Lead PI / Institution: Michael Behrenfeld, Oregon State University

Project Title: First steps - Linking remotely-detectable optical signals, photic layer plankton properties, and export flux

CoPIs / institutions: Emmanuel Boss (University of Maine), Lee Karp-Boss (University of Maine), Jason Graff (Oregon State University), Kimberly Halsey (Oregon State University)

Measurements to be made & from which ship: All measurements from process ship

Plankton Rates & Physiology

Property*	Approach	Instrument
Phytoplankton biomass	Direct analytical measurement	BD Influx Cell Sorter (BD ICS), Shimadzu TOC/N analyzer
	Phytoplankton phosphate	BD ICS, long-path spectrometer
	Phytoplankton ATP	BD ICS, luminometer
	Cell size and abundance	BD ICS, Imaging Flowcytobot (IFCB), FlowCam (descoped)
	Particulate backscattering, particulate beam attenuation	Wetlabs BB-3, BB-9, AC-S
	NPP / Division rate	On-deck incubations
	Corrected pigment	HPLC
$a_{ph\lambda}$, chl	Particulate backscattering, particulate beam attenuation	Wetlabs BB-3, BB-9, AC-S
pigments	Corrected pigment	HPLC
POC	Direct analytical measurement	Exeter Analytical Elemental Analyzer
	Total particulate phosphate	Long-path spectrometer
POP	Total particulate phosphate	Long-path spectrometer
NPP	Trace-metal clean 24 h ^{14}C uptake	On-deck incubations
	Biomass × division rate	see above and below
	Phytoplankton NADH	BD ICS / luminometer
ϕ	Fluorescence	Fast repetition rate fluorometer
μ	Dilution experiment (descoped)	BD ICS, IFCB, FlowCam (descoped), HPLC

	NPP / C_{phyto}	see above
l	Dilution experiments (descoped) μ - *r*	BD ICS, IFCB, FlowCam (descoped), HPLC μ above, *r* below
r	Temporal change in biomass	BD ICS, IFCB, FlowCam (descoped), HPLC, AC-S
Physiology	Trace-metal clean ^{14}C uptake photosynthesis-irradiance Dilution experiments (descoped)	Photosynthetron BD ICS, IFCB, FlowCam (descoped), HPLC

* $a_{ph\lambda}$ = phytoplankton spectral absorption; POC = particulate organic carbon; POP particulate phosphate; NPP = net primary production; ϕ = fluoresecence quantum yield; μ = phytoplankton division rate; *l* = phytoplankton loss rate; *r* = phytoplankton accumulation rate.

Plankton Community Composition & Export Flux

Instrument	Particle Field	Size Range
BD ICS	Total, Phytoplankton (PCC, PSD)	~1 to 64 µm
Coulter Counter	Total PSD	Aperture dependent
IFCB	Protists, fecal pellets, aggregates (PSD, ZCC)	5 to 150 µm
FlowCam (descoped)	Protists, fecal pellets, aggregates (PSD, ZCC)	30 to 300 µm
UVP	Export flux, zooplankton, marine snow, fecal pellets (PSD, ZCC)	~100 to ~2000 µm
LISST (partial descope)	Total PSD, Volume Scattering (VSF)	1.2 to 250 µm
HPLC	Phytoplankton (ChemTax)	Total population

Optics

Instrument	Optical Properties	Derived Properties
ACS	Hyperspectral particulate absorption, scattering, attenuation	Pigments, POC, C_{phyto}, PSD, Community
BB3, BB9	Spectral backscattering	as for ACS
SLOWDROP	Water column absorption, scatter, attenuation, spectral backscatter, VSF	as for ACS and LISST
Hyper-SAS (descoped)	High temporal resolution of Ed and Rrs	remote sensing properties
Hyper-Pro	Surface and or profiles of Ed and Rrs	underwater light field

Equipment to be brought to sea:

Instrument
BD Influx Cell Sorter
FRRf
AC-S (2)
LISST
Hyper Pro
Filter-no-filter system
BB3
BB9
IFCB
UVP5-HD
Photosynthetron

Known field requirements (vans, ship equipment, lab bench space, hoods, over the side time, sampling equipment, etc.):

1. Trace metal clean source of seawater
2. Radioisotope van
3. Hood
4. CTD rosette seawater samples
5. Deployment time for optics
6. Lab bench space: 12 linear feet of open, continuous lab bench space in a location that is not susceptible to getting wet for BD Influx, space for DI water source (4' x 4'), filtration space (6' to 8' bench - near sink best), FRRf space (3' x 3' near flow through seawater source), 3 linear feet of bench space for optics with sink, laptop bench space for remote logging into optics,
7. Need to be able to plumb ship's flow-through seawater system with diaphragm pump and have the flow-through plumbing cleaned shortly before each campaign
8. Space on the CTD/rosette frame for mounting the UVP
9. Support from the ship's crew for deploying SLOWDROP
10. The BD Influx is very heavy and requires movement with the ship's crane during mobilization and demobilization and assistance from the ship's deck crew for moving to and positioning within the lab.
11. Arrangements will be necessary for securing liquid nitrogen at port, shipping and receiving hazardous chemicals (e.g., acids, 14C), and disposal of hazardous waste post-cruise.

Berthing guesstimate: Workload for our project is equivalent to 5 full time scientists. We requested 5 berths, but can handle a minimum of 3 (Jason Graff, one from Halsey group, one from Boss group) if others on the ship can assist with workload.

Needed measurements from other groups:

1. Dilution experiment incubations and access to incubators
2. Measurements of export

Which EXPORTS Science Questions does your project respond to best:

1. Science Question 1 (SQ1), How do upper ocean ecosystem characteristics determine the vertical transfer of organic matter from the well-lit surface ocean?

2. Contributions to subquestions 1a, 1b, 1c, 2b, 2d

What aspects of your inclusion on the EXPORTS Science team are you most excited about:

1. Cross-fertilization between NAAMES and EXPORTS projects
2. Addresses important science questions

Lead PI / Institution: Ken Buesseler, WHOI

Project Title: Elucidating Spatial and Temporal Variability in the Export and Attenuation of Ocean Primary Production using Thorium-234

CoPIs / institutions: Claudia Benitez-Nelson, U. South Carolina; Laure Resplandy, Princeton

Measurements to be made & from which ship: Survey ship

Equipment to be brought to sea: in-situ pumps; beta counters; water processing/filter processing gear

Known field requirements (vans, ship equipment, lab bench space, hoods, over the side time, sampling equipment, etc.):

One lab van, sample using CTD/Rosette; 9 in-situ pumps (need space to store/work on & winch/wire to hang over side); hood on occasion, some lab space for pump processing

Sampling time-

1) with CTD/Rosette- 4L, 60 profiles, 12 depths upper 300m, plus up to 60 surface samples (underway or with bucket)

2) pumps- 12 casts 6 depths (4 per state) 6-8 hours each (depends upon demand for subsamples) 0-750m (overlapping top 5 depths with traps) 3 size classes -1-20 micron, 20-50; >50 (50 micron could be 100 but would take longer pumping time to get same amount of material). Filtered material can be shared.

Berthing guesstimate: 4 essential for ^{234}Th in water (working 24/7 two shifts of 2) plus 2 for in situ pumps (may have down time for one to help hydro or other groups)

Needed measurements from other groups: Yes! Link to traps & other export proxies; other C flux pathways (zoo & DOM); food web; physical forcing; etc.

Which EXPORTS Science Questions does your project respond to best: SQ1a-1d; SQ2a-d; some SQ3 with modeling and comparison to other data

What aspects of your inclusion on the EXPORTS Science team are you most excited about: Unprecedented opportunity to study biological carbon pump!

Lead PI / Institution: Craig A. Carlson / UCSB

Project Title: **Evaluating the Controls of Dissolved Organic Matter Accumulation, its Availability to Bacterioplankton, its Subsequent Diagenetic Alteration and Contribution to Export Flux**

CoPIs / institutions: Dennis A. Hansell / Univ. of Miami (RSMAS)

Measurements to be made & from which ship: DOC and TDN variability will be used to assess flux and portion of NCP partitioned as DOM will be measured on both survey and process ship. DOM bioavailabiity/ microbial remineralization and instantaneous bacterial production will be measured on process cruise.

Equipment to be brought to sea: upright incubator type for DOM remineralization experiments on, microcentrifuge for Bact Prod, numerous carboys for incubations, small pumps, slide making equipment, small field microscope- all on process cruise.

Known field requirements (vans, ship equipment, lab bench space, hoods, over the side time, sampling equipment, etc.):

Survey ship- CTD Rosset with 24- 36 Niskin bottles. 6 linear ft of bench space for sample prep. -20 chest freezer space for frozen seawater only. An acceptable alternative is volatile free storage space (walk in refridge) or hold space for DOM sample storage

Process ship- CTD Rosset with 24- 36 Niskin bottles.

• 10 linear ft of bench space for sample prep.

• clean storage space i.e. -20 chest freezer space for frozen seawater only. An acceptable alternative is volatile free storage space (walk in refridge) or hold space for DOM sample storage.

• Space for two upright incubators are requested for DOM remineralization experiments.

• Occasional use of hood space for fixing samples and making slides.

• RAD van for bacterial production work require about 4- 5 linear feet of bench space. Liquid Scintillation counter,

Berthing guesstimate: one berth requested on Survey ship...could help with hydroteam; Based on previous field programs 2 berth are requested to accomplish the experimental and profile work conducted on the Process ship. Some sharing of effort could be accommodated.

Needed measurements from other groups: Vertical profiles of Inorganic nutrients specifically nitrogen (NO3, NO2, NH4), POC/PON, estimates of NCP, Bio-ARGO floats for estimate of NCP for times when ships are not on station. Estimates of EZ integrated PP would be

helpful. Estimates of physical transport i.e. subduction, mixing and submesoscale variability essential.

Which EXPORTS Science Questions does your project respond to best: *The SQ have been modified for specificity to the role of DOC in export.*

SQ1 How do upper ocean ecosystem characteristics determine the vertical transfer of DOC from the well-lit surface ocean?

1a *How does plankton community structure regulate the upper layer accumulation of DOC?*

1b *How does DOC export vary with plankton community structure?*

1d *How do physical and ecological processes act together to export DOC?*

SQ2 What controls the efficiency of vertical transfer of organic matter below the well-lit surface ocean?

2a *What is the transfer efficiency of DOC to the mesopelagic?*

2b *How is the transfer efficiency of DOC related to plankton community structure in the well-lit surface ocean?*

2d *How does variability in environmental and/or ecosystem features define the relative importance of processes that regulate the transfer efficiency of organic matter to depth (i.e., microbial degradation, bioavailability, physical subduction)?*

SQ3 How can the knowledge gained from EXPORTS be used to reduce uncertainties in contemporary & future estimates of the export and fate of upper ocean net primary production?

3a *What key plankton ecosystem characteristics (cf., food-web structure and environmental variations) are required to accurately model the export and fate of DOC?*

3d *How can the mechanistic understanding of contemporary planktonic food web processes developed here be used to improve predictions of the export and fate of DOC under future climate scenarios?*

What aspects of your inclusion on the EXPORTS Science team are you most excited about?

Beyond the opportunity to participate with the large collaborative / synergistic group, we are excited to assess the contribution of DOM partitioning to NCP and vertical export with all complementary measurements of flux. We are excited to assess bioavailability of various pools of DOM lability i.e. bacterial carbon demand will be used to assess flux of the most labile DOM pool and longer DOM bioavailabilty/ remineralization exp will be used to asses flux of semi-labile DOM through heterotrophic microbial demand in surface and mesopelagic zones. These experiments will help to estimate the "export potential" of the seasonally produced DOM in the Pacific and Atlantic basins.

Lead PI / Institution: Meg Estapa, Skidmore College

Project Title: Linking sinking particle chemistry and biology with changes in the magnitude and efficiency of carbon export into the deep ocean

CoPIs / institutions: Ken Buesseler, Woods Hole Oceanographic Institution; Colleen Durkin, Moss Landing Marine Labs; and Melissa Omand, University of Rhode Island

Measurements to be made & from which ship: See attached Table of Measurements (Proposal Appendix V). All measurements are to be made from drifting platforms deployed and recovered from the "Process Ship"

Equipment to be brought to sea: (Trap numbers and types are pending finalized budget adjustment) Neutrally buoyant sediment traps (8); 5-depth surface-tethered drifting sediment trap array; WireWalker with CTD, bio-optical, and bio-acoustic sensors; Low-level RISØ beta counters (2); stereomicroscopes and inverted microscope with camera; lab equipment (sample splitters, filter racks, computers, etc) to support all of the above.

Known field requirements (vans, ship equipment, lab bench space, hoods, over the side time, sampling equipment, etc.):

Requirements assume we have 8 NBSTs, 500 m STT array, and 500 m WireWalker

- 16 feet of bulkhead in protected main deck or high bay space to secure upright and access 8 NBSTs
- 64 sq feet of main deck space to store STT and WW trap frames and floats when not deployed
- Crane or stern A-frame for NBST deployment
- Crane or side A-frame for NBST recovery (recovery cannot be over stern)
- Stern A-frame, plus TSE winch (or other secondary winch) on main deck for STT and WW deployment
- At least 24 feet of bulkhead (with floor-to-ceiling vertical clearance and away from electrical outlets) in wet lab with main deck access, to rack and process sediment trap tubes (56 per deploy not including spares, ten tubes fit in 4 linear feet). Bulkhead should have vertical strut channel @2 ft spacing, or will need to construct a load-bearing frame.
- 10 feet bench space in wet or dry lab with main deck access, for STT trap controller programming, WW sensor frame prep and storage when not deployed, and occasional NBST programming or repair work (can be split into 4' and 6' sections, doesn't need to be contiguous)
- 6 feet bench space in wet lab for trap sample splitting and filtration (two sample splitters and large filter manifold)
- 6 feet bench space in dry lab with adjacent gas tank storage, for beta counters, computer, and drying oven.
- 4 feet bench space in dry lab for microscope & camera
- Occasional fume hood access to poison trap brine (conc. formaldehyde)
- Refrigerator space for gel samples (approx 2 cubic ft? depending on how quickly we freeze them)
- -20°C freezer space for 42 - 5" dia x 3" high gel sample jars
- -80°C freezer space for DNA cryovials
- Dedicated CTD cast prior to each trap deployment to collect water to fill traps (from deepest trap depth, notionally 500 m)
- 120VAC power on deck near CTD and NBST storage area
- Internet access for position data from drifting assets
- A lot of storage for boxes and crates!
- 1 hour of wire time per NBST and 1 hour for WW (=9 h total) prior to first deployment for reserve buoyancy tests (best done alongside prior to departure with crew assistance if water density is less than at deployment site, or at sea in calm conditions)
- 1 hour each for STT and WW to wind the TSE winch, prior to first deployments (can be done alongside or underway to field site)
- 15 minutes of wire time to deploy each NBST (=2 h total per set of deployments, =6 h per cruise if 3 deployment sets)
- 2 hours of wire time for each STT deploy
- 1 hour of wire time for each WW deploy
- 1 hour +/- 30 minutes of search and recovery time per NBST (=8 +/- 4 h per set of deployments, =24 +/- 12 h per cruise), assuming ship is already in vicinity of drifting assets prior to recovery window (otherwise also need steaming time)
- 2 hours of wire time for each STT recovery
- 1 hour of wire time for each WW recovery

Berthing guesstimate: 4 full time dedicated personnel, one person who may be able to contribute to other projects,

plus contributions from other teams when STT is recovered and perhaps with other aspects of sample processing (gel trap imaging, zooplankton picking, filter babysitting)

Needed measurements from other groups: Near real-time, objectively-analyzed velocity measurements (if someone is already doing this), ^{234}Th deficits

Which EXPORTS Science Questions does your project respond to best: SQ1 and SQ2

What aspects of your inclusion on the EXPORTS Science team are you most excited about:
Working with great people! Going after a challenging observational goal that can only be accomplished the way we're approaching it.

Appendix. Table of Proposed Measurements

Analyte	Sampling	Method	Reference(s)
POC and PON fluxes	NBST Bulk flux tubes - formalin brine	C/N elemental analysis	Lamborg et al., 2008
PIC flux	NBST Bulk flux tubes - formalin brine	Coulometry	Lamborg et al., 2008
bSi flux	NBST Bulk flux tubes - formalin brine	Alkaline digestion and Si analysis	Lamborg et al., 2008
Mass flux	NBST Bulk flux tubes - formalin brine	Gravimetry	Lamborg et al., 2008
^{234}Th flux	NBST Bulk flux tubes - formalin brine	Beta counting	Lamborg et al., 2008
Single particle raw sequences	NBST Polyacrylamide gels	DNA sequencing	
Single particle organismal contents	NBST Polyacrylamide gels	DNA sequencing	Durkin et al., *in prep*
Bulk DNA raw sequences	NBST Bulk flux tubes - RNAlater	DNA sequencing	
Bulk organismal contents	NBST Bulk flux tubes - RNAlater	DNA sequencing	
Gel trap raw imagery	NBST Polyacrylamide gels	Microscopy	
Single particle visual ID	NBST Polyacrylamide gels	Microscopy	Durkin et al., 2016
Number fluxes of aggregates, fecal pellets, and single cells	NBST Polyacrylamide gels	Microscopy	
Carbon fluxes of aggregates, fecal pellets, and single cells	NBST Polyacrylamide gels	Modeling	
Sinking particle size distribution	NBST Polyacrylamide gels	Microscopy	Durkin et al., 2015
Time-resolved POC flux	NBST Optical sediment trap	Attenuance flux	Estapa et al., 2017
Profiles of calibrated biooptics: backscattering, beam attenuation	WireWalker	WETLabs sensors (Eco Triplet and C-Star)	
Profiles of acoustic backscatter	WireWalker	Nortek Signature ADCP	
POC profiles	WireWalker	Cross-calibration to bottle samples	
Uncalibrated in vivo Chl fluorescence profiles	WireWalker	WETLabs Eco-Triplet	

Analyte	Sampling	Method	Reference(s)
Uncalibrated oxygen profiles	WireWalker		
CTD profiles	WireWalker		
POC flux due to aggregates	WireWalker	Backscattering "spike" fluxes	Briggs et al., 2011
POC flux due to small particles	WireWalker	Integrated backscattering	Dall'Olmo and Mork 2014, Jackson et al. 2015
Raw platform space-time coordinates	NBST and WireWalker		

Lead PI / Institution: Marchetti (UNC – Chapel Hill)

Project Title: Quantifying the carbon export potential of the marine microbial community: coupling of biogenic rates and fluxes with genomics at the ocean surface

CoPIs / institutions: Cassar (Duke) and Gifford (UNC – Chapel Hill)

Measurements to be made & from which ship: Process Ship (see Table of Measurements).

Equipment to be brought to sea:

EIMS
Satlantic FIRe Fluorometer (if needed)
Seawater flow-through incubators
Filtering manifolds and equipment, etc.

Known field requirements (vans, ship equipment, lab bench space, hoods, over the side time, sampling equipment, etc.):

Field observations from all three investigators require access to a CTD/rosette. Six Niskin bottles are required for each sampling site. A total of 15 L in triplicate are required for the following: 0.5 L for chlorophyll *a* concentrations, 1 L for NO_3 and DIC uptake measurements, 0.5 L for phytoplankton and bacterial cell enumeration, 4 L for eukaryotic metatranscriptomics, 4 L for bacterial metagenomics, 4 L for bacterial metatranscriptomics, and 1 L for 16S and 18S rRNA amplicon libraries. In addition, 2 L are required from each Niskin for rinsing sample bottles before sample collection. PI Gifford requires triplicate 2 L aliquots of water from each sample site from a trace metal clean rosette for the community and bacterial respiration rate measurements. Ship board primary production incubations require 2 m^2 of deck space with access to surface underway seawater. For our primary productivity calculations, require the measurement of dissolved nutrients [e.g., NO_3, PO_4 and $Si(OH)_4$] and DIC concentrations at our sample locations.

The EIMS (PI Cassar) requires: 1) access to underway seawater (2-3 L min^{-1}), preferably as close to the ship's seawater intake as possible to minimize temperature change and possible respiration within the ship's lines, and 2) a nearby sink to hold the wet chemistry elements and drain seawater continuously, as well as approximately 2.5 square meters of bench space adjacent to the sink. The dimensions of the major EIMS parts (in cm) are as follows:

1) Mass spectrometer with pumping station 33 x 32 x 52, length of the arm on the upper part is 70
2) PC 25 x 24 x 7 plus a monitor (22') and a keyboard
3) BK power supply 23 x 36 x 11
4) Sampling bucket in sink: 25 x 25 x 46. We can make a smaller one if there's not

enough space in the sink.

Respiration incubations (PI Gifford) and the FIRe fluorometer (PI Marchetti) require: 1) access to underway seawater, 2) 0.8 m x 3 m bench space each for the incubators/equipment, 3) sink or drain for exiting seawater flow through, 4) power supply and bench space for monitor and keyboard. All three investigators require bench space for water filtration of samples. Storage of nucleic acid and stable isotope samples require 0.5 m^2 of -20°C shelf space and 0.5 m^2 of -80°C shelf space. Storage and transport of samples requires access to 40 L liquid nitrogen (PIs Gifford and Marchetti will provide dewars).

Berthing guesstimate: 5

Needed measurements from other groups: Dissolved inorganic nutrients (NO_3, PO_4 and $Si[OH]_4$, and possibly NH_4) and dissolved inorganic carbon.

Which EXPORTS Science Questions does your project respond to best: SQ1a

What aspects of your inclusion on the EXPORTS Science team are you most excited about: Each group that is involved in the program brings a distinct set of research expertise to the EXPORTS team. We are most excited about the opportunity to collaborate with these groups and combine our measurements in a way that has never been done before.

Appendix A: Table 1: Proposed field measurements for EXPORTS (Marchetti, Gifford and Cassar)

Measurement	Abbreviation (if any)	Lead PI	Discrete or Underway[a]	Size-fraction	Depth of integration[b]	Method	Errors and Uncertainties
Chlorophyll a	Chl a	Marchetti	D	5 µm, GF/F	ML	Acetone extraction, acidified	mean, st. dev
Dissolved inorganic carbon uptake	ρDIC	Marchetti	D	5 µm, GF/F	ML	$H^{13}CO_3$ stable isotope, 6h incubation	mean, st. dev
Nitrate uptake	ρNO_3	Marchetti	D	5 µm, GF/F	ML	$Na^{15}NO_3$ stable isotope, 6h incubation	mean, st. dev
Particulate carbon	PC	Marchetti	D	5 µm, GF/F	ML	Mass Spectrometer	mean, st. dev
Particulate nitrogen	PN	Marchetti	D	5 µm, GF/F	ML	Mass Spectrometer	mean, st. dev
Maximum photochemcial yield of PSII	F_v/F_m	Marchetti	U	whole	surface	Satlantic FIRe fluoromter	binned average
Absorption cross-section of PSII	σ	Marchetti	U	whole	surface	Satlantic FIRe fluoromter	binned average
Large phytoplankon cell counts		Marchetti	D	whole	ML	Light microscopy	mean, st. dev
Eukaryotic plankton metatranscriptomics		Marchetti	D	whole	ML	RNA-Seq, Illumina HiSeq4000	p-values
Respiration rates		Gifford	D	whole, 5 µm	ML	Oxygen optodes	mean, st. dev
Bacterial cell abundance		Gifford	D	whole, 5 µm	ML	Epiflourescence microscopy	mean, st. dev
Bacterial metagenomics		Gifford	D	5 µm, 0.22 µm,	ML	DNA sequencing. Illumina MiSeq	mean, st. dev
Bacterial metatranscriptomics		Gifford	D	5 µm, 0.22 µm,	ML	RNA-Seq, Illumina HiSeq4000	p-values, mean, st. dev
Net Community Production	NCP	Cassar	U	N/A	ML	Equilbrator Inlet Mass Spectrometry	binned average (± 30%; Cassar et al. 2014)
DNA sequencing for 16S and 18S rDNA		Cassar/Marchetti /Gifford	D	0.45 µm filter	ML	Illumina MiSeq platform	mean, st. dev

[a]D = discrete depths, U = underway
[b]ML = mixed layer

Lead PI / Institution:
Susanne Menden-Deuer, University of Rhode Island

Project Title:
Quantifying Plankton Predation Rates, and Effects on Primary Production, Phytoplankton Community Composition, Size Spectra and Potential for Export

CoPIs / institutions:
Tatiana Rynearson, , University of Rhode Island

Measurements to be made & from which ship:
The ship will be the process ship. See table 1 below for measurements.

Equipment to be brought to sea:
Deckboard incubators (6), coulter counter, fluorometer, flowcytometer (Guava), filtration rigs, FlowCam,

Known field requirements (vans, ship equipment, lab bench space, hoods, over the side time, sampling equipment, etc.):
Lab bench space, occasional hood access, CTD/Niskin samples, including to depths of >500 m.

Berthing guesstimate:
Three to six

Needed measurements from other groups:
Hydrography, lightfield, nutrients, particle types and concentrations at depth, flux rates, metazoan predator dynamics

Which EXPORTS Science Questions does your project respond to best: To address SQ1a, we determine the rates of transfer of organic matter among the organic and inorganic pools and estimate net primary production by measuring concurrently the rates of primary production and loss (herbivory) as well as feeding capacity in the twilight zone. To gain a predictive understanding of the linkages between surface processes and export production, we will correlate abiotic and biotic conditions with rate estimates. Insights into SQ1b are gained through repeat measurements made across multiple ecosystem states. Based on repeat observations, we can develop statistically rooted, predictive and diagnostic relationships among the measured ecosystem/carbon cycling states and the rate processes using non-dimensional scaling analyses and regression. We can contribute to SQ1c because heterotrophic protists feed directly on transparent exopolymeric particles (TEP, Sherr 1988). TEP feeding rates are not investigated in our main experiments measuring herbivory, but collaboratively, we can investigate the influence of grazing on TEP and visa versa, should others be funded to measure and manipulate TEP. SQ1d will be illuminated through a comparison of the magnitude of herbivory relative to submesoscale advection and sinking flux providing quantitative descriptions of their *relative* importance. Our estimates of phytoplankton

growth and mortality rates in the surface ocean and grazing capacity at depth contributes important data to SQ2a. Characterization of the size structure and taxonomic composition, along with predation-induced shifts therein contribute to SQ2d. The goals of SQ3 are addressed in a number of ways, because our proposed research provides metrics that quantify biologically mediated carbon flow in the surface ocean and assess the relative importance of abundance and size structure in driving these rates. Our data will form the basis for addressing SQ3b, because our proposed results can identify correlates between dynamics of plankton populations, their taxonomic composition and abundance/biomass (rates vs. stocks) and the environmental conditions they occur in. Answering these questions will be a key driver of EXPORTS success.

What aspects of your inclusion on the EXPORTS Science team are you most excited about:
Collaboratively investigating the interdependency of environmental forcing and biological responses in distinct ECC states to drive export production.

Table 1 Proposed measurements. At sea measurements will be made from the process ship.

MEASUREMENT	UNIT	INSTRUMENT	METHOD
Chl a concentration	µg Chl L-1	Turner AU 10	Graff & Rynearson (2011)
FlowCytometry	Fluorescence per cell/ Forward scatter	Guava Flow Cytometer	Krediet et al. (2015)
Particle Size (near real time)	Equivalent spherical diameter	Coulter Counter	Kim & Menden-Deuer (2013)
Species diversity (near real time)	Images	FlowCam	Alvarez et al. (2011)
Species composition & abundance	Counts (cells L-1) & Biomass (µg C L-1)	Microscope	Menden-Deuer & Lessard (2000)
Phytoplankton growth, herbivorous predation (dilution)	Rates d-1	Incubation	Landry & Hassett (1982) Morison & Menden-Deuer, in press
Protist grazing capacity (ingestion)	Ingested cells predator-1 hr-1	Incubation	Martin-Cereda et al. (2008)

Incubation-free genetic sensor of protist grazing	Qualitative (feeding/ starving) & Quantitative (rates d-1)	Real-time thermocycler	In development (see text)
Consumption of herbivorous protists by macrozooplankton	Species composition, relative abundances	Illumina MiSeq sequencing platform	Cleary et al. 2012, Cleary et al. 2016

Lead PI / Institution: **Collin Roesler/ Bowdoin College**

Project Title: **Phytoplankton community structure, carbon stock, carbon export and carbon flux: What role do diatoms play in the North Pacific and North Atlantic Oceans?**

CoPIs / institutions: **Heidi Sosik/ WHOI**

Measurements to be made & from which ship:

All from survey ship:

1. **Underway Hyperspectral Remote Sensing Reflectance**
2. **Underway Flow-through system with sensor package/configuration:**
   A. **Temperature and Salinity**
   B. **Imaging FlowCytobot**
   C. **Automated Size-Fractionated inherent optical properties (total, <20um, <2um, <0.2um):**
      i. **Hyperspectral absorption and attenuation**
      ii. **(Particle size distributions – validation on size fractionation)**
      iii. **3 channel backscattering (in non-absorbing wavebands)**
      iv. **CDOM fluorescence (with Fchl and bb at 4th wavelength)**
      v. **3 channel excitation chlorophyll fluorometer**
3. **Discrete inline size-fractionated water sample analyses (total, <20um, <2um, <0.2um)**
   A. **Spectrophotometric absorption (QFT measured in a center-mounted integrating sphere, extraction to retrieve NAP and phyt components from particulate; <0.2um and <GFF filtrate CDOM absorption measured in 10-cm cuvette transmission-mode configuration)**
   B. **HPLC pigments to be analyzed by NASA OBPG**
   C. **POC to be analyzed by University of Maine or NASA OBPG**
   D. **Conventional Flow Cytometry (frozen for post-cruise analysis)**
4. **Discrete water samples collected from hydrocast profiles**
   A. **Spectrophotometric absorption (QFT measured in a center-mounted integrating sphere, extraction to retrieve NAP and phyt components from particulate)**
   B. **Conventional Flow Cytometry (frozen for post-cruise analysis)**

Equipment to be brought to sea:

1. **Underway HyperSAS (requested as part of proposal, but provided by other group)**
2. **Underway Flow-through system with sensor package/configuration:**
   A. **Aero pump (high throughput diaphragm pump; requested in proposal)**
   B. **Fully-developed and tested plug and play inline system with plumbing, Sequoia flow control switches, automated sequential filtration system, data controllers, sensor power, and data archiving**
   C. **SeaBird Thermosalinograph (Temperature and Salinity)**

D. **Imaging FlowCytobot (requested in proposal)**
E. **WET Labs Hyperspectral absorption and attenuation meter (ac9plus as backup)**
F. **Sequoia LISST 100x (Particle size distributions)**
G. **WETLabs BB3 (custom non-absorbing wavebands; requested in proposal)**
H. **WETLabs 3X1M Chl fluorometer (440nm, 470nm, 532 nm)**
I. **WETLabs BBFL2 (Chl and CDOM fluorescence, bb 4th wavelength, redundancy Fchl)**

Known field requirements (vans, ship equipment, lab bench space, hoods, over the side time, sampling equipment, etc.):

1. **Install Aero pump to drive flow through water system (minimize particle disruption for flow through system)**
2. **Install HyperSAS on ship bow (minimize detection of wake, ship-induced waves; ship shading)**
3. **Bench space with sink for flow through system with access to pure water system (integrate into flow system for automated pure water calibrations)**
4. **Bench space for sample filtration, two liquid nitrogen dewars, desiccator, drying oven**
5. **CTD/Rosette/fluorometer/transmissometer**

Berthing guesstimate:

Assuming continuous operations and watches, we request 4 berths

Needed measurements from other groups:

From our descoping discussions thusfar, we expect the following to be the responsibility of other groups with the understanding of timely sharing of data

1. **IFCB analysis of complete set of discrete water samples from depth profiles into the twilight zone (Zhang and Huot)**
2. **Conventional Flow Cytometry of discrete water samples from depth profiles and inline samples (Zhang and Huot and/or Menden-Deuer)**
3. **POC analysis of discrete water samples from depth profiles, inline system (size fractionated) (NASA OBPG)**
4. **HPLC analysis of discrete water samples from depth profiles, inline system (size fractionated) (NASA OBPG)**
5. **Nutrients (nitrate/nitrite, silicate, phosphate, ammonium) from discrete water samples from depth profiles (NASA FSG)**

Which EXPORTS Science Questions does your project respond to best:

SQ1: How do upper ocean ecosystem characteristics determine the vertical transfer of organic matter from the well-lit surface ocean?

a. How does plankton community structure regulate the export of organic matter from the surface ocean?

SQ2: What controls the efficiency of vertical transfer of organic matter below the well-lit surface ocean?
b. How is the transfer efficiency of organic matter to depth related to plankton community structure in the well-lit surface ocean?

SQ3: How can the knowledge gained from EXPORTS be used to reduce uncertainties in contemporary & future estimates of the export and fate of upper ocean net primary production?
b. How do key planktonic ecosystem characteristics vary and can they be assessed knowing surface ocean processes alone?

What aspects of your inclusion on the EXPORTS Science team are you most excited about:

1. Collecting a high quality synoptic data set that provides unequivocal validation products for PFT inversion models thereby allowing validation to be performed at each step from radiance reflectance to IOPs to PFT absorption spectra to pigment-based phytoplankton community composition to imaging-based community structure to phytoplankton carbon.

2. Understanding the role of diatoms in export carbon in the subarctic North Pacific Ocean

3. Quantifying spatial variations in carbon flux retrieved from satellite via PFT inversion modeling

Lead PI:

David Siegel, ERI, UCSB, Santa Barbara, CA 93106-3060, Ph: 01-805-893-4547; Em: david.siegel@ucsb.edu

Title:

Synthesizing Optically- and Carbon Export-Relevant Particle Size Distributions for the EXPORTS Field Campaign

Co-I's:

Adrian Burd, UGA; Andrew McDonnell, UAF; Norm Nelson, ERI, UCSB; Uta Passow, MSI, UCSB,

Measurements to be made and from which ship:

In situ PSD observations from UVP-5 and LISST-Deep from both ships
Aggregate characterization from collected samples on process ship
Discrete phytoplankton, DOM and detrital absorption spectra & FDOM characterization from both ships
Spectroradiometer casts (C-OPS) from both ships
Modeling of aggregate dynamics
Core CTD & hydrographic sampling & analysis from both ship's niskins (CHN, nuts, O2, Chl, HPLC, BSi & PIC)

Equipment to be brought to sea:

2 UVP-5 & 2 LISST-Deep mounted on the ship's CTD rosette (both ships)
2 C-OPS to be hand lowered (both ships)
3 Marine Snow Catchers (huge niskins that will be likely on hydro wire and tripped via messenger - process ship)
Microscopes, laboratory incubator and rolling table for aggregate characterization (process ship)
Ultrapath CDOM analyzer (survey ship likely - process ship samples brought back - or vice versa)
Multi tower filter rigs for hydrographic sampling (both ships)

Known Field Requirements: (both ships unless noted)

CTD / rosette from ship's equipment
Space near CTD garage for UVP/LISST work - access to ship's auxiliary port for UVP particle data
Space for deploying C-OPS with small space for cable and access to mast for incident irradiance spectra
Lab space for aggregate characterization (process only), ap's/CDOM, hydrography filtering, Chl-fluorometry & winkler titrators
Sample storage at 4 and -20C (~ 2 m^2)
Space for 30L liquid N2 dewar - preferably in walking freezer
Help with sample return and liquid N2 / dry ice at demob location
Hydrowire and wince for marine show catchers to 500 m and space for storage for up to three (process)

Berthing Guesstimate:

Science proposal - 5 (3 process 2 survey)
Hydro team - 4 (2 process 2 survey)
There may be some play with the hydro team # if other groups help out in a serious way

Needed Measurements from Other Groups;

Zooplankton / microbial / DOC collaborations with experiments
Help with O2 core measurements for sensor cals
PSD from Coulters, etc.
Trap fluxes & gel traps
Photo biomass & composition
Zoop biomass & composition
NPP / NCP
In situ respiration profiles
Lithogenic ballasting materials
Tow-yo surveying with VPR
AUV surveying & snow cam

Which EXPORTS Science Questions does your project respond to best:

Maybe uniquely - SQ1C “Controls on particle aggregation / disaggregation”
Also SQ2A “ mesopelagic transfer efficiency pathways” and SQ2D states “ecosystem variations select transfer efficiency pathways”
Contributes to many others...

What aspects of your inclusion on the EXPORTS Science team are you most excited about:

Getting to participate what will be THE gold standard biological pump field program
Working again with the very best scientists in the world
I am terrified about how we will coordinate among all of the elements (two ships, AUV array, etc.)

Lead PI / Institution: Deborah K. Steinberg, Virginia Institute of Marine Science, College of William and Mary

Project Title: Zooplankton-Mediated Export Pathways: Quantifying Fecal Pellet Export and Active Transport by Diel and Ontogenetic Vertical Migration in the North Pacific and Atlantic Oceans

CoPIs / institutions: Amy E. Maas, Bermuda Institute of Ocean Sciences

Measurements to be made & from which ship:
zooplankton biomass and community structure- Process ship
fecal pellet production experiments- Process ship
respiration/excretion experiments- Process ship
bioacoustics- Survey Ship (Process ship alternative)

Equipment to be brought to sea:
temperature controlled incubator (in lab, metabolic experiments)
plankton nets and frames, flow meters
respirometry equipment (O2 meter and probes)
incubation bottles, trays, picking and sorting equip.
plankton splitter
2 x dissecting microscopes, one with a digital camera system
dewar/s with liquid nitrogen

Known field requirements (vans, ship equipment, lab bench space, hoods, over the side time, sampling equipment, etc.):
MOCNESS (multiple opening-closing net)
Underwater Video Profiler (UVP)
hull-mounted echosounders on the Survey Ship
Freezers (-20C and -80C)
Deckboard incubators with running seawater for fecal pellet production experiments
fume hood
lab bench space
winch with enough conducting wire to tow a MOCNESS down to 1000m
winch with enough wire to tow other plankton nets in surface 200m
A-frame and/or J-frame for conducting tows

Berthing guesstimate: 4 on the Process ship. Presumably the bioacoustics on the survey ship can be collected without us on board (just running the echosounder when in transit). At the meeting we'll have to discuss whether we want any net tows on the survey ship to ground truth, or just do that on process ship)

Needed measurements from other groups:
phytoplankton biomass and community structure (in situ and satellite-derived)
sinking particle flux at multiple depths (sediment traps)
particle profiles including particle size spectra and showing particle maxima layers

light attenuation
temperature and oxygen profiles

Which EXPORTS Science Questions does your project respond to best:
SQ1 (subquestions 1a and 1b concerning plankton community structure and effects on export), and SQ2 (subquestions 2a, 2b, and 2d concerning transfer efficiency, and environmental/ ecosystem controls affecting export and carbon transformations)

What aspects of your inclusion on the EXPORTS Science team are you most excited about:
Experiencing first hand the years of planning put into action, working with this fabulous team of scientists, the opportunity to wow our colleagues with the beauty of open ocean zooplankton, finally having all the measurements we need in one collaborative "wheelhouse" to properly measure bio pump

Lead PI / Institution: Xiaodong Zhang, University of North Dakota

Project Title: Optically resolving size and density distributions of particles in the dissolved-particulate continuum from 20 nm to 20 mm to improve the estimate of carbon flux

CoPIs / institutions:
Dr. Deric Gray, Naval Research Laboratory, USA
Dr. Yannick Huot, Université de Sherbrooke, Canada
Dr. Lionel Guidi, Laboratoire d'Océanographie de Villefranche, France

Measurements to be made & from which ship:
Survey cruise with a focus on profiling of these measurements: IOPs of spectral absorption coefficient and spectral volume scattering functions, underwater imaging of particles, particle size and density distributions

Equipment to be brought to sea: One profiling package we proposed includes: ac-9, ac-s, BB-9, WETStar, and CDT. This package goes down to 200 m. For our discrete instruments, we need temperature and salinity to estimate scattering by pure seawater. That is the reason we need CDT below 200 m. Since there is a possibility to de-scope our ac package, we now need temperature and salinity at every discrete depths, which we're taking measurements using our instruments.

Instruments	Profile depth (m)	Measurements	Estimated products
CTD	200 m	salinity, temperature, depth	
ac-9, ac-s	200 m	$a(\lambda)$ and c(λ) at multiple or hyperspectral wavelengths	Phytoplankton size classes and CDM
BB-9	200 m	$\beta(117°)$ at 9 wavelengths	Multispectral b_b
WETStar	200 m	Fluorescence	Chlorophyll-a
UVP	600 m	Images of particles	PSD from 100 μm – 20 mm
The following measurements use water samples collected by a rosette at each depth			
MVSM	rosette depth	β from 10 to 179° every 0.25° at 443, 490, 510, 532, 555, 565, 590, and 620 nm	Multispectral backscattering coefficients
LISST-100X	rosette depth	β from 0.07° to 14° in 32 intervals at 532 nm	PSD from ~1 – 100 μm
MVSM+ LISST-100X	rosette depth	β from 0.07 to 179° at nearly 700 angles	PSD from 0.02 to 200 μm. Between 0.2 to 200 μm, 7 possible particle types (refractive index = 0.75, 1.02, 1.04, 1.06, 1.10, 1.16 and 1.20). Between 0.02 and 0.2 μm, index is assumed to be 1.05.
LISST-VSF	rosette depth	β from 0.1 to 15° in 32 intervals and 15 to 150°	PSD from 0.02 to 200 μm for 7 possible particle types (refractive index = 0.75,

		every 1°	1.02, 1.04, 1.06, 1.10, 1.16 and 1.20)
Imaging Flow Cytometer	rosette depth	Images of particles	PSD from 5 – 100 μm
ViewSizer	rosette depth	Tracking Brownian motions of submicron particles	PSD for submicron particles

Known field requirements (vans, ship equipment, lab bench space, hoods, over the side time, sampling equipment, etc.):
During field campaigns, we will require daily access to a clean water source, with an anticipated amount of approximately 10 L per day.
On the research vessel, we will require approximately 2 m^2 of deck space for our IOP instrument, attachment of our UVP instrument to a rosette, and approximately 5 m of bench space within a wet lab for LISST-VSF, LISST-100X, MVSM, ViewSizer and Imaging FlowCytobot. We will need approximately 10 L of water samples collected at each depth.

Berthing guesstimate: 3, optimal 5

Needed measurements from other groups:
Sediment trap to provide independent particle flux measurements
HPLC analysis on profiling water samples
CTD at depths below 200 m

Which EXPORTS Science Questions does your project respond to best:
How particle size distribution and types vary with depths due to aggregation/disaggregation (SQ-1c);
How dissolved organic matter vary with depths (SQ-1b); and How mineral particles, such as opal and dust, regulate the export of organic matter (SQ-1b).
How do different phytoplankton size classes vary in their export of organic matter (SQ-1a).

What aspects of your inclusion on the EXPORTS Science team are you most excited about:
Over the years, we have made several progress in using optical measurements to infer biogeochemical stocks. It is exciting to finally test and compare our results with the experts in the various fields of oceanic carbon flux.

Lead PI / Institution

Craig Lee, Applied Physics Laboratory, University of Washington

Project Title

Autonomous Investigation of Export Pathways from Hours to Seasons

CoPIs / institutions

Eric D'Asaro, Applied Physics Laboratory, University of Washington

David Nicholson, Chemical Oceanography Department, Woods Hole Oceanographic Institution

Melissa Omand, Graduate School of Oceanography, University of Rhode Island

Mary Jane Perry, self-affiliated

Andrew Thompson, Department of Environmental Science and Engineering, California Institute of Technology

Measurements to be made & from which ship

Autonomous

Sustained measurements in a float-following framework.

Float will drift and sample just below the euphotic zone, accompanied by a profiling glider.

Additional gliders will sample the region around the float.

Systems will sample for a ~6-month span, targeted for deployment well before, and recovery well after, the main sampling period.

Measurements include: T, S, dissolved oxygen (NCP from budgets), nitrate (NCP from budgets), chlorophyll fluorescence (phytoplankton biomass proxy), optical backscatter (POC proxy), PAR, multi-spectral irradiance, optical attenuation (beam-c, POC proxy), acoustic backscatter (from 1 MHz ADCP, mesozooplankton proxy), optical sediment trap, Snocam for particle characterization.

Ship-based

We would like to establish one set of sensors for use on the survey vessel CTD as the program reference sensors (the gold standard), and are willing to coordinate this, as well as the pre- and post-cruise calibration of the survey and process ship sensors.

Will need collocated calibration casts between survey ship and process ship, and survey ship and autonomous floats and gliders.

Provided that other components will provide calibration and proxy measurements, we will not need our own specific sampling from the ships. We will need the ability to target some survey ship sampling to be tightly collocated with the other platforms, though.

Equipment to be brought to sea

Lightweight deployment and recovery gear (no special storage or handling requirements) to be sent on survey ship in case emergencies arise that require recovery of autonomous platforms.

Similar equipment will be used on deployment and recovery cruises, which are envisioned to take place from a vessel of opportunity.

Known field requirements (vans, ship equipment, lab bench space, hoods, over the side time, sampling equipment, etc.)

Crane or davit for deployment and recovery of floats and gliders.

CTD casts dedicated to calibration of autonomous sensors (see below).

Berthing guesstimate

One person (likely Melissa Omand, who will sail in support of this and the Estapa component).

Needed measurements from other groups

Calibration: Used to cross-calibrate all sensors (process ship CTD, autonomous platforms, etc). This will require collocated casts with the process ship and with each autonomous platform.

Proxy Building: Sensor-based sampling paired with analyses of collocated in situ samples will also be used to build proxy relationships. These casts do not need to be collocated with the autonomous platforms.

The following measurements will be needed collocated with floats and gliders for calibration:

- oxygen (optode paired with bottle oxygen samples for calibration)
- HPLC (paired with fluorometer for proxy-building)
- chlorophyll (paired with fluorometer for proxy-building)
- nutrients (paired with nitrate sensor for calibration)

Additional samples for proxy building:

- HPLC (paired with fluorometer for proxy-building)
- POC (paired with backscatter and beam-c for proxy-building)
- phytoplankton (paired with fluorometer and backscatter for proxy-building)
- zooplankton net and/or UVP profiles (paired with Nortek ADCP that we will supply, for proxy-building)

Will need at least 4 casts per float and glider per cruise, plus inter-ship calibration casts.

Float/glider casts must begin within 100 m of the diving target vehicle.

Additional casts will be needed for generation of optical phytoplankton & POC proxies.

Will need 6-10 bottles per cast of Chlorophyll, HPLC, nutrients, POC, pico/nano phytoplankton all by specified protocols.

Which EXPORTS Science Questions does your project respond to best

SQ 1 (a,b,d) and 2 (a, b).

What aspects of your inclusion on the EXPORTS Science team are you most excited about

Understanding variability in export pathways as a function of NCP and carbon export over temporal and spatial scales that are large enough to encompass numerous states – scales we've

not been previously able to access. Contributing to this large, integrated program and advancing our approaches for using autonomous platforms for problems at the interface of biology, biogeochemistry and physics.