



## REVIEW OF TECHNICAL REPORTS ON COMMERCIAL FISHERIES

**Date:** 23 May 2014

**REVIEW OF REPORT(S) BY:** JPEC Ltd

**FOR:** THE ENVIRONMENTAL PROTECTION AUTHORITY  
(EPA)

*NB: This report is a review of the technical report(s) provided by Chatham Rock Phosphate (CRP)*

- 1. The contractor is required to review the quality of information provided and comment on whether best available information has been used<sup>1</sup> and to identify any areas of uncertainty or inadequacy in the information. The report should also describe areas where further information might be necessary to inform an assessment of the effects.*
- 2. The report should not make any recommendation on whether the application should be approved or declined.*

### Introduction

#### *Scope and nature of review*

1. This review relates to the marine consent application and environmental impact assessment lodged by Chatham Rock Phosphate Ltd (Golder Associates (NZ) Ltd 2014). The activity that the consent application and impact assessment relate to is mining submarine phosphorite deposits on the Chatham Rise. The marine consent process is triggered by this activity under the Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012 (referred to hereafter as the “EEZ Act”). This review is commissioned under section 44 of that Act.

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<sup>1</sup> Section 61(5): Best available information means the best information that, in the particular circumstances, is available without unreasonable cost, effort or time

2. The proposed activity will be undertaken using a custom-fitted vessel to remove material from the seabed for on-board processing to separate phosphate-containing particles  $\geq 2$  mm in size from the rest of the benthic material collected. Following processing, waste material will be piped underwater from the vessel for discharge on average within 10 m of the seabed in mined areas.
3. The area covered by the marine consent application spans 10,192 km<sup>2</sup> <sup>(2)</sup>. This includes (i) Minerals Prospecting Licence (MPL) 50270 granted in 2010, at 4,726 km<sup>2</sup> in area, and of which 1,019 km<sup>2</sup> is under offer of relinquishment, (ii) an 820 km<sup>2</sup> area inside MPL 50270, for which a mining permit was granted in 2013 (MP 55549), and, (iii) two areas comprising a total of 6,486 km<sup>2</sup> for which prospecting permit applications (PP 55971, PP 55967) have been lodged (Figure 4, Golder Associates (NZ) Ltd (GANZ) 2014). The marine consent is sought for a period of 35 years.
4. The scope of this review is commercial fisheries. That is, the components of the marine consent application and environmental impact assessment relating to commercial fisheries have been reviewed. In addition, certain appendices to that application and assessment document have been considered, where these include material relevant to commercial fisheries. Specific appendix documents are referred to as appropriate in this review report.
5. The review is technical in nature. It considers the applicant's description of the existing environment in relation to commercial fisheries and whether the effects of the proposed mining activity on this environment are adequately addressed. This includes a consideration of the uncertainty and adequacy of information available (reference s 61 1(c), EEZ Act). Further, the review considers whether best practice modelling and the best available information (reference s 61 1(b), EEZ Act) have been used, and the identification of (i) known thresholds or accepted levels of effects, (ii) areas of uncertainty in the effects and the potential scale and significance of these, and, (iii) areas where further technical information is considered necessary to ensure the effects of the proposal are adequately assessed and that the analysis of effects takes into account the best available information.
6. The effects of oil (or other chemical) spills resulting from the mining operation on commercial fisheries are not considered in this review.

*Key components and findings of the consent application and impact assessment*

7. GANZ (2014) reported that commercial fishing occurring on the Chatham Rise includes the mid-water and bottom trawl and bottom longline methods, catching species such as hoki (*Macruronus novaezelandiae*), hake (*Merluccius australis*), alfonsino (*Beryx splendens*, *B. decadactylus*), orange roughy (*Hoplostethus atlanticus*), black and smooth oreos (*Allocyttus niger*, *Pseudocyttus maculatus*), warehouse (*Seriolaella* spp.), ling

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<sup>2</sup> Note that the individual areas comprising the marine consent area add to a total of 10,193 km<sup>2</sup>. The difference is presumably a consequence of rounding the figures.

(*Genypterus blacodes*), pale and dark ghost sharks (*Hydrolagus bemisi*, *H. novaezelandiae*), scampi (*Metanephrops challengeri*), spiny dogfish (*Squalis acanthias*), lookdown dory (*Cyttus traversi*), sea perch (*Helicolenus* spp.), and stargazer (*Kathetostoma giganteum*).

8. The probabilities of capture of these species (except scampi and stargazer) and others are predicted across the Chatham Rise in Golder (2014a). Predictions are based on modelling using information on fish distribution collected from research trawls conducted from 1979 – 2005. Environmental information was also incorporated (e.g., depth, sea surface and estimated sea floor temperature, and chlorophyll-a concentrations). Model-fitting was conducted using boosted regression trees; modelling methods are described in detail by Leathwick et al. (2006).
9. The hoki fishery is one of New Zealand’s most economically important fisheries. It is certified as sustainable by the Marine Stewardship Council, and has been since 2001. GANZ (2014) report that in 2008, the total market value of hoki quota was estimated at \$730 million. O’Driscoll and Ballara (2014<sup>3</sup>; Appendix 18) report that the estimated value of hoki exports in 2012 was \$195 million.
10. In 2011/12, 30% of the catch of hoki taken from the New Zealand Exclusive Economic Zone was landed at the Chatham Rise. Other areas in which hoki are fished include Cook Strait. The Cook Strait fishery is based on spawning hoki, whereas the Chatham Rise fishery catches non-spawning fish. By catch weight, bottom trawling was the most important fishing method used to capture Chatham Rise hoki (GANZ 2014; O’Driscoll and Ballara 2014).
11. Hoki are predicted to occur across the entire marine consent area with a probability of capture of 100% in most of this area. The probability of capture falls below 100% at the eastern end of PP 55967 (Golder 2014a).
12. In addition to reporting on some characteristics of the fishery, O’Driscoll and Ballara (2014) reviewed the biology and distribution of hoki on the Chatham Rise. This report found that in most years, > 80% of the hoki between 2 and 3 years old occur on the Rise. Older and younger (1-2 years) hoki also occur there. Spawning females are occasionally caught on the western Chatham Rise, but an analysis using fisheries observer data from 1990 – 2013 revealed spawning fish have seldom been sampled elsewhere on the Rise.
13. Hoki catchability is known to vary with time of day; catch rates are highest from 0900h-1200h NZST. Trawl survey tows show mean catch rates in the marine consent area (excluding the areas proposed for relinquishment) to be lower than the whole of the Chatham Rise for hoki 1-2 years old, whereas rates for hoki 2-3 years old and 3 years and older were similar (O’Driscoll and Ballara 2014).

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<sup>3</sup> citing <http://www.seafoodnewzealand.org.nz/our-industry/key-facts/>

14. Hake is trawl-caught as non-target species in the hoki fishery and also as a target species (GANZ 2014). Hake are predicted to be caught throughout the marine consent area but with the highest probabilities of capture in MPL 50270. HAK 4 is the Quota Management Area (QMA) relevant to the marine consent application. GANZ (2014) report that catches in this QMA have declined since 1998/99 to 161 t in 2011/12.
15. Ling is harvested using the longline and trawl methods. GANZ (2014) draw on Dunn et al. (2013) in reporting that the Chatham area was the most productive for the ling longline fisheries although recent catches are substantially lower than at the peak of the fishery in the mid-1990s. Ling export revenues were approximately \$54 million in 2007 (MPI 2013).
16. Citing Horn et al. (2013), GANZ (2014) report that current ling catches are likely to be sustainable long-term, but catches at the level of the total allowable commercial catch are considered likely to cause declines. Golder (2014a) reported that the probability of capturing ling is 100% in much of the marine consent area, except PP 55967 where probabilities of capture are still moderate to high.
17. Silver warehou (*Seriolella punctata*), white warehou (*Seriolella caerulea*), alfonsino, and ghost sharks are taken as non-target catch of other fisheries (e.g., hoki), and some target fishing may also occur (e.g., for silver warehou, alfonsino). These species show a range of probabilities of capture throughout the marine consent area, including > 50% (Golder 2014a).
18. Many other commercial species occur in parts of the marine consent area with low to moderate probabilities of capture, for example, tarahiki (*Nemadactylus macropterus*), common warehou (*Seriolella brama*), rig (*Mustelus lenticulatus*), gemfish (*Rexea solandri*), school shark (*Galeorhinus galeus*), Ray's bream (*Brama brama*) and southern blue whiting (*Micromesistius australis*) (Golder 2014a).
19. While orange roughy are caught on the Chatham Rise, their probability of capture in the marine consent area is zero (Golder 2014a).
20. Note that conclusions in GANZ (2014) are not always concordant with prediction plots in Golder (2014a), for example, relating to the likelihood of catching white warehou in the marine consent area.
21. Spiny rock lobsters (*Jasus edwardsii*) and longfin (*Anguilla dieffenbachii*) and shortfin eels (*A. australis*) have not been caught on the Rise, but these species also form the basis of commercial fisheries. The potential for mining impacts on these species was raised by stakeholders. However, due largely to the probable distribution of these animals at various life stages away from the mining area, mining was assessed as unlikely to have any impacts and these species were not considered further (MacDiarmid 2013; GANZ 2014).

22. The potential mechanisms identified by GANZ (2014) through which mining may affect commercial fisheries on the Chatham Rise are manifold. Potential impacts identified include the disturbance of (i) fish by mining equipment at the seabed, (ii) key fish species by the sediment plume resulting from the mining activity, (iii) scampi and the removal of scampi in their burrows, and, (iv) spawning behaviour and the eggs of key species. Ling is highlighted as an example of a commercial species likely to be locally affected by mining activity, given this species' extensive utilisation of demersal habitat including during spawning.
23. The possible impacts of total suspended solids and sedimentation on fish, including eggs and larvae, are reviewed (Page 2014a, b; Appendices 27, 28). Reviews highlight the paucity of available information on total suspended solids that is directly relevant to fish stocks occurring on the Chatham Rise, including the different life stages of these stocks.
24. Historic and current anthropogenic pressures on the Chatham Rise have the potential to lead to cumulative impacts on the marine environment. GANZ (2014) consider the cumulative impacts of mining on the Chatham Rise in the context of other anthropogenic impacts: whaling, and trawl fishing impacts on seabirds, marine mammals, benthos and non-benthic bycatch species.
25. Overall, the marine consent application and environmental impact assessment (GANZ 2014) reports that the potential impact of mining on fisheries resources is a low environmental risk. This results from the conclusion that the potential impacts of the mining activity are unlikely to occur, and that impacts would be restricted to the mined area, short-term (< 6 months) in duration, and reversible. The potential consequence of impacts is identified as medium. Off the main crest of the Chatham Rise and within short distances of the mining activity, no significant impacts on key spawning, juvenile or young fish habitats were identified.
26. The assessment concluded that mining will contribute to cumulative impacts on benthic resources on the crest of the Chatham Rise. However, the extent of this impact is identified by GANZ (2014) as being very small compared to the area affected by bottom trawling. Further, the intensity of the impacts is identified as different for fishing, in which case habitats may be trawled more than once, compared to mining, in which case any area will be mined once (although impacts caused by the return of the processed material to the seabed will occur throughout the mining period and the possibility of a second pass of mining is raised in the consent application).

#### *Overview of review findings*

27. The marine consent application and environmental impact assessment prepared by GANZ (2014) and submitted by Chatham Rock Phosphate Ltd contains a significant amount of information relating to commercial fisheries and the potential effects of mining activity on those fisheries.

28. In reviewing the information provided, five main areas emerge where additional information is needed, and is available, to better assess the effects of the activity proposed:

- a more detailed characterisation of the commercial fishing activities in the full marine consent area, in terms of methods, areas, and landed catches by species, and including the recent data available (i.e., to the end of the 2012/13 fishing year);
- an up-to-date evaluation of the spawning areas used by commercial species in the marine consent area and across the Chatham Rise;
- a more focused investigation of information on underwater noise produced by dredging and any known sensitivities of marine fish to noise in this range;
- consideration of the cumulative effects of mining through the entire spatial and temporal extent of the marine consent sought, and including bottom longline fishing, as well as trawl fishing conducted on the sea floor, in that consideration; and,
- consideration of the effects of displacement and exclusion of fishing effort from the mining area in both environmental and utilisation-focused contexts.

29. In addition, a more robust assessment of the effects of mining would be facilitated by clarifying some details of the activity proposed (e.g., whether mining be undertaken using one or two passes over the substrate, and the depth of the second pass, if it occurs).

## Analysis of the information

### *Commercial fish species and life stages present*

30. The marine consent application and environmental impact assessment document identifies a number of commercial fish species, comprising “main” commercial fisheries on the Chatham Rise and “bycatch” species included in the Quota Management System (QMS). The commercial species comprising the “main” fisheries include hoki, hake, ling, scampi, silver warehou, orange roughy and oreos. The QMS species considered as bycatch here include, for example, spiny dogfish, stargazer, pale ghost shark, and lookdown dory. Examples of bycatch species not included in the QMS are also listed.

31. The work of Hurst et al. (2000) and O’Driscoll et al. (2003) provides the basis for an examination of the distributions of various life stages of fish on the Chatham Rise, including commercial species (e.g., as presented in Tables 11 and 12, and various text sections). Hurst et al. (2000) and O’Driscoll et al. (2003) used the (former) Ministry of Fisheries ‘*trawl*’, ‘*obs\_lfs*’ and ‘*obs*’ databases (Sanders and Fisher 2010; Mackay 2011) as the main sources of information for much of their reports.

32. The *trawl* database comprises data collected from research trawls conducted by research vessels and chartered commercial vessels. In addition to trawl survey data, the *trawl* database also includes information collected during trawl surveys but using other sampling methods (Mackay 2011). The *obs\_lfs* and *obs* databases are now incorporated into the Central Observer Database (*cod*), which includes catch-effort and biological information for commercial (and non-commercial) species (Sanders and Fisher 2010).
33. These databases contain a significant amount of accessible information collected in research and monitoring contexts since the Hurst et al. (2000) and O’Driscoll et al. (2003) work was completed. Therefore, updated extracts from the *trawl* and *cod* databases should be used to provide updated distributions of different life stages of commercial fish for consideration as part of this marine consent application. This would be particularly useful for commercial species (and particular life stages) for which distributions in the marine consent area are not well elucidated based on the older information in the Hurst et al. (2000) and O’Driscoll et al. (2003) reports. (Note that O’Driscoll and Ballara (2014) present an update of where spawning hoki have been caught using data collected by fisheries observers. Therefore, that work would not need repeating).
34. O’Driscoll et al. (2003) followed the analytical approach used by Hurst et al. (2000). A re-examination of these methods would be appropriate with a view to updating them if needed, given developments in knowledge and analytical methods in the intervening period of more than a decade.

#### *Ecosystem context*

35. In addition to describing the distributions of some species, commercial fish are considered in an ecological context in the consent application and impact assessment, for example, as part of fish assemblages characterised using distribution and environmental conditions (Table 13, informed by the work of Leathwick et al. (2006), (GANZ 2014)), guilds (Table 14, GANZ (2014)), and in the trophic model described by Pinkerton (2013).
36. The mass-balance food-web model described by Pinkerton (2013) evaluates the trophic structure of the Chatham Rise, and includes commercial fish species. The trophic model encompasses the marine consent area, and goes beyond it in all directions to cover much of the Chatham Rise.
37. Mass-balance models are effective tools widely used for exploring ecosystem dynamics, testing knowledge of ecosystem structure, and exploring the effects of environmental changes and environmental management scenarios<sup>4</sup>. As with any modelling approach, assumptions are necessary to support model construction and operation.
38. Pinkerton’s (2013) model addresses trophic connections and non-trophic transfers of organic carbon. Beyond trophic connections and carbon transfer, organism functions are

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<sup>4</sup> e.g., [www.ecopath.org](http://www.ecopath.org)

not considered in the model. For example, the overall ecological importance of biogenic habitat-forming organisms such as corals is not evaluated (e.g., Costello et al. 2005; D’Onghia et al. 2011). Assumptions used in the Pinkerton (2013) model include that there are no long-term trends playing out in the ecosystem and that it is in balance in an “average” year.

39. Significant uncertainties are unavoidable in the mass-balance modelling approach given the imperfect nature of datasets. For example, Pinkerton (2013) notes that better information on the abundances of middle-trophic level prey species on the Chatham Rise would help constrain the model. In addition, the model has not been validated (e.g., using isotope analyses) and Pinkerton (2013) identifies that exploring the effects of parameter uncertainty would be informative.
40. Commercial fish species prevail in the demersal fish group included in the model. This group is supported by six middle-trophic level groups, which provide 82% of demersal fish prey overall. These prey were arthropods, small demersal fish, mesopelagic fish, squid, krill and salps (Pinkerton 2013). Significant changes in the biomass of these key prey groups could reasonably be expected to have some effect on the biomass of their commercial fish predators. Effects of mining on pelagic species are expected to be minimal given sediment plumes are not expected to enter the upper water column and the euphotic zone (GANZ 2014).
41. Amongst commercial fish species, hoki showed the highest trophic importance in the model. On that basis, changes in hoki biomass would be expected to have substantial flow-on ecosystem effects through trophic linkages. Most other commercial species tended towards mid-level importance, but may also contribute to flow-on effects.
42. Despite any limitations of the model (e.g., as are inevitable given the data available), it incorporates a huge volume of data and provides a useful tool to evaluate the trophic importance of fish, including commercial species, in the Chatham Rise ecosystem. It also supports considerations of the potential indirect effects of mining on commercial fish species, should mining affect, for example, the prey organisms consumed by these species.
43. Commercially important fish species and trawl fishing activity are also usefully considered in the analysis of spatial management options undertaken (Rowden et al. 2014; Appendix 32). Rowden et al. (2014) note the potential to include longline fishing data in future iterations of this work. Describing how this work will be progressed would contribute to an assessment of the environmental effects of the mining proposed.

*Potential effects of mining on commercial fish species and life stages*

44. The marine consent application and environmental impact assessment document identifies the following amongst the potential effects of mining. These effects may be relevant to commercial fish species:

- changes in water quality around the drag-head
  - increased levels of suspended sediment
  - increased sedimentation
  - noise caused by the mining operation
  - disruption of spawning behaviour
  - disturbance of scampi and fish eggs on the sea bed
  - disturbance of fish around the drag-head
  - benthic habitat loss in mined areas
  - entrainment of biota by the drag-head (e.g., scampi, fish eggs)
  - possible entrainment of biota in the jet intake approximately 20 m above the seabed
45. Effects are clearly dependent on the location and characteristics of the mining activity. Therefore, in addition to local effects at and immediately adjacent to the site of mining operations, the extent to which effects propagate through fish habitat is important.
46. Referring to Golder (2014b) and the operation of the mining method, GANZ (2014) conclude that potential changes in water quality are largely associated with sediment dynamics following the disposal of the mined material post-processing.
47. The depth at which material is deposited post-processing is shown, using modelling (Hadfield 2013; Deltares 2014), to affect the characteristics of the resultant sediment plume. On the basis of that modelling, the post-processing material disposed of will be deposited at not more than 10 m above the seabed, on average (GANZ 2014).
48. The models of Hadfield (2013) and Deltares (2014) have not been reviewed here and their outputs are taken as presented in GANZ (2014). In summary, modelling shows that suspended sediment plumes will be centred on the mining area and the plume dimensions, while varying with season, are expected to end in the order of (low) tens of kilometres of the mining site horizontally, and the seabed vertically. Concentrations of total suspended solids near the seabed at the Chatham Rise are reported in GANZ (2014) to have been measured at 0.1 – 1 mg/L. Model predictions exceed these concentrations with increasing proximity to the mining site.
49. Within a few days of the cessation of mining, suspended sediment concentrations are predicted to return to levels comparable with the lower end of ambient levels. Modelling of suspended solids finds that no suspended clay and silt from the return of post-processing waste will extend into the euphotic zone or above the mixed layer (GANZ 2014).
50. Sedimentation of discarded post-processing material on the seabed will also be centred on the mining area. Some resuspension of mined sediments may occur at the seabed (GANZ 2014).
51. Sudden releases of sediment higher than the (on average) 10 m above the seabed at which material is to be discharged post-processing may occur following a blockage in the riser.

The resultant plume is estimated to be 10 m in diameter and settle to the seabed within 40 m of the release point (GANZ 2014).

52. The effects of suspended sediment on plankton, fish eggs, larvae, and older fish are considered in the reviews by Page (2014a, b). Page (2014a) found few reports describing the occurrence of fish eggs and larvae in the area of MPL 50270. The full extent of the marine consent area should be considered.
53. Sensitivities to suspended sediments for non-New Zealand species vary widely, for example, with the effects on eggs and larvae becoming apparent at low (e.g., 3 mg/L) to high levels (e.g., 1,000 mg/L) (Page 2014a).
54. Given the difficulties with detecting eggs and larvae at sea, considering the occurrence of running ripe females as indicators of spawning activity is recommended by Page (2014a). Considering spent animals (O'Driscoll et al. 2003; Horn 2005) is also appropriate in this regard. However, as noted by Page (2014a), the locations of eggs is also affected by currents and buoyancy changes during development.
55. While noting that spawning location is only part of the picture, identifying all commercial species known to spawn on the Chatham Rise would contribute to the assessment of potential impacts of the mining activity on fish eggs, and larvae, depending on the distances these drift from spawning sites. (See paragraphs 33 – 34 above).
56. Page (2014a) notes that little information is available on the structure and vulnerability of eggs of Chatham Rise spawners to suspended sediments. Some anecdotal information on egg adhesion is provided in Patchell et al. (1987). While not formally quantifying adhesion, Patchell et al. (1987) note that the some eggs of some species (e.g., 80% of hake and 20% of hoki eggs) were sticky, while others (silver warehou) were not.
57. Beyond the egg and larval stages, Page (2014a, b) notes the lack of studies on the effects of suspended sediment on New Zealand marine fish. Numerous studies are available of lethal and sub-lethal levels of suspended sediment for fish species found elsewhere. However, the appropriateness of generalising these to New Zealand marine species is unknown.
58. Key influences across all studies appear to be the concentration of sediments and exposure duration (e.g., Wilber and Clarke 2001). Sediment concentrations and exposure durations are considered in relation to (albeit not thoroughly known, and variable) ambient levels in the modelling undertaken for the marine consent application (Hadfield 2013; Deltares 2014).
59. Fish foraging efficacy and depredation may also be affected by turbidity. Again, Page (2014b) found no work on New Zealand marine species in these respects. However, studies on other species includes striped bass (*Morone saxatilis*) larvae (Breitburg 1988) and chum salmon (*Oncorhynchus keta*), walleye pollock (*Theragra chalcogramma*) and sablefish (*Anoplopoma fimbria*) (De Robertis et al. 2003).

60. Page (2014a, b) concluded that based on the information available and knowledge gaps in relation to New Zealand species that dedicated research would be required to understand the effects of suspended solids on fish at all stages of their life history, and that species for which any life stage is spent near or at the sea floor (e.g., ling), the risks of negative impacts of suspended solids are greatest.
61. No additional information was found on thresholds relevant to tolerances of marine fish to total suspended sediments or sedimentation.
62. The significance of uncertainties about the vulnerability of fish eggs, larvae and adults to suspended solids and sedimentation may be scaled by considering the extent of the sediment plume.
63. No specific information is available on the noise associated with the operation of the drag-head, riser, sinker, and pump unit to be used in the proposed mining operation. GANZ (2014) reflects that the typical noise levels associated with the operation of dredging vessels are 180 – 190 dB re 1 $\mu$ Pa at 1 m, but note that this varies between vessels.
64. Considering the effects of underwater noise on fish is a standard part of best practice for assessing the impacts of submarine developments and activities. The effects of noise on fish are less well known than, for example, marine mammals (e.g., Weilgart 2007). However, a substantial body of information is available, albeit diverse in nature. For example, studies traverse a range of submarine activities, types of noise, durations, distances, etc.
65. The effects of noise on fish responses may include behavioural disturbance, masking of ambient noises relevant to fish, temporary hearing loss, physical damage, fish moving towards vessels, and fish leaving an area, e.g., by diving (Popper et al. 2006 and reviewed in De Robertis and Handegard 2013). Responses to noise also differ amongst different species of marine fish (De Robertis and Handegard 2013).
66. As reported in GANZ (2014), a number of limits for noise in relation to industrial activities have been identified, e.g., for shipping, seismic surveys and pile driving.
67. Other limits have been identified in relation to concerns about fish avoidance of research vessels conducting fishery surveys (De Robertis and Handegard 2013). For example, in response to concerns about fish avoidance of noise biasing fishery surveys, the International Council for the Exploration of the Sea (ICES) developed low frequency limits of 1 – 1000 Hz for underwater radiated noise produced by research vessels. However, the ICES limit on radiated noise is known to be well above the hearing thresholds of many marine fish. De Robertis and Handegard (2013) conclude that given the current state of knowledge, noise produced by research vessels may still affect fish behaviour.

68. Another set of criteria against which to assess underwater noise are provided by Nedwell et al. (2007). These criteria relate to decibel limits above specific species' hearing thresholds.
69. A wide variety of sensitivities to noise are reported in the literature. Citing examples including cod (*Gadus morhua*), Mitson and Knudsen (2003) considered that the hearing capability of marine commercial fish species ranges from “a few hertz to possibly tens of kilohertz”. GANZ (2014) refer to the review work of Kastelein et al. (2008) on other marine fish species as well.
70. Presenting a summary of studies examining the sensitivities of fish to noise in the marine environment in the range reported to be produced by dredges<sup>5</sup>, or at similar levels to the noise considered likely to result from the mining operation, and including propagation distances of these noise levels, would be informative for this assessment, while recognising that information from New Zealand species *per se* is lacking. Considering cutter-suction dredges as well as trailing suction dredges may be appropriate in this context, given the make-up of the drag-head described.
71. GANZ (2014) reports that the guidelines of the World Organisation of Dredging Associations (WODA 2013) will be used, in relation to assessing underwater noise in the proposed mining area. Noise monitoring is proposed at the start of mining operations, and noise management measures are identified in Table 32. Additional information on how WODA guidance (or other noise management approaches) will be utilised is needed, especially in the context of knowledge gaps on the characteristics of noise emitted by the mining operation and the sensitivities of New Zealand marine fish to noise.
72. Noise and the passing drag-head may disturb spawning fish, and the potential effects of this will be better assessed on the basis of updated information collated on spawning as per paragraphs 33 – 34 above.

#### *Cumulative impacts*

73. The cumulative impacts of the mining activity are considered in relation to human impacts on seabirds and marine mammals, non-benthic fisheries bycatch and benthic fishing impacts. The assessment focuses on bottom trawling. GANZ (2014) conclude that mining will result in cumulative impacts on benthos, in addition to those caused by bottom trawling, but conclude that the cumulative impacts of mining will be small in contrast to fishing. This conclusion is based on the area of mining (450 km<sup>2</sup> over the first 15 years), and the operation of a single-pass system.
74. However, whether mining will be conducted in a single pass (removing 0.35 m of material per pass on average, and up to 0.5 m) or will also include a second pass in at least some locations is not clear (page 50, GANZ (2014)).

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<sup>5</sup> e.g., as found in [www.ntepa.nt.gov.au/\\_\\_data/assets/pdf\\_file/0020/7436/EAW\\_EIS\\_ch13.pdf](http://www.ntepa.nt.gov.au/__data/assets/pdf_file/0020/7436/EAW_EIS_ch13.pdf)

75. Further, the modelling of Mormede and Dunn (2013) is used in GANZ (2014) to convey that mortalities of 50 – 80 % of benthic organisms occur in one trawl. Mormede and Dunn (2013) note that such mortality estimates could be derived in a variety of ways (e.g., using expert knowledge and considering the impacts of different parts of the fishing gear). In any case, fishing impacts assumed to cause partial mortalities amongst benthic fauna are in contrast to the mortality of all organisms removed from the seabed, as is expected during the mining operation (GANZ 2014).
76. The assessment of cumulative impacts on the benthic environment does not appear to consider bottom longline activity. While the effects of bottom trawling on benthos and the seabed are recognised as more severe than bottom longlining, the latter fishing method also has benthic impacts (e.g., Chuenpagdee et al. 2003; PFMC 2005; NEFMC 2010). These should be considered as part of the evaluation of cumulative impacts.
77. In addition, the assessment of cumulative impacts should clarify whether trawls classified as mid-water, but occurring on the bottom, are included.
78. Finally, a Benthic Protected Area (BPA) overlaps significantly with the marine consent area (Figure 6, GANZ (2014)). BPAs legally took effect in 2007 and comprise spatial restrictions on bottom fishing activities<sup>6</sup>. (Note that BPAs do not exclude bottom longline fishing). Therefore, mining will cause benthic impacts in a seabed area where bottom trawling is not permitted. Mining this area could contribute significantly to cumulative impacts with respect to benthic disturbance on the Chatham Rise and should be considered.
79. In addition to the cumulative effects of extractive activities on the environment, the cumulative effects of all fishing exclusions are relevant in an economic context. The BPA excludes some fishing methods, and mining activity will add to areas in which fishing cannot occur, at least in the short term. As mentioned elsewhere in this review, the extent of the exclusions combined is important to consider, in the short-term (e.g., due to the presence of the mining vessel, sediment plumes and noise) as well as longer term (e.g., if fish do not readily recolonise mined areas).

*The nature and extent of commercial fisheries and mining effects*

80. As noted above, the marine consent application and environmental impact assessment contains a significant amount of information relating to commercial fisheries and the potential effects of mining activity on those fisheries.
81. A more cohesive, systematic description of the commercial fisheries occurring in and around the marine consent area would facilitate the assessment. For example, a comparison of the proportion of total allowable commercial catch (TACC) caught in the marine consent area (or the best possible spatial approximation for the area, given the

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<sup>6</sup> <http://www.fish.govt.nz/en-nz/Environmental/Seabed+Protection+and+Research/Benthic+Protection+Areas.htm>

available data) versus the rest of the relevant species' QMAs would be informative to an assessment of potential mining effects. Reporting these catches over time, e.g., a five year period (ending with the 2012/13 fishing year) would be appropriate.

82. Conducting a similar analysis, i.e., comparing catches inside consent area versus within the boundaries of the appropriate QMA, using catch rates (or volumes) derived from trawl survey data would also be informative, especially given the exclusion of bottom trawl fishing from the BPA.
83. Baird (2014; Appendix 19) characterises longline fishing effort targeting ling from 1990 – 2013 in an area on the Chatham Rise that encompasses the extent of the marine consent application. As mentioned in paragraph 81, evaluating the importance of these areas in terms of catch landed, compared to other areas inside the QMA, will better indicate the importance of the area covered by the marine consent application in a fisheries context.
84. Some information on trawling is presented in Beaumont et al. (2013) as Appendix 14 to the application. This appendix does not deal with the full extent of the marine consent area. Information on trawl fisheries in the full extent of the marine consent area is therefore required.
85. In addition, the information included in Beaumont et al. (2013) should be updated. Information up to the end of the 2012/13 fishing year is available on the location of trawl fishing effort, and catch information by species (e.g., in the MPI database *warehouse*). This up-to-date information should be used to inform the assessment of the consent application.
86. It would be useful to overlay the marine consent area on the map in Figure 94.
87. Mid-water trawl statistics presented do not quite cover the entire marine consent area and it would be useful to capture the area across the boundary of statistical areas 404 and 049, and 410 and 052. In addition, one more fishing year of mid-water trawl effort information is now available (2012/13). However, these are not expected to be significant issues in terms of the adequacy or uncertainty of the information for the consenting process.
88. As for commercial fishing by species, and for catch taken by longlining (paragraphs 82, 83), the assessment of impacts on trawl fisheries should be informed by considering the spatial extent and commercial catch by species within the marine consent area and compared to the rest of the relevant QMAs. Baird (2014) uses the timeframe of 1990 – 2013 in her examination of ling longlining activity. A similar period would usefully be considered for trawl activity, although a shorter period (e.g., 2003 – 2013) would suffice.
89. GANZ (2014) consider that the impacts of the proposed activity on fishing are low, including in terms of localised impacts on fish, the risk that fish do not recolonise mined areas, and the ability to access fishing quota. They note that the marine consent area is substantially smaller than the relevant QMAs. Clough et al. (2014; Appendix 6) reflect that the scale of change in terms of the economic departure from business-as-usual is

expected to be “less than minor” for fish catches. However, they note that the speed of recovery of mined areas will influence the economic extent of the proposed mining activity’s effects. The effects of displacement of fishing effort to other parts of QMAs in the short-term (due to mining activity) or in the longer term (if commercial species do not recolonise or are less abundant in mined areas) are not considered quantitatively (e.g., in terms of fishing effort and catch; see paragraph 81).

90. Quantitatively considering the extent of effort exclusion is necessary to fully assess mining impacts and is a global standard where closures of fishing areas are introduced (e.g., for fisheries management, marine protection or industrial developments, (Dinmore et al. 2003; Halpern et al. 2004; Hiddink et al. 2006; Berkenhagen et al. 2010)). Examining a worst-case scenario for spatial exclusion over time would be informative in considering the potential effects of the proposed activity on commercial fisheries.
91. Displacing fishing effort may also invoke sustainability issues (e.g., due to targeting a different part of the stock occurring in a different area) as well as economic issues resulting from different utilisation patterns (e.g., the operational practicality and cost-effectiveness of landing fish from other locations). A review of available information could be conducted to explore this.
92. More broadly, the prospect of mining activity occurring in areas where fishing quota exists may affect quota value. Intuitively, negative effects on quota values would appear more likely where a large consent application is under consideration or approved, because of the potentially reduced area in which fish may be caught. Clough et al. (2014) refer to the compensation of quota holders in relation to aquaculture, and the Resource Management Act’s undue adverse effects test. They conclude that assuming the seabed recovers rapidly, the disturbance the proposed activity causes to bottom long-lining should be less than would result from the permanent exclusion of fishing activity from the seabed.
93. GANZ (2014) note that the hoki fishery is certified as sustainable by the Marine Stewardship Council (MSC). This fishery was certified in 2001 and has been recertified twice since that time (2007, 2012). MSC is the global best-practice standard for sustainable fisheries certification. In addition to hoki, the hake fishery (including HAK4) and ling fishery (including LIN4) are currently being assessed<sup>7</sup>. These assessments are now at the peer-review stage, with a determination on certification expected in 2014. A pre-assessment process has also been undertaken for orange roughy<sup>8</sup>.

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<sup>7</sup> [www.msc.org/track-a-fishery/fisheries-in-the-program/in-assessment/pacific/NZ\\_EEZ\\_hake\\_trawl/assessment-downloads](http://www.msc.org/track-a-fishery/fisheries-in-the-program/in-assessment/pacific/NZ_EEZ_hake_trawl/assessment-downloads);  
[www.msc.org/track-a-fishery/fisheries-in-the-program/in-assessment/pacific/NZ\\_EEZ\\_ling\\_trawl\\_and\\_longline/assessment-downloads](http://www.msc.org/track-a-fishery/fisheries-in-the-program/in-assessment/pacific/NZ_EEZ_ling_trawl_and_longline/assessment-downloads)

<sup>8</sup> [www.deepwater.co.nz/our-species/orange-roughy/msc-pre-assessment-of-new-zealand-orange-roughy-fisheries/](http://www.deepwater.co.nz/our-species/orange-roughy/msc-pre-assessment-of-new-zealand-orange-roughy-fisheries/)

### *Points of clarification*

94. An assessment of the effects of the proposed activity would be facilitated by addressing the following points of clarification:

- confirming whether the planned spatial extent of mining of approximately 30 km<sup>2</sup> per year, or reaching the annual production target, will constrain the extent of mining activity annually (e.g., section 1.2, the second full paragraph on page 4; section 4.4.2.2, paragraphs 1 and 3; section 4.8 Summary).
- identifying the technology inside the drag-head, i.e., whether water jets alone or together with a cutterhead will be used to loosen sediments;
- ensuring consistency in describing the depths of water in which mining will occur (identified as “generally” 350 – 450 m, although most of PP 55967 is shallower and this area comprises almost half of the marine consent area); and,
- clarifying the depth of mining extractions (section 4.4.4, last paragraph on page 50) should a second pass occur, and the likelihood of a second pass being undertaken.

### Discussion

95. This review identifies five main areas where additional information is sought to inform the review, and is available to at least some extent. These are:

- a more detailed characterisation of the commercial fishing activities in the full marine consent area, in terms of methods, areas, and landed catches, and including the recent data available (i.e., to the end of the 2012/13 fishing year);
- an up-to-date evaluation of the spawning areas used by commercial species in the marine consent area and across the Chatham Rise;
- a more focused investigation of information on underwater noise produced by dredging and any known sensitivities of marine fish to noise in this range;
- consideration of the cumulative effects of mining through the entire spatial and temporal extent of the marine consent sought, and including bottom longline fishing, as well as trawl fishing conducted on the sea floor, in that consideration; and,
- consideration of the effects of displacement and exclusion of fishing effort from the mining area in both environmental and utilisation-focused contexts.

96. Key knowledge gaps where information that would be pertinent to the review is not available include:

- some characteristics of the mining activity, e.g., noise generated;

- effects of suspended sediments and sedimentation on relevant commercial fish species;
- effects of noise on commercial species; and,
- the likelihood of commercial species recolonizing mined areas in the short term or longer term, with particular reference to demersal spawners.

97. In terms of the significance of the unavailable information identified in paragraph 96, the last two areas are especially important. However, noise is expected to only have short-term effects while mining occurs. The lack of information and the uncertainty relating to whether commercial species will recolonise mined areas is most important by far. This could affect commercial fishing in both the short and longer term.

98. As with any scientific material, there is uncertainty inherent in much of the information used to examine environmental effects of the proposed activity, including the potential effects of mining on commercial fishing. *Excluding* cases where more information is available and knowledge gaps where no information exists, the uncertainty reflected in the information presented is not expected to preclude a robust assessment of the proposed activity.

99. Note that the additional available information identified in paragraph 95 however is considered essential for a robust assessment using the best available information to occur. Overall, this information will support a better characterisation of commercial fishing activity and fisheries that may be affected by mining.

100. References have been included throughout this report. Some of these will be relevant to the areas where additional information is sought.

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