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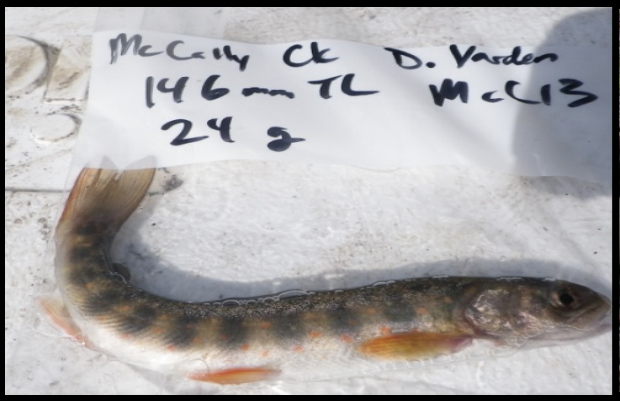
Mercury and Arsenic in the Aquatic Biota of Middle Kuskokwim River Region



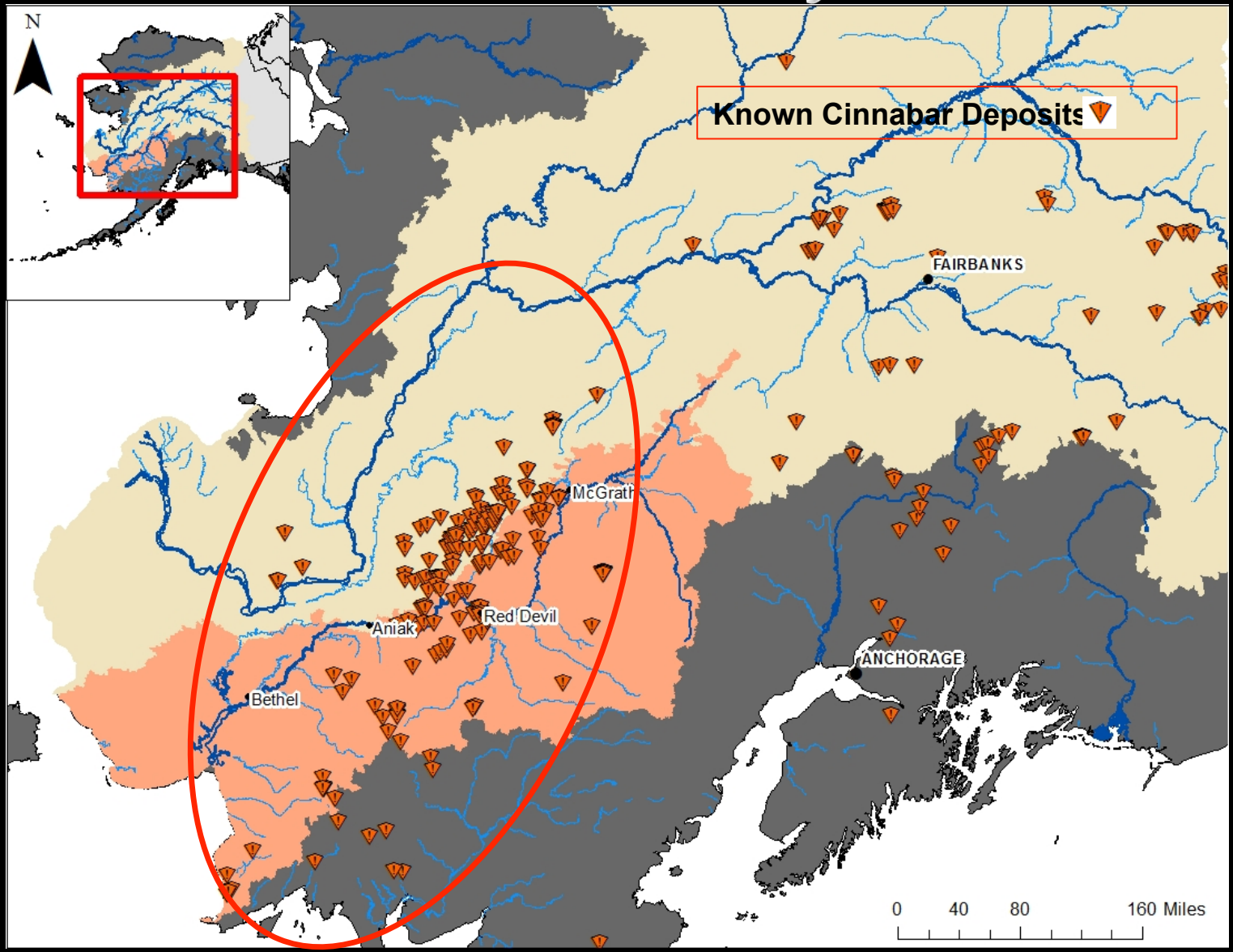




Angela Matz, U.S. Fish and Wildlife Service
Matthew Varner, Bureau of Land Management
Matthew Albert and Klaus Wuttig, Alaska Dept. of Fish and Game

Alaska's Mercury Belt

Cinnabar: mercury(II) sulfide, HgS



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Potential Mercury Sources for Kuskokwim River Biota

- Erosion of underlying geology
- Land use
- Permafrost degradation
- Atmospheric Deposition
  - ✓ Global
  - ✓ Regional:
    - Volcanoes, forest fires

Hg SOURCES

- Watershed Size
- Concentrations

bioavailable

- Wetlands/anaerobic sediment in watershed
- Sulfate-reducing bacteria
- Organic carbon

Hg becomes methylated

- **Trophic level**
- Age
- Location (habitat)

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As SOURCES
(erosion, land use)

Concentrations

As becomes bioavailable

Location (habitat)

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Distribution, speciation, and transport of mercury in stream-sediment, stream-water, and fish collected near abandoned mercury mines in southwestern Alaska, USA

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Abstract

Concentrations of total Hg, Hg (II), and methylmercury were measured in stream-sediment, stream-water, and fish collected downstream from abandoned mercury mines in southwestern Alaska to evaluate environmental effects to surrounding ecosystems. These mines are found in a broad belt covering several tens of thousands of square kilometers, primarily in the Kuskokwim River basin. Mercury ore is dominantly cinnabar (HgS), but elemental mercury (Hg^0) is present in ore at one mine and near retorts and in streams at several mine sites. Approximately 1400 t of mercury have been produced from the region, which is approximately 99% of all mercury produced from Alaska. These mines are not presently operating because of low prices and low demand for mercury. Stream-sediment samples collected downstream from the mines contain as much as 5500 μg/g Hg. Such high Hg concentrations are related to the abundance of cinnabar, which is highly resistant to physical and chemical weathering, and is visible in streams below mine sites. Although total Hg concentrations in the stream-sediment samples collected near mines are high, Hg speciation data indicate that concentrations of Hg (II) are generally less than 5%, and methylmercury concentrations are less than 1% of the total Hg. Stream waters below the mines are neutral to slightly alkaline (pH 6.8–8.4), which is a result of the insolubility of cinnabar and the lack of acid-generating minerals such as pyrite in the deposits. Unfiltered stream-water samples collected below the mines generally contain 500–2500 ng/l Hg; whereas, corresponding stream-water samples filtered through a 0.45-μm membrane contain less than 50 ng/l Hg. These stream-water results indicate that most of the Hg transported downstream from the mines is as finely-suspended material rather than dissolved Hg. Mercury speciation data show that concentrations of Hg (II) and methylmercury in stream-water samples are typically less than 22 ng/l, and generally less than 5% of the total Hg. Muscle samples of fish collected downstream from mines contain as much as 620 ng/g Hg (wet wt.), of which 90–100% is

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Recommendations

ıal Operations Plan - 2012

antification of fish and aquatic insect tis
skokwim River, Alaska

To understand the existing levels of mercury and other contaminants in the aquatic community (fish and insects) of the Kuskokwim River and select tributaries.

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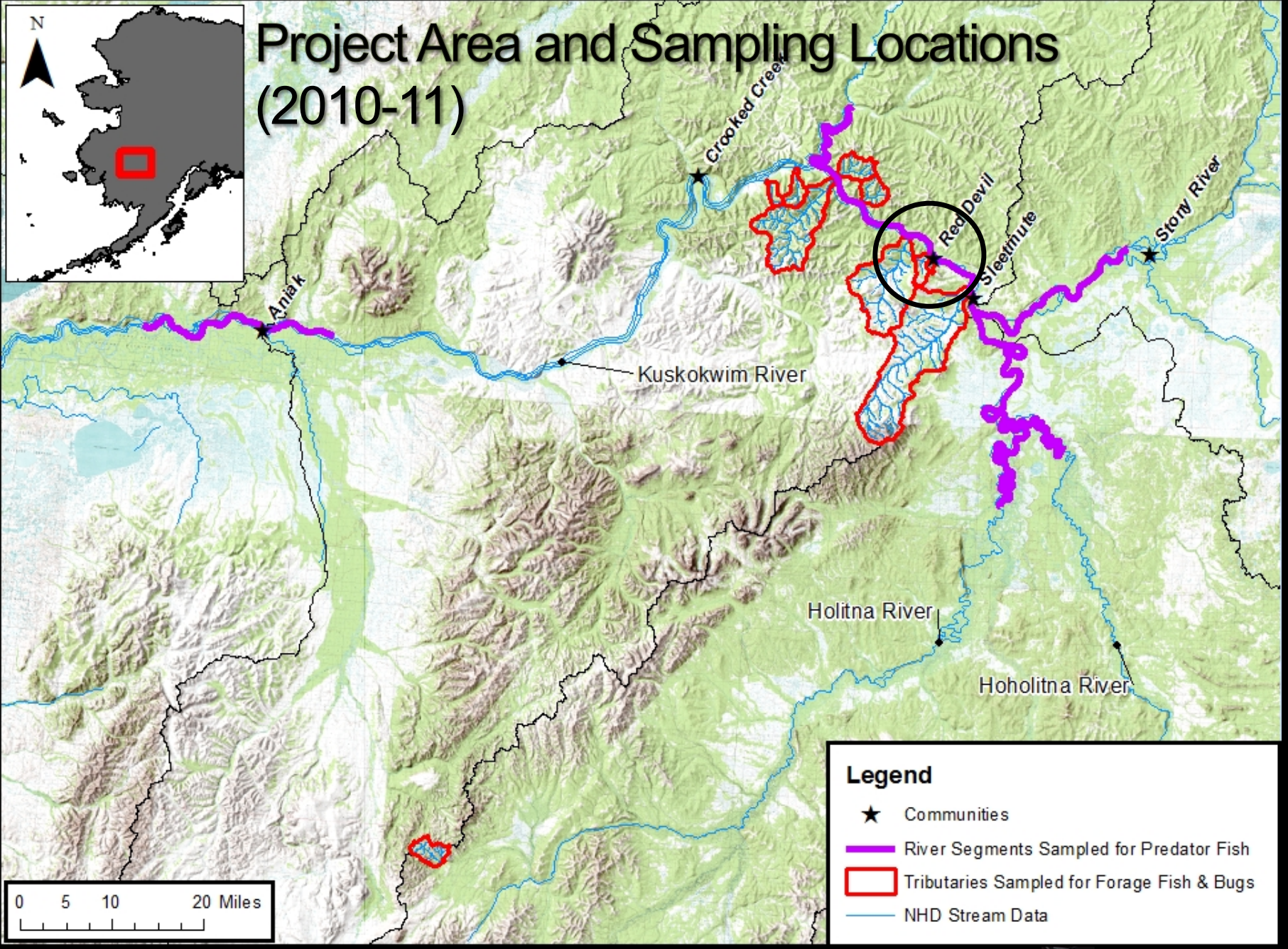
Methods

Samples - collected for metals analysis:
- whole (macroinvertebrates, small fish)
- skinless filet (large fish)
- muscle plugs (telemetered fish)

Analytical procedures:
- EPA methods for analysis of metals and inorganic arsenic
- EPA Validation Level IV QA/QC review

Telemetry
- LotekTM coded tags with motion sensors
- Flights ~ monthly and some shore-based tracking stations

Data analysis
- Depended on data (sample size and distribution) and question; often
- GLM (multivariate or univariate) with age/length as covariate for Hg



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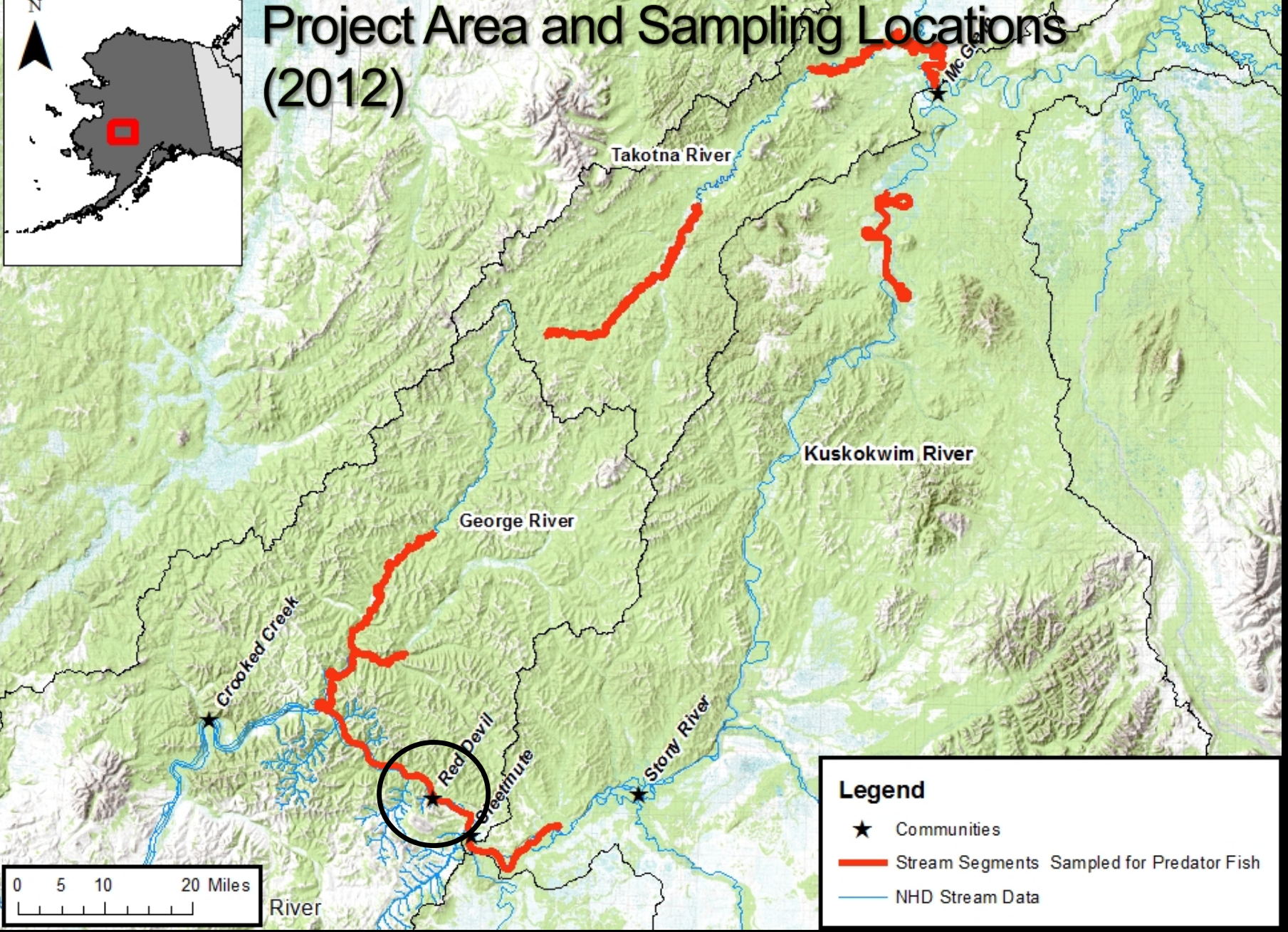
Project Area and Sampling Locations (2012)



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Kuskokwim River Small Tributary Habitats and Biota

Small streams……

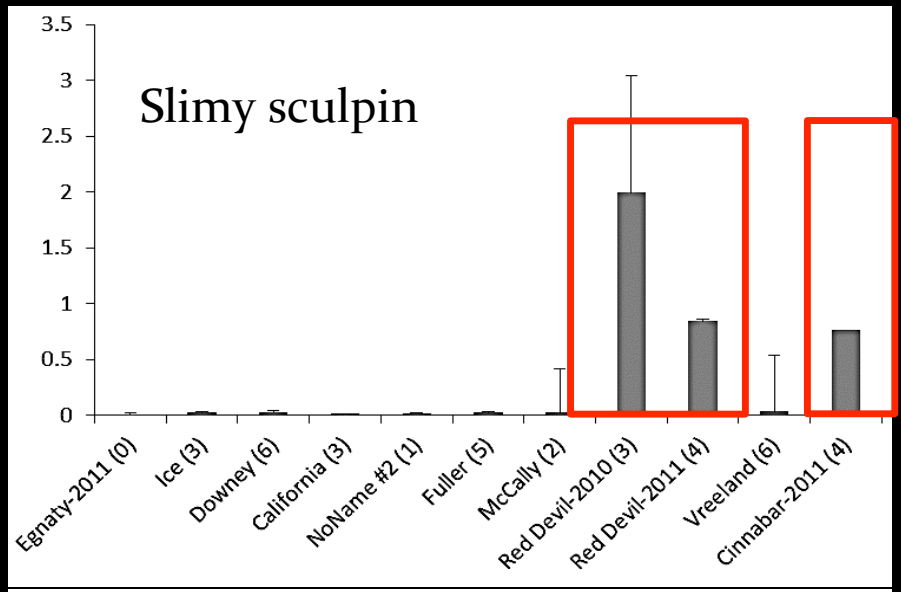
Relatively small biota (forage fish) with local movements

- Macroinvertebrates
- Slimy sculpin (HR ~ 250 ft)
- Young (small) Dolly Varden
- Young (small) Arctic grayling
- Young (small) salmon

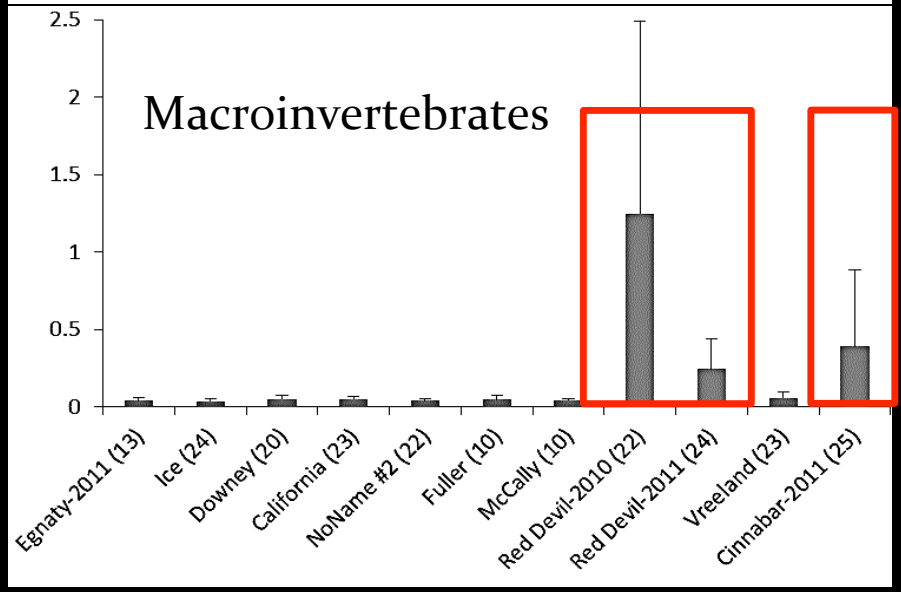
Elevated mercury and arsenic in small creeks with abandoned mines on them (Red Devil, Cinnabar); variation with fish age and ecological niche.

Kuskokwim River Small Tributary Mercury Results (2010-11)

Total mercury (ug/g, ww), whole body



Total mercury (ug/g, ww), whole body



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Kuskokwim River Small Tributary Mercury Results (2010-11)

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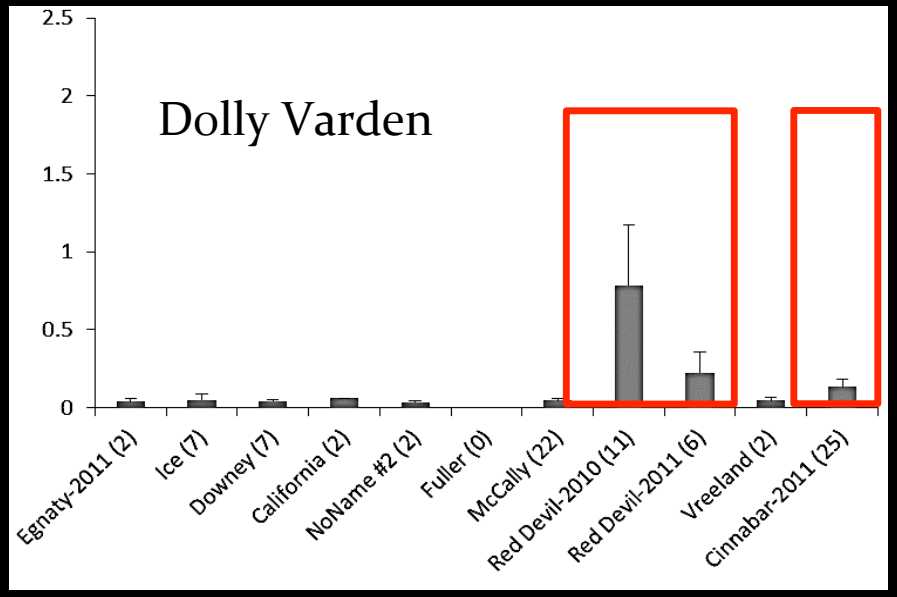
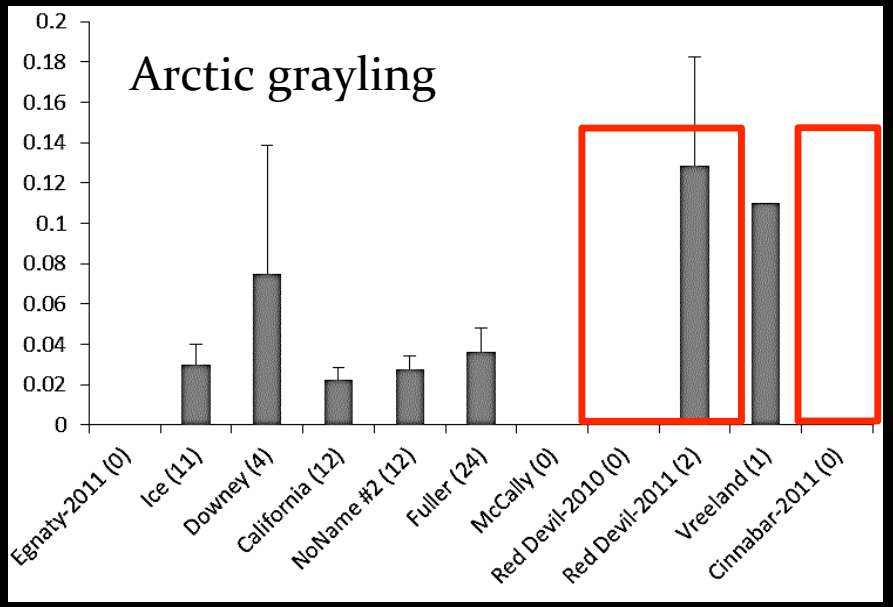


Total mercury (ug/g, ww), whole body



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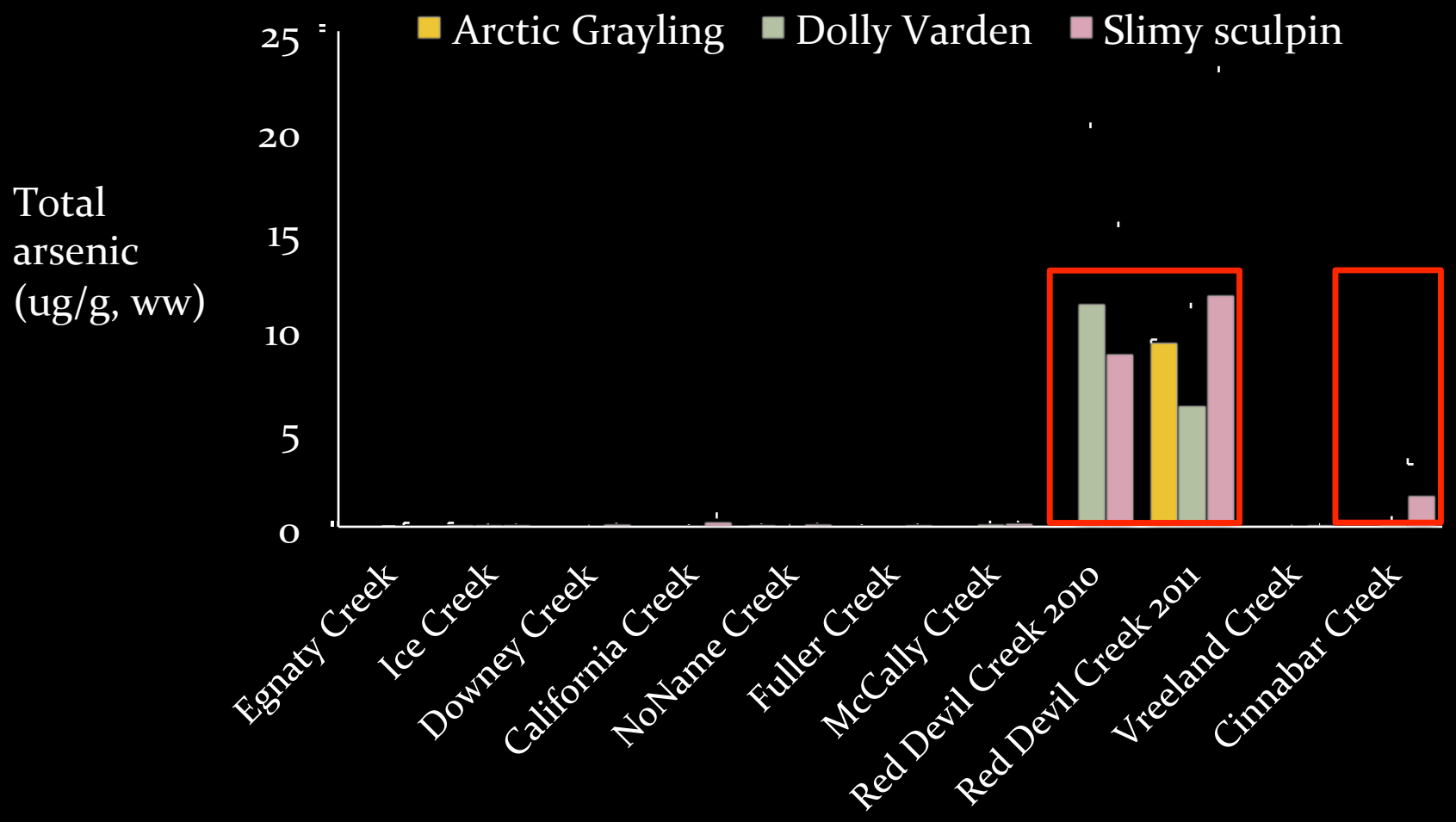
Kuskokwim River Small Tributary Arsenic Results (2010-11)

Tributary Sampling Results



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Kuskokwim River and Large Trib Rivers: Habitats and Biota

Large rivers……and the Kuskokwim

Relatively large fish
- Burbot or lush
- Northern pike
- Arctic grayling

With relatively larger home ranges

Mercury patterns are species-specific.

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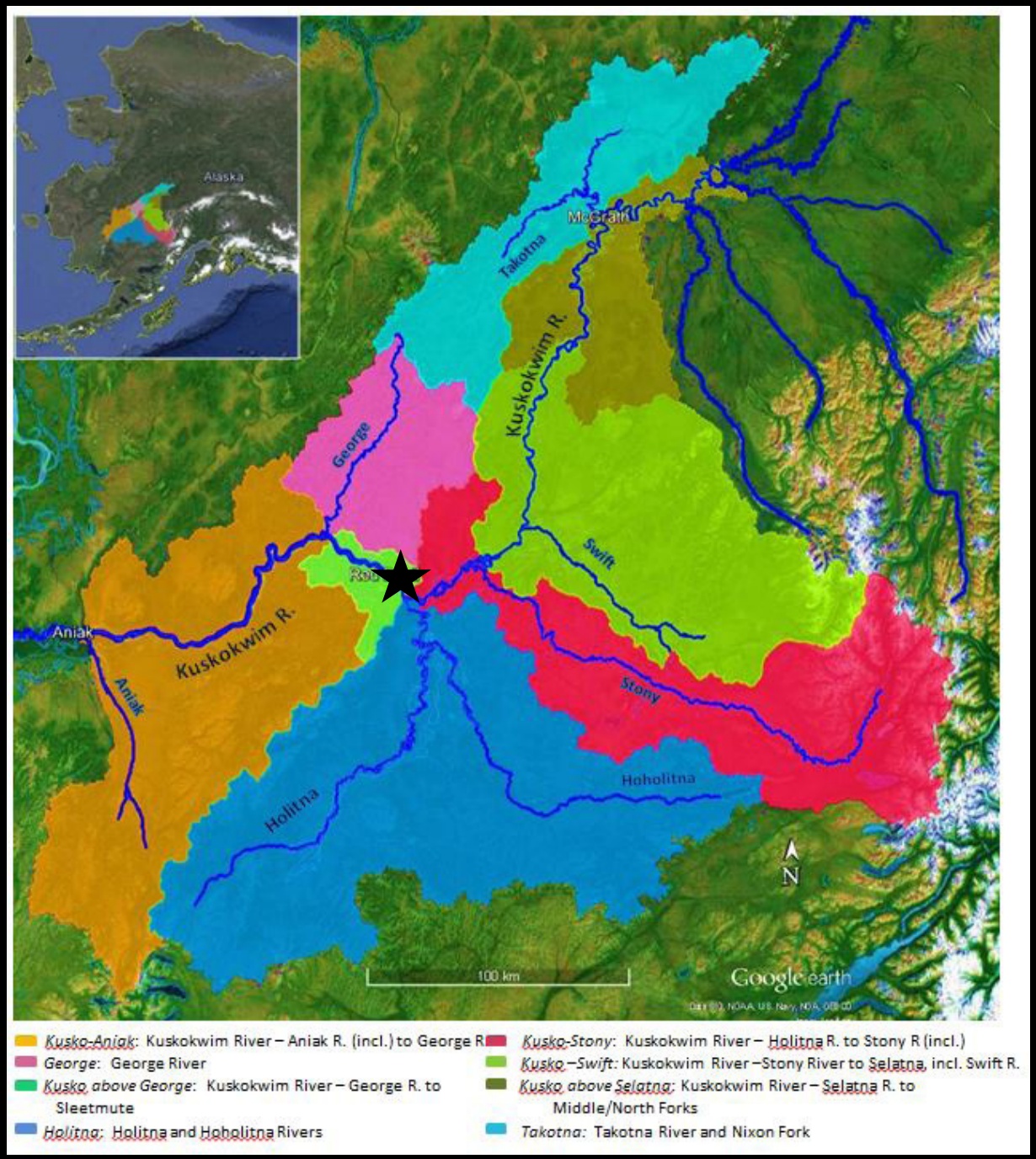
Kuskokwim River and Large Trib Rivers: Habitats and Biota

Telemetry Tracking of Sampled Fish

- From 2011-12 the BLM in cooperation with ADF&G tagged:
  - 154 burbot (lush)
  - 245 northern pike
  - 170 Arctic grayling
  - Burbot and Pike tags lasted 2+ years
  - Grayling tags lasted 1 year
- The tracking data and individual fish contaminant levels provided essential information for understanding the exposure pathways in the Kuskokwim Basin



Watersheds used for analysis of mercury in telemetered fish.

Based on USGS Hydrologic Unit Codes (HUCs) for Alaska.

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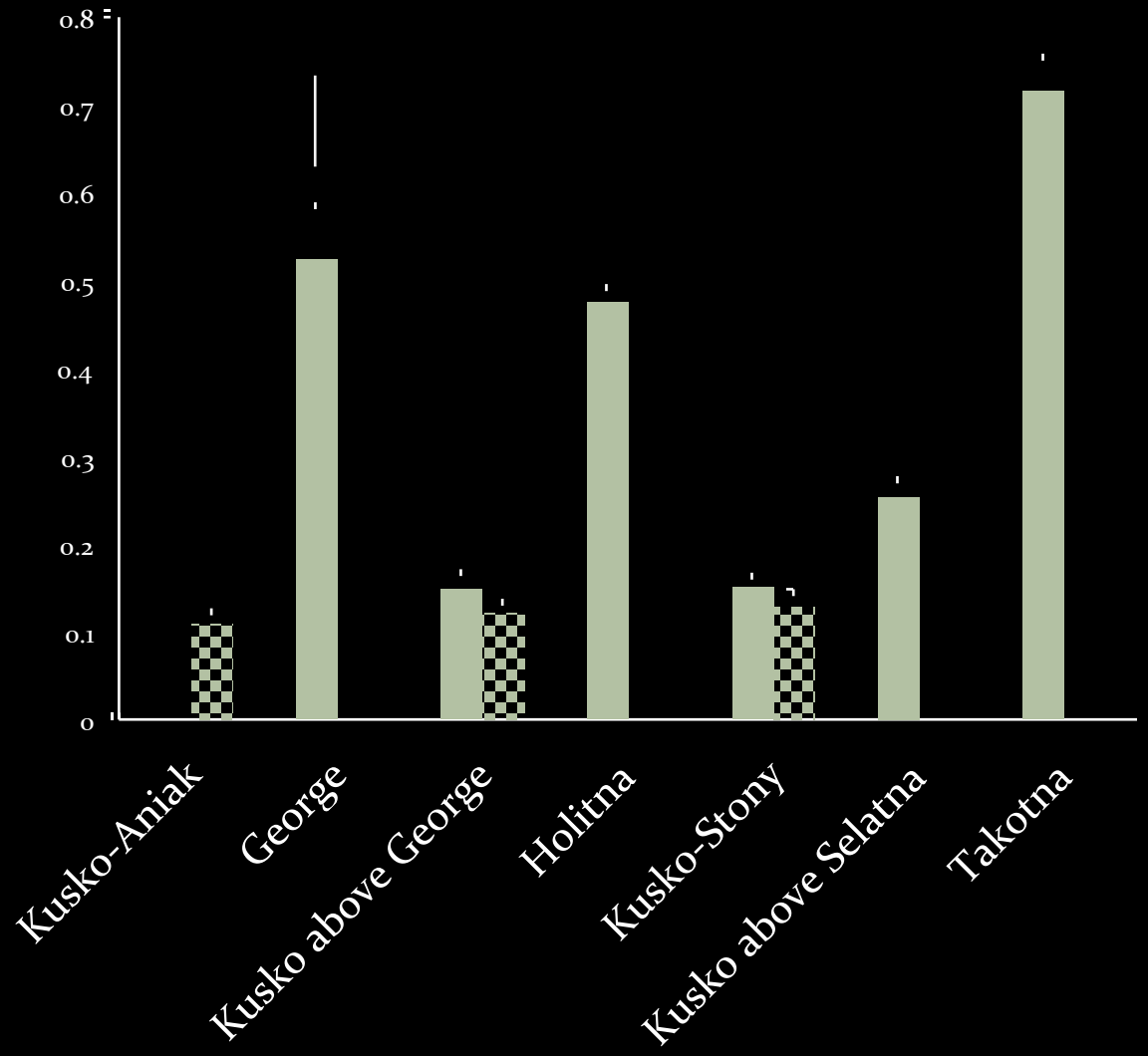
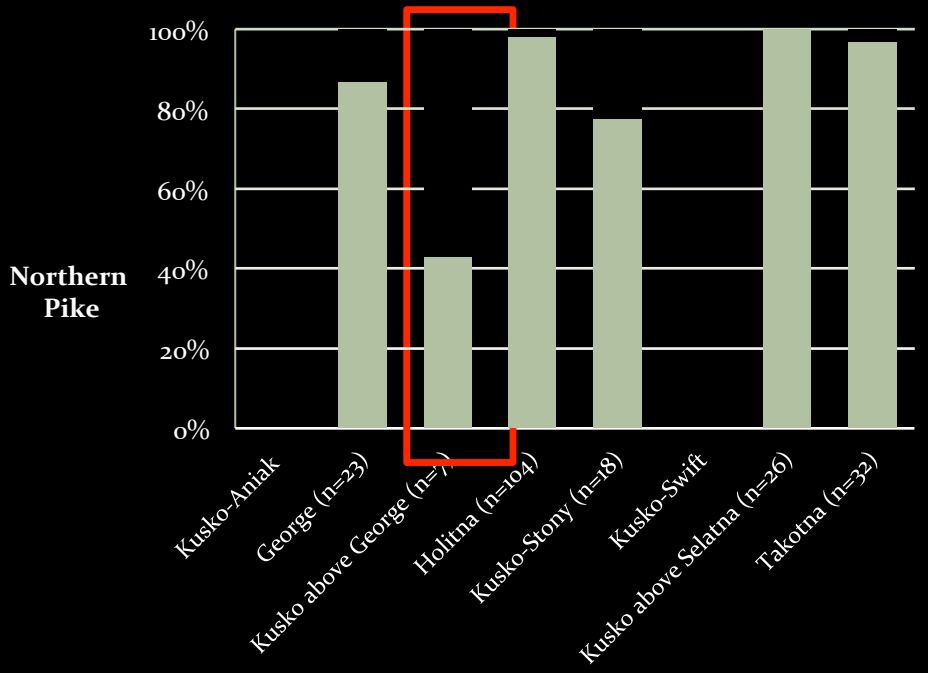
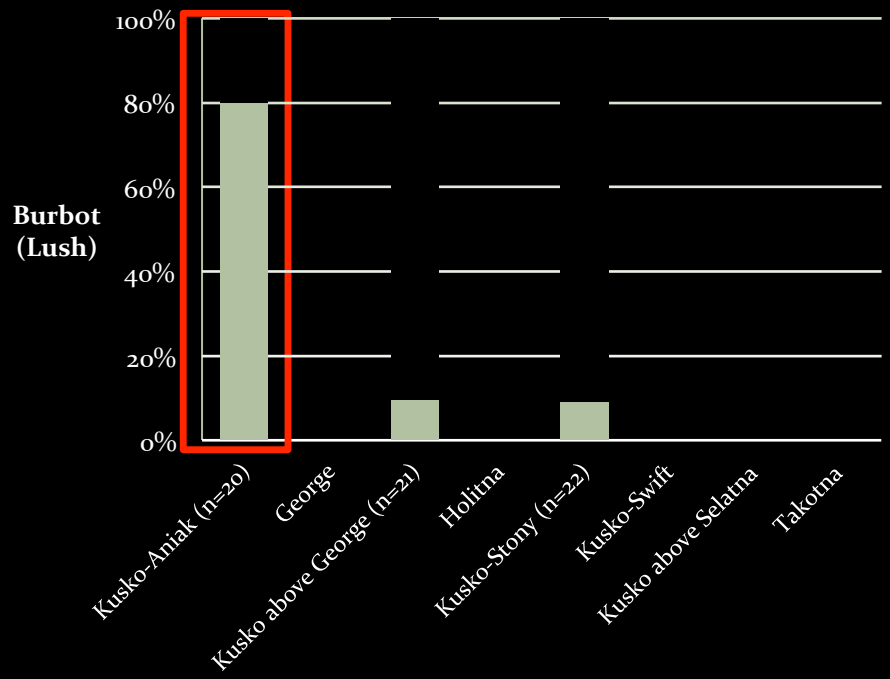
Total mercury (ug/g, ww) in muscle







Percentage of telemetered fish that stayed within their capture watershed (capture = max-use; solid bars) and those that did not (open bars).

(Max-use watershed = majority of locations.)

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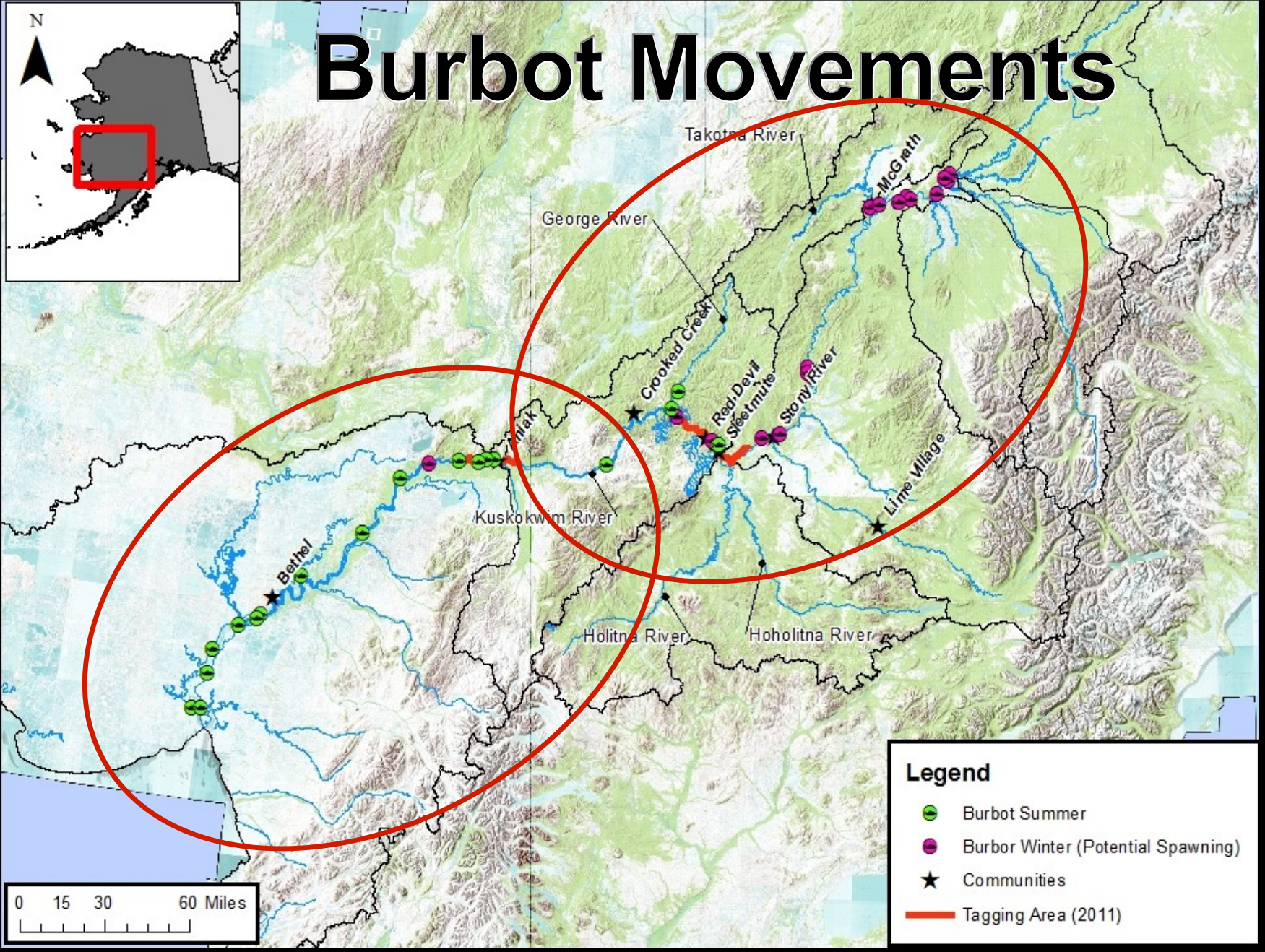
Burbot Movements



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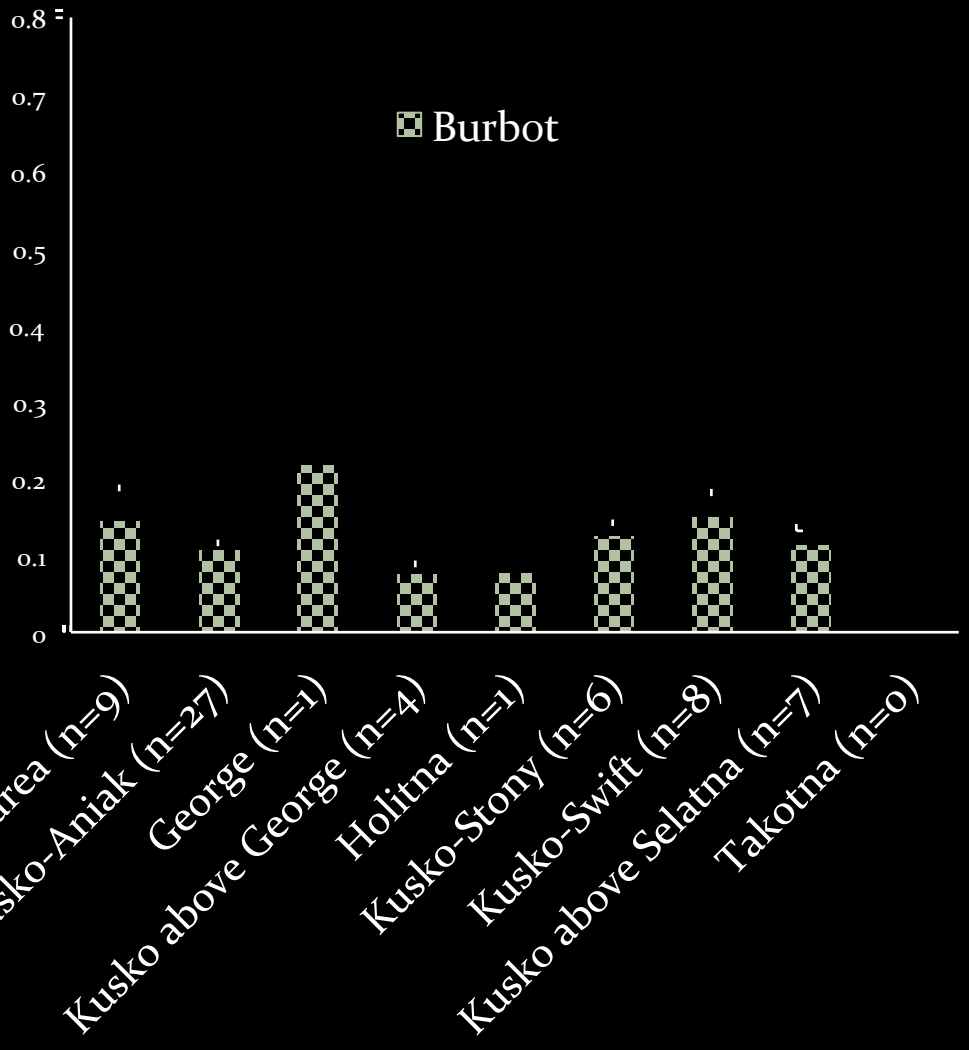
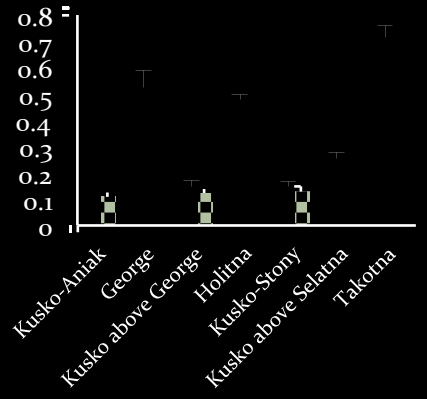
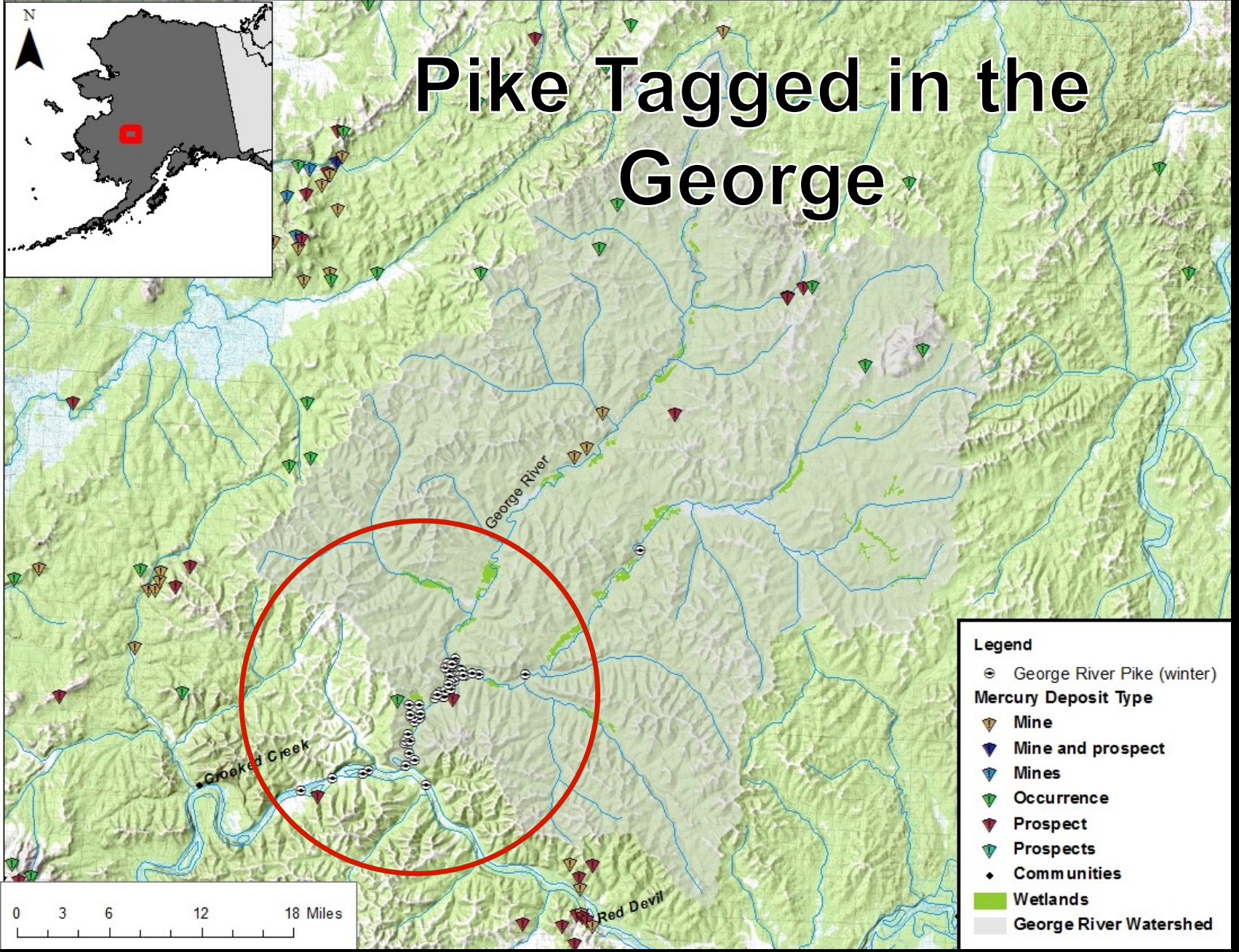
Total mercury (ug/g, ww)





Capture watersheds

Pike Tagged in the George



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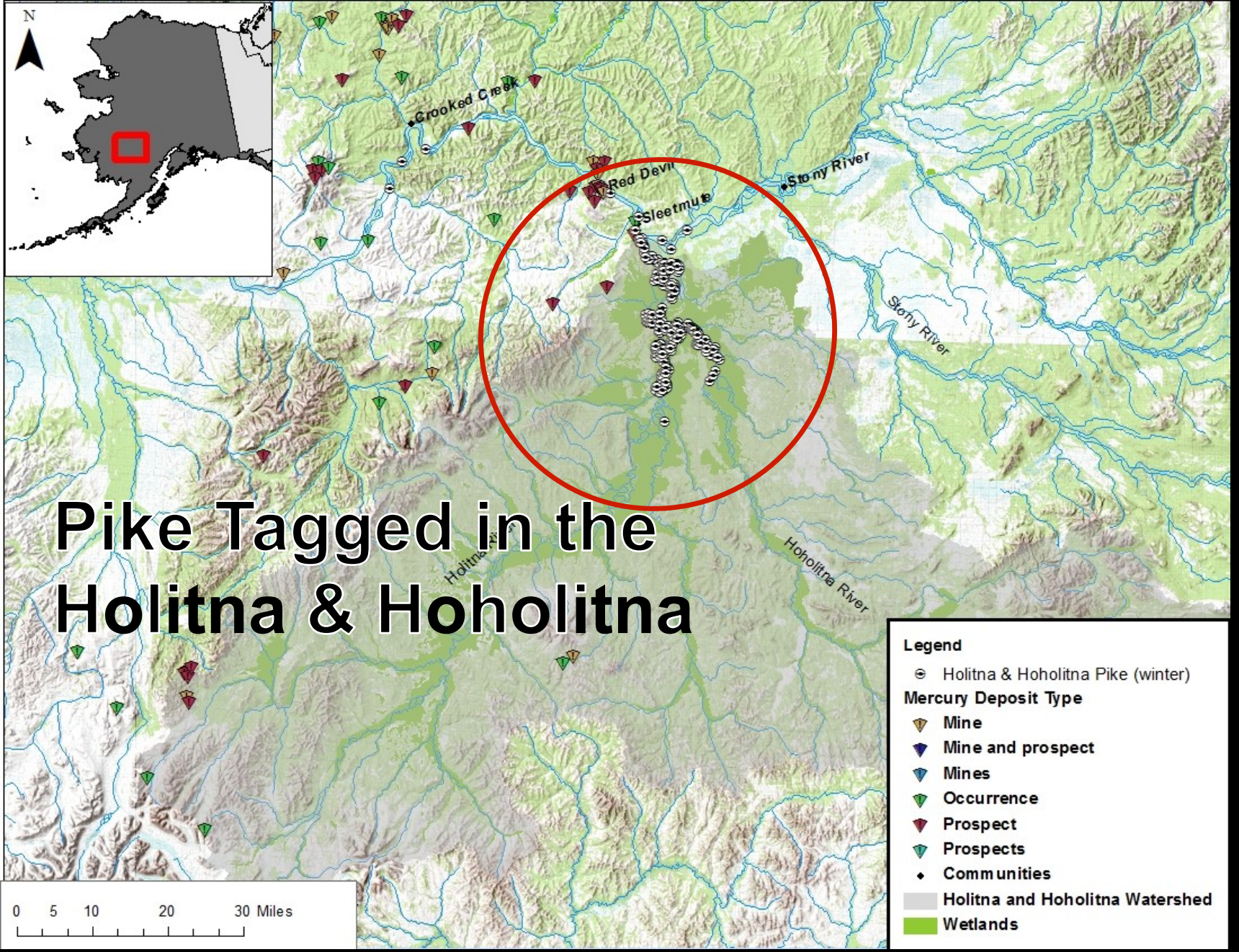

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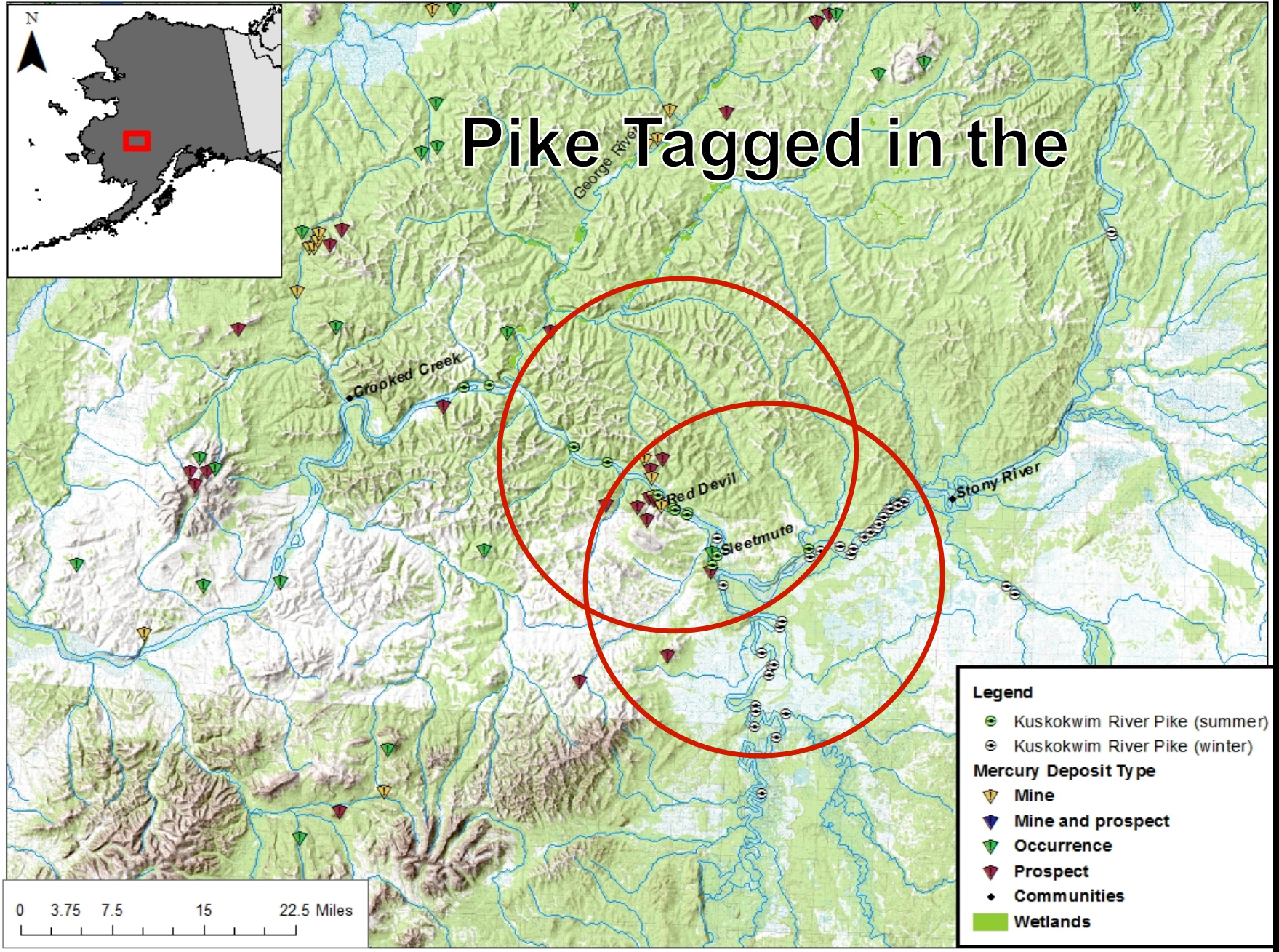

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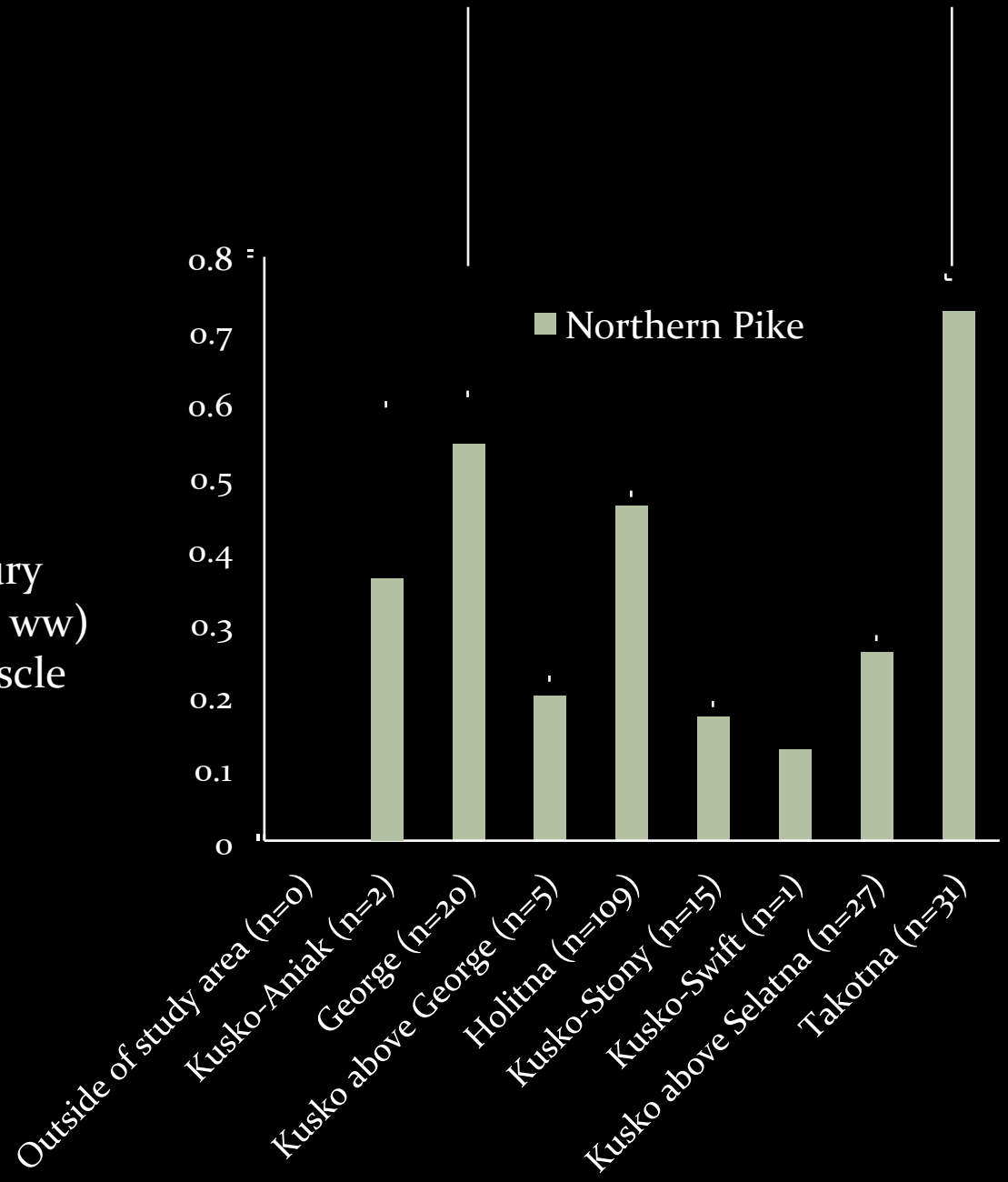
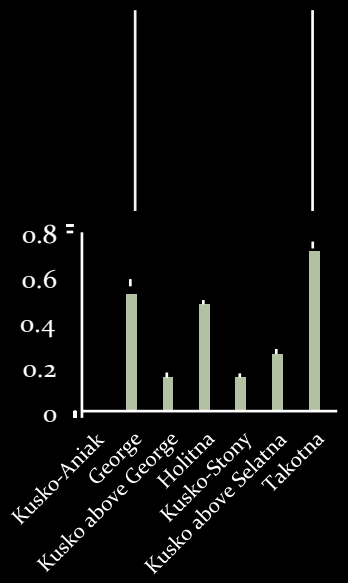
Total mercury (ug/g, ww) in muscle





Capture watersheds

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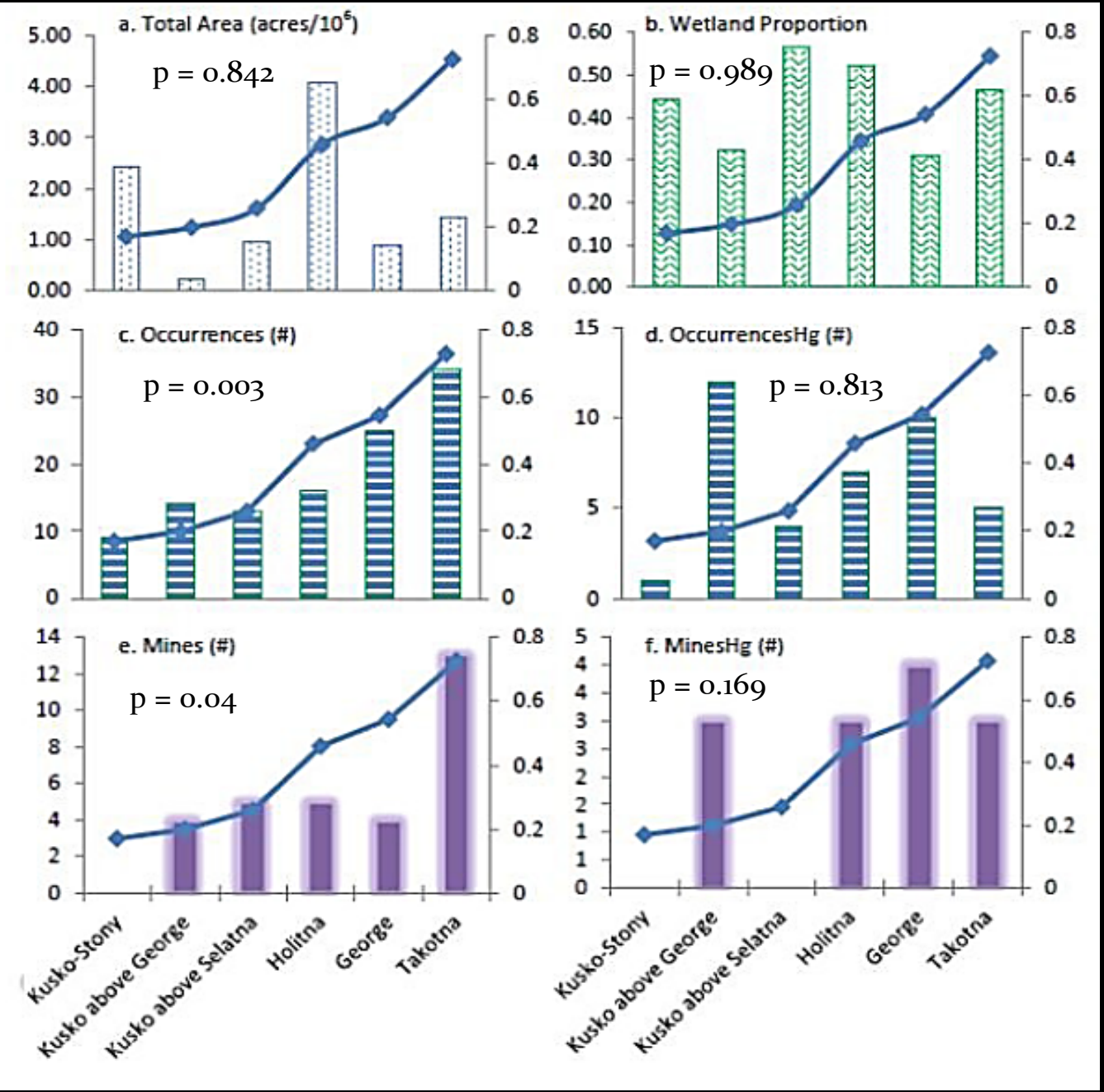
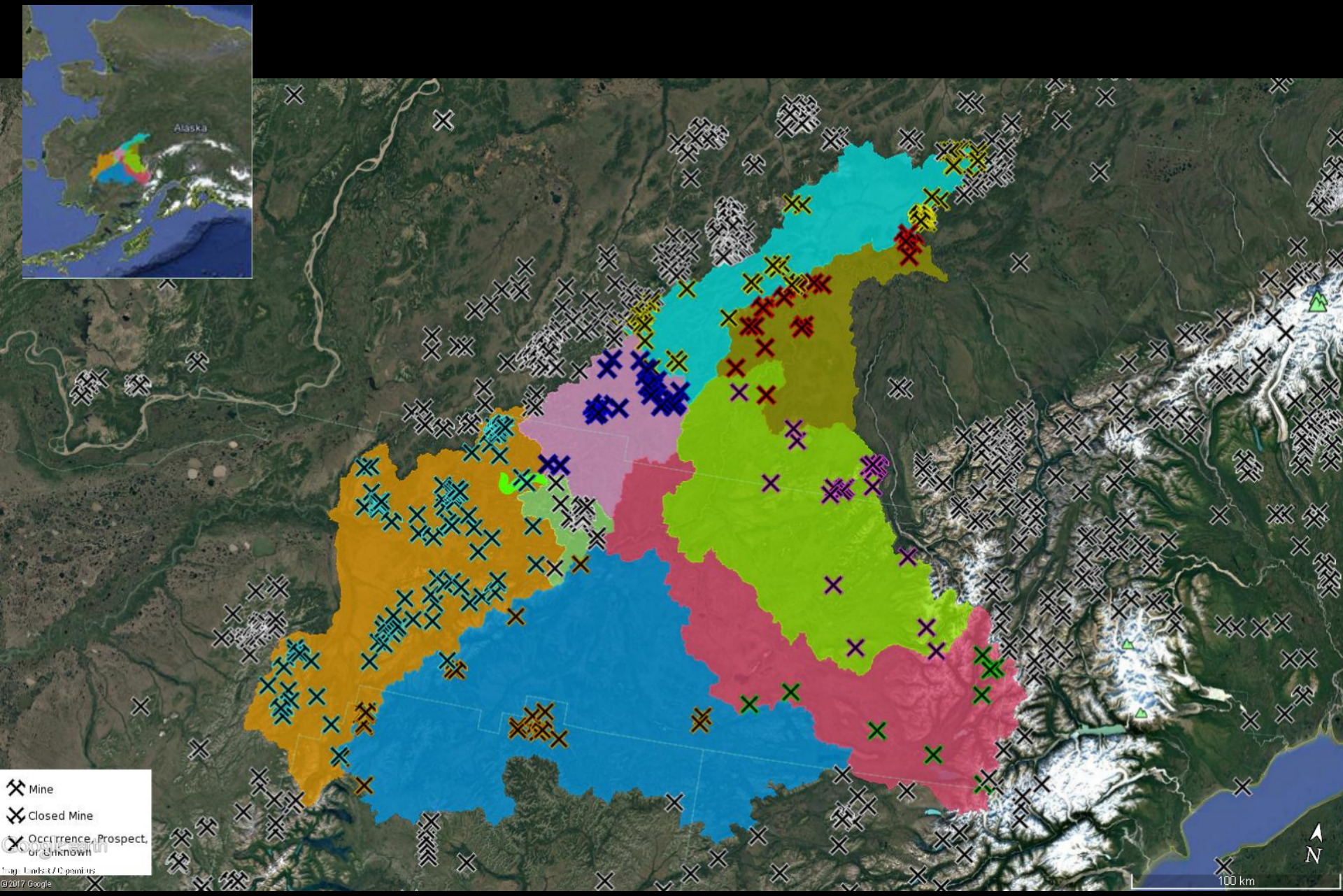
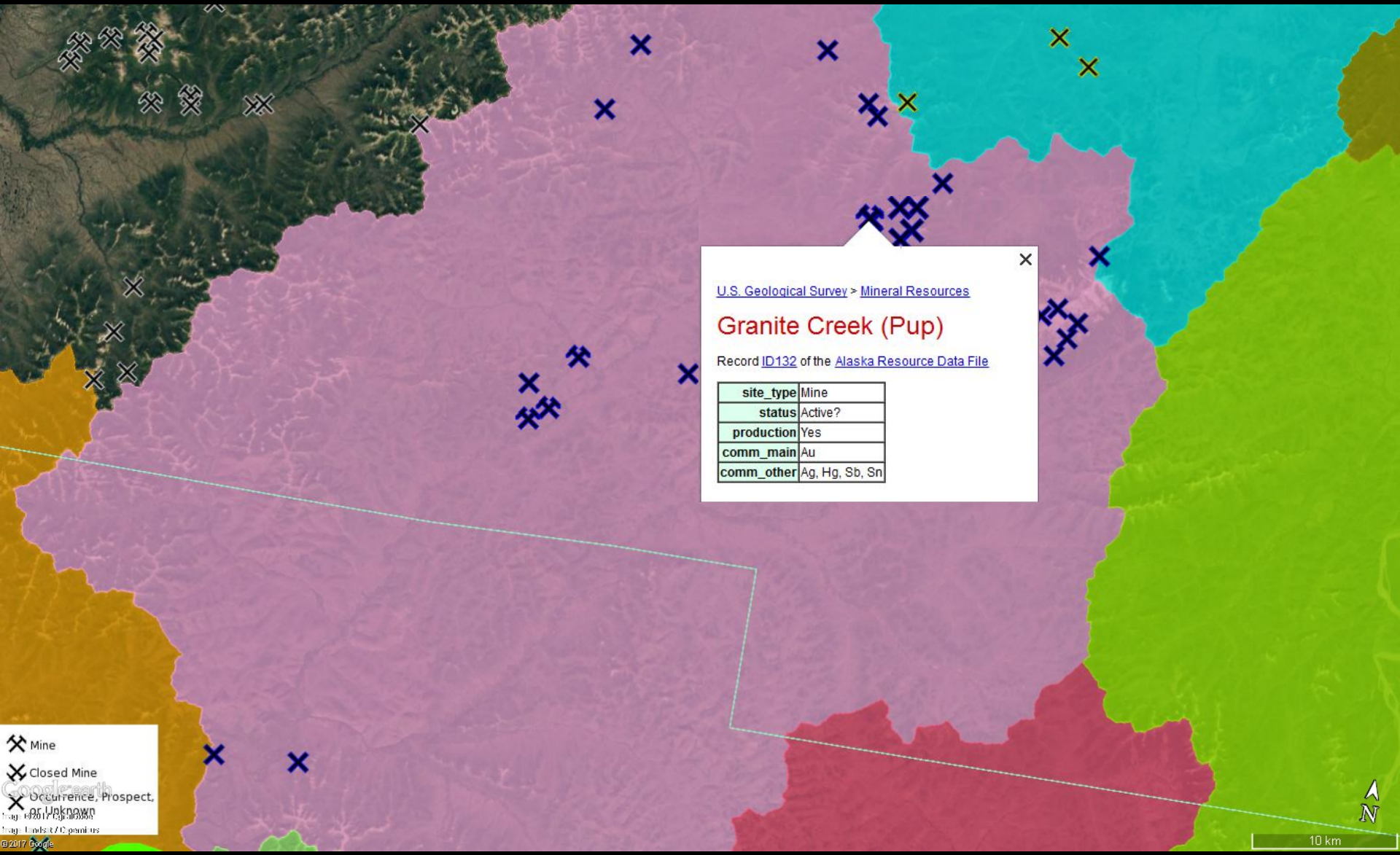


Total mercury (ug/g, ww) in northern pike muscle



USGS (2008). Alaska Resource Data File, http://ardf.wr.usgs.gov.



USGS (2008). Alaska Resource Data File, http://ardf.wr.usgs.gov.

Conclusions

- Biota in Red Devil Creek have measurable and biologically significant elevation of Hg and, to a lesser extent, As.

- Cinnabar Creek, in the Holitna River headwaters, appears to have conditions similar to Red Devil Creek and has similar elevated Hg and As.

Key Mercury Conclusions

- Despite the elevated levels in Red Devil Creek, the turbid and swift conditions of the Kuskokwim River provide limited habitat for pike.
- Resident pike in the George, Holitna, and Takotna Rivers had the highest concentrations of Hg, while pike captured in the Kuskokwim had the lowest.
- Pike [Hg] were significantly related to the number of mineral occurrences and mines, but not watershed size or percent wetland by watershed.
- Burbot (lush) traveled widely across the entire study area; they had lower and less variable (by watershed) [Hg] compared to pike.

Questions?

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https://www.blm.gov/programs/public-safety-and-fire/abandoned-mine-lands/regional-information/alaska/projects/red-devil-mine