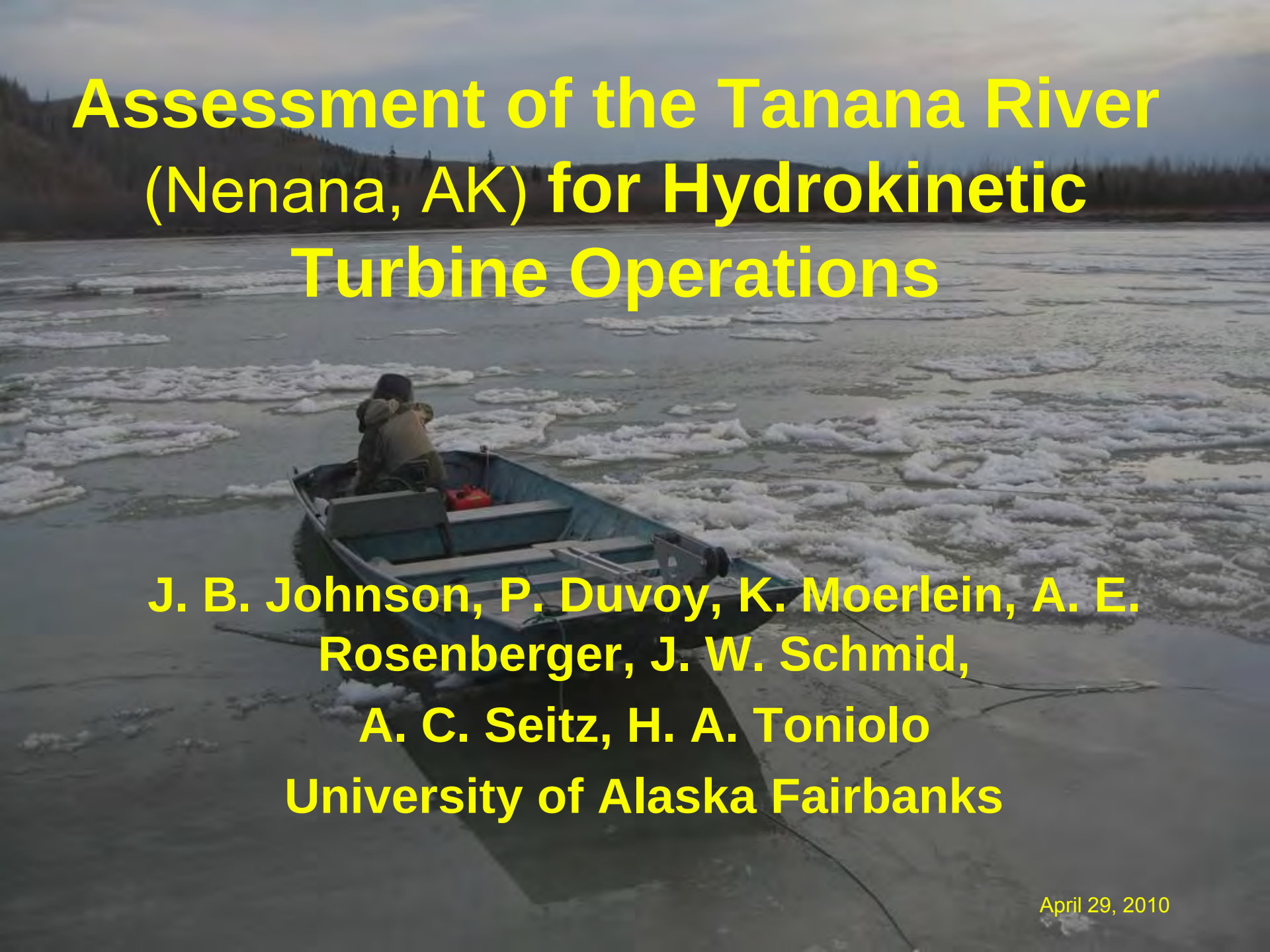
# Assessment of the Tanana River (Nenana, AK) for Hydrokinetic Turbine Operations



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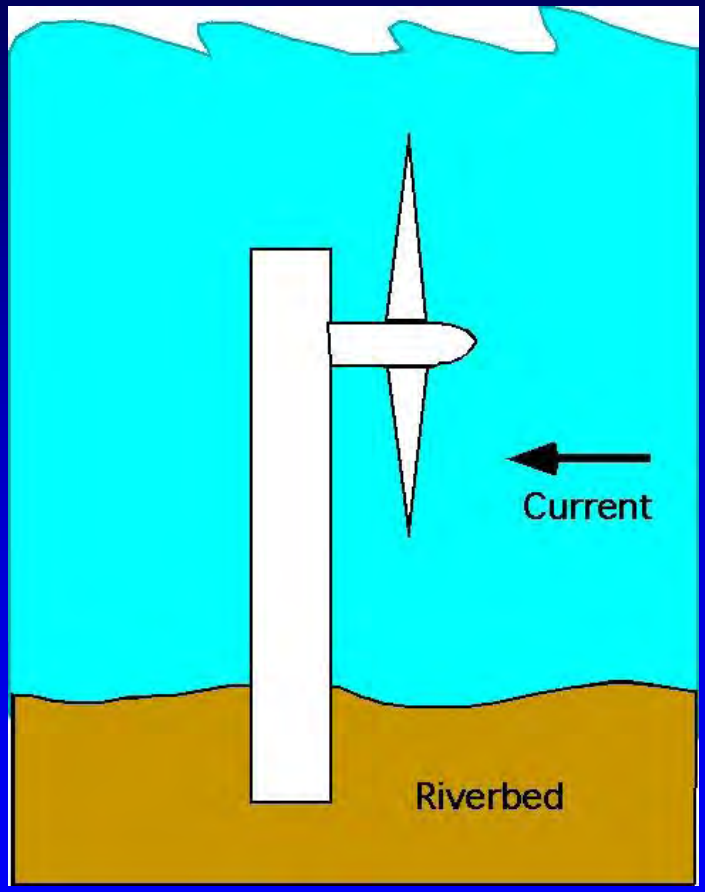
University of Alaska Fairbanks

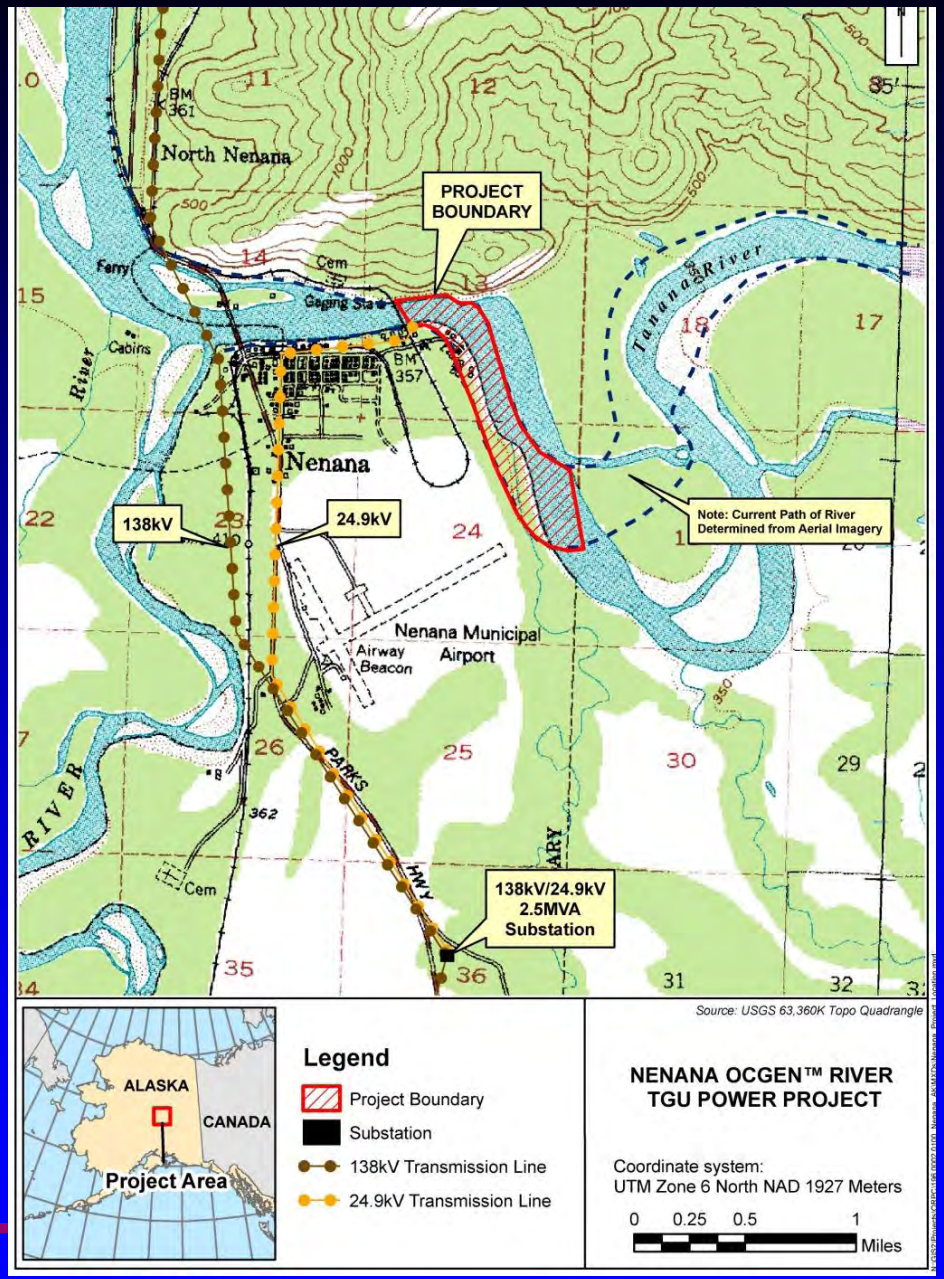
April 29, 2010

# Hydrokinetic Energy Technology

- Underwater turbines convert river kinetic energy into electrical power
- Turbines are placed in relatively high-velocity river currents
- Does not require dams or power houses
- Technology is considered pre-commercial



- **Tanana River Test Site** (Nenana, AK)
- Ocean Renewable Power Company plans to install a demonstration hydrokinetic turbine 2011-2012.
- Goals: Assess river conditions prior to - and after - installation of a hydrokinetic turbine (I.e., turbine - river environment interactions)
  - The river power resource: summer & winter
  - The river environment
  - River debris conditions
  - Fish population & behavior

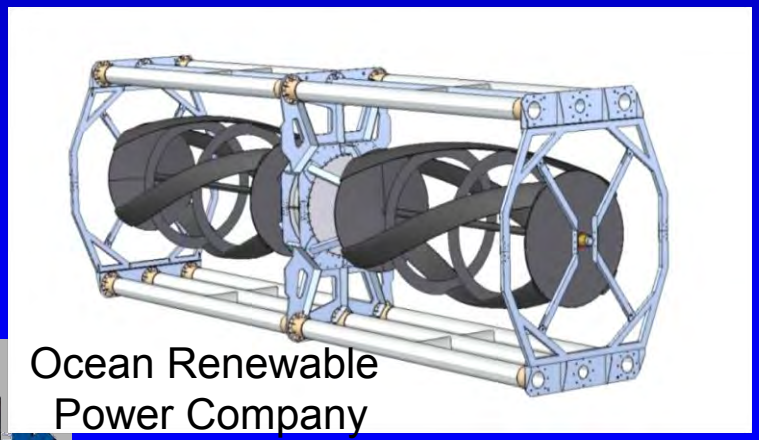


# Hydrokinetic Generation Devices

**Cross-flow turbines**


OpenHydro

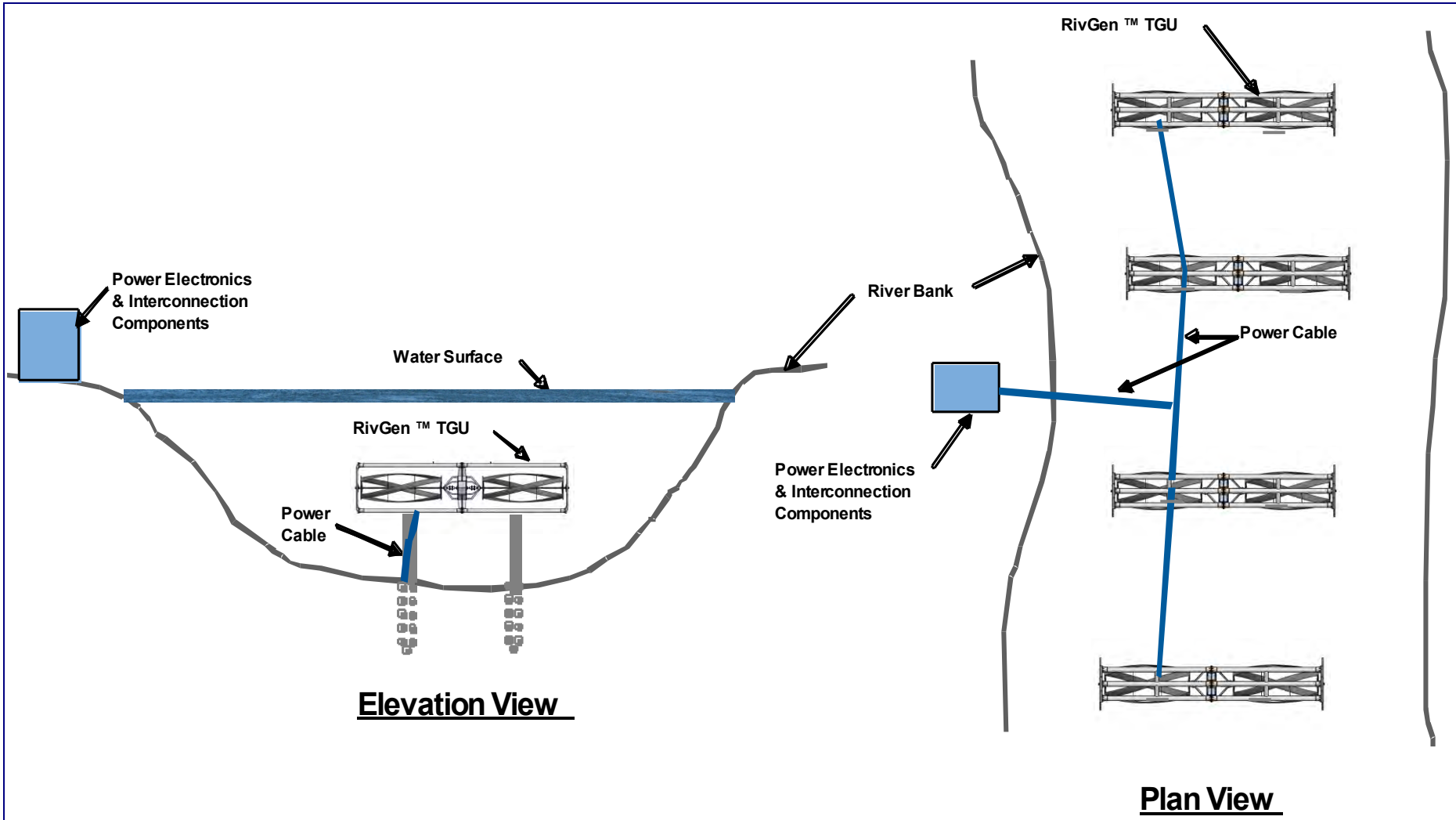

**Axial-flow turbines**



Ocean Renewable Power Company


**Turbine images used with permission**

# Possible Turbine Deployment Scenario



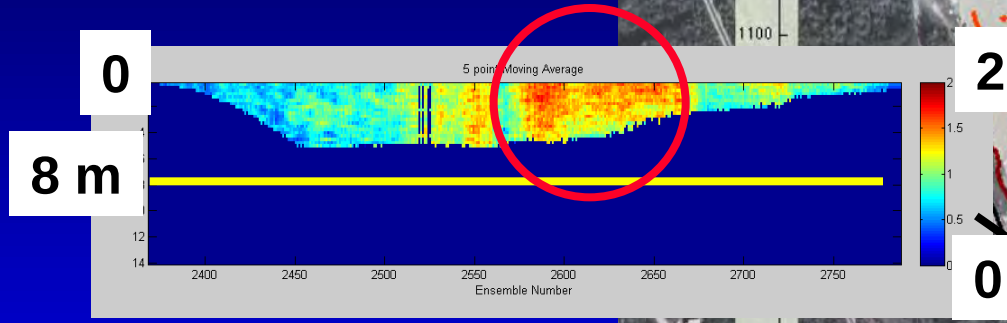
# Factors Affecting the Hydrokinetic Resource

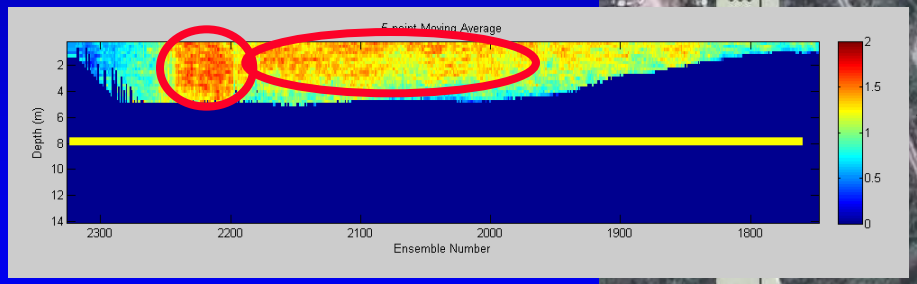
- Specific power (power per unit cross-sectional area)
- Debris (video after talk)
- Ice
  - Frazil ice
  - Ice jams
- River environment
  - current velocity seasonal variation
  - Turbulence
  - Sediment deposition and erosion
  - Channel stability
- Fish
  - Mortality & injury
  - Effects on migration within the river

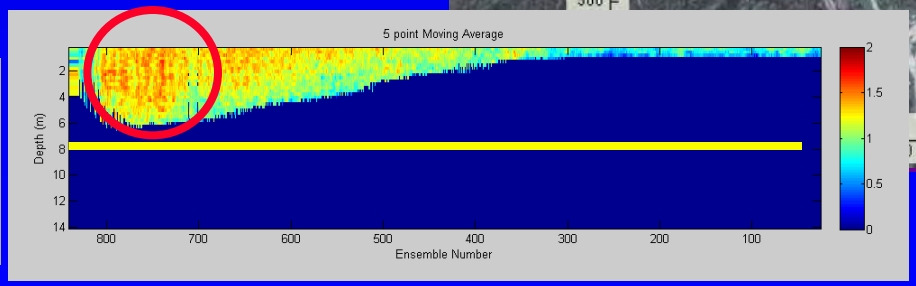
# Tanana River Test Site Bathymetry and October 2008 Current

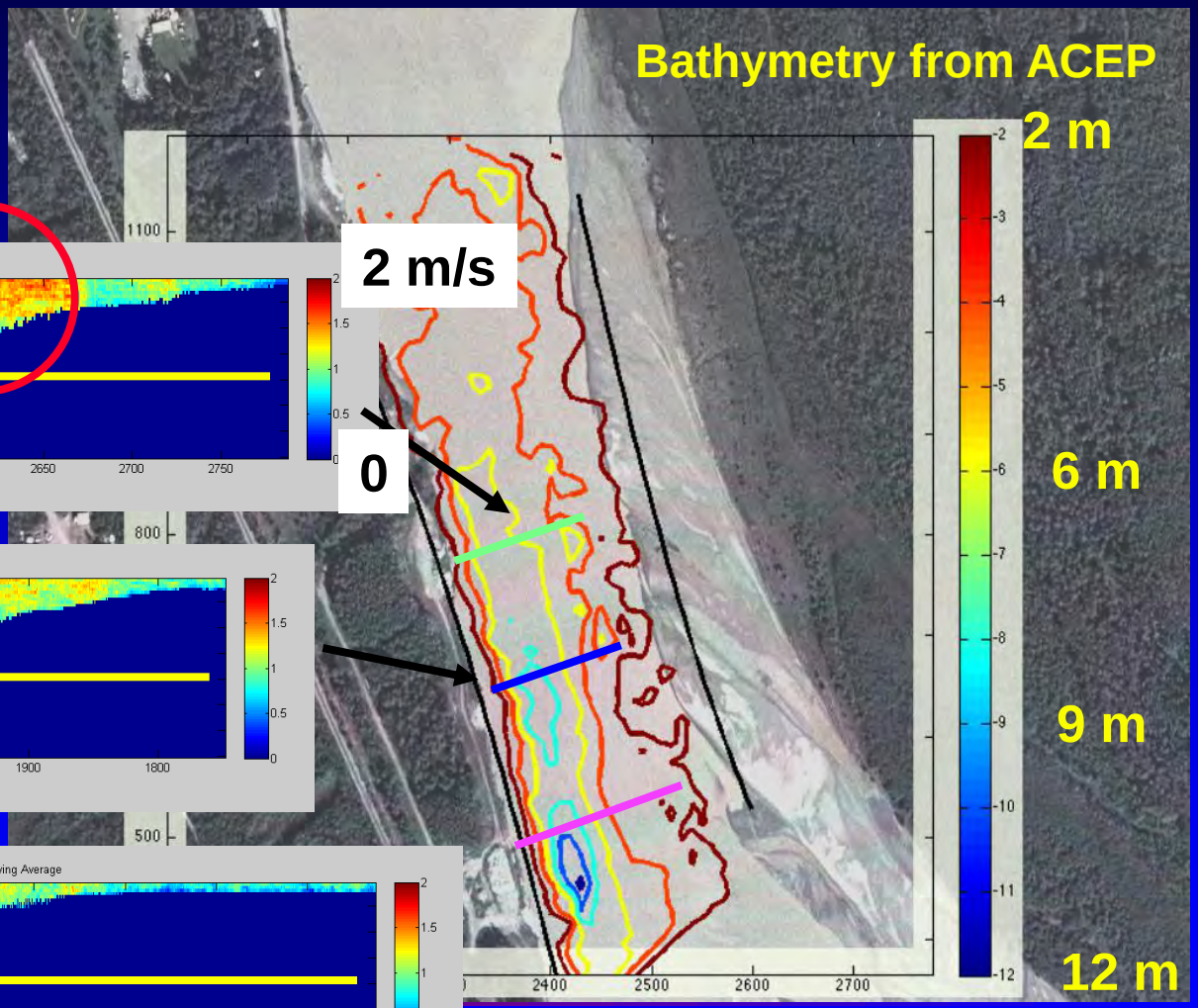
Current data from Terrasond

Bathymetry from ACEP



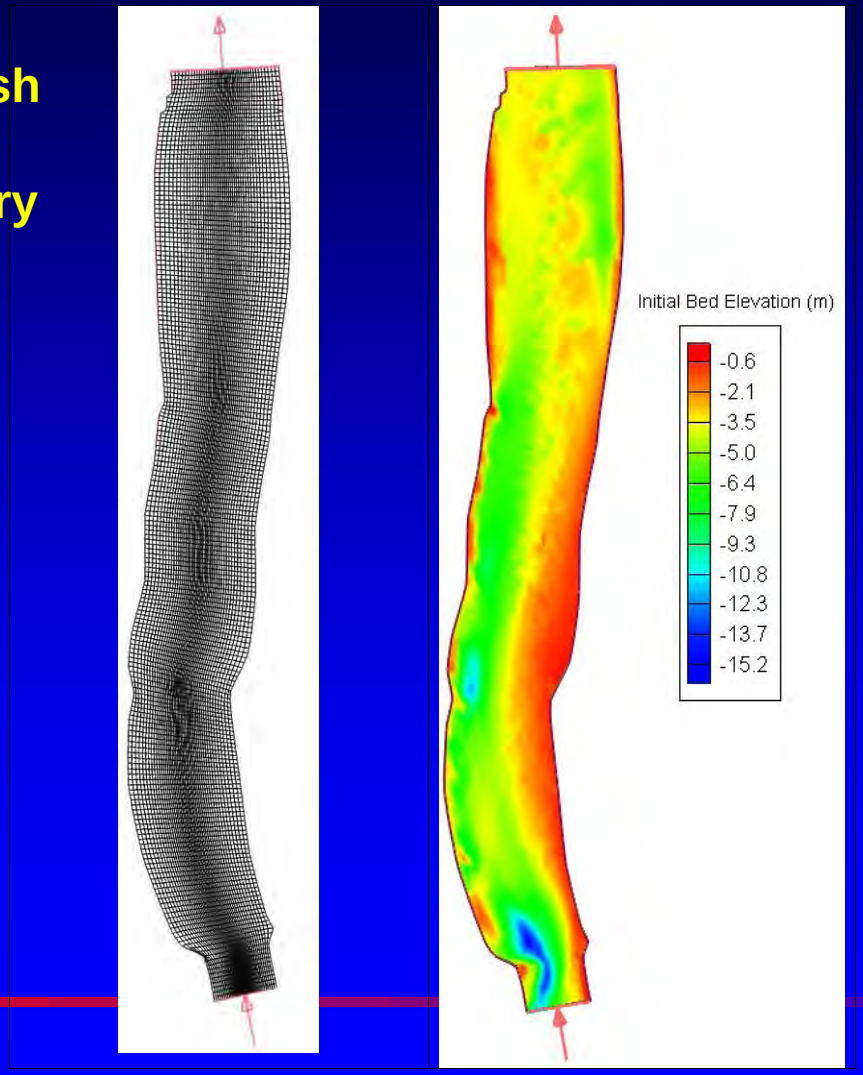



# 2-D River Modeling Inputs

**Model mesh Of the bathymetry**




**Measured bathymetry**

# 2-D River Modeling Results

Velocity (m/s)

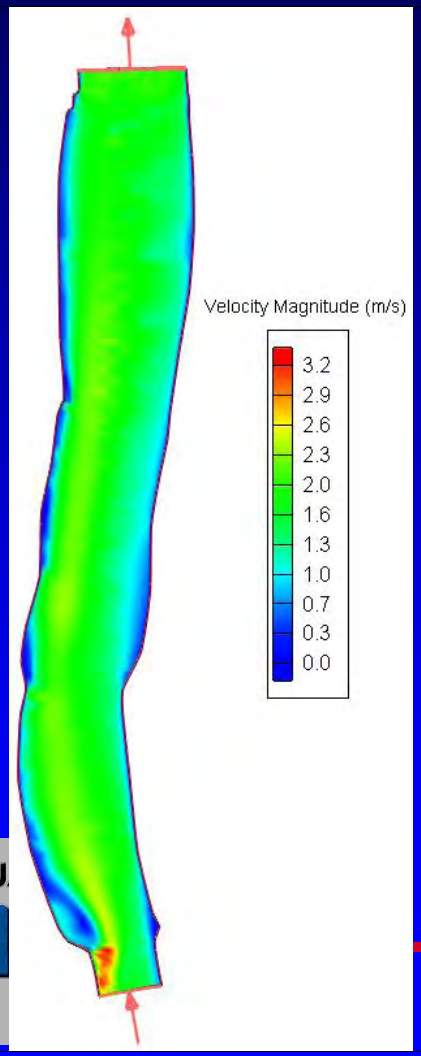



Figure 4a

Maximum velocity

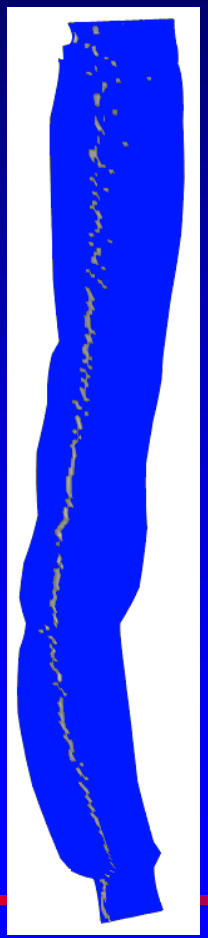
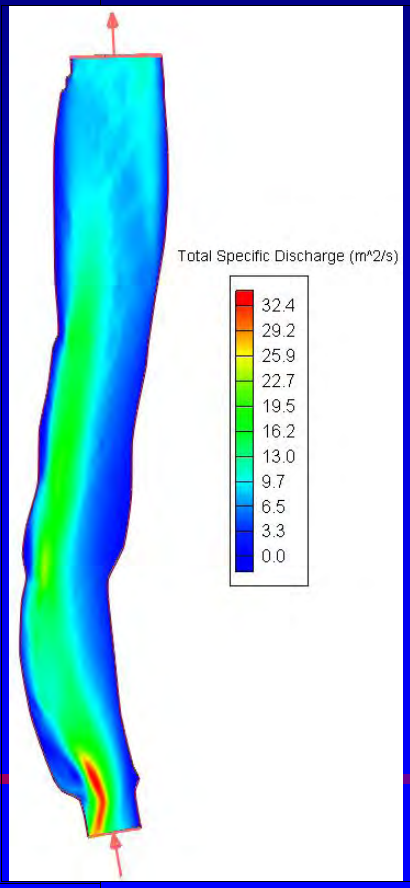
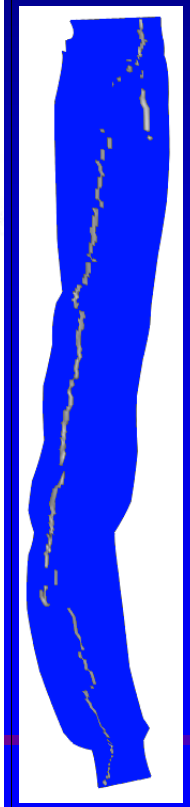


Figure 4b

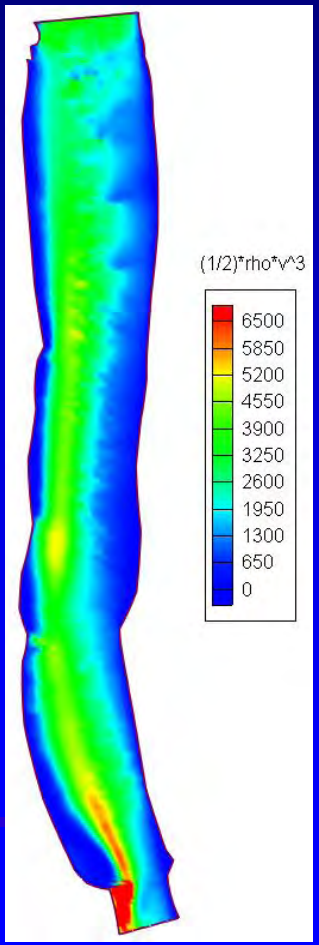
Specific Discharge ($m^2/s$)



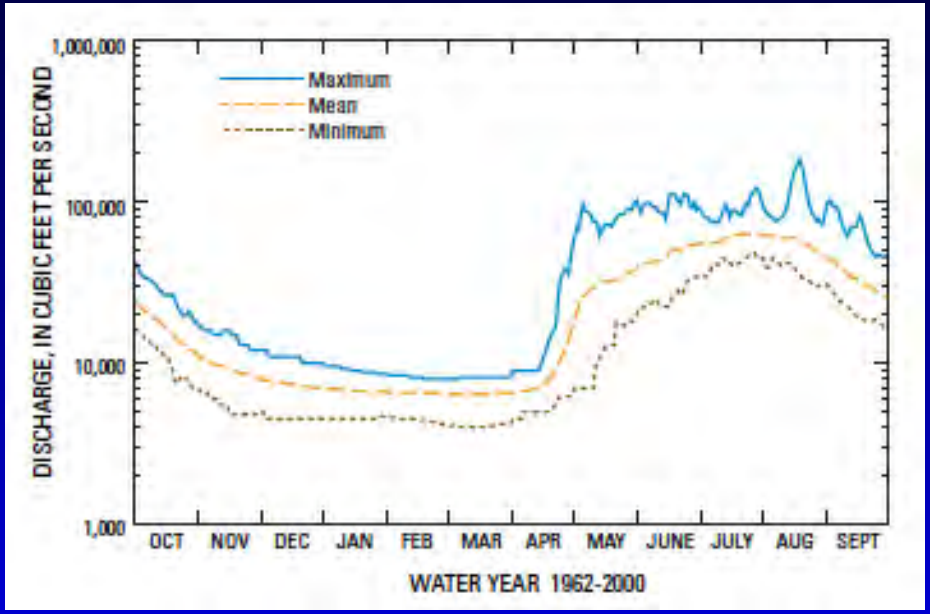

Max. Specific Discharge

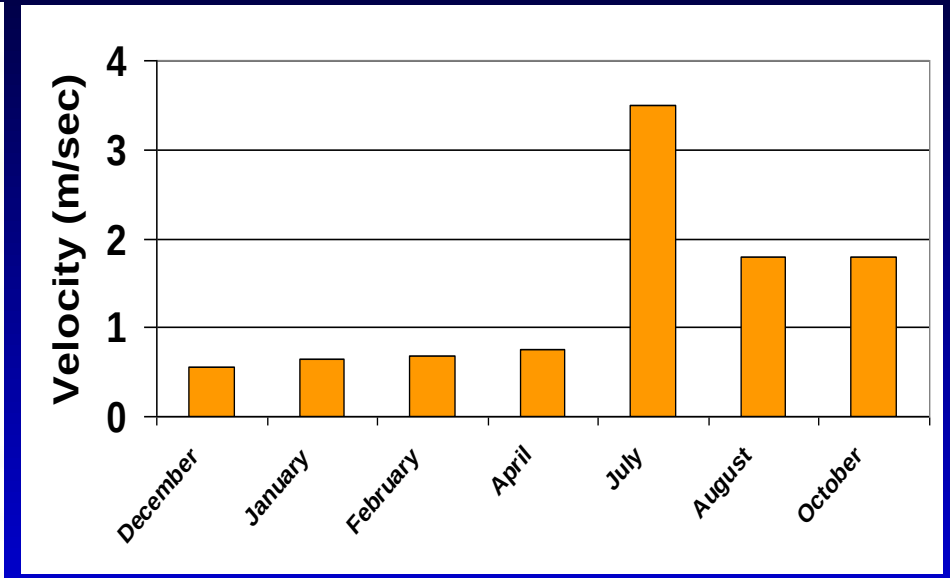


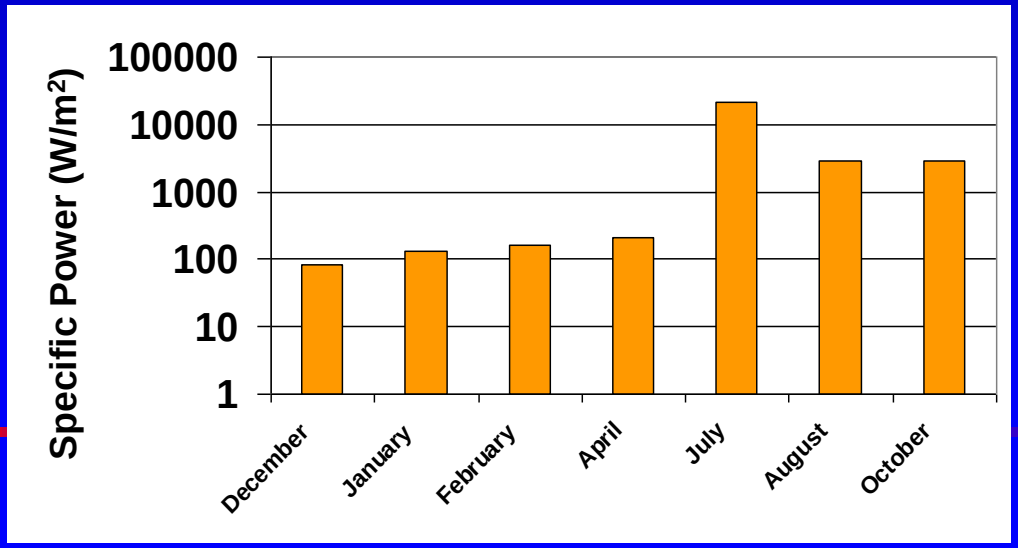
Power / area ($W/m^2$)



# Nominal Seasonal Variation of Discharge, Velocity and Specific Power



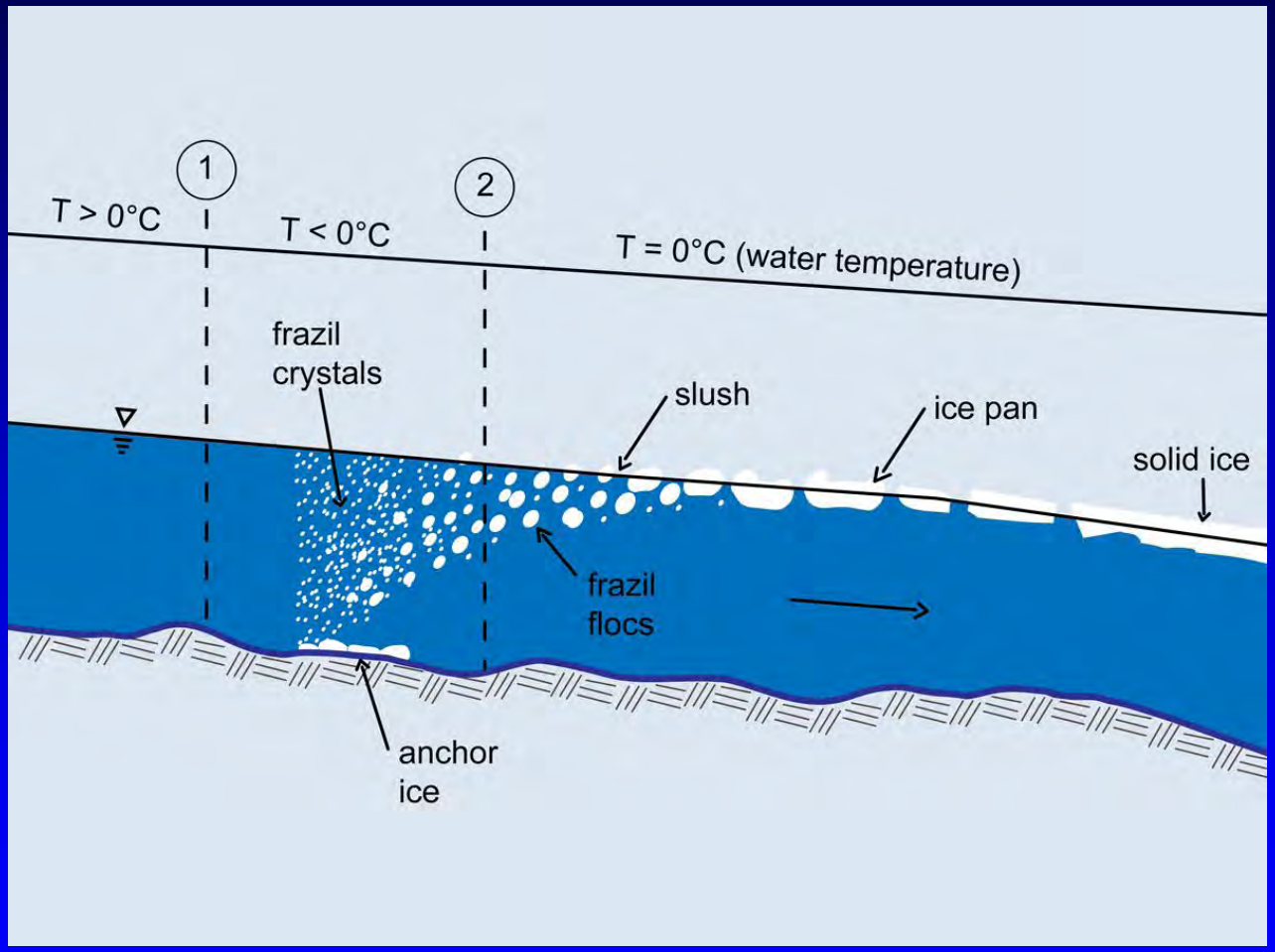



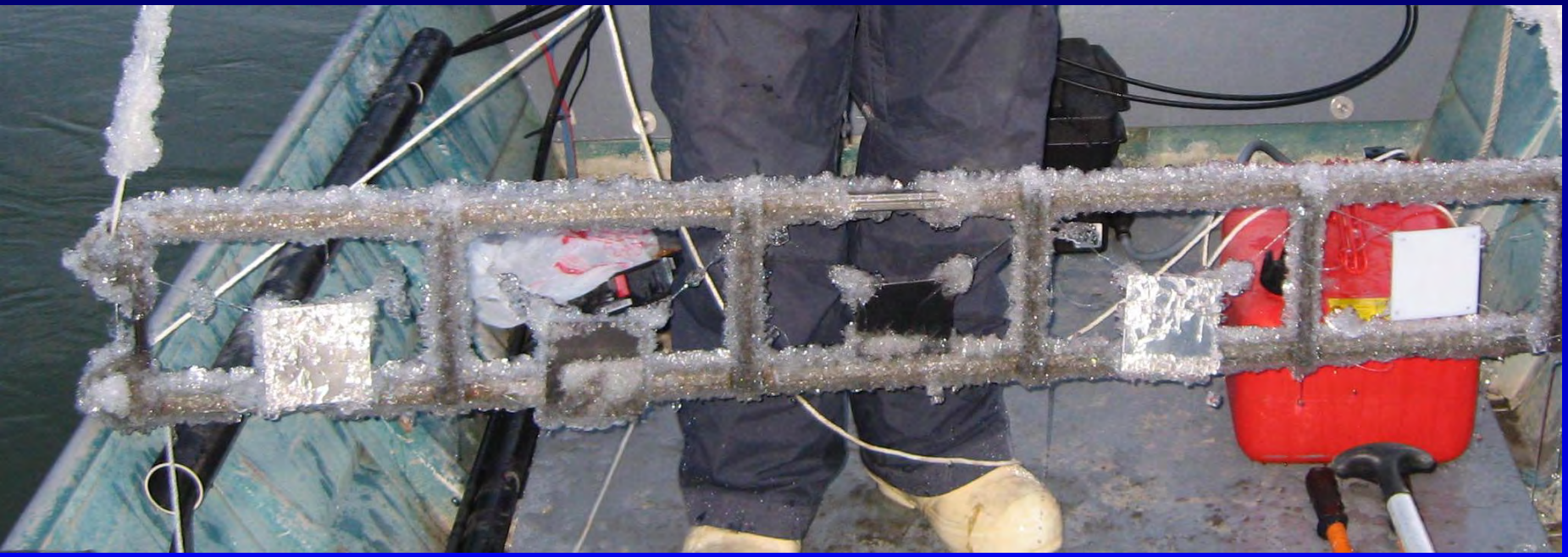
# Ice Condition Effects

- Freeze-up
  - Frazil ice formation
    - When water temperature < 0°C
    - Forms ice buildup on all object in water
  - Ice sheet formation
    - Changes in water current velocity and stage
- Winter ice sheet
  - Constricted channel depth
  - Hanging frazil ice granule curtains
- Breakup
  - Potential impact and riverbed gouging

# Frazil Ice Evolution

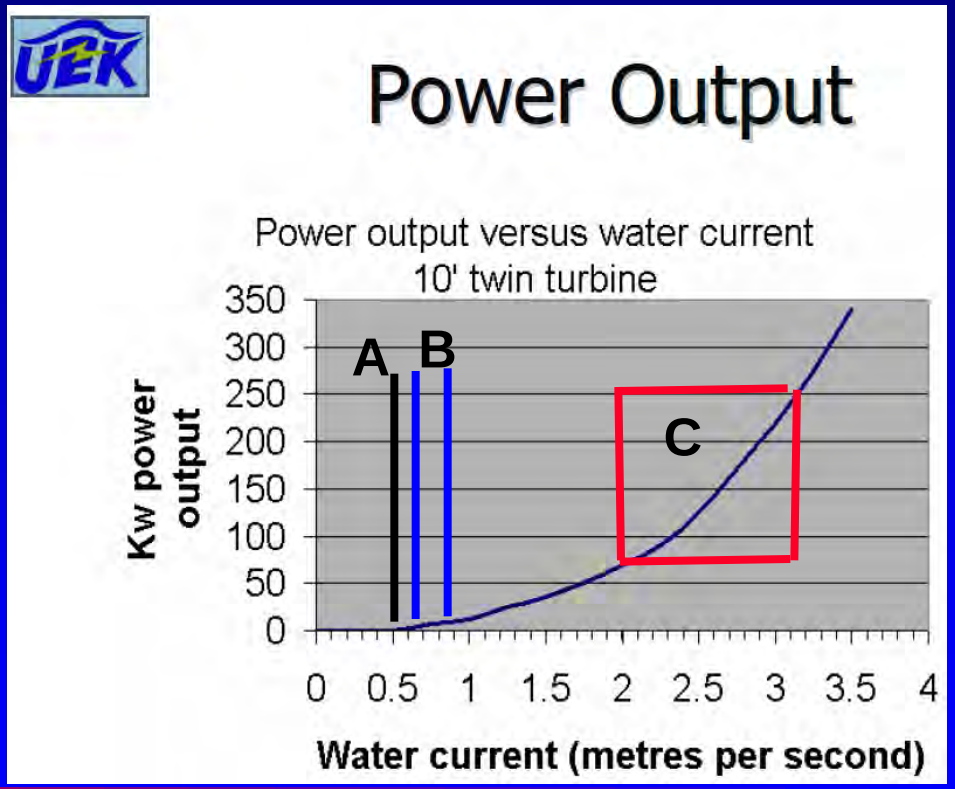


# Frazil Deposition



# Power Requirements for Turbines

- Hydrokinetic turbines have a resistance to motion that must be overcome (A)
- An electric power generation curve that is non-linear with respect to current velocity
  - Tanana Max. range (B) - 2009-2010 (ice-covered)
  - Tanana Max. range (C) - August, 2009 (open water)



# Hydrokinetic Devices- Potential Impacts

- Fish stress/ mortality
- River stage
- Sediment disruption
- Shear stress
- Noise
- Electromagnetic fields
- Toxicity (coatings, etc.)

# Migratory Resident Fish

Arctic grayling

Burbot

# Anadromous

Coho salmon

Chum salmon

Chinook salmon

# Juvenile Salmon

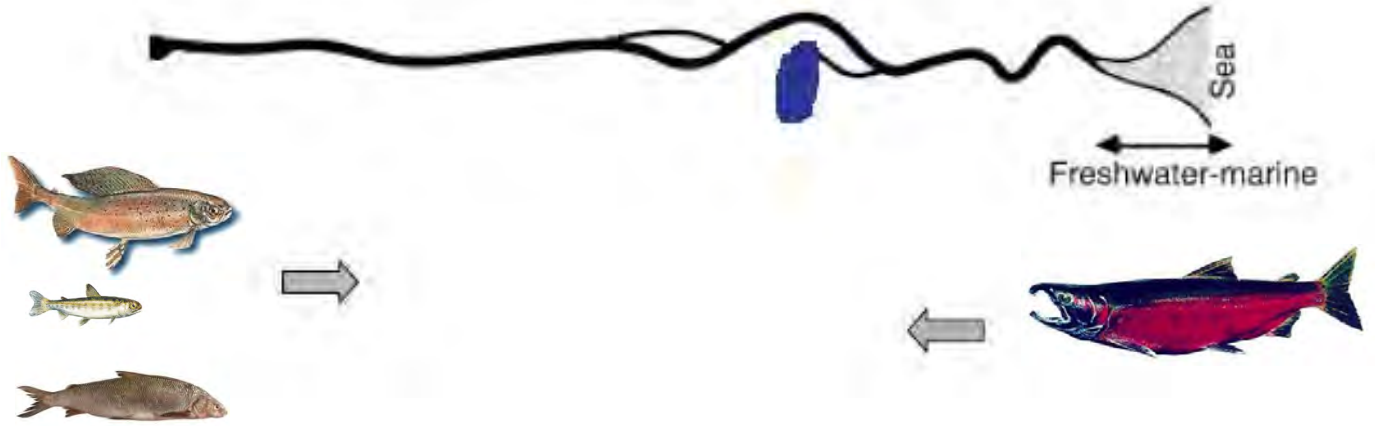
Coho salmon

Chum salmon

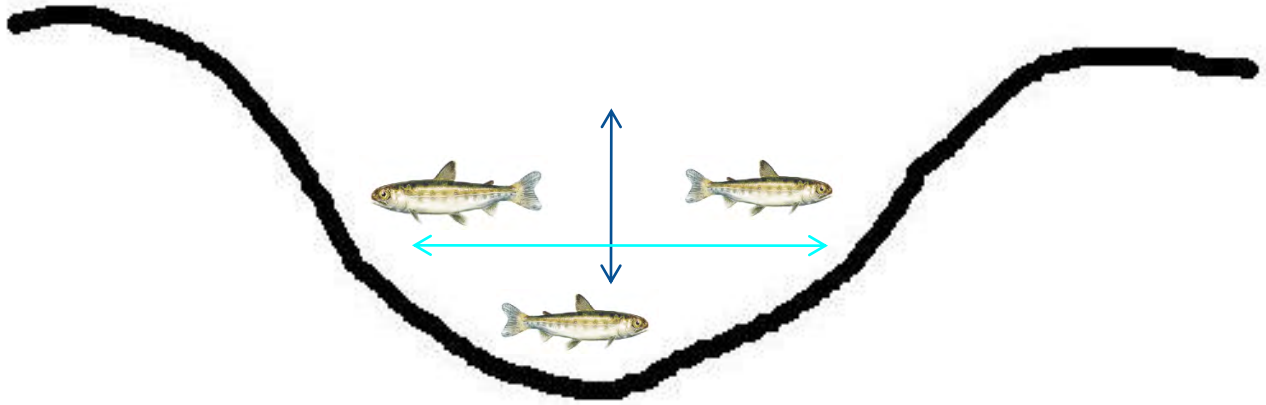
Chinook salmon

# Knowledge Gaps

**Large scale/Longitudinal Movement**




**Lateral and Vertical Movement**



# Tanana Fish Movement

## (incomplete)

| Fish Type | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEPT | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Resident Fish** | | | | | | | | | | | | |
| Whitefish | | | | | | | | | | | | |
| Burbot | | | | | | | | | | | | |
| Arctic Grayling | | | | | | | | | | | | |
| **Anadromous** | | | | | | | | | | | | |
| Chum salmon Š fall run | | | | | | | | | | | | |
| Chum Š summer run | | | | | | | | | | | | |
| Chinook salmon | | | | | | | | | | | | |
| Coho Salmon | | | | | | | | | | | | |

| | |
|---|---|
| Upstream movement | |
| Downstream movement | |
| General movement associated with feeding | |

# Summary

- The hydrokinetic resource at the Nenana test site is optimal for power generation from May - Sept. decreasing through Oct.
- Turbulence and discharge indicate a stable high specific power channel in the upper part of the test reach and shifting channel in the lower reach.
- Frazil ice growth conditions occur throughout October
- Fish migrate upstream and down stream throughout the open water and ice covered seasons
  - Many gaps about fish populations and behaviors exist
- Future work will include studies on:
  - Improving knowledge of river dynamics,
  - Fish populations and behaviors
  - Debris
  - Turbine interactions with the river environment.

# Debris - Log Raft Versus Fish Wheel