# SOLEC BIOLOGICAL INTEGRITY WORKSHOP

# PROCEEDINGS

## Impacts of Non-Native Species on the Biological Integrity of the Great Lakes Basin Ecosystem

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# 1.0 SOLEC BIOLOGICAL INTEGRITY WORKSHOP

## *1.1 Overall Purpose of the Workshop*

The State of the Lakes Ecosystem Conference (SOLEC) has its roots in the Great Lakes Water Quality Agreement (GLWQA) and its overall purpose: "..to restore and maintain the chemical, physical and biological integrity of the waters of the Great Lakes basin ecosystem". **The role of SOLEC workshops is to help develop and refine the suite of SOLEC indicators, while the role of State of the Lakes Ecosystem Conferences is to discuss and evaluate the state of the Great Lakes as determined by the indicator suite.** Refer to Appendix A.

One theme of SOLEC 2002 is biological integrity. By focusing on biological integrity, the intent is to test the robustness of the current suite of SOLEC indicators in order to measure and monitor the integrity of the biological component of the Great Lakes basin ecosystem. However, the suite was not originally developed with this in mind. The subset of SOLEC indicators in Appendix B, all have connections to biological integrity but as they stand, they are not an integrated suite and complete suite. In order to support the SOLEC 2002 theme, a Biological Integrity Workshop was held and companion case study papers were written. The primary focus of this work was on the definition/development of indicators and indices to monitor and measure biological integrity.

The workshop will engage participants to:

- Explore the state of knowledge (science) regarding the impact of non-native species (e.g. fish, insects, birds, plants, trees, shrubs) on Great Lakes ecosystem components;
- Explore with experts the strengthening of current indicators and development of new indicators and indices that will measure the state of the biological integrity of the Great Lakes system with specific focus on non-native species;
- Identify managerial options (i.e. prevention, eradication, control) toward non-native species that assist achievement of ecosystem objectives (Great Lakes Water Quality Agreement, Lakewide Management Plans, Fish Consumption Goals and Objectives); and
- Produce a set of indicators, issues and questions for further discussion and refinement at SOLEC 2002.

Appendix C details the agenda for the two - day workshop.

## *1.2 The Case Study Approach*

The papers developed for discussion at the Biological Integrity Workshop were created using a case study approach, based on selected non-native species and their impacts on biological integrity. Non-native species have been recognized as one of the key stresses affecting biological integrity in the Great Lakes basin ecosystem. This focus offered participants an opportunity to examine the impact of non-native species on the health and resiliency of native species. It also served to help identify other environmental factors, often acting in combinations with non-native species pressures, which impact biological integrity.

"Integrity" is not specifically defined in the Great Lakes Water Quality Agreement (GLWQA), therefore the following definition was applied during the workshop:

> "***Biological integrity is the capacity to support and maintain a balanced, integrated and adaptive biological system having the full range of elements (the form) and processes (the function) expected in a region's natural habitat."***
>
> \- by James R. Karr, modified by Douglas P. Dodge.

A series of experts in a number of areas were asked to contribute their expertise in the preparation of case studies. The case studies were used by participants to help further identify the impacts of non-native species on native species and natural environments, and to develop some potential indicators of these impacts. Please refer to Appendix D for the case studies.

The preparation of the case study papers began with an initial interview with the subject expert. The information gathered through the interviews was used to prepare a short paper, with the aid of a ghostwriter, and was presented at the Biological Integrity Workshop in December 2001. Discussions at the workshop included the content of these papers, common themes, and at a broader scale, showed how to link to other impacts on biological integrity. Table 1.1 lists the case study categories.

**Table 1.1**: Case Study Categories

| Non-native | Location |
|---|---|
| Fish | Open Water |
| Aquatic Invertebrates | Open Water |
| Sea Lamprey | Open Water |
| Mute Swans | Wetlands |
| Purple Loosestrife | Wetlands |
| Trees, plants & insects | Terrestrial |
| Agriculture | Terrestrial |

In addition to these case studies, papers were prepared providing a more holistic overview of non-native species' impacts in the basin ecosystem from a First Nations/Tribal perspective.

Each case study explores what is known about the impact of non-native species on native species and natural environments. This information was used to further develop or refine existing indicators in the SOLEC indicator suite (Appendix B) or to develop other necessary indicators in order to determine biological integrity of the Great Lakes basin ecosystem. The study of the non-native species' impacts should present indicators that are based on applied science and available data so that their use can be translated/linked to other impacts on biological integrity in the Great Lakes basin ecosystem. Although non-native species are used as case studies during these investigations, indicators should also be applicable to other potential stresses on biological integrity (e.g., climate change). Table 1.2 offers three examples of simplified indicator case studies.

**Table 1.2:** Simplified Indicator Case Study Examples

| Example | Relationship | Impact | Indicator |
|---|---|---|---|
| 1 | Sea Lamprey – Lake Trout | Trout do not reach reproductive size/age | Recruitment population |
| 2 | Purple Loosestrife – Native Plants | Decreases in number of native plant species | Changes in native plant species mix |
| 3 | Eurasian Ruffe – Native Fish Species | Affect species mix of native small fish and prey species | Alterations in preyfish mix |

After the authors delivered brief presentations of their case study (Appendix E) the indicators presented in the case studies were evaluated/reviewed during the workshop for their ability to be applied to other stresses in the basin and for feasibility of application based on data requirements versus availability. Each author was involved in the review and discussion process at the workshop. Recommendations from each work group (Open Water, Wetlands, Terrestrial) are presented in Section 3.0. The review conducted during the workshop will serve to produce a more robust set of SOLEC indicators for discussion at SOLEC 2002.

## ***Case Study Issues***

As mentioned previously, definition and development of indicators and indices to monitor biological integrity was the primary focus of the workshop. The following questions were posed to the experts as guidelines for considering existing or developing new indicators of biological integrity based on applied science and available data. Evaluation of the indicators can help to determine realistic management options.

### Science Issues concerning extent and impact of non-native species

- When (at what stage in the lifecycle) does the non-native species interfere with native species?
- How does the non-native species interfere? i.e. with other species or the habitat.
- How do the native species compensate, if at all?
- Do environmental conditions favour the success of the non-native species? Why? Are these conditions reversible? How?

### Indicators and Indices to monitor extent and impact of non-native species

- How did you monitor the relationship between native and non-native species?
- Is there an appropriate SOLEC indicator, or set of indicators, (see Appendix B), that could be used to monitor the biological integrity of the native species?
- Is it feasible to develop indices of biological integrity to better categorize or classify the state of the Great Lakes basin ecosystem? If yes, what are some possible indices of Biological Integrity?

## ***Supplementary Issues***

The following questions were addressed at the Biological Integrity Workshop as time permitted. These discussions are included in section 3.0 and will be revisited at SOLEC 2002.

### Managerial Actions

- What management actions need to be taken to protect or restore the biological integrity of the Great Lakes basin ecosystem? (With respect to non-native species? With respect to Genetically Modified Organisms (GMOs)?)
- What action(s) would enable recovery of the native species?
- What action(s) would ensure the recovery was sustainable?

### Potential Invaders to the Great Lakes

- What are potential invaders to the Great Lakes? Are the effects of these invaders anticipated to be more deleterious than the non-native species that we have previously encountered?
- What research has been done on these potential invaders?
- What preventative measures exist to hinder this invasion of non-native species?
- Are there indicators/evidence to predict the number of non-native species that will enter the Great Lakes region?

# 2.0 WORKSHOP PRESENTATIONS

## *2.1 Opening Remarks*

Presented by Paul Horvatin, SOLEC co-chair

Hello, my name is Paul Horvatin from U.S. EPA and co-chair of SOLEC. Harvey Shear, of Environment Canada, the Canadian co-chair of SOLEC, and I would like to welcome you to this 'off-year' workshop. Let me take a few minutes to explain about SOLEC, and how this workshop will contribute to the SOLEC indicator process.

**Background**

The first SOLEC (State of the Lakes Ecosystem Conference), in 1994, was simply a conference where over 500 Great Lakes scientists and decision makers came together to discuss the state of the lakes. At that time, our assessment was based on an 'ad hoc' set of indicators and the best professional judgement of the scientists and managers involved.

Now we have developed a strong scientific reporting framework based on indicators and the SOLECs have become a central stage for the Canadian and American governments to report out against some of their obligations under the Great Lakes Water Quality Agreement.

**SOLEC Indicator Framework**

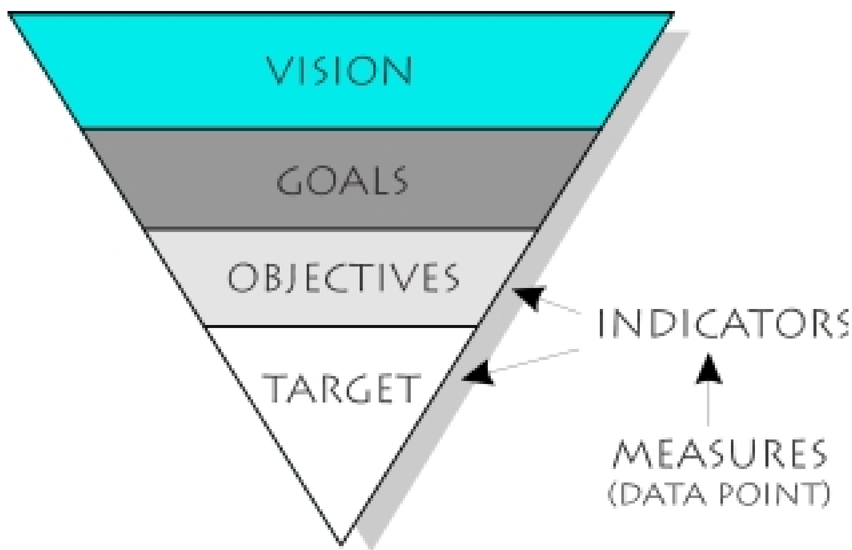


**Figure 2.1**

This diagram clearly expresses how indicators fit into the overall Great Lakes basin ecosystem health framework. Our 'vision' comes from the Great Lakes Water Quality Agreement – it is a description of how we want the lakes to be. Our 'goals' are still qualitative statements, but are more specific in order to provide direction for plans and projects. The 'Objectives' are specific descriptions of the state or condition that must be met in order to achieve the goals and the vision. 'Targets' are specific quantitative endpoints or reference values that provide the context for assessing whether or not an objective is being met.

Indicators are developed for both targets and objectives. They help us measure progress towards goals. The SOLEC indicator suite includes 80 indicators of Great Lakes basin ecosystem health. These indicators have been organized into three broad groupings: geographic (open and nearshore waters, coastal wetlands, terrestrial), issues (human health, societal), and unbounded (cross cutting issues such as climate change and acid rain).

**Biological Integrity**

SOLEC organizers recognize that the organization of these grouping does not address the 'ecosystem integrity' approach – so we are beginning to look at the SOLEC indicator suite to report out in the 'integrity' aspects of the ecosystem. At this workshop we are beginning the process with biological integrity. In future SOLEC reporting cycles we will expand to physical and chemical integrity. It will be a difficult task to attempt to report out on biological integrity in isolation, while leaving chemical and physical integrity untapped. We therefore decided to begin with one facet of biological integrity – non-native species and their impacts on biological integrity.

**The SOLEC Process**

*SOLEC has been, and continues to be a development process. It relies on, and is successful because of, the contribution of hundreds of knowledgeable people from the Great Lakes community. These people have helped to move the indicator process forward. Behind the indicator framework is real science, from some of the best freshwater and other scientists in the world.*

The major development work is done in SOLEC 'off-years', like this Biological Integrity workshop – which brings together experts and harvest their knowledge and passion.

**The Biological Integrity Workshop**

For this workshop, we have generated a starting point to discuss the issue of the impacts of non-native species on biological integrity. This starting point includes 47 'biological' indicators from the SOLEC suite and ten case study papers (and related indicators) prepared by experts. In order to improve and refine this mix – we have invited you, the experts, to the workshop. Your job is to develop a proposed set of biological integrity indicators that can be brought forward at SOLEC 2002 for further discussion and acceptance.

To achieve this we are asking you to accept the following definition of biological integrity, by James Karr and modified by Doug Dodge. "*Biological integrity is the capacity to support and maintain a balanced, integrated and adaptive biological system having the full range of elements (the form) and processes (the function) expected in a region's natural habitat.*" We could probably have a five-day workshop discussing the definition of biological integrity alone, but we are trying to prevent that by providing this definition.

We ask that you take what you hear from this morning's presentations with our definition of biological integrity and collaborate in the breakout sessions this afternoon. The goal of those sessions will be to produce three lists of biological integrity indicators – one for terrestrial, one for coastal wetlands and one for open and nearshore waters.

Each group will report back at the end of the day with their lists and tomorrow each group will continue its work. Through a refining process using the SOLEC criteria of necessary, sufficient, feasible and understandable, each group will identify a small group of indicators to bring forward at SOLEC 2002.

Remember that the model SOLEC uses in indicator development is the 'pressure-state-response' model. For this workshop, it is important that we look for indicators of 'impact' (or state) on biological integrity from the perspective of non-native species (the ‘pressure’) on native species. We are not looking for ‘response’.

With this focus, we expect to draw your knowledge and expertise out for the benefit of the Great Lakes community. To assist us in working through the next two days we have prepared a workbook to guide us through.

**The Workshop Agenda**
Our agenda today is structured around three key components:

First we will hear from a panel of 8 experts who have collaborated in the preparation of the discussion papers to kick off the workshop. Each panelist will approach the topic of ‘invasive species and their impacts on biological integrity’ from a different perspective. Dr. Doug Dodge will chair this session with his overview presentation on the common issues from all these papers. After all the presentations, Dr. Dodge will lead a discussion with the morning presenters.

This afternoon, we will split into three different groups – terrestrial, coastal wetlands, and open and nearshore waters. The purpose of these sessions is to brainstorm a long list of biological integrity ‘state’ indicators for each group, then compare and contrast them with the SOLEC biological indicators. At the end of the day we will join back together for a brief report of the indicators by each group.

Tomorrow morning, we will continue our look at the long lists and discuss them further. Once again we will separate into our groups to refine and winnow down the lists to a manageable size.

Later on we will hear from one of our esteemed colleagues, James Karr, who has agreed to present his overview of this workshop. Then we will discuss other aspects of biological integrity, and the necessary steps to move towards SOLEC 2002.

I would like to welcome you all to this workshop, and on behalf of the SOLEC steering committee, express our thanks for the time and knowledge you are contributing. Your contribution to this workshop will result in the development of really useful and useable Great Lakes ecosystem indicators.

## *2.2 Case Study Presentations*

Please refer to the case study papers found in Appendix D of these proceedings. All presentations are included in this appendix except for the presentation given by Mona Staats from Six Nations Indian Reserve that has been included here.

**Six Nations Perspective on Biological Integrity**

The Six Nations holistic overview of the natural ecosystem was given by Mona Staats. Mona focussed on the importance of knowledge and values.

**1. Six Nations Overview by Mona Staats**
- Mona greeted all the participants and gave a brief outline of the Thanksgiving Address (included in the Six Nations case study paper – section 7 of Appendix D).
- She also reminds us that we need to respect the Creator and be thankful for all the gifts he has given us.

- Remember that a weed is a weed, until you become knowledgeable about it (for example – if you become knowledgeable about its medicinal properties, then the weed becomes an herb).
- Education is very important –especially the passing on of knowledge from generation to generation.
- Indicators of the winter season include the wooly bear caterpillar and paper wasps. This year the wooly bears are missing a brown band around their middles (generally the wider the strip, the more severe the winter will be). Paper wasps on the other hand have built their nests way up high in the trees – an indication of a cold winter. The information from these different species is not conflicting, they are telling us that the winter will be up and down in severity.
- If you have it in you to dream, then you have it in you to succeed.
- All of us are born with a computer (our brains) and we need to program it well.

## *2.3 An Overview of the Case Study Papers – Similarities and Common Themes Prepared and Presented by Doug Dodge*

There are two ways to look at the invasion of non-native species after reviewing the case study papers:

**1. The "*Susceptible to Invasion*" territory is likely to be:**

- Geologically 'young', e.g. Laurentian - Great Lakes basin;
- Under system-wide stress/stresses e.g. pollution, land-clearing, habitat fragmentation;
- Mismanaged, over-harvested, mono-cultured (reduced diversity), e.g. fish & trees;
- Nurturing a successful invader that is promoting conditions favoring further invasion e.g. *Homo sapiens*, carp;
- Populated by susceptible native species that are unique and often hyper-specialized, and unable to compensate, e.g. diporeia, American chestnut;
- Usually without 'predators' to control invader, e.g. zebra/quagga mussels

**2. The *"Successful Invader"* is likely to be:**

- A weedy generalist, cosmopolitan - tolerant of a wide variety of environments; NOTE: *Petromyzon. marinus* (sea lamprey) does not fit this mold (successful specialist without predators);
- Intentionally introduced, sometimes to control a now unwanted previous invader, (salmon eat alewife);
- Endowed with high reproductive capacity;
- Sometimes 'protected' by law;
- Poised to take advantage of environmental clean-up, to establish before native species can recover, e.g. St. Marys' clean up of phenols created a hospitable area for sea lamprey;
- Rapidly adaptable to major landscape, continental and global changes, e.g. land clearances, droughts, climate-warming;
- Genetically plastic and able to mutate for resistance to control programs;
- Rarely behaves the same in its new home as it did in its original native range.

**Impacts of non-native species include:**

- Predation on native species at one or more life-stages;
- Direct competition for food and space which can lead to decreased population growth rates of native species; Interference with reproduction of natives species, for habitat, or chemically;
- Alteration of habitat to advantage of invader;
- Cascading effects on community;
- Are first seen by communities of people long accustomed to living with and on the land and water;
- Others - neither known nor can be predicted!

**Some other thoughts:**

- Need more collaborative research.
- What are the limits to growth [Fry, 1946] of the new invader in its native range; does the Great Lakes basin provide a wider scope for growth?
- Will existing monitoring predict the success of invaders?
- Are we integrating local knowledge bases with the 'statistics' sciences?
- Are monitoring programs sensitive to perturbations caused by invaders, especially during early stages of invasion?
- What is the potential role of indices?

**Charge for the participants attending the Biological Integrity workshop:**

Review the Conceptual Model (see Figure 2.1) of the relationship between indicators, measures, targets, objectives, goals, and visions and determine:

- What is the desired state of that component?
- What is the desired state for that indicator?
- What are the goals and objectives of the work that you specialize in and how does it fit into this relationship model?

Keep the list of indicators as short as possible.

Do not discuss the definition of Biological Integrity at this workshop. The theme of SOLEC 2002 has been determined to be biological integrity and we want to show some steps towards progress on reporting on biological integrity at SOLEC 2002 and SOLEC 2004.

# 3.0 BREAKOUT SESSIONS: DISCUSSION AND INDICATOR LISTS

The workshop participants were divided according to their areas of expertise into three work groups focusing on terrestrial, wetlands, and nearshore and open waters. Each group was assigned the task of brainstorming indicators to assess the biological integrity of the Great Lakes basin ecosystem. The results from the first day were revisited on the second day to further refine their indicators by applying the SOLEC criteria of necessary, sufficient, feasible and understandable while looking at gaps, balance and duplications. A recommended list appears for each group in the following sections.

## *3.1 Nearshore and Open Waters*

**Facilitator: Lois Corbett, LURA Consulting**
**Session Recorder: Richard Butler, LURA Consulting**

### ***Participants***

| | | | |
|---|---|---|---|
| *Rod Allan* | *Stephen Crawford* | *Robert O'Gorman* | *Tom Trudeau* |
| *Judy Beck* | *Marg Dochoda* | *Bob Kavetsky* | *Sarah Whitney* |
| *Paul Bertram* | *Mark Dryer* | *Brian Locke* | |
| *Gavin Christie* | *Tom Edsall* | *Tom Nalepa* | |

### ***General Discussion Points***

- Should we examine indicators of pressures on the lake?
- There needs to be a push to develop indictors that are aimed at the public as an audience. Take the indicators and then provide simple direction based on this information. There needs to be some clarity regarding the difference between a indicator of the health and sustainability of the food chain (part of the Habitat group) and an indicator of fish population (Fish group).
- Extinction needs to be clarified. Does this represent an indicator of issues within trophic structure (Biomass and Energy Flow)? It may also represent significant alteration of structure (Fish) or it also may represent the damage occurring due to habitat alteration (Habitat).

### ***Objectives***

The following objectives were assigned by the group to develop indicators, assuming there are no restraints regarding time or availability of resources. It was noted that there is a need to keep indicators simple to allow the public to understand the state; once you have this information then you can approach the problem. Comments from the group are added below each objective.

**1. Biomass and Energy Flow**

*The Great Lakes food web shall be characterized by a balanced flow of energy through its multiple trophic levels. (i.e. there will be no irregular stagnation of energy or biomass at a given trophic level due to dysfunctional/absent relationships between predator and prey). Key trophic integrators:* ***a)*** *biomass present;* ***b)*** *biomass available to next trophic level; and* ***c)*** *response of next trophic level.*

- Need to identify feedback and trickle-down effects that happen within the food chain (e.g. increased number of zebra mussels may lead to decreased population numbers for some species, but it may lead to increased numbers for other species). There is a need to be careful to not include a value to these changes;
- Look at indices of *invertebrate* abundance and biomass; include mysis and benthos;
- Investigate what the fish are *feeding* on (connection of fish to lower level) – key species;

- Look at changes that are affecting lower-trophic levels, such as what are the key species? Does it vary onshore to offshore, shallow to deep, etc? E.g. Walleye + Hexagenia.

**2. Habitat**

*Natural species diversity (both the genetic diversity within a single species and the diversity of the total number of species) and sustainable aquatic communities.*

- What does natural mean? How do you get back to natural self-sustaining stocks?
- Are we describing the state and status, or are we developing indicators that will allow us to fix the lakes to modify them to a desired state?
- Need to take a long-term perspective on changes within lakes; short-term changes to communities that appear to be beneficial may, over the long-term, have significantly detrimental effects.
- *Similar to SOLEC indicator #104 Benthos, Diversity and Abundance.*
- Genetic diversity is a complex issue. There have been recently introduced non-native species and some that have been present for a longer period and are now, perhaps, incorporated.

**3. Zero Tolerance**

*Relates directly to a proposed non-native species indicator. This objective addresses plans and actions to restrict the further introduction of non-native species into the Great Lakes basin.*

- The rate of invasions is important.
- Are we producing indicators of change, or are we determining whether changes are good or bad?
- This objective includes issues such as:
    - Population (responsibility considerations)
    - Rates of invasion (what, when, from where)
    - Rates of recovery (eradicating sea lamprey)
    - Vectors being closely monitored and actions required to keep us at/move towards zero invasions(ballast, geographic considerations)

**4. Fish**

*To examine the status of fish in the Great Lakes as they are impacted by non-native species. This could include abundance, presence/absence, health, growth/condition, habitat, reproduction, stocking, mortality, biomass, or potential harvest.*

> **Caveat 1**: There has been significant discussion regarding the necessity for a clear focus for this objective, whether the indicators should examine fish communities or populations, and whether such an examination should or could include the relationships between the trophic levels.

- The group examined the goal, and the scope was determined to be somewhat overlapping with the trophic level objective.
- It was determined by the group that too much information is covered by the SOLEC indicators, which need to be addressed and made more specific based on the desired information.
- There was considerable discussion regarding the focus of this objective:
    - To sort, i.e. to choose an actual indicator for a given fish species, there is a need to decide on an **objective**
    - A matrix (Table 3.1) was created to divide fish community by trophic structure from primary producer, to first, second, tertiary consumers, followed by a harvest level. Anyone can then measure any species or population that represents a community at a given level.

**Table 3.1:** Matrix dividing a fish community by trophic structure.

| | Non – Native Species | Native Species |
|---|---|---|
| Harvestable | | |
| Tertiary Consumer | | |
| Secondary Consumer | | |
| Primary Consumer | | |
| Primary Producer | | |

***Recommended Indicators***

The following indicators were recommended by the work group for the suite of Great Lake indicators.

**N/S/F/U -** Necessary/Sufficient/Feasible/Understandable
**✓, ✗ , or Hold** - Keep it, reject it, hold for now.
**#X -** Refers to a SOLEC indicator
**CS -** indicator from a case study.

| Indicator Title and Description | N/S/F/U | ✓, ✗ , or Hold | Related SOLEC Indicator or Case Study (CS) |
|---|---|---|---|
| **Objective 1: Biomass and Energy Flow**<br>The Great Lakes food web shall be characterized by a balanced flow of energy through its multiple trophic levels. (i.e. there will be no irregular stagnation of energy or biomass at a given trophic level due to dysfunctional/absent relationships between predator and prey). Key trophic integrators: **a)** Biomass present; **b)** Biomass available to next trophic level; and **c)** response of next trophic level | | | |
| **1. Biomass of Zebra / Quagga / Goby**<br>This could not be reported on in 2 years, but there are people who could gather this information | **N/F** | ✓ | A modified #104 Benthos Diversity and Abundance, look towards # 9002 Exotic Species modified, CS |
| **2. Change (trends, status, etc.) in nearshore and open water zooplankton community (biomass)** | **N/F/U** | ✓ | Similar to #116 Zooplankton Populations as Indicators of Ecosystem Health |
| **3. Relative abundance and condition of key species**<br>(Diporeia, Mysis, Lake Trout, Walleye, Whitefish) including changes in nearshore and open water prey fish communities | **N/F/U** | ✓ | Similar to #17 Preyfish Populations, CS |
| **4. Invertebrate biomass utilized by fish**<br>Undecided as to the necessity of the indicator | **F/U** | Hold | Evaluated within #9 Walleye and *Hexagenia* |
| **5. Interruption of energy flow between trophic levels**<br>– interruption exacerbated by Non-Native species e.g. Biomass of Zebra / Quagga / Goby; e.g. Diet | **N/F/U** | ✓ | Similar to CS |
| **Objective 2: Habitat**<br>Natural species diversity (both the genetic diversity within a single species and the diversity of the total number of species) and sustainable aquatic communities. similar to SOLEC indicator #104 (Benthos Diversity and Abundance) | | | |
| **6. Fish species diversity**<br>a) spatial and temporal considerations; and b) species diversity and abundance | **N/F/U** | ✓ | Similar to #17 Preyfish Populations |

| Indicator Title and Description | N/S/F/U | ✓, ✗, or Hold | Related SOLEC Indicator or Case Study (CS) |
|---|---|---|---|
| **7. Zooplankton Communities**<br>a) spatial and temporal considerations; and b) species diversity and abundance | **N/F/U** | ✓ | Similar to #109 Phytoplankton Populations, #116 Zooplankton Populations as Indicators of Ecosystem Health (Covered by other indicators and #109) |
| **8. Benthos communities**<br>a) spatial and temporal considerations; and b) species diversity and abundance | **N/F/U**<br>Modify current indicator | ✓ | Similar to #104 Benthos Diversity and Abundance, CS |
| **Objective 3: Zero Tolerance**<br>Relates directly to a proposed exotic species indicator, this objective addresses plans and actions to restrict the further introduction of non-native species into the Great Lakes basin. | | | |
| **9. Human population**<br>Abundance and distribution (may be represented within another suite of indicators such as societal responsibility or land use) in relationship with non-native Species | **N/F/U** | ✓ | It may be more appropriate within another suite such as land-use or societal responsibility |
| **10. Number of non-native species and rate of invasion over time**<br>a) Any new invasive species discovered?<br>b) Numbers of all non-native species<br>c) Number of new non-native species<br>d) Rate of invasions | **N/F/U** | ✓ | Similar to #9002 Exotic Species, CS; being developed at SOLEC |
| **Objective 4: Fish**<br>To examine the status of fish in the Great Lakes as they are impacted by non-native species. This could include abundance, presence/absence, health, growth/condition, habitat, reproduction, stocking, mortality, biomass, or potential harvest. | | | |
| **11. Sustainable harvest of subsistence, sport, and commercial fish** (including trout and salmon) | **N/F/U** | ✓ | Similar to #8 Salmon and Trout, #9 Walleye and *Hexagenia*, #93 Lake Trout and Scud, CS |
| **12. Walleye population status** | **N/F/U**<br>Modify current indicator | ✓ | Similar to #9 Walleye and *Hexagenia* |
| **13. Extinctions / Extirpations**<br>Commercial extinction or threatened native and non-native species | **N/F/U** | ✓ | Similar to #8161 Threatened Species (unbounded) |
| **14. Number of native and non-native fish stocked** | **N/F/U** | ✓ | Similar to #8 Salmon and Trout |
| **15. Lake Trout –** natural reproduction status | **N/F/U**<br>Modify current indicator | ✓ | Similar to #93 Lake Trout and Scud |
| **16.** Ratio of non-native species to native species and the biomass at each trophic level | Not Feasible at this time | Hold | |
| **17. Fish habitat**<br>a) amount; b) spatial distinction; and c) percent disturbed | **N/F/U** | ✓ | Similar to #6 Aquatic Habitat |

| Indicator Title and Description | N/S/F/U | ✓, ✗, or Hold | Related SOLEC Indicator or Case Study (CS) |
|---|---|---|---|
| 18. **Sea lamprey populaton** – related mortality of fish and / or tolerance level | **N/F/U** | ✓ | Similar to #18 Sea Lamprey, CS |
| 19. **Pressures for invasions**<br>a) Number of times the Welland Canal is opened (a measure of ship traffic)<br>b) Fish stocking<br>c) A measure of the amount of ballast released into the Great Lakes basin<br>d) Species approved for aquaculture in the Great Lakes basin (and sources)<br>e) Non-native species (including disease) elsewhere in North America as a measure of range potential | For future discussion | Hold | |

## ***SOLEC Non-native Species Indicator Review***

The indicators appear to document the destruction rather than outlining the functioning of the ecosystem.

## ***Options for Managerial Actions***

Challenges of this workshop (as listed by each participant) :

- Marshall information to provide strategies for the future. Policies and treatments in the future are extremely costly.
- Describe, with as few indicators as possible, the present conditions within the Lakes.
- Balance the biology with politics. Can we balance these needs?
- Short, concise list of indicators needed for public and mangers. Presently going the wrong way fast, need to heighten sense of emergency.
- Describe succinct indicators that can be used to produce management interventions. Can we do something about it?
- Problem: do we have enough information? How do we separate science from management? How do we package indicators so that they are relevant?
- If we are on downward scale, how do we reverse this process? What management decisions can be made? What options do we have?
- The inconsistencies between rigorous science and management decision-making.
- Learn how to use indicators. Move from philosophical tool to ground-level tool.
- Balance risk of not having the right information with risk of inactivity.
- Demonstration project from different agencies.
- Consensus on which indicators to use which will allow results; finding the funding and resources to implement; relating the results into useful solutions.
- Need to understand prevention aspect of non-native species invasions.

## *3.2 Wetlands*

**Facilitator: David Dilks, LURA Consulting**
**Session Recorder: Stacey Cherwaty, Environment Canada**

### ***Participants***

| | | | |
|---|---|---|---|
| *Dennis Albert* | *Duane Heaton* | *Jeffrey Reutter* | *Mike Williams* |
| *Madeline Austen* | *Norman Jacobs* | *Harvey Shear* | |
| *Laura Evans* | *Mike Klepinger* | *Roger Thoma* | |
| *John Gannon* | *Mike Penskar* | *Doug Wilcox* | |

### ***General Discussion Points***

The wetlands group identified some general questions that they proceeded to address during their discussion session. The general questions follow.

***Define the future state of wetlands. Are we trying to 'restore', 'rehabilitate', and/or 'preserve' the current condition of the wetlands - to what level? What is it that we want to see in the future for the Great Lakes' wetlands?***

- Pristine state is the ultimate goal; will never get there but it is something to strive for;
- Absence or reduction of non-natives species;
- Increase in the abundance of native species;
- Diversity of wetland species – dynamic equilibrium of natural habitat types; remove dams (return to naturalized conditions). Although it must be noted that many of these structures (dams) do support wildlife and wetlands;
- In some case studies the wetland systems are not allowed to fluctuate, natural landscape function of the ecosystem is needed, and wetland is not just a box but rather it includes landscape adjacent to the wetland buffer zone which allows the wetland to fluctuate normally;
- Reduced sediment and nutrients in wetlands;
- Return to natural wetland functions: natural hydrology, natural biogeochemistry, chemical changes (interaction of sediment in the water column), production, decomposition, habitat;
- Leave it in a state where future generations can make their own decisions (sustainable use);
- Be able to hunt, trap and get what you are looking for successfully - goals are needed that are realistic for the wetlands (there is concern with the number of people living on wetland coasts);
- Fish and waterfowl may be able to absorb toxics (natural function) but we do not want to get to the point where these organisms are no longer edible or useful;
- Achieve no loss, but a net gain of wetlands;
- Utilization of wetlands to remove contaminants, toxics (biogeochemistry);
- Healthy biological communities; holistic community;
- Healthy habitat over a wide range of wetland types; and
- Minimize effects from global warming, if there are effects. Anthropogenic impacts may induce this effect (sea levels will rise, but the Great Lakes water levels will lower because of evaporation due to the temperature increase).

**Definition of METRICS and INDICATORS**
There was discussion concerning the use of the term 'indicator', so that the following definitions were provided for further discussions within the wetlands breakout group.
**Metric** - Individual measure of the biological (or physical or chemical) community is a metric

**Indicator** - an indicator is comprised of a number of metrics i.e. fish community health is the indicator and the metrics could be the number of fish with lesions, number of native fish versus non-native fish, etc. The way that 'indicator' is defined here would reduce the number of indicators in the SOLEC suite to 2-3 indicators and there would be an increase in the number of measures within a particular indicator.

Some participants did not want to incorporate a number of metrics into one indicator, since it might make it too complicated to understand. It was mentioned that you do not need to know all metrics to determine the health of the system, if reporting on the status of the wetlands in the Great Lakes. Some metrics are too expensive to measure or time budget issues exist with testing.

## ***Objectives***

With the pressure of non-native species, refine the indicators from the SOLEC suite or develop new indicators which are priorities in achieving an ‘ideal’ state for future wetlands as determined by this group. The future goals for the desired state of wetlands are to:

1. **Return to and benefit from natural fluctuations**
2. **Holistic and health of biological communities - Sustainable Use**
3. **Net gain (or at least no net loss) of wetlands**
4. **Reduced sediments and nutrient inputs (physical stress)**

## ***Recommended Indicators***

In the Wetland breakout session, it was identified that the Great Lakes Wetland Consortium (which emerged from SOLEC 96) has already established a comprehensive indicator program. This program includes a suite of indicators/metrics as well as several indices, addressing the state of coastal wetlands in the Great Lakes basin. The Consortium’s program is now being fine-tuned – data collection protocols and methods are being tested and geographic variations are being examined.

In this context, the group reviewed the SOLEC indicators and case study indicators in relation to the Consortium Indicators/metrics, and identified gaps in the consortium’s indicator program in view of the indicators brainstormed by the group. The following table shows the results of the review of the SOLEC indicators and case studies.

**N/S/F/U** - Necessary/Sufficient/Feasible/Understandable
**✓**, **✗** , **or Hold** - Keep it, reject it, hold for now.
**#X -** Refers to a SOLEC indicator
**CS -** indicator from a case study.

| Indicator Title and Description | Status of Indicator vis a vis Consortium Program |
|---|---|
| **20. Coastal Wetland Invertebrate Community Health (#4501)**<br>Need a system calibrated to each area, each year, i.e. if lake levels are higher than the previous year, this will affect the species and the impacts on the wetlands. | Covered by Coastal Wetland Consortium (CWC) |
| **21. Coastal Wetland Fish Community Health (#4502)** | Covered by CWC |
| **22. Deformities, Eroded Fins, Lesions, and Tumors (DELT) in Coastal Wetland Fish (#4503)**<br>Part of the Fish Community Health Indicator, it is a metric of fish community health.<br>**Should be kept as a metric involved with Fish Community Health (#4502 Coastal Wetland Fish Community Health)** | Covered by CWC |

| Indicator Title and Description | Status of Indicator vis a vis Consortium Program |
|---|---|
| **23. Amphibian Diversity and Abundance (#4504)** | Covered by CWC through Bird Studies Canada (MMP) |
| **24. Wetland-Dependent Bird Diversity and Abundance (#4507)**<br>Bird Studies Canada has developed protocol for this indicator. Consortium will contract people to do this type of work. | Will be covered by CWC |
| **25. Coastal Wetland Area by Type (#4510)**<br>Lake Ontario group will be doing this work. Methodology not yet determined. | Will be covered by CWC |
| **26. Presence, Abundance and Expansion of Invasive Plants (#4513)**<br>Component of Plant Community Health Indicator. This indicator is part of a bigger problem. | Will be covered by CWC |
| **27. Contaminants in Snapping Turtles Eggs (#4506)**<br>Some sampling is too invasive and the data is not predictive of a certain area as snapping turtles can live for long periods of time and can pick up contaminants in varying locations. | Will not be covered by the CWC<br>Potential GAP |
| **28. Sediment Flowing into Coastal Wetlands (#4516)**<br>Difficult to sample. Costly to do sampling. Light measurement method could be used. | Not being covered by any group. HOLD FOR FUTURE |
| **29. Effect of Water Level Fluctuations (#4861)**<br>Work has already been done for Lake Superior. | Covered in IJC work |
| **30. Gain in Restored Coastal Wetland Area by Type (#4511)**<br>Continuous monitoring. This is a response indicator.<br>**Indicator tied into #4510 Coastal Wetland Area by Type.** | Covered by CWC |
| **31. Mute Swan Indicator**<br>Needs to be a Sub-component of Healthy Bird Community indicator.<br>Marsh Monitoring Program (MMP) is not looking at Mute Swans except for calls.<br>**Similar to Case Studies Potential Indicators** | Should be added to MMP |
| **32. Purple Loosestrife, Phragmites Indicators**<br>**Similar to Case Studies Potential Indicator** | Covered by CWC |
| **33. Sediment Available for Coastal Nourishment**<br>Do not know if CWC will be doing this work.<br>**Similar to #8142 Stream Flow and Sediment Discharge** | GAP |
| **34. Extent of Hardened Shoreline (#8131)**<br>More attention should be paid to this indicator | Will be covered by CWC<br>Potential GAP |
| **35. Artificial Coastal Structures (#8146)**<br>More attention should be paid to this indicator<br>**Indicator is tied into indicator #8131 Extent of Hardened Shoreline** | Will be covered by CWC<br>Potential GAP |
| **36. Habitat Adjacent to Coastal Wetlands (#7055)**<br>Covered by Doug Wilcox's work but not sure if Consortium will add this indicator to its list. GIS databases are available with this data. | Covered by Doug Wilcox work |

| Indicator Title and Description | Status of Indicator vis a vis Consortium Program |
|---|---|
| **37. Habitat Fragmentation (#8114)**<br>Inherent in Plant Community Health Indicator but no one is currently focused on this metric. Some work done but not on a basin-wide measure. Use old air photos and compare them to current air photos. Applies more as a terrestrial indicator. All data must be analysed with the water level of that year in mind. | GAP as it applies to Coastal wetlands |
| **38. First Emergence of Water Lily Blossoms in Coastal Wetlands (#4857)**<br>50-60 years of data are available. Not covered by CWC. Trying to get this program started through a volunteer program. | GAP |
| **39. Breeding Bird Diversity and Abundance (#8150)**<br>No plan currently in effect. Partially covered by CWS through Bird Community Health Indicator. | GAP/Partially covered |
| **40. Threatened Species (#8161)**<br>This indicator fits in with Bird Community Health Indicator | Covered by CWC |
| **41. Exotic Species (#9002)**<br>Components covered by CWC. No program strictly focused on non-native species. | Covered by CWC |
| **42. Other GAPs identified**<br>- CWC does not include successful hunting, fishing, bird-watching, and gathering of medicinal herbs in their indicators<br>- Dyked (managed) wetlands are not included in the Consortium indicators<br>- CWC indicators do not explicitly address wetland functions. CWC agreed to review entire suite of program metrics to determine what information can be gleaned about wetland functions.<br>- Genetic composition is not being tested | |

## ***SOLEC and the Biological Integrity Workshop***

The same points are revisited in this breakout session that have been addressed by the Coastal Wetland Consortium and the previous development of SOLEC Coastal Wetland indicators 5 years ago. Some participants believe that progress is being made very slowly with respect to indicators.

SOLEC is a process and the Coastal Wetland Consortium is a direct result of SOLEC 96. The purpose of this Biological Integrity Workshop is to ground truth the 47 SOLEC indicators, and see which ones do not belong or are not necessary. The workshop was created to see who is actually going to go out there to conduct the monitoring for these indicators that will help define biological integrity in the future.

Non-native species are covered in every component in everything that is being done. Studies cannot be limited to non-native species or important details and data will be missed.

The group decided that they want these wetlands to serve all of the natural functions of a wetland. They questioned whether you could end up with a high quality wetland that does not serve all the natural functions. Wetlands behave differently at different times. Underlying assumption is that the healthier the community is, the more natural functions are being provided. When things are handled properly within a wetland, such as limiting phosphorus inputs, then the health of the fish seems better. This would help to build on what has been done rather than duplicate work.

Indicators are to be used to help determine where things are going to be degraded and what you can do to stop it. Tom Burton and his work is getting down to the group of indicators that can determine the health of the biological community. Roger Thoma looked at the disturbance levels and the site with the least level of disturbance. He then investigated how this site is structured and created a reference site. There is no Great Lakes site that has not been affected. Will not be going back to Pre-Cambrian times.

How do you measure natural functions? Would it be feasible to try to measure this? Few wetlands meet all of these functions. We can't treat our wetlands as a way to get rid of contaminants that we are not controlling properly.

## ***SOLEC Non-native Indicator Review***

The indicator description appears to be looking for some individual effort that is looking for non-native species specifically - looking at aspects of non-native species i.e. no one is researching non-native species such as plankton or crabs.

Plant and fish metrics will include some of this information but we are not going out to look for non-native species.
Is SOLEC calling for an overall assessment of all non-native species in all of the Great Lakes?
Indicator needs to specify if it is referring to "new" invaders or both new and existing non-native species.

## ***Options for Managerial Actions***

- Managers require the indicator information early so that informed decisions can be made;
- Set endpoints for indicators where appropriate;
- Need to communicate the value of indicator programs;
- Need initiative to inform elected officials about wetland values;
- Information on degraded sites should be used to prioritize sites which require restoration;
- Move beyond monitoring to action;
- Stop ballast releases;
- Interpret information and put into a language that is understood by everyone;
- Help to share progress, i.e. decrease in non-native species by remediation programs needs to be circulated;
- Develop new legislation, based on current situations in the world e.g. Biological Warfare using Non-native species.
- Legislative protection for remaining high quality areas;
- Protect sensitive sites through regulations;
- Enforcing legislation;
- Education is required (Watershed Academy is in the works if funding is granted);

## *3.3 Terrestrial*

**Facilitator: Sally Leppard, LURA Consulting**
**Session Recorder: Eric Advokaat, LURA Consulting**

### ***Participants***

*Roxane Corbiere*
*Anthony Hopkin*
*Paul Horvatin*
*James Karr*
*Lionel Normand*
*Dale Phenicie*
*Derek Pitawanakwat*
*William Route*
*Mona Staats*
*Nancy Stadler-Salt*
*Paul Zorn*

### ***General Discussion Points***

- The words "integrity," "balance" and "natural" are very hard to define, but a common understanding of these terms is crucial to being able to make sure we are all working on the same track.
- We have impacted the Great Lakes basin ecosystem and we cannot go back to the way it was 300 years ago. However, we may be able to maintain and enhance the biological integrity that we do have left by maintaining existing genetic stocks.
- We may not know exactly where we are going, but we know we will recognize it when we see it.
- We have remnant populations in remnant areas that we want – it is not everything we might like, but we have to play the cards we have been dealt as well as we can.
- We also need to consider future generations.
- Ecosystems are made up of Parts and Processes:
- Some examples of a terrestrial ecosystem's biological Parts are species, genes, behaviours, species assemblages, communities, individuals, and landscapes. Parts are measured by counting things.
- Some examples of a terrestrial ecosystem's biological Processes are disease, birth and death rates, levels of mutation and recombination, competition, predation, co-evolution, demographic rates, nutrient cycling and flow rates, and meta-population dynamics. Processes are measured as rates.
- Because we are concerned with indicators, it is an ecosystem's Parts that we are interested in at this point.
- We must avoid the hubris that might drive us to assume we understand the true value of any element, regardless of cultural perspective. It is for society to decide what to do with the information we give them.
- Central to adaptive management is the ability to change practices in response to new information and understandings.
- The goal does not communicate well the way it is currently written – it should also be described in lay terms.
- One suggestion is that "Our biological selves are a small part of the integrity of the Creator and that is what we have to enlarge upon".
- This exercise establishes indicators, but also principles for consolidation when developing policy or management plans. It stimulates thought processes and evaluation – even if the indicators we are considering are never used or are only used intermittently.
- It is not possible to use one indicator to measure both extent and quality.
- If a species is established in the wild and is non-native, it has to be considered invasive – even if we don't know if it has a deleterious effect.
- We measure anything that is non-native because that measures biological integrity rather than human values.

- The first survey of an ecosystem should be done by the type of environment: marsh, plains etc., and that 2nd survey ought to be done by taxonomic classification, such as birds, insects, mammals, etc.
- It was decided that the "Parts" of an ecosystem reflect 5 different types of diversity that would frame participants' search for relevant indicators. Those 5 levels of diversity are:

    1. Landscape Diversity;
    2. Community Diversity;
    3. Species Diversity;
    4. Genetic Diversity; and
    5. Individual Diversity.

- If one is concerned about the protection of herbal plants, one needs to be concerned about the protection of wetlands and inner forests, because some herbal plants live in those areas. So if one has protected those areas, one can be fairly confident of having protected those herbal plants.
- At the same time, however, one needs to have indicators at the level of individual diversity to make absolutely sure that the specific herbal plant about which one is concerned is in fact present.
- To protect bears in the west you need to protect large dead trees for the males to over-winter in.
- To protect mountain lions, you need to protect rocky outcrops.
- It is also important to create the patch of ecosystem that is most diverse – which is not necessarily the same thing as the largest patch.
- At the landscape level of diversity, one can think about the:

    1. Quantity (of natural cover);
    2. Matrix (surrounding land uses);
    3. Size and shape (of patches or fragments);
    4. Distribution (of natural habitat); and
    5. Connectivity or patchiness.

- We need to have some measure of habitat quality, such as number of snags.
- We need to consider the practicality of certain indicators over others – some indicators are simply too expensive to use right now.

## ***Objectives***

To the extent possible, maintain or restore the capacity of the Great Lakes terrestrial ecosystem to support and maintain an (balanced) integrated and adaptive biological system having a full range of elements and processes expected in a region's natural habitat.

**Caveat 1:** The goal, and much of the other language used by SOLEC, does not communicate well to non-scientists. One lay translation may be that "Our biological selves are a small part of the integrity of the Creator, and that is what we must enlarge upon."
**Caveat 2:** The definitions of "integrity," "natural" and "balance" need to be more clearly developed.
**Caveat 3:** Must always have a standard or benchmark against which we measure.
**Caveat 4:** Be careful of using indicator species.

## *Recommended Indicators*

The following indicators were recommended by the work group for the suite of Great Lake indicators.

**N/S/F/U** - Necessary/Sufficient/Feasible/Understandable
**✓, ✗, or Hold** - Keep it, reject it, hold for now.
**#X** - Refers to a SOLEC indicator
**CS** - indicator from a case study.

| Indicator Title and Description | N/S/F/U | ✓, ✗, or Hold | Related SOLEC Indicator or Case Study (CS) |
|---|---|---|---|
| **Landscape Diversity**<br>Can be subdivided into (1) Quantity of natural cover; (2) Matrix of surrounding land uses; (3) Size and shape of patches/fragments; (4) Distribution of natural habitat; and (5) Connectivity. These 5 are a good start but not complete, as they do not pick up differences in complexity between heterogeneous and homogeneous landscapes. | | | |
| **43. Land Use**. This allows one to look at the rate of change from any one landscape type (e.g. agriculture, forest, wetlands, or protected areas) to any other type (e.g. parking lots, malls, mines, etc.) and vice versa. Measuring this indicator over time will allow one to calculate conversion rates and trends over time. Includes both habitat quantity and quality including fragmentation, but might need separate indicators for these because they require different measurement techniques. | **N, F** | | Similar to #8114 Habitat Fragmentation, #8129 Area, Quality, and Protection of Special Lakeshore Communities #8136 Extent and Quality of Nearshore Land Cover, CS, but an expansion to a basinwide perspective, not just within 1 km from shore. |
| **44. Special Places.** Area, quality and protection of special places at the landscape level. Special places includes:<br>• Ecologically unique areas e.g. rocky outcrops, large dead trees; and<br>• Cultural treasures, e.g. burial grounds and areas where medicinal herbs grow.<br>This is a measure of the numbers protected and the change in those numbers protected over time and is meant to protect the full richness of the communities that exist in the landscape. | **N, F** | | Similar to #8129 Area, Quality, and Protection of Special Lakeshore Communities, but an expansion to a basin-wide perspective, not just within 1 km from shore. |
| **Community Diversity** | | | |
| **45. Number and Relative Abundance of Non-native Species.** This is a reflection of the amount of change or divergence from the natural system. Depending on the context, would measure either number (in a standardized sample) or relative abundance (or biomass in some cases), because usually only one will give the clearest "signal" in that context. However, in some contexts it will be important to measure both. In addition to tracking all non-native species, we also need to specifically track the priority ones – those that are known to be particularly aggressive. This is a more specific look at degradation than the Floristic Quality Index, which simply measures overall degradation in general, as opposed to explaining that degradation as a result of the presence and relative abundance of non-native species. | **N, F** | | Same as #8134 Nearshore Plant and Wildlife Problem Species, but expanded to the entire basin. Similar to #9002 Exotic Species, CS |

| | Indicator Title and Description | N/S/F/U | ✓, ✗, or Hold | Related SOLEC Indicator or Case Study (CS) |
|---|---|---|---|---|
| **46.** | **Floristic and Faunal Quality of Native Species.**<br>Floristic and faunal quality measures could include:<br>• Species richness;<br>• "Tolerance" to human activity;<br>• Diversity of bird species;<br>• Diversity of amphibians and reptiles (e.g. salamander)<br>The specific index or indicator that is measured would be dictated by the specific place and context – although standardization is also very important for the sake of comparison. It may be that these indicators should be grouped according to habitat. | **Necessary, some of it is Feasible** | | Similar to #4504 Amphibian Diversity and Abundance, #8150 Breeding Bird Diversity and Abundance (unbounded) |
| **47.** | **Crop Health.**<br>This includes crop height, magnitude of biomass, flowering, flowering dates, pod sets for beans. | | | Similar to CS |
| **48.** | **Percent Crop Reduction by the End of the Year.** | | | Similar to CS |
| | **Species Diversity** | | | |
| **49.** | **Range of Non-native Species.**<br>Measuring this over time would give the rate of expansion or contraction. | **N, F** | | Similar to #9002 Exotic Species, CS |
| **50.** | **Iconic Species Counts.**<br>Some species are individually important or iconic, such as pileated woodpeckers, martens, medicinal herbs, productivity of bald eagles, American Otter, or rare species. These counts over time will allow SOLEC to track trends in distribution. | **N, some of it is Feasible** | | |
| | **Genetic Diversity** | | | |
| **51.** | **Life-History Diversity.**<br>This indicator is an analog and complement to Genetic Diversity. | **N, some of it is Feasible** | | |
| **52.** | **Measure of Genetic Diversity.**<br>Need a measure of this, such as mitochondrial DNA. This indicator should be held aside until techniques are improved sufficiently to be useful. | **N, some of it is Feasible On Hold** | | |
| | **Individual Diversity** | | | |
| **53.** | **Flora and Fauna Morphological Deformities.**<br>Such as random collection of information on the amount of diseased trees. This measure applies to both flora and fauna. | **N, F** | | Similar to CS |
| **54.** | **Proportion of Individuals Occupied by a Non-Native Disease or Insect Infestation.**<br>For example, First Nations communities on Manitoulin Island have recently noticed increased numbers of mutations in the medicinal Northern Pitcher Plant. | **N, F** | | Similar to CS |
| **55.** | **Mortality or long-term damage.** | **N, F** | | |

| | Indicator Title and Description | N/S/F/U | ✓, ✗, or Hold | Related SOLEC Indicator or Case Study (CS) |
|---|---|---|---|---|
| | **Other** | | | |
| **56.** | **Amount of Pesticides Used.** Limit/totally eliminate toxic sprays over our protected parks (need to phrase as an indicator). | | | Similar to CS |
| **57.** | **Restore (and maintain for future generations) Beautiful Native Ways.** For example, giving thanks and respect to all living things. | | | Similar to CS |
| **58.** | **Eliminate the Space Station and Use the Money for Mother Earth's Problems.** | | | |
| **59.** | **Use of Management Plans.** There is no evidence that this is correlated to quality of the resource. It is not an indicator of the state of biological integrity – it's more an indicator of human response to this pressure. This is a societal indicator. This indicator will need to be broadened to include the other ecosystem components. It is also more of a response than a state indicator. | | | Similar to #8139 Community /Species Plan |

## ***SOLEC Exotic Species Indicator Review***

This item was not addressed by this work group.

## ***Options for Managerial Actions***

- Managers need to have overall education on the issues.
- Managers need to take a hard look at their monitoring programs to determine what needs to be collected and monitored and to review the implications of any new set of indicators against what they're doing and what resources they have available. Managers can educate the public about the relationship between the state of the ecosystem and any particular target in order to build support for their programs and gain some funding. Market the outputs to get public support for more monitoring and to affect policies.
- Hire a bio-statistician – design studies to be done so that the numbers that are generated can be statistically analyzed to produce meaningful results. There is a potential problem from grabbing data from multiple sources and using it to make management decisions. If the study wasn't specifically designed to be the basis for inferential management decision, then decisions based on those numbers could be criticized at a later date. Verify and interpret data. QA/QC is essential.
- Existing databases may yield new information when new statistical analyses and tools are applied to them. Databases need to be shared – a metadatabase is being developed for this purpose.
- Data-sharing agreements among partners must be inclusive, and managers must work together. For example, new Canadian federal legislation requires Parks Canada to report on "ecological integrity". In order to do this, Parks Canada has developed an entire framework and set of indicators that might be helpful to SOLEC.
- Consistency of monitoring across the basin. QA/QC is essential.
- It is important to be able to pass on information to younger generations so they understand the value of things.

# 4.0 WORKSHOP OVERVIEW AND IMPRESSIONS – JAMES KARR

James Karr presented impromptu comments about the SOLEC Biological Integrity Workshop. The following are his notes detailing the points made during his presentation at the workshop.

**1. Need to tie several concepts together to make the framework and goals coherent.** Those concepts are:

***Integrity**:* the biological condition and character of sites with minimal human influence, ideally this is "wild nature".

***Biological condition***: the character of sites. Wild nature has a condition equal to biological integrity defined above.

***Healthy**:* a human defined goal that specifies the desired condition at a site. It may diverge from integrity.

***Unhealthy**:* biological condition below some threshold that results in local or nearby degradation.

***Sustainable**:* sites with biological integrity or above the healthy-unhealthy threshold are assumed by definition to be sustainable.

***Unsustainable**:* sites below the threshold are both unhealthy and their use in that context or framework is unsustainable.

For more on the context of my use of these words, see figures and accompanying text as follows: Fig. 3, page 19 in Karr and Chu, *Restoring Life in Running Waters* (1999) and Fig. 12.1, page 213 in paper by Karr in Pimentel et al., *Ecological Integrity* (2000). Both of the cited documents are in books published by Island Press.

**2. Think gradient.**

Avoid the tendency to think in terms of sites that are impaired or unimpaired as if there are two classes. In reality, we are dealing with places that reflect a gradient of biological condition from undisturbed (biological integrity) to various levels of degradation. See figures cited above and premise 30, page 139 in Karr and Chu (cited above).

**3. Understand the benchmark or baseline condition**.

All sites have a biological condition expected in the absence of human activity (biological integrity) although few if any sites truly reflect that condition today because of the pervasive influence of human actions. But that benchmark condition still provides a stable base that can be used to evaluate sites with diverse human influence. That biological condition of integrity (or desired divergences from that condition as in healthy above) can serve as benchmark, guide, and goal for assessment and planning processes (see section of paper from *Ecological Integrity* book cited above on pages 214-215).

**4. Think integratively about the entire process** from conception of the problem to development of indicators through to the communication of the results to policymakers and citizens. I group these into 5 critical phases and no matter how good one step may be the system will fail unless attention is paid to all of them, including to moving all of them forward, at the same time. Those phases are conceptual, design, sampling, analytical, and communication. The lessons here include the importance of thinking in terms of all three levels of view (satellite, biplane, and canoe), for different kinds of environments (wetlands, lakes, uplands), organisms (birds, fish, bugs), and kinds of human influence (mining, agriculture, industrialization, point and non point sources, etc.). Failing to connect across these dimensions will, over the long-term, result in a flawed process. In short, don't spend an infinite amount of time on selecting indicators without giving attention to the other core and crucial issues.

**5. Understand the importance of two questions: What to measure? How to decide?**

The failure to develop a systematic approach to answering these two questions has derailed many monitoring and assessment programs before they get off the ground.

It is generally important to avoid the use of species as indicators. They are not widely distributed enough to provide strong signal in a wide diversity of circumstances. Moreover, population sizes of single species are often so naturally variable that it is difficult to sort out signal from noise.

Several other thoughts on this general topic. First, theory and logic are often not a good guide to metric selection. Empirical evidence of a consistent relationship across a gradient of human influence is crucial. When selecting measures be sure to pick measures that are relevant to the societal endpoints that encompass the primary goal. That goal is most often some framing of biological condition. Counts of bureaucratic activity (permits issued, fines levied, and other such bean counts) rarely directly connect to that biological condition. In streams, trophic dynamics are often mentioned as the best measures. Empirical evidence suggests otherwise. Here again don't trust theory and logic.

It is important to have multiple measures from diverse levels of biology (individual health, population, community, landscape, etc.) that reflect biological sensitivity to various human influences and over a range of spatial scales. (Note that the levels and the scales here are not the same although they are often confused.)

**6. Be careful about habitat goals.** Scientists and mangers often resort to language that says to restore habitat. Remember that the goal is biological and just as connections between permits issued or chemical water quality standards and biology are often not strong, our presumptions about the desired configuration of habitat is often not connected to the real habitat needs of species. Besides, the goal here is to protect biological or ecological integrity, not manage places to maximize the *presumed* optimal habitat of some narrowly defined species.

**7. The goal needs to be understanding of the importance of "whole things."** Here I quoted from my paper in the *Ecological Integrity* book mentioned above. The title of that paper is "Health, integrity, and biological assessment: The importance of measuring whole things" (pages 209-226).

**8. Think carefully about organizing and framing indicators in new ways.** Current discussions of indicator development focus on huge list of measures. Attempt to find the common measures or classes of measures that will boil the metrics down to 10 or 12, and discuss them as the same set of a dozen or so indicators, framed to convey biological character regardless of habitat type. We use the same set of indicators to assess the condition of small streams in areas as wide ranging as the Tennessee River system, the Pacific Northwest (Oregon, Washington, and Idaho), Rocky Mountains (Wyoming) and several regions in Japan. Rather than being buried in indicators, we select using the 2 questions listed above. We invoke a standard process of indicator evaluation and assessment. Low and behold, when this happens, a very similar set of measures emerges. The process of indicator development and selection should work harder to define that common ecological principle and context framework, as opposed to the current one which seems more attuned to making long lists, repetitively at sequential meetings.

**9. Keep in mind that the goal is assessment, not monitoring.** Biologists and water managers in a larger sense have monitored for most of the last century or more. It can be shown without much trouble that not much useful has come from much of that monitoring. A process that simply advocates more of the same "unguided or poorly guided monitoring" will not change the situation. Frame and form the process as one with an assessment goal, not a data collection (monitoring) goal. By doing that we refocus the energies and efforts to more effectively answer the two questions above as well as to place the task in the larger 5-phase process that I mentioned in item 4 above. That should both strengthen the intellectual foundations of the process as well as the probability that it will produce policy relevant information that can be communicated to diverse stakeholders.

## 5.0 FUTURE STEPS

Non-native species have been used to develop the initial case studies, but future development requires us to examine other stressors such as climate change, habitat fragmentation, pollution, genetically modified organisms (GMOs), and possibly many other factors that can affect the biological integrity of the Great Lakes basin ecosystem.

The next major goal to determine the affects of these factors is to produce an initial report on biological integrity for further discussions at SOLEC 2002. Specific breakout groups will be designed with biological integrity as a common theme in order to build on the achievements of this workshop and any additional knowledge developed before the October 2002 conference in Cleveland, Ohio.

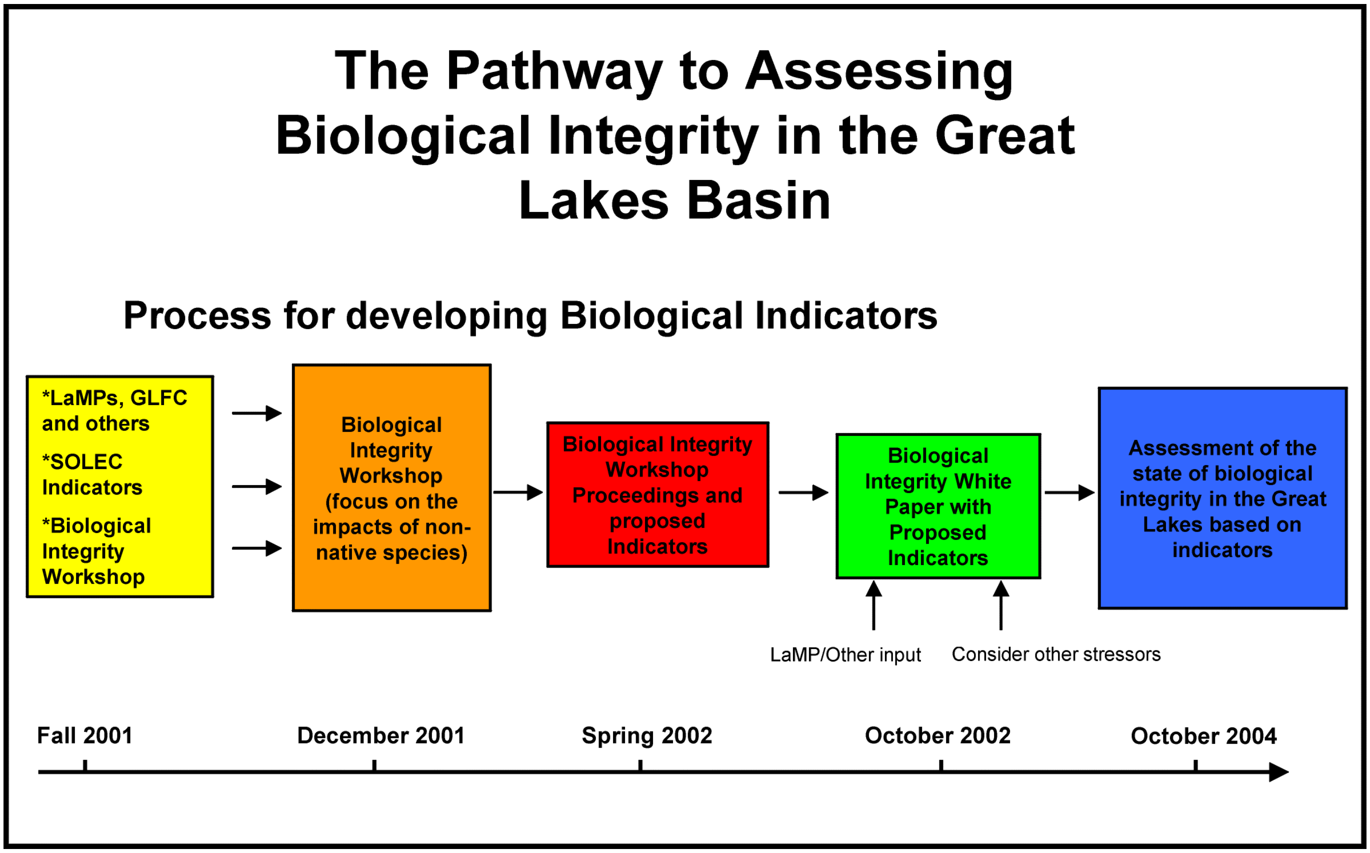


**Figure: 5.1**

In preparation for the first report, various activities will be created to stimulate ideas and discussion that may feed into the conference breakout sessions. These activities may include posting information on web sites, creating technical panels to further investigate other factors affecting biological integrity, etc. The information posted on the web site may include reports, group discussions, and data by possibly using a GIS interface further in the future.

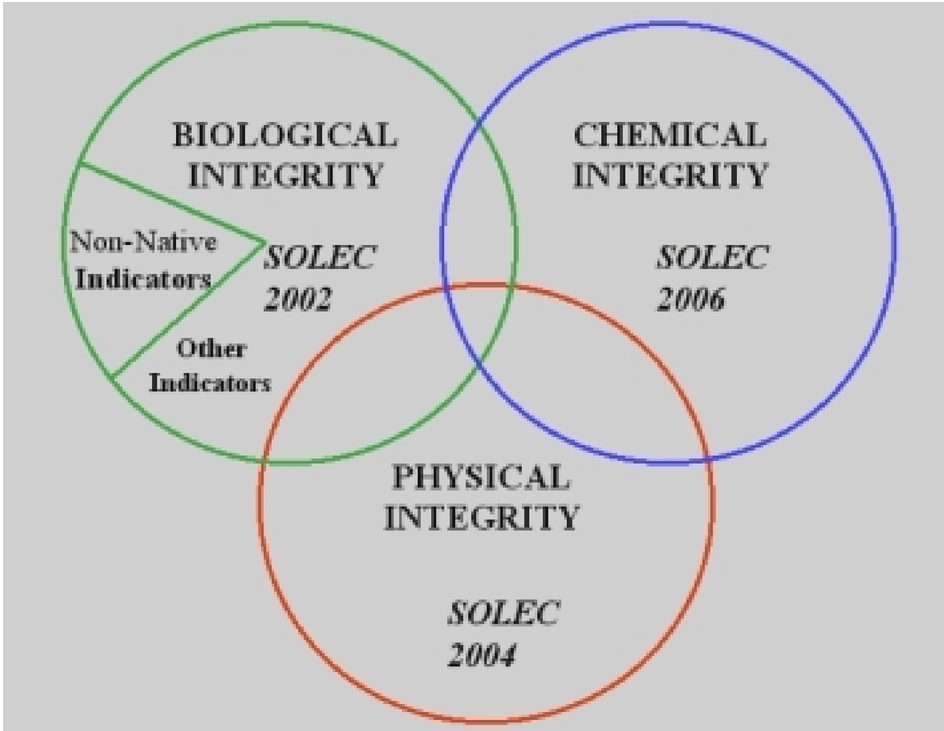


**Figure 5.2:** Future steps to assessing the biological, chemical and physical integrity of the Great Lakes basin ecosystem.

Only one slice of the biological integrity pie has been examined so far, as shown in Figure 5.2. It is quite complex to disentangle biological integrity from chemical and physical integrity, but with the help from many individuals all over the Great Lakes basin, it may be possible to begin understanding its role within the whole system. In addition, Figure 5.2 demonstrates SOLEC's commitment to support the purpose of the Great Lakes Water Quality Agreement "..to restore and maintain the chemical, physical and biological integrity of the waters of the Great Lakes Basin ecosystem" by further defining the scope of biological, chemical and physical integrity of the Great Lakes basin ecosystem during future conferences.

## 6.0 LIST OF APPENDICES

# Appendix A: SOLEC BACKGROUND

# Appendix B: Great Lakes Basin Indicators List

## Appendix C: WORKSHOP AGENDA

# Appendix D: CASE STUDIES

# Appendix E: COLLABORATOR PRESENTATIONS

## Appendix F: WORKSHOP PARTICIPANTS