplankton range, including chain-forming species. IFCB measures not only fluorescence and light scattering, but also captures a high resolution (~1 µm) image of each cell or chain (Fig. 7); it is also optimized to analyze larger sample volumes (5 mL) to improve sampling statistics for rare microplankton (Olson & Sosik 2007). This standard IFCB (and Staining IFCB described below) will be used for analysis of discrete samples from vertical profiles, underway surface sampling, and grazing experiments (section 3.8). We have previously shown that IFCB provides sampling of many phytoplankton taxa with performance that is equivalent to or better than results from conventional manual microscopy (Brosnahan et al. 2015, Campbell et al. 2010, Olson & Sosik 2007). IFCB produces large numbers of images (typically 10^5 h^{-1} in coastal waters), so manual analysis will be prohibitive. We will automatically analyze images and assign them to taxonomic groups following approaches we have developed for the multi-year IFCB time series at the Martha's Vineyard Coastal Observatory (Peacock et al. 2014, Sosik & Olson 2007). For taxonomic identification, we will manually inspect and identify images to produce training sets to develop automated classifiers (genus or species level) following the approach in Sosik and Olson (2007), except with a Random Forest classifier algorithm (Breiman 2001) in place of the support vector machine. Estimation of particle size from light scattering is highly uncertain for these large, inhomogeneous, irregularly shaped particles, so we will use image analysis to estimate dimensions and individual cell biovolumes (Moberg & Sosik 2012, Sosik & Olson 2007). We will use this information to compute abundance and biomass-based size spectra for various taxonomic groupings (e.g., from single species to aggregation of all diatoms). To facilitate this work, we will

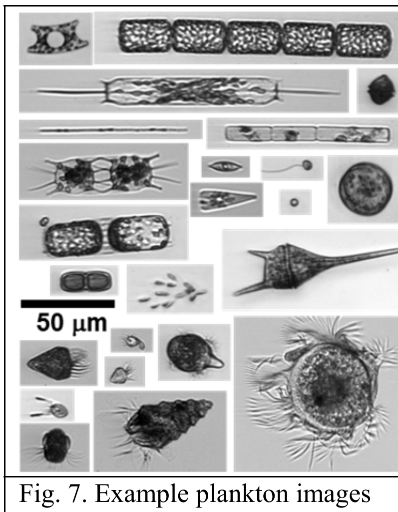

Fig. 7. Example plankton images collected by IFCB during deployments at the Martha's Vineyard Coastal Observatory.

take advantage of an informatics pipeline we developed to handle these large data sets, enabling image analysis, feature extraction, classification, error correction, and open access to image data and results (Sosik & Futrelle 2012).

Staining Imaging FlowCytobot – The standard IFCB is optimized for sampling of phytoplankton (through triggered imaging of particles that exhibit chlorophyll fluorescence), but it also has proven very effective for imaging and identification of many types of protozoa, notably those that are either mixotrophic or contain fluorescent prey in their guts (Fig. 7 right, rows below the scale bar). The Staining IFCB (IFCB-S), recently developed in the Sosik lab, will allow us to quantify protozoa more completely because it has added features that enable automated incubation of samples with a live cell fluorescent stain (Brownlee et al. 2016). We will operate the IFCB-S continuously during underway surface sampling, and as time permits, for analysis of discrete samples from CTD casts and incubation experiments. The same data analysis and processing pipeline developed for phytoplankton images will be applied to these data (which will include phytoplankton, along with the protozoa).

3.4 Pigment and POC analysis

Particulate material from discrete water samples (1-2 L from CTD casts and selected underway samples) will be collected onto GFF filters under <5 mm Hg vacuum pressure, and then immediately stored in liquid nitrogen to preserve phytoplankton pigments. Chlorophylls and accessory pigment concentrations will be determined by standard high performance liquid chromatography (HPLC) methods (Hooker et al. 2005, Van Heukelem & Thomas 2001). We expect to collect ~240 HPLC samples (including ~5% replicates) from each cruise. Post-analysis processing will include customized application of CHEMTAX (Mackey et al. 1996), an optimization procedure for chemotaxonomic characterization of different phytoplankton classes (e.g., diatoms, dinoflagellates, prymnesiophytes, cyanobacteria, cryptophytes, etc.) on the basis of marker pigment and diagnostic pigment ratios. If merited by residual analysis, separate optimization runs will be conducted for different depth layers or cross-shelf zones. These analyses will complement the flow cytometry and imaging flow cytometry by providing information about taxa that are difficult to distinguish by optical cross-sections or light microscopy (e.g., pico- to small nano-sized prymnesiophytes and prasinophytes). Size-fractionated (whole water and <20 μm) chlorophyll samples filtered onto GFF filters will be frozen for later fluorometric analysis, whereas appropriate volumes (0.5-2 L) for POC will be filtered through combusted GFF filters, placed in combusted glass vials, covered with aluminum foil, and dried at 60˚C (Gardner et al. 2000). Samples will be analyzed on a Costech ECAS 4010 elemental analyzer at VIMS. Blanks are filters through which ca. 5 mL filtered seawater has been passed. As with HPLC, replicates will be processed for ~5% of all samples.

3.5 Net primary productivity

Size-fractionated primary productivity will be measured with simulated *in situ* techniques (e.g., Harrison et al. 1985, Lohrenz et al. 1991, Smith et al. 2000). Samples will be collected from known isolumes and placed in sterile 285 mL Qorpak bottles, to which ~20 μCi $NaH^{14}CO_3$ will be added. Bottles will be placed in an on-deck incubator through which surface seawater flows to maintain appropriate temperatures; irradiance will be attenuated by neutral density filters to mimic those at the depths sampled (with blue filters at isolumes below 30% E_o; (Laws et al. 1990)). Irradiance will be quantified using a BioSpherical Instruments sensor placed near the incubators. After 24 h, samples will be filtered through GFF filters and placed in 7 mL scintillation vials. Size fractionations will be completed at all stations using 20 μm Poretics filters on subsamples from each bottle. 100 μL 1N HCl will be added to volatilize absorbed inorganic ^{14}C. Ecolume (5 mL) will be added to each vial, and all vials will be counted after 24 h on a liquid scintillation counter at sea. Total activity will be measured by counting 100 μL of non-acidified sample in β-phenethanylamine (Smith et al. 2000).

While the ^{14}C method is relatively "standard", interpretation of the results is not. Specifically, the start of incubations can bias each measurement due to the relative importance of nocturnal phytoplankton respiration (e.g., Marra 2009, McAllister et al. 1964). To help us compare results, we will sample three locations at the same time each day: shelf, shelfbreak, and slope. We will also conduct time-course measurements to try to assess the relative importance of respiration at each location to facilitate spatial comparisons. Most importantly, all grazing experiments (section 3.8) will be conducted at the same stations as primary productivity measurements to allow a direct assessment of growth and loss processes in controlling phytoplankton biomass.

3.6. Net community productivity and gross primary productivity

In situ gas tracers will be used to quantify net community productivity (NCP) and gross primary productivity (GPP) at all stations, providing rate estimates that average over temporal scales of 2-3 days. Spatial variability on order of kilometers has frequently been observed in rates calculated from these tracers (Estapa et al. 2015, Lockwood et al. 2012, Stanley et al. 2010) and thus the data will be able to reflect any changes in rates of productivity across the shelfbreak. The large number of rates calculated by this method will complement the incubation-based biological productivity and grazing measurements that are less numerous. Measurement of GPP will be especially useful for testing H_3. If the enhanced shelfbreak productivity is due to grazer-mediated control, then rates of GPP at the shelfbreak front should be large, compared to surrounding waters, as the phytoplankton must have first photosynthesized before they were consumed. If there is no enhancement due to bottom-up control, then rates of gross O_2 productivity at the shelfbreak front will be similar to surrounding water. NCP rates will enable us to calculate a ratio of NCP:GPP which is a measure of the export efficiency and which, according H_{4a}, will peak at the shelfbreak.

GPP will be determined by measurements of the triple O_2 isotope ratio of dissolved oxygen since photosynthetic processes result in mass dependent fractionation, whereas stratospheric processes lead to mass independent fractionation of O_2 mixed into the water during gas exchange (Juranek & Quay 2013, Luz & Barkan 2000). Thus the triple O_2 isotope ratio quantifies the fraction of dissolved O_2 arising from photosynthesis. Samples (300 per cruise) will be collected from the surface at every station to obtain detailed spatial resolution and at 4 additional depths for ¼ of the stations to make corrections for vertical transport. The samples will be collected in custom-made, pre-poisoned evacuated flasks (Emerson et al. 1991) and measured on the isotope ratio mass spectrometer at WHOI (Stanley & Howard 2013, Stanley et al. 2015). Sample precision on that system is typically better than 5 per meg for $^{17}\Delta$, 0.01 per mil for $\delta^{17}O$, and 0.008 for $\delta^{18}O$. Rigorous quality control is performed through daily analysis of air standards and equilibrated water samples. Rates of GPP will be calculated from $\delta^{17}O$ and $\delta^{18}O$ (Prokopenko et al. 2011) with corrections made for entrainment and mixing in both the vertical and horizontal dimensions (Howard et al. 2016, Nicholson et al. 2014).

NCP will be calculated from O_2/Ar ratios made on the same samples as the triple O_2 isotopes (sample precision = 0.2 per mil) and from a shipboard mass spectrometer that measures O_2/Ar ratios continuously in underway water with precision of 2 per mil on a timescale of seconds to minutes (Cassar et al. 2009). The continuous data will give rates of NCP with spatial resolution of several kilometers, while the discrete samples will allow for depth profile information required for correcting for physical transport, and calculation of NCP:GPP ratios. The O_2/Ar approach takes advantage of the similar solubility (Garcia & Gordon 1992, Hamme & Emerson 2004) and molecular diffusivity (Jähne et al. 1987) of both to quantify net biological production of oxygen, while correcting for physical processes (Craig & Hayward 1987, Emerson et al. 1991, Spitzer & Jenkins 1989). Solving mass balance equations, including estimates of gas exchange, allows the O_2/Ar ratios to be converted to rates of NCP (Hendricks et al. 2004, Juranek & Quay 2005, Reuer et al. 2007, Stanley et al. 2010). Corrections for vertical and horizontal mixing, especially important in this dynamic region, will be possible (Haskell et al. 2016, Jonsson et al. 2013) because of the frequent depth profiles and the wealth of physical oceanographic data collected as well as model simulations (section 4).

To use the rates from the gas tracer data to assess the model (Section 3.9) and to compare the gas tracer-based rates to NPP from the ^{14}C incubations, a photosynthetic quotient needs to be applied (to convert from O_2 to carbon). Laboratory studies with diatoms, chlorophytes, and cyanobacteria in a range of nutrient-limited conditions (Halsey et al. 2010, Halsey et al. 2013, Kana 1992) have shown that the amount of O_2 used for non-carbon producing reactions (i.e., the Mehler reaction, photorespiration, etc.) is 20-25% of the gross O_2 flux, resulting in a photosynthetic quotient of 1.25 to 1.33. This is less variable than the canonical photosynthetic quotients of 1.1 to 1.4 proposed by Laws (1991). We will apply photosynthetic quotients carefully, realizing the quotients may differ on the shelfbreak front and elsewhere, and we will use the nutrient data, ^{14}C incubation results, and NCP:GPP ratio to assess the photosynthetic quotient for each location.

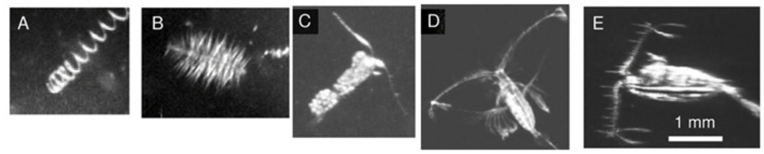

Fig. 8. Example images from the VPR: (A) helical diatom chain, (B) *Chaetoceros* chain, (C-E) copepods. Scale bar in (E) applies to all images.

3.7 Color Digital-Autonomous VPR (DAVPR)

The VPR is an underwater video system that images and identifies plankton and seston in the size range of 50 µm to >1 cm. It has been used extensively in shelf and slope waters to quantitatively map abundance patterns of both delicate and hardy plankton and seston over long distances (1000s of km) with high along-track spatial resolution (cm) (Ashjian et al. 2001, Davis et al. 1992, 2005, Gallager et al. 1996, Norrbin et al. 1996). The non-destructive nature of optical sampling allows us to observe, measure, and count fragile forms in their natural undisturbed state. Detailed intercomparisons of abundance estimates with those from more traditional sampling methods have established the accuracy of the VPR system (Basedow et al. 2013, Benfield et al. 1996, Broughton & Lough 2006).

The VPR can be deployed in a number of configurations, including both towed and profiling modes. Although the towed VPR-II system would have obvious appeal in this frontal environment, the abundance of fishing gear in this area makes the risk of entanglement too great. We will therefore opt for profiling mode with the color digital-autonomous VPR (DAVPR), which is available as shared use equipment at WHOI. The DAVPR fits inside the CTD-rosette frame, with the body clamped in place of a Niskin Bottle. It has a color digital video camera (UNIQ UC-1830CL, 1 megapixel, 10-bits/pixel, 15 frames s^{-1}) and a 20 cm diameter ring illuminator. The ring illuminator provides uniform dark field illumination, yielding better images of elongated and spinose forms. The DAVPR measurements will be used to quantify the abundance and distribution of large phytoplankton and mesozooplankton (Fig. 8), as well as marine snow. These measurements will be complemented by traditional vertical net tows with a ¼ m^2 MOCNESS (also available as shared use equipment) at selected stations.

3.8 Zooplankton grazing

Traditional zooplankton grazing studies have measured grazing by individual taxa, usually copepods, which were added to experimental containers with known phytoplankton concentrations, with the removal of cells over time used to estimate grazing (Campbell et al. 2005, Durbin & Durbin 1992, Frost 1972, Turner & Borkman 2005). While such studies are informative, they only assess grazing by the particular zooplankton species and stage and do not provide information on the impact of microzooplankton grazing (ciliates and heterotrophic dinoflagellates), which have been shown to be quantitatively significant grazers (Calbet & Landry 2004, Irigoien et al. 2005). Microzooplankton grazing is usually estimated with the dilution method (Landry & Hassett 1982). However, some assumptions of this technique are controversial (Agis et al. 2007, Calbet & Saiz 2013, Dolan et al. 2000, Schmoker et al. 2013, Stoecker et al. 2015). To assess the total grazing impact, the grazing of microzooplankton (< 200 µm) and mesozooplankton (> 200 µm) must be simultaneously measured.

These problems have been addressed in our recent studies of zooplankton grazing on dinoflagellates (Petitpas et al. 2015, Turner 2010), which involved incubating natural phyto- and zooplankton to evaluate net growth rates of a target phytoplankton species (*Alexandrium fundyense*). If concentrations of *A. fundyense* were significantly lower after incubation, then the decreases were attributed to grazing. Conversely, if post-incubation concentrations were significantly higher, this was interpreted as growth exceeding grazing. We will employ modified methods of Turner (2010) to measure grazing rates on all phytoplankton taxa in natural seawater samples. Changes in phytoplankton abundance after incubation will be quantified with a suite of methods to cover the full size range of the species assemblage (see below): conventional light microscopy of samples preserved in Utermöhl's solution (Petitpas et al. 2015), and counts from both the FCM and IFCB (Section 3.3). Changes in chlorophyll will also be quantified with standard fluorometric methods. We will conduct one experiment within each of the 12 transects, and the times and locations will coincide with the primary production measurements. Rate process measurements will be made on stations inshore of, offshore from, and at the front.

Grazing experiments will include 4 types of incubations: 1) whole plankton incubated under simulated *in situ* irradiance, 2) whole plankton incubated in the dark, 3) microzooplankton (< 200 µm) incubated under simulated irradiance, and 4) microzooplankton (< 200 µm) incubated in darkness. Dark treatments will minimize phytoplankton growth, allowing separation of grazing from growth of phytoplankton, and integrating circadian cycles in growth and feeding of heterotrophic protists (Jakobsen & Strom 2004). Incubations will be conducted under conditions similar to those of productivity measurements (section 3.5), with samples kept in a deck incubator at ambient temperature, and light in the grazing incubations reduced to 30% E_o with neutral density screens to avoid photo-oxidation of chlorophyll at high light. Incubations will run for 24 h. All treatments will include 3 separate carboys, with 3 replicate subsamples taken from each (432 samples per cruise) for post-incubation counts and identification of phyto-, microzoo- and mesozooplankton.

All samples will be analyzed to quantify and identify phytoplankton from picoplankton to large chain-forming diatoms, as well as their grazers. Changes in abundances of picoplankton and small nanoplankton will be measured by FCM at sea. Changes in microplankton, including chain-forming diatoms and protozoa, will be quantified with the IFCB at sea and conventional microscopy on the Utermöhl-preserved samples ashore. Abundances of microzooplankton and mesozooplankton grazers during incubations will be quantified with conventional microscopy. This will allow estimates of losses from grazing, and growth over and above losses, both for individual phytoplankton taxa as well as for the entire assemblage.

At selected stations where rates are being measured, we will also perform comparisons of the aforementioned grazing studies with the "two-point" dilution technique (Chen 2015 and references therein). This will help to place the results of our grazing studies within the context of the dilution technique, which despite emerging caveats, is still widely used.

3.9 Data synthesis

For each of the cruises, we will time-average the physical and biological data from the 12 transects centered on the front, along with the mooring and mobile asset data from the Pioneer Array. This will help remove high-frequency signals, allowing us to obtain a robust representation of the temporal mean structure of physical and biological properties across the front. We anticipate the plankton community responses to changes in physical circulation will take place over time scales longer than the 1-3 day synoptic scales. Thus, a two-week mean will help reveal how the frontal circulation is related to persistent characteristics of the plankton communities. Data from the individual transects and the differences among them will provide a measure of the temporal variability of the frontal circulation and help quantify how synoptic physical processes affect the plankton.

The FCM and IFCB measurements will enumerate each phytoplankton cell P_i and its associated volume V_i within a given sample, with V_i estimated from light scattering for the FCM (Laney & Sosik 2014) and image analysis for the IFCB (Moberg & Sosik 2012). The carbon content of each cell will be estimated with literature based carbon-to-volume relationships according to Menden-Deuer and Lessard (2000): $\log(C_i) = \alpha + \beta \log(V_i)$; they showed that large diatoms follow a different function than other protists (presumably due to their relatively large vacuoles), so IFCB images will be used to determine the appropriate conversion for each cell type. C_i values can be summed to estimate phytoplankton carbon in size classes of diameter d (µm) that reflect the ecosystem model structure:

$$C_{pico\_nano} = \sum_{i,d<20} C_i \qquad C_{micro} = \sum_{i,d>20} C_i \qquad C_{total} = \sum_{i} C_i$$

POC measurements provide a check on the phytoplankton carbon estimates, as we expect $C_{total} < POC$ because there are other forms of carbon included in POC such as zooplankton and detritus. The FCM/IFCB-derived phytoplankton carbon measurements will also be used together with chlorophyll measurements to compute C:Chl ratios, which will help constrain that parameter in the model.

Light and dark incubations will be used to measure temporal changes in phytoplankton carbon:

$$\left(\frac{dC}{dt}\right)_{light} = growth - grazing \qquad \left(\frac{dC}{dt}\right)_{dark} = -grazing$$

where the total phytoplankton carbon is broken down into the two different size classes. FCM and IFCB measurements in the initials and finals will permit expression of the inferred rates in terms of carbon

$$\frac{dC}{dt} = \frac{(\sum C_i)_{final} - (\sum C_i)_{initial}}{\Delta t}$$

thus providing the opportunity to check for consistency between the incubation-derived growth rates and the ^{14}C productivity measurements

$$\left(\frac{dC}{dt}\right)_{light} - \left(\frac{dC}{dt}\right)_{dark} = growth = \mu C =?\ ^{14}C$$

where μ is the specific growth rate for phytoplankton. Changes in chlorophyll during the incubations, normalized to phytoplankton carbon from the FCM/IFCB, will provide another consistency check.

Growth and grazing (g) rates will be estimated for different size classes of phytoplankton:

$$\left(\frac{dC_{micro}}{dt}\right)_{light} - \left(\frac{dC_{micro}}{dt}\right)_{dark} = \mu_{micro} C_{micro} \qquad \left(\frac{dC_{micro}}{dt}\right)_{dark} = g_{micro} C_{micro}$$

Thus a suite of rate estimates will be available to constrain the model (section 4):

Volumetric photosynthetic rate: size-fractionated ^{14}C	[g C m^{-3} d^{-1}]
Specific phytoplankton growth rates: μ_{total}, μ_{pico_nano}, μ_{micro}	[d^{-1}]
Volumetric grazing rate: $\left(\frac{dC_{total}}{dt}\right)_{dark}$, $\left(\frac{dC_{pico\_nano}}{dt}\right)_{dark}$, $\left(\frac{dC_{micro}}{dt}\right)_{dark}$	[g C m^{-3} d^{-1}]
Specific grazing rates: g_{total}, g_{pico_nano}, g_{micro}	[d^{-1}]
Gross primary production	[g C m^{-2} d^{-1}]
Net community production	[g C m^{-2} d^{-1}]

Volumetric rates will be converted into nitrogen units via the Redfield ratio, constrained by C/N measurements of particulate material. Rates of GPP and NCP will be used as a diagnostic tool to assess the model: GPP will provide an upper limit on modeled photosynthesis, and NCP rates will provide a check on the balance of primary and secondary production. Note that the gas tracer measurements will yield estimates only for the mixed layer; the ^{14}C incubation profiles will be used to scale this mixed layer production for the entire euphotic zone. Because the model only tracks particulate organic carbon, whereas the gas tracer-based rate measurements will include contributions of dissolved organic carbon (DOC), we will assume that DOC fuels ~20% of NCP (Carlson et al. 2010). A recent study has shown DOC production is a near constant fraction of new production and thus by extension of NCP (Romera-Castillo et al. 2016).

In addition to the rate measurements providing constraints on the model (section 4), incubation-based rate information will be extrapolated to larger spatial and temporal scales. Specifically, to expand productivity estimates over similar time and space scales of biomass and composition measurements, a simple bio-optical model will be used to generate productivity from chlorophyll derived from gliders and other platforms. Near-surface quenching of fluorescence during daytime will be corrected with procedures developed from other glider experiments (Kaufman et al. 2014). Using corrected chlorophyll data, productivity will be estimated from a model that combines PAR data, photosynthesis versus irradiance responses, and temperature to estimate productivity (Behrenfeld & Falkowski 1997). Estimates will also be made from satellite algorithms, but we recognize that sub-surface biomass maxima (such as those which might occur) will not be adequately resolved by such models. Hence, a combination of these methods will allow for primary production to be estimated on a variety of temporal and spatial scales. We will take a similar approach to extrapolating the grazing measurements, applying the biomass-normalized rates to biomass estimates from the VPR and IFCB/IFCB-S. These extrapolations will be less spatially extensive than those for primary production facilitated by glider data and satellite imagery, but they will help to extend the scope of our observations.

To evaluate the undersampling hypothesis H_{4b}, we will construct long-term seasonal means of the frontal structure from the entire record of Pioneer Array measurements. Although this will be straightforward for physical oceanographic variables, it will be more challenging for bio-optical instruments for which intercalibration is an issue (Alkire et al. 2012, Briggs et al. 2011, Johnson et al. 2009). We will work directly with the OOI team to make best use of pre- and post-deployment calibration information to ensure that our long-term seasonal means of the cross-frontal structure of fluorescence and backscattering are as accurate as possible. We will also examine the possibility that acoustic data from the Pioneer Array can be used to make quantitative estimates of zooplankton biomass, or at least the seasonal variations thereof (Flagg & Smith 1989, Heywood et al. 1991).

4. Modeling, hypothesis testing, and overall synthesis

Our strategy builds on the foundation of prior models of both the physics and biology of the region. For example, Chen and He (2010) describe hindcasting studies of the circulation in the Middle Atlantic Bight / Gulf of Maine (MABGOM) region. The MABGOM model (Fig. 9) is embedded within the existing data assimilative North Atlantic Hybrid Coordinate Ocean Model (HYCOM; 2007, Chassignet et al. 2003) via a one-way nesting technique (Blayo & Debreu 2006, Marchesiello et al. 2001). Hindcast simulations accurately depict the mean shelf circulation and features of the synoptic variability (Chen & He 2010, Chen et al. 2014). Nested within the MABGOM domain is a high-resolution (1 km) model of the shelfbreak (Fig. 9b), in which a planktonic ecosystem model has been run (He et al. 2011). This inner nest builds on experience from prior nested models of the inner shelf (He & Wilkin 2006, Wilkin 2006), and is described in detail in Chen and He (2010). Although highly relevant to the proposed research, this set of models is not an ideal configuration for our application. Nonetheless, the results of these studies do provide guidance for our specific implementation.

The model we plan to use will build on those implemented by PI Zhang in a recently completed project (see section 6). Like prior models of the region, the New England Shelf Ecosystem and Circulation (NESEC) Model is based on the Regional Ocean Modeling System (ROMS; Shchepetkin & McWilliams 2005). A key attribute of the NESEC implementation is the capability to assimilate data, which will provide realistic estimates of the ocean's physical state on which our coupled physical-biological simulations will be based. ROMS contains algorithms for four-dimensional variational assimilation (4DVAR; Moore et al. 2011a, b, c), which uses observations to correct model initial and boundary conditions and surface forcing, while maintaining the dynamical balance of the system. An appeal of this methodology is that the resulting fields can feed into the term balance analysis, which is important for computing the tracer fluxes associated with physical/biological processes. ROMS 4DVAR has been applied in several coastal areas, including the New York Bight (Zhang et al. 2010). It is currently being used in a MAB model (ESPRESSO; Wilkin & Hunter 2013) for real-time forecasting and hindcasting in a large regional domain that includes the NESEC model domain (Fig. 3).

4.1 Regional 3D hydrodynamic simulations and state estimation

Horizontal resolution of the NESEC model will be 1 km, well below the deformation radius in the region (5-10 km). The model will have ~80 vertical layers. Atmospheric forcing will be specified from the operational North America Mesoscale (NAM) model; oceanic boundary conditions will be provided by ESPRESSO. The simulation will span 2018-2019, covering all cruises. The model will first be tuned to reproduce the regional circulation pattern depicted by the existing observations, so the data assimilation system can be built upon the best possible background "free-run" solution. The annual and seasonal mean of the shelf circulation from this free-run will be compared with climatology (Linder & Gawarkiewicz 1998, Linder et al. 2004, Zhang et al. 2011) and linear models (Lentz 2008a, b).

We will then use 4DVAR data assimilation to correct the fine-scale processes in the model and to provide an improved ocean state for analysis of the frontal dynamics and the hydrodynamic context for 3D

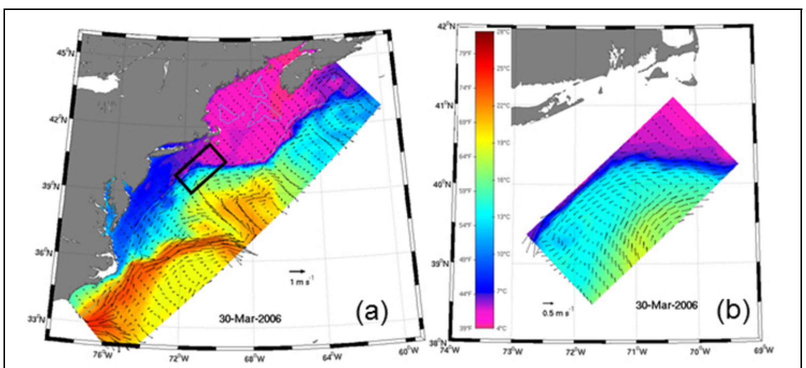

Fig. 9. Simulated sea surface temperature fields on March 30, 2006 (Chen & He 2010). Surface velocity vectors are shown in both the shelf-wide model (a) and its nested 1-km resolution shelfbreak model (b). Domain of the inner nest is depicted by the solid black line in (a).

physical-biological simulations. We will first test the linearization embedded in the tangent linear and adjoint models of the 4DVAR system, which puts a constraint on the length of the individual data assimilation window. Based on our experience, we expect the data assimilation window to be 5-7 days. Data assimilative hindcasts in the NESEC domain will thus be cast in consecutive overlapping windows with a one-day offset as in Zhang et al. (2010). We will then form a continuous reanalysis of the ocean state by concatenating the last day of each of the overlapping windows. This approach diminishes the issue of initialization shocks at the start of each analysis window. With the 4DVAR machinery, we plan to assimilate all available physical measurements, both *in situ* (Pioneer Array and our cruise) and remotely sensed (HF radar-measured surface currents and satellite-measured SST). We will coordinate this effort with our long-term collaborator J. Wilkin (Rutgers) who is funded by NSF (OCE-1459646) to conduct a model-based synthesis of Pioneer Array physical data to infer cross-shelf fluxes, frontal variability, and characteristics of the array. Our interactions will include sharing setups of the model and 4DVAR system, as well as data streams for model initialization, assimilation, and validation.

Our hindcast 4D physical fields will facilitate several lines of inquiry into processes occurring in the vicinity of the shelfbreak. To begin with, analysis of the corrections that 4DVAR makes to open boundary conditions and surface forcing will shed light on limitations of the larger domain ocean model and NAM model in the NESEC area, respectively. Data from the Pioneer Array will be particularly valuable for evaluating these corrections, both in terms of the forcing (meteorological measurements from moorings) and the boundary conditions (glider data). Secondly, the residual differences between simulated and observed properties will provide guidance as to the most important deficiencies of the interior model itself. As such, we will analyze those residuals, identify any coherent patterns, and undertake model improvements as warranted. Thirdly, we will analyze the model output to reveal the characteristic frontal dynamics, including frontal meandering and vorticity dynamics, and the effects of these 3D processes on frontal upwelling, bottom boundary layer detachment, and subsequent transport pathways of those detached fluid parcels. This will provide a quantitative basis on which to assess the relative importance of the four upwelling mechanisms that comprise hypothesis H_1.

4.2 Regional 3D physical-biological simulations

As with the hydrodynamic component, we will build on prior biological models of the region. For example, the seven-component planktonic ecosystem model of Fennel et al. (2006) was implemented for the North East North American (NENA) shelf, nested within the same HYCOM North Atlantic basin-scale model described above. The 10 km horizontal resolution of the NENA model is considerably coarser than will be used in the proposed research, yet comparisons with measurements presented in Fennel et al. (2006) and Hofmann et al. (2008) show that the model captures the large-scale low-frequency characteristics of the region. Modeled mean seasonal cycles of nitrate, ammonium, surface chlorophyll, and primary production generally fall within one standard deviation of observations. Lehmann et al. (2009) found that a more complex ecosystem model can provide even more skillful representation of observations in this region.

The Lehmann et al. (2009) model (based on Lima and Doney (2004)) is well suited to the proposed research, as it differentiates between two "functional groups" (Hood et al. 2006) of phytoplankton: small (picoplankton) and large (diatoms). Such formulations have been included in a number of ecosystem models (Aumont et al. 2003, Chai et al. 2003, Dugdale et al. 2002, Dutkiewicz et al. 2005, Gregg et al. 2003, Ji et al. 2006, Jin et al. 2006, Kishi et al. 2007, Moore et al. 2004). For the present purposes, we will expand the treatment of zooplankton from one type to two, such that microzooplankton and mesozooplankton will be explicitly represented to allow direct comparisons with data from the IFCB and VPR. We will use the measured rates of primary production and grazing, as well as the NCP and GPP estimates to constrain rate processes of the model (see section 3.9 above). To provide initial and boundary conditions for the high-resolution NESEC domain, we will run the biological component in the ESPRESSO model, specifying the initial and boundary conditions with the approach described in Fennel et al. (2006). Given the distance between the boundaries of the ESPRESSO model and the embedded NESEC model, we expect biological constituents to be dynamically adjusted prior to fluid entering into the interior subdomain. We will not conduct data assimilation with either biological model. Skill of the

NESEC biological solutions will be evaluated against our cruise data, with particular emphasis on plankton size structure and composition, as well as nutrient and biomass distributions. Robustness of the solutions will be quantified via parameter dependence and sensitivity analysis.

After quantifying the skill of the model in simulating the observed distributions, we will diagnose the solutions in detail. Initially we will characterize the simulated nutrient, phytoplankton and zooplankton distributions in the frontal area to test hypotheses $H_2 - H_{4a}$. Term balances in the model solutions will be examined in conjunction with the physical and biological observations to understand how frontal circulation affects the productivity and taxonomic composition of the plankton. We will then compute the annual and seasonal along-shelf averaged biomasses of small and large phytoplankton, and small and large zooplankton, and compare to the 2D model results (Zhang et al. 2013). This will allow us to investigate the effects of 3D structure (e.g., cross-shelf meandering of the front) on the climatological cross-shelf distributions of biomass and productivity. Time series of nutrient and biomass fluxes across the shelfbreak will be computed, and their seasonal variation and vertical scales will be examined. EOF analyses on the nutrient and biomass fluxes will be used to check whether they have systematic patterns in space and/or time that can be explained by changes in external forcing. To address H_{4b}, these analyses will be conducted on both seasonal and synoptic time scales to elucidate the degree to which episodic events affect the mean patterns in phytoplankton in and around the front. We will resample the model with space/time resolution typical of the climatology to quantify the degree to which frontal enhancement is captured by such observations, thereby providing a model-based assessment of H_{4b}.

5. Broader impacts

The broader impacts of this project fall into three main categories: 1) “advance discovery and understanding while promoting teaching, training and learning”, 2) “broad dissemination to enhance scientific and technological understanding”, and 3) “benefits to society”.

We will promote teaching and training by incorporating the approaches and results from the proposed studies into a graduate course in physical/biological interactions that Dr. McGillicuddy co-teaches with Prof. Glenn Flierl in the MIT/WHOI Joint Program. The proposed research will also involve graduate and undergraduate students. We anticipate entraining at least 10 undergraduates among the four institutions, drawing from the WHOI Summer Student Fellowship and NSF REU programs, the Wellesley Summer Science Center Research Program, and the UMassD internship program. These programs specifically target underrepresented groups, including first generation college students, and we will seek participants within this pool of candidates who are outside of typical science career paths.

We plan to convey our work to public audiences through open lectures, interviews, and production of at least one article specific to the broader question of the importance of frontal processes to ecosystems. Such an article is proposed for *Oceanus,* a twice-yearly publication by WHOI with a print circulation of 7,000. The magazine also publishes an average of nearly one article per week on its home page, which averages ~45,000 visitors per month. We also plan a three-part video documentary to be produced by Science Media, a company that has produced several such pieces for NSF-sponsored research. A videographer will participate in each of the three cruises, crafting three episodes that focus on the following topics: (1) interdisciplinary science of a highly productive frontal region: physics, chemistry, and biology; (2) use of the OOI assets together with shipboard observations for adaptive sampling of highly dynamic phenomena; and (3) the impact of what is learned on stewardship of living marine resources, with specific connection to the fishing community.

Lastly, better understanding of the dynamics of the shelfbreak front will benefit society by providing an improved scientific basis for stewardship of an important region for both commercial fisheries and biodiversity. Results from the field program will be shared with the Commercial Fisheries Research Foundation (CFRF), a non-profit established by commercial fishermen in southern New England. McGillicuddy and Sosik participated in a joint workshop with CFRF in January 2013 (Gawarkiewicz et al. 2013) that highlighted fishermen’s concerns about rapid ecosystem change and their strong support for basic research in the region. The workshop prioritized research objectives for the shelfbreak ecosystem and highlighted both nutrient distributions and trophic interactions as areas needing further basic field measurements. CFRF holds frequent workshops bringing the academic community together with fishermen and results will be shared at either an appropriate workshop or a CFRF board meeting.

6. Results from prior NSF support

Note: publications listed in section D, marked with a symbol for each PI (,#,@,&,%,^).*

[*]**McGillicuddy, D.J.**, Davis, C.S., Dyhrman, S.T., and J.W. Waterbury**.** OCE-0925284 ($1,321,055; 12/01/2009 - 09/30/2013), *Quantification of Trichodesmium spp. vertical and horizontal abundance patterns and nitrogen fixation in the western North Atlantic*. ***Intellectual merit:*** We tested the hypothesis that populations of *Trichodesmium* spp. deep in the euphotic zone are actively fixing nitrogen, contributing a significant source of new nitrogen heretofore underestimated. Seven refereed publications have resulted thus far, with more in preparation. ***Broader impacts:*** The project provided training for 1 postdoctoral fellow, 3 graduate students, 2 undergraduates, and 1 high school student. An online “citizen science” activity was developed in which participants enumerate *Trichodesmium* images from VPR data.

Petitpas, C.M.: no prior NSF support.

[#]**Smith, W.O.** ANT-0944254 ($365,203; 07/01/2011 - 06/30/2015), *Collaborative Research: Impact of Mesoscale Processes on Iron Supply and Phytoplankton Dynamics in the Ross Sea*. ***Intellectual merit:*** Primary findings were 1) a detailed annual Fe budget indicated the importance of deep-water sources for growth 2) a previously poorly described stage of *Phaeocystis* was observed using the VPR; and 3) spatially variable mixed layers result in substantial spatial variations in biomass. Thus far the project has resulted in 8 peer-reviewed publications with others in preparation; numerous national/international presentations given. ***Broader impacts***: One graduate and two undergraduate students were supported.

Olson, R.J., [@]**Sosik, H.M.** OCE-1130140 ($934,340; 9/15/2011-8/31/2016), *Collaborative Research: Enhanced Imaging Flow Cytometry for Plankton Studies via Acoustic Focusing and Emulsion Microfluidics.* ***Intellectual Merit:*** We developed new capabilities that integrate with the automated imaging-in-flow cytometer Imaging FlowCytobot: acoustic focusing to concentrate particles into the center of the sample stream above the flow cell; physical sorting of imaged cells; and automated live-cell staining for protozoans. To date, the project has resulted in 2 publications, 1 patent application, and over 20 presentations. ***Broader Impacts:*** training two undergraduates, enabling two PhD theses, advancing community technologies, and outreach activities through the Zephyr Education Foundation.

[&]**Stanley, R.** and A. Spivak: OCE-1233678. (8/12 to 7/16) “*Eutrophication Effects on Sediment Metabolism and Benthic Algal-bacterial Coupling: An Application of Novel Techniques in a LTER Estuary*” ($384,493 to Stanley). ***Intellectual Merit:*** We probed effects of increased nutrient loading in salt-marsh creeks and ponds and found increased rates of gross primary production but more negative net community production, a shift in active members of microbial communities, and light respiration rates double those of dark, as described in 3 published papers. ***Broader Impacts****:* We mentored 13 female undergraduate students (including under-represented minorities and first generation college students) and one doctoral student, and provided information on managing an important economic resource.

[%]**Turner, J.T.** subaward from Anderson, D.M., Richlen, M. and Ralston, D. OCE-0430724 ($540,596.00; 09/15/2011 - 08/31/2014), Microbial influences on *Alexandrium* populations. ***Intellectual merit***: We performed whole-community incubation experiments to assess net zooplankton community grazing impact on *Alexandrium* populations in the Nauset Marsh System (NMS) on Cape Cod, resulting in a publication in *Harmful Algae*. ***Broader impacts***: The project provided the basis for a portion of the dissertation research for 1 doctoral student. Environmental and biological data contributed to the management of resources within the NMS, which is part of the Cape Cod National Seashore.

[^]**Zhang, W.G.** and G. Gawarkiewicz: OCE-1129125, $590,249; 09/01/2011–08/31/2015, Dynamics of frontal meandering and related exchange processes at the shelfbreak south of New England. ***Intellectual Merit***: Five journal articles were published on the following topics: 1) shelfbreak variability, 2) an unusual case of Gulf Stream influencing the shelfbreak, 3) mechanisms of frontal meander, 4) dynamics of warm-core ring water onshore intrusion, and 5) the influence of persistent shelfbreak upwelling on local biological productivity and the impact of grazing on phytoplankton biomass. ***Broader Impacts***: We communicated shelfbreak oceanography to general public in New Bedford Fish Expo and a Shelfbreak Ecosystem Workshop, and this project supported the mentoring of two postdocs.

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Professional Preparation:

1987 B.A., *cum laude*, Engineering Sciences, Harvard College, Cambridge, MA.
1989 M.S., Applied Physics, Harvard University, Cambridge, MA.
1993 Ph.D., Earth and Planetary Sciences, Harvard University, Cambridge, MA.
1993-1995 Postdoctoral Scholarship, Woods Hole Oceanographic Institution, Woods Hole, MA

Appointments:

2007-Present Senior Scientist, Woods Hole Oceanographic Institution.
1999-2007 Associate Scientist (tenure in 2003), Woods Hole Oceanographic Institution.
1995-1999 Assistant Scientist, Woods Hole Oceanographic Institution.

Products Most Relevant to Proposal:

1. **McGillicuddy, D.J.**, Anderson, D.M., Lynch, D.R. and D.W. Townsend, 2005. Mechanisms regulating the large-scale seasonal fluctuations in *Alexandrium fundyense* populations in the Gulf of Maine. *Deep-Sea Research II*, **52**, 2698-2714.
2. He R., Chen K., Fennel K., Gawarkiewicz, G.G. and **D.J. McGillicuddy**, 2011. Seasonal and interannual variability of physical and biological dynamics at the shelfbreak front of the Middle Atlantic Bight: nutrient supply mechanisms. *Biogeosciences*, 8, 2935–2946.
3. **McGillicuddy, D.J.**, Townsend, D.W., He, R., Keafer, B.A., Kleindinst, J.L., Li , Y., Manning, J.P., Mountain, D.G., Thomas, M.A., and D.M. Anderson, 2011. Suppression of the 2010 *Alexandrium fundyense* bloom by changes in physical, biological, and chemical properties of the Gulf of Maine. *Limnology and Oceanography*, 56(6), 2411–2426.
4. Zhang, W.G., Gawarkiewicz, G.G., **McGillicuddy, D.J.** and J.L. Wilkin, 2011. Climatological mean circulation at the New England shelf break. *Journal of Physical Oceanography*, 41, 1874-1893.
5. Zhang, W.G., **McGillicuddy, D.J.**, and G.G. Gawarkiewicz, 2013. Is biological productivity enhanced at the New England shelfbreak front? *Journal of Geophysical Research: Oceans*, 118, 517–535, doi:10.1002/jgrc.20068.

Other Significant Products:

1. **McGillicuddy, D.J.**, Robinson, A.R., Siegel, D.A., Jannasch, H.W., Johnson, R., Dickey, T.D., McNeil, J., Michaels, A.F., and A.H. Knap, 1998a. Influence of mesoscale eddies on new production in the Sargasso Sea. *Nature*, **394**, 263-265.
2. **McGillicuddy, D.J.**, Anderson, L.A., Doney, S.C., and M.E. Maltrud, 2003. Eddy-driven sources and sinks of nutrients in the upper ocean: results from a 0.1 degree resolution model of the North Atlantic. *Global Biogeochemical Cycles*, **17**(2), 1035, doi:10.1029/2002GB001987.
3. Davis, C.S. and **D. J. McGillicuddy**, 2006. Transatlantic Abundance of the N_2-Fixing Colonial Cyanobacterium *Trichodesmium*. *Science*, **312**, 1517-1520.
4. **McGillicuddy, D.J.**, Anderson, L.A., Bates, N.R., Bibby, T., Buesseler, K.O., Carlson, C.A., Davis, C.S., Ewart, C., Falkowski, P.G., Goldthwait, S.A., Hansell, D.A., Jenkins, W.J., Johnson, R., Kosnyrev, V.K., Ledwell, J.R., Li, Q.P., Siegel, D.A. and D.K. Steinberg, 2007.

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5. **McGillicuddy, D.J.**, 2011. Eddies Masquerade as Planetary Waves. *Science*, 334, 318-319.

Synergistic Activities

- Development and presentation of a public outreach lecture "Oases in the Oceanic Desert: Turbulent Storms in the Sea and their Impact on Biological Productivity."
- Service on national and international scientific steering committees (U.S. JGOFS, U.S. GLOBEC, GEOHAB).
- Teaching in the MIT/WHOI Joint Program; guest lectures in undergraduate and graduate level courses in ocean science.
- Development of a general computational tool for inversion of the two-dimensional advection-diffusion reaction equation ("Scotia 1.0").

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Professional Preparation:

MIT, Cambridge, MA, Civil Engineering/Water Resources and Environmental Engineering, S.B. 1987.
MIT, Cambridge, MA, Civil Engineering/Water Resources and Environmental Engineering, S.M. 1987.
University of California, San Diego, Scripps Institution of Oceanography, La Jolla, CA, Ph.D. 1993.
Woods Hole Oceanographic Institution, Woods Hole, MA, Postdoctoral Scholar 1993-1996.

Appointments:

Senior Scientist, Woods Hole Oceanographic Institution, 2008-present.
Associate Scientist, Woods Hole Oceanographic Institution, 1999-2008.
Assistant Scientist, Woods Hole Oceanographic Institution, 1994-1999.
Postdoctoral Scholar, Woods Hole Oceanographic Institution, 1993-1996.

5 Closely Related Products:

Hunter-Cevera, K.R., A.F. Post, and H.M. Sosik. 2015. Diversity of *Synechococcus* at the Martha's Vineyard Coastal Observatory: Insights from culture isolations, clone libraries, and flow cytometry. Microbial Ecology. DOI 10.1007/s00248-015-0644-1.

Peacock, E. E., R. J. Olson, and H. M. Sosik. 2014. Parasitic infection of the diatom *Guinardia delicatula*, a recurrent and ecologically important phenomenon on the New England Shelf. Marine Ecology Progress Series. 503: 1-10. (Feature Article)

Hunter-Cevera, K.R, Neubert, M.G., Solow, A.R., Olson, R.J., Shalapynok, A., and Sosik, H.M. 2014. Phytoplankton division rates from size distributions. Proceedings of the National Academy of Sciences of the United States of America. 111: 9852–9857.

Arrigo, K.R., D.K. Perovich, R.S. Pickart, Z.W. Brown, G.L. van Dijken, K.E. Lowry, M.M. Mills, M.A. Palmer, W.M. Balch, F. Bahr, N. R. Bates, C. Benitez-Nelson, B. Bowler, E. Brownlee, J.K. Ehn, K.E. Frey, R. Garley, S.R. Laney, L. Lubelczyk, J. Mathis, A. Matsuoka, B.G. Mitchell, G.W.K. Moore, E. Ortega-Retuerta, S. Pal, C.M. Paloshenski, R.A. Reynolds, B. Schieber, H.M. Sosik, M. Stephens, and J.H. Swift. 2012. Massive phytoplankton blooms under Arctic sea ice. Science.10.1126/science.1215065.

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5 Other Significant Products:

Fischer, A.D., E.A. Moberg, H. Alexander, E.F. Brownlee, K.R. Hunter-Cevera, K.J. Pitz, S.Z. Rosengard, and H.M. Sosik. 2014. Sixty years of Sverdrup: A retrospective of progress in the study of phytoplankton blooms. Oceanography. 27: 222-235.

Laney, S.R., R.J. Olson, and H.M. Sosik. 2012. Diatoms favor their younger daughters. Limnology and Oceanography 57: 1572–1578.

Moberg, E.A. and H.M. Sosik. 2012. Distance maps to estimate cell volume from two-dimensional plankton images. Limnology and Oceanography: Methods. 10: 278–288.

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Olson, R.J. and H.M. Sosik. 2007. A submersible imaging-in-flow instrument to analyze nano- and microplankton: Imaging FlowCytobot. Limnology and Oceanography: Methods. 5: 195-203

Synergistic Activities:

1) Chief Scientist of the Martha's Vineyard Coastal Observatory (2006-present); http://www.whoi.edu/mvco

2) Associate Editor / Editorial Board: Limnology and Oceanography (2003-present), Methods in Oceanography (2012-present); Limnology and Oceanography: Methods (2002-2008);

3) American Geophysical Union, Secretary of Ocean Sciences Section. Recent activity: 2016 AGU Fall Meeting Planning Committee; AGU-ASM Joint Colloquium on Microbes and Climate Change Steering Committee (2015-2016); Ocean Sciences Honors and Recognition Committee (2015-present).

4) NASA research teams and strategic planning committees. Recent activity: Ocean Color Research Team (2000-present); GEO-CAPE Science Working Group (Decadal Survey mission planning, 2009-present); Ocean Biology and Biogeochemistry Program's Working Group on Field Campaigns (2014-present, panel review of EXPORTS and Arctic-COLORS); Biodiversity and Ecological Forecasting Team (2011-2015); Carbon Cycle and Ecosystems Management Operations Working Group (advance/strategic planning group, 2006-2010).

5) Co-developer of automated submersible flow cytometry (including commercial license), Imaging FlowCytobot Data Dashboard for shared access data and data products: http://ifcb-data.whoi.edu/, and published open-access big data sets (millions) of annotated plankton images: http://hdl.handle.net/10.1575/1912/7341.

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Professional Preparation:

Zhejiang University, Hangzhou, China	Fluid Mechanics	B.S.	2000
Zhejiang University, Hangzhou, China	Fluid Mechanics	M.E.	2003
Rutgers, The State University of New Jersey	Oceanography	Ph.D.	2009
Woods Hole Oceanographic Institution	Oceanography	Postdoc	2009-2011

Appointments:

2015-present	Associate Scientist, Woods Hole Oceanographic Institution
2011-2015	Assistant Scientist, Woods Hole Oceanographic Institution
2009-2011	Post-doctoral Scholar, Woods Hole Oceanographic Institution
2004-2009	Research assistant, Institute of Marine and Coastal Sciences, Rutgers University

Products Most Relevant to the Proposal:

1. **Zhang, W. G.**, G. G. Gawarkiewicz, 2015: Dynamics of the direct intrusion of Gulf Stream ring water onto the Mid-Atlantic Bight shelf, *Geophysical Research Letters*, 42, 7687-7695.
2. **Zhang, W. G.**, G. G. Gawarkiewicz, 2015: Length-scale of the finite-amplitude meanders of shelfbreak fronts, *Journal of Physical Oceanography*, 45, 2598-2620.
3. **Zhang, W. G.**, C. Cenedese, 2014: The dispersal of dense water formed in an idealized coastal polynya on a shallow sloping shelf, *Journal of Physical Oceanography*, 44, 1563-1581.
4. **Zhang, W. G.**, D. J. McGillicuddy, and G. G. Gawarkiewicz, 2013: Is biological productivity enhanced at the New England Shelfbreak Front? *Journal of Geophysical Research - Oceans*, **118**, 517-535.
5. **Zhang, W. G.**, G. G. Gawarkiewicz, D. J. McGillicuddy, and J. L. Wilkin, 2011: Climatological mean circulation at the New England shelf break. *Journal of Physical Oceanography*, 41, 1874-1893.

Other Significant Products:

6. **Zhang, W. G.**, T. F. Duda, Ilya A. Udovydchenkov, 2014: Modeling and analysis of internal-tide generation and beam-like onshore propagation in the vicinity of shelfbreak canyons, *Journal of Physical Oceanography*, 44, 834-849.
7. **Zhang, W. G.**, T. F. Duda, 2013: Intrinsic nonlinear and spectral structure of internal tides at a shelfbreak, *Journal of Physical Oceanography*, 43, 2641-2660.
8. **Zhang, W. G.**, J. L. Wilkin, J. C. Levin, 2010, Towards building an integrated observation and modeling system in the New York Bight using variational methods, Part II: representer-based observing system design, *Ocean Modelling*, 35, 134-145.
9. **Zhang, W. G.**, J. L. Wilkin, O. M. E. Schofield, 2010, Simulation of age and residence time in the New York Bight, *Journal of Physical Oceanography*, 40, 965-982.

10. **Zhang, W. G.**, J. L. Wilkin, R. J. Chant, 2009, Modeling of the pathways and mean dynamics of river plume dispersal in New York Bight*, Journal of Physical Oceanography*, 39, 1167-1183.

Synergistic Activities:

Contribution to the development of Regional Ocean Modeling System (ROMS)

Creation of a publically available nutrient and chlorophyll climatology of the shelfbreak region south of New England

Member of an NSF OCE PO proposal review panel

Participation of the NSF EarthCube Early-Career Strategic Visioning Workshop

Participation of the NSF Ocean Observatory Initiative cyber-infrastructure beta test

BIOGRAPHIC SKETCH

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Professional Preparation

Undergraduate Institution: University of Rochester, Rochester, New York; B.S., Biology-Geology, 1972

Graduate Institution: Duke University, Durham, North Carolina; Ph.D., Botany (Minor: Chemistry), 1976

Appointments

2014-2015	King's Professor of Environmental Science, Gothenburg University, Sweden
2009-2012	Visiting Researcher, Institute of Oceanography, Nha Trang, Vietnam
2008-2010	Adjunct Professor, Jinan University, Guangzhou, China
2004	Visiting Researcher, National Institute of Atmospheric and Water Research, Hamilton, NZ
1998-present	Associate/Full Professor, Virginia Institute of Marine Science, College of William & Mary
1989	Chancellor's Award for Research Excellence, University of Tennessee
1985-1998	Member, Science Alliance, University of Tennessee
1983-1984	Visiting Research Professor, Naval Postgraduate School, Monterey, CA (Arctic Chair in Marine Sciences)
1987- 1998	Associate Director and Professor, Department of Botany and Graduate Program in Ecology, University of Tennessee
1976-1987	Assistant/Associate Professor, Department of Botany and Graduate Program in Ecology, University of Tennessee

Products Most Relevant to the Proposed Research

Smith, W.O., Jr., D.J. McGillicuddy Jr., E.B. Olson, V. Kosnyrev, E.E. Peacock and H.M. Sosik. 2016. Mesoscale variability in intact and ghost colonies of Phaeocystis antarctica in the Ross Sea: Distribution and abundance. *J. Mar. Systems* doi:10.1016/j.jmarsys.2016.05.007.

Smith, W.O., Jr. and K. Donaldson. 2015. Photosynthesis-irradiance responses in the Ross Sea, Antarctica: a meta-analysis. *Biogeosciences* 12: 1-11.

McGillicuddy, D.M. Jr., P.N. Sedwick, M.S. Dinniman, K.R. Arrigo, T.S. Bibby, B.J.W. Greenan, E.E. Hofmann, J.M. Klinck, **W.O. Smith, Jr.,** S.L. Mack, C.M. Marsay,

B.M. Sohst, and G. van Dijken. 2015. Iron supply and demand in an Antarctic shelf system. *Geophys. Res. Letters* 42, doi:10.1002/2015GL065727.

Smith, W.O. Jr., D.G. Ainley, K.R. Arrigo, and M.S. Dinniman. 2014. The oceanography and ecology of the Ross Sea. *Ann. Rev. Mar. Sci.* 6: 469-487.

Smith, W.O., Jr., M.S. Dinniman, E.E. Hofmann and J. Klinck. 2014. Impacts of changing winds and temperatures on the oceanography of the Ross Sea in the 21st century. *Geophys. Res. Letters* 41, doi:10.1002/2014GL059311.

Other Significant Products

Kaufman, D.E., M.A.M. Friedrichs, **W.O. Smith, Jr.,** B.Y. Queste, and K.J. Heywood. 2014. Biogeochemical variability in the southern Ross Sea as observed by a glider deployment. *Deep-Sea Res. I* 92: 93-106.

Smith, W.O., Jr. and R.M. Jones. 2014. Vertical mixing, critical depths, and phytoplankton growth in the Ross Sea. *ICES J. Mar. Science*, doi:10.1093/icesjms/fsu234.

Heywood, K.H., S. Schmidtko, C. Heuzé, J. Kaiser, T.D. Jickells, B.Y. Queste, D.P. Stevens, M. Wadley, A.F. Thompson, S. Fielding, D. Guihen, E. Creed, J. Ridley, and **W.O. Smith, Jr.** 2015. Importance of processes at the Antarctic continental slope for climate and the carbon cycle. *Phil. Trans. Roy. Soc., ser. A,* 373, doi:10.1098/rsta.2013.0047.

Smith, W.O., Jr., K.T. Goetz, D.E. Kaufman, B.Y. Queste, V. Asper, D.P. Costa, M.S. Dinniman, M.A.M. Friedrichs, E.E. Hofmann, K.J. Heywood, J.M. Klinck, J.T. Kohut, and C.M. Lee. 2014. Multi-platform, multi-disciplinary investigations of the Ross Sea, Antarctica. *Oceanogr.* 27: 180-185.

Mosby, A. and **W.O. Smith, Jr.** 2015. Phytoplankton growth rates in the Ross Sea, Antarctica. *Aq. Microb. Ecol.* 74: 157-171.

Synergistic Activities

- Service on national and international scientific steering committees (U.S. JGOFS, ICED, OCB)
- Teaching within the VIMS graduate program and W&M undergraduate program in environmental science and marine sciences minor
- Training of graduate students in Vietnam in biological oceanography
- Presentation of seminars to public groups to inform them of the value of oceanographic research and present results from decades of oceanographic research in the Southern Ocean
- Advising governmental agencies in China on future Southern Ocean research

BIOGRAPHICAL SKETCH

Rachel H. R. Stanley
Assistant Professor, Department of Chemistry
Wellesley College
Wellesley, MA 02481
rachel.stanley@wellesley.edu Tel: 781-283-3122 Fax: 781-283-3642

PROFESSIONAL PREPARATION

Massachusetts Institute of Technology	Cambridge, MA	S.B. Chemistry, 2000
National Oceanography Centre	Southampton, United Kingdom	Fulbright Fellowship, 2000-2001
MIT/WHOI Joint Program	Woods Hole, MA	Ph.D. Chemical Oceanography, 2007
Princeton University	Princeton, NJ	NOAA Climate and Global Change Postdoctoral Fellow and Hess Postdoctoral Fellow, Department of Geosciences, 2007-2009

APPOINTMENTS

Jan 2015 to present: Assistant Professor, Department of Chemistry, Wellesley College, Wellesley, MA
May 2016 to present: Adjunct Scientist, WHOI, Woods Hole, MA
July 2009 to Dec. 2014: Assistant Scientist, Department of Marine Chemistry and Geochemistry, Woods Hole Oceanographic Institution, Woods Hole, MA

PRODUCTS

Publications Most Relevant to the Proposed Research
**Denotes student of Stanley*

Stanley, R. H. R. and D. J. McGillicuddy, Jr., "Submesoscale Hotspots of Productivity and Respiration: Insights from High-Resolution Oxygen and Fluorescence Sections", Submitted to Deep Sea Research, I.

Stanley, R. H. R., Z. O. Sandwith, and W. J. Williams. "Rates of summertime biological productivity in the Beaufort Gyre: A comparison between record-low and more typical ice conditions" Journal of Marine Systems. 147, 29-44. (2015).

Stanley, R. H. R., and E. Howard*, "Quantifying rates of benthic microalgal photosynthesis using the triple-isotope composition of dissolved oxygen." Limnology and Oceanography Methods. 11 360-373. (2013).

Goldman, J., S. Kranz, J. Young, P. Tortell, **R. H. R. Stanley,** M. L. Bender, F. Morel. "Gross and net production during the spring bloom along the Western Antarctic Peninsula" New Phytologist, 205. 182-191. (2015)

Kearns, P. J., J. H. Angell, E.M. Howard*, L. A. Deegan, **R. H. R. Stanley** and J. L. Bowen, "Nutrient enrichment induces dormancy and decreases diversity of active bacteria" in press at Nature Communications.

Other Significant Publications:

*Manning, C. M., **R. H. R. Stanley**, and D. E. Lott, III, "Continuous Measurements of Dissolved Ne, Ar, Kr, and Xe Ratios with a Field-deployable Gas Equilibration Mass Spectrometer". Analytical Chemistry, 88, 3040-3048. (2016) .

Stanley, R. H. R. W. J. Jenkins, S. C. Doney, and D. E. Lott, III "The ^{3}He Flux Gauge in the Sargasso Sea: a Determination of Physical Nutrient Fluxes to the Euphotic Zone at the Bermuda Atlantic Time Series Site." Biogeosciences. 12, 5199-5210. doi: 10.5194/bg-12-5199-2015 (2015).

Stanley, R. H. R., and W. J. Jenkins, "Noble Gases in Seawater as Tracers for Physical and Biogeochemical Ocean Processes" in P. Burnard (ed.), The Noble Gases as Geochemical Tracers, Advances in Isotope Geochemistry, DOI: 10.1007/978-3-642-28836-4_4. Springer-Verlag Berlin Heidelberg (2013).

Stanley, R. H. R., S. C. Doney, W. J. Jenkins, and D. E. Lott III, "Apparent oxygen utilization rates calculated from tritium and helium-3 profiles at the Bermuda Atlantic Time-series Study site." Biogeosciences, doi:10.5194/bgd-8-9977-2011, 9977-10015 (2012).

Stanley, R.H.R., J.B. Kirkpatrick, N. Cassar, B.A. Barnett, and M.L. Bender. Net community production and gross production rates in the Western Equatorial Pacific. Global Biogeochemical Cycles. doi:10.1029/h2009GB003651. (2010).

SYNERGISTIC ACTIVITIES

- Currently serving as the United States Representative to the international research initiative Surface Ocean Lower Atmosphere Study (SOLAS)
- Served on the scientific committee of the Gas Transfer at Water Surfaces symposium in 2015 and on the writing committee for the NASA ocean biology and biogeochemistry field experiment EXPORTS (2014-2015)
- Mentored 11 undergraduate students so far at Wellesley college (within first year and a half there) and two graduate, 4 undergraduate and 3 high school students while at Woods Hole Oceanographic Institution.
- Serves as a reviewer for numerous journal articles and for federal proposals.
- Teaches classes at Wellesley College on Aquatic Chemistry, Advanced Inorganic Chemistry, and General Chemistry

BIOGRAPHICAL SKETCH

Jefferson T. Turner
Department of Biology and
School for Marine Science and Technology (SMAST)
Violette Research Building, Room 202, SMAST Room 212
University of Massachusetts Dartmouth
Dartmouth, MA 02747

phone: 508-999-8229
508-910-6332
Email: jturner@umass.edu

Professional Preparation:

Guilford College, Greensboro, NC	Biological Sciences	B.S. 1969
University of South Florida, St. Petersburg, FL	Marine Science	M.A. 1972
Texas A&M University, College Station, TX	Oceanography	Ph.D. 1977

Appointments:

Assistant Professor, Associate Professor, Professor, Chancellor Professor, University of Massachusetts Dartmouth	1979-Present
Associate Research Scientist, New York Ocean Science Laboratory, Montauk	1978-1979
Postdoctoral Researcher, University of West Florida, Pensacola	1977-1978

Products Most Relevant to Proposal:

Petitpas, C. M., J. T. Turner, B. A. Keafer, D. J. McGillicuddy Jr., and D. M. Anderson (2015) Zooplankton community grazing impact on a toxic bloom of *Alexandrium fundyense* in the Nauset Marsh System, Cape Cod, Massachusetts, USA. Harmful Algae 47: 42-55.

Turner, J. T. (2010) Zooplankton community grazing impact on a bloom of *Alexandrium fundyense* in the Gulf of Maine. Harmful Algae 9: 578-589.

Turner, J. T. (2006) Harmful algae interactions with marine planktonic grazers, Chapter 20, p. 259-270. In: E. Granéli & J. T. Turner (editors), *Ecology of Harmful Algae*. Ecological Studies 189. Springer-Verlag, Berlin & Heidelberg.

Turner, J. T. and D. G. Borkman. (2005) Impact of zooplankton grazing on *Alexandrium* blooms in the offshore Gulf of Maine. Deep-Sea Research II 52: 2801-2816.

Turner, J. T. and P. A. Tester (1997) Toxic marine phytoplankton, zooplankton grazers, and pelagic food webs. Limnology and Oceanography 42: 1203-1214.

Other Significant Products:

Petitpas, C. M., J. T. Turner, J. R. Deeds, B. A. Keafer, D. J. McGillicuddy Jr., P. J. Milligan, V. Shue, K. D. White, and D. M. Anderson. (2014) PSP toxin levels and plankton community composition and abundance in size-fractionated vertical profiles during spring/summer blooms of the toxic dinoflagellate *Alexandrium fundyense* in the Gulf of Maine and on Georges Bank, 2007, 2008, and 2010: 2. Plankton community composition and abundance. Deep-Sea Research II 103: 350-367.

Ianora, A., M. Bastianini, Y. Carotenuto, R. Casotti, V. Roncalli, A. Miralto, G. Romano, A. Gerecht, A. Fontana, J. T. Turner. (2015) Non-volatile oxylipins can render some diatom blooms more toxic for copepod reproduction. Harmful Algae 44: 1-7.

Turner, J. T., Borkman, D. G., Libby, P. S. (2011). Zooplankton trends in Massachusetts Bay, USA: 1998-2008. Journal of Plankton Research 33: 1066-1080.

Turner, J. T., Borkman, D. G., Lincoln, J. A., Gauthier, D. A., Petitpas, C. M. (2009). Plankton studies in Buzzards Bay, Massachusetts, USA. VI. Phytoplankton and water quality, 1987 to 1998. Marine Ecology Progress Series 376: 103-122.

Turner, J. T. (2015) Zooplankton fecal pellets, marine snow, phytodetritus and the ocean's biological pump. Progress in Oceanography 130: 205-248.

Synergistic Activities:

1. Teaching 4-6 undergraduate and graduate courses per year in biology, oceanography, and biogeography (1979 - present)
2. Department Chair, Biology Department, UMass Dartmouth (2004-2006)
3. Collaboration with colleagues at Woods Hole Oceanographic Institution, University of Maine, NOAA, & US FDA, in studies of red tide blooms in the Gulf of Maine and on Cape Cod, and toxin accumulation and transport in zooplankton (1998 - present)
4. Year-round monitoring of plankton communities in Buzzards Bay (since 1987) and Boston Harbor, Massachusetts Bay and Cape Cod Bay (since 1992)
5. Editorial Board, *Harmful Algae*, *Journal of Experimental Marine Biology and Ecology*, *Aquatic Microbial Ecology*, *Journal of Plankton Research*, *Marine Ecology: An Evolutionary Approach*

BIOGRAPHICAL SKETCH

Christian M. Petitpas
Research Associate
School for Marine Science and Technology (SMAST)
University of Massachusetts Dartmouth
New Bedford, Massachusetts 02744

Phone: (508) 910-6385
Email: cjadlowic@umassd.edu

Professional Preparation:

University of Massachusetts Dartmouth	Biology/Biochemistry minor	B.S. 2002
University of Massachusetts School for Marine Science and Technology (SMAST), Marine Science and Technology-Living Marine Resources Science and Management		M.A. 2011
University of Massachusetts SMAST, Marine Science and Technology-Living Marine Resources Science and Management		Ph.D. 2015

Appointments:

Environmental Review Assistant, Massachusetts Division of Marine Fisheries	2009-present
Research/Technical Associate, University of Massachusetts Dartmouth	2005-present
Research Assistant, University of Massachusetts Dartmouth	2001-2004
Guest Investigator/Research Intern, Woods Hole Oceanographic Institution	2001-2004

Products Most Relevant to Proposal:

Petitpas, C. M., J. T. Turner, B. A. Keafer, D. J. McGillicuddy Jr., and D. M. Anderson (2015) Zooplankton community grazing impact on a toxic bloom of *Alexandrium fundyense* in the Nauset Marsh System, Cape Cod, Massachusetts, USA. Harmful Algae 47: 42-55.

Petitpas, C. M., J. T. Turner, J. R. Deeds, B. A. Keafer, D. J. McGillicuddy, Jr., P. J. Milligan, V. Shue, K. D. White, & D. M. Anderson. (2013) PSP toxin levels and plankton community composition and abundance in size-fractionated vertical profiles during spring/summer blooms of the toxic dinoflagellate *Alexandrium fundyense* in the Gulf of Maine and on Georges Bank, 2007, 2008, and 2010. 2. Plankton community composition and abundance. Deep-Sea Research II, DOI: 10.1016/j.dsr2.2013.04.012

Deeds, J. R., C. M. Petitpas, V. Shue, K. D. White, B. A. Keafer, D. J. McGillicuddy, Jr., P. J. Milligan, D. M. Anderson, & J. T. Turner. (2013) PSP toxin levels and plankton community composition and abundance in size-fractionated vertical profiles during spring/summer blooms of the toxic dinoflagellate *Alexandrium fundyense* in the Gulf of Maine and on Georges Bank, 2007, 2008, and 2010. 1. Toxin levels. Deep-Sea Research II, 10.1016/j.dsr2.2013.04.013

Turner, J.T., D.G. Borkman, J. A. Lincoln, D. A. Gauthier, C. M. Petitpas. 2009. Plankton studies in Buzzards Bay, Massachusetts, USA, VI. Phytoplankton and water quality, 1987 to 1998. Mar Ecol. Prog. Ser. 376: 103-122.

Synergistic Activities:

1. Part-time lecturer teaching courses in Biological Oceanography (lecture and laboratory) and Principles of Sustainability at University of Massachusetts Dartmouth and Northeast Maritime Institute.
2. Year-round monitoring of water quality and plankton communities in Buzzards Bay, MA since 2000 (monitoring began in 1987).
3. Collaboration with colleagues at Woods Hole Oceanographic Institution, University of Maine, NOAA, & US FDA, in studies of red tide blooms in the Gulf of Maine and on Cape Cod, and toxin accumulation and transport in zooplankton (2001-present)
4. Organized and presented Harmful Algal Bloom (HAB) Workshops for the Massachusetts Shellfish Officers Association (MSOA) Constable Training Program at MA Maritime Academy. Local shellfish constables, who are tasked to initiate, promote and manage shellfisheries in their city or town, were taught the basic biology and ecology of harmful algae and how to microscopically identify local harmful algae in water samples.
5. Organized and presented hands-on learning workshops at the 4th, 5th and 6th Annual Greenlight for Girls/STEM4Girls events. These events were dedicated to inspiring girls of all backgrounds age 10-15 years old to pursue STEM (Science, Technology, Engineering and Mathematics) subjects by introducing them to the world of science in fun and exciting ways.

SUMMARY YEAR 1
PROPOSAL BUDGET

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months)	
	Proposed	Granted
AWARD NO.		

ORGANIZATION
Woods Hole Oceanographic Institution

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Dennis McGillicuddy

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. Dennis J McGillicuddy - Principal Investigator	2.00	0.00	0.00	45,064	
2. Heidi M Sosik - Co-Principal Investigator	2.00	0.00	0.00	40,803	
3. Weifeng Zhang - Co-Principal Investigator	4.00	0.00	0.00	47,424	
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (3) TOTAL SENIOR PERSONNEL (1 - 6)	8.00	0.00	0.00	133,291	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	0	
2. (4) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	16.50	0.00	0.00	120,742	
3. (1) GRADUATE STUDENTS				37,623	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (1) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				3,495	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				295,151	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				85,050	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				380,201	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.) 64TB Data Server $ 7,500					
TOTAL EQUIPMENT				7,500	
E. TRAVEL 1. DOMESTIC (INCL. U.S. POSSESSIONS)				4,158	
2. FOREIGN				0	
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 0 2. TRAVEL 0 3. SUBSISTENCE 0 4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				23,878	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				3,078	
5. SUBAWARDS				0	
6. OTHER				141,197	
TOTAL OTHER DIRECT COSTS				168,153	
H. TOTAL DIRECT COSTS (A THROUGH G)				560,012	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) Modified Total Direct Costs (MTDC) (Rate: 54.0200, Base: 478200) (Cont. on Comments Page)					
TOTAL INDIRECT COSTS (F&A)				278,648	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				838,660	
K. SMALL BUSINESS FEE				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				838,660	

M. COST SHARING PROPOSED LEVEL $ 0 AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Dennis McGillicuddy

ORG. REP. NAME*
David Stephens

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET COMMENTS - Year 1

** I- Indirect Costs
Modified Total Direct Costs (MTDC) GRA (Rate: 54.0200, Base 37623)

SUMMARY PROPOSAL BUDGET

YEAR 2

ORGANIZATION: Woods Hole Oceanographic Institution			FOR NSF USE ONLY		
			PROPOSAL NO.	DURATION (months) Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR: Dennis McGillicuddy			AWARD NO.		

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. Dennis J McGillicuddy - Principal Investigator	1.00	0.00	0.00	23,321	
2. Heidi M Sosik - Co-Principal Investigator	2.00	0.00	0.00	36,948	
3. Weifeng Zhang - Co-Principal Investigator	4.00	0.00	0.00	45,570	
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (3) TOTAL SENIOR PERSONNEL (1 - 6)	7.00	0.00	0.00	105,839	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	0	
2. (4) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	15.50	0.00	0.00	103,110	
3. (1) GRADUATE STUDENTS				39,127	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (1) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				3,618	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				251,694	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				73,352	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				325,046	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. U.S. POSSESSIONS)				7,182	
2. FOREIGN				0	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ 0					
2. TRAVEL 0					
3. SUBSISTENCE 0					
4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				12,428	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				6,500	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				3,192	
5. SUBAWARDS				0	
6. OTHER				90,281	
TOTAL OTHER DIRECT COSTS				112,401	
H. TOTAL DIRECT COSTS (A THROUGH G)				444,629	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) Modified Total Direct Costs (MTDC) (Rate: 54.0200, Base: 371629) (Cont. on Comments Page)					
TOTAL INDIRECT COSTS (F&A)				221,890	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				666,519	
K. SMALL BUSINESS FEE				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				666,519	
M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $				

PI/PD NAME: Dennis McGillicuddy	FOR NSF USE ONLY		
	INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME*: David Stephens	Date Checked	Date Of Rate Sheet	Initials - ORG

 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

SUMMARY PROPOSAL BUDGET COMMENTS - Year 2

**** I- Indirect Costs**
Modified Total Direct Costs (MTDC) GRA (Rate: 54.0200, Base 39127)

SUMMARY PROPOSAL BUDGET

YEAR 3

ORGANIZATION: **Woods Hole Oceanographic Institution**				FOR NSF USE ONLY		
				PROPOSAL NO.	DURATION (months) Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR: **Dennis McGillicuddy**				AWARD NO.		
A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)	
1. **Dennis J McGillicuddy - Principal Investigator**	1.00	0.00	0.00	**18,098**		
2. **Heidi M Sosik - Co-Principal Investigator**	2.00	0.00	0.00	**32,774**		
3. **Weifeng Zhang - Co-Principal Investigator**	4.00	0.00	0.00	**43,536**		
4.						
5.						
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**		
7. (**3**) TOTAL SENIOR PERSONNEL (1 - 6)	7.00	0.00	0.00	**94,408**		
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)						
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**		
2. (**4**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	10.50	0.00	0.00	**61,912**		
3. (**1**) GRADUATE STUDENTS				**40,692**		
4. (**0**) UNDERGRADUATE STUDENTS				**0**		
5. (**1**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**3,745**		
6. (**0**) OTHER				**0**		
TOTAL SALARIES AND WAGES (A + B)				**200,757**		
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**59,224**		
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**259,981**		
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)						
TOTAL EQUIPMENT				**0**		
E. TRAVEL 1. DOMESTIC (INCL. U.S. POSSESSIONS)				**12,753**		
2. FOREIGN				**0**		
F. PARTICIPANT SUPPORT COSTS						
1. STIPENDS $ **0**						
2. TRAVEL **0**						
3. SUBSISTENCE **0**						
4. OTHER **0**						
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**		
G. OTHER DIRECT COSTS						
1. MATERIALS AND SUPPLIES				**2,500**		
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**6,500**		
3. CONSULTANT SERVICES				**0**		
4. COMPUTER SERVICES				**3,268**		
5. SUBAWARDS				**0**		
6. OTHER				**42,635**		
TOTAL OTHER DIRECT COSTS				**54,903**		
H. TOTAL DIRECT COSTS (A THROUGH G)				**327,637**		
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **Modified Total Direct Costs (MTDC) (Rate: 54.0200, Base: 256124) (Cont. on Comments Page)**						
TOTAL INDIRECT COSTS (F&A)				**160,340**		
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**487,977**		
K. SMALL BUSINESS FEE				**0**		
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				**487,977**		
M. COST SHARING PROPOSED LEVEL $ **0**	AGREED LEVEL IF DIFFERENT $					
PI/PD NAME: **Dennis McGillicuddy**				FOR NSF USE ONLY — INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME*: **David Stephens**				Date Checked	Date Of Rate Sheet	Initials - ORG

 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

SUMMARY PROPOSAL BUDGET COMMENTS - Year 3

**** I- Indirect Costs**
Modified Total Direct Costs (MTDC) GRA (Rate: 54.0200, Base 40692)

SUMMARY PROPOSAL BUDGET

Cumulative

ORGANIZATION: Woods Hole Oceanographic Institution				FOR NSF USE ONLY	
				PROPOSAL NO.	DURATION (months): Proposed / Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR: Dennis McGillicuddy				AWARD NO.	

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. Dennis J McGillicuddy - Principal Investigator	4.00	0.00	0.00	86,483	
2. Heidi M Sosik - Co-Principal Investigator	6.00	0.00	0.00	110,525	
3. Weifeng Zhang - Co-Principal Investigator	12.00	0.00	0.00	136,530	
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (3) TOTAL SENIOR PERSONNEL (1 - 6)	22.00	0.00	0.00	333,538	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	0	
2. (12) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	42.50	0.00	0.00	285,764	
3. (3) GRADUATE STUDENTS				117,442	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (3) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				10,858	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				747,602	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				217,626	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				965,228	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.) $ 7,500					
TOTAL EQUIPMENT				7,500	
E. TRAVEL 1. DOMESTIC (INCL. U.S. POSSESSIONS)				24,093	
2. FOREIGN				0	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ 0					
2. TRAVEL 0					
3. SUBSISTENCE 0					
4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				38,806	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				13,000	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				9,538	
5. SUBAWARDS				0	
6. OTHER				274,113	
TOTAL OTHER DIRECT COSTS				335,457	
H. TOTAL DIRECT COSTS (A THROUGH G)				1,332,278	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)					
TOTAL INDIRECT COSTS (F&A)				660,878	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				1,993,156	
K. SMALL BUSINESS FEE				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				1,993,156	
M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $				

PI/PD NAME: Dennis McGillicuddy	FOR NSF USE ONLY		
	INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME*: David Stephens	Date Checked	Date Of Rate Sheet	Initials - ORG

C *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

Budget Information

The Woods Hole Oceanographic Institution (WHOI) is a non-profit [501c(3)] research and education organization subject to the cost principles of 2 CFR 200. WHOI Principal Investigators are responsible for conceiving, funding and carrying out their research programs. Senior Personnel are expected to raise 12 months of support for themselves and their staff by writing proposals and obtaining sponsored research grants and contracts from a variety of sources. Some teach voluntarily in WHOI's Joint Program, but support for this is limited. NSF has confirmed to WHOI that salary support from grants beyond 2 months per year can be justifiable for these Principal Investigators.

The rates included in the proposal are negotiated with our cognizant government agency.

For 2017 and beyond, WHOI has a negotiated rate agreement with the Office of Naval Research and uses the method of allocation of indirect costs to Modified Total Direct Costs (MTDC). The normal exclusions contained in 2 CFR 200.68 (MTDC) apply, as well as the following cost categories; ship use, submersible use, vessel charters and ship fuel.

A proposed labor month is equal to 152 hours or 1824 hours annually versus 2080 hours (40 hours/week for 52 weeks). The difference is for vacations, holidays, sick time, and other paid absences, which are included in the Paid Absences calculation. WHOI cannot "waive" or reduce overhead rates on any sponsored research project due to the structure of our negotiated rates with our cognizant government agency (Office of Naval Research). When a program sets limits on overhead, WHOI must use Institution unrestricted funds to pay the unfunded portion of the overhead costs.

Budget Justification

Salaries: As lead investigator, Dr. McGillicuddy will oversee all aspects of the project. His group's responsibilities include acquisition and analysis of (1) hydrography, (2) nutrients, and (3) Video Plankton Recorder (VPR) data at CTD stations. Dr. McGillicuddy requests two months salary in year one and one month in years two and three. He will serve as chief scientist in all three cruises. O. Kosnyrev will participate in all of the cruises and serve as Dr. McGillicuddy's primary assistant for post cruise data analysis and visualization. Ms. Kosnyrev will also be responsible for submission of our data to BCO-DMO as described in our data management plan. Salary support requested for Ms. Kosnyrev to carry out these tasks amounts to three months per year in years one and two, followed by two months in year three.

Salary support in the amount of two months per year is requested for PI Sosik to oversee the phytoplankton observation and analysis components of the project, including participation in cruises. Four months salary per year is requested for Research Assistants E. Peacock and E. Crockford to maintain and prepare instrumentation and laboratory apparatus and supplies required for phytoplankton and pigment observations and to conduct routine sampling on cruises. In year three they will perform supervised data processing and analysis of the observations. Sosik will supervise a full time Graduate Research Assistant pursuing a Ph.D. in the MIT/WHOI Joint Program. The student (TBA) will participate in the proposed cruises, and focus his/her thesis research on analysis and interpretation of the IFCB observations.

PI Rachel Stanley (Wellesley College) will supervise the gas tracer components of the project. Salary support for her is requested through the Wellesley component of the proposal. Z. Sandwith will participate in all the cruises, where she will be in charge of the equilibrator inlet mass spectrometer and will collect samples for triple oxygen isotopes. Additionally, Sandwith will run the triple oxygen isotope samples on the mass spectrometer system at WHOI. For these tasks, 5.5 months of salary support is requested in year one, 4.5 months in year two, and two weeks in year three.

PI Zhang requests four months salary support per year to (1) participate in the cruises, (2) implement the 4DVAR data assimilation system, (3) conduct the realistic physical and biological simulations, (4) conduct model-data comparisons, (5) use the model results to diagnose the various mechanisms of upwelling, and (6) analyze results of the biological simulations and sensitivities of the results to various biological parameters.

Two weeks of support for S. Barkley is requested each year to assist with grant management, manuscript preparation, travel and cruise logistics, and preparation of project reports. These tasks are specifically related to the project and are not supported by overhead.

Equipment: Allowances are requested for an 64TB (usable space) Raid file server to store the model output locally for dynamical analysis.

Travel: Funds are requested for team members to attend national scientific meetings to report on the results of the project. For budgeting purposes, the estimated cost of attending a meeting in San Francisco, CA (e.g., AGU) is specified for domestic travel (one person in years 1 and 2 and three persons in year 3, seven days per trip totaling $4,158/$4,202/$4,251) and the Ocean Sciences meeting in New Orleans, LA ($2,980 for one person in year 2 for seven days). Estimates for airfare are based on rates currently available on Expedia for refundable tickets and include an allowance for baggage and agent fees. Ground transportation costs include rental car(s) and transportation to/from the airports. Meeting registration fees are based on previous meetings. Per diem expenses are based on rates currently available via the GSA website (http://www.gsa.gov/portal/category/21287) for domestic travel. Travel funds are not required for the cruises as they are WHOI to WHOI.

Other Direct Costs:

Supplies: The network of workstations currently available in the laboratories of PIs McGillicuddy, Sosik, and Zhang will be sufficient for the research proposed herein. However, allowances for computer supplies specific to the proposed work (CPU upgrades, backup units, toner cartridges, batteries and electronic storage devices) are requested to keep this infrastructure current ($8,000 year 1, $2,500 year 2, $2,500 year 3). We request funds ($6,000 year 1 and $4,000 year 2) to purchase laboratory supplies required for sample collection and analysis (e.g., bottles, filters, vacuum pumps, reagents) and instrument maintenance (e.g., cables, replacement syringes and pumps). Additionally, funds are requested for consumable supplies for the equilibrator inlet mass spectrometer during the cruise, such as equilibrator cartridges, filters, tubing, filaments, etc. ($3,200 in year 1, $2,100 in year 2). In year 1, funds are also requested for a replacement gear pump for the equilibrator inlet mass spectrometer ($1,200). Supplies required for analyzing the triple oxygen isotope mass spectrometer include a filament and gold gasket for each set of cruise samples (oxygen is harsh on filaments and makes them need to be replaced more often that is common for analysis of other gases) ($2,600 in year 1, $1,300 in year 2), and gases such as liquid nitrogen, compressed nitrogen and helium ($2,078 in years 1 and 2). Funds are also requested for sampling supplies for the triple oxygen isotope samples (torrlube grease, tubing) ($300 in year 1, $150 in year 2) and for miscellaneous supplies needed during analysis (turbo pump wicks, rough pump oil, vaccum grease, etc.) amounting to $500 in year 1 and $300 in year 2.

Publications: Publication costs are requested to disseminate the results in peer-reviewed journals.

Computer Services*:* Support for Technical Assistance is requested to maintain the local computational infrastructure we will be using in this research (38 hours per year at $81, $84, $86 hourly rate). WHOI's policy is for hardware repairs, upgrades, and maintenance of computer systems to be charged at a flat hourly rate for technical assistance plus the cost of parts.

Other Costs*:* Nutrient samples will be run at the WHOI Nutrient Analytical Facility. We have budgeted for 864 samples per cruise, with a per sample charge of $29 in year 1 ($50,112) and $30 year 2 ($25,920) to measure a full suite of nitrate + nitrite, phosphate, silicic acid, and ammonium. Outside services for HPLC pigment analysis will be required in years 1 and 2 (240 samples per cruise, for a total of $33,600 in year 1 and $16,800 in year 2). GRA tuition costs for the TBA student in the Sosik lab is requested in each year ($27,955 year 1, $29,353 year 2, $30,821 year 3). The custom-made sample bottles for the triple oxygen isotope samples will be pumped down on the vacuum preparation lines of the Isotope Geochemistry Facility (IGF) at WHOI. Funding for the costs associated with labor and line use for pumping those sample bottles is requested ($4000 in year 1, $2,000 in year 2). Funding is also requested for a one-time factory servicing (year 2), including cleaning and maintenance, of the Pfeiffer mass spectrometer used in the equilibrator inlet mass spectrometer system ($2,500).

Outside services for video documentaries described in Broader Impacts (section 5 of the proposal) will be provided by Science Media (portfolio available at www.sciencemedia.nl). The firm is led by creative director Dan Brinkhuis, an award-winning producer who has worked with many scientific institutions worldwide, including the International Ocean Discovery Program (IODP/NSF) Netherlands Organization for Scientific Research (NWO), Royal Netherlands Institute for Sea Research (NIOZ), Woods Hole Oceanographic Institution, University of California, Utrecht University, Consortium for Ocean Leadership, NTR SchoolTV (public broadcasting), and Scientific Committee on Oceanic Research (SCOR). In short, the plan is to capture the highlights of the cruises on HD video by a professional videographer. The videographer will follow the proceedings, connect with the key science staff (interviews) and tell the science story while this science project is in progress and new insights are gained by making a suit of short videos (approximately 10 min. each) on three specific themes and one final overarching documentary (20 min) after the field research phase:

1 Interdisciplinary science of a highly productive frontal region: physics, chemistry, biology.
2 Use of OOI assets together with shipboard observations for adaptive sampling.
3 Impact of what is learned on stewardship of living marine resources, with specific connection to the fishing community.
4 Summary of the projects highlights & scientific conclusions.

The aim with this video series is also to inspire (layman) audiences and students to ‘feel’ the excitement of (multi-disciplinary) marine research and its ‘curiosity’ driven team of scientists. Sharing the vision & mission and how they operate and cooperate to get results, embrace difficulties (and cope with failures) is a very interesting cinematic and dramatic viewpoint. Filming: on board shooting will utilize two High Definition (16:9) cameras: one main professional camera and a smaller compact GoPro HD cam as backup. The GoPro HD camera can even be rigged on marine equipment and can handle water depth of 60 meters. Both are proven and compact sets for travelling, easy to handle & have amazing professional HD imaging capabilities. Editing: on board editing platform will be Apple's (laptop) Final Cut Pro system & other design applications. This professional and high end editing system can be used for all suggested videos. Other benefits: easy transfer for creating Internet clips, photographic material can be incorporated and exported to all kind of resolutions/formats. All rights to the content will be owned by WHOI. If WHOI were to resell the content, a fee to ScienceMedia would be incurred. Science Media’s plan for this project is described in the following letter with a total budget of $49,852 ($25,130 year 1, $13,308 year 2, $11,414 year 3).

SUMMARY PROPOSAL BUDGET

YEAR 1

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months)	
	Proposed	Granted
AWARD NO.		

ORGANIZATION
College of William & Mary Virginia Institute of Marine Science

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Walker Smith

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Walker O Smith - Professor**	1.00	0.00	0.00	**16,562**	
2.					
3.					
4.					
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**1**) TOTAL SENIOR PERSONNEL (1 - 6)	1.00	0.00	0.00	**16,562**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**	
2. (**1**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	6.00	0.00	0.00	**28,356**	
3. (**0**) GRADUATE STUDENTS				**0**	
4. (**2**) UNDERGRADUATE STUDENTS				**4,000**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**48,918**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**18,267**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**67,185**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. U.S. POSSESSIONS)				**14,687**	
2. FOREIGN				**0**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **0**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**35,600**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**0**	
3. CONSULTANT SERVICES				**0**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**0**	
6. OTHER				**0**	
TOTAL OTHER DIRECT COSTS				**35,600**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**117,472**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **MTDC (Rate: 45.7000, Base: 117472)**					
TOTAL INDIRECT COSTS (F&A)				**53,685**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**171,157**	
K. SMALL BUSINESS FEE				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				**171,157**	

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME **Walker Smith**	**FOR NSF USE ONLY**		
	INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME*	Date Checked	Date Of Rate Sheet	Initials - ORG

 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET

YEAR 2

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months)	
	Proposed	Granted
AWARD NO.		

ORGANIZATION
College of William & Mary Virginia Institute of Marine Science

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Walker Smith

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. Walker O Smith - Professor	1.00	0.00	0.00	17,390	
2.					
3.					
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)	1.00	0.00	0.00	17,390	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	0	
2. (1) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	6.00	0.00	0.00	29,774	
3. (0) GRADUATE STUDENTS				0	
4. (2) UNDERGRADUATE STUDENTS				4,000	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				51,164	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				19,166	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				70,330	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. U.S. POSSESSIONS)				9,710	
2. FOREIGN				0	
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 0 2. TRAVEL 0 3. SUBSISTENCE 0 4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				16,300	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				1,500	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				0	
6. OTHER				0	
TOTAL OTHER DIRECT COSTS				17,800	
H. TOTAL DIRECT COSTS (A THROUGH G)				97,840	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) MTDC (Rate: 45.7000, Base: 97839)					
TOTAL INDIRECT COSTS (F&A)				44,712	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				142,552	
K. SMALL BUSINESS FEE				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				142,552	

M. COST SHARING PROPOSED LEVEL $ 0 AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Walker Smith

ORG. REP. NAME*

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET

YEAR 3

ORGANIZATION **College of William & Mary Virginia Institute of Marine Science**				FOR NSF USE ONLY PROPOSAL NO.	DURATION (months) Proposed / Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR **Walker Smith**				AWARD NO.	

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Walker O Smith - Professor**	1.00	0.00	0.00	**18,260**	
2.					
3.					
4.					
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**1**) TOTAL SENIOR PERSONNEL (1 - 6)	1.00	0.00	0.00	**18,260**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**	
2. (**1**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	4.50	0.00	0.00	**23,447**	
3. (**0**) GRADUATE STUDENTS				**0**	
4. (**2**) UNDERGRADUATE STUDENTS				**4,000**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**45,707**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**16,983**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**62,690**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. U.S. POSSESSIONS)				**5,133**	
2. FOREIGN				**0**	
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ **0** 2. TRAVEL **0** 3. SUBSISTENCE **0** 4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**3,900**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**1,500**	
3. CONSULTANT SERVICES				**0**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**0**	
6. OTHER				**0**	
TOTAL OTHER DIRECT COSTS				**5,400**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**73,223**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **MTDC (Rate: 45.7000, Base: 73222)**					
TOTAL INDIRECT COSTS (F&A)				**33,462**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**106,685**	
K. SMALL BUSINESS FEE				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				**106,685**	
M. COST SHARING PROPOSED LEVEL $ **0**	AGREED LEVEL IF DIFFERENT $				

PI/PD NAME **Walker Smith**	FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME*	Date Checked	Date Of Rate Sheet	Initials - ORG

 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET

Cumulative

ORGANIZATION College of William & Mary Virginia Institute of Marine Science	**FOR NSF USE ONLY** PROPOSAL NO.	DURATION (months) Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR Walker Smith	AWARD NO.		

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. Walker O Smith - Professor	3.00	0.00	0.00	52,212	
2.					
3.					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)	3.00	0.00	0.00	52,212	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	0	
2. (3) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	16.50	0.00	0.00	81,577	
3. (0) GRADUATE STUDENTS				0	
4. (6) UNDERGRADUATE STUDENTS				12,000	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				145,789	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				54,416	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				200,205	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. U.S. POSSESSIONS)				29,530	
2. FOREIGN				0	
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 0 2. TRAVEL 0 3. SUBSISTENCE 0 4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				55,800	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				3,000	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				0	
6. OTHER				0	
TOTAL OTHER DIRECT COSTS				58,800	
H. TOTAL DIRECT COSTS (A THROUGH G)				288,535	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)					
TOTAL INDIRECT COSTS (F&A)				131,859	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				420,394	
K. SMALL BUSINESS FEE				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				420,394	

M. COST SHARING PROPOSED LEVEL $ 0 AGREED LEVEL IF DIFFERENT $

PI/PD NAME Walker Smith	**FOR NSF USE ONLY**		
	INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME*	Date Checked	Date Of Rate Sheet	Initials - ORG

C ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

Budget Justification: Virginia Institute of Marine Sciences

Salaries/benefits: Salary is requested for PI W. Smith (3 months in three years). He will participate in each cruise (a total of 48 days at sea) and in the planning, field work, data processing, and synthesis-publication of the results. Funds for technical support (Ms. Liza Delizo; 6, 6 and 4 months in the three years) are requested, as she will be responsible for a) the purchasing of supplies used in the field work and laboratory analyses, b) packing and shipping of all VIMS expedition gear; c) participating in the cruises, and d) processing all POC/PN samples. Funds are also requested for an undergraduate student (TBA) who will participate in the cruises and possibly use these data in a senior Honor's thesis.

Fringe benefits are calculated at 40% of permanent employee salaries.

Travel-Domestic: Travel funds are requested in each year to support cruise participants traveling to Narragansett, RI to deploy on the vessel, as well as to participate in PI and national meetings as detailed below:

Item	Year 1	Year 2	Year 3
Car rental for travel to RI	$2,554	$1,477	---
Lodging and food before and after cruise (3 people, 6 days, 2 rooms)	7,200	2,700	---
Tolls	50	50	---
Miscellaneous cruise travel costs	800	800	400
PI meeting: Woods Hole, MA	1,183	1,383	1,383
National meeting	2,900	3,200	3,400
Total	**$14,687**	**$8,410**	**$4,133**

Hotel costs are calculated at $150 per night per room, and food estimated to be $100 per person per day. Meeting costs (including registration, travel, lodging and per diem) as based on attendance at an Ocean Sciences (or similar) meeting. PI meeting costs are based on 2.5-day meetings, air and bus travel to WHOI, and lodging/hotel costs as for cruise travel.

Materials and Supplies: The table below supplies the request for funds for materials and supplies needed for the field efforts (two cruises in Year 1, one in Year 2) and subsequent laboratory analyses of returned samples.

Item	Year 1	Year 2	Year 3
Filters (GFF and Poretics for size fractionations)	3,600	1,800	0
Non-^{14}C chemicals (CN expendables, acids)	1,600	800	500
Glassware, bottles, vials	1,500	600	0
^{14}C costs (isotope purchase, disposal costs/transport, LSC chemicals and vials, incubation Qorpaks)	18,000	9,000	0
Replacement lap top computer for cruise use	2,200	0	0
Light sensor recalibration/refurbishment	1,600	0	0
Cruise expendables (pipette tips, supplies, etc.)	1,400	700	0
Construction of simulated in situ incubators	2,500	0	0
Neutral density screening (Cinemills)	800	400	0
Outreach supplies	0	0	800

Shipping of gear to/from URI	1,800	1,800	0
Miscellaneous (telephone, Fedex, copying, lab chemicals, etc.)	600	1,200	2,600
TOTAL	**$35,600**	**$16,300**	**$3,900**

Field supplies include filters for size fractionated samples (POC and ^{14}C, using GFF and Poretics filters), vials for the storage of CN and BSi samples, and chemicals both for the field and laboratory analyses of these samples. A major cost is for use of ^{14}C-HCO_3, including ^{14}C isotope purchase for 3 cruises (ca. $2,500 per cruise), LSC supplies (LSC vials and Ecolume; HCl, pipette tips, pipettes, β-phenethylamine), and transport of radio-waste (vials, liquid waste and dry waste) back to VIMS by a regulated carrier for disposal under the VIMS NRC license. Although exact costs are unknown at this time, we estimate those transport costs to be ca. $5,000 per cruise. Funds for the purchase of Qorpak incubation bottles (we estimate we will need 350 per cruise) and costs for miscellaneous cruise expendables are also requested. Two BioSpherical Instruments quantum sensors in Smith's lab will be recalibrated at the factory prior to the first cruise ($1,600), and simulated in situ incubators will be constructed for cruise use ($2,500 in Year 1). Miscellaneous costs in all years include funds for Xerox, telephone usage and express mail charges, as well as miscellaneous lab items and software upgrades. A replacement lap-top $2,200) for cruise use is budgeted for Year 1. In Year 3 costs are included to help prepare a detailed presentation for use at Marine Science Day at VIMS that provides the results, significance, and the potential impact on fisheries yields and fish stock preservation. This will be completed in conjunction with Science Media (http://www.sciencemedia.nl/home) who will actively be involved in the entire project's outreach activities.

Publications: Funds are requested in Years 2 and 3 to help defray the costs of publication, as it is anticipated that some papers will be published in journals that have fees for color figures, open access, and page charges.

Indirect Costs: Indirect costs are computed as Modified Total Direct Costs at 45.7% of the base amount.

SUMMARY PROPOSAL BUDGET

YEAR 1

ORGANIZATION **Wellesley College**			FOR NSF USE ONLY PROPOSAL NO.	DURATION (months) Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR **Rachel Stanley**			AWARD NO.		

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Rachel Stanley - Assistant Professor**	0.00	0.00	1.00	8,965	
2.					
3.					
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	1.00	8,965	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	0	
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0	
3. (0) GRADUATE STUDENTS				0	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				8,965	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				1,587	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				10,552	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. U.S. POSSESSIONS)				0	
2. FOREIGN				0	
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 5,000 2. TRAVEL 0 3. SUBSISTENCE 0 4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				5,000	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				19,900	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				0	
6. OTHER				0	
TOTAL OTHER DIRECT COSTS				19,900	
H. TOTAL DIRECT COSTS (A THROUGH G)				35,452	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **F&A Cost (Rate: 75.3000, Base: 8965)**					
TOTAL INDIRECT COSTS (F&A)				6,751	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				42,203	
K. SMALL BUSINESS FEE				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				42,203	
M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $				

PI/PD NAME **Rachel Stanley**	FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME* **Elizabeth Demski**	Date Checked	Date Of Rate Sheet	Initials - ORG

 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET

YEAR 2

ORGANIZATION **Wellesley College**				FOR NSF USE ONLY PROPOSAL NO.	DURATION (months) Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR **Rachel Stanley**				AWARD NO.		
A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)	
1. **Rachel Stanley - Assistant Professor**	0.00	1.00	1.00	13,851		
2.						
3.						
4.						
5.						
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0		
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	1.00	1.00	13,851		
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)						
1. (0) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	0		
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0		
3. (0) GRADUATE STUDENTS				0		
4. (0) UNDERGRADUATE STUDENTS				0		
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0		
6. (0) OTHER				0		
TOTAL SALARIES AND WAGES (A + B)				13,851		
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				4,123		
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				17,974		
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)						
TOTAL EQUIPMENT				0		
E. TRAVEL 1. DOMESTIC (INCL. U.S. POSSESSIONS)				3,470		
2. FOREIGN				0		
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 5,000 2. TRAVEL 0 3. SUBSISTENCE 0 4. OTHER 0						
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				5,000		
G. OTHER DIRECT COSTS						
1. MATERIALS AND SUPPLIES				500		
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0		
3. CONSULTANT SERVICES				0		
4. COMPUTER SERVICES				0		
5. SUBAWARDS				0		
6. OTHER				0		
TOTAL OTHER DIRECT COSTS				500		
H. TOTAL DIRECT COSTS (A THROUGH G)				26,944		
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **F&A Cost (Rate: 75.3000, Base: 13851)**						
TOTAL INDIRECT COSTS (F&A)				10,430		
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				37,374		
K. SMALL BUSINESS FEE				0		
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				37,374		
M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $					
PI/PD NAME **Rachel Stanley**				FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME* **Elizabeth Demski**				Date Checked	Date Of Rate Sheet	Initials - ORG

 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET

YEAR 3

ORGANIZATION **Wellesley College**				FOR NSF USE ONLY PROPOSAL NO.	DURATION (months) Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR **Rachel Stanley**				AWARD NO.		
A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)	
1. **Rachel Stanley - Assistant Professor**	0.00	0.00	1.00	9,511		
2.						
3.						
4.						
5.						
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0		
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	1.00	9,511		
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)						
1. (0) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	0		
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0		
3. (0) GRADUATE STUDENTS				0		
4. (0) UNDERGRADUATE STUDENTS				0		
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0		
6. (0) OTHER				0		
TOTAL SALARIES AND WAGES (A + B)				9,511		
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				1,683		
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				11,194		
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)						
TOTAL EQUIPMENT				0		
E. TRAVEL 1. DOMESTIC (INCL. U.S. POSSESSIONS)				3,650		
2. FOREIGN				0		
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 0 2. TRAVEL 0 3. SUBSISTENCE 0 4. OTHER 0						
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0		
G. OTHER DIRECT COSTS						
1. MATERIALS AND SUPPLIES				0		
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				2,000		
3. CONSULTANT SERVICES				0		
4. COMPUTER SERVICES				0		
5. SUBAWARDS				0		
6. OTHER				0		
TOTAL OTHER DIRECT COSTS				2,000		
H. TOTAL DIRECT COSTS (A THROUGH G)				16,844		
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **F&A Cost (Rate: 75.3000, Base: 9511)**						
TOTAL INDIRECT COSTS (F&A)				7,162		
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				24,006		
K. SMALL BUSINESS FEE				0		
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				24,006		
M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $					
PI/PD NAME **Rachel Stanley**				FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME* **Elizabeth Demski**				Date Checked	Date Of Rate Sheet	Initials - ORG

 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

SUMMARY PROPOSAL BUDGET

Cumulative

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months)	
	Proposed	Granted
AWARD NO.		

ORGANIZATION
Wellesley College

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Rachel Stanley

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Rachel Stanley - Assistant Professor**	0.00	1.00	3.00	32,327	
2.					
3.					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	1.00	3.00	32,327	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	0	
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0	
3. (0) GRADUATE STUDENTS				0	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				32,327	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				7,393	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				39,720	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. U.S. POSSESSIONS)				7,120	
2. FOREIGN				0	
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 10,000 2. TRAVEL 0 3. SUBSISTENCE 0 4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				10,000	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				20,400	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				2,000	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				0	
6. OTHER				0	
TOTAL OTHER DIRECT COSTS				22,400	
H. TOTAL DIRECT COSTS (A THROUGH G)				79,240	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)					
TOTAL INDIRECT COSTS (F&A)				24,343	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				103,583	
K. SMALL BUSINESS FEE				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				103,583	

M. COST SHARING PROPOSED LEVEL $ 0 AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Rachel Stanley

ORG. REP. NAME*
Elizabeth Demski

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INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

C ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

STANLEY BUDGET JUSTIFICATION

Wellesley College is a nonprofit liberal arts college for undergraduate women. Wellesley's federally negotiated overhead rate is 75.3%. Fringe benefits are calculated at 35.7% of academic year salaries and wages and at 17.7% of summer salaries and wages, consistent with institutional standards

Personnel: Prof. Rachel Stanley will oversee all aspects of the gas tracer component of this proposal. She will oversee the collection and analysis of the discrete samples for triple oxygen isotope and O_2/Ar and will oversee the collection of data from the continuous underway equilibrator inlet mass spectrometer. Stanley is also an adjunct scientist at Woods Hole Oceanographic Institution and through her adjunct position there, she will oversee Zoe Sandwith (Sandwith is supported in WHOI budget) who will be responsible for the day-to-day running of the samples. Stanley will be intimately involved with the data (looking at it on a daily basis – everything is available through the internet) and will be the ultimate resource in terms of deciding how and when to run samples. Stanley will also be responsible for calculating rates of net community and gross primary production from the gas tracer data and for aiding in the interpretation of that data in the synthesis activities. Stanley will mentor two undergraduate students per summer, funded through this project (see below) and through Wellesley College (see Facilities). One month of summer salary support is requested for Stanley in years 1 and 3 of this proposed research and 0.5 months of summer salary is requested for Stanley in year 2. In addition, in year 2, she will be on her pre-tenure leave – a sabbatical year when she is released from teaching responsibilities so that she can concentrate on research. Thus one month of academic salary is requested for year 2.

Participant Support Costs: Wellesley College has a large summer student science program. For example, in 2014, 125 undergraduate students participated in the program, with 36% of those being underrepresented minorities and first generation college students. Funding is being requested to support one summer student in years 1 and 2 ($5000 per summer). The student will participate in the summer cruise in year 1 and will work on data analysis in year 2.

Travel: Funds are requested in year 2 and 3 for Stanley and one undergraduate to attend a national conference (AGU in year 2 and Ocean Sciences in year 3) to present this work. The costs include airfare for two ($500 per person in year 2, $525 per person in year 3), per diem for two ($336 per person in year 2, $353 per person in year 3), 2 hotel rooms ($750 per room in year 2, $788 per room in year 3), and ground transport ($149 per person in year 2, $159 per person in year 3). The total for the conferences is thus $3470 in year 2 and $3650 in year 3. It will likely be the first conference the undergraduate will have ever attended, and should be a transformative experience for the undergraduate, as well as a useful way of disseminating the findings gleaned from this study.

Lab Materials and Supplies: Funding is requested to fabricate 135 custom-made glass sample bottles in order to collect the discrete gas tracer samples ($129 per bottle x 135 bottles = $17415, price based on previous experience making these bottles, with most of cost coming from the Louwers-Halper valve). Stanley already has several hundred bottles so the request is only made for additional bottles required to do two large cruises in quick succession. Funds are requested to buy a new laptop in order to quickly and efficiently calculate the productivity rates from the gas tracer data and do other data analysis associated with the research ($1985). A modest amount of supplies will have to be purchased to do testing on the equilibrator inlet mass spectrometer at Wellesley before it goes to sea. Thus $500 per year in years 1 and 2 is requested to buy tubing, compressed nitrogen, o-rings, grease, tip-seals, etc.

<u>Publications:</u> Funding ($2000) is requested in year 3 to pay for publication costs for the results stemming from this proposed research. Efforts will be made to publish in an open access journal.

SUMMARY PROPOSAL BUDGET

YEAR 1

ORGANIZATION University of Massachusetts, Dartmouth				FOR NSF USE ONLY PROPOSAL NO.	DURATION (months) Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR Jefferson T Turner				AWARD NO.		

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. Jefferson T Turner - Chancellor Professor	0.00	0.00	1.00	15,380	
2. Christian M Petitpas - Research Associate	6.00	0.00	0.00	28,000	
3.					
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (2) TOTAL SENIOR PERSONNEL (1 - 6)	6.00	0.00	1.00	43,380	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	0	
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0	
3. (1) GRADUATE STUDENTS				20,500	
4. (2) UNDERGRADUATE STUDENTS				11,520	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				75,400	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				12,253	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				87,653	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. U.S. POSSESSIONS)				0	
2. FOREIGN				0	
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 0 2. TRAVEL 0 3. SUBSISTENCE 0 4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				10,000	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				0	
6. OTHER				10,569	
TOTAL OTHER DIRECT COSTS				20,569	
H. TOTAL DIRECT COSTS (A THROUGH G)				108,222	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) 53709 (Rate: 55.0000, Base: 97652)					
TOTAL INDIRECT COSTS (F&A)				53,709	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				161,931	
K. SMALL BUSINESS FEE				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				161,931	

M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $		
PI/PD NAME Jefferson T Turner	FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME*	Date Checked	Date Of Rate Sheet	Initials - ORG

 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

SUMMARY PROPOSAL BUDGET

YEAR 2

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months)	
	Proposed	Granted
AWARD NO.		

ORGANIZATION
University of Massachusetts, Dartmouth

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Jefferson T Turner

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. Jefferson T Turner - Chancellor Professor	0.00	0.00	1.00	15,841	
2. Christian M Petitpas - Research Associate	6.00	0.00	0.00	29,400	
3.					
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (2) TOTAL SENIOR PERSONNEL (1 - 6)	6.00	0.00	1.00	45,241	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	0	
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0	
3. (1) GRADUATE STUDENTS				21,115	
4. (2) UNDERGRADUATE STUDENTS				3,840	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				70,196	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				12,762	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				82,958	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. U.S. POSSESSIONS)				0	
2. FOREIGN				0	
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 0 2. TRAVEL 0 3. SUBSISTENCE 0 4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				2,500	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				0	
6. OTHER				11,054	
TOTAL OTHER DIRECT COSTS				13,554	
H. TOTAL DIRECT COSTS (A THROUGH G)				96,512	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) 47002 (Rate: 55.0000, Base: 85458)					
TOTAL INDIRECT COSTS (F&A)				47,002	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				143,514	
K. SMALL BUSINESS FEE				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				143,514	

M. COST SHARING PROPOSED LEVEL $ 0 AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Jefferson T Turner

ORG. REP. NAME*

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INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

SUMMARY PROPOSAL BUDGET

YEAR 3

ORGANIZATION University of Massachusetts, Dartmouth				FOR NSF USE ONLY PROPOSAL NO.	DURATION (months) Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR Jefferson T Turner				AWARD NO.		
A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR		Funds Requested By proposer	Funds granted by NSF (if different)
1. Jefferson T Turner - Chancellor Professor	0.00	0.00	1.00		16,316	
2. Christian M Petitpas - Research Associate	6.00	0.00	0.00		30,870	
3.						
4.						
5.						
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00		0	
7. (2) TOTAL SENIOR PERSONNEL (1 - 6)	6.00	0.00	1.00		47,186	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)						
1. (0) POST DOCTORAL SCHOLARS	0.00	0.00	0.00		0	
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00		0	
3. (1) GRADUATE STUDENTS					21,748	
4. (0) UNDERGRADUATE STUDENTS					0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)					0	
6. (0) OTHER					0	
TOTAL SALARIES AND WAGES (A + B)					68,934	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)					13,314	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)					82,248	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)						
TOTAL EQUIPMENT					0	
E. TRAVEL 1. DOMESTIC (INCL. U.S. POSSESSIONS)					6,546	
2. FOREIGN					0	
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 0 2. TRAVEL 0 3. SUBSISTENCE 0 4. OTHER 0						
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS					0	
G. OTHER DIRECT COSTS						
1. MATERIALS AND SUPPLIES					2,500	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION					2,000	
3. CONSULTANT SERVICES					0	
4. COMPUTER SERVICES					0	
5. SUBAWARDS					0	
6. OTHER					11,564	
TOTAL OTHER DIRECT COSTS					16,064	
H. TOTAL DIRECT COSTS (A THROUGH G)					104,858	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) 51312 (Rate: 55.0000, Base: 93295)						
TOTAL INDIRECT COSTS (F&A)					51,312	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)					156,170	
K. SMALL BUSINESS FEE					0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)					156,170	
M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $					
PI/PD NAME Jefferson T Turner				FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME*				Date Checked	Date Of Rate Sheet	Initials - ORG

 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

SUMMARY PROPOSAL BUDGET

Cumulative

ORGANIZATION University of Massachusetts, Dartmouth				FOR NSF USE ONLY PROPOSAL NO.	DURATION (months) Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR Jefferson T Turner				AWARD NO.		
A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)	
1. Jefferson T Turner - Chancellor Professor	0.00	0.00	3.00	47,537		
2. Christian M Petitpas - Research Associate	18.00	0.00	0.00	88,270		
3.						
4.						
5.						
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0		
7. (2) TOTAL SENIOR PERSONNEL (1 - 6)	18.00	0.00	3.00	135,807		
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)						
1. (0) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	0		
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0		
3. (3) GRADUATE STUDENTS				63,363		
4. (4) UNDERGRADUATE STUDENTS				15,360		
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0		
6. (0) OTHER				0		
TOTAL SALARIES AND WAGES (A + B)				214,530		
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				38,329		
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				252,859		
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)						
TOTAL EQUIPMENT				0		
E. TRAVEL 1. DOMESTIC (INCL. U.S. POSSESSIONS)				6,546		
2. FOREIGN				0		
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 0 2. TRAVEL 0 3. SUBSISTENCE 0 4. OTHER 0						
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0		
G. OTHER DIRECT COSTS						
1. MATERIALS AND SUPPLIES				15,000		
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				2,000		
3. CONSULTANT SERVICES				0		
4. COMPUTER SERVICES				0		
5. SUBAWARDS				0		
6. OTHER				33,187		
TOTAL OTHER DIRECT COSTS				50,187		
H. TOTAL DIRECT COSTS (A THROUGH G)				309,592		
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)						
TOTAL INDIRECT COSTS (F&A)				152,023		
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				461,615		
K. SMALL BUSINESS FEE				0		
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				461,615		
M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $					
PI/PD NAME Jefferson T Turner				FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME*				Date Checked	Date Of Rate Sheet	Initials - ORG

C ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

Budget Justification: University of Massachusetts Dartmouth

Salaries: Funds are requested each year for one month of summer salary to support Dr. Turner, who will oversee UMass Dartmouth's contributions to this project. Salary support of six months per year is being requested for Dr. Petitpas, and a graduate student stipend is being requested for a graduate student (TBA) to pursue a Master of Science degree in the University of Massachusetts Intercampus Marine Science (IMS) Program at UMass Dartmouth's School for Marine Science and Technology (SMAST). Funds are also requested to support the participation of two undergraduate students from underrepresented groups at a rate of $12 per hour. Fringe rates are: 1)1.67% for PI summer salary and graduate student stipend and 2) 33.50% for Dr. Petitpas' Research Associate salary. Additional fringe costs include Health & Welfare ($16.50/week) for Dr. Petitpas and the graduate student health insurance fee (currently $2,086/year). Dr. Turner, Dr. Petitpas, the graduate student and one of the undergraduate students will participate in all three cruises. Specific responsibilities of Dr. Turner's group: 1) cruise preparation and mobilization/demobilization; 2) shipboard sampling and performance of incubation/grazing experiments, interacting with the Sosik group for FCM and IFCB counts of the initial and final samples; 3) microscopic analyses of incubation samples (Petitpas and Turner); 4) Chl *a* assays of grazing samples (graduate student); 5) microscopic analysis of MOCNESS net tow samples (Petitpas and Turner); 6) data analyses; and 7) manuscript preparation.

Equipment: Not Applicable

Travel: Funds are requested for Dr. Turner and Dr. Petitpas (or Dr. Turner and graduate student) to attend and present results from this proposed research at a national scientific meeting, which usually convene over a 5 to 6-day period. For budgeting purposes, expenses are anticipated to be comparable to those incurred for the PI to attend a recent meeting of the Association for the Sciences of Limnology and Oceanography in New Orleans, LA [airfare ($769), lodging ($1,190), conference registration fees ($455), ground transportation ($311); per diem ($71/day)]. Additional allowances have been included for baggage fees and airport parking (total = $244). Travel funds for annual PI meetings at WHOI are not needed due to the close proximity of the two institutions.

Other Direct Costs:
Supplies: The PI's research laboratories at UMass Dartmouth's main campus and SMAST provide most of the infrastructure and other necessary equipment to perform the proposed grazing experiments, microscopic analyses and data synthesis (e.g., buckets, sieves, labware, compound and stereo microscopes with camera equipment, fluorometer, computers, etc.). However, we are requesting funds to purchase additional laboratory/research supplies:

Sample jars and tubes	$4,800
Chemicals/reagents (formalin, acetone, ethanol, Utermöhl's)	$1,700
Plankton nets	$2,500
Filters (GF/F)	$1,200
Carboys	$1,400
Foul weather gear/steel-toe boots	$2,400
Laboratory expendables (pipette tips, microscope lamps, gloves, etc.)	$1,000

Publications: Publication costs are requested to disseminate results in peer-reviewed journals in year 3.

Other Costs: We request funds to cover the curriculum support ($485/credit), college ($719), and health ($150) fees to support the full costs of the full-time graduate student in the IMS Program at SMAST.

Indirect Costs:

Facilities and Administrative (F&A) or Indirect Costs

The F&A rate was determined by prior negotiation with an agency of the Federal Government. UMass Dartmouth's rate has been negotiated with the Department of Health and Human Services. The F&A rate covers all expenses incurred by the institution which cannot be directly attributable to the contract/grant (such as overhead expenses, supporting services and/or use of facilities). UMass Dartmouth's negotiated rate (55%) effective July 1, 2015 is based on Modified Total Direct Costs (MTDC; a.k.a. base in budget form). MTDC excludes capital equipment, curriculum support fees, subcontracts in excess of $25,000, fellowships and scholarships.

Current and Pending Support

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: **DENNIS MCGILLICUDDY**

Other Agencies (including NSF) to which this Proposal has been/will be submitted.

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

D. MCGILLICUDDY, D. ANDERSON - PCM-HAB: Implementation of an Operational Model for Prediction of Alexandrium Fundyense Blooms in the Gulf of Maine

POC:Quay Dortch 301-713-3338 x157 Quay.Dortch@noaa.gov

Source of Support: *National Oceanic & Atmospheric Admin.(NOAA) NA11NOS*

Total Award Amount: $1,854,199 Total Award Period Covered: 9/1/2011 - 8/31/2016

Location of Project: WHOI

Person-Months Per Year Committed to the Project: Cal: 2.23/2.05/1.86/1.69 Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

D. MCGILLICUDDY - Physical and Biological Dynamics of Nonlinear Mesoscale Eddies: Satellite Observations, In Situ Measurements, and Numerical Simulations on a Global Scale

POC:Eric Lindstrom 202-358-4540 eric.j.lindstrom@nasa.gov

Source of Support: *NASA Grants NNX13AE47G*

Total Award Amount: $899,538 Total Award Period Covered: 1/15/2013 - 1/14/2017

Location of Project: WHOI

Person-Months Per Year Committed to the Project: Cal: 2.00/1.00/1.00/1.00 Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

D. MCGILLICUDDY - Collaborative Research Type 2 L02170291 MOBY: Modeling Ocean Variability and Biogeochemical Cycles

POC:Eric C. Itsweire 703-292-7593 eitsweir@nsf.gov

Source of Support: *National Science Foundation (NSF) OCE-1048897*

Total Award Amount: $1,236,042 Total Award Period Covered: 3/1/2011 - 2/28/2017

Location of Project: WHOI

Person-Months Per Year Committed to the Project: Cal: 2.00/1.50/1.25/1.00/1.00 Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

J. STEGEMAN, D. ANDERSON, D. MCGILLICUDDY, M. HAHN, N. ALURU, D. RALSTON - WHCOHH: Harmful Algal Bloom Dynamics and Epigenetic Mechanisms of Toxin Action

POC:Frederick L. Tyson 919-541-0176 tyson2@niehs.nih.gov

Source of Support: *National Institutes of Health (NIH) 1P01ES021923/5P/3P/4P*

Total Award Amount: $2,108,838 Total Award Period Covered: 9/24/2012 - 7/31/2017

Location of Project: WHOI

Person-Months Per Year Committed to the Project: Cal: 0.39/0.47/0.60/0.87/1.20 Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

D. ANDERSON, D. MCGILLICUDDY - MERHAB: GOM-ESP: Incorporation of Environmental Sample Processor Technology into Gulf of Maine HAB Monitoring and Management

POC:Marc Suddleson 301-713-3338 ext. 162 Marc.Suddleson@noaa.gov

Source of Support: *National Oceanic & Atmospheric Admin.(NOAA) NA11NOS*

Total Award Amount: $5,307,591 Total Award Period Covered: 9/1/2011 - 8/31/2017

Location of Project: WHOI

Person-Months Per Year Committed to the Project: Cal: 0.32/1.00/1.00/0.50/1.00 Acad: Sumr:

Current and Pending Support

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: **DENNIS MCGILLICUDDY**

Other Agencies (including NSF) to which this Proposal has been/will be submitted.

Support: [X] Current [ ] Pending [ ] Submission Planned in Near Future [ ] *Transfer of Support

Project/Proposal Title:

J. STEGEMAN, D. ANDERSON, D. MCGILLICUDDY - WHCOHH: Harmful Algal Bloom Dynamics and Epigenetic Mechanisms of Toxin Action

Source of Support: *Director's Other Innovative C/S 21192300*

Total Award Amount: $18,899 Total Award Period Covered: 9/1/2012 - 8/31/2017

Location of Project: WHOI

Person-Months Per Year Committed to the Project: Cal: 0 Acad: Sumr:

Support: [X] Current [ ] Pending [ ] Submission Planned in Near Future [ ] *Transfer of Support

Project/Proposal Title:

J. STEGEMAN, D. ANDERSON, D. MCGILLICUDDY, M. HAHN - WHCOHH: Harmful Algal Bloom Dynamics and Epigenetic Mechanisms of Toxin Action

POC:Henrietta N. Edmonds 703-292-8029/7427 hedmonds@nsf.gov

Source of Support: *National Science Foundation (NSF) OCE-1314642*

Total Award Amount: $4,321,138 Total Award Period Covered: 3/15/2013 - 2/28/2018

Location of Project: WHOI

Person-Months Per Year Committed to the Project: Cal: 0.90/0.68/0.77/1.21/1.31 Acad: Sumr:

Support: [X] Current [ ] Pending [ ] Submission Planned in Near Future [ ] *Transfer of Support

Project/Proposal Title:

D. MCGILLICUDDY, M. PURCELL, R. STANLEY - Adaptive Sampling of Hotspots in Net Community Production Using the VPR, REMUS, and Traditional Hydrographic Methods

POC:Rob Munier rmunier@whoi.edu

Source of Support:

Total Award Amount: $437,095 Total Award Period Covered: 3/28/2016 - 3/16/2018

Location of Project: WHOI

Person-Months Per Year Committed to the Project: Cal: 0 Acad: Sumr:

Support: [X] Current [ ] Pending [ ] Submission Planned in Near Future [ ] *Transfer of Support

Project/Proposal Title:

D. ANDERSON, B. KEAFER, D. MCGILLICUDDY - ECOHAB: Interannual Variability of PSP Toxicity in Eastern Maine: Testing the Leaky Gyre Hypothesis and Improving Regional Forecasts and Management

POC:Quay Dortch (240) 533-0198 Quay.Dortch@noaa.gov

Source of Support: *National Oceanic & Atmospheric Admin.(NOAA) NA15NOS*

Total Award Amount: $731,817 Total Award Period Covered: 9/1/2015 - 8/31/2018

Location of Project: WHOI

Person-Months Per Year Committed to the Project: Cal: 0.50/0.50/0.50 Acad: Sumr:

Support: [ ] Current [X] Pending [ ] Submission Planned in Near Future [ ] *Transfer of Support

Project/Proposal Title:

D. ANDERSON, D. MCGILLICUDDY - BIO-2. Transport and Fate of Harmful Algal Blooms (HABs)

POC:Director of Research (Laurence P. Madin)

Source of Support: *U.S. Geological Survey (USGS)*

Total Request Amt: $48,262 Total Award Period Covered: 4/1/2016 - 3/31/2017

Location of Project: WHOI

Person-Months Per Year Committed to the Project: Cal: 0 Acad: Sumr:

Current and Pending Support

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: **DENNIS MCGILLICUDDY**

Other Agencies (including NSF) to which this Proposal has been/will be submitted.

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

D. MCGILLICUDDY - Mechanisms Controlling Mesoscale/Submesoscale Hotspots in Net Community Production/Export, with Simulation-Based Studies on How to Sample Them

Source of Support: *NASA Grants*
Total Request Amt: $567,089 | Total Award Period Covered: 7/1/2016 - 6/30/2019
Location of Project: WHOI
Person-Months Per Year Committed to the Project: Cal: 0.75/0.75/1.50/1.50 Acad: Sumr:

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

D. MCGILLICUDDY - NSFGEO-NERC: Collaborative Research: Bloom Initiation Dynamics in the Ross Sea (BID-RS)

Source of Support: *National Science Foundation (NSF)*
Total Request Amt: $739,723 | Total Award Period Covered: 3/1/2017 - 2/28/2020
Location of Project: WHOI
Person-Months Per Year Committed to the Project: Cal: 2.00/1.00/1.00 Acad: Sumr:

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

D. MCGILLICUDDY - Diagnosing Mechanisms of Physical/Biological Interaction at the Oceanic Mesoscale: Satellite Observations in situ Measurements, and Numerical Simulations on a Global Scale
POC:Lisa Day Mercer 206-685-1008 ldaymercer@apl.washington.edu

Source of Support: *Subawards (NASA Prime)*
Total Request Amt: $427,043 | Total Award Period Covered: 1/1/2017 - 12/31/2020
Location of Project: WHOI
Person-Months Per Year Committed to the Project: Cal: 0.25/0.50/0.50/0.50 Acad: Sumr:

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

D. MCGILLICUDDY, H. SOSIK, W. ZHANG, R. STANLEY - Collaborative Research: Shelfbreak Frontal Dynamics: Mechanisms of Upwelling, Net Community Production, and Ecological Implications

* This Proposal
Source of Support: *National Science Foundation (NSF)*
Total Request Amt: $1,993,155 | Total Award Period Covered: 10/1/2017 - 9/30/2020
Location of Project: WHOI
Person-Months Per Year Committed to the Project: Cal: 2.00/1.00/1.00 Acad: Sumr:

Current and Pending Support

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: **HEIDI SOSIK**

Other Agencies (including NSF) to which this Proposal has been/will be submitted.

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

H. SOSIK, R. OLSON - Seasonal Anomalies as Proxies for Phytoplankton Community Response to Climate Trends on a Temperate Continental Shelf

POC:Paula Bontempi 202-358-1508 paula.bontempi@nasa.gov

Source of Support: *NASA Grants NNX13AC98G*

Total Award Amount: $968,020 Total Award Period Covered: 12/5/2012 - 12/4/2016

Location of Project: WHOI

Person-Months Per Year Committed to the Project: Cal: 3.00/3.00/3.00 Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

H. SOSIK, S. LANEY - Time-series of Hyperspectral Remote Sensing Reflectance in Support of GEO-CAPE Mission Development

POC:Barry Lefer barry.lefer@nasa.gov

Source of Support: *NASA Grants NNX14AR71G*

Total Award Amount: $208,991 Total Award Period Covered: 8/29/2014 - 3/1/2017

Location of Project: WHOI

Person-Months Per Year Committed to the Project: Cal: 1.00/0.88 Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

M. CAPE, F. STRANEO, H. SOSIK, M. CHARETTE - Pathways and Impact of Glacial Meltwater on Ocean Chemistry and Phytoplankton Communities in Southeast Greenland

POC:Carol Anne Clayson cclayson@whoi.edu

Source of Support: *WHOI - Ocean & Climate Change Institute 2015 OCCI Awa*

Total Award Amount: $74,510 Total Award Period Covered: 6/20/2015 - 6/30/2017

Location of Project: WHOI

Person-Months Per Year Committed to the Project: Cal: 0 Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

H. SOSIK, R. OLSON - MRI Development: Imaging FlowCytobot on Autonomous Vehicles for Plankton Research and Harmful Algal Bloom Mitigation

POC:Kandace S. Binkley 703-292-8581/7577 kbinkley@nsf.gov

Source of Support: *National Science Foundation (NSF) OCE1428703*

Total Award Amount: $517,998 Total Award Period Covered: 9/1/2014 - 8/31/2017

Location of Project: WHOI

Person-Months Per Year Committed to the Project: Cal: 2.00/2.00 Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

R. OLSON, H. SOSIK - Collaborative Research: Enhanced Imaging Flow Cytometry for Plankton Studies via Acoustic Focusing and Emulsion Microfluidics

POC:Kandace S. Binkley 703-292-8581/7577 kbinkley@nsf.gov

Source of Support: *National Science Foundation (NSF) OCE-1130140*

Total Award Amount: $934,340 Total Award Period Covered: 9/15/2011 - 8/31/2017

Location of Project: WHOI

Person-Months Per Year Committed to the Project: Cal: 1.00/1.00/2.00 Acad: Sumr:

Current and Pending Support

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: **HEIDI SOSIK**

Other Agencies (including NSF) to which this Proposal has been/will be submitted.

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

R. GAST, H. SOSIK, R. OLSON - Dynamics of Protistan Grazers: Diversity, Abundance and Prey Relations

POC:David L. Garrison 703-292-8582/7588 dgarriso@nsf.gov

Source of Support: *National Science Foundation (NSF) OCE-1434440*

Total Award Amount: $999,445 Total Award Period Covered: 9/1/2014 - 8/31/2017

Location of Project: WHOI

Person-Months Per Year Committed to the Project: Cal: 1.50/1.50/1.50 Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

M. BROSNAHAN, D. ANDERSON, H. SOSIK, R. OLSON - Enhanced Monitoring and Spatial Mapping of Toxic Algal Blooms: Field Implementation of an Acoustic Cell Concentrator Coupled with Imaging-in-flow Cytometry

POC:Joshua Brown 301-734-1271 joshua.brown@noaa.gov

Source of Support: *National Oceanic & Atmospheric Admin.(SeaGrant) NA14O*

Total Award Amount: $149,612 Total Award Period Covered: 2/1/2016 - 1/31/2018

Location of Project: WHOI

Person-Months Per Year Committed to the Project: Cal: 0.50/0.50 Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

H. SOSIK, R. OLSON, D. ANDERSON - Transition of Imaging FlowCytobot to Operational Support for Harmful Algal Bloom Mitigation and Research

POC:Regina Evans 240-533-9468 Regina.Evans@noaa.gov

Source of Support: *National Oceanic & Atmospheric Admin.(NOAA) NA15NOS*

Total Award Amount: $1,477,659 Total Award Period Covered: 8/1/2015 - 7/31/2018

Location of Project: WHOI

Person-Months Per Year Committed to the Project: Cal: 2.00/2.50/2.89 Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

H. SOSIK - PCMHAB: Expanding Harmful Algal Bloom Mitigation in the Gulf of Mexico with Operational Support and Training for the Imaging FlowCytobot Network

POC:Marc Suddleson 240-533-0305 Marc.Suddleson@noaa.gov

Source of Support: *National Oceanic & Atmospheric Admin.(NOAA) NA15NOS*

Total Award Amount: $358,968 Total Award Period Covered: 9/1/2015 - 8/31/2018

Location of Project: WHOI

Person-Months Per Year Committed to the Project: Cal: 0.80/1.70/1.50 Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

H. SOSIK, S. BEAULIEU - CyberSEES: Type 2: Collaborative Research: A Computational and Analytic Laboratory for Modeling and Predicting Marine Biodiversity and Indicators of Sustainable Ecosystems

POC:Todd Leen 703-292-8930 tleen@nsf.gov

Source of Support: *National Science Foundation (NSF) CCF-1539256*

Total Award Amount: $629,174 Total Award Period Covered: 9/1/2015 - 8/31/2018

Location of Project: WHOI

Person-Months Per Year Committed to the Project: Cal: 1.75/1.75/1.75 Acad: Sumr:

Current and Pending Support

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: **HEIDI SOSIK**

Other Agencies (including NSF) to which this Proposal has been/will be submitted.

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

J. BELLINGHAM, C. KAISER, D. YOERGER, H. SOSIK, L. FREITAG - Center for Marine Robotics - Robots to the Sea: Catalyzing Growth of the Massachusetts Marine Technology Industry - Program Management

POC:Patrick Larkin 508-870-0312 ext. 235 larkin@masstech.org

Source of Support:

Total Award Amount: $1,704,998 Total Award Period Covered: 10/1/2015 - 9/30/2020

Location of Project: WHOI

Person-Months Per Year Committed to the Project: Cal: 0.46/1.01/1.03/1.01/1.00 Acad: Sumr:

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

M. ABBOTT, A. BOWEN, J. BELLINGHAM, H. SOSIK, J. KINSEY - Advanced Technology Initiative A New Paradigm for Ocean Science

POC:Chris Mentzel (650) 213-3000 Chris.Mentzel@moore.org

Source of Support: *Grants, Non-Government*

Total Request Amt: $249,996 Total Award Period Covered: 7/1/2016 - 12/31/2017

Location of Project: WHOI

Person-Months Per Year Committed to the Project: Cal: 0.25/1.25 Acad: Sumr:

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

H. SOSIK - Biological and Physical Drivers of O2 Saturation and Net Community Production Variability at the Western Antarctic Peninsula

POC:Valerie Bennett 919.613.8146 Valerie.Bennett2@Duke.Edu

Source of Support: *Subawards (NSF Prime)*

Total Request Amt: $211,902 Total Award Period Covered: 4/1/2017 - 3/31/2020

Location of Project: WHOI

Person-Months Per Year Committed to the Project: Cal: 1.00/1.00/1.00 Acad: Sumr:

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

H. SOSIK, S. BEAULIEU, R. JI, S. LENTZ, J. LLOPIZ, M. NEUBERT - LTER: Linking Pelagic Community Structure with Ecosystem Dynamics and Production Regimes on the Changing Northeast US Shelf

POC:David Garrison 703-292-7588 dgarrison@nsf.gov

Source of Support: *National Science Foundation (NSF)*

Total Request Amt: $6,761,998 Total Award Period Covered: 5/1/2017 - 4/30/2023

Location of Project: WHOI

Person-Months Per Year Committed to the Project: Cal: 1.00/1.50/1.50/1.50/1.50/1.50 Acad: Sumr:

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

D. MCGILLICUDDY, H. SOSIK, W. ZHANG, R. STANLEY - Collaborative Research: Shelfbreak Frontal Dynamics: Mechanisms of Upwelling, Net Community Production, and Ecological Implications

* This Proposal

Source of Support: *National Science Foundation (NSF)*

Total Request Amt: $1,993,155 Total Award Period Covered: 10/1/2017 - 9/30/2020

Location of Project: WHOI

Person-Months Per Year Committed to the Project: Cal: 2.00/2.00/2.00 Acad: Sumr:

Current and Pending Support

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: **WEIFENG ZHANG**

Other Agencies (including NSF) to which this Proposal has been/will be submitted.

Support: [X] Current [ ] Pending [ ] Submission Planned in Near Future [ ] *Transfer of Support

Project/Proposal Title:
W. ZHANG, S. LENTZ - Circulation and Transport in the Hudson Shelf Valley
POC:Eric C. Itsweire 703-292-8582/7593 eitsweir@nsf.gov

Source of Support: *National Science Foundation (NSF) OCE-1154575*
Total Award Amount: $709,692 Total Award Period Covered: 2/15/2012 - 1/31/2017
Location of Project: WHOI
Person-Months Per Year Committed to the Project: Cal: 4.00/4.00/4.00 Acad: Sumr:

Support: [X] Current [ ] Pending [ ] Submission Planned in Near Future [ ] *Transfer of Support

Project/Proposal Title:
T. DUDA, J. LYNCH, Y. LIN, K. HELFRICH - Integrated Modeling and Analysis of Physical Oceanographic and Acoustic Processes
POC:Dr. Robert H. Headrick 703-696-4135 bob.headrick@navy.mil

Source of Support: *Office of Naval Research (ONR) N00014-11-1-0701*
Total Award Amount: $7,492,443 Total Award Period Covered: 6/1/2011 - 9/30/2017
Location of Project: WHOI
Person-Months Per Year Committed to the Project: Cal: 2.16/6.18/5.92/3.42/1.42/4.03/2.59 Acad: Sumr:

Support: [X] Current [ ] Pending [ ] Submission Planned in Near Future [ ] *Transfer of Support

Project/Proposal Title:
Y. LIN - Alaska North Shore Ocean Acoustics Study
POC:Dr. Raymond Soukup 703-696-4302 raymond.soukup@navy.mil

Source of Support: *Office of Naval Research (ONR) N00014-15-1-2196*
Total Award Amount: $502,003 Total Award Period Covered: 3/14/2015 - 2/28/2018
Location of Project: WHOI
Person-Months Per Year Committed to the Project: Cal: 0.50/0/0.50 Acad: Sumr:

Support: [ ] Current [X] Pending [ ] Submission Planned in Near Future [ ] *Transfer of Support

Project/Proposal Title:
A. PROSHUTINSKY, W. ZHANG, R. KRISHFIELD - Characteristics and Dynamics of Internal Solitary Waves at Hotspots in the Arctic Ocean
POC:Eric Lindstrom 202-358-4540 eric.j.lindstrom@nasa.gov

Source of Support: *NASA Grants*
Total Request Amt: $428,347 Total Award Period Covered: 1/1/2017 - 12/31/2018
Location of Project: WHOI
Person-Months Per Year Committed to the Project: Cal: 3.00/3.00 Acad: Sumr:

Support: [ ] Current [X] Pending [ ] Submission Planned in Near Future [ ] *Transfer of Support

Project/Proposal Title:
Y. LI, W. ZHANG, ASST SCI A - Impacts of Gulf Stream Warm-Core Rings on Gulf of Maine Circulation
POC:Dr. Eric Itsweire

Source of Support: *National Science Foundation (NSF)*
Total Request Amt: $495,948 Total Award Period Covered: 1/1/2017 - 12/31/2019
Location of Project: WHOI
Person-Months Per Year Committed to the Project: Cal: 3.00/3.00/3.00 Acad: Sumr:

Current and Pending Support

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: **WEIFENG ZHANG**

Other Agencies (including NSF) to which this Proposal has been/will be submitted.

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

G. GAWARKIEWICZ, R. TODD, W. ZHANG - Dynamics of Shelfbreak Processes and Shelf/Slope Exchange South of New England
POC:Eric Itsweire 703-292-8582 eitsweir@nsf.gov

Source of Support: *National Science Foundation (NSF)*
Total Request Amt: $998,774 Total Award Period Covered: 3/1/2017 - 2/29/2020
Location of Project: WHOI
Person-Months Per Year Committed to the Project: Cal: 1.00/1.00/1.00 Acad: Sumr:

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

W. ZHANG, E. MAKSYM, R. JI, S. JENOUVRIER - Collaborative Research: Polynyas in Coastal Antarctica (PICA): Linking Physical Dynamics to Biological Variability
POC:Paul Cutler (703) 292-4961 pcutler@nsf.gov

Source of Support: *National Science Foundation (NSF)*
Total Request Amt: $795,202 Total Award Period Covered: 5/1/2017 - 4/30/2020
Location of Project: WHOI
Person-Months Per Year Committed to the Project: Cal: 2.50/2.50/3.00 Acad: Sumr:

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

D. MCGILLICUDDY, H. SOSIK, W. ZHANG, R. STANLEY - Collaborative Research: Shelfbreak Frontal Dynamics: Mechanisms of Upwelling, Net Community Production, and Ecological Implications

* This Proposal
Source of Support: *National Science Foundation (NSF)*
Total Request Amt: $1,993,155 Total Award Period Covered: 10/1/2017 - 9/30/2020
Location of Project: WHOI
Person-Months Per Year Committed to the Project: Cal: 4.00/4.00/4.00 Acad: Sumr:

Current and Pending Support: Dr. Walker Smith

Investigator: **Walker Smith**	Other agencies to which this proposal has been/will be submitted. **None**

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: *Effects of Temperature on Phytoplankton Growth Rates*
Source of Support: NSF-PLR
Total Award Amount: $275,578 Total Award Period Covered: 4/1/2015-3/30/2018
Location of Project: VIMS, Ross Sea
Person-Months Per Year Committed to the Project. Cal: 1.0 Acad: Sumr:

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: *NSFGEO-NERC: Collaborative Research - Bloom Initiation Dynamics in the Ross Sea (BID-RS)*
Source of Support: NSF-PLR
Total Award Amount: $734,933 Total Award Period Covered: 3/1/2017-2/29/2020
Location of Project: VIMS, Ross Sea
Person-Months Per Year Committed to the Project. Cal: 1.5 Acad: Sumr:

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: *Collaborative Research: Crystal Krill-Copepod-Phytoplankton Interactions in the Ross Sea*
Source of Support: NSF-PLR
Total Award Amount: $657,563 Total Award Period Covered: 2/1/2017-1/31/2020
Location of Project: VIMS, Ross Sea
Person-Months Per Year Committed to the Project. Cal: 1.0 Acad: Sumr:

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: *Collaborative Research: Shelfbreak frontal dynamics: mechanisms of upwelling, net community production, and ecological implications* ***(this proposal)***
Source of Support: NSF-OCE
Total Award Amount: $420,394 Total Award Period Covered: 10/1/2017-09/30/2020
Location of Project: Ross Sea, VIMS, US NE coast
Person-Months Per Year Committed to the Project. Cal: 1 Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:
Source of Support:
Total Award Amount: $ Total Award Period Covered:
Location of Project: Viet Nam
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:
Source of Support:
Total Award Amount: $ Total Award Period Covered:
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Current and Pending Support – Rachel Stanley

Department of Chemistry

Wellesley College, Wellesley MA

Current:

NSF: "*Quantifying rates of biological production to better understand the carbon cycle in the Canada Basin*." PLR-1547011. 6/1/13 to 5/31/16. Original total $235,537 and then transferred to Wellesley on July, 8 2015. Transferred amount: $119,409. Remaining Commitment: 0 months/year. Ends in May, 2017, before this proposal will start.

Dalio Foundation as subaward through Woods Hole Oceanographic Institution: "*Adaptive sampling of hotspots in net community production using the VPR, REMUS, and traditional hydrographic methods.*" Total proposal: $477,095. 4/1/16 to 3/31/18. Co PI with Dennis McGillicuddy. Subaward to Stanley at Wellesey $29,836 Commitment: 1 summer month in 2016, 0.5 summer months in 2017.

NSF: "*Collaborative Research: RUI: Investigating Gas Exchange Processes using Noble Gases in a Controlled Environment*." 09/1/2016 to 08/31/2019. $149,958; Commitment: 1 summer month/ year and one additional academic month during my sabbatical year 2018.

Pending:

NSF: *LTER: Linking Pelagic Community Structure with Ecosystem Dynamics and Production Regimes on the Changing Northeast US Shelf.* 5/1/2017 to 4/30/2023. Subaward to Wellesley College for $181,320. Commitment: 1 summer month/ year and one additional academic month during my sabbatical year 2018.

This proposal: *Collaborative Research: Shelfbreak Frontal Dynamics: Mechanisms of Upwelling, Net Community Production, and Ecological Implications.* 10/1/17 to 9/30/2020. $103,583 to Wellesley College. Commitment: 1 summer month in 2018 and 2020 and 0.5 summer month in 2019. One academic month in 2018 (during my sabbatical year).

Current and Pending Support

(See GPG Section II.C.2.h for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Jefferson Turner

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Harbor Outfall Monitoring 8

Source of Support: Battelle Memorial Institute (MWRA prime) US001-0000253836

Total Award Amount: $ 148,110 Total Award Period Covered: 01/25/11 - 12/31/17

Location of Project: University of Massachusetts Dartmouth SMAST

Person-Months Per Year Committed to the Project. Cal:0.00 Acad: 0.00 Sumr: 1.00

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Rust Tides of the Toxic Dinoflagellate Cochlodinium Polykrikoides in Buzzards Bay

Source of Support: Woods Hole Sea Grant A101229

Total Award Amount: $ 75,379 Total Award Period Covered: 02/01/15 - 12/31/17

Location of Project: University of Massachusetts Dartmouth SMAST

Person-Months Per Year Committed to the Project. Cal:0.00 Acad: 0.00 Sumr: 0.00

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Collaborative Research: Shelfbreak frontal dynamics: mechanisms of upwelling, net community production, and ecological implications

Source of Support: NSF

Total Award Amount: $ 461,615 Total Award Period Covered: 10/01/17 - 09/30/20

Location of Project: University of Massachusetts Dartmouth SMAST

Person-Months Per Year Committed to the Project. Cal:0.00 Acad: 0.00 Sumr: 1.00

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Summ:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

 USE ADDITIONAL SHEETS AS NECESSARY

Current and Pending Support

(See GPG Section II.C.2.h for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Christian Petitpas

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Collaborative Research: Shelfbreak frontal dynamics: mechanisms of upwelling, net community production, and ecological implications

Source of Support: NSF

Total Award Amount: $ 461,615 Total Award Period Covered: 10/01/17 - 09/30/20

Location of Project: University of Massachusetts Dartmouth SMAST

Person-Months Per Year Committed to the Project. Cal:6.00 Acad: 0.00 Sumr: 0.00

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Summ:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Facilities, Equipment and other Resources

Laboratory:

Both the Accuri C6 flow cytometer and the Color Digital-Autonomous VPR (DAVPR) will be provided at no cost to the project via the shared use equipment pool of the WHOI Biology Department.

Several standard Imaging FlowCytobot (IFCB) instruments are available in the Sosik laboratory to support time series (e.g., MVCO) and process cruise observations. In addition, there is one recently developed Staining IFCB that expands capability to discriminate live microplankton cells that may not exhibit chlorophyll fluorescence. One standard IFCB and the Staining IFCB will be available at no cost for the cruise work proposed for this project.

In the Sosik laboratory, we will have access to facilities and equipment to support maintenance and evaluation of instruments in preparation for the proposed cruise operations. These include a wide variety of electrical, optical, electronic equipment and testing devices, including power supplies, function generators, digital oscilloscopes, diode lasers, LEDs, photomultipliers, amplifiers, and PIC microprocessor systems. We also have extensive phytoplankton culturing facilities and a phytoplankton culture collection that can be used to evaluate instrument performance during testing and configuration.

In the Stanley laboratory at WHOI, there is a Thermofisher 253 Isotope Ratio Mass Spectrometer configured specifically for measuring triple oxygen isotopes and O_2/Ar ratios. The attached automated processing line makes use of a custom-made cryogenic trap, Neslab recirculating chillers, GC column, refrigerated bath, turbomolecular pumps, and mechanical pumps. The entire system is under automated control and can be checked from the internet. Sample precision on that system is typically 5 per meg for $^{17}\Delta$, 0.01 per mil for $\delta^{17}O$, and 0.008 per mil for $\delta^{18}O$.

Our nutrient samples will be run at WHOI's Nutrient Analytical Facility. The facility utilizes several state of the art methods and instruments for quantifying bio-element concentrations in environmental samples. The facility operates a SEAL AA3 four-channel segmented flow analyzer to determine dissolved nutrient concentrations in aquatic ecosystems ranging from groundwater to the open ocean. It offers a high sample throughput coupled with simple and rapid method changeover to maximize productivity in determining nutrients including: ammonium, nitrate, nitrite, orthophosphate, silicate, and total dissolved nitrogen. The methods used for analysis are USEPA approved.

Clinical: N/A

Animal: N/A

Computer: The computational infrastructure of Dr. McGillicuddy's laboratory consists of a network of eight Dell Precision T7400n Workstations operating Redhat Enterprise Linux 5.2, each unit with two quad core Xeon processors running at 3.00GHz, 8 GB memory, and 500 GB disk space. A 2.6TB and a 3.4TB Raid server are available for local storage of model results and visualizations. These systems are sufficient to carry out the proposed data analysis. Computational infrastructure in the Sosik laboratory includes two Dell Precision T7500/7600 six core workstations with >3TB storage for routine data analysis and access; and, for more demanding image analysis and classification tasks, three Dell R710 PowerEdge servers (rack mounted), each with two 6-core Xeon X5660s 2.8GHz processors, 72 GB of RAM, and 5TB of local disk space. The R710 servers are connected to a BackBlaze Storage Pod with 120TB installed disk storage and to one another via dedicated 10 GigE switch. Zhang owns a portion of a WHOI community computer cluster (288 out of the total 2160 computing cores), and he has access to the entire cluster through a cluster queuing system. Should this proposal be successful, Zhang will apply for time at one of the national supercomputer centers, to supplement WHOI computer resources.

Office: All personnel have adequate office space.

Other resources: A wide range of shop services and facilities is available to WHOI staff including a precision machine shop, carpentry shop, and graphics services. WHOI's Computer and Information Services (CIS) group provides computer services including technical support, consulting and applications programming services for distribution and central computing systems used by the WHOI community.

FACILITIES, EQUIPMENT & OTHER RESOURCES: VIMS

FACILITIES: *Identify the facilities to be used at each performance site listed and, as appropriate, indicate their capacities, pertinent capabilities, relative proximity, and extent of availability to the project. Use "Other" to describe the facilities at any other performance sites listed and at sites for field studies. USE additional pages as necessary.*

The Virginia Institute of Marine Science (VIMS) of the College of William and Mary is a modern, well-equipped marine laboratory with an extensive complex of facilities located near the mouth of the York River. Smith's lab is located in Chesapeake Bay Hall, where he has multiple instruments and computers, and where he is authorized to process radioactive samples. His office is in 201 Maury Hall.

Laboratory: Dr. Smith's laboratory is equipped with fluorometers, HPLC systems, growth chambers, a Fisons Elemental (CHN) Analyzer, drying ovens, an Accuri C6 flow cytometer and work station, spectrophotometers, scintillation counter, microscopes (Walz PAM microscope and epifluorescent microscope), filtration rigs and pumps, combustion ovens, and active fluorescence gear (PAM and FRR fluorometers). All of these equipment items are available for use in this project as needed.

Clinical: n/a

Animal: n/a

Computers: All VIMS personnel are provided with PC's that are networked together and have access to a central data base. VIMS has a dedicated department for IT support and network maintenance.

Office: Smith is housed in Maury Hall, where he has access to the VIMS network, faxes, Xerox facilities and recycling.

MAJOR EQUIPMENT: *List the most important items available for this project and, as appropriate identifying the location and pertinent capabilities of each.*

Smith has the following in his laboratory and available to the project: a Waters HPLC system with autosampler (upgraded 10/2014), CHN analyzer, 3 Turner Designs Fluorometers; 3 inverted microscopes with attached digital cameras; spectrophotometer; combustion oven; drying ovens; flow cytometer

OTHER RESOURCES: *Provide any information describing the other resources available for the project. Identify support services such as consultant, secretarial, machine shop, and electronics shop, and the extent to which they will be available for the project. Include an explanation of any consortium/contractual arrangements with other organizations.*

FACILITIES: Wellesley College

Prof. Stanley's laboratory at Wellesley College has two field deployable equilibrator mass spectrometer systems. One is an at-sea Equilibrator Inlet Mass Spectrometer (EIMS) of the style of Cassar et al. (2009) for measuring O_2/Ar ratios. This instrument is equipped with a Pfeiffer quadrupole mass spectrometer, Agilent compact pumping station with a turbomolecular pump and scroll pump, a VICI switching valve allowing for automated calibration (although bottle samples will be taken for additional calibration), a Membrane minimodule cartridge, and an assortment of gear pumps, flow meters, filters, fused silica capillary and tubing. The instrument measures the ratios of O_2/Ar in underway water from a ship with an equilibration time of several minutes (time is set by timescale of equilibration of gas within the catridge). Precision is typically better than 0.2%.

The second mass spectrometer is a a Gas Equilibrator Mass Spectrometer (GEMS), which is configured to make measurements of a suite of noble gas mole ratios (Manning et al., 2016). The system is similar to the EIMS but has a a Hiden triple filter quadrupole mass spectrometer, hot and cold zirconium-iron-vanadium getters (SAES ST2002), and a Membrana Extra-Flow equilibrator cartridge. The instrument measures ratios of the noble gases (Ne, Ar, Kr and Xe) in air or water depending on the position of the VICI switching valve. Water (from a tank or an underway system of a ship or a coastal embayment) is pumped through the Membrane Extra-Flow where the gas equilibrates with the headspace in the cartridge. In order to aid equilibration, a small pump recirculates the air in the headspace through two drying cartridges.

Stanley's lab also includes an assortment of laboratory equipment which is useful for sample preparation, testing, and analysis such as a convection oven and a temperature-regulated water bath.

Stanley has an office and access to multiple desktop and laptop computers. If required, she has access to workstations at Wellesley College. Additionally, Wellesley College has a machine shop with welding capabilities.

Wellesley College has a vibrant research program, including a summer research program which has 100 to 130 students per summer, roughly 35% of which are minorities and first generation college students. Endowed funds and internal fellowships will support summer students on this project each year. During the semester, students will do research on this project usually for credit but may be sponsored by the college's Sophomore Early Research Program in which work-study funds are given to low-income students who perform research in labs.

REFERENCES for Facilities Section

Cassar, N., Barnett, B.A., Bender, M.L., Kaiser, J., Hamme, R.C., Tilbrook, B., 2009. Continuous High-Frequency Dissolved O_2/Ar Measurements by Equilibrator Inlet Mass Spectrometry. Analytical Chemistry 81, 1855-1864.

Manning, C., Stanley, R.H.R., Lott III, D.E., 2016. Continuous Measurements of Dissolved Ne, Ar, Kr, and Xe Ratios with a Field-deployable Gas Equilibration Mass Spectrometer. Analytical Chemistry, 88, 3040-3048.

Facilities, Equipment and other Resources: University of Massachusetts Dartmouth

Laboratory: Dr. Turner has two laboratories with equipment available to the project: one on the main campus of UMass Dartmouth and one at SMAST in New Bedford, MA. Both laboratories are equipped with Olympus BX40 compound microscopes and Wild Heerbrugg M5A stereo microscopes, and the SMAST laboratory has an additional Olympus SZH10 stereo microscope. The Olympus microscopes on the SMAST campus are equipped with Zeiss AxioCam MRc5 camera equipment and software. Additional laboratory equipment available at no cost to the project include a Turner Designs fluorometer, -80°C freezers, laboratory refrigerators, fume hoods, centrifuges, mass balances, vacuum pumps, sieves and a variety of general labware.

Clinical: N/A

Animal: N/A

Computer: Dr. Turner's offices and laboratories are equipped with multiple desktop and laptop computers and printers with appropriate software and network access to provide adequate computing and word processing capabilities in support of this research.

Office: All personnel have adequate office space.

Other resources: In addition to the space, facilities, and resources listed above, UMass Dartmouth will provide several other forms of support for the program, including core facilities maintenance, laboratory personal protective gear and hazardous waste disposal services through UMass Dartmouth's Department of Environmental Health & Safety (EH&S), and access to a truck/box truck for the purpose of transporting equipment during cruise mobilization/demobilization. Additionally, UMass Dartmouth offers an extensive array of computing and information technology support services through the Department of Computing and Information Technology Services (CITS).

Data management plan

All data collected during this project will be managed by the Biological and Chemical Oceanography Data Management Office (BCO-DMO) located at WHOI. The BCO-DMO will also handle submission of the data to NODC for final archiving at the end of the project. We will meet with BCO-DMO staff during the first six months of our project to discuss details associated with each of our data types and define protocols for producing appropriate data format, documentation of quality control, and metadata. BCO-DMO staff will also provide guidance on best practices for cruise data management (cruise reports and sampling event logs) and facilitate the publication of our results after the cruise. Underway data are critical to this project, and we are pleased to contribute standard underway ship-based measurements as well as our own measurements as part of the UNOLS central data repository at http://www.rvdata.us/catalog/, managed by the Rolling Deck to Repository (R2R) project.

While access to data will be limited to the participating investigators for an initial period of time, public access to all data and supporting documentation (metadata) will be granted within two years. Data and metadata from this project will be available as part of the larger BCO-DMO data system. The ability to integrate results from this project with those from prior research will greatly enhance the value of the data to be collected and ensure its central maintenance and accessibility into the future.

Dr. McGillicuddy has extensive experience with BCO-DMO staff, having worked closely with them in management of data from the NSF-sponsored EDDIES project (OCE-0241310), Quantification of *Trichodesmium* spp. vertical and horizontal abundance patterns and nitrogen fixation in the western North Atlantic (OCE-0925284), as well as a collection of data sets dealing with harmful algal blooms in the Gulf of Maine:

http://www.bco-dmo.org/project/2048
http://www.bco-dmo.org/project/2104
http://www.bco-dmo.org/project/2118

Results from three of Dr. McGillicuddy's modeling projects are also archived there:

http://www.bco-dmo.org/dataset/3198
http://www.bco-dmo.org/dataset/3195
http://www.bco-dmo.org/project/473687

and we will do the same for the modeling results generated by the present project. We will also supply model output (or links thereto) to the two relevant regional components of NOAA's Integrated Ocean Observing System: the Northeastern Regional Association of Coastal and Ocean Observing Systems (NERACOOS), and the Mid-Atlantic Regional Coastal Ocean Observing System (MARCOOS).

Image and image product data sets – Because of the unique challenges in effectively sharing the large image data sets and the analysis products associated with them, we will also provide specialized access to these observations. This will be accomplished with mechanisms already established in the Sosik laboratory for rapid and easy web-based access to these types of data. This access includes not only raw images (~several GBytes day^{-1}), but also the metadata associated with each image (e.g., date/time, as well as fluorescence, light scattering, location in camera field, etc.) and the routine image products produced from our analysis pipeline (masks to identify target pixels, extracted features and biomass metrics, taxonomic classification results for each image). This will follow the pattern currently implemented for IFCB imagery collected at MVCO; see http://ifcb-data.whoi.edu/ where images and associated metadata are openly accessible through html, PNG, JPG, RDF, XML, and other standard formats via web services.

Mentoring Plan

Not applicable.

Project Title: Collaborative Research: Shelfbreak frontal dynamics: mechanisms of upwelling, net community production, and ecological implications

Project Short Title: SBF phys/bio | **Project Status:** Draft

UNOLS Project ID #: 105432 | **Version #:** 0

Last Modified: 8/6/2016 9:59:00 AM | **Date Submitted:**

Project Created By: Dennis J. McGillicuddy

P.I. Name: Dennis J. McGillicuddy | **Institution:** WHOI

Phone: (508) 289-2683 | **Fax:**

Email: dmcgillicuddy@whoi.edu

Institution: WHOI - Woods Hole Oceanographic Institution

Address: Woods Hole, MA 02543 USA

Co P.I. Name	Institution	Phone	Email
Heidi M. Sosik	WHOI	(508) 289-2311	hsosik@whoi.edu
Weifeng Gordon Zhang	WHOI	(508) 289-2521	wzhang@whoi.edu
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Rachel Stanley	Wellesley College	(781) 283-3122	rachel.stanley@wellesley.edu

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Science Discipline: Multi-Disciplinary | **Large Program Abbr:**

If Other Science Discipline, specify:

Large Program Comments:

Project Status: New Proposal

Agency/Division/Program	Grant/Project Number	Agency Funding Status
NSF/OCE/BIO		To Be Submitted

Agency Description:

Institutional Proposal #:

Proposal Deadline submitted for: 8/15/2016

Project Start Date: 10/01/2017 | **End Date:** 9/30/2020

Project Budget: $2,978,748

Year	Ship(s) Requested (Name Or Size)	Total Days Req.	Start Date	Repeat/Multi-ship/ Clearance Req./Est. Cost	Status
2018	Neil Armstrong	17	5/01/2018	N/N/N/0	Draft
2018	Neil Armstrong	17	7/15/2018	N/N/N/0	Draft
2019	Neil Armstrong	17	5/01/2019	N/N/N/0	Draft

Project Webpage:

Summary of Field Work: CTD transects across the shelfbreak front in the vicinity of the Pioneer Array.

Summary of Facility Requirements: Standard hydrographic sampling.

Summary of Other Requirements or Comments:

Project Short Title:	SBF phys/bio	**UNOLS Project ID #:**	105432
PI Name:	Dennis J. McGillicuddy	**Version #:**	0
Last Modified:	8/6/2016 9:59:00 AM	**Date Submitted:**	
Institution:	WHOI - Woods Hole Oceanographic Institution		
Funding Agencies:	NSF/OCE/BIO		

UNOLS Request ID #:	1008789	**Last Modified:**	8/03/2016
Request Type:	Primary	**Date Submitted:**	
Submitted By:	Dennis J. McGillicuddy		

Year	Ship/Facility	Optimum Start	Earliest Start	Latest Start
2018	Neil Armstrong	5/01/2018	4/15/2018	5/16/2018

Dates To Avoid:

	Science Days	Mob Days	DeMob Days	Transit Days (Est)	Total
Op Days Needed	12	2	1	2	17

Multi-Ship OP? No **Description:**

Repeating Cruise? No **# of Cruises:** 0 **Interval:**

Repeating Description:

Schedule Justification:

	Lat/Long	Marsden Grid	Navy Op Area
Beginning			NA06
Ending			NA06

Op Area Summary: Pioneer Array

Op Area Size: 100

Op Area Details: Operations area primarily within the Pioneer Array, although departures to the nearby environs are possible.

Foreign Clearance Required: No

Coastal States:

Foreign Clearance Comments:

ITAR/EAR regulated equipment: No

If yes, permit applied for: No

Start Port: Woods Hole, MA, USA

Intermediate Ports: None

End Port: Woods Hole, MA, USA

Port Explanation:

Chief Scientist: Dennis J. McGillicuddy

 # in Science Party: 22 **# of Science Teams:** 1 **# of Marine Techs:** 1

Science Party Explanation: Standard science party; operator provided technician should have extensive experience with CTD operations.

Instrumentation that affects scheduling

ADCP

Instrumentation Explanation:

Major Ancillary Facilities

General Purpose Lab Van
Radioisotope Lab Van

Ancillary Facilities Explanation:

Project Short Title:	SBF phys/bio	**UNOLS Project ID #:**	105432
PI Name:	Dennis J. McGillicuddy	**Version #:**	0
Last Modified:	8/6/2016 9:59:00 AM	**Date Submitted:**	
Institution:	WHOI - Woods Hole Oceanographic Institution		
Funding Agencies:	NSF/OCE/BIO		

UNOLS Request ID #:	1008788	**Last Modified:**	8/03/2016
Request Type:	Primary	**Date Submitted:**	
Submitted By:	Dennis J. McGillicuddy		

Year	Ship/Facility	Optimum Start	Earliest Start	Latest Start
2018	Neil Armstrong	7/15/2018	7/01/2018	8/01/2018

Dates To Avoid:

	Science Days	Mob Days	DeMob Days	Transit Days (Est)	Total
Op Days Needed	12	2	1	2	17

Multi-Ship OP? No **Description:**

Repeating Cruise? No **# of Cruises:** 0 **Interval:**

Repeating Description:

Schedule Justification:

	Lat/Long	Marsden Grid	Navy Op Area
Beginning	40° N/70° W	152	NA06
Ending	40° N/71° W	152	NA06

Op Area Summary: Pioneer Array

Op Area Size: 100

Op Area Details: Operations area primarily within the Pioneer Array, although departures to the nearby environs are possible.

Foreign Clearance Required: No

Coastal States:

Foreign Clearance Comments:

ITAR/EAR regulated equipment: No

If yes, permit applied for: No

Start Port: Woods Hole, MA, USA

Intermediate Ports: None

End Port: Woods Hole, MA, USA

Port Explanation:

Chief Scientist: Dennis J. McGillicuddy

 # in Science Party: 22 **# of Science Teams:** 1 **# of Marine Techs:** 1

Science Party Explanation: Standard science party; operator provided technician should have extensive experience with CTD operations.

Instrumentation that affects scheduling

ADCP

Instrumentation Explanation:

Major Ancillary Facilities

General Purpose Lab Van
Radioisotope Lab Van

Ancillary Facilities Explanation:

Project Short Title:	SBF phys/bio	**UNOLS Project ID #:**	105432
PI Name:	Dennis J. McGillicuddy	**Version #:**	0
Last Modified:	8/6/2016 9:59:00 AM	**Date Submitted:**	
Institution:	WHOI - Woods Hole Oceanographic Institution		
Funding Agencies:	NSF/OCE/BIO		

UNOLS Request ID #:	1008787	**Last Modified:**	8/03/2016
Request Type:	Primary	**Date Submitted:**	
Submitted By:	Dennis J. McGillicuddy		

Year	Ship/Facility	Optimum Start	Earliest Start	Latest Start
2019	Neil Armstrong	5/01/2019	4/15/2019	5/16/2019

Dates To Avoid:

	Science Days	Mob Days	DeMob Days	Transit Days (Est)	Total
Op Days Needed	12	2	1	2	17

Multi-Ship OP? No **Description:**

Repeating Cruise? No **# of Cruises:** 0 **Interval:**

Repeating Description:

Schedule Justification:

	Lat/Long	Marsden Grid	Navy Op Area
Beginning	40° N/70° W	152	NA06
Ending	40° N/71° W	152	NA06

Op Area Summary: Pioneer Array

Op Area Size: 100

Op Area Details: Operations area primarily within the Pioneer Array, although departures to the nearby environs are possible.

Foreign Clearance Required: No

Coastal States:

Foreign Clearance Comments:

ITAR/EAR regulated equipment: No

If yes, permit applied for: No

Start Port: Woods Hole, MA, USA

Intermediate Ports: None

End Port: Woods Hole, MA, USA

Port Explanation:

Chief Scientist: Dennis J. McGillicuddy

 # in Science Party: 22 **# of Science Teams:** 1 **# of Marine Techs:** 1

Science Party Explanation: Standard science party; operator provided technician should have extensive experience with CTD operations.

Instrumentation that affects scheduling

ADCP

Instrumentation Explanation:

Major Ancillary Facilities

General Purpose Lab Van
Radioisotope Lab Van

Ancillary Facilities Explanation: