MEDIUM TERM MANAGEMENT PLAN

Purpose

- Develop a medium term management plan to reduce threats and recover the Enos Lake stickleback pairs.

Method

Using current information and the stickleback recovery strategy goals, determine appropriate measures for (1) recovery of the stickleback species pairs, and (2) protection of those conditions essential for sympatry in Enos Lake.

Results

The following is a medium term management plan to address the goal: ***"…to secure the long-term viability of all extant populations of stickleback species pairs…"*** and to ***"Establish or recover a viable population of the Enos Lake species pair",*** as described in the Recovery Strategy[2] for the stickleback species pairs.

The Government of Canada, through the SARA provisions, poses several questions to be addressed by each recovery strategy in assessing recovery feasibility:

1. Are individuals of a species capable of reproduction currently available to improve the population growth rate or population abundance?
2. Is sufficient suitable habitat available to support the species, or could it be made available through habitat management or restoration?
3. Can significant threats to the species or its habitat be avoided or mitigated through recovery actions?
4. Do the necessary recovery techniques exist and are they demonstrated to be effective?

The stickleback recovery strategy answers these questions in the affirmative; suggesting that recovery is indeed considered to be technically and biologically feasible. However, the recovery strategy for the stickleback species pairs provides conditions to ensure that actions and decisions are realistic and conform to the current situations found in Enos Lake. These conditions are met in this Management Plan.

The goal, as identified above, is addressed through actions directed to (1) **Recovery**, or the return of the sympatric stickleback pair to Enos lake by returning the lake conditions to those favoring sympatry, and (2) **Protection,** or the long term protection of those physical, chemical, and biological conditions that support sympatry.

1. RECOVERY IMPLEMENTATION.

Recovery Implementation Group (RIG) Objectives:

The general goal is to return the lake to conditions favorable to sympatry, so that the stickleback pair can be reestablished either naturally, or through re-introduction.

The following statements on information needed, studies done or proposed, and decision points are adapted from the Recovery Strategy for Stickleback Species Pairs, specifically Sections 12 and 13 (Recommended Approach and Knowledge Gaps), to form a medium-term work plan for the RIG, stakeholders and the community.

Information Needed for Recovery Implementation:

1. **Confirm or assume the status of pure benthic and limnetic forms in Enos Lake so that a decision can be made on whether the stickleback pair can be reestablished naturally, or whether re-introduction is needed.**

The relative strength of pure benthic and limnetic forms in Enos Lake, to be confirmed by genetic analyses by University of Wisconsin and the Fred Hutchinson Cancer Research Center in Seattle, is critical to the choice of strategy for the recovery of the stickleback pair. For example, a confirmation of complete hybridization may suggest that recovery can only be achieved by the removal of all hybrid fish from the lake, and the re-introduction of pure forms from their captive locations (UBC and Murdo-Frazer park in North Vancouver), following the return of the lake to conditions favorable to sympatry.

On the other hand, a confirmation that there remain some pure benthic and limnetic forms in Enos Lake may justify a decision to allow a natural return to sympatry, following the return of the lake to favorable conditions.

Regardless of which recovery mechanism is chosen, there seems to be a scientifically supported rationale for continued study of the cause of hybridization, the mechanism of effect and the reversibility of effect in Enos Lake, along with work to return Enos Lake to pre-hybridization conditions. Even if recovery of the Enos Lake stickleback population is not feasible, an opportunity exists to gain an understanding of the hybridization mechanisms so as to prevent such events within other sympatric pair populations.

Studies: 2007-08 - Stickleback trapping and identification by morphological features.
(not part of HSP funded project)
-Genetic analysis by U. of Wisc. and Fred Hutchison Cancer Research Center in Seattle.
These studies address the Recovery Strategy sections on Basic Biology and Threat Clarification Knowledge Gaps. .
2008-09 (Proposed) – Continue trapping for stickleback distribution and identification by form.

2. Identify the agent(s) causing the hybridization, the mechanism of effect, and the means of reversing the effect, so that an appropriate focus can be placed on recovery actions to return the lake to conditions suitable for sympatry.

Crayfish Effects:

The most frequently cited agent causing hybridization is the introduced signal crayfish, acting through one or several habitat-disruptive mechanisms. One such mechanism is the large abundance of crayfish stirring up bottom sediments and thereby increasing water turbidity and affecting stickleback mate recognition. A second mechanism is crayfish consumption of large amounts of macrophytic vegetation in the littoral zone and thereby reducing stickleback spawning habitat. A third mechanism is the loss of invertebrate food organisms from the loss of macrophyte vegetation, and its effect on reduced size of benthic stickleback. Another, non-habitat related effect of the crayfish may be their direct predation on stickleback.

What do we understand about these possibilities, and which seems to be the most likely alternative?

The suggestion that increased water turbidity caused by crayfish disturbance of the lake bottom may have triggered the hybridization may be difficult to test as there are no historic water quality records with which to compare current conditions. Certainly, there does not appear to be much evidence of any general elevated turbidity in Enos Lake judging from water analyses in 2007; however, elevated levels may still exist as very localized events in areas where interference with stickleback mate recognition may occur. Research suggests that only a slight shift in water transparency is enough to impede mate recognition by stickleback. Therefore, some increased turbidity, even though not measured in the current studies, cannot be ruled out as a contributor to hybridization.

Regarding the suggestion that there has been a loss of macrophyte vegetation from Enos Lake, we are again faced with a lack of historic information. The extent of macrophyte vegetation before the hybridization was never measured despite all the work done on Enos Lake stickleback. Some anecdotal reports suggest large areas of macrophytes existed in the lake up to at least the late 1990s, but no species identification was done, nor measurements taken of its extent. What we do know, however, is that there is currently little macophyte vegetation in Enos Lake; with one measurement in August, 2007 showing only a total of 3 to 5% of the total littoral zone being vegetated, with only a portion of this comprised of types useful to stickleback.

There is no historic information on invertebrates and their association with macrophytes, and no measure of direct predation on stickleback by crayfish.

Physical and Chemical Effects:

Other possible agents causing the hybridization include external sources of an increase in turbidity, chemical changes affecting water colour, and modifications to the lake level through impoundment events in the 1950s and again in the early 1990s and seasonal draw down of the lake level by a water license holder .

Except for the outlet damming and impoundment, there is no evidence of any change to the physical or chemical properties of Enos Lake as a result of any outside agent. The Enos Lake watershed remains relatively undeveloped, with only one urban development area that has affected water quality; however, this development is very recent and postdates the onset of the hybridization. Water quality analyses of Enos Lake since this land disturbance shows no apparent adverse effects of this development.

There has been some suggestion that Enos Lake water colour has changed – becoming less tea-coloured – which may have altered the transmission of some colours and thereby interfered with stickleback mate identification and selection. However, there are no historic water quality data with which to compare current conditions, and it is uncertain what mechanism would have altered the water colour. Normally, the tea colour is from organic tannins and is measured directly by colour analysis, or indirectly by concentration of organic carbon.

Enos Lake was first impounded in the 1950s for use as a domestic water source. The outlet dam was subsequently raised in 1994 to accommodate storage of 140 acre feet, or a drawdown of 1 metre for golf course irrigation.

It is uncertain what effect these impoundments have had on the Enos Lake ecosystem and the stickleback pair. It would seem that the first impoundment had little effect on stickleback hybridization, as distinct pairs were evident into the 1990s; well after the installation of the dam.

The 1994 additional impoundment may coincide with the onset of the stickleback hybridization, although a mechanism of effect is unclear. Examination of the lake's bathymetry shows that the 1994 increase in lake elevation created additional littoral zone by flooding a large marsh area, which could be interpreted as potentially additional stickleback habitat for spawning and feeding. Past annual summer drawdowns of up to 1 meter may have had negative effects, if they have interfered with stickleback spawning. No measurements have been made of such effects however, and only rough guesses can be made. Lake level measurements in 2007 showed only a 0.1 m drawdown, suggesting a small, if any, effect on spawning.

A Working Hypothesis for Crayfish Effects:

Because of the uncertainties of physical and chemical agents as causes of hybridization, a focus has been placed on the introduced crayfish as having the highest likelihood of yielding results through study. Although externally driven changes to water quality and impoundment effects are not part of the focus of future planned investigations on Enos Lake, they will remain as possible contributing agents to hybridization, and may be considered for further study should supporting evidence emerge that confirms such effects.

The working hypothesis for the Enos Lake work is therefore that the invasive crayfish have drastically reduced macrophyte vegetation and have induced stickleback hybridization through a loss of spawning habitat and/or invertebrate food organisms. Investigative studies have, and will continue to focus on the crayfish-macrophyte vegetation interaction.

Studies: 2007-08:
- Aquarium observations of crayfish vegetation preference.
- Enclosure studies to measure crayfish consumption of vegetation.
- Macrophyte vegetation surveys of Enos Lake.
- Baseline biophysical descriptions on Enos Lake against which to compare future changes.

2008-09: (Proposed)
- Removal of a significant proportion of crayfish from Enos Lake, and measurement of effects on macrophyte vegetation, invertebrates, and stickleback growth.
- Comparative studies of Enos Lake and the Texada Island lakes to identify any unique conditions that might confirm a causative agent for hybridization (UBC Graduate student study).

2009 onward: (Proposed)
Continued measurement of the effects of the reduced crayfish on macrophytes, invertebrates and stickleback growth.

These studies address some of the key approaches in the Recovery Strategy sections on Threat Clarification, Rebuilding Techniques Knowledge Gaps.

2. PROTECTION.

Recovery Implementation Group (RIG) Objectives:

Protection refers to the long-term maintenance of the physical, chemical and biological conditions of Enos Lake that are favorable to the support of the stickleback pair.

The focus of Protection is therefore on the prevention of harmful changes to Enos Lake from future development and activities in the Enos Lake watershed, and the prevention of the introduction of alien species into the watershed.

Information Needed for Protection:

1. Describe the "ideal" stickleback pair lake; or those conditions necessary for the support of sympatry.

In order to protect and maintain conditions essential to stickleback sympatry we must first of all define what these conditions are, including physical, chemical and biological conditions.

This information can be inferred from conditions found in other sympatric lakes on Texada Island, and from evidence of Enos Lake conditions prior to hybridization.

Unfortunately, there are few data recorded from Enos Lake prior to hybridization, and only informed guesses can be offered on historic conditions, and what changes may have taken place to these conditions that would have contributed to, or caused hybridization.

Assessment work undertaken in 2007 shows that Enos Lake appears to be a typical small Vancouver Island lake with no particularly unusual physical or chemical features that would suggest a problem in supporting stickleback sympatry. A limited analysis of lake zooplankton however shows relatively few large zooplankters, an unusual condition for this type of lake. Whether this affects the normal feeding of the limnetic stickleback is not known, but an intriguing possibility is that a low abundance of preferred food items may be one agent driving the benthic and limnetic forms closer together and thereby increasing opportunities for hybridization. More research would be needed to prove this.

Studies: 2007- 08:
- Physical bathymetry described.
- Limited plankton sampling.
- Water chemistry sampling:
  - Full spectrum analysis 2X year
  - Temp., dissolved oxygen, conductivity profiles weekly during summer.

- Comparison of Enos Lake condition with Texada lakes.

2008- 09 (Proposed):

- Continue water chemistry analysis program.
- Expand plankton sampling program.
- Continue to source historic information on Enos Lake conditions before hybridization.

2. Describe the effect that the licensed draw down has had on stickleback spawning and on the macrophyte vegetation of the littoral zone. Identify a draw- down regime that would have minimal effects on stickleback spawning and macrophyte vegetation.

Fairwinds is licensed to store 140 acre feet of water on Enos Lake, which equates to an annual maximum draw down of 1 metre. There has been no staff gauge or other recording device in Enos Lake to verify that the license requirements have meet met, and no measurement or recording of the timing of the draw down until 2007 when daily water level records were kept. Therefore, it is not clear what, if any impact past draw downs have had on stickleback or vegetation. Fairwinds uses the water for golf course irrigation, and therefore draws down the lake in periods of dry conditions; usually July and August, which coincides with some stickleback spawning, so there is a possibility at least that some impact on spawning has occurred in the past.

In 2007, the lake levels were fairly consistent throughout the summer, with a drop of only 0.1 metres from June to September. There were no abrupt changes in level during this period. This would suggest that there may have been only a small impact on stickleback spawning and vegetation in 2007; however, no direct observations or measurements were made to confirm this.

A draw down regime that would have minimal effects on stickleback spawning and vegetation would be one that maintained a constant lake level throughout the spawning period (mainly June to August), and avoided abrupt water level changes. It may be possible to accomplish this by minimizing water use for irrigation, and by an earlier draw down to Dolphin Lake, if it is possible to use more of Dolphin Lake for storage at least early in the year. Fairwinds' application for an Audubon Certification for its golf course may support such a minimal-effect regime.

Studies: 2007-08: - Recommend a lake level regime that would minimize effects.

3. Describe the risk posed by current and future urban development in the Enos Lake watershed.

Current and impending urban development in the Enos Lake watershed pose several risks to water quality and flow regime of Enos Lake. Typical effects of urban development that should be avoided include the following:

Hydrological Effects:
Changes in flow volumes and regime can be caused by the interruption of the natural rainfall and runoff pattern through diversions and land drainage, and reduced infiltration to the ground.

Water Quality Effects:
Construction activity in particular can result in elevated sediment loading, both suspended and dissolved, and in increased turbidity.
Ongoing urban land use activities can result in chemical contamination of drainage waters, from fertilizers, pesticides, herbicides, petrochemical residues, and a host of other chemicals that are in common use by urban dwellers and that are discarded irresponsibly or otherwise find their way into drainage systems and ultimately into streams and lakes.

Invasive Species Introduction:
The risk of introduction of invasive species increases with rising population. Of most concern is the risk of introduction of unwanted aquatic species into the Enos lake system that pose a threat to the stickleback

These issues are addressed through several stewardship activities initiated in 2007 and which should be continued into the future.

Studies: 2007-08:
- Work with landowner (Fairwinds) to develop a storm water management plan for Enos lake.
- Develop and distribute a brochure to the public to inform and change behaviours to assist in recovery efforts.
- Host information and education meetings with the public and interest groups.
- Contribute to a minimum-effect urban development plan for the remainder of the Fairwinds property.

2008-09 (proposed):
- It is proposed that the 2007-08 stewardship projects be continued in 2008-09.