Sarnia • Lambton Environmental Association

Industries Working Together

The St. Clair River - Biomonitoring

This monograph, one in a series of single issue documents dealing with Lambton County environment, has been prepared by the Sarnia-Lambton Environmental Association in co-operation with the School Boards of Lambton Kent.

Introduction

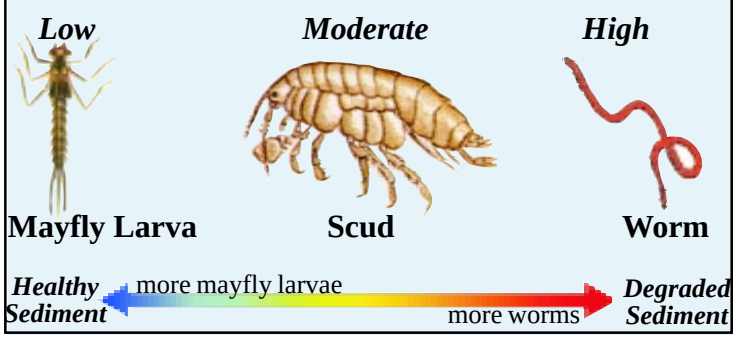
Biological monitoring techniques use living organisms to assess water quality and ecosystem health. These studies rely on the responses of living organisms to reveal changes in the ecosystem. Biomonitoring assumes that aquatic organisms are natural monitors of stresses placed on ecosystems and that responses to stresses are measurable.

The St. Clair River contains several biological levels that form its aquatic community; these levels include bacteria, plankton, aquatic plants, benthic organisms and fish. Since the 1950s, the Sarnia-Lambton Environmental Association, the Ministry of Environment, and others have been actively monitoring these life forms in the St. Clair River.

Facts

The St. Clair River
• Over 40 years of benthic studies show that the river's health is improving.
• Fish utilize all energy sources including benthic organisms, plankton, algae, plants.
• The river has the most abundant, diverse and healthy fish community of the 17 Canadian and Binational Areas of Concern as identified by the International Joint Commission. *MOE, 1991, page 273*

Benthic organisms have differing tolerances to pollution; their relative populations help indicate sediment quality



Key Words

benthic - pertaining to or living at the bottom of a body of water; more than 300 benthic species live in the river

bioaccumulation - the intake and retention of substances by organisms

biomonitoring - environmental assessment through the use of living organisms (eg. fish, water fleas)

ecosystem - an interacting complex of living organisms together with non-living factors in their environment

histology - a branch of anatomy which includes microscopic studies of plant and animal tissues

histopathology - deals with tissue changes associated with disease

in situ - in the original location; pertaining to sediments - at or near the bottom of the river

sediment - the fines or soils on the bottom of a river or lake

Benthic Studies Indicate Sediment Recovery

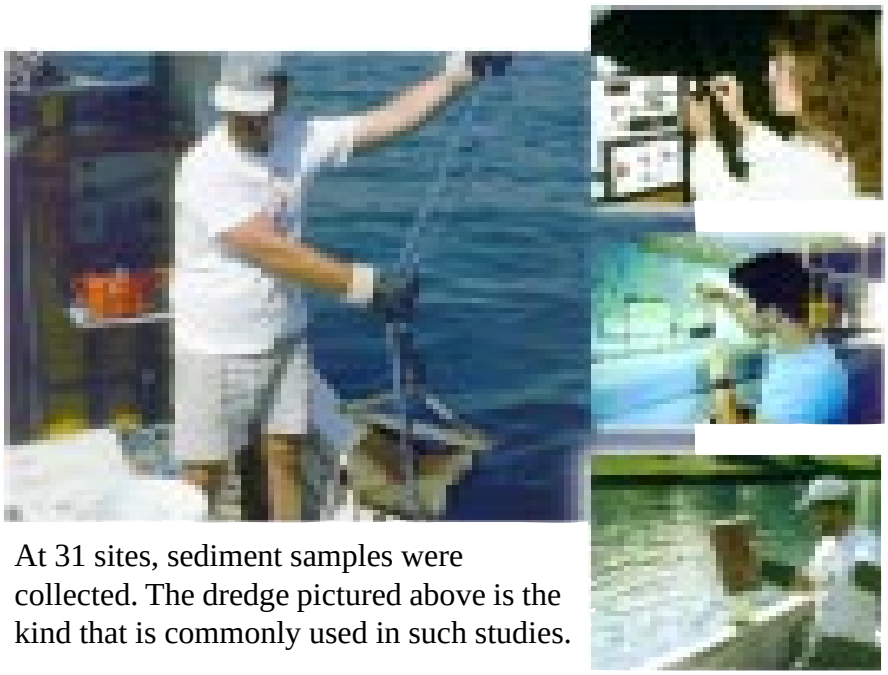
Sarnia-Lambton Environmental Association studies (1957) of the river bottom showed populations of benthic animals that were characteristic of degraded conditions. This study indicated a narrow band of reduced quality, ie. smaller populations and fewer species of benthic animals along the Canadian shoreline. The Ontario Ministry of Environment has also done successive studies which show increases in benthic species distribution; these results indicate progressive improvements to the river's health.

1957	- Contaminants in river sediments prompted remedial actions.
1957 to 1995	- Benthic studies document recovery of sediments along the Canadian shore; most have returned to unimpaired status.
1995	- Impaired sediments remain in three relatively small areas; they are the results of discharges that occurred up to 100 years ago.

Sediment Quality:

Since 1957, many sediment samples from both the Canadian and U.S. near-shore sections have been studied. ***Increased numbers of contaminant-intolerant species show that the sediment quality is returning to normal.***

An Integrated Study -1994 - 95



At 31 sites, sediment samples were collected. The dredge pictured above is the kind that is commonly used in such studies.

Chemistry
What contaminants are present?

Toxicity
Are aquatic organisms that live within or above sediments affected by contaminants?

Benthos
What organisms and how many of them are present?

Chemistry - Analyses of samples determine the kinds and amounts of contaminants present.

Toxicity - Test species are placed in water columns; each column contains a sediment sample. Toxicity evaluations are based on the following:

- 21 day Fathead Minnow to determine survival (acute response*)
- 21 day mayfly larva - survival and growth (acute & chronic response**)
- 10 day midge larva - survival and growth (acute & chronic response)
- 28 day aquatic worm - survival and reproductive success (acute & chronic response)

Benthos - The kinds and numbers of organisms are counted in each sample.

**** acute response*** - *response to a toxic material that rapidly results in death.*

***** chronic response*** - *a non-lethal response to a toxic material; eg. reduced reproductive success.*

1994 - 95 Study Results

The map below shows the sample site locations within the Zone 2 study area. The pie charts present a simplified summary of results for each of the elements of the study. The legend explains the significance of the colours for each segment. An example is provided for Zone 2, Site C, Nearshore.

Areas of Study

LEL (Lowest Effect Level)

a level of contamination that can be tolerated by the majority of benthic organisms

SEL (Severe Effect Level)

a level of contamination at which a pronounced detrimental effect on the sediment-dwelling community can be expected

LEGEND

Chemistry ***Benthos***

Zone 2, Site C Nearshore

Chemistry

- 7 compounds exceeded LEL
- mercury exceeded SEL;

Benthos

- the benthic community at this site was statistically similar to the reference sites, it is classified as unimpaired

Toxicity

- reproduction of aquatic worms was reduced, (lab tests)
- despite the laboratory results, aquatic worms accounted for 71% of the benthic community at the sample site. Pollutech1992

Integrating the results of the three individual elements of the study leads to the conclusion that toxic chemicals are stressing the system in Zone 2 at site C nearshore. Pollutech, 1992

1995 - 1996 In Situ Toxicity Studies

- Laboratory toxicity tests identify the "worst case" potential for biological availability which may not result in toxicity in situ. Additional work was done to evaluate the laboratory "worst case procedure" to more realistically simulate in situ exposures.
- A St. Clair R. sediment study (Moran, 1998) found significant differences in survival between laboratory and in situ (in river) toxicity tests for fathead minnows; laboratory 21-day static exposures resulted in significant mortality, while in situ 21-day exposures had no significant mortality.
- Differences in laboratory and in situ toxicity tests for the fathead minnow may relate to changes in bio-availability of sediment contaminants in laboratory conditions that do not occur in place on the river bottom.

Pollutech Env., 1999, page 90

1996 Establishing Reference Conditions - St. Clair River

Sediment quality is not pristine outside the study areas. The benthic community structure observed in the study areas is indistinguishable from that of the reference areas, despite the identification of contaminants that are relatively unique to the three study areas. *Pollutech Env., 1999, page ii*

Overall Study Conclusion

The initial 1994-95 studies (Moran et al) classified seven sediment locations as demonstrating strong evidence of pollution-induced degradation from sediments. Application of in situ toxicity testing results permits the former interpretation "strong evidence of pollution-induced degredation" to be more favourably expressed as "toxic chemicals are stressing the system".

Water Quality Assessment

In a healthy ecosystem, organisms are capable of survival, growth and reproduction. Undesirable conditions alter ecosystems; life systems are jeopardized. Biomonitoring studies have been used to assess the St. Clair River. These studies have involved two test areas, one upstream and the other downstream from the industries. Large and small test species have been used in these studies; particular attention has been given to vulnerable periods in life cycles, eg. reproduction.

Biomonitoring Studies - Some Examples

Areas of Study

Daphnia (Water Fleas)
size 0.2 - 3 mm

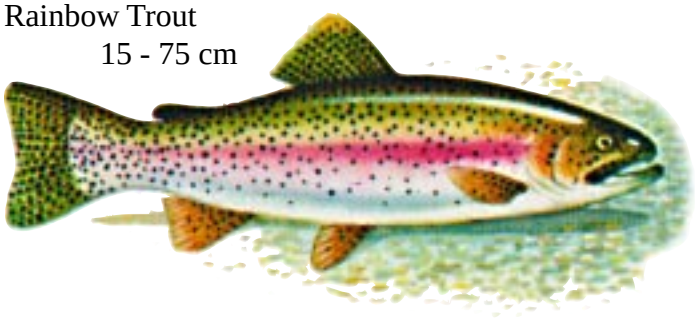
15 x
actual size

- survival
- reproduction success
- development to adult stage

Fathead Minnow
5 cm - 8 cm

- survival
- egg production/hatching success
- larval development to adult stage
- microscopic investigations of tissues
- similar investigations using offspring from previous year's study

Rainbow Trout
15 - 75 cm



- survival
- egg hatching success
- growth rates, flesh taste
- bioaccumulation determinations
- microscopic investigations of tissues

Pollutech, 1992

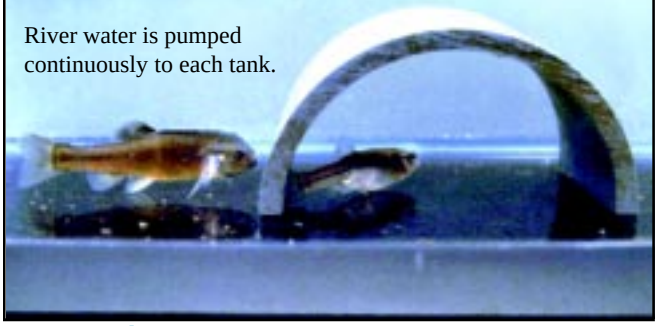
No significant differences have been observed when the test populations both upstream and down have been compared. Good water quality occurs both upstream and downstream from Sarnia/ Lambton industries and municipalities. Chemical monitoring of the river is described in *Monograph W1.*

Breeding Tank - Ten tanks were located upstream from industry; another ten were downstream.

The female Fathead Minnow deposits eggs on the undersides of rocks and sticks; the male fertilizes, guards and cleans them.

A semi-circular PVC section simulates natural surfaces for egg attachment.

River water is pumped continuously to each tank.



Life Cycle Studies - Fathead Minnows which are native to this area serve as a test species.

1992

20 breeding tanks were established; eggs were collected, counted daily and placed in incubators. Egg hatching success was charted and histopathological investigations were conducted.

1993

The same studies were continued using first generation fish from the 1992 experiments and also some of their offspring (second generation).

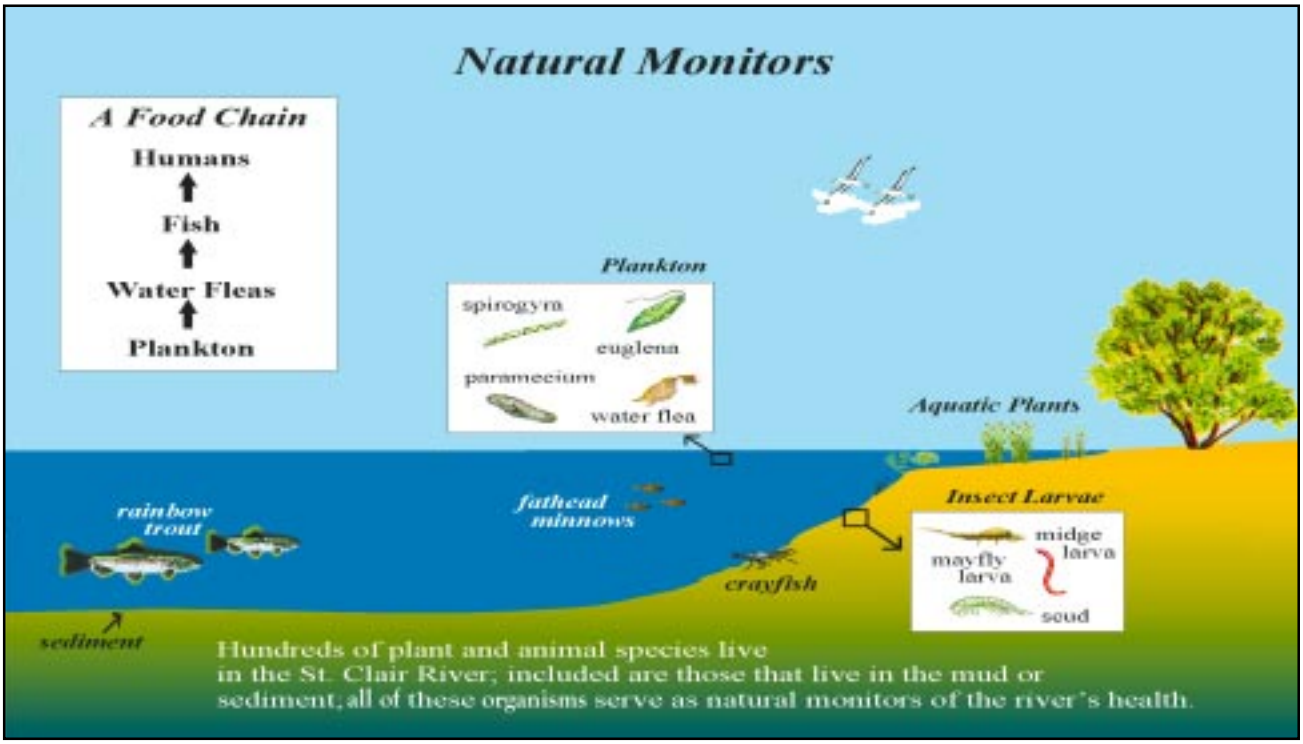
Conclusion

Fathead Minnows thrive and reproduce equally well at the upstream and downstream test locations.

(Pollutech, 1994, pages 22 -23)

Examples of St. Clair River Species That Have Been Studied

Recognizing that no single organism can give a complete picture of the river's health, several species are used in specific monitoring programs. The potential effects of water and sediment contamination on aquatic organisms, survival, growth and reproduction are some of the studies that have used species such as those pictured below.



Conclusion

Biomonitoring provides information that is generally unattainable from traditional physical/chemical monitoring techniques. Identifying causes of responses however, cannot be done without the inclusion of appropriate chemical analyses. Identification of specific causal links is very difficult.

Resources

Ontario Ministry of Environment (MOE)/Michigan Dept. of Natural Resources, St. Clair River Remedial Action Plan (RAP) Stage I, 1991 and Stage II, 1994

Pollutech 1992, Rainbow Trout Egg Hatching Trials

Pollutech 1992, Daphnia magna/Daphnia pulex Survival and Reproduction Study

Pollutech 1994, Fathead Minnow Life Cycle Effects Monitoring, 1992-1993

Pollutech EnvirQuatics 1998, Investigation of Fathead Minnow Toxicity When Exposed to Contaminated Sediments

Pollutech EnviroQuatics 1999, St. Clair River Sediment Program, Establishment of a Reference Condition

Pollutech EnviroQuatics 2003, Assessment of Bioaccumulation/Biomagnification Potential and Trends

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** references available in our resource centre*

** additional copies of this monograph are available from the Sarnia-Lambton Environmental Association or on-line at http:\\www.sarniaenvironment.com*

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