

PI Name/Short Description: Black Tern (*Chlidonias niger*) - reproductive index in emergent marshes [E9, E26]

Technical Workgroup: Environmental TWG

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Performance Indicator Metric: The Black Tern performance indicator represents an index of reproductive potential in emergent marsh during the breeding season, based on the carrying capacity, an annual estimate of the number of potential breeding pairs in emergent marsh weighted by water depth and water level increase, multiplied by an annual estimate of nest success, based on the probability that a breeding female will successfully hatch a nest, according to the magnitude of water level change.

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: Black Tern is designated as Vulnerable by Ontario Ministry of Natural Resources (OMNR) and Endangered by New York State Department of Environmental Conservation (NYSDEC). 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) critical to the natural cycle of the Black Tern. Black Tern is a surrogate species for Pied-billed Grebe (*Podilymbus podiceps*) and wildfowl species that use emergent marshes as feeding and rearing habitats.

Temporal validity: Valid for the Black Tern breeding season from second week of May to the end of July (QM 18 to QM28). The PI does not consider cumulative effect from previous years.

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: Black Tern construct nests on floating vegetation in emergent marsh vegetation, and require marsh habitat that is flooded for nesting and feeding. Emergent marsh habitat availability is directly linked to long-term water supplies. The percentage of marsh habitat flooded or stranded, and the rate of water level change (rapid rise > 20cm or 7.87 in) are also important annual hydrologic factors. During the nesting period, water levels increases can drown eggs and chicks. Water level decreases can increase ground predator access to nests.

Algorithm: This PI is influenced by hydraulic attributes responsible for emergent marsh surface area. More specifically, its algorithm was developed using Lower St. Lawrence hydrologic values based on a 2D water level and topographic model, for the carrying capacity values, and upon Ontario and Québec nest record data of nesting chronology, nest heights and water depths below the nest, for the nest success rate. Three hydraulic attributes were considered: *mean water depth*, the maximum *water level increase* and the maximum *water level decrease*.

The algorithm for the Black Tern 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: The algorithm is based on water depth relationship with the density of breeding pairs, weighted by a persistency rate of breeding activities due to water increase using a water increase index (Table 1). The water increase index was determined using: 1) the highest increase of water level (in meters) between two quarter-month during the breeding periods and 2) the wetland transition before and after fluctuation (Tab. 1).

$$\text{Black Tern carrying capacity value} = (0.1074 + 0.3979 * \text{WD} - 0.0590 * \text{WD}^2) * P_{\text{rate}}$$

where: WD = water depth; P_{rate} = Persistency rate calculated from the non linear relationship between breeding pair density and water increase index (IN): if IN = 0 then $P_{\text{rate}} = 1$; if IN = 0.2 then $P_{\text{rate}} = 0.74$; if IN = 0.4 then $P_{\text{rate}} = 0.09$ and if IN = >0.4 then $P_{\text{rate}} = 0$; water depth algorithm lower and upper limits = -0.26 meter to 1.8 meter; null carrying capacity upper limits = 0.033 ind./0.64ha.

Table 1: Determination of water increase index (IN)

Wetland transition	Increase of water level (meter)			
	0-0.2	0.21-0.50	0.51-0.70	>0.70
Wet-wet	0	0.4	0.4	0.6
Dry-wet	0.2	0.6	0.8	0.8
Dry-dry	0.6	0.8	0.8	0.8

Table 1: Determination of water increase index (IN)

Wetland transition	Increase of water level (inches)			
	0-0.08	0.08-0.2	0.2-0.28	>0.28
Wet-wet	0	0.15	0.15	0.24
Dry-wet	0.08	0.24	0.31	0.31
Dry-dry	0.24	0.31	0.31	0.31

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 Black Tern 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.

$$\text{Black Tern nest success rate} = n_1 + [(1 - n_1) * rr * n_2]$$

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

Table 2: Black Tern 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 <= 30 (11.81 in)	and RW > DW	PF = 0
If RW > 30 (11.81 in) and RW < 69 (27.17 in)	and RW > DW	PF = 0.3277 * Ln (RW) - 0.3838
If RW > 69 (27.17 in)	and RW > DW	PF = 1
If RW < DW	and DW <= 36 (14.17 in)	PS = 0
If RW < DW	and DW > 36 (14.17 in) and DW < 94 (37.01 in)	PS = -0.0002 * DW ² + 0.0453 DW - 1.3473
If RW < DW	and DW >= 94 (37.01 in)	PS = 1

Calibration Data: No data available

Validation Data: No external or internal validation as been performed. Relationship between Black Tern and water level are biologically significant and were verified with scientific literature and expert opinion.

Documentation & References:

Jean-Luc DesGranges, Joel Ingram, Bruno Drolet, Caroline Savage, Jean Morin and Daniel 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 (2000-2004).

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.
- Sampling design and survey locations were representative of wetland habitats within the larger study area.
- Wetland habitat models are providing an accurate, relative estimate of emergent marsh habitat.
- Breeding bird density models developed from LSL data are representative of the larger study area.
- 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: We are very confident in the associations between water levels and wetland bird PIs. Black Terns nest almost exclusively in wetland habitats and are thus sensitive to hydrologic alterations that impact wetland vegetation communities. Lake Ontario and St. Lawrence River specific research results and a moderate body of scientific literature document the close association between Black Tern occurrence, emergent marsh area and water depth (i.e. if flooded emergent marsh habitat does not exist, the birds do not occur in the wetland). Thus we are confident that the PI allows for an accurate relative comparison of Black Tern breeding habitat availability and suitability among alternate water level and flow regimes within the study area. This is the first level of hydrologic association. The second is related to water depth and fluctuation within the various wetland vegetation habitats. Again, our research and published literature support the influence of water depth and fluctuation on the probability of wetland bird species presence and abundance for several species (PIs). Both the wetland habitat and breeding bird estimates are based upon hydrologic associations derived from a subset of study wetlands that are extrapolated to generate study area estimates.

Although hydrologic variables are strongly associated with habitat and bird 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 Black Tern breeding populations. For these reasons the PI values should only be considered as relative measures between plans (index).

2) Significance of PI: The Black Tern is experiencing regional population declines (Ontario and New York State) and the North American Bird Conservation Initiative (NABCI) considers the Lower Great Lakes/St. Lawrence plain (BCR 13) critical to its natural cycle. The Black Tern PI is also a surrogate species for Pied-billed Grebe (*Podilymbus podiceps*) and Common Moorhen (*Gallinula chloropus*) and several wildfowl species that use deep emergent marshes as feeding and rearing habitats. The Black Tern and Pied-billed Grebe are listed by the NYSDEC as endangered and threatened respectively. The Black Tern is also listed as vulnerable by OMNR.

3) Sensitivity of PI: Black Tern PI is retained as a Key PI because it clearly shows an important vulnerability and sensitivity to alternations in water levels and flows, and as such it should be used to evaluate potential environmental responses to alternative water regulation plans.