Response to the reviews of Drs Gibbs (Cawthron) and Broekhuizen/Stephens (NIWA).

ASR Ltd, Thursday, September 07, 2006

Introduction

Both reviewers have provided many helpful comments. On close reading of the reviews, it is evident that they are satisfied with the modeling and the methods adopted. They are also satisfied that the calibrations, as presented, stating that they are credible and indicate that the model is able to reproduce the dynamics of the Bay. In essence, they are stating that the work makes significant progress and provides useful information for the AMA project.

Our view is the same. We feel that the modeling is very complex and has greatly advanced our knowledge of the Bay. Several novel methods were developed to provide a high quality result over a broad physical region that is subject to a very broad range of physical, chemical and biological phenomena. It should also be acknowledged that nobody has previously attempted open coast combined hydrodynamic and phytoplankton modeling in New Zealand, at such a scale. Previous major attempts have been in the Marlborough Sounds or Hauraki Gulf, both of which are less exposed to open water, being more bounded by land. Open coast hydrodynamic modeling is traditionally the hardest to undertake and most difficult to achieve due to exposure to large scale currents, very deep water (several km's) at the boundaries and lack of detailed temporal information at depth. Indeed, we are very pleased with the success of the project overall.

Careful reading of the reviews reveals that the writers have made three main requests:

- Inclusion of more phenomena in the hydrodynamic and primary production models
- More sensitivity testing
- More calibration with existing data

These developments would be beneficial. A pathway to achieve the reviewer's requests is presented below. A considerable amount of data has been collected during the study and so there is scope for further development by utilizing this existing information. Additional data collection would also be a long-term benefit, although we feel that the full span of the existing data is substantial and could be more fully utilized prior to commencement of an expensive field data collection programme, even though long-term monitoring may be taken up by EBOP. The modeling should be used to determine the most appropriate monitoring programme, both spatially and temporally and this is best achieved once the recommendations of the reviewers are treated.

In the sections below, the focus is on addressing the matters raised by the reviewers.

Hydrodynamic modeling with Model 3DD

The key factors that remain outstanding in the hydrodynamic model are:

Finer grid sizes over a larger region – the model grid size could reduced to 2 km from 3 km to improve resolution and extended beyond East Cape to better simulate the conditions around the Cape.

Consideration of the East Auckland Current – modeling would utilize satellite observations of sea surface currents to form boundary conditions for 3DD. The current sometimes penentrates the Bay, but is nearly always influential along the Coromandel and East Cape regions. At East Cape, the East Auckland current causes major upwellings of nutrients.

Utilisation of the New Zealand model – the reviewers have noted some deviations in the model calibration which we believe is associated with the passage of coastal trapped waves. These can be treated by nesting the Bay in our large New Zealand model, which can treat the coastal trapped wave phenomena and provide the boundary information needed for the Bay model grid.

Incorporation of the farms – the reviewers have asked if the physical impact of the farms on the currents could be incorporated into the hydrodynamic model. They remain uncertain if this effect would be significant, but could be tested.

Sensitivity testing – considerable effort has gone into testing the sensitivity of the model during calibration. However, more effort would be focused on the boundary conditions in deep water. Also, systematic presentations of results coming from sensitivity testing may satisfy the reviewer's requests for further information about model behaviour.

More calibration with existing data – the large field program produced many megabytes of scientific data. The data collection occurred over more than 2 years and so the modeling needs to span this full period. Much of the field information has been utilized in the model calibration, but there are periods in the data that have not been modeled, mostly due to the considerable time it takes to model in 3 dimensions over such long time periods and then do repeat simulations for calibration and sensitivity testing. However, the further modeling would be warranted to take full advantage of the measurements. This would provide more confidence to the reviewers and allow further sensitivity testing to occur over a broader time period. Many more calibration plots would be generated during this modeling.

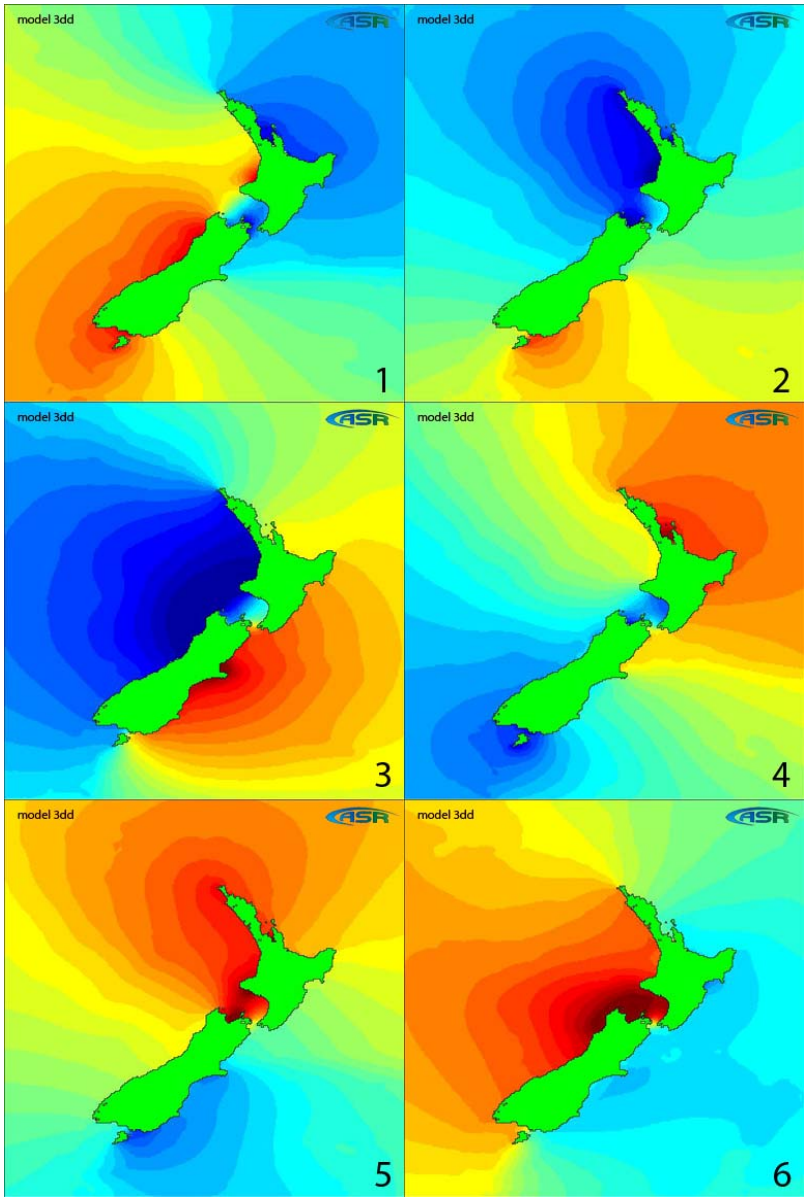

Figure 1: ASR's numerical model of New Zealand waters. The images show the tides rotating around both islands.

Primary Production (PP) Modelling with Model 3DDLife

While we have carefully selected the equations to be used in the PP modeling, the "science" is by no means definitive at this stage. Consequently, there are differences of opinion among the experts about the "best" equations to use. This is particularly evident in the NIWA review, where many of the comments are opinions about choice of equations, rather than providing definitive advice. In view of this, a response to the review is difficult to make, without undertaking sensitivity tests of the various options.

Phenomena in the PP modeling – the reviewers have requested further assessment through sensitivity testing of the PP model, including choice of equations. This would be worthwhile, with the following refinements of the model:

- More detailed information about nutrients being discharged from the rivers. Re-analyse the EBOP river data for this purpose.
- Sensitivity of the results to the deep ocean nutrient boundaries, by trialing different scenarios.
- Introduction of 3 or more phytoplankton and zooplankton size classes (species), with emphasis on choosing classes with different growth rates
- Sensitivity of growth rates to the solar radiation inputs and the level of the theremocline
- Testing of alternative equations to describe phytoplankton/zooplankton uptakes of nutrients
- Clearance rates in the mussels
- High resolution modeling of the farms to examine short-term (transient) phytoplankton physiology-driven demographic responses.
- More concern with the simulated vertical distribution of the phytoplankton, particularly in relation to the level of the mussels.
- Incorporation of fine-scale modeling around the farms
- Modelling of water column nutrient exchanges with the seabed. The model has this capability but data analysis is required for its implementation.
- With the above matters completed, more statistical analysis of the models' accuracy.

Conclusion

The reviewers have asked for more modeling to be undertaken. The benefit of adopting the reviewer's recommendations is that confidence in the model will be further improved and all developments will form the basis for planning decision making in the future, as aquaculture becomes more intense in the Bay, with more species under consideration.