EXport Processes in the Ocean from RemoTe Sensing – EXPORTS

Status and Plans for its First Cruise to the Northeast Pacific Ocean

David A. Siegel, Ivona Cetinic & the EXPORTS Science Team

Goal & Hypothesis

EXPORTS's goal is to improve predictions of the export and fate of ocean NPP using satellite data and numerical models.

Advances in remote sensing, genomics, in situ imaging & autonomous tools make achieving this goal possible

EXPORTS' focus is on the quantifying the export pathways of upper ocean NPP over a range of biogeochemical states

Hypothesis: Carbon export from the euphotic zone and its fate within the twilight zone can be predicted knowing characteristics of the surface ocean ecosystem.

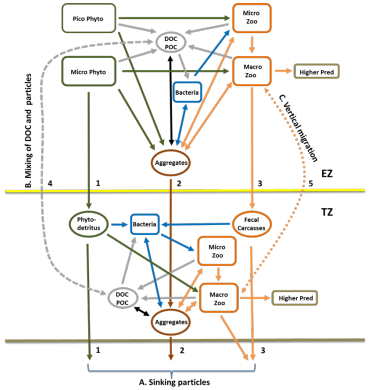
Science Questions

Q1: How do the characteristics of upper ocean ecosystems determine the vertical transfer of organic matter from the well-lit surface ocean?

Q2: What controls the efficiency of vertical transfer of organic matter below the well-lit surface ocean?

Q3: How can the knowledge gained be used to reduce uncertainties in contemporary & future estimates of the export and fates of NPP?

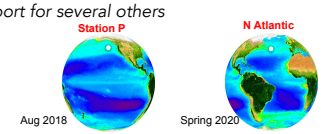
Focus on Pathways



Overall Project Plans

NASA plans to conduct two field deployments followed by a modeling & synthesis phase

- *The EXPORTS field science team has been competed by NASA (15 projects supported)*
- *NSF has funded 3 projects & recommended support for several others*

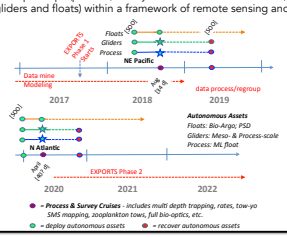


- *The first cruise will sail to Station P while a second is planned to sail to the North Atlantic*
- *EXPORTS is a coordinated sampling program with two ships & multiple autonomous vehicles*

Timeline

EXPORTS Field Program

… requires multiple ships (process, survey and vehicle launch/retrieval), autonomous platforms (gliders and floats) within a framework of remote sensing and modeling activities.



EXPORTS Field Science Team

Plus 2 more NSF projects recently recommended for support!!

EXPORTS Field Science Team

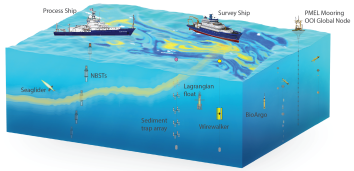
Project Investigators	Measurements & Platform
Michael Behrenfeld (OSU), Emmanuel Boss (UMaine), Jason Graff (OSU), Lionel Guidi (LOV), Kim Halsey (OSU), & Lee Karp-Boss (UMaine)	• Phytoplankton Biomass, Community Composition & Rates • Particle / Aggregate Size Distribution • IOP & AOP UW & Profiling • Process Ship
Ken Buesseler (WHOI), Claudia Benitez-Nelson (USC) & Laure Resplandy (Princeton)	• Thorium-234 Export & High Volume, Size-Frac Pumping from Survey Ship • Submesoscale Phys-BGC Modeling
Craig Carlson (UCSB) & Dennis Hansell (RSMAS)	• DOC on both ships • DOM Quality & Bioavailability & Bacterial Production on Process Ship
Meg Estapa (Skidmore), Ken Buesseler (WHOI), Colleen Durkin (MLML) & Melissa Omand (URI)	• Neutrally & Surface Tethered Sediment Trap Fluxes • Wirewalker Autonomous Profiler • Deploy from Process Ship
Andrea Fassbender (MBARI)*	• Biogeochemical Profiling Floats • Continue Station P long-term record • Carbonate system (Survey Ship)
Bethany Jenkins (URI), Mark Brzezinski (UCSB) & Kristen Buck (USF)*	• Diatom growth w/ nutrient additions • Uptake of Fe/NO_3/Si & NPP by size • Cellular Si deposition • Metatranscriptomic metabolism proxies (all on Process Ship)
Craig Lee (UW), Eric D'Asaro (UW), David Nicholson (WHOI), Melissa Omand (URI), Mary Jane Perry (self) & Andrew Thompson (CalTech)	• Lagrangian Float & Seaglider deployment & analyses • Reference frame for Process Ship & ~6 month temporal context • Construct sensor-based BGC proxies
Adrian Marchetti (UNC), Nicolas Cassar (Duke) & Scott Gifford (UNC)	• NCP via O_2/Ar (Both Ships) • New & regen PP and community & bacterial respiration (Process Ship) • 18S/16S rDNA community structure • Metagenomics phyto physiology
Susanne Menden-Deuer (URI) & Tatiana Rynearson (URI)	• Phyto growth & µZoo grazing rates • Phyto / µZoo taxonomic composition • MacroZoo gut content grazing • Process ship
Collin Roesler (Bowdoin) & Heidi Sosik (WHOI)	• Underway size-fractionated IOPs & hyperspectral reflectance spectra • Single cell imaging & enumeration • Survey Ship
Alyson Santoro (UCSB) & Phillip Boyd (U Tasmania)	• Microbial respiration & N remineralization in the mesopelagic • Microbial community composition of sinking particles via metagenomics • Process ship
David Siegel (UCSB), Adrian Burd (UGA), Andrew McDonnell (UAF), Norm Nelson (UCSB) & Uta Passow (UCSB)	• In situ particle size spectra using LISST & UVP (Both Ships) • Marine snow catchers (Process Ship) • Core hydrographic sampling and analyses (Both Ships) • Aggregate dynamics modeling
Deborah Steinberg (VIMS) & Amy Maas (BIOS)	• Zooplankton abundance, respiration & fecal pellet production • Quantify export by zoop migration • MOCNESS, UVP & acoustics • Process Ship
Ben Van Mooy (WHOI)*	• Lipidomics of sinking & suspended particles (samples from Process Ship)
Xiaodong Zhang (UND), Deric Gray (NRL), Lionel Guidi (LOV) & Yannick Huot (Sherbrooke)	• Particle size/composition distributions from 20 nm to 2 cm via inversion of light scattering & imaging data • Survey Ship

* Project funded by NSF

The NE Pacific Cruise

First cruise will sail to Station P (50°N 145°W)

- Leverages long-term sampling by Canada's Line P program, NOAA PMEL's Ocean Climate Mooring and the OOI global node
- Unique site with Fe-limitation for phytoplankton growth & low mesoscale energy levels
- R/V Revelle & R/V Ride set sail August 2018 with 27 days of sampling planned



A Coordinated Experiment

- A **process ship** (*R/V Revelle*) measuring rates and time series of stocks follows a **Lagrangian float**
- A **survey ship** (*R/V Ride*) provides spatial information of ocean optics & biogeochemistry
- An **autonomous glider** will survey about the process ship and a **BioArgo float** will provide a long-term perspective
- Coordinated sampling plan enables all export pathways to be quantified along with the data needed predict them from satellite observations
- See EXPORTS Field Science Team table on the left for further details on measurements to be made

On-Going Planning

The Science Team is developing plans for…

- Each **platform** (ships & AUV)
  - operational plans for each field component
- Each **parameter** group (export pathway, biological rates, optics, particle composition & BGC stocks)
  - protocol documents for each observable
  - head start on metadata construction as well as fostering intergroup collaboration
- **situational awareness**
  - coordinated sampling & emergency planning
  - interplatform communication is critical
- **data / sample management**
  - Ensure long-term legacy of the field efforts

Want more?? - www.oceanexports.org