BEFORE THE …	**Environmental Protection Authority**
Under	**Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012**
And	
In the matter of	**Application for a marine dumping consent to dump dredged material at a deep-sea site east of Great Barrier Island (EEZ100015)**

Statement of evidence of Clinton Anthony John Duffy
on behalf of the Director-General of Conservation
Dated 31 October 2018

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Introduction

1. My full name is Clinton Anthony John Duffy.

2. I am employed by the Department of Conservation (DOC), Marine Ecosystems Team as a Technical Advisor – Marine based in Auckland. I have worked for the Department of Conservation since June 1989. I have 29 years' experience in coastal and marine management, policy and research. I was employed by the Nelson/Marlborough Conservancy, DOC, to lead a dive survey of the Marlborough Sounds in 1989 and have held a variety of marine and freshwater technical support and scientific positions within DOC since then.

3. I am a member of the New Zealand Marine Sciences Society, the International Union for the Conservation of Nature (IUCN) Shark Specialist Group – Australia and Oceania, and the Oceania Chondrichthyan Society. I am also a Marine Associate of the Auckland War Memorial Museum and an expert reviewer for Marine Conservation Action Fund, New England Aquarium. I have authored or co-authored more than 70 scientific papers and reports on aspects of marine species biology, marine ecology and biogeography, and marine protected areas.

4. My qualifications are a M.Sc. (Hons) in Zoology from the University of Canterbury, Christchurch, New Zealand (1990). I am currently enrolled as a Ph.D. student (part-time) in the Institute of Marine Science, University of Auckland.

5. My role (Technical Advisor – Marine) includes assessment of resource consent applications for activities within the Coastal Marine Area and Exclusive Economic Zone; assessment of marine reserve permit applications; review of research and funding proposals; research contract supervision; provision of technical support to DOC operations staff and external groups (e.g. Foundation North; Tai Timu Tai Pari Sea Change Hauraki Gulf Marine Spatial Plan Stake-Holder Working Group); advice and research on protected sharks and rays; and marine species identifications.

6. In preparing my evidence I have read the following documents:

- the Public notice: Coastal Resources Limited marine dumping consent application
- CRL Impact Assessment: Northern disposal area, Marine consent to dump application and supporting impact assessment, Osborne Hay (North) Limited. 75 pp.
- CRL Appendix 3: Site Location and Proposed Disposal Points, 31.05.2018, EEZ100015-006
- CRL Appendix 5: Northern disposal area – assessment of source material, ecological and sediment quality effects assessment of disposal. Report for Coastal Resources Limited. Bioresearches. 166 pp.
- CRL Flaim Thesis Appendix 3a: Proposal for dredged sediment disposal on the continental shelf in the EEZ: environmental impact assessment August, 2008. Coastal Marine Group, Dept. of Earth and Ocean Science, University of Waikato. 96 pp.
- CRL Flaim Thesis Appendix 3b: Post-disposal monitoring of the Auckland Marine Disposal Ground. Report for Coastal Resources Ltd. Permit no. 555. Coastal Marine Group, Dept. of Earth and Ocean Science, University of Waikato. 186 pp.
- CRL NIWA Review: Review of post-disposal monitoring of the Auckland Marine disposal ground. NIWA Client Report No: WLG2011-31. Report for Maritime New Zealand. National Institute of Water & Atmospheric Research Ltd. 25 pp.
- Post 150,000m^3 disposal characterisation of seabed changes. Report for Coastal Resources Limited. Bioresearches. 110 pp.
- Statements of evidence of Connon James Andrews, Simon John Childerhouse and Simon West for Coastal Resources Limited

7. I have also reviewed the relevant scientific literature and specimen collection records of the National Marine Invertebrate Collection, NIWA, and the Auckland War Memorial Museum.

Code of Conduct

8. I have read and agree to comply with the Code of Conduct for Expert Witnesses produced by the Environment Court. While this is not an Environment Court hearing, I have prepared this evidence in accordance with, and I agree to comply with, that code for this hearing. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed. I confirm that the issues addressed in this brief of evidence are within my area of

expertise. I am authorised to give this evidence on behalf of the Director-General of Conservation.

Scope of evidence

9. My evidence will deal with the following:

   a. The ecological values present in the vicinity of the Northern Disposal Area
   b. The effects of dumping on the ecology of the Northern Disposal Area and its environs
   c. Biological monitoring of the Northern Disposal Area.

I conclude that although dumping of dredge spoil at the Northern Disposal Area will adversely affect the benthic ecology of a small part of the northeast North Island continental shelf the application understates the ecological values likely to have been present at and surrounding the disposal area. This appears to be due in part to the method (100 mm cores) used to monitor the benthic fauna which is strongly biased toward meiofaunal organisms such as small polychaetes and foraminifera. I recommend that the monitoring programme include box core or grab sampling and high-resolution imaging of the sea floor to monitor benthic macrofauna, baited underwater video or short duration beam trawls to monitor demersal fishes, and at least two control sites located at comparable depths to the disposal area.

Ecological values present at mid-outer shelf depths east of Great Barrier Island

10. Lee et al. (2015) mapped the benthic habitats occurring off northeast Great Barrier Island from the shore to over 150 m depth by combining existing bathymetric and substratum information with data obtained from three underwater video surveys of the sea floor totalling 119 stations. They identified four distinct biotopes or habitats: (1) shallow water algal-dominated rocky reefs, (2) deep reefs characterised by a diverse epifauna of sponges and bryozoans, (3) a brittle star (*Amphiura* sp.) and sea anemone (*Edwardsia* sp.) assemblage on muddy sand and (4) hydroids on mud (Fig. 1).

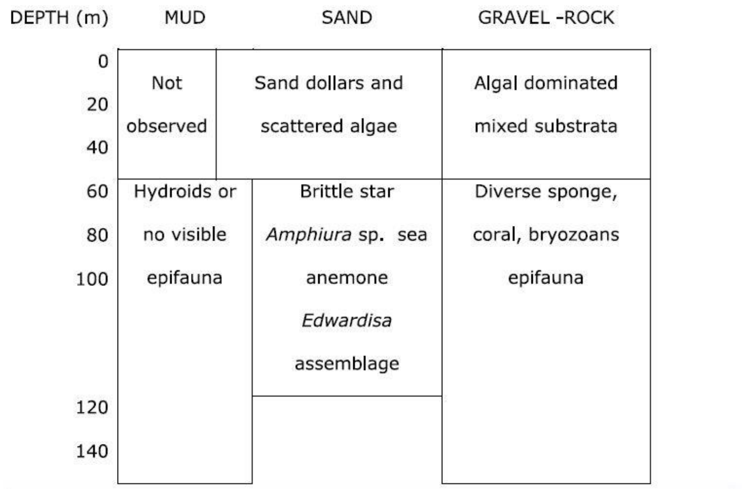

Fig. 1. Matrix of benthic biotopes recorded on the continental shelf northeast Great Barrier Island (from Lee et al. 2015).

11. Rocks and rocky reefs occurring below 30 m depth support diverse encrusting epifaunal assemblages characterised by sponges, bryozoans and protected corals. Lee et al. (2015) identified 50 species of sessile invertebrates on these reefs, including significant numbers of the hexactinellid (glass) sponges *Symplectella rowi* and *Rossella ijimai,* the giant pipe sponge *Isodictya cavicornuta,* black corals and gorgonians.

12. The muddy sand biotope is characterised by ophiuroids (brittle stars), and the sea anemone *Edwardsia* sp. occurs between 50 m and at least 120 m depth (Lee et al. 2015). Hayward et al. (1982) sampled muddy sand habitat off Rakitu Island between 40-70 m depth, describing the infaunal invertebrate assemblage as a bivalve-ophiuroid association characterised by the bivalves *Cuspidaria willetti, Cuspidaria trailli* and *Notocallista multistriata* and the brittle star *Amphiura* sp. Other common species included several different groups of polychaete worms (terebellids, *Pectinaria australis*, maldanids, *Sigalion* sp.), the bivalve *Nemocardium pulchellum* and the gastropod *Austrofusus glans* (Hayward et al. 1982). The assemblage described by Hayward et al. (1982) shares many species in common with the *Nemocardium pulchellum* - *Venericardia purpurata* and the *Nemocardium pulchellum* - *Pleuromeris zelandica* communities, two of the most widespread New Zealand shelf communities identified by McKnight (1969). McKnight (1969) reported the *Nemocardium pulchellum* - *Venericardia purpurata* community from gravelly sand, muddy sand and mud substrata

between 10 m to more than 300 m depth around North and South Islands, and the *Nemocardium pulchellum - Pleuromeris zelandica* community from muddy sand, sandy mud and mud between 18-274 m depth (mainly 20-130 m depth) around the North Island and the northeast South Island. As there are only subtle differences in the composition of these assemblages most of the taxa recorded from them are likely to occur in muddy outer shelf sediments east of Great Barrier Island, including the Northern Disposal Area. Although Lee et al. (2015) observed that mud dominated habitats below 90 m depth east of Great Barrier Island support low numbers of epifauna identifiable by video it is not known if this reflects the natural assemblage composition of these habitats or is a product of ongoing disturbance by bottom-trawling (Baird et al. 2011; Lee et al. 2015; Tuck et al. 2017) (Fig. 2).

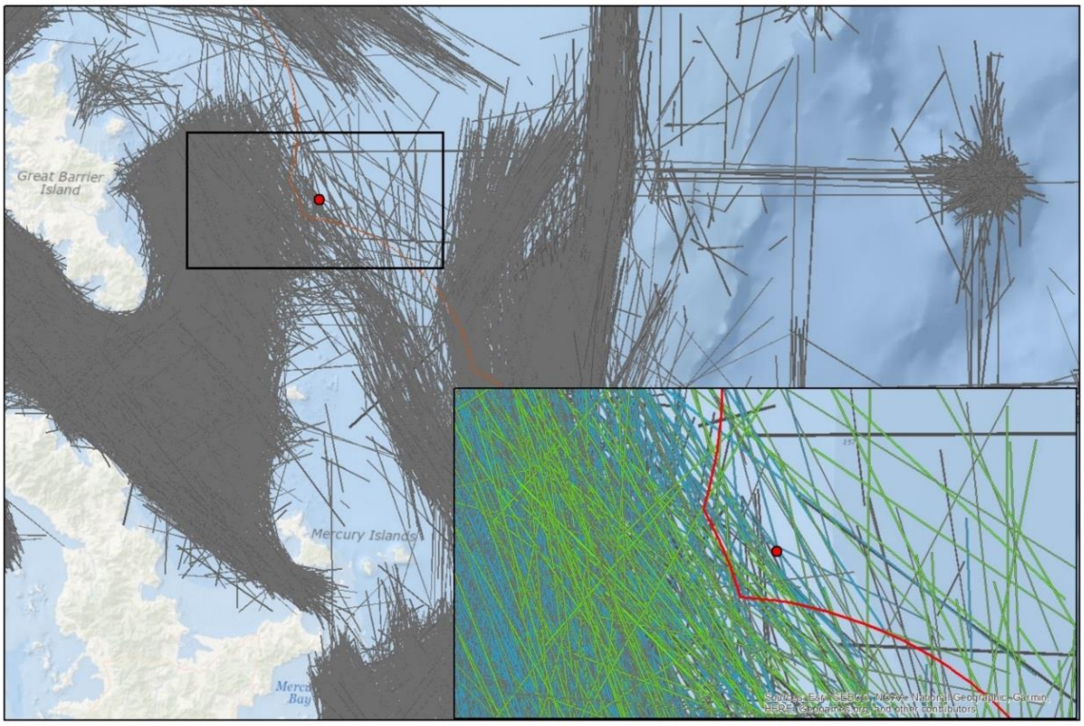

Fig. 2. Estimated commercial bottom trawl footprint 1989-2010 (solid red circle indicates the location of the CRL application area). Estimated trawl tracks are indicated by solid straight lines overlaid on a bathymetric model of the seafloor. The seaward boundary of the Territorial Sea is shown in red. The inset shows trawl tracks by target species in and around the application area: green tracks are trawls targeting tarakihi (*Nemadactylus macropterus*), blue tracks are those targeting snapper (*Pagrus chrysophrys*), black tracks are tows for all other species (Black & Tilney 2017).

13. Flaim & de Lange (2011) identified 29 taxa in benthic cores (70 mm internal diameter) prior to dumping commencing at the site, and 34 taxa post-dumping. The most diverse groups in these samples were polychaete worms and

foraminifera. Foraminifera were the numerically dominant taxa. Only four molluscan taxa were recorded, three bivalves (?*Dosinia* sp., *Nucula nitidula*, *N. nitidulaformis*), and the gastropod *Solariella plicatula* (as *Spectamen plicatulum*). *Nucula nitidula* reaches a maximum reported size of 8 mm and is a common shallow water coastal species. *Nucula nitidulaformis* reaches 4.5 mm, and *Solariella plicatula* 4 mm. *Nucula nitidulaformis* is an outer shelf-upper continental slope species. Stationary underwater video deployments showed the bottom in the application area to be a flat, muddy plain. Epifauna were sparse but included occasional small sponges and an unidentified species of sea pen (Cnidaria: Pennatulacea, cf. *Funiculina quadrangularis*).

14. Biological specimens collected from the outer shelf east of Great Barrier Island and Coromandel Peninsula held in the National Marine Invertebrate Collection at NIWA Greta Point and by Auckland War Memorial Museum are listed in Appendix 1. These collections are relatively modest, reflecting the low amount of sampling conducted in this area but nevertheless demonstrate the presence of a variety of macrofaunal species including gastropod and bivalve molluscs, a mantis shrimp, sea stars and two species of holothurian known to prefer deep mud substrates.

Fishes

15. The application area is commercially fished for a variety of species. The main commercial method is bottom trawling for tarakihi (*Nemadactylus macropterus*) and snapper (*Pagrus chrysophrys*) (Fig. 2). Estimated bottom trawl frequency in the application area is low to moderate, the most intensively fished area of the shelf is located closer to Great Barrier Island at depths less than 100 m (Baird et al. 2011; Black & Tilney 2017; Tuck et al. 2017) (Fig. 2).

16. Tong & Elder (1966) provide one of the earliest descriptions of demersal fish assemblages occurring in the region. They found snapper to be almost ubiquitous (present at > 75% of sites snapper) at shelf depths, with other common species (present at 50-75% of sites) being horse mackerel (*Trachurus* spp.), john dory (*Zeus faber*), scaly gurnard (*Lepidotrigla brachyoptera*), tarakihi, trevally (*Pseudocaranx georgianus*) and witch (*Arnoglossus scapha*). Snapper occurred

most frequently from 0-46 m depth but larger catches of snapper were made between 90-180 m depth in autumn and winter suggesting a seasonal shift by part of the population into deeper water. Tarakihi were most abundant below 90 m year-round (Tong & Elder 1966). Kendrick & Francis' (2002) observations on species associations in Hauraki Gulf were very similar. They analysed data from 1381 research trawl tows (Appendix 2) and identified two mid to outer shelf species assemblages. The first of these (Group B) was associated with sand and deep mud and characterised by high abundance of lemon sole (*Pelotretis flavilatus*), blue cod (*Parapercis colias*), red gurnard (*Chelidonichthys kumu*), opal fish (*Hemerocoetes monopterygius*), frost fish (*Lepidopus caudatus*), witch, blue mackerel (*Scomber australasicus*), arrow squid (*Nototodarus gouldi*), rough (*Zearaja nasuta*) and smooth (*Dipturus innominatus*) skates and scaly gurnard. Catch rates of blue cod and red gurnard were highest on sand, whereas catch rates of lemon sole were low on deep mud. The second assemblage (Group D) was associated with deep mud and characterised by high catch rates of school shark and tarakihi. Snapper were most abundant in the inner Hauraki Gulf on mud bottom but were caught in nearly all tows and comprised 85% of the total weight of the catch. Species largely confined to deep water in the outer Gulf were sea perch (*Helicolenus percoides*), mirror dory (*Zenopsis nebulosus*), spotted gurnard (*Pterygotrigla picta*), northern spiny dogfish (*Squalus griffini*), cucumber fish (*Chlorophthalmus nigripinnis*), silverside (*Argentina elongata*), Capro dory (*Capromimus abbreviatus*) and gem fish (*Rexea solandri*). These species occurred in fewer than 5% of the tows reflecting the fact that deep tows were under-represented in the data set (Kendrick & Francis 2002). Zintzen et al. (2012) recorded a similar suite of species from outer shelf sites east of Great Barrier Island using baited underwater video (Table 1). One notable difference being the abundance of at least two species of hagfishes (blind eels) in the videos compared to the trawl survey data. The elongate body shape of hagfishes means they are not well sampled by trawls.

17. Although the shelf east of Great Barrier Island was not identified as a habitat of particular significance to fisheries management by Morrison et al. (2014) juveniles of at least 13 coastal fishes have been recorded in research trawls there (Hurst et al. 2000). The species most abundant as juveniles are jack mackerel and arrow squid (Hurst et al. 2000). The area does not appear to be important as a

nursery area for tarakihi (Hurst et al. 2000). Juvenile deepwater fishes recorded from the general vicinity of the Northern Disposal Area include silverside, northern spiny dogfish, smooth skate, frost fish and mirror dory (O'Driscoll et al. 2003).

18. Pelagic fishes recorded over the shelf east of Great Barrier Island include pelagic sharks, particularly shortfin mako (*Isurus oxyrinchus*) and blue shark (*Prionace glauca*), spine-tailed devil ray (*Mobula mobular*), kahawai, trevally, jack mackerel, Murphy's mackerel (*Trachurus murphyi*), kingfish, trevally, mahimahi (*Coryphaena hippurus*), blue mackerel, skipjack tuna (*Katsuwonus pelamis*), black marlin (*Makaira mazara*), striped marlin (*Kajikia audax*), pelagic puffer (*Arothron firmamentum*), Cheeseman's puffer (*Lagocephalus cheesemanii*) and the hoodwinker sunfish (*Mola tecta*) (Bagley et al. 2000; C.D. Struthers, Te Papa, pers. comm..; pers. obs.). Aerial sightings of pelagic fishes suggest this area is not in itself a pelagic hotspot but forms part of a wider northeast North Island hotspot stretching from the Bay of Plenty to east of North Cape (Bagley et al. 2000). The most abundant commercially fished pelagic species occurring east of Great Barrier Island appear to be the three mackerel species and skipjack tuna (Bagley et al. 2000).

19. While the mid to outer continental shelf east of Great Barrier Island and Coromandel Peninsula is poorly known the application and environmental impact assessment significantly understate the biodiversity values of the outer continental shelf east of Great Barrier Island and Coromandel Peninsula. This is exemplified by statements made in the environmental impact assessment such as:

> "*A lack of sea floor habitat conducive to feeding suggests that bottom feeding fin fish are unlikely to inhabit the muddy bottom at the NDA.*"

20. In general, the benthic invertebrate and demersal fish assemblages occurring east of Great Barrier Island are probably typical of large areas of the continental shelf around North and upper South Islands, albeit somewhat modified by bottom trawling (McKnight 1969; Leathwick et al. 2006a, b, 2012; Flaim & de Lange 2011).

Table 1. Fish species recorded at baited underwater video stations on the continental shelf east of Great Barrier Island by Zintzen et al. (2012); * = most abundant species; † = may include *Eptatretus cryptus*; depth range observed by Zintzen et al. (2012) followed in brackets by depth range recorded in research trawls by Anderson et al. (1998).

Species	Common name	Depth range (m)
*Cephaloscyllium isabellum**	Carpet shark	46 – 538 (7 – 637)
*Chelidonichthys kumu**	Red gurnard	39 – 101 (5 – 430)
Dipturus innominatus	Smooth skate	107 – 690 (13 – 1444)
*Eptatretus cirrhatus**†	Common hagfish	107 – 708
Galeorhinus galeus	School shark	62 – 301 (4 – 1057)
Helicolenus sp.*	Sea perch	62 – 538
Lepidopus caudatus	Frost fish	62 (9 - 1057)
*Nemadactylus macropterus**	Tarakihi	64 – 301 (11 – 486)
*Neomyxine caesiovitta**	Blueband hagfish	97 – 1161
*Pagrus auratus**	Snapper	39 – 107 (4 – 277)
Polyprion oxygeneios	Hapuku	91 – 301 (14 – 582)
*Pseudocaranx georgianus**	Trevally	46 – 107 (4 – 240)
*Seriola lalandi**	Kingfish	39 – 101 (4 – 217)
*Squalus griffini**	Northern spiny dogfish	91 – 538 (15 – 954)
Thyrsites atun	Barracouta	49 – 103 (5 – 671)
Zearaja nasuta	Rough skate	64 (14 – 1465)
Zeus faber	John dory	91 (5 – 366)

Effects on the ecology of the Northern Disposal Area

21. As demonstrated by the monitoring undertaken to date the benthic invertebrate assemblages that naturally occurred in the centre of the Northern Disposal Area have been modified by the dumping of dredged sediments. Burial and smothering by sediment will kill many of the organisms occurring at the centre of the disposal area, whereas colonisation by opportunistic species (e.g. predators and scavengers) and natural settlement and recruitment processes will further modify the assemblage structure. The ongoing, pulsed nature of the disturbance means that the benthic fauna at the centre of the disposal area will be in a continuous disturbance-recovery cycle dominated by short-lived species with rapid growth rates and high dispersal abilities. Further away from the centre of the disposal area some benthic species may be able to survive by burrowing their way to the surface

of the deposited sediment, but little information is available on the mobility of indigenous outer shelf invertebrates. Some shallow water (≤ 30 m depth) species subject to periodic natural disturbance by burial can burrow through up to 30 cm of deposited sediment to reach the surface however survival decreases with increasing sediment depth and burial by dissimilar sediments (Fenwick & Stenton-Dozey 2015). As outer shelf habitats such as those found in the Northern Disposal Area are subject to naturally low levels of disturbance and terrestrial sedimentation many of the species occurring in them are likely to have limited ability to move upward through deposited sediments.

22. Flaim & de Lange (2011) identified 29 taxa in benthic cores (70 mm internal diameter) prior to dumping commencing at the Northern Disposal Area, and 34 taxa post-dumping. The most diverse groups in these samples were polychaete worms and foraminifera. Foraminifera were the numerically dominant taxa. Benthic foraminifera are known to be sensitive to a variety of environmental variables including oxygen levels (high oxygen levels promote productivity), light (symbiotic species require light for growth), disturbance (high disturbance leads to very rapid reproduction) and food (organic detritus) supply (Murray 1983; Ernst 2002). Epifaunal foraminifera (those living at the sediment surface) are likely to respond rapidly to changes in productivity of overlying waters, since fresh organic detritus is mainly consumed at the sediment surface (Ernst 2002). Populations of infaunal foraminifera may peak following disturbance probably due in part to increased food availability as other infaunal invertebrates die (Langlet et al. 2013).

23. The effects on demersal fishes are harder to gauge. Most species should be able to avoid burial and smothering by the dumped material and associated density current and sediment plume. Some opportunistic species (e.g. snapper, tarakihi) may be temporarily attracted into the area following dumping to feed on invertebrates contained in the spoil. Others may avoid it due to changes to sediment composition and texture, and/or prey availability. Effects on pelagic species are likely to be short-lived and confined to avoidance of those parts of the plumes with the highest concentrations of suspended sediments.

Monitoring

24. Sedimentary habitats occurring on the outer shelf around the upper North Island support two widespread invertebrate assemblages characterised by the bivalves *Nemocardium pulchellum*, *Venericardia purpurata* and *Pleuromeris zelandica*, and a variety of associated macrofauna including polychaetes, brittle stars, infaunal urchins (*Echinocardium cordatum*, *Brissopsis oldhami*, *Spatangus multispinus*) and holothurians (McKnight 1969; Appendix 1). Populations of these relatively large, long-lived species respond quite differently to disturbance than species with short generation times and rapid growth (Fenwick & Stenton-Dozey 2015).

25. While species such as benthic foraminifera may be sensitive bioindicators, their rapid responses to disturbance and short-term natural fluctuations in environmental conditions increase spatial and temporal variability and make it difficult to detect the long-term effects of chronic disturbance. Recovery of benthic foraminifera will also provide no information on the recovery of slow growing, long-lived species.

26. Monitoring of benthic invertebrates in the Northern Disposal Area to date is strongly biased towards small meiofaunal organisms such as foraminifera. The NIWA review of the monitoring of the Northern Disposal Area concluded among other things that the low level of replication and use of small cores meant it was unlikely that the program sampled the area in enough detail to monitor any changes related to disposal (MacDiarmid 2011). Following this review the sampling design and size of the cores were changed. Core size was increased slightly from 70 mm to 100 mm internal diameter. Following this change the samples remain numerically dominated by benthic foraminifera.

27. As recommended by the NIWA review the use of a box corer or grab designed to eliminate 'washout' on ascent with appropriate replication is required to improve the representativeness of the monitoring program and adequately sample the benthic marcofauna (MacDiarmid 2011). This review also recommended the use of an improved imaging system to quantify the abundance of epifaunal organisms and surface trace evidence (i.e. burrows, mounds, tracks) of large infauna. These

recommendations included the use of scaling lights to determine the area sampled and improved lighting.

28. Lee et al. (2015) also concluded underwater video (a combination of ROV, baited underwater video and drifted 'drop down video') is a useful tool for identifying and describing the physical habitats and dominant epifauna occurring across the shelf in this region but noted that in-situ is still necessary for species-level identification and quantification of abundances. This is especially the case for infauna in muddy sediments where no epifauna may be visible (Lee et al. 2015). Combining underwater still and video imagery (usually taken continuously or at selected points along a transect) with sampling methods such as grabs, epibenthic sleds and small beam trawls is standard practice when describing the benthos of offshore areas (e.g. Bowden et al. 2011; Forrest et al. 2016; Clark et al. 2017).

Conclusions

29. The Northern Disposal Area covers a small part of the continental shelf of the northeast North Island. Outer shelf sediments in this region support at least two wide-spread faunal assemblages characterised by a variety small – moderate sized bivalves, brittle stars, infaunal urchins and holothurians. Deep reef habitats occurring east of Great Barrier Island and around Cuvier Island, southwest of the Northern Disposal Area, support highly diverse filter-feeding assemblages, including protected corals and glass sponges. These assemblages are likely to be highly sensitive to sedimentation (Lee et al. 2015). These reefs also support regionally important commercial rock lobster and line fisheries. The demersal fish assemblage is dominated snapper, tarakihi and school shark.

30. The biological assemblages occurring within the sediments of the Northern Disposal Area have been altered by ongoing disposal of dredge spoil and to a lesser extent bottom trawling. Adverse effects on benthic organisms have been greatest at the centre of the disposal area. Negative effects will increase with increased volume and frequency of dumping and dissimilarity of dredged material to that occurring in the disposal area.

31. Any increase in the volume of dumping approved at this site should not negatively impact benthic and pelagic habitats beyond the existing boundaries of the disposal area.

32. The monitoring program should include at least two control sites located at comparable depths northwest and southeast of the Northern Disposal Area.

33. Monitoring should be conducted at the same time each year to ensure comparability of the results and minimise seasonal variation.

34. The monitoring design should be optimised for sampling epibenthic and infaunal macro-invertebrates. This should include high resolution imaging of sea floor habitats and box core/grab sampling. Core sampling for meiofauna and benthic foraminifera should continue to provide continuity with the monitoring undertaken to date.

35. Demersal fish assemblages should be monitored with baited underwater video or short-duration beam trawls (e.g. Langlois et al. 2010; Zintzen et al. 2012; Clark et al. 2017).

36. Voucher specimens of all species recorded live in samples should be deposited in a at least one of the following collections: Auckland War Memorial Museum; Museum of New Zealand Te Papa Tongarewa; National Marine Invertebrate Collection, NIWA, Great Point.

37. The abundance of non-indigenous marine species identified during monitoring should be reported separately to indigenous marine species. The detection of any live unwanted marine organisms in the disposal area should be reported immediately to the Ministry for Primary Industries and EPA.

38. Monitoring should continue following the cessation of dumping long enough to determine if recovery of benthic macro-faunal assemblages is occurring and the nature of the response across the NDA.

Clinton Anthony John Duffy

DATED this 31st day of October 2018

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Appendix 1

Table A1.1. Benthic invertebrate specimens collected between 90 – 200 m depth east of Great Barrier Island and northern Coromandel Peninsula held by the National Marine Invertebrate Collection, NIWA, Greta Point, Wellington.

Phylum	**Class**	**Order**	**Family**	**Genus**	**Species**	**Accession Number**
Foraminifera	Granuloreticulosea	Foraminiferida (Foraminifera)	Cassidulinidae	*Globocassidulina*	*canalisuturata*	929 (Holotype), 930-932 (Paratypes)
Porifera	Demospongiae	Haplosclerida				95321-23
Cnidaria	Hydrozoa	Leptothecata	Lafoeidae	*Acryptolaria*	*conferta*	12358
Cnidaria	Anthozoa	Alcyonacea	Isididae	*Acanella*		104265
Cnidaria	Anthozoa	Scleractinia	Turbinoliidae	*Kionotrochus*	*suteri*	87796, 87810
Cnidaria	Anthozoa	Scleractinia	Flabellidae	*Monomyces*	*rubrum*	88470, 88506
Cnidaria	Anthozoa	Scleractinia	Caryophylliidae	*Caryophyllia*	*profunda*	127418
Cnidaria	Anthozoa	Scleractinia	Flabellidae	*Flabellum*	*knoxi*	127419
Annelida	Polychaeta	Amphinomida	Amphinomidae			121537
Annelida	Polychaeta	Phyllodocida	Polynoidae	*Euphione*	*squamosa*	124670
Arthropoda	Maxillopoda	Pedunculata	Calanticidae	*Scillaelepas*	*studeri*	12783
Arthropoda	Malacostraca	Amphipoda	Caprellidae			7140
Arthropoda	Malacostraca	Stomatopoda	Squillidae	*Anchisquilloides*	*mcneilli*	23934, 23952, 23954, 23984
Arthropoda	Malacostraca	Decapoda	Pandalidae	*Chlorotocus*	*novaezealandiae*	6208, 10290, 11888
Arthropoda	Malacostraca	Decapoda	Thalassinidae			6406
Arthropoda	Malacostraca	Decapoda	Palinuridae	*Jasus*	*edwardsii*	126762
Arthropoda	Malacostraca	Decapoda	Paguridae			17770
Arthropoda	Malacostraca	Decapoda	Leucosiidae	*Ebalia*		9972
Arthropoda	Malacostraca	Decapoda	Raninidae	*Lyreidus*	*tridentatus*	16850, 16882
Mollusca	Scaphopoda					16372
Mollusca	Gastropoda	Neogastropoda	Volutidae	*Alcithoe*	*larochei*	4153
Mollusca	Gastropoda	Neogastropoda	Volutidae	*Alcithoe*	*tigrina*	91523
Mollusca	Gastropoda	Nudibranchia	Tritoniidae	*Tritonia*	*incerta*	19727
Mollusca	Cephalopoda	Octopoda	Octopodidae	*Octopus*	*kaharoa*	84350
Bryozoa	Gymnolaemata	Cheilostomata	Conescharellinidae	*Conescharellina*	*pala*	458 (Paratype)
Brachiopoda	Rhynchonellata	Terebratulida	Terebratellidae	*Calloria*	*inconspicua*	62765
Brachiopoda	Rhynchonellata	Terebratulida	Terebratellidae	*Neothyris*	*compressa*	67007
Brachiopoda	Rhynchonellata	Terebratulida	Terebratellidae	*Neothyris*	*lenticularis*	65248, 65249, 65387
Brachiopoda	Rhynchonellata	Terebratulida	Terebratellidae	*Terebratella*	*haurakiensis*	69330, 69333
Echinodermata	Asteroidea	Valvatida	Goniasteridae	*Anthenoides*	*cristatus*	2917
Echinodermata	Asteroidea	Paxillosida	Astropectinidae	*Astropecten*	*dubiosus*	18843
Echinodermata	Asteroidea	Paxillosida	Astropectinidae	*Psilaster*	*acuminatus*	20021
Echinodermata	Asteroidea	Paxillosida	Astropectinidae	*Psilaster*	*acuminatus*	20072
Echinodermata	Asteroidea	Paxillosida	Luidiidae	*Luidia*	*neozelanica*	116160

Phylum	**Class**	**Order**	**Family**	**Genus**	**Species**	**Accession Number**
Echinodermata	Asteroidea	Paxillosida	Pseudarchasteridae	*Pseudarchaster*	*garricki*	105865
Echinodermata	Crinoidea	Comatulida	Antedonidae	*Argyrometra*	*mortenseni*	95976
Echinodermata	Ophiuroidea	Ophiurida	Amphiuridae	*Amphiura*	*rosea*	107242
Echinodermata	Echinoidea	Cidaroida	Cidaridae	*Ogmocidaris*		115909
Echinodermata	Echinoidea	Cidaroida	Cidaridae	*Ogmocidaris*	*benhami*	116040
Echinodermata	Echinoidea	Clypeasteroida	Laganidae	*Peronella*	*hinemoae*	50226-28
Echinodermata	Holothuroidea	Dendrochirotida	Phyllophoridae	*Pentadactyla*	*longidentis*	73999
Echinodermata	Holothuroidea	Molpadiida	Molpadiidae	*Heteromolpadia*	*marenzelleri*	68031

Table A1.2. Biological specimens collected from the continental shelf east of Great Barrier Island held by the Auckland War Memorial Museum.

Phylum	Class	Order	Family	Taxonomic Classification	Accession Number
Mollusca	Scaphopoda	Dentaliida	Dentaliidae	*Antalis nana*	MA16859
Mollusca	Scaphopoda	Dentaliida	Dentaliidae	*Dentalium* sp.	MA27661
Mollusca	Scaphopoda	Dentaliida	Dentaliidae	*Fissidentalium zelandicum*	MA130623
Mollusca	Gastropoda	Littorinimorpha	Rissoidae	*Haurakia semireticulata*	MA65676
Mollusca	Gastropoda	Neogastropoda	Borsoniidae	*Bathytoma* sp.	MA37900
Mollusca	Gastropoda	Neogastropoda	Borsoniidae	*Maoritomella albula*	MA37921
Mollusca	Gastropoda	Neogastropoda	Buccinidae	*Austrofusus glans*	MA13285
Mollusca	Gastropoda	Neogastropoda	Drilliidae	*Splendrillia aoteana*	MA16687
Mollusca	Gastropoda	Neogastropoda	Pseudomelatomidae	*Antimelatoma buchanani*	MA37953
Mollusca	Gastropoda	Neogastropoda	Raphitomidae	*Taranis gratiosa*	MA38395
Mollusca	Gastropoda	Seguenziida	Seguenzioidea	*Lissotesta granum*	MA65677
Mollusca	Gastropoda	Trochida	Solariellidae	*Zetela textilis*	MA14230
Mollusca	Bivalvia	Anomalodesmata	Verticordiidae	*Haliris setosa*	MA82379
Mollusca	Bivalvia	Arcida	Arcidae	*Bathyarca cybaea*	MA13344, MA14562, MA82378
Mollusca	Bivalvia	Carditida	Condylocardiidae	*Benthocardiella* sp.	MA13146
Mollusca	Bivalvia	Carditida	Condylocardiidae	*Cuna compressidens*	MA82384
Mollusca	Bivalvia	Carditida	Condylocardiidae	*Cuna* sp.	MA15890
Mollusca	Bivalvia	Imparidentia	Lasaeidae	*Arthritica bifurca*	MA14396
Mollusca	Bivalvia	Nuculida	Nuculidae	*Ennucula strangei*	MA82381
Mollusca	Bivalvia	Nuculanida	Nuculanidae	*Poroleda lanceolata*	MA72961
Mollusca	Bivalvia	Nuculanida	Nuculanidae	*Saccella hedleyi*	MA98493
Mollusca	Bivalvia	Venerida	Neoleptonidae	*Neolepton antipodum*	MA16807
Chordata	Actinopterygii	Perciformes	Bramidae	*Pteraclis velifera*	MA5321

Appendix 2

Research trawl stations used to describe Hauraki Gulf demersal fish assemblages by Kendrick & Francis (2002).

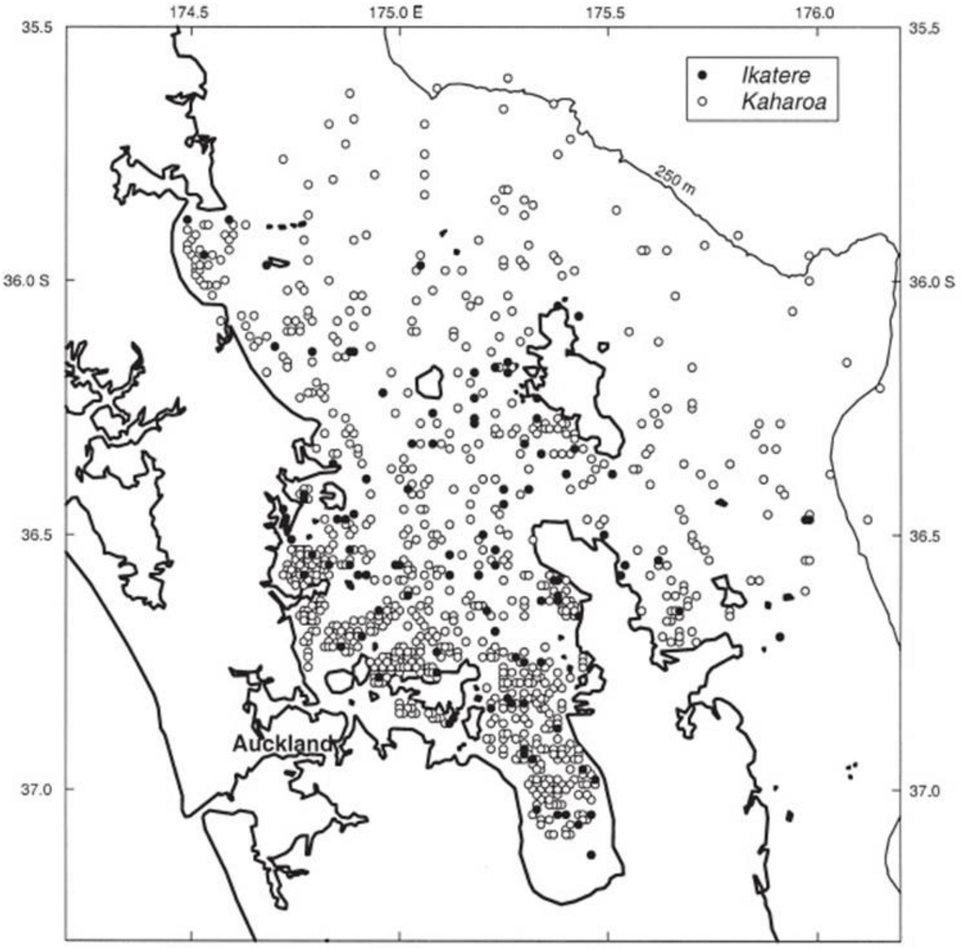

Fig. 1 Location of trawl tows carried out in the Hauraki Gulf, New Zealand by RV *Ikatere* (*N* = 419) and RV *Kaharoa* (*N* = 962). *Ikatere* trawl stations were repeated in many surveys, so each point represents multiple tows.