**Lesson 1: Proportional LRPs based on the Salmon Scanner tool could be readily estimated for all SMUs, regardless of data availability, and were consistent with the multi-dimensional approach that has been developed for Wild Salmon Policy assessments.**

* Proportional LRPs based on the Salmon scanner could be applied in all three case studies; whereas aggregate-abundance methods required a strong positive relationship between observed aggregate abundance and the log-odds of all CUs being above their lower benchmarks (logistic regression LRP) and / or sufficient data to parameterize a population dynamics model (projected LRP). While the Interior Fraser Coho case study met both of these requirements, WCVI Chinook could only meet the second, and ISC Chum could not meet either of them.
* The use of the Pacific Salmon Scanner tool to estimate proportional LRPs was especially valuable for data-poor SMUs because it allowed a mix of data quality and benchmark types to be applied, depending on what was available for a given CU in a given year. For example, in the ISC Chum case study, applying the Salmon Scanner to develop proportional LRPs allowed all seven CUs to be included when assessing SMU status by using alternative trend-based metrics for CUs without percentile benchmarks.

**Lesson 2: Annual status estimates from aggregate abundance LRPs and proportional LRPs will differ from each other in some cases**

* While annual status estimates from aggregate abundance methods showed generally good consistency with estimates from proportional methods using the recommended Salmon Scanner tool, they did not always match.
  + For the Interior Fraser Coho case study, status tended to drop below proportional LRPs when abundance of individual CUs was low, and drop below aggregate abundance LRPs when aggregate abundances were low. While these conditions corresponded in most years, they did not always. The proportion of years with matching status estimates for proportional and aggregate abundance LRPs ranged from 72-86%, depending on the method used to estimate CU benchmarks.
  + For the WCVI Chinook case study, status was below the LRP in all years regardless of whether a proportional LRP or aggregate abundance LRP based on projections was used, which meant that the two approaches matched in 100% of years. However, the low contrast in historical status for this case study limits the applicability of this result.

**Lesson 3: Data from all component CUs should be used whenever possible. When data are missing from one or more CUs, careful consideration should be given to the question of whether status can be inferred from other CUs within the SMU. While there may be cases where inference is possible, uncertainty in resulting status estimates will be increased, and this uncertainty should be clearly communicated in status assessments.**

* In the case of ISC Chum, using data from all seven CUs when available (even if only a subset of years) resulted in status dropping below the LRP more frequently than when only a subset of CUs were used in all years. This result occurs because for proportional LRPs, there is an asymmetry in how missing CUs may affect SMU status relative to the LRP. Adding additional CUs may decrease status from above to below the LRP if the additional CU is Red and all other CUs are Amber or Green. However, adding an additional CU will never increase status from below to above an LRP because if a Red CU already exists, adding a new Amber or Green CU will not make a difference; the 100% threshold for all CUs to be above Red cannot be met. Given that ISC Chum CUs have low correlations in among-CU spawner abundances over time, and experience different environmental drivers in their freshwater habitats, inferring status of missing CUs from other CUs with data is not recommended. Therefore, status estimates that only include a portion of CUs are potentially biased.
* In the case of Interior Fraser Coho, results from missing data scenarios for the logistic regression approach showed that it may be possible to use data-rich CUs as indicators for CUs with missing data. However, logistic regression-based LRPs were more uncertain when more than 1 CUs was missing, and the logistic regression model frequently failed to converge, so caution should be used when applying this method to SMUs with missing data. Furthermore, Interior Fraser Coho display higher levels of among-CU correlations in spawner abundances over time that ISC Chum, so the extent to which this result can be applied to other SMUs is expected to be dependent on the level of covariation in CU status among CUs within an SMU.

**Lesson 4: Logistic regression LRPs have several limitations and should only be used when (i) aggregate abundance LRPs are required and (ii) all assumptions of the logistic regression model can be met.**

Logistic regression LRPs are empirically derived from past observations of SMU abundance and CU statuses. By fitting a logistic regression to historical data, we identified historical abundance levels associated with probabilities that all component CUs have statuses above their lower benchmarks. Similar to the proportional LRP, this aggregate abundance method depends on the outcomes of individual CU assessments, which are sensitive to structural assumptions underlying the CU-level benchmarks and data availability.

Logistic regression-based LRPs could only be estimated for one of our three case study SMUs, which suggests that they may only be an option for a small proportion of SMUs. Even for Interior Fraser Coho where a logistic regression fit was possible, estimates did not converge for all retrospective years, and status estimates were sensitive to missing data. Taken together, our exploration of logistic regression LRPs for our three case studies highlighted some limitations of this approach.

First, logistic regression LRPs are limited to conditions that have been historically observed. This can be a problem when there is poor contrast in historical data, as was the case for WCVI Chinook. In this case, there were no years when all component inlets exceeded their lower benchmarks. However, similar challenges could occur in cases where no CUs drop below their lower benchmarks. The dependence on historically observed conditions is a further limitation when there have been changes in the correlation in populations dynamics among CUs over time such that current (or future) correlations are not represented by historical data.

Second, model diagnostics do not support logistic regressions and their associated LRPs when CU-level abundances are not correlated or only weakly correlated. Here, we found that logistic regression LRPs could be estimated for Interior Fraser Coho (average correlation in spawner abundances among CUS of 0.56), but not for Inside South Coast Chum (average correlation among CUs of 0.12). Also, the wide range in productivities and capacities among CUs for the Inside South Coast Chum case study contributed to the weak relationship between aggregate abundances and CU-level statuses. In general, model diagnostics as described in Section \@ref(MethodsChapter) can be used to support or reject logistic regression LRPs. We illustrate how these diagnostics are used to evaluate model fit in Sections \@ref(IFCChapter) and \@ref(ISCchumChapter).

**Lesson 5: Stochastic simulations can be used to estimate aggregate abundance LRPs under certain conditions.**

Projection LRPs rely on closed-loop simulation models to quantify the emergent relationship between aggregate SMU abundances and the probabilities that all CUs are above their lower benchmarks, given a predefined level of exploitation. The most important requirements for this approach are CU-specific estimates of stock-recruitment parameters (productivity and capacity) and covariance in recruitment among CUs. Parameter estimates for productivity and capacity can be based on posterior distributions from stock recruitment analyses (see Interior Fraser Coho case study, Section \@ref(IFCChapter)) or more qualitatively from expert input, life-stage models, or watershed-area model estimates (see WCVI Chinook case study, Section \@ref(WCVIchinookChapter)).

Furthermore, we demonstrated an approach to choosing parameters and model assumptions used in the projections so that correlations in spawner abundances in projections were similar to observed correlations. We recommend that correlations in CUs within projections are explored under various model assumptions, and that model parameters are tuned to derive realistic correlations.

The projection LRP approach is flexible and allows for consideration of structural uncertainty in the SMU population dynamics and consideration of alternative future scenarios. For example, for the WCVI Chinook case study, sensitivity analyses were performed to assess the impacts of correlations in recruitment residuals and variability in exploitation among inlets. For the Interior Fraser Coho study case, structural uncertainty in the formulation of the stock recruit model was considered through alternative projection scenarios, and sensitivity analyses were performed regarding the variability in smolt-to-adult survival coefficient among CUs. Future implementations of the projection LRPs could also take into consideration shifts in stock recruitment parameters, and future variability in fishery exploitation rates.

**Lesson 6: Projected LRPs are highly sensitive to exploitation rates**

Sensitivity analyses showed that projection LRPs are sensitive to the assumed levels of exploitation in the projections. Higher exploitation rates resulted in higher required SMU aggregate abundance to ensure that all CUs remain above their lower benchmarks. The sensitivity to exploitation rate increases as variability in stock-recruitment parameters among CUs increase, and also as uncertainty in parameter estimates increase. This property of projection LRPs is explored in Appendix \@ref(app:ERsensitivity-appendix). Therefore projection LRPs developed under historical and current exploitation rates cannot necessarily be used as a basis for evaluating alternative management procedures. However demonstrating the changes in aggregate abundances required for all CUs to be above lower benchmarks (i.e. changes in projection LRP) under different exploitation scenarios may help analysts and managers understand the implications of changing exploitation rates on the ability to achieve WSP objectives.

**Lesson 7: For enhanced stocks, a key uncertainty in LRP development will be the contribution of hatcheries to total abundances**

* Should this be included? It wasn’t really evaluated, but it was a challenge that was noted; especially for WCVI Chinook