**Introduction:**

Population models are mathematical constructs that attempt to quantitatively describe how abundance indices are observed to vary over time. When successfully applied, these models capture some essence of the variation observed in the data, providing insight on underlying biological processes, the impact of fishing activities, and a means to predict future dynamics of the population.

In this report, we present a size-based population model of the annual dynamics of the Southern Gulf of Saint Lawrence snow crab population. Though size-based, the model also partitions crab by instar, i.e. the moult group which represents the number of moults crab have undergone since larval settlement, allowing for the specification of biological effects based on instar, as well as on size or survey year.

Instar membership is determined by the application of a structured growth process, which models the expected growth-at-moult and its variation between successive instars, to the modes observed in size-frequency data. Biological processes included in the model are growth-at-moult, population recruitment, natural and fishing-related mortality, along with skip-moulting and moult-to-maturity probabilities.

Sampling-related processes are incorporated in the form of survey trawl size-selectivity curves as well as global year effects, intended to shed light on potential differences in catchability between survey years, which have been associated with vessel changes, as well as other survey sampling changes.

For the purposes of this study, the snow crab population is assumed to be closed: a reasonable assumption as the stock is naturally bounded by the Gaspé Pensinsula to the North, Cape Breton Island to the Southeast, and the deep warm waters of the Laurentian Channel between the two, though limited movement of crab along the margins of Gaspé and Cape Breton are known to occur.

We provide the following note of caution: Population models such as those presented here are often over-parameterized, meaning that in some way the amount of information being estimated exceeds the inherent information content of the data. Such analyses often yield multiple solutions, representing potentially conflicting biological states, though they may explain patterns in the data to a comparable degree. It is often the case that external biological information or assumptions are imposed on the model to constrain the parameter space to solutions that are more consistent with biological knowledge.

Thus population model development is generally a protracted process, involving multiple iterations of adding or removing features, testing underlying assumptions, and examining a suite of diagnostics, such as residual analyses, predictive tests, cross-validations. From this process, the robustness properties of the model with respect to its various outputs gradually reveal themselves and the appropriate degree of confidence in the model may be gained.

In this context, the model described here is not presented as a *fait accompli*, but rather as a proposition of prototype that contains the right balance of simplicity and complexity to provide, in the short-term, improvements in:

* the retroactive estimation and prediction of annual variations in skip-moulting and moult-to-maturity probabilities.
* the prediction of future population dynamics, specifically fishery recruitment.
* relative catchability estimates between different survey years, or survey vessels, which may provide a means of retroactively standardizing the snow crab survey abundance and biomass time series.

In the longer-term, the proposed modelling framework may also be expected to yield:

* estimates of annual growth estimates, in the form of mean instar size estimates.
* fishery-independent estimates of fishing mortality, including discard mortality.
* a framework for modelling spatially-reference stock dynamics.

**Description of Population Model Processes:**

In the literature, benthic stages of snow crab instars are numbered using roman numerals, with I representing the first stage after the megalopses larvae have settled on the bottom and moulted.

Instars I to VIII are considered sexually immature and characterized by high relative grow rates. Adolescence begins with the onset of gonadal development at instar VIII, which is characterized by lower relative growth rates. Sexual maturity in the form of a terminal moult is attained at instars IX or larger. Mature female snow crab are made up of instars IX and X.

Females only rarely attain instar XI and were not considered in the analysis. Mature male snow crab moult to maturity over a much wider size range, from instars IX to XIII. As for females, instar XIV males were considered as relatively rare and not considered in the model. It follows that instar X in females and instar XII in males were the largest adolescent instars.

Growth in the model is defined by two processes defined over instar class: one which specifies the probability of moulting from one instar to the next, and the other which specifies the predicted increase in size and size variation when moulting.

Two types of moulting processes were considered. The first was the probability of moulting to maturity by instar stage. Although the probability of moulting to maturity for the largest adolescent instars, i.e. instar IX in females and XII in males, was considered to be 1, instars VIII in females and instars VIII-XI in males show variability from year-to-year, which was considered in the model. The second moulting process was skip-moulting, which was considered only for males. Skip-moulting occurs primarily among adolescent males who, as the name implies, delay moulting for a year, then undergo a terminal moult to maturity the following year. Similar to maturity moults, rates of skip-moulting varies from year to year, which was considered in the model. With the exception of skip-moulters, moulting was considered to occur annually.

Instar IV was the smallest instar treated in the model, since instars I, II and III not represented in survey trawl catches. As such, population recruitment was identified with instar IV abundance per year.