

PI Name/Short Description: Least Bittern (*Ixobrychus exilis*) - reproductive index in emergent marshes [E8, E29]

Technical Workgroup: Environmental TWG

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Performance Indicator Metric: This PI represents an index of reproductive potential in emergent marsh during the breeding season, based on the habitat supply, annual estimate of the number of potential breeding pairs using the study area, and annual estimate of nest success rate that is influenced by water levels fluctuations.

The PI response includes an aggregation of annual index values into a 2-year moving mean value. This smoothing technique was used to reduce extreme annual PI values and incorporate a lag in the response of the PI to changing habitat conditions. The aggregated 100 year plan scenarios are expressed by the percent of time that the PI index exceeds the first quartile value for plan 1958DD for the comparable water supply series (e.g. Historic, S1, S2 S3, etc). This metric will be used for plan evaluation by calculating a ratio of metrics between two plans.

Ecological Importance/Niche: Least bittern is designated as Vulnerable by Ontario Ministry of Natural Resources (OMNR) and Threatened by New York State Department of Environmental Conservation (NYSDEC), the Committee on the Status of Endangered Wildlife in Canada (COSEWIC; Schedule 1), and the Species at Risk Act (SARA). Protecting the ecosystems of vulnerable, threatened, and endangered species is essential for species survival and the conservation and protection of biological diversity. The North American Bird Conservation Initiative (NABCI) considers the Lower Great Lakes/St. Lawrence plain (BCR 13) as critical to the natural cycle of the Least Bittern.

Temporal validity: Valid for the Least Bittern breeding season from last quarter month of May to end of July (QM 19 –QM 28).

Spatial validity: Valid for the Lake Ontario, Upper St. Lawrence River (Unit 1), and the Lower St. Lawrence River to Lake Saint-Pierre (except Lake Saint-François and Laprairie Basin) where emergent marsh exists.

Hydrology Link: Least Bittern usually construct nests in emergent vegetation 20 cm (7.87 in) to 80 cm (31.5 in) above to water surface, and require marsh habitat that is flooded for nesting and feeding. Nests are typically located in emergent marsh with water depths ranging from 10 cm (3.94 in) to 100 cm (39.37 in). Emergent marsh habitat availability is directly linked to long term water supplies. The percentage of marsh habitat flooded or stranded, flood amplitude, recurrence and duration, as well as the rate of water

level change (rapid rise or drop > 20 cm or 7.87 in) are also important hydrologic factors. During the nesting period, water levels increases can drown eggs and chicks, and water level decreases, increase ground predator access to nests.

Algorithm: This PI is influenced by hydraulic attributes responsible for nesting habitat availability and nest success rate. More specifically, the potential nesting habitat was developed for the Lower St. Lawrence River section, using 2D probabilistic modeling based on the combination of hydrodynamic (water depth) and emerging plants models. In Lake Ontario and Upper St. Lawrence River, the potential nesting habitat was developed using presence/absence modeling based on the same parameters as in the Lower St. Lawrence. For both regions, the nest success rate was based upon Ontario and Québec nest record data of nesting chronology, nest heights and water depths below the nest. Three hydraulic attributes were considered: *mean water depth*, the maximum *water level increase* and the maximum *water level decrease*.

The algorithm for Least Bittern reproductive success PI (index) is made from the multiplication of the carrying capacity values (estimated number of breeding pairs) and nest success rate.

Carrying capacity value in Lower St. Lawrence River section: The algorithm gives the carrying capacity value of Least Bittern (estimated number of breeding pairs) based on the probability occurrence of Least Bittern nesting habitat within the study area [Eq. 1] multiplied by a fix density value [Eq. 2]. The estimated nesting habitat [Eq. 1] is based on water depth suitability (*pIXEX*) ; probability occurrence of Cattail (*pTYPHA_A* and *pTYPHA_L*) and of deep marshes vegetation (ex: *Scirpus fluviatilis*) (*pMp*). The parameters [Eq. 1] and the fix density [Eq. 2] were determined upon expert opinion and literature review.

[Equation 1] Least Bittern nesting habitat probability in Lower St. Lawrence River section =

$$\text{presIXEX} = (\text{power}(\text{pIXEX}, 0.5) * \text{power}(\text{pTYPHA_A}, 0.2) * \text{power}(\text{pTYPHA_L}, 0.2) * \text{power}(\text{pMp}, 0.1))$$
where: $\text{pIXEX} = ((1/0.248 * \text{sqrt}(2 * \pi))) * \exp(-0.5 * (\text{power}(((\text{depth} - 0.598) / 0.248), 2))) / 1.6086$
 nesting habitat is considered as suitable if $\text{presIXEX} > 0.5$

[Equation 2] Least Bittern carrying capacity value (pair #/0.64ha) = $\text{presIXEX} * 0.0384$

Carrying capacity value in Lake Ontario and Upper St. Lawrence River (Unit 1): Suitable nesting habitat area was based on an annual estimate of emergent marsh habitat that contained an average of 10 to 100 cm (3.94 to 39.4 in) of standing water during the breeding season. The area estimate was multiplied by a fix pair density (0.06 pairs/ha) to generate an annual carrying capacity estimate. The habitat parameters and density were determined upon expert opinion and literature review.

Nest success rate: This rate is based on nest initiation estimates, nest height and water depth below nest data. Nest height data was adjusted to account for Least Bittern specific nest resilience to flooding. Probability of nest loss estimates due to water level increases or decreases were determined based upon a statistical relationship between magnitude of water level change and probability of nest flooding or stranding. Water level change over a nest exposure period was calculated as the maximum water level increase and decrease

from the quarter month of nest initiation over the preceding five quarter month period (Tab. 2). Either the probability of flooding or stranding was used depending of which had the higher probability value. The other reproductive variables included in the annual nest success rate equation, baseline nest success (in the absence of hydrologic impact) and the probability that a female will renest if the first nest attempt is unsuccessful (renesting rate) were held constant.

[Equation 3] Least Bittern nest success rate = $n_1 + [(1 - n_1) * rr * n_2]$

Where: n_1 or n_2 = nest success attempt 1 or 2 where $n_1 = BN * (1 - PF)$ **or** $BN * (1 - (PS * PSF))$
 BN = Baseline nest success = 0.6; PF = Prob. of nest flooding (see Tab. 1); PS = Prob. of nest stranding (see Tab. 1); PSF = Prob. of nest failure due to stranding = 0.5; rr = renest rate = 0.6

Table 1: Least Bittern nest flooding/stranding probability (PF/PS)

Rise of water level (RW; cm, in)	Decrease of water level (DW; cm, in)	Black Tern flooding/stranding probability
If RW <= 20 (7.87 in)	And RW > DW	PF = 0
If RW > 20 (7.87 in) and RW < 82 (32.28 in)	And RW > DW	PF = -5E-05 * RW ² + 0.0159 * RW
If RW > 82 (32.28 in)	And RW > DW	PF = 1
If RW < DW	And DW <= 29 (11.42 in)	PS = 0
If RW < DW	and DW > 29 (11.42 in) and DW < 1.09 (.43 in)	PS = 0.7461 * Ln(DW) - 2.4948
If RW < DW	and DW >= 1.09 (.43 in)	PS = 1

Calibration Data: No data available

Validation Data: For Lower St. Lawrence River section, existing data were used for external validation of the potential nesting habitat (50 recorded observations). The rate of correct predicted even was 80%. No internal or external validation was performed for the carrying capacity value for Lake Ontario and Upper St. Lawrence River section and for the nest success rate.

Documentation and References: Giguère, S, J. Morin, P. Laporte and Mingelbier, M. (2005) Évaluation des impacts des fluctuations hydrologiques sur les espèces en péril. Tronçon fluvial du Saint-Laurent (Cornwall – Pointe-du-Lac). Rapport final déposé à CMI (2002 - 2005). Environnement Canada, Région du Québec, Service canadien de la faune

DesGranges, J.-L., J. Ingram, B. Drolet, C. Savage, J. Morin, and D. Borcard. (2005) Lake Ontario- St. Lawrence river water level regulation review: Use of wetland breeding bird evaluation criteria within an integrated environmental response model. IJC final wetland bird technical report (2000-2005).

Risk and Uncertainty Assessment:

This PI is based on the following assumptions:

- Breeding habitat supply and reproductive success are significant factors influencing the size and integrity of regional breeding populations.
- Predicted bird response to hydrologic conditions based upon literature review and experts opinion are valid.
- Wetland habitat models are providing an accurate, relative estimate of emergent marsh habitat.
- Quarter month hydrologic data is representative of real hydrologic conditions.
- Predicted bird response to hydrologic conditions based on statistical modeling is valid.
- Transformation from a 2D to 1D hydrologic model in the LSL is correct.

Confidence, Significance and Sensitivity:

1) Confidence rating:

This PI has a good confidence rating. It has been built from a good amount of literature information that was available from region of interest. The models have also been evaluated with the assistance of SAR experts, and the Lower St. Lawrence carrying capacity for Least Bittern has been validated with independent field data. A “precaution” principle has also been used in order to obtain a “conservative” type PI. Thus we are confident that the PI allows for an accurate relative comparison among alternate water level and flow regimes within the study area for: (1) Least Bittern breeding habitat availability and suitability and (2) impacts of water levels fluctuation on the nest success rate.

Although hydrologic variables are strongly associated with habitat and Least Bittern density and occurrence, there is also a significant amount of variation not explained by hydrology. In order to assess 100 year water level scenarios, the predictive models necessarily ignore, or hold constant other important population variables (e.g. productivity, age and sexes distribution) and environmental variables (e.g. predation, food availability, pollution, exotic species) that can also impact reproductive success (habitat carrying capacity and nest success), and have an influence on regional Least Bittern breeding populations. For these reasons the PI values should only be considered as relative measures between plans (index).

2) Significance of the species: The Least Bittern is designated as Threatened by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). The species is listed in the Schedule 1 of the Species at risk Act; the species and its critical habitat are legally protected under this Act. Critical habitat protection will be applied when it is identified within the Recovery Strategy or Action Plan. The North American Bird Conservation Initiative (NABCI) considers the Lower Great Lakes / St. Lawrence plain (BCR 13) as critical to the natural cycle of the Least Bittern.

3) Sensitivity to water levels management: The Least Bittern nest exclusively in wetland habitats. Lake Ontario and St. Lawrence River specific research results and scientific literature document the close association between Least Bittern occurrence and specific hydrological condition. Least Bittern PI is retained as a Key PI because it clearly shows an important vulnerability and sensitivity to alternations in water levels and

flows, and is listed as a Species at risk. As such it should be used to evaluate potential environmental responses to alternative water regulation plans.