Biodiversity Research

ZBD2009-03	The vulnerability of rhodoliths to environmental stressors and characterisation of associated biodiversity
ZBD2009-10	Multi-species analysis of coastal marine connectivity
ZBD2009-13	Ocean acidification impact on key NZ molluscs
ZBD2009-25	Predicting impacts of increasing rates of disturbance on functional diversity in marine benthic ecosystems

Project Title: The vulnerability of rhodoliths to environmental stressors and characterisation of associated biodiversity

Project Code: ZBD2009-03

Start Date: 1 September 2009

Length of project: 2.5 years

Vessel Use: Small boats as required

Overall Objectives:

1. To evaluate the vulnerability of New Zealand rhodolith species to environmental stressors and to characterise diversity of rhodolith beds

Specific Objectives:

1. To characterise the distribution and physical characteristics of two New Zealand rhodolith beds and characterise the associated biodiversity.

2. To measure the growth rates and evaluate the vulnerability of New Zealand species of rhodoliths to environmental stressors

Reporting Requirements

Specific Objectives 1, 2

1. To submit to MFish, a Progress Report as specified in Research Reporting form 4 by 31 January 2010.

2. To present the results of reporting requirement 1 to a meeting of the Biodiversity Research Advisory Group by 30 March 2010.

3. To submit to MFish, a Progress Report as specified in Research Reporting form 4 by 31 January 2011.

4. To present the results of reporting requirement 1 to a meeting of the Biodiversity Research Advisory Group by 30 March 2011.

5. To submit to MFish a draft AEBR as specified in Research Reporting form 6 by 30 September 2011.

6. To present the findings of the draft AEBR, incorporating specific objectives 1 – 3 above, to a meeting of the Biodiversity Research Advisory Group and/or Aquatic Environment Working Group by 30 October 2011. Presentations to more than one meeting in Wellington may be required.

Project Update Reports

No Project Update Reporting is required for this project.

Work In Progress Reports

Monthly Work In Progress Reporting (Form 13) is required for this project in accordance with the Conducting Research with the Ministry document.

Data Reporting

To submit any data generated, collected or modified during the course of this project to the Research Data Manager, MFish by 30 December 2011.

Rationale:

General

The term maerl refers to biogenic sediments characterized by accumulations of live and dead unattached coralline algae. The maerl-forming algae can take the form of rhodoliths which are nodules or unattached branched growths. The complex morphology of rhodoliths provides a very heterogeneous habitat. Maerl grounds form a unique ecosystem with a high benthic biodiversity supporting many rare and unusual species. They occur throughout the world, across wide latitudinal and depth ranges and form structurally and functionally complex habitats made up of branching or rounded thalli that collectively create a fragile, structured biogenic matrix over coarse or fine carbonate sediment. Productive fisheries are often coincident with maerl beds and it is thought that the high level of functional diversity that they provide may be an important driver in maintaining such productivity. The complex habitat structure also provides refugia for juvenile fish and settlement habitat for shellfish larvae.

Recent studies in the northern hemisphere have shown that rhodolith beds are relatively fragile and easily impacted by a number of different anthropogenic activities such as harvesting, trawling, anchoring, or activities that reduce water quality through siltation and eutrophication, effluent discharges and offshore dumping. Coastal structures that influence currents (e.g. breakwaters, quays, sea-walls, marinas), and aquaculture related structures such as shellfish rafts and fish cages can also impact maerl beds. Maerl beds are commercially exploited for their calcium/magnesium mineral content in some parts of the world, but it grows very slowly and cannot therefore be considered a renewable resource in the normal sense.

The taxonomy of rhodoliths has been regarded as difficult but in New Zealand, this is reasonably well-defined (MFish projects ZBD2001/05 and ZBD2004/07). All known published references to living maerl beds in New Zealand have been identified (MFish project ZBD2001/06) although additional beds have been located since that work was completed.

Objective 1

This objective seeks to compare and contrast the biodiversity associated with rhodolith beds in at least two localities. Tenders should specify the collection of vouchered reference specimens which can be the basis for future taxonomic evaluation. An assessment of biodiversity drivers should also be incorporated into the tender.

Objective 2
As an initial step in understanding the functional role of maerl beds in New Zealand's marine coastal systems this project seeks to assess the vulnerability of New Zealand maerl species to specific environmental stressors. This work will enable coastal/regional/resource planners/managers to evaluate the risks to these habitats and that these data could result in evidence-based environmental protection measures being established.

Tenders should consider how they might investigate questions such as: how do growth rates of New Zealand rhodolith species compare with growth rates recorded elsewhere in the world? How does temperature influence growth rates of New Zealand rhodolith species? How resilient are New Zealand rhodolith species to disturbance (e.g., physical disruption, reduction of light, anoxia, eutrophication)? Do New Zealand rhodolith species differ in their responses to increased acidification? Are there species associated with rhodolith beds which are sensitive to disturbance that have the potential to be used for monitoring disturbance to rhodolith habitats?

Strategic Relevance

This project links to strategic themes 3, 5 and 7 identified in the Biodiversity Medium Term research Plan 2008–13. It also contributes to Objective 3.1 (d), (e), and (f) and 3.4 (a) to (d) of the New Zealand Biodiversity Strategy (that MFish was identified as lead agency). It also links to the benthic section of the Aquatic Environment Research Programme to determine direct and indirect effects of fishing on benthic biodiversity, habitats of particular significance for fisheries management, and maintenance of biological diversity in the marine environment. This project is therefore consistent with the *Marine Environment Research* section of the *Ministry of Fisheries Strategic Research Directions* document.

The project will provide for an assessment of threats to biodiversity, the development of an environmental monitoring system, increased community awareness of the effects of our activities on marine biodiversity, the identification of species and habitats at risk from fishing, and improved environmental impact assessment of fishing. In particular, this project will enable the identification of the species or habitats most at risk from dredge fishing (as mandated by the Ministry's *Strategy for Managing the Environmental Effects of Fishing*), and contribute to the Ministry's priority (in the *Statement of Intent*) of improving the environmental performance of fishing. Consistent with the 2005 Strategy for Managing the Environmental Effects of Fishing (SMEEF), the information will also be used to develop and refine standards for the effects on benthic habitat through better understanding of the rate of recovery of specific habitats.

Weighting of Objectives

Weightings indicate the relative importance of each of the objectives. The weightings for the objectives in this project are (in order): 0.3., 0.7.

Project Title: Multi-species analysis of coastal marine connectivity

Project Code: ZBD2009-10

Start Date: 1 September 2009

Length of project: 3 years

Vessel Use: No major vessel required

Overall Objectives:

1. Determine overall patterns of regional connectivity in a broad range of NZ coastal marine organisms to define the geographic units of genetic diversity for protection and the dispersal processes that maintain this diversity.

Specific Objectives:

1. Review previous studies of marine connectivity and population genetics in NZ coastal organisms to determine the preliminary range of patterns observed, and the principal gaps (taxonomic, geographic and ecological) in our understanding.
2. In a range of invertebrate and vertebrate marine organisms, determine geographic patterns of genetic variation using standardised sampling and molecular techniques.
3. Analyse data across past and present studies to reveal both common and unique patterns of connectivity around the NZ coastline, and the locations of common barriers to dispersal.

Reporting Requirements

Specific Objectives 1, 2 and 3

1. To submit to MFish, a Progress Report as specified in Research Reporting form 4 by 31 January 2010.

2. To present the results of reporting requirement 1 to a meeting of the Biodiversity Research Advisory Group by 30 March 2010.

3. To submit to MFish, a Progress Report as specified in Research Reporting form 4 by 31 January 2011.

4. To present the results of reporting requirement 1 to a meeting of the Biodiversity Research Advisory Group by 30 March 2011. To submit to MFish, a Progress Report as specified in Research Reporting form 4 by 31 January 2010.

5. To present the results of reporting requirement 1 to a meeting of the Biodiversity Research Advisory Group by 30 March 2012.

6. To submit to MFish a draft AEBR as specified in Research Reporting form 6 by 30 September 2012.

7. To present the findings of the draft AEBR, incorporating specific objectives 1 – 3 above, to a meeting of the Biodiversity Research Advisory Group and/or Aquatic Environment Working Group by 30 October 2012. Presentations to more than one meeting in Wellington may be required.

Project Update Reports

No Project Update Reporting is required for this project.

Work In Progress Reports

Monthly Work In Progress Reporting (Form 13) is required for this project in accordance with the Conducting Research with the Ministry document.

Data Reporting

To submit any data generated, collected or modified during the course of this project to the Research Data Manager, MFish by 30 December 2012.

Rationale:

General

Research in recent years has revealed that populations of many marine species are far more 'closed' than previously believed (Cowen *et al.*, 2006). That is, many populations depend far more on local recruitment for their continued survival, than on recruitment of individuals from distant locations. The implication of this is that contrary to previous belief, populations of many species may be far more vulnerable to local depletion and stochastic events than previously suspected, and may therefore require more careful management. For those species that have more 'open' populations, and rely to a greater extent on recruitment from distant locations, it is also important to know the directions and/or approximate distances that most recruits travel in order to populate a region. Some populations may act as sources of recruits, while others are predominantly sinks. A number of methods can be used to estimate these parameters (Levin, 2006), but genetic techniques can play a crucial role, particularly for those species that disperse primarily as planktonic larvae, and are thus difficult to track (Palumbi, 2004).

Internationally, great advances have been made recently in this area using molecular techniques. Firstly, the methodologies of using molecular data to estimate connectivity have been improving dramatically (e.g., Kinlan *et al.*, 2005). Secondly, progress has been made in integrating research across many species in a comparative approach, so as to provide information about landscape connectivity processes (in a terrestrial context) or 'seascape' processes (in a marine context) (e.g., Bay *et al.*, 2006). Within NZ, a number of excellent population genetic studies have been undertaken over the years (e.g., Ayers, Waters, 2005; Goldstien *et al.*, 2006; Star *et al.*, 2003). However, most of these have concentrated on examining just one species at a time, each sampled from different locations at different times. Also, most studies have had sampling strategies that can address questions of connectivity only on a very broad scale, or only for specific regions. As a result, although some general conclusions can be drawn about overall patterns of connectivity around the NZ coastline, many datasets are difficult to compare directly, and are unlikely to reveal fine-scale patterns of structure that become evident with more detailed sampling.

This project seeks to implement a broad-scale comparative study that examines a number of species across a taxonomic and ecological range, so as to provide (for the first time) an overview of the major patterns of connectivity around the NZ coastline. Sampling should be undertaken, as far as possible, from a number of standardised sites for all species, using standardised molecular techniques, so that direct comparisons can be made. Sampling sites should be chosen to address a number of past and present hypothetical restrictions to connectivity.

There are likely to be a number of management applications from this research. The principal immediate outcomes are likely to be in the delineation of distinct geographic units of genetic biodiversity that require protection in the developing system of marine protected areas (MPAs). Determining common patterns of connectivity will also help define the general scales and directions of dispersal and recruitment for marine communities. This information is important in helping determine both the size and spacing of MPAs, so that sufficient recruitment can occur within reserves, and that reserves can be linked through effective recruitment (Palumbi, 2004). In the longer term, it is only through an understanding of the processes that have led to the establishment of genetic diversity within NZ species, that we can understand how modifications from human impact or climate change are likely to affect this diversity.

Strategic Relevance

One aim of the NZ Biodiversity Strategy is to "maintain and restore viable populations of all indigenous species and subspecies across their natural range and maintain their genetic diversity". In response to this, the Biodiversity Medium Term Research Plan (2008–13) is developing a strategy and work stream to examine genetic diversity within NZ marine species.

Weighting of Objectives

Weightings indicate the relative importance of each of the objectives. The weightings for the objectives in this project are (in order): 0.1., 0.5., 0.4

References:

Ayers KL, Waters JM (2005) Marine biogeographic disjunction in central New Zealand. *Marine Biology* **147**, 1045-1052.

Bay LK, Crozier RH, Caley MJ (2006) The relationship between population genetic structure and pelagic larval duration in coral reef fishes on the Great Barrier Reef. *Marine Biology* **149**, 1247-1256.

Cowen RK, Paris CB, Srinivasan A (2006) Scaling of Connectivity in Marine Populations. *Science* **311**, 522-527.

Goldstien SJ, Schiel DR, Gemmell NJ (2006) Comparative phylogeography of coastal limpets across a marine disjunction in New Zealand. *Molecular Ecology* **15**, 3259-3268.

Kinlan BP, Gaines SD, Lester SE (2005) Propagule dispersal and the scales of marine community process. *Diversity & Distributions* **11**, 139-148.

Levin LA (2006) Recent progress in understanding larval dispersal: new directions and digressions. *Integrative and Comparative Biology* **46**, 282-297.

Palumbi SR (2004) MARINE RESERVES AND OCEAN NEIGHBORHOODS: The Spatial Scale of Marine Populations and Their Management. *Annual Review of Environment and Resources* **29**, 31-68.

Star B, Apte S, Gardner JPA (2003) Genetic structuring among populations of the greenshell mussel Perna canaliculus revealed by analysis of randomly amplified polymorphic DNA. *Marine Ecology-Progress Series* **249**, 171-182.

Project Title Ocean acidification impact on key NZ molluscs

Project Code: ZBD2009-13

Start Date: 1 September 2009

Length of project: 3 years

Vessel Use: None

Overall Objectives:

1. Identify the potential impacts of ocean acidification on at least 2 ecologically and economically important NZ mollusc species, and likely local and ecosystem-scale implications of this threat.

Specific Objectives:

1. Controlled laboratory experiments will be used to determine the effect of pCO_2 levels that are predicted to occur in NZ waters over the next few decades on a variety of life history stages of at least two key NZ mollusc species. A number of response variables will be assessed (e.g., growth, physiological condition, shell morphology and mortality).

2. Implications of these responses to the local and broader ecosystems will be assessed.

Reporting Requirements

Specific Objectives 1 and 2

1. To submit to MFish, a Progress Report as specified in Research Reporting form 4 by 31 January 2010.

2. To present the results of reporting requirement 1 to a meeting of the Biodiversity Research Advisory Group by 30 March 2010.

3. To submit to MFish, a Progress Report as specified in Research Reporting form 4 by 31 January 2011.

4. To present the results of reporting requirement 1 to a meeting of the Biodiversity Research Advisory Group by 30 March 2011. To submit to MFish, a Progress Report as specified in Research Reporting form 4 by 31 January 2010.

5. To present the results of reporting requirement 1 to a meeting of the Biodiversity Research Advisory Group by 30 March 2012.

6. To submit to MFish a draft AEBR as specified in Research Reporting Form 6 by 30 September 2012.

7. To present the findings of the draft AEBR, incorporating specific objectives 1 – 3 above, to a meeting of the Biodiversity Research Advisory Group and/or Aquatic Environment Working Group by 30 October 2012. Presentations to more than one meeting in Wellington may be required.

Project Update Reports

No Project Update Reporting is required for this project.

Work In Progress Reports

Monthly Work In Progress Reporting (Form 13) is required for this project in accordance with the Conducting Research with the Ministry document.

Data Reporting

To submit any data generated, collected or modified during the course of this project to the Research Data Manager, MFish by 30 December 2012.

Rationale:

General

Ocean acidification associated with increased atmospheric CO_2 levels is a pressing threat to coastal and oceanic ecosystems (IPCC 2007). Absorption of this excess atmospheric CO_2 by the oceans results in increased pCO_2 levels and, consequently, a decrease in ocean pH (e.g., Gazeau et al. 2007). This acidification has important implications for organisms that depend on calcium carbonate ($CaCO_3$) for shell generation (e.g. Royal Society 2005), such as molluscs, echinoderms and corals. As well as influencing shell formation and dissolution, acidification can also affect many physiological processes; for example, increased energy requirements for shell generation will have consequences for the organism's fitness, growth and reproduction, and for their ability to cope with other stressors. This is likely to have flow on to the local community and wider ecosystem, and to the value of economically important species.

Physiological and ecological impacts of ocean acidification are poorly understood (Kleypas et al. 2006), and information on how, or even if, calcifying organisms will acclimate to this change is urgently needed (Siebel and Fabry 2003, Feely et al. 2004, Royal Society 2005). The few experiments conducted to date have demonstrated negative effects on growth and metabolism of shallow water bivalves, gastropods and sea urchins, and shell dissolution in pteropods (Michaelidis et al. 2005, Orr et al. 2005, Shirayana & Thornton 2005, Gazeau et al. 2007). However, there is currently no information on how key NZ calcifying species will respond to this change, or the likely consequences to their broader ecosystems.

There are many mollusc species around NZ with important roles in maintaining ecosystem diversity and function (e.g., cockles, *Austrovenus stutchburyi*; pipi, *Paphies australis*; paua, *Haliotis iris*; green lipped mussel, *Perna canaliculus*). These are often key species (e.g., important in biogeochemical processes, providing habitat structure, filtering large volumes of water), and as such are important in maintaining healthy ecosystem function and influencing diversity. As many of these species are also economically important, the outcomes of this research also have significant application for aquaculture. The experiments proposed here will provide new data with which we can begin to assess the likely implications of ocean acidification on these species.

It is well recognised that early life history stages of molluscs are more vulnerable than adult stages to stress. Consequently, this project seeks to investigate physiological responses of a variety of life history stages (e.g., juveniles, adult) of at least two key NZ mollusc species to levels of ocean CO_2 saturation predicted to occur over the following decades. Controlled laboratory experiments will be conducted to quantify the effect of increased pCO_2 on a number of response variables (e.g., growth, physiological condition, shell morphology and mortality). The experiments will be of several months duration, to determine the potential of these species to adapt to this change. In combination, the results of these experiments and detailed information on the role of these species in ecosystem structure and function will be used to predict local and ecosystem-scale implications of ocean acidification.

Strategic Relevance

In response to a gap analysis of progress on the New Zealand Biodiversity Strategy, the Biodiversity Medium Term Research Plan introduced two new strategic workstreams in 2007: 5). *To determine the effects of climate change and increased ocean acidification on marine biodiversity…and* 7). *To identify threats and impacts to biodiversity and ecosystem functioning beyond natural environmental variation).* This project addresses both workstreams.

There has also been growing awareness of measurable changes to ocean pH around the globe, including New Zealand waters (NZ Royal Society). As aquaculture interests strengthen and fisheries resources become more closely managed, it is essential that we understand the implications of widespread changes in the New Zealand marine environment.

Weighting of Objectives

Weightings indicate the relative importance of each of the objectives. The weightings for the objectives in this project are (in order): 0.7., 0.3

References:

Feely, R.A., Sabine, C.L., Lee, K., Berelson, W., Kleypas, J., Fabry V.J., Millero, F.J. 2004. Impact of anthropogenic CO_2 on the $CaCO_3$ System In the oceans. *Science 305 (5682)*:362-366.

Gazeau, F. Quiblier, C., Jansen, J.M., Gattuso, J.-P., Middelburg, J.J., Heip, C.H.R. 2007. Impact of elevated CO_2 on shellfish calcification. *Geophysical Research Letters 34*, L07603, doi:10.1029/2006GL028554.

Kleypas, J.A., R.A. Feely, V.J. Fabry, C. Langdon, C.L. Sabine, and L.L. Robbins, 2006. *Impacts of Ocean Acidification on Coral Reefs and Other Marine Calcifiers: A Guide for Future Research*, report of a workshop held 18–20 April 2005, St. Petersburg, FL, sponsored by NSF, NOAA, and the U.S. Geological Survey, 88 p.

Michaelidis B., Ouzounis C., Paleras A., Pörtner H.O. 2005. Effects of long-term moderate hypercapnia on acid-base balance and growth rate in marine mussels *Mytilus galloprovincialis*. *Marine Ecology Progress Series 293*:109–118.

Orr, J.C., Fabry, V.J., Aumont, O., Bopp, L., Doney, S.C., Feely, R.A., Gnanadesikan, A. Gruber, N., Ishida, A., Joos, F., Key, R.M., Lindsay, K., Maier-Reimer, E., Matear, R., Monfray, P., Mouchet, A., Najjar, R.G., Plattner, G.-K., Rodgers, K.B., Sabine, C.L., Jorge L. Sarmiento, J.L., Schlitzer, R., Slater, R.D., Totterdell, I.J., Weirig, M.-F. Yamanaka, Y., Yool, A. 2005. Anthropogenic ocean acidification over the twenty-first century and its impact on calcifying organisms. *Nature 437*:681-686.

Royal Society 2005. Ocean acidification due to increasing atmospheric carbon dioxide. Policy document 12/05 ISBN 0 85403 617 2 Clyvedon Press Ltd, Cardiff, UK. 57 p.

Seibel, B.A., Fabry, V.J. 2003. Marine biotic response to elevated carbon dioxide. *Advances in Applied Biodiversity Science 4*:59–67

Shirayama, Y., Thornton, H. 2005. Effect of increased atmospheric CO_2 on shallow water marine benthos. *Journal of Geophysical Research 110*:C09S09.

Project Title: Predicting impacts of increasing rates of disturbance on functional diversity in marine benthic ecosystems

Project Code: ZBD2009-25

Start Date: 1 September 2009

Length of project: 3 years

Overall Objectives:

1. To better understand potential impacts on ecosystem function of rates of disturbance associated with natural and human impacts, and predicted increases in rates of disturbance associated with climate variability and change

Specific Objectives:

1. Further develop landscape ecological model of disturbance/recovery dynamics in marine benthic communities, incorporating habitat connectivity, based on existing model by Lundquist, Thrush, and Hewitt.
2. Predict impacts of increasing rates of disturbance on rare species abundance, functional diversity, relative importance of biogenic habitat structure, and ecosystem productivity.
3. Use literature and expert knowledge to quantify rare species abundance, biomass, functional diversity, habitat structure, and productivity of various successional community types in the model.
4. Field test predictions of the model in appropriate marine benthic communities where historical rates of disturbance are known, and benthic communities have been sampled.

Reporting Requirements

Specific Objectives 1 – 4

1. To submit to MFish, a Progress Report as specified in Research Reporting form 4 by 31 January 2010.

2. To present the results of reporting requirement 1 to a meeting of the Biodiversity Research Advisory Group by 30 March 2010.

3. To submit to MFish, a Progress Report as specified in Research Reporting form 4 by 31 January 2011.

4. To present the results of reporting requirement 1 to a meeting of the Biodiversity Research Advisory Group by 30 March 2011. To submit to MFish, a Progress Report as specified in Research Reporting form 4 by 31 January 2010.

5. To present the results of reporting requirement 1 to a meeting of the Biodiversity Research Advisory Group by 30 March 2012.

6. To submit to MFish a draft AEBR as specified in Research Reporting form 6 by 30 September 2012.

7. To present the findings of the draft AEBR, incorporating specific objectives 1 – 3 above, to a meeting of the Biodiversity Research Advisory Group and/or Aquatic Environment Working Group by 30 October 2012. Presentations to more than one meeting in Wellington may be required.

Project Update Reports

No Project Update Reporting is required for this project.

Work In Progress Reports

Monthly Work In Progress Reporting (Form 13) is required for this project in accordance with the Conducting Research with the Ministry document.

Data Reporting

To submit any data generated, collected or modified during the course of this project to the Research Data Manager, MFish by 30 December 2011.

Rationale:

General

Marine soft sediment habitats are the most common marine benthic habitat, and contribute substantially to primary productivity and ecosystem function, particularly in coastal areas (Bolam *et al.* 2002). Both natural and anthropogenic disturbances impact these habitats, with the potential to result in habitat fragmentation and long term degradative change (Paine & Levin 1981; Watling & Norse 1998; Kaiser *et al.* 2000). Seascapes are composed of complex, heterogeneous communities, often formed through biogenic structure. The roles of habitat structure in subtidal soft sediment communities are extensive, including the provision of settlement habitat and refuge sites from predation, modification of biogeochemical processes and exchanges, and sedimentation stabilization (Turner *et al.* 1999; Thrush *et al.* 2001; Diaz *et al.* 2003; Hewitt *et al.* 2005; Scharf *et al.* 2006). The general pattern, repeated across broad spatial scales, is that high rates of disturbance to benthic communities reduces habitat structure, resulting in communities with decreased diversity, and the loss of large and long-lived sedentary species that create habitat structure (Dayton *et al.* 1995; Scheffer *et al.* 2001; Thrush & Dayton 2002). Thus at high rates of disturbance, communities are reduced to homogenous, simple, low diversity communities, with reduced contribution to primary production and ecosystem function (Sousa 1984; Thrush *et al.* 2001; Wlodarska-Kowalczuk *et al.* 2005).

As human and natural disturbances result in changing landscape properties in coastal marine systems, it is important to understand how seascapes (and their structure-forming species) respond to different spatial and temporal rates of disturbance. The importance of functional and rare species diversity, habitat structure and associated successional processes required for biogenic habitats to be created are often ignored in theoretical models of metapopulations and metacommunities that predict impacts of dispersal or disturbance on community diversity and productivity (Wilcox *et al.* 2006).

This project seeks to expand on a spatially explicit patch dynamic model (Thrush *et al.* 2005) as a framework to illustrate how increasing rates of disturbance to benthic marine ecosystems influence functional diversity, abundance of rare species, ecosystem productivity, and biogenic habitat structure. The objective is to determine the spatial and temporal rates of disturbance that result in long term degradative change and decreases in species abundance and biodiversity in marine soft sediment communities in order to better inform managers of appropriate rates of disturbance that minimize impacts to benthic habitats. Model predictions should be tested by sampling communities with known historical rates of disturbance, resulting in further model developments and enhancement to better represent biological reality.

Strategic Relevance

This project links to strategic themes 3, 5 and 7 identified in the Biodiversity Medium Term research Plan 2008–13. It also contributes to Objective 3.1 (d), (e), and (f) and 3.4 (a) to (d) of the New Zealand Biodiversity Strategy (that MFish was identified as lead agency). It also links to the benthic section of the Aquatic Environment Research Programme to determine direct and indirect effects of fishing on benthic biodiversity, habitats of particular significance for fisheries management, and maintenance of biological diversity in the marine environment. This project is therefore consistent with the *Marine Environment Research* section of the *Ministry of Fisheries Strategic Research Directions* document.

The project will provide for an assessment of threats to biodiversity, the development of an environmental monitoring system, increased community awareness of the effects of our activities on marine biodiversity, the identification of species and habitats at risk from fishing, and improved environmental impact assessment of fishing. In particular, this project will enable the identification of the species or habitats most at risk from dredge fishing (as mandated by the Ministry's *Strategy for Managing the Environmental Effects of Fishing*), and contribute to the Ministry's priority (in the *Statement of Intent*) of improving the environmental performance of fishing. Consistent with the 2005 Strategy for Managing the Environmental Effects of Fishing (SMEEF), the information will also be used to develop and refine standards for the effects on benthic habitat through better understanding of the rate of recovery of specific habitats.

Weighting of Objectives

Weightings indicate the relative importance of each of the objectives. The weightings for the objectives in this project are (in order): 0.3., 0.2., 0.3, 0.3

References:

Bolam S.G., Fernandes T.F. & Huxham M. (2002). Diversity, biomass, and ecosystem processes in the marine benthos. *Ecological Monographs*, 72, 599-615.

Dayton P.K., Thrush S.F., Agardy T.M. & Hofman R.J. (1995). Environmental effects of fishing. *Aquatic Conservation: Marine and Freshwater Ecosystems*, 5, 205-232.

Diaz R.J., Cutter G.R., Jr. & Able K.W. (2003). The importance of physical and biogenic structure to juvenile fishes on the shallow inner continental shelf. *Estuaries*, 26, 12-20.

Hewitt J.E., Thrush S.F., Halliday J. & Duffy C. (2005). The importance of small-scale habitat structure for maintaining beta diversity. *Ecology*, 86, 1619-1626.

Kaiser M.J., Ramsay K., Richardson C.A., Spence F.E. & Brand A.R. (2000). Chronic fishing disturbance has changed shelf sea benthic community structure. *Journal of Animal Ecology*, 69, 494-503.

Paine R.T. & Levin S.A. (1981). Intertidal landscapes: disturbance and the dynamics of pattern. *Ecological Monographs*, 51, 145-178.

Scharf F.S., Manderson J.P. & Fabrizio M.C. (2006). The effects of seafloor habitat complexity on survival of juvenile fishes: Species-specific interactions with structural refuge. *Journal of Experimental Marine Biology and Ecology*, 335, 167-176.

Scheffer M., Carpenter S., Foley J.A., Folke C. & Walker B. (2001). Catastrophic shifts in ecosystems. *Nature*, 413, 591-596.

Sousa W.P. (1984). The role of disturbance in natural communities. *Annual Review of Ecological Systematics*, 15, 353-391.

Thrush S. & Dayton P.K. (2002). Disturbance to marine benthic habitats by trawling and dredging: Implications for marine biodiversity. *Annual Review of Ecology and Systematics*, 33, 449-473.

Thrush S.F., Hewitt J.E., Funnell G.A., Cummings V.J., Ellis J., Schultz D., Talley D. & Norkko A. (2001). Fishing disturbance and marine biodiversity: the role of habitat structure in simple soft-sediment systems. *Marine Ecology Progress Series*, 223, 277-286.

Thrush S.F., Lundquist C.J. & Hewitt J.E. (2005). Spatial and temporal scales of disturbance to the seafloor: a generalized framework for active habitat management. *American Fisheries Society Symposium*, 41, 639-649.

Turner S.J., Thrush S.F., Hewitt J.E., Cummings V.J. & Funnell G. (1999). Fishing impacts and the degradation or loss of habitat structure. *Fisheries Management and Ecology*, 6, 401-420.

Watling L. & Norse E.A. (1998). Disturbance of the seabed by mobile fishing gear: a comparison to forest clearcutting. *Conservation Biology*, 12, 1180-1197.

Wilcox C., Cairns B.J. & Possingham H.P. (2006). The role of habitat disturbance and recovery in metapopulation persistence. *Ecology*, 87, 855-863.

Wlodarska-Kowalczuk M., Pearson T.H. & Kendall M.A. (2005). Benthic response to chronic natural physical disturbance by glacial sedimentation in an Arctic fjord. *Marine Ecology Progress Series*, 303, 31-41.