**Summary Report**

**The Panel was, however, concerned about the utility of the model outside of the current decade as recent strong year classes exit the biomass (i.e., when density dependent effects are reduced and no longer reduce survival, length-at-age, weight-at-age).**

For the EGB projections, the analyst converted the EGB base model implemented in WHAM to an operating model within the OpenMSE framework (https://openmse.com; Hordyk et al. 2022) to develop closed-loop simulations. The state dynamics of the two models were demonstrated to be identical. The primary purpose of this step was to allow investigation of reference points (TOR 11 for EGB only), projection of various management options (TOR 6), and evaluation of “Plan B” options (TOR 8). For TOR 6 two operating models were configured for investigating short-term projections. Both operating models assume the estimation of *M* from 2010 to 2019 (“step up” of the Mest base model). However, for simulated future data one of the models reverts to the historical *M*=0.2 (“low M”) while the other maintains the recent estimated *M* for all projection years (“high M”, MLE of 0.473).

**Ultimately, projections and risk evaluation based on the “low M” scenario were conditionally identified for consideration, while acknowledging the possibility of a future scenario with higher *M*. This conclusion was reached given the higher *M* produced estimates of projected SSB lower than any historical SSB, i.e., stock levels outside of historical precedent. The Panel noted that if decreasing *M* is a function of density dependence it is not clear how long it would take for the density dependence effect to diminish. In this regard, the analyst suggested that the final selection of an *M* projection scenario for the upcoming TRAC assessment could be based on inspection of two years of additional biological and survey data.** The Panel supported the proposed projection methodology proposed for EGB.

**Center for Independent Experts independent review report of Georges Bank and Eastern Georges Bank Haddock research track:** Anders Nielsen

Time varying natural mortality does seem reasonable for EGB haddock. As seen under TOR 1, occasional huge recruitment events expand the haddock habitat into areas not preferred by haddock under low or normal abundance conditions. It seems reasonable that a higher natural mortality could be experienced in the less preferred areas. Furthermore, higher competition for food also seems likely under high abundance conditions, which is further supported by the observed decline in weight and length at age in the most recent period with high abundance (TOR 3).

Four different approaches to include time varying natural mortality were tested (age-invariant AR, separable AR survival, age-invariant externally assigned doubling of natural mortality in the last 10 years, and age-invariant estimated natural mortality in the last 10 years). These four options all reduced the retrospective pattern and the options where yearly mortalities/survivals were estimated somewhat supported the selection of a 10-year window of increased natural mortality. The option to estimate a single age-invariant natural mortality for the last 10 years was selected based on simplicity, best retrospective pattern, and simulation testing.

The proposed model does solve the retrospective problem, and it seems consistent with other observations: Empirical total mortality calculation under TOR 3, habitat expansion TOR 1, and decrease in weight and length at age TOR 3. The proposed model does also have a few issues to consider: The abrupt change in natural mortality from one year to the next may seem unrealistic; the somewhat arbitrary selection of the period (which the model is fairly sensitive to); **and selection of what to do when more data years become available (continue to estimate, revert to baseline natural mortality of 0.2, or something else).**

The main difficulty when projecting the EGB haddock model is the assumption about natural mortality (M). Here a low M=0.2 scenario and a high M scenario (where M is set to the estimated value in the last 10 years (M=0.473)) is conducted.

The projections are very sensitive to the M scenario, **and it is unclear what is the natural choice for short term projections**. **Since it is short term, it could be argued that M should stay high as estimated in recent years, but if M is connected to density, then M should be adjusted lower when the density becomes lower.** **The final choice of an M-scenario should be based on most recent information at the time where the short-term forecast is conducted. A long-term research recommendation could be made to study the relationship between density and natural mortality, so the choice of M-scenario could be less ad-hoc.**

7)

**Powers:**

An underlying theme of several TORs is density-dependence of parameters in response to the extraordinary year classes. But the experiments and analyses focus on time periods when density was higher and growth rates were lower and M was (probably) higher. So, the focus was on blocks of time where rates were constant. **This approach suffices for estimating SSB and F in the past, but it raises the question of when does density-dependence change back.** This arises in projections and BRPs (TORs 5, 6). The problem is that a density-dependent model of the parameters has not been proposed in this assessment. One such model is the Beverton-Holt model using post-recruitment parameters for a cohort (dN/dt=-(Minf+bN)N). In this case Minf might be fixed at 0.2. This can be similar to a Lorenzen M relationship (already implemented in WHAM) but rescales for cohort size (Powers 2014. ICES Journal of Marine Science, doi.10.1093/icesjms/fst22; also note that the catch equation under this M relationship is not the same as the Baranov equation). At any rate, I am comfortable with the current modeling approaches going forward for the management track assessment. But the activity of a WHAM WG will be extremely important.

**Ultimately, projections and risk evaluation based on the “low M” scenario were conditionally identified for consideration, while acknowledging the possibility of a future scenario with higher M.** This conclusion was reached given the higher *M* produced estimates of projected SSB lower than any historical SSB, i.e., stock levels outside of historical precedent. But if decreasing M is a function of density dependence, it is not clear how long it would take for the density dependence effect to dissipate. The analyst suggested that the final selection of an M projection scenario for the upcoming TRAC assessment could be based on inspection of two years of additional biological and survey data, a sort of “Plan C”. I can support this approach in principle.

It is interesting that projections for both GB and EGB are suggesting reversion to “base” M estimates. I think this is a natural consequence when density-dependence is not modeled explicitly (see TOR 4).

From an assessment standpoint I would emphasize two aspects for implementation: 1) the exploration of WHAM model structures and estimation techniques for evaluating density-dependence, climate shifts, etc; and 2) the linkage of GB-EGB assessments through, perhaps, MSEs and MPs.