Technical report RT-135

Preliminary Performance indicators of the Environment Technical Working Group (Lower St. Lawrence)

Jean Morin, Olivier Champoux, Sylvain Martin, Katrine Turgeon, Marc Mingelbier, Sylvain Giguère, Daniel Rioux, Alain Armellin, Denis Lehoux, Bruno Drolet, Diane Dauphin, Christiane Hudon, Yves de Lafontaine, Jean-Luc Desgranges, Joe dePinto, Todd Redder & Brad Parker.

Environment Canada (MSC, CWS, CSL) & FAPAQ

Mars 2004

Pour fin de citation :

Morin J., O.Champoux, S.Martin, K.Turgeon, M.Mingelbier, S.Giguère, D.Rioux, A.Armellin, D.Lehoux, B.Drolet, D.Dauphin, C.Hudon, Y.de Lafontaine, J.L.Desgranges J. dePinto, T. Redder & B.Parker. 2004. **Preliminary Performance indicators of the Environment Technical Working Group (Lower St. Lawrence).** *Technical report MSC-hydrology RT-135, Environment Canada (MSC, CWS, CSL) & FAPAQ. 82p.*

Preliminary Performance indicators of the Environment Technical Working Group (Lower St. Lawrence)

Jean Morin, Olivier Champoux, Sylvain Martin, Katrine Turgeon, Marc Mingelbier, Sylvain Giguère, Daniel Rioux, Alain Armellin, Denis Lehoux, Bruno Drolet, Diane Dauphin, Christiane Hudon, Yves de Lafontaine,Jean-Luc Desgranges Joe dePinto, Todd Redder & Brad Parker.
Environnement Canada (MSC, CWS, CSL) & FAPAQ

Cautionary statement for SVM operator:
In their actual state (March 1st 2004), the Performance Indicators presented herein represent the best information available on the species or on biotic component they are representing. Generally speaking, they are in their "final-prototyping" form; however, most of these indicators represent surface area available for nesting or feeding, or represent "good" plant habitat. In their actual state, they represent only a portion of the complexity associated with these PI, as an example, the nesting habitat has to be completed with the amount of nest flooded or stranded during the rest of the nesting season. It is important to recognize that the addition of nest flooding/stranding indicators can change drastically the score of a given plan, in comparison with the score obtained from the actual indicators only. These indicators will be completed during the spring & summer 2004.

Introduction

The Environment TWG is building several Performance Indicators (PI) that are aiming at quantify/qualify the impact of regulation on fauna and flora. The actual indicators are a first cut of the several indicators (between 60 and 200) that will be produced for the Lower St. Lawrence River. Several levels of integration are planned for the summer 2004, in order to reduce such complexity in environmental PIs.
In the actual document, we present a general methodology that was used to produce the indicators and we document in detail the 26 indicators prepared for the "March 2004-PFEG Workshop", with the following structure: 1) the responsible party 2) the origin and description of the indicators, 3) its temporal validity (portion of the year), 4) its spatial validity, 5) the variables used in the modelling, 6) the calibration data, 7) the validation data, 8) the links with the hydrology and finally, for the spatially explicit models, we present 9) a map of the spatial distribution of the indicator for an average discharge, 10) the comparison between the 2D model results and their approximation for the SVM, and finally, 11) we present the comparison between the calculation of the performance indicator based on two different discharge series: 1958DD and PreProject.

General methodology:
The PIs were developed over several years of study within the Env TWG, 3 types of models were used for the Lower St. Lawrence:

1) Statistical relations with long term data series (1D)
2) Local spatial model driven by water level only (2D)
3) System wide, spatially explicit model (physical variable driven) (2D)
   A) Data driven model
   B) Data calibrated habitat models
   C) Knowledge-based habitat models

The first type of model, "one-dimensional statistical approach" is based on relationship between water level temporal series at one station and biological data. Several statistical variables are derived from water level such as median water level over a period, standard deviation for another time step period. Seasonal variability of water level pattern is included in relationships. Performance indicator developed with this model is the fish global indicator and the migration of Eels.

The second type of model is based on a linear interpolation of water levels and on a local digital elevation models to obtain an approximation of water depth. Water depth are calculated for several time periods and used to establish statistical relations. Performance indicator developed with this model is the Lake Saint-Pierre wetland quality group and the Boucherville Island pike reproduction.

The third type of model, the two-dimensional system-wide model is based on the combination of several numerical models that describes the change in the physics associated with change in discharge. This system includes results from hydrodynamic model (water level, current velocities, depth and specific discharge), wind waves model (wave energy & wave shear stress) and eulerian transport-diffusion model (water masses spatial distribution, index of suspended matter concentration, index of light penetration, index of deposited material). The system is using large amount of data: high-resolution bathymetry and topography, substratum maps, aquatic macrophytes distribution and floodplain emerging plants that are also used in specific models.
These data were temporally interpolated for conditions present during biological sampling and used for the calibration of statistical models (Data calibrated habitat models; Fish feeding habitat, submerged plants, wetland type and part of wetland birds). For the data driven models, precisely interpolated water level, predicted wetlands and biological data from the field are combined for calculating a performance indicator (Migratory & part of wetland birds). The “Knowledge-based habitat models” are combining precise spatial variables and models to produce habitat model for species or guild from which we have little or no data (Rare species and frog models).

For the March 2004 version of our indicators, we used modelled wetland classes, but these wetland models did not take into account the temporal change in there composition. Wetlands were therefore considered as static and represent the calibration year of 1985, see for details:

Turgeon K., O. Champoux, S. Martin et J. Morin. 2004. Modélisation des milieux humides de la plaine inondable du Saint-Laurent, du lac Saint-Pierre au lac Saint-Louis. Rapport scientifique SMC-Hydrologie RS-104, Environnement Canada, Sainte-Foy, 62 pages.

Table of content:

I. Fish "feeding ground" habitat models

1 Performance indicator: Fish feeding habitat; Surface (ha) of potential habitat for Pumpkinseed (LEGI) Lepomis gibbosus (Crapet-soleil).

Person responsible: Mingelbier & Morin

Origin and description of the indicator: This series of fish indicators give the area of fish suitable habitat for a large spectrum of water discharge conditions. They integrate the living, growth and feeding habitat for several key species.

Temporal validity: Valid between August 1st and October 31st

Spatial validity: Valid between Lake St. Louis and Lake St. Pierre (except Laprairie Basin)

Variables used in the 2D modeling:

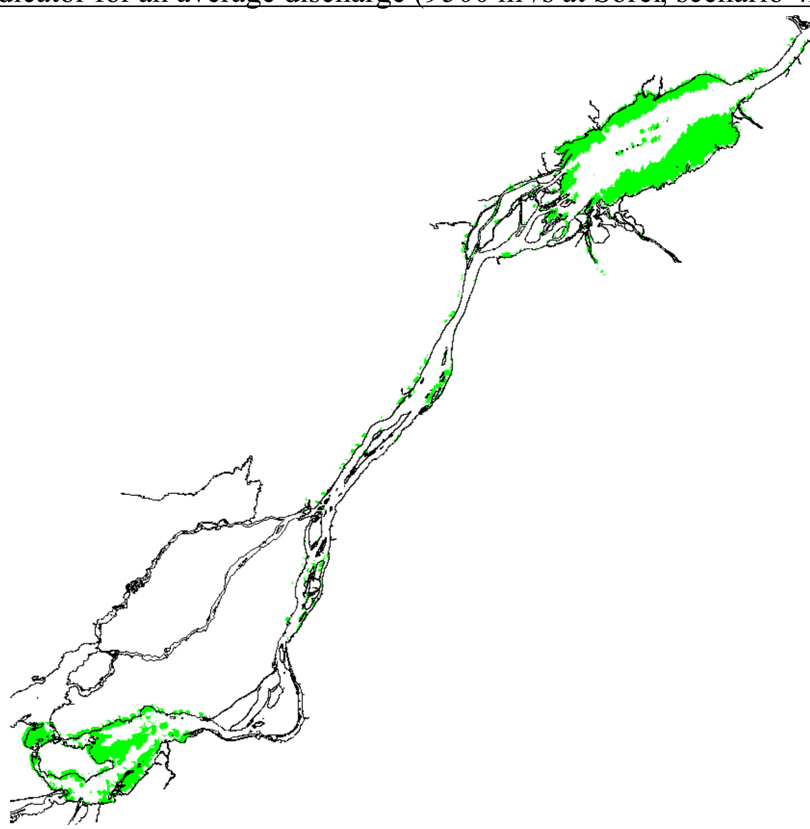
1. 2 D hydrodynamics model: Current velocity
2. Field sampling: % of Clay Substratum-index
3. Biological model: Simulated density of vegetation.

Calibration data: The model is based on data collected in the field (512 sites of gillnets and seines) for 147 presences and 365 absences. Performance are of $R^2 = 0.30$ and %Good = 79%.

Validation data: Leave one out method in 512 samples

Links with hydrology: Fish is a major component of the aquatic ecosystem, influenced at various degrees by the water discharge. Water discharge regulation may have adverse effects on habitat supply.

Map of the indicator for an average discharge (9500 m³/s at Sorel; scenario 4P):



Transfers from full 2D explicit models to simplified SMV curves:

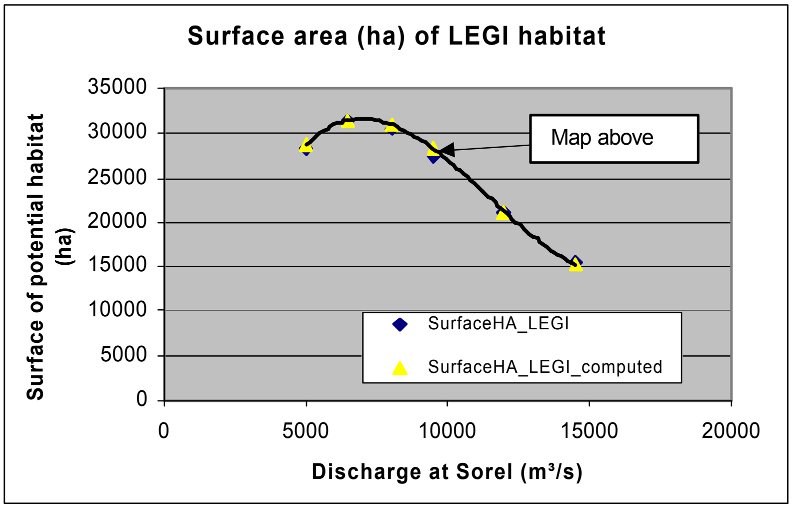


Figure: Relation between the calculated "Surface area of potential habitat" for LEGI and the discharge in Sorel, data and best fit curve: LEGI=-17451.1032+16.4786*(Q_Sorel) -0.0017*(Q_Sorel)^2+0.0000000496*(Q_Sorel)^3

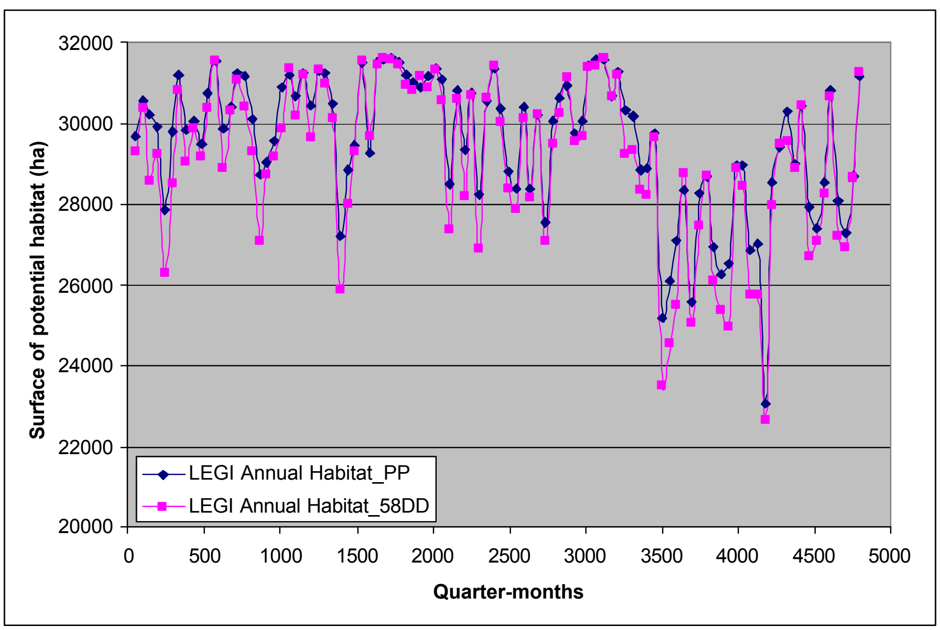


Figure: Comparison of the Performance indicator for the 100 years discharge series: Plan 1958DD and PreProject.

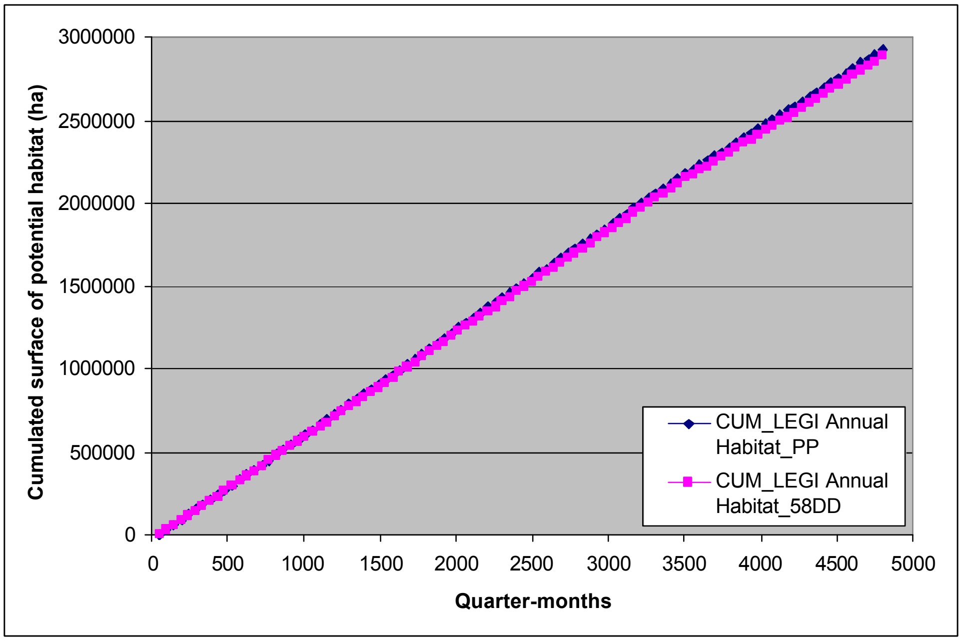


Figure: Comparison of the temporally cumulated Performance Indicator for the 100 years discharge series: Plan 1958DD and PreProject.

2 Performance indicator: Fish feeding habitat; Surface (ha) of potential habitat for Northern pike (ESLU) *Esox lucius* (*Grand brochet*).

Person responsible: Mingelbier & Morin

Origin and description of the indicator: This series of fish indicators give the area of fish suitable habitat for a large spectrum of water discharge conditions. They integrate the living, growth and feeding habitat for several key species.

Temporal validity: Valid between August 1st and October 31st

Spatial validity: Valid between Lake St. Louis and Lake St. Pierre (except Laprairie Basin)

Variables used in the 2D modeling:

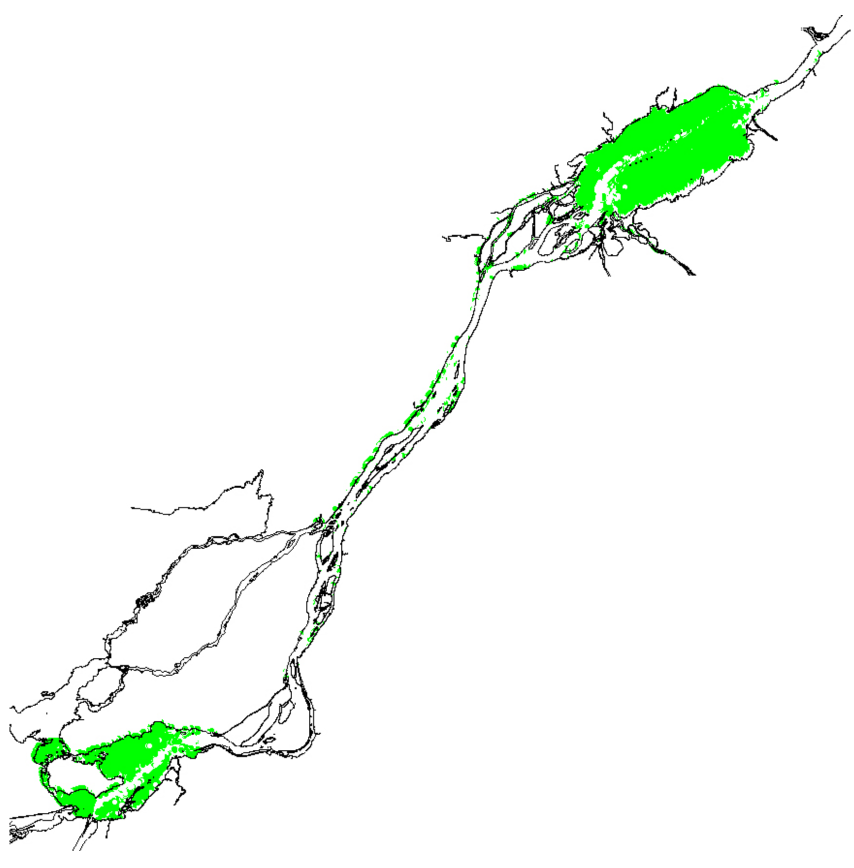
1. 2 D hydrodynamics model: Ratio of incidental light reaching the bottom, Slope of the bottom
2. Biological model: Simulated density of vegetation.

Calibration data: The model is based on data collected in the field (512 sites of gillnets and seines) for 171 presences and 341 absences. Performance are of $R^2 = 0.40$ and %Good = 83%.

Validation data: Leave one out method in 512 samples

Links with hydrology: Fish is a major component of the aquatic ecosystem, influenced at various degrees by the water discharge. Water discharge regulation may have adverse effects on habitat supply.

Map of the indicator for an average discharge (9500 m³/s at Sorel; scenario 4P):



Transfers from full 2D explicit models to simplified SMV curves:

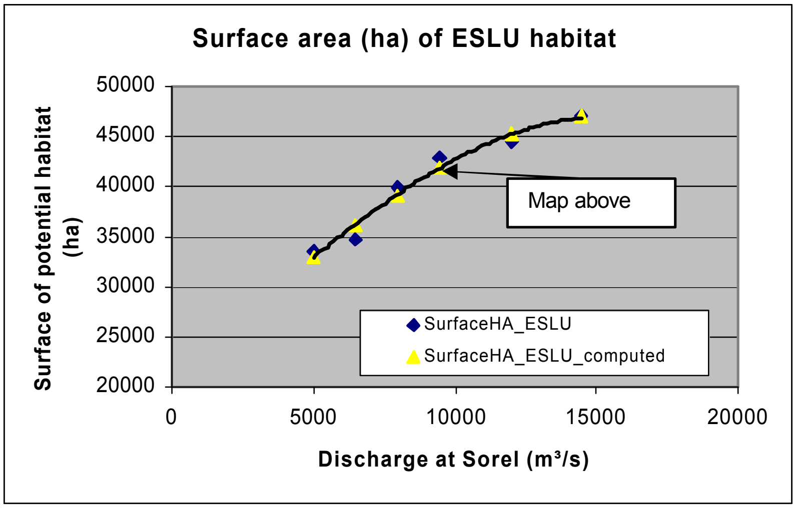


Figure: Relation between the calculated "Surface area of potential habitat" for ESLU and the discharge in Sorel, data and best fit curve: ESLU=-0.0000000038*(Q_Sorel)^3 + 0.00001*(Q_Sorel)^2 + 2.4657* (Q_Sorel) + 20713

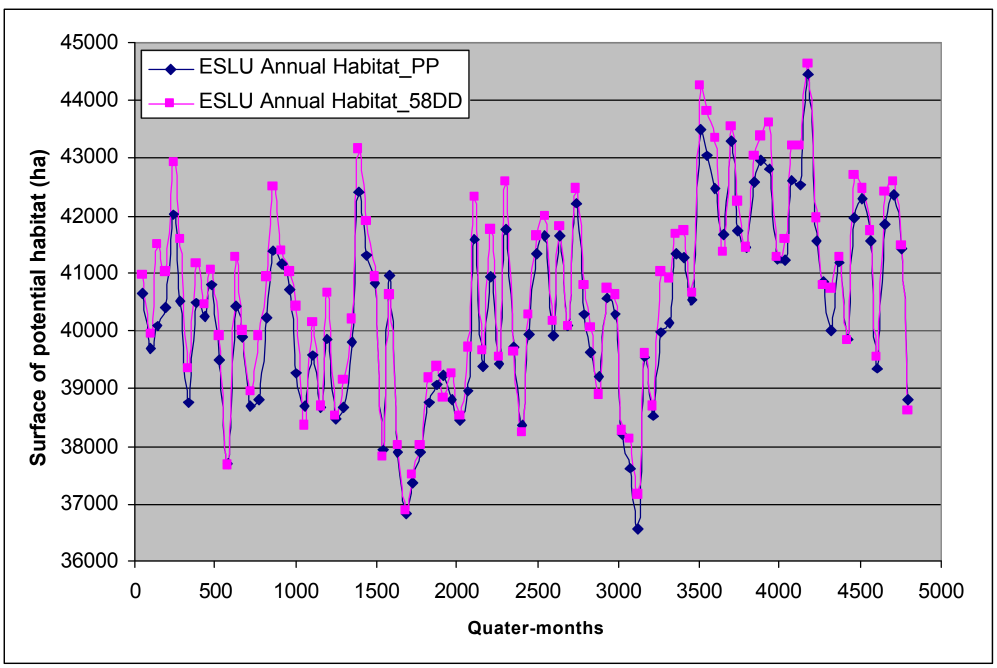


Figure: Comparison of the Performance indicator for the 100 years discharge series: Plan 1958DD and PreProject.

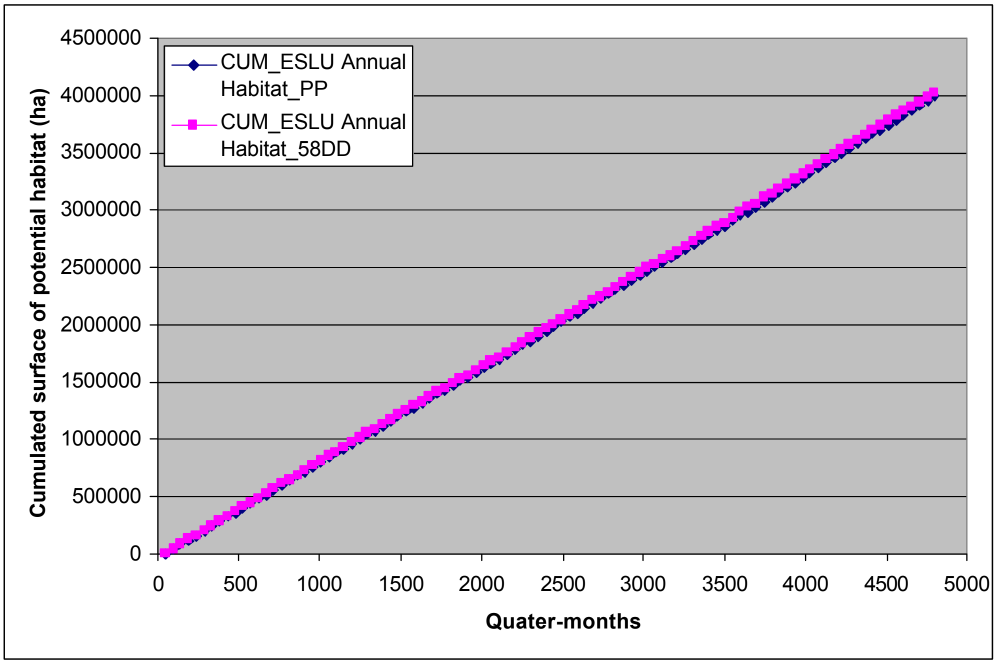


Figure: Comparison of the temporally cumulated Performance Indicator for the 100 years discharge series: Plan 1958DD and PreProject.

3 Performance indicator: Fish feeding habitat; Surface (ha) of potential habitat for Lake sturgeon (ACFU) *Acipenser fulvescens* (*Esturgeon jaune*).

Person responsible: Mingelbier & Morin

Origin and description of the indicator: This series of fish indicators give the area of fish suitable habitat for a large spectrum of water discharge conditions. They integrate the living, growth and feeding habitat for several key species.

Temporal validity: Valid between August 1st and October 31st

Spatial validity: Valid between Lake St. Louis and Lake St. Pierre (except Laprairie Basin)

Variables used in the 2D modeling:

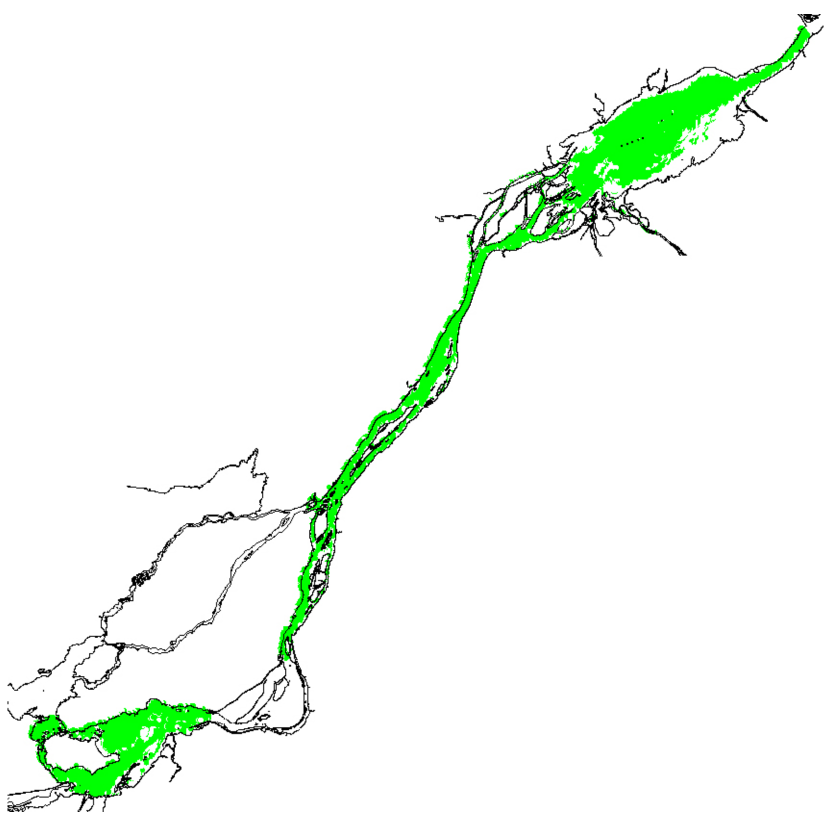
1. 2 D hydrodynamics model: Ratio of incidental light reaching the bottom
2. Field sampling: % of Silt Substratum-index
3. Biological model: Probability of presence of *Myriophyllum spicatum*

Calibration data: The model is based on data collected in the field (512 sites of gillnets and seines) for 105 presences and 407 absences. Performance are of $R^2 = 0.42$ and %Good = 86%.

Validation data: Leave one out method in 512 samples

Links with hydrology: Fish is a major component of the aquatic ecosystem, influenced at various degrees by the water discharge. Water discharge regulation may have adverse effects on habitat supply.

Map of the indicator for an average discharge (9500 m³/s at Sorel; scenario 4P):



Transfers from full 2D explicit models to simplified SMV curves:

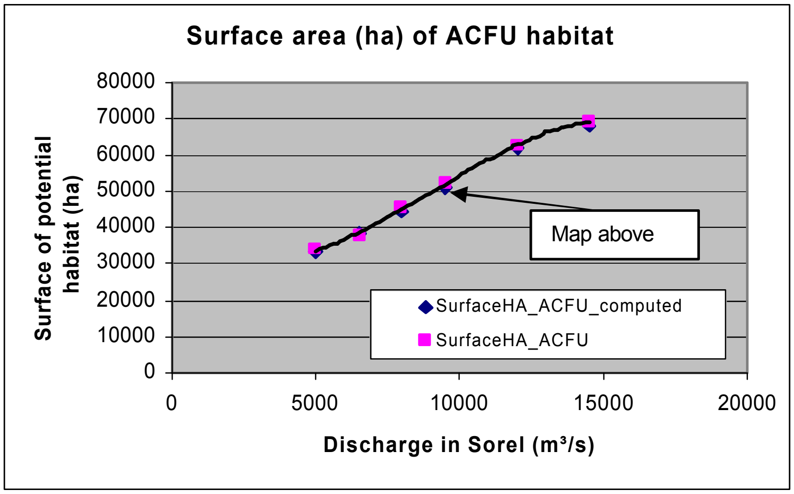


Figure: Relation between the calculated "Surface area of potential habitat" for ACFU and the discharge in Sorel, data and best fit curve: ACFU=-0.00000004*(Q_Sorel)^3 + 0.0011*(Q_Sorel)^2 - 5.48*(Q_Sorel) + 38236

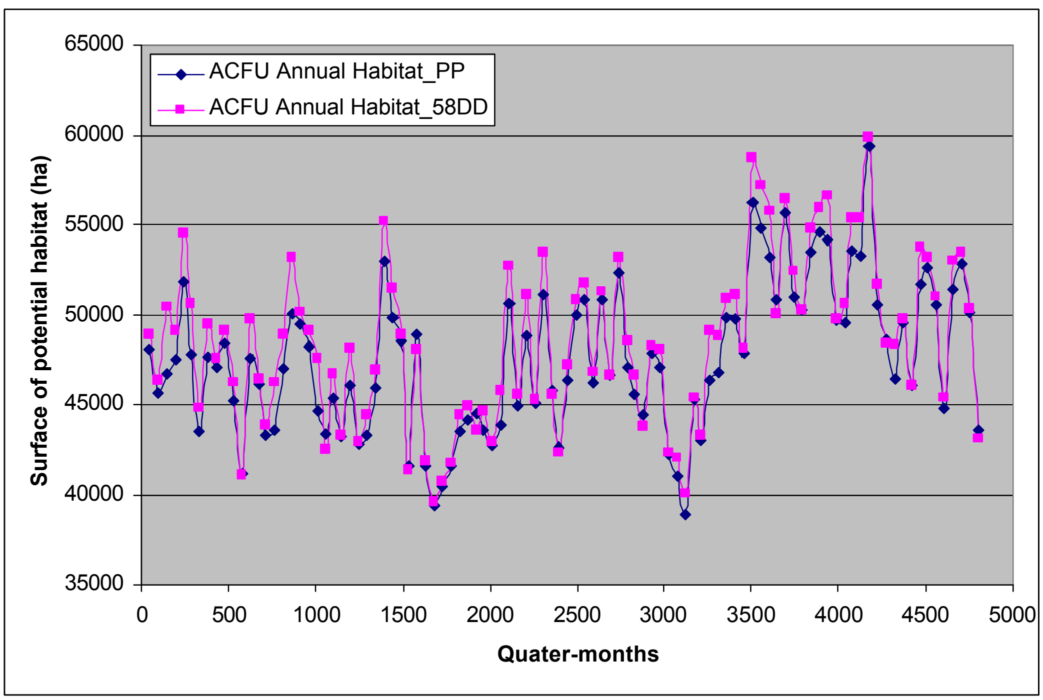


Figure: Comparison of the Performance indicator for the 100 years discharge series: Plan 1958DD and PreProject.

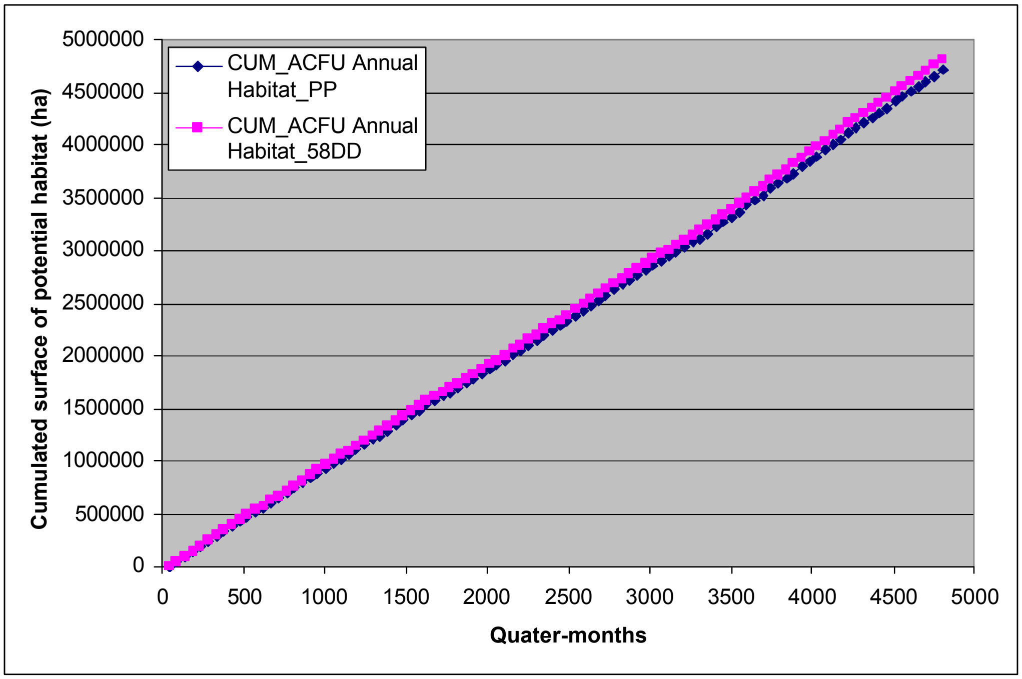


Figure: Comparison of the temporally cumulated Performance Indicator for the 100 years discharge series: Plan 1958DD and PreProject.

4 Performance indicator: Fish feeding habitat; Surface (ha) of potential habitat for Golden shiner (NOCR) *Notemigonus crysoleucas (Méné jaune)*

Person responsible: Mingelbier & Morin

Origin and description of the indicator: This series of fish indicators give the area of fish suitable habitat for a large spectrum of water discharge conditions. They integrate the living, growth and feeding habitat for several key species.

Temporal validity: Valid between August 1st and October 31st

Spatial validity: Valid between Lake St. Louis and Lake St. Pierre (except Laprairie Basin)

Variables used in the 2D modeling:

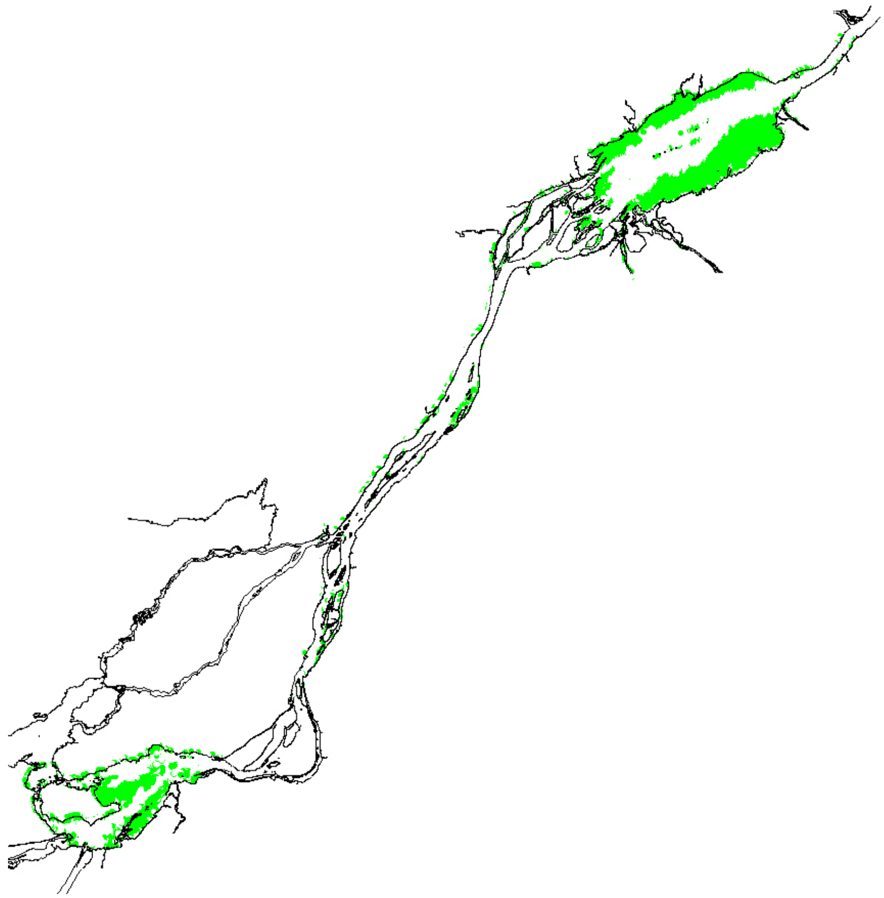
1. 2 D hydrodynamics model: Current velocity
2. Field sampling: % of Clay Substratum-index
3. Biological model: Simulated density of vegetation.

Calibration data: The model is based on data collected in the field (512 sites of gillnets and seines) for 142 presences and 370 absences. Performance are of $R^2 = 0.26$ and %Good = 77%.

Validation data: Leave one out method in 512 samples

Links with hydrology: Fish is a major component of the aquatic ecosystem, influenced at various degrees by the water discharge. Water discharge regulation may have adverse effects on habitat supply.

Map of the indicator for an average discharge (9500 m³/s at Sorel; scenario 4P):



<u>Transfers from full 2D explicit models to simplified SMV curves</u>:

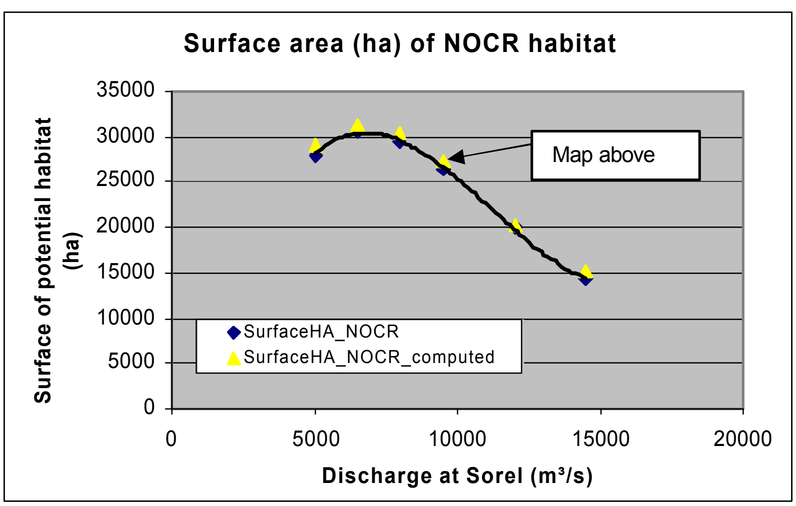


Figure: Relation between the calculated “Surface area of potential habitat” for NOCR and the discharge in Sorel, data and best fit curve: NOCR= 0.000000051*(Q_Sorel)^3 - 0.00169*(Q_Sorel)^2 + 15.79*(Q_Sorel) - 14000

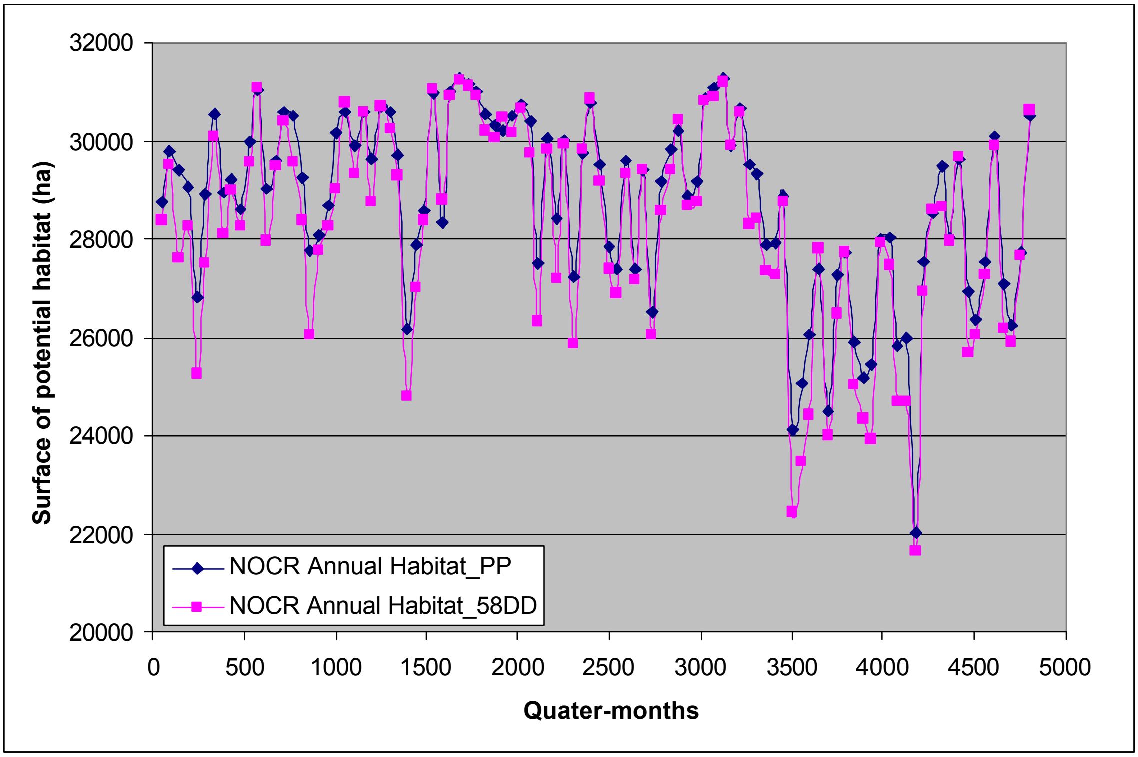


Figure: Comparison of the Performance indicator for the 100 years discharge series: Plan 1958DD and PreProject.

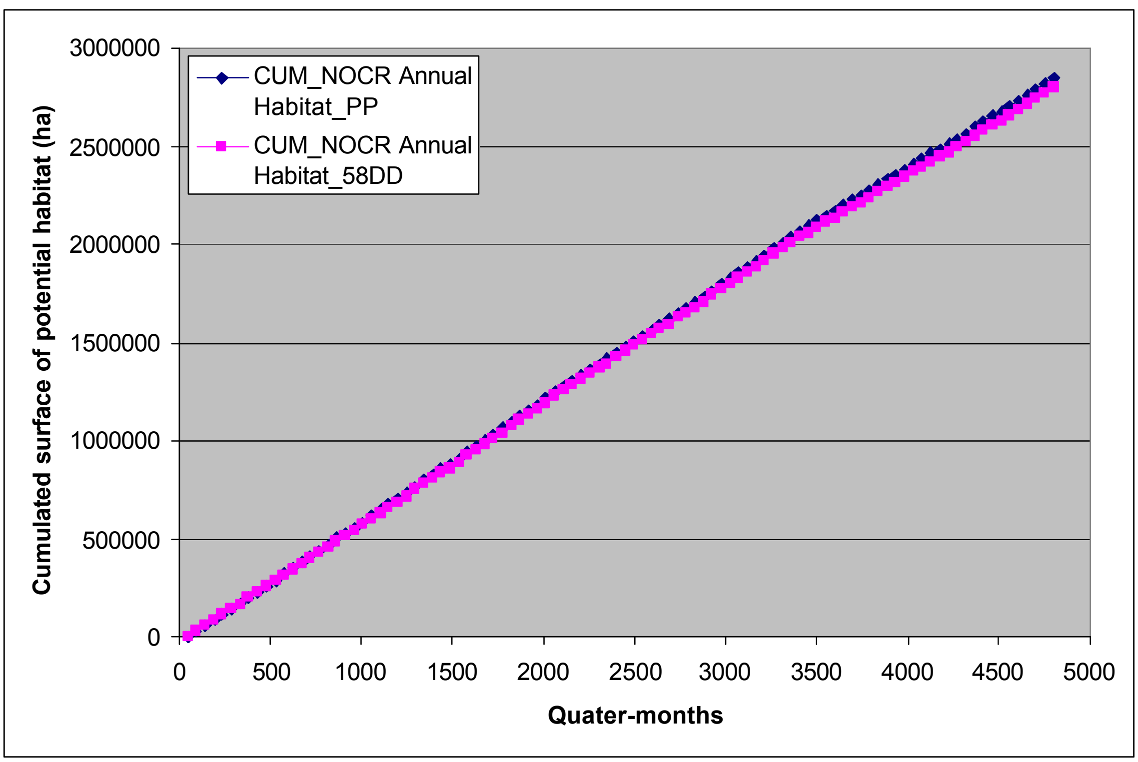


Figure: Comparison of the temporally cumulated Performance Indicator for the 100 years discharge series: Plan 1958DD and PreProject.

5 Performance indicator: Fish feeding habitat; Surface (ha) of potential habitat for Brown bullhead (ICNE) *Ameiurus nebulosus (Barbotte brune)*

Person responsible: Mingelbier & Morin

Origin and description of the indicator: This series of fish indicators give the area of fish suitable habitat for a large spectrum of water discharge conditions. They integrate the living, growth and feeding habitat for several key species.

Temporal validity: Valid between August 1st and October 31st

Spatial validity: Valid between Lake St. Louis and Lake St. Pierre (except Laprairie Basin)

Variables used in the 2D modeling:

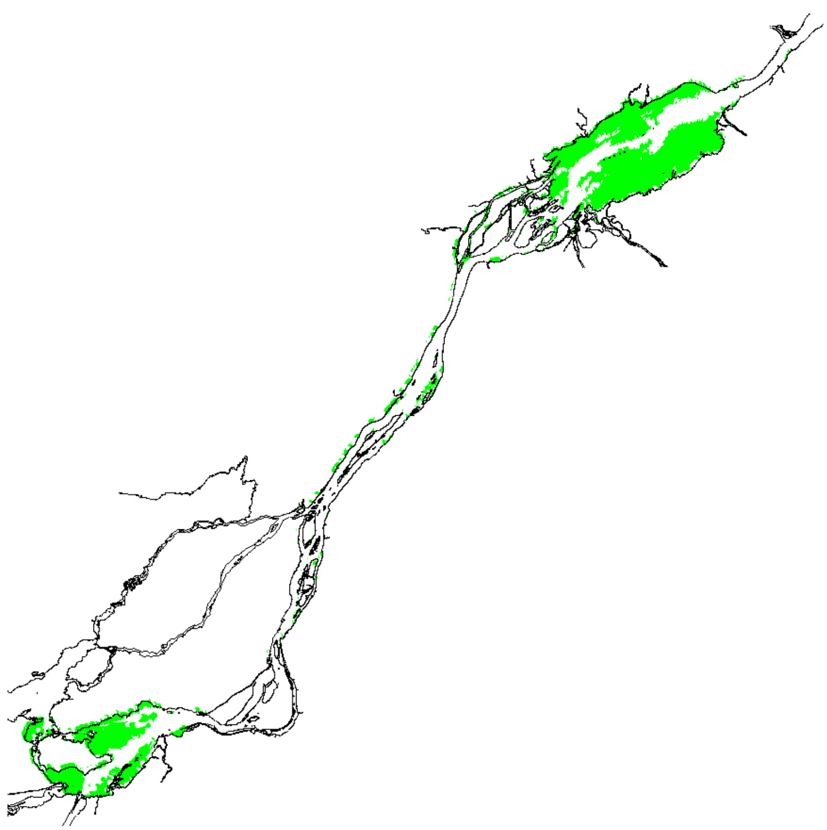
1. 2 D hydrodynamics model: Ratio of incidental light reaching the bottom, Current velocity
2. Field sampling: % of Silt Substratum-index
3. Biological model: Probability of presence of *Vallisneria americana*

Calibration data: The model is based on data collected in the field (512 sites of gillnets and seines) for 172 presences and 340 absences. Performance are of $R^2 = 0.34$ and %Good = 81%.

Validation data: Leave one out method in 512 samples

Links with hydrology: Fish is a major component of the aquatic ecosystem, influenced at various degrees by the water discharge. Water discharge regulation may have adverse effects on habitat supply.

Map of the indicator for an average discharge (9500 m³/s at Sorel; scenario 4P):



Transfers from full 2D explicit models to simplified SMV curves:

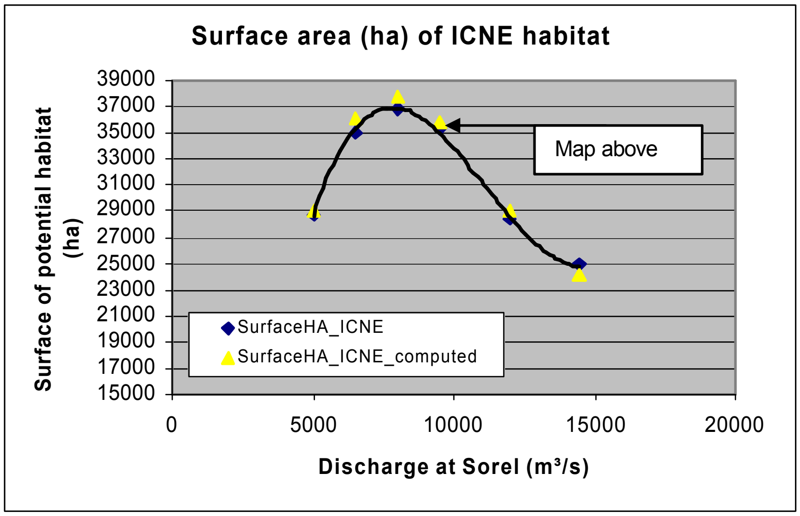


Figure: Relation between the calculated "Surface area of potential habitat" for ICNE and the discharge in Sorel, data and best fit curve: ICNE=0.0000000792*(Q_Sorel)^3 - 0.0027*(Q_Sorel)^2 + 27.747*(Q_Sorel)- 51998

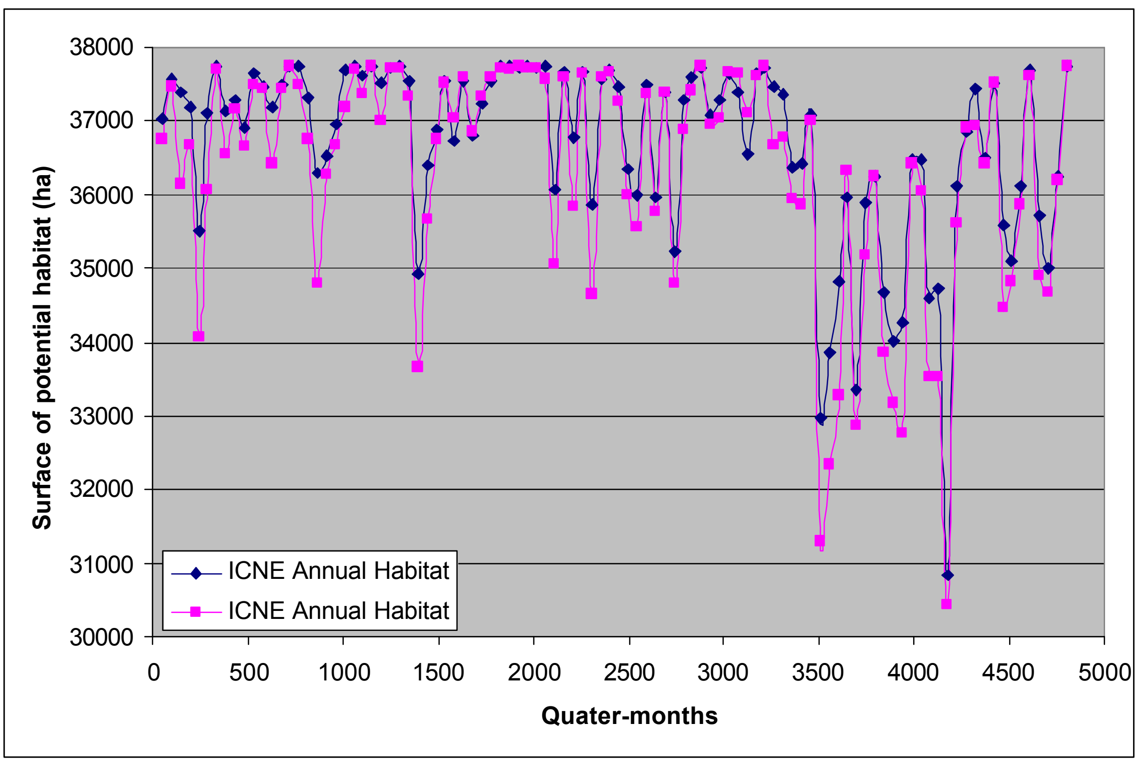


Figure: Comparison of the Performance indicator for the 100 years discharge series: Plan 1958DD and PreProject.

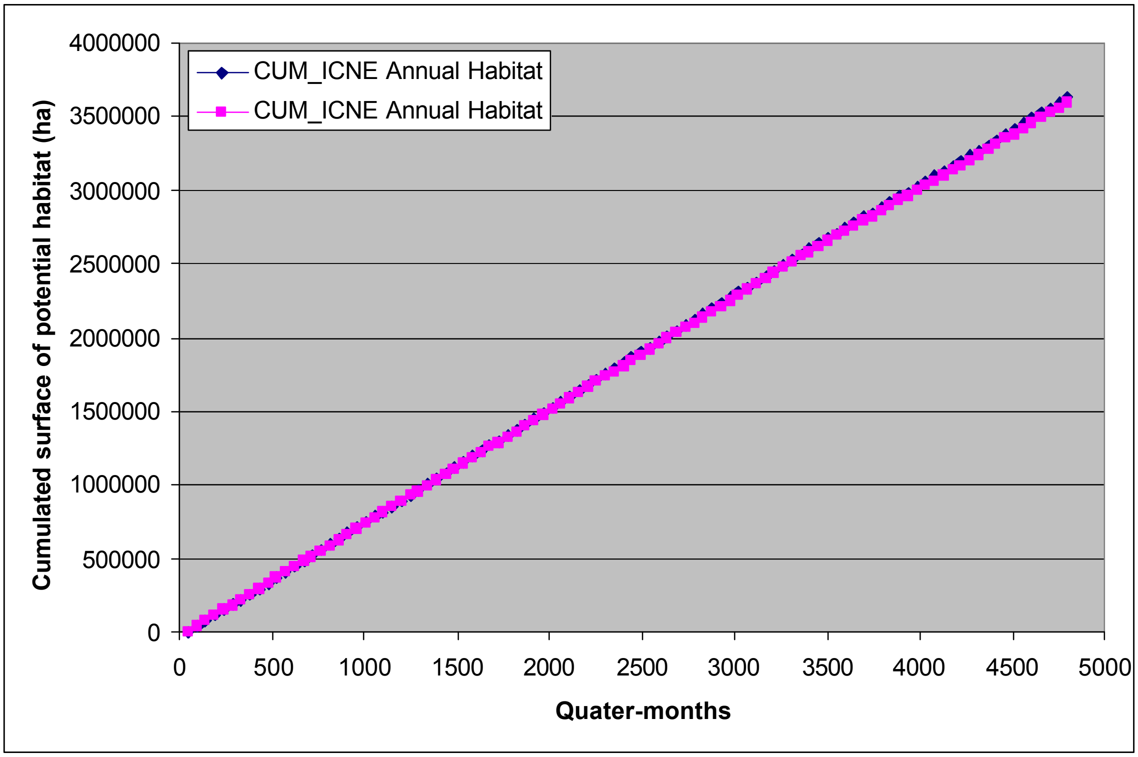


Figure: Comparison of the temporally cumulated Performance Indicator for the 100 years discharge series: Plan 1958DD and PreProject.

6 Performance indicator: Fish feeding habitat; Surface (ha) of potential habitat for Largemouth bass (MISA) *Micropterus salmoides (Achigan à grande bouche)*

Person responsible: Mingelbier & Morin

Origin and description of the indicator: This series of fish indicators give the area of fish suitable habitat for a large spectrum of water discharge conditions. They integrate the living, growth and feeding habitat for several key species.

Temporal validity: Valid between August 1st and October 31st

Spatial validity: Valid between Lake St. Louis and Lake St. Pierre (except Laprairie Basin)

Variables used in the 2D modeling:

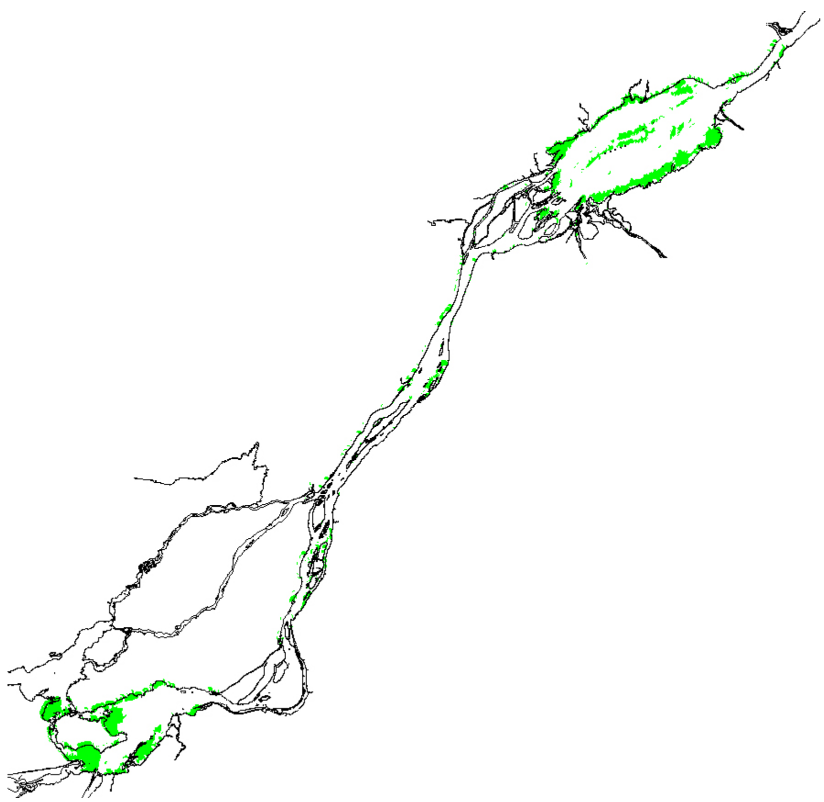
1. 2 D hydrodynamics model: Current velocity
2. Field sampling: % of Gravel Substratum-index

Calibration data: The model is based on data collected in the field (512 sites of gillnets and seines) for 44 presences and 365 absences. Performance are of $R^2 = 0.21$ and %Good = 80%.

Validation data: Leave one out method in 512 samples

Links with hydrology: Fish is a major component of the aquatic ecosystem, influenced at various degrees by the water discharge. Water discharge regulation may have adverse effects on habitat supply.

Map of the indicator for an average discharge (9500 m³/s at Sorel; scenario 4P):



Transfers from full 2D explicit models to simplified SMV curves:

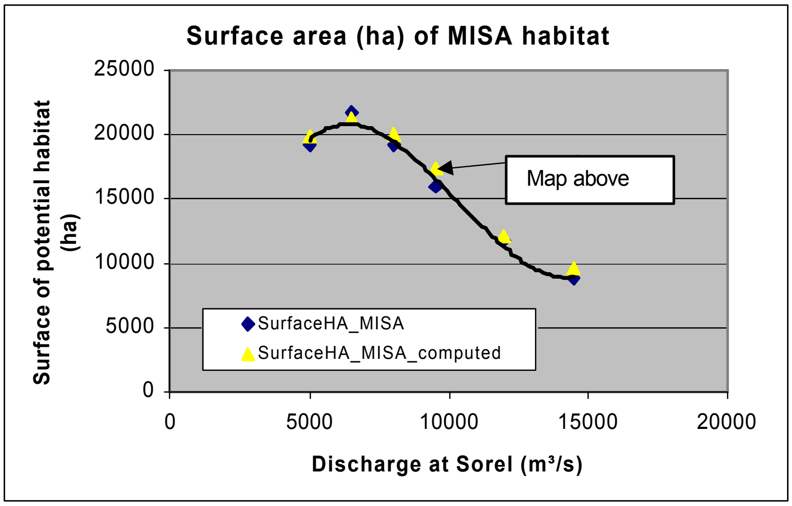


Figure: Relation between the calculated “Surface area of potential habitat” for MISA and the discharge in Sorel, data and best fit curve: MISA=0.0000000482*(Q_Sorel)^3 - 0.0015*(Q_Sorel)^2 + 13.341*(Q_Sorel) - 15340

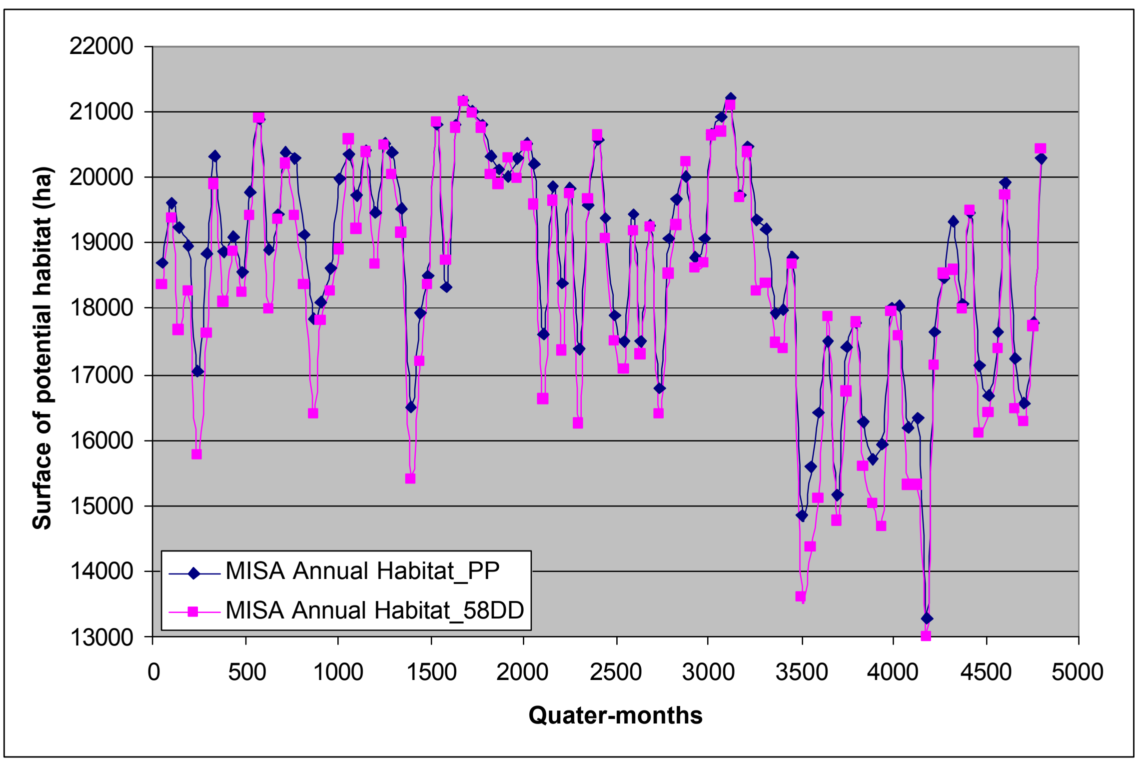


Figure: Comparison of the Performance indicator for the 100 years discharge series: Plan 1958DD and PreProject.

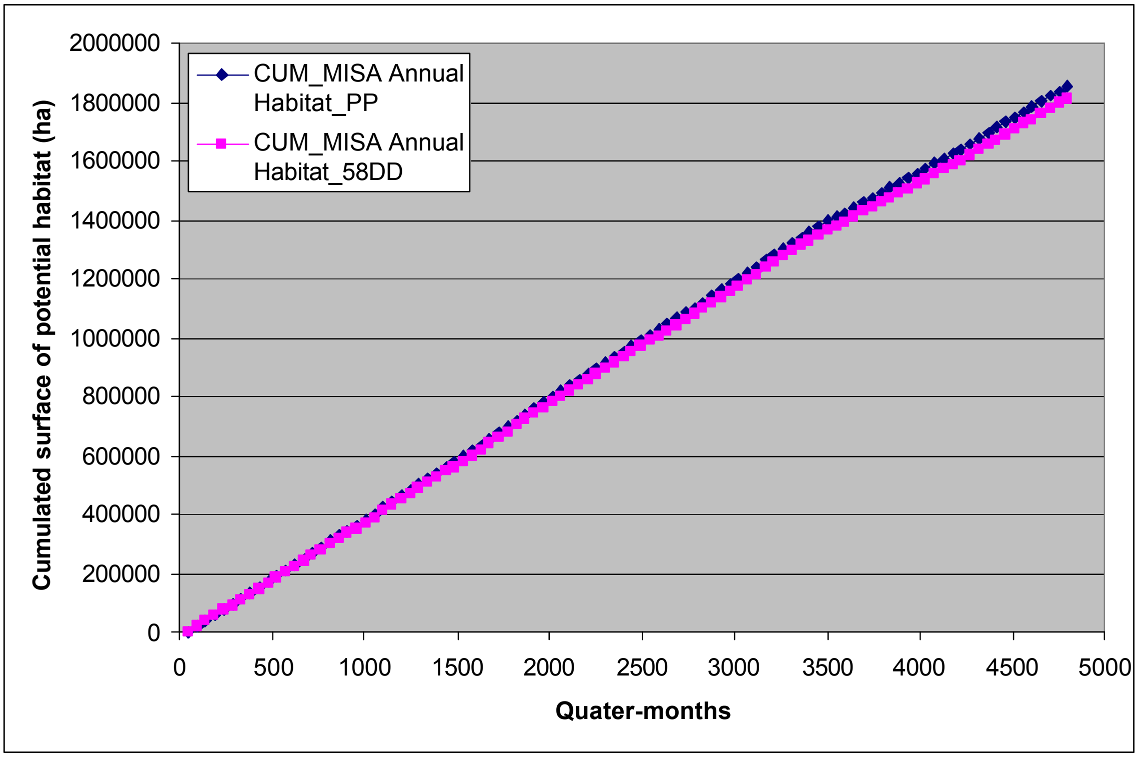


Figure: Comparison of the temporally cumulated Performance Indicator for the 100 years discharge series: Plan 1958DD and PreProject.

7 Performance indicator: Fish feeding habitat; Surface (ha) of potential habitat for Sauger (STCA) *Stizostedion canadense (Doré noir)*

Person responsible: Mingelbier & Morin

Origin and description of the indicator: This series of fish indicators give the area of fish suitable habitat for a large spectrum of water discharge conditions. They integrate the living, growth and feeding habitat for several key species.

Temporal validity: Valid between August 1st and October 31st

Spatial validity: Valid between Lake St. Louis and Lake St. Pierre (except Laprairie Basin)

Variables used in the 2D modeling:

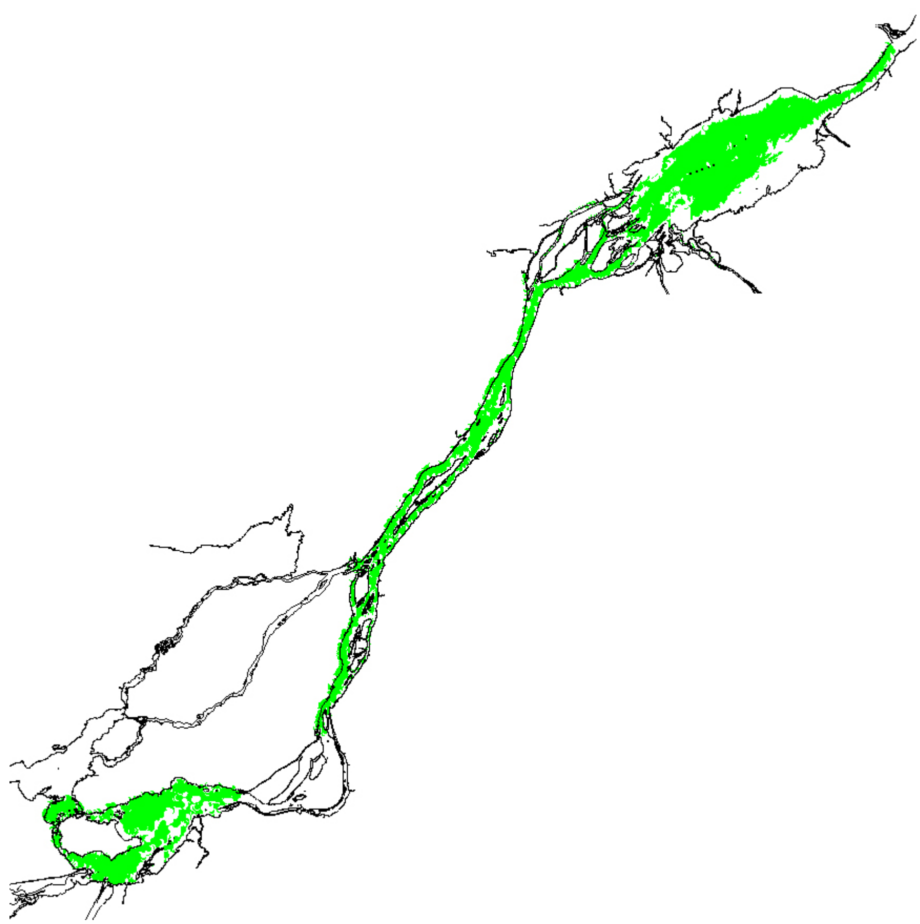
- 2 D hydrodynamics model: Ratio of incidental light reaching the bottom, Depth, Slope of the bottom

Calibration data: The model is based on data collected in the field (512 sites of gillnets and seines) for 150 presences and 362 absences. Performance are of $R^2 = 0.48$ and %Good = 87%.

Validation data: Leave one out method in 512 samples

Links with hydrology: Fish is a major component of the aquatic ecosystem, influenced at various degrees by the water discharge. Water discharge regulation may have adverse effects on habitat supply.

Map of the indicator for an average discharge (9500 m³/s at Sorel; scenario 4P):



Transfers from full 2D explicit models to simplified SMV curves:

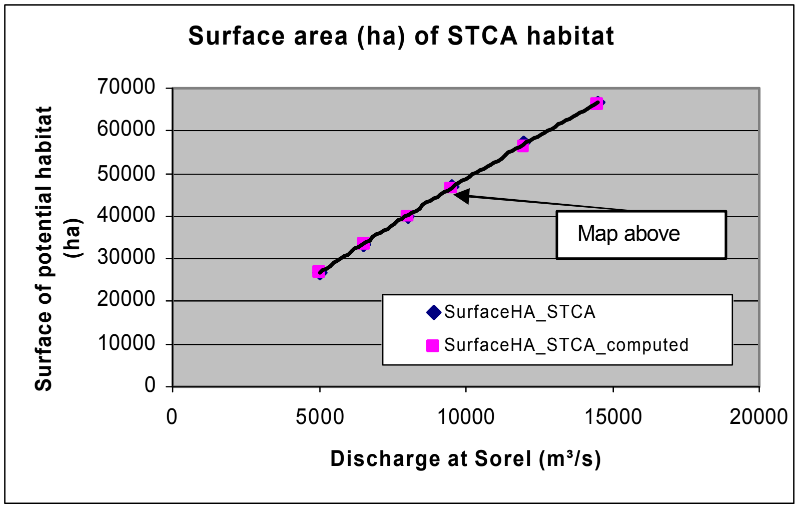


Figure: Relation between the calculated “Surface area of potential habitat” for STCA and the discharge in Sorel, data and best fit curve: STCA=-0.00005*(Q_Sorel)^2 + 5.132*(Q_Sorel) + 2201.8

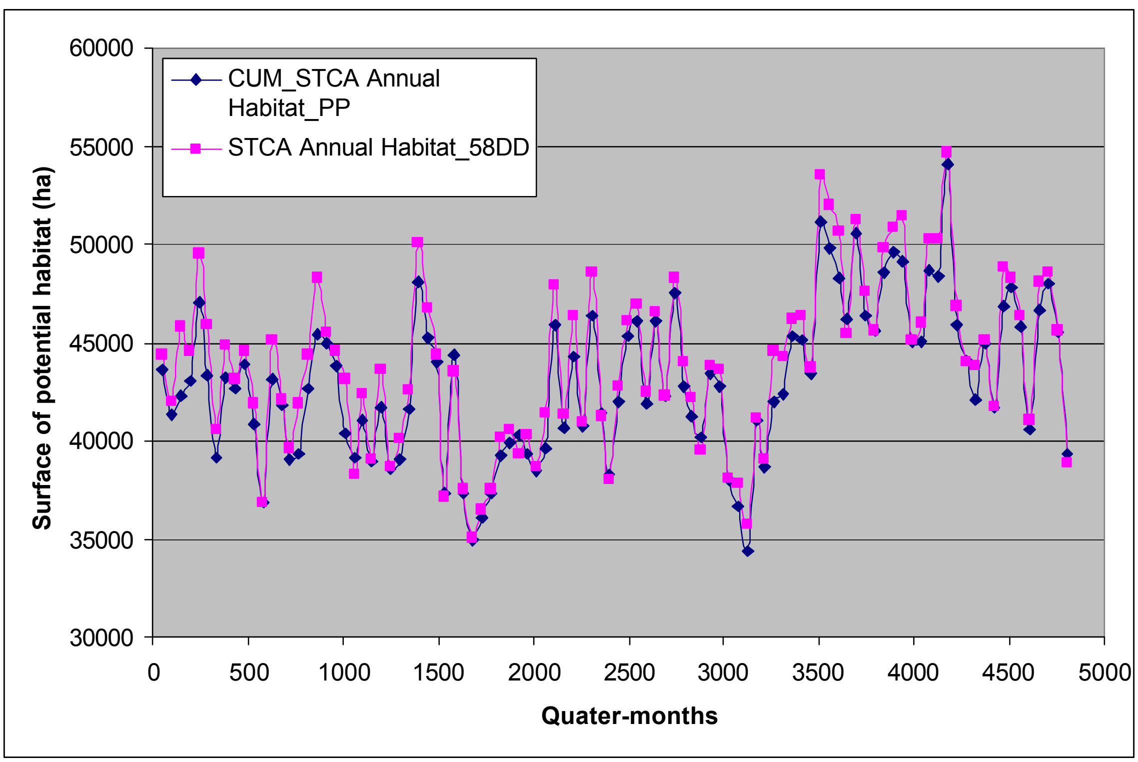


Figure: Comparison of the Performance indicator for the 100 years discharge series: Plan 1958DD and PreProject.

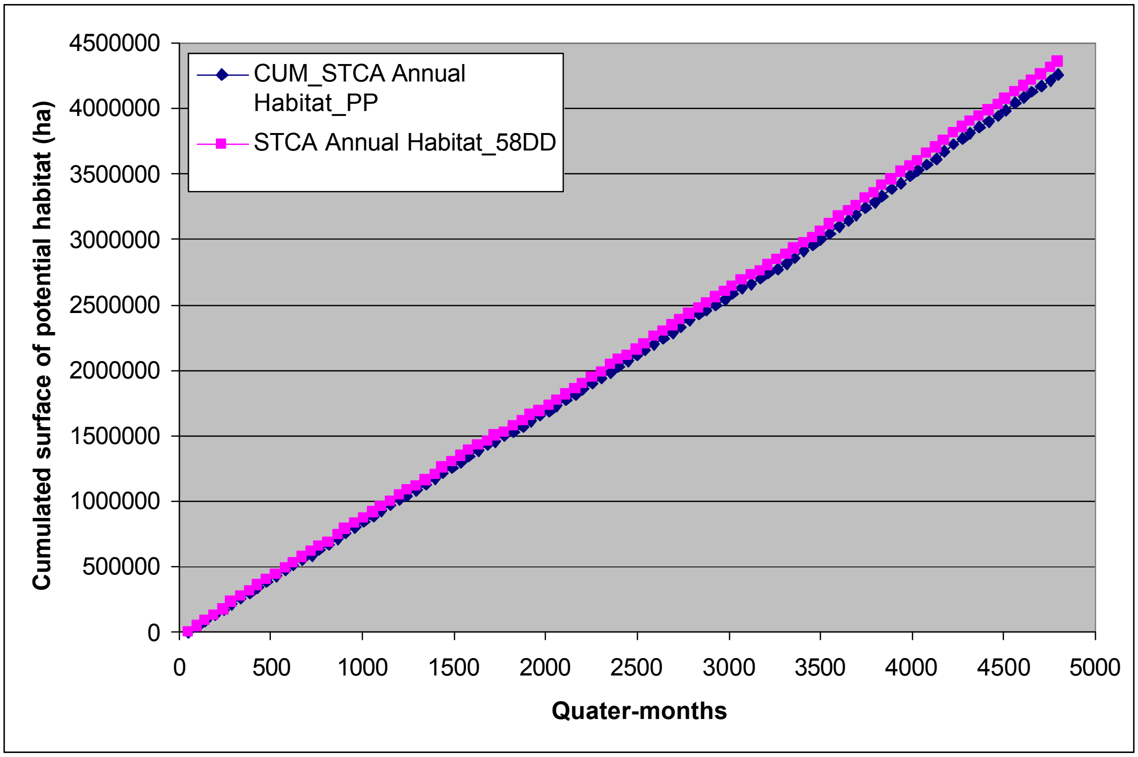


Figure: Comparison of the temporally cumulated Performance Indicator for the 100 years discharge series: Plan 1958DD and PreProject.

8 Performance indicator: Fish feeding habitat; Surface (ha) of potential habitat for Yellow perch (PEFL) *Perca flavescens (Perchaude)*

Person responsible: Mingelbier & Morin

Origin and description of the indicator: This series of fish indicators give the area of fish suitable habitat for a large spectrum of water discharge conditions. They integrate the living, growth and feeding habitat for several key species.

Temporal validity: Valid between August 1st and October 31st

Spatial validity: Valid between Lake St. Louis and Lake St. Pierre (except Laprairie Basin)

Variables used in the 2D modeling:

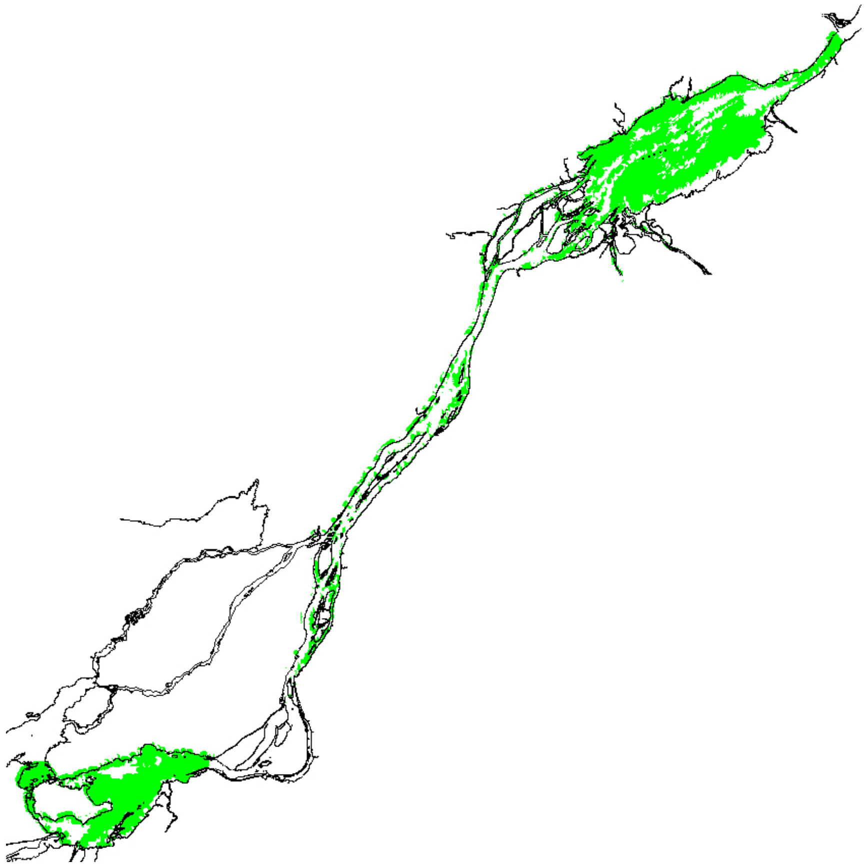
1. Field sampling: % of Clay Substratum-index
2. Biological model: Simulated density of vegetation.
3. Biological model: Probability of presence of *Vallisneria Americana, Potamogeton richardsoni*

Calibration data: The model is based on data collected in the field (512 sites of gillnets and seines) for 369 presences and 143 absences. Performance are of $R^2 = 0.29$ and %Good = 78%.

Validation data: Leave one out method in 512 samples

Links with hydrology: Fish is a major component of the aquatic ecosystem, influenced at various degrees by the water discharge. Water discharge regulation may have adverse effects on habitat supply.

Map of the indicator for an average discharge (9500 m³/s at Sorel; scenario 4P):



Transfers from full 2D explicit models to simplified SMV curves:

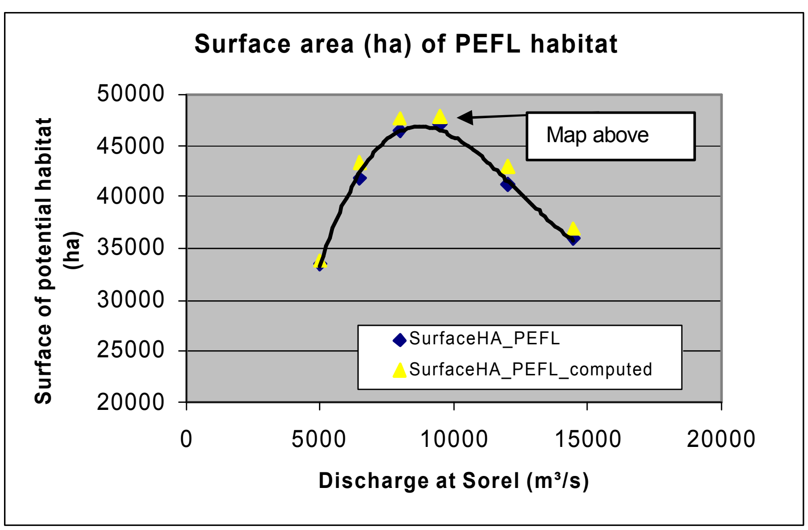


Figure: Relation between the calculated "Surface area of potential habitat" for PEFL and the discharge in Sorel, data and best fit curve: PEFL=0.0000000635*(Q_Sorel)^3 - 0.0024*(Q_Sorel)^2 + 27.573*(Q_Sorel) - 51926

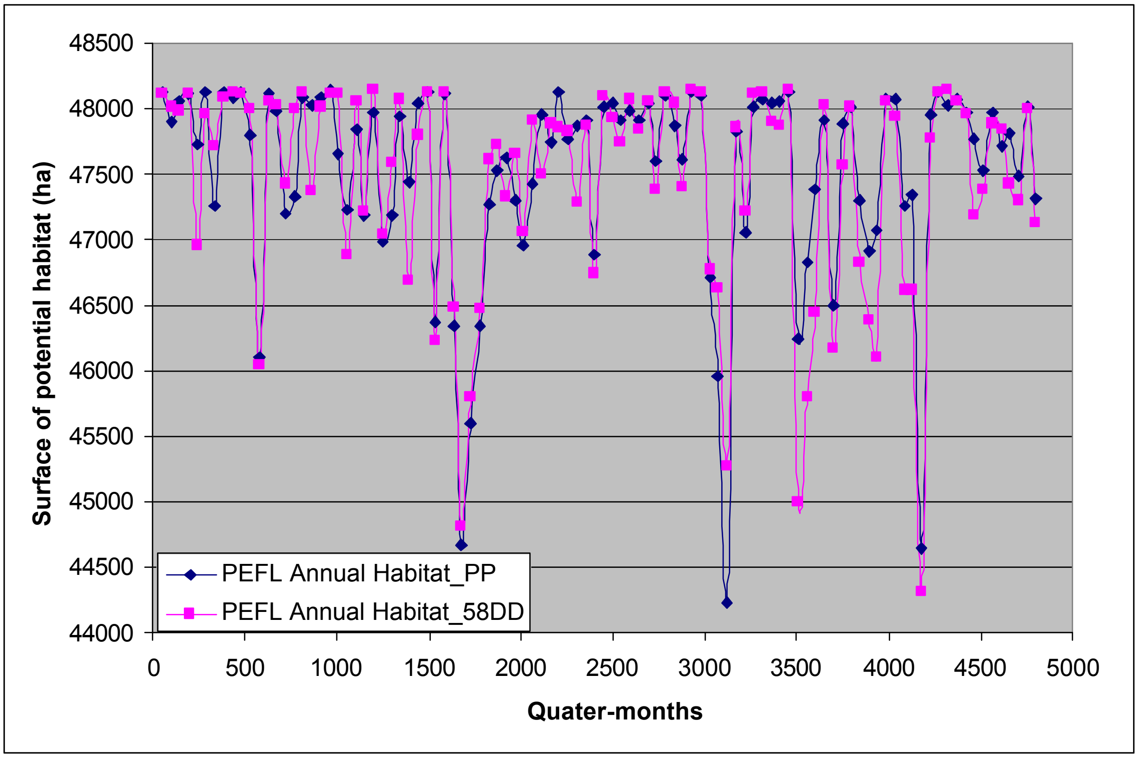


Figure: Comparison of the Performance indicator for the 100 years discharge series: Plan 1958DD and PreProject.

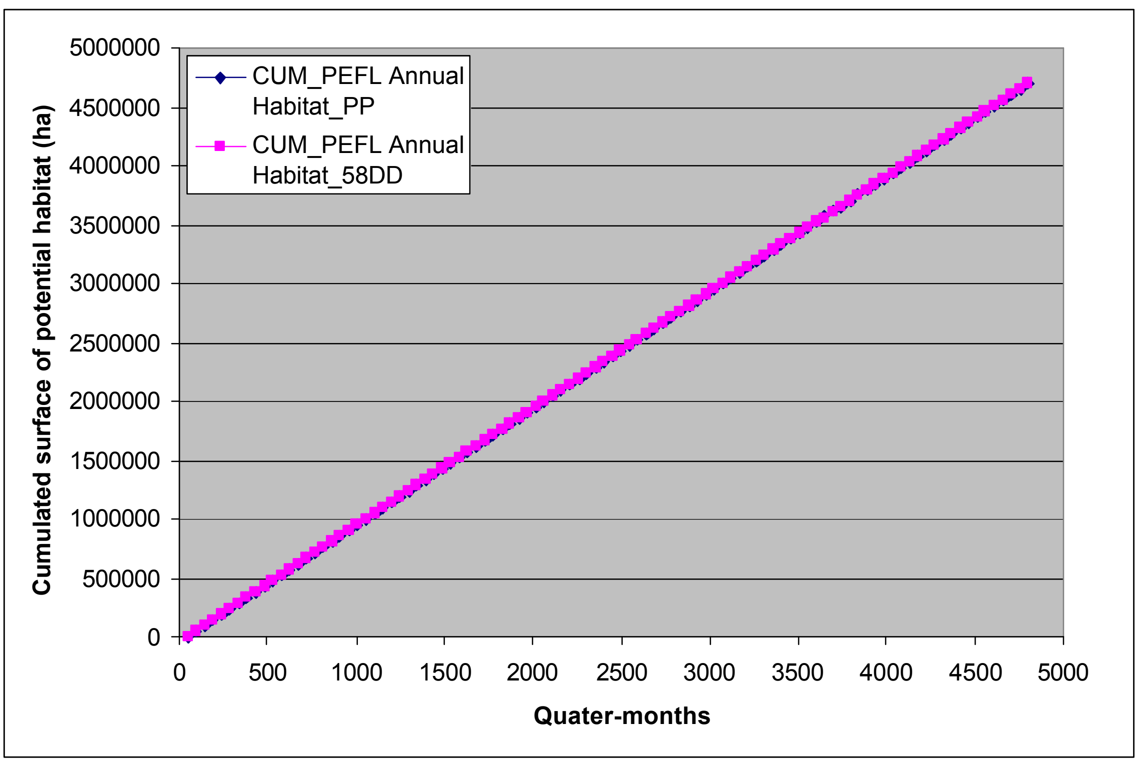


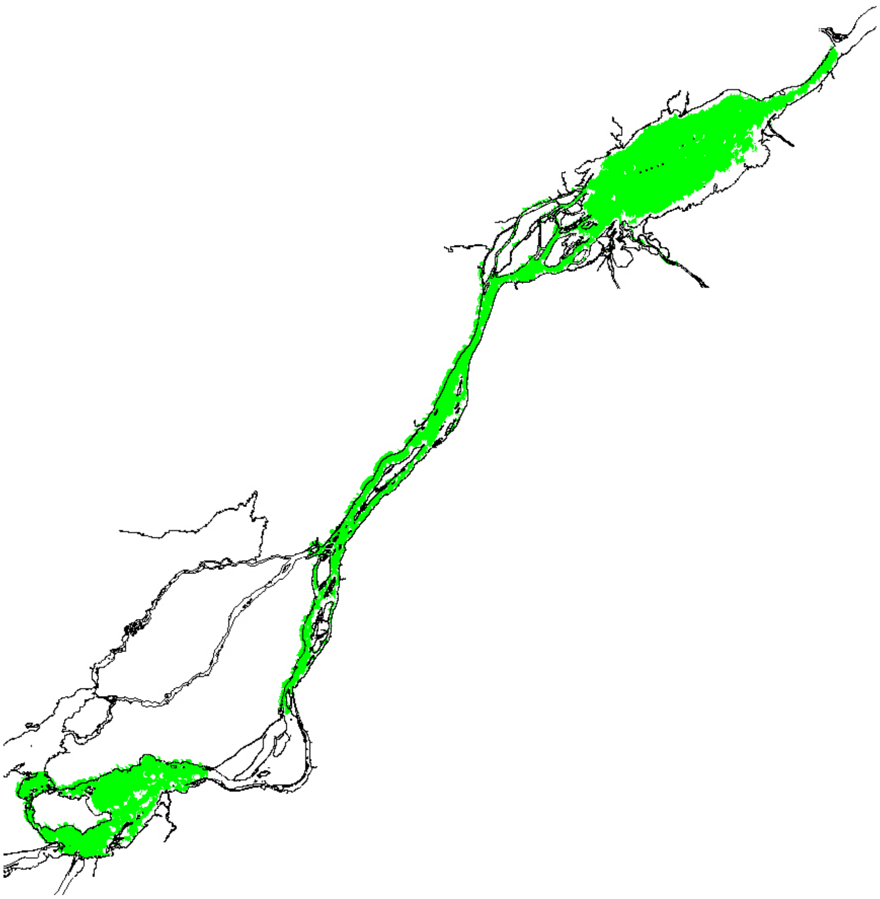
Figure: Comparison of the temporally cumulated Performance Indicator for the 100 years discharge series: Plan 1958DD and PreProject.

9 Performance indicator: Fish feeding habitat; Surface (ha) of potential habitat for Walleye (STVI) *Stizostedion vitreum (Doré jaune)*

Person responsible: Mingelbier & Morin
Origin and description of the indicator: This series of fish indicators give the area of fish suitable habitat for a large spectrum of water discharge conditions. They integrate the living, growth and feeding habitat for several key species.
Temporal validity: Valid between August 1st and October 31st
Spatial validity: Valid between Lake St. Louis and Lake St. Pierre (except Laprairie Basin)
Variables used in the 2D modeling:
- 2 D hydrodynamics model: Ratio of incidental light reaching the bottom, Depth, Current velocity, Slope of the bottom
- Field sampling: % of Galet, Cailloux, Gravel, Sand, Silt, Clay Substratum-index
- Biological model: Simulated density of vegetation.
- Biological model: Probability of presence of *Vallisneria americana*, *Heterentera dubia*, *Potamogeton richardsoni, Elodea canadiensis, Potamogeton pectinaus, Myriophyllum spicatum, Alisma graminea, Ceratophyllum demersum*

Calibration data: The model is based on data collected in the field (512 sites of gillnets and seines) for 263 presences and 249 absences. Performance are of $R^2 = 0.36$ and %Good = 80%.
Validation data: Leave one out method in 512 samples
Links with hydrology: Fish is a major component of the aquatic ecosystem, influenced at various degrees by the water discharge. Water discharge regulation may have adverse effects on habitat supply.

Map of the indicator for an average discharge (9500 m³/s at Sorel; scenario 4P):



Transfers from full 2D explicit models to simplified SMV curves:

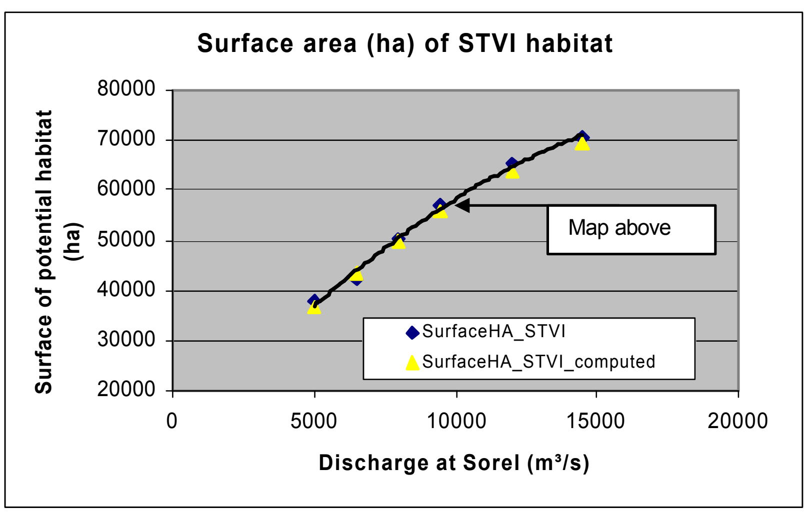


Figure: Relation between the calculated “Surface area of potential habitat” for STVI and the discharge in Sorel, data and best fit curve: STVI= -0.000158*(Q_Sorel)^2 + 6.5389*(Q_Sorel) + 7799.8

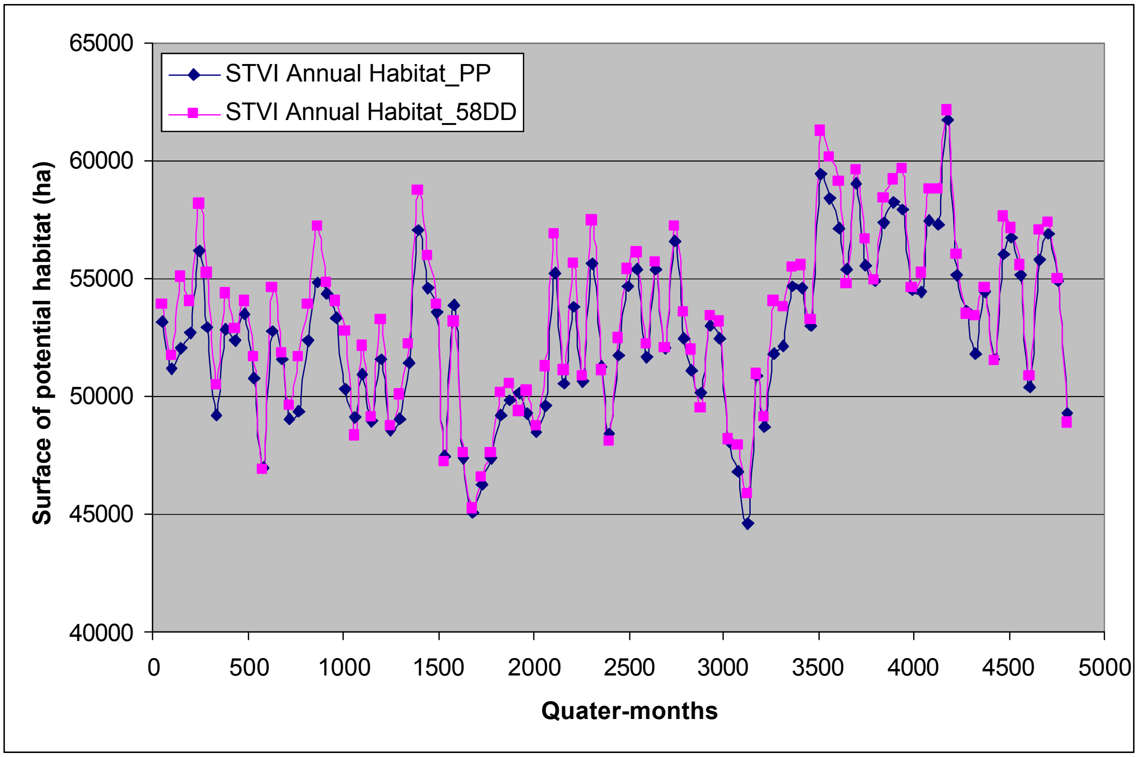


Figure: Comparison of the Performance indicator for the 100 years discharge series: Plan 1958DD and PreProject.

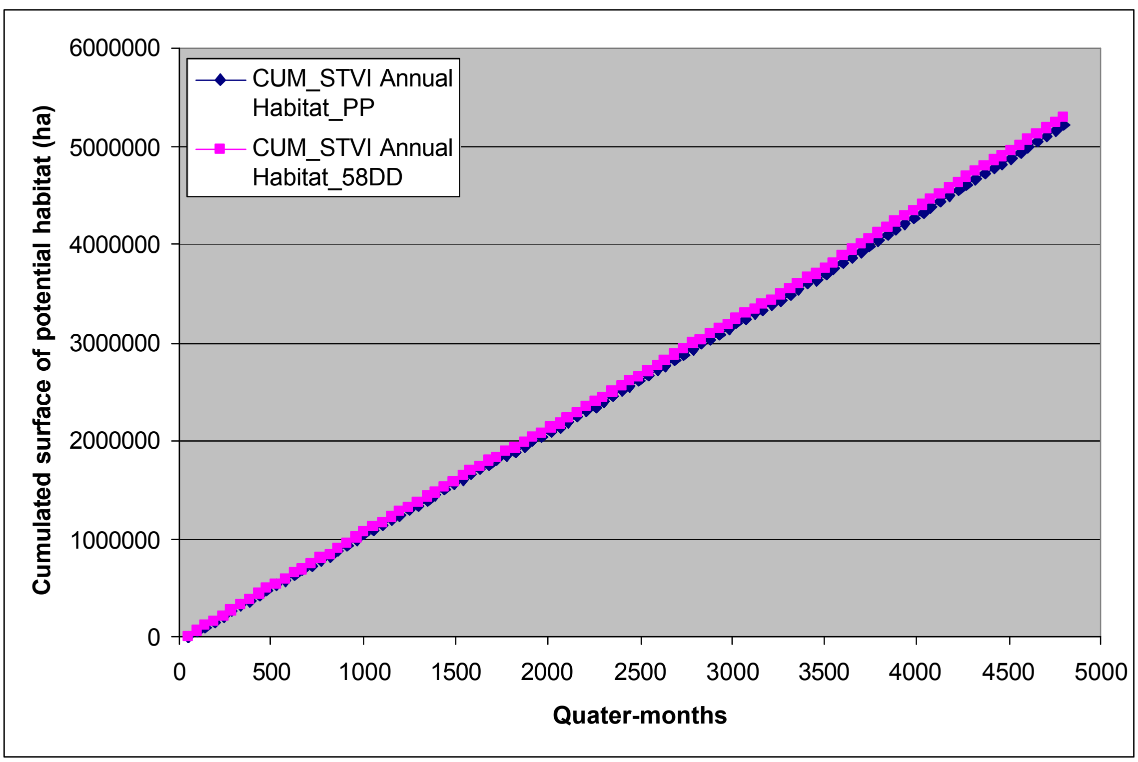
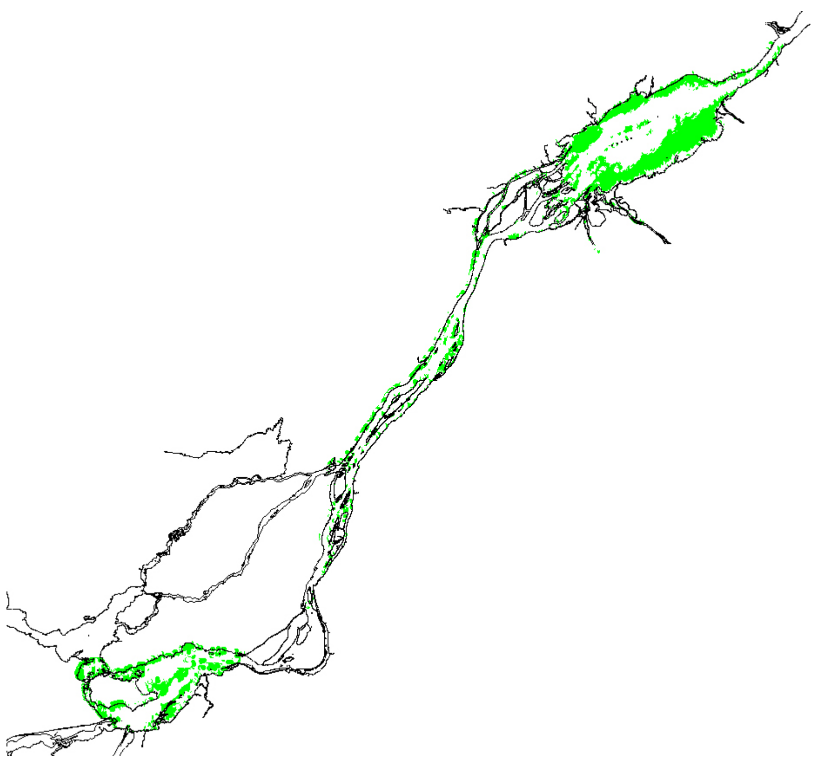


Figure: Comparison of the temporally cumulated Performance Indicator for the 100 years discharge series: Plan 1958DD and PreProject.

10 Performance indicator: Fish feeding habitat; Surface (ha) of potential habitat for Spottail shiner (NOHU) *Notropis hudsonius (Queue à tache noire)*

Person responsible: Mingelbier & Morin
Origin and description of the indicator: This series of fish indicators give the area of fish suitable habitat for a large spectrum of water discharge conditions. They integrate the living, growth and feeding habitat for several key species.
Temporal validity: Valid between August 1st and October 31st
Spatial validity: Valid between Lake St. Louis and Lake St. Pierre (except Laprairie Basin)
Variables used in the 2D modeling:
- 2 D hydrodynamics model: Ratio of incidental light reaching the bottom, Slope of the bottom
Calibration data: The model is based on data collected in the field (512 sites of gillnets and seines) for 183 presences and 329 absences. Performance are of $R^2 = 0.32$ and %Good = 79%.
Validation data: Leave one out method in 512 samples
Links with hydrology: Fish is a major component of the aquatic ecosystem, influenced at various degrees by the water discharge. Water discharge regulation may have adverse effects on habitat supply.
Map of the indicator for an average discharge (9500 m^3/s at Sorel; scenario 4P):



Transfers from full 2D explicit models to simplified SMV curves:

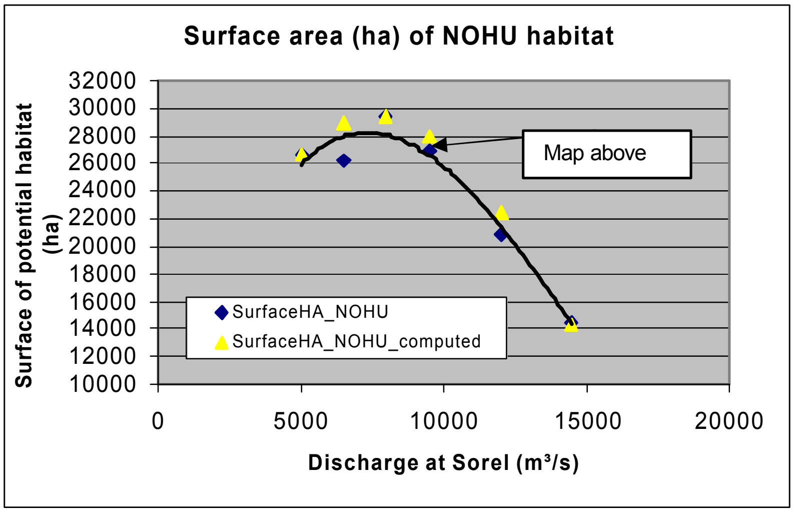


Figure: Relation between the calculated "Surface area of potential habitat" for NOHU and the discharge in Sorel, data and best fit curve: NOHU= 0.0000000132*(Q_Sorel)^3 - 0.0007*(Q Q_Sorel)^2 + 8.2844*(Q_Sorel) + 1093.5

Indicator evolution for 1958DD and PreProject plans:

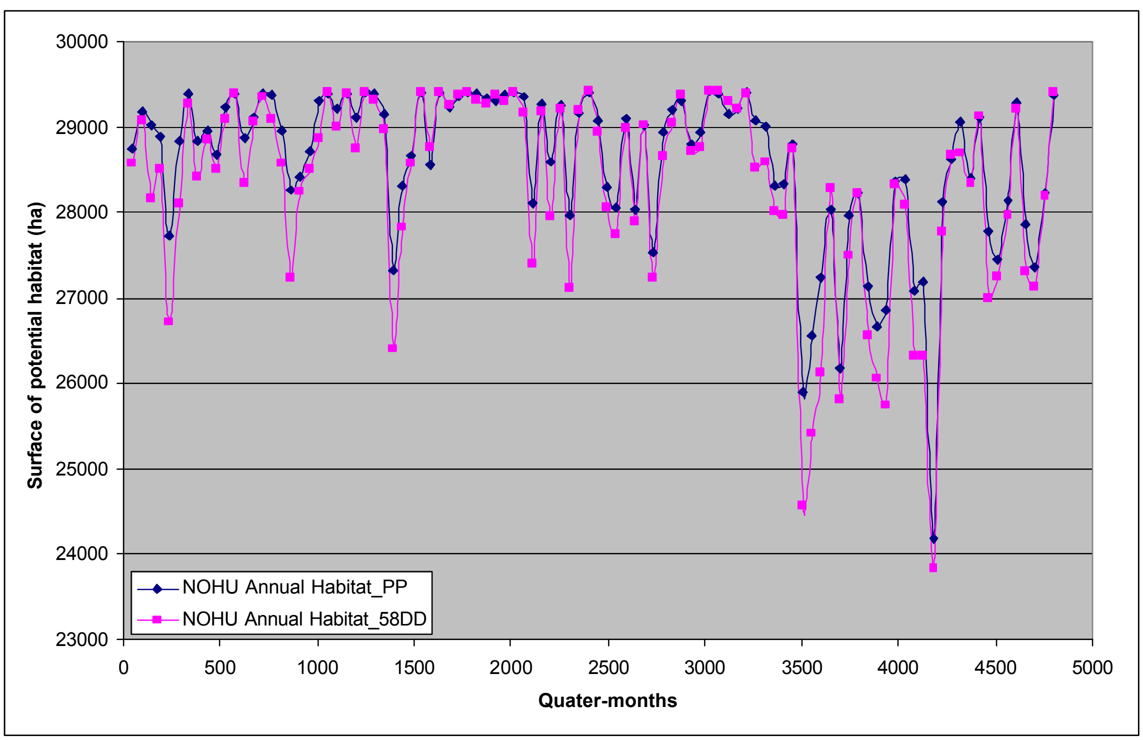


Figure: Comparison of the Performance indicator for the 100 years discharge series: Plan 1958DD and PreProject.

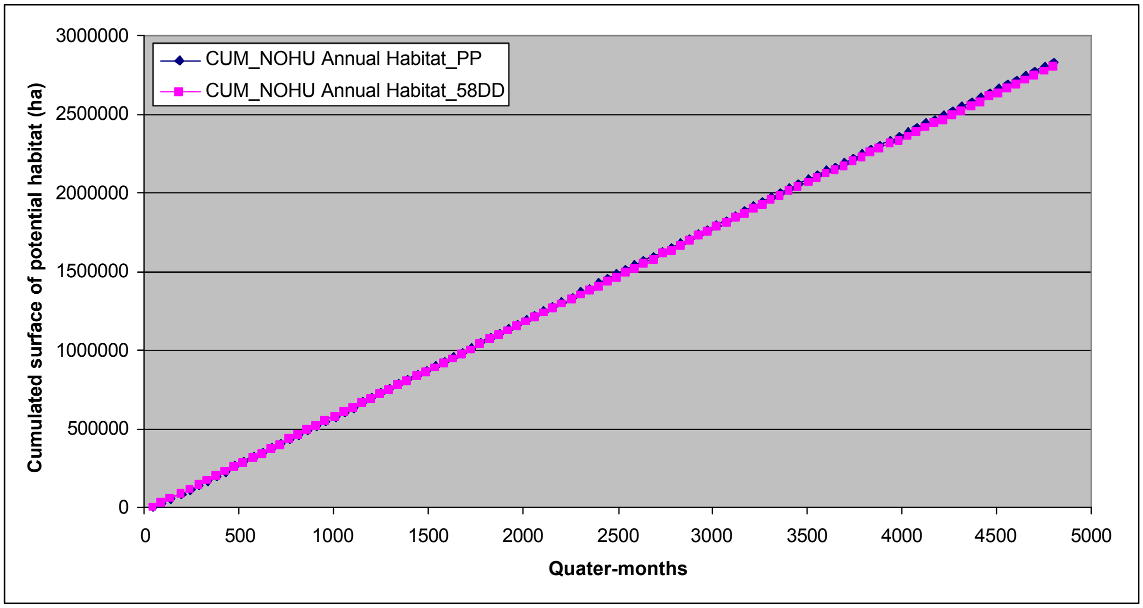


Figure: Comparison of the temporally cumulated Performance Indicator for the 100 years discharge series: Plan 1958DD and PreProject.

II. Herptile habitat models: reproduction and hibernation

11 Performance indicator: Reproduction habitat of frogs

Person responsible: Armellin, Rioux & Morin

Origin and description of the indicator: The amphibians play an important role in the wetlands because of their position in the food chain and their important biomass. In their life cycle, they use both the aquatic environment and the terrestrial environment, making them, very sensible to variation in the ecosystem. The vegetation of the flood plain (marsh, submerged vegetation, wet meadow, etc.) is an important part of their habitat. They offer food and shelters against the predators. The variation in water level can affect these habitats, therefore affecting the habitat of the frogs. The indicator gives the available surface area of reproduction habitat for different conditions in spring time.

Temporal validity: This indicator is applied during the early April period, the 2 first quarter-months of April.

Spatial validity: From Lake Saint-Louis to Trois-Rivières.

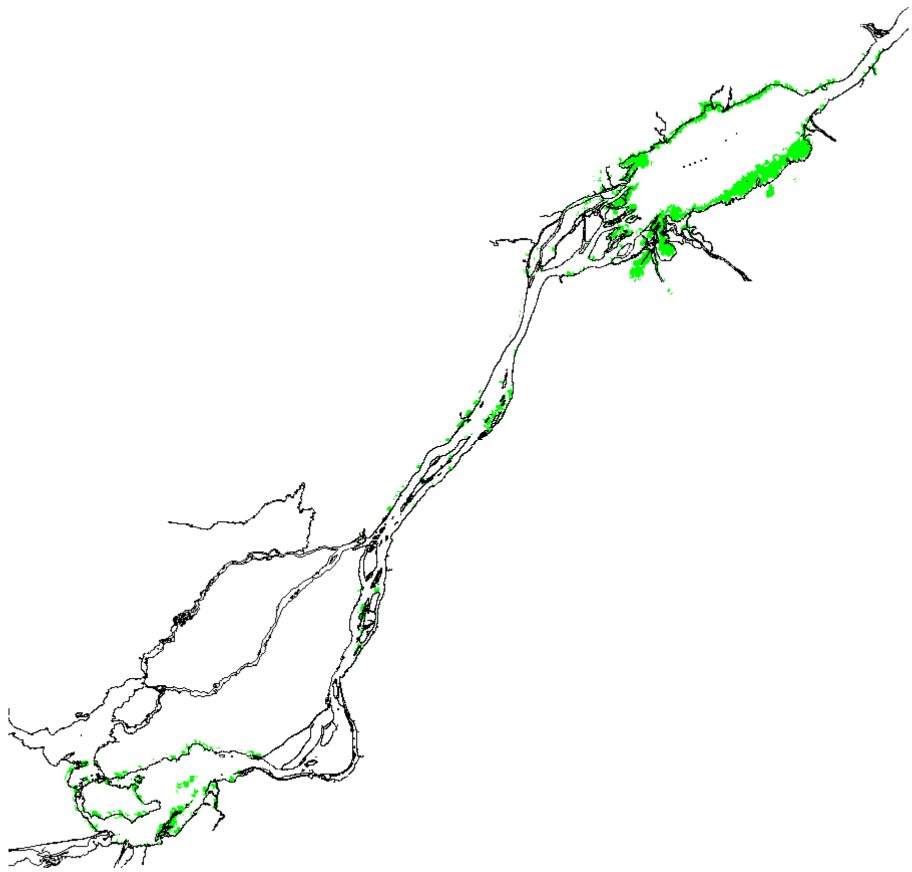
Variables used in the 2D modeling: 1) presence of Deep marsh
2) Water depth and 3) velocity of the current.

Calibration data: There no data involved in this indicator, the model is based on expert opinion and literature data.

Validation data: None available, part from expert opinion.

Links with hydrology: The high water level during spring time will favour the frog reproduction in the emergent vegetation. Then the variation of water level will be a limiting factor in the survival of the eggs.

Map of the indicator for an average discharge (9500 m³/s at Sorel; scenario 4P):



Transfers from full 2D explicit models to simplified SMV curves:

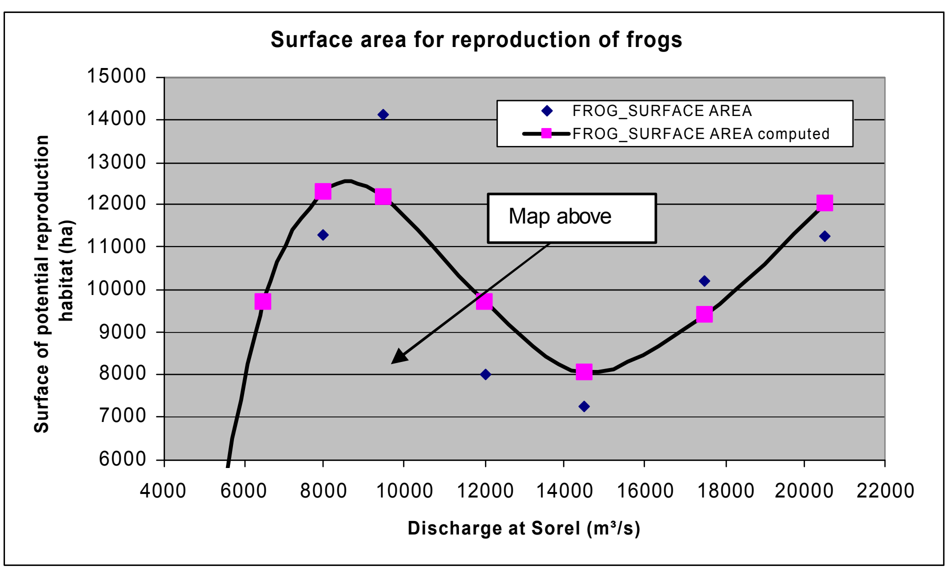


Figure: Relation between the calculated “Surface area of potential reproduction habitat for frogs and the discharge in Sorel, data and best fit curve: FROG_SURFACE AREA=-83000+31.2052* Q_Sorel -0.0036* Q_Sorel ^2+0.00000017163* Q_Sorel ^3-0.00000000000289*Q_Sorel^4; with R2=0.8894

<u>Indicator evolution for 1958DD and PreProject plans</u>:

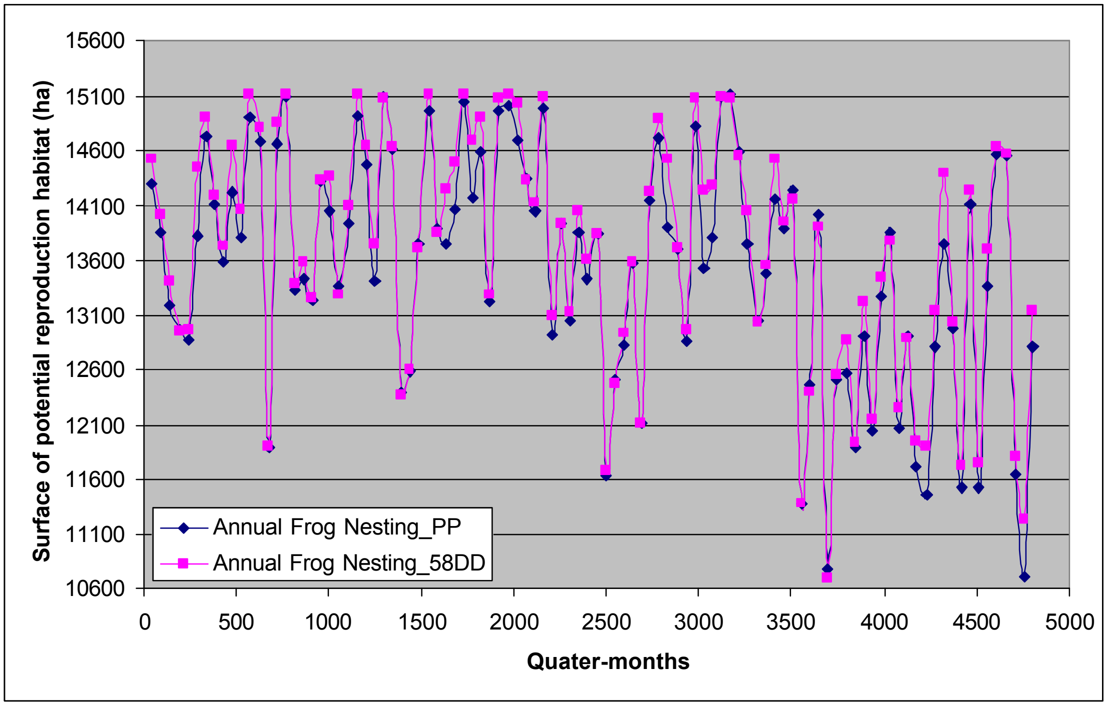


Figure: Comparison of the Performance indicator for the 100 years discharge series: Plan 1958DD and PreProject.

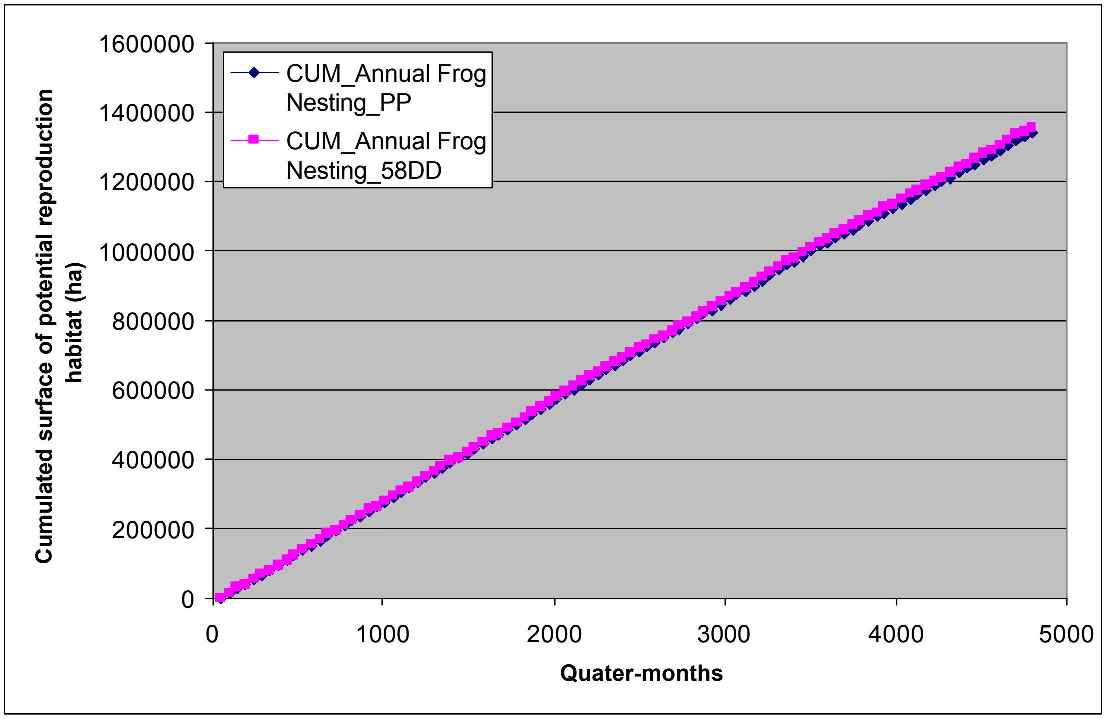


Figure: Comparison of the temporally cumulated Performance Indicator for the 100 years discharge series: Plan 1958DD and PreProject.

12 Performance indicator: Hibernation habitat of frogs

Person responsible: Armellin, Rioux & Morin

Origin and description of the indicator: The amphibians play an important role in the wetlands because of their position in the food chain and their important biomass. In their life cycle, they use both the aquatic environment and the terrestrial environment, making them, very sensible to variation in the ecosystem. The vegetation of the flood plain (marsh, submerged vegetation, wet meadow, etc.) is an important part of their habitat. They offer food and shelters against the predators. The variation in water level can affect these habitats, therefore affecting the habitat of the frogs. Many frogs hibernate in the substratum, underwater. The water level protects them against ground frost if it is high enough but, water level fluctuations can become lethal if it goes too low. The indicator gives the available surface area of hibernation habitat when the frogs go in its dormant state.

Temporal validity: From mid-October to mid-April

Spatial validity: From Lake Saint-Louis to Trois-Rivières.

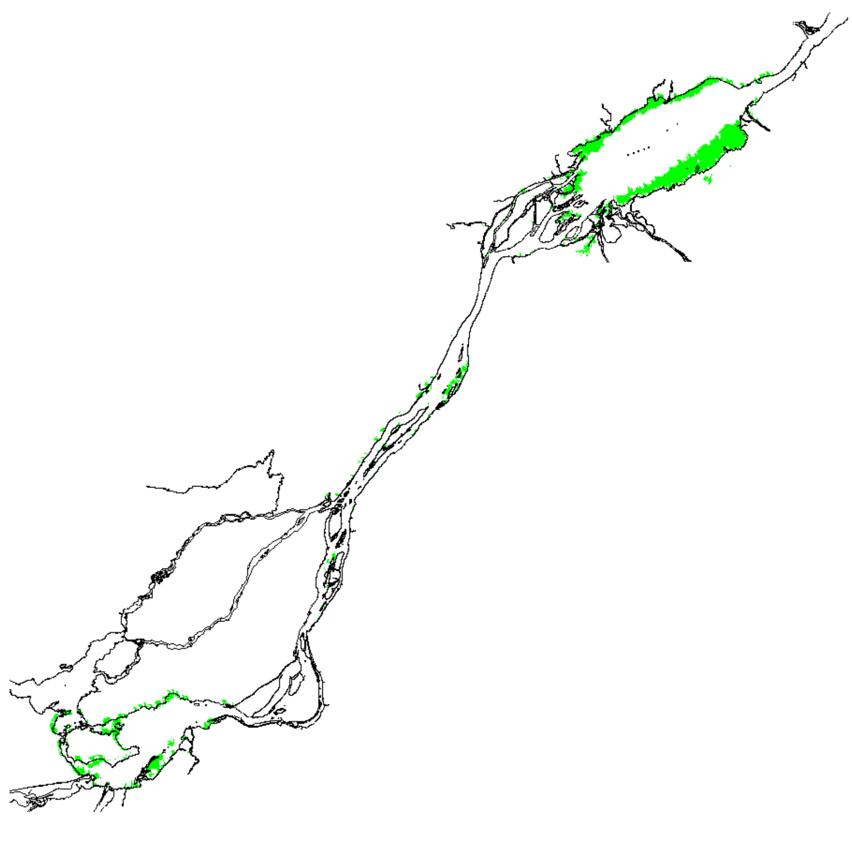
Variables used in the 2D modeling: 1) Current velocity, 2) water depth and 3) substratum characteristics

Calibration data:

Validation data:

Links with hydrology: The fluctuation of water level is vital for the hibernation habitat of frogs. If the water level gets too low, the ice cover might go down to the bottom and kill the frogs. Therefore, the water level needs to be twice as high as the ice cover to be optimal.

Map of the indicator for an average discharge (9500 m^3/s at Sorel; scenario 4P):



Transfers from full 2D explicit models to simplified SMV curves:

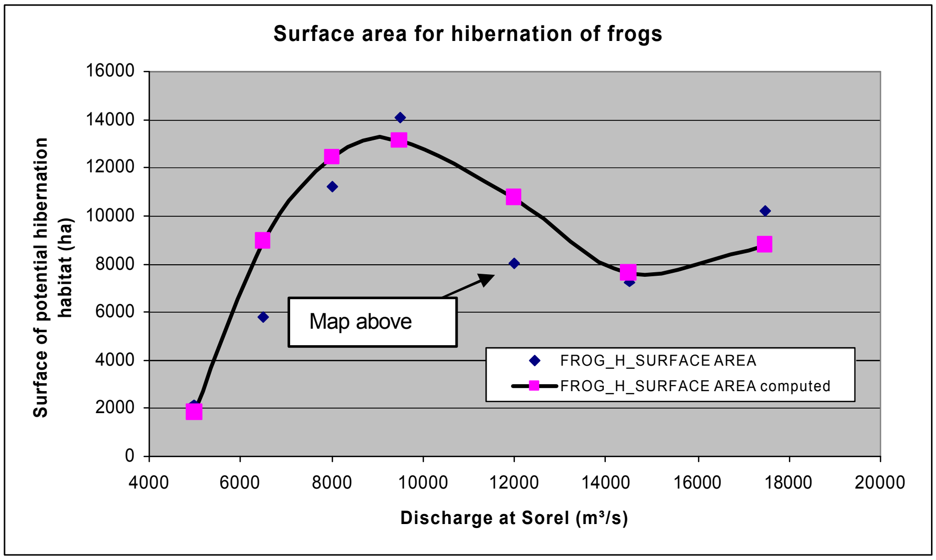


Figure: Relation between the calculated "Surface area of potential hibernation habitat for frogs and the discharge in Sorel, data and best fit curve: FROG_H_SURFACE AREA=0.0000000455*Q_Sorel^3 - 0.0017* Q_Sorel ^2 + 19.757* Q_Sorel - 60146; with R2=0.8494

Indicator evolution for 1958DD and PreProject plans:

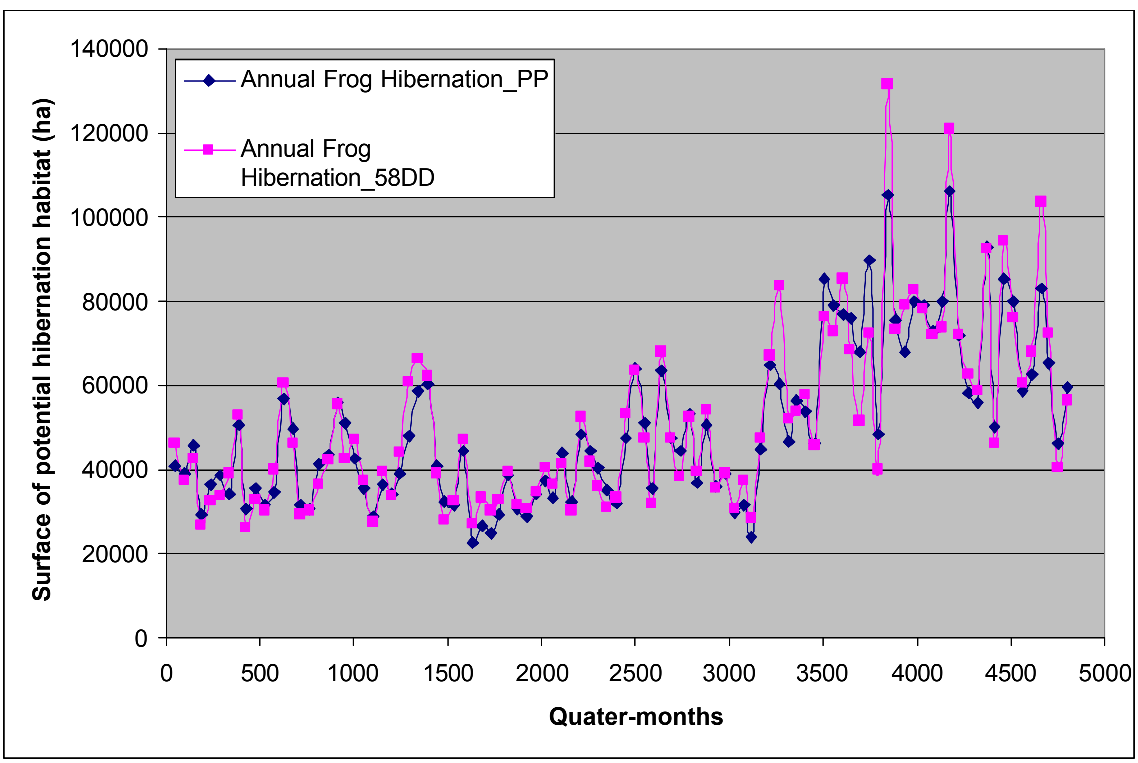


Figure: Comparison of the Performance indicator for the 100 years discharge series: Plan 1958DD and PreProject.

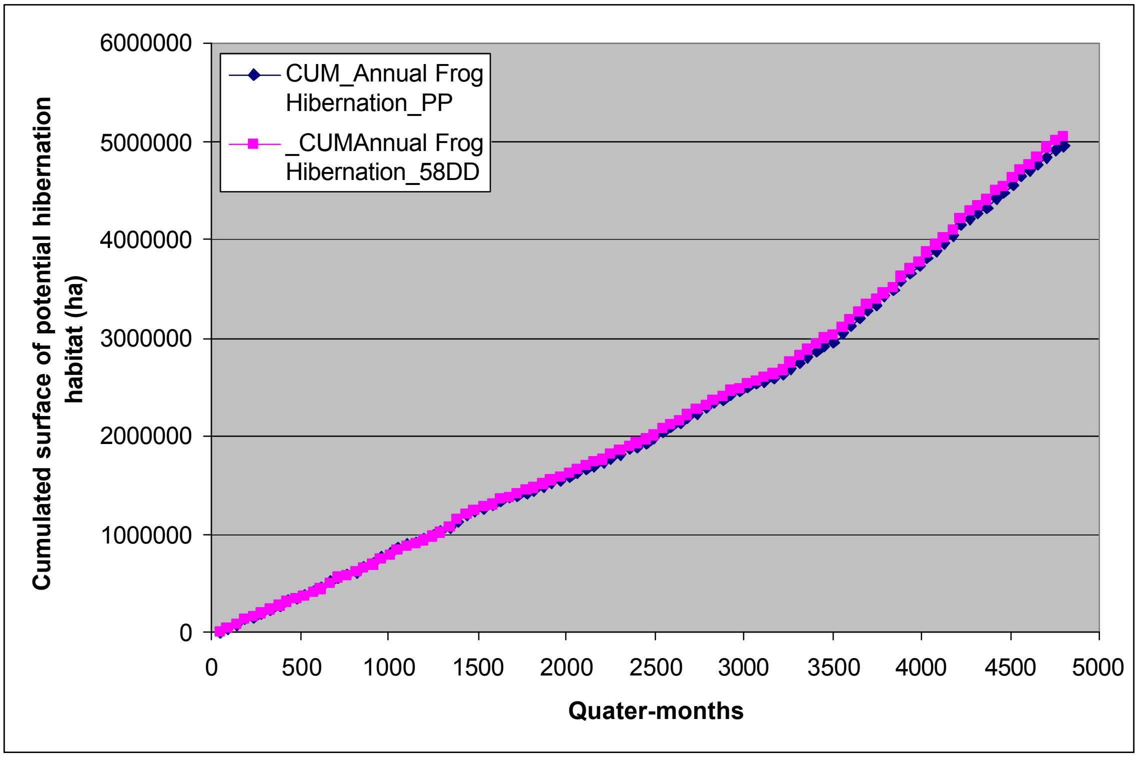


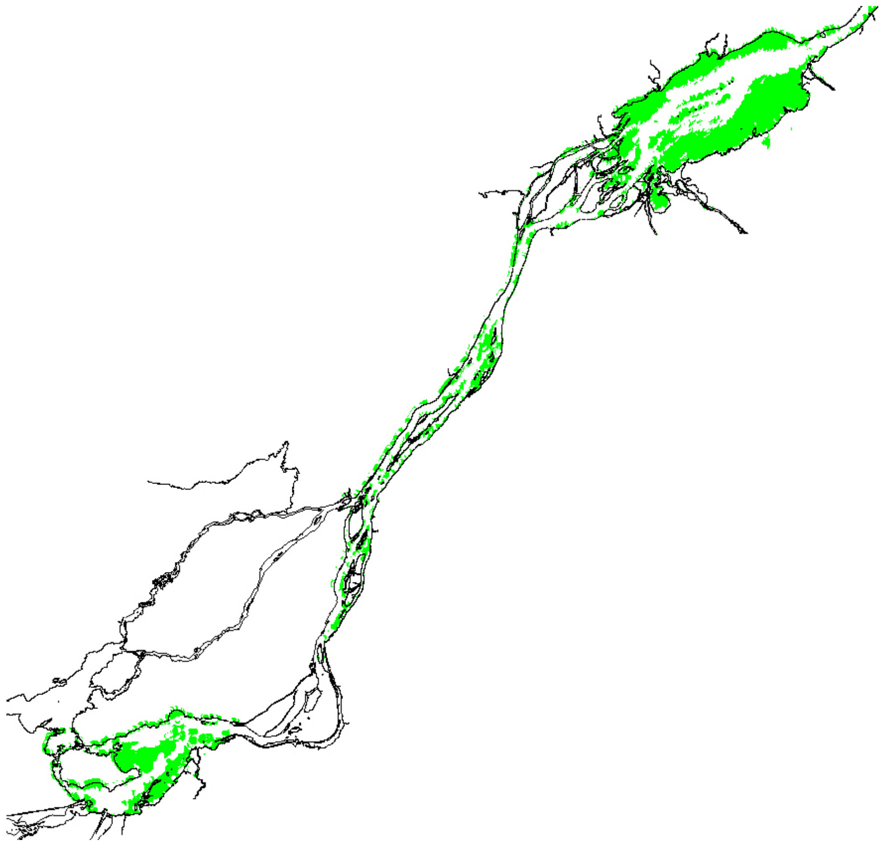
Figure: Comparison of the temporally cumulated Performance Indicator for the 100 years discharge series: Plan 1958DD and PreProject.

III. Submerged plants habitat models: species distribution and density

13 Performance indicator: Surface area (ha) covered by *Vallisneria americana*

Person responsible: Morin, Turgeon, Champoux & Martin
Origin and description of the indicator: The presence of submerged species is fundamental to the habitat description of several fish and herptile species. This indicator has been developed in order to model properly the suitable habitat evolution. The modeling is based on approximately 7000 presence/absence observations. These observations were done during the maximum seasonal growth of the submerged vegetation between 1995 and 2001 with submersible video camera. These data were collected for mapping the spatial distribution of submerged plants that was later used for hydrodynamic modelling of the summer conditions. These observations were used along with 2D modelled variables allowed to produce spatial distribution models. The indicator predicts the surface area where *Vallisneria americana* is considered as present on the river bed. This presence is not exclusive so that other species can also be present in the local plant community.
Temporal validity: This indicator is valid for the 3 last quarter-month of August and for 4 quarter-month of September.
Spatial validity: Valid for the lower St. Lawrence River from Lake St. Louis to Trois-Rivières.
Variables used in the 2D modeling: 2D modelling of submerged plant density is based on several variables that are calculated without the influence of plant friction on currents and on other variables. For the specific "logistic regression" model, controlling variables are: light intensity on the bottom, current velocity, wave action (spring 17 km $\cdot h^{-1}$) and the bottom slope.
Calibration data: 7251 observations made in several summers from 1995 to 2001. The prevalence was 0.311 (2257/7251). The correct classification rate was 80.5%.
Validation data: about 700 sub-samples from the total database and about 200 samples from the fish habitat database associated with the "Réseau de suivi Ictyologique du Québec".
Links with hydrology: The hydrology during spring and fall play a major role as for the distribution of wave energy on the bottom and for fine particle accumulation. Direct influence of discharge and level are impacting on current, water depth and on light penetration during summer.

Map of the indicator for an average discharge (9500 m³/s at Sorel; scenario 4P):



Transfers from full 2D explicit models to simplified SMV curves:

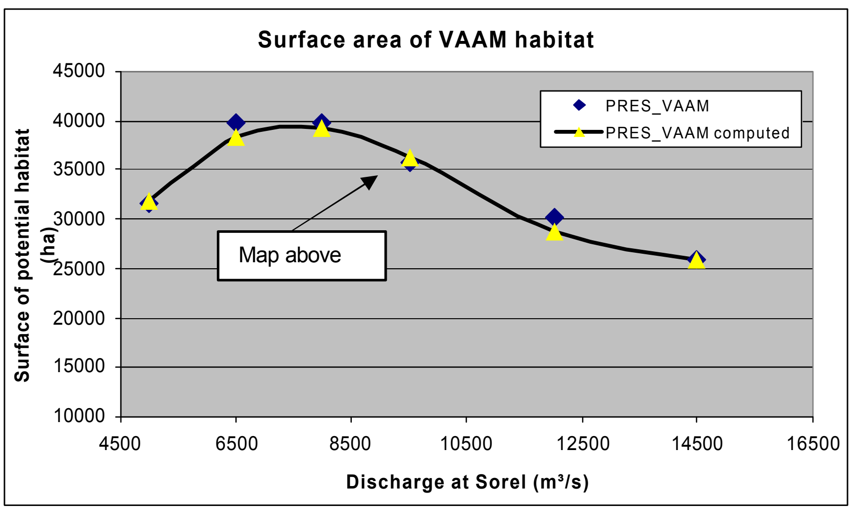


Figure: Relation between the calculated "Surface area of potential habitat" for VAAM and the discharge in Sorel, data and best fit curve: PRES_VAAM = 0.000000099* Q_Sorel ^3 - 0.0032* Q_Sorel ^2 + 31.3* Q_Sorel – 57035; r2=0.9893

Indicator evolution for 1958DD and PreProject plans:

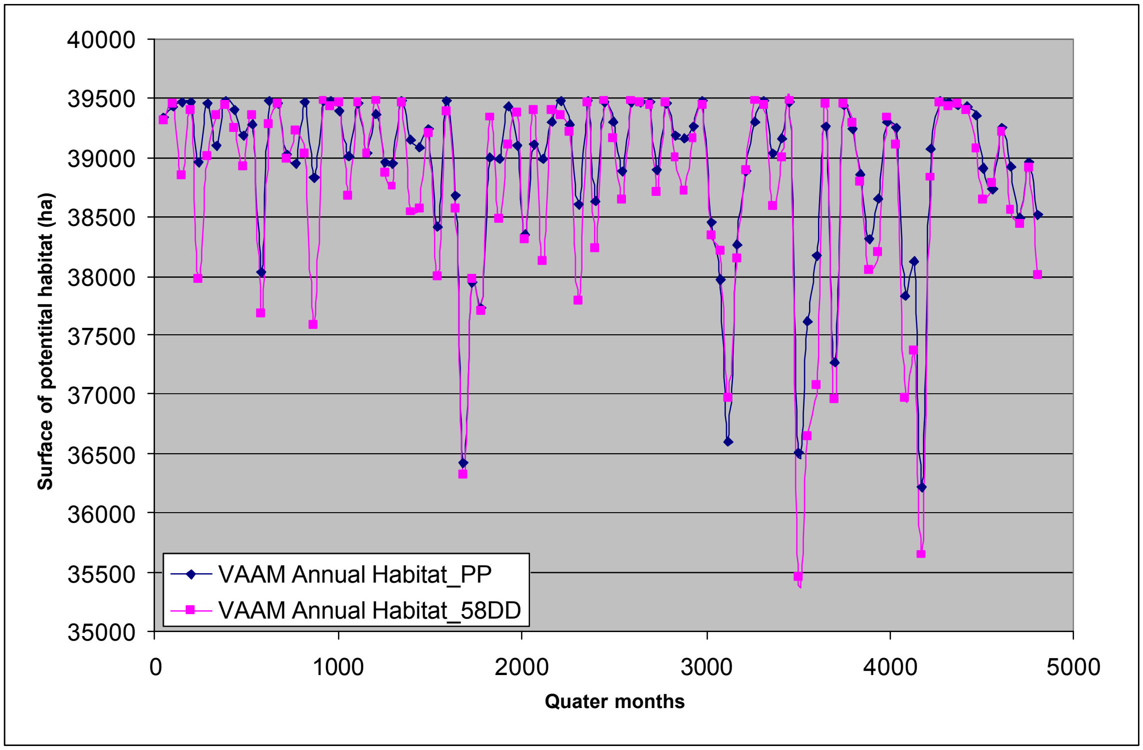


Figure: Comparison of the Performance indicator for the 100 years discharge series: Plan 1958DD and PreProject.

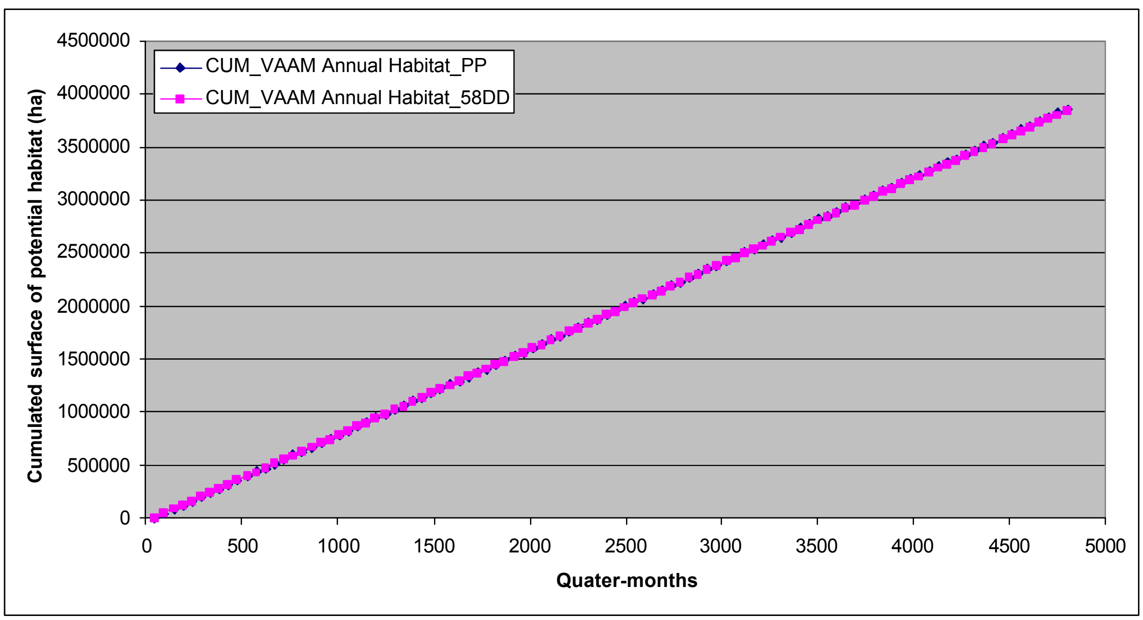


Figure: Comparison of the temporally cumulated Performance Indicator for the 100 years discharge series: Plan 1958DD and PreProject.

14 Performance indicator: Surface area (ha) covered by *Hetherantera dubia*

Person responsible: Morin, Turgeon, Champoux & Martin

Origin and description of the indicator: The presence of submerged species is fundamental to the habitat description of several fish and herptile species. This indicator has been developed in order to model properly the suitable habitat evolution. The modeling is based on approximately 7000 presence/absence observations. These observations were done during the maximum seasonal growth of the submerged vegetation between 1995 and 2001 with submersible video camera. These data were collected for mapping the spatial distribution of submerged plants that was later used for hydrodynamic modelling of the summer conditions. These observations were used along with 2D modelled variables allowed to produce spatial distribution models. The indicator predicts the surface area where *Hetherantera dubia* is considered as present on the river bed. This presence is not exclusive so that other species can also be present in the local plant community.

Temporal validity: This indicator is valid for the 3 last quarter-month of August and for 4 quarter-month of September.

Spatial validity: Valid for the lower St. Lawrence River from Lake St. Louis to Trois-Rivières.

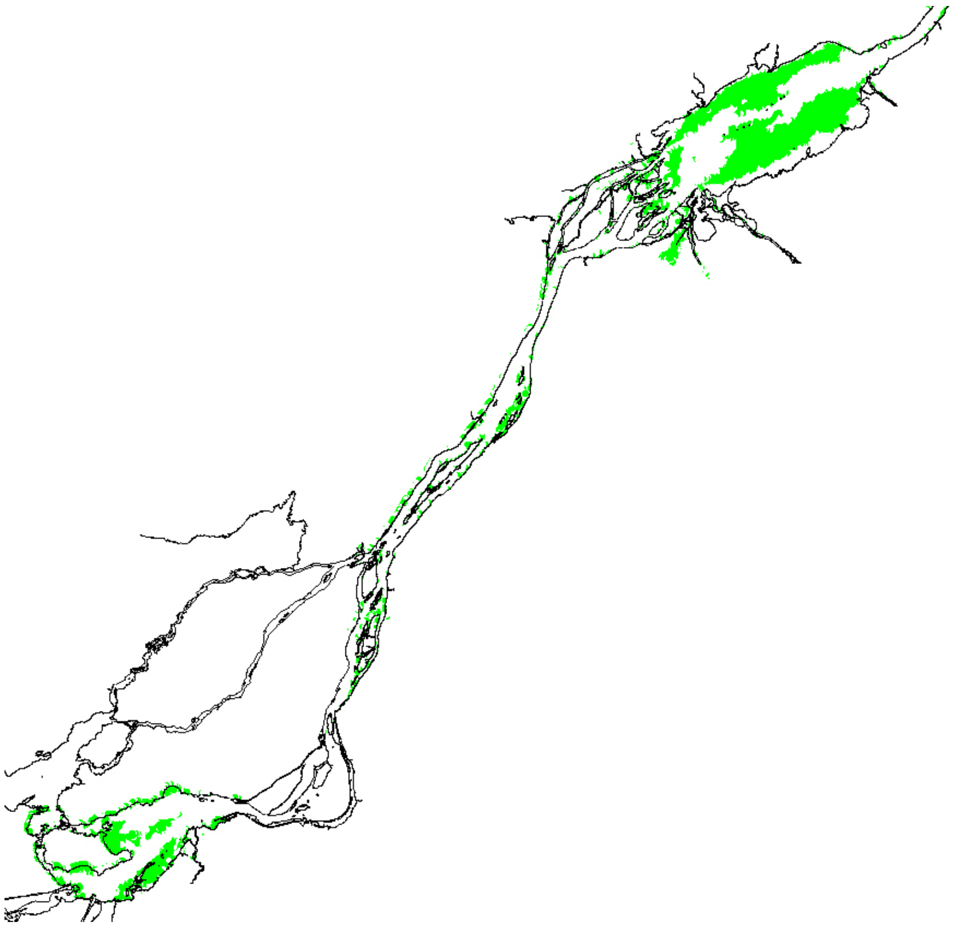
Variables used in the 2D modeling: 2D modelling of submerged plant density is based on several variables that are calculated without the influence of plant friction on currents and on other variables. For the specific "logistic regression" model, controlling variables are : light intensity on the bottom, current velocity, wave action (spring 17 $km \cdot h^{-1}$) and the bottom slope.

Calibration data: 7251 observations made in several summers from 1995 to 2001. The prevalence was 0.110 (554/7251). The correct classification rate was 79.1%.

Validation data: about 700 sub-samples from the total database and about 200 samples from the fish habitat database associated with the "Réseau de suivi Ictyologique du Québec".

Links with hydrology: The hydrology during spring and fall play a major role as for the distribution of wave energy on the bottom and for fine particle accumulation. Direct influence of discharge and level are impacting on current, water depth and on light penetration during summer.

Map of the indicator for an average discharge (9500 m³/s at Sorel; scenario 4P):



Transfers from full 2D explicit models to simplified SMV curves:

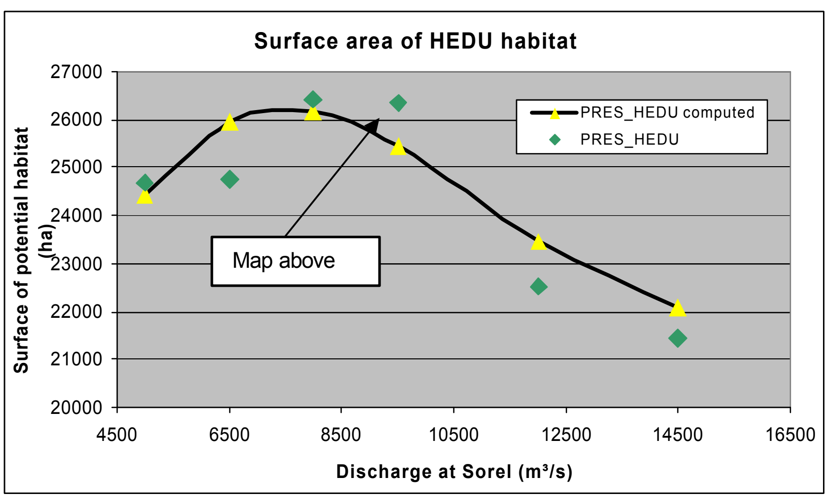


Figure: Relation between the calculated "Surface area of potential habitat" for HEDU and the discharge in Sorel, data and best fit curve: PRES_HEDU = 0.0000000208* Q_Sorel ^3 - 0.000698* Q_Sorel ^2 + 6.9603* Q_Sorel + 4500; r2=0.9235

Indicator evolution for 1958DD and PreProject plans:

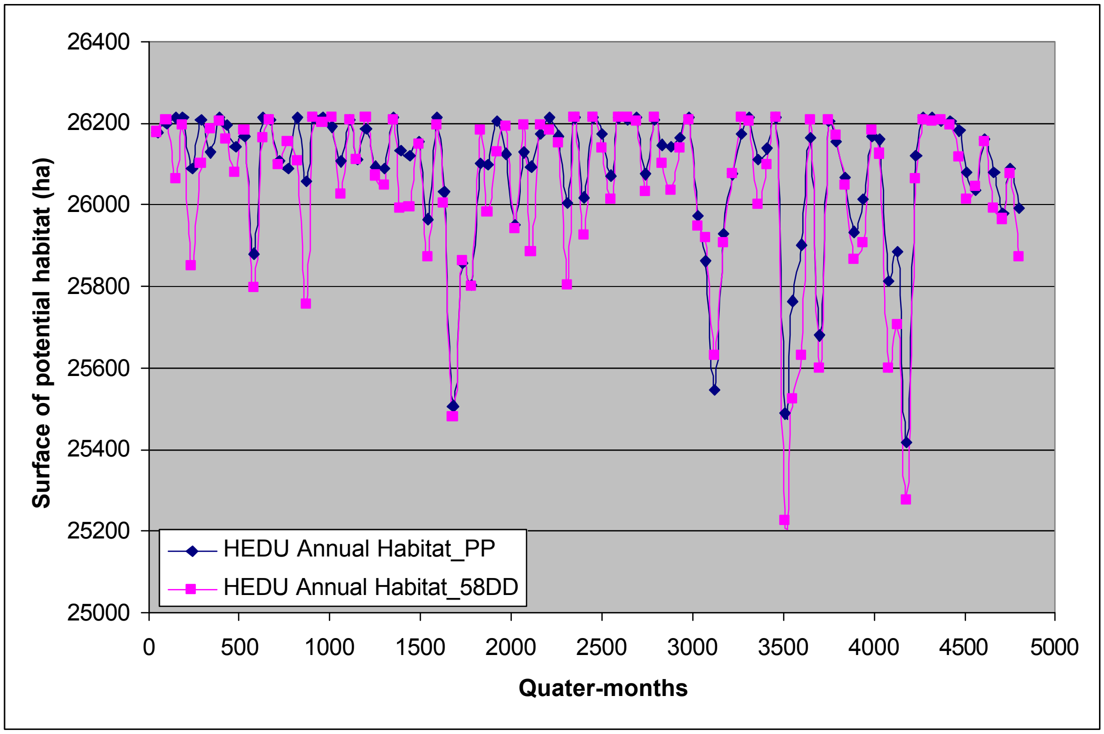


Figure: Comparison of the Performance indicator for the 100 years discharge series: Plan 1958DD and PreProject.

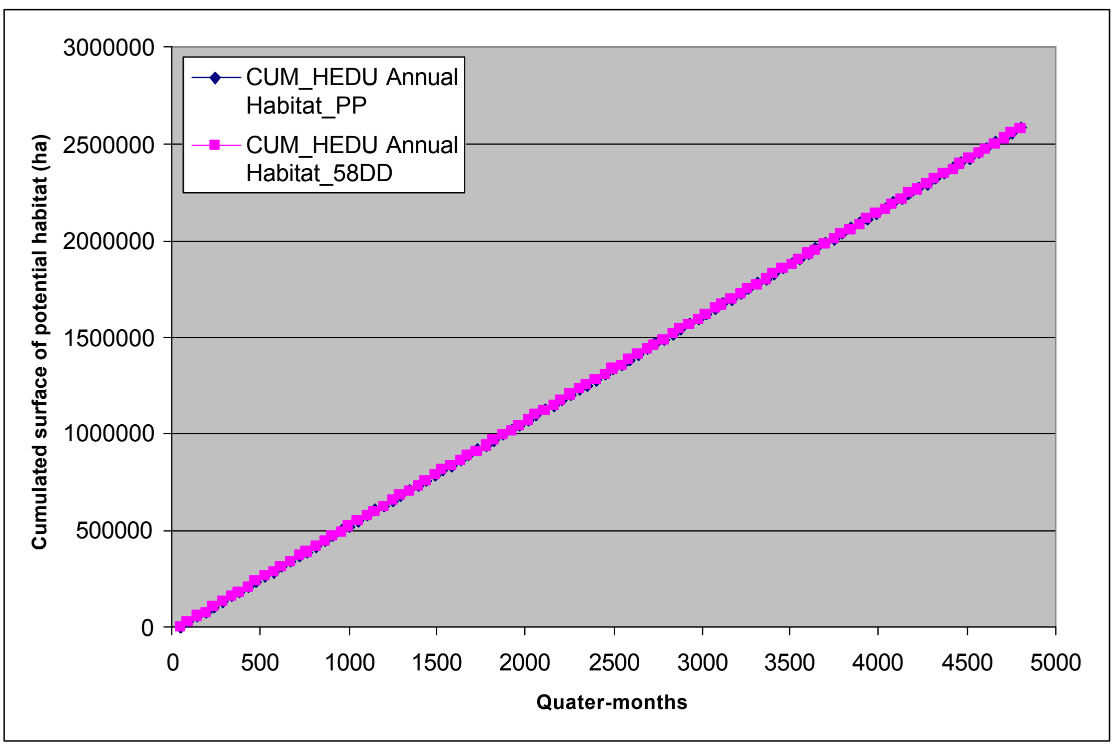


Figure: Comparison of the temporally cumulated Performance Indicator for the 100 years discharge series: Plan 1958DD and PreProject.

15 Performance indicator: Surface area (ha) covered by *Myriophyllum spicatum*

Person responsible: Morin, Turgeon, Champoux & Martin

Origin and description of the indicator: The presence of submerged species is fundamental to the habitat description of several fish and herptile species. This indicator has been developed in order to model properly the suitable habitat evolution. The modeling is based on approximately 7000 presence/absence observations. These observations were done during the maximum seasonal growth of the submerged vegetation between 1995 and 2001 with submersible video camera. These data were collected for mapping the spatial distribution of submerged plants that was later used for hydrodynamic modelling of the summer conditions. These observations were used along with 2D modelled variables allowed to produce spatial distribution models. The indicator predicts the surface area where *Myriophyllum spicatum* is considered as present on the river bed. This presence is not exclusive so that other species can also be present in the local plant community.

Temporal validity: This indicator is valid for the 3 last quarter-month of August and for 4 quarter-month of September.

Spatial validity: Valid for the lower St. Lawrence River from Lake St. Louis to Trois-Rivières.

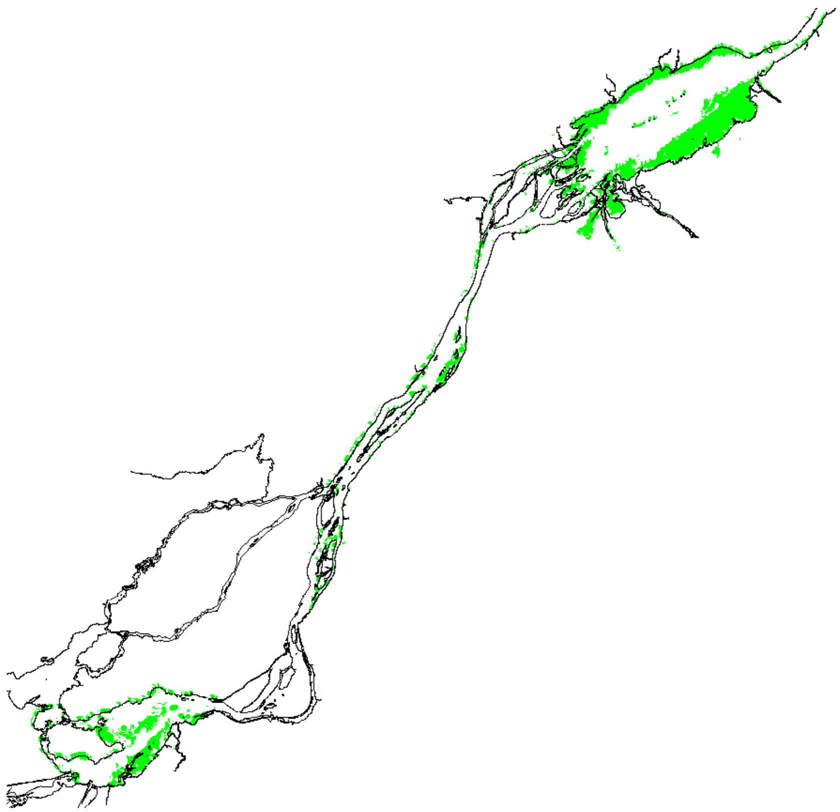
Variables used in the 2D modeling: 2D modelling of submerged plant density is based on several variables that are calculated without the influence of plant friction on currents and on other variables. For the specific "logistic regression" model, controlling variables are: light intensity on the bottom, current velocity and the accumulation of fine particle on the bottom.

Calibration data: 7251 observations made in several summers from 1995 to 2001. The prevalence was 0.078 (566/7251). The correct classification rate was 83.7%.

Validation data: about 700 sub-samples from the total database and about 200 samples from the fish habitat database associated with the "Réseau de suivi Ictyologique du Québec".

Links with hydrology: The hydrology during spring and fall play a major role as for the distribution of wave energy on the bottom and for fine particle accumulation. Direct influence of discharge and level are impacting on current, water depth and on light penetration during summer.

Map of the indicator for an average discharge (9500 m³/s at Sorel; scenario 4P):



Transfers from full 2D explicit models to simplified SMV curves:

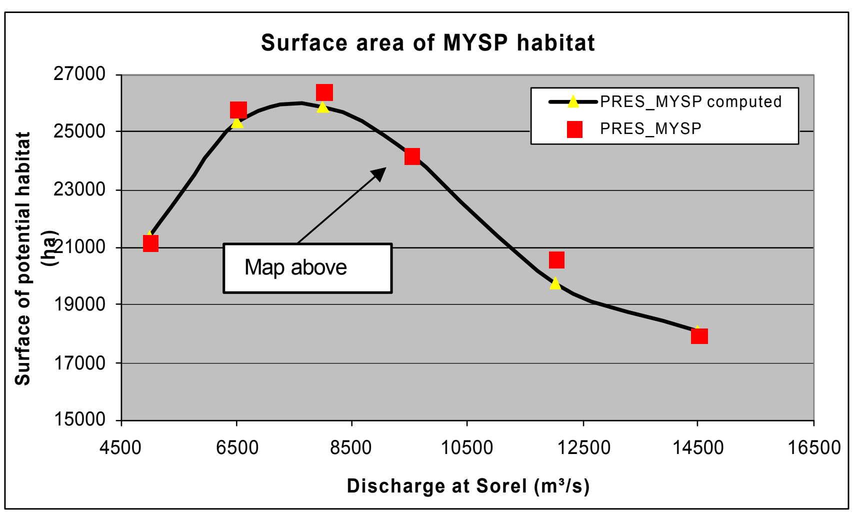


Figure: Relation between the calculated "Surface area of potential habitat" for MYSP and the discharge in Sorel, data and best fit curve: PRES_MYSP= 0.0000000588* Q_Sorel ^3 - 0.0019* Q_Sorel ^2 + 18.607* Q_Sorel -; r2=0.9927

Indicator evolution for 1958DD and PreProject plans:

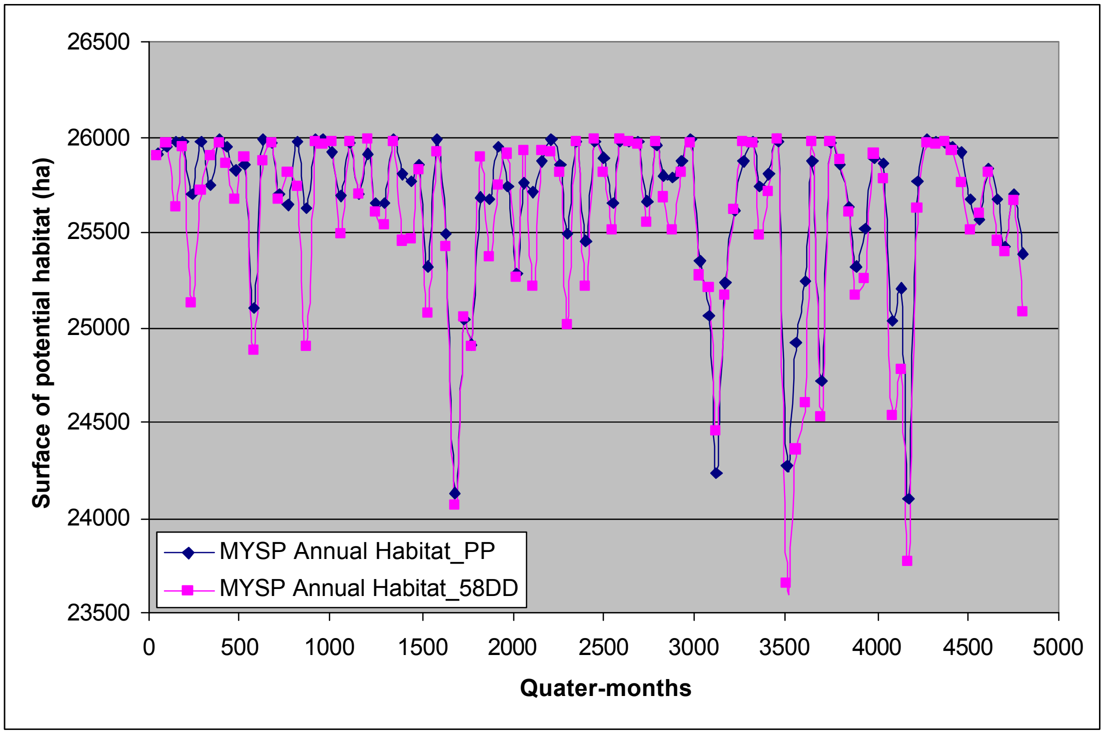


Figure: Comparison of the Performance indicator for the 100 years discharge series: Plan 1958DD and PreProject.

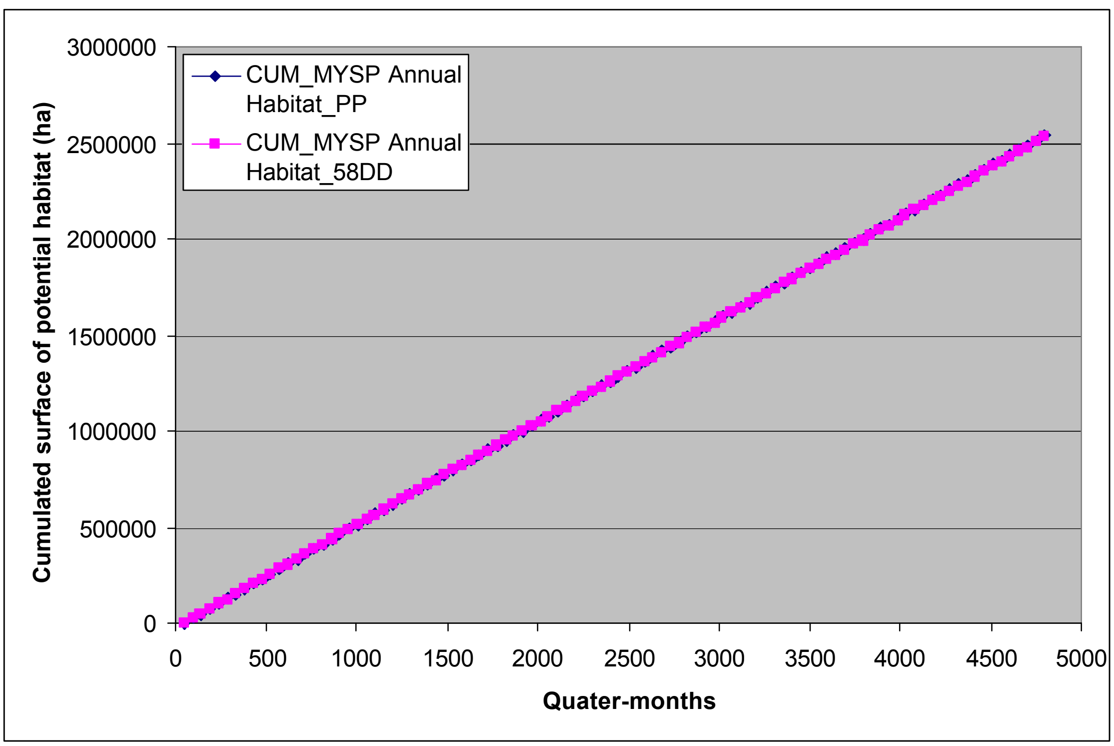
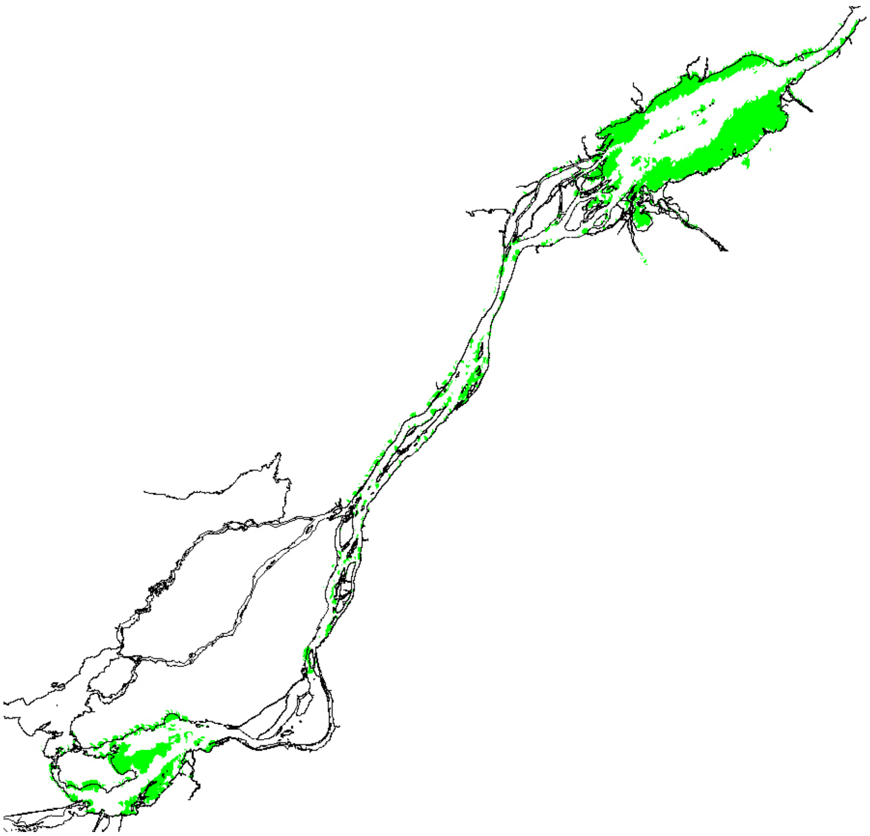


Figure: Comparison of the temporally cumulated Performance Indicator for the 100 years discharge series: Plan 1958DD and PreProject.

16 Performance indicator: Surface area (ha) covered by *Potamogeton richardsonii*
Person responsible Morin, Turgeon, Champoux & Martin
Origin and description of the indicator: The presence of submerged species is fundamental to the habitat description of several fish and herptile species. This indicator has been developed in order to model properly the suitable habitat evolution. The modeling is based on approximately 7000 presence/absence observations. These observations were done during the maximum seasonal growth of the submerged vegetation between 1995 and 2001 with submersible video camera. These data were collected for mapping the spatial distribution of submerged plants that was later used for hydrodynamic modelling of the summer conditions. These observations were used along with 2D modelled variables allowed to produce spatial distribution models. The indicator predicts the surface area where *Potamogeton richardsonii* is considered as present on the river bed. This presence is not exclusive so that other species can also be present in the local plant community.
Temporal validity: This indicator is valid for the 3 last quarter-month of August and for 4 quarter-month of September.
Spatial validity: Valid for the lower St. Lawrence River from Lake St. Louis to Trois-Rivières.
Variables used in the 2D modeling: 2D modelling of submerged plant density is based on several variables that are calculated without the influence of plant friction on currents and on other variables. For the specific "logistic regression" model, controlling variables are: light intensity on the bottom, current velocity, wave action (spring 17 $km \cdot h^{-1}$), specific discharge and the bottom slope.
Calibration data: 7251 observations made in several summers from 1995 to 2001. The prevalence was 0.110 (794/7251). The correct classification rate was 81.5%.

Validation data: about 700 sub-samples from the total database and about 200 samples from the fish habitat database associated with the "Réseau de suivi Ictyologique du Québec".
Links with hydrology: The hydrology during spring and fall play a major role as for the distribution of wave energy on the bottom and for fine particle accumulation. Direct influence of discharge and level are impacting on current, water depth and on light penetration during summer.

Map of the indicator for an average discharge (9500 m³/s at Sorel; scenario 4P):



Transfers from full 2D explicit models to simplified SMV curves:

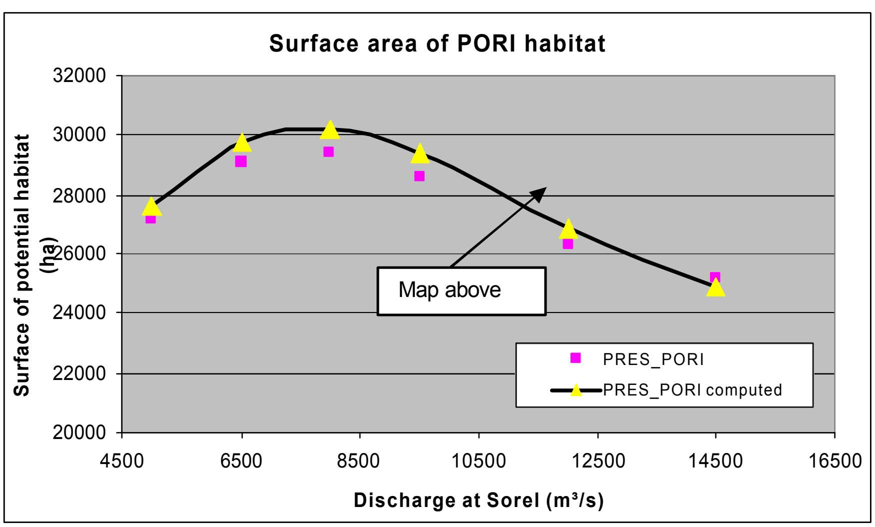


Figure: Relation between the calculated “Surface area of potential habitat” for VAAM and the discharge in Sorel, data and best fit curve: PRES_PORI = 0.0000000264* Q_Sorel ^3 - 0.000904* Q_Sorel ^2 + 9.2139* Q_Sorel + 848.56; r2=0.9934

Indicator evolution for 1958DD and PreProject plans:

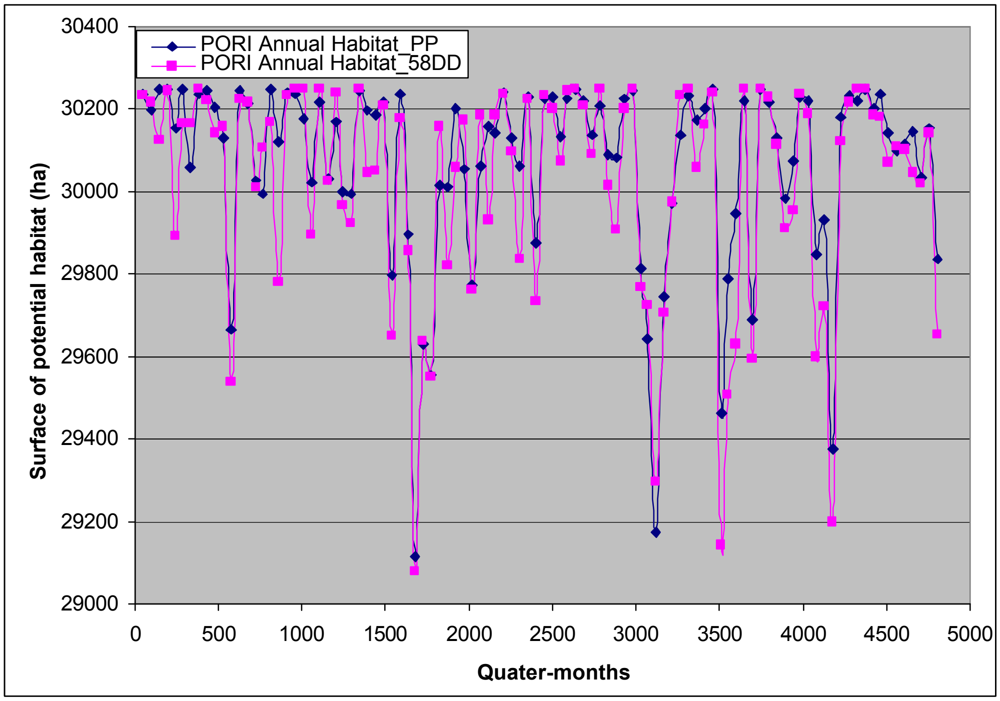


Figure: Comparison of the Performance indicator for the 100 years discharge series: Plan 1958DD and PreProject.

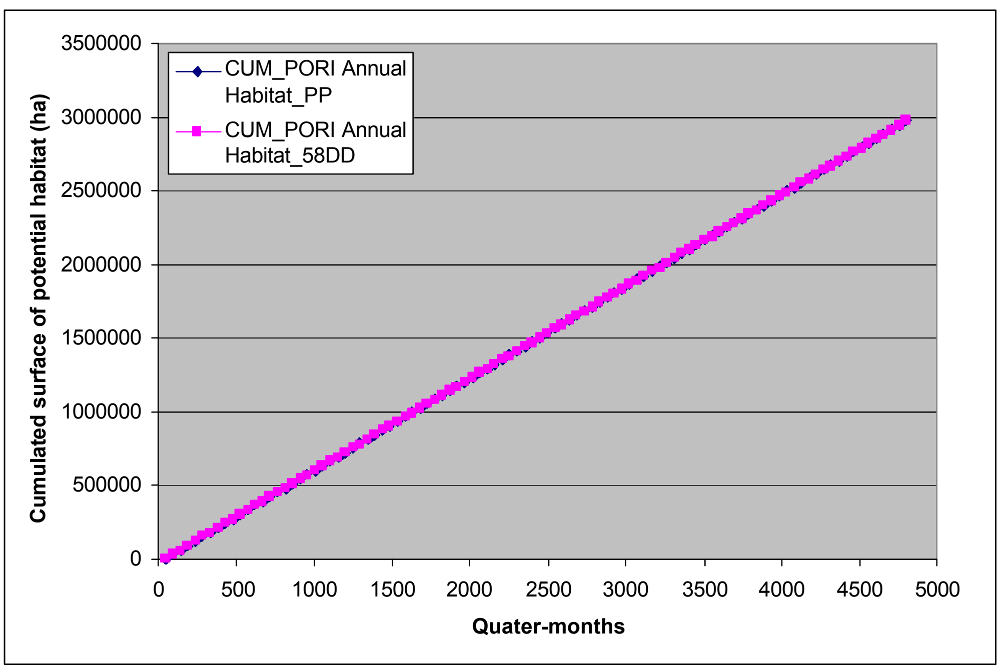


Figure: Comparison of the temporally cumulated Performance Indicator for the 100 years discharge series: Plan 1958DD and PreProject.

17 Performance indicator: Surface area (ha) covered by *Alisma gramineum*

Person responsible: Morin, Turgeon, Champoux & Martin

Origin and description of the indicator: The presence of submerged species is fundamental to the habitat description of several fish and herptile species. This indicator has been developed in order to model properly the suitable habitat evolution. The modeling is based on approximately 7000 presence/absence observations. These observations were done during the maximum seasonal growth of the submerged vegetation between 1995 and 2001 with submersible video camera. These data were collected for mapping the spatial distribution of submerged plants that was later used for hydrodynamic modelling of the summer conditions. These observations were used along with 2D modelled variables allowed to produce spatial distribution models. The indicator predicts the surface area where *Alisma gramineum* is considered as present on the river bed. This presence is not exclusive so that other species can also be present in the local plant community.

Temporal validity: This indicator is valid for the 3 last quarter-month of August and for 4 quarter-month of September.

Spatial validity: Valid for the lower St. Lawrence River from Lake St. Louis to Trois-Rivières.

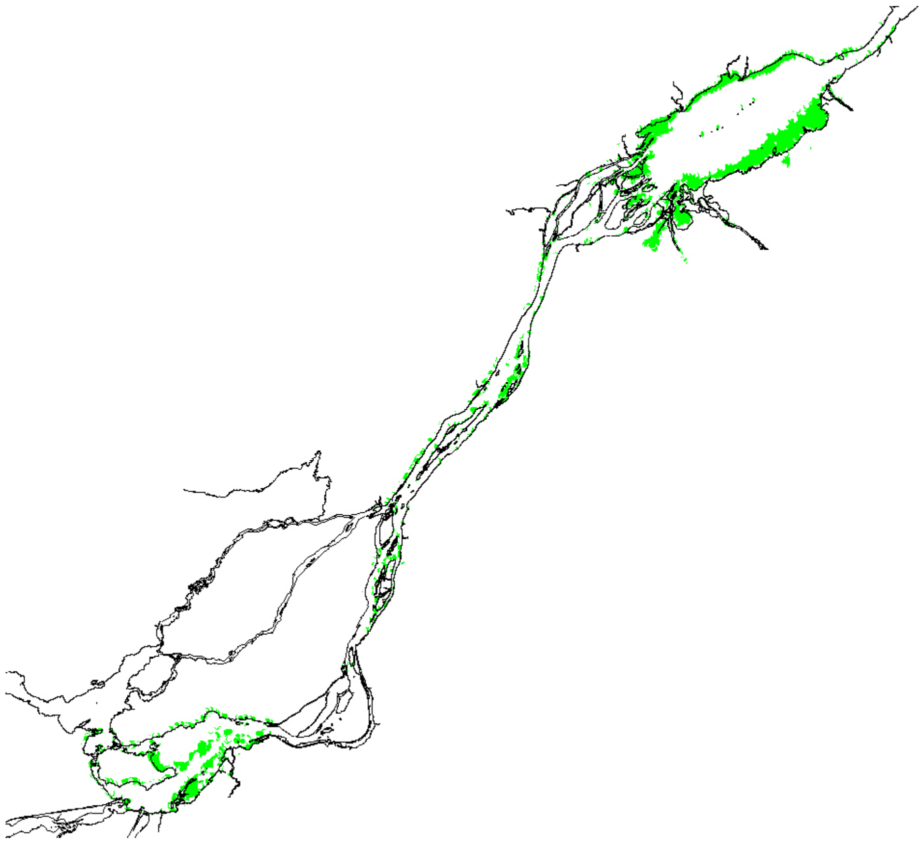
Variables used in the 2D modeling: 2D modelling of submerged plant density is based on several variables that are calculated without the influence of plant friction on currents and on other variables. For the specific "logistic regression" model, controlling variables are: light intensity on the bottom, current velocity, wave action (spring 17 $km \cdot h^{-1}$) and specific discharge.

Calibration data: 7251 observations made in several summers from 1995 to 2001. The prevalence was 0.027 (198/7251). The correct classification rate was 89.1%.

Validation data: about 700 sub-samples from the total database and about 200 samples from the fish habitat database associated with the "Réseau de suivi Ictyologique du Québec".

Links with hydrology: The hydrology during spring and fall play a major role as for the distribution of wave energy on the bottom and for fine particle accumulation. Direct influence of discharge and level are impacting on current, water depth and on light penetration during summer.

Map of the indicator for an average discharge (9500 m³/s at Sorel; scenario 4P):



Transfers from full 2D explicit models to simplified SMV curves:

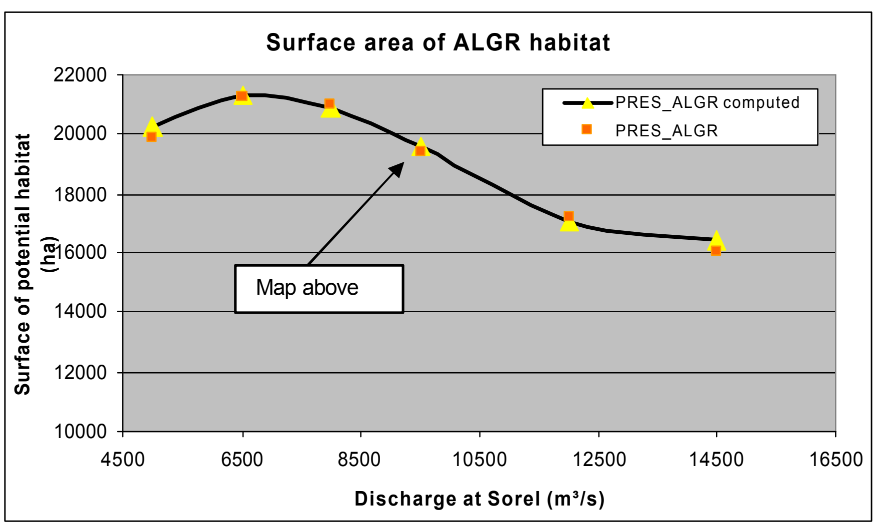


Figure: Relation between the calculated "Surface area of potential habitat" for ALGR and the discharge in Sorel, data and best fit curve: PRES_ALGR = 0.0000000293* Q_Sorel ^3 - 0.0009* Q_Sorel ^2 + 8.1261* Q_Sorel – 1500; r2=0.9936

Indicator evolution for 1958DD and PreProject plans:

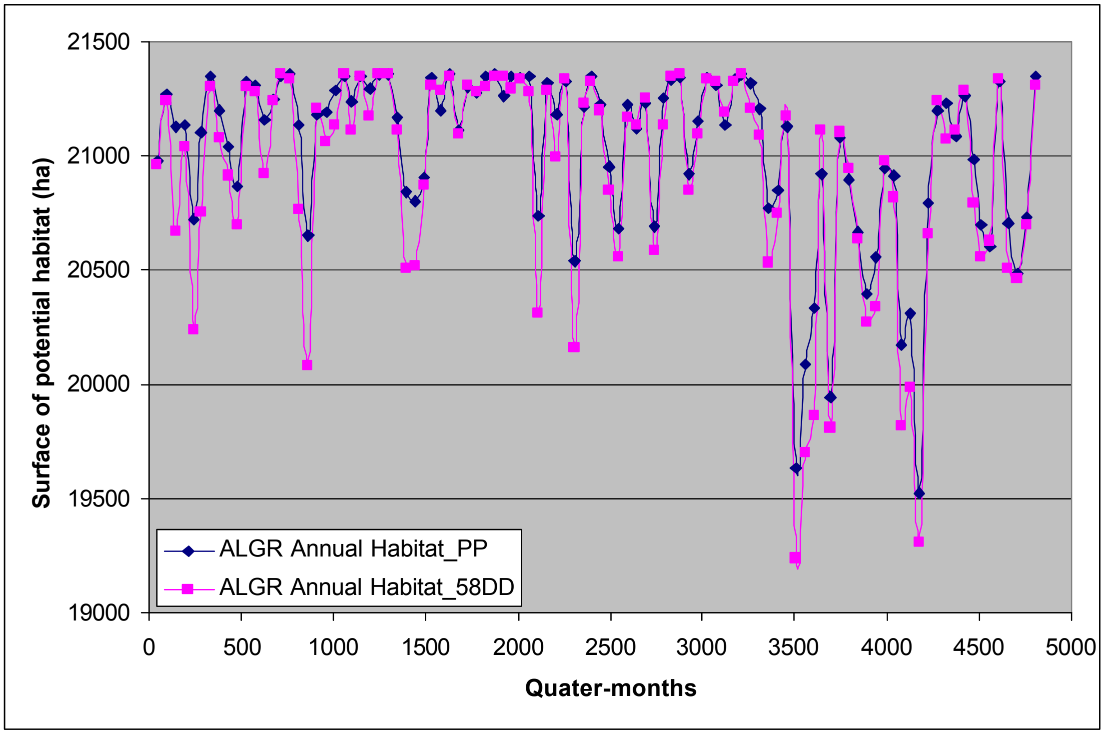


Figure: Comparison of the Performance indicator for the 100 years discharge series: Plan 1958DD and PreProject.

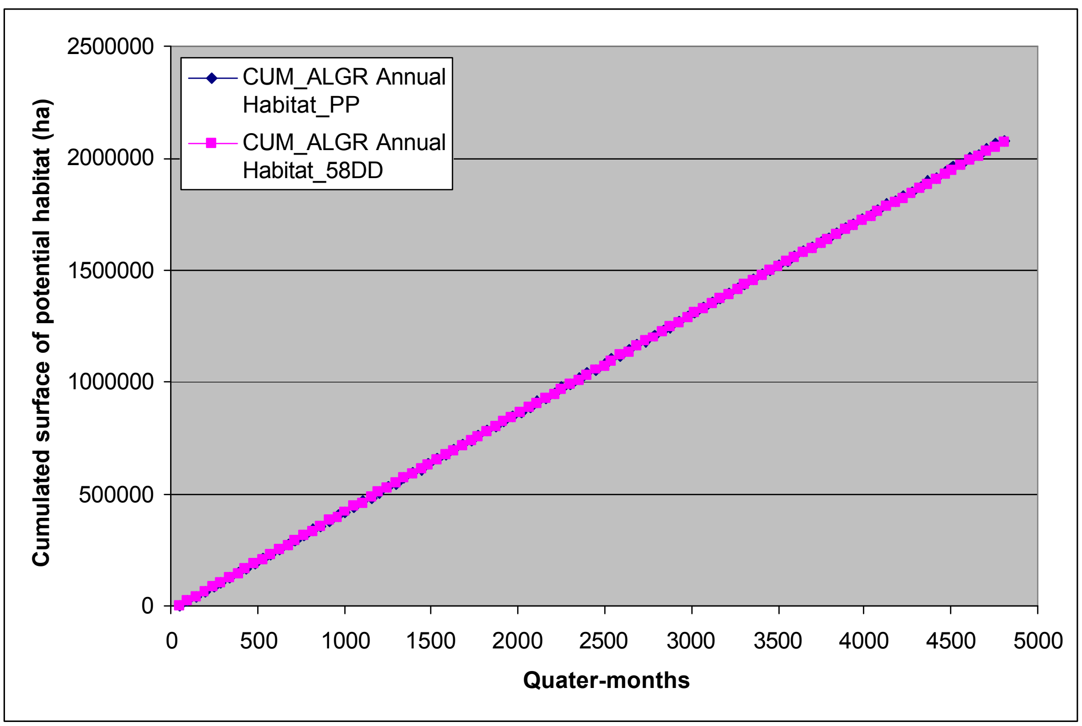


Figure: Comparison of the temporally cumulated Performance Indicator for the 100 years discharge series: Plan 1958DD and PreProject.

18 Performance indicator: Surface area (ha) covered by density classes of submerged plants

Person responsible: Morin, Turgeon, Champoux & Martin
Origin and description of the indicator: The presence of the relative density of submerged species is fundamental to the habitat description of several fish and rare species. This indicator has been developed in order to model properly the suitable habitat evolution. The modeling is based on approximately 7000 presence/absence observations. These observations were done during the maximum seasonal growth of the submerged vegetation between 1995 and 2001 with submersible video camera. These data were collected for mapping the spatial distribution of submerged plants that was later used for hydrodynamic modelling of the summer conditions. The relative density is a qualitative classification of the submerged plants density of stem. It has been used since 1995 for plants mapping and for fish habitat characteristics. The value of "4" is given to area where plants are forming canopy, "3" for area where submerged plants are covering the entire substratum, "2" where plant are abundant but the substratum is slightly visible, "1" where the substratum is clearly visible and exposed while "0" represent the absence of plants. Here in the "high density" comprise density from 3 to 4, "medium density" comprise density from 2 to 3 et "low density" comprise density from over 0 to 2.
Temporal validity: This indicator is valid for the 3 last quarter-month of August and for 4 quarter-month of September.
Spatial validity: Valid for the lower St. Lawrence River from Lake St. Louis to Trois-Rivières.
Variables used in the 2D modeling: 2D modelling of submerged plant density is based on several variables that are calculated without the influence of plant friction on currents and on other variables. For the specific "regression trees (CART)" model, controlling variables are :

? For Lake Saint-Pierre: Water depth and current velocity.
? For Berthier-Sorel Archipelago-Mtl: Light intensity on the bottom
? For Lake Saint-Louis: Light intensity on the bottom

These variables were selected as significant by the regression trees relations with Proportional reduction in error of 0.5386 in Lake St. Pierre; of 0.3403 in Berthier-Sorel Archipelago-Mtl; and, of 0.5853 in Lake Saint-Louis
Calibration data: 7251 observations made in several summers from 1995 to 2001.
Validation data: about 700 sub-samples from the total database and about 200 samples from the fish habitat database associated with the "Réseau de suivi Ictyologique du Québec".
Links with hydrology: The hydrology during spring and fall play a major role as for the distribution of wave energy on the bottom and for fine particle accumulation. Direct influence of discharge and level are impacting on current, water depth and on light penetration during summer.

Map of the indicator for an average discharge (9500 m³/s at Sorel; scenario 4P):

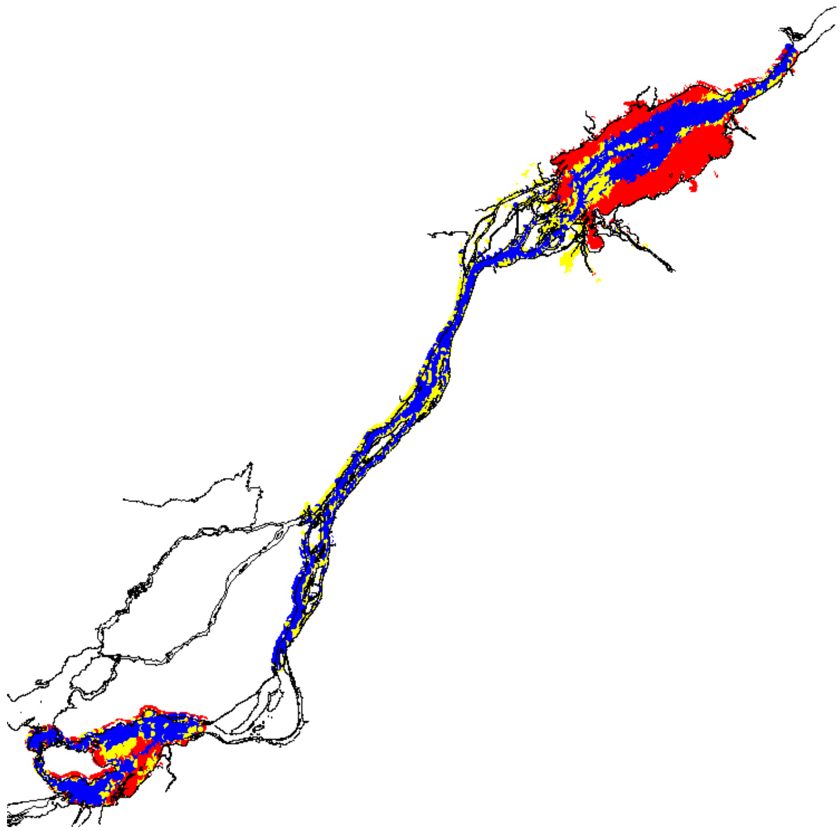


Figure: Spatial distribution of density classes for submerged plants for an average discharge (9500m³/s at Sorel)
Red: high density, yellow: medium density and blue: low density

Transfers from full 2D explicit models to simplified SMV curves:
Following the general methodology, surface area of the indicator calculated with the full 2D models for 8 discharge scenarios are used to simplify the spatialized modelling into direct relationships with discharge. For Submerged plants density index, these relations are shown in the following figure.

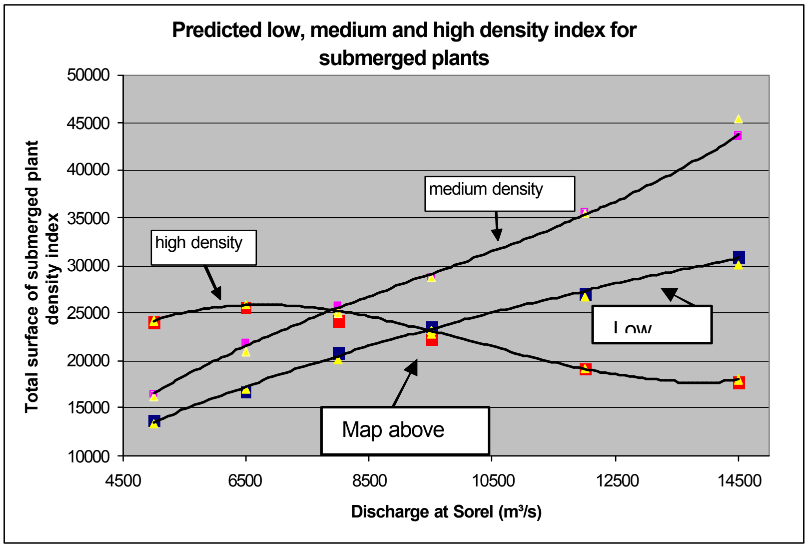


Figure: Relation between the 2D modeling of density classes and the discharge in Sorel, data and best fit curve:
Low_Density (ha) = -3446.7646+(4.2428* Q_Sorel)-(0.0002* Q_Sorel ^2)+(0.00000000462* Q_Sorel^3), with r²=.9923
Medium_Density (ha) = 5337.9319+8.3607*Q_Sorel-0.0008* Q_Sorel ^2+0.0000000266* Q_Sorel ^3, with r²=.9978
High_Density (ha) = 0.0000000452* Q_Sorel ^3 - 0.001397* Q_Sorel ^2 + 12.68* Q_Sorel - 10000, with r²=.9855

In order to simplify the use of the submerged plant density indicators, a global density index is proposed. This index is calculated with the following relation

$$Global\_Density\_Index = ((ha\_Low*1)+(ha\_Med*2)+(ha\_High*3))/6$$

Where *Global_Density_Index* is the surface area of the global density index, *ha_Low* is the surface are in hectare of the low density class, *ha_Med* is the surface are in hectare of the medium density class and *ha_High* is the surface are in hectare of the high density class. The *Global_Density_Index* relation with discharge in Sorel is then computed with polynomial regression tools and is presented in the following figure:

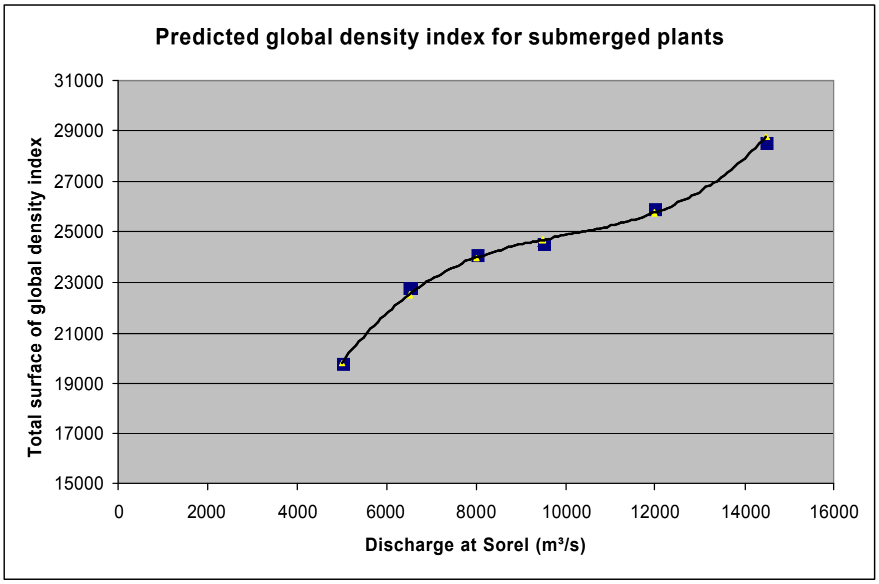


Figure: Relation between the calculated Global_Density Index and the discharge in Sorel, data and best fit curve:Global_density=5337.9319+8.3607*Q_Sorel-0.0008* Q_Sorel ^2+0.0000000266* Q_Sorel ^3, with r^2=.9686

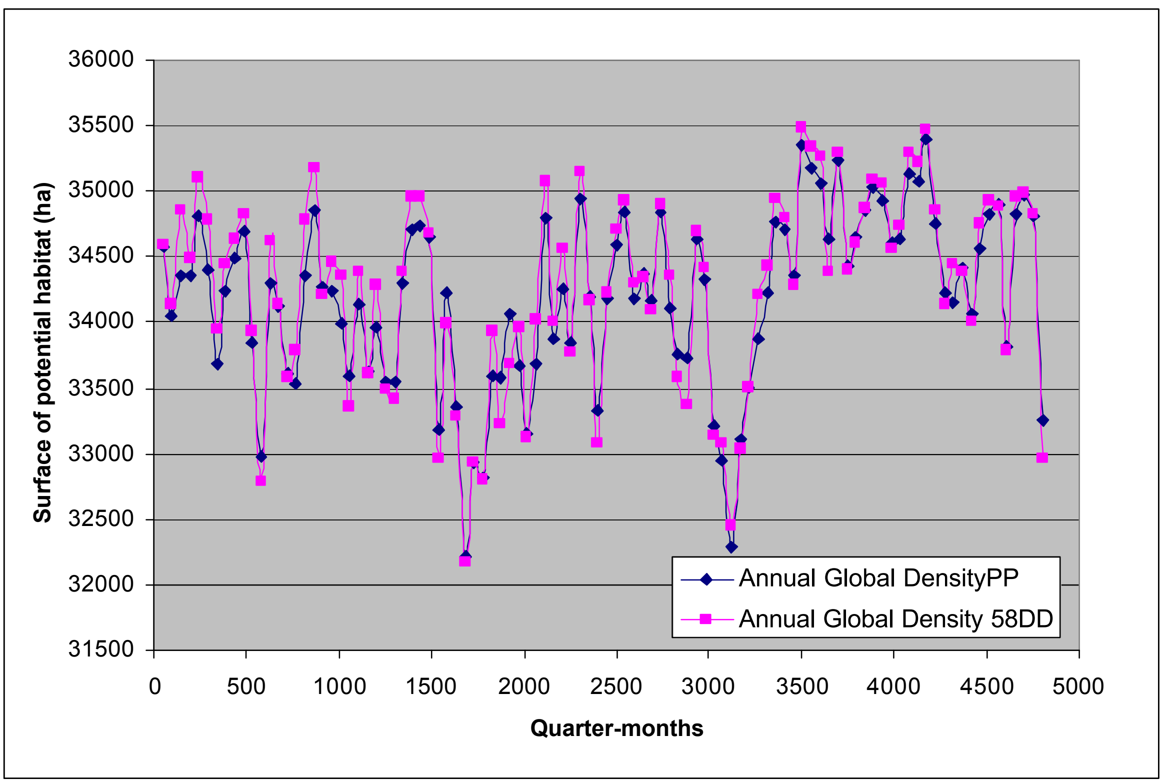


Figure: Comparison of the Performance indicator for the 100 years discharge series: Plan 1958DD and PreProject.

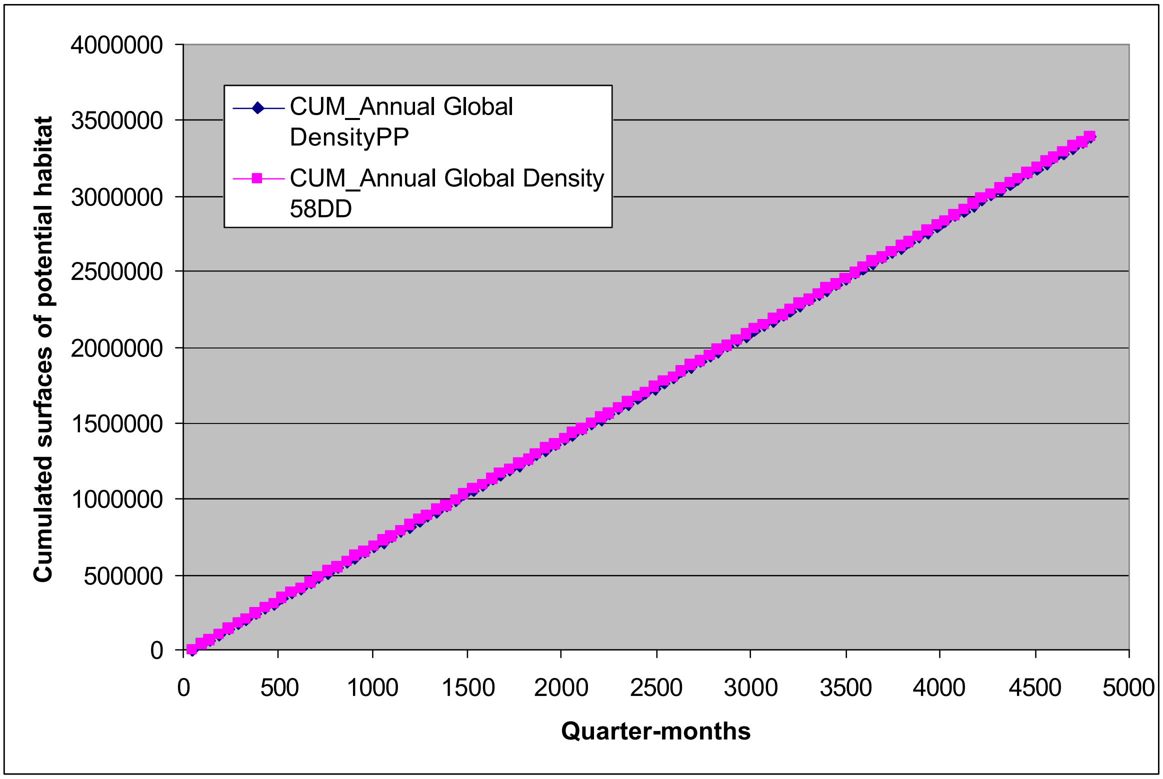


Figure: Comparison of the temporally cumulated Performance Indicator for the 100 years discharge series: Plan 1958DD and PreProject.

IV. Rare & endangered species: reproduction habitat

19 Performance indicator: Rare& Endangered species of bird; Available surface area for nest initiation of Least Bittern (IXEX) *Ixobrichus exilis (Petit blongios)*

Person responsible: Giguère, Laporte & Morin

Origin and description of the indicator: Least Bittern is designated as Threatened by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and it (individual and critical habitat) will be protected by the Species at Risk Act (Bill C-5) by June 2004. The indicator gives the available surface area of nest initiation habitat for different water discharge.

Temporal validity: Valid for the two last quarter-month of June.

Spatial validity: Valid for the Lower St.Lawrence between Lake St.Louis and Lake St.Pierre (except Laprairie Basin)

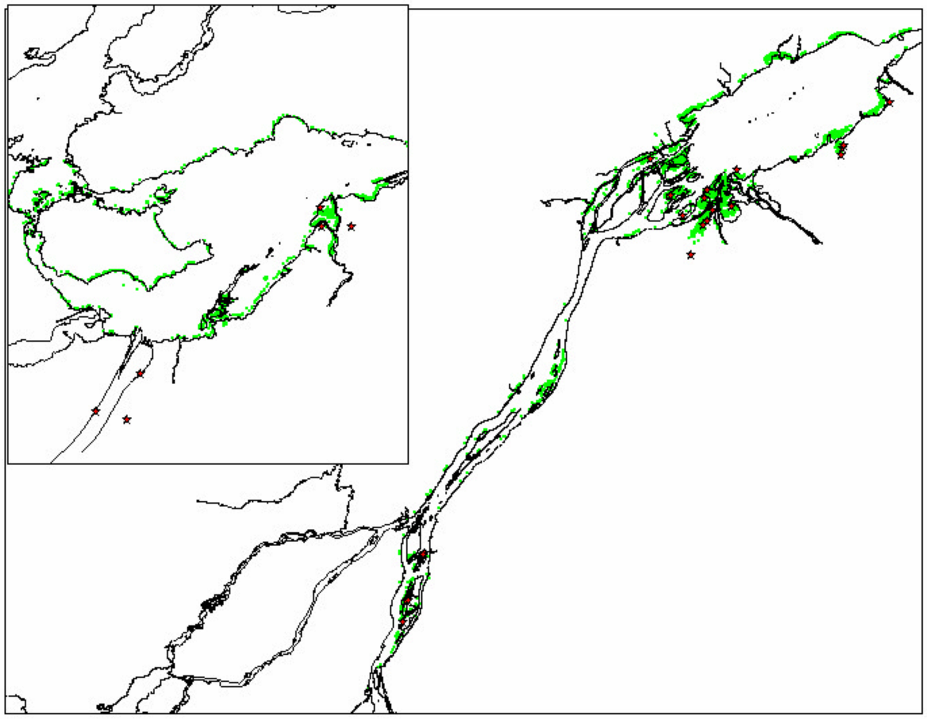
Variables used in the 2D modeling: 1) Probability of presence of Typha latifolia 2) Probability of presence of Typha angustifolia; 3) Probability of presence of Deep Marsh; 4) Water depth between 35 cm and 83 cm for designated quarter of month;5) Threshold: Probablities between 0.3 and 1.0 were considered as available surface area

Calibration data: The model is base on the parameters and values coming from literature review (60 references) and expert's opinions

Validation data: 46 occurrences coming from the Quebec Threatened Birds Data Bank.

Links with hydrology: 1) Hydrology plays a major role in the long term emergent marsh vegetation dynamic; 2) If water depth is not adequate within the nest initiation period, nest initiation could be retarded or fail.

Map of the indicator for an average discharge (9500 m³/s at Sorel; scenario 4P):



Transfers from full 2D explicit models to simplified SMV curves:

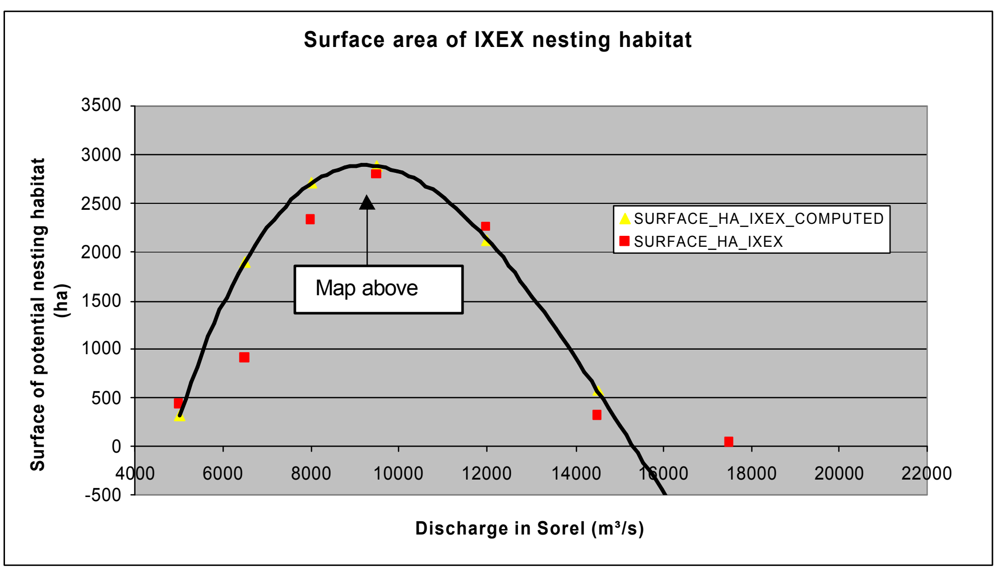


Figure: Relation between the calculated surface area for IXEX nesting habitat and the discharge in Sorel, data and best fit curve : IXEX_COMPUTED = 0.0000000066*Q_Sorel^3 - 0.0003* Q_Sorel ^2 + 3.8463* Q_Sorel - 12244, with r²=.9241

<u>Indicator evolution for 1958DD and PreProject plans</u>:

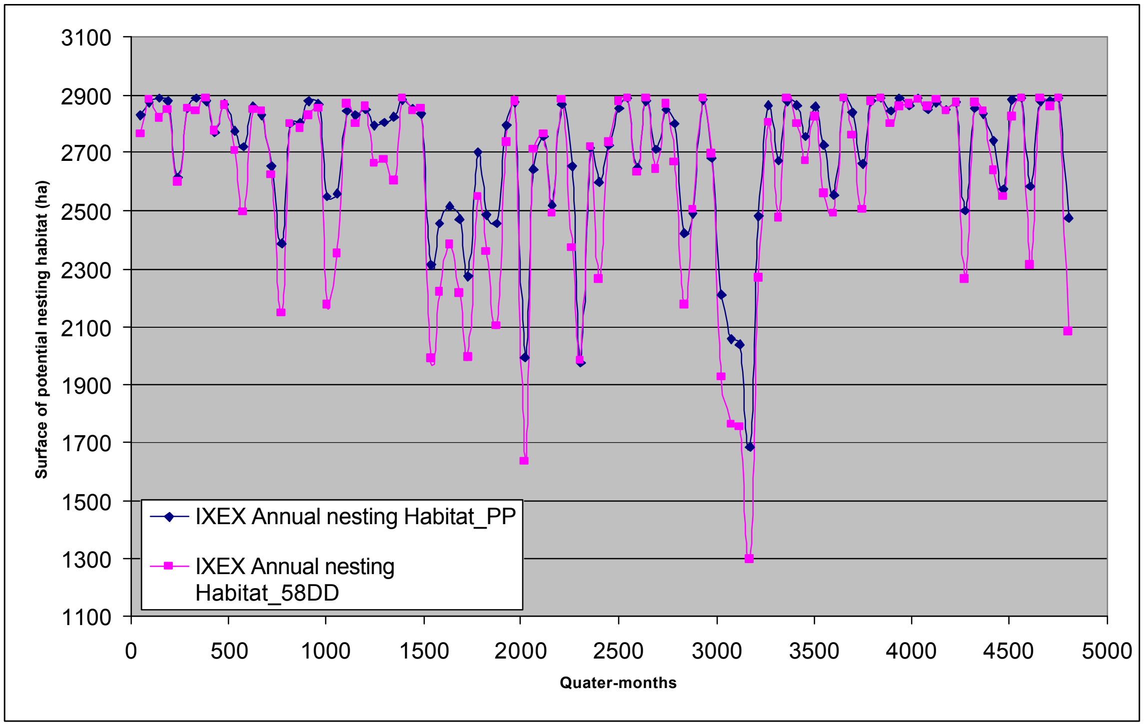


Figure: Comparison of the Performance indicator for the 100 years discharge series: Plan 1958DD and PreProject.

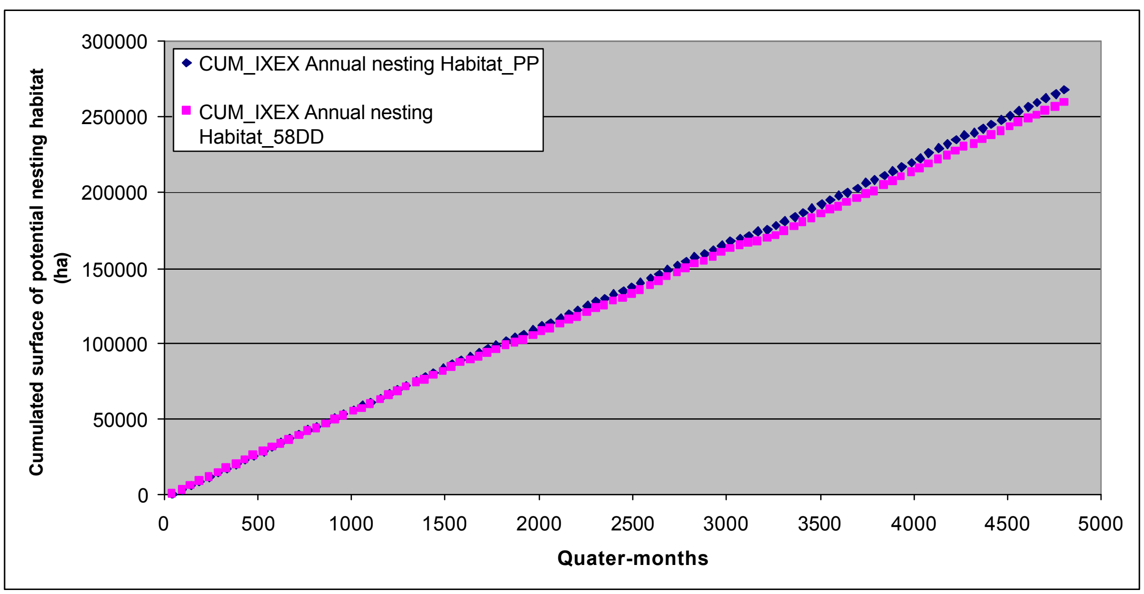


Figure: Comparison of the temporally cumulated Performance Indicator for the 100 years discharge series: Plan 1958DD and PreProject.

20 Performance indicator: Rare& Endangered species of bird; Available surface area for nest initiation of Yellow Rail (CONO) *Coturnicops noveboracensis (Râle Jaune)*

Person responsible: Giguère, Laporte & Morin

Origin and description of the indicator: Yellow Rail is designated as Special Concern by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). This species will not be protected before 2006 by the general interdictions (annex 1) of the Species at Risk Act (Bill C-5). The indicator gives the available surface area of nest initiation habitat for different water discharge. The reproduction within the study zone are not yet confirmed but is strongly suspected.

Temporal validity: Valid for the two last quarter month of May

Spatial validity: Valid for the Lower St.Lawrence between Lake St. Louis and Lake St. Pierre (except Laprairie Basin)

Variables used in the 2D modeling: 1) Presence probability of Wet Meadow
2) Presence of saturated substrate

This is a presence/absence probabilities model; all the presence probabilities were considered as available surface area in the final calculation

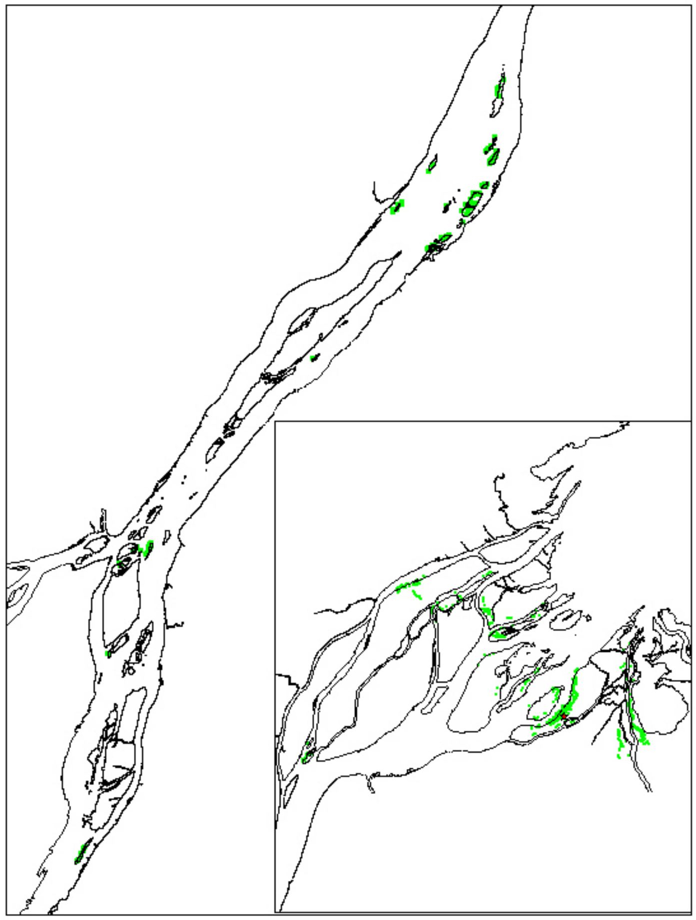
Calibration data: The model is base on the parameters and values coming from literature review and expert's opinions (more info in Giguère and Laporte 2002-2003 final report)

Validation data: Only one occurrence is available within the reproduction period coming from the Banque de Données sur les oiseaux menaces du Québec (Quebec Threatened Birds Data Bank). Experts have also been consulted (Michel Robert and François Shaffer, Env. Can. – Canadian Wildlife Service).

Links with hydrology: 1) Under natural conditions, hydrology plays a major role in the medium / long term wet meadow vegetation dynamic. On the other hand, it seems that in the study zone, wet meadows are more controlled by human activities

2) Water levels too high within the nest initiation period can made unavailable nest initiation habitat. Under such conditions, nest initiation could fail or be retarded.

Map of the indicator for an average discharge (9500 m³/s at Sorel; scenario 4P):



Transfers from full 2D explicit models to simplified SMV curves:

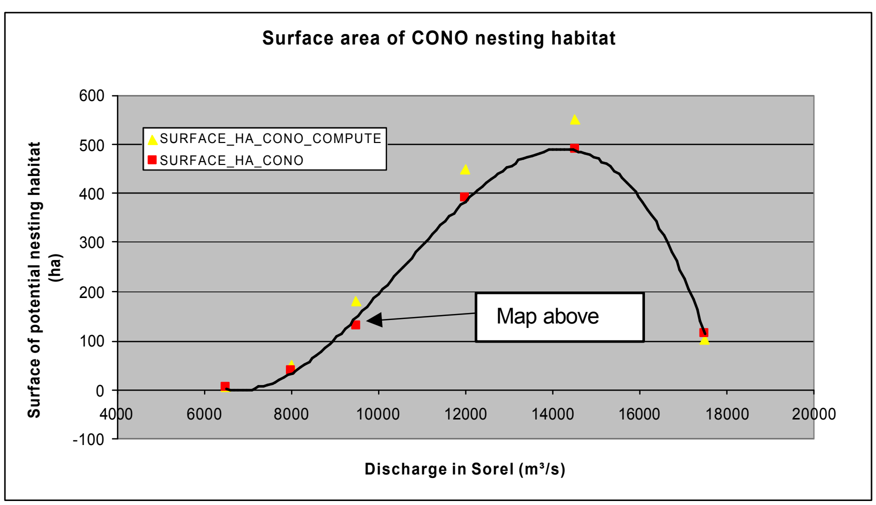


Figure: Relation between the calculated surface area for CONO nesting habitat and the discharge in Sorel, data and best fit curve : CONO_COMPUTE = -0.00000000271* Q_Sorel ^3 + 0.00008456* Q_Sorel ^2 - 0.768* Q_Sorel + 2170, with r^2=.9959

Indicator evolution for 1958DD and PreProject plans:

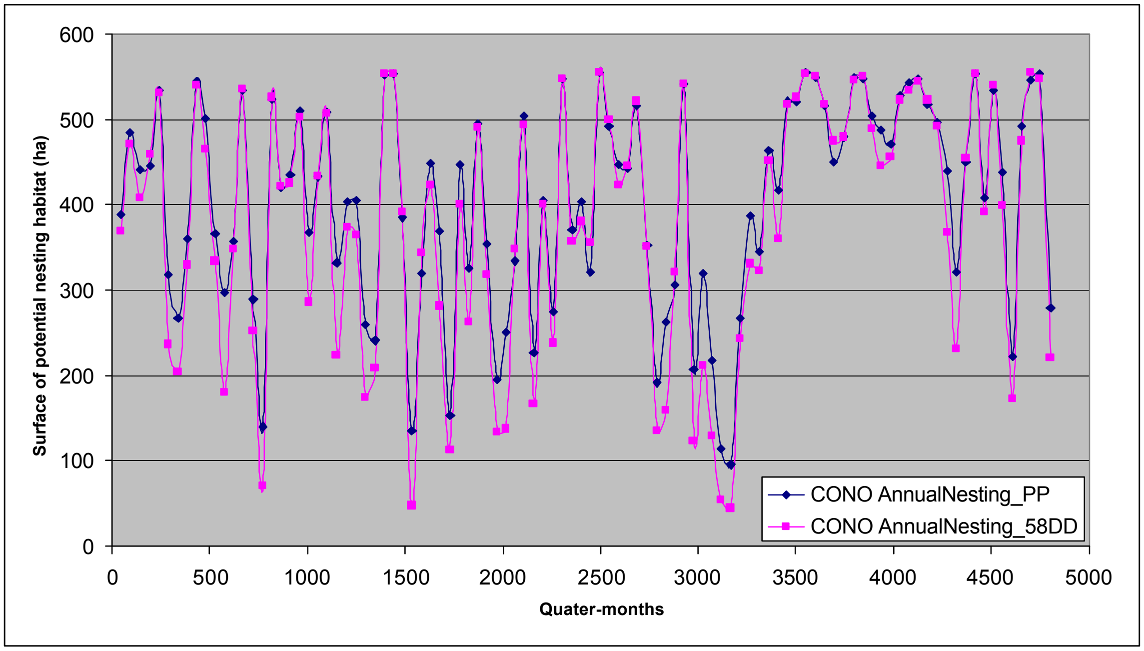


Figure: Comparison of the Performance indicator for the 100 years discharge series: Plan 1958DD and PreProject.

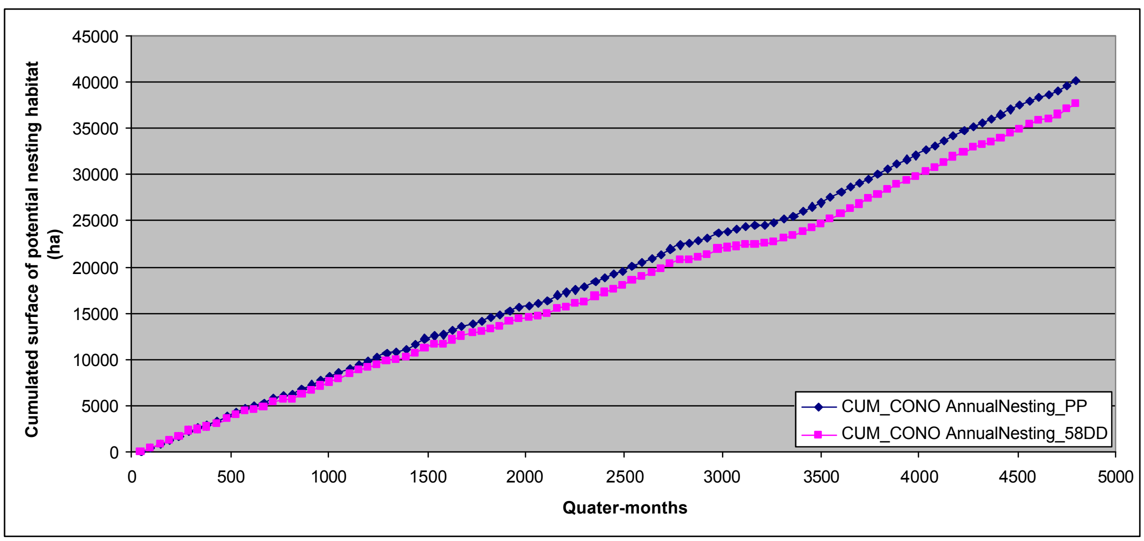


Figure: Comparison of the temporally cumulated Performance Indicator for the 100 years discharge series: Plan 1958DD and PreProject.

21 Performance indicator: Rare& Endangered species of fish; Available spawning surface area for Channel Darter (PECO) *Percina copelandi (Fouille-roche gris)*

Person responsible: Giguère, Laporte, Champoux & Morin

Origin and description of the indicator: Channel Darter is designated as Threatened by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). The species and its critical habitat will be protected by summer 2005 under the general interdictions (annex 1) of the Species at Risk Act (Bill C-5). The indicator gives the available surface area of spawning habitat for different water discharge.

Temporal validity: Valid for the two last quarter month of June and the four quarter month of July.

Spatial validity: Valid for the Lower St.Lawrence between Lake St.Louis and Lake St.Pierre (except Laprairie Basin)

Variables used in the 2D modeling:

1) Presence probability of gravely and pebbles substrate some rocks,
2) Presence of water depth between 45 cm and 150 cm

This is a presence / absence probabilities model, all the presence probabilities were considered as available surface area in the final calculation.

Calibration data: The model is base on the parameters and values coming from literature review and expert's opinions (more info in Giguère&Laporte 2002-2003 final report).

Validation data: Three occurrences are available within the reproduction period coming from the Société de la Faune et des Parcs du Québec (FAPAQ).

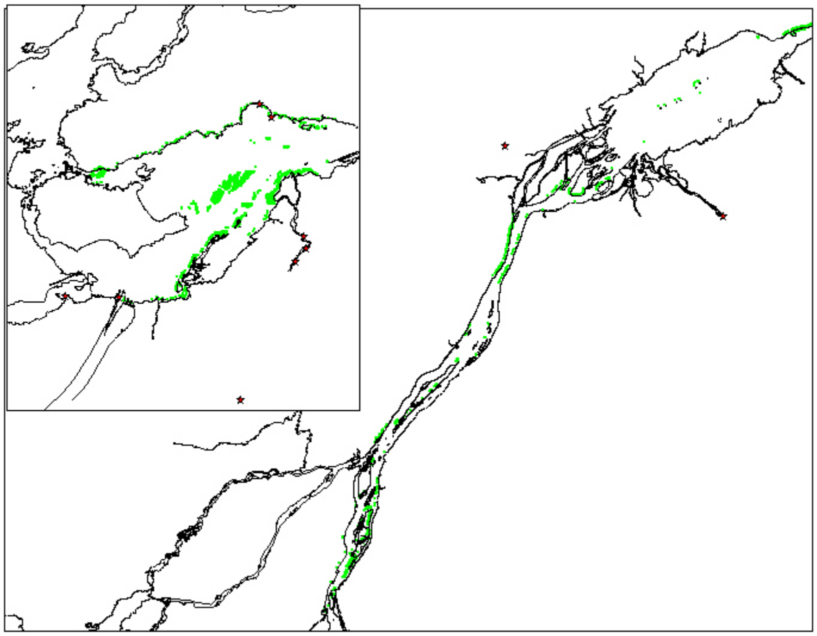
Links with hydrology:

1) Flow velocity directly drives the substrate composition. The coarse substratum is the most important parameter required by this species for spawning.

2) Water levels too high could changes (drop) water temperature, which control spawning migration and larvae development.

3) Water levels too low can dry up eggs and larvae.

Map of the indicator for an average discharge (9500 m³/s at Sorel; scenario 4P):



Transfers from full 2D explicit models to simplified SMV curves:

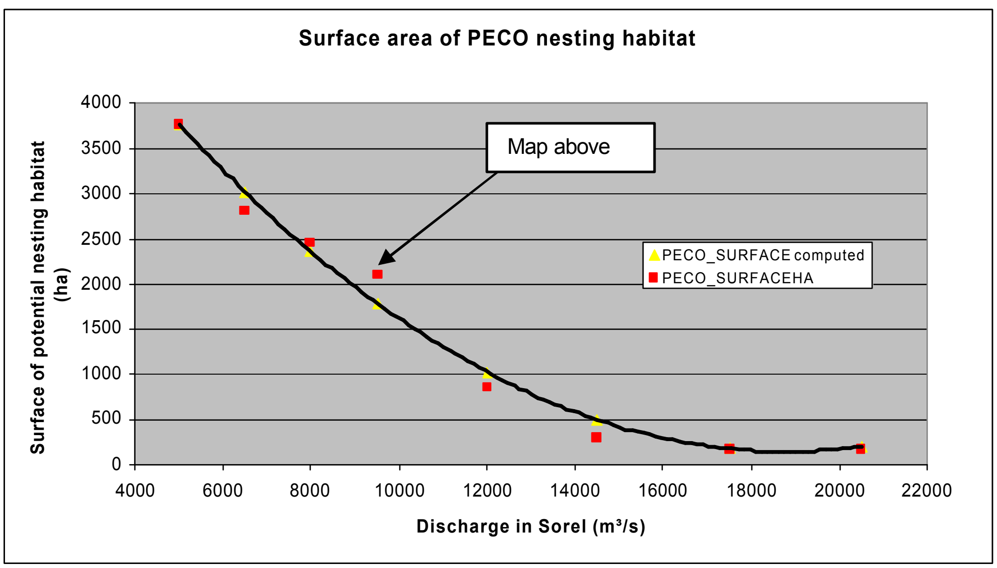


Figure: Relation between the calculated surface area for PECO nesting habitat and the discharge in Sorel, data and best fit curve : PECO_computed = 0.000019*Q_Sorel^2 - 0.714* Q_Sorel + 6856.6, with r²=.9842

Indicator evolution for 1958DD and PreProject plans:

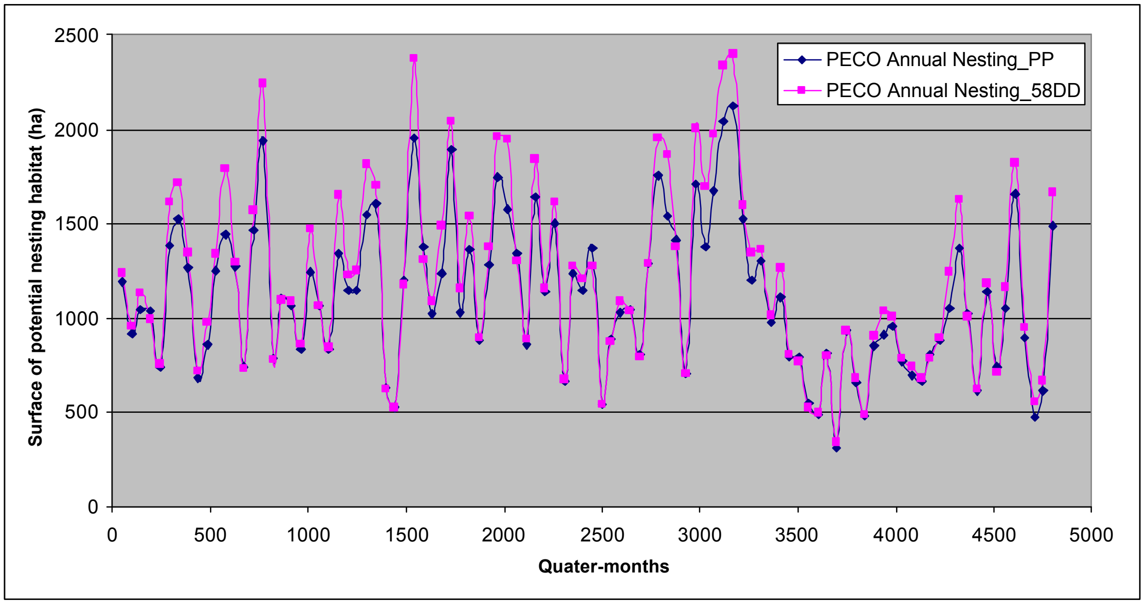


Figure: Comparison of the Performance indicator for the 100 years discharge series: Plan 1958DD and PreProject.

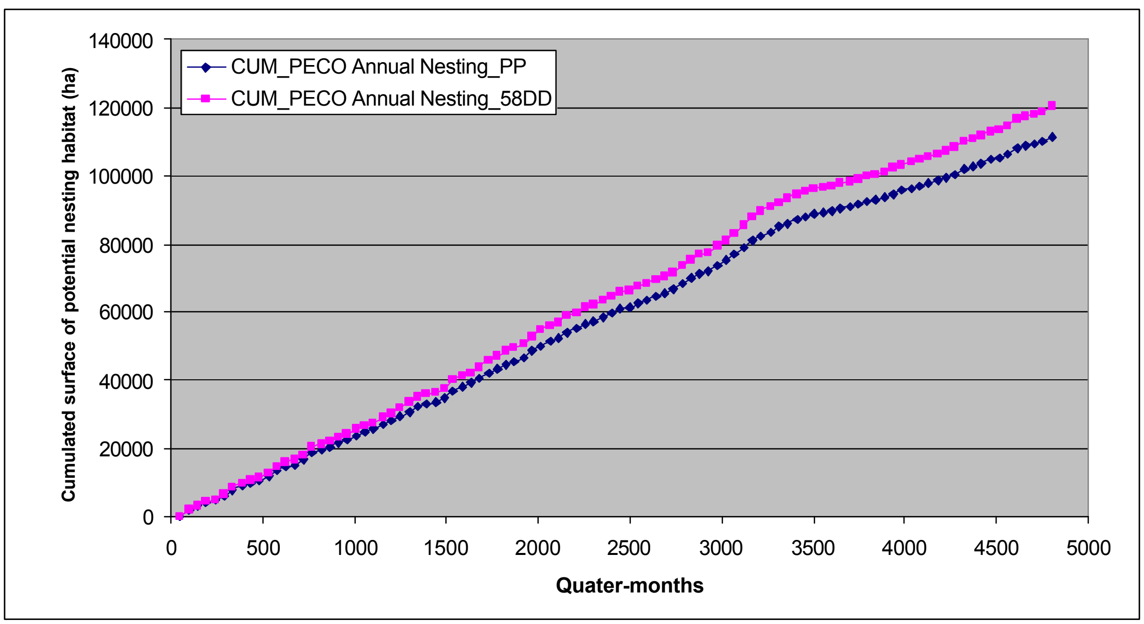


Figure: Comparison of the temporally cumulated Performance Indicator for the 100 years discharge series: Plan 1958DD and PreProject.

V. Migratory birds

22 Performance indicator: Use of the floodplain by migratory bird (number of individual)

Person responsible: Lehoux, Dauphin, Champoux & Morin
Origin and description of the indicator: During spring, the Lake St. Pierre flood plain represents the most important migratory stopover of the St. Lawrence for waterfowl. An economic spin-off is related to aquatic bird observation in the sector. The reproductive success of the birds could be reduced significantly if inappropriate conditions are encountered on staging areas. The performance indicator gives the number of birds which are accommodating in the non managed portion of the Lake St. Pierre flood plain by different water levels.
Temporal validity: Valid between April 10th and May 7th.
Spatial validity: Lake St. Pierre flood plain.
Variables used in the modeling: Relation between the abundance of waterfowl in the non managed portion of the Lake St. Pierre flood plain and different water levels at Sorel station.
Calibration data: The model is based on survey data.
Validation data: This performance indicator shows an important correlation between water levels and bird abundance in the non managed portion of the Lake St. Pierre flood plain (demonstrated by survey data; r^2= 0,68).
Links with hydrology: Adequate water levels provide the following benefits:

? ensure optimal aquatic birds distribution in the Lake St. Pierre flood plain;
? prevent a too small flood plain surface forcing the birds to concentrate mainly in managed marshes where available food could be a limiting factor and increase inter an intra-specific stress;
? prevent the birds from being in poor physiological health due to poor nutrition which could potentially reduce their reproductive success significantly;
? ensure that most important flood plain of the fresh water portion of the St. Lawrence is sustained;
? Maintain the economic spin-off related to aquatic bird observation, a very important activity in the Lake St. Pierre sector.

Indicator evolution for 1958DD and PreProject plans:

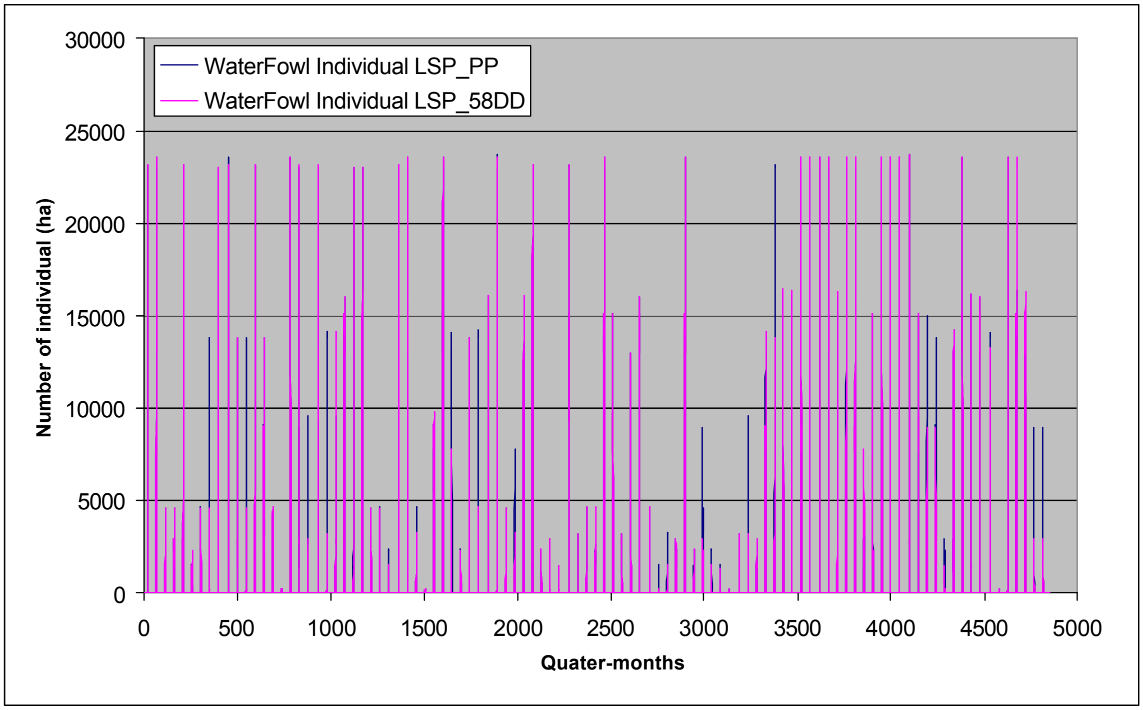


Figure: Comparison of the Performance indicator for the 100 years discharge series: Plan 1958DD and PreProject.

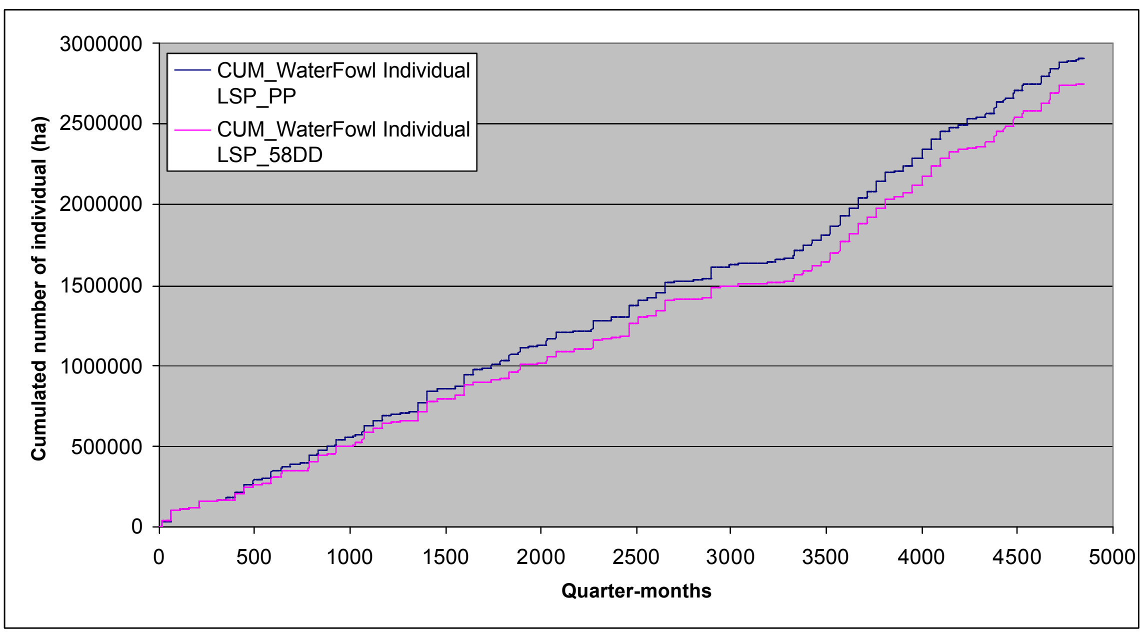


Figure: Comparison of the temporally cumulated Performance Indicator for the 100 years discharge series: Plan 1958DD and PreProject.

VI. Fish global indicators

23 Performance indicator: Total number of fish in the river

Person responsible: de Lafontaine & Marchand
Origin and description of the indicator: Indicator of annual abundance of various adult fish species. Catch data were obtained from a time series of daily fish records at the St-Nicolas experimental trap fishery. Daily catches were recorded from May 15 to November 1, each year since 1975 and were summed over the entire fishing season to derive the annual abundance index.
Temporal validity: One value computed per year.
Spatial validity: Lower SLR between Sorel Islands and Quebec City. Data collected at one site, but fish migrate and populations are distributed between Sorel Islands and Quebec City.
Variables used in the modeling: Daily water levels recorded at Jetty #1 (Montreal Harbour). The variables were used to calculate various descriptive parameters on a seasonal basis (For example: average water level during springtime).
Calibration data: Real catch data at St. Nicolas' trap, between 1975 and 2002.
Validation data: None.
Links with hydrology: This indicator is based on the ration of the intensity of the spring water level (flood) and the mean summer level.
Indicator evolution for 1958DD and PreProject plans:

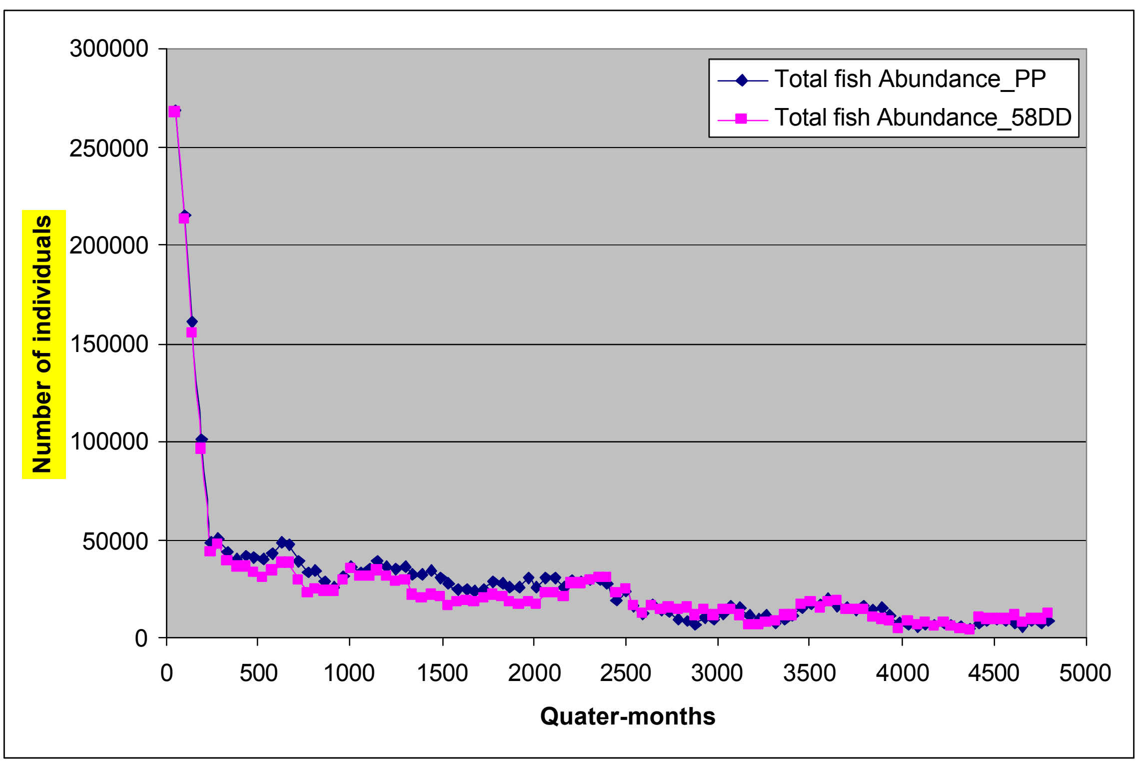


Figure: Comparison of the Performance indicator for the 100 years discharge series: Plan 1958DD and PreProject.

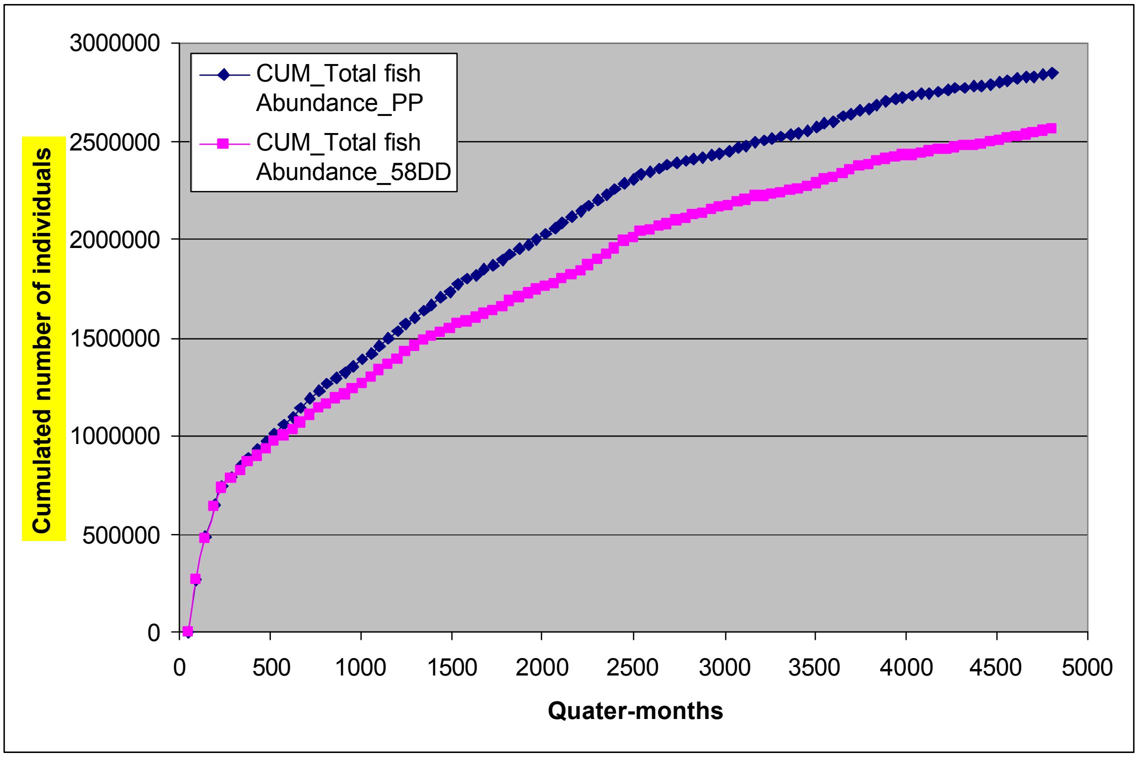


Figure: Comparison of the temporally cumulated Performance Indicator for the 100 years discharge series: Plan 1958DD and PreProject.

24 Performance indicator: Timing of American Eel Migration

Person responsible: de Lafontaine & Marchand

Origin and description of the indicator: The timing of eel migration from the lower St. Lawrence River to the Atlantic Ocean depends on the mean water level in the lower river in late summer (Aug-Sept). A relatively higher mean water level results in migration occurring relatively earlier. The regression for this PI was based on water levels for the Montreal Harbor Jetty #1 gage.

Catch data were obtained from a time series of daily fish records at the St-Nicolas experimental trap fishery. Daily catches were recorded from May 15 to November 1, each year since 1975.

Temporal validity: One value computed per year.

Spatial validity: Lower SLR between Sorel Islands and Quebec City. Data collected at one site, but fish migrate and populations are distributed between Sorel Islands and Quebec City.

Variables used in the modeling: Daily water levels recorded at Jetty #1 (Montreal Harbour). The variables were used to calculate various descriptive parameters on a seasonal basis (For example: average water level during springtime).

Calibration data: Real catch data at St. Nicolas' trap, between 1975 and 2002.

Validation data: None.

Links with hydrology: This indicator is based on the ration of the intensity of the spring water level (flood) and the mean summer level.

Comments/Caveats:

The regression is essentially in final form, but the importance of this PI is unclear. A later migration date may impact the reproductive success of this species, but there doesn't appear to be any hard evidence that this is the case (J.DePinto).

Indicator evolution for 1958DD and PreProject plans:

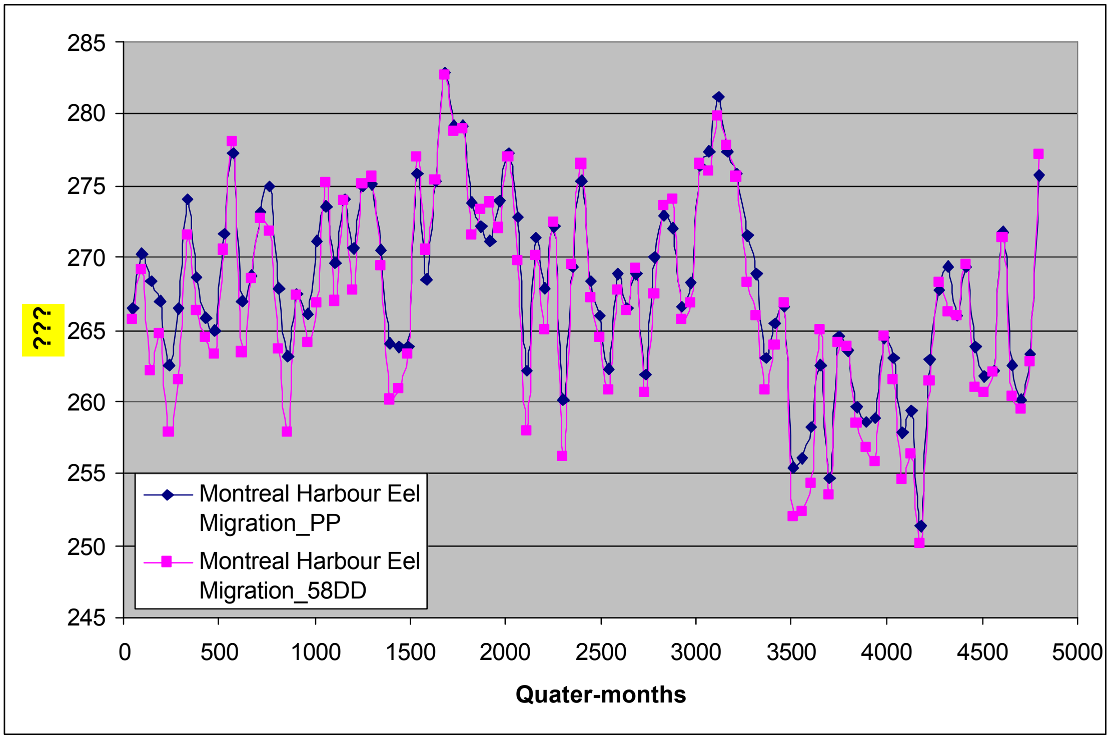


Figure: Comparison of the Performance indicator for the 100 years discharge series: Plan 1958DD and PreProject.

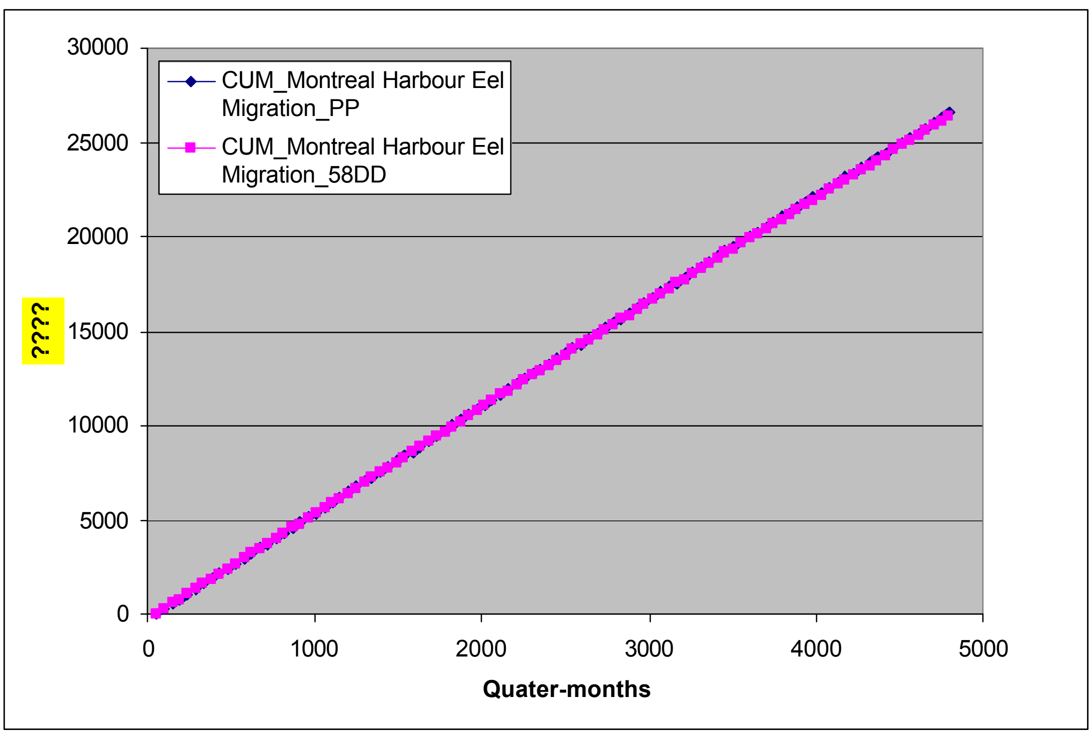


Figure: Comparison of the temporally cumulated Performance Indicator for the 100 years discharge series: Plan 1958DD and PreProject.

VII. Lake Saint-Pierre's wetland quality

25 Performance indicator : wetlands, high marsh, open marsh, and emergent Coverage, Phragmites Progression in Lake St. Pierre

Person responsible: Hudon

Origin and description of the indicator: Hudon has generated several regressions relating water level at Sorel to total coverage of wetlands, high marsh, open marsh, and emergent cover in Lake St. Pierre. The progression rate of *Phragmite australis* is also related to the growing season average water level, with higher levels resulting in

Temporal validity: Each of these PIs are calculated based on the average water level during the growing season (Apr-Sept) at Sorel.

Spatial validity: Lake St. Pierre only.

Variables used in the modeling:

Calibration data:

Validation data:

Links with hydrology:

Comments/Caveats:

In general, these PIs tend to be strongly driven by decadal changes in climate. Preliminary results indicate that regulation makes only small differences in the wetland/emergent plant coverage relative to fluctuations in interannual basin supply (J. DePinto).

Indicator evolution for 1958DD and PreProject plans:

Lake Saint-Pierre Total Wetland

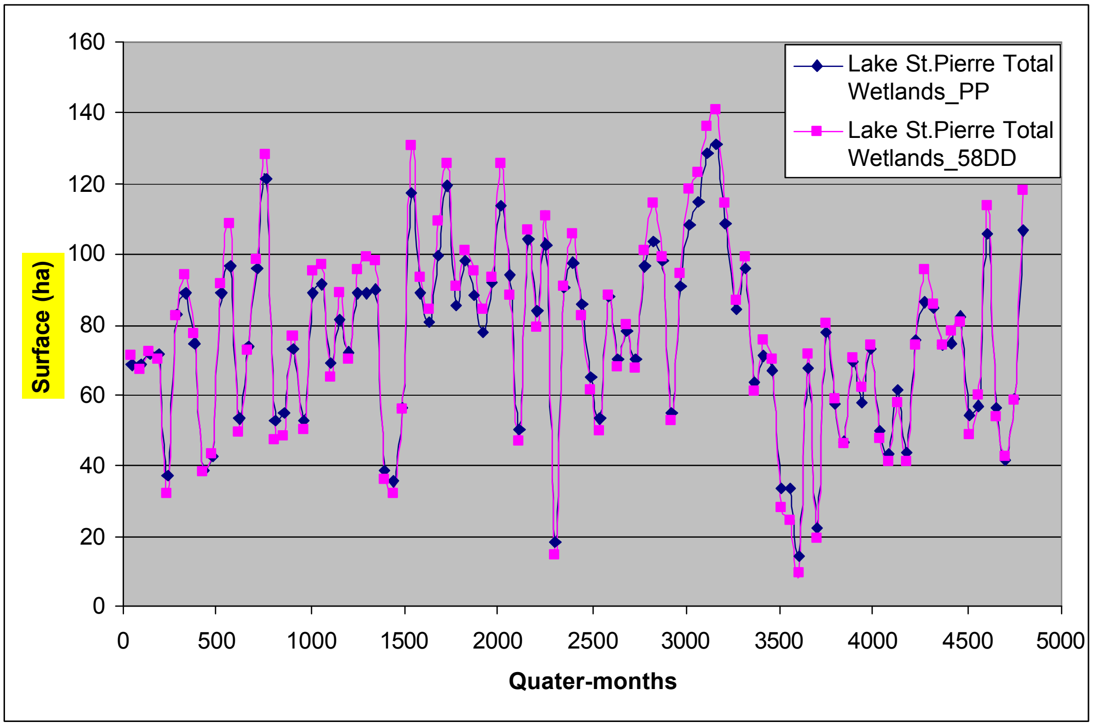


Figure: Comparison of the Performance indicator for the 100 years discharge series: Plan 1958DD and PreProject.

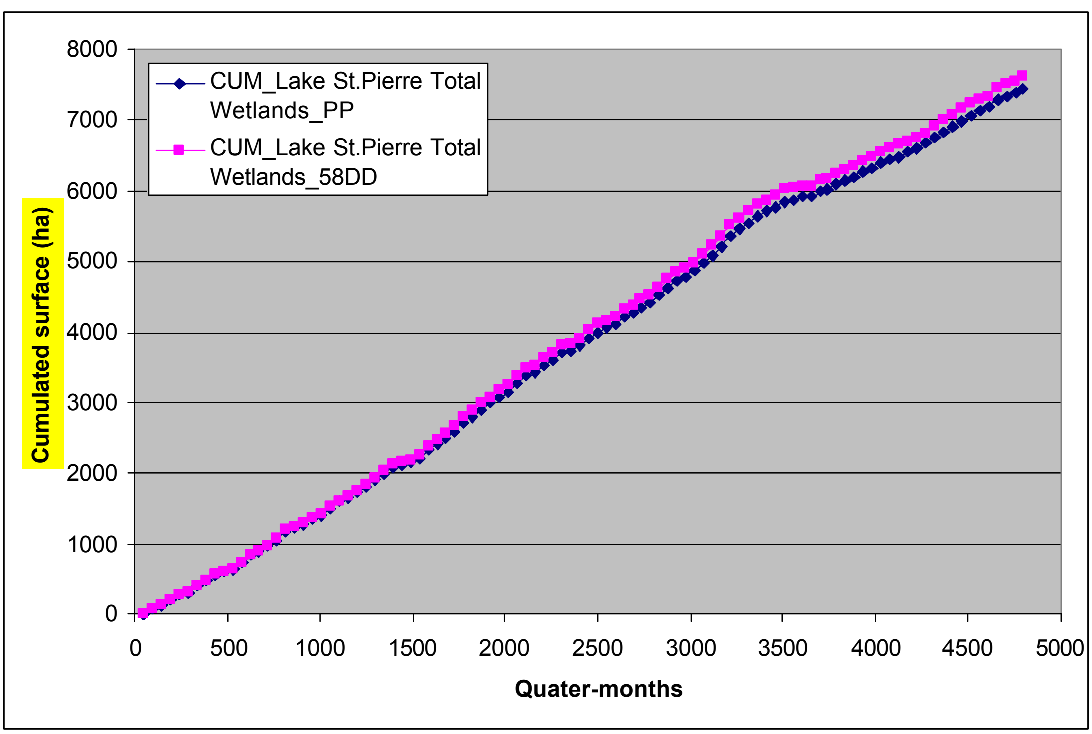


Figure: Comparison of the temporally cumulated Performance Indicator for the 100 years discharge series: Plan 1958DD and PreProject.

Lake Saint-Pierre emergent marshes coverage

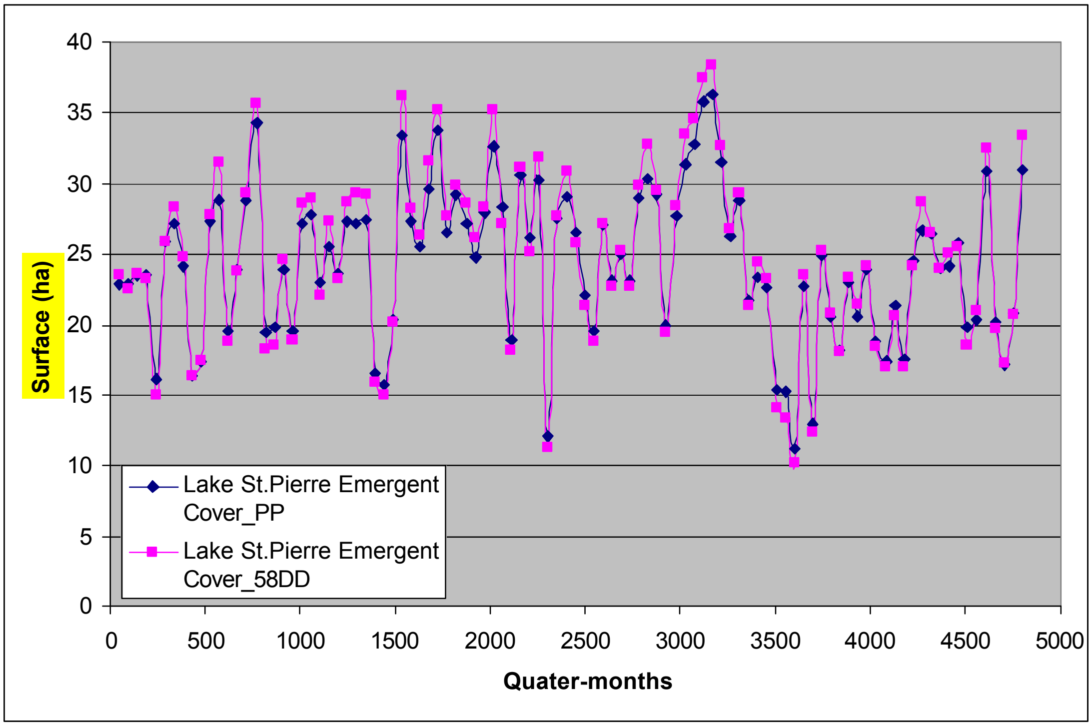


Figure: Comparison of the Performance indicator for the 100 years discharge series: Plan 1958DD and PreProject.

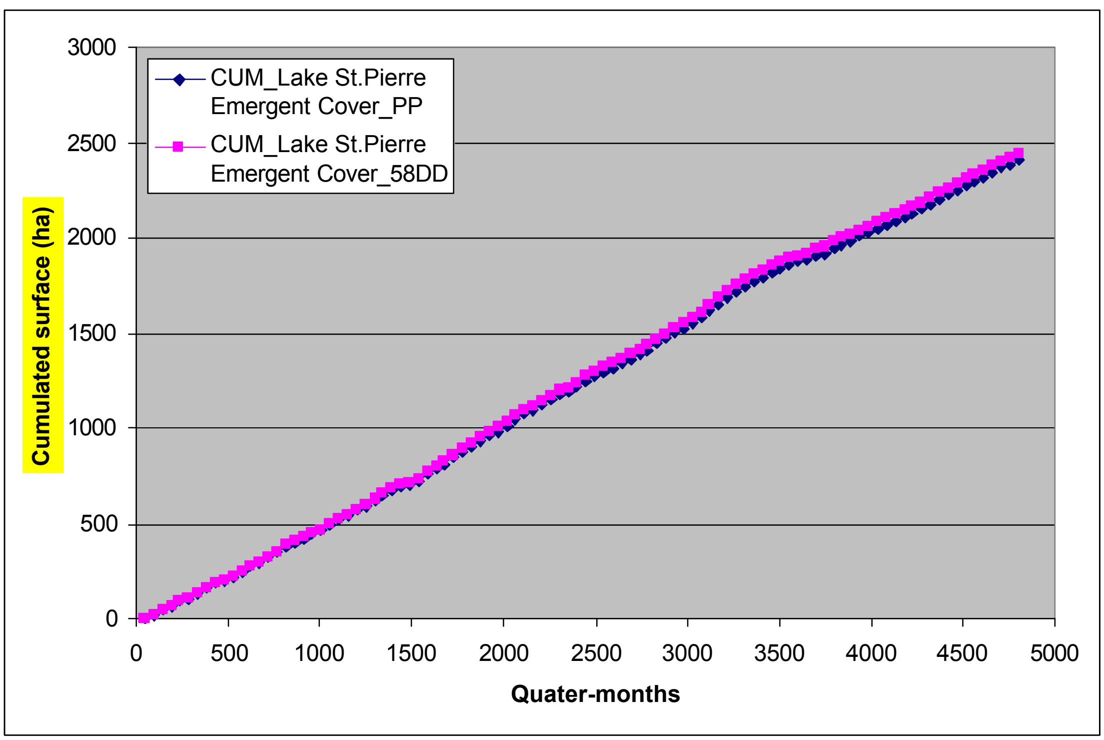


Figure: Comparison of the temporally cumulated Performance Indicator for the 100 years discharge series: Plan 1958DD and PreProject.

Lake Saint-Pierre open marsh coverage

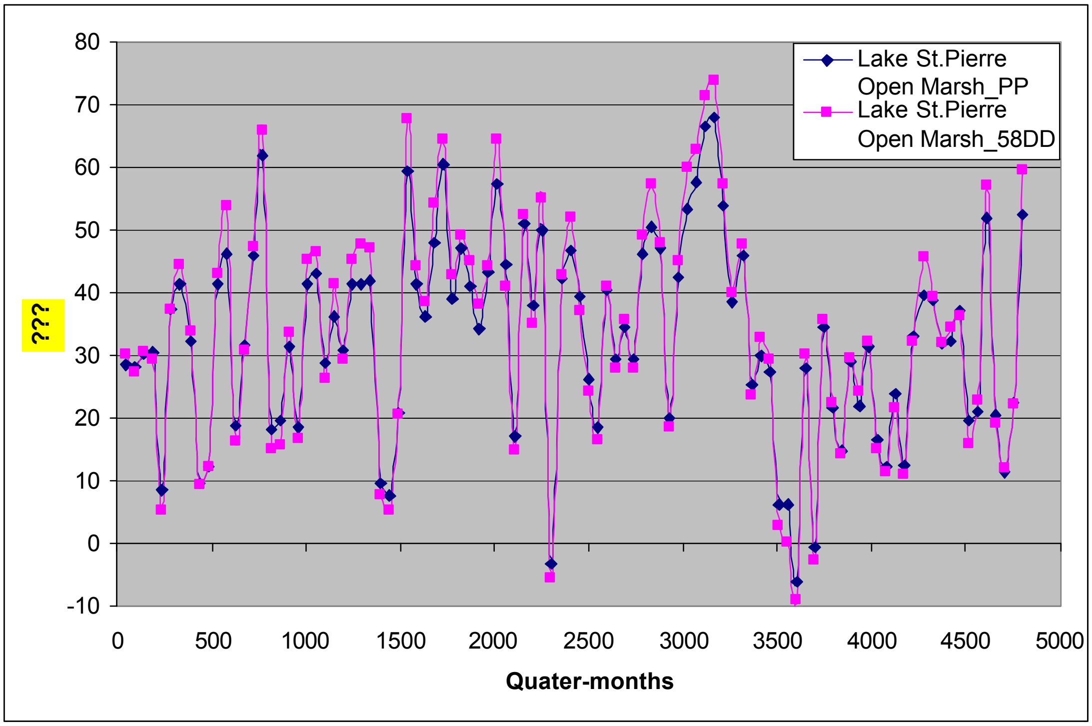


Figure: Comparison of the Performance indicator for the 100 years discharge series: Plan 1958DD and PreProject.

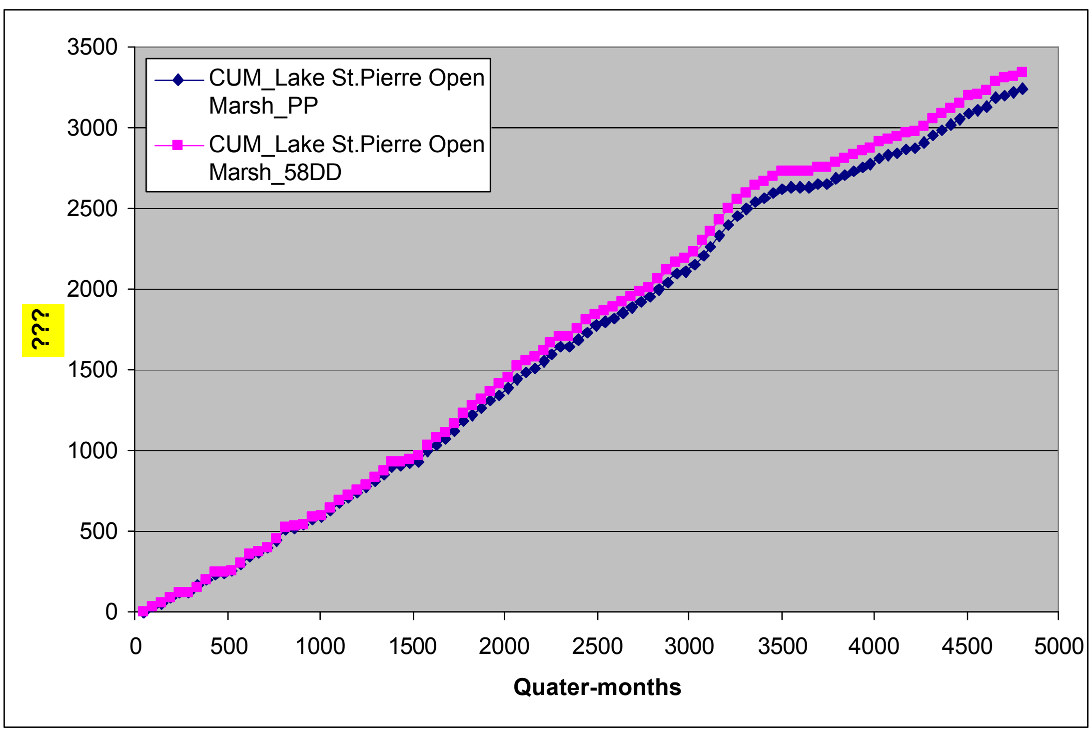


Figure: Comparison of the temporally cumulated Performance Indicator for the 100 years discharge series: Plan 1958DD and PreProject.

Lake Saint-Pierre high marsh coverage

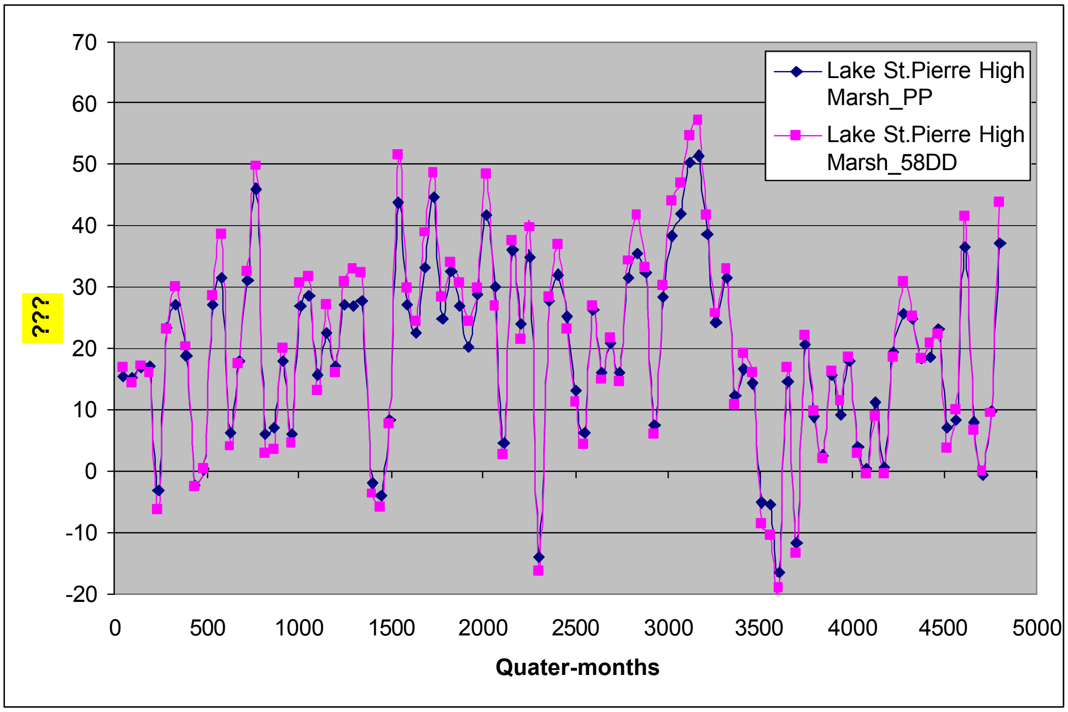


Figure: Comparison of the Performance indicator for the 100 years discharge series: Plan 1958DD and PreProject.

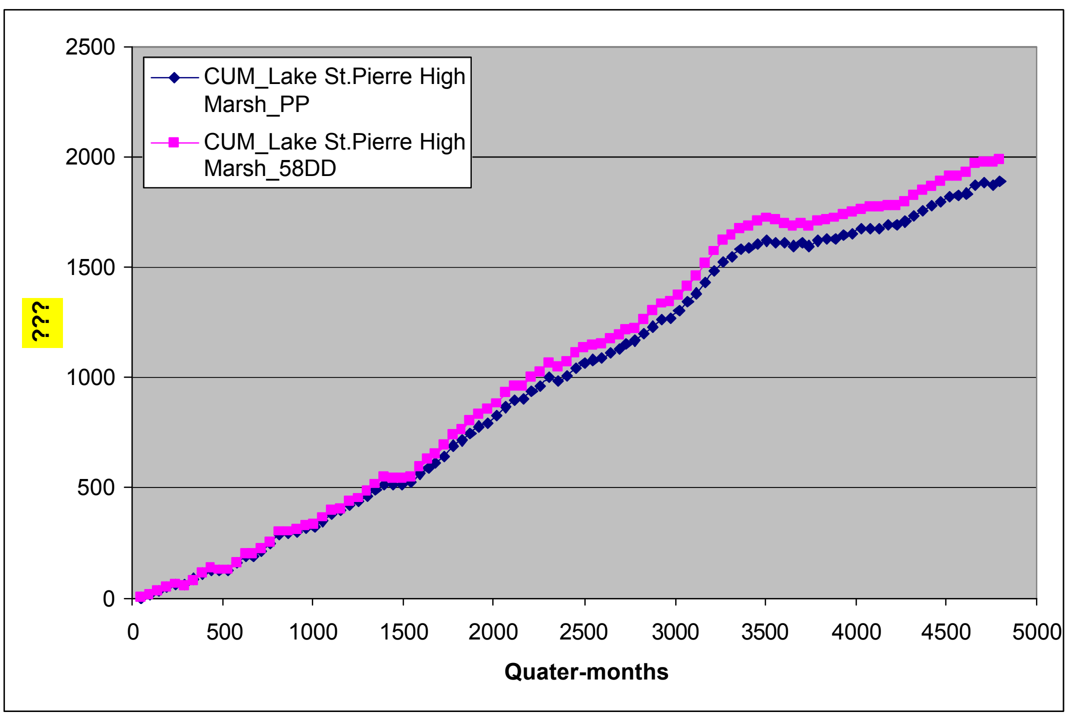


Figure: Comparison of the temporally cumulated Performance Indicator for the 100 years discharge series: Plan 1958DD and PreProject.

Lake Saint-Pierre phragmites progression

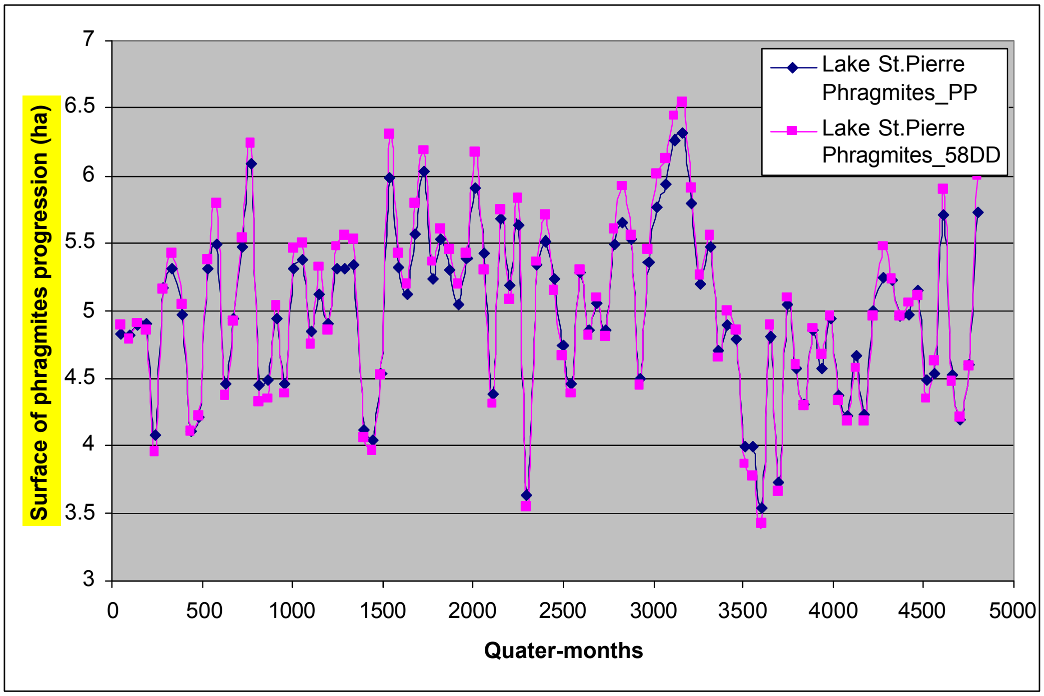


Figure: Comparison of the Performance indicator for the 100 years discharge series: Plan 1958DD and PreProject.

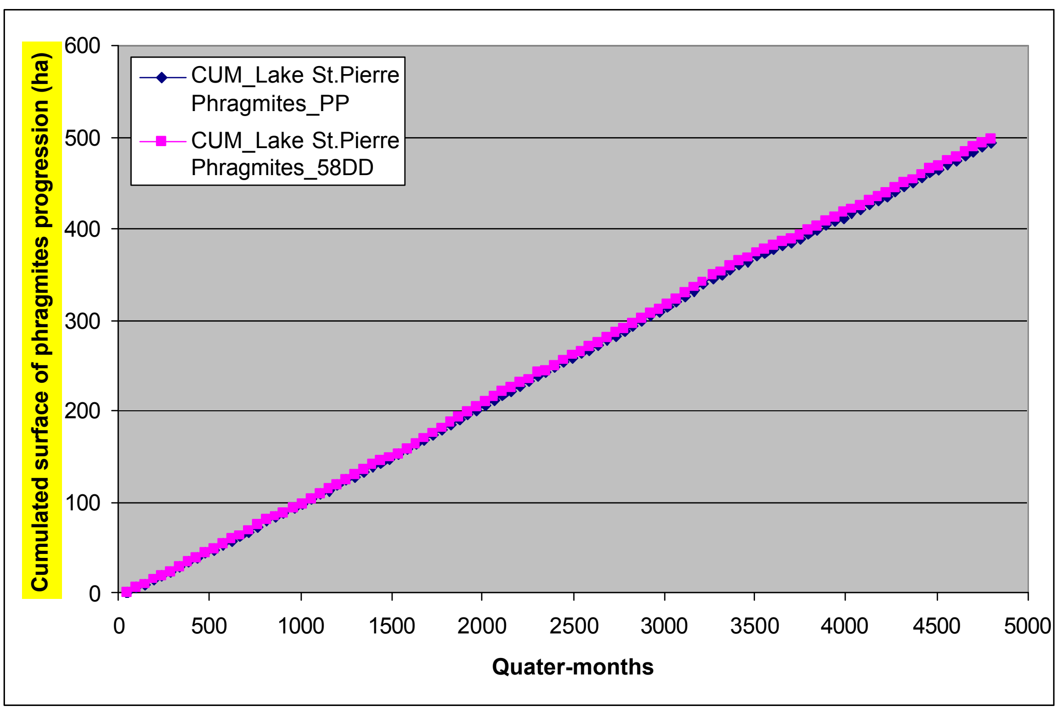


Figure: Comparison of the temporally cumulated Performance Indicator for the 100 years discharge series: Plan 1958DD and PreProject.

VIII. Boucherville Islands northern pike reproduction

26 Performance indicator: Northern Pike Year Class Strength Index (YCSI)

Person responsible: Armellin
Origin and description of the indicator: Northern pike YCSI is positively correlated with the minimum water level during the spring spawning period. In general, higher water levels during the spring allow northern pike access to wetland areas for spawning. For simplicity, the spring spawning period was assumed to occur during the month of April (QM 13-16) - see below for more details.
Temporal validity: April
Spatial validity: Boucherville Islands.
Variables used in the modeling:
Calibration data:
Validation data:
Links with hydrology:.
Comments/Caveats:
The regression implemented here is based on the actual "spawning period", which is defined as a 28-day period following the onset of spawning (when water temperatures reach 4 degrees Celsius).
Armellin apparently has generated regressions for YCSI and April water levels, which appear to be just as strong and would be much easier to use in the SVM. Therefore, we should consider replacing the current regression with the April regression (J. DePinto).

Indicator evolution for 1958DD and PreProject plans:

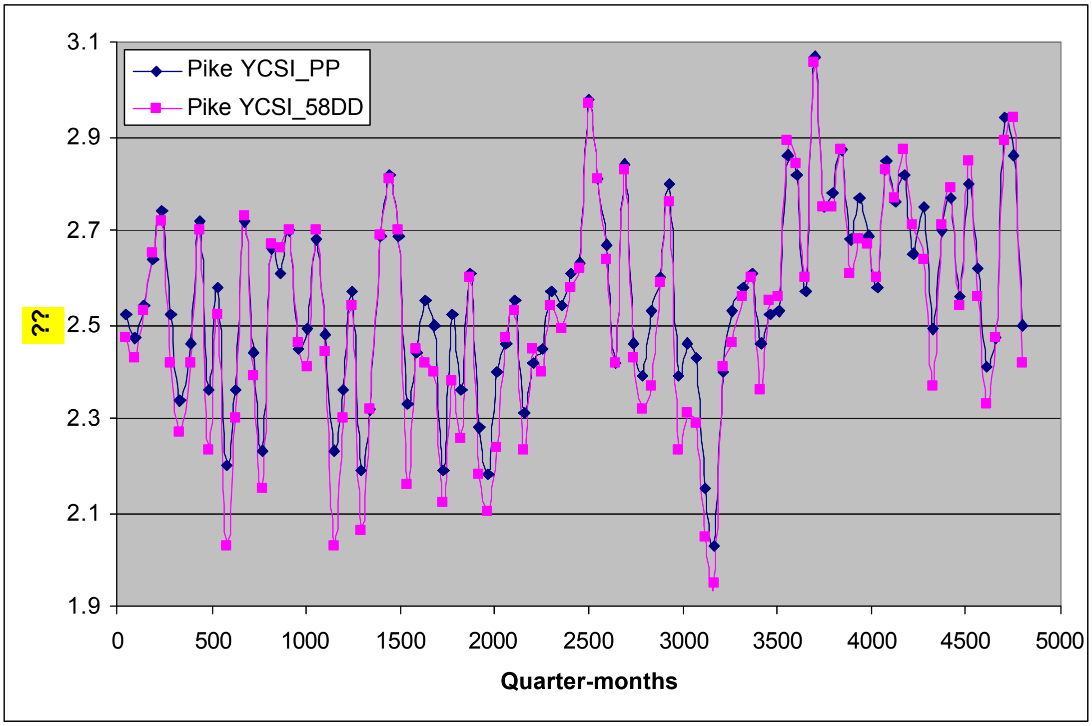


Figure: Comparison of the Performance indicator for the 100 years discharge series: Plan 1958DD and PreProject.

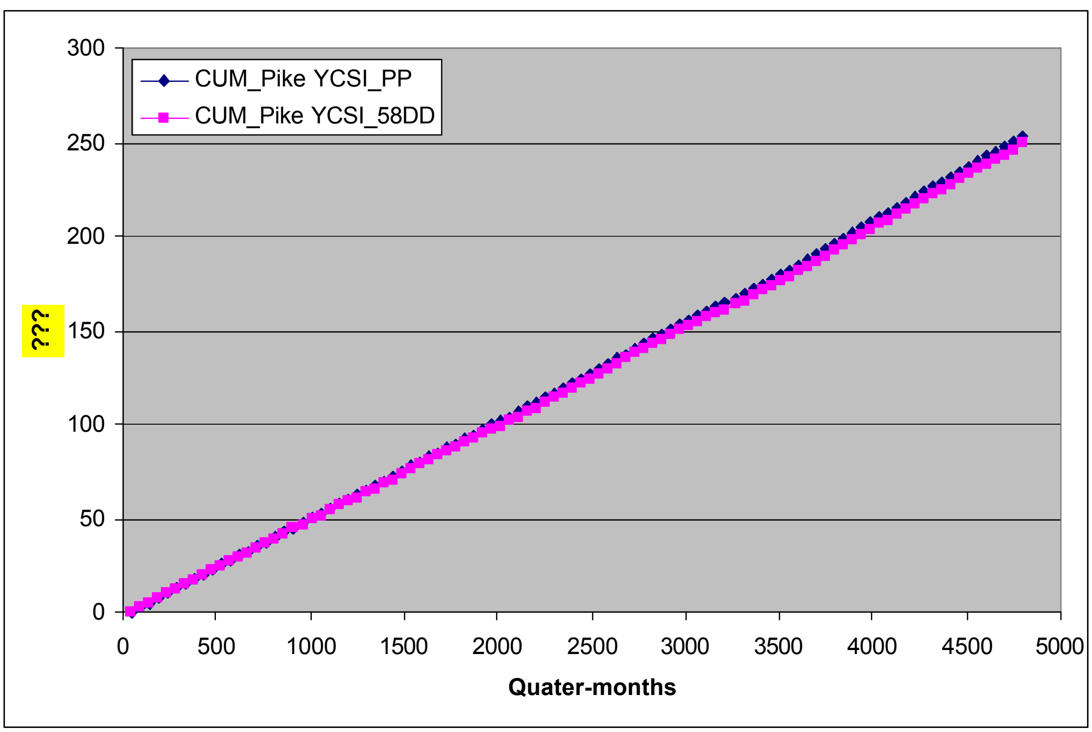


Figure: Comparison of the temporally cumulated Performance Indicator for the 100 years discharge series: Plan 1958DD and PreProject.