Freshwater Contaminants

SOUTHEAST ALASKA NETWORK – PROTOCOL DEVELOPMENT SUMMARY

PARKS WHERE PROTOCOL WILL BE IMPLEMENTED: GLBA, KLGO, SITK

Justification/Issues Being Addressed

Contaminants can enter Alaskan freshwater ecosystems from local or global sources via long-range atmospheric transport and marine-derived contaminants delivered to freshwaters during anadromous fish spawning runs (Blais et al. 2007). Mercury (Hg) and a suite of persistent organic pollutants (POPs) are not produced in SE Alaska, but these long-range global contaminants are probably entering the ecosystems of all SEAN parks.

Mercury is emitted primarily by fossil fuel burning, from which global emissions continue to increase, particularly in Asia (Pacyna and Pacyna 2002). Specifically, China is dramatically increasing its coal consumption (+14% annually in 2006 and 2007), and mercury released in the process is carried to Alaska along trans-Pacific atmospheric flow currents (Bradsher and Barboza 2006; Dastoor and Larocque 2004; Pacyna and Pacyna 2005). Sediment cores collected from lakes in GLBA and in neighboring Chichagof Island show that modern Hg accumulation rates in sediments are 2-3 times preindustrial accumulation rates and continue to rise (Engstrom and Swain 1997; Fitzgerald et al. 2006). Furthermore, bacteria common in wetland environments are known to convert even low levels of inorganic Hg to highly toxic methylmercury (MeHg). Wetland-generated methylmercury can readily be transported to near-shore marine systems by organic-rich outflowing streams, thereby making it bioavailable to freshwater and marine organisms. A 2007 NPS survey provided the first baseline dataset on Hg in SEAN streams from a one-time sampling event of streamwater, benthic macroinvertebrates, sediments, and juvenile fish of 17 streams with variable landscape characteristics (Nagorski et al. results pending). The establishment of a Mercury Deposition Network site in Bartlett Cove in 2008 will provide valuable information on atmospheric mercury inputs to the region, and marine contaminants (including Hg and POPs) will be conducted under the Oceanography vital sign. Therefore, the monitoring activities under this vital sign provide a critical link between airborne and marine contaminant monitoring

POPs comprise a long list of toxic and stable organic compounds derived from pesticides (both historic and current use), industrial/urban-use compounds, and combustion byproducts. POPs have been identified in arctic- and subarctic seawater, lake sediments, zooplankton, various fishes, whales, seals, bears, eagles, and indigenous peoples who rely on subsistence harvests (AMAP, 2004). Like mercury, POPs are carried via long-range atmospheric transport pathways and, upon deposition, can bioaccumulate as they pass across trophic levels. POPs of particular concern in high latitudes include dieldrin, Dichloro-Diphenyl-Trichloroethane (DDT), polychlorinated biphenyls (PCBs), chlordane, and Polycyclic Aromatic Hydrocarbons (PAHs) (NPS 2007). A new generation of POPs (or more broadly, semi-volatile organic compounds or SOCs) has been measured in high latitude air, seawater, and freshwater sediments as well (Van Oostdam et al., 2003). These include brominated flame retardents (in particular polybrominated diphenyl ethers (PBDEs), perfluorinated alkane compounds (PFAs), short chain chlorinated

paraffins (SCCPs), and polychlorinated naphthalenes (PCNs). Studies in Southeast Alaska and adjacent areas include an evaluation of POPs imported to lakes in the Copper River basin (just north of GLBA) by migrating sockeye salmon (Ewald et al., 1998); an evaluation of POPs in seabird eggs (Vander Pol et al., 2004); a study of POPs levels in vegetation and air in GLBA and the Stikine-LeConte Wilderness, Tongass National Forest, as part of the Western Airborne Contaminants Assessment Project (WACAP) (results pending), and a survey of POPs in juvenile coho salmon in 19 SEAN streams during 2007 (Nagorski et al. results pending).

Specific Monitoring Objectives to be Addressed by the Protocol

1. Assess the level of mercury and POPs in various physical and biological components of SEAN ecosystems.
2. Compare the contamination levels against state and federal criteria (when available) and to findings from other studies.
3. Determine temporal trends in the contaminant occurrence and concentration.
4. Determine whether particular landscape types are disproportionately efficient at accumulating and/or exporting contaminants within their watersheds.

Basic Approach

Freshwater, marine/intertidal, and precipitation/air contaminant monitoring in SEAN parks will be closely integrated, particularly for Hg monitoring in the Bartlett Cove area of GLBA. Testing for freshwater contaminants will be most effective (in terms of both cost and interpretation) by sampling parameters that integrate contaminant exposure over relatively long periods of time (e.g. lakebed sediments and resident fish) rather than relying on water samples that represent narrow temporal conditions. Sediments accumulate contaminants, especially in lakes, where cores may be sampled and dated to examine changes over the course of decades or centuries (e.g. work by Engstrom and Swain [1997] and Fitzgerald et al. [2006]). Streambed sediments represent a much more recent signature of contaminants in the watershed but may be complicated by grainsize variations and the inability to date them. Resident fish (e.g., threespined stickleback, cutthroat trout, rainbow trout and Dolly Varden) and juvenile salmon that have not yet migrated out of their natal streams (coho, sockeye, and chinook) would stay in freshwater systems long enough to bioaccumulate toxins specific to their watersheds and may prove to be excellent indicators of contaminant loads in SEAN parks. Benthic macroinvertebrates (BMI) may also have the potential to accumulate contaminants.

The three watersheds (Bartlett River in GLBA, Taiya River in KLGO, and Indian River in SITK) that will be monitored for other freshwater vital signs (Freshwater physicochemical characteristics, Streamflow, and Benthic Macroinertebrates and Algae) will be sampled for Hg (total and methyl) and POPs every 5-10 years (frequency depending on budget availability) using resident or juvenile anadromous fish, macroinvertebrates, streambed sediments, and water; we expect that POPs would be detectable only in fish tissues. In addition, resident fish and sediments will be sampled from several GLBA lakes. Priority lakes in GLBA should be in the Bartlett River watershed, including a lake in the mid-watershed reach accessible to anadromous salmonids, and Bartlett Lake (or other isolated aquatic system components devoid of anadromous salmonids, e.g. DV in the Falls Creek watershed), in order to compare the effects of atmospheric deposition (as collected under the Airborne Contaminants vital sign) with atmospheric deposition plus anadromous fish contaminant contributions. At least five

individual fish will be taken from each lake/isolated system, with the addition of several water samples and soil samples from the contributing watershed. Contaminants will be measured at a glacially dominated lake as well. In this case, end-of-season snowpack samples will also be included in order to measure the contaminants in precipitation over the course of the winter, as the Bartlett Cove Hg deposition site may not be representative of colder, drier areas of the bay. An auxiliary component to the monitoring of this vital sign may include coring of the lake sediments for historical contaminant deposition profiles (ideally once every ~10 years), continuing the efforts in the region by Daniel Engstrom's research group to track Hg deposition trends in the Glacier Bay region since global industrialization.

Sampling sites in all parks will be selected with an emphasis on collocation of sites monitored under the other freshwater vital signs (Physicochemical Water Quality, Macroinvertebrates and Algae, and Streamflow).

Principal Investigators and NPS Lead

GLBA: Chad Soiseth, Fisheries Biologist
SITK: Geoffrey Smith, Biologist
KLGO: Dave Schirokauer, Natural Resources Program Manager
Sonia Nagorski, Ph.D., Environmental Science Program, University of Alaska Southeast

Development Schedule, Budget, and Expected Interim Products

Detailed protocol development, including various cost scenarios, will take place in 2010-2012. Results of the studies by the WACAP group and Nagorski et al.'s 2007 contaminants survey (results pending for both) in the SEAN will help evaluate protocols, identify baseline concentrations, and location of potential focus study areas. Because of the high expense associated with contaminants analyses, this protocol will be implemented not annually but on a 5-10 year rotating interval, depending on funding. The estimated costs for monitoring of this vital sign are as follows:

Item	Estimated Cost
Monitoring in 3 study streams (Bartlett, Taiya, Indian Rivers) Each watershed: (1) Triplicate Hg samples ($300/ea) of fish, BMI, sediments, and water (2) Triplicate POPs samples ($750/ea) in fish)	$17,600 every 5-10 years
Monitoring in 3 GLBA lakes: Each lake system: (1) 5 Hg samples ($300/ea) of fish, soils, and duplicates of water (2) 5 fish samples for POPs ($750/ea) (3) 2 water samples for full chemistry ($350/ea) (4) 2 snowpack samples for Hg ($300/ea) for the glacial lake watershed)	$28,000 every 5-10 years
Lake coring for chronological deposition profiles. Each of 2 lakes: (1) 6 cores sectioned into 10 sections, analyzed for Hg and ^{210}Pb; air and boat access to and on lake).	$30,000-50,000 every 10 years

Costs associated with travel and ancillary water quality parameters for the 3 study streams are additional and can be combined with the Freshwater Physicochemical Water Quality vital sign monitoring efforts. The above estimates also do not account for expenses associated with travel, salary (in-house or contractor), overhead, and other potential costs outside of chemical analyses.