Changing Arctic Carbon cycle in the cOastal Ocean Near-shore (CACOON): a new project on the changing Arctic coast

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Details on the project:

I. Background

No other region has warmed as much or as rapidly in the past decades as the Arctic. A new project, CACOON, investigates how the ecosystems are influenced by this warming. Funded by the British Natural Environment Research Council (NERC) and the German Federal Ministry of Education and Research (BMBF), CACOON will help to better predict changes to the Arctic coastal-marine environment.

Arctic rivers (Fig. 1) annually carry around 13% of all dissolved organic carbon transported globally from land to ocean, despite the Arctic Ocean making up only approximately 1% of the Earth's ocean volume. Arctic shelf waters are therefore dominated by terrestrial carbon pools, so that shelf ecosystems are intimately linked to freshwater supplies. Arctic ecosystems also contain perennially frozen carbon that may be released by further warming. Climate change already thaws permafrost, reduces sea-ice and increases riverine discharge over much of the pan-Arctic, triggering important feedbacks (Mann et al. 2015). The importance of the near-shore region, consisting of several tightly connected ecosystems that include rivers, deltas, estuaries and the continental shelf, is however often overlooked. We need year-round studies to be able to predict the impact of shifting seasonality, fresher water, changing nutrient supply and greater proportions of permafrost-derived carbon on coastal waters.

Fig. 1: Map of the six largest river catchments draining into the Arctic Ocean. CACOON will focus on the Lena (Fig. 2) and Kolyma (Fig. 3) Rivers, two great watersheds that comprise 19% of the pan-Arctic watershed and drain into the East Siberian Arctic Shelf (ESAS), the largest shelf system in the AO. *Credit: Greg Fiske (WHRC)*

Fig. 2: Satellite mosaic image of the Lena Delta region, *© ESA-BELSPO 2015, from 27 July 2014*

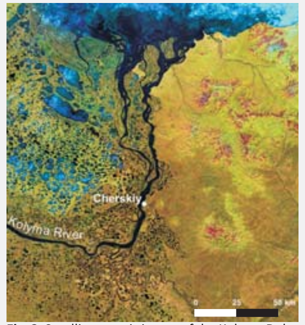

Fig. 3: Satellite mosaic image of the Kolyma Delta region

Tab. 1: Parameters measured within the CACOON project

Field measurements	Water Temperature, Salinity, Dissolved Oxygen, pH, Size-fractionated chlorophyll-a, Depth. Downwelling light field. Environmental parameters, (e.g. T, salinity, O_2, depth) will be measured using calibrated, multiparameter sondes over the depth-profile (YSI Exo2). Ambient light, (Biospherical Aq. radiometer; Edz, 305, 340, 380nm, PAR, surface ref).
Laboratory Isotopic Analyses	Dissolved and Particulate OC (DOC/ POC), Total Dissolved and Particulate Nitrogen (TDN/ PON), archaeal membrane lipids, n-alkyl lipids, and phytoplankton-derived lipids, Nutrients (nitrate/ nitrite, phosphate, silicate), CO2, CH4 & N2O, Chlorophyll-a, DIC, Total Suspended Solids (TSS) & Organic matter fraction of TSS. CDOM UV-VIS spectra, Major ions/elements (HCO_3, SO_4, Cl, F, Br, Na, K, Ca, Mg, Fe, P, S).
Laboratory concentration measurements	Dissolved: $\delta^{13}C$, $\Delta^{14}C$, $\delta^{15}N$, $\delta^{2}H_2O$, $\delta^{17}O$, $\delta^{18}O$, Particulate: $\delta^{13}C$, $\Delta^{14}C$, $\delta^{15}N$
Other laboratory analyses	Photochemistry, Respiration, FT-ICR-MS, Py-GCMS

Fig. 4: Eroding Pleistocene ice-rich permafrost (yedoma) at Duvanny Yar, a river bank at the Kolyma river. *Credit: Aron Stubbins*

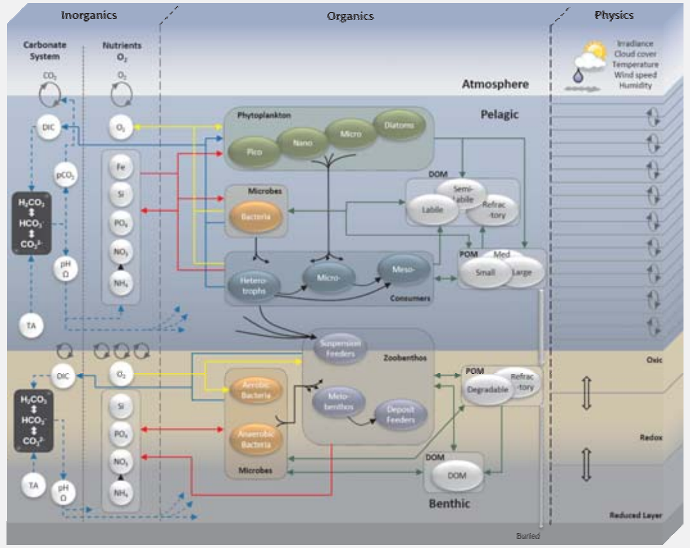

Fig. 5: Schematic description of the main processes represented within the ERSEM (*European Regional Seas Ecosystem*) model (e.g. *Butenschön et al. 2016*). We will use the multi-scale modelling framework FVCOM (*Finite Volume Ocean Model*) -FABM (*Framework for Aquatic Biogeochemical Model*) CCST (*USGS Community Coastal Sediment Transport*) - ERSEM to resolve the complex physical and biogeochemical processes involved in terrestrail OM transformations in estuarine and coastal systems.

II. Aims

CACOON will quantify the effect of changing freshwater export and terrestrial permafrost thaw (Fig. 4) on the type and fate of river-borne organic matter (OM) delivered to Arctic coastal waters, and resultant changes on ecosystem functioning in the coastal Arctic Ocean. We will achieve this though a combined observational, experimental and modelling study. We will conduct laboratory experiments to parameterise the susceptibility of terrigenous carbon to abiotic and biotic transformation and losses (Tab. 1 and Fig. 6) , then use the results from these to deliver a marine ecosystem model capable of representing the major biogeochemical cycles of carbon, nutrients and OM cycling in these regions (Fig. 5). We will apply this model to assess how future changes to freshwater runoff and terrigenous carbon fluxes alter the biogeochemical structure and function of shelf ecosystems.

The general project aims are to:

- generate novel seasonally-explicit datasets of OM source and transformation across the Kolyma and Lena River nearshore environments
- identify and parameterise key abiotic and biotic processes affecting terrestrial organic matter fluxes from land-to-ocean
- deliver projections of how future changes to freshwater runoff and terrestrial organic matter fluxes will alter the biogeochemical structure and function of shelf ecosystems

III. Workpackages

Workpackage 1: Characterise OM sources and trends across the near-shore environment, to examine the seasonal supply of carbon and nutrients to coastal shelf seas, and how this may change with permafrost thaw.

H1: Increased contributions of terrestrial OM from permafrost thaw will alter the composition, nutrient loads and optical properties across the Arctic near-shore environment.

Workpackage 2: Quantify biological and physical processes across the near-shore environment, to detect and parameterize relationships between terrestrial OM composition and fate.

H2: The quantity, age and composition of terrOM will alter during transport through the nearshore, affecting its susceptibility to environmental processes and fate.

Workpackage 3: Examine the effects of changing freshwater export, timing and permafrost to the Arctic coastal ecosystems, to assess how future changes in terrestrial OM supply and composition will impact near-shore biogeochemical processes and atmospheric gas fluxes.

H3: Changing riverine fluxes and the composition and quantity of terrestrial OM loads will alter the biogeochemical structure, and function of shelf ecosystems (planktonic community structure, productivity, CO_2 exchange with the atmosphere, patterns of acidification)

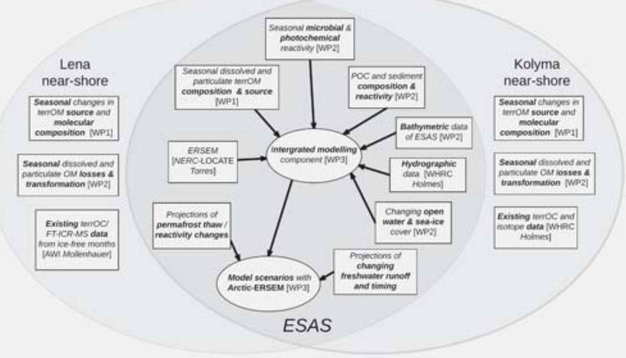

Fig. 6: CACOON structure, links between work-packages and co-ordinated collection and analysis of samples from the Lena and Kolyma near-shore ecosystems. Existing datasets will be used in addition to new knowledge to inform an integrated modelling approach, delivering information on processes occurring across the ESAS region.

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