Cover Page for Proposal Submitted to the National Aeronautics and Space Administration

NASA Proposal Number

21-OCEANstep2-0018

NASA PROCEDURE FOR HANDLING PROPOSALS

SECTION I - Proposal Information

Principal Investigator	E-mail Address	Phone Number
William Burt	wburt2@alaska.edu	907-474-7547

Street Address (1)	Street Address (2)
2150 Koyukuk Drive	ONeil Building 123

City	State / Province	Postal Code	Country Code
Fairbanks	AK	99775	US

Proposal Title : **Enhancing ocean color remote sensing tools to better constrain fisheries forecasting models in a critical subarctic system**

Proposed Start Date	Proposed End Date	Total Budget	Year 1 Budget	Year 2 Budget	Year 3 Budget
07 / 01 / 2021	06 / 30 / 2024	730,877.00	138,000.00	344,940.00	247,937.00

SECTION II - Application Information

NASA Program Announcement Number	NASA Program Announcement Title
NNH21ZHA001NRA-OCEAN	Minority University Research and Education Project/ Science Mission Directorate Research: Ocean Biology and Biogeochemistry (OCEAN)

For Consideration By NASA Organization *(the soliciting organization, or the organization to which an unsolicited proposal is submitted)*

NASA , Headquarters , Office of STEM Engagement , Integration , Minority University Research and Education Program

Date Submitted	Submission Method	Grants.gov Application Identifier	Applicant Proposal Identifier
04 / 15 / 2021	Electronic Submission Only		

Type of Application	Predecessor Award Number	Other Federal Agencies to Which Proposal Has Been Submitted
New		

International Participation	Type of International Participation
No	

SECTION III - Submitting Organization Information

DUNS Number	CAGE Code	Employer Identification Number (EIN or TIN)	Organization Type
615245164	3R2B4		2A

Organization Name (Standard/Legal Name)	Company Division
University Of Alaska, Fairbanks	GRANTS AND CONTRACTS ADMINISTRATION

Organization DBA Name	Division Number
GRANTS & CONTRACTS	

Street Address (1)	Street Address (2)
2145 N. TANANA LOOP	

City	State / Province	Postal Code	Country Code
FAIRBANKS	AK	99775	USA

SECTION IV - Proposal Point of Contact Information

Name	Email Address	Phone Number
William Burt	wburt2@alaska.edu	907-474-7547

SECTION V - Certification and Authorization

Certification of Compliance with Applicable Executive Orders and U.S. Code

By submitting the proposal identified in the Cover Sheet/Proposal Summary in response to this Research Announcement, the Authorizing Official of the proposing organization (or the individual proposer if there is no proposing organization) as identified below:

- certifies that the statements made in this proposal are true and complete to the best of his/her knowledge;
- agrees to accept the obligations to comply with NASA award terms and conditions if an award is made as a result of this proposal; and
- confirms compliance with all provisions, rules, and stipulations set forth in this solicitation.

Willful provision of false information in this proposal and/or its supporting documents, or in reports required under an ensuing award, is a criminal offense (U.S. Code, Title 18, Section 1001).

Authorized Organizational Representative (AOR) Name	AOR E-mail Address	Phone Number
Tapiana Wray	tewray@alaska.edu	907-474-1989

AOR Signature *(Must have AOR's original signature. Do not sign "for" AOR.)*	Date

PI Name : **William Burt**	NASA Proposal Number
Organization Name : **University Of Alaska, Fairbanks**	21-OCEANstep2-0018

Proposal Title : **Enhancing ocean color remote sensing tools to better constrain fisheries forecasting models in a critical subarctic system**

SECTION VI - Team Members

Team Member Role	Team Member Name	Contact Phone	E-mail Address
PI	**William Burt**	**907-474-7547**	**wburt2@alaska.edu**
Organization/Business Relationship		Cage Code	DUNS#
University Of Alaska, Fairbanks		**3R2B4**	**615245164**
International Participation	U.S. Government Agency		Total Funds Requested
No			**0.00**
Team Member Role	Team Member Name	Contact Phone	E-mail Address
Co-I	**Curry Cunningham**	**907-360-4217**	**cjcunningham@alaska.edu**
Organization/Business Relationship		Cage Code	DUNS#
University Of Alaska, Fairbanks		**3R2B4**	**615245164**
International Participation	U.S. Government Agency		Total Funds Requested
No			**0.00**
Team Member Role	Team Member Name	Contact Phone	E-mail Address
Other Professional	**Benjamin Lowin**	**907-750-9157**	**bflowin@alaska.edu**
Organization/Business Relationship		Cage Code	DUNS#
University Of Alaska, Fairbanks		**3R2B4**	**615245164**
International Participation	U.S. Government Agency		Total Funds Requested
No			**0.00**
Team Member Role	Team Member Name	Contact Phone	E-mail Address
Other Professional	**Hisatomo Waga**	**907-474-7413**	**hwaga@alaska.edu**
Organization/Business Relationship		Cage Code	DUNS#
University Of Alaska, Fairbanks		**3R2B4**	**615245164**
International Participation	U.S. Government Agency		Total Funds Requested
No			**0.00**

PI Name : **William Burt**	NASA Proposal Number
Organization Name : **University Of Alaska, Fairbanks**	21-OCEANstep2-0018

Proposal Title : **Enhancing ocean color remote sensing tools to better constrain fisheries forecasting models in a critical subarctic system**

SECTION VII - Project Summary

Phytoplankton represent the fundamental food source for higher trophic level marine animals. As ocean warming continues, certain areas are likely to become increasingly stratified, which is linked to phytoplankton communities dominated by smaller cells. These communities create longer food chains, and ultimately, decreased biomass at higher trophic levels (i.e., fish). These threats are amplified in the Northern Gulf of Alaska (NGA), which hosts one of the richest fisheries in the nation, while also exhibiting a warming trend nearly twice the global average, and rapid freshening due to glacial melt. Recent studies also point to alterations in the NGA's spring phytoplankton bloom, which may have cascading impacts to higher trophic levels. Despite these concerns, creating links between long-term changes in the phytoplankton community and recruitment of important fish species like salmon and groundfish, remains a significant challenge.
Preliminary satellite analyses and long-term records of phytoplankton size data reveal evidence of recent climate-driven shifts in both phytoplankton community composition (PCC) and spring bloom phenology. Building on these findings, and leveraging our team's collective resources and expertise, the goal of this project is to integrate shipboard observations and ocean color remote sensing into quantitative analyses of climate-driven variability at the base of the marine food chain and assess the potential impacts of these changes to groundfish and salmon stocks.

The project has four primary objectives:
-Develop regional bio-optical relationships to assess patterns in phytoplankton Chl, C:Chl, and productivity
-Conduct a regional satellite matchup analysis for the NGA to assess uncertainties in the current ocean color algorithms.
-Elucidate patterns and drivers of variability in PCC and spring bloom phenology across the satellite record
-Develop and integrate time-series metrics into fisheries forecast models to assess their predictive capabilities for the recruitment of commercially-valuable groundfish and salmon stocks.

Bio-optical relationships will be developed using a state-of-the-art flow-through optical system aboard multiple NGA expeditions. These estimates, combined with a large historical Chl database, will be used to create a satellite matchup dataset for Chl algorithm evaluation. We will then employ existing techniques for satellite analyses of PCC and bloom phenology, and compare results to the long-term size-fractioned Chl record. Newly-developed PCC and bloom metrics will then be incorporated into fisheries models using a Bayesian Adaptive Sampling method as well as cross-validation techniques to evaluate their potential to improve stock-specific recruitment forecasts.

The proposed work addresses NASA-OCEAN Goal 1, and specifically Objective 1.1: Quantitative remote sensing analyses of impacts and/or vulnerability of aquatic ecosystems to climate variability and change. Additionally, in strong alignment with the priorities, goals and objectives of CoSTEM, NASA STEM Engagement, and MUREP, the project focuses on maximizing opportunities for a range of minority students, while also making NASA-related research and products more relevant and accessible to minority populations. This includes fellowships for 2 graduate students (1 dedicated to an Alaska Native student), who will take on much of the data analysis and dissemination under the guidance of the interdisciplinary senior team members. Also, the project will award 3+ undergraduate scholarships to under-represented minority students, and conduct meaningful high-school outreach in a predominantly Alaska-Native community. To achieve this, we will work closely with Tamamta, a $3,000,000 NSF/NRT funded Indigenous-led graduate school training program, leverage a well-established Research Experience of Undergraduate (REU) program, and expand SOSSI, the PI's recently launched high-school outreach program.

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SECTION VIII - Other Project Information

Proprietary Information

Is proprietary/privileged information included in this application?

Yes

International Collaboration

Does this project involve activities outside the U.S. or partnership with International Collaborators?

No

Principal Investigator	Co-Investigator	Collaborator	Equipment	Facilities
No	**No**	**No**	**No**	**No**

Explanation :

NASA Civil Servant Project Personnel

Are NASA civil servant personnel participating as team members on this project (include funded and unfunded)?

No

Fiscal Year	Fiscal Year	Fiscal Year	Fiscal Year	Fiscal Year	Fiscal Year
Number of FTEs	Number of FTEs	Number of FTEs	Number of FTEs	Number of FTEs	Number of FTEs

PI Name : **William Burt**	NASA Proposal Number
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Proposal Title : **Enhancing ocean color remote sensing tools to better constrain fisheries forecasting models in a critical subarctic system**

SECTION VIII - Other Project Information

Environmental Impact

Does this project have an actual or potential impact on the environment?	Has an exemption been authorized or an environmental assessment (EA) or an environmental impact statement (EIS) been performed?
No	**No**

Environmental Impact Explanation:

Exemption/EA/EIS Explanation:

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SECTION VIII - Other Project Information

Historical Site/Object Impact

Does this project have the potential to affect historic, archeological, or traditional cultural sites (such as Native American burial or ceremonial grounds) or historic objects (such as an historic aircraft or spacecraft)?

No

Explanation:

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SECTION IX - Program Specific Data

PI Name : **William Burt**	NASA Proposal Number
Organization Name : **University Of Alaska, Fairbanks**	21-OCEANstep2-0018

Proposal Title : **Enhancing ocean color remote sensing tools to better constrain fisheries forecasting models in a critical subarctic system**

SECTION X - Budget

Cumulative Budget

Budget Cost Category	Funds Requested ($)			
	Year 1 ($)	Year 2 ($)	Year 3 ($)	Total Project ($)
A. Direct Labor - Key Personnel	29,945.00	38,312.00	47,077.00	115,334.00
B. Direct Labor - Other Personnel	41,638.00	148,138.00	67,424.00	257,200.00
Total Number Other Personnel	3	4	2	9
Total Direct Labor Costs (A+B)	71,583.00	186,450.00	114,501.00	372,534.00
C. Direct Costs - Equipment	0.00	0.00	0.00	0.00
D. Direct Costs - Travel	10,188.00	4,693.00	11,332.00	26,213.00
Domestic Travel	10,188.00	4,693.00	11,332.00	26,213.00
Foreign Travel	0.00	0.00	0.00	0.00
E. Direct Costs - Participant/Trainee Support Costs	0.00	0.00	0.00	0.00
Tuition/Fees/Health Insurance	0.00	0.00	0.00	0.00
Stipends	0.00	0.00	0.00	0.00
Travel	0.00	0.00	0.00	0.00
Subsistence	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00
Number of Participants/Trainees				0
F. Other Direct Costs	7,261.00	43,856.00	47,206.00	98,323.00
Materials and Supplies	1,000.00	1,000.00	1,000.00	3,000.00
Publication Costs	0.00	3,000.00	6,000.00	9,000.00
Consultant Services	0.00	0.00	0.00	0.00
ADP/Computer Services	0.00	0.00	0.00	0.00
Subawards/Consortium/Contractual Costs	0.00	0.00	0.00	0.00
Equipment or Facility Rental/User Fees	0.00	0.00	0.00	0.00
Alterations and Renovations	0.00	0.00	0.00	0.00
Other	6,261.00	39,856.00	40,206.00	86,323.00
G. Total Direct Costs (A+B+C+D+E+F)	89,032.00	234,999.00	173,039.00	497,070.00
H. Indirect Costs	48,968.00	109,941.00	74,898.00	233,807.00
I. Total Direct and Indirect Costs (G+H)	138,000.00	344,940.00	247,937.00	730,877.00
J. Fee	0.00	0.00	0.00	0.00
K. Total Cost (I+J)	138,000.00	344,940.00	247,937.00	730,877.00
Total Cumulative Budget				730,877.00

PI Name : **William Burt**	NASA Proposal Number
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SECTION X - Budget

Start Date :	End Date :	Budget Type :	Budget Period :
07 / 01 / 2021	**06 / 30 / 2022**	**Project**	**1**

A. Direct Labor - Key Personnel

Name	Project Role	Base Salary ($)	Cal. Months	Acad. Months	Summ. Months	Requested Salary ($)	Fringe Benefits ($)	Funds Requested ($)
Burt, William	**PI**	**11,482.00**	**2**			**22,964.00**	**6,981.00**	**29,945.00**
							Total Key Personnel Costs	**29,945.00**

B. Direct Labor - Other Personnel

Number of Personnel	Project Role	Cal. Months	Acad. Months	Summ. Months	Requested Salary ($)	Fringe Benefits ($)	Funds Requested ($)
1	**Post Doctoral Associates**	**3**			**17,268.00**	**4,766.00**	**22,034.00**
1	**Graduate Students**	**3**			**12,329.00**	**1,196.00**	**13,525.00**
1	**Undergraduate Students**	**2.3**			**5,541.00**	**538.00**	**6,079.00**
3	Total Number Other Personnel					Total Other Personnel Costs	**41,638.00**
						Total Direct Labor Costs (Salary, Wages, Fringe Benefits) (A+B)	**71,583.00**

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Proposal Title : **Enhancing ocean color remote sensing tools to better constrain fisheries forecasting models in a critical subarctic system**

SECTION X - Budget

Start Date :	End Date :	Budget Type :	Budget Period :
07 / 01 / 2021	**06 / 30 / 2022**	**Project**	**1**

C. Direct Costs - Equipment

Item No.	Equipment Item Description	Funds Requested ($)
	Total Equipment Costs	**0.00**

D. Direct Costs - Travel

	Funds Requested ($)
1. Domestic Travel (Including U.S. Territories and Possessions)	**10,188.00**
2. Foreign Travel (Including Canada and Mexico)	**0.00**
Total Travel Costs	**10,188.00**

E. Direct Costs - Participant/Trainee Support Costs

		Funds Requested ($)
1. Tuition/Fees/Health Insurance		**0.00**
2. Stipends		**0.00**
3. Travel		**0.00**
4. Subsistence		**0.00**
Number of Participants/Trainees:	Total Participant/Trainee Support Costs	**0.00**

PI Name : **William Burt**	NASA Proposal Number
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Proposal Title : **Enhancing ocean color remote sensing tools to better constrain fisheries forecasting models in a critical subarctic system**

SECTION X - Budget

Start Date :	End Date :	Budget Type :	Budget Period :
07 / 01 / 2021	**06 / 30 / 2022**	**Project**	**1**

F. Other Direct Costs

	Funds Requested ($)
1. Materials and Supplies	**1,000.00**
2. Publication Costs	**0.00**
3. Consultant Services	**0.00**
4. ADP/Computer Services	**0.00**
5. Subawards/Consortium/Contractual Costs	**0.00**
6. Equipment or Facility Rental/User Fees	**0.00**
7. Alterations and Renovations	**0.00**
8. Other: **Sensor Calibration, Curriculum Development**	**4,750.00**
9. Other: **OSM Registration**	**1,511.00**
10. Other:	**0.00**
Total Other Direct Costs	**7,261.00**

G. Total Direct Costs

	Funds Requested ($)
Total Direct Costs (A+B+C+D+E+F)	**89,032.00**

H. Indirect Costs

	Indirect Cost Rate (%)	**Indirect Cost Base ($)**	Funds Requested ($)
Facilities and Administration (F&A)	**55.00**	**89,032.00**	**48,968.00**
Cognizant Federal Agency: **Office of Naval Research (ONR); POC: Shea D. Kersey, Contracting Officer; Phone: (703) 696-2055**		Total Indirect Costs	**48,968.00**

I. Direct and Indirect Costs

	Funds Requested ($)
Total Direct and Indirect Costs (G+H)	**138,000.00**

J. Fee

	Funds Requested ($)
Fee	**0.00**

K. Total Cost

	Funds Requested ($)
Total Cost with Fee (I+J)	**138,000.00**

PI Name : **William Burt**	NASA Proposal Number
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SECTION X - Budget

Start Date :	End Date :	Budget Type :	Budget Period :
07 / 01 / 2022	**06 / 30 / 2023**	**Project**	**2**

A. Direct Labor - Key Personnel

Name	Project Role	Base Salary ($)	Cal. Months	Acad. Months	Summ. Months	Requested Salary ($)	Fringe Benefits ($)	Funds Requested ($)
Cunningham, Curry	**Co-I**	**11,684.00**	**.5**			**5,842.00**	**1,776.00**	**7,618.00**
Burt, William	**PI**	**11,769.00**	**2**			**23,538.00**	**7,156.00**	**30,694.00**
							Total Key Personnel Costs	**38,312.00**

B. Direct Labor - Other Personnel

Number of Personnel	Project Role	Cal. Months	Acad. Months	Summ. Months	Requested Salary ($)	Fringe Benefits ($)	Funds Requested ($)
1	**Post Doctoral Associates**	**9**			**53,100.00**	**14,656.00**	**67,756.00**
2	**Graduate Students**	**12**			**64,671.00**	**9,481.00**	**74,152.00**
1	**Undergraduate Students**	**2.3**			**5,679.00**	**551.00**	**6,230.00**
4	Total Number Other Personnel					Total Other Personnel Costs	**148,138.00**
						Total Direct Labor Costs (Salary, Wages, Fringe Benefits) (A+B)	**186,450.00**

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Proposal Title : **Enhancing ocean color remote sensing tools to better constrain fisheries forecasting models in a critical subarctic system**

SECTION X - Budget

Start Date :	End Date :	Budget Type :	Budget Period :
07 / 01 / 2022	**06 / 30 / 2023**	**Project**	**2**

C. Direct Costs - Equipment

Item No.	Equipment Item Description	Funds Requested ($)
	Total Equipment Costs	**0.00**

D. Direct Costs - Travel

	Funds Requested ($)
1. Domestic Travel (Including U.S. Territories and Possessions)	**4,693.00**
2. Foreign Travel (Including Canada and Mexico)	**0.00**
Total Travel Costs	**4,693.00**

E. Direct Costs - Participant/Trainee Support Costs

		Funds Requested ($)
1. Tuition/Fees/Health Insurance		**0.00**
2. Stipends		**0.00**
3. Travel		**0.00**
4. Subsistence		**0.00**
Number of Participants/Trainees:	Total Participant/Trainee Support Costs	**0.00**

PI Name : **William Burt**	NASA Proposal Number 21-OCEANstep2-0018
Organization Name : **University Of Alaska, Fairbanks**	

Proposal Title : **Enhancing ocean color remote sensing tools to better constrain fisheries forecasting models in a critical subarctic system**

SECTION X - Budget

Start Date :	End Date :	Budget Type :	Budget Period :
07 / 01 / 2022	**06 / 30 / 2023**	**Project**	**2**

F. Other Direct Costs

	Funds Requested ($)
1. Materials and Supplies	**1,000.00**
2. Publication Costs	**3,000.00**
3. Consultant Services	**0.00**
4. ADP/Computer Services	**0.00**
5. Subawards/Consortium/Contractual Costs	**0.00**
6. Equipment or Facility Rental/User Fees	**0.00**
7. Alterations and Renovations	**0.00**
8. Other: **Sensor Calibration, Curriculum Development**	**4,750.00**
9. Other: **OSM Registration**	**0.00**
10. Other: **Graduate Tuition and Fees**	**35,106.00**
Total Other Direct Costs	**43,856.00**

G. Total Direct Costs

	Funds Requested ($)
Total Direct Costs (A+B+C+D+E+F)	**234,999.00**

H. Indirect Costs

	Indirect Cost Rate (%)	Indirect Cost Base ($)	Funds Requested ($)
Facilities and Administration (F&A)	**55.00**	**199,893.00**	**109,941.00**
Cognizant Federal Agency: **Office of Naval Research (ONR); POC: Shea D. Kersey, Contracting Officer; Phone: (703) 696-2055**	Total Indirect Costs		**109,941.00**

I. Direct and Indirect Costs

	Funds Requested ($)
Total Direct and Indirect Costs (G+H)	**344,940.00**

J. Fee

	Funds Requested ($)
Fee	**0.00**

K. Total Cost

	Funds Requested ($)
Total Cost with Fee (I+J)	**344,940.00**

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SECTION X - Budget

Start Date :	End Date :	Budget Type :	Budget Period :
07 / 01 / 2023	**06 / 30 / 2024**	**Project**	**3**

A. Direct Labor - Key Personnel

Name	Project Role	Base Salary ($)	Cal. Months	Acad. Months	Summ. Months	Requested Salary ($)	Fringe Benefits ($)	Funds Requested ($)
Cunningham, Curry	**Co-I**	**11,976.00**	**1**			**11,976.00**	**3,641.00**	**15,617.00**
Burt, William	**PI**	**12,063.00**	**2**			**24,126.00**	**7,334.00**	**31,460.00**
							Total Key Personnel Costs	**47,077.00**

B. Direct Labor - Other Personnel

Number of Personnel	Project Role	Cal. Months	Acad. Months	Summ. Months	Requested Salary ($)	Fringe Benefits ($)	Funds Requested ($)
2	**Graduate Students**	**12**			**58,359.00**	**9,065.00**	**67,424.00**
2	Total Number Other Personnel					Total Other Personnel Costs	**67,424.00**
						Total Direct Labor Costs (Salary, Wages, Fringe Benefits) (A+B)	**114,501.00**

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SECTION X - Budget

Start Date :	End Date :	Budget Type :	Budget Period :
07 / 01 / 2023	**06 / 30 / 2024**	**Project**	**3**

C. Direct Costs - Equipment

Item No.	Equipment Item Description	Funds Requested ($)
	Total Equipment Costs	**0.00**

D. Direct Costs - Travel

	Funds Requested ($)
1. Domestic Travel (Including U.S. Territories and Possessions)	**11,332.00**
2. Foreign Travel (Including Canada and Mexico)	**0.00**
Total Travel Costs	**11,332.00**

E. Direct Costs - Participant/Trainee Support Costs

		Funds Requested ($)
1. Tuition/Fees/Health Insurance		**0.00**
2. Stipends		**0.00**
3. Travel		**0.00**
4. Subsistence		**0.00**
Number of Participants/Trainees:	Total Participant/Trainee Support Costs	**0.00**

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SECTION X - Budget

Start Date :	End Date :	Budget Type :	Budget Period :
07 / 01 / 2023	**06 / 30 / 2024**	**Project**	**3**

F. Other Direct Costs

	Funds Requested ($)
1. Materials and Supplies	**1,000.00**
2. Publication Costs	**6,000.00**
3. Consultant Services	**0.00**
4. ADP/Computer Services	**0.00**
5. Subawards/Consortium/Contractual Costs	**0.00**
6. Equipment or Facility Rental/User Fees	**0.00**
7. Alterations and Renovations	**0.00**
8. Other: **Sensor Calibration, Curriculum Development**	**750.00**
9. Other: **OSM Registration**	**2,595.00**
10. Other: **Graduate Tuition and Fees**	**36,861.00**
Total Other Direct Costs	**47,206.00**

G. Total Direct Costs

	Funds Requested ($)
Total Direct Costs (A+B+C+D+E+F)	**173,039.00**

H. Indirect Costs

	Indirect Cost Rate (%)	**Indirect Cost Base ($)**	Funds Requested ($)
Facilities and Administration (F&A)	**55.00**	**136,178.00**	**74,898.00**
Cognizant Federal Agency: **Office of Naval Research (ONR); POC: Shea D. Kersey, Contracting Officer; Phone: (703) 696-2055**		Total Indirect Costs	**74,898.00**

I. Direct and Indirect Costs

	Funds Requested ($)
Total Direct and Indirect Costs (G+H)	**247,937.00**

J. Fee

	Funds Requested ($)
Fee	**0.00**

K. Total Cost

	Funds Requested ($)
Total Cost with Fee (I+J)	**247,937.00**

Enhancing ocean color remote sensing tools to better constrain fisheries forecasting models in a critical subarctic system

1. Scientific and Educational Motivation

Phytoplankton represent the fundamental food source for higher trophic level animals in marine systems. Observations and modeling studies suggest that the ocean is becoming increasingly stratified in response to a warming climate, limiting nutrient exchange to the upper sunlit ocean and favoring small cells able to grow in warmer, nutrient poor conditions (Morán et al., 2010, Rhein et al., 2013). Phytoplankton assemblages dominated by smaller cells are associated with longer food chains and decreased energy transfer to higher trophic levels such as zooplankton, and ultimately, fish (Sommer et al., 2002; Barnes et al., 2011). Elucidating long-term climate-driven changes in phytoplankton community composition remains a challenge (see IOCCG, 2014 and Brewin et al., 2017), and knowledge gaps exist regarding possible consequences for abundance and distribution of fish stocks (Friedland et al., 2012). In the Northern Gulf of Alaska (NGA) threats of increased water column stratification are amplified by accelerated glacial melt (Hill et al., 2015), a sea surface warming trend roughly twice the global average, and more recently, recurring 'heatwave' events (Suryan et al., 2021). These changes also threaten to alter the NGA's spring phytoplankton bloom, upon which numerous species rely on for survival. Given that the NGA contains one of the most valuable fisheries in the nation (McDowell Group, 2020), investigating these climate-driven threats and linking them to fisheries is of immense social and economic importance.

The newly-funded NGA Long Term Ecological Research program (NGA-LTER) aims to elucidate and track ecosystem shifts in this critical high-latitude region. An NGA-LTER team (including this PI) have begun compiling *a unique 24-year record of shipboard phytoplankton size data collected across the NGA*, revealing evidence of shifts in phytoplankton community composition that align with recent heatwave events (Figure 1). Leveraging NGA-LTER resources and building on these findings, **this project goal is to integrate shipboard observations and ocean color remote sensing into quantitative analyses of climate-driven variability at the base of the marine food chain and assess the potential impacts of these changes to groundfish and salmon stocks.** This work responds to NASA OCEAN Goal 1, aligning with *Objective 1.1: Quantitative remote sensing analyses of impacts and/or vulnerability of aquatic ecosystems to climate variability and change*.

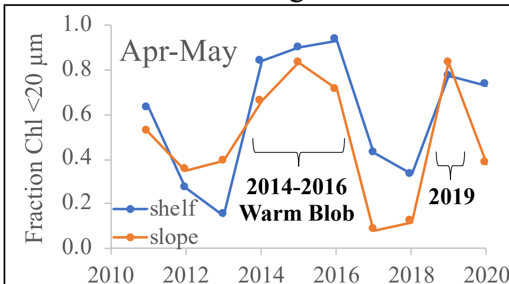


Fig. 1: Size fractionated Chl data along the NGA's Seward Line showing dominance of small cells during heatwave years.

The university of Alaska Fairbanks (UAF) is an Alaska Native and Native Hawaiian (ANNH) minority serving institution (MSI) with a 24% Alaska Native student body (https://uaf.edu/facts/), yet as of 2019, only 3% of students (and <1% of faculty) in the UAF College of Fisheries and Ocean Sciences (CFOS, PI's academic unit) were Alaska Native. Motivated by these inequities in STEM education, which persist nationwide (see Estrada et al., 2016), global leadership in Indigenous programs is now part of UAF's 2019-2025 Strategic Planning Goals, and in 2020, CFOS launched 'Tamamta'. This $3,000,000 NSF/NRT funded graduate student training program is aimed at 'Indigenizing' fisheries and marine sciences (inaugural cohort has 9 funded Indigenous graduate students, P. Westley, pers. comm.). Building on this progress, this NASA **project aims to maximize opportunities for a range of underrepresented minority students (specifically Alaska Native students), while also making NASA-related research and products more relevant and accessible to minority populations.**

2. Scientific Background

2.1 The NGA and its spring phytoplankton bloom

The NGA hosts a uniquely complex mosaic of water masses, and is characterized by strong seasonality in both physical drivers (light, temperature, freshwater input) and biological productivity. A fast-moving coastal current constrains land-derived material to a narrow nearshore band, while also producing mesoscale eddies that migrate across the offshore waters (see Figure 2, and Crawford et al., 2005). Nutrient dynamics are particularly convoluted, with numerous interactions between iron-limited offshore waters (high nutrient low chlorophyll or ‘HNLC waters’), nitrate-limited ‘shelf waters’, and the nearshore Alaska Coastal Current (ACC) heavily influenced by large turbid river plumes that are iron-rich and nutrient-depleted. Indeed, relationships between measured primary productivity and chlorophyll (Chl) from the NGA-LTER program show significant variability both spatially and seasonally, indicating extensive differences in physiological growth conditions driven by nutrient and light availability (S. Strom, pers. comm.). Given these intricacies, it is unsurprising that biogeochemical models have difficulties reproducing key features like the spring bloom (see Figure 3). For these reasons, the NGA can be considered *an ideal location to establish state-of-the-art measurement techniques aimed at unravelling how complex physicochemical conditions impact phytoplankton communities, and how this may be changing in response to climate forcing.*

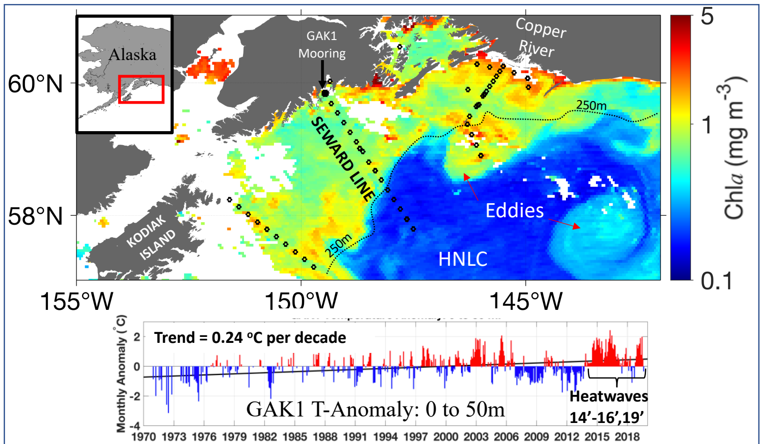


Fig. 2: **TOP:** NGA study area. Chlorophyll image (VIIRS July 3rd, during 2020 cruise) illustrates regional complexity. Station locations (black circles) show relatively sparse coverage. **BOTTOM:** 50-year temperature anomaly record from the GAK1 mooring (location on map), including recent heatwaves (2014-2016, 2019).

The NGA’s seasonal dynamics of primary productivity, particularly on the shelf, are punctuated by a large diatom-dominated spring bloom (Strom et al., 2006). Subsequent bloom collapse due to rapid nutrient depletion is followed by shoaling of the mixed layer, leading to a stratified summertime system dominated by smaller-celled nano-and picoplankon that persists until a secondary mixing-driven autumn bloom (Childers et al., 2005). The timing of these general seasonal patterns have been shown to vary considerably (Waite and Mueter, 2013), and recent analyses by this PI show peaks in satellite Chl during anomalously warm years occurring later in the season or even not at all (Figure 4). Such variations in bloom timing and magnitude

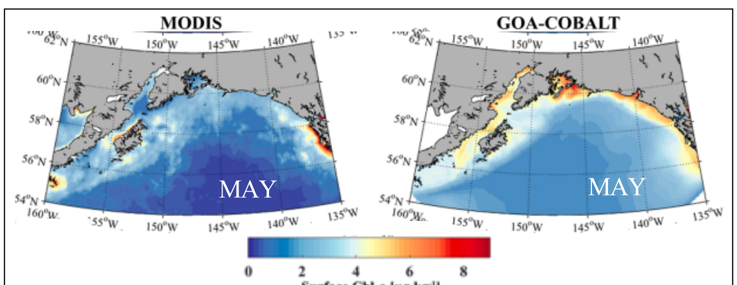


Fig. 3: Discrepancies between satellite Chl (**left**) and modeled Chl (GOA-COBALT model, **right**), attributed to poorly constrained C:Chl ratios (from Hauri et al., 2020).

have serious implications for the success of many secondary consumers (e.g. copepods, Coyle and Pinchuk, 2003) and the higher trophic level organisms, such as important fisheries species, that depend upon them. The cascading impact of altered bloom timing on upper-trophic level predators has been observed elsewhere (Hunt et al., 2008, 2011), but only surmised in the NGA (Suryan et al., 2021). Additionally, there is strong regional variability in the NGA, with distinctly different spring bloom timing among broader regions (shelf vs. deep water, Waite and Mueter, 2013).

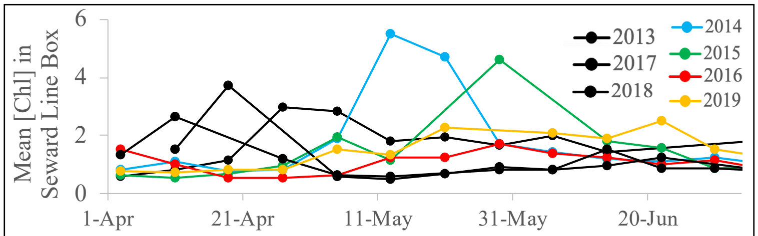


Fig. 4: Mean satellite chl along the Seward Line (8-day composites) showing a late or lacking peak during heatwave years (see Fig.2)

2.2 Estimates of the phytoplankton community via bio-optics and remote sensing

Understanding the patterns and controls of phytoplankton biomass, physiology and productivity is critical to both our fundamental understanding of the marine system, and climate-induced shifts in that system over time. Consistent multi-year monitoring platforms are particularly important in high-latitude systems, where climate-driven changes are occurring most rapidly. However, directly measuring the phytoplankton community is laborious and time consuming. For example, Chl and primary productivity measurements along the NGA-LTER are made, on average, ~20 km and ~80 km apart respectively. In addition to traditional station-based sampling, monitoring programs like the NGA-LTER require new technologies to capture important regional patterns or fine-scale structures of phytoplankton biomass and productivity (illustrated in Figure 2).

Optical measurements present a powerful tool for overcoming the inherent limitations of discrete ship-based measurements. They can be made at high spatial and temporal resolution from ships, buoys, underwater or airborne autonomous platforms, or can provide more synoptic measurements through satellite ocean color. Typical bio-optical models derived from such measurements include Chl estimates from satellite band ratios (O'Reilly et al., 1998), and via particulate absorption line-height (absLH, see Roesler and Barnard, 2013), phytoplankton carbon estimates via particulate backscatter (Graff et al., 2015), particulate organic carbon (POC) via particulate attenuation (Behrenfeld and Boss, 2006), and net primary productivity via productivity models (Westberry et al., 2008; Fox et al., 2020). Combining models for Chl and phytoplankton carbon facilitates study of phytoplankton carbon-to-chlorophyll ratios (C:Chl), a valuable metric of phytoplankton pigmentation or physiological condition (Behrenfeld et al., 2015) which varies considerably with abiotic conditions, but is commonly applied as a fixed value within biogeochemical models (either for the whole community, or within a 'size class', see Figure 3). Indeed, annual cycles of satellite-derived C:Chl in a region of the southern Gulf of Alaska was shown to vary 6-fold (Westberry et al., 2016), and shipboard research in a

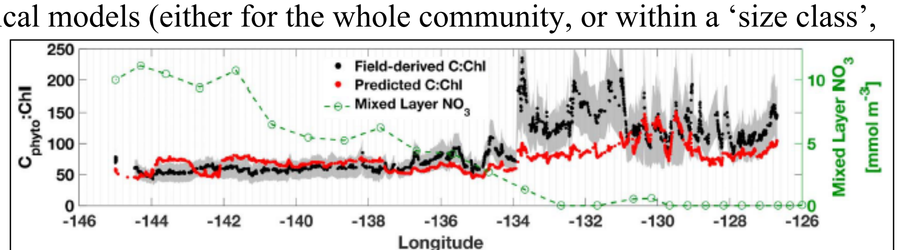


Fig. 5: Variable C:Chl (estimated via bio-optics) throughout N-limited and HNLC water, alongside C:Chl as predicted using changes in light fields (from Behrenfeld et al., 2015). From Burt et al., 2018.

similar area led by this PI revealed >10-fold variability in C:Chl, as well as regional and mesoscale patterns throughout nitrate-limited and HNLC waters (see Figure 5). Utilizing repeat field datasets from a state-of-the-art flow-through optical system established aboard on *R/V Sikuliaq* during the 2020 NGA-LTER field season, **Objective 1A** of the proposed research will address the question: *How does phytoplankton biomass, C:Chl, and productivity vary across unique water masses, their frontal boundaries, and other mesoscale features (e.g., eddies) present in the NGA.* By constraining this variability spatially, seasonally, and interannually, this proposed work can significantly enhance our broader scientific understanding, as well as biogeochemical modelling efforts both in the NGA and elsewhere.

Despite the power of satellites to provide synoptic insight into primary production, the standard band ratio algorithms have serious limitations in providing accurate estimates of Chl in the NGA. This arises from several factors that include i) the presence of colored dissolved organic material (CDOM) that absorbs in the same part of the visible spectrum as phytoplankton. This violates the underlying assumption of band ratio algorithms that Chl is the only absorbing water constituent (Lewis and Arrigo, 2020). ii) Challenges in achieving accurate atmospheric correction in sediment-laden waters such as the glacial meltwaters that flow into the NGA (Hill et al., 2015). Atmospheric correction relies on water leaving radiance in the near infrared (NIR) being zero or negligible in order to infer the atmospheric signal, but in turbid waters, this is often not true (Frouin et al. 2019). iii) Photoacclimation by phytoplankton growing in the NGA's low light conditions that causes high pigment packaging (Lewis and Arrigo, 2020) and thus deviation from the relationships between Chl and water leaving radiance in global band ratio algorithms (O'Reilly et al., 1998). Indeed, the only published satellite matchup analyses for the NGA reported a root-mean-square error (RMSE = 0.91 in log space, Waite and Mueter, 2013) that is 2-8 times higher than the range reported from prior studies (Brewin et al., 2016). In addition to the factors detailed above, this may also be due to the coarse nature of their matchups (~50 *in situ* samples matched to 9km, 8-day MODIS-Aqua composites), further highlighting the need for a more in-depth analysis. Further evidence of the inappropriateness of standard ocean color algorithms lies in an analysis done by this PI in the southern Gulf of Alaska using flow-through optically-derived chl data and 4km, 3-day MODIS-Aqua composites. This analysis, shown in Figure 6, revealed varying performance between different algorithms and a significant bias in C_{phyto} data. Combining these two products to assess C:Chl ratios revealed a relatively weak relationship between field and satellite-derived data ($r^2 = 0.55$, Burt et al., 2018).

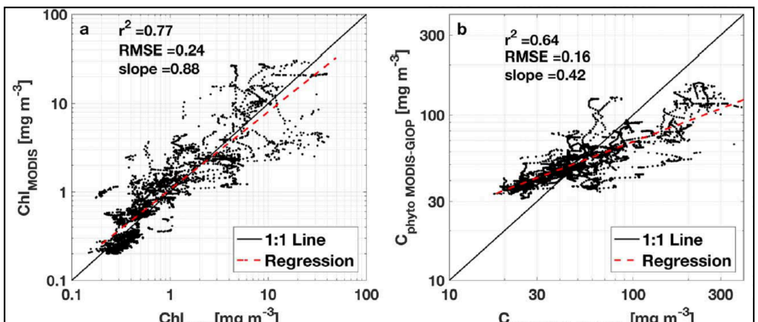


Fig. 6: Satellite matchups from Burt et al., (2018). Statistics are for log-transformed data. Chl_{ACS} = chl derived from optical measurements; C_{phyto} data are derived from satellite and underway *in situ* b_{bp}.

The lack of any rigorous ocean color algorithm testing in these areas is likely due to difficulties obtaining high-quality matchups due to notoriously cloudy conditions and high zenith angle. Waite and Mueter (2013) found that after excluding winter data (95% of pixels between November – February were not available), approximately 40% of pixels were unavailable. A more recent analysis by this PI revealed an average of 70 cloud-free days (between March-October) for a given 4kmx4km VIIRS chl pixel across the NGA study region. In an effort to overcome these challenges, we will accumulate a vast *in situ* Chl database comprised of more than 100 multi-week expeditions spanning nearly 25 years. Utilizing this, **Objective 1B** of the proposed project will address these questions: *What are the uncertainties associated with current ocean color products across different areas of the NGA, and how can this information (and/or a regional algorithm) significantly improve future numerical modeling and fisheries research that often rely on these data for model validation.*

2.3 Optical metrics of phytoplankton community composition and bloom phenology

There are currently a number of approaches for estimating phytoplankton community composition (PCC) from ocean color (IOCCG, 2014, Catlett and Siegel, 2018; Chase et al., 2017; Kramer and Siegel, 2019). However, these methods are associated with high degrees of uncertainty (Brewin et al. 2011, 2017) and there is still little consensus in the community on which approach yields the most ecologically relevant information (Shimoda & Arhonditsis, 2016). More recently, an approach has been developed that classifies ocean color in terms of its spectral shape (Vandermuelen et al. 2020). This approach has been shown to detect temporal, spatial, and spectral trends in ocean color and in **Objective 2A** of the proposed work, *we hypothesise that trends in PCC revealed by the LTER size-fractioned Chl dataset will also be evident in the ocean color record analyzed in this way.* Furthermore, this approach will allow us to investigate both the temporal variability and wide degree of spatial heterogeneity that exists in the NGA.

Satellite time series are a powerful and frequently used tool for assessing spatiotemporal changes in phytoplankton blooms (Brody et al., 2013, and references therein), with many studies reporting climate-driven shifts (e.g., Visser and Both, 2005). For example, satellite data from the Arctic have revealed shifts from a single spring bloom to a two-bloom (spring and fall) cycle (Ardyna et al., 2014; Waga and Hirawake, 2020). Several methods have been used to estimate metrics such as bloom initiation, peak, extent, and termination, and supplemental satellite data (e.g., SST) can be used to further investigate important drivers of bloom dynamics (Henson et al., 2018; Thomalla et al., 2011, and many others).

2.4 Fisheries forecasting models

Accelerated warming is bringing about major changes in fish species composition, distribution, and in some cases, species collapse (e.g. Pacific Cod, Barbeaux et al., 2017), and ultimately generating considerable uncertainty for both scientists and fisheries-reliant communities across Alaska. Sustainable management of Alaska's valuable commercial fisheries resources is heavily dependent upon understanding and predicting how the survival, growth and recruitment processes of exploited fish stocks respond to environmental and trophic forcing. Management of both salmon and groundfish resources has demonstrated increasing reliance on predictions for future abundance or survival based on attributes of the physical and biological environment measured at representative spatial and temporal scales (Cooper at al., 2019; Brenner et al., 2021). Preseason forecasts for the abundance of Pacific salmon returning to natal rivers provides a critical foundation on which annual fishery management plans are developed, with the accuracy of these forecasts influencing the efficacy of harvest regulation and efficiency of harvesting and processing sectors. Likewise, the management process for Alaska's groundfish species by the North Pacific Fishery Management Council (NPFMC) has placed increased importance on exploring and quantifying direct linkages between marine ecosystem processes and the estimated recruitment (juvenile production) of groundfish species, as described in the Ecosystem and Socioeconomic Profiles (ESPs) associated with annual groundfish stock assessments (see Barbeaux et al., 2020 for Pacific Cod, and Goethel et al., 2020 for Alaska sablefish).

Research by Co-I Cunningham and colleagues has focused on the development of statistical and Machine Learning methods for predicting patterns in the abundance and recruitment of Alaskan salmon and groundfish stocks based on time series of physical environmental predictors (i.e., sea surface temperature, SST) and key biological indicators (i.e., abundance of predators). However, to date, efforts to improve forecast methods have relied extensively on remotely-sensed data products describing physical processes in the marine environment (e.g., SST), rather than utilizing estimates of the phytoplankton community at spatial and temporal scales that are directly relevant to critical periods of high survival variation in the species' life history (i.e., the spring bloom). As such, prior forecast efforts have been limited to inferring mechanistic connections between fish survival and physical environmental variables, rather than leveraging metrics relating to the phytoplankton population, such as primary productivity, community composition and spring bloom phenology, which may provide more robust predictions for realized survival and abundance at later life history stages. In **Objective 2B**, we will develop such metrics to investigate the following question: *To what extent do changes in phytoplankton dynamics impact economically important higher trophic levels species such as salmon.*

3. Scientific Objectives

The project is split into two phases, with the first focused on developing enhanced *in situ* and remote sensing data products, and the second utilizing these products to conduct time series analyses and model simulations. The bulk of the analyses in each phase will be conducted by graduate students under the supervision and guidance of a multi-disciplinary team with considerable expertise and experience in the various project components. The project also has a substantial educational component aimed at building a larger and more diverse STEM workforce by engaging high-school and undergraduate students with unique and authentic learning experiences. The project phases and primary objectives are described below:

Phase 1: **Integrating autonomous ship-based systems and historical measurements to enhance monitoring capabilities and remote-sensing data products**

- **Objective 1A:** Develop regional bio-optical relationships to assess patterns in phytoplankton Chl, C:Chl, and productivity both regionally and across mesoscale features
- **Objective 1B:** Conduct a regional satellite matchup analysis for the NGA to assess uncertainties in the current ocean color algorithms.

Phase 2: **Assessing climate-driven changes in the phytoplankton community composition and spring bloom phenology, and exploring impacts to higher-trophic levels**

- **Objective 2A:** Elucidate patterns and drivers of variability in phytoplankton community composition and spring bloom phenology across the satellite record
- **Objective 2B:** Develop and integrate time series metrics into fisheries forecast models to assess their predictive capabilities for the recruitment, survival, or distribution of commercially-valuable groundfish and salmon stocks.

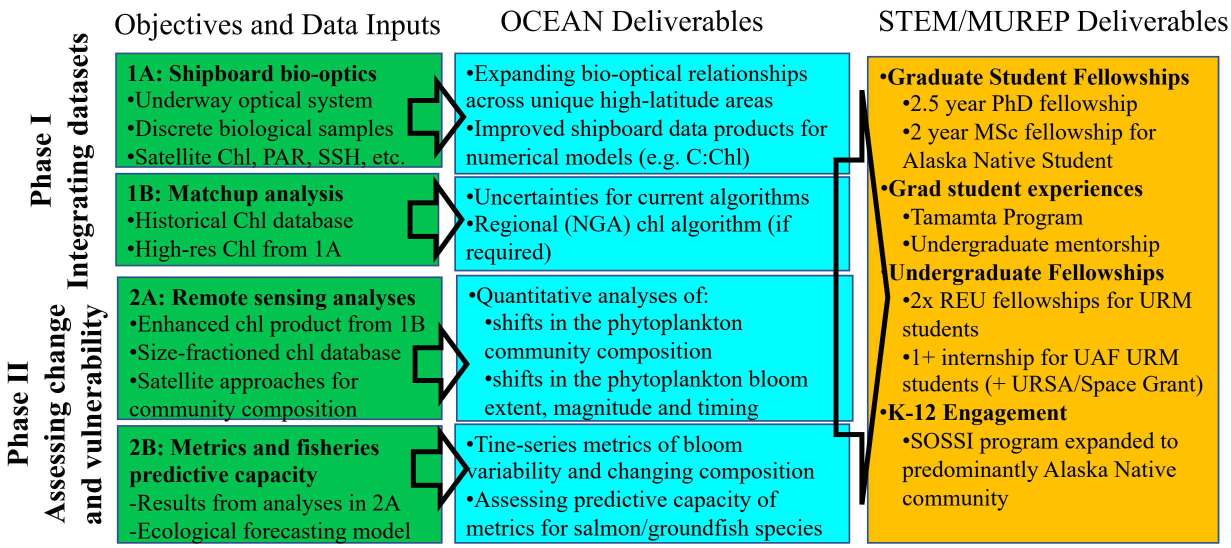


Fig. 7: Summary of the objectives, data sources, and OCEAN-MUREP deliverables

3.1 Addressing weaknesses identified during Step1 reviews

In response to the Step1 review process, important changes have been made to the project. Namely, the project has a greater focus on specific quantitative analyses of ecosystems and climate variability through a 20+ year time series analysis into the patterns and drivers of phytoplankton community composition and spring bloom phenology (Objective 2A). With this, analyses of atmospheric correction and sub-pixel variability were removed to maintain project feasibility. We have also added a team member (postdoc-Waga) with expertise in ocean color algorithms and satellite-based time series analyses, facilitating a more appropriately-sized role for Dr. Susanne Craig (Technical Advisor). Finally, the educational programs, goals and strategies for recruiting students from underrepresented minority (URM) groups, and roles for team members, are now described in greater detail.

4. Research Plan

4.1 Phase I: Integrating ship-based and historical data to enhance monitoring capabilities and satellite data products

4.1.1 Objective 1A: Assess phytoplankton biomass, C:Chl and productivity using bio-optics

Shipboard optical data will be collected during two *R/V Sikuliaq* expeditions each year (~May and ~July, ~2.5 weeks each). The *R/V Sikuliaq* permanent flow-through system includes additional physical and optical sensors. NGA-LTER collaborators collect discrete measurements of Chl (size-fractionated via fluorometry as well as high performance liquid chromatography, or HPLC), particulate organic carbon, phytoplankton carbon (C_{phyto}, via epifluorescence microscopy), and primary productivity (via 13C-NPP incubations), as well as macronutrients and trace metals (both on-station and using a surface-towed 'iron-fish', see Aguilar-Islas and Bruland, 2006). High-resolution surface optical data is collected using an autonomous underway optical system. The system, built in 2020, closely follows best-practices protocols for flow-through optical data (Boss et al., 2019; which includes insight from the PI's earlier system). Briefly, the system includes an automated valve for regular 'filtered' measurements used to isolate particulate optical properties, a Seabird hyperspectral absorption/attenuation meter (AC-s), and a Seabird BB-3 backscatter meter within a dark chamber. An earlier version of this system is described in detail in Burt et al. (2018).

Optical measurements will be matched to direct on-station biological measurements in order to develop regional bio-optical models for estimation of Chl, POC, C_{phyto}, and primary productivity. Results from two preliminary *R/V Sikuliaq* surveys in 2020 (truncated due to COVID-restrictions) indicate that Chl estimated via absorption line height is accurate both in open ocean waters as well as in optically complex and heterogeneous coastal areas (see Figure 8). Preliminary C:Chl data (not shown) reveal elevated ratios within HNLC waters and interesting patterns near fronts and eddies, as well as erroneously high ratios in coastal areas likely driven by high concentrations of CDOM. In 2021, we will begin to isolate and track the CDOM signal using a 'MilliQ module' for regular 'clean water' optical measurements (see Boss et al., 2019 for details), and compare these to estimates made by a CDOM fluorometer (WetLABS Eco-triplet, installation into the *R/V Sikuliaq* underway system in summer 2021).

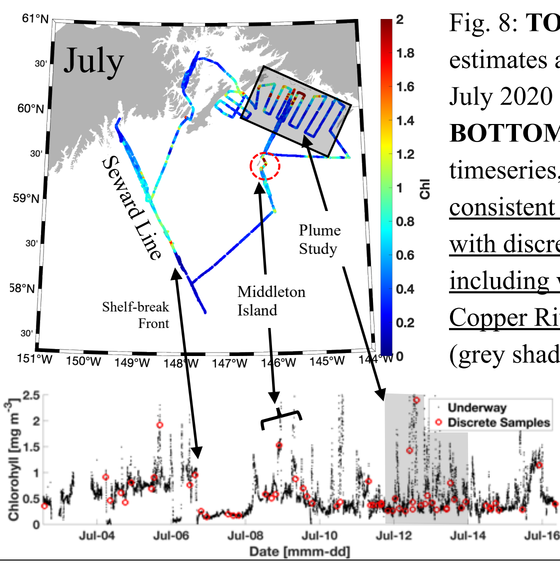


Fig. 8: **TOP**: Chl estimates along the July 2020 cruise track. **BOTTOM:** Chl timeseries, showing consistent agreement with discrete samples, including within the Copper River Plume (grey shaded box).

Two full-length (~2.5 week) expeditions are scheduled for spring and summer 2021 (and every year thereafter). Data processing steps are well-established and can largely be done onboard, thus, interpreting 2 years of shipboard data (4 multi-week expeditions) will begin at the project outset. The PhD student (Ben Lowin) has applied for the 2021 Ocean Optics course hosted at the University of Maine, and will receive additional guidance from thesis advisory committee members that include experts in phytoplankton phenology (Dr. Suzanne Strom, Western Washington University) and bio-optics (Dr. Emmanuel Boss, University of Maine).

4.1.2 Objective 1B: Conduct a regional satellite matchup analysis for the NGA to assess uncertainties in the current ocean color algorithms

To date, over 100 *in situ* Chl datasets spanning 24 years have been identified (see Table 1), with most data available in two size fractions (above/below 20 microns). Additional data may become available through various partners, including those at NOAA (see Partnerships section). Satellite data will initially focus on the level-2 SeaWIFS and MODIS-Aqua products, although others may be considered (e.g., VIIRS, Sentinel-2, Sentinel-3, Landsat-8), especially if focusing on specific coastal regions like those near the GAK1 mooring (Figure 2).

Matching up satellite and *in situ* data will follow strict guidelines set by published standards (Bailey and Werdell, 2006; Groom et al., 2019), which includes a ±3-hour window around the satellite overpass within solar and sensor zenith angles of 75 and 60°, respectively. Satellite values will be averaged within 5 × 5 pixel (5 × 5 km) boxes centered on an *in situ* observation, with satellite values removed when the median coefficient of variation within the box exceeds 0.15. Using the resulting matchup dataset, statistical analyses such as RMSE and bias will be performed both regionally and within different NGA water masses.

If a sufficient set of matchups are achieved, development of an NGA-tuned empirical Chl algorithm will be explored by splitting the matchup dataset into an algorithm development subset (70%), and an algorithm validation subset (30%). The NGA-based coefficients and resulting algorithm will then be compared to the standard global algorithms (OC3M for MODIS and OC3S for SeaWiFS). The MODIS and SeaWiFS satellites measure at slightly different wavelengths, thus two separate sets of coefficients would need to be developed.

All satellite analyses and interpretation, including exploring applications of these data to enhancing the upcoming NASA Plankton, Aerosol, Cloud, Ocean Ecosystem (PACE) mission, will be done in collaboration with Dr. Susanne Craig, the current Lead for the PACE mission system vicarious calibration and apparent optical property activities. Dr. Craig has agreed to serve as a Technical Advisor throughout this project (see Project Management section).

Table 1: In situ chl datasets (1997-project completion) available across the NGA. Each 'x' represents a multi-week shipboard campaign. Corresponding satellite products also shown.

	← SeaWIFS →																											
						← MODIS-AQUA →																						PACE
	97	**98**	**99**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
Mar		x	x	x	x	x	x	x																				
Apr		x	x	x	x	x	x							x														
May		x	x	x	x	x	x	x	x	x	x	x	x	x	xx	x	xx	x	x	x	x	xx	xx	x	x	x	x	x
Jun																												
Jul		x			x	x		x						x	x	x	x					xx	xx	x	x	x	x	x
Aug			x	x	x	x	x							x	xx	xx	xx	x	x	x	x							
Sep									x	x	x	x	x	xx	xx	x	xxx	x	x	x	x	xx	xx	x	x	x	x	x
Oct	x	x	x	x	x	x	x	x							x													

x –Seward Line Vicinity; x – Kodiak Island Vicinity; x – Southeast (SE) Alaska ; x – NOAA (mostly SE Alaska)

4.1.3 Error and Uncertainty

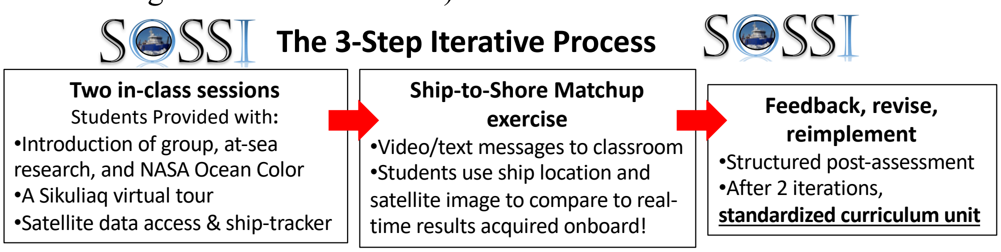
Data processing techniques for the underway optical system have been published in detail by this PI (see Burt et al., 2018), and closely follow the Boss et al. (2019) protocols. Uncertainty propagation includes step-wise error propagation, such that all raw (e.g., raw absorption spectra), processed (e.g., binned particulate absorption), and computed (e.g., Chl via line height) data are accompanied by well-defined uncertainties. All uncertainties will be made clear in the published work, and will be tabulated in the accompanied datasets.

Underway optical data from 2020 appear to be high-quality, but direct estimates of phytoplankton carbon and primary productivity from the 2020 expeditions are not yet available, thus it is not yet conclusive whether the impeller-style pump aboard *R/V Sikuliaq* is destroying delicate cells and thus biasing flow-through measurements (as found in Cetinić et al. 2016). Collecting parallel samples for detailed microscopy from both Niskin bottles and the underway system outflow will help to resolve this potential issue. Mitigation would involve installing a diaphragm pump alongside the current system, which has been deemed feasible through discussions with *R/V Sikuliaq* technical staff.

In the event that the large *in situ* database still yields an inadequate number of satellite matchups for robust statistical analyses, matchup criteria will be relaxed from the strict guidelines outlined here. The vast majority of the *in situ* Chl database cites using fluorometric methods, and initial quality-control will be done to ensure consistency in sampling methodologies. Discrepancies are sometimes found between Chl data collected via fluorometry versus via HPLC (e.g., in the Southern Ocean, Marrari et al., 2006), thus HPLC will only be added to the matchup database if good agreement is found (as was reported in the Arctic, Lewis and Arrigo, 2020). Investigating these potential discrepancies will help inform future sampling approaches both in the NGA and elsewhere (e.g., the Line P time series further south).

4.1.4 STEM-Engagement: The SOSSI and REU Programs

The Students Observing Sikuliaq Satellite Information (SOSSI) Program is a K-12 outreach program developed by PI-Burt and launched in March 2021. The program is centered on engaging in-person and remote classroom activities with Alaska high schools, utilizing our world-class vessel (*R/V Sikuliaq*) and our connections to NASA. In this program, high-school students conduct matchup analyses between satellite images and real-time bio-optical data from the PI's group during our annual spring cruise. This year, we will develop the 'virtual tour' using a smartphone (see www.matterport.com), and prepare for our first in-class session in March, 2022 (at Hutchison High School in Fairbanks).



Although already funded (<15k over 3 years), the current program only funds 1 month of graduate student effort each year (see budget, no time for PI-Burt), and thus is limited to a single set of in-class and remote interactions with one local high school class. Integrating SOSSI into this NASA-funded program will enable us to expand to multiple classrooms, adequately compensate educators for their time assisting with curriculum development ($1000 per year up from $250), and dedicate more time to developing a strong and lasting curriculum unit. Expansion can begin with a classroom in Anchorage (discussions already underway), where the PI regularly travels. <u>With NASA support our primary aim is to expand SOSSI into a predominantly Alaska Native rural community classroom</u>. This will be achieved through the PI's ongoing partnership with the Center for Alaskan Coastal Studies (CACS), an education center located in Homer, Alaska dedicated to science-based environmental education and stewardship. Importantly, engagement with this classroom will be led by the Alaska Native MSc student (see below), providing the next generation of potential STEM scientists with a valuable role model. Given the time required to establish partnerships and recruit/train the graduate student, we propose to visit the Homer community in Spring 2024 (year 3 of the project).

The NGA-LTER's education and outreach (E&O) component includes a Research Experience for Undergraduate (REU) program, whereby a cohort of undergraduate students complete funded projects that involve participation in the summer *R/V Sikuliaq* expedition. Real shipboard experience combined with the student cohort environment makes the REU program a unique and meaningful educational experience (see https://nga.lternet.edu/education-outreach/reu/). This proposed project budgets for 1 REU student in 2022 (year 1), and in support of this work the NGA-LTER has agreed to fund an additional REU position for PI-Burt in summer 2024 (the REU program is not scheduled to run in 2023). Any years with pandemic restrictions (as in 2021), REU's will participate remotely. The PI's 2021 REU student (a URM student) will, among other tasks, build MATLAB scripts for compilation of both the historical database and relevant satellite imagery. Continuing to successfully disburse REU scholarships to URM students will be achieved with help from NGA-LTER E&O team, who broadly advertise positions, compile applications, and provide lists of qualified students to each REU mentor. In 2021, this process yielded 3 qualified candidates from URM groups. The PI will also utilize published literature for guidance in effective undergraduate mentorship, in particular a recently published framework for enhanced diversity, equity and inclusion specifically for REU-type students (McGill et al., 2021; this practical guide will be sent to all REU students as a form of informal mentor-mentee agreement).

4.2 Phase II: Assessing climate-driven changes and exploring impacts to higher-trophic levels

4.2.1 Objective 2A: Elucidate patterns and drivers of variability in phytoplankton community composition and spring bloom phenology across the satellite record

To develop an optical approach for detecting climate driven trends in PCC, we will undertake an analysis of the relationships between various existing optical models (IOCCG, 2014; and those developed later) and LTER size-fractionated Chl. Such existing models we will assess include, but are not limited to, earlier approaches outlined by Brewin et al., 2011, and more recent developments like accessory pigment identification (Chase et al., 2017), and the spectral shape approach outlined by Vandermuelen et al. (2020). This latest approach permits robust 'joining' of ocean color records from the SeaWiFS and MODIS-Aqua time series, and shows promising capability to detect long-term spatiotemporal changes in ocean-color, suggesting that evaluation against our ~25 year *in situ* record would yield impactful results both for the NGA community and the ocean color community at large.

Analyses focused on bloom phenology will initially follow methods outlined in recent work by team member Postdoc-Waga (see Waga and Hirawake, 2020), involving modeling of daily satellite Chl data using a parametric Gaussian function. Postdoc-Waga has succeeded in retrieving phytoplankton bloom metrics (number of Chl peaks, amplitude, timing, and duration of Chl peaks) in the Bering–Chukchi Seas based on this approach (Waga and Hirawake, 2020; Waga et al., submitted). Alternatively, Chl data can be modeled using spline estimates, an approach used by our NOAA partners that have revealed evidence of delayed bloom signals in Shelikof Strait (above Kodiak Island, see Figure 2) during recent anomalous warm years (J. Nielsen, pers. comm.).

Satellite-based approaches can be supplemented further using the large *in situ* historical database, as well as using additional satellite products. Examples of potential analysis include assessing patterns in relation to shifts in zooplankton populations (well documented along the Seward Line back to 2002) such as mucus-net feeders that efficiently graze smaller cells or copepods that predominantly feed on larger cells (i.e., diatoms). Historical April-May Seward Line expeditions are likely to overlap with the peak or remnants of spring blooms, facilitating use of past shipboard data in the bloom analyses. From 2020 onward, these can also integrate the high resolution *in situ* bio-optical data from Phase I. Long-term observations from the GAK1 mooring can also provide information regarding changes in physical mixing (i.e., winter mixing intensity or onset of seasonal stratification). Supplemental satellite-based time series could include sea surface temperature, salinity, and sea surface height (to assess potential influence from eddies). Water column stability, a well-known driver of bloom dynamics (e.g. Chiswell, 2011; Ferrari et al., 2015), can be reconstructed using a combination of Argo floats (MIxed

Layer dataset from Argo, or MILA) and/or available shipboard data. Incorporating some of these additional products/analyses likely goes beyond the scope of this particular project, in which case they will be mentioned as potential future efforts to continue investigating the myriad of potential drivers.

4.2.2 Objective 2B: Develop and integrate time series metrics into fisheries forecast models to assess their predictive capabilities for the recruitment, survival, or distribution of commercially-valuable groundfish and salmon stocks

We will explore whether the satellite-based size-structure and spring bloom metrics described above can improve the precision and reliability of predictions for the abundance and recruitment of commercially-important groundfish and salmon stocks in the NGA region. Specifically, we will integrate the newly-developed metrics within existing ecological forecasting methods, and explore the extent to which predictive performance may be improved.

In preparation for this proposal, Co-I Cunningham has synthesized an extensive dataset containing fish productivity (abundance of recruits per spawning individual) time series for 73 stocks of Pacific salmon (including Sockeye, Pink, Chum, and Chinook salmon) spawning in the Gulf of Alaska. The newly-developed phytoplankton time series metrics will be evaluated for their potential to improve stock-specific recruitment forecasts, in addition to density-dependent and nearshore temperature effects using Bayesian Adaptive Sampling (BAS) methods for prediction (see Clyde et al. 2011). In addition, as part of a prior research effort focused on improving integration of ecosystem information within the Alaskan fishery management process, Co-I Cunningham has collected time series of groundfish recruitment from recent stock assessments, whose connection with existing ecosystem indicators is already underway using a similar BAS approach. Forecast models for Gulf of Alaska groundfish recruitment will be extended to include the indices developed as part of this research.

The efficacy of newly-derived metrics in improving forecast performance for salmon and groundfish stocks will be evaluated in two ways. First, BAS methods for prediction have the benefit of directly quantifying the inclusion probability for predictor variables, which provides a direct measure of whether inclusion of new metrics improve predictive performance. Second, both leave-one-out and rolling window (i.e., 1-step ahead) cross-validation will be used to compare the out-of-sample predictive performance of forecast models with and without the new predictor variables. The result will be a comprehensive evaluation of the extent to which forecast performance may be improved through inclusion of remotely-sensed metrics of the phytoplankton community across salmon and groundfish stocks.

4.2.3 Error and Uncertainty

Uncertainties of the time series analyses within optically-complex coastal waters, specifically in the ACC, will require close attention and detailed reporting. Persistent cloudiness, especially during bloom periods, will present a significant challenge in the time series analyses. To help combat this, the Gaussian fitting technique will interpolate time series variations based on available data points. Waga and Hirawake (2020) demonstrated that one Chl value every 20 days is sufficient for estimating the presence/absence of a Chl peak. However, uncertainties in bloom dynamics will be substantial during these periods, and thus will need to be quantified and reported accordingly. Elucidating patterns across a ~25 year satellite record that contains shorter-term climatic events (e.g. El Niño's in '97-'98, '03, '15 and heatwaves in 14'-16', '19) presents a significant challenge, but also presents a unique opportunity to compare phytoplankton and ecosystem responses to repeated events.

4.2.4 STEM-Engagement: The Tamamta Program & Undergraduate Internships

Research within Objective 2B will be taken on by an CFOS Oceanography MSc student. This position will be dedicated to an Indigenous student, who will be enrolled in the newly-established CFOS Tamamta Program. Tamamta, meaning "all of us" in the Sugpiaq and Yup'ik languages of the Indigenous peoples of Alaska's southcentral coast, is a graduate student training program led by Indigenous faculty that focuses on developing education for underrepresented minorities, and particularly Alaska Native students. The Tamamta mission is "transforming western and indigenous fisheries and marine sciences together" (see tamamta.org for more details). The NASA-funded MSc student will be a Tamamta Fellow, and as such, will participate in curriculum and activities in a cohort environment. Tamamta Fellows focus on a co-production approach, whereby Indigenous and Western knowledge is brought together to address key questions in fisheries and ocean sciences. In initial discussions with Tamamta leadership, potential ideas for this proposed work are centered on exploring approaches to integrating NASA satellite data products into Indigenous frameworks for understanding and managing fisheries resources. To ensure successful recruitment of an Alaska Native graduate student, PI Burt will work closely with Tamamta personnel, following their well-established strategies and practices, and importantly, will begin this work at the project's outset (>1 year prior to the Fall 2022 semester).

As in Phase I, this second project Phase includes dedicated funds for fellowship opportunities to undergraduate URM students. Specifically, a summer 2023 undergraduate internship will be offered to an Alaska Native student. The student will be mentored by the MSc student, and advised by the PI (proposed activities outlined in Project Management Section). Additional scholarship opportunities within both project Phases will utilize two pathways: the UAF Undergraduate Research & Scholarly Activity (URSA) scholarship program and the Alaska Space Grant Internship program. The PI, already successful within both the programs, will co-write applications (multiple calls per year) with current UAF undergraduate students. Either of these scholarships will enhance career opportunities for the undergraduate student, while also facilitating valuable mentorship opportunities for the graduate students.

5. Technical and Educational Relevance

5.1 Alignment to NASA-OCEAN Priorities

This work will advance research towards NASA-OCEAN Goal 1 under *Objective 1.1: Quantitative remote sensing analyses of impacts and/or vulnerability of aquatic ecosystems to climate variability and change*. Specifically, through a multi-decadal remote sensing analysis of phytoplankton size structure and bloom dynamics, this work will investigate long-term patterns, key drivers of change, as well as perturbations due to recent abrupt climate-driven events (i.e., recurring heatwaves). These results will then be used to quantitatively assess how changes at the base of the marine food chain may impact higher trophic levels with immense social and economic implications. Additionally, our shipboard bio-optics will help unravel key patterns and controls of phytoplankton production that will help assess future change in this vital ecosystem. Through these *in situ* data products and a well-constrained (or regionally-tuned) Chl algorithm, this work will improve current biogeochemical modeling efforts aimed at assessing current impacts and identifying vulnerability in the NGA marine ecosystem.

The proposed work will stimulate significant long-term capacity building for PI-Burt and Co-I Cunningham, as well as their respective MSI, and will undoubtedly enhance capability of the team members and their institution to participate in future ROSES solicitations. This project directly responds to a number of UAF's 2019-2025 strategic goals ('solidify our global leadership in Indigenous programs', 'achieve tier 1 research status', 'embrace and grow a culture of respect, diversity, inclusion, and caring', see https://uaf.edu/strategic/goals.php). At a state-wide level, the research will build capacity within two of Alaska's key research 'arenas' laid out in the current Alaska Science and Technology Plan (ASTP, 2016). These include 'Environmental Monitoring and Management' via enhanced shipboard techniques, satellite products, and modeling capabilities, as well as 'Community Resilience and Sustainability' via quantitative analyses of ecosystem vulnerability and meaningful K-12 STEM education.

This project specifically addresses multiple sub-elements of the current Ocean Biology and Biogeochemistry (OBB) program solicitation: it seeks to assess effects of rapid environmental change on biological community structure using multi-platform observational data (sub-element 2.1), while also preparing for new ocean measurements (e.g. the PACE mission, sub-element 2.4) through the quantitative analyses related to PCC, and through consistent shipboard hyperspectral observations that expand valuable PACE validation data into an important high-latitude region. Regardless of this proposal outcome, PI-Burt will apply to the PACE Early Adopter Program in Fall 2021 in an effort to further enhance partnerships that can better direct his research towards goals of PACE and NASA more generally. This research also addresses some of the Marine and Terrestrial Ecosystems Highest Priority Science and Applications Objectives within The National Academies of Sciences, Engineering and Medicine (NASEM) Decadal Survey. For example, evaluating changes in phytoplankton C:Chl ratios across the various light and nutrient regimes of the NGA will advance our understanding of the physiological dynamics of aquatic primary producers (Question E-1c, deemed 'Most Important').

5.2 Alignment to CoSTEM, NASA STEM and MUREP

In close alignment with the NASA Science 2020-2024: A Vision for Science Excellence (NASA/NASEM, 2020), the project will inspire through active and purposeful engagement with a diverse group of students spanning many age groups across Alaska (with a specific focus on Alaska Native groups) by introducing them to NASA's capabilities and a vast array of publicly-available information. It will develop interconnectivity and partnerships both within UAF, and through multiple NASA Centers (Space Grant, headquarters). More broadly, our team's mentality, and our focus on providing opportunities for URM groups will create a more inclusive and accessible STEM learning environment. To date, the PI's commitments to building a diverse STEM workforce include dedicated webinar training on 'JEDI' (Justice, Equity, Diversity, Inclusion) practices in STEM, service on the CFOS Diversity Committee, active participation in elementary school outreach in predominantly Alaska Native communities (through NOAA-funded ELACS: Environmental Literacy through Alaskan Climate Stewards program. Contact: Sheryl Sotelo), and the hiring of a URM student for the 2021 summer REU program.

This project directly addresses all three goals of NASA's current STEM Engagement Priorities. The project creates opportunities for a diverse set of graduate students (1 Caucasian PhD, 1 Alaska Native MSc) and undergraduate students (3+ from URMs) to contribute to NASA's work (Priority #1). The project will deliver at least 3 student-led peer-reviewed publications and multiple student presentations at international and regional conferences. The SOSSI and REU programs will engage students in <u>authentic learning experiences</u> with NASA's people and content (Priority #2), and in both programs many of the students will come from underrepresented and underserved communities (Objective 2.1). The SOSSI program is particularly well-aligned with Priority #3, as it would highlight our NASA-funded shipboard and satellite research to attract diverse groups of students to STEM. In addition to high-school student's direct and virtual experiences with our team (Objective 3.2), the SOSSI program will provide an online virtual tour of our lab aboard *R/V Sikuliaq*, with numbers of visitors to the site monitored and reported.

Phase II of this proposed work will be a truly unique learning experience for both the MSc student and the mentors (PI Burt and Co-PI Cunningham). The MSc research itself will be a unique blend of oceanographic and fisheries-based science, and the Tamamta approach will provide all parties with extensive training in knowledge co-production that can be applied to their future research (both within NASA and elsewhere). Through student and PI-led conference presentations, we will highlight the unique nature of this NASA-funded project that focuses on student-led research, STEM engagement at multiple levels, enhancement of diversity within STEM fields, and co-production of knowledge with local communities.

6. Partnerships and Collaboration

This project team brings together a broad range of expertise and will build and enhance numerous partnerships. The project will develop an interdisciplinary partnership between PI-Burt and Co-I Cunningham, two recently-hired CFOS tenure-track faculty with significant resources available for this work (PI-Burt: NGA-LTER, bio-optical system, Co-I Cunningham: fisheries data and model structure). PI-Burt has also established valuable partnerships with regional NOAA scientists (Lisa Eisner, Jens Nielsen, Jordan Watson, Janet Duffy-Anderson), facilitating incorporation of additional Chl datasets as well as collaboration on mutually-relevant analyses such as bloom dynamics and Chl metrics that are included in annual NOAA Ecosystem Status Reports and are presented to the North Pacific Fishery Management Council. Significant involvement with the Tamamta program will expose all team-members, collaborators, NASA, and other agencies to a unique and ground-breaking cultural education program that has the potential to make meaningful strides towards improving STEM opportunities for Indigenous students. The project will also involve significant collaboration with NASA Centers, specifically through Dr. Susanne Craig, the current lead for the PACE mission system vicarious calibration and apparent optical property activities.

7. Project Tasks and Timeline

All project tasks will be overseen by PI-Burt. In the project timeline (shown below), objectives are split into specific tasks, each with a primary student responsible, a corresponding mentorship team, and a timeline for completion. Each task and team member role is detailed in the Project Management section below.

Project Tasks	**Responsibility**	YEAR 1				YEAR 2				YEAR 3			
	Student+Mentor(s)	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2
1A.1 Build bio-optical models	PhD student + WB												
1A.2 Evaluate bio-optical patterns	PhD student + WB												
1B.1 Compile Chl data	Ugrad + PhD student												
1B.2 Chl matchup analysis	PhD student + Waga/WB												
2A.1 Community comp. analyses	PhD student + WB/Waga												
2A.2 Spring bloom analyses	PhD student + Waga/WB												
2B.1 Compute size and bloom metrics	MSc student + Waga/CC												
2B.2 Model runs and interpretations	MSc student + CC												

Ugrad = Undergraduate REU/internship sudents; WB = PI - Will Burt; CC = Co-I Curry Cunningham

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Suryan, R. M., Arimitsu, M. L., Coletti, H. A., et al. 2021. Ecosystem response persists after a prolonged marine heatwave. *Scientific Reports,* 11:6235

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Vandermeulen, R. A., Mannino, A., Craig, S. E., & Werdell, P. J. 2020. 150 shades of green: Using the full spectrum of remote sensing reflectance to elucidate color shifts in the ocean. Remote Sensing of Environment, 247, 111900. https://doi.org/10.1016/j.rse.2020.111900

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Westberry, T., Behrenfeld, M. J., Siegel, D. A., and Boss, E. 2008. Carbon-based primary production modeling with vertically resolved photoacclimation. Global Biogeochemical Cycles 22, GB2024, https://doi.org/10.1029/2007GB003078

PROJECT MANAGEMENT PLAN

PI-Burt will act as primary supervisor for the postdoc and both graduate students, and thus will oversee all aspects of data analysis, interpretation and dissemination. This includes all project reporting, time management, and data submission. PI-Burt will meet 1-on-1 with the postdoc and graduate students every 1-2 weeks, and all members (aside from Co-I Cunningham) will attend weekly Burt Lab meetings. General progress meetings with all team members will take place every month.

As mentioned above, the majority of data analysis and dissemination of results will be done by graduate students. The PhD graduate student (Ben Lowin), will be responsible for much of the analyses within the first 3 Objectives, constituting the bulk of the students PhD thesis research. The PhD student will also lead at least 2 peer-reviewed publications (bio-optics + time series analyses). This PhD student's current funding expires in March 2022. The MSc student will be responsible for the research under Objective 2B, and for leading the corresponding peer-reviewed manuscript in year 3. Significant guidance and training throughout each project task will be provided by various team members. PI-Burt will assist with data analysis and interpretation from the shipboard bio-optics system (Tasks 1A.1 and 1A.2), as well as time series analyses under Objective 2A. Postdoc Waga will be responsible for assisting with the satellite-based analyses, including the Chl matchup exercise (and potential algorithm development, Task 1B.2) and the analyses in Phase II (Tasks 2A.1, 2A.2, and 2B.1). Co-I Cunningham will co-advise the MSc graduate student, and will provide expertise and oversight for the fisheries modelling component (Task 2B.2). Finally, collaborator Susanne Craig will serve as Technical Advisor, and will meet with PI-Burt informally (multiple meetings each year via zoom) throughout the project period to discuss project progress, past and potential future analyses, and relevance to the current PACE mission. In-person meetings will also be arranged whenever possible (e.g., Ocean Sciences 2022/2024, NASA PI meetings, PI-Burt's NASA Review Panel assignments).

The proposed work will also provide 3+ undergraduate fellowships. Activities for the summer 2022 REU student (mentor: PhD student, supervisor: PI Burt) can include analysis of bio-optical and parallel datasets from their summer *R/V Sikuliaq* cruise, and reviewing outcomes from the first SOSSI implementation (completed during the previous spring). The student intern in summer 2023 (mentor: MSc student, supervisor: PI Burt) will primarily work on indigenous knowledge co-production strategies, as well as reviewing outcomes and curriculum development from the second SOSSI implementation. Activities for the summer 2024 REU student (mentors: PhD and/or MSc student, supervisor: PI Burt) can include cruise participation and accompanying data analysis, and assisting with final curriculum development for SOSSI.

DATA MANAGEMENT PLAN

PI-Burt has significant experience collecting, processing, analyzing, and submitting bio-optical data (see publications within CV and associated Pangaea DOI's), and will be responsible for all data management for this project. The data produced by this project will be both substantial and diverse, and will consist on optical, biological, and satellite products. Data collected aboard *R/V Sikuliaq* (SKQ) will be structured by expedition, resulting in 8-10 main datasets spanning July 2020 (SKQ_0720) to July 2024 (SKQ_0724). We will utilize MATLAB data structures to organize the various data types from each expedition.

Data Types, Volumes and Formats:
High-resolution *in situ* optical data will be comprised of raw measurements (raw spectra, backscatter at 3 wavelengths), processed data (particulate spectra and particulate backscatter), and computed products (Chl, POC, C_{phyto}, net primary productivity in 1-minute time bins). Due to its high volume, raw data will be stored as a mat-files only, whereas median-binned data will be made available as both mat-files and tables of csv files. Optical data will be ground-truthed using discretely measured biological data (Chl, POC, C_{phyto}, net primary productivity). Additional discrete measurements to help analyze and interpret results include flow cytometric counts, macro/micronutrients, and physical parameters (temperature, salinity, mixed-layer light, etc.). All discrete data will be organized by sequential station number, compiled into a single data table, and stored as both a MATLAB matrix and a csv spreadsheet. The historical Chl data table will be compiled and stored in the same format. Finally, the specific satellite data products (i.e. the specific 'nc' files) used for our analysis will be well documented, and all processed satellite data (i.e. an array of data matrices cropped to the NGA region) will be stored within the MATLAB structure.

Data Archival and Availability:
All data collected by our team will be archived in the SeaWIFS Bio-optical Archive and Storage System (SeaBASS). It is important to note that data collected by other members of the NGA-LTER team (e.g. incubation-based primary productivity), will only be submitted if used specifically in peer-reviewed manuscripts, or with specific permission from the associated group PI (e.g. S. Strom). As mentioned in the S/T/M plan, data collection and processing methods will follow published protocols (e.g. Boss et al., 2019). In accordance with the NGA-LTER project, data will also be archived annually in the NGA-LTER data portal (Research Workspace, managed by Axiom Data Science). The Workspace will also provide our group with access to supplemental data from other NGA-LTER participants.
Accepted peer-reviewed manuscripts, and all data associated with that manuscript (e.g. used in the text, and to reproduce figures, tables and other representations), will be made publicly available at the time of publication either via SeaBASS or NASA PubSpace. The manuscript itself will also be uploaded to NASA PubSpace immediately following publication.

FACILITIES, EQUIPMENT, AND PERSONNEL

In order to the complete this project successfully, the University of Alaska Fairbanks (UAF) will continue to provide office space (O'Neil Room 123), laboratory space (Irving II Room 239), administrative support, as well as library, web and computing resources throughout the project period. Critical sampling equipment both underway optical data (AC-S spectrometer and BB-3 backscatter meters) are already in-place. These instruments will be housed in the PI's laboratory and transported to the *R/V Sikuliaq* for all field surveys.
Collaboration with the Northern Gulf of Alaska Long Term Ecological Research Program (NGA-LTER) will provide our research team with ship-time aboard *R/V Sikuliaq*, which includes access to parallel underway sampling devices (for temperature, salinity, nutrients, etc.), and data from station depth profiles (CTD, turbidity, etc.) and associated water samples (see resource support letter from R. Hopcroft, NGA-LTER lead PI).

WILLIAM J. BURT

University of Alaska Fairbanks — Tel: (907) 474-7547
College of Fisheries and Ocean Sciences — Email: wburt2@alaska.edu
Fairbanks, Alaska 99775-7220

EDUCATION:

University of British Columbia	Marine Biogeochemistry	PDF	2016-19
Dalhousie University	Chemical Oceanography	Ph.D.	2015
University of Victoria	Geoscience (Minor: Oceanography)	B.Sc	2008

PROFESSIONAL EXPERIENCE:

2019-present	Assistant Professor (Tenure-Track), University of Alaska – Fairbanks
2016-2019	NSERC Postdoctoral Fellow**,** University of British Columbia
2015-2016	Postdoctoral Investigator, Dalhousie University
2013	Visiting Student, University of Bergen, Norway
2008	Undergraduate Research Assistant, University of Victoria
2005, 2007, 2008	Seagoing Research Assistant, Fisheries and Oceans, Canada

PREVIOUS MAJOR FUNDING/AWARDS:

2020	UA Coastal Marine Institute Project Funding
2020	NPRB Core Research Program Funding
2016-2019	NSERC Postdoctoral Fellowship
2013-2015	Level 2 Isaak Walton Killam Level 2 Predoctoral Scholarship

PUBLICATIONS MOST RELEVANT TO THIS PROPOSAL:

Suryan, R. M., M. L. Arimitsu, H. A. Coletti, and 46 others including **W.J. Burt** (2021). Ecosystem response persists after a prolonged marine heatwave. *Scientific Reports,* 11:6235.

S. Z. Rosengard, S. Z., R. W. Izett, **W. J. Burt**, N. Schuback, and P. D. Tortell (2020). Decoupling of ΔO_2/Ar and particulate organic carbon dynamics in nearshore surface ocean waters. *Biogeosciences*, 17, 3277-3298.

Behrenfeld, M. J., P. Gaube, A. D. Penna, R. T. O'Malley, **W. J. Burt**, Y. Hu, P. Bontempi, D. K. Steinberg, E. S. Boss, D. A. Siegel, C. A. Hostetler, P. Tortell, and S. C. Doney (2019). Global satellite-observed daily vertical migrations of ocean animals. *Nature*, 576, 257-261.

Burt, W. J., and P. D. Tortell (2018). Observations of Zooplankton Diel Vertical Migration from High-Resolution Surface Ocean Optical Measurements. *Geophysical Research Letters*, 45, 13396-13404.

Zeng, C., S. Rosengard, **W. J. Burt**, A. Pena, N. Nemcek, T. Zeng, K. Arrigo, and P. D. Tortell (2018). Optically-derived estimates of phytoplankton size class and taxonomic group biomass in the Eastern Subarctic Pacific Ocean. *Deep-Sea Research I*. 136, 107-118.

Burt, W. J., T. K. Westberry, M. J. Behrenfeld, C. Zeng, R. W. Izett, and P. D. Tortell (2018). Carbon : Chlorophyll ratios and net primary productivity of Subarctic Pacific surface waters derived from autonomous shipboard sensors. *Global Biogeochemical Cycles*, 32, 267-288.

OTHER RELEVANT PUBLICATIONS (from a total of 11):

Horwitz, R. M., A. E. Hay, **W. J. Burt**, R. Cheel, J. Salisbury, and H. Thomas (2019). High-frequency variability of CO2 in Grand Passage, Bay of Fundy, Nova Scotia, *Biogeosciences*, 16, 605-615.

Miller, L. A., T. Burgers, **W. J. Burt**, M. A. Granskog, and T. Papakyriakou (2019). Air-Sea CO2 Flux Estimates in Stratified Arctic Coastal Waters: How Wrong Can We Be? *Geophysical Research Letters*, 46, 235-243.

Lemay, J., H. Thomas, S. E. Craig, **W. J. Burt**, K. Fennel, and B. J. W. Greenan (2018). Hurricane Arthur and its effect on the short-term variability of pCO_2 on the Scotian Shelf, NW Atlantic. *Biogeosciences,* 15, 2111-2123.

Burt, W. J., H. Thomas, L. A. Miller, M. A. Granskog, T. N. Papakyriakou, and L. Pengelly (2016). Inorganic Carbon Cycling and Biogeochemical Processes in an Arctic Inland Sea (Hudson Bay). *Biogeosciences*, 13, 4659-4671.

Burt, W. J., H. Thomas, M. Hagens, J. Pätsch, N. M. Clargo, L. A. Salt, V. Winde, and M. E. Böttcher (2016). Carbon sources in the North Sea evaluated by means of radium and stable carbon isotope tracers. *Limnology and Oceano*graphy, 61, 666-683.

Burt, W. J., H. Thomas, J. Pätsch, A. M. Omar, C. Schrum, U. Daewel, H. Brenner, H. J. W. de Baar (2014). Radium isotopes as a tracer of sediment-water column exchange in the North Sea. *Global Biogeochemical Cycles*, 28, 786-804..

Burt, W. J., H. Thomas, and J.-P. Auclair (2013), Short-lived radium isotopes on the Scotian Shelf: Unique distributions and tracers of cross-shelf CO_2 and nutrient transport, *Marine Chemistry*, 156, 120-129.

Burt, W. J., H. Thomas, K. Fennel, and E. Horne (2013). Sediment-water column fluxes of carbon, oxygen and nutrients in Bedford Basin, Nova Scotia, inferred from 224Ra measurements. *Biogeosciences*, 10, 53-66.

PRIOR SCIENTIFIC/TECHNICAL/MANAGEMENT PERFORMANCE:

This PI has a strong record of external funding during his time as an assistant professor, postdoctoral researcher, and graduate student. As an assistant professor in his first year, he has established two externally-funded research programs, each with it's own graduate student. As a postdoctoral researcher, he co-led the development of an ocean optics program at the University of British Columbia. High S/T/M performance is also indicated by a strong and consistent publication record in high-impact journals, including 2 recent co-publications in *Nature* and *Nature Scientific Reports*. The PI's PhD thesis research was nominated for "Best Thesis" in the faculty of science at his convocation ceremony.

TEACHING:

- Instructor: Chemical Oceanography (graduate/undergraduate class), UAF (spring 2020)
- Part-time instructor in 2 courses at University of British Columbia (2016-2018)
- Instructional Skills Workshop (ISW) Certificate, University of British Columbia (2018)

OTHER ACTIVITIES:

- Member of the CFOS Diversity Committee and the UAF Emergency Scholarship Committee
- Recent NASA Panel Review member
- Current member of the RBR2020 Cohort, an international mentorship and professional development program for early-career researchers sponsored by RBR technologies

Dr. Curry James Cunningham

Assistant Professor of Fisheries
University of Alaska Fairbanks
College of Fisheries and Ocean Sciences
17101 Point Lena Loop Road
Juneau, Alaska
99801

Email: cjcunningham@alaska.edu
Voice: 907.360.4217
Website: www.currycunningham.com
Twitter: @CurryCunningham
GitHub: https://github.com/curryc2

Experience

• Groundfish stock assessment author and management strategy evaluation coordinator for the NOAA Alaska Fisheries Science Center.

• Developing management strategy evaluations (MSEs) and paired simulation-estimate analyses to investigate Bristol Bay Alaska commercial sockeye salmon fisheries.

Employment

2017-2019 Research Fisheries Biologist, National Oceanic and Atmospheric Administration, Alaska Fisheries Science Center, Auke Bay Laboratories. Groundfish stock assessment and management strategy evaluation.

Academic Positions

2019-present Assistant Professor, University of Alaska Fairbanks – College of Fisheries and Ocean Sciences.

2019-present Affiliate Faculty, Alaska Pacific University – Fisheries, Aquatic Science, & Technology Laboratory.

2015-2017 Postdoctoral researcher, University of Alaska Fairbanks, College of Fisheries and Ocean Sciences.

Education

2010-2015 PhD, University of Washington, School of Aquatic and Fishery Sciences. Advisors: Drs. Ray Hilborn and Thomas Quinn.

2005-2010 BSc in Animal Biology, University of British Columbia, Vancouver.

Select Peer-reviewed Publications (*Featured on journal cover, ‡Faculty 1000 recommended)

Thorson, J. T., **C. J. Cunningham**, E. Jorgensen, A. Havron, P.-J. F. Hulson, C. C. Monnahan, and P. von Szalay. 2021. The surprising sensitivity of index scale to delta-model assumptions: Recommendations for model-based index standardization. **Fisheries Research** 233.

Oke, K.B., **C. J. Cunningham**, P. A. H. Westley, M. L. Baskett, S. M. Carlson, J. Clark, A. P. Hendry, V. A. Karatayev, N. W. Kendall, J. Kibele, H. K. Kindsvater, K. M. Kobayashi, B. Lewis, S. Munch, J. D. Reynolds, G. K. Vick, and E.P. Palkovacs. 2020. Accelerating declines in salmon body size impact ecosystems and people. **Nature Communications**.

Litzow, M. A., M. J. Malick, N. A. Bond, **C. J. Cunningham**, J. L. Gosselin, and E. J. Ward. 2020. Quantifying a Novel Climate Through Changes in PDO-Climate and PDO-Salmon Relationships. **Geophysical Research Letters.**

Jones, L., E. Schoen, R. Shaftel, **C. J. Cunningham**, S. Mauger, D. Rinella, and A. St. Savior. 2020. Regional and watershed-scale climate drivers influence Chinook salmon productivity in southcentral Alaska. **Global Change Biology**.

Litzow, M. A., M. E. Hunsicker, N. A. Bond, B. J. Burke, **C. J. Cunningham**, J. L. Gosselin, E. L. Norton, E. J. Ward, and S. G. Zador. 2020. The changing physical and ecological meanings of North Pacific Ocean climate indices. **Proceedings of the National Academy of Sciences**: 201921266.

HISATOMO WAGA

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International Arctic Research Center hwaga@alaska.edu
University of Alaska Fairbanks https://hisatomo-waga.com

EDUCATION

Ph.D. in Fisheries Sciences
Graduate School of Fisheries Sciences, Hokkaido University, March 2018
Dissertation Title: Spatiotemporal variability in phytoplankton and benthic communities in the Pacific Arctic

M.S. in Fisheries Sciences
Graduate School of Fisheries Sciences, Hokkaido University, March 2015
Thesis title: Distributional shifts in size structure of phytoplankton community

B.S. in Fisheries Sciences
School of Fisheries Sciences, Hokkaido University, March 2013

PROFESSIONAL EXPERIENCE

Postdoctoral Researcher (August 2019–present)
International Arctic Research Center, University of Alaska Fairbanks

Postdoctoral Researcher (April 2018–March 2020)
Faculty of Fisheries Sciences, Hokkaido University

PEER-REVIEWED PUBLICATIONS RELEVANT TO THIS PROPOSAL

Nishio, S., Sasaki, H., **Waga, H.**, and Yamamura, O. (*available online*). Effects of the timing of sea ice retreat on demersal fish assemblages in the northern Bering and Chukchi Seas. *Deep-Sea Res. II*. doi:10.1016/j.dsr2.2020.104910

Waga, H., Hirawake, T., and Nakaoka, M. (2021). Influences of size structure and post-bloom supply of phytoplankton on body size variations in a common Pacific Arctic bivalve (*Macoma calcarea*). *Polar Sci.* 27, 100554. doi:10.1016/j.polar.2020.100554

Waga, H., and Hirawake, T. (2020). Changing occurrence of fall bloom and its impact on phytoplankton size structure in the Pacific Arctic. *Front. Mar. Sci.* 7, 6207. doi:10.3389/fmars.2020.00209

Waga, H., Hirawake, T., Fujiwara, A., Grebmeier, J. M., and Saitoh, S.-I. (2019). Impact of spatiotemporal variability in phytoplankton size structure on benthic macrofaunal distribution in the Pacific Arctic. *Deep-Sea Res. II* 162, 114–126. doi:10.1016/j.dsr2.2018.10.008

OTHER PEER-REVIEWED PUBLICATIONS

Hirawake, T., Uchida, MM., Abe, H., Alabia, I.D., Hoshino, T., Masumoto, S., Nishioka, J., Nishizawa, B., Oki, A., Takahashi, A., Tanabe, Y., Tojo, M, Tsuji, M, Ueno, H., **Waga, H.**, Watanabe, Y., Yamaguchi, A., and Yamashita, Y. (2021). Response and biodiversity status of Artic ecosystem under environmental change: Findings in the ArCS project. *Polar Sci.* 27, 100533. doi:10.1016/j.polar.2020.100533

Waga, H., Hirawake, T., and Grebmeier, J.M. (2020). Recent change in benthic macrofaunal community composition in relation to physical forcing in the Pacific Arctic. *Polar Biol.* 43, 285–294. doi:10.1007/s00300-020-02632-3

Waga, H., Hirawake, T., and Ueno, H. (2019). Impacts of mesoscale eddies on phytoplankton size structure. *Geophys. Res. Lett.* 46. doi:10.1029/2019GL085150

Waga, H., Hirawake, T., Fujiwara, A., Kikuchi, T., Nishino, S., Suzuki, K., Takao, S., and Saitoh, S.-I. (2017). Differences in Rate and Direction of Shifts between Phytoplankton Size Structure and Sea Surface Temperature. *Remote Sens.* 9, 222. doi:10.3390/rs9030222

CURRENT AND PENDING SUPPORT

Enhancing ocean color remote sensing tools to better constrain fisheries forecasting models in a critical subarctic system			
Principal Investigator:		Other agencies (including NASA) to which this proposal has been/will be submitted.	
William Burt			
Support:	Current		
Project/Proposal Title: Quantifying Phytoplankton in the Gulf of Alaska			
Source of Support: North Pacific Research Board			
Total Award Period Covered: 08/2020 - 01/31/2023			
Total Amount Received: $174,907			
Person-Months Per Year Committed to the Project: 0.75 months per year			
Support:	Current		
Project/Proposal Title: Exploring Radium isotopes as tracers of groundwater inputs, flushing rates, and produced water in Cook Inlet			
Source of Support: Bureau of Ocean Energy Management			
Total Award Period Covered: 09/2020 - 01/2023			
Total Amount Received: $200,964			
Person-Months Per Year Committed to the Project: 0.5 months per year			
Support:	Current		
Project/Proposal Title: The Students Observing Sikuliaq Satellite Information (SOSSI) Program			
Source of Support: North Pacific Research Board			
Total Award Period Covered: 03/2021 - 02/2024			
Total Amount Received: $19,997			
Person-Months Per Year Committed to the Project: 0 months per year			

CURRENT AND PENDING SUPPORT

Enhancing ocean color remote sensing tools to better constrain fisheries forecasting models in a critical subarctic system	
Co-Investigator: **Curry Cunningham**	Other agencies (including NASA) to which this proposal has been/will be submitted.
Support: Current Project/Proposal Title: Technical review of Yukon River Canadian-origin Chinook salmon Interim Management Escapement Goal Source of Support: Bering Sea Fisherman's Association Total Award Period Covered: 10/01/19 - 06/30/22 Total Amount Received: $75,972 Person-Months Per Year Committed to the Project: 1.0 month per year	
Support: Current Project/Proposal Title: Evaluation of Spatio-temporal Methods for Standardizing Data from Multiple Fishery- Independent Surveys in the GOA and BSAI Source of Support: Pollock Conservation Cooperative Research Center Total Award Period Covered: 08/01/20 - 05/31/23 Total Amount Received: $83,781 Person-Months Per Year Committed to the Project: 0.7 months per year	
Support: Current Project/Proposal Title: Improving Preseason Forecasts with Artificial Intelligence Methods and Ecosystem Information Source of Support: University of Washington Total Award Period Covered: 01/06/20 - 08/31/21 Total Amount Received: $15,000 Person-Months Per Year Committed to the Project: 0.5 months per year	

Support: Current Project/Proposal Title: Development and deployment of statistical salmon forecast tools for the Bristol Bay commercial fishery Source of Support: University of Washington Total Award Period Covered: 07/01/20 - 09/01/21 Total Amount Received: $11,519 Person-Months Per Year Committed to the Project: 0.8 months per year
Support: Current Project/Proposal Title: CICOES: Cunningham Alaska Sablefish Source of Support: University of Washington (NOAA Prime) Total Award Period Covered: 08/01/20 - 07/31/21 Total Amount Received: $83,991 Person-Months Per Year Committed to the Project: 0.0 months per year
Support: Current Project/Proposal Title: Understanding movement patterns of juvenile and adult sablefish in Alaska (CICOES) Source of Support: University of Washington (NOAA Prime) Total Amount Received: $11,248 Total Award Period Covered: 08/01/20 - 07/31/21 Person-Months Per Year Committed to the Project: 0.0 months per year

CURRENT AND PENDING SUPPORT

<table>
<tr><td colspan="2">Enhancing ocean color remote sensing tools to better constrain fisheries forecasting models in a critical subarctic system</td></tr>
<tr><td>Co-Investigator:

Hisatomo Waga</td><td>Other agencies (including NASA) to which this proposal has been/will be submitted.</td></tr>
<tr><td colspan="2">Support: Current

Project/Proposal Title: Remote Sensing of Environmental change in Arctic Coastal Aquatic Ecosystems

Source of Support: NASA ROSES-2020

Total Award Period Covered: 5/15/2021 - 5/14/2023

Total Amount Received: $970,000

Person-Months Per Year Committed to the Project: 3 months in year 2, and 5 months in year 3</td></tr>
</table>

TABLE OF WORK EFFORT

Name	Role	Commitment (months per year)													
		Institution Support	Institution Research Time	Year 1 (July21-Jun22)			Year 2 (July22-Jun23)			Year 3 (July23-Jun24)			Sum		
				This Project		Other Projects	This Project		Other Projects	This Project		Other Projects	This Project		Other Projects
				NASA Support	Total		NASA Support	Total		NASA Support	Total		NASA Support	Total	
William Burt	PI	9	3	2	3	1.25	2	3	1.25	2	3	0	6	9	2.5
Curry Cunningham	Co-I	9	3	0	0	3	0.5	1	0.8	1	2	0	1.5	3	3.8
Hisatomo Waga	Postdoc	0	0	3	6	6	9	9	3	0	0	5	12	15	14
PhD Student	PhD Student	0	0	3	12	0	11	12	0	11	12	0	25	36	0
TBD	MSc Student	0	0	0	0	0	12	12	0	12	12	0	24	24	0
Sum of work effort:		**0**	**0**	**8**	**21**	**10.25**	**34.5**	**37**	**5.03**	**26**	**29**	**5**	**68.5**	**87**	**20.3**

Comments:

COLLEGE OF FISHERIES AND OCEAN SCIENCES
University of Alaska Fairbanks
P.O. Box 757220, Fairbanks, Alaska 99775-7220

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Apr 6, 2021

To: NASA MUREP-OCEAN Program Panel Reviewers

From: Russ Hopcroft

I am writing to confirm ship-time and undergraduate scholarship support required for the proposal "Enhancing ocean color remote sensing tools to better constrain fisheries forecasting models in a critical subarctic system". The Northern Gulf of Alaska Long-Term Ecological Program (NGA-LTER) conducts 3 multi-week cruises annually funded by NSF and other partners. The May "spring" and July "summer" cruises are conducted from the R/V *Sikuliaq* and currently scheduled through 2023, with renewal anticipated for subsequent years. I confirm that PI Will Burt and/or his graduate student are invited to participate in all LTER expeditions aboard the *Sikuliaq* for the duration of this proposed work (2021-2024). I also confirm that PI Burt will be provided support for 1 undergraduate internship during the project period as part of the NGA-LTER's research experience for undergraduates (REU) program.

Dr. Russell R. Hopcroft
Professor of Oceanography
Lead PI, Seward Line and Northern Gulf of Alaska LTER

PROJECT TITLE:	**Enhancing ocean color remote sensing tools to better constrain fisheries forecasting models in a critical subarctic system**
PI:	**William Burt**
START DATE:	**7/1/21**
END DATE:	**6/30/24**
TOTAL BUDGET:	**$730,877**
DEPT #:	**OPDcfos 21-331**
BANNER #:	**S00028555**

							FY22 7/1/21 Year 1	
SALARIES AND WAGES							**Hours**	
Senior Personnel				**Hourly Wage**	**Leave Rate**	**Yearly Increase**		
Total Number of Hours	Employee Name							
1044.00	William Burt	F9 - Faculty (UNAC)		$53.38	20.6%	1.025	348	$22,964
			Total Senior Personnel					$22,964
Other Personnel								
Total Number of Hours								
2080.00	Post Doc (≤ 3 Years)	FN - Faculty (Non-Union)		$28.85	12.3%	1.025	520	$17,268
Student Employees								
Number of Students								
1	PhD before Adv. to Candidacy	GT - Graduate, summer		$23.02	0.1%	1.025	522	$12,329
1	Undergraduate Student	ST - Undergrad, summer		$13.50	0.1%	1.025	400	$5,541
			Total Other Personnel					$35,138
			TOTAL SALARIES AND WAGES					**$58,102**
FRINGE BENEFITS								
Senior Personnel	William Burt	F9 - Faculty (UNAC)			30.4%			$6,981
			Total Senior Personnel					$6,981
Other Personnel								
	Post Doc (≤ 3 Years)	FN - Faculty (Non-Union)			27.6%			$4,766
Student Employees								
	PhD before Adv. to Candidacy	GT - Graduate, summer			9.7%			$1,196
	Graduate Student Health Insurance (AY20-21 = $2,687/year)				$2,687	1.07	0	$0
			Total Other Personnel					$6,500
			TOTAL FRINGE BENEFITS					**$13,481**
			TOTAL SALARIES AND BENEFITS					**$71,583**

TRAVEL		Number of Trips							
1. Domestic Travel	**Description**	Year 1	Year 2	Year 3	**Purpose**	**Travelers**	**Item Cost**	**Yearly Increase**	
Airfare	RT Fairbanks, AK/ Washington, DC (placeholder)	1	1	1	OCRT Meeting	1	1000	1.05	$1,050
Lodging		4	4	4		1	258	1	$1,032
Expenses		4	4	4		1	76	1	$304
Ground Transportation		1	1	1		1	100	1.05	$105
Airfare	RT Fairbanks, AK/ Honolulu, HI	1			Ocean Sciences Meeting	2	1000	1.05	$2,100
Lodging		5				2	177	1	$1,770
Expenses		5				2	149	1	$1,490
Ground Transportation		1				2	100	1.05	$210
Airfare	RT Fairbanks/ Anchorage, AK	1	1	1	Fieldwork	1	200	1.05	$210
Ground Transportation	RT Anchorage/ Seward, AK	1	1	1		1	130	1.05	$137
Lodging	Seward	4	4	4		1	299	1	$1,196
Expenses	Seward	4	4	4		1	146	1	$584
					Total Domestic Travel				$10,188

	Total Foreign Travel	$0
	TOTAL TRAVEL	**$10,188**
CONTRACTUAL SERVICES	**Description**	
3005 - Consultants/Evaluators Professional services	Sensor Calibration	$4,000
Other Contractual Service	Curriculum Development	$750
3661 - Tuition/Registration Fees	OSM Registration: 2020 Rate of $660/ea + 7% annual	$1,511
	TOTAL CONTRACTUAL SERVICES	**$6,261**
COMMODITIES	**Description**	
4015 - Supplies (Program / Project Specific)	Misc. Project Supplies	$1,000
	TOTAL COMMODITIES	**$1,000**
A. MTDC (total costs subject to F&A)		**$89,032**
B. Facilities and Administration (F&A)	**Sponsored Research 55.0%**	**$48,968**
C. Total Costs Exempt from F&A		**$0**
D. Total Direct Costs (A+C)		**$89,032**
E. Total Sponsor Request (B+D)		**$138,000**

PROJECT TITLE: Enhancing ocean color remote sensing tools to better constrain fisheries forecasting models in a critical subarctic system
PI: William Burt
START DATE: 7/1/21
END DATE: 6/30/24
TOTAL BUDGET: $730,877
DEPT #: OPDcfos 21-331
BANNER #: S00028555

							FY23 7/1/22 Year 2	
SALARIES AND WAGES							**Hours**	
Senior Personnel			**Hourly Wage**	**Leave Rate**	**Yearly Increase**			
Total Number of Hours	Employee Name							
1044.00	William Burt	F9 - Faculty (UNAC)	$53.38	20.6%	1.025		348	$23,538
261.00	Curry Cunningham	F9 - Faculty (UNAC)	$53.00	20.6%	1.025		87	$5,842
					Total Senior Personnel			$29,380
Other Personnel								
Total Number of Hours								
2080.00	Post Doc (≤ 3 Years)	FN - Faculty (Non-Union)	$28.85	12.3%	1.025		1560	$53,100
Student Employees								
Number of Students								
1	PhD before Adv. to Candidacy	GN - Graduate, academic	$23.02	0.1%	1.025		609	$14,744
1	PhD after Adv. to Candidacy	GT - Graduate, summer	$25.53	0.1%	1.025		696	$18,687
1	M.S. after Comp Exams	GT - Graduate, summer	$21.34	0.1%	1.025		696	$15,620
1	M.S. after Comp Exams	GN - Graduate, academic	$21.34	0.1%	1.025		696	$15,620
1	Undergraduate Student	ST - Undergrad, summer	$13.50	0.1%	1.025		400	$5,679
					Total Other Personnel			$123,450
					TOTAL SALARIES AND WAGES			**$152,830**
FRINGE BENEFITS								
Senior Personnel	William Burt	F9 - Faculty (UNAC)		30.4%				$7,156
	Curry Cunningham	F9 - Faculty (UNAC)		30.4%				$1,776
					Total Senior Personnel			$8,932
Other Personnel								
	Post Doc (≤ 3 Years)	FN - Faculty (Non-Union)		27.6%				$14,656
Student Employees								
	PhD before Adv. to Candidacy	GN - Graduate, academic		0.0%				$0
	PhD after Adv. to Candidacy	GT - Graduate, summer		9.7%				$1,813
	M.S. after Comp Exams	GT - Graduate, summer		9.7%				$1,515
	M.S. after Comp Exams	GN - Graduate, academic		0.0%				$0
	Undergraduate Student	ST - Undergrad, summer		9.7%				$551
	Graduate Student Health Insurance (AY20-21 = $2,687/year)			$2,687	1.07		2	$6,153
					Total Other Personnel			$24,688
					TOTAL FRINGE BENEFITS			**$33,620**
					TOTAL SALARIES AND BENEFITS			**$186,450**

TRAVEL		Number of Trips							
1. Domestic Travel	**Description**	Year 1	Year 2	Year 3	**Purpose**	**Travelers**	**Item Cost**	**Yearly Increase**	
Airfare	RT Fairbanks, AK/ Washington,	1	1	1		1	1000	1.05	$1,103
Lodging	DC (placeholder)	4	4	4	OCRT	1	258	1	$1,032
Expenses		4	4	4	Meeting	1	76	1	$304
Ground Transportation		1	1	1		1	100	1.05	$110

Airfare	RT Fairbanks/ Anchorage, AK	1	1	1	Fieldwork	1	200	1.05	$221
Ground Transportation	RT Anchorage/ Seward, AK	1	1	1		1	130	1.05	$143
Lodging	Seward	4	4	4		1	299	1	$1,196
Expenses	Seward	4	4	4		1	146	1	$584
								Total Domestic Travel	$4,693
								Total Foreign Travel	$0
								TOTAL TRAVEL	**$4,693**
CONTRACTUAL SERVICES	**Description**								
3005 - Consultants/Evaluators Professional services	Sensor Calibration								$4,000
Other Contractual Service	Curriculum Development								$750
3332 - Publication Page Charges	Publication Fees ($3,000/publication)								$3,000
								TOTAL CONTRACTUAL SERVICES	**$7,750**
COMMODITIES	**Description**								
4015 - Supplies (Program / Project Specific)	Misc. Project Supplies								$1,000
								TOTAL COMMODITIES	**$1,000**
A. MTDC (total costs subject to F&A)									**$199,893**
B. Facilities and Administration (F&A)							**Sponsored Research**	**55.0%**	**$109,941**

STUDENT SERVICES							
Tuition and Student Fees *(at 2020 - 2021 rates)*	**$/Credit**	**$/Semester**	**# Credits**	**Total**	**Yearly Increase**	**# Students**	
Alaska Resident Tuition (graduate level)	$513		18	$9,234	1.05	1	$10,180
Student Fees - Resident		$693		$1,386	1.05	1	$1,528
Non-Resident Tuition (graduate level)	$1,079		18	$19,422	1.05	1	$21,413
Student Fees - Non Resident		$900		$1,800	1.05	1	$1,985
						TOTAL STUDENT SERVICES	**$35,106**
C. Total Costs Exempt from F&A							**$35,106**
D. Total Direct Costs (A+C)							**$234,999**
E. Total Sponsor Request (B+D)							**$344,940**

PROJECT TITLE:	**Enhancing ocean color remote sensing tools to better constrain fisheries forecasting models in a critical subarctic system**	
PI:	**William Burt**	
START DATE:	**7/1/21**	
END DATE:	**6/30/24**	
TOTAL BUDGET:	**$730,877**	
DEPT #:	**OPDcfos 21-331**	**FY24**
BANNER #:	**S00028555**	**7/1/23**

SALARIES AND WAGES			**Hourly Wage**	**Leave Rate**	**Yearly Increase**	**Year 3 Hours**	
Senior Personnel							
Total Number of Hours	Employee Name						
1044.00	William Burt	F9 - Faculty (UNAC)	$53.38	20.6%	1.025	348	$24,126
261.00	Curry Cunningham	F9 - Faculty (UNAC)	$53.00	20.6%	1.025	174	$11,976
					Total Senior Personnel		$36,102
Student Employees							
Number of Students							
1	PhD after Adv. to Candidacy	GT - Graduate, summer	$25.53	0.1%	1.025	348	$9,577
1	PhD after Adv. to Candidacy	GN - Graduate, academic	$25.53	0.1%	1.025	609	$16,760
1	M.S. after Comp Exams	GT - Graduate, summer	$21.34	0.1%	1.025	696	$16,011
1	M.S. after Comp Exams	GN - Graduate, academic	$21.34	0.1%	1.025	696	$16,011
					Total Other Personnel		$58,359
					TOTAL SALARIES AND WAGES		**$94,461**
FRINGE BENEFITS							
Senior Personnel	William Burt	F9 - Faculty (UNAC)		30.4%			$7,334
	Curry Cunningham	F9 - Faculty (UNAC)		30.4%			$3,641
					Total Senior Personnel		$10,975
Student Employees							
	PhD after Adv. to Candidacy	GT - Graduate, summer		9.7%			$929
	PhD after Adv. to Candidacy	GN - Graduate, academic		0.0%			$0
	M.S. after Comp Exams	GT - Graduate, summer		9.7%			$1,553
	M.S. after Comp Exams	GN - Graduate, academic		0.0%			$0
	Graduate Student Health Insurance (AY20-21 = $2,687/year)			$2,687	1.07	2	$6,583
					Total Other Personnel		$9,065
					TOTAL FRINGE BENEFITS		**$20,040**
					TOTAL SALARIES AND BENEFITS		**$114,501**

TRAVEL		Number of Trips Year 1	Year 2	Year 3					
1. Domestic Travel	**Description**	**1**	**2**	**3**	**Purpose**	**Travelers**	**Item Cost**	**Yearly Increase**	
Airfare	RT Fairbanks, AK/ Washington, DC (placeholder)	1	1	1	OCRT Meeting	1	1000	1.05	$1,158
Lodging		4	4	4		1	258	1	$1,032
Expenses		4	4	4		1	76	1	$304
Ground Transportation		1	1	1		1	100	1.05	$116
Airfare	RT Fairbanks, AK/ New Orleans, LA			1	Ocean Sciences Meeting	3	800	1.05	$2,778
Lodging				5		3	158	1	$2,370
Expenses				5		3	71	1	$1,065
Ground Transportation				1		3	100	1.05	$347
Airfare	RT Fairbanks/ Anchorage, AK	1	1	1	Fieldwork	1	200	1.05	$232
Ground Transportation	RT Anchorage/ Seward, AK	1	1	1		1	130	1.05	$150
Lodging	Seward	4	4	4		1	299	1	$1,196

Expenses	Seward 4 4 4			1	146	1		$584
						Total Domestic Travel		$11,332
						Total Foreign Travel		$0
						TOTAL TRAVEL		**$11,332**
CONTRACTUAL SERVICES	**Description**							
Other Contractual Service	Curriculum Development							$750
3661 - Tuition/Registration Fees	OSM Registration: 2020 Rate of $660/ea + 7% annual							$2,595
3332 - Publication Page Charges	Publication Fees ($3,000/publication)							$6,000
						TOTAL CONTRACTUAL SERVICES		**$9,345**
COMMODITIES	**Description**							
4015 - Supplies (Program / Project Specific)	Misc. Project Supplies							$1,000
						TOTAL COMMODITIES		**$1,000**
A. MTDC (total costs subject to F&A)								**$136,178**
B. Facilities and Administration (F&A)				**Sponsored Research**		**55.0%**		**$74,898**
STUDENT SERVICES								
Tuition and Student Fees *(at 2020 - 2021 rates)*	**$/Credit**	**$/Semester**	**# Credits**	**Total**	**Yearly Increase**		**# Students**	
Alaska Resident Tuition (graduate level)	$513		18	$9,234	1.05		1	$10,690
Student Fees - Resident		$693		$1,386	1.05		1	$1,604
Non-Resident Tuition (graduate level)	$1,079		18	$19,422	1.05		1	$22,483
Student Fees - Non Resident		$900		$1,800	1.05		1	$2,084
						TOTAL STUDENT SERVICES		**$36,861**
C. Total Costs Exempt from F&A								**$36,861**
D. Total Direct Costs (A+C)								**$173,039**
E. Total Sponsor Request (B+D)								**$247,937**

PROJECT TITLE:	**Enhancing ocean color remote sensing tools to better constrain fisheries forecasting models in a critical subarctic system**
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TOTAL BUDGET:	**$730,877**
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			END 6/30/24
SALARIES AND WAGES			**Total Project**
		Total Senior Personnel	$88,446
		Total Other Personnel	$216,947
		TOTAL SALARIES AND WAGES	**$305,393**
FRINGE BENEFITS			
		Total Senior Personnel	**$26,888**
Student Employees			
		Total Other Personnel	**$40,253**
		TOTAL FRINGE BENEFITS	**$67,141**
		TOTAL SALARIES AND BENEFITS	**$372,534**
TRAVEL			
		Total Domestic Travel	$26,213
		Total Foreign Travel	**$0**
		TOTAL TRAVEL	**$26,213**
CONTRACTUAL SERVICES	**Description**		
3005 - Consultants/Evaluators Professional services	Sensor Calibration		**$8,000**
Other Contractual Service	Curriculum Development		**$2,250**
3661 - Tuition/Registration Fees	OSM Registration: 2020 Rate of $660/ea + 7% annual		**$4,106**
3332 - Publication Page Charges	Publication Fees ($3,000/publication)		**$9,000**
		TOTAL CONTRACTUAL SERVICES	**$23,356**
COMMODITIES	**Description**		
4015 - Supplies (Program / Project Specific)	Misc. Project Supplies		**$3,000**
		TOTAL COMMODITIES	**$3,000**
A. MTDC (total costs subject to F&A)			**$425,103**
B. Facilities and Administration (F&A)		**Sponsored Research 55.0%**	**$233,807**
STUDENT SERVICES			
		TOTAL STUDENT SERVICES	**$71,967**
C. Total Costs Exempt from F&A			**$71,967**
D. Total Direct Costs (A+C)			**$497,070**
E. Total Sponsor Request (B+D)			**$730,877**

University of Alaska Fairbanks Budget Justification

Estimated costs associated with the proposed project are detailed below. Costs are budgeted in accordance with Federal Regulations and UA Board of Regents policies. Unless otherwise stated, all rates are current and include annual increases where appropriate for subsequent project years.

Salaries:

348 hours (2.0 mos.) per year are requested for PI Burt (at $53.38/hour) to lead the project, recruit students, supervise the postdoc and students, and conduct educational outreach. 87 and 174 hours (0.5 mo. and 1.0 mo.) are requested in years 2 and 3, respectively, for Co-PI Cunningham (at $53.00/hour) to supervise the M.S. student through both integration of the phytoplankton time series metrics into the fisheries recruitment model, and interpretation of the model results.

One year of support (3.0 mos. in year 1, 9.0 mos. in year 2) is budgeted for a postdoctoral fellow (TBH, at $28.85/hour) to guide and mentor the M.S. and PhD students through compilation, processing, and analyses of the satellite-data. Support is budgeted for 2 graduate students: a Ph.D. student and a M.S. student. The Ph.D. student and has been budgeted at 3.0 months in year 1 (summer only) and 11.0 months (academic year and summers) in years 2 and 3, with 1.0 academic month of salary in years 2 and 3 being covered by the current SOSSI program. The M.S. student is budgeted at 12.0 months (academic year and summers) in years 2 and 3. The PhD student will conduct the bulk of analyses related to the first 3 Objectives, whereas the M.S. student will focus primarily on Objective 4. Last, support is requested for two 5-week undergraduate summer internships, one student per year in years 1 and 2, to assist in a variety of tasks (see Project Management section).

Salaries are listed at the current FY21 rate and include a leave reserve of 20.6% for faculty, 12.3% for postdocs ≤ 3 Years, and 0.1% for students. Salaries also include an annual inflation increase of 2.5%. Should this increase not occur as planned, the project will be charged actual salary at the time of effort.

Benefits:

Staff benefits are applied according to UAF's FY21 provisional fringe benefit rates. Rates are 30.4% for faculty salaries, 27.6% for postdocs ≤ 3 Years, and 9.7% for students (summers only for students). A copy of the rate agreement is available at http://www.alaska.edu/cost-analysis/negotiation-agreements/. Health insurance is included for each graduate student at the AY20-21 rate of $2,637 per student per year with a 7.0% annual inflation increase.

Travel:

Travel is listed below at the FY21 base rate. An inflation rate of 5% per year has been included for all air and ground transportation costs. All airfare cost data is based on Internet research. All Per Diem is in accordance with GSA/JTR Regulations.

Domestic:

One trip is requested each year for one person to travel to Seward, AK for fieldwork on cruises. RT airfare from Fairbanks, AK to Anchorage, AK is requested at $200/trip. $130/trip is requested for a shuttle from Anchorage to Seward. Per Diem (meals/incidentals/lodging) for

Seward is budgeted at $445/day x 4 days/trip. Two cruises occur each year, but travel costs for 1 of these trips is greatly reduced by travelling in a LTER group vehicle, thus only one of the two annual trips is formally included in the budget.

One trip is requested each year for the PI to attend the annual Ocean Color Research Team (OCRT) meeting. Using Washington, DC as a placeholder, RT airfare from Fairbanks is requested at $1,000/trip. Per Diem is requested at $334/day x 4 days/trip. $100/trip is requested for ground transportation.

Support is requested for 2 people in year 1 and 3 people in year 3 to attend the annual Ocean Sciences Meeting (OSM). We anticipate the meeting to be held in Honolulu, HI in year 1 (at $1,000/ticket for airfare) and New Orleans, LA in year 3 (at $800/ticket for airfare). Per Diem is budgeted at $326/person x 5 days for Honolulu and $229/person x 5 days for New Orleans. Ground transportation is requested at $100/person/trip for both locations.

Commodities (Materials & Supplies):

$1,000 per year is requested for miscellaneous project supplies for shipboard sampling, such as additional tubing and filters.

Contractual Services and Other Direct Costs:

$4,000 is requested in years 1 and 2 for sensor calibration (amount based on most recent calibration). $750 is requested each year to compensate local teachers for their assistance with curriculum development. $4,106 is requested for OSM registration fees (2020 rate of $660/person + 7% annual inflation). $9,000 is requested for publication fees (est. $3,000 each, based on open-source publication fees).

Per UAF policy, tuition and fees are included in years 2 and 3 for both graduate students. One student has been budgeted as an Alaska resident, with tuition at $513 per credit for 9 credits per semester and fees at $693 per semester (academic year only). The second student has been budgeted as a non-resident, with tuition at $1,079 per credit for 9 credits per semester) and fees at $900 per semester (academic year only). Student tuition and fees are listed at the AY20-21 rate with a 5% inflation increase per year.

Indirect Costs:

Facilities and Administrative (F&A) Costs are negotiated with the Office of Naval Research. The rate for sponsored research at UAF is calculated at 55.0% (FY20-FY22 predetermined agreement) of Modified Total Direct Costs (MTDC). MTDC includes Total Direct Costs minus tuition and associated fees, scholarships, participant support costs, rental/lease costs, subaward amounts over $25,000, and equipment. A copy of the rate agreement is available at: http://www.alaska.edu/cost-analysis/negotiation-agreements/.