**Comments on the Inconsistencies in the Snow Crab Survey Protocol in the Wake of the 2019 Stock Assessment RAP**

**By Tobie Surette**

**Background:**

The snow crab commercial biomass estimate is a central result of the sGSL’s annual stock assessments, being used to directly define quotas for the fishery in the following year. For the biomass estimates to play such a central role in the management of this fishery requires sound statistical sampling design, robust fishing protocols, catch standardization and analysis.

The statistical sampling design and the analysis of standardized catches have been the subject of public reviews, both during annual assessments processes and notably during the Framework Assessments of 2006 and 2010. These frameworks redefined the trawl survey bounds, the spatial sampling design, and cemented the set of analytical methods that are currently used to estimate snow crab biomass.

Such is DFO Science’s commitment to the consistent application of these analytical methods that in 2019, when a switch from Matlab to the R statistical language was made, comparisons were made to ensure that results obtained on both platforms were nearly identical, insuring that results were within fractions of a percentage point. In contrast, most aspects of the fishing protocols used aboard the survey vessel and issues related to catch standardization have not been the subjects nearly the same degree of public scrutiny or review.

This has left the survey with important knowledge gaps about which factors can unknowingly influence catches. Being unaware or leaving these factors uncontrolled leaves the survey vulnerable to systematic biases, as the execution of some survey protocols have been inconsistent from year to year or from region to region. Failure to identify and control these factors led to serious biases in snow crab biomass estimates during the 2019 RAP and preliminary investigations hint at other important sources of bias in the historical times series.

**Comments on the January 2020 Snow Crab RAP:**

The 2019 snow crab survey introduced a new survey vessel and included a comparative fishing experiment with the previous survey vessel, in the hopes that any differences in fishing effects could be either ruled out or accounted for and corrected.

Early on in the survey, it became apparent that snow crab survey catches were abnormally large, raising concerns that some unknown mechanism was artificially inflating catches. A plethora of trawl probe observations, plus the inclusion of a comparative fishing experiment, made the 2019 survey very data rich, and it was hoped that any catch biases or underlying mechanisms could be elucidated. In this context, a number of analyses were performed, consisting of comparisons between survey vessel and trawl behaviour between different years, a formal analysis of data from the comparative fishing experiment, and indirect estimations of catch biases.

Unfortunately, results from the comparative experiment proved to be at odds with the aforementioned issues, and the analysis was hindered by weak swept area data, required for catch standardization, due to weak relaying of acoustic trawl acoustic mensuration signals. In the end, comparative experiment results were ambiguous, suggesting that whatever catch mechanisms were at play were particular to the locale where the experiment was performed, rather than being representative of the larger survey.

This led in turn to investigations into other survey data to identify the possible mechanism to explain why catches had systematically increased. It was shown that: 1) the new survey vessel had much poorer speed control than the previous vessel, 2) tows had a prolonged latent trawling phase during the trawl winching phase, which had up to this year been wholly ignored in the catch standardization (i.e. not included in the swept area estimation), and 3) rather than the survey vessel reversing its speed at the end of trawling, as was prescribed by protocol, it was shown that the vessel kept its heading, with only a moderate slowing of its speed progress, leading to a substantial portion of each tows’ swept area occurring during this latent trawling phase, representing about 30-50% of the total swept area.

It was shown further that the latent trawling phase in 2019 increased by ~12% with respect to 2018. During the 2019 RAP, this statistic was largely misconstrued as the best estimate of the actual bias in the catches, rather than an being estimate relating to this particular aspect of trawling.

However, direct comparisons of length-frequencies of female and sub-legal male snow crab showed a systematic increase across all sizes of ~30%. Such uniform increases across a broad range of sizes cannot be explained by any known natural process in the southern Gulf: recruitment leads to a spike in smaller sizes and overall migration is negligible (i.e. is a closed population). Further, snow crab survey by-catch levels of American Plaice, Atlantic Cod and Hyas crab, three widely distributed species in the southern Gulf, showed similar annual increases at about the same level of 30%. Corresponding increases were not observed for snow crab and these species in the September survey, raising further questions about their validity.

The picture for commercial male abundance added to the confusion. In contrast to smaller snow crab and the by-catch species mentioned above, levels of commercial snow crab were oddly comparable to those of 2018. This led to the hopeful supposition that the commercial portion was somehow exempt of whatever process seemed to be inflating those of smaller crab. This supposition was bolstered by the observation that the 2019 commercial biomass estimate seemed to be in reasonable agreement with the predicted value stemming from fishery recruitment model in 2018. However, this special interpretation of the 2019 commercial snow crab biomass is problematic:

1. ***Catchability***: This interpretation necessarily leads to the idea that the catchability for commercial-sized males in 2019 is somehow different, indeed less, than that smaller sized male and female snow crab. Given the nature of the trawl being used, it is hard to imagine a mechanism whereby larger males should somehow be less apt to being caught than smaller individuals. I am not aware of such a mechanism being suggested in any past assessments.
2. ***Variability***: The dynamics of female and non-commercial male snow crab are driven by the natural processes of recruitment, natural mortality and migration. In addition to these, commercial snow crab highly is highly impacted by fishing activity, both directly via declared landings (known) and indirectly through fishery by-catch mortality (unknown). This latter process makes the commercial component dynamics more difficult to predict than non-commercial crab. This variability may even be more pronounced in recent years, given the known large-scale redistribution and local concentration of fishing effort brought about by Northern Atlantic Right Whale area closures in recent years.
3. ***Consistency with the recruitment model***: Whatever the mechanism, mortality for commercial males is known to be highly variable and the consistency of the biomass estimate with the predictive recruitment model, which is highly uncertain, should not be used as a basis for justifying its validity. Indeed, a spike in commercial mortality is a more likely explanation for the commercial crabs’ consistency with prior prediction.
4. **September survey index**: In contrast to the snow crab survey, the September survey index showed a decrease in commercial biomass with respect to 2018. Though this estimate is more uncertain due to its lower sampling intensity, it is consistent with a significant overestimation in commercial biomass.

**Consistency of the survey time series:**

* Survey **vessel speed** and **end-of-tow manoeuvres** varied significantly impact the duration and extent of the latent trawling phase. This aspect of trawling was largely uncontrolled in past surveys and thus represents, through their unaccounted contribution to the trawl swept area, a significant source of regional and annual bias in snow crab survey catches.
* **Winch hauling speed** was not controlled in past surveys and is expected to vary from vessel to vessel and may even vary according to the inclinations of the winch operator. Winch speed has a direct impact on the duration and extent of the latent trawling phase.
* Investigations into swept area statistics showed large swings in annual swept area. If we assume that the analytical method has been consistently applied (and to my knowledge it has), this implies to annual **differences** either with **measurement of the trawl** net or **trawl geometry**. This may reflect changes in the placement or performance of trawl acoustic sensors, or changes in the configuration of the trawl through time. In particular, studies have highlighted the importance of controlling and monitoring trawl symmetry in fishing survey protocols. Such controls are implemented in many ICES bottom trawl survey protocols, as in NOAA bottom trawl surveys. The Gulf’s own September multispecies survey has such controls in place.

**Recommendations:**

* Internal or external review to clearly identify weaknesses in the trawl survey fishing protocol, with the aim of clarifying and formalizing fishing protocols to address any issues.
* Present a summary draft of this survey protocol to stakeholders during the 2020 RAP.
* Allot some time during future snow crab RAPs to present and openly discuss issues with fishing protocols, survey index standardization and survey index validation. Addressing these issues is critical to improving the consistency of abundance and biomass indices, as well as the credibility of DFO Science in delivering these central survey results.