NIWA
Taihoro Nukurangi

# Memorandum

To: Ministry for the Environment　　Date: 24 March 2014

From: Richard Gorman　　Our Ref: MFE13305

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Subject: **Review of the report "Astrolabe Reef Wave Modelling"**

## Executive summary


A report prepared by MetOcean Solutions Limited describing high resolution modelling of wave patterns in the vicinity of Astrolabe Reef has been reviewed by NIWA.

The report compares wave patterns found in simulations with and without the presence of a section of the wreck of *MV Rena* on the reef. It is found that only minor local differences can be observed, with approximately 1% differences in wave height at 1 km distance from the reef, reducing further at greater distances.

Our review finds that the methods used are in general suitable, and the results presented are appropriate for the stated purpose, with no significant gaps identified.

Some specific improvements to the report have been suggested.


## 1 Introduction

A series of high resolution wave model simulations was undertaken by MetOcean Solutions Limited to investigate the effect of the submerged stern section of the *MV Rena* on wave patterns in the vicinity of Astrolabe Reef. The Ministry for the Environment has commissioned NIWA to provide an external review of the report describing those simulations. That review is presented below.

## 2 Summary of the report

The report[1] describes the application of a phase-resolving wave model (CGWAVE [1]) to investigate the effects of the presence of a submerged section of *MV Rena* on wave conditions in the vicinity of Astrolabe Reef. A series of monochromatic incident wave

[1] MetOcean Solutions Ltd (2013). Astrolabe Reef wave modelling: Wave effects modelling of the submerged stern section of the Rena. Draft report Version RevC dated 10/09/2013

conditions are investigated, along with two spectral simulations representing examples of "mean" and "storm" conditions selected from a hindcast wave climate. Comparing wave patterns found in simulations with and without the presence of the vessel section on the reef, it is found that only minor local differences can be observed, with approximately 1% differences in wave height at 1 km distance from the reef, reducing further at greater distances.

# 3 Review comments

The methods used are in general suitable, with the phase-resolving CGWAVE model being an appropriate tool for investigating the effects on refraction and diffraction of waves over the relevant spatial scales. The results presented are appropriate and sufficient to adequately quantify those impacts.

No calibration or verification of the model against field measurements was reported. Ideally, this would be done to give confidence in the performance of the model, and quantify its accuracy. However, by its nature, a phase-resolving wave model such as CGWAVE applied to an open water situation is difficult to verify against field data. In this situation an uncalibrated model is still an acceptable tool to explore sensitivity to bathymetry changes, provide the model has been adequately tested in other similar applications, and has been applied in an appropriate way. This is the case for CGWAVE, which has become well accepted for such investigations. The application of the model in this study generally appears to be suitable: in particular the spatial resolution is sufficiently fine to adequately resolve waves in the vicinity of the reef.

Some detailed comments on the report are given below.

1. In the Introduction, it would be helpful to note the vertical extent and depth below the water surface of the submerged section of the *Rena*.

2. Some description of the boundary conditions used in the simulations should be included. Normally in CGWAVE applications (as described by Demibirlek and Panchang [1]) a semi-circular or circular boundary is used for open water. This allows for a combination of the applied incident wave plus reflected or scattered waves leaving the domain. Partially reflecting boundary conditions are typically applied on a straight line boundary (modified to accommodate an actual shoreline). In the reported Astrolabe Reef simulations, a semi-circular mesh domain has been used, with the straight boundary apparently located in open water between Astrolabe Reef and Motiti Island (it would be helpful to indicate this on a map, for example by adding the domain extent to Figure 1.1). Possibly a fully-absorbing "land" boundary may perform satisfactorily (or at least as well as an open-water boundary) in this situation, but if this "non-standard" choice has been made, some discussion would seem to be required.

3. It should be noted that the wave rose in Figure 3.1 is based on peak (rather than mean) wave direction.

4. In Section 4, it is noted that for spectral simulations a "cosine-squared spreading function of 10 was used". This is not a very clear description of the

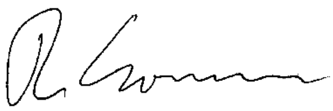
directional spreading function, i.e. was it $\cos^p(\theta - \theta_0)$, $\cos^{2s}((\theta - \theta_0)/2)$ or some other choice?

5. It would be helpful to clarify the nature of the wave crest pattern (Figures 4.2-4.21) and significant wave height outputs (Figures 4.22-4.27). Are the former snapshots at an instant in time of a non-stationary simulation (which is only suggested by the Figure 4.21 caption indicating T=0), while the latter are derived from full time series over a certain duration of simulation?

6. In the transect plots (Figure 4.21 and Figures 4.24-4.27), it is not clear from which end of the transect distances are taken.

7. Both the significant wave height plots (Figures 4.22 and 4.23) show two areas of elevated wave height near the circular boundary as prominent features. Differences in location of these areas between the two simulations appear to approximately correlate with the different incident wave directions. Is it possible that these are artefacts, perhaps from the boundary conditions? In that case it would be helpful to discuss any impact these have on the ability of the model to simulate wave conditions in the vicinity of Astrolabe Reef.

8. The bibliography includes the SWAN manual (Holthuijsen et al, 2004), but this is not cited in the text.



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# 4 References

1. Demibirlek, Z. and V. Panchang, *CGWAVE: A Coastal Surface Water Wave Model of the Mild Slope Equation*. 1998, USACE: Washington, DC, USA.