The St. Marys River

White Sucker Tumour Prevalence and Potential Causes

Presentation Overview

- Types of fish tumours and their causes
- The IJC fish tumour BUI guidelines
- Results of the St. Marys River and Upper Great Lakes tumour research
- Causal probabilities and future choices

Potential Causes of Fish Cancer

1) Genetics
   - Unlikely for wild populations
2) Radiation
   - Unlikely for aquatic animals
3) Virus
   - Yes for skin, No for liver tumours
4) Chemical Carcinogens
   - Relatively few in aquatic systems

Classes of Tumours used in Great Lakes Fish Studies

i. **External (Skin and Lip)**
   - Cancers
   - Papillomas

ii. **Internal (Liver)**
   - Cancers (Liver cells or bile duct cells)
   - Neoplasms
   - Preneoplasms : Not considered tumors, not recommended for BUI since many never become tumors

Biomarker Traits: Strong to Weak

Causal Certainty

- Liver neoplasms
- Skin neoplasms
- Barbel deformities
- Altered Foci

Sensitivity

- Barbel deformities
- Altered Foci
- Skin neoplasms
- Liver neoplasms

Evidence that PAHs Cause Liver Cancer in Fish I.

- Liver tumour epizootics have been correlated with PAHs in 11 species: 3 East Coast, 4 Great Lakes, and 4 West Coast
- Fish tumour rates are positively correlated with changes in PAH sediment concentrations.
- Fish exposed to PAH carcinogens in water developed liver cancer.
- Sac fry injected with PAH sediment extracts developed liver cancer

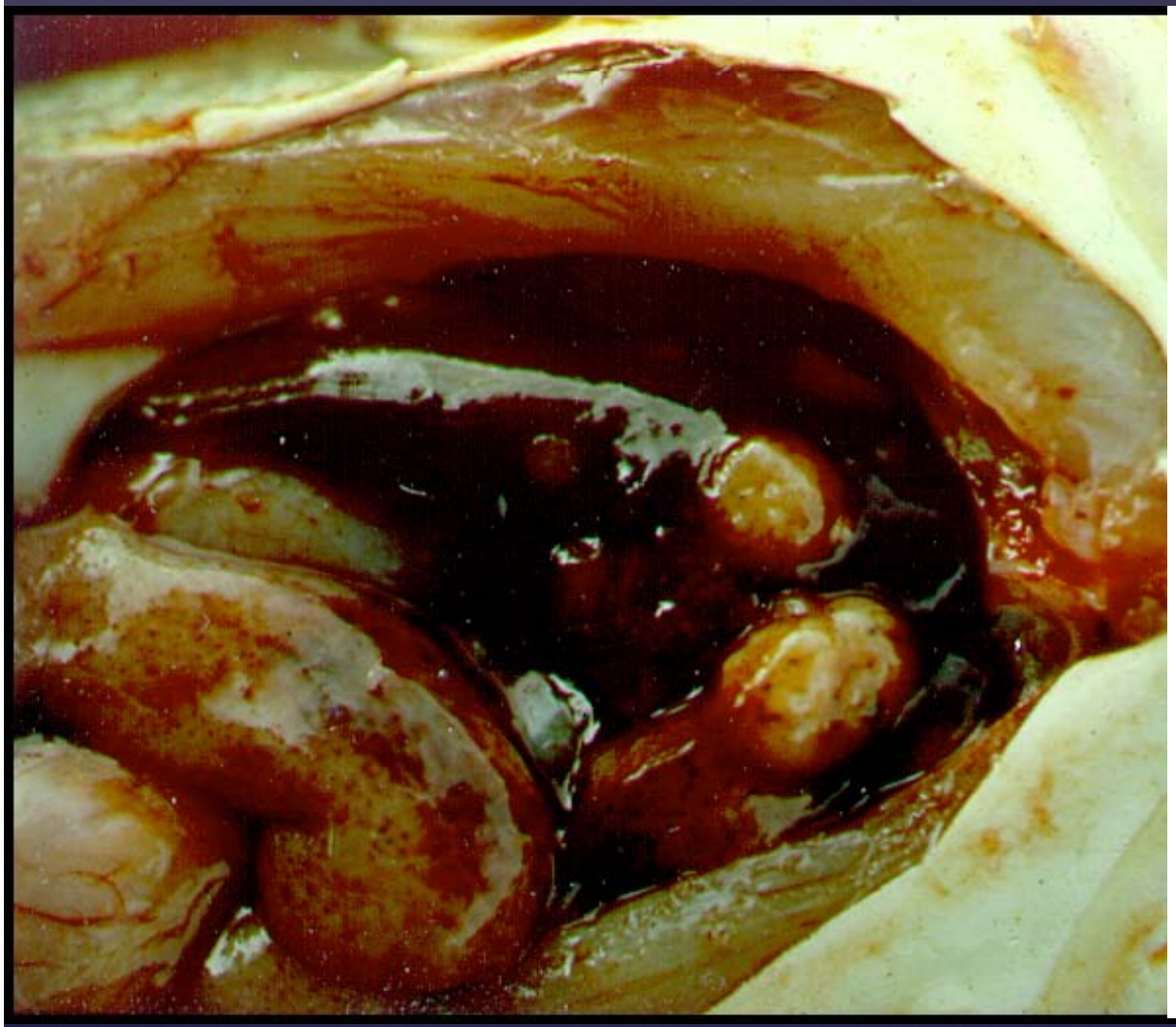
Evidence that PAHs Cause Liver Cancer in Fish II.

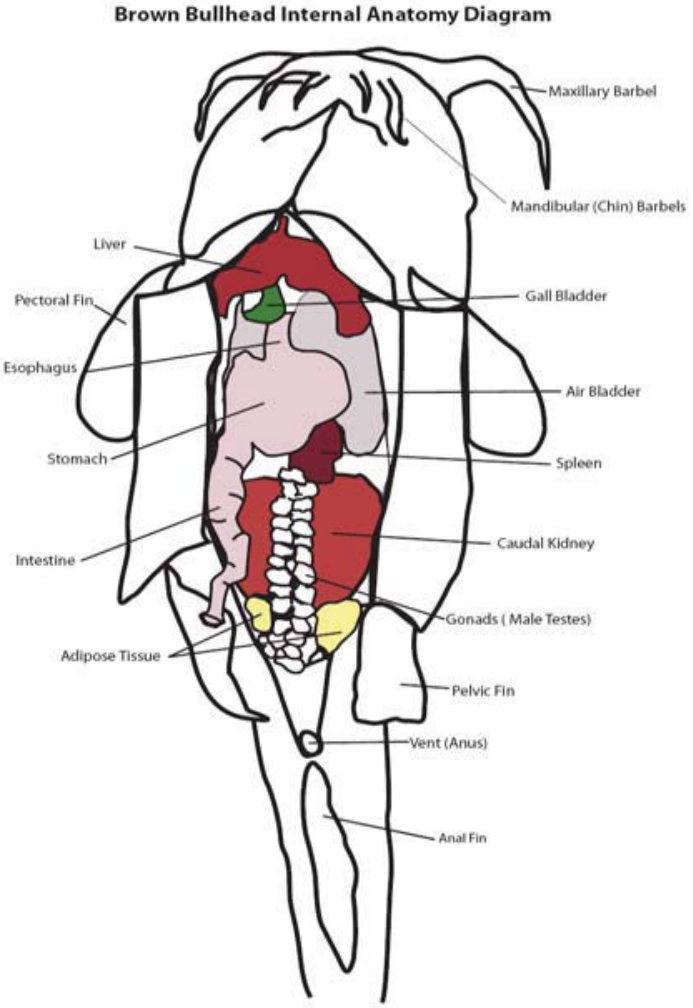
- Fish fed PAH sediment extracts developed liver cancer
- In laboratory experiments fish livers converted B(a)P to a diol-epoxide (ultimate carcinogen)
- Fish exposed to PAH formed PAH/DNA adducts.
- Elevated PAH/DNA adduct levels were found in fish from contaminated Great Lakes locations

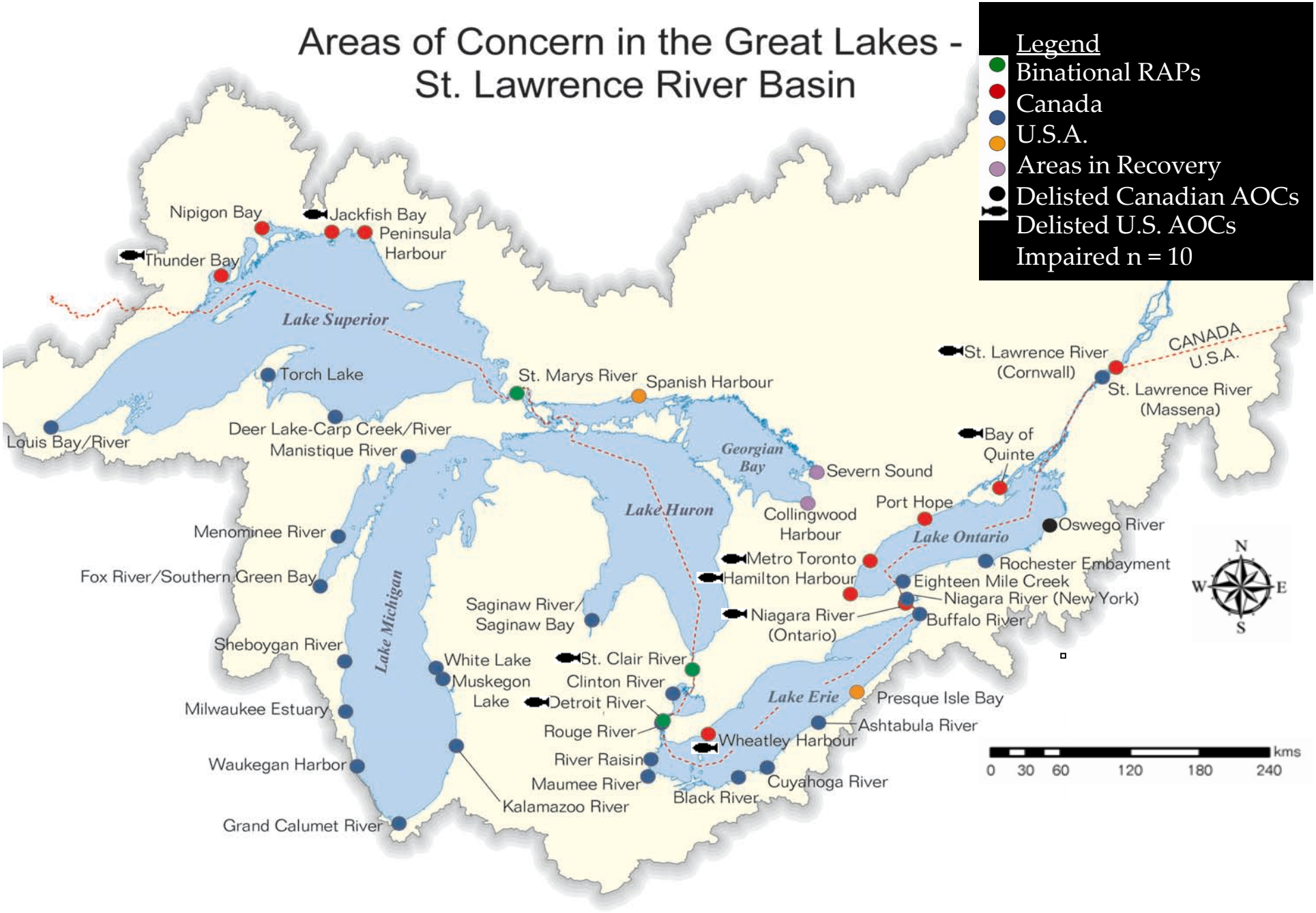
USX Facility

Coke Plant Outfall

Liver Tumors






Areas of Concern in the Great Lakes -
St. Lawrence River Basin
Legend
Binational RAPs
Canada
U.S.A.
Areas in Recovery
Delisted Canadian AOCs
Delisted U.S. AOCs
Impaired n = 10
Nipigon Bay
Jackfish Bay
Peninsula Harbour
Thunder Bay
Lake Superior
Torch Lake
St. Marys River
Spanish Harbour
Louis Bay/River
Deer Lake-Carp Creek/River
Manistique River
Georgian Bay
Severn Sound
Lake Huron
Collingwood Harbour
Menominee River
Fox River/Southern Green Bay
Lake Michigan
Saginaw River/ Saginaw Bay
Sheboygan River
White Lake
Muskegon Lake
St. Clair River
Clinton River
Detroit River
Milwaukee Estuary
Rouge River
Waukegan Harbor
River Raisin
Maumee River
Kalamazoo River
Grand Calumet River
Black River
Lake Erie
Wheatley Harbour
Presque Isle Bay
Ashtabula River
Cuyahoga River
Metro Toronto
Hamilton Harbour
Niagara River (Ontario)
Lake Ontario
Port Hope
Oswego River
Rochester Embayment
Eighteen Mile Creek
Niagara River (New York)
Buffalo River
St. Lawrence River (Cornwall)
CANADA
U.S.A.
St. Lawrence River (Massena)
Bay of Quinte
N
W
E
S
kms
0 30 60 120 180 240

IJC Delisting Guidelines for BUI #4: Fish Tumours, 1991

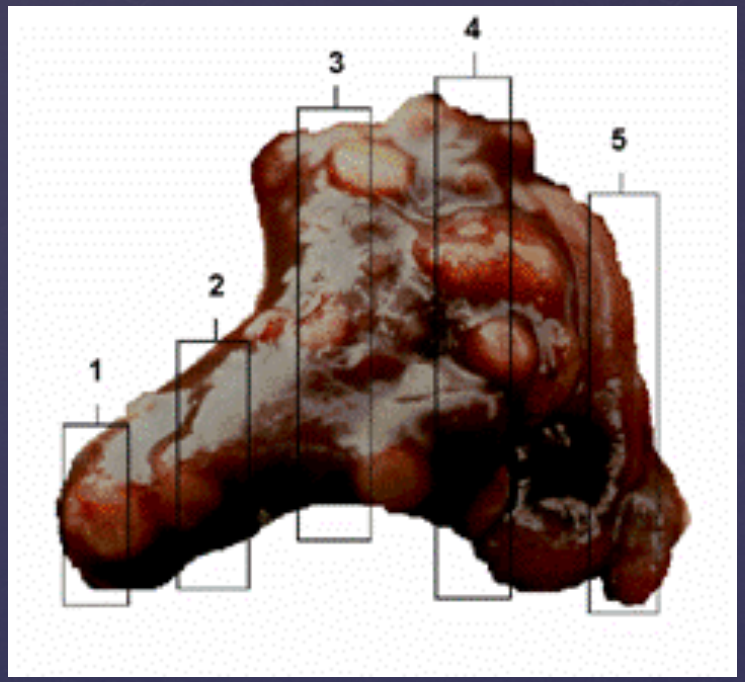
When the incidence rates of fish tumours or other deformities do not exceed rates at unimpacted control sites

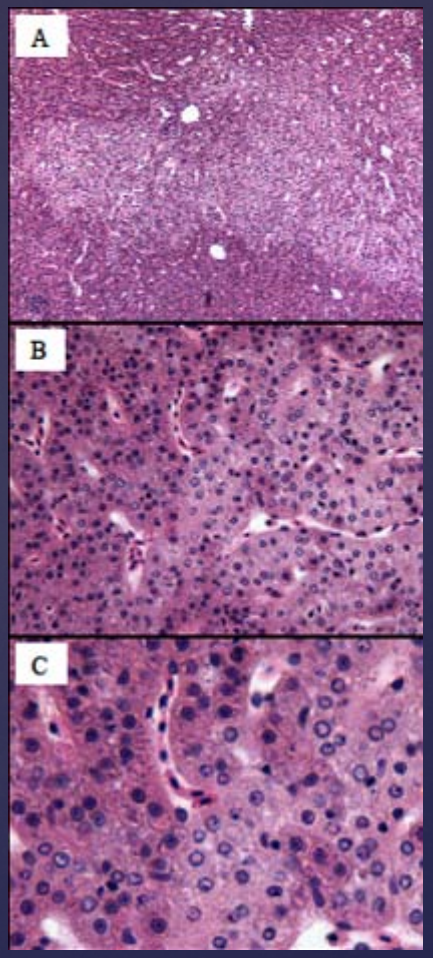
When survey data confirm the absence of neoplastic or preneoplastic liver tumours in bullheads or suckers

St. Marys River AOC Delisting Criteria

This beneficial use will no longer be impaired when a survey from within the AOC of a locally abundant member of the sucker family, encompassing a diverse age range, indicates a liver tumor prevalence rate of less than 5% - and/or – which is *not statistically* different from that of a suitable reference site.

In the Laboratory



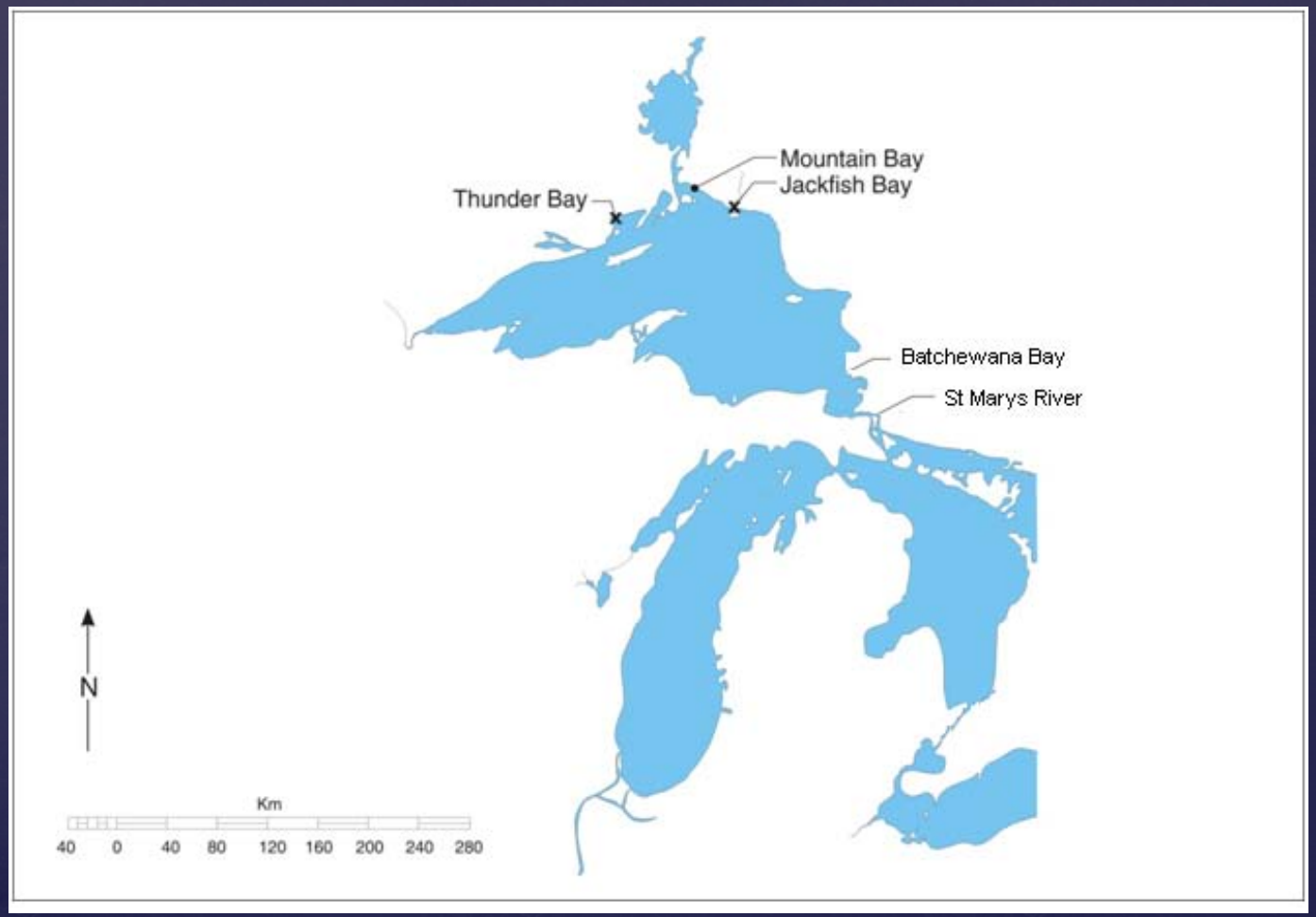


Acknowledgements

Environment Canada collected the fish (White suckers) from two locations within the AOC, and a Lake Superior reference site

Fisheries & Oceans Canada completed the actual liver tumour diagnosis

Location of St. Marys River and Batchewana Bay



White Sucker Liver Tumour Surveys1982 to 1990 with Prevalence less than 3%

Location in Ontario	N	Liver Tumor Prevalence
Hamilton Harbour	168	1.2%
Forty Mile Creek	133	0.0
Bay of Quinte	239	0.4
South Bay	228	0.0
Lake Nipissing	231	0.4
Black Bay	231	0.0
Total/Average %	1,230	0.3

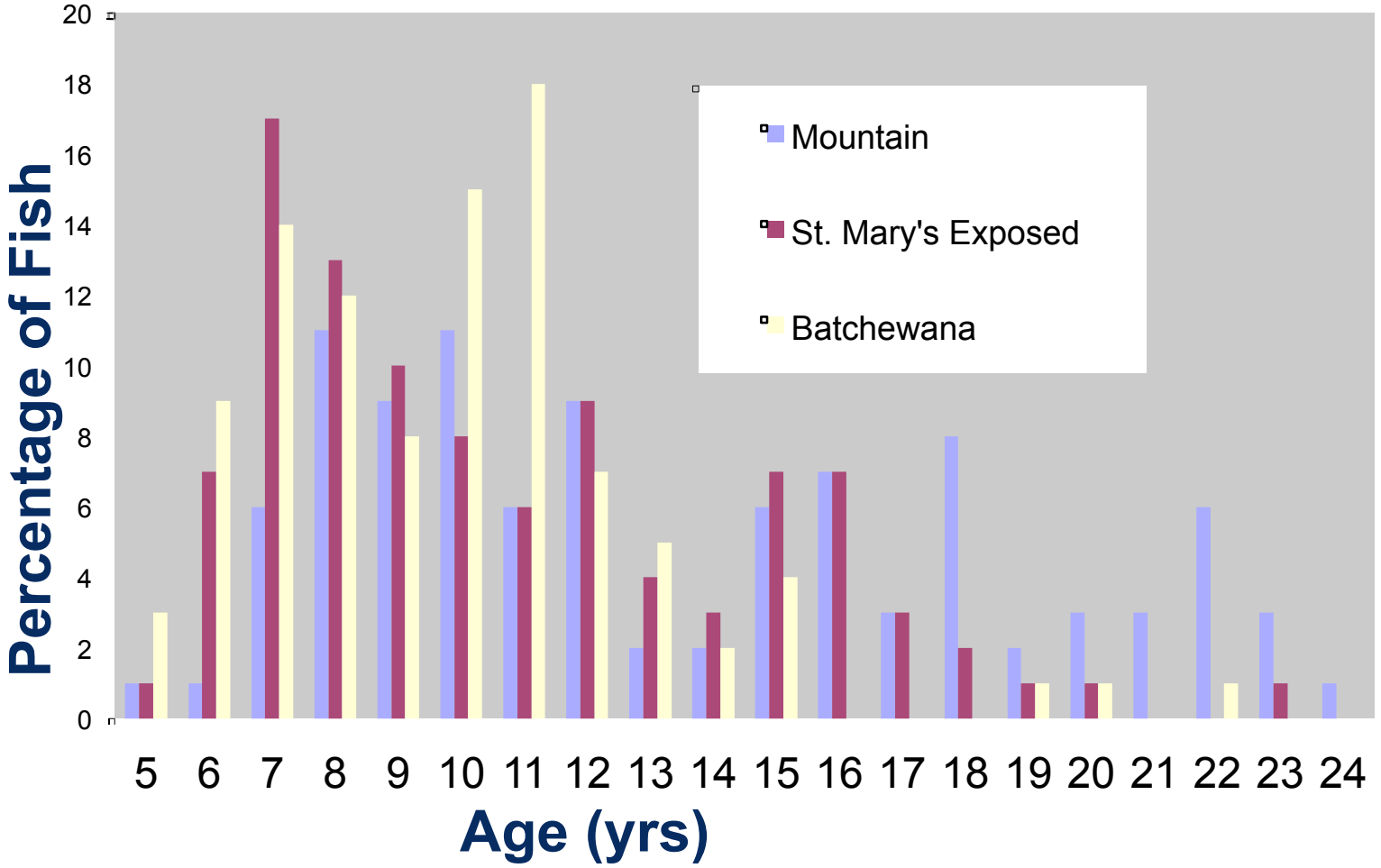
Prevalence of white sucker liver neoplasms in Lake Superior from 1985-1990 (R=Reference)

Location	Survey Date	N	% Neoplasms
Jackfish Bay (AOC)	1985-90	194	7.1
Thunder Bay (AOC)	1985-90	112	7.1
St. Marys River (AOC)	1985-90	184	9.2
Batchewana Bay (R)	1985-90	230	8.6
Mountain Bay (R)	1985-90	75	2.4

Prevalence of white sucker liver neoplasms surveyed in Lake Superior waters from 2006-2009 (AOC= Area of Concern; R=Reference site; S=St.Marys River)

Location	Date	N	% Neoplasm
Jackfish Bay (AOC)	2006-07	100	0.0
Thunder Bay (AOC)	2006-07	100	2.0
Batchawana Bay (R)	2009	100	5.0
Mountain Bay (R)	2006-07	100	0.0
Combined References	2006-2009	200	2.5
Bellevue (S, AOC)	2009	100	12.0
Partridge Point (S, AOC)	2009	41	7.0
St. Marys River Combined (AOC)	2009	141	10.6

Age Distribution of Fish Sampled



Fish with neoplastic tumours collected from the St. Marys River

Age (years)	Length (cm)	Weight (grams)
St. Marys River – Bellevue Marina		
6	40.4	894
8	42.1	1047
9	46.9	1234
11	45.3	1368
14	49.5	1550
15	45.5	1258
16	40.6	1506
16	47.5	1423
16	47	1446
18	48.9	1031
19	50.9	1804
23	48.4	1373
St. Marys River – Partridge Point		
6	36.2	665
17	47.7	1492
21	49.6	1649

Dry weight (ppm) of benzo(a)pyrene [B(a)P] and total PAH in St. Marys River sediment (AOC and reference locations [R]).

Date	Location	B(a)P	Total PAH
1992	Point aux Pins Bay (R)	0.03	0.97
2006	Upstream Reference (R)	0.009	0.09
2010	Upstream Reference (R)	0.015-0.02	0.27-0.41
1992	West Algoma Slip	5.00	291.7
1990	Algoma Slip	0.77-50	18.5-2,389
1987	Bellevue Marine Park	0.55-3.08	12.2-61.5
2006	Bellevue Marine Park	0.19-3.2	2.5-30.9
2009	East Bellevue Marine Park	1.69-3.73	19.02-38.45
2010	East Bellevue Marine Park	0.96-1.42	20.04-29.47
2010	Lake George Channel	0.96-1.17	11.9-24.3
1992	Lake George	0.52	4.75

Ppm dry weight of benzo(a)pyrene [B(a)P] and total PAH in contaminated and reference areas [R] in the USA.

Date	Location	B(a)P	Total PAH
1980s	Tumour Epizootic Sites (9)	0.83-23.0	
1980s	Reference Sites (5, ave.)	0.07	
1986	Old Woman Creek (R)	0.01-0.12	0.23-0.63
2003-04	Conneaut River (R)	0.073	
1999	Huron River (R)		0.607
1980	Black River	43.0	1,096
1982	Black River	21.0	381
1984	Black River	8.8	185
1987	Black River	0.24	4.27

Conclusions and Recommendations

1. Two options for data:
   A. Older fish exposed pre-dredging

   B. Sediment PAH still too high

2. New fish survey to compare age and tumor prevalence data

3. New sediment samples to check PAHs

Thank You