Port Phillip Channel Deepening Project
Supplementary Environmental Effects Statement
Panel Hearing

Expert Witness Statement of Matt Edmunds

Prepared for Port of Melbourne Corporation

June 2007

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1. Introduction

1.1 Name and Qualifications

Dr Matt Edmunds

Australian Marine Ecology Pty Ltd

82 Parsons St

Kensington

VIC 3031

BSc (Hons), first class, Marine, Freshwater and Antarctic Biology, University of Tasmania

PhD, Zoology, University of Tasmania

I have specialist expertise in coastal ecological investigations. I have been designing and implementing research and monitoring programs for nineteen years. My work encompasses a broad range of ecological aspects, including community-environment relationships, taxonomy, population dynamics and environmental impact assessment. I have substantial experience in experimental/sampling design and analysis, in addition to a strong practical background in underwater sampling and survey techniques. These include visual censuses, underwater photography, sediment sampling, taxonomic collections and use of remote underwater vehicles. My research has helped establish standardised survey and sampling techniques in southern Australia. I was the principal investigator to systematically and comprehensively describe and compare intertidal, subtidal and deep reef communities across Victoria. A copy of my *curriculum vitae* is provided in Appendix A.

1.2 Instructions and Information

I have been engaged by Maunsell Australia Pty Ltd on behalf of the Port of Melbourne Corporation to provide an Expert Witness Statement that:

(a) addresses additional matters/new information pertaining to rock falls that has arisen since I completed my technical reports for inclusion in the SEES; and

(b) responds to rock falls issues raised through the submission process.

In preparing this statement, I have reviewed and relied on the following base information:

Australian Marine Ecology documents and materials – deep reef biology:

Elias J, Edmunds M and Hart S (2004) *Port Phillip Bay Channel Deepening Environmental Effects Statement – Marine Ecology Specialist Studies. Volume 7: Deep Reef Habitat Study*. Australian Marine Ecology Report 164. Channel Deepening EES Volume 3 A1. Port of Melbourne Corporation. Melbourne, 48 pp.

Edmunds M, Gilmour P, Power B, Shimeta J, Pickett P, Judd A, Baker K, Sams M, Wassnig M, Williams J, Crozier J, Stewart K and Monk J (2006) *Port Phillip Bay Channel Deepening Project. Supplementary Environmental Effects Statement – Marine Ecology Specialist Studies. Volume 8: Deep Reef Biota*. Australian Marine Ecology Report 357. Channel Deepening Project Supplementary Environmental Effects Statement Appendix 47, Port of Melbourne Corporation, Melbourne.

Edmunds M, Gilmour P, Power B, Shimeta J, Pickett P, Judd A, Baker K, Sams M, Wassnig M, Williams J, Crozier J, Stewart K and Monk J (2007) *SEES Volume 9 Deep Reefs Appendix D. Population Distributions*. Australian Marine Ecology Report 361. Channel Deepening Project Supplementary Environmental Effects Statement Appendix 47, Port of Melbourne Corporation, Melbourne.

Edmunds M, Shimeta J, Judd A and Baker K (2007) *Port Phillip Bay Channel Deepening Project Supplementary Environmental Effects Statement – Rock Fall Impact Assessment.* Australian Marine Ecology Report 374. Channel Deepening Project Supplementary Environmental Effects Statement, Appendix 54, Port of Melbourne Corporation, Melbourne. 205 pp [although an impact report – this document substantially advances the biology from the initial existing conditions report].

Video: Video footage from diving and ROV surveys in The Rip, elsewhere in Port Phillip Heads and elsewhere in Victoria.

Australian Marine Ecology documents – rock falls impact assessment:

Edmunds M, Stewart K and Williams J (2005) *Channel Deepening Project Trial Dredge Study. Performance Assessment for Rock Falls in The Rip. Pre-Dredging Survey.* Report to Port of Melbourne Corporation. Australian Marine Ecology Report 316 Version 1.0, Melbourne, 18 pp.

Edmunds M, Stewart K and Williams J (2005) *Channel Deepening Project Trial Dredge Study. Performance Assessment for Rock Falls in The Rip. During-Dredging Survey*. Report to Port of Melbourne Corporation. Australian Marine Ecology Report 318 Version 3.0, Melbourne, 27 pp.

Edmunds M, Crozier J and P Gilmour (2005) *Channel Deepening Project Trial Dredge Study. Performance Assessment for Rock Falls in The Rip. Post-Dredging Survey*. Report to Port of Melbourne Corporation. Australian Marine Ecology Report 320 Version 3.0. Melbourne, 38 pp.

Edmunds M and Pickett P (2005) *Channel Deepening Project Trial Dredge Study. Investigation of Rock Falls in The Rip. Post-Dredging Survey 2.* Report to Port of Melbourne Corporation. Australian Marine Ecology Report 323. Melbourne, 25 pp.

Edmunds M, Bryant C, Crozier J, Gilmour P, Pickett P, Stewart K and Williams J (2006) *Port Phillip Bay Channel Deepening Project. Trial Dredging Experiment: Deep Reef Impact Assessment*. Report to Port of Melbourne Corporation. Australian Marine Ecology Report 334, Melbourne.

Edmunds M, Judd A, Pickett P, Stewart K and Crozier J (2007) *Port Phillip Bay Channel Deepening Project. Trial Dredging Program: Deep Reef Monitoring, December 2006*. Report to Port of Melbourne Corporation. Australian Marine Ecology Report 377, Melbourne. 139 pp

Edmunds M and Gilmour P (2007) *Port Phillip Bay Channel Deepening Project. Trial Dredging Program: Rip Bank Monitoring, December 2006*. Report to Port of Melbourne Corporation. Australian Marine Ecology Report 379, Melbourne. 103 pp.

Video: Video footage from diving and ROV surveys on Rip Bank.

Australian Marine Ecology documents – rock falls impact prediction:

Edmunds M and Sams M (2006) *Port Phillip Bay Channel Deepening Project Supplementary Environmental Effects Statement – Modelling Rock Fall Scenarios.* Report to Maunsell. Australian Marine Ecology Report 371, Melbourne, 52 pp.

Edmunds M, Shimeta J, Judd A and Baker K (2007) *Port Phillip Bay Channel Deepening Project Supplementary Environmental Effects Statement – Rock Fall Impact Assessment.* Australian Marine Ecology Report 374. Channel Deepening Project Supplementary Environmental Effects Statement, Appendix 54, Port of Melbourne Corporation, Melbourne. 205 pp

SEES public documents (rock falls components):

SEES Main Document, 9.2.3 Marine Habitats, Deep Canyon, page 9-19.

SEES Main Document, 14 The Entrance – Project Area 4, pages 14-1 to 14-52.

Appendix 47 – Australian Marine Ecology (2006) *Port Phillip Bay Channel Deepening Project Supplementary Environment Effects Statement – Marine Ecology Specialist Studies. Volume 9: Deep Reef Biota.* Australian Marine Ecology, Kensington, Victoria

Appendix 52 – CEE (2007) *Overview Impact Assessment – Deep Canyon*. CEE Consultants, Richmond Victoria.

Appendix 54 – Australian Marine Ecology (2007) *Port Phillip Bay Channel Deepening Project Supplementary Environment Effects Statement. Rockfall Impact Assessment*. Australian Marine Ecology, Kensington, Victoria

Reviews and responses to rock falls studies:

- Deep reef community and habitat mapping workshop, Melbourne, 17 March 2006 (including scientists: Drs Graham Edgar, Neville Barrett, Jacques Locat, Brett Light, Mick Keough and Des Lord).
- Entrance Assessment Strategy Review, Dr Keith Hayes, 7 September 2006.
- Peer Review, Dr Nev Barrett, Tasmanian Aquaculture and Fisheries Institute, 13 July 2006.
- Peer Review, Dr Lynne McArthur, RMIT University, November 2006.
- IEG - Review, rock falls impact assessment report, 9 December 2006.
- Response to IEG review, Matt Edmunds, 9 December 2006.
- Review, Dr Eric Bird, Comments on the Geomorphology of Entrance Deep, Port Phillip Heads, and Australian Marine Ecology Reports 357 and 374.
- IEG - Advice on the Channel Deepening Project SEES, Independent Expert Group, May 2007.

Other information reviewed and cited:

Australian Faunal Directory http://www.environment.gov.au/biodiversity/abrs/online-resources/fauna/afd/ [last accessed 12 June 2007]

Bergquist P and Skinner IG (1982) Sponges (Phylum Porifera). **In**: (Shepherd SA and Thomas IM, eds) *Marine Invertebrates of Southern Australia. Part I.* Handbook of the Flora and Fauna of South Australia, Government Printer, South Australia.

Bock PE (1982) Bryozoans (Phylum Bryozoa). **In**: (Shepherd SA and Thomas IM, eds) *Marine Invertebrates of Southern Australia. Part I.* Handbook of the Flora and Fauna of South Australia, Government Printer, South Australia.

Kelleher G and Kenchington R (1992) *Guidelines for Establishing Marine Protected Areas*. Marine Conservation and Development Report. IUCN, Gland, Switzerland.

Ponder W, Hutchings P and Chapman R (2002) *Overview of the Conservation of Australian Marine Invertebrates.* Report to Environment Australia. Australian Museum, Sydney.

Sorokin SJ, Currie DR and Ward TM (2005) *Sponges from the Great Australian Bight Marine Park (Benthic Protection Zone)*. Report to Wildlife Conservation Fund for the Wildlife Advisory Committee, South Australian National Parks and Wildlife Council. South Australian Research and Development Institute (Aquatic Sciences), Adelaide.

Thackway R (ed., 1996) *Developing Australia's Representative System of Marine Protected Areas: Criteria and Guidelines for Identification and Selection.* Proceedings of a technical meeting held at the South Australian Aquatic Sciences Centre, West Beach, Adelaide, 22-23 April 1996. Department of the Environment Sport and Territories, Canberra.

Watson JE (1982) Hydroids (Class Hydrozoa). **In**: (Shepherd SA and Thomas IM, eds) *Marine Invertebrates of Southern Australia. Part I*. Handbook of the Flora and Fauna of South Australia, Government Printer, South Australia.

1.3 Experience Relevant to the Rock Falls Component of the SEES

In relation to the Channel Deepening Project, I was heavily involved as a marine ecology specialist since February 2003. To date, I have authored over 104 reports associated with this project. Further details of my involvement are provided below. Other experience pertaining to port related matters includes marine ecology studies at Portland Harbour, Apollo Bay Harbour, Lorne and Lakes Entrance.

In relation to deep habitat field studies, I am one of few scientists that have observed many different deep habitats, first hand, in southeastern Australia. My deep diving experience and observations includes Tasmanian reefs at Bathurst Channel, Bruny Island, Tasman Peninsula, Forestier Peninsula, Maria Island, Isle des Phoques and Bicheno. I have extensively dived the deep reefs of The Rip, Portsea Hole and Wilsons Promontory. I have been a key instigator in the advancement of deep reef science and ecology, including the development of remotely operated vehicle (ROV) survey systems and standard protocols for quantitative data collection. I have done video/ROV surveys of deep habitats in Victoria at Discovery Bay, Cape Bridgewater, Port Campbell, Twelve Apostles, Port Phillip Heads, Inverloch, Wilsons Promontory and all the way across Bass Strait (several times). I have participated in several hundred instrument deployments for deep habitat studies and have analysed abundances of deep biota from over 9500 video frames.

I am one of few scientist to have systematically examined, documented and compared deep reef assemblages and species across different bioregions, environmental gradients and microhabitat types. The monitoring associated with the Trial Dredging Program is one of only two deep reef temporal studies in southern Australia, the other being at Bathurst Channel in Tasmania.

I have substantial experience in the analysis of quantitative biological data, including community composition, patterns and differences between sites and over time and associations between biota and environmental conditions. This experience includes: fish-reef habitat relationships in southeastern Tasmania; seaweed and invertebrate community associations with environmental variables on reefs in Victoria; biogeography of subtidal reef communities in central Victoria; long-term trends in subtidal reef populations and communities. I also have considerable experience in impact prediction (environmental impact assessments) and impact measurement and description. Example references are contained in my *curriculum vitae* (Appendix).

2. Involvement in Port Channel Deepening Project (CDP)

2.1 Role in Channel Deepening Project

I have been involved in the Channel Deepening Project since February 2003 – at the commencement of the EES. I have produced over 105 reports for this project. A chronology of my work associated with the project follows.

EES Marine Ecology Existing Conditions Field Surveys, February-May 2003

Field surveys to describe the species and assemblages present at key places in Port Phillip Bay. This was to fill knowledge gaps – most of the key assets of concern to the Project were not investigated as part of the Melbourne Water Port Phillip Bay Environmental Study (CSIRO).

Field surveys were designed in accordance with the original budget and schedule for completion of the whole EES by August 2003.

Field investigations included:

- quantitative sediment infauna and microphytobenthos surveys in the north and south of the Bay;
- quantitative seagrass and seasquirt (Pyura) bed communities throughout the south of the Bay; and
- qualitative deep reef habitat surveys at Schnapper Deep, Portsea Hole, Spec and Farside reefs, The Plateau and Lonsdale Wall.

EES Marine Ecology Existing Conditions Reports, April-September 2003

Synthesis of available information and new survey results to provide a comprehensive description of existing conditions, including key natural assets of conservation concern.

EES Marine Ecology Assets and Physical Effects, September-December 2003

Definition of environmental management assets/components for impact and risk assessment. Definition of physical effects that these assets would be exposed to.

EES Primary Production and Turbidity Impact Modelling, November 2003-February 2004

Synthesis of available information on photosynthesis, primary production and associated parameters (including PPBES models). Construction of primary production models that dovetail with outputs from the turbidity model to provide direct assessment of impacts from a specified dredge schedule. Models were constructed for:

- *Heterozostera* seagrass;
- *Amphibolis* seagrass;

- microphytobenthos (sediment microalgae); and
- *Ecklonia* kelp.

Seagrass patch recovery models were constructed for *Heterozostera* and *Amphibolis*.

EES Impact and Risk Assessment, October 2003-May 2004

Vulnerability, impact and risk assessments for each natural asset against each disturbance/effect type. Monitoring and performance assessment recommendations, including concepts of a light budget and adaptive management feedback systems to protect primary producers.

EES Report Revisions and Panel Hearings, May 2004-December 2005

Additional documents associated with the Panel Hearings, including modelling of different dredging scenarios. Appearances before the panel.

Baseline Monitoring and Research, September 2004-March 2005

Implementation of monthly monitoring, other baseline surveys and research investigations to:

- provide calibration data for light-driven models;
- provide baseline data for assessment of potential impacts;
- provide further information to fill knowledge gaps and decrease uncertainty.

Development of performance assessment procedures and reviews of these by University of Melbourne.

Monthly Monitoring Program, March 2005-February 2006

Monitoring of plant populations and associated physical data from nearby instrument loggers to determine baseline data on natural variability and provide data for model development and determination of light requirements for plants.

Trial Dredging Experiments and Performance Assessment, March 2005-January 2006

Design and implementation of experiments to take advantage of the Trial Dredging to fill knowledge gaps. This included collecting data for improving primary production models. Performance assessment analysis and reporting with respect to substratum removal and rock falls.

Trial Dredging Impact Assessment, November 2005-April 2006

Qualitative and quantitative surveys to describe the magnitude and extent of rock fall impacts, using diving and remotely operated vehicle (ROV) video survey methods.

SEES Deep Reef Existing Conditions, March-June 2006

Quantitative remotely operated vehicle (ROV) video surveys throughout The Rip to comprehensively describe the nature and distribution of the deep reef biota. Production of an existing conditions report that synthesised all existing information, including placing the findings in perspective with observations elsewhere. This study involved two field teams and a large laboratory team and was one of the largest marine ecological studies ever done in southern Australia. The design was guided by an initial workshop with scientific experts in temperate Australian marine life, habitat mapping and rock fall modelling.

SEES Marine Ecology Existing Conditions, April-September 2006

Update of the original EES existing conditions reports to include new data collected, such as from the baseline monitoring program, as well as alteration of all tables and figures to reflect site number, formatting, restructuring changes for SEES.

SEES Rock Falls Scenarios Modelling, August-September 2006

Implementation of a gravitational transport model (*g-Trans*) to examine the pathways of rubble flows down the slopes and potential levels of exposure to biota. Different head loadings were examined.

SEES Rock Falls Impact Assessment, August-September 2006, January 2007

Improved analysis of biological data to more robustly define assemblage units. Collation of environmental spatial data. Analysis of predictive associations between assemblage units and environmental parameters. Mapping of assemblages at three scales: patch data without interpolation, patch data with interpolation according to physical habitat distributions. Modelling of rock fall magnitudes and distributions using *g-Trans*. Assessment of relative impacts on each assemblage type in accordance with rock fall exposure. An opportunity was later provided to analyse impacts on population abundances (but without any interpolation of distributions).

Trial Dredge Ongoing Monitoring Program, November 2006-December 2007

Repeated quantitative surveys on Rip Bank to assess impacts and recovery from rock falls over time. Reporting of video and photographs provided by PoMC from qualitative surveys of Rip Bank to examine impacts and recovery of substratum removal and rock falls. Surveys were/are/will be November 2006, May 2007 and November 2007.

2.2 Relevant Technical Reports (Rock Falls)

Rock falls sections of the SEES were:

Appendix 47 – Australian Marine Ecology (2006) *Port Phillip Bay Channel Deepening Project Supplementary Environment Effects Statement – Marine Ecology Specialist Studies. Volume 9: Deep Reef Biota*. Australian Marine Ecology, Kensington, Victoria

Appendix 54 – Australian Marine Ecology (2007) *Port Phillip Bay Channel Deepening Project Supplementary Environment Effects Statement. Rockfall Impact Assessment*. Australian Marine Ecology, Kensington, Victoria

Other documents that were pertinent to the rock falls component of the SEES were:

Elias J, Edmunds M and Hart S (2004) *Port Phillip Bay Channel Deepening Environmental Effects Statement – Marine Ecology Specialist Studies. Volume 7: Deep Reef Habitat Study*. Australian Marine Ecology Report 164. Channel Deepening EES Volume 3 A1. Port of Melbourne Corporation. Melbourne, 48 pp.

Edmunds M, Crozier J and P Gilmour (2005) *Channel Deepening Project Trial Dredge Study. Performance Assessment for Rock Falls in The Rip. Post-Dredging Survey*. Report to Port of Melbourne Corporation. Australian Marine Ecology Report 320 Version 3.0. Melbourne, 38 pp.

Edmunds M and Pickett P (2005) *Channel Deepening Project Trial Dredge Study. Investigation of Rock Falls in The Rip. Post-Dredging Survey 2.* Report to Port of Melbourne Corporation. Australian Marine Ecology Report 323. Melbourne, 25 pp.

Edmunds M, Bryant C, Crozier J, Gilmour P, Pickett P, Stewart K and Williams J (2006) *Port Phillip Bay Channel Deepening Project. Trial Dredging Experiment: Deep Reef Impact Assessment*. Report to Port of Melbourne Corporation. Australian Marine Ecology Report 334, Melbourne.

Edmunds M and Sams M (2006) *Port Phillip Bay Channel Deepening Project Supplementary Environmental Effects Statement – Modelling Rock Fall Scenarios.* Report to Maunsell. Australian Marine Ecology Report 371, Melbourne, 52 pp.

Subsequent documents pertinent to this statement were:

Edmunds M, Judd A, Pickett P, Stewart K and Crozier J (2007) *Port Phillip Bay Channel Deepening Project. Trial Dredging Program: Deep Reef Monitoring, December 2006*. Report to Port of Melbourne Corporation. Australian Marine Ecology Report 377, Melbourne. 139 pp

Edmunds M and Gilmour P (2007) *Port Phillip Bay Channel Deepening Project. Trial Dredging Program: Rip Bank Monitoring, December 2006*. Report to Port of Melbourne Corporation. Australian Marine Ecology Report 379, Melbourne. 103 pp.

3. Additional Matters

3.1 Overview of Issues Arising

The primary documents presented to the panel pertaining to rock fall impact assessment are:

- *Appendix 52 Overview Impact Assessment – Deep Canyon;*
- *SEES Main Report;* and
- *Advice on the Channel Deepening Project Supplementary Environment Effects Statement, Independent Expert Group, May 2007*.

These documents discounted and overlooked some important considerations that were within subordinate documents of Appendices 47 and 54. Also, there is additional information that has an important bearing on understanding the biological consequences and risks of rock removal and rock falls. This information has arisen out of further assessments of the significance of natural values in The Rip.

I have taken a constructive approach of synthesising information into a form that may directly assist the Panel in understanding natural values and potential impacts. To this end, I have structured the information under the same headings used by the IEG:

- What is the fauna and flora of the Entrance, and what is its significance to Victoria's marine biodiversity?
- How will this biota be affected by removal of rock in the entrance?
- If there are impacts, how will recovery occur?

3.2 What is the fauna and flora of the Entrance and what is its significance to Victoria's marine biodiversity?

The marine environment at the Entrance, Port Phillip Heads, consists of banks of intermediate depth reefs of approximately 17 m deep with a very deep, steep sided canyon meandering between them from between the Heads to approximately 1.6 km to the north. The huge volumes of water ebbing or flooding through the heads cause considerable turbulence, hence this area is called The Rip.

The Entrance is a unique marine environment like nowhere else in Australia. The combination of features that make this environment unique include: very high current flows (3-8 knots); high exposure to swell; high depth range (14 to 100 m); highly eroded rock faces creating a complex of different substratum structures; high particulate loading in the water column during strong tides and storms; adjacent productivity from seagrass and kelp beds; and fully marine salinity. Specific environmental features are described in the SEES Technical Appendices 47 and 54. Perhaps the most similar environment is Bathurst Channel in southwest Tasmania, which also consists of a narrow deep channel with moderately high current flows. Bathurst Channel differs considerably in that it has a brackish surface layer with a high concentration of tannins, limiting light to above 10 metres. All other coastal environments in Victoria do not have any where near the same current speeds, depth range (most of Bass Strait is less than 85 m) and substratum structures. They also differ in levels swell exposure, water clarity and temperature.

The tops of the rocky banks, particularly Rip Bank, Nepean Bank, The Plateau and the top of Lonsdale Wall, are covered by an *Ecklonia* kelp bed. These intermediate depth kelp beds are different in community composition to shallower *Ecklonia* kelp beds in the region, having a much lower abundance and diversity of mobile invertebrates (particularly seastars), different fish assemblage and lower abundances of understorey algae. The kelp beds generally extend to the edge of the canyon. There is generally an abrupt drop in the reef below 20 m and there are isolated small stands of kelp on horizontal shelves of reef to depths of approximately 27 m.

From approximately 20-25 m depth, the reef surface is dominated by sessile invertebrates. These communities are generally termed sponge gardens after the predominance and variety of sponges present. The sessile invertebrate communities are also comprised of ascidians, bryozoans, hydroids and corals. There is a high diversity of biota comprising these communities – this being visually obvious from the morphological structures present. The species and diversity of sessile invertebrates at Port Phillip Heads is comparatively well documented.

For the sponges, there have been over 271 validated species collected from Port Phillip Heads, which is a substantial proportion of the 523 known species from Victoria and the 1416 valid species in the Australian fauna (Australian Fauna Directory). Importantly, a large proportion of sponges collected at Port Phillip Heads are only known from that area: 115 species (species only known from an area are known as endemics, hence Port Phillip Heads has a high degree of endemism). Most of these species were determined from extensive sampling in the late nineteenth century and a large proportion of these samples remain unclassified (Australian Fauna Directory). More recent sampling in Australian has not extended the range of species known only from Port Phillip, but rather identified additional areas of high biodiversity and endemism (Ponder *et al.* 2002; Sorokin *et al.* 2005).

For bryozoans, there have only been a few main collection areas in southern Australia, one of these being Port Phillip, making it difficult to establish species distributions. Nevertheless, Port Phillip is considered to be a place of high bryozoan diversity, having a more diverse bryozoan fauna than Europe (P. Cook, P Bock; Cited in Ponder *et al.* 2002). Port Phillip Heads is noted as one of three areas particularly rich in hydroid fauna (Watson 1982; the others also being very high current areas of Backstairs Passage in S.A. and Crawfish Rock in Westernport). Port Phillip is the type locality for three ascidian species, one of which is only known from Port Phillip Heads (Australian Fauna Directory).

Most sessile invertebrate species can only be identified through collection and laboratory examinations. The considerable time required to identify each specimen, particularly sponges, currently precludes ecological studies of sessile invertebrate communities to species level. For the SEES studies, deep reefs were surveyed using a standardised video technique to describe the abundances and distributions of sessile invertebrates. Where possible, species were identified, otherwise morphological types were used. This meant the SEES studies did not increase our understanding of species richness from previous studies, but they were first comprehensive study of distributions of species and morphotypes. The abundances and distributions of 74 species and morphotypes were mapped in SEES Technical Appendix 47, Volume 9.

Assemblages are defined as the collection of different species/types within a particular area and are structured by both the type of species present and their abundances. These species may interact to form a community and different communities may have different ecological functions. For the SEES studies, differences in the sessile invertebrate assemblages were likely to have differing ecological functions in terms of biogenic habitat provision for other species, such as crabs, molluscs and echinoderms. Differences in assemblage structure were also likely to reflect other differences in ecological processes. Therefore, variations in assemblage structure were not only a direct indicator of differences in biodiversity of sessile invertebrates, but were possibly also a surrogate for biodiversity differences in the communities as a whole. Assemblage structures were described in SEES Technical Appendix 47, Volume 9 and were analysed in more detail in Appendix 54.

The sessile invertebrate assemblages of The Rip were quite distinct from those observed using similar or comparable methods at Point Addis and Wilsons Promontory (Appendix 47). The deep reefs at Wilsons Promontory has a much higher algal component (having much clearer water), as well as much higher abundances of gorgonian coral fans *Pteronisis* sp, sea whips *Primnoella australasiae*. *Pteronisis* was uncommon at Port Phillip Heads and *Primnoella* was not observed at all. In contrast, the most abundant hydroids at Port Phillip Heads, *Nemertesia procumbens* and the feathery red hydroid *Halopteris glutinosa* were not observed in the Wilson Promontory surveys. Sponge coverage is 65 % at Port Phillip Heads, compared to 10 % at Wilsons Promontory (Appendix 47). Point Addis was distinct in having a dominance of erect sponges rather than encrusting sponges (as opposed to Port Phillip Heads), with an average cover of 15-26 % cover. (*c.f.* 65 % at Port Phillip Heads). The bryozoan colonies at Point Addis differed in having a dominance of erect crustose species rather than bushy arborescent species typical of Port Phillip Heads (Appendix 47). More recent deep reef surveys at The Arches (Port Campbell) and Twelve Apostles found new types of assemblages, which had some affinities to Point Addis but none with Port Phillip Heads (Parks Victoria, unpublished report).

The sessile invertebrate fauna at Port Phillip Heads includes a suite of species that commonly occur throughout southern Australia. These include distinctive species such as the hydroids *Solanderia fusca*, *Nemertesia procumbens* and *Gymnangium superbum*, jewel anemones *Corynactis australis* and bryozoan *Orthoscuticella ventricosa*. The presence of such common, well known species does not make the area any less unique (as inferred from other SEES documents). Rather, it is the relative abundances of such species that contribute to different and unique assemblage structures (and ecological processes). A good analogy is Popes Eye within Port Phillip Bay. The fishes on this reef are all common species elsewhere in Victoria, but the mixture of types of species present and their abundances is very different to anywhere else. Hence, this area is attributed with very high conservation values.

In summary, Port Phillip Heads is a place of high biodiversity, including many (> 100) species known only from Port Phillip Heads. Sessile invertebrate assemblage structure is distinctive from other deep reef systems in Victoria, namely The Arches, Twelve Apostles, Point Addis and Wilsons Promontory. This uniqueness is likely to be driven, in part, by the unique physical habitat, particularly the strong currents and lower light levels (from suspended sediments) in which sessile filter feeders usually thrive.

There are marked environmental gradients and discontinuities in the marine environment at Port Phillip Heads. These were initially described in Appendix 47 and analysed in more detail in Appendix 54. The environmental factors described and mapped included depth, wave surge, current speed and insolation, as well as substratum relief, slope and curvature. Combined differences in these factors, and others such as sand cover, result in considerably different environmental conditions and habitats throughout The Rip (the Entrance area dominated by the canyon seascape). Of importance to the SEES impact assessment was determining how different the biota was between the differing environs:

- are there differences in assemblage structure in the different places and habitats of The Rip? and if so
- what are the nature of the differences – are there unique assemblages and where are they?

These questions were initially addressed in Appendix 47 using standard multivariate analyses to compare the assemblages between 129 reef patches. There were substantial differences in assemblage structure between locations within The Rip. Some of these differences were visually obvious, for example between the jewel anemone community of Uelmans Deep, the arborescent sponge communities of Lonsdale Wall, the bryozoan communities of the 60 m deep sandy shelfs and the diverse encrusting sponge communities of Rip Bank. There were also other, more subtle community structure differences, with these differences varying along continua of change (*i.e.* some differences are not discrete and were never expected to be discrete). These differences in assemblage structure were described using both ordination and clustering techniques in Appendices 47 and 54 (depicting degrees of differences in assemblage types between patches and areas in The Rip).

A reasonable proportion of the variations in assemblage structure (> 30 %) corresponded with differences in environmental conditions (this proportion could be a lot higher with better resolution of environmental parameters – particularly sand cover). There was also some degree of spatial autocorrelation (assemblages closer to one another were more similar). These findings suggest there are likely to be deterministic factors structuring the assemblages. Such factors may include differences in survivability of different species in different habitats and recruitment being largely influenced by adjacent, nearby populations. There are also expected to be stochastic (random) factors in the formation of sessile invertebrate assemblages, with the type and timing of species arriving to colonise an area being open to chance events. The results presented in Technical Appendices 47 and 54 provide strong evidence that species and morphotypes are not randomly distributed throughout The Rip and that there is likely to be some dependence on particular habitat types. This finding is consistent with other sponge studies: most sponge species appear to have very strict niche requirements and are found only in narrow-range physical and geochemical regimes (J. Hooper, cited in Ponder *et al.* 2002).

To map various assemblage types and differences, a mosaicing or tiling method was used (Appendix 54). There was a carefully considered treatment of dividing the range of assemblage structures into types, classes or groups. This was not to define, or predicated on, distinct or discrete groupings (as inferred by other SEES documents), but such divisions are required before any mapping could be done. Each tile or patch on the map was assigned a colour and number code to display the distribution of various assemblage structures. The mapping was then extended to use the environment-biota relationships to predict what type of assemblages may be present in the unsurveyed areas, based on the physical habitat conditions there. This mapping was done at a patch scale (approximately 10 x 50 m areas) and a 2 x 2 m grid cell scale. The three resulting maps of distributions (surveyed patches, mapped patches and mapped grid cells) were used for assessing impacts, comparing these distributions with predicted rock fall distributions (Figures 3.11 to 3.13; Appendix 54).

In summary, the environmental conditions in The Rip are not uniform, with a variety of different physical habitats present, varying continuously along gradients or discretely across boundaries in different places. The distribution of biota in The Rip is not uniform – abundances of species and assemblage structures vary considerably between places. There are spatial relationships in the data – the assemblages are not random in structure and distribution. Species and assemblages appear to be dependent, to some degree, on particular environmental conditions and habitats. It would be inappropriate to consider impacts without considering the ecological and conservation significance of these spatial differences.

So having described the flora and fauna, what is the significance to Victoria's biodiversity? There are a range of generic criteria that are usually applied to determine conservation significance of an area (Kelleher and Kenchington 1992; Thackway 1996; Ponder *et al.* 2002). Such criteria include (but are not limited to):

- presence of endangered or threatened marine species and their habitats;
- areas of high biodiversity;
- areas of high productivity;
- presence of critical life stages of valued species (rare, endangered, commercial) or important ecosystem processes;
- irreplacability;
- naturalness;
- rarity, uniqueness – including unusual biogeographic qualities, habitats, geological or biological features;
- vulnerability, fragility or susceptibility;
- diversity – including variety of habitats, communities and species richness; and

- ecological importance – including key species for maintenance of ecosystem processes, significant habitats that help protect rare, threatened, endemic or migratory species, ecosystem stabilisation, energy and nutrient transfer and provision of habitat.

The application of such criteria for conserving marine invertebrates is well reviewed by Ponder *et al.* (2002) and was initially considered in the discussion of Appendix 47 (Volume 9). There is adequate information to determine the significance of the Entrance invertebrate fauna for some of the above criteria. These are presented below. The scale of the assessment is important. Because rock fall impacts will not be uniform over the area, the values of the different assemblages within The Rip need to be assessed.

High biodiversity. Port Phillip Heads is very rich in sessile invertebrate species, containing a significant proportion of the known Australian species. The richness of species and morphotypes was not uniform within The Rip. Higher regions of richness were observed at Rip Bank West, Lonsdale Wall South, Catacombs Ridge and various patches around The Plateau. Taking into account the relative abundances of species and types, assemblages with the greatest variety in their structure (diversity) were Rip Bank West, Lonsdale Wall North and a few patches around The Plateau.

Uniqueness. The canyon seascape of The Entrance is unique to Australia. The various environments and habitats within this seascape are also unique. These include: the very deep basins (Uelmans Deep, Bombie Basin and Dune Basin), the maze of ridge and wall structures that comprise Catacombs Ridge and the very steep wall and ledge structures with undercut caverns around the southern perimeter of The Plateau. The assemblages within Port Phillip Heads are distinct from anywhere else and contain a high proportion of endemic species, known only from that locale.

Ecological importance. Sessile filter feeders flourish in areas where currents are strong and this is obviously the case at Port Phillip Heads. The sponge coverage (and probably biomass per unit area) is greater here than anywhere else observed in Victoria. The sponges, and other invertebrates such as ascidians and bryozoans, are ecologically important in providing biogenic habitat to multitudes of commensal invertebrates such as crustaceans, worm, molluscs and echinoderms, as well as huge numbers of microorganisms (Bergquist and Skinner 1982). All of the filter-feeding invertebrates play an important role in energy and matter transfer from the water column to the benthic community. This is particularly important in Port Phillip Heads where there is little to no macroalgal component of the community, unlike other deep reefs of Victoria (although there is also a direct supply of drift algal matter). The ecological importance is variable within areas of The Rip, for example there are bare sand and sparse assemblages on rubble areas that are considered of less ecological importance (although some of these areas may harbour rare or unique species or assemblages and other aspects of conservation value). It is feasible that some sponges have habitat altering or stabilisation properties, by altering sand movement and settlement patterns.

Naturalness. Few introduced species were identified in the Heads benthic assemblage, which suggests that this area has a high degree of biological naturalness and that there is not a high likelihood of marine pest invasion. The physical environment of Port Philip Heads has been subject to considerable human activity for over 150 years. A minor cause of physical disturbance has been over 700 ship wrecks in the region, which have left a small amount of unnatural materials on the substratum (particularly ballast materials). Of greater influence were extensive blasting activities from the 1860s to 1980s on Rip Bank, Nepean Bank and the Plateau. It is highly likely that the blasting activity contributed to the rubble present in the deeper basins, particularly Bombie Basin, Mordor Plain and Plateau Well. It is likely that the rubble in the more distant areas of Lonsdale Wall Channel and Uelmans Deep is predominantly derived from natural causes, as there are barrier structures between these basins and the slopes where blasting has occurred.

Vulnerability and Fragility. The endemic species and assemblages within Port Phillip Heads are vulnerable from the perspective of being restricted in distribution and not being represented elsewhere. In general, sponges were not considered fragile or susceptible to rock falls below a certain volume and period of exposure – as evidenced from the trial dredging operations. Some invertebrate species may be fragile and susceptible to impacts but little is known. There is a possibility species have changed because of blasting impacts, with some larger distinctive sponges present in the 1880s not being observed in modern times (Ponder *et al.* 2002). The different assemblages within The Rip have varying vulnerabilities to rock falls in accordance with their spatial distributions. The substratum itself has an element of fragility. The rocky substratum consists of poorly cemented or consolidated sand and shell grit (calcarenite). The trial dredging has found that this rock can be quite friable. Where the superficial rock layers have been removed, this can expose non-durable layers leading to local disintegration of habitats.

In summary, the sessile invertebrate fauna of The Entrance is highly significant to Victoria's biodiversity. There is a high richness of species compared to the known Australian fauna and a high proportion of these are known only from that area. The assemblage structures within the area are unique, being distinctly different to other documented deep reef assemblages in Victoria. There is reasonable information to assume the relatively high biomass of sponge assemblages of The Rip are important in providing habitat for other species in the community.

3.3 How will this biota be affected by removal of rock in the Entrance?

The first step of the impact assessment was to describe the key biological features and to map the distribution of these features, as described above. The next step was to model the rock fall process. This estimated the volumes of rock that each area or patch of substratum would be exposed to, taking into account the bathymetric features that would tend to funnel or disperse the flow of rock down the slopes. The modelling produced maps of rock fall exposure and footprints, which were fully described in Appendix 54.

The next step was to compare the rock fall distributions with the distribution of assemblages and species/morphotypes. This was done in terms of the proportional area of each assemblage exposed and the relative volumes of passing rock exposure. Full details are provided in Appendix 54. Some of the assemblages are exposed to substantial relative levels of rock fall, with no representation of these assemblages in non-impacted areas (particularly Assemblages 3, 4, 7, 23) while other heavily impact assemblages are well represented in non impact areas, such as Lonsdale Wall (*e.g.* Assemblages 5, 21 and 25; Appendix 54). There is some uncertainty as to what the exact impacts from the rock fall exposure would be – some areas on Trial Dredge Wall were predicted to have a high rock fall exposure but there was no measurable effect. It was noted from the rock fall modelling, as well as the trial dredge monitoring, there is substantial patchiness in the rock fall impacts, with most impacts occurring toward the top of the reef and in scree slope areas (*i.e.* where there were natural runnels or drainage formations). It is very unlikely that falling rock will completely scour large areas of reef given the trial dredge and modelling observations. The predominant long term effects predicted would be smothering of biota in or near the basins where the rock would ultimately migrate to. The biomass of sessile biota was generally depauperate in and near these basins, although some projecting bombies, ridges and rock faces nearby supported reasonable biomass and diversity (such as Middle Reach Gullies).

To ensure the impacts were not underestimated, the levels of rock fall exposure were used directly to assess the implications of the impacts. In this case, the criteria for assessing the importance of the impacts were the standardised consequence criteria used throughout the SEES investigations. Using this framework, the rock fall consequences were ‘moderate’ for most assemblage types, but were ‘major’ for some assemblages (Appendix 54). A similar process was used to assess the observed populations of species and morphotypes. This analysis identified seven types of sponges that may be subject to impacts of ‘major’ consequence (Appendix 54).

As noted in the impact assessment (Appendix 54), monitoring of the Trial Dredge Area indicated there were ongoing rock fall impacts from continuing reef disintegration. More recent surveys (May 2007) indicated that this process is continuing, with no stabilisation of the substratum surface and substantial disintegration of some reef structures. This process was not modelled or assessed as part of the SEES. This process increases the ecological risks, in that complete habitat structures within a reef patch can disintegrate and the recovery times are substantially longer.

In summary, the impact assessment identified that rock fall impacts could have ‘major’ consequences for particular assemblages and sponge types. Given this, the possibility of adversely affecting endemic and unique species is not inconsequential. There is currently insufficient information to make strong predictions on impacts on features of state and national significance (biodiversity, endemism, ecological processes, *etc.*), but it should be noted that they are at risk. A new risk, not assessed as part of the SEES is the disintegration of habitat following dredging.

3.4 If there are impacts, how will recovery occur?

The trial dredge monitoring program has been very insightful into the recovery processes (Australian Marine Ecology reports 334, 377 and 379):

- the recovery process commences rapidly following the disturbance;
- there is a succession of recovery stages (described elsewhere) – initial stages are generally rapid colonising species comprising a community dissimilar to unimpacted assemblages, but some ‘climax’ community species are also observed recolonisers;
- succession from observations to date are towards a structure similar to that observed previously, however there are also natural variations occurring that influence these trends and further monitoring is required to fully understand the natural and recovery time trends;
- the insights into natural variations are invaluable in developing an understanding of the biological dynamics;
- recovery is highly dependent on the disturbance to the substratum – there is evidence of multiple successional stages present at some sites, indicating periodical, ongoing scouring effects;
- there are substantial ongoing rock fall processes occurring following dredging, with new rock fall material being derived from reef disintegration; and
- the ongoing rock fall processes include continual impacts around scree slopes as well as pulse impacts where there are periodical surges of rock material over longer sections of reef edge.

In summary, the ongoing rock fall impacts have substantially confounded the ability to estimate recovery rates using data from the monitoring program. The time for recovery will largely depend on the time required for the reef to stabilise. As noted above, reef disintegration may lead to the loss of particular habitat structures in some areas. If this case arises, then it is likely a different assemblage will develop.

4. Response to Submissions

4.1 Scope of Reviews

Four submissions were provided to me by Maunsell for review with respect to rock fall issues. These were submissions 47, 111, 143 (Chapter 7) and 159. Submission comments are in italics, followed by my response in normal text. Only issues pertaining to the rock fall modelling and biological impact prediction were responded to. The determination of initial rubble head loads for the model was the responsibility of Boskalis, but some comment was provided here on sensitivity of impact predictions to different head loads.

4.2 Submission 47

Rock Falls at the Heads. This was not possible? This happened, it can happen again on a much larger scale. What happens then, tides change radically, sponge gardens are lost forever. [Page 2]

Rock falls were always claimed to be possible with moderate consequences hence a high risk level (*EES Marine Ecology Specialist Studies Volume 22: Deep Reef Impact and Risk Assessment*, EES Volume 3A2; *Trial Dredging Risk Assessment: Marine Ecology*, AME Report 306).

The rock fall modelling in SEES Appendix 54 indicates the likely scale of rock falls.

There is no scientific or engineering evidence to indicate tides will change radically. Any radical habitat changes would occur at scales of metres to tens of metres and not encompass the whole deep reef habitat in The Rip.

Sponge gardens as a general entity will never be lost – some form of sponge garden would return. There are different sponge assemblages in the region of The Rip and some assemblages are more vulnerable than others. Full details are provided in SEES Appendix 54.

4.3 Submission 111

What about rock falls in channels? The whole plan does not seem to be properly indexed. [Page 1]

There are two different assessments of rock falls in channels, documented in Appendices 52 and 54. The SEES Main Document reports the findings of Appendix 52 (page 14-22).

Damage to Marine Parks.

The risk of damage to the marine park from rock falls is considered minimal, as the rocky material would fall into a low biomass, low diversity, sedimentary environment, containing little in the way of sponge gardens. The material is largely prevented from migration elsewhere into the park by entrapment in sediment and cobble hollows and barrier reef structures (Catacombs Ridge). There are high diversity communities outside the park that are of greater conservation concern. This was addressed in Section 3, above.

Such a diverse marine community, with still thousands of species unclassified (think of rain forests in Brazil – each tree can produce up to 200 new species when checked). [Page 1]

The biodiversity of the deep reef sessile invertebrate (sponge garden) communities of southern Australia are not extensively studied and understood. It has been estimated that only approximately 30 % of the sponges are known (Ponder *et al.* 2002). Despite a paucity of scientific investigations on Victoria's sessile reef invertebrates, there is strong evidence to suggest that Port Phillip Heads is a place of high biodiversity and endemism. Using sponges as an example, there are currently 1416 valid sponge species known in Australia, of which 271 species have been collected from Port Phillip Heads. Of these, 112 are known only from the Port Phillip Heads region (Australian Faunal Directory). The submitter's concept and concern for biodiversity is considered valid. It is important to consider impacts on biodiversity from rock falls. This issue was addressed in Section 3 above.

4.4 Submission 143

We estimate... rock fell uncontrolled...Some fell into the adjacent Marine National Park. [page 7]

There was no evidence at all, or plausible process, where trial dredging rock material entered the marine national park. This was carefully audited and confirmed by EPA.

We contend that rockfall would occur at least the same rate as did occur in the simpler dredging exercise during the trial. [page 7]

The edge of The Plateau was not treated uniformly in the g-Trans modelling – full details are provided in Appendix 54. The head loadings of rock fall material were estimated by Boskalis and input into the g-Trans model. The volume of rock fall is largely determined by draghead efficiency and frequency of 'cleanup' runs – which determine the amount of residual material. Boskalis provides these estimates for different scenarios in Appendix 21. These were modelled in Edmunds and Sams (2006, *Modelling Rock Fall Scenarios*). The greatest uncertainty is in the degree of reef disintegration in the years following dredging. This has not been modelled yet.

As verified by Dr. Matt Edmunds and consultants DHI in Technical Appendix 21, under normal ocean conditions rocks move approximately in a north or south direction, not westerly towards the most sensitive edge identified by PoMC. [page 8]

The rock movements are mostly north-south, in accordance with the direction of swell action. There was additional eastward movement of rock out of the trial dredge area, which was reported in the impact assessment report. Currents on The Plateau run east-west at depth (following the canyon) and there are already small scree slopes on the western side of The Plateau, indicating mechanisms for westward migration.

The western edge of The Plateau is not the most sensitive biologically, it is the most sensitive socially or politically in that it is near the marine protected area. There are other areas with higher biodiversity considered more vulnerable – particularly Dune Basin in the east (Appendix 54).

We predict that much greater areas of the canyon and Marine Park will be affected in the short and long term by uncontrolled rockfall. When the rocks fall some will drop onto ledges. Rocks will either stay put and smother existing habitat or migrate further down the canyon in response to currents. The extent of potential ongoing damage is not adequately represented in the modelling. [page 10]

A range of scenarios were examined using *g-Trans*, including five formal options for scenario modelling (Australian Marine Ecology Report No. 371). Many informal model runs were also examined, including gross overestimates of head loads. There was a tendency for the material to flow down the same runnels (albeit at higher loadings) and fill the same area of the basins – the perimeter of the footprints did not vary greatly. The differences were largely manifested in the degree of cover within the footprint extent and in the time for the material to 'drain' from the slopes. There were also differences in the tendency for the western slope material to migrate northward and then down the slope towards Uelmans Deep. The conclusion was that higher rock fall loadings lead to more concentrated and longer lasting effects rather than markedly greater areas of impact – there is a high degree of confidence that the modelling represents relative differences in rock fall impacts over the region.

Nearly all rock is expected to migrate reasonably rapidly towards the basins once it goes over the edge. There are few observations from Trial Dredge Wall where rock has stayed on the slopes. There are no observations of permanent accumulations of rock on the ledges around The Plateau (there are some scree slopes).

The *g-Trans* model is kinetic and not dynamic – the processes are not scaled through time and therefore it does not inform of how long it takes for rock fall material to drain down the slopes. On-going observations at the Trial Dredge Area indicated that a large proportion of the residual rubble migrated during storms at the end of the trial dredge activities. Some of the residual rubble formed an underwater equivalent of 'windrows', which also became mobile at various times, probably during storms. Importantly, it appears the greatest contribution to long-term rock fall effects is continued disintegration of the reef surface, which was still occurring in the Trial Dredge Area. I concur with the submitter that there is considerable uncertainty about the period of time that the reef will continue to fragment and cause rock falls. This issue is addressed in Section 3, above.

4.5 Submission 159

Further, the estimated rockfall does not include loose rock that might fall down subsequent to the dredging. [page 7]

Recent monitoring at the Trial Dredge Area indicates this can occur for some time afterwards and hinder recovery of communities. This is valid concern, also raised by Submitter 143, and was addressed in Section 3, above.

In appendix 54 the modelling of the rockfall assumes that only 0.78 % of the rocks dredged will fall, and that this will fall evenly along the 18 hectares of canyon wall rather than most in one place. This we doubt. [page 7]

Appendix 54 does not assume the head loading of rocks that will fall. This input was estimated by other SEES project components (Appendix 21) and provided to me for modelling.

The initial head loading of rocky rubble was not evenly distributed around the perimeter of the dredge area. Loadings were provided for nine sections at the head of the reef or edge of dredging (Appendix 54, pages 22-23). The power of the g-Trans model is that it does not take the overly simplistic approach and assume an even distribution of rock fall. Instead, it takes into account the complex bathymetry (topography) at a grid scale of 2 m to model rock fall drainages. For each 2 m grid cell, it records how much rock is present in the grid cell at any one time (to calculate footprints of exposure) and how much passes over that grid cell over the course of the model run (total rock fall exposure). The g-Trans model was invaluable as a guide to determine the extent and distribution of impacts, including where they would be concentrated (*e.g.* Appendix 54, page 24). These data could then be compared directly with distributions of species and communities to determine what biological components are at risk, by how much and where.

ACF is highly sceptical of the ... SEES claim that regrowth of pre-existing diversity in these communities will occur within 5 years (p14-27)...Recovery rates seem to be based on speculation and extrapolation of initial colonisation observations after 15 months. But it is unknown if the now existing mix of species at the entrance will ever occur again after dredging. [page 7]

It is agreed that the regrowth of pre-existing diversity within five years is not supported by any evidence. The SEES claim is not supported by observations in Appendix 54 (Section 7 – Recovery of Deep Reef Biota, pp 116-120). Here, we (the authors) stated that establishment of some sort of benthic assemblage is likely within 1-2 years, provided there was no ongoing disturbance. Appendix 54 highlighted the fact there was ongoing rock fall disturbances and that this was restricting recovery (although there had been substantial recovery since post-dredging).

The evidence indicates the recolonisers are very similar species to adjacent reef patches. This was further supported by monitoring results in December 2006 (Australian Marine Ecology reports 377 and 379). Rock falls are highly unlikely to permanently change the mix of species over the whole entrance region. There are some assemblages (mix of species) that are only present in rock fall areas. These are of the greatest conservation concern.

Some of the species found there are very slow growing and their diversity is a result of a long evolution. [page 7]

There is little to no hard scientific evidence that some species are very slow growing (Appendix 47, Volume 9), although there is anecdotal evidence that species are long lived. Regardless, it remains a possibility (not fact) that there are slow growing species in The Rip.

The diversity in The Rip is not a result of long evolution within this region - this habitat is relatively recent (*c.* 8 000 years). There is a high level of endemism in southern Australian sessile biota in general though and there are localised areas with a high degree of endemism along the coast, including one at Port Phillip Heads.

The SEES claims that only 13.5 hectares of the canyon, of which 0.4 has is in the Port Phillip Heads Marine National Park, will be affected. This refers to square surface area only as a horizontal grid. It does not take into account that the canyon's reef habitat grows on the steep and vertical slopes of the canyon and therefore surfaces impacted upon should be assessed as a square vertical area. How big would the area be if it was laid out flat? [page 8]

Appendix 54 did both planar and surface area calculations, including for each assemblage type (Appendix 54, pages 78-79). At a measurement scale of 2 m, the whole surface area (excluding caves and caverns) was estimated to be 127 hectares for a planar area of 74 hectares (factor of 1.86). This is an important statistic in that it indicates substantial habitat complexity, which can influence species diversity and community dynamics.

In this case, the planar statistics for impact assessment were considered more pertinent because a large proportion of the wall areas are actually undercuts beneath ledges above, and therefore protected from scouring. Also, the impact forces in the model are gravity driven, so it is the amount of rock material present per unit area in the horizontal plane that is of most relevance.

5. Conclusion

In assessing rock fall impacts in The Rip, the primary SEES documentation has overlooked some findings of the deep reef existing conditions study and the subsequent impact assessment (Appendices 47 and 54). Some of these issues were raised by submitters. Additional information has arisen which also influences the assessment and significance of rock fall impacts.

Key biological matters that the Panel should consider in formulating its advice are:

- Port Phillip Heads is an area of high biodiversity, including many (> 100) species known only from Port Phillip Heads. Sessile invertebrate assemblage structure is distinctive from other deep reef systems in Victoria, namely The Arches, Twelve Apostles, Point Addis and Wilsons Promontory. This uniqueness is likely to be driven, in part, by the unique physical habitat, particularly the strong currents and lower light levels (from suspended sediments) in which sessile filter feeders usually thrive;

- The environmental conditions in The Rip are not uniform, with a variety of different physical habitats present, varying continuously along gradients or discretely across boundaries in different places. The distribution of biota in The Rip is not uniform – abundances of species and assemblage structures vary considerably between places. There are spatial relationships in the data – the assemblages are not random in structure and distribution. Species and assemblages appear to be dependent, to some degree, on particular environmental conditions and habitats. It would be inappropriate to consider impacts without considering the ecological and conservation significance of these spatial differences.

- The sessile invertebrate fauna of The Entrance is highly significant to Victoria's biodiversity. There is a high richness of species compared to the known Australian fauna and a high proportion of these are known only from that area. The assemblage structures within the area are unique, being distinctly different to other documented deep reef assemblages in Victoria. There is reasonable information to assume the relatively high biomass of sponges assemblages of The Rip are important in providing habitat for other species in the community.

- The impact assessment identified that rock fall impacts could have 'major' consequences for particular assemblages and sponge types. Given this, the possibility of adversely affecting endemic and unique species is not inconsequential. There is currently insufficient information to make strong predictions on impacts on features of state and national significance (biodiversity, endemism, ecological processes, etc.), but it should be noted that they are at risk. A new risk, not assessed as part of the SEES is the disintegration of habitat following dredging.

- Ongoing rock fall impacts have substantially confounded the ability to estimate recovery rates using data from the monitoring program. The time for recovery will largely depend on the time required for the reef to stabilise. As noted above, reef disintegration may lead to the loss of particular habitat structures in some areas. If this case arises, then it is likely a different assemblage will develop.

In conclusion, if the issue of ongoing reef breakage is removed from consideration and the estimated level of rock fall eventuates, I am reasonably confident that the marine natural values of The Rip would not be adversely affected in the long term. This confidence arises from the observations on Trial Dredge Wall, where rock falls did not cause large swathes of impacts, and from the engineering and procedural advancements to produce substantially less volume of rock spillage. The rock fall modelling also indicates that impacts on the slopes would be patchy, increasing the prospects for recolonisation from adjacent, unimpacted populations/patches. There remains, however, risks to biodiversity and endemic species and any dredging activity should be cognisant of these risks. The emergent issue of exposure of non-durable reef layers and ongoing substratum disintegration has a large bearing on predicting adverse affects. The above conclusion is only applicable if the dredged substratum stabilises over a short period of time, produces minimal rock fall material with respect to that predicted for the SEES and there are no major changes to the canyon wall substratum structures. I consider it vital that there is appropriate monitoring during and after dredging to inform and facilitate management decisions and actions to best protect the biodiversity of Port Phillip Heads.

I have made all the enquiries that I believe are desirable and appropriate and that no matters of significance which I regard as relevant have to my knowledge been withheld from the Panel.

Appendices

Curriculum Vitae
Dr Matt Edmunds
Marine Ecologist

Education

1987-1990	Bachelor of Science (Honours), First Class Marine, Freshwater and Antarctic Biology University of Tasmania, Hobart Thesis: *The Community Ecology of Fishes on Tasmanian Rocky Reefs.*
1991-1995	Doctor of Philosophy, Zoology University of Tasmania, Hobart Thesis: *The Ecology of the Juvenile Southern Rock Lobster,* Jasus edwardsii *(Hutton 1875) (Palinuridae).*

Certificates

Drivers licence
Tasmanian Motor Boat Licence
Coxswains (limited)
Radio Operators Certificate of Proficiency
NASDS Master Diver
ADAS Australian Commercial Diver Part 1
ADAS Certificate IV Occupational Diving Dive Supervisor
CMAS International Certificate for Scientific Research Diving
DAN Oxygen Provider

Awards

1990	Ralston Trust Honours Prize, University of Tasmania
2000	Royal Humane Society of Australasia Bronze Medal

Employment

1999-present	Director, Australian Marine Ecology Pty Ltd
1990-1999	Marine Biologist, Consulting Environmental Engineers Pty Ltd
1990-1995	Teaching, Department of Zoology, University of Tasmania
1990-1991	Technical Officer, Tasmanian Division of Sea Fisheries
1989-1990	Technical Officer, CSIRO Division of Fisheries
1988-1989	Research Assistant, University of Cambridge

Memberships and Committees

- Commercial Rock Lobster Committee, Victorian Fisheries Co-Management Council
- Victorian Scientific Advisory Committee for the Flora and Fauna Guarantee Act
- Panel for Inquiry into MPAs in Bruny Bioregion, Tasmanian Resource Planning and Development Commission

Background

Dr Edmunds is a director of Australian Marine Ecology Pty Ltd. He has specialist expertise in coastal ecological investigations and he has been designing and implementing research and monitoring programs for 20 years. His work encompasses a broad range of ecological aspects, including community-environment relationships, taxonomy, population dynamics and environmental impact assessment.

Dr Edmunds has substantial experience in experimental/sampling design and analysis, in addition to a strong practical background in underwater sampling techniques. His field experience includes thousands of research dives in cold and difficult conditions, predominantly involved with quantitative underwater visual censusing. More recently, he has been at the forefront in establishing quantitative deepwater visual censuses using drop-video, towed video and ROV technology.

His work in environmental consulting has focussed on the ecological assessment of wastewater discharges, dredging and other disturbances, as well as the assessment of natural spatial and temporal variations in fished populations and reef communities. These assessments include: multivariate comparisons of subtidal and intertidal reef benthic biota, infauna and intertidal communities near pulp-mill and sewage discharges; before-after-control-impact type analyses of population abundances and community assemblages; power analysis of monitoring programs; and assessment and implementation of remote sensing methods for habitat mapping and environmental monitoring.

Experience and Expertise

Experimental Design and Analysis

Dr Edmunds has substantial experience in the design, implementation and analysis of ecological investigations, particularly for marine populations and communities, and for environmental impact assessments. He is familiar with most biostatistical analyses, including: ANOVA models, multivariate analyses of community structure (including MANOVA, CVA, CCA, ANOSIM and MDS), diversity indices, dominance curves, univariate and multivariate tests of hypotheses and before-after/control-impact (BACI) analyses. He is also familiar with regression analyses (linear and non-linear), power and cost-benefits analyses, cluster analysis, analysis of spatial patterns, as well as population and fishery assessment statistics (including CMR models from tagging studies). Dr Edmunds has been involved with teaching statistics to undergraduate students at the University of Tasmania, and is able to communicate the principles and interpretation of biostatistical analyses in a clear and concise manner, in both written and oral form.

Dr Edmunds has experience with a variety of underwater sampling methods for epibenthic biota and infauna. These include diving visual census techniques, ROV census techniques, underwater photography, video, sediment sampling and biological collections. His strong practical and analytical skills ensure his work is both efficient and effective.

Experience – Fisheries Biology and Assessment

Dr Edmunds has a strong background in fishery science, particularly coastal fisheries, through research and consulting with Tasmanian Division of Sea Fisheries, CSIRO Division of Fisheries, University of Tasmania, South Australian Research and Development Institute and Australian Marine Ecology. He has ongoing involvement with scientists, management and fishers, including the Southern Rock Lobster Research Group, and fishery assessment and modelling workshops, Abalone Management Plan Steering Committee and Commercial Rock Lobster Fisheries Committee. Through his population dynamics investigations, he has an understanding of the implementation and implications of fishery management options, for both the fishers and the fishery stocks.

Scientific experience includes:

- Taxonomic revision of the *Squalus* (dog shark) genus in Australasian waters.
- Coastal reef fish stock assessment.
- Spatial and size variations in fecundity and maturity of the southern rock lobster *Jasus edwardsii.*
- The population ecology of juvenile *Jasus edwardsii.*
- Standing stocks of the seaweed *Undaria pinnatifida*.
- Population biology and gonad quality of the sea urchin *Heliocidaris erythrogramma.*
- Density and size structure of abalone, rock lobster, sea urchin, periwinkle and wrasse (Labridae) stocks on Victorian reefs.

Experience – Population and Community Ecology

Dr Edmunds has substantial experience and expertise in ecological investigations in a wide range of coastal marine habitats. Major projects include:

- The behavioural ecology of the seahorses *Hippocampus abdominalis* in Tasmania and *H. breviceps* in Victoria.
- Fish assemblage-habitat relationships on Tasmanian rocky reefs.
- Ecology of the introduced Japanese seaweed *Undaria* in Tasmanian waters.
- Ecology of juvenile southern rock lobster *Jasus edwardsii*.
- Review of the Westernport marine environment, with contributions on seagrass, fish and invertebrate communities.
- Assessment of an acoustic methods for mapping the standing stocks of epibenthic flora and fauna.
- Benthic marine habitat and biological assemblage mapping of the Wesley Vale region.
- Photographic records of biota in disturbed and undisturbed habitats.
- Investigation of the composition, standing crop and nutrient content of macrophyte assemblages in Port Phillip Bay.
- Investigation of biological-environmental relationships in Victorian subtidal reef communities.
- Implementation of a long-term monitoring program for Victorian reef flora and fauna.
- Investigations in temporal and spatial variations in Victorian reef communities.
- Project design for monitoring lobster populations within marine reserves in Tasmania.
- Reef assemblage structures and distribution for oil spill atlas.
- Biogeography of Victorian reefs including identification of spatial units and description of reef community types.
- Biological assessment of marine protected area proposals for eastern Victoria.
- Modelling of seagrass, diatom and seaweed production and population dynamics.
- Sponge community-habitat relationships on Victorian deep reefs.

Environmental Impact Assessment and Monitoring

Qualitative and quantitative environmental assessment projects include:

- Impact assessment and monitoring of wastewater discharges on benthic organisms at George Town, Devonport, Wesley Vale, Burnie and Hobart in Tasmania.
- Impact assessment and monitoring of wastewater discharges at Baxters Beach, Phillip Island, Altona, Venus Bay and Boags Rocks in Victoria.
- Impact assesment and monitoring of wastewater discharges at Wollongong and Boambee Head, Corambirra Point and Woolgoolga in New South Wales.
- Pilot studies and biological monitoring designs for Baxters Beach and Boags Rocks outfalls, Victoria, as well as Coffs Harbour EIS, NSW.
- Temporal and spatial comparisons of infaunal community structure and diversity at Wesley Vale.

- Recruitment and community succession on artificial substrata near paper mill effluent outfalls.
- Water quality assessment and monitoring near paper mill outfalls.
- Measurement and modelling of winds, currents and plume dispersal.
- Analysis of metals bioaccumulation in oysters, northern Tasmania.
- Habitat and biological assemblage mapping for dredging and beach restoration at Hampton, Port Phillip Bay.
- Impact assessment and monitoring of dredging at Hampton, Port Phillip Bay.
- Investigation of dredging effects in the Maribyrnong River
- Investigation of impacts of sewage overflows in the Illawarra region.
- Review of marine biological impacts of Sydney ocean outfalls for Cronulla STP EIS.
- Odour modelling for industrial and rural developments.
- Modelling clarifier performance for paper mill wastewater treatment plant.
- Design and implementation of monitoring program for performance assessment of Victorian marine protected areas.
- Assessment of ecological status of the Bunurong Marine Sanctuary.
- Impact assessment of previous and proposed dredging in Port Phillip Bay, including biological modelling and risk assessments.
- Modelling of reductions in primary production by seaweed, kelp and microalgae exposed to suspended sediment plumes.
- Rock fall modelling from dredging and impact assessment on sponge garden communities.
- Monitoring for impacts and recovery of deep reef sponge communities.

Scientific Review

- Anonymous reviewer, Environmental Projects Office, CSIRO.
- Anonymous reviewer, Bulletin of Marine Science, population dynamics of spiny lobsters.
- Peer reviewer, C. P. Norman, habitat use of early benthic phase lobsters.
- Anonymous reviewer, Marine Ecology Progress Series, juvenile lobster populations and artificial habitats.
- Review and editing, Andrew N. 1999. Under Southern Seas: The Ecology of Australia's Rocky Reefs. UNSW Press, Sydney.
- Peer reviewer, Beca AMEC, lead consultant to Tasmanian Resource Planning and Development Commission, marine ecology components of Gunn's Pulp Mill IIS.

Conferences, Workshops and Seminars

(Selection only – chronological order)

- Australian Marine Sciences Association Conference, Melbourne, July 1993. Paper: Shelter utilisation and availability for the southern rock lobster, *Jasus edwardsii.*
- CSIRO Seminar Series, Hobart, September 1993. Paper: Lobsters and the Mandelbrot Set: The implications of fractals on the population dynamics of the southern rock lobster, *Jasus edwardsii*.
- Rock Lobster Scientist Meeting, Wellington, April 1994. Discussion leader: Measuring juvenile abundance.
- Australian Society for Fish Biology, Canberra, August 1994. Paper: Ontogenetic shifts in diet of the southern rock lobster.
- University of Tasmania Workshop: Application of Fractals to Ecology, Hobart, February 1995. Co-convenor (with Belinda Robson) and discussion leader.
- Southern Rock Lobster Population Modelling Workshop, Adelaide, August 1995. Paper: Microtagging and the population dynamics of the juvenile southern rock lobster.

- Southern Rock Lobster Early Life History Workshop, Hobart, May 1996. Discussion leader: Density dependence in early benthic phase lobsters.
- Southern Rock Lobster Recruitment Workshop, Hobart-Adelaide, February 1999. Paper: Ecology of juvenile lobsters and recruitment limitations.
- Australian Marine Sciences Association Conference, Melbourne, July 1999. Paper: Impact assessment of reef biota near the Boags Rocks sewage discharge.
- Monitoring Marine Protected Areas, TAFI, Hobart, October 1999. Papers: Monitoring in Victoria and Census of rock lobster populations.
- Monitoring Marine Protected Areas, NRE, Melbourne, September 2001. Papers: Census Methods and Temporal Patterns.
- Primary production modelling for environmental management in Port Phillip Bay, Melbourne, 2006.
- Deep reef habitat mapping in Port Phillip Bay, Melbourne, 2006.

Selected Publications and Reports

(Selection only – chronological order)

Edmunds M (1990) *Community Ecology of Fishes on Tasmanian Rocky Reefs*. Honours Thesis, University of Tasmania.

Edmunds M (1995) *The Ecology of the Juvenile Southern Rock Lobster, (*Jasus edwardsii *Hutton 1875) (Palinuridae).* Ph. D. Thesis. University of Tasmania.

May D & Stephens A (eds.) (1996) *The Westernport Marine Environment. Based on a Report to the Environment Protection Authority by Consulting Environmental Engineers.* State Government of Victoria Environment Protection Authority, **Publication 493**, Melbourne. [Chapters: Fish and Fisheries, Invertebrates]

Chidgey S S & Edmunds M (1997) Standing crop and nutrient content of macrophytes in Port Phillip Bay. *CSIRO Port Phillip Bay Environmental Study Technical Report* **32**.

Edmunds M, Chidgey S S & Willcox S T (1998) *Association between Biological Communities and Rock Type on Victorian Reefs*. Report to Victorian Environment Conservation Council.

Edmunds M (1998) *Relationship between Species Richness and Rock Type for Intertidal Animals in Victoria. Review of Data Provided by the Marine Research Group of Victoria*. Consulting Environmental Engineers report to Victorian Environment Conservation Council, Melbourne.

Chidgey S S, Edmunds M and Willcox S T (1998) *Boags Rocks Environmental Impact Assessment Task 1.1. Biological Assessment of the Offshore Marine Biota*. Consulting Environmental Engineers report to CSIRO Environmental Projects.

Edmunds M and Willcox S T (1999) *Marine Biological Impacts Study. Part I. Existing Discharges*. CEE Northern Australia report to Coffs Harbour City Council. Project Report No. **CHEIS R09**.

Edmunds M, Willcox S T and Reid M T (1999) *Marine Biological Impacts Study. Part II. Deep Sea Release Location*. CEE Northern Australia report to Coffs Harbour City Council. Project Report No. **CHEIS R10**.

Frusher S, Prescott J & Edmunds M (1999) Southern Rock Lobsters. **In:** Andrew N. 1999. *Under Southern Seas: The Ecology of Australia's Rocky Reefs*. UNSW Press, Sydney.

Edmunds M (2000) *Ecological Status of the Central Victoria Bioregion, 2000: Macroalgae, Invertebrate and Fish Populations in the Bunurong Marine Protected Area*. **In:** L. W. Ferns (ed., in prep.). *Ecological Performance Assessment and Reporting for Victoria's Marine Environment*. Department of Natural Resources and Environment, East Melbourne.

Edmunds M (2002) Marine Biodiversity of Victoria. **In**: *Management Strategy for Victorian Marine National Parks and Sanctuaries*. Parks Victoria, Melbourne.

Roob R, Edmunds M and Ball D (2000) *Victorian oil spill response atlas: Biological resources. Macroalgal communities in central Victoria*. Report to Australian Marine Safety Authority, Australian Marine Ecology Report No. 109, Melbourne.

Edmunds M, Roob R and Ferns L (2000) Marine Biogeography of the Central Victoria and Flinders Bioregions – a Preliminary Analysis of Reef Flora and Fauna. **In**: L. W. Ferns and D. Hough (eds). *Environmental Inventory of Victoria's Marine Ecosystems Stage 3 (Volume 2).* Parks, Flora and Fauna Division, Department of Natural Resources and Environment, East Melbourne. Australia.

Edmunds M, Roob R and Ling S (2001) *Biological Assessment of Proposals for Marine Protected Areas in the Twofold Shelf Bioregion*. Report to the Abalone Fishermens Cooperative Ltd. Australian Marine Ecology Report 122, Melbourne.

Edmunds M (2001) *A Review of Biases and Error Pertaining to Underwater Visual Census Methods used in Southern Australia*. Report to Department of Natural Resources and Environment. Australian Marine Ecology Report No. 125, Melbourne.

Edmunds M and others (1999-2007) Various Australian Marine Ecology reports to clients [182 reports in total]

Edmunds M and others (2003-2007) Parks Victoria Technical Series [17 reports]

Edmunds M and Hart S (2003) *Parks Victoria Standard Operating Procedure: Biological Monitoring of Subtidal Reefs*. Parks Victoria Technical Series No. 9. Parks Victoria, Melbourne.

Gilmour P, Edmunds M, Lindsay M and Monk J (2006). *Victorian Subtidal Reef Monitoring Program: The Reef Biota in the Port Phillip Bay Marine Sanctuaries*. Parks Victoria Technical Series No. 30. Parks Victoria, Melbourne.

Lindsay M, Edmunds M, Gilmour P, Bryant C and Williams J (2006). *Victorian Subtidal Reef Monitoring Program: The Reef Biota at Port Phillip Heads Marine National Park*. Parks Victoria Technical Series No. 32. Parks Victoria, Melbourne.

Edmunds M and others (2003-Present) *Channel Deepening Project EES and SEES Reports* [104 reports – see following Appendix]

Last PR, Edmunds M and Yearsley GK (2007) Part 2 – *Squalus crassispinus* sp. nov., a new spurdog of the 'megalops-cubensis group' from the eastern Indian Ocean. **In**: Last PR, White WT and Pogonoski JJ (eds.) *Descriptions of New Dogfishes of the genus* Squalus *(Squaloidea: Squalidae)*. CSIRO Marine and Atmospheric Research Paper No. 14, CSIRO, Hobart.