US GEOTRACES Guidelines for participating in the western Arctic section
December 2013

US GEOTRACES Arctic proposals: Supplementary information: 15 January 2014

The Guidelines document to aid in preparation of proposals for participation in the US GEOTRACES Arctic expedition has been supplemented with the following information:

1) The first three words of your proposal project title should be:
   “GEOTRACES Arctic Section: <followed by specific title relevant to your work>”

2) Requested project start dates should be after 1 October 2014. NSF suggests that any time between 1 October 2014 and 1 February 2015 would be reasonable.

3) It is anticipated that there will be a cruise logistics meeting prior to the cruise and a data workshop approximately a year after the cruise. Travel expenses for these meetings will be covered by the US GEOTRACES Project Office. Individual PIs do not need to budget for these expenses.

4) Mobilization/Demobilization - Embarkation/disembarkation
   a) Gear will be loaded aboard the Healy in Seattle, and unloaded in Seattle following the cruise, so PIs should budget for shipping costs to/from Seattle.
   b) If you have substantial amounts of gear and supplies, then budget travel costs for someone from your group to assist in loading and offloading the ship. If your needs are small, such as a few boxes or ice chests, then the super techs supported by the management grant can handle your supplies.
   c) Cruise personnel will embark and disembark in Dutch Harbor, Alaska. Each PI should budget travel expenses to/from Dutch Harbor for cruise participants.
   d) If you have time sensitive samples that need to be air freighted home from Dutch Harbor then budget for this in your proposal. Otherwise, samples will be offloaded in Seattle.

5) The station and sampling plan is shown in Figure 2 of Management Proposal and described in accompanying text. The following details for water and particle sampling may be helpful in preparing proposals, although the details may be adjusted slightly at the cruise logistics meeting:

1 Pacific end member station (to 1000 m; 12 water and 8 pump depths)
1 Norton Sound station (approx. 63.5N) (shallow)
1 Chirikov Basin (approx. 65N) (shallow)
1 southern Chuckchi Sea (approx. 67.5N) (shallow)
1 northern Chuckchi Sea (approx. 70N) (shallow)
6 Chuckchi shelf stations (shallow)
13 regular deep stations (to bottom; 24 water and 16 pump depths)
4 "super" stations (to bottom; 24 water and 16 pump depths; additional casts for large volume samples)

If ice and weather are favorable, a regular full depth station in the Makarov Basin will be converted to a super station.
6) The Arctic offers unique opportunities for outreach and education. PIs may wish to collaborate with colleagues to develop new strategies that cannot be achieved on an individual basis. For example, co-chief scientist Bill Landing <wlanding@fsu.edu> is partnering with PolarTrec for cruise-related outreach (see description in the Management proposal, available on the US GEOTRACES web site). You may email Bill if you have ideas for collaborating with him, and this could also be incorporated into your Broader Impacts statement.

This information will also be added to the Guidelines document on the US GEOTRACES web site <http://www.usgeotraces.org/Arctic_Guidelines_v61.pdf>.

Questions may be directed to David Kadko <dkadko@rsmas.miami.edu> or Bob Anderson <boba@ldeo.columbia.edu>.
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PURPOSE

This document was prepared by the Arctic cruise management team and then reviewed and modified by the US GEOTRACES Scientific Steering Committee (SSC) to serve as a resource for members of the chemical oceanography (marine geochemistry) community when developing research plans for participation in the US GEOTRACES western Arctic section tentatively scheduled for late-summer 2015. These guidelines also offer information that will aid in the preparation of individual research proposals. NSF Chemical Oceanography and Arctic Sciences have informed us that, in order to complete peer review and proposal processing in time for the U.S. GEOTRACES Arctic field season, proposals should be submitted for the 15 February 2014 Chemical Oceanography Program proposal target date. In addition to Chemical Oceanography, Arctic Natural Sciences should also be named for shared consideration of the proposal. Participation is open to anyone eligible to submit proposals to NSF.

RESEARCH THEMES AND OBJECTIVES

A western Arctic section was selected by the SSC as a high priority for US GEOTRACES to allow study of factors that influence the supply, removal and internal cycling of trace elements and their isotopes that can be studied within a single section. These include:

1) **Fluxes of TEIs through the Bering Strait** - A GEOTRACES goal is to quantify the fluxes of TEIs into and out of the Arctic Ocean through choke points.

2) **River sources and chemical evolution of surface waters** - Over the Canada Basin the polar mixed layer holds large contributions of fluvial water. Marine and terrigenous-sourced DOM will likely display distinct interactions with the TEI's in the mixed layer.

3) **Boundary scavenging and chemical evolution of deep waters** - Collectively, the proposed international GEOTRACES sections will enable investigators to define the chemical evolution of deep waters as they mix from the Atlantic into the Canada Basin. These sections will also identify sources and sinks of TEIs at the basin margins.

4) **Atmospheric deposition** - In the Arctic atmospheric deposition is an important transport mechanism for both natural aerosols and contaminants.

5) **Sea-ice transport** - Sea ice is a platform for retention and transport of TEIs derived from various sources, with consequent partitioning of TEIs between water, snow, ice, and melt ponds.

6) **Sediment-Water Exchange and shelf-basin interaction** - The broad continental shelves of the Arctic Ocean are of particular interest because of the intense sediment diagenesis that mobilizes TEIs and impacts their biogeochemical cycling.

In addition to these central themes, GEOTRACES seeks to document the distributions of TEIs in the Arctic Ocean before any further perturbation by climate change. TEI studies related to other processes are also deemed relevant to the Arctic GEOTRACES effort, for example, water column cycling (includes pelagic sea-ice formation, sea-ice analyses, and surface water under ice floes), water mass and circulation tracers.

These aspects offer excellent opportunities to examine the distribution and speciation of trace elements and isotopes and their interaction with marine organisms as well as their
overall supply, removal and internal cycling. Individual proposals will benefit by demonstrating that the proposed research supports goals related to one or more of these themes. Furthermore, as the goal of the cruise is to integrate research across all themes, individual proposals will benefit if they are integrative as well.

In addition to these themes, the SSC encourages investigators to submit proposals bringing new ideas to the program, provided that they are justified in terms of objectives that support the mission and goals of GEOTRACES, as defined in the Science Plan.

ADDITIONAL INFORMATION AND RESOURCES

Several documents that can be helpful in planning for the Arctic section are available via the internet:


2) International GEOTRACES workshops in 2009 and 2012 provided a context for research throughout the Arctic, including the US section. The reports of these workshops are available at: <http://www.geotraces.org/libraries/documents/Arctic_Report.pdf> and <http://www.geotraces.org/images/stories/documents/workshops/Artic/2012_Arctic_Workshop_Canada/Arctic_report_June12.pdf>


4) A US GEOTRACES implementation workshop in June 13-15, 2012 refined the scientific goals of the Arctic section. The report from that workshop, which served as the basis for planning the US Arctic section, is available at: <http://www.usgeotraces.org/documents/US%20GEOTRACES%20Arctic%20Implementati onPlan.pdf>


Investigators planning to submit an individual research proposal should pay particular attention to the management proposal, as it provides for the ship-board collection of aerosol, precipitation, water samples, sediments, as well as for hydrography and nutrient measurements. Collection of other types of samples (e.g., sea-ice sampling, in situ filtration) must be covered by individual proposals, so it is vital that anyone interested in these types of samples coordinate the development and submission of their proposals (see next section).

RESEARCH COORDINATION/LETTERS OF INTENT

Investigators who need water samples for their research should be cognizant of sample size limitations. Following the precedent of the earlier US GEOTRACES sections, it
is anticipated that the following will be collected at each sample depth at each regular full-depth station:

- 22 liters of filtered seawater collected using the trace metal-clean rosette
- One sample of suspended particulate material collected from one 12-liter GO-Flo bottle for trace metal analysis
- 30 liters of water collected using a standard Niskin bottle that will be divided as needed between unfiltered samples and water that is filtered through a 0.45-micron pore diameter Acropak capsule.

Analyses that require a substantial fraction of the available water cannot be accommodated at regular full depth stations. A small number of full depth “super” stations (ca. 4) will provide additional casts to collect water for analyses that require larger volumes. This will be augmented by a larger number of shallow (<500m) super stations to accommodate interest in the release of TEIs from ice, and to take into account high resolution sampling dictated by the strong stratification characteristic of the upper Arctic Ocean. Sample volumes of up to 20-liters will be collected using the standard Niskin rosette at super stations.

Other samples will be available in limited quantity as well. For example, as noted above, a single sample of total suspended matter will be collected at each depth from one GO-Flo bottle on the trace metal clean rosette. It is anticipated that these filters will be used primarily to determine concentrations of particulate trace elements. Proposals that apply non-destructive analytical methods to the filters prior to digestion for trace element analysis are welcome provided that the methods can be demonstrated to avoid contaminating the filters and that the non-destructive analyses are coordinated with the primary trace element measurements.

The collection of aerosol and ship-board precipitation samples is covered under the management proposal. Aliquots of these samples will be made available to other investigators. Those investigators proposing analyses of aerosols and precipitation are encouraged to coordinate their sampling and sample needs in advance of preparing their proposals. Letters of intent will be solicited and posted (see below) to facilitate coordination of research plans.

It is anticipated that larger samples of suspended particulate material will be collected by in situ filtration. The collection of particles by in situ filtration depends on the submission of an individual proposal to collect these samples that passes review successfully. Investigators planning to submit a proposal for in situ filtration should incorporate a plan for sharing aliquots of the filters with other investigators. Other investigators proposing analyses that require material collected by in situ filtration are encouraged to coordinate their sampling and sample needs in advance of preparing their proposals. Letters of intent will be solicited and posted (see below) to facilitate coordination of research plans.

Following the precedent of earlier US GEOTRACES sections, proposals may be submitted to collect samples from underway pumping systems as well as from over-the-side pumping systems while on station.
Arctic sampling will have unique aspects not encountered in prior US GEOTRACES cruises, including snow, ice, melt pond and sediment collection.

For the sea-ice sampling, the management proposal will provide technical support in the form of on-ice sampling assistance and field team safety, and to procure necessary expedition supplies needed for the sea ice work (e.g. generators, snowmobile, tents). The collection of snow/ice/meltpond samples as well as shallow surface waters immediately beneath the ice depends on the submission of an individual proposal(s) to provide the necessary sampling equipment to collect these samples that passes review successfully. Investigators planning to submit a proposal to collect these samples should incorporate a plan for sharing aliquots of the material with other investigators. Other investigators proposing analyses that require sea-ice are encouraged to coordinate their sampling and sample needs in advance of preparing their proposals.

The management proposal will provide some technical assistance for sediment collection. In addition, the management proposal will provide a multicorer that collects eight individual tubes to be divided equally between pore water and solid phase work. Multicorer deployments will be limited to shelf stations. A mono corer will be used to collect a single tube of surface sediment at each full-depth deepwater station. It is anticipated that samples from the mono corer will be limited to solid phase analyses.

Investigators who are contemplating the submission of a proposal to participate in the Arctic section are encouraged (if not already done so) to submit a letter of intent to the US GEOTRACES Project Office <geotraces@ldeo.columbia.edu> describing their plans. A one-page document covering items listed below is sufficient. Letters of intent will be posted on the US GEOTRACES web site to facilitate coordination of research activities. Letters are voluntary, but past experience has shown that everyone benefits by sharing information about proposal plans well in advance of the proposal deadline to facilitate collaboration and coordination of logistics.

Topics to cover in a letter of intent include:
1) Research goals and relevance to the overall objectives of the section,
2) Sample requirements,
3) Berth requirements*, and
4) Anticipated collaboration and synergies.

*As was the case in the Atlantic and Pacific sections, it is anticipated that berths will be at a premium during the Arctic cruise. Due to the large number of sampling activities during the cruise, each person at sea will be expected to contribute to the collection of samples for a number of groups. If a dedicated berth is required, for example to perform analyses at sea, then this should be noted in the letter of intent and justified in the proposal. A group of “super techs” will be funded by the management proposal (see proposal for details) as a strategy to assure effective coordination of sampling and to avoid unnecessary duplication of requests among individual PI proposals. This approach worked well for the US GEOTRACES North Atlantic expedition so it has been recommended as standard operating practice for subsequent US GEOTRACES cruises. The group will include two for sampling the standard Niskin rosette, two for sampling the trace metal clean rosette, and one for sea ice/sediment operations.
STRATEGIES TO REDUCE COSTS

The SSC sensed that the cumulative awards for the Atlantic were more costly than necessary, partly because of duplication of effort and partly because the inability to coordinate proposals led to more people funded to go to sea than the number of berths available on the ship. The SSC identified the following recommendations to minimize unnecessary costs for future expeditions:

1) Proposals that cover multiple parameters are encouraged.
2) Collaborative proposals that cover the core measurements to be made along the entire section are encouraged. Splitting the cruise track between separate proposals creates a liability that one proposal will be funded and the other declined.
3) Investigators involved in collaborative proposals are urged to eliminate unnecessary redundancies. It will be helpful to identify a lead PI for each collaborative proposal who will make the effort a major part of their research program in 2014 - 2016, thereby taking on most of the responsibilities and associated expenses. Collaborating PIs are encouraged to take a supporting role, thereby keeping their budgets as low as possible.
4) Junior scientists are encouraged to participate either with their own stand-alone proposal or, if they prefer, as part of a collaborative proposal under the mentorship of a more established PI. Again, early submission of letters of intent will help facilitate the latter.
5) It is essential that PIs share sampling responsibilities at sea. This will be dictated in any case by berth limitation. NSF review of proposals will be aided if PIs indicate in their proposals where resources (e.g., sampling equipment, seagoing personnel) will be shared. A sound plan for sharing resources at sea will also be viewed favorably during proposal review.
6) PIs are advised to submit proposals that cover the full cost of their research while also indicating where costs can be cut if other specific proposals are funded that allow resources to be shared.

OTHER INFORMATION FOR POTENTIAL PIs

Likely, the ship will originate in Seattle, and it would be anticipated that major loading of equipment will take place there. Mobilization and demobilization are planned for Dutch Harbor, where loading of personal gear and some equipment would take place.

PRIORITY GUIDELINES

At the request of the NSF Chemical Oceanography program, the SSC has developed a set of priorities, appended to this document, to facilitate the writing and reviewing of individual proposals. Priorities are organized by research theme and according to variables to be determined.

See the Appendix for additional information about the priority guidelines.
Appendix - Arctic Parameter Priority

The US GEOTRACES Scientific Steering Committee has developed this description of priorities for the US GEOTRACES section in the western Arctic to provide a framework for proposing research as a contribution to the section. This document is also intended to facilitate review of the proposals by NSF. Parameters (variables) to be studied along the section are divided into three categories: “key”, “essential” and “of interest”.

**Key parameters** are designated in Table 2 of the GEOTRACES Science Plan as those that must be measured on every GEOTRACES section. Selection of key parameters was guided by the following considerations: 1) their anticipated contribution to the fulfillment of the GEOTRACES mission and 2) the readiness of the international community of ocean chemists to undertake a global survey of the parameter.

**Essential parameters** are those considered to be necessary specifically for the Arctic section, either to provide an overall oceanographic context for the cruise or to interpret the distribution, supply or removal of other trace elements and isotopes.

**Parameters of interest** incorporate most parameters, including most trace elements and isotopes. The rationale for designing most parameters in this manner is to allocate as much of the available funding as possible to the most scientifically compelling proposals.

Listed below are the parameters included in each category, with annotations where explanations may be helpful. The “of interest” list is not meant to be exclusive. Compelling proposals on any topic relevant to the marine biogeochemical cycling of trace elements and their isotopes, including informing Arctic processes, along the western Arctic section are welcome.

**Key Parameters (from Table 2 of the GEOTRACES Science Plan)**

- **Dissolved and particulate trace element concentrations**: Fe, Al, Zn, Mn, Cd, Cu
- **Dissolved stable isotopes**: $\delta^{15}$N of nitrate and $\delta^{13}$C of dissolved inorganic carbon
- **Dissolved and particulate radioisotope concentrations**: $^{230}$Th, $^{231}$Pa.
- **Radiogenic isotope ratios**: Dissolved and particulate Nd isotope ratios; Dissolved Pb isotope ratios as well as measurements of dissolved Pb concentrations.
- **Solid phases**: Particles in the water column and aerosols. GEOTRACES considers that particles and aerosols must be collected on each section, but that the specific parameters to be measured in the solid phases may vary from one section to another depending on the scientific questions and processes of interest that are specific to each section.
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NOTE: Key parameters are expected to contribute to each theme so they are not repeated throughout the sections below. Other parameters are organized according to the categories listed above to help facilitate searches for additional information. This organizational scheme is not meant to prescribe or to proscribe the use of any parameter.

NOTE: The Arctic is unique to other GEOTRACES basin studies to date. For numerous TEIs, measurement not only in the water column, but also in the additional repositories of ice, snow and melt ponds are critical.

1. **Fluxes of TEIs through the Bering Strait**

**Essential Parameters**

a) Co, Hg.

**Parameters of interest**

a) Mooring Data (e.g. T, S, velocity; cooperative with R. Woodgate)
b) Dissolved organic carbon
c) Concentrations of specific ligands for binding Fe, Cu and other TEIs

2. **River sources and chemical evolution of surface waters**

**Essential Parameters**

a) Co, Hg.
b) $\delta^{18}O$ of H$_2$O. Evaluate partitioning of water sources (river, ice melt, seawater)
c) XCTDs-to enhance resolution of mesoscale features (i.e. eddies, fronts) that have been shown to be prominent in the Arctic and affect TEI distributions and transport.

**Parameters of interest**

a) Ba: dissolved and particulate concentration (total and acid leachable particulate fraction)- as a tracer of Arctic halocline and river waters.
b) Concentrations of specific ligands for binding Fe, Cu and other TEIs
c) CDOM
d) Lignins
e) Dissolved rare earth elements (to interpret Nd isotopes and to constrain supply from rivers).

3. **Boundary scavenging, internal cycling and chemical evolution of deep waters**

**Essential Parameters**

a) Co, Hg.
b) Dissolved and particulate concentrations of $^{234}$Th (export fluxes from the surface ocean)
c) Particulate concentrations of POC, opal and CaCO$_3$ determined with samples collected by *in situ* filtration (to infer the influence of particle composition on the sorption and removal of other trace elements and isotopes)
d) Particulate concentrations of lithogenic trace elements with samples collected by *in situ* filtration (to characterize the source of lithogenic phases)

**Parameters of interest (must support GEOTRACES objectives concerning biogeochemical cycles of TEIs)**

a) $^{14}$C of DIC
b) $^3$He, $^3$H-$^3$He
c) CFC-SF$_6$
d) Concentrations of specific ligands for binding Fe, Cu and other TEIs
e) Dissolved organic carbon
f) Dissolved and particulate concentrations of $^{228}$Th,
g) Dissolved and particulate concentrations of $^{210}$Pb and $^{210}$Po,
h) Dissolved Si isotopes
i) Particulate Si isotopes (may be measurable only near the continental margin)
j) Trace element distribution within individual cells
k) Anthropogenic radionuclides in snow, ice, seawater and particles
l) Isotope ratios of particulate authigenic (leachable) trace elements
m) Particulate concentrations of authigenic trace elements with samples collected by *in situ* filtration (to characterize the removal of reactive elements)
n) Dissolved and particulate rare earth elements (to interpret Nd isotopes and to constrain supply and removal from margin sediments),
o) Optical characterization of particle abundance and/or composition.
p) DIC, TA, pH
q) $^{18}$O/$^{16}$Ar concentration ratio (net community production)
r) Triple oxygen isotopes (gross primary production)
s) $^{15}$N/$^{16}$Ar concentration ratio (denitrification)
t) $^{15}$N$_2$O concentrations (empirically linked to cycling of Cu and, possibly, other trace metals)
u) Dissolved $^{227}$Ac
v) Shipboard ADCP
w) LADCP
x) Circulation tracers derived from nuclear fuel reprocessing, (e.g., $^{129}$I, $^{237}$Np).

4. **Atmospheric deposition**

**Essential Parameters**

a) Dissolved and particulate trace element concentrations in snow, ice and melt ponds: Fe, Al, Zn, Mn, Cd, Cu and Co. Snow, ice and meltponds represent important repositories
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for TEIs in this environment. Large volume samples would need to be collected and
subsampled by the PIs to share with the community.
b) Dissolved and particulate TEIs from near-surface water immediately under sea ice. A
clean battery powered pump system would also need to be provided by the PIs.
c) Key TEIs, Co, Hg and others in aerosols and precipitation.
d) Aerosol, precipitation, melt pond, water column samples for $^7$Be and $^{232/230}$Th isotopes
- tracers of atmospheric deposition, an important geochemical input to the Arctic
e) Evaluation of percentage ice and meltpond coverage; snow thickness (general sea ice
survey)

Parameters of interest

a) Concentrations of total and soluble rare earth elements in aerosols,
b) $^{210}$Pb and $^{210}$Po in aerosols
c) Dissolved, particulate and aerosol Sr isotope ratios
d) Anthropogenic radionuclides
e) Br$_2$ in surface snow; (precursor to Br* radical, an important Arctic atmospheric
species, important factor in Hg oxidation; would have to be linked to Hg investigations)

5. Sea-ice transport

Essential Parameters

a) Dissolved and particulate trace element concentrations in snow, ice and melt ponds:
Fe, Al, Zn, Mn, Cd, Cu and Co.
b) Hg - monomethyl, dimethyl, total, elemental (contaminant of concern related to local
fisheries as well as to regional mining and smelting);

Parameters of interest

a) $^{143}$Nd/$^{144}$Nd in coastal sediments and sea ice sediments
b) $^{87}$Sr/$^{86}$Sr in coastal sediments and sea ice sediments
c) Other geochemical indicators of provenance to trace sources of lithogenic material
carried by ice
d) $^{210}$Pb in sea ice sediments
e) Dissolved Al, Fe and $^{232}$Th-associated with the of presence of ice-rafted sediments

6. Sediment-Water Exchange and shelf-basin Interaction

Essential Parameters

a) Quartet of radium isotopes to evaluate rate of exchange (tracer of sediment contact).
b) Dissolved Fe isotope ratios (diagnostic of Fe source)
c) NO3 and PO4 at GO-SHIP standards (management proposal)
d) $\delta^{15}$N of NO$_3$

**Parameters of interest (must support GEOTRACES objectives concerning biogeochemical cycles of TEIs)**

a) Analysis of sediment samples for key TEIs and others
b) Analysis of pore water fluids for key TEIs and others (likely limited to multi cores on the shelf)
c) Dissolved Fe(II) - (to define the sensitivity of Fe cycling, and to complement studies of other elements for which the redox cycle of Fe may play a role as a source or as a sink),
d) Concentrations of specific ligands for binding Fe, Cu and other TEIs
e) Soluble and colloidal (or soluble and dissolved) Fe
f) Shipboard dissolved Mn concentration
g) Sulfide concentration, ideally at nanomolar detection (as a regulator of metal speciation)
h) $\delta^{18}$O of Nitrate,
i) $\delta^{15}$N of Nitrite,
j) $\delta^{15}$N of N$_2$O,
k) $\delta^{15}$N of N$_2$
l) CH$_4$
m) V: dissolved and particulate concentration, speciation of dissolved V
n) Cr: dissolved and particulate concentration, speciation of dissolved Cr
o) Ag: dissolved and particulate concentration (total and acid leachable particulate fraction)
p) Mo: particulate Mo concentrations and stable isotope ratios
q) Concentrations of labile Ni and of Ni-binding ligands
r) Hf isotopes
s) I: dissolved, redox speciation
t) Particulate Fe(II)/Fe(III) fractionation,