BEFORE THE EPA
CHATHAM ROCK PHOSPHATE MARINE CONSENT APPLICATION

IN THE MATTER of the Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012

AND

IN THE MATTER of a decision-making committee appointed to consider a marine consent application made by Chatham Rock Phosphate Limited to undertake rock phosphate extraction on the Chatham Rise

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STATEMENT OF EVIDENCE OF RAYMOND ALLEN WOOD FOR
CHATHAM ROCK PHOSPHATE LIMITED

Dated: 28 August 2014

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EXECUTIVE SUMMARY

1. CRP has completed six voyages to the Chatham Rise to collect data to verify the analyses of older data and to support new analyses of the proposed consent area. New data include oceanographic measurements, a variety of sea bed samples, a dense coverage of bathymetry data, transects with very high resolution bathymetry data, transects with video and still images of the sea floor, measurements of geotechnical properties of the sea floor, and geophysical data. The coverage of data could always be improved, but there are more data available for the proposed marine consent area than any comparable part of New Zealand's EEZ.

2. The data collected by CRP have been integrated with other data to validate global models of oceanographic conditions on the Chatham Rise and predict the distribution of discharged sediments on the sea floor and in the water column, to predict the distribution of benthic habitats and communities, and to confirm and refine the understanding of the phosphorite resource and the physical properties of the sea floor and the underlying sediments.

3. These analyses underpin the development of the proposed mining system and mining plan, the spatial planning that identified the proposed mining exclusion zones, and the proposed monitoring plan and conditions on mining operations.

4. CRP recognises that the marine consent area coincides with a benthic protection area (BPA) and used a spatial planning exercise to show that the conservation goals of the BPA can be met and extended with modern data. The spatial planning exercise used a broad spectrum of input data to identify areas predicted to have high conservation values and relatively low economic values. These were assessed with criteria such as geographic distribution and reserve size, and with other data about the seabed environment to derive proposals for reserve areas that reflect multi-dimensional values and costs. The desired outcome is not that there is a net loss in conservation area or value on the Chatham Rise, but rather that the areas are more carefully chosen to maximise the full suite of values: social, environmental, economic and cultural.
5. The proposed monitoring plan is designed to capture the spatial and temporal aspects of the effects of mining operations at scales that are relevant for observing and predicting the impacts of these effects. The monitoring plan includes fixed sites that will record continuous measurements of oceanographic conditions, sediment rate and sound throughout the life of the project. These will be augmented by periodic surveys that collect 3D measurements of oceanographic conditions (including total suspended solids) and systematic, repeated observations and samples of the benthic environment. The periodic surveys will observe and measure changes in benthic environments and communities, including those associated with the proposed recolonisation trials.

6. The proposed conditions on mining operations are based on the best scientific evidence of the sensitivity of organisms and of the likely nature and extent of effects from the mining operations. The proposed conditions are designed to minimise environmental impacts of the operation and encourage on-going improvements in engineering design and operations.

INTRODUCTION

Qualifications and experience

7. My full name is Raymond Allen Wood.

8. I have a BA degree in geology from Dartmouth College (magna cum laude, with honours, James B. Reynolds post-graduate fellowship) and an MA in geology from the University of Texas at Austin (University Fellow).

9. I am the Chief Operating Officer of Chatham Rock Phosphate Limited (CRP) and have held that position since April 2013. Prior to that, I worked as part of CRP’s management team for three years on contract from GNS Science.

10. I was previously Principal Scientist at GNS with areas of expertise in geology and geophysics; specifically basin modelling, Continental Shelf delineation, crustal structure determination, marine geophysics, seismic
stratigraphy and swath mapping. I held also several management positions at GNS Science, including Section Manager, Group Manager and Chairman of the Information Services Advisory Committee.

11. I have collected and analysed data and published papers on the structure and tectonics of New Zealand. Areas of particular interest included the Chatham Rise, Hikurangi Plateau, Challenger Plateau, New Caledonia Basin, Hikurangi margin, offshore Fiordland and Resolution Ridge, and the onshore Hanmer Basin. Many of the projects integrated geology and tectonics to infer resource prospectivity.

12. I was involved in research on the geology of the Chatham Rise in the 1980s, and more recently was a co-author of a peer-reviewed paper on the origin of pockmarks on the Rise. I led two marine surveys to the Chatham Rise for Chatham Rock Phosphate in 2011-2012. I was the lead author on the primary reference on the geological history and resource productivity of the Chatham Rise, and a co-author on a peer-reviewed paper on the geological framework of the Chatham Rise phosphorite deposit.

13. I was the lead technical advisor to the New Zealand continental shelf project. New Zealand’s continental shelf project was a twelve year project that, under the terms of article 76 of the UN Convention on the Law of the Sea, defined the extent of New Zealand’s sovereign rights to resources on and beneath the sea floor in areas beyond the 200 mile line (EEZ). It was a $44 million dollar project that collected data from many of the remote parts of New Zealand’s marine territory, processed and analysed those data, and resulted in a 2,683 page submission to the Commission on the Legal Continental Shelf supporting New Zealand’s definition of its continental shelf.

14. I was the lead technical advisor to the team supporting New Zealand’s maritime boundary negotiations with Australia. These negotiations fixed the boundary where the maritime territories overlapped in the Tasman Sea, the South Fiji Basin and the Macquarie Ridge region south of New Zealand.
15. I have been the technical director for continental shelf projects for the governments of Brunei, the Philippines, Sri Lanka and Oman. My responsibilities were similar in scope to those for the New Zealand project: lead the integration and analysis of existing data, apply the principles and formulae of Article 76 of the Law of the Sea Convention, and lead the writing of the technical components of the submission to the United Nations. The Philippines and Sri Lanka have presented these submissions to the United Nations.

16. I am a member of the Society of Exploration Geophysics, American Association of Petroleum Geologists and the Geoscience Society of New Zealand. I am one of the Environmental Protection Authority's Decision Makers for considering marine consent applications under the Exclusive Economic Zone and Continental Shelf Amendment Act 2012.

Code of Conduct

17. I confirm that I have read the Code of Conduct for expert witnesses contained in the Environment Court of New Zealand Practice Note 2011 and that I have complied with it when preparing my evidence. Other than when I state that I am relying on the advice of another person, this evidence is entirely within my area of expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions that I express.

Role in the project and marine consent application

18. My role in the marine consent application process has been to manage and contribute to CRP's activities to achieve its strategic goals. This has included overseeing the technical operations of the company, working with New Zealand Petroleum and Minerals (NZPaM) and the Environmental Protection Authority (EPA) to obtain the necessary permits and consents for the project, assisting with finding finance for the project, and contributing to communications with stakeholders and interested parties.

19. My contribution to the technical operations of the company have included preparation for the six surveys completed in 2011 – 2012; leading two of
those surveys; working with Boskalis to identify a mining system and mining plan that are practical, economic, and environmentally responsible; and identifying scientific objectives, scoping research and contracting with research teams.

20. Geological and environmental objectives have been nearly equally addressed by CRP’s research. The scientific studies have focused on collecting and interpreting data about the distribution and physical and chemical properties of the deposit, on the benthic habitats and communities in the proposed consent area, and on the ocean processes on the central Chatham Rise. These studies have provided input for modelling to predict the extent of the resource both inside and outside the mining permit area, to predict the extent of sedimentation and suspended sediments from the mining operations, and to predict the spatial distribution of benthic habitats and communities. They have also underpinned the proposed work programmes that are part of CRP’s application to renew its Minerals Prospecting Licence (MPL 55070) and of the two new prospecting permits adjacent to it.

21. I worked closely with the primary authors of the marine consent application at Golder Associates (NZ) Limited to contract research to fill gaps in our knowledge; to review, compile, integrate and organise this research; and contribute to and review the completed application and its appendices. I have been the primary point of contact for communications with the EPA team dealing with our environmental consent application.

Scope of evidence

22. In this brief of evidence, I will discuss:

(a) the geomorphology of the Chatham Rise;

(b) the environmental research programme leading up to the Application;

(c) the proposed mining approach based on CRP’s research;
(d) proposed monitoring of effects;

(e) spatial planning and mining exclusion areas;

(f) benthic protection areas;

(g) mine planning;

(h) responses to submissions

23. I also comment on consent conditions where it relates to my evidence.

GEOMORPHOLOGY OF THE CHATHAM RISE

24. The Chatham Rise has been of scientific and commercial interest for decades, and its morphology is well understood. The regional shape of the sea floor has historically been known from single-beam echosounding measurements made by research and commercial vessels.

25. Since the mid-1990’s satellite altimetry data have been used to estimate the shape of the sea floor, including that of the Chatham Rise. These data have less resolution than echosounding data, typically averaging depths over areas of a few square kilometres. The greatest value of these data is that they provide a comprehensive coverage of the ocean.

26. Most recently vessels use multibeam swath bathymetry systems to map the shape of the sea floor. These data provide a regional map that typically has a resolution of 20-50 metres. These data can be collected from instruments towed close to the sea floor, providing spatial resolution that can be as fine as a few centimetres.

27. NIWA has compiled a map of New Zealand’s regional bathymetry that is based on all available data, including single- and multi-beam bathymetry data and satellite altimetry data. This map includes the Chatham Rise and has a spatial resolution of about 250 m.
28. These regional data show that the crest of the Chatham Rise is less than 500 m deep, and has four banks shallower than 250 m deep. The proposed mining area is generally 350 to 450 m deep. Some parts of the consent area are shallower than 250 m deep.

29. The consent area lies across a broad saddle about 100 km wide in the crest of the Chatham Rise.

30. Analysis of the relatively dense coverage of single-beam echosounder data collected in the 1980s by the RV Sonne showed that the sea floor in the consent area is characterized by local ridges and valleys. The scientists speculated that these were iceberg furrows caused by collisions of the keels of icebergs from Antarctica with the sea floor of the Chatham Rise (this was confirmed by modern data as described below).

31. Exploration and mining operations require a more detailed knowledge of the sea floor shape than is available from the single-beam echosounder and satellite altimetry data. To meet this need, CRP surveyed more than 1,200 square kilometres of the sea floor with multi-beam swath bathymetry data (25 m horizontal resolution). These data cover most of the proposed mining permit area and some of the adjacent parts of the marine consent area.

32. I note that paragraph 70 of the EPA staff report states that the geomorphology of the seabed was described for approximately half of the current mining permit area (MP55549), but not for the other half of MP55549, the wider marine consent area or the surrounding area. Therefore, the EPA staff consider that uncertainty remains with respect to the current state of the environment in the area where it is proposed that the activity will be undertaken, and the environment surrounding this area.

33. That statement is, in my view, incorrect. The EIA clearly shows that CRP surveyed more than 1,200 square kilometres of the sea floor with multi-beam swath bathymetry data (25 m horizontal resolution), covering 700 km$^2$ of the proposed mining permit area (85%) and 500 km$^2$ of the adjacent marine consent area. This mapping, when integrated with the
other environmental data, is sufficient to understand the state of the environment where mining will take place for at least 15 years.

THE RESEARCH PROGRAMME

Introduction

34. The Chatham Rise is one of the best studied parts of New Zealand’s Exclusive Economic Zone (EEZ). It has been an area of interest for scientists for decades. Appendix 7 lists 135 research voyages in GNS Science and NIWA’s databases that have collected data in the region of the proposed marine consent since 1961. These voyages have collected oceanographic, biological, environmental, geological and geophysical data. They include reconnaissance voyages whose purpose was to explore unknown areas, and voyages with much more targeted objectives (e.g., fisheries management, oil exploration, phosphate exploration).

35. One of the first tasks for CRP was to review the available data about the resource, the environment, and the general shape and physical properties of the sea floor. As mentioned in the EIA, reconnaissance surveys in the 50’s, 60’s and 70’s showed that phosphorite is present in the surface sediments of much of the central and eastern Chatham Rise. More extensive surveys by the RV Valdivia and RV Sonne in 1979 and 1981 identified an area of greatest phosphorite concentration in the area of CRP’s mining licence. Scientists have speculated on the processes affecting the distribution and concentration of the phosphorite resource and this is the subject of ongoing research.

36. These previous surveys collected photographs and videos of the sea floor and described the sediment samples. These data showed that:

(a) the phosphorite is locally common at the surface and that the shape and nature of the sea floor vary on a scale of tens to hundreds of metres;

(b) the phosphorite is distributed throughout the uppermost sedimentary layer, that the phosphorite-bearing sediments are
locally thin and the underlying chalk is exposed at the sea floor in places;

(c) the underlying chalk is usually very sticky;

(d) the benthic communities are diverse (reflecting the variability in factors such as the nature of the sea floor);

(e) benthic organisms attach to some nodules but not all;

(f) the sea floor morphology has been shaped by iceberg furrows; and

(g) corals are more common in the eastern part of the area where nodules at the sea floor are observed to be larger.

Figure 1 Presence and absence information for phosphorite on the Chatham Rise (Note: ‘absence’ locations do not necessarily mean there is no phosphorite at that location. Limitations in the sample methods could result in an ‘absence’ result).

37. The phosphorite and sediment samples were analysed to determine their sedimentology (especially phosphorite content), chemistry, grainsize and physical properties. These analyses showed that:
(a) the resource is a lag deposit (dominated by erosion rather than sedimentation);

(b) the phosphorite formed at least 5 million years ago, that the phosphorite occurs as the coarse fraction (> 1 mm diameter) of the surficial sediments;

(c) that most of the phosphorite is greater than 8 mm in diameter and occasionally pieces are larger than 150 mm;

(d) the phosphorite nodules have been subsequently coated with glauconite but there has been relatively little sedimentation since the formation of the phosphorite; and

(e) the physical properties of the sea floor are unlikely to be suitable for sea floor mining machinery such as that proposed to mine the massive sulphide deposits at Solwara, Papua New Guinea.

38. The shape and subsurface structure of the sea floor were known from numerous single-beam bathymetry recordings and from seismic reflection data collected by regional reconnaissance surveys, by oil exploration surveys, and by surveys of the phosphorite deposit in 1979 and 1981. Various maps of the sea floor have been compiled. Before the CRP surveys, the best information about the shape of the sea floor available for the project was a compilation of bathymetry data from the entire EEZ by NIWA at a resolution of 250 m.¹ These data show the major features of the Chatham Rise but do not have sufficient detail to show the small-scale sea floor features observed locally on the RV Validvia and RV Sonne echosounder data and regionally on the recent multibeam swath bathymetry data.

¹ CANZ, 2008: New Zealand Region Bathymetry, 1:4 000 000, 2nd Edition. NIWA Chart, Miscellaneous Series No. 85.
Considerable research had been done on the oceanographic properties of the Chatham Rise. This research had described the location and behaviour of the major water masses (Subtropical and Sub-Antarctic water bodies meet at the Subtropical convergence), the dominant current direction along the rise (west to east, complicated by large eddies), and the speed of the currents (tidal flows of 10 to 40 cm/s). Oceanographic data are described in more detail in Appendices 8 and 10.

Beaumont et al. (2014)(Appendix 14 of the EIA) point out that the environmental importance of the Chatham Rise is reflected in the considerable body of environmental and fisheries knowledge that exists for the Chatham Rise, including assessments of fisheries catch and by-catch, marine community structures, area covered by trawls, effects of trawling on the substrate and benthic fauna of seamounts, biodiversity,
and analyses of sediment types, bathymetry, oceanography, and hydrology (e.g., Anderson et al. 2001; Bull et al. 2001; Rowden et al. 2002; Clark and O’Driscoll 2003; Livingston et al. 2003; Baird et al. 2006; Hadfield et al. 2007; Dunn 2009). Research has also been done on the nature and distribution of sea birds and mammals.

41. As a result of this review, CRP undertook six surveys to obtain additional and more specific baseline oceanographic data, map the sea floor shape in detail, photograph and sample the sea floor habitats and organisms, sample the sea floor sediments, and measure the physical properties of the sea floor.

![Figure 3: Data collected by the six CRP surveys in 2011 and 2012. The mining licence boundary is also shown.](image)

42. These data were collected in the mining permit area to confirm and improve knowledge of the chemistry and physical properties of the phosphorite nodules and the uppermost sediment layer, to improve the interpretation of the resource distribution, to improve the interpretation of the benthic environments, and to obtain local oceanographic data. The data collected and analysed from these voyages have been used:

(a) in the design of the mining system and mining plan;
(b) to confirm and improve the resource estimate;
(c) to obtain environmental baseline data to assess the potential impacts of the proposed mining project;
(d) to predict the spatial distribution of benthic habitats and communities;
(e) to provide the core information for understanding the nature and behaviour of the sediment plume;
(f) to guide the development of a monitoring plan; and
(g) to guide the development of a spatial planning proposal for the marine consent area.

43. CRP has provided the data at no cost to scientists involved with the project to support their own research, and CRP has encouraged them to publish their results.

44. Mr Campbell McKenzie's evidence discusses the phosphorite resource related research in more detail.

Research completed to date

45. CRP has completed six voyages to the Chatham Rise:

(a) In May 2011 we deployed two current meters near the centre of the mining permit area, and collected bottom samples with a van Veen grab.

(b) In July 2011 we deployed two turbidity meters near the centre of the mining permit area, and collected bottom samples with a van Veen grab. A total of 45 samples were collected by these two voyages.

(c) In December 2011 a 12 day voyage collected multi-beam swath bathymetry data, seismic reflection data, sidescan sonar data, and magnetic data. It recovered the current and turbidity moorings.

(d) In February 2012 a 9 day voyage collected 50 grab samples (total of 32 t), geotechnical data for mining design and multi-beam swath bathymetry data.
In March 2012 an 18 day voyage collected benthic ecology data along remotely operated vehicle (ROV) transects totalling 77 km distributed throughout the mining permit area. Data collected included 150 hours of video and 17,000 still photos, 62,000 biological and geological observations from the video, 130 box core samples from 38 sites, 12 benthic biological samples and high-resolution bathymetry data (3 km$^2$). It also collected multi-beam swath bathymetry data.

In April 2012 a 13 day voyage collected data to assess the physical properties of the phosphorite and sediment layer. These data included vibrocores from 13 locations, 2 box cores, 134 cone penetration tests, 3 ROV jet tests, and 4 ROV transects (including 600 environmental observations). It also collected multi-beam swath bathymetry data.

CRP also contributed to the 2013 Oceans Survey 2020 (OS20/20) voyage that extended the environmental transects beyond the mining permit area. The voyage collected multi-beam swath bathymetry data, seabed photographs, and samples of the seabed sediment and organisms from eight areas on the crest of the Chatham Rise. The survey areas were chosen to lie between the transects collected by the 2007 OS20/20 voyage, inside the BPA and in the region of CRP’s detailed benthic study areas.

Collection of baseline turbidity and oceanographic conditions data

One of the top priorities identified for additional data was the collection of baseline data on the natural turbidity and oceanographic conditions near the sea floor in the proposed mining licence area. CRP commissioned IXSurvey New Zealand Limited to deploy two moorings to measure turbidity and currents. The moorings were deployed near the centre of the mining permit area. The site was chosen to complement existing data and to be representative of the oceanographic conditions on the central crest of the Chatham Rise.
48. There was a problem with the turbidity meters on the first voyage and only current meters were deployed. A second voyage was required to deploy the turbidity meters. We collected about 7 months of current data and 6 months of turbidity data. These data were processed by IX Surveys and analysed by Deltaires (2013b, 2014a)(Appendix 10 of the EIA) and Dr. Melissa Bowen of the University of Auckland (2012). The data were analysed to determine the direction, speed, stratification and components of current flow, and the level of turbidity and used to constrain the sedimentation and plume dispersion models. The turbidity data provide a relative measure of turbidity because the ADCP recorded turbidity in nephelometric turbidity units (NTU) and the Aqualoggers recorded turbidity in formazin turbidity units (FTU) and because no water samples were collected which would have enabled the turbidity data to be calibrated (e.g., Nodder 1997).

49. The issue of natural turbidity levels arising from resuspension of sea floor material is summarised by scientists from Deltaires, NIWA and HR Wallingford in the answer to EPA questions 17 and 18, and is discussed in the evidence of Ms Jamie Lesinski, Dr Scott Nodder and
Dr Jeremy Spearman (refer also to relevant material in EIA Appendices 10, 12, 26).

50. Paragraph 75: Internal tide velocities were not measured during stratified ocean conditions, typical of late spring, summer and early autumn, when they are most pronounced. Therefore, the EPA staff consider that best available information was not used with respect to the seasonal variance of internal tide velocities and the degree to which they influence the resuspension and dispersion of sediments. The EPA staff consider that this information would be readily available without incurring unreasonable cost, effort or time.

**Detailed seafloor mapping**

51. Exploration and mining operations require a more detailed knowledge of the sea floor shape than what was available at the start of the project. In particular, the engineers need to design the mining system to cope with the range in depth and sea floor slopes. To meet this need, CRP mapped more than 1,200 square kilometres of the sea floor with multibeam swath bathymetry data (25m horizontal resolution).

52. On the environmental survey (March 2012) CRP collected similar multibeam swath bathymetry data along the 39 ROV transects in the mining licence area. These data were collected from a sensor a few metres above the sea floor and have a horizontal resolution of about 10 centimetres.

53. These high resolution bathymetric data provide a greater understanding of the nature of the sea floor, including how rapidly it changes. These data show features such as burrows made by organisms that live on and beneath the sea floor, areas of phosphorite at the sea floor, and areas characterised by stony corals. They show that the morphology of the sea floor has been almost entirely shaped by iceberg furrows. These details of the sea floor are essential for planning the mine operations and for understanding the spatial changes in sea floor habitats.
54. As a result of the CRP surveys, about 700 km$^2$ (86%) of the mining permit is covered with multibeam swath bathymetry data. About 500 km$^2$ of the marine consent area outside the mining permit is also covered with these data. The 2013 OS2020 multibeam swath bathymetry data have recently been added to the database but they have not yet been included in the analyses. The rest of the licence and permit areas are covered by NIWA’s 250 m resolution bathymetry grid. As discussed above, the 250 m resolution bathymetry grids are adequate for regional interpretations and survey planning but are not good enough for modelling the resource or the benthic environment at the level of detail required, or for mine planning.

55. Completing the coverage of multibeam swath bathymetry data in the rest of the mining permit area and in the prospecting licence and permit areas is a priority for the work programmes proposed for those tenements.

56. The multibeam swath bathymetry data have been used to help design the mining system and mining plan. They provide estimates of the likely range of depths and slopes that may be encountered in each mining block, which I discuss below. They have also been used as input for models of sea floor habitats as discussed by Dr Rowden in his evidence and reports.
Chemistry and physical properties of phosphorite deposit and seabed

57. The value and uses of the resource depend primarily on its chemistry, and the performance of the drag-head and processing system depend primarily on the physical properties of the sediment. Both the physical properties and chemistry were investigated in the 1980’s, but because they are fundamental to the success of the project it was necessary to confirm the chemistry and physical properties of the phosphorite and the associated sediments, and of the underlying chalk.

58. No suitable samples remain from the Valdivia and Sonne surveys so it was necessary to collect additional samples of the sea floor sediments. As described above, samples were collected by CRP using a variety of equipment on the voyages to deploy the moorings and on the Dorado Discovery voyages.

59. The primary tools for obtaining samples of the sea floor sediments were a clamshell grab with a capacity of about one cubic metre, a box corer, a van Veen grab and a vibrocorer. Samples from 49 sites were collected with the clamshell grab. Samples from 45 sites were collected with the
van Veen grab, 120 box core samples were collected, and 13 vibrocorer samples were collected. The sites were chosen to be representative of the geology of the proposed mining area. These samples have been analysed by CRL, the University of Waikato and Boskalis to determine their chemical composition, grainsize distribution and physical properties. These results confirmed the earlier analyses, and have been integrated with them. Analysis of these samples to determine the organisms living in the sediment is discussed below.

Figure 7: Map showing the distribution of samples collected in the region.

60. The performance of the draghead component of the mining system depends strongly on the physical properties of the sea floor. The fourth Dorado Discovery voyage in 2012 collected 126 cone penetration test (CPT) results and 18 vibrocores from representative areas to estimate the properties of the sea floor. The sampling concentrated on the western part of the mining permit, where mining is expected to commence, and measurements were made in closely spaced transects across characteristic sea floor features (e.g., ridges, furrows). The CPT and vibrocore data were interpreted to determine the thickness, geology, shear strength and density of the sea floor sediments.

61. The Boskalis engineers completed scaled tests in their lab of the ability of the water jets to mobilise the sea floor sediments to better estimate
the factors affecting the production of the draghead. The results contributed to the specifications of the draghead power units and the size and spacing of the water jets.

Environmental research

62. Environmental data were collected by the Valdivia and Sonne surveys that explored the Chatham Rise resource in the 1970s and 1980s, and by many other research surveys over many decades.

63. However, we decided that these data were not sufficient to understand the potential environmental effects of the mining operations on organisms that live on and in the sea floor. We commissioned NIWA biologists and ecologists, led by Dr David Bowden and Dr Ashley Rowden, to advise us on a survey plan.

64. The purpose of the survey was to efficiently sample representative areas of the benthic habitats and ecosystems in the proposed mining area to derive a robust estimate of their geographic distributions (Rowden et al. 2013). Dr Rowden discusses the survey plan, the collection and analysis of the data, and its use for modelling of benthic habitats and spatial planning in more detail in his evidence and reports.

65. The plan required a series of transects, each one nautical mile long, distributed throughout the mining permit and in areas to the east and west. Photographs of the sea floor were to be taken along each transect to record organisms living on the sea floor, and two samples were to be collected to record organisms living in the sea floor sediments.

66. The March 2012 survey completed the 39 transects inside the mining permit area but did not have time to collect those in areas to the east and west. Each transect was surveyed with an ROV that photographed the sea floor, collected very high resolution multibeam swath bathymetry data, and collected selected samples of benthic organisms with its manipulator arm.

67. The imagery data were logged in real time by two biologists and two geologists who recorded the organisms they saw and the characteristics
of the sea floor. The image analysis was subsequently repeated onshore by a biologist who was able to view the imagery more slowly and record a more complete list of organisms. These observations are georeferenced and can be used for spatial analysis of trends in the habitats and ecosystems.

68. The multibeam swath bathymetry data were interpreted to identify the nature of the sea floor and the distribution of phosphorite nodules and corals.

69. Two samples of the sea floor along each transect were collected with a box corer. These samples were examined by biologists and the organisms in the sediments identified. Sub-samples of the box cores were also taken and used for elutriate analyses. A few samples were 'washed' (affected by recovery) and not suitable for biological analysis. These were retained and the physical properties were analysed as described above.

70. Many other research projects were completed to investigate specific questions about the environment of the Chatham Rise. These questions focused on the nature and distribution of benthic and pelagic organisms, how these organisms fit into the Chatham Rise ecosystem, the nature and distribution of seabirds and mammals, the potential effects of mining operations, the potential impacts of those effects on benthic and pelagic organisms (including recolonization), and spatial planning to maximise conservation and economic values. Reports on these projects are included as appendices to the EIA:

(a) Data on the Chatham Rise benthos: Macro-faunal and in-faunal communities (Beaumont et al. 2013a)
(b) Biological and fishing data within the Minerals Prospecting Licence 50270 area within the Chatham Rise (Beaumont et al. 2013b)
(c) Benthic communities on MPL area 50270 on the Chatham Rise (Rowden et al. 2013)
(d) Benthic epifauna communities of the central Chatham Rise crest (Rowden et al. 2014a)
In addition, substantial additional work has been carried out following the lodgement of the EIA to respond to the EPA's and DMC's requests for further information. In my opinion, even bearing in mind the information principles in section 61 of the EEZ Act, the information assembled is both substantial and scientifically appropriate to enable a marine consent to be granted. It is always possible to gather further information, but this would not substantially enhance the understanding of the environment or the assessment of effects on a scale appropriate for consideration of this application.

Future research

CRP has made and will continue to make significant R & D investment over the life of its mining operations. It will conduct further offshore
surveys to collect geological and environmental data in its mining permits and prospecting permits/licences.

73. CRP has and will have obligations under the terms of its mining and prospecting licences and permits and, if granted, its marine consent to undertake surveys of its licence and permit areas. These surveys will be used to improve the understanding of the nature and distribution of the phosphate deposit, of the physical properties of the sea floor, and of the benthic habitats and communities.

74. CRP will install moorings to collect additional data about oceanographic conditions and to confirm the effectiveness of the technology for monitoring the environmental effects of mining. CRP may test components of the mining system on the sea floor of the Chatham Rise.

Research related to mining permits and prospecting permits/licences

75. Under the terms of its prospecting licence and mining permit and prospecting permit application areas if approved, CRP has proposed a work programme that includes detailed surveys of the sea floor and subsurface. These surveys will complete the regional multibeam bathymetric mapping of the licence and permit areas, and conduct a programme of sea floor sampling to validate and extend the existing sample coverage and to test the assumptions made from existing data, including the environmental and prospectivity modelling.

76. These surveys are also designed to verify the benthic habitat model as recommended in Dr. Rowden’s report (Appendix 16), and to collect sufficient data to assess the conservation and economic values and contribute to the decision whether mining can proceed in the prospecting licence and permit areas as stipulated in the conditions proposed in the EIA.

77. Detailed surveys in the mining permit area will focus on the initial mining blocks and those areas not yet mapped with modern data. These surveys will collect high resolution bathymetry data, photographs of the sea floor and sufficient samples to assess variations in the physical properties of the sea floor sediments. These data will be analysed and
interpreted to extend and improve the geological and environmental models of the proposed marine consent region.

78. CRP proposes a similar work programme for its prospecting licence and the other two prospecting permit application areas, adapted to reflect the fewer data in these areas. The surveys will collect regional multibeam bathymetry data and sea floor samples, and detailed transects similar to those collected in the mining permit areas. These data will be interpreted to extend and improve the geological and environmental models of the region and to support an application for a mining permit, which would be necessary before a marine consent could be exercised beyond the mining permit area.

79. To monitor mining efficiency it is necessary to estimate the resource present in the mining blocks before mining begins and the resource remaining in the blocks after mining is completed. Until the performance of the mining system is determined, it is expected that every mining block will be surveyed and sampled before and after mining to gather this information. These data will also as a matter of routine be analysed for information about the benthic environments and communities. The surveys will be repeated if mining moves to an area where the performance of the mining system is expected to be different (i.e., the sediments are thinner/thicker, the nodule size is larger/smaller). These surveys are included in the work proposed for the mining permit area, and will be continued if permissions and consents are granted for mining elsewhere in the proposed marine consent area.

PROPOSED MONITORING

80. The objectives of the proposed monitoring activities are to collect further information about background environmental conditions in the marine consent area and to measure the effects of mining activities.

81. Monitoring includes the following:

- Long-term oceanographic information (turbidity, current speed and direction, temperature, conductivity, and pressure) and sedimentation data.
• Water turbidity (suspended solids) prior to, during, and after mining.

• Benthic ecology monitoring to assess the impacts of mining outside the mining blocks.

• Benthic ecology monitoring to assess the nature and rate of recolonization inside the mining blocks.

• Sound levels of the mining vessel and mining system.

**Monitoring long-term oceanographic conditions and sedimentation rate**

**82.** Background oceanographic and sedimentation data will be collected by moorings deployed at sites chosen to adequately sample the oceanographic conditions in the marine consent area. A broad spectrum of oceanographic data will be collected to identify natural variations in the marine environment. It is anticipated that the locations and timing of these deployments will depend on discussions with the Environmental Reference Group.

**83.** The moorings will use standard sensors to monitor turbidity, current speed and direction, temperature, conductivity, pressure and sedimentation. The oceanographic instruments will be chosen and deployed to collect information about the complete water column, but will be designed to provide detailed information about the lower part of the water column (where the mining effects are predicted to be greatest) and less detailed information about the remainder of the water column. Sediment traps will be used to collect sediment near the sea floor.

**84.** The instruments will be deployed before mining begins and will be maintained throughout the life of the project. The performance of the moorings and technology developments in this field will be regularly reviewed. The instruments and/or the locations may be changed to improve performance following discussions with the proposed Environmental Reference Group.
Monitoring effects of mining operations on water turbidity

85. Turbidity prior to, during and after mining will be monitored by an AUV or similar equipment (Figure 8). The survey vehicle will be equipped with sensors capable of measuring turbidity and fluorescence, current speed and direction, temperature, conductivity, pressure, and particle size distribution. CRP has discussed the requirements for these surveys with scientists at Woods Hole Oceanographic Institution (WHOI) and they are confident that they can provide a package of instruments that is able to make these measurements. CRP and WHOI are discussing a voyage in early 2015 to demonstrate the capabilities and effectiveness of their AUV. There are other options for collecting these measurements (e.g., NIWA’s deep towed imaging system - DTIS) if the WHOI AUV is not available or not suitable.

86. The measurements will be made with a survey pattern designed to determine both the regional water quality (including that of the shallow part of the water column) and the turbidity associated with mining activities. The survey pattern will have sufficient range and duration to monitor the spatial and temporal distribution of suspended sediments. These surveys will take place every six months for the initial two years of the mining operation, and once a year thereafter.

Figure 8: Woods Hole Oceanographic Institution AUV capable of completing monitoring and other surveys (Photo by Christopher Reddy, WHOI)
Monitoring impacts of mining outside the mining blocks

87. Environmental information collected to identify spatial changes in benthic habitats and the marine environment outside the mining blocks as a result of mining activities will include targeted observations of the sea floor surface and sea floor sampling. These data will be used to quantitatively assess changes in the structure of epifaunal and infaunal communities in and adjacent to the mining blocks. These surveys will take place every three months for the initial 18 months of the mining operation, and once a year thereafter.

88. Spatial changes in the marine environment will be monitored with photographs and other sensor data collected at the oceanographic monitoring sites and along transects within and radiating from the mining blocks by an AUV or similar towed or tethered equipment. The photographs and other data will be analysed by qualified biologists and geologists to identify changes in the nature of the seabed and the seabed organisms.
89. Sea floor samples will also be collected at the oceanographic monitoring sites and at sites along the radial transects using appropriate sampling equipment, probably a box corer or a similar sampling device. The samples will be analysed to identify the physical properties of the sediments and the organisms living in them.

90. The photographs and sample data will be integrated and used to assess and monitor the impacts of mining activities on organisms outside the mining blocks. Some effect on the organisms living on the sea floor outside the mining blocks is expected from deposition of the sediment returns. Comparison of photographs taken before mining and periodically
after mining will show what these effects are and how far they extend. Similarly, analysis of the organisms living in the sea floor sediments will be used to determine what effects the mining process has on them in areas outside the mining blocks.

**Monitoring the nature and rate of recolonisation inside the mining blocks**

91. Monitoring will also assess natural recolonisation following completion of mining in the first mining block, and assess the viability and value of installing material to provide added hard substrate habitat, thereby possibly enhancing biodiversity within and adjacent to mined areas on the Chatham Rise.

92. Data collected to monitor natural recolonisation is the same as those collected to monitor the effects outside the mining blocks. The data will be collected at defined distances from the edge of the mining activity. An AUV, or similar equipment, will take photographs and/or videos of the seabed to identify visual changes in epifaunal communities. Seabed samples will be collected using appropriate sampling equipment, for example, a box-corer.

93. These surveys will be completed every year for the first 5 years of the mining project, and every other year for the next 10 years of the project.

94. Inside the mining blocks most of the sea floor organisms are likely to have been removed by the mining operations. The photographs and sample data will be integrated and used to assess the nature and timing of natural recolonisation of organisms living on and beneath the sea floor inside the mining blocks.

95. As noted earlier, it may be possible to enhance biodiversity within and adjacent to the mined areas by adding hard substrate to the sea floor. Four test sites will be established to assess the viability and value of adding hard substrate habitat. A variety of hard substrate types will be placed on the seabed to determine the practicality of larger scale deployments. The sites will also be monitored every year for the first 5 years of the mining project to determine variations in the development of benthic and pelagic communities, and every other year for the next 10
years of the project. If adding hard substrate is determined to be viable and valuable then it is proposed that, following protocols developed in conjunction with the proposed Environmental Reference Groups, hard substrate recolonisation areas will be established on the crest of the Chatham Rise by CRP.

THE MINING SYSTEM

96. The mining system (vessel, dredging equipment, sediment processing etc.) proposed for this project is described in more detail by Mr van Raatle of Boskalis. However, it is based on a conventional suction draghead and onboard mechanical separation of the phosphorite from the other sediments.

97. Designing the mining system required knowledge of the nature of the sediments and their physical properties and the shape of the sea floor. CRP’s research has been essential for the design of the mining system.

98. The samples collected in the 1970’s and 80’s were only analysed in three categories: less than 1 mm diameter, 1 to 8 mm in diameter, and greater than 8 mm diameter. These analyses showed that the phosphorite is concentrated in the fraction greater than 1 mm in diameter, but the grainsize analyses did not provide sufficient detail for Boskalis’ design needs. CRP and Boskalis analysed the samples collected during the 2010 and 2011 voyages in much more detail and determined that most of the phosphorite is greater than 2 mm in diameter, a size that is much easier to design for in the separation plant. These results guided the design of all the components of the separation plant.

99. In addition, the size distribution of the phosphorite fed into the design of the draghead system and the mining plan. Achievement of the desired annual production figure requires consideration of the rate that sediment can be delivered to the processing plant on the mining vessel, and other factors such as the size of the mining vessel and the distance to port.

100. The design of the mining system requires consideration of the physical properties of the sea floor sediments. The size of the draghead, the
water jet design (number, configuration and flow), the power in the pump unit, and the size of the riser, sinker and the processing plant are all based on how the sediments react to jetting (like clay or like silt) and how much of the underlying clay may be included in the mined material.

101. Boskalis engineers used sediments collected during the CRP surveys to undertake laboratory scale tests of the performance of water jets. The results fed directly into the design of the draghead and influenced the design of the other components of the mining system. The design of the diffuser which returns unwanted material back to the sea floor is tailored to minimise the dispersion and plume formation of the non-phosphorite material, and is based on the measured properties of this sediment fraction.

102. The distribution of the phosphorite within the sea floor sediments affects the design of the draghead and pump system, and influences the production and recovery rates. The sampling and cone penetrometer test (CPT) data have been analysed to predict the thickness of the phosphorite-bearing sediment layer and the distribution of phosphorite within that layer. The evidence of Mr van Raalte outlines how these factors have been addressed in the design of the mining system.

103. The risers and sinkers need to be able to accommodate variations in the topography of the sea floor. The multibeam swath bathymetry data collected by CRP provided the information needed to estimate the shape of the sea floor in mining blocks and the maximum sea floor slopes. These factors have affected the choice of size and configuration of the components of the pump and draghead unit, and the control systems for that unit.

104. The decision to deploy the diffuser near but not on the sea floor was based on analysis that shows this option provides the greatest control over the location of the diffuser.

105. Analysis of oceanographic data and experience on the rise during CRP’s surveys in 2011 and 2012 showed that the vessel operations must be oriented northeast-southwest to safely and efficiently accommodate the
prevailing swell directions. This affected the design of the proposed mining blocks and is discussed by Mr van Raalte.

SPATIAL PLANNING AND MINING EXCLUSION AREAS

106. Before addressing CRP’s spatial planning and proposed mining exclusion areas, it is necessary to understand the background to the current BPAs which are areas protected from bottom trawling, but not long-lining, under the Fisheries (Benthic Protection Areas) Regulations 2007. I describe the background to the BPAs, before describing CRP’s proposal.

Benthic Protection Areas

107. I am familiar with the process that led to the creation of the BPAs and with discussions about their strengths and weaknesses. While working for GNS Science, I was asked by the Deepwater Group Limited to provide geographic information system (GIS) support for their development of BPAs through regulations under the Fisheries Act 1996. I was not involved in the discussions that led to the decision to identify and promote these areas.

108. The objective of my analysis was clear: the BPAs were to be large, relatively unaffected by bottom trawling, have simple boundaries, and be broadly representative of the marine environment. The assessment of the degree of fishing impact was based on the distribution of bottom trawling, estimated from the Ministry of Fisheries’ database of trawling effort.

109. The model of the marine environment used for the analysis was the Marine Environment Classification 2005 (MEC) which used physical variables to identify 20 classes of marine environments. It was the best marine classification available at the time.

110. The goal of the project was to protect at least 10% of each of the nine MEC oceanic environment classes, and representative parts of three

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2 The Marine Environmental Classification was developed as a partnership project between the Ministry and NIWA with the support of the Ministry of Fisheries and the Department of Conservation. The MEC provides a general map that shows the variation in both the physical and biological characteristics of New Zealand’s marine area within the EEZ.
Areas both east and west of New Zealand had to be included. After several iterations 17 areas were identified that covered an area of 1.2 million square kilometres. The legislation putting the BPAs into effect came into force on 15 November 2007.

111. There was considerable public discussion of the value of the BPAs, including whether they were representative of the benthic environments. The BPAs successfully achieved the simplistic goals set at the time they were created. However, in my opinion that does not mean they are an optimum spatial planning solution for maximizing the environmental, economic, and social values of New Zealand’s marine territory. For example, Leathwick et al. (2008)\(^3\) predicted that the conservation benefits of BPAs are significantly less than those predicted for marine conservation areas identified using spatial planning tools.

112. In particular, the BPAs were an EEZ-wide proposal that only addressed some of the values relevant to the fishing industry, particularly the impacts of bottom trawling on the benthic environment. Other values, such as the economic value of other resources such as phosphorite, were explicitly not considered in creating BPAs. Accordingly, the BPAs were established under fishery legislation and do not affect other activities in the EEZ.

113. The value of the BPAs for other values relevant to the fishing industry, such as spawning or nursery areas, is not apparent from analysis of fishery data. O’Driscoll et al. (2014)(response to EPA question 34) concluded that there was no evidence that CRP’s revised consent area (approximately corresponding to the eastern two-thirds of the BPA) was particularly important as a spawning ground for any of the 29 species examined. The data in Appendix 17 (based on the dataset provided by MPI from previous work by Leathwick et al. (2006)) indicates that juvenile fish are widespread on the Chatham Rise or concentrated in areas other than the BPA and the proposed marine consent area. O’Driscoll and MacGibbon (2014)(response to EPA questions 38 and 39) report a total long-line catch of 99 tonnes and a bottom trawling catch of 65 tonnes in

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the revised marine consent area for the last 10 years, and by implication that the area does not host a significant concentration of adult fish.

114. The BPAs used EEZ-scale databases, with the limitations in data coverage and quality that that accompany that large scale. The much more detailed environmental and economic data available in some areas, such as the Chatham Rise, were not used at the finest scale possible. As more comprehensive data become available, I consider that the conservation objectives of the BPAs can be better achieved through spatial planning that considers all costs and benefits of marine protected areas. Smaller-scale plans for areas with better data coverage and data quality could produce solutions with better conservation, economic and social benefits. The mining exclusion zones in the proposed marine consent area are products of the application of spatial planning tools to high quality data.

CRP’s spatial planning and mining exclusion areas

115. CRP recognised the need to include an analysis of the benthic environment in its mine planning, and, as discussed above, commissioned NIWA to guide the collection and analysis of environmental data to determine benthic community structure and their environmental drivers, to produce predictive models of the distribution of benthic communities, and to compare the structure and distribution of observed benthic communities with benthic communities previously sampled elsewhere on the Chatham Rise. Initially this was confined to the mining permit area but it was subsequently extended to a larger area on the crest of the central part of the Chatham Rise, including most of the marine consent area. The area was expanded because analysis of the initial results showed that it was difficult to make informed judgements about the relative merits of economic and conservation values without a wider context for the both the resource and the environment. The environmental data collection and analysis are discussed more thoroughly by Dr Rowden in his evidence.

116. NIWA’s initial analysis focused on predicting the potential extent of suitable habitats that were associated with benthic communities identified from the environmental samples and other data collected inside
the proposed mining area (Appendix 15 of the EIA). This analysis highlighted a number of scientifically interesting features, and at least one that was important for CRP’s mine planning.

117. The analysis predicted that a protected stony coral, *Goniocorella dumosa*, occurred in dense patches not seen elsewhere on the rise. The communities characterised by this coral were predicted by the modelling to be most common in the eastern part of the proposed mining permit area, and this was supported by observations made by NIWA biologists of data collected on the 2012 ROV transects and on the 2013 OS2020 deep-towed video transects.

118. NIWA’s analysis and predictions raised a question about how to use these results for mine planning. The stony coral *Goniocorella dumosa* is widespread in New Zealand’s EEZ. However, to consider conservation values associated with them it was necessary to know whether the concentration of phosphorite in the proposed mining area provided a unique environment for the communities characterised by *Goniocorella dumosa* and therefore whether some mining exclusion areas should be identified inside the mining area, or whether these communities are widespread on the Rise and whether they could be protected by measures that did not lie entirely inside the mining area.

119. CRP commissioned NIWA to expand their study to consider the community structure of the central part of the crest of the Chatham Rise. Similar data to that used for the analysis inside the mining licence were collected by voyages in 2007 and 2013 elsewhere in the marine consent area. The results of this work provided context for the previous results and allowed CRP to identify areas that have strong conservation values and areas that have strong economic values (Appendix 16 of the EIA).

120. An Ocean Surveys 20/20 (OS20/20) voyage to the Chatham Rise in 2007 collected photographs and samples along north-south transects east and west of the mining permit area. These environmental data were analysed by NIWA scientists using a technique similar to that used for CRP’s data.
121. In July 2013, NIWA scientists led another OS20/20 voyage to the Chatham Rise. One of the objectives of the voyage was to collect environmental data in the BPA on the crest of the Rise to improve understanding of the biodiversity along the central Chatham Rise. CRP offered to contribute its environmental data to this project, and the survey was therefore designed to collect data complementary to the CRP data. CRP commissioned NIWA scientists to process and analyse the environmental data from both OS20/20 voyages so they could be integrated with the CRP data.

122. The combined dataset covered most of the central Chatham Rise shallower than 500 metres. The data were modelled to identify community structures and to predict habitat suitability for these communities. The results were similar to those for the proposed mining area.

Figure 10: Figure 3-7 from Rowden et al. (2014a)/Appendix 16 of the EIA) showing the spatial distribution of communities. The interpretation reflects the distribution of input data for the benthic community modelling.

123. Most significantly, the modelling predicted that habitat suitable for communities characterised by *Goniocorella dumosa* extends northwest-southeast through the prospecting licence area, including the eastern part of the proposed mining permit area. This distribution agreed with that of the previous modelling and extended the results into the proposed
marine consent area. A very large area of suitable coral habitat is predicted to lie about 100 kilometres northwest of the prospecting licence. About half of this area has been affected by bottom trawling.

Figure 11: Predicted probability of habitat for community O (including stony coral) from Rowden et al. (2014a)(Appendix 16 of the EIA)

124. Once CRP had a model of the predicted habitat distribution and community structure it was possible to identify areas that are likely to have high conservation values, measured as predicted biodiversity. CRP commissioned NIWA scientists to use the software tool Zonation to input a wide variety of data, including areas predicted to a large phosphorite resource, and identify areas that maximised predicted biodiversity and minimised the impact on predicted economic value. Dr Rowden has described this analysis in more detail in his evidence.

125. At the start of this project, Dr Robin Falconer and I met with NIWA scientists and agreed on inputs for the modelling. Factors that affected the choice of input data were that they were continuous across an area larger than the model area, they were based on empirical data rather than expert opinion, they were direct representations of biodiversity rather than proxies, and they were relevant to the project objective of identifying areas likely to have high levels of biodiversity. Chosen input
layers included information related to benthic communities, fish, phytoplankton, marine mammals and seabirds.

126. NIWA scientists ran the model and provided CRP with the results as a grid of data showing spatial distribution of predicted biodiversity. They advised us that probabilities more than 70% might be useful guides for our consideration of which areas could be identified as mining exclusion areas.

127. The discussions with NIWA scientists highlighted that not all factors relevant for identifying mining exclusion areas were suitable for inclusion in the modelling. Other factors that guided the identification of CRP’s proposed mining exclusion areas were preservation of a representative sample of the iceberg furrows, a more refined version of the MEC system described above, and areas of basement outcrop not included in the modelling.

128. The iceberg furrows that characterise this part of the Chatham Rise merit preservation as geomorphological areas of interest. Iceberg furrows are common on other continental margins, but they have not been reported elsewhere in New Zealand’s EEZ showed that this part of the crest of the Chatham Rise has been extensively affected by iceberg furrows. The furrows vary in scale from about 10 metres across and less than a metre deep, to more than 200 metres across and more than 10 metres deep. The longest observed furrow is about 25 kilometres long. CRP has proposed that significant iceberg furrows are included in the proposed mining exclusions areas.
Figure 12: Iceberg furrows stand out prominently on this map of the slope of the sea floor, based on multibeam swath bathymetry data collected in the western part of the mining licence area

129. A more refined version of the MEC system than that used for the BPA analysis has 200 MEC classes, four of which lie on the crest of the Chatham Rise in the region encompassing the marine consent area. The proposed mining exclusion areas include parts of all four of these MEC classes.

130. Some areas where basement rocks (schist or greywacke) are likely to be exposed at the seabed (Falconer et al. 1984) and that may offer large areas of hard substrate for organisms such as Goniocorella dumosa have been identified on seismic reflection data from the region but were not included in the model inputs. They are included in the mining exclusion areas.

131. CRP identified mining exclusion areas that are centred on areas predicted to be of high biodiversity value by the Zonation modelling or on areas of basement outcrop, that provide representative spatial coverage of the marine consent area, both along and across the crest of the Rise,
that are regularly shaped and that are large enough to be meaningful. The total proposed mining exclusion areas cover about 18% of the proposed marine consent area. NIWA scientists estimated the percentage of biodiversity protected by the proposed mining exclusion areas and presented the results as a spreadsheet (Rowden et al. 2014b)(Appendix 32 of the EIA).

132. The results show that the proposed mining exclusions areas could protect at least 80% of the suitable habitat for Communities n and o (those characterised by the stony coral Goniocorella dumosa) predicted to occur in the marine consent area. The proposed mining exclusion areas did not significantly increase the protection of some of the input factors, but these factors are not strongly represented in the marine consent area. For example, the total area predicted to have at least a 70% chance of a suitable habitat for Community g is 20 km$^2$ and for Community j it is 2 km$^2$. The inability of the proposed solution to protect communities with such small areas is not significant compared to the likely success in protecting the other communities.

133. The collection of carefully chosen environmental data integrated with existing data sets allowed NIWA scientists to predict the spatial distribution of benthic habitats and communities along the crest of the central Chatham Rise, an area of about 37,000 km$^2$. Similar data were used to predict the distribution of the phosphorite deposit beyond the densely sampled area in the mining licence area. The environmental and resource data were integrated and analysed to develop a spatial plan that balances economic and conservation values. Areas predicted to have high biological diversity and conservation values relative to their economic value are identified as preferred areas for protection; areas predicted to have high economic values relative to biological diversity and conservation values are identified as preferred areas for mining.

134. CRP has committed to using its best endeavours to try to ensure that the areas identified through the marine spatial planning exercise can be protected through an appropriate legal mechanism from all future seabed disturbance activities.
MINE PLANNING

135. In their evidence, Mr van Raalte describes the plan proposed to mine each mining block, Mr McKenzie describes the distribution of the resource, and Dr Rowden describes the distribution of benthic habitats in the marine consent area. This information has been used to guide the development of a plan to mine the resource in the mining permit area.

136. As Mr McKenzie says in his evidence, normal mine development and operations, regardless of whether they are onshore or offshore, require an on-going assessment of the factors affecting costs and revenue, and modification of these factors, if possible, to optimise the utilisation of the resource. The mining permit granted to CRP by New Zealand Petroleum and Minerals includes an obligation for on-going work in the mining permit area to refine the understanding of the resource distribution and to modify the mining schedule as required to maximise the utilisation of the resource.

137. Changes in costs or revenue can result in changes in optimum mining operations. For example, if the price of phosphate rises then areas with relatively low concentrations of phosphorite become economically viable and might be mined at a given point in time in preference to richer areas. The acquisition and interpretation of new geological and environmental data, along with other factors such as the development of new markets that affect the optimisation analysis, are likely to change the order in which the blocks are mined. This is standard practice in all mining operations and ensures the best outcome for the operating company and the Crown.

138. A sequence of mining blocks for the first 5 years was presented in the EIA. It was based on the resource and environmental data available when the EIA was written. It has been modified slightly from the sequence in the EIA and described in the response to the request for further information 6 from the EPA. The changes in priorities reflect recent input from mining geologists who included cost factors as well as production factors in the optimisation process.
139. Factors that controlled the choice of the mining blocks for the first five years are:

- large amount of existing data in the mining blocks;
- maximising economic returns in the early years of the project;
- avoiding mining exclusion areas;
- consideration of the potential for recolonisation of mined blocks; and
- the need to determine if there are significant spatial changes in sea floor properties across the mining permit area.

140. The early mining blocks target areas that are predicted to have high phosphorite concentrations. Most of these are in the western part of the mining permit areas, but some blocks are chosen in the eastern part of the permit areas to test the prediction that there is no significant spatial variation in the physical characteristics of the seabed sediments and to spread the environmental effects.

141. The information about benthic biodiversity guided the proposal for mining exclusion areas. These areas are predicted to have high conservation values and will not be mined, and the mining plan is designed to keep the thickness of discharged sediment below 1 cm in the mining exclusion areas.

142. The choice of mining block locations attempts to preserve local sources of benthic species to recolonise the blocks by immigration. The block sequence is chosen to minimise sedimentation overlap in any one year and reduce the number and extent of multiple sedimentation events over time.

143. Over a 15 year mining period the central part of the western licence area is predicted to receive multiple sedimentation events (more than 5) greater than 1 mm in thickness. This area is predicted to be surrounded by a zone about 5 km wide that receives 1 to 4 of these events.
DECISION TO REMOVE EASTERN PROSPECTING AREA

144. The primary reason the eastern prospecting permit application area (PPA55967) was included in the proposed marine consent area was to have sufficient space to demonstrate alternative spatial planning options to the BPA.

145. Following consultation with Ngai Tahu in March 2014, CRP became aware of cultural concerns about fossilised whale bones on the crest of the Chatham Rise. Most of these fossilised bones are thought to be in the area covered by the eastern prospecting permit application area. It would have been possible to include the known fossil localities in the proposed mining exclusion areas (and this has been done for the known locality in the revised marine consent area), but CRP decided that a better solution would be to remove the eastern prospecting area from the proposed consent area and refine the knowledge of the extent of the fossilised whale bone deposits during prospecting surveys in this permit area. The data collected by these surveys should provide a more comprehensive picture of the distribution of the fossilised whale bones, and if commercial deposits of phosphorite are identified in this area then more informed mining exclusion zones protecting them can be developed.

146. The discussions with Ngai Tahu also highlighted concerns of ling long-lining fishermen about the potential impact of mining activities. Subsequent reports on the extent of commercial fishing in the original marine consent area commissioned by CRP confirmed that ling long-lining is the only significant commercial fishing activity in the region. This activity is seasonal and it is my opinion that it might be possible to coordinate mining activities with long-lining. However, planning this coordination would add complexity to the application, and CRP decided that it would be best to remove the eastern prospecting area from the proposed consent area and reassess this issue if commercial deposits of phosphorite are identified.
RESPONSES TO SUBMISSIONS

The Crown

147. At paragraph 27 of the Crown’s submission (page 14) the Crown states "The Mid Chatham Rise BPA covers 8,732 km². It contains a benthic community dominated by stony corals, which are found in a significant concentration within the marine consent area."

148. The predicted distribution of stony corals is discussed in more detail in Rowden et al. (2013, 2014a,b)(Appendix 15, 16, 32). The models of benthic habitat and community structure predict that habitat suitable for this community extends beyond the mining permit area. The proposed no-mining areas include those parts of the proposed marine consent area with the highest probability of hosting this community. The proposed conditions provide for the protection of new areas of significant biodiversity value identified by the on-going environmental surveys that will be undertaken by the project.

149. At paragraph 28, the Crown then states "Large scale mining within the BPAs has the potential to undermine their purpose of mitigating impacts on the benthic environment from deepwater bottom fishing activities and would be inconsistent with the fishing industry and decision-makers’ intent in establishing the BPA network."

150. The objective of a marine reserve should be to maximise environmental, economic and cultural values of New Zealand’s ocean space. The BPA’s address one component of this objective, but as pointed out earlier in my evidence their potential economic costs were ignored. The purpose of the spatial planning exercise undertaken for this project that defined proposed mining exclusion zones was two-fold: first of all to identify areas predicted to have high conservation values and relatively low economic values, and secondly to show that it is possible to use modern data and analysis tools to derive proposals for reserve areas that reflect multi-dimensional values and costs. The desired outcome is not that there is a net loss in conservation area or value on the Chatham Rise, but rather that the areas are more carefully chosen to maximise the full
suite of social values: environmental, economic and cultural. The only change to the design criteria of the existing BPA’s that might be required if they are modified using new data is that the areas may no longer be as large or have as simple shapes.

151. At paragraph 29, the Crown states "Mining in the Mid Chatham Rise BPA could undermine international recognition of the area’s status as a protected area. Under IUCN guidelines for classifying marine protected areas, mining can only take place at a scale that is compatible with the area’s stated conservation management objectives. Allowing mining within the BPA could raise questions internationally over New Zealand’s commitment to biodiversity protection.”

152. As stated above, the desired outcome is not that there is a net loss in conservation area or value on the Chatham Rise, but rather that the areas are more carefully chosen to maximise the full suite of social values: environmental, economic and cultural. New Zealand’s commitment to biodiversity protection would be strengthened if better data than the EEZ-wide datasets that underlie the BPA’s were used to show that the protected areas have biodiversity value.

153. At paragraph 41 the Crown states” Furthermore, while the mining exclusion areas will not be directly mined, they may be affected by sediment resulting from adjacent mining (within 3km based on the results of the plume modelling. Buffers will be required to mitigate sedimentation effects in these areas.

154. The predicted effect of sediment on the proposed mining exclusion areas is discussed in the answer to EPA questions 6 (see also the answer to EPA question 7). The models predict that the effects of sediment distribution will not extend far beyond the mining blocks, and that the proposed mining exclusion areas will have little or no sediment deposition.
Deep Water Group

155. Paragraph 15.2 of the DWG’s submission states “Is over-reliant on un-validated models and lacks real baseline data. The baseline monitoring data is spatially limited in comparison with the large size of the application area, and does not reflect the full range of seasonal, spatial or annual variability. Baseline information for the area beyond CRP’s mining permit is almost entirely absent and the majority of Appendices address the “initial mining area” only;”

156. The coverage of data could always be improved, but there are more data available for the proposed marine consent area than any comparable part of New Zealand’s EEZ. CRP is committed to collecting more baseline oceanographic and environmental data throughout the term of the project, and contributing those data to national databases for the national good. I believe that the data supporting this application provide data at sufficient temporal and spatial scales to understand the primary environmental drivers and guide management decisions.

157. Oceanographic data and its verification are discussed in EIA Appendices 8 and 10. Design of the environmental surveys and validation of the data are discussed in EIA Appendices 15, 16 and 32.

158. Paragraph 18.1 of the DWG’s submission states “The proposed “no-mining” areas do not serve to mitigate or offset or compensate the adverse effects of CRP’s mining activity. CRP does not own the seabed and has no control over the use of these areas by other parties or of future marine protection regulatory processes. The no-mining area is therefore ineffective as it is not protected by a statutory mechanism nor is it in place in perpetuity. Moreover, by promoting the exclusion of other users from the no-mining areas CRP seeks to shift the cost of mitigation of adverse effects of mining to the fishing industry;”

159. The appropriateness of the BPA’s could be subject to the same criticism, i.e. they have no influence over the use of these areas by activities other than bottom trawling. Promoting the exclusion of mining from the BPAs shifts the cost of mitigation of adverse effects of fishing to the mining industry and other potential users.
160. As stated above, the desired outcome is not a net loss in conservation area or value on the Chatham Rise, but rather that conservation areas are more carefully chosen to maximise the full suite of social values: environmental, economic and cultural.

161. A comparison of the adverse effects of fishing and mining has been provided in the response to EPA question 37.

162. At paragraph 18.4, the DWG says "The monitoring programme is sporadic and limited, with no real-time monitoring of the plume or other aspects of the mining operation to confirm that it is operating as predicted."

163. The proposed monitoring programme includes both continuous and periodic components. It is a compromise between capability and affordability. The dynamic ocean conditions and relatively remote location of the site make it impractical to maintain continuous, real-time monitoring of the mining operations.

164. The monitoring programme includes moorings deployed around the mining sites that provide continuous, long-term records of turbidity, oceanographic conditions, and sound levels. Periodic surveys by an AUV or similar instrument will provide a 3D image of the plume concentration and extent, and of the effects of sedimentation. The mooring data will be retrieved at least as frequently as the AUV surveys are conducted, possibly more often if required by biofouling of the sensors. CRP and Boskalis have identified procedures that will be followed if the monitoring indicates the mining system is not operating as predicted.

165. The proposed monitoring programme is budgeted to cost US$3 million per year.

Fisheries Inshore New Zealand

166. Paragraph 12 of this submission states "Chatham Rock has proposed a number of initiatives which it contends will sufficiently mitigate the adverse impacts of their mining activities. The proposal to set aside
areas for no mining appears to be setting aside those areas that are commercially unattractive rather than having a scientific underpinning to protect the remaining ecosystem and provide sufficient critical mass for the mining-impacted ecosystem to recover."

167. The analysis that was used to identify areas to set aside as mining exclusion zones is described in Appendix 32 and in my evidence. The potential economic value of the areas was one factor, but the analysis was primarily driven by environmental data. It is likely that some or all of the mining exclusion areas contain economic deposits of phosphorite, but they are proposed to be set aside for environmental or cultural reasons. The areas identified as mining exclusion zones all have predicted levels of high biodiversity, are areas where other data indicate hard substrate (and therefore favourable habitat for corals) is likely to occur, are areas where fossils of cultural importance are predicted to occur, or are areas preserved for their cultural geologic value (iceberg furrows).

Ray Wood
28 August 2014