Before Hearing Commissioners
at Christchurch

under:	the Resource Management Act 1991
in the matter of:	applications CRC172455, CRC172522, CRC172456, and CRC172523 to undertake channel deepening dredging and maintenance dredging in Lyttelton Harbour
and	
in the matter of:	**Lyttelton Port Company Limited** *Applicant*

Summary and response evidence of Ross Sneddon (Marine Ecology)

Dated: 28 April 2017

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SUMMARY AND RESPONSE EVIDENCE OF ROSS SNEDDON

INTRODUCTION

1 My name is Ian Ross Sneddon.

2 I prepared evidence dated 28 March 2017 for Lyttelton Port Company Limited (*LPC*) in relation to its applications for resource consent to undertake works known as the Channel Deepening Project (*CDP*).

3 My qualifications and experience are as outlined in that evidence.

SCOPE OF EVIDENCE

4 This evidence is divided into two parts:

4.1 Part 1 consists of a summary of my evidence as filed; and

4.2 Part 2 contains evidence in response to evidence filed by submitters.

PART 1: SUMMARY OF EVIDENCE

5 I have undertaken assessment work in relation to the potential effects of the CDP on the marine ecology of Lyttelton Harbour and southern Pegasus Bay. This included the following principal components:

5.1 Characterisation of the marine receiving environment and fisheries resources from the available scientific literature and from focused surveys of subtidal and intertidal areas in the vicinity of proposed CDP activities;

5.2 Consideration of the principal physical and chemical stressors potentially associated with the CDP and assessment of the relative sensitivity of ecological receptors to them;

5.3 Interpretation of the sediment plume and sediment dynamics modelling reports produced by MetOcean Solutions Ltd with regard to potential marine ecological effects;

5.4 Assessment of the likely effects on marine ecological receptors and fisheries resources from the CDP and ongoing maintenance dredging and disposal;

5.5 Recommendations for monitoring of key ecological receptors.

6 Survey work I have been involved with in relation to the sites of potential concern spans a 10 year period and has involved SCUBA diving, benthic sampling and transect methods as well as collection

of hydrographic and hydrodynamic data via side-scan sonar and deployed instruments.

Receiving environment

7 The soft sediment seabed areas of inshore Pegasus Bay and Lyttelton Harbour are relatively flat and dominated by fine soft sediments although Harbour substrates are spatially more variable in texture.

8 Sediment transport processes operating along the outer coastline and within the harbours are very active, resulting in a relatively turbid coastal marine environment to which benthic communities are adapted. The seafloor sediment communities reflect the dynamic nature of this environment, being dominated by small-bodied, fast-growing, opportunistic taxa with relatively short life cycles. Such organisms will rapidly recolonise a site of disturbance, facilitating its recovery.

9 Reef habitats are largely limited to narrow margins immediately adjacent to the shoreline. Kelp forest of varying density was a consistent feature of reef transects in 4 m water depths, but large canopy-forming macroalgae were sparse at 7 m, most likely due to light limitation. Reef communities exist along natural gradients of generally decreasing wave exposure and increasing turbidity from the outer coasts into the inlets and Harbour, with corresponding increases in the prevalence of deposited silt films and pockets on reef surfaces.

Effects assessment

10 The information compiled from surficial sediment sampling within the areas to be dredged, together with the depth to which these areas will be deepened, suggests that concentrations of contaminants in the dredged material will not approach levels of concern to marine ecology, either as suspensions in the water column, or in deposited sediments at the spoil ground. I further consider that dredge spoil material generated by the CDP will be similar in texture and composition to the native sediments of the offshore spoil grounds

11 The nature and scale of the physical disturbance represented by both dredging and spoil deposition is such that the complete loss, albeit temporary, of all benthic communities must be assumed within the areas directly affected by these activities. A spreading zone margin of 300–500 m around each spoil ground will potentially also be affected by direct deposition.

12 The principal mechanism by which effects to the wider marine environment can occur from CDP activities is via the production of turbidity plumes from dredging and spoil disposal and their subsequent transport and dispersion with ambient currents.

Ecological effects will depend upon the sensitivity of biota to stressors associated with these plumes, their ability to recover from short-term perturbations and the spatial area over which such stressors operate. Assessment of this sensitivity must be made in the context of background processes which result in a naturally turbid environment. Highly variable but persistent turbidity does not necessarily mean that communities adapted to these conditions will be unaffected by further increases in suspended sediment concentrations (*SSC*). However, it is likely that they will be more tolerant, in absolute terms, of temporarily elevated turbidity than those established in clear-water environments.

13 Plume concentration contours predicted by modeling suggest that any effects on benthic communities arising from suspended spoil particulates settling out of the water column will be minimal beyond 500 m from the spoil ground boundary. Spoil sediments which remain in suspension or which are subsequently resuspended will be incorporated into the significant natural sediment resuspension and deposition processes operating within inshore Pegasus Bay.

14 Plume modeling for spoil disposal activities has indicated that sediment plumes will not reach shoreline reef habitats at concentrations likely to significantly exceed background ranges. Similarly, for the central to outer Harbour, model outputs indicate that dredging plumes (and associated deposition) will be largely constrained to within, or near to, the dredged channel.

15 Sediment plumes arriving at the shoreline from a particular source must exceed that of the natural background (in severity, frequency or duration) before such turbidity will cause additional stress in reef communities. A mitigating factor for such communities in Pegasus Bay lies in the fact that plumes which undergo greater dispersion with distance from source will displace water of increasing natural turbidity as they near the shoreline. Additionally, except within the highly sheltered but more naturally turbid upper reaches of inlets, intertidal and shallow subtidal reef substrates are kept clear of accumulated sediment deposits by persistent wave action.

16 During the CDP, dredging and spoil disposal will not occur in close proximity to shoreline reef habitats. Dredging within the Harbour will be constrained to within and close to the boundaries of the presently maintained channel and swing basin which lie along the Harbour axis and adjacent to the Port, respectively. Based on the very limited potential identified by hydrodynamic modeling for plumes to impinge upon the coastline and the Banks Peninsula inlets, and the deployed system for monitoring turbidity, I believe that there is negligible risk to paua and lobster stocks, existing mussel farms and any soft sediment shellfish stocks at the heads of the inlets.

17 Analysis of landed catch data for Pegasus Bay indicates that there will be only very limited spatial overlap between the potential effects of CDP activities and commercial fishing activity. This principally relates to a small but relatively productive area for yellow-belly flounder in waters immediately offshore from Godley Head. However, I consider that the mobility of inshore fish species and the uniformity of benthic substrates in the area generally facilitate the avoidance by fish of areas of direct disturbance during the CDP. Similarly, restriction of dredging activity to the Harbour axis and the constraint of plume advection to bi-directional tidal flows suggests that dredging will not present a significant barrier to fish movement into and out of the Harbour.

Monitoring

18 Although my assessment concludes that significant adverse effects to high-value ecological receptors are very unlikely, the scale of the project and a level of uncertainty associated with some elements means that a precautionary approach to monitoring is warranted. I believe that the level of monitoring described in LPC's proposed conditions of consent effectively addresses this need.

19 A spatial array of 14 continuously recording instrument platforms has been deployed to collect baseline data for a period of at least a year before dredging commences. This data set will enable the characterization of the background level and variability of turbidity for the sea area covered. Once these background conditions are defined, any significant departure from background during dredging can be identified, inferences made concerning the extent and propagation of plumes, and potential sources investigated.

20 I consider that the proposed ecological monitoring design involving multiple surveys of 19 benthic sample stations, six subtidal reef sites and four intertidal reef sites gives acceptable statistical power to detect and interpret ecologically meaningful effects which may result from CDP activities while maintaining adequate coverage of the spatial area of potential concern.

PART 2: RESPONSE EVIDENCE

21 I have had the opportunity to read expert evidence lodged in relation to the CDP by other submitters and I respond to a number of issues raised that are within my areas of expertise.

22 As an overall comment on submitted evidence dealing with ecological aspects, I find very little disagreement regarding the potential responses of marine communities to increased sediment loading. But I note that the extensive discussion on this in the Marine Ecology Assessment submitted as Appendices 15A and 15B to the Applications (*Report*) is seldom mentioned in the submitted evidence, even as points of agreement.

23 Further, while there is much discussion of the value of a range of ecological receptors (especially in regard to characterisation and monitoring), there is little consideration in the expert evidence submitted of the mechanisms contributing to actual risk as a factor in such assessment.

Evidence of Dr Christopher Hepburn for Te Hapū o Ngāti Wheke, Te Rūnanga o Koukourārata, Ngāi Tahu Seafood and Te Runanga o Ngāi Tahu

24 In paragraph 27 of his evidence Dr Hepburn makes reference to a statement made in Cawthron's Report to the effect that "*reef communities and key species are adapted to and tolerant of additional sediment loads because they are simply present on Banks Peninsula*" but does not cite where this statement was made. There is no statement in our Marine Ecology Report which uses the key word "*additional*" in the context of the sensitivity of reef communities to suspended sediments.

25 Dr Hepburn raises the possibility of shifts in community composition from macroalgal-dominated to invertebrate-dominated systems with reductions in light penetration. These shifts were discussed and acknowledged in the Marine Ecology Report in the context of persistent changes in turbidity, should they occur at the coastline (A15A-Section 7.3.2-pages 111-115). I consider that there is no fundamental disagreement in the range of potential responses in reef communities.

26 Dr Hepburn states in paragraph 28 of his evidence that he does not agree that "*communities are adapted or tolerant simply because they (or their remnants) remain in areas considered turbid*". This does not make logical sense unless the system is considered to already be in a process of transition in regard to turbidity as the principal stressor. If a community exists in an area which is naturally turbid, then it is by definition both adapted to and tolerant of such conditions. Species for which natural conditions are marginal are, by definition, at the edges of their natural range.

27 If rocky reef communities were at or near to an ecological tipping point (which Dr Hepburn considers may be the case) evidence for this would be currently observable for key species or communities. This would manifest as a discontinuity or break-point in these communities along the natural gradient of turbidity exposure into the Harbour and inlets. The absence of such a break-point indicates instead a community continuum with turbidity (and other conditions) whereby structural shifts can (and probably do) occur each way with seasonal and inter-annual cycles in weather. Such shifts have been documented for macroalgal biomass in the cited

paper by Desmond et al. (2015)[1] of which Dr Hepburn was a co-author.

28 In paragraph 29 of his evidence, Dr Hepburn states that a comment is made in our report to the effect that replacement of species less tolerant of sediment with those more tolerant will occur as a response to higher sediment loads. While our report considered changing patterns of dominance within community structure, we did not refer explicitly to complete replacement of taxa within communities, which lies at the extreme end of the spectrum of such responses. By implying that such replacement is the fundamental response of such communities to any additional sediment load, Dr Hepburn does not acknowledge the more subtle shifts which are the more likely consequence.

29 In paragraph 30, Dr Hepburn refers to "*the shallow and narrow depth distributions of kelp and other habitat forming macroalgal species in the region*" being indicative that "*these areas are already impacted by high sediment loads*". Reference to a naturally present component of a system as an impact (in the absence of a clear rationale) misrepresents the current state of that system and the communities it supports.

30 I concur with what Dr Hepburn states in paragraphs 33-35, regarding the ecological importance of kelp forests/macroalgae in shallow reef communities and the potential consequences of their loss.

31 In paragraphs 38-39, Dr Hepburn discusses the effects of sedimentation on the recruitment and survival of kelp (*Macrocystis pyrifera*) germlings. Due to the wave-induced shear which prevents the accumulation of sediments on reefs associated with even partially exposed shorelines (such as most of those closest to CDP activities), it is important to make a distinction between sedimentation (as accumulation) and increased depositional flux. In wave-exposed environments, small increases in sediment loading are very unlikely to result in fine sediment accretion since any settled silt films will be inherently ephemeral in nature.

32 While I acknowledge that even temporary settled films may affect *Macrocystis* recruitment and survival, this species' local range extends well into the upper reaches of Lyttelton Harbour where high turbidity and more quiescent conditions frequently allow such films to persist.

[1] Desmond MJ, Pritchard DW, Hepburn CD. 2015. Light Limitation within Southern New Zealand Kelp Forest Communities. PLoS ONE 10(4): e0123676. doi:10.1371/journal.pone.0123676

33 The statement, in paragraph 40, that "*Macrocystis pyrifera kelp forests are very sensitive to the effects of sedimentation*" is somewhat misleading given the naturally high variability in its standing biomass. Foster and Schiel (2010)[2] is cited by Dr Hepburn in support of this statement, but in reference to "*the loss of Macrocystis pyrifera forests in California*" the authors of this paper note that "*Given the high degree of canopy and biomass fluctuations seasonally and inter-annually it is remarkable that this species … is so robust and that kelp forests flourish in virtually all areas now that they occupied historically.*" Testament to the robustness of this fast-growing species is its conspicuous establishment on the side of the advancing face of the Te Awaparahi Bay reclamation in Lyttelton Harbour during the construction phase in 2012-13.

34 Dr Hepburn's evidence contains many examples of possible ecological responses to increases in suspended sediment loading to reef environments. As I have noted above, these are in broad agreement with the discussions presented in our Report for the CDP. However, the issues most pertinent to the assessment of effects on reef habitats are the likelihood of such sustained changes in loading occurring at the coastline and, in the event they do occur, the likelihood that they would remain undetected by the monitoring systems and triggers in place (and therefore unaddressed).

35 In discussing potential effects of sedimentation on pāua in paragraphs 44-47, Dr Hepburn refers to concerns around fisheries decline but it is not clear whether this is meant to apply specifically to pāua stocks. Our recent surveys have found the species to be locally very abundant. Although adult size was observed to be small, this stunted nature of the stock appears to have been long recognized.[3]

36 I concur with most of the points Dr Hepburn makes regarding the potential sensitivity of pāua early life stages to deposited sediments, much of which aligns with discussion in our Report. However, the surveys completed as part of that Report found pāua to be plentiful on suitable substrates on the northern shoreline of Lyttelton Harbour within the current maintenance dredge spoil grounds. While there is no baseline data to suggest that they might not have been even more abundant prior to the use of the spoil ground over many decades, this seems unlikely given the consistency of pāua numbers with other sites in the area.

[2] Foster, M. S., Schiel, D. R. (2010). Loss of predators and the collapse of southern California kelp forests (?): Alternatives, explanations and generalizations. Journal of Experimental Marine Biology and Ecology, 393: 59-70.

[3] Sainsbury KJ. 1982. Population dynamics and fishery management of the paua, *Haliotis iris*. Population structure, growth, reproduction, and mortality. New Zealand Journal of Marine and Freshwater Research 16: 147–161.

37 Dr Hepburn draws a connection, in terms of effects on pāua, between the effects of shifting sand deposits and fine sediment deposition, citing Schiel (1993).[4] But the author of this paper stated that "*The major identifiable source of mortality was the movement of sand and the complete or partial burial of juvenile habitat*". The paper made no reference to sedimentation via fine sediment deposition from the water column, so the comparison made is somewhat tenuous.

38 Regarding the potential for sedimentation on reef surfaces, I reiterate from my evidence dated 28 March 2017 that the spatial distribution of deposited fine sediments is mediated largely by hydrodynamics rather than by the size or proximity of the source. Fine seabed sediments already present adjacent to shoreline reefs do not accumulate upon them despite the operation of active resuspension processes.

39 In paragraphs 55 and 57, Dr Hepburn expresses concern over what he sees as the low number of ecological monitoring sites, especially within the inlets and Harbour, giving the example of possible widespread sedimentation as a project outcome. This view appears to consider particular ecological receptors (such as shoreline reef habitats) in isolation from other monitored parameters. The monitoring design balances the scope and depth of monitoring across multiple parameters and receptors while accommodating potential confounding influences and practical constraints.

40 The purpose of assurance monitoring is to provide validation of the assessment findings and so protect against the undetected occurrence of significant unanticipated effects. I contend that it is less important to focus efforts on teasing out the less than minor transient effects which may ensue from a project of this scale. Rather, the focus of monitoring should be on providing coverage of a range of important and indicative receptors at an appropriate spatial scale.

41 The spatial constraints and existing gradients within Lyttelton Harbour do not lend themselves well to a standard BACI (Before-After-Control-Impact) design. The footprint of proposed dredging activity also extends past Harbour limits, so a decision to consider a boundary to potential effects at the Harbour heads would appear somewhat arbitrary. Based on proximity to dredging, there are four subtidal reef stations, eight subtidal sediment stations, four intertidal stations and six continuous turbidity monitoring stations. Appropriate data for interpretation of the extent, magnitude and causality of effects will be provided by the spatial coverage,

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[4] Schiel, D. (1993). Experimental evaluation of commercial-scale enhancement of abalone *Haliotis iris* populations in New Zealand. Marine Ecology Progress Series 97: 167-181.

temporal replication and multiple lines of evidence available from this design.

Evidence of Dr Daniel Pritchard for Te Hapū o Ngāti Wheke, Te Rūnanga o Koukourārata, Ngāi Tahu Seafood and Te Runanga o Ngāi Tahu

42 In reference to the adaptation of marine communities to turbid conditions, Dr Pritchard claims in paragraph 133 of his evidence that "*communities adapt by species becoming locally extinct*". This ignores the fact that there is a whole spectrum of community response to altered conditions, ranging from the very subtle to the extreme of local extinction. Because all species exist in their own preferred range of conditions, response to a stressor will first manifest as changing patterns of dominance within a community as ambient conditions move towards, or away from, the preferred optimum for a given organism.

43 As an example, the macroalga *Ecklonia radiata* is found to a depth of 7-8 m on the Southern Pegasus Bay coastline, but to only 2 m at the more turbid location of Battery Point in Lyttelton Harbour. This is almost certainly an adaptation to reduced light levels and such a shift occurs wherever there is a spatial turbidity gradient, but in no way does this represent a local extinction.

44 Although, as I have already noted, such potential shifts were acknowledged and discussed in our Report, our assessment did not go as far as predicting ecologically significant changes in reef communities for the simple reason that the overall changes in turbidity conditions at the coastline during the CDP are predicted to be very small. I acknowledge that even a small change in turbidity, if sustained for long enough, will lead to a response in reef communities; but these systems are not static and small transient shifts will occur within a background of natural variability.

Evidence of Professor Islay Marsden for Te Hapū o Ngāti Wheke, Te Rūnanga o Koukourārata, Ngāi Tahu Seafood and Te Runanga o Ngāi Tahu

45 In paragraph 22 of her evidence, Professor Marsden raises concerns over potential dissimilarities between dredged material and native sediments at the spoil ground. As I have stated in my evidence dated 28 March 2017, what is known of the sedimentary history of Lyttelton Harbour would not lead us to suspect that the nature of sediments would vary significantly down the profile along the center-line of the Harbour.

46 This has been confirmed by the evidence of **Dr Michael Page**, who confirms in his evidence that the profile is dominated by loess soils from the seabed surface down to the full depth of dredge cut. Although a small amount of variability in consolidation was noted,

this would not appear to be enough to result in a significant post-recovery alteration of the benthic habitat at the spoil ground.

47 While I cannot comment on the constraints contributing to the choice of dredge size for the CDP, I do not consider that there is latitude for use of sections of the spoil ground over different temporal scales as Prof. Marsden suggests in paragraph 24, especially since there is scant data on recovery rates from which to design such a system with any confidence. I believe that – within operational constraints - a relatively even distribution of deposited sediments is the best way to minimize potential benthic impacts.

48 I acknowledge Prof. Marsden's contention in paragraph 26 that the macrofaunal densities in the areas sampled for our Report may not be described as particularly sparse. I would stress, however, that the findings of the Report are generally consistent with the previous Lyttelton Harbour studies she cites, all of which were carefully reviewed in the preparation of our Report.

49 Paragraph 27 of Prof. Marsden's evidence states that our Report "suggests that the fauna is now less diverse than it used to be", and that "some key benthic species have not been recorded in baseline surveys". I note that nowhere in our Report do we suggest a decline in diversity has occurred. Prof Marsden does not provide any indication of the benthic species apparently left out of baseline surveys.

50 I concur with Prof. Marsden's suggestion in paragraph 31 that the epifauna may have been under-sampled in terms of spatial density owing to the difficult substrate for a standard epibenthic research dredge design. This limitation was discussed in our Report. I am confident, however, that the 26 individual research dredge trawls carried out have provided a reasonably good inventory of the less mobile epifaunal species occurring across the area.

51 To reiterate a key point of my 28 March evidence, it is neither practical nor effective to directly monitor all ecological receptors. The primary monitoring focus in soft sediment areas should be the infauna, being the group which forms the very basis of benthic communities and their successional recovery. In areas of direct disturbance, the macroinvertebrate community will re-establish and recover before the larger and more mobile epifauna, but due to the considerable areas of similar substrates in the wider area, a failure of the epifaunal community to subsequently re-establish is extremely unlikely.

52 There are considerable challenges in documenting the extent of larger epifaunal species such as scallops and horse mussels, which anecdote suggests may be present in some of the bays of the Harbour (paragraph 38 of Prof Marsden's evidence). Even if sonar

methods could be reliably employed in these benthic areas of persistent near-zero underwater visibility, such communities would need to be "ground-truthed" by divers. Notwithstanding the destructiveness of dredge sampling methods on such populations, these are unlikely to give a good indication of population density or extent, unless employed at high spatial intensity, even where the presence of these species is identified.

53 In paragraph 35, Prof. Marsden notes that a procedure to evaluate the response in the level of community characterization with increasing sample replication does not appear to have been followed, and in paragraph 36 suggests that the number of replicates at each monitoring site be increased from 3 to 5 or 6 to improve precision. An analysis of the response in mean taxa richness with increasing replication was carried out for sampling at the offshore channel deepening spoil ground, although I concede this did not form a part of the higher-level discussion of monitoring in our Report.

54 Adding to the discussion on benthic sample replication in my evidence in chief, I note that sampling in triplicate or less is not unprecedented for key investigations within Lyttelton Harbour. A recent NIWA study[5] in the upper Harbour employed single grab samples collected from each station "*to optimise spatial coverage across the relatively homogeneous area*". Fenwick (2003)[6] sampled benthic macrofaunal communities in triplicate at stations within the Port operational area. The frequently cited study of the central to upper Harbour by Hart et al. (2008)[7], of which Prof. Marsden was a co-author, reported from the results of replicate sampling that "*3 replicates were likely to be representative of the sites selected*". I consider that, based on the now extensive historical sampling record in this benthic environment, and for an effect size appropriate to assurance monitoring, triplicate sampling provides a suitable level of precision.

55 In several paragraphs, Prof Marsden contends that there should be more detailed investigations of soft shore sites in the upper reaches of the Harbour and Port Levy. Targeted investigations of these habitats have not been carried out for the following reasons:

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[5] Tait L. 2015. Lyttelton Harbour wastewater project: Assessment of ecological effects. NIWA Client Report No: CHC2015-091as, prepared for Jacobs New Zealand Ltd. 41p plus appendices.

[6] Fenwick G 2003. Port of Lyttelton ecological monitoring: May 2003. NIWA client report CHC2003-079. 21 p. plus appendices.

[7] Hart D, Marsden ID, Todd DJ, de Vries WJ. 2008. Mapping of the bathymetry, soft sediments and biota of the seabed of upper Lyttelton Harbour. Estuarine Research Report 36/ Canterbury Regional Council Report 08/35. 36p plus appendices.

55.1 the spatial extent of significant plume effects predicted by modelling does not include these areas;

55.2 even if dilute but detectable plumes reached these areas, the relative increase in SSC above background would be significantly smaller than for other shoreline areas in closer proximity to the source; and

55.3 it is unlikely that persistent plumes could reach these areas without registering and exceeding triggers at continuous turbidity monitoring stations.

56 In paragraph 48 of her evidence, Prof Marsden makes the suggestion that (ecological) monitoring be carried out annually. In fact the current baseline monitoring is being carried out on a 4-monthly basis and it is the intention to maintain this frequency into the project and post-project phases. In paragraph 49, she suggests that a 5-yearly monitoring frequency for the proposed maintenance dredging spoil ground is inappropriately long. I concur with this view for a newly established spoil ground and I understand that it is the intention to set an initial annual frequency (providing spoil deposition is carried out in any one year), with potential to scale this back to 5-yearly based on the results of real-time turbidity monitoring during maintenance dredge campaigns.

Dated: 28 April 2017

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Ross Sneddon