Note to students:

This presentation received a 46/50 as graded by me and their fellow students. Keep in mind, the grade also reflects things you didn't see (delivery, presentation, participation, etc.). The content was very good, too long, way too much text, and the delivery was good. I thought this was an interesting MI issue and the students liked the quote they incorporated. Their grade was higher than it would have been normally since they were the only group to go on the first day of presentations.

Greg

BIO 365: Group Project
Mercury Contamination

Chemistry (Review)

- Atomic Symbol: Hg
- Heavy Metal
- Liquid at standard conditions of Temperature and Pressure
- Naturally occurring
- No known human physiological uses
- Potentially very hazardous (National Academy of Sciences—1978)
- Primary Exposures through the consumption of fish (World Health Organization-1989)

Toxicology

- Hg is a neurotoxic agent: especially in developing embryos, prenatal development, adolescence, and general neural growth

Specific Neurotoxicity

- Decrease cognitive performance in children (Grandjean et al 1998)
- During the proliferation stage of cellular development a G2-M Phase arrest is seen (stoppage of Mitosis) due to microtubular disruption (Miura et al 1999)
- During the differentiation stage of neuronal development the microtubular network is disrupted greatly inhibiting the development of dendrites and axons (Heidemann et al 2001)
- Preferentially inhibits the Voltage Sensitive Calcium Ion Channel of neurons over any other cells (5x more MeHg needed to inhibit other cell's Calcium channels) (Sirois and Atchison 2000)
  - Decreases Efficiency of Synaptic Transmission

Fukuda-1998

- Increased prevalence in neurological complaints including:
  - Heart palpitations
  - Stiffness in the shoulders, neck and back.
  - tingling in the hands and legs
  - Staggering when standing
  - Tremors in the hands
  - Dizziness
  - Tinnitus (ringing of ears) at low tones
  - Difficulty hearing
  - Loss of pain sensation in the legs and hands
  - Cramps in the hands and limbs
  - Muscular atrophy in the hands and limbs
  - Fatigability
  - Visual Dimness

Hg Sources (Review)

- Medical Waste Incinerators (27%)
- Coal-fired power plants (21%)
- Refuse incineration (23%)
- Disposal of commercial products containing Hg
- Dental amalgams
- Metal Smelters (Sudbury, Ontario)
- Mining and Mining Wastes
- Anti-fungal drugs and pesticides

Applicable environmental regulations

- MCL 324.3109 (Michigan regulation): A person shall not directly or indirectly discharge into the waters of the state a substance that is or may become injurious to any of the following:
  - Public Health, safety, and welfare
  - Causes harm to flora and fauna
  - Any of the Designated Uses of the Waters of the state

Designated Uses

- Public water supply
- Industrial water supply
- Agricultural water supply
- Recreation
- Fishing
- Other aquatic life
- Wildlife
- Navigation

Backround Bioremediation Studies : Aquatic Systems

- Mozambique Tilapia (*Oreochromis mossambicus*) used as test fish
- water hyacinth (*Eichhornia*), aquarium watermoss (*Salvinia*), water thyme (*Hydrilla*), muskgrass (*Chara*), and wild celery (*Vallisneria*) used as remedial vegetation

Experimentation Setup

- LC100 (lethal conc. at which 100 % mortality occurs) for Tilapia previously determined to be 1.0 ppm for $HgCl_2$
- Aquatic plants were allowed to remain in contaminated water for 48 hours
- 9 different experimental sets
  - 2 control groups
  - 1 set with all plants in system
  - 1 set without any plants
  - 1 set for each of the individual plant types

Results

- As expected, 100% fish mortality in set without plants
- 20% fish mortality in the *Eichhornia* set
- Mortality ranged from 40-80% in the other individual sets
- Concentration of Hg in tissue of fish dropped 76% in combined plant set
- Concentration of Hg in the water dropped 80% in the combined plant set

What This Means

- All plant sets decreased levels of Hg contamination in the water
- Combined plant set most successful because of the types of plants used
  - *Eichhornia* and *Salvinia* are floating plants which absorb Hg in the surface layer
  - *Chara* and *Hydrilla* are plants present in the column of the water system
  - *Vallisneria* is a benthic plant and takes up the Hg through it's root system

What This Means (cont'd)

- The Hg taken up by these plants is stored in their tissues
- It is suggested by this experiment that resultant plant growth can be harvested regularly, each time leaving some plants to regrow a new crop, so that the water purification becomes a continuous process. (Shrivastava and Rao 1997)

Upper Peninsula Issues

We Haven't really touched on any of these issues this semester, so we thought we would

Introduction to the Deer Lake issue.

Testament of a Fisherman

by Robert Traver

- I fish because I love to
  because I love the environs where trout are found
  which are invariably beautiful;
  because of all the television commercials, cocktail parties,
  and assorted social posturing I thus escape;
  because, in a world where most men seem to spend
  their lives doing things they hate,
  my fishing is at once an endless source of delight
  and an act of small rebellion;
  because trout do not lie or cheat and cannot be bought
  or bribed or impressed by power,
  but respond only to quietude and humility and endless
  patience;

- because I suspect that men are going this way for the last time
and I for one don't want to waste the trip;
because mercifully there are no telephone on trout waters;
because only in the woods can I find solitude without loneliness;
because bourbon out of an old tin cup always tastes better out there;
because maybe one day I will catch a mermaid;
and, finally, not because I regard fishing as being so terribly important,
but because I suspect that so many other concerns of men
are equally unimportant
and not nearly so much fun.

John Voelker, aka Robert Traver (pen name) (1903-1991)

- **Practiced law for a brief time in Chicago, but was a Lifelong Ishpeming resident**
- **University of Michigan Law School 1928**
- **Michigan Supreme Court Judge 1957-1959**
- **Writings include Trout Magic, Trout Madness, Small Town D.A., Laughing Whitefish, and Anatomy of a Murder**
- **Anatomy of a Murder, made into a 1950s motion picture and nominated for 7 academy awards including best picture.**

John Voelker (1903-1991)

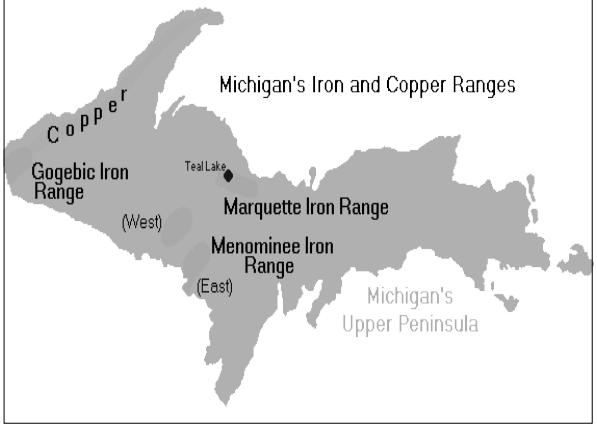
- One of the most widely read outdoor authors of our time.
- Widely respected and devoted flyfisherman
- And in a twisted sort of irony John Voelker, who embodied much of the values of the Upper Peninsula's people had a home overlooking Deer Lake's South Shore.

AOC Deer Lake

A 906 Acre Lake,
North of Ishpeming, Michigan

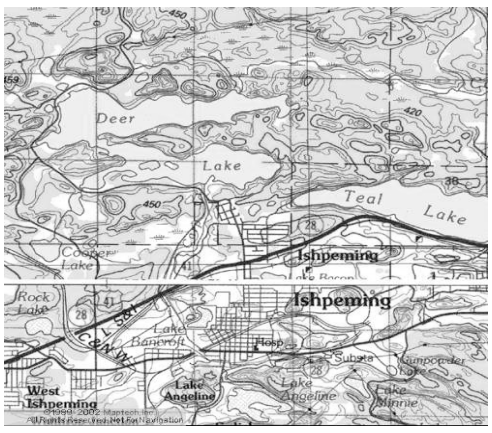
Deer Lake Introduction

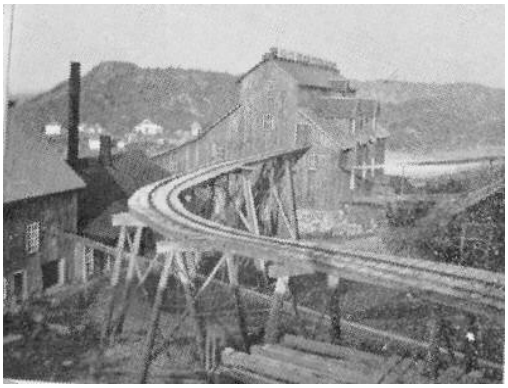
- To date, there is not only an advisory on the consumption of fish taken from Deer Lake, but it is *Illegal to possess fish taken from Deer lake.*
- In 1981 measurements in excess of 1.5ppm mercury were taken from fish in the lake.
- Sediment levels ranged from 2.0-16.0ppm.
- Primary Polluters: Nearly 150 years of the mining industry.



Primary Polluters

- Ropes Gold Mine
  - In operation for 14 years beginning in the early 1880's.
  - Produced $654,000 worth of gold in the 14 years (1880's $$$ not quite the same at 2003 $$$)
  - Prior to 1897 the primary processing reagent of gold was mercury, with little environmental regulations
  - Ropes mine no longer in existence, not a factor in remediation or possible litigation

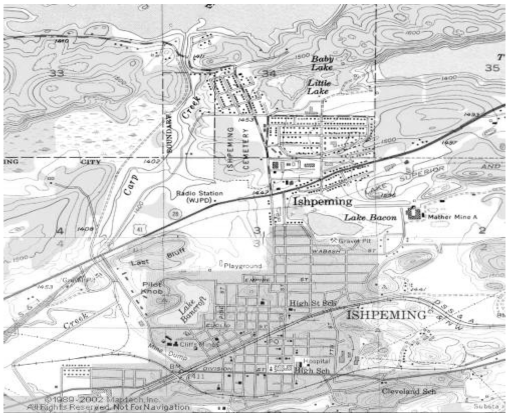




Primary Polluters

- Cleveland Cliffs Iron Company
  - Laboratory in Downtown Ishpeming assays and analysis of iron samples from various mines and mining processes
  - Mercury used in Iron Ore Research at the Division Street Lab passed into the Ishpeming Wastewater treatment facility and subsequently into the Carp River for about 50 years.
  - The mercury made its way downstream to Deer Lake (technically a basin, has a dam→stopped further downstream contamination)
  - Division Street Lab discharges also passed to Deer Lake creating massive algal blooms
  - The Division Street Lab was replaced in 1985

No real way of telling which polluter contributed the majority of the pollution, but CCI has accepted a generous amount of responsibility as they are the only viable of the two companies.



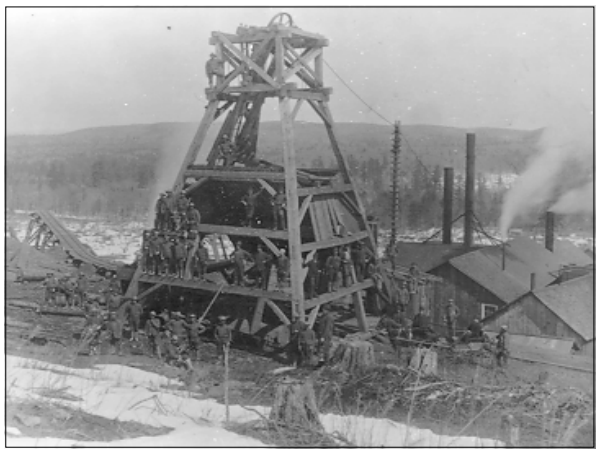
Cleveland Cliffs Iron Company

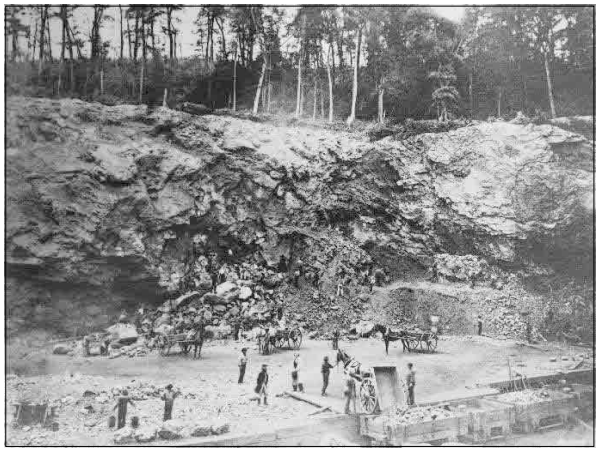
- Compare Detroit & GM/Ford/Chrysler with Marquette County & CCI
- Economy of the Central Upper Peninsula dependent on the operations of CCI
- Tilden Mine and Empire Mine CCI managed and fully or completely owned by CCI
- LS&I Railroad, Wisconsin Electric (formerly UPPCO), Shipping Industry, Blondeau Trucking, A. Lindberg and Sons, and many other companies are all highly associated with CCI

CCI History

- Iron Ore discovered in Negaunee, MI in 1844
- A group of investors from Cleveland, Ohio formed the Cleveland Iron Company on November 9th, 1847, 1st public stock issued November 27, 1847.
- Cleveland Mine opened in 1853 producing 4000 tons of high grade ore in it's first year of production
- 1890-Iron Cliffs Mining Company (Samuel Tilden) and Cleveland Iron Company (William Mather) merge to form the Cleveland Cliffs Iron Mining Company
- By 1905 the Jackson Mining Company merged completing the mergers of the three dominant companies in Michigan Iron Mining
- Therefore Creating a virtual monopoly on the Marquette Iron Range

A Century of Amazing Technological Advances Allows Mining on the Marquette Range to Go From This. . .





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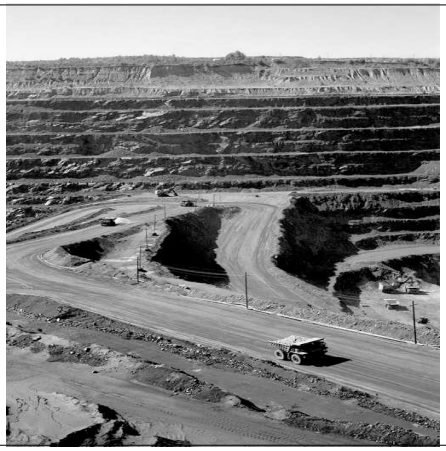

Advancements @ a Price

- Many of the advancements would not have been possible without the Division Street Lab in Ishpeming
- A joint agreement between CCI and the Michigan DNR was reached in 1984
- In 1997 a Public Advisory Council was also formed consisting of 20 representative individuals
- Remediation was begun

Initial Discovery Levels in Deer Lake

- Fish levels exceeding 1.5ppm
- Sediment levels 2-16ppm
- Herons, Kingfishers, and Bald Eagle concentrations of 40ppm
- Bald Eagles producing eggs that don't hatch

Remediation

- Deer Lake was drained from a 906 acre lake down to 90 acre lake beginning in late 1984.
- In late 1986 Rotenone was used to kill the remaining fish in the lake
- Carp Creek was routed around the lake during this time
- Deer Lake was refilled in 1987
- Northern Pike were initially stocked and Walleye were stocked annually through 1991
  - Fisheries biologist concur that natural reproduction has been deemed successful

Remediation

- Deer Lake has developed into an excellent fishery for both walleye and northern pike species
- Designated a catch and release fishery by the MDEQ
- Deer Lake fish continue to exceed the 0.5ppm level

Positive Signs

- The 2002 Michigan fish advisory still find that Hg levels in Deer Lake fish exceed 0.5 ppm (but are on the decline), and therefore are deemed unsafe for consumption. (which has little consequences since it is a catch and release fishery)
- Exception to those fish caught in Deer Lake tributaries.
  - Brook Trout tested averaged 0.17ppm Mercury, (possible reasons for: their diet)

Positive Signs

- In 1998, for the first time in at least 20 years, A bald eagle in the Deer Lake vicinity produced 2 viable, hatching eggs

Future Outlook

- "The Remedial Action Plan will be updated, which will aid agency staff when management strategies come up for review.
- Stream clean-ups and beaver dam removals will continue.
- A lake clean-up is in the planning stage.
- Water quality monitoring by public schools will continue.
- The PAC will assist with the release of state and Cleveland Cliffs Iron Company negotiations for public review and comment.
- "Testing and monitoring around the lake will continue."
  - Deer Lake Public Advisory Council, 1999

Future Outlook

- Cleveland Cliffs will most likely continue to be a responsible company when dealing with environmental contaminants.
- Historically, CCI has worked with community groups for betterment of the communities they operate in.
  - College Scholarship Programs
  - Involvement in Local Schools
  - Community Program Sponsorship

With continued yearly monitoring, only time will tell whether efforts have been successful in reducing the mercury level in Deer Lake

Who knows maybe within 5 or 10 more years the Mercury Levels will drop below the 0.5ppm action level

References:

- http://www.epa.gov/glnpo/aoc/drlake.html, through www.great-lakes.net
- Ropes Gold Mine Photographs courtesy of Michigan Technological University.
- Iron Range Upper Penninsula Map, http://www.geo.msu.edu/geo333/ishpemingnegaunee.html
- Maps courtesy of http://mapserver.maptech.com

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